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PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

M'HAMED BOUGARA UNIVERSITY OF BOUMERDES
FACULTY OF TECHNOLOGY
Laboratory of Coatings, Materials & Environment (LCME)

1st National Conference on Materials Applications and Renewable Energy

Boumerdes, Algeria • 24–25 June 2026

NC-MARE 2026

BOOK OF ABSTRACTS

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We are pleased to announce the opening of the call for abstract applications for the First National Conference on Materials Applications and Renewable Energy in Hybrid Mode (On-site and Online) NC-MARE 2026, which will take place on 24–25 June 2026 at the University of Boumerdes. This conference will bring together researchers, engineers, and industry experts to discuss the challenges and solutions that materials applications offer to accelerate the energy transition. Objectives of the conference:

❖ Discuss the latest innovations and advancements in materials applications for renewable energy, energy storage and efficiency.

❖ Promote synergies between the academic research, industry, and government sectors.

❖ Discover innovative opportunities for sustainable development through next-generation materials applications.

❖ Evaluate the technical and economic challenges associated with the large-scale adoption of these technologies.

The conference focuses on two main themes:

1- Materials Science & Applications

- Physical Chemistry of Materials
- Nanomaterials and Nanotechnology
- Soft Matter Physics, Polymers & Hybrid Materials
- Multiscale modeling and AI for materials

2- Renwelable Energy Systems

- Renwelable energy and Storage
- Computational fluid dynamics
- Sustainable and Green Energy Technologies
- Heat and mass transfer • Hydrogen Energy Systems and Applications
- Nanofluids for Enhanced Heat Transfer

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Numerical Analysis Of Forced Convection In Inclined Couette-Taylor Rotating Systems

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Abstract: This study presents a numerical simulation of 3D heat transfer by forced convection of distilled water with variable properties and a Prendl number of, confined within an inclined Couette-Taylor-type rotating annular channel subjected to a temperature gradient of . The inner cylinder is hotter, with a temperature of , and rotates at an angular velocity represented by the dimensionless Taylor number [),]. The outer cylinder has a lower temperature, , and is at rest Ta=0. Both ends of the conduct are fixed and adiabatic. In this study, we investigate the effect of the duct's angle of inclination on the dynamics of counter-rotating cells within the gap in the case of the first instability (), as well as its heat transfer performance. The governing equations are solved using the finite volume method with second-order spatial and temporal discretization. The calculations were performed for forced convection, with a Grashof number and a critical condition (), for and this applies to various angles of the rotating annular duct (). The results show that axial heat transfer within the gap increases as the angle of inclination increases, and this affects the axial Nusselt number. The dynamic and thermal fields are axisymmetric at different positions in the rotating system.

Keywords: Taylor-Couette system, Duct inclination, Forced convection, Numerical simulation, Critical condition.

The Temperature Uniformity Of Aluminium Billets Heated DC

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Abstract: The objective of this paper is to analyse and improve the temperature uniformity of aluminium billets heated by DC induction heaters. To accomplish this, a 3D electromagnetic model coupled with a heat transfer model is developed to calculate the heating process of the billets which are rotated in a uniform transverse DC magnetic field. The simulation results demonstrate that lower rotation speeds consistently yield better temperature uniformity along the radial direction, due to the increase in power penetration. However, the behavior is significantly different for the temperature distribution along the axial direction. When the rotation speed is low, the temperature at the ends is lower than other parts, but this situation reverses as the rotation speeds increase "skin effect. This specific phenomenon is referred to as the "ending effect".

Keywords: DC induction heating; Rotation speed; Aluminum billets; Power penetration; Skin effect; Ending effect

Numerical Investigation Of Flow And Heat Transfer Characteristics In A Helically Baffled Shell-And-Tube Heat Exchanger

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Abstract: This work presents a comprehensive study on the enhancement of thermal performance in shell-and-tube heat exchangers through theoretical analysis and numerical simulation. It begins with an overview of heat exchanger fundamentals, including their operating principles, components, classifications, and industrial applications, with particular emphasis on shell-and-tube configurations. The study then investigates various heat transfer enhancement techniques, including passive methods such as fins, twisted tapes, and nanofluids, as well as active methods such as mechanical vibration and pulsating flow, highlighting their effects on heat transfer efficiency. Finally, a Computational Fluid Dynamics (CFD) analysis using ANSYS CFX is conducted to evaluate fluid flow and thermal behavior within the heat exchanger, focusing on key performance parameters such as temperature distribution, heat transfer coefficient, thermal effectiveness, and pressure drop. The results provide valuable insights for optimizing heat exchanger design and improving energy efficiency in industrial thermal systems.

Keywords: heat exchanger, heat transfer, computational fluid dynamics, energy-efficient

Nanobiocomposite PLA/Cellulose Fibers: Biodegradability and Durability

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Abstract: Polylactide (PLA) fibers reinforced with cellulose nanowhiskers are attracting increasing interest in medical and textile applications because of their biodegradability, biocompatibility, and bio-based origin. However, exposure to moisture and temperature variations can affect their durability. In medical uses, these fibers operate in humid physiological environments, while in textiles they are exposed to washing and environmental conditions. Therefore, studying their hydrothermal aging and degradation is essential to evaluate fiber stability and optimize performance. In this work, nanobiocomposite fibers based on Polylactide and cellulose nanowhiskers (PLA/CNW), containing 1 and 3 wt% CNW, were produced by melt spinning and drawing in the presence of maleic anhydride-grafted polylactide (PLA-g-MA) as a compatibilizer. Their resistance to hygrothermal aging was investigated in a climatic chamber at 95% relative humidity and at 45 °C and 60 °C.

The results show that both PLA and PLA/PLA-g-MA/CNW fibers degrade through chain scission. Hydrolysis causes reductions in molecular weight and thermal and mechanical properties, while increasing crystallinity and accelerating crystallization kinetics in all fibers. Degradation occurred faster at 60 °C than at 45 °C. Nanobiocomposite fibers were more sensitive to hydrolysis than pure PLA because the hydrophilic cellulose fillers promote water diffusion into the matrix. This behavior is advantageous for biomedical applications requiring temporary mechanical support and predictable resorption in humid environments. The enhanced sensitivity of cellulose-filled fibers may reduce the need for surgical removal after healing while maintaining performance during the recovery period.

Keywords: Fibers; Nanobiocomposite; Polylactide; Nanowhiskers.

Gaialene-Based Nanobiocomposite Films Reinforced with Halloysite Nanotubes

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Abstract: This work falls within the field of nanobiocomposite polymer materials intended for applications in the packaging sector. It focuses on the synthesis and characterization of films based on a bio-resin, Gaialene (starch-grafted polyethylene), reinforced with a natural mineral filler : halloysite nanotubes (HNT). The aim is to optimize the properties of these nanobiocomposites and enhance their performance for use in this field. In this study, three types of films were developed: pure Gaialene (G), G/HNT with 3% HNT by weight, and G/HNT/PE-g-MA with 5% compatibilizer. The addition of PE-g-MA is intended to improve adhesion between the matrix and the filler. The films were prepared by melt processing, involving extrusion followed by hot pressing. This method allowed the production of homogeneous films with a thickness of approximately 100 µm.

FTIR spectroscopy characterization revealed two types of interactions between the nanocomposite components: a physical interaction through hydrogen bonding, and a chemical interaction in the form of esterification involving the hydroxyl groups of HNT and starch, as well as the carboxyl groups of PE-g-MA. Moreover, morphological analysis showed improved dispersion of HNT in the presence of PE-g-MA, confirming its role as a compatibilizer. In addition, X-ray diffraction (XRD) analysis revealed an increase in the degree of crystallinity of the nanocomposites, attributed to the nucleating effect of HNT. This increase in crystallinity is expected to enhance the mechanical strength and reduce the permeability of the material, which is particularly beneficial for packaging applications.

Keywords: Gaialene; Halloysite nanotube; Nanobiocomposite; Films.

Tunable Dual-Band THz Absorber Based on Graphene-Loaded Double Circular Ring Frequency Selective Surface

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Abstract: This paper presents the design and simulation of a tunable dual-band terahertz (THz) absorber based on a graphene-loaded double circular ring frequency selective surface (FSS). The proposed structure consists of two concentric circular ring resonators incorporating graphene, placed on a dielectric substrate backed by a metallic ground plane. The unique tunable surface conductivity of graphene, controlled by varying the chemical potential through electrostatic gating, enables dynamic adjustment of the dual absorption bands without any structural modification. Full-wave electromagnetic simulations are performed using COMSOL Multiphysics, where graphene conductivity is modeled using the Kubo formalism. The double circular ring geometry produces two distinct resonance modes, achieving near-perfect absorption at two THz frequencies simultaneously. Parametric studies are carried out to optimize the ring dimensions, substrate properties, and graphene chemical potential to maximize absorption performance. The simulation results demonstrate high absorption efficiency, with effective tunability across the THz band. The absorber is suitable for applications in THz sensing, imaging, spectroscopy, and next-generation wireless communications.

Keywords: Terahertz Absorber, Graphene, Frequency Selective Surface, COMSOL Multiphysics, Kubo Formalism, Chemical potential

Restoring Lubricant Performance of Used Compressor Oil from a Refinery: Acid/Clay vs. Solvent Extraction – Screening & Optimization by Experimental Design

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Abstract: This study developed and optimized two techniques for regenerating used compressor lubricating oil from the Algiers refinery: the acid/clay method and solvent extraction. The used oil was first pretreated by filtration and distillation to remove dust, solid particles, water, and light hydrocarbons, achieving a 66.4% reduction in water content. After each treatment, the regenerated oil was analyzed and compared to new oil, used oil, and pretreated oil based on pour point, cloud point, kinematic viscosity at 37°C and 100°C, density, flash point, refractive index, water content, oxidation index, nitration index, and heavy metal content. Four different acids followed by green clay adsorption were tested. Sulfuric acid yielded the best results, followed by nitric, hydrochloric, and acetic acids. Optimal results with sulfuric acid included a further 66.7% reduction in water content, a 4.1% decrease in viscosity at 37°C, a 7.7% decrease at 100°C, and a 4.7% increase in flash point compared to the pretreated stage. Nickel and aluminum were reduced by 70.6%, while zinc and silicon were eliminated by 90.1% and 80%, respectively. Solvent extraction revealed that 1-butanol is the most effective solvent compared to propanol and acetone. The treated oil properties approached those of new oil, with oxidation andnitration indices reduced to 0.044 and 0.022, respectively, versus 0.011 and 0 for new oil. Three key parameters for each method were optimized using a Box-Behnken design implemented in Expert Design software. The optimal acid/clay conditions were: volume ratio V(oil)/V(acid) = 6.78, temperature of 48.09°C, and treatment duration of 40 min. For solvent extraction, optimal conditions were: mass ratio m(solvent)/m(oil) = 2.469, temperature of 55°C, and extraction duration of 80 min.

Keywords: Used lubricating oil; Compressor oil; Acid/clay treatment ; Solvent extraction; Box-

Highly mesoporous Ni/Mn microspheres assembled from ultrathin nanoflakes as pseudocapacitive electrode materials for supercapacitors

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Abstract: Transition metal-based electrode materials are increasingly attracting interest as potential candidates for fast electrochemical energy storage. In this study, a straightforward and economical hydrothermal method was used to produce Ni/Mn carbonate nanohybrids by optimizing the growth temperature and precursor ratio. The morphological and structural features of the obtained products were studied using scanning electron microscopy, transmission electron microscopy, powder X-ray diffraction, Fourier-transform infrared spectroscopy, and X-ray photoelectron spectroscopy. Moreover, the capacitive characteristics of the Ni/Mn-based nanomaterial were evaluated in an aqueous 6 M KOH electrolyte using a three-electrode cell via cyclic voltammetry and galvanostatic charge/discharge tests. Our findings demonstrate that the bi-carbonate nanostructure obtained at 120 °C for 6 h with a precursor ratio of Ni/Mn = 2/1 exhibits a specific capacitance of around 778.2 F g-1 at 5 mV s-1 (179.1 mAh g-1 at 0.5 A g-1). Furthermore, the nanohybrid exhibits a unique morphology of highly mesoporous microspheres with an average size of about 2 µm that interfere with each other without clear boundaries, resulting in a novel pore arrangement within the aggregates. High-resolution transmission electron microscopy confirms that these microspheres are assembled from interconnected ultrathin nanoflakes. The increased concentration of the nickel precursor enhances the driving force for nanoflake aggregation, accelerating the process while simultaneously reducing the mean thickness of the nanoflakes, making this material an ideal candidate for high-performance supercapacitor applications.

Keywords: Mesoporous microspheres; interconnected nanoflakes; pseudocapacitive; electrochemistry; supercapacitors.

Beyond Silicon: Computational Insights into the Halide Perovskite $KZnBr_3$ for Next-Generation Photovoltaics

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Abstract: Halide perovskites have attracted considerable attention in recent years owing to their remarkable optoelectronic properties including high absorption coefficients, tunable bandgaps, and long carrier diffusion lengths. making them promising candidates for photovoltaic and optoelectronic device applications. For the successful commercialization of perovskite-based devices, a thorough understanding of their mechanical properties is essential, as these directly govern material processability, thin-film fabrication, and long-term device stability. In this work, we present a first-principles investigation of the structural and mechanical properties of the cubic halide perovskite $KZnBr_3$ using the Full-Potential Linearized Augmented Plane Wave (FP-LAPW) method, as implemented in the WIEN2k code, within the Generalized Gradient Approximation (GGA-PBE). The lattice parameter was determined to be a = 5.2866 Å, obtained by fitting total energy versus volume data to the Birch-Murnaghan equation of state. The second-order elastic constants C_{11}, C_{12}, and C_{44} were computed, from which the bulk modulus, shear modulus, Young's modulus, and Poisson's ratio were derived. Mechanical stability was confirmed through the Born stability criteria. To the best of our knowledge, this represents the first theoretical study of the mechanical properties of $KZnBr_3$. The obtained results show good agreement with trends reported for isostructural halide perovskite compounds, lending confidence to the reliability of the present approach. These findings provide a foundational understanding of the mechanical behaviour of $KZnBr_3$ and contribute to the broader effort of identifying mechanically stable halide perovskites suitable for device integration.

Keywords: halide perovskites; $KZnBr_3$; mechanical properties;first-principles; WIEN2k; DFT

Comparative Study of Two Particle Size Analysis Methods for Fe_2Al_5 Intermetallics Simulating UAl_2 Targets

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Abstract: Powder particle size distribution is a key parameter in the manufacturing of UAl_2 target cores for medical radioisotope production due to its influence on homogeneity, densification, porosity, and irradiation behavior. This study compares particle size characterization results obtained by image analysis and laser diffraction for Fe_2Al_5 intermetallic powders simulating the UAl_2 target fabrication process. The Fe_2Al_5 powders were produced by melting, followed by crushing and milling, and subsequently classified into fine and medium fractions. To ensure a direct comparison, 120 identical particle size classes ranging from 0.01 to 3800 µm were defined for both techniques. The results show that laser diffraction has limited specificity for the fine fraction because it cannot distinguish agglomerates without complementary microscopic observations. Image analysis revealed that the DMajor and DFeret descriptors provide the most representative particle size distributions. The study further demonstrates that results obtained by image analysis and laser diffraction can be reliably correlated for non-spherical powders. Among the image-analysis descriptors, particle width is the most appropriate parameter for comparison with laser diffraction measurements. Nevertheless, systematic differences remain due to the random orientation of irregularly shaped particles during image acquisition, which affects the measured dimensions.

Keywords: intermetallics, Fe_2Al_5 powder, particle size characterization, image analysis, laser particle size analysis

Laser Doping of Silicon from PSG Source Layer for Advanced Solar Cell Applications

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Abstract: Localized laser doping of silicon is considered a promising technique for the fabrication of high-efficiency solar cells. In this work, a laser doping process from a phosphosilicate glass (PSG) source layer was investigated using a nanosecond pulsed infrared laser (λ = 1064 nm) with an optical spot diameter of approximately 65 µm. Three series of samples were prepared using frequencies of 25, 30, and 35 kHz, while the laser power was varied from 2.25 W to 4.5 W for each frequency. The doping performance was evaluated through sheet resistance measurements. The obtained results showed a characteristic decrease in sheet resistance for all investigated series, highlighting three main doping regimes. These behaviors were confirmed by Atomic Force Microscopy (AFM) observations as well as by Electrochemical Capacitance-Voltage (ECV) concentration profiles. The results demonstrate the potential of laser doping from a PSG source layer for applications in next-generation solar cells requiring localized processes and reduced thermal budgets.

Keywords: Laser doping; Phosphosilicate glass (PSG); Nanosecond infrared laser; Sheet resistance; Solar cells

Room-Temperature Synthesis of Zinc Oxide Nanoparticles for Flexible Gas Sensors

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Abstract: The study presents a simple, cost-effective, and energy-efficient method for synthesizing zinc oxide nanoparticles (ZnO NPs) at room temperature and their application in flexible gas sensors. By using a highly basic solution (pH ≈ 13), well-crystallized ZnO nanoparticles were successfully synthesized without the need for a calcination step, reducing both processing time and energy consumption. The synthesized nanoparticles exhibited good thermal stability, low levels of organic residues, and a narrow particle size distribution ranging from 30 to 80 nm. Their properties were comparable to those of nanoparticles produced by the conventional hydrothermal method.

The ZnO nanoparticles, both before and after calcination, were integrated into wearable gas sensors operating under ambient conditions (room temperature and 30–50% relative humidity). This approach overcomes a major limitation of conventional ZnO-based gas sensors, namely their reliance on high operating temperatures, which restricts their use in flexible and wearable devices.

Gas sensing results showed that the surface properties of ZnO nanoparticles strongly influence sensor selectivity and sensitivity toward different target gases. The effects of temperature, humidity, and mechanical deformation were also investigated. These findings demonstrate the potential of room-temperature synthesized ZnO nanoparticles for the development of low-power, flexible gas sensors suitable for wearable electronics and Internet of Things (IoT) applications.

Keywords: Zinc oxide nanoparticles, Room temperature, pH effect, Flexible gas sensor, Styrene detection

Coprecipitation synthesis of Al-substituted Cobalt ferrite spinel nanostructures for enhanced visible-light photocatalytic degradation of Congo red

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Abstract: This study focused on the synthesis and caracterisation of CoFe2-xAlxO4 ($0 \leq x \leq 1.5$) spinel nanomaterials via the co-precipitation for the photocatalytic degradation of Congo Red. The XRD patterns indicated a pure cubic structure of synthesized nanoparticles. The substitution significantly improved the material properties, decreasing the crystallite size from 112 nm to 15 nm (a 86.6% reduction) . FT-IR analysis confirms the presence of spinel characteristics vibration bands corresponding to Co–O and Fe–O bonds. The direct bandgap energy (Eg) values are calculated by Tauc's plot and found to increase slightly upon increasing the substituting concentration from 1.33 to 1.91 eV. Congo Red (CR) is selected as a target pollutant to investigate the photocatalytic performance under visible light and natural sunlight. The obtained results showed that the substitution has a significant impact on the photocatalytic performance of nanoparticles and the best photodegradation of 99.9 % was found with CoFe0.5Al1.5O4 under natural sunlight with a pseudo-first-order kinetics.

Keywords: CoFe2O4; CoAl2O4, Spinel structure; Co-precipitation; photocatalysis; Congo Red

Optimization of the Synthesis of Carbon Quantum Dots (CQDs) for Protective Coatings on Photovoltaic Modules

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Abstract: The performance and durability of solar panels are strongly affected by UV-induced degradation, which gradually reduces their efficiency and lifetime. Carbon Quantum Dots (CQDs) can convert UV radiation into visible light, thus improving solar energy harvesting while simultaneously protecting the polymer encapsulant from UV light. In this communication, we report the synthesis of CQDs and their potential use as protective coatings for photovoltaic applications. In particular, the objective of this work is to determine the optimal synthesis conditions for CQDs. The CQDs were synthesized from citric acid and urea using a hydrothermal method. Different synthesis temperatures (160-240 °C) and reaction times (4-12 h) were explored to evaluate their influence on CQD properties. The synthesized CQDs were characterized using FTIR spectroscopy, UV–Visible spectroscopy and photoluminescence (PL) analysis. The results showed that the synthesis temperature and reaction time significantly influence the optical properties of CQDs, while the surface chemical structure remains relatively stable. At 220 °C, the PL intensity increased with longer synthesis times, and after 8 h, intrinsic emission became dominant over defect-related emissions. In addition, increasing the temperature shifted the PL emission from green to blue, whereas temperatures above 240 °C enhanced defect-related emissions. These findings demonstrate the importance of controlling synthesis parameters to obtain CQDs with improved optical performance for solar panel protection and enhanced power conversion efficiency.

Keywords: Carbon Quantum Dots (CQDs); Hydrothermal Synthesis; Photoluminescence; UV Protection; Photovoltaic Modules; Optical Properties

The strength activity index of diatomite : a proxy to the pozzolanicity adequation for a partial substitution of clinker in cements

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Abstract: Innovation in terms of composite and hybrid materials that aims to be in tune with the implementation of more eco-friendly technologies is among today's biggest challenges. Facing the alarming natural resources fast depletion and its corollary environmental impacts we are heading towards is of a great deal on a global scale. Reducing the clinker content of cementitious materials, the calcinations process of which causes important greenhouse gas emission rates and consumes fossil combustibles to generate energy, falls relevantly under this scope. Within the Algerian cement industry where natural pozzolana is widely used as a siliceous additive, besides the sand and the siliceous limestone, little investigation has been carried out on the strength activity index (SAI) of diatomite to assess its pozzolanic potential for a possible adequation as a supplementary cementitious material for the partial replacement of clinker. In that regard, we experimentally assessed the SAI of Sig's diatomite through a battery of physical and mechanical tests performed on fresh pastes and hardened mortars made out of a given proportion of CEMI component, partially replaced by 5, 10, 15 and 20 % of diatomite. These formulations were set in compliance with the "NA442/2013" and the "EN FN 197-1/2012" norms. The results revealed the high pozzolanic potential of diatomite, with strength activity index values above the 75 % standard threshold, for contents up to 15 %. Its silica- and calcium hydroxide-rich nature, large specific surface area, high porosity and pozzolanic reactivity caused it to enhance the strength-gain of the experimental cementitious mixtures.

Keywords: Strength activity index (SAI); Diatomite; Pozzolanicity; Clinker; Partial substitution; Cementitious materials

Contribution of the Solar Field in the Hassi R'Mel ISCC Power Plant to Fossil Fuel Consumption Reduction

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Abstract: This work aims to assess the contribution of the solar field integrated into the Hassi R'Mel Integrated Solar Combined Cycle (ISCC) power plant to the reduction of fossil fuel consumption and associated emissions. The plant combines solar thermal energy with a gas–steam combined cycle, where a parabolic trough solar field is used to generate additional steam that feeds the steam turbine. A thermo-energetic modeling and simulation approach was developed using the OpenModelica environment to analyze the plant behavior under nominal and varying operating conditions. Particular attention was paid to the influence of Direct Normal Irradiance (DNI) on solar steam production and natural gas savings. The results show that the solar contribution reaches its maximum during summer, leading to a significant reduction in natural gas consumption with a maximum daily saving of about 94 tons of fuel. During spring and autumn, intermediate operating conditions are observed, with daily savings estimated at approximately 66 and 67 tons of natural gas, respectively. Overall, solar integration improves the plant efficiency and reduces CO_2 emissions, highlighting the potential of ISCC technology as an effective transitional solution toward a more sustainable energy mix in regions with high solar resources.

Keywords: Parabolic trough concentrators; direct normal irradiation; efficiency; mass flow rate of htf.

Stability of transmission networks under massive integration of photovoltaic power

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Abstract: Large-scale integration of photovoltaic power plants is transforming the operation of transmission networks by reducing synchronous generation and overall system inertia, while introducing significant variability. This paper evaluates the impact of high photovoltaic penetration on the static and dynamic stability of transmission networks, based on simulations performed on the PIAT (Pole Adrar, Ain Salah, Timimoune) test system to analyze its behavior under different load scenarios and PV penetration levels. First, the study examines the static stability of the PIAT network by analyzing voltage profiles at each bus, as well as power flow redistribution, active and reactive losses, and variations in generation reserves. Next, the system's dynamic stability is evaluated by analyzing frequency and voltage responses to disturbances, such as the loss of a generator, a transmission line, or a PV plant. The results show that high PV penetration reduces system inertia and increases sensitivity to disturbances, leading to the appearance of critical conditions beyond which operational security cannot be ensured. The paper also proposes mitigation strategies based on advanced control of PV plants, reactive power support, virtual inertia, and energy storage integration. These solutions significantly improve stability margins and operational security. This work highlights the technical limits of photovoltaic integration in transmission networks and emphasizes the importance of coordinated planning and advanced control strategies to ensure a safe and reliable energy transition.

Keywords: Photovoltaic penetration, frequency stability, system inertia, voltage stability, power reserves, network congestion

Robust Funnel Control of a Wind Turbine under

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Abstract: This paper presents an innovative control strategy for optimizing the performance of a wind energy conversion system subjected to parametric uncertainties and external disturbances. Although Funnel Control is recognized for its ability to guarantee transient and steady-state performance within a funnel, its robustness can be compromised by severe external disturbances. To overcome this limitation, we propose the integration of Active Disturbance Rejection Control (ADRC).

The central element of this approach lies in the use of an Extended State Observer (ESO) capable of estimating and compensating in real time the total disturbance, including aerodynamic nonlinearities and wind gusts. The resulting linearized system is then regulated by a Funnel control law, ensuring that the speed tracking error remains confined within the funnel boundaries, thereby protecting the mechanical structure of the turbine. Simulation results obtained under MATLAB/Simulink demonstrate the superiority of the FC-ADRC structure over classical controllers (PI) and Funnel Control alone, particularly in terms of robustness against inertia variations and maximum power extraction accuracy (MPPT).

Keywords: Funnel control, ADRC, Wind Turbine, Disturbance, Performance, Robustness Voltage Sag and Swell Compensation; Load Voltage Control.

Performance Evaluation of parabolic trough power plant CSP for electricity generation: Techno-Economic analysis applied in Algeria

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Abstract:
A techno-economic analysis of six locations on the CSP power plant system applied in Algeria is carried out. Three main indicators were been evaluated: the annual energy produced, the overall performance and the levelized cost of electricity LCOE. Such feasibility and analysis study was performed by comparing optimum CSP power plant configurations under the same market data and metrological conditions, by using the same performance indicators. The current study is carried out using SAM software (system advisor model).

It was found that The region of Illizi has shown best performance compared to other locations with an annual energy of 76,805 mil.kWhe, an Overall efficiency of 45,1 % and LCOE Of 42,6 Dzd/kWh.in addition, using thermal storage system allows an evolution of 28 % of the performance of the CSP power plants and a discount of 14% of the electricity cost LCOE.

Keywords: Concentrating solar power plants, parabolic trough, overall performance, economic analysis, LCOE.

Numerical Investigation of Atmospheric Vortex Generation by a Solar Updraft Tower for Renewable Energy Production

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Abstract: This study investigates the numerical simulation of atmospheric vortex generation by a solar updraft tower for renewable energy production. The primary objective is to examine the underlying formation mechanisms and structural characteristics of the generated vortex, and to assess its potential for power generation. A three dimensional Computational Fluid Dynamics (CFD) approach is employed to model the thermo-fluid behavior within the system. The analysis focuses on the velocity and pressure fields in order to characterize vortex intensity and flow structure. Particular attention is given to tangential velocity profiles, which are compared to theoretical models such as the Rankine combined vortex. Furthermore, the generated vortex is classified according to its maximum tangential velocity using the Fujita scale, providing a physical interpretation of its intensity. The energy performance of the system is evaluated by estimating the power output associated with the induced airflow. The results demonstrate the feasibility of controlled atmospheric vortex generation using solar energy and highlight its potential as an innovative and sustainable technology for power generation.

Keywords: Solar updraft tower; Atmospheric vortex; Renewable energy; Computational Fluid Dynamics (CFD); Power generation.

Design and Functionalization of Clay–polymer Hybrid Materials Using Organosilanes for Enhanced Surface and Thermal Properties

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Abstract: The development of clay/polymer hybrid nanocomposites represents a promising approach for designing high-performance multifunctional materials. In this context, the incorporation of polymers into layered clay matrices significantly enhances both thermal and surface properties. The objective of this study is to develop a novel nanocomposite based on montmorillonite clay modified with organosilanes, followed by in situ polymerization within the interlayer space of the mineral, in order to optimize dispersion and interfacial interactions. The methodology involves the preliminary functionalization of clay using organosilane agents to improve its compatibility with the monomer, followed by in situ polymerization leading to the formation of intercalated or even exfoliated structures. The obtained materials were characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and thermogravimetric analysis (TGA). XRD results show an increase in interlayer spacing, confirming the intercalation of polymer chains. FTIR analysis reveals the appearance of new characteristic bands corresponding to silane and polymer bonds, indicating effective chemical interactions between the two phases. TGA results demonstrate a significant improvement in thermal stability, with an increase in the polymer degradation temperature of up to 30–40 °C compared to the pristine structure. Furthermore, surface properties indicate a marked reduction in wettability, corresponding to enhanced hydrophobic behavior, as evidenced by reduced water loss observed in thermograms. These improvements are attributed to both nanoscale structuring and chemical modification at the clay–polymer interface. In conclusion, this work demonstrates that the combination of organosilane functionalization and in situ polymerization is an effective strategy for developing nanocomposites with high thermal resistance and low wettability. The scientific contribution lies in the simultaneous control of structure and interface, paving the way for advanced applications in coatings and protective materials.

Keywords: Clay/Polymer Nanocomposites; Organosilanes; In Situ Polymerization; Thermal Stability; Hydrophobicity; Interfacial Interactions.

Assessing the Double-Impact Resistance of CARALL Laminates: Effects of Impact Spacing and Energy Variation.

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Abstract: Recent advances in composite manufacturing have renewed interest in fibre metal laminates (FMLs), particularly Carbon Fiber Reinforced Aluminum Laminates (CARALL), across various engineering applications. These hybrid structures, combining metallic layers with fibre-reinforced composites, are designed to withstand impact loading due to their superior damage tolerance and energy absorption capability. However, under realistic service conditions, they are often subjected to repeated impacts at different locations, and the interaction between successive impacts remains insufficiently understood. In this study, the double-impact behavior of CARALL laminates is experimentally investigated, focusing on the effects of inter-impact spacing and energy level. Two successive impacts were applied at controlled distances and varying energy levels. The response is analyzed through force–displacement curves, and Cross-sectional views of the damaged zones further assess damage accumulation across both impact sites. The results demonstrate that both spacing and energy level significantly influence the second impact response. At higher energies and larger distances, the subsequent impact tends to behave independently, indicating reduced interaction. Conversely, at small spacing distances, strong interaction is observed, leading to noticeable changes in stiffness and damage distribution. Furthermore, impact energy affects not only the extent of damage but also the critical distance beyond which the two impacts behave independently.

Keywords: Fibre metal laminates; Low velocity impact; Multi-impact response; Damage mechanics; Impact dynamics; Composite structures.

Elucidating Multilayer Adsorption Mechanisms in Recycled Pla-Based Composites Derived from 3D Printing Waste: Kinetic and Isotherm Investigation of Crystal Violet Uptake

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Abstract: This study synthesized polylactic acid (PLA) microspheres and their composites with activated carbon (AC) and sodium alginate (SA) from 3D printing waste using an oil-in-water emulsion solvent evaporation technique. The materials PLA, PLA/AC, PLA/SA, and PLA/AC/SA were characterized by FTIR, XRD, DSC-TGA, and BET. FTIR confirmed SA peaks in PLA matrices, while XRD revealed increased crystallinity with SA incorporation. Adsorption performance toward Crystal Violet (CV) was evaluated by studying contact time, adsorbent dosage, pH, initial concentration, and NaOH regeneration. Incorporating 5% AC into PLA microspheres enhanced adsorption capacity by 60% within 240 minutes, whereas SA alone increased it by only 16%. The ternary composite PLA/AC/SA exhibited a synergistic effect, improving maximum adsorption capacity by 74%. Kinetic modeling showed the pseudo-second-order model as the best fit, indicating a chemisorption-dominated mechanism. The intraparticle diffusion model revealed a two-step mechanism: liquid film diffusion followed by intraparticle diffusion and surface adsorption onto active sites. Isotherm modeling indicated that BET, Freundlich, and Sips models best fitted the experimental data, with a maximum adsorption capacity of 8.6 mg/g, confirming a multilayer adsorption mechanism consistent with low-porosity materials like PLA. Increasing pH enhanced removal efficiency, reaching 92.97% at pH 11 within 240 minutes, with an adsorption capacity of 4.6 mg/g for PLA/SA. Finally, NaOH regeneration of spent adsorbents significantly improved adsorption capacity by forming new surface functional groups on PLA and activating accessible AC within pores and the PLA matrix.

Keywords: Polylactic Acid; 3D Printer Waste; Sodium Alginate; Crystal Violet; Multilayer Adsorption; Modeling.

Vacancy-type defects in 6H-SiC single crystals under neutron and ion irradiation

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Abstract: Vacancy-type defects in 6H-SiC single crystals and their evolution under irradiation were investigated using positron annihilation spectroscopy. Immediately after irradiation, silicon monovacancies (VSi) aggregate into stable (VSi-VC)3 hexavacancy clusters, which persist across the full dose range, indicating early defect saturation and the absence of further clustering. With increasing fluence, additional VSi are primarily eliminated through recombination with interstitials, which becomes the dominant defect-annihilation mechanism. An increase of the irradiation temperature enhances VSi mobility and accelerates the onset of saturation. These results demonstrate that (VSi-VC)3 represents the final, highly stable aggregated form and radiation-resistant vacancy configuration in 6H-SiC under the present irradiation conditions. This remarkable radiation tolerance of 6H-SiC confirms its suitability for next-generation nuclear systems and radiation-hardened electronic devices.

Keywords: Silicon carbide SiC, irradiation dose, Positron annihilation spectroscopy (PAS), vacancy clusters, saturation, recombination process.

Correlating Optical Emission Spectroscopy Diagnostics with SIMTRA Simulations in RF Magnetron Sputtering of Titanium

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Abstract: This study investigates the characteristics of Argon plasma in an RF magnetron sputtering discharge used for the deposition of Titanium and Nickel thin films. Optical Emission Spectroscopy (OES) was employed to diagnose the plasma, specifically analyzing the evolution of emission lines under varying gas pressures. Complementing the experimental approach, the transport of sputtered atoms from the target to the substrate was modeled using the Monte Carlo simulation code, SIMTRA. A strong correlation was established between the spectroscopic measurements and the simulation results. The findings indicate that an increase in working pressure induces a decrease in electron temperature () from approximately 1.9 eV to 1.5 eV, accompanied by a rise in the absolute emission intensity of Titanium species. This behavior is attributed to the thermalization of sputtered atoms and a transition from a ballistic to a diffusive transport regime, as corroborated by the increase in particle accumulation and collision frequency observed in the simulations.

Keywords: Optical emission spectroscopy; Magnetron sputtering; Titanium; SIMTRA

CFD-Based Investigation of Shear Stress Distribution and Energy Dissipation in Hydraulic Jumps: Implications for Sustainable Hydraulic Structures and Green Energy Management

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Abstract: This paper presents a three-dimensional computational fluid dynamics (CFD) investigation of the hydraulic jump phenomenon in a compound channel, with particular emphasis on shear stress distribution, velocity field evolution, and energy dissipation mechanisms. Numerical simulations were performed using the FLUENT solver with the Volume of Fluid (VOF) method to accurately track the free surface. Three inlet opening heights were examined (h_1 = 2 cm, 2.5 cm, and 4 cm) at a high Froude number (F_1 = 12). Results reveal that the opening geometry exerts a decisive influence on the flow structure: narrow openings concentrate kinetic energy and generate intense localized shear stresses (up to ~850 Pa), while wider openings promote a more distributed energy dissipation. Numerical predictions show excellent agreement with experimental data, with relative errors ranging from 3.9% to 9.4%. These findings offer direct engineering relevance for the sustainable design of dissipation structures in hydraulic systems, contributing to more energy-efficient and structurally safe water infrastructure.

Keywords: CFD, hydraulic jump, shear stress, VOF, energy dissipation

Control of the Vortex Dynamics in Helical Flows of Immiscible Fluids

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Abstract: Vortex patterns widely occur in industrial devices involving confined helical flows and may also be observed in the ambient environment as large-scale recirculation streams. The dynamics of such vortices may be either harmful or beneficial, depending on the application. Numerous previous studies have reported on swirling flows of single fluids, while investigations concerning layered systems of immiscible fluids remain relatively scarce. The present numerical study explores helical flows generated inside a cylindrical enclosure filled with two superposed immiscible fluids. The investigation mainly focuses on the interface behavior and the associated vortex dynamics under the combined effects of shear stress and surface tension. The results reveal the development of very thin interfacial recirculation cells, absent in single-fluid configurations, and associated with axial bubble-type vortices. The onset conditions and intensity of these reverse-flow regions were found to be highly sensitive to the background rotation rate, fluid volume fraction, and enclosure aspect ratio. Furthermore, the simulations provided detailed quantitative vortex characteristics that are difficult to capture experimentally. In addition, differential rotation of a thin central rod proved to be an effective method for controlling flow stagnation and the associated recirculation zones. However, high rod rotation rates generated Taylor-type vortices in the less viscous phase due to centrifugal instability, showing qualitative agreement with experimental observations.

Keywords: immiscible fluids, cylinder, swirl, vortex control, numerical simulation.

Stability of conductive fluid flow in a cylindrical cavity under an axial magnetic field

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Abstract: The present communication investigates numerically the hydrodynamic instabilities occurring in a cylindrical container filled with a conducting viscous fluid and submitted to an axial magnetic field. The rotation of the bottom disk generates an axisymmetric swirling flow, leading to the formation of a vortex breakdown bubble along the symmetry axis a key instability in this configuration. The governing Navier-Stokes and electric potential equations are solved using the finite volume method. For both steady and oscillatory regimes, various combinations of electrical conductivity are considered. The results show that vortex breakdown is suppressed when the magnitude of the magnetic field exceeds a critical value.

Keywords: magnetohydrodynamic; swirling, coaxial cylinder; MHD

Assessment of Energy Promoter Configurations for Turbulent Drag Reduction in Circular Pipes Using CFD

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Abstract: Pressure losses caused by wall friction in pipes and tubes lead to significant energy consumption and operational costs in fluid transport systems. To mitigate these losses, considerable research has focused on passive flow-control techniques to improve hydraulic performance. In the present study, a numerical investigation was conducted to evaluate the effects of different energy-promoter configurations on turbulent flow behavior in internally ribbed circular tubes. Three rib arrangements were analyzed: fully ribbed, half-ribbed, and sectionally ribbed configurations. Water was employed as the working fluid, and the resulting pressure losses were determined for each case using computational fluid dynamics (CFD) simulations. The results demonstrate that rib configuration has a substantial impact on flow structure and hydraulic performance. Among the configurations examined, the sectionally ribbed tube exhibited the most favorable behavior, achieving lower pressure losses and improved flow characteristics compared with both the fully ribbed and half-ribbed tubes. These findings highlight the potential of optimized rib arrangements as an effective passive strategy for reducing turbulent drag and enhancing the energy efficiency of pipe flow systems.

Keywords: Turbulent flow; Drag reduction; Pressure drops; Energy promoters; Friction loss reduction; Hydraulic performance

Comparative Analysis of CFD and Blade Element Momentum Methods for Wind Turbine Performance Optimization

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Abstract: The growing global demand for renewable energy has increased the need to enhance the efficiency and performance of wind energy conversion systems. This study presents a comparative investigation of a 10 kW horizontal-axis wind turbine equipped with an S809 airfoil using two widely adopted aerodynamic analysis methods: Blade Element Momentum (BEM) theory and Computational Fluid Dynamics (CFD). The primary objective is to evaluate and optimize blade performance by analyzing power output, torque, and power coefficient across a range of tip speed ratios (TSRs). The BEM simulations were conducted using QBlade, while the CFD analyses were performed in ANSYS Fluent employing a structured mesh to accurately capture the flow behavior around the blade, particularly near the tip region. The results indicate that the BEM approach predicts higher power output at lower TSRs, whereas the CFD model provides a more detailed representation of the aerodynamic flow phenomena and blade-tip effects. Both methods consistently identify an optimum operating range between TSRs of 6 and 7, where the turbine achieves its maximum power coefficient and favorable torque characteristics. The comparative analysis demonstrates that combining BEM and CFD methodologies offers a comprehensive understanding of wind turbine aerodynamic performance, enabling more accurate performance prediction and supporting the design and optimization of efficient wind turbine blades.

Keywords: Wind turbine; Blade Element Momentum; Computational Fluid Dynamics; Power coefficient; Aerodynamic performance; Blade optimization.

ANSYS CFD Modeling for Aeration Basin Optimization: Mapping Dissolved Oxygen and Sensor Positioning

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Abstract: Aeration constitutes a critical phase in biological wastewater treatment, ensuring the oxygenation necessary for the activity of microorganisms responsible for the degradation of organic matter. In this context, the present study develops a Computational Fluid Dynamics (CFD) simulation to evaluate the hydrodynamics and distribution of dissolved oxygen (DO) in a rectangular aeration basin with a capacity of 320 m³. A multiphase Euler-Euler multiphase approach coupled with the k-ε Mixture turbulence model was implemented in ANSYS Fluent 16.2 to simulate the transient gas-liquid flow induced by 60 fine bubble diffusers (bubble diameter: 3 mm). The effect of different air flow rates was analyzed at an operating temperature of 30 °C. Oxygen mass transfer between air and water was explicitly modeled by integrating the interfacial area and the volumetric mass transfer coefficient.
The numerical model was validated against the results of Shah et al. The ANSYS Fluent 16.2 simulations highlight optimal mixing homogenization and efficient recirculation, drastically reducing stagnant zones. Increasing the air flow rate optimizes hydrodynamic circulation and the uniformity of the DO field. The spatial distribution analysis indicates an optimal location for the DO sensor in the central region, approximately 2 m above the diffusers, where temporal variabilities are the lowest.

Keywords: Mass transfer ; Multiphase flow ; Aeration tank ; Dissolved oxygen ; CFD ANSYS Fluent.

Mixed Convection of a Ternary Hybrid Nanofluid in a Cavity with a Heated Plate and Driven Sidewalls

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Abstract: This study presents a numerical investigation of the laminar mixed convection of a ternary hybrid nanofluid in a cavity with driven sidewalls. The bottom wall of the cavity is partially heated by a central heat source, while the sidewalls are kept at a constant cold temperature. The thermal conductivity and dynamic viscosity depend on temperature and nanoparticle size. The governing equations were solved using the finite volume method combined with the SIMPLER algorithm for velocity-pressure coupling. The numerical model was validated by comparison with reliable experimental and numerical data reported in the literature. A detailed analysis was conducted to examine the effects of the nanoparticle volume fraction and various operating parameters; including the Reynolds number, Richardson number, and heated plate size on the hydraulic and thermal behavior of the system. The findings demonstrate that ternary hybrid nanofluids can significantly enhance heat transfer and improve the thermal efficiency of the system. Furthermore, increasing the Reynolds number (Re) and Richardson number (Ri) improves heat transfer within the cavity.

Keywords: Ternary hybrid nanofluid; Mixed Convection; Cavity; Nanoparticles; Heat Transfer Enhancement; FVM.

Temperature-Dependent Thermal Conductivity and Nonlinear Radiative Effects on MHD Nanofluids Flow in the Near Wall Region: A Computational Analytical Approach

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Abstract: The study was designed to investigate the combined effect of temperature dependent thermal conductivity (TDTC) in laminar magnetohydrodynamic flow (MHD), and nonlinear thermal radiation on magnetic nanofluids (MN-fluids) in the near wall region (NWR). In this context, our treatment focuses particularly on two kinds of magnetic nanoparticles: Magnetite (Fe3O4) and Cobalt Ferrite (CoFe2O4) and explores their behavior as they will occur in different base fluids for example water or kerosene. After utilizing similarity transformations, the governing partial differential equations were transformed into a system of ordinary differential equations, which were then individually solved both numerically with the 4th–5th order Runge-Kutta method; and analytically using Generalized Adomian Decomposition Method (GDM). The effects of several governing parameters, including (TDTC), nonlinear thermal radiation R, pressure gradient m, Hartman number M, and the MN-paticules volume fraction ϕ on the dimensionless velocity and temperature distributions have been thoroughly examined. The results reveal that water-based cobalt ferrite nanofluids exhibit higher flow velocities compared to their kerosene-based counterparts. Thermal radiation leads to an increase in fluid temperature, while robust magnetic fields enhance flow stability by suppressing boundary layer separation. Additionally, considering temperature-dependent thermal conductivity is essential for accurately modeling heat transfer in nanofluids.

Keywords: Temperature-dependent thermal conductivity (TDTC), Radiation effect, Magnetic-nanofluids (MN-fluids), Magneto-hydrodynamics (MHD), Near wall region flow (NWR), GDM method.

3D Simulation Of Heat Transfer In A Laterally Heated Cubic Cavity For A Low Prandtl Number Fluids

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Abstract: Natural convection in enclosed cavities is a fundamental benchmark in fluid dynamics, providing critical insights for thermal management and renewable energy systems. This study presents a highly resolved three-dimensional numerical simulation using COMSOL of natural convection in a laterally heated cubic cavity (aspect ratio Ax = Ay = Az = 1). Filled with air ($Pr = 0.71), the enclosure is analyzed to investigate the exact thermo-hydrodynamic transition from a motionless conductive state to the early onset of convection.A high-resolution parametric sweep was conducted, varying the Rayleigh number (Ra) from 0 to 1000. The 3D Navier-Stokes and energy equations were solved numerically under the Boussinesq approximation. The results mathematically confirm the pure conduction limit; as Ra goes to 0, the average Nusselt number (Nu) at the hot wall is exactly 1.00, indicating heat is transferring purely through conduction. As Ra exceeds 200, buoyancy forces begin to overcome viscous resistance, initiating creeping convection rolls. By Ra = 1000, weak convection is established, enhancing overall heat transfer by approximately 7%.

Keywords: Natural convection, Computational Fluid Dynamics, Cubic Cavity, Nusselt number

Hydrogène Production By Photocatalyse Method Using A New Semiconductor Material

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Abstract: The development of efficient photocatalysts for hydrogen production has become an important research area in renewable energy technologies. Photocatalytic water splitting under visible light is considered a promising approach for sustainable hydrogen generation using solar energy. Titanium dioxide (TiO_2) is one of the most widely studied semiconductor photocatalysts due to its chemical stability, low cost, and non-toxicity. However, its wide band gap (~3.2 eV) restricts its photocatalytic activity mainly to the ultraviolet region, which limits its efficiency under solar irradiation. In this study, a $TiO_2Cu_3(PO_4)_2$ composite photocatalyst was synthesized and experimentally investigated for photocatalytic hydrogen production under visible light irradiation. The incorporation of $Cu_3(PO_4)_2$ aims to improve light absorption and promote efficient separation of photogenerated charge carriers. The structural and optical properties of the synthesized materials were characterized using several techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy, and UV–Visible spectroscopy. These analyses confirmed the successful formation of the $TiO_2Cu_3(PO_4)_2$ heterostructure and provided insight into its structural and optical properties. Photocatalytic experiments carried out under visible light irradiation demonstrated that the $TiO_2Cu_3(PO_4)_2$ composite exhibits enhanced photocatalytic activity compared with pure TiO_2. This improvement is mainly attributed to the formation of a heterojunction between TiO_2 and $Cu_3(PO_4)_2$, which facilitates charge separation, reduces electron–hole recombination, and extends light absorption toward the visible region. These results highlight the potential of the $TiO_2Cu_3(PO_4)_2$ composite as an efficient photocatalyst for visible light driven hydrogen production.

Keywords: Hydrogen production, Photocatalysis, Visible light activity, $TiO_2Cu_3(PO_4)_2$ composite

Modeling The Impact Of Hydrogen Addition On Swirling Premixed Methane Flames

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Abstract: Premixed combustion stabilized by swirl has attracted considerable interest in the industrial sector. It is widely found in various thermal power engineering devices, including furnaces, boilers, engines, and gas turbines. This has prompted several researchers to improve how these burners work to enhance their efficiency and reduce their emissions. Furthermore, these emissions can be lowered in some cases through combustion techniques, particularly very lean combustion combined with renewable energy solutions. The gradual integration of hydrogen (H_2) into methane (CH_4) is being considered as a solution to reduce NOx and CO emissions while improving combustion performance. The objective of this work is to characterize the impact of adding 40% hydrogen to methane on the premixed combustion of an LSB burner on flame structure, maximum temperature, and pollutant emissions. The results show an improvement in flame stability as well as a reduction in NOx and CO emissions.

Keywords: (Hydrogen Addition;swirl burner);(Premixed combustion);(pollutant emissions);(methane CH_4).

Low Cost and fast Measurement and Analysis of Chloride Concentration in Water

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Abstract: The measurement and analysis of chloride concentration in water are important processes for evaluating water quality in drinking, industrial, and environmental systems. Chloride ions are commonly present in water due to natural sources, industrial discharges, agricultural activities, and wastewater contamination. Excessive chloride concentrations may cause corrosion in pipelines, affect aquatic ecosystems, and alter the taste of drinking water. This study focuses on the determination of chloride concentration in water samples using a low cost and fast analytical methods based on quantitative chemical analysis. The measurements were carried out using a colorimetric technique combined with a developed mobile application, where the intensity of the developed color is proportional to the chloride ion concentration in the sample. The mobile application is used to take a photo of a sample to be analyzed and immediately convert the color into a concentration on-site and without using analytical apparatus. Experimental data were analyzed to determine chloride levels and compare them with standard water quality guidelines.

The results demonstrate that the applied method provides accurate, rapid, and reliable measurements for chloride detection in different water samples. The analysis also highlights the importance of continuous monitoring of chloride concentration to ensure water safety and environmental protection. This work confirms that colorimetric analysis using mobile application is an effective technique for routine laboratory assessment of chloride ions and other colorimetric detections in water.

Keywords: Chloride concentration measurement; Water quality analysis; Colorimetric analysis; Water monitoring;mobile application colorimetric analysis; Environmental analysis;Drinking water quality; Laboratory analysis

Accelerated DFT–Machine Learning Prediction of SiC for Nuclear Applications

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Abstract: Silicon carbide (SiC) is a leading candidate structural and cladding material for advanced fission and fusion reactors, owing to its exceptional thermal stability, radiation tolerance, and mechanical strength under extreme neutron irradiation. Conventional density functional theory (DFT) captures SiC's structural, elastic, and vibrational properties with high fidelity but scales poorly with system size, limiting its use for the large supercells needed to model point defects, dopant configurations, and irradiation-induced disorder relevant to reactor environments. We present a graph neural network (GNN) surrogate model trained on DFT-derived energies, forces, and phonon properties of pristine and defected SiC polytypes (3C, 4H, 6H) to bridge this gap. The GNN encodes local atomic environments as graphs, enabling transferable prediction of formation energies, elastic constants, and vibrational density of states across defect types (vacancies, interstitials, substitutional impurities) and supercell sizes far beyond direct DFT tractability. Benchmarking against DFT reference calculations demonstrates prediction accuracy within a few meV/atom for total energies and close agreement for phonon-derived thermal properties, at a fraction of the computational cost. The accelerated framework enables systematic screening of defect formation energetics and thermal transport degradation in irradiated SiC, with direct input to thermal neutron scattering law (S(α,β)) generation for reactor physics codes. This DFT–GNN pipeline establishes a scalable route for predictive, radiation-damage-informed materials design in SiC-based nuclear components.

Keywords: Silicon carbide (SiC); Graph neural network; Density functional theory; Radiation damage; Thermal neutron scattering

Machine Learning-Based Prediction of High-Entropy Alloy Properties

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Abstract: High-entropy alloys (HEAs) offer an immense compositional design space, combining four or more principal elements in near-equimolar ratios to achieve exceptional strength, corrosion resistance, and radiation tolerance. Systems such as CoCrFeMnNi (Cantor alloy) and refractory HEAs based on Mo, Nb, Ta, W, and V exemplify this diversity, spanning FCC and BCC architectures with distinct mechanical and thermal behavior. This vast configurational space makes exhaustive experimental or first-principles exploration computationally prohibitive. We present a machine learning framework for rapid prediction of HEA structural, mechanical, and thermodynamic properties, trained on density functional theory (DFT) reference data spanning CoCrFeMnNi-type FCC alloys and refractory BCC compositions. The model learns composition-property relationships using elemental descriptors and local atomic environment features, enabling accurate prediction of formation energy, lattice parameters, elastic constants, and phase stability without explicit DFT calculation for each new composition. Validation against DFT benchmarks shows strong predictive accuracy across both alloy classes, substantially reducing screening time compared to conventional ab initio methods. The framework enables high-throughput identification of promising CoCrFeMnNi-derived and refractory HEA compositions for structural and nuclear applications, where radiation tolerance and mechanical stability under extreme temperature and irradiation environments are critical design targets. This DFT-informed machine learning approach establishes an efficient pathway for accelerated HEA discovery and property optimization across compositionally complex alloy systems.

Keywords: High-entropy alloys; CoCrFeMnNi; Refractory alloys; Machine learning; Density functional theory

Study of thermophysical properties of nanofluids

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Abstract: The thermophysical properties of nanofluids represent a modern and significant field of research in thermal engineering. Nanofluids are fluids that contain nanoparticles (smaller than 100 nanometers) suspended in base fluids such as water or oils. In this paper, the thermal conductivity, specific heat capacity, and viscosity of metal oxide nanofluids (CuO, SiO2, Al2O3, TiO2) based on Therminol VP-1™ at a 4% volume concentration were studied as heat transfer fluids. A model was developed to simulate various theoretical models of the thermal properties of nanofluids, as proposed by numerous researchers, to identify the model that best aligns with and simulates the behavior of nanofluids.

Keywords: thermophysical properties; Nanofluids; nanoparticles; Numerical simulation

Development Of Enzyme-Based Biosensor For Environmental Monitoring

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Abstract: Biosensors, combining a selective biological recognition element and a sensitive transducer, are versatile analytical tools applied more and more in different fields, such as medicine, food quality and safety control, and environment pollution monitoring. The intention of this article is to reflect the advances and describe the trends on biosensors for environmental applications. Biosensors are useful analytical tools for environmental monitoring, capable of providing results in real time, simple to use, portable and cost-effective. Biosensors, detecting and measuring specific compounds or compound classes such as pesticides, hazardous industrial chemicals, toxic metals, and pathogenic bacteria biosensors and bioanalytical assays have been designed to measure biological effects such as cytotoxicity, genotoxicity, biological oxygen demand, pathogenic bacteria, and endocrine disruption effects.

Keywords: Keywords –.Enzyme; Biosensors; Environmental ;analysis;pollutant

Biochemical Properties Of Free And Immobilized Tyrosinase In Copper Alginate Beads

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Abstract: The aim of this work is to study the kinetics of phenol oxidation by the tyrosinase (EC:1.14.18.1) soluble and immobilized in beads calcium alginate. Tyrosinase is extracted from mushroom (Agaricus bisporus), and its enzymatic activity is measured by spectrophotometric method at 400 nm using phenol as substrate. Soluble tyrosinase is relatively stable during twenty days of storage at -15°C. A study of various operating parameters on the kinetics of oxidation of phenol by the both systems was investigated.The value of the Michaelis-Menten (Km) for the immobilized enzyme (1, 3 mM) is about two times higher compared to that of the soluble enzyme (0, 6 mM). Nevertheless, the maximum velocity (Vmax) is 30-times lower. The optimal pH and temperature are shifted from 7, 6 to 5,6 and from 45 to 55°C, for soluble and immobilized tyrosinase, respectively. The immobilized enzyme showed a highest thermal stability and its activity is maximal for alginate beads with a diameter of 3,4 mm.

Keywords: Keywords: Mushroom; Agaricus bisporus; Tyrosinase; extraction; immobilization; alginate; kinetic.

Atomistic Investigation of Ni and Mo Interstitial Diffusion in Crystalline Silicon at Different Temperatures

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Abstract: In this work, we investigate the temperature-dependent migration behaviour of single and binary Ni (fcc) and Mo (bcc) atoms embedded in a relaxed crystalline silicon (Si) substrate using molecular dynamics simulations performed with LAMMPS code. Atomic trajectories were analyzed and visualized using x at temperatures of 10, 300, 500, 700, and 900 K. The results indicate that both single Ni and Mo atoms preferentially occupy interstitial sites and migrate through the Si lattice primarily along the (111) planes over the entire temperature range. Atomic displacement increases significantly with temperature, reflecting enhanced diffusion kinetics. Ni atoms exhibit larger jump distances and higher mobility compared to Mo atoms, suggesting lower effective migration barriers within the Si substrate. In the binary Ni and Mo configuration, both species follow similar interstitial diffusion pathways; however, their migration trajectories differ while remaining confined to interstitial regions. Overall, increasing temperature enhances atomic mobility through increased kinetic energy, leading to longer jump lengths and greater diffusion distances. This study provides atomic-scale insight into the interstitial diffusion mechanisms of transition-metal impurities in crystalline Si. Such understanding is essential for controlling impurity transport, dopant behavior, and defect engineering in semiconductor processing, microelectronics fabrication, and high-temperature device applications. Moreover, it offeres a promising pathway for engineering silicon-based materials for advanced optoelectronic, spintronic and microelectronic applications.

Keywords: Interstitial diffusion, Atomic mobility, silicon, Molecular Dynamics simulation.

Magnonic Storage Of Informations And Energy Via Spin Waves In Ferromagnetic Nanomaterials

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Abstract: We investigated the generation, propagation, and detection of spin waves via cubic ferromagnetic interfaces in ultra-thin films (a few nanometers thick). At this scale, information transport and energy storage can be driven by magnetic excitations, specifically spin waves (or magnons) arising from collective spin oscillations. By leveraging spin-orbit effects within nanostructures, we successfully manipulated spin interface excitations at the interfaces of materials traditionally used as thick films for their low magnetic losses. In this work, we use the matching method to calculate the localized energetic states and magnonic density of states (MDOS) for tow considered interfacial systems: bcc-bcc and fcc-fcc interface lattices. The evolution of the magnetic spectra is presented as a function of the variation of the exchange integrals, along the high symmetry paths. These findings pave the way for submicron magnonic circuits designed for high-frequency telecommunications and reconfigurable logic devices. This approach offers a Beyond-CMOS alternative, capable of processing the ever-increasing data volumes of our modern information society, within nanoscale systems. These systems, known as spin wave devices, can transport energy at frequencies ranging from the Gigahertz to the Terahertz regime.

Keywords: Spin waves; ; Magnonic density of states; Spin interface excitations; Cubic ferromagnetic interfaces

Thermal Effects on ISFET Performance in Aqueous pH Monitoring

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Abstract: Abstract. Chemical sensors ISFET -type offer innovative solutions for the detection of chemical species by using a membrane or ion-sensitive layer, which is the interface between the aqueous medium and the insulation. The research on these sensors is mainly directed towards the study of new ion-sensitive layers in order to improve sensor detection parameters such as sensitivity and linearity, which are influenced by temperature. In this work, we examined the influence of temperature on the sensitivity and electrical behavior of an AlN membrane sensor. The results obtained with this membrane were compared with the results obtained with other detection membranes such as Si3N4, Al2O3, SnO2. The aim is to determine which sensor is most efficacious.

Keywords: Keywords: Chemical sensor ISFET, MOSFET, aqueous solution, pH, AlN membrane.

Nanoparticle-Based Inhibitors for Asphaltene Deposition Prevention – Insights from MgO NPs and Advanced Nanocomposites

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Abstract: Asphaltene deposition remains a critical flow-assurance challenge in crude oil production, contributing to pipeline blockage, formation damage, equipment fouling, and substantial operational expenditures. The instability of asphaltenes under changing pressure, temperature, and compositional conditions often leads to aggregation, precipitation, and irreversible surface adsorption, thereby compromising production efficiency. This study presents a rigorous comparative assessment of nanotechnology-based strategies developed to mitigate asphaltene aggregation and deposition phenomena. Particular emphasis is placed on the rational design, controlled synthesis, surface engineering, and formulation of nano-inhibitors, with the objective of identifying the key physicochemical parameters governing inhibition efficiency in both model solvents and real crude oil systems.

The analysis systematically evaluates nanoparticle synthesis routes—including metal oxide nanoparticles and surface-functionalized nanocomposites—alongside dispersion protocols and stability optimization techniques. Critical variables such as particle size distribution, surface charge density, specific surface area, hydrophilic–lipophilic balance, and tailored interfacial interactions with asphaltene aggregates are examined in relation to standard evaluation methods, including precipitation onset temperature measurement, sedimentation delay analysis, dynamic flow-loop testing, and rheological monitoring.

Results demonstrate that engineered nanomaterials can significantly outperform conventional chemical inhibitors by achieving enhanced colloidal stabilization at lower dosages while maintaining long-term effectiveness under reservoir-relevant conditions. Mechanistic insights indicate that inhibition performance arises from a synergistic interplay between steric hindrance, electrostatic repulsion, and targeted interfacial adsorption governed by nanoparticle surface chemistry. Collectively, these findings establish a structure-guided, nanotechnology-driven framework for developing scalable, high-performance asphaltene inhibitors for advanced and sustainable flow-assurance applications.

Keywords: Asphaltene deposition, nanoparticle inhibitors, MgO nanoparticles, nanocomposites, adsorption mechanisms

Synthesis of $MgAl_2O_4$ and PEI-Modified $MgAl_2O_4$ Nanocomposites for Enhanced Adsorption and Photocatalytic Removal of Cr(VI) from Aqueous Solutions

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Abstract: Hexavalent chromium (Cr(VI)) contamination in industrial wastewater poses a serious environmental and public health risk due to its high toxicity, mobility, and persistence. Developing efficient and sustainable treatment technologies is therefore essential for chromium remediation. In this study, spinel magnesium aluminate ($MgAl_2O_4$) and polyethylenimine-functionalized $MgAl_2O_4$ composites ($MgAl_2O_4$–PEI) with PEI loadings of 30, 50, and 70 wt% were synthesized and evaluated for Cr(VI) removal from aqueous solutions via adsorption and photocatalysis. The materials were characterized by X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and Brunauer–Emmett–Teller (BET) analysis, confirming successful PEI incorporation while preserving the spinel structure. Adsorption tests showed that pristine $MgAl_2O_4$ achieved 14% Cr(VI) removal, whereas PEI-modified samples exhibited improved performance. The 30 wt% PEI composite reached the highest adsorption efficiency (30%), followed by 50 wt% (19%) and 70 wt% (4%), attributed to progressive blockage of active sites at higher polymer loading. Photocatalytic experiments under solar irradiation significantly improved Cr(VI) removal compared to bare $MgAl_2O_4$ (16%). Removal efficiencies of 87%, 81%, and 79% were obtained for $MgAl_2O_4$–PEI with 30, 50, and 70 wt% PEI, respectively. This improvement is attributed to synergistic interactions between surface amine groups enhancing Cr(VI) uptake and the photocatalytic activity of $MgAl_2O_4$. Overall, the $MgAl_2O_4$–PEI (30 wt%) composite exhibited the best performance, combining high adsorption capacity and photocatalytic efficiency. These results demonstrate the potential of PEI-functionalized spinel nanomaterials for efficient treatment of chromium-contaminated wastewater.

Keywords: $MgAl_2O_4$; polyethylenimine (PEI); Cr(VI) removal; adsorption; photocatalysis; wastewater treatment.

Study And Design Of A Photonic Crystal-Based Biosensor

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Abstract: In this study, a photonic crystal structure composed of air holes etched into a silicon substrate was designed and simulated as an optical biosensor for detecting glucose concentration in human blood. The sensor operates by exploiting changes in the refractive index caused by variations in glucose concentration, which result in a shift in the resonant wavelength. The obtained results demonstrate excellent performance, with a sensitivity of 3145.83 nm/RIU, a high figure of merit (FOM) of 157291.5, a very low detection limit, and a stable quality factor (Q-factor) ranging from 73559.5 to 73957.6. These values confirm the high sensitivity, stability, and accuracy of the proposed sensor. Furthermore, the biosensor enables label-free and real-time glucose monitoring using only a small blood sample, making it a promising candidate for biomedical sensing applications and non-invasive diagnostic systems. In addition, its ultra-compact size, lightweight design, and low power consumption make it highly suitable for integration into nanotechnology-based devices and portable biomedical platforms.

Keywords: Photonic Crystal ,Waveguide, biosensor , CST Studio Suite.

High-Sensitivity Temperature Sensor Based on Two-Dimensional Photonic Crystals for Multiple Applications

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Abstract: In this effort, a two-dimensional photonic crystal (2DPC) is simulated. The results of the design and analysis of the detection performance of a temperature sensor based on two-dimensional photonic crystals In our design,we used a Y-shaped branch. This device is developed for temperature detection in harsh environmental conditions for temperatures ranging from 0 °C to 360 °C with high sensitivity . The device is also based on the use of a hexagonal type network consisting of an array of air holes dug in a silicon substrate. The detection principle based on the variation of the refractive index of the Si due to a change in temperature which changes the position of the transmission peaks. A shift is created that will be used to calculate the sensitivity. The OptiFDTD algorithm was used to simulate the transmission of light for different temperatures. The photonic band gap (PBG) studied using the plane wave expansion method (PWE). The results are promising because the simulated sensor has a high sensitivity (70.8 pm/°C) for an ultra-compact size, weight and energy consumption which is suitable for nanotechnology.

Keywords: 2D-photonic crystals . Temperature sensor . FDTD . PWE . Sensitivity

Controlled Hydrothermal Synthesis and Characterization of Ag-Doped ZnS Nanoparticles for Radiation Detection Applications

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Abstract: Zinc sulfide (ZnS) is a well-known wide band gap semiconductor (~3.5 eV), recognized for its excellent optical transparency, high electron mobility, and non-toxicity. In this study, pure and Ag-doped ZnS nanoparticles were successfully synthesized via a controlled hydrothermal method at low temperature (120 °C), using zinc acetate ($Zn(CH_3COO)_2 \cdot 2H_2O$) and thiourea ($SC(NH_2)_2$) as precursors, while deionized water was employed to adjust the pH of the solution. Silver doping was introduced using $AgNO_3$ at concentrations of 1, 2, and 3%. The structural properties were investigated by X-ray diffraction, confirming the formation of a cubic ZnS phase. The crystallite size, estimated using the Debye–Scherrer equation, was found to be in the range of 4–10 nm. Scanning electron microscopy analysis revealed a relatively homogeneous morphology composed of spherical nanoparticles with sizes ranging from 50 to 80 nm. Optical properties were studied using UV–visible absorption spectroscopy, showing a slight variation in the band gap energy, with values around 3.7 eV, influenced by Ag incorporation. The controlled hydrothermal synthesis and Ag doping were found to play a key role in tuning the structural and optical properties of ZnS nanoparticles. These results demonstrate that Ag-doped ZnS nanoparticles exhibit promising characteristics for radiation detection applications, due to their controlled size, enhanced optical behavior, and improved material properties.

Keywords: Ag-ZnS nanoparticles; Hydrothermal method; UV-visible; XRD

ZnO–CuO Heterostructure for Enhanced Photocatalytic Degradation under UV Irradiation

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Abstract: This study investigates the photocatalytic performance of pure ZnO and a ZnO–CuO heterostructure for the degradation of organic pollutants in wastewater. The photocatalysts were synthesized via a microwave-assisted method and characterized using XRD, FTIR, SEM, BET, and UV–Vis spectroscopy. Photocatalytic activity was evaluated through the degradation of methylene blue (MB) under UV irradiation. The results indicate that the ZnO–CuO heterostructure exhibits enhanced photocatalytic activity compared with pure ZnO, owing to improved separation of photogenerated charge carriers and reduced electron–hole recombination. The heterostructure shows higher degradation efficiency under UV irradiation, demonstrating its potential for environmental remediation and wastewater treatment applications.

Keywords: Keywords: ZnO-CuO, photocatalysis, methylene blue, microwave synthesis, UV irradiation.

Structural and Optical Properties of Iron Oxide nanoparticles and Their Potential Applications

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Abstract: This study aims to synthesize and structurally characterize iron oxide nanoparticles using green method. This work specifically focuses on investigating the crystalline properties, phase identification and optique properties of the resulting materials. The X-ray diffraction (XRD) analysis results, processed using X'Pert HighScore software, confirmed the formation and purity of the crystalline phases, showing a high match with the standard reference patterns for Iron Oxide . The prominent diffraction peaks were successfully indexed, and the crystallite size was estimated. The UV-Vis absorption spectra revealed enhanced light-harvesting capabilities in the visible and near infrared regions, confirming tuned optical properties and band gap transition. These distinct structural and optical properties open promising prospects for using these materials in various fields, particularly in antibacterial and photocatalysis due to their chemical and physical stability.

Keywords: Iron oxide, Green method, X-ray diffraction, Nanoparticles.

Optimizing spray cycle number for enhanced structural, optical, and electrical properties of CuO thin films

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Abstract: This study systematically investigates the influence of spray cycle number (25–150) on the properties of CuO thinfilms deposited via spray pyrolysis on glass substrates. Structural showing a progressive increase in crystallite size from 40 nm (25 cycles) to 99 nm (150 cycles) and a corresponding reduction in dislocation density (1.28 ·1015 to 0.47 ·1015 lines/m2). Raman spectroscopy confirmed phase purity and improved crystallinity with increasing cycles. UV– Vis spectroscopy demonstrated high visible-light transmittance (70 % at 25 cycles, decreasing to 45 % at 150 cycles) and a tunable direct band gap narrowing from 4.1 eV to 2.2 eV, attributed to reduced quantum confinement and strain relaxation. Four-point probe electrical measurements revealed enhanced conductivity, with resistivity decreasing exponentially from 8.2·102 Ω cm to 1.5 ·102 Ω cm due to improved grain connectivity and defect annihilation. Atomic force microscopy (AFM) and scanning electron microscopy (SEM) analyses complemented these findings, showing a transition from porous, irregular grains (40 ± 3 nm) to dense, faceted microstructures (99 ± 5 nm) with reduced surface roughness (68 nm–50 nm RMS). These results collectively demonstrate that spray cycle optimization tailors CuO films for optoelectronic applications, balancing transparency, conductivity, and crystallinity.

Keywords: Copper oxide; (CuO) ;thin films;Spray pyrolysis; Structural properties; Optoelectronic applications

Study of the aging behavior of sandwich panels with epoxy/jute skins and a cork core

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Abstract: This work focuses on the design and Characterization of innovative sandwich panels, belonging to the biocomposite family. The objective is to develop an ecological alternative using natural fibers : an agglomerated cork core is combined with skins made of a jute and epoxy resin composite. The study concentrates on the durability of these materials by analyzing the impact of hygrothermal aging (water immersion) on their mechanical properties. A crucial point of the research is the improvement of the fiber/matrix interface, which is the weak link in this type of composite. To achieve this, a surface treatment (specifically an alkaline treatment) is applied to the jute fibers. The methodology compares treated and untreated samples through mechanical tests (three-point bending, compression), water absorption analysis, and non-destructive characterization by ultra Sound. The results confirm that the alkaline treatment is essential : it reduces water absorption, protects the interface, and allows the panel to maintain a much better mechanical resistance after aging, thus validating the viability of this solution for sustainable applications.

Keywords: Sandwich Panel, Composite Materials, Biocomposites, Jute Fibers, Agglomerated Cork

Energy and Thermal Performance Enhancement of PEM Fuel Cells for Automotive Applications Using Nanofluids

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Abstract: This study focuses on the energy analysis of the performance of a fuel cell intended for the automotive sector, highlighting the influence of operating conditions such as temperature and pressure on both the fuel cell and the overall system. It also includes a numerical investigation of forced convective heat transfer of a nanofluid in the parallel cooling channels of a proton exchange membrane fuel cell (PEMFC). The objective is to evaluate the thermal performance of a single cell by analyzing the effect of the nanoparticle volume fraction in the base fluid. Copper nanoparticles were used due to their favorable thermal properties, chemical stability, and relatively low cost, with concentrations ranging from 0 to 5% by volume in water. CFD simulations were performed using ANSYS Fluent for a two-dimensional laminar flow inside a horizontal channel. The results show that the addition of nanoparticles significantly enhances the thermal conductivity of the fluid, thereby increasing the cooling capacity of the PEMFC.

Keywords: PEMFC; energy analysis; nanofluide; CFD simulations; cooling capacity

Thermal performance of a ternary Al_2O_3–Cu–TiO_2/water hybrid nanofluid: comparison with single-component and hybrid nanofluids

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Abstract: The focus of this work is on combining two or three different types of nanoparticles; this study concentrates on characterizing the flow of a ternary nanofluid (Al_2O_3-Cu-TiO_2 / water) in a horizontal cylindrical channel. The channel is divided into three sections: the central, heated section is 1 m long, while the lateral, adiabatic sections are each 0.5 m long. The inlet flow is purely axial at ambient temperature. Three-dimensional numerical simulations, based on the finite volume method and Boussinesq approximations, were carried out. The effects of various parameters were investigated, notably the Reynolds number ($300 \leq Re \leq 720$) and the volume fraction of nanoparticles ($0 \leq \varphi \leq 0.5\%$), on heat transfer and flow characteristics. The results showed a significant improvement in the thermal conductivity of the nanofluid, as well as an increase in the Nusselt number and a more homogeneous temperature distribution, compared to a simple or hybrid nanofluid. Increasing the volume fraction of the nanofluid intensifies heat transfer but leads to a decrease in flow velocity due to pressure losses.

Keywords: Ternary hybrid nanofluid; volume fraction; mixed convection; heat transfer; Nusselt.

Thermal oxidation of Cu thin films: Photovoltaique application of CuO/Si heterojunction

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Abstract: The aim of this work is optimization of the elaboration parameters, of inexpensive CuO thin films, destined to the photovoltaic devices, as an alternative material. The solar energy is one of the multiple used energy sources, it's clean, sustainable and needs the adapted devices with non-expensive materials, with good performance. In this study, we have deposited the copper thin films onto the glass and silicon (n type and p type) substrates, by thermal evaporation, different copper masse powders are considered. After thin films deposition, the samples are thermally oxidized at 300 °C, during 3h. The structural and optical characterizations indicate the formation of the only CuO phase after oxidation of Cu thin films. The electrical properties of the deposited CuO/p-Si and CuO/n-Si heterojunctions were investigated by the dark and light current-potential bias-temperature characterizations. In the first hand, the obtained results show that all deposited heterojunctions exhibit a good electrical behavior, with a rectification ratio around 101 and 102. In the other hand, it's clear that the photovoltaic performance of the samples depends, considerably on the CuO layer thickness. Effectively, the short-circuit current density (Jsc) and open-circuit voltage (Voc) varied between 6,6 10-3 mA/cm2 - 0,1V and 1,4 10-2 mA/cm2 – 0,2V, respectively. One samples, with 35 mg of copper powder mass, stand out by the best electrical performance, with Voc and Jcc parameters.

Keywords: Thermal oxidation, thin films, heterojunction, photovoltaic

Enhancement of Transport Properties in Bronzoid-Type Monophosphate Compounds through Substitution and Cation Insertion

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Abstract: Phosphates and arsenates have garnered growing interest from researchers due to their fascinating structural chemistry and diverse technological applications. Their unique physical and chemical properties make them suitable for use in electronics, magnetism, and catalysis. This study focuses on monophosphate compounds of the bronzoid type, specifically $KNb_4WP_3O_{21}$and $K_3Nb_3WP_2O_{17}$. To broaden the structural family and enhance the transport properties of these materials, we introduced various substitutions into both compounds. By substituting phosphorus with arsenic at the tetrahedral sites in $KNb_4WP_3O_{21}$, we observed a shift from an insulating bronzoid-like behavior to that of a conducting bronze. Additionally, increasing the cation concentration (from alkali, alkaline-earth, or group IB elements) inserted into the cavities significantly enhanced the semiconducting properties of these compounds.

Keywords: Phosphates, Arsenates, Transport properties, Conducting bronze, Semiconducting properties, Cation insertion

Microstructural and electrochemical study of a titanium alloy in a corrosive environment

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Abstract: Abstact-Titanium and its alloys are widely used in the aerospace and automotive industries, especially the Ti6Al4V alloy, due to their desirable mechanical and physicochemical properties. In particular, thanks to their excellent corrosion resistance, these alloys are materials of choice in acidic environments. The objective of this work is to characterize, mechanically and electrochemically, the Ti-6Al4V alloy after heat treatment at two temperatures, 950°C and 1150°C, for two holding times, and after immersion tests in 3% and 5% hydrochloric acid (HCl) solutions. The resulting microstructures were observed, and microhardness (HV) measurements were taken to assess the modifications. Corrosion behavior was analyzed by electrochemical tests, namely open circuit potential (OCP) monitoring, potentiodynamic tests, and electrochemical impedance spectroscopy (EIS) tests with an evaluation of the thermal effect on electrochemical behavior.

Keywords: Ti6Al4V; heat treatment; corrosion; acidic environment; electrochemical impedance spectroscopy.

Microstructure and Mechanical Properties of Functionally Graded Steels Produced by Additive Manufacturing

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Abstract: Metal additive manufacturing has gained significant attention in recent years due to its ability to produce complex three-dimensional components through layer-by-layer deposition, offering enhanced design flexibility compared to conventional manufacturing processes. In this context, functionally graded materials (FGMs) have emerged as a promising approach for engineering components with spatially tailored properties, enabling both performance optimization and cost reduction by combining different materials within a single structure. The present work focuses on the fabrication of multi-material steel structures using additive manufacturing, specifically based on 308LSi and ER70S-6 alloys. A suitable deposition strategy was developed to ensure the successful production of functionally graded configurations. A comprehensive characterization was conducted to investigate the microstructural evolution and mechanical behavior across the graded regions. The results provide insights into the relationship between processing conditions, microstructure, and resulting properties, contributing to a better understanding of FGMs and their potential for targeted engineering applications.

Keywords: Additive manufacturing; Functionally graded materials (FGMs); Microstructural evolution; Mechanical properties; Multi-material steels; 308LSi/ER70S-6.

Field-Singularity-Driven Surface Discharges at Triple-Junction Interfaces in High-Voltage Insulation

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Abstract: Triple-junction interfaces in high-voltage insulation systems—where the gaseous medium, metallic electrode, and solid dielectric converge—are recognized as intrinsic sites of electrostatic field singularity and premature surface discharge inception. This paper presents a combined experimental and physics-based modeling investigation of discharge current behavior under independently controlled variations of inter-electrode spacing, applied voltage, and electrode-tip curvature. Systematic parameter decoupling reveals the mechanisms governing local field enhancement, charge injection, energy redistribution, and streamer inception at triple-junction regions. Comparative experiments performed on silicone rubber, porcelain, and heat-tempered glass demonstrate that dielectric permittivity, interfacial polarization, and surface micro-topography critically influence discharge growth kinetics. Polynomial regression models, constrained by physical consistency, accurately reproduce the measured responses. The results establish field-grading-oriented design guidelines for triple-junction optimization, enabling effective mitigation of surface flashover and significant improvement of reliability, operational stability, and service lifetime in high-voltage insulation systems.

Keywords: Triple junction; Surface discharge; Electric field singularity; Streamer inception; High-voltage insulation.

Impact of the Use of Construction Waste on Water Demand and Setting Time of cement

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Abstract: In this study, construction waste was valorised as a supplementary cementitious material through the partial substitution of clinker. A total of ten specimens were prepared with replacement levels of 10% and 30%. The water demand and setting times were subsequently determined using the Vicat apparatus. The results show that increasing the substitution rate leads to a higher water demand. Specifically, for a 10% replacement, the water demand ranged from 0.28 to 0.30, whereas it increased to 0.30–0.35[1]. for cements incorporating 30% waste. This higher substitution level also influences the setting behaviour, with an initial setting time exceeding 45 minutes and a final setting time remaining below 400 minutes, thereby complying with standard cement requirements. Overall, a replacement rate of 10% appears to be optimal for this Portland cement

Keywords: clinker, Final setting time, initial setting time, Portland cement

Physicochemistry of Ti-6Al-4V Recrystallization: Activation Energy and KJMA Modeling in Continuous Heating

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Abstract: In the present research, an approach based on the Kolmogorov-Johnson-Mehl-Avrami model was applied to investigate the recrystallization kinetics of the Ti-6Al-4V titanium alloy following plastic deformation. To achieve this, Differential Scanning Calorimetry analyses were conducted at a constant heating rate of 50 °C/min. This methodological framework enabled the precise determination of key recrystallization kinetic parameters, with a particular focus on the activation energy required for the process. The experimental results and subsequent modeling provided deep insights into the microstructural evolution of the alloy. Specifically, the calculated value of the Avrami exponent (n) suggests that sub-grain growth occurs through surface nucleation mechanisms governed by interface-controlled reactions. By applying the additivity rule to non-isothermal heating conditions, the study successfully bridges the gap between theoretical Kolmogorov-Johnson-Mehl-Avrami predictions. These findings are crucial for optimizing heat treatment protocols to control grain size and enhance the mechanical properties of Ti-6Al-4V components.

Keywords: KJMA model in continuous heating; additivity rule; Ti-6Al-4V; recrystallization; activation energy

Structural, electronic, and elastic properties of Scandium selenide under hydrostatic pressure

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Abstract: This study reports an ab initio analysis of the structural, electronic, and elastic properties of scandium selenide (ScSe) in the NaCl (B1) structure under hydrostatic pressure, employing density functional theory (DFT) within the pseudopotential plane-wave framework. The exchange–correlation effects were described using the generalized gradient approximation (GGA). The calculated equilibrium lattice parameter is in very good agreement with previously reported experimental and theoretical data, validating the reliability of the computational method. The electronic band structure, examined using both GGA and the hybrid B3LYP functional, indicates that ScSe exhibits metallic character, with no band gap at the Fermi level. Regarding the elastic behavior, the elastic constants C_{11} and C_{12} increase progressively with applied pressure, whereas C_{44} remains nearly unchanged, suggesting an anisotropic mechanical response. Furthermore, the mechanical stability assessment demonstrates that the NaCl (B1) phase of ScSe satisfies the Born stability criteria and remains mechanically stable up to approximately 33 GPa.

Keywords: First-principle calculations; Structural properties; Electronic properties; Elastic properties.

Valorization and Investigation of the Mechanical and Physical Properties of Afarès Oak Wood in Algeria

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Abstract: The aim of this study was to characterize the physical and mechanical properties of Afarès oak wood and to determine its classification. The study was conducted in one part of the Akfadou forest and the other in the Jijel forest. Physical and mechanical tests were performed on 20 standardized specimens taken from a set of 8 felled trees. The study demonstrates the influence of the tree and its location on the physical and mechanical properties; the tree's own characteristics play a predominant role in determining the components of shrinkage, moisture content, density, bending, shear, and compression. The results place Afarès oak wood in the category of high-shrinkage, medium-weight to heavy woods, ranging from slightly to very slightly shrink. The results confirm that axial, tangential, and radial shrinkage remain high. The various results of this expertise show the influence of station effects on the properties of the species considered; we also note that it has interesting mechanical characteristics for the different stations, which leads us to suppose its use in wooden structures (houses, sheds, etc.).

Keywords: AFARES OAK, physical properties, mechanical properties, valorization

Study of the multilayer adsorption of ethylene on a graphite surface

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Abstract: In this work, we study multilayer adsorption using grand canonical Monte Carlo simulation and the gas-on-lattice model. The system under study is ethylene on a homogeneous graphite surface. The primary objective of this study is to evaluate the behavior of the adsorbed film : first, by reproducing the observed isotherm shapes; second, by quantitatively analyzing the systems through an examination of phase transitions, critical temperatures, and phase diagrams. The isotherms generated over a temperature range from 50 K to 170 K reproduce a number of interesting features observed experimentally : (i) within a certain temperature range, the isotherms consist of a series of vertical steps typical of layer-by-layer growth, with each step corresponding to the formation of a distinct monomolecular layer. (ii) Above a certain temperature, known as the critical layer temperature, these distinct layers tend to disappear, meaning that the film thickness increases continuously. (iii) The adsorbed film exhibits the peculiarity of consisting of a finite number of layers that increases with temperature in the undersaturated region. Each layer forms at a certain temperature Tn and at a certain pressure Pn. (iv) We observe a thin-film-to-thick-film transition near the triple point temperature Ttr. Indeed, immediately after Ttr, the number of layers increases rapidly with temperature. In addition to this qualitative description, the obtained isotherms allow for the determination of quantitative information, including the temperatures and relative pressures of layer formation, critical point temperatures, and phase diagrams.

Keywords: adsorption ; multilayer ; ethylene ; graphite ; isotherm

Modeling Multilayer Adsorption : A Monte Carlo Approach Using A Gas-On-Lattice Model

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Abstract: The gas-on-lattice model is one of the most widely used theoretical tools for studying adsorption phenomena on solid surfaces. Introduced in 1978 by De Oliveira and Griffiths, it represents an extension of the Ising model applied to surface phenomena. In this model, gas particles occupy the sites of a semi-infinite lattice, where each site can be either occupied or empty. Owing to its simplicity and flexibility, this model is capable of reproducing various experimental behaviors, such as monolayer and multilayer adsorption, stepwise isotherms, and hysteresis phenomena. To investigate these systems, the Monte Carlo method is widely used because of its ease of implementation and numerical efficiency. Based on statistical mechanics, it enables the analysis of phase transitions and adsorption isotherms. Simulations are generally carried out within the grand canonical ensemble, which is particularly suitable for adsorption phenomena since it describes a system in equilibrium with a heat and particle reservoir.

Keywords: modeling ; simulation ; adsorption ; multilayer

Structural Electronic and Optical Properties of $Sr_xCd_{1-x}F_2$ Mixed Fluorides

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Abstract: The structural, electronic, and optical properties of cubic fluorides CdF_2, SrF_2, and their mixed compounds $Sr_xCd_{1-x}F_2$ were investigated using the full-potential linearized augmented plane wave (FP-LAPW) method as implemented in the WIEN2k code within the framework of density functional theory (DFT). Structural properties were calculated using the Wu–Cohen generalized gradient approximation (WC-GGA) for the exchange–correlation potential. For the electronic properties of $Sr_xCd_{1-x}F_2$, in addition to WC-GGA, the Engel–Vosko GGA (EV-GGA) and the modified Becke–Johnson (mBJ) potential proposed by Tran and Blaha were employed in order to achieve improved band gap estimations. Optical properties were evaluated using the mBJ potential. calculated band gaps range from 6.61 eV to 11.14 eV, revealing wide band gap semiconducting behavior and strong ultraviolet optical responses. These characteristics make the materials promising candidates for renewable energy applications, including solar energy conversion, UV photodetectors, radiation shielding, and advanced photonic energy devices. Their tunable properties suggest potential for next-generation energy-efficient technologies.

Keywords: FP-LAPW, DFT, WC-GGA, WIEN2k code. fluorides.

Study of the adsorption kinetics of the food dye Tartrazine Yellow using a plant-based waste

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Abstract: Over the past decades, there has been an increasing use of plants and plant-based wastes for the treatment of water contaminated with dyes. The aim of this study is to monitor the batch removal of the food dye Tartrazine Yellow using an agricultural waste. The pseudo-first-order and pseudo-second-order kinetic models, as well as the intraparticle diffusion model, were evaluated. The kinetic study showed that adsorption equilibrium was reached within the first 50 minutes of contact. The obtained results indicate that the adsorption of Tartrazine onto the biomass follows a second-order kinetic model. Regarding intraparticle diffusion, the rate constants increase with increasing initial dye concentration, whereas temperature variation has no significant effect on the rate constant values, which remain nearly constant.

Keywords: adsorption, biomass, Tartrazine Yellow, plants.

Prediction of stiffness loss in composite laminates with transverse cracks and delamination under hygrothermal desorption conditions

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Abstract: The stiffness reduction of cross-ply composite laminates containing transverse cracks and mid-layer delamination is predicted using a modified shear-lag model with a stress perturbation function. Good agreement is observed between the proposed prediction model and experimental results. The material properties of the composite are influenced by variations in temperature and transient moisture concentration during the desorption process, based on a micromechanical laminate model. The transient, non-uniform moisture distribution leads to stiffness reduction. The results show that stiffness degradation depends on crack density, thickness ratio, and environmental conditions. This study highlights the importance of understanding material property degradation in the failure progression of laminates, particularly when delamination growth is extensive.

Keywords: delamination ; desorption ; stiffness ; Transverse cracking.

Theoretical study of an acoustic wave sensor for real-time monitoring of engine oil viscosity

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Abstract: The industrial world is increasingly seeking ways to miniaturize and refine the capabilities of various control systems, particularly sensors of all kinds. The miniaturization of sensors based on guided wave technology is highly sought after and valued for its efficiency and safety. The main waves that can be guided in piezoelectric or non-piezoelectric materials are of different natures, affecting the material in different ways depending on the frequency at which they are excited. The advantage of Love-guided waves lies in the confinement of their energy near the free surfaces of the waveguide, and therefore their high sensitivity to variations in the external environment. MEMS (Microelectromechanical Systems) devices based on Love waves are being theoretically studied for their potential role as a promising technological platform for the development of sensors, based on the propagation of acoustic waves, for liquid environments. This work demonstrates the choice of using piezoelectric materials to optimize the sensitivity of a Love wave sensor for measuring the viscosity of a Newtonian liquid by exploiting the fundamental Love mode L0

Keywords: Sensor; piezoelectricity; viscosity; Love waves.

Optimizing Mixing Parameters to Tailor Thermal Conductivity in Foam Concrete

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Abstract: As the construction industry increasingly demands lightweight and energy-efficient materials, foam concrete has emerged as a promising candidate owing to its low density, favorable thermal insulation properties, and compatibility with sustainable building practices. The thermal performance of this material is fundamentally governed by its microstructure, which is, in turn, highly sensitive to processing conditions particularly those associated with the mixing stage. This study investigates the influence of two critical mixing parameters: rotational speed and mixing duration. Insufficient mixing speed results in poor air bubble dispersion throughout the matrix, whereas excessively high speeds promote bubble rupture and compromise foam stability. Similarly, mixing time exerts a direct effect on blend homogeneity: short durations prevent uniform foam distribution, while prolonged mixing accelerates bubble coalescence and structural breakdown. Both phenomena alter the porosity level and void distribution within the concrete matrix two parameters that are intrinsically linked to thermal conductivity. Experimental results demonstrate that careful optimization of mixing speed and duration enables effective control over bulk density and yields a measurable improvement in the thermal efficiency of the material. This contribution highlights the significance of these often-overlooked processing parameters and proposes optimal mixing conditions for producing low thermal conductivity foam concrete, in line with current requirements for energy-efficient and durable construction.

Keywords: Foam concrete, Mixing speed, Mixing duration, Thermal conductivity, Bulk density

Pore Size Refinement and Spatial Homogeneity in Foam Mortar: Governing Role of Mixing Duration Under the Mixed Foaming Method

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Abstract: Controlling pore architecture, size, morphology, and spatial distribution, is the central challenge in producing high-performance foam mortar via the mixed foaming method, where all constituents including the foaming agent are introduced simultaneously. Unlike the pre-foaming method, this approach offers no direct visual control over foam quantity, making mixing duration a decisive lever for governing the resulting porous network. This study examines how mixing duration, varied from 2 to 12 minutes at 1000 rpm and foaming agent dosages up to 0.2%, shapes pore architecture at both millimeter and micrometer scales. Optical microscopy reveals a progressive reduction in average pore diameter with increasing mixing time: from approximately 1300 µm at 2 minutes to 200 µm at 12 minutes, while pore distribution simultaneously evolves from irregular to highly homogeneous. Notably, this refinement occurs without any measurable change in foam generation rate beyond 5 minutes, confirming that mixing duration acts selectively on pore geometry rather than porosity content. Bubble morphology also transitions from ellipsoidal toward perfectly spherical at 1000 rpm, reflecting improved foam stability within the fresh matrix. These microstructural changes translate directly into thermal consequences: extending mixing from 5 to 12 minutes reduces thermal conductivity from 0.359 to 0.181 W/m•K, a reduction of nearly 50%, confirming that pore size, independently of density, is a primary determinant of heat transfer in this material.

Keywords: foam mortar, mixed foaming method, pore size, pore distribution, thermal conductivity, mixing duration

Compressive and flexural strength evolution of alkali-activated iron-rich slag mortars: toward optimized paving and prefabrication binders

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Abstract: Growing pressure to reduce the carbon footprint of the construction sector has accelerated interest in alkali-activated materials as cement-free alternatives capable of valorizing industrial waste streams. This study develops and characterizes eco-efficient mortars produced from air-cooled grey cast iron slag — a metallurgical by-product — activated through combined sodium hydroxide and sodium silicate systems. Two key activator parameters were systematically varied: sodium hydroxide concentration (6, 8, and 10 M) and the sodium silicate-to-sodium hydroxide mass ratio (SS/SH = 2 and 2.5), with the solid-to-liquid ratio fixed at 2.7. Specimens were cured at 65°C under dry conditions and mechanically tested at 7, 28, 90, and 528 days. Results reveal a sustained strength gain over time, reaching 52.6 MPa in compression and 8.8 MPa in flexure at 528 days. The combination of 8 M NaOH with SS/SH = 2 proved optimal, promoting the formation of a dense N–A–(Fe)–S–H gel responsible for continuous microstructural consolidation and long-term strength development. These findings establish iron-rich slag as a viable and competitive precursor for alkali-activated binders, with performance levels compatible with paving elements and prefabricated construction products. Beyond their mechanical merits, these mortars represent a concrete contribution to waste valorization and circular economy objectives in the building materials industry.

Keywords: alkali-activated materials, air cooled grey cast iron slag, NaOH concentration · SS/SH ratio, low-carbon binder, circular economy

Effect of Glass Composition on Glass Transition and Crystallization in Oxide and Oxyfluoride Glass Systems

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Abstract: This work presents a comprehensive literature review on the effect of glass composition on glass transition and crystallization behavior in oxide and oxyfluoride glass systems. Glass composition is a key factor governing structural rigidity, thermal stability, and resistance to crystallization, which are critical for advanced functional applications. Published studies show that increasing network formers such as SiO_2 and Al_2O_3 strengthens the glass network through enhanced connectivity, leading to higher glass transition (Tg) and crystallization (Tx) temperatures. Similarly, rare-earth oxides like Gd_2O_3 and Tb_2O_3 improve thermal stability by increasing bond strength and network rigidity. In contrast, network modifiers such as alkali oxides or fluorine disrupt the network by creating non-bridging oxygen sites, resulting in lower Tg and higher crystallization tendency. Thermal analysis by Differential Scanning Calorimetry (DSC), combined with X-ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR), reveals strong correlations between compositional changes, structural organization, and thermal behavior. Future research should focus on optimizing glass compositions using advanced techniques including Raman spectroscopy, nuclear magnetic resonance (NMR), and in-situ XRD to better understand structural rearrangements during heating. Multi-doped systems (e.g., $Ce^{3+}/Tb^{3+}/Gd^{3+}$) are promising for enhancing both thermal stability and optical performance. Precise control of glass composition remains essential for developing advanced glass materials for optical, scintillation, and related technological applications.

Keywords: Glass transition; Crystallization; Thermal stability; Rare-earth elements; Oxide glasses; Oxyfluoride glasses

Estimating the Wave Function at the Origin for Doubly Heavy Mesons via a Three-Parameter Variational Approach

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Abstract: The wave function at the origin (WFO) is a key quantity in the study of heavy quarkonia, as it enters the calculation of hyperfine splittings and determines production and decay amplitudes. In this work, we employ the variational method using three-parameter trial functions to investigate the ground state of a two-body system interacting via central potentials of the Cornell, Martin, and global types. We compute the ground-state energy, the mean relative distance ⟨r⟩, and the squared wave function at the origin |ψ(0)|^2, the latter being particularly relevant for heavy-meson physics. Our variational results are compared with available numerical solutions for these potentials, showing good agreement and demonstrating the efficiency of the three-parameter approach. The inclusion of additional variational parameters provides greater flexibility in reproducing the true wave function, improving accuracy for short-distance observables such as the WFO. The results confirm that the three-parameter variational method offers a reliable and computationally efficient alternative to more demanding numerical techniques for heavy quarkonium systems.

Keywords: Variational method; Heavy quarkonia; Wave function at the origin; Cornell potential; Martin potential; Three-parameter trial functions

Development of a Planar ZnO-Based pH Sensor Using DropSens Screen-Printed Electrodes

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Abstract: A compact planar pH sensor was effectively created using DropSens screen-printed electrodes (SPEs) and assessed via open-circuit potential (OCP) measurements. The sensor consists of a basic two-electrode design, featuring a ZnO-sensitive working electrode and a reference electrode made of Ag/AgCl. The reference electrode was created through electrodeposition, ensuring a consistent and repeatable potential necessary for precise pH measurement.The ZnO sensing layer was applied using spray pyrolysis, producing uniform, strongly bonded thin films with outstanding chemical stability. Due to its semiconducting characteristics and significant surface interaction with hydrogen ions (H^+), ZnO displayed a consistent potentiometric reaction to changes in pH. The developed sensor exhibited a nearly Nernstian response with a sensitivity of around −45 mV/pH, along with excellent repeatability and lasting stability.To enhance the sensing capabilities, ZnO was doped with tin (Sn). The incorporation of Sn enhanced the electrochemical properties of the sensing layer and increased the sensitivity to approximately −50 mV/pH, signifying a more responsive reaction to changes in proton concentration. Moreover, the sleek and compact structure allows for measurements using small sample volumes and facilitates integration into cost-effective, portable analytical devices.

Keywords: pH sensor, Zinc oxide, spray pyrolysis, screen-printed electrodes.

Interpretation of the 5p⁶4f6d Configuration in Nd V (Quadruply Ionized Neodymium)

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Abstract: Lanthanide ions exhibit a highly complex energy-level structure. The study of their high-resolution spectra in the vacuum ultraviolet (VUV) region provides valuable information on their wavefunctions and radiative properties. The present work focuses on the interpretation of the 5p⁶4f6d electronic configuration in the spectra of quadruply ionized neodymium (Nd V). The objective of this study is to establish the energy-level diagram and to characterize the corresponding wavefunctions and radiative properties, such as transition probabilities and Landé g-factors. The spectra are produced in the laboratory using a vacuum sliding-spark discharge source and are recorded with the VUV spectrograph at the Meudon Observatory. Dedicated software packages are employed to determine line positions and intensities and to derive the corresponding wavelengths. For this purpose, a suitable calibration procedure has been adopted based on the reference wavelengths of light atoms (O, C, N, etc.). The theoretical interpretation of the spectra is carried out using the Slater–Racah parametric method implemented in the Cowan suite of codes (RCN/RCN2/RCG/RCE) [1]. The starting point is provided by Relativistic Hartree–Fock (HFR) calculations performed with the RCN code. Compared with Ref. [2], the configuration basis has been extended by including the additional configurations 5p⁶4f5f and 5p⁶4f6d. The ab initio values of the atomic parameters (electrostatic radial integrals and spin–orbit interaction parameters) obtained from the RCN2 code are scaled using scaling factors (SF = Pfit/PHFR) before being introduced into the RCG code for Hamiltonian diagonalization. The final stage, performed with the RCE code, consists of a least-squares fitting procedure applied to the atomic parameters in order to minimize the discrepancies between calculated and observed energy levels.

Keywords: Atomic spectroscopy; Lanthanide; Slater–Racah method; Electronic configurations; Energy levels; Sliding-spark discharge.

Comparative Study of Two Particle Size Analysis Methods for Fe_2Al_5 Intermetallics Simulating UAl_2 Targets

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Abstract: Powder particle size distribution is a key parameter in the manufacturing of UAl_2 target cores for medical radioisotope production due to its influence on homogeneity, densification, porosity, and irradiation behavior. This study compares particle size characterization results obtained by image analysis and laser diffraction for Fe_2Al_5 intermetallic powders simulating the UAl_2 target fabrication process. The Fe_2Al_5 powders were produced by melting, followed by crushing and milling, and subsequently classified into fine and medium fractions. To ensure a direct comparison, 120 identical particle size classes ranging from 0.01 to 3800 µm were defined for both techniques. The results show that laser diffraction has limited specificity for the fine fraction because it cannot distinguish agglomerates without complementary microscopic observations. Image analysis revealed that the DMajor and DFeret descriptors provide the most representative particle size distributions. The study further demonstrates that results obtained by image analysis and laser diffraction can be reliably correlated for non-spherical powders. Among the image-analysis descriptors, particle width is the most appropriate parameter for comparison with laser diffraction measurements. Nevertheless, systematic differences remain due to the random orientation of irregularly shaped particles during image acquisition, which affects the measured dimensions.

Keywords: intermetallics, Fe_2Al_5 powder, particle size characterization, image analysis, laser particle size analysis

Study of the Effect of AUC Decomposition Parameters on the Properties of Prepared UO_3 and U_3O_8 Powders

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Abstract: This study examines the influence of thermal decomposition parameters of ammonium uranyl carbonate (AUC) on the properties of intermediate oxides UO_3 and U_3O_8, which are key precursors for ceramic UO_2 nuclear fuel.

Parameters varied include temperature (100–900°C), duration (1 min to 6 h), and atmosphere (air and nitrogen). Thermal decomposition was performed in a muffle furnace, with TG-DTA analyses. Powders were characterized by UV-visible spectroscopy (O/U ratio), thermogravimetry (uranium content), and BET specific surface area.

Mass loss increased sharply from 5.6% at 100°C to 42% at 200°C, reaching 47% at 800°C. At 200°C, O/U ratio was 3.52 and uranium content 80.5%, indicating amorphous UO_3. Between 400–500°C, O/U decreased from 2.85 to 2.74 and uranium content reached 84.7%, marking transformation into U_3O_8. At 600–700°C, O/U stabilized between 2.67 and 2.69 (stoichiometric U_3O_8).
DTA-ATG curves confirmed these transformations: an endothermic peak (120–200°C) due to NH_3 and CO_3 release, an exothermic peak near 490°C (UO_3 crystallization), and an endothermic peak around 600°C (U_3O_8 formation).

BET surface area was very low at 100°C (6 m^2/g), peaked at 82 m^2/g at 200°C (amorphous UO_3), then decreased to 20.9 m^2/g at 400°C and 1 m^2/g at 800°C (stoichiometric U_3O_8). Calcination at 200–300°C under air produces high-surface-area UO_3 favorable for reduction into UO_2, while 600–800°C yields very low surface area U_3O_8 (<2 m^2/g).

Keywords: AUC, Decomposition, UO_3, U_3O_8, DTA-TG.

Effect of annealing temperature on the properties of $CuInS_2$ thin films prepared by Electrodeposition and sulfurization

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Abstract: In this work, four $CuInS_2$ thin films were prepared by electrodeposition followed by sulfurization to study the effect of annealing temperature on their structural and optical properties. To prepare Cu-In thin films, electrolyte solutions containing 10 mM copper chloride CuCl2 and 20 mM indium chloride InCl3 were used. Then, four samples of Cu-In were deposited on indium tin oxide (ITO) substrates. The deposition process was carried out at ambient temperature for 20 minutes, under an applied potential of 7 V. The as-deposited samples were placed in glass capsules with a quantity of powdered sulfur. The capsules were annealed for 60 min at different temperatures: 250, 350, 450 and 510 ºC. The structural and optical properties of the samples were characterized by X-ray diffraction and UV-visible spectroscopy.

X-ray diffraction analysis confirmed the presence of the CuInS2 phase with a tetragonal chalcopyrite structure with a preferential orientation along the (112) plane. We also noted that the growth of the CuInS2 phase occurred at the expense of the secondary CuS phase. In the visible region, the transmittance of the films sulfurized at 250 ºC and 350 ºC remained relatively low, reaching a maximum value of about 13%, whereas it did not exceed 5% for the films sulfurized at 450 ºC and 510 ºC. The optical band gap energy of the sulfurized films at 250, 350, 450, and 510 ºC was found to be 1.95, 2.00, 1.57 and 1.56 eV, respectively.

Keywords: $CuInS_2$; Electrodeposition; sulfurization; characterization.

Kinetic Investigation of Pesticide Removal through Adsorption

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Abstract: Phytosanitary products constitute a significant source of environmental pollution due to their toxicity toward human health and ecosystems. Among these substances, pesticides are of particular concern because of their persistence in soils and aquatic environments, as well as their potential acute and chronic effects. To mitigate these risks, various treatment technologies have been developed, among which adsorption has emerged as an effective, economical, and environmentally sustainable method.

The present study investigates the removal of a pesticide from aqueous solutions through adsorption using a food waste-derived adsorbent. This approach promotes the valorization of organic waste while offering a sustainable and promising solution for water decontamination. A series of batch adsorption experiments was performed to evaluate the effects of key operational parameters, including the initial pesticide concentration, adsorbent dosage, and solution pH.

The results demonstrated that the highest removal efficiency, reaching 84%, was achieved under optimal conditions corresponding to an adsorbent dosage of 0.15 g/L and a pH value of 9.5. Suggesting that chemisorption plays a predominant role in the interaction between the adsorbent surface and pesticide molecules. Furthermore, equilibrium data were best described by the Langmuir isotherm model ($R^2 = 0.97$), indicating monolayer adsorption on a homogeneous surface. These findings highlight the potential of food waste-based materials as low-cost and eco-friendly adsorbents for the treatment of pesticide-contaminated water, Différentes analyses ont été effectuées pour caractériser l'adsorbant : MEB et DRX.

Keywords: Adsorption; Pesticide removal; Adsorbent; Food waste.

Additively manufactured by WAAM-CMT 316L stainless steel with improved corrosion resistance in an acidic environment

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Abstract: Wire arc metallurgy and cold metal transfer (WAAM-CMT) have experienced remarkable growth in recent years, opening new possibilities for manufacturing metallic components with complex geometries and multi-scale mesh structures. Compared to conventional manufacturing processes and subtractive machining, additive manufacturing offers advantages in terms of cost reduction, weight optimization, enhanced functionality, and improved production efficiency. However, limited knowledge of the mechanical properties, durability, and long-term performance of components manufactured using this technology still hinders its wider industrial adoption. Therefore, characterizing parts produced by additive manufacturing is crucial for the successful application of these technologies. Consequently, increasing research efforts are being deployed to address the challenges associated with additive manufacturing, particularly the corrosion behavior of metals produced using this technique. This study focuses on AISI 316L austenitic stainless steel, a material commonly used in the chemical, pharmaceutical, petroleum, food processing, and marine industries due to its excellent corrosion resistance in marine and acidic environments, as well as its high ductility. The 3D printing of 316L stainless steel is therefore a significant area of research. This study examines the influence of machining and heat treatment processes on the microstructure and corrosion susceptibility of 316L stainless steel produced using WAAM-CMT technology. The relationship between microstructural properties and corrosion resistance in a 0.5 M sulfuric acid (H_2SO_4) solution was evaluated. Furthermore, the effectiveness of the inhibitor SB (aminophenol derivative) for protecting corrosion-sensitive metallic components was investigated using dynamic polarization. The results demonstrated strong inhibition efficiency in a 0.5 M sulfuric acid (H_2SO_4) solution at a constant temperature of 20 °C, reaching 90.4% for an inhibitor concentration of 10^{-3} M. These results indicate that inhibitor L acts as an effective corrosion inhibitor in the oxidizing environment of sulfuric acid.

Keywords: WAAM-CMT, AISI 316L stainless steel, corrosion, Schiff base, electrodynamic polarization.

Influence of Deposition Time on the Properties of ZnO Thin Films Prepared by Electrodeposition

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Abstract: This work focuses on the preparation and characterization of ZnO thin films deposited by electrodeposition onto ITO-coated glass substrates. A series of four samples was prepared by varying only the deposition time, while all other synthesis parameters and post-treatment conditions were kept constant. The obtained films were thermally annealed in air at 550 °C for one hour to enhance their physicochemical properties.
The influence of deposition time on the structural, morphological, optical, and electrical properties of the prepared films was investigated using several characterization techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), UV–Visible spectroscopy, and Hall effect measurements. The results indicate that all samples exhibit good homogeneity, strong adhesion to the substrate, and high transparency. Structural analysis revealed a hexagonal wurtzite phase with a preferred orientation along the [002] direction, indicating good crystallinity.
The optical and electrical properties were investigated for the sample deposited for 45 minutes. UV–Visible spectroscopy revealed a maximum transmittance of approximately 86% in the visible region, an optical band gap energy of 3.40 eV, and an Urbach energy of 88 meV. Hall effect measurements at room temperature confirmed n-type conductivity, with a resistivity of 5.0 × 10-2 Ω cm and a Hall mobility of 69.12 cm2/V s. These findings demonstrate that electrodeposited ZnO thin films possess promising structural and optoelectronic properties for potential applications as buffer or window layers in photovoltaic devices.

Keywords: ZnO; electrodeposition; deposition time; optoelectronic properties; photovoltaic devices.

Laser Doping of Silicon from PSG Source Layer for Advanced Solar Cell Applications

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Abstract: Localized laser doping of silicon is considered a promising technique for the fabrication of high-efficiency solar cells. In this work, a laser doping process from a phosphosilicate glass (PSG) source layer was investigated using a nanosecond pulsed infrared laser (λ = 1064 nm) with an optical spot diameter of approximately 65 µm. Three series of samples were prepared using frequencies of 25, 30, and 35 kHz, while the laser power was varied from 2.25 W to 4.5 W for each frequency. The doping performance was evaluated through sheet resistance measurements. The obtained results showed a characteristic decrease in sheet resistance for all investigated series, highlighting three main doping regimes. These behaviors were confirmed by Atomic Force Microscopy (AFM) observations as well as by Electrochemical Capacitance-Voltage (ECV) concentration profiles. The results demonstrate the potential of laser doping from a PSG source layer for applications in next-generation solar cells requiring localized processes and reduced thermal budgets.

Keywords: Laser doping; Phosphosilicate glass (PSG); Nanosecond infrared laser; Sheet resistance; Solar cells

DFT study of the stability, structural and magnetic properties of oxygen inserted Fe4N compound as an electrocatalytic

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Abstract: Iron nitride is an excellent candidate for magnetic-field-assisted electrocatalysis; consequently, the study of the material stability in presence of oxygen is essential. The first-principles density functional theory (DFT) calculations are performed to investigate the stability, structural, electronic and magnetic properties of Fe4N. The energetically favorable phase structure is determined with and without Oxygen atoms. The results indicate an increase in lattice parameters and the local environment of oxygen is rich to Fe and prefers occupied the octahedral sites. The magnetic moment of the Fe4N is evaluated to be 1,64 μB. These results are in good agreement with experimental result. However, the presence of oxygen decreases the magnetization through zero for 37,5 %-at of O. The electronic characterization reveals a strong hybridization Fe-O.

Keywords: Iron nitride; Oxygen impurity; DFT calculations; magnetic properties

Textural Study of Activated Carbon Prepared by Phosphoric Acid Activation and Characterized by Nitrogen Adsorption Using the BET Method

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Abstract: This study focuses on the textural characterization of activated carbon by nitrogen adsorption/desorption at 77 K using the BET method. The obtained isotherm exhibits typical behavior of microporous to mesoporous materials, with a hysteresis loop indicating the presence of a developed porous structure. The BET analysis was performed in the linear region between P/P0 = 0.05 and 0.30, yielding an excellent linear correlation (R^2 = 0.99566). The calculated textural parameters show a monomolecular volume of 221.18 cm^3/g and a BET constant C of 86.09, indicating a strong interaction between the adsorbed nitrogen and the surface of the material. The specific surface area obtained is very high, reaching 961.2 m^2/g, which confirms the strong development of the porosity of the activated carbon. The total pore volume was estimated at 0.699 cm^3/g, while the micropore volume represents approximately 62.7% of the total pore volume. The average pore radius is estimated at 14.55 Å, corresponding to an average diameter of 2.91 nm, characteristic of narrow mesopores. These results demonstrate that the studied material possesses a porous texture favorable for adsorption applications, particularly in water treatment, gas purification, and catalytic processes.

Keywords: activated carbon; adsorption; BET method; specific surface area; microporosity; mesoporosity

Optimization of the Synthesis of Carbon Quantum Dots (CQDs) for Protective Coatings on Photovoltaic Modules

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Abstract: The performance and durability of solar panels are strongly affected by UV-induced degradation, which gradually reduces their efficiency and lifetime. Carbon Quantum Dots (CQDs) can convert UV radiation into visible light, thus improving solar energy harvesting while simultaneously protecting the polymer encapsulant from UV light. In this communication, we report the synthesis of CQDs and their potential use as protective coatings for photovoltaic applications. In particular, the objective of this work is to determine the optimal synthesis conditions for CQDs. The CQDs were synthesized from citric acid and urea using a hydrothermal method. Different synthesis temperatures (160-240 °C) and reaction times (4-12 h) were explored to evaluate their influence on CQD properties. The synthesized CQDs were characterized using FTIR spectroscopy, UV–Visible spectroscopy and photoluminescence (PL) analysis. The results showed that the synthesis temperature and reaction time significantly influence the optical properties of CQDs, while the surface chemical structure remains relatively stable. At 220 °C, the PL intensity increased with longer synthesis times, and after 8 h, intrinsic emission became dominant over defect-related emissions. In addition, increasing the temperature shifted the PL emission from green to blue, whereas temperatures above 240 °C enhanced defect-related emissions. These findings demonstrate the importance of controlling synthesis parameters to obtain CQDs with improved optical performance for solar panel protection and enhanced power conversion efficiency.

Keywords: Carbon Quantum Dots (CQDs); Hydrothermal Synthesis; Photoluminescence; UV Protection; Photovoltaic Modules; Optical Properties

Occurrence of ibuprofen in treated wastewater effluent from Djelfa city, Algeria, and its degradation by the UVC/H2O2 process

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Abstract: Ibuprofen is one of the most frequently detected pharmaceutical residues in aquatic environments and may persist in treated wastewater effluents after conventional treatment. Its continued release into receiving waters highlights the need for complementary post-treatment strategies.

This work investigates the occurrence of ibuprofen in treated wastewater effluent from Djelfa city, Algeria, and its degradation by the UVC/H2O2 process. Effluent samples were collected at the outlet of the wastewater treatment plant after conventional treatment, prepared for analysis, subjected to solid-phase extraction (SPE), concentrated, and analyzed by GC–MS in order to investigate the presence of ibuprofen in the treated discharge. In parallel, degradation experiments were conducted under controlled conditions using the UVC/H2O2 process. A Box–Behnken design was applied to examine the influence of the main operating parameters on the oxidation process, while the evolution of ibuprofen during treatment was monitored by UV spectrophotometry. This contribution presents an analytical and experimental framework combining environmental detection with advanced oxidation treatment of a relevant pharmaceutical contaminant and highlights the potential of UVC/ H2O2 as a polishing step for treated wastewater.

Keywords: Ibuprofen; treated wastewater effluent; Djelfa city; UVC/ H2O2; Box–Behnken design; advanced oxidation; solid-phase extraction (SPE); GC–MS; UV spectrophotometry

Effect of Annealing Time on Cu_2ZnSnS_4 Thin Films Deposited on FTO Substrates by Electrodeposition for Photovoltaic Applications

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Abstract: Kesterite Cu2ZnSnS4 (CZTS) is a promising absorber material for photovoltaic applications due to its low cost, non-toxic elements, and earth abundant constituents. It exhibits a direct band gap of 1.5 eV and a high absorption coefficient (>104 cm-1) . CZTS thin films were deposited on FTO/glass substrates by electrodeposition using a two-electrode system. The electrolyte bath consisted of CuCl2, ZnSO4.7H2O, SnCl2.H2O, and Na2S2O3·5H2O as precursor materials. The films were then sulfurized and annealed at 550°C. To investigate the effect of annealing time, two representative durations (15 and 90 min) were selected.
The structural properties were analyzed by X-ray diffraction (XRD), while Raman spectroscopy was used to confirm the phase composition.

XRD analysis confirms the formation of the kesterite CZTS phase with a preferred orientation along the (112) plane. The film annealed for 15 min shows the presence of secondary phases such as SnS related compounds, whereas these phases disappear in the 90 min sample, indicating improved phase purity. In addition, the crystallite size increases with annealing time, reflecting enhanced crystallinity.
Raman spectroscopy further confirms the kesterite structure with characteristic peaks around 306-310 cm-1, supporting the XRD results and indicating improved phase quality at longer annealing time .
These results demonstrate that annealing time significantly influences the structural quality and phase purity of CZTS thin films, making it a key parameter for optimizing their photovoltaic properties.

Keywords: Cu2ZnSnS4; Thin films; Electrodeposition; Annealing time; X-ray diffraction; Raman spectroscopy.

Properties of Quasi-monocrystalline Silicon Suitable for Photovoltaic Purposes

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Abstract: Quasi-monocrystalline silicon is a widely recognized material ideal for manufacturing photovoltaics as it incorporates all the qualities of monocrystalline silicon and relatively low production costs of multicrystalline silicon. This paper aims at analyzing structural and thermal properties of quasi-monocrystalline (mono-like) silicon using scanning electron microscopy, X-ray diffraction, and thermal analysis.
The obtained results prove that mono-like silicon is a highly crystalline material with macro-scale heterogeneity and microstructure on the millimeter scale typical for mono-like silicon material; in addition, X-ray diffraction proves high crystallographic perfection of the sample studied. Thermal analysis has revealed high stability of mono-like silicon material up to 700°C which proves high thermal resistance and stability of structural integrity and mechanical behavior; hence, the presented high crystalline quality and favorable thermomechanical properties show high suitability of quasi-monocrystalline silicon material for producing electrical power via photovoltaic power conversion.
Thus, the above-mentioned results prove high suitability of quasi-monocrystalline silicon as a material for photovoltaic generation thanks to its high crystallinity and stability.

Keywords: Quasi-monocrystalline silicon; Photovoltaic-grade silicon; SEM; XRD; Crystalline quality; Thermal stability.

Removal of Copper from Wastewater Using Hybryd bio- Composites

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Abstract: The removal of heavy metals from wastewater represents a major environmental challenge. In this study, a hybrid biocomposite based on hydroxyapatite and tea biomass (HAp–DT) was investigated for copper removal from wastewater.

The treatment efficiency was evaluated using ICP-OES analysis before and after adsorption. The obtained results showed that the HAp–DT biocomposite is highly effective for copper removal, achieving a removal efficiency of approximately 99%. This high performance indicates a strong affinity of the prepared material toward copper ions in aqueous solution.

The remarkable adsorption behavior of the HAp–DT composite can be attributed to the combined effect of hydroxyapatite and lignocellulosic biomass, which provide active sites favorable for metal retention. The synergy between the mineral and organic phases gives this hybrid material a strong potential as a low-cost and environmentally friendly adsorbent for wastewater treatment. These results highlight the effectiveness of hybrid biocomposites in the remediation of metal-contaminated effluents.

Keywords: adsorption , wastewater, biocomposite, heavy metals, Hydroxyapatite, Biomass.

Evaluation of the critical distance for productivity between the electricity grid and autonomous photovoltaic pumping

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Abstract: This comparative study employs a differential cost-benefit analysis between extending an electrical grid infrastructure and deploying a stand-alone photovoltaic (PV) micro-generator system dedicated to a stationary hydroelectric load. The load profile is characterized by a daily energy demand of 1.5 kWh and a strict power constraint of 0.75 kW, imposing a binary operating regime at full load (100% of nominal current). To compensate for the intermittency of the irradiance and ensure continuity of service, the system incorporates gravity-fed energy storage in the form of a water reservoir with a reserve capacity of 6 kWh/day, while the installed peak power of the PV array is set at 2.07 kW to compensate for systemic losses and guarantee the motor start-up threshold.

By integrating the Advanced Load (for dynamic demand modeling) and Advanced Grid (for infrastructure cost modeling) simulation modules used in Homer Pro software, the analysis identifies an economic tipping point, or critical break-even distance, of 0.45 km. Beyond this interconnection radius, the marginal cost of grid extension—including capital expenditures (CAPEX) related to the transmission line and associated resistive losses—exceeds the total cost of ownership (TCO) of the standalone PV system.

The results demonstrate the system's feasibility and establish the decentralized solution as the optimal techno-economic option.

Keywords: Keywords: Electrical grid ; Photovoltaic Pumping; ; Advanced Load; Cost Modelling;

Comparative Study of Two Parabolic Solar Cookers with Thermal Energy Storage

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Abstract: The growing demand for sustainable cooking solutions in regions with high solar potential is driving the development of solar thermal technologies integrated with energy storage systems. However, conventional solar cookers remain constrained to peak sunshine hours, significantly limiting their practical utility. This study presents a comparative experimental analysis of the thermal performance of a parabolic solar cooker incorporating two distinct thermal storage approaches: a latent heat storage system using a phase change material (PCM), and a hybrid configuration combining both latent and sensible heat storage. Experimental trials were conducted under clear-sky conditions to evaluate charging and discharging phases, temperature evolution, cooking performance, and thermal retention capacity. The first configuration integrates acetanilide as a phase change material within a double-walled aluminum cooking vessel, with performance optimization through black-painted exterior surfaces and acrylic glazing to enhance solar absorption and minimize convective losses. The second configuration employs a triple-walled design combining acetamide PCM (latent storage) with sand (sensible storage) to improve thermal stability and extend energy availability.

Results demonstrate that optimizing solar absorption and thermal insulation significantly increases both the maximum temperature reached and the overall storage capacity. The PCM-only system achieved maximum temperatures of 186.3°C with glazing, while the dual-storage system exhibited superior thermal stability and slower heat discharge. The hybrid system enabled successful twice-daily cooking sessions (midday and evening), with evening cooking rates 1.5 to 2 times faster than midday sessions. Stored latent energy proved substantially greater than sensible energy (approximately 2.7 times higher), while the sand layer contributed to limiting thermal losses and maintaining food temperatures between 60.2°C and 70.6°C even at 8:00 PM. This study thus proposes a sustainable, high-performance solar cooking solution particularly suited to rural or isolated areas.

Keywords: Solar energy, Thermal energy storage, Phase change materials, Parabolic solar cooker, Sustainable development, Hybrid thermal storage

Numerical Modeling and Experimental Validation of Fault Diagnosis in Photovoltaic Systems

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Abstract: Photovoltaic conversion is experiencing considerable growth worldwide due to its clean, silent and available nature. However, like any industrial system, a photovoltaic installation can be subjected to various faults and anomalies leading to performance degradation or even system unavailability. This work proposes an in-depth study of faults affecting the photovoltaic generator part (DC) of a PV installation. This study focuses on the modeling and analysis of faults in photovoltaic systems, combining numerical simulation and experimental validation. Several mathematical models of photovoltaic cells were developed using MATLAB/SIMULINK, in particular the single-diode model , the two-diode model and the Bishop model , which incorporates a nonlinear multiplier to account for avalanche effects in reverse bias conditions in photovoltaic systems. Simulations of the current-voltage (I-V) and power-voltage (P-V) characteristics show a good representation of the photovoltaic module's behavior under normal and degraded conditions. Finally, partial shading faults were reproduced experimentally to compare the measured results with the model predictions. The results obtained demonstrate the reliability of the developed models for fault diagnosis and performance optimization of photovoltaic systems, thus contributing to improved production and maintenance of solar installations.

Keywords: PV systems, shading, faults, experimental validation, Matlab simulink.

Corrosion Mechanisms of Silver Metallization and Their Role in Snail Trail Formation in Crystalline Silicon Photovoltaic Modules

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Abstract: Snail trails are common degradation patterns observed in crystalline silicon photovoltaic (PV) modules, appearing as brown or dark discoloration on solar cells. Once considered mainly aesthetic defects, recent studies show that they are closely related to the corrosion of silver metallization within the module structure.

This work reviews the main physicochemical mechanisms involved in snail trail formation, focusing on the coupled effects of silver corrosion, EVA encapsulant degradation, humidity, UV irradiation, and microcracks. Under environmental stress, EVA degradation generates reactive species such as acetic acid, which promotes the dissolution and migration of silver ions from grid fingers and busbars. These reactions lead to the formation of compounds including silver carbonate (Ag_2CO_3), silver acetate ($AgCH_3COO$), and silver chloride (AgCl), commonly detected in affected areas.

The literature also indicates that microcracks accelerate moisture ingress and electrochemical reactions, increasing metallization degradation. In addition to visual discoloration, snail trails may contribute to higher series resistance, localized power losses, and long-term reliability issues. Overall, snail trails can be considered a coupled chemical–electrochemical degradation phenomenon affecting the stability of silver metallization in PV modules.

Keywords: Silver corrosion; Photovoltaic modules; Snail trails; EVA degradation; Metallization reliability

Enhancing sugar recovery from Carob biomass through an optimized physical pretreatment

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Abstract: The valorization of lignocellulosic biomass for biofuel production requires efficient strategies to release fermentable sugars. This study investigates the impact of microwave-assisted pretreatment on carob biomass, focusing on the effect of microwave power levels (450 W, 600 W, 800 W) using a particle size of 250 µm. Preliminary characterization of the raw material showed $10.6 \pm 0.4\%$ moisture, $89.4 \pm 0.4\%$ dry matter, $2.79 \pm 0.2\%$ ash, $97.2 \pm 0.2\%$ organic matter, $40.78 \pm 0.04\%$ total sugars, and $4.98 \pm 0.4\%$ proteins. The highest sugar release was achieved at 800 W, producing 86.18 g/L of total sugars. This improvement can be attributed to the disruption of the lignocellulosic structure caused by microwave irradiation, which facilitates the breakdown of complex polysaccharides. Compared with conventional pretreatment methods, microwave processing offers reduced processing time and lower chemical requirements. These findings highlight the potential of microwave-assisted pretreatment as a promising and sustainable technique for maximizing sugar recovery from carob biomass and promoting its application in biomass valorization.

Keywords: Carob; Pretreatment; Sugars; Biomass valorization; Renewable energy

Development of a DNN model for biogas production using a hybrid BO-TPE approach in an anaerobic wastewater treatment plant

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Abstract: Deep neural networks have been regarded as accurate models to predict complex energy production processes due to their ability to learn from a huge number of data sets via artificial intelligence. To improve the performance of these models, the main challenge is to select the appropriate hyperparameters, such as: number of hidden layers and hidden units, activation function, optimizer, learning rate, and others. The use of a hybrid Bayesian optimization with tree-structured Parzen estimator (BO-TPE) to model biogas production from wastewater treatment plant data using deep neural network (DNN) has been performed.

The data preprocessing process has been carried out according to three steps: removing columns with many missing values, removing rows with significant missing data, and finally deleting the remaining missing values using dropna. Different normalization techniques, including standardization and RobustScaler, were compared.

This study presents a promising deep neural network (DNN), optimised using the hybrid BO-TPE method for modelling biogas production, which makes use of the many features of RobustScaler. This model predicts a maximum volume of 2,236.105 Nm^3/day and performs well (R^2 = 0.712, MAE = 164.610, RMSE = 223.429). The StandardScaler gives 2063.375 Nm^3/d with R^2 = 0.690 (MAE = 170.5179, RMSE = 231.5192). These results provide an autonomous approach to control key variables of a large digester installation for renewable energy production and combined heat and electricity generation.

Keywords: Deep neural network; Hybrid BO-TPE; Biogas; wastewater.

The Use of Solar Renewable Energy in Cooling Systems

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Abstract: Solar Energy source is a sustainable, a totally inexhaustible and environmentally friendly alternative to the fossil fuels available. It is a renewable and an economic energy that can be harnessed sustainably over a long term and thus stabilizes the energy costs. Solar cooling technologies have been developed to decrease the augmentation electricity consumption for air conditioning and to displace the peak load during hot summer days. For this context, in this preset work, An annular finned adsorber that is the most important component of the adsorption solar refrigerating system, is considered to investigate the performance of a solar cooling system using Silicagel-Water adsorbent-adsorbate pair. The modeling of the adsorption cooling system requires the resolution of the equation describing the energy and mass transfer in every element of the system. Wilson and Dubinin- Astakhov models of the system performances are sensitive to the fins geometry. For the considered data measured for clear type days of May, Jun and August 2025 in Algeria, the performances of the cooling system are very significant.

Keywords: Solar, Renewable Energy, Cooling System, Modeling,

Thermo-Energetic Analysis of a Vapor-Compression Air-Conditioning System Powered by Photovoltaic Energy with Battery Storage in Algeria

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Abstract: Air-conditioning is the fastest-growing electricity end-use in the Algerian residential sector, while the national grid remains dominated by natural gas. This work investigates a grid-connected solar air-conditioning system combining a 4.44 kWp bifacial PV array (LONGi LR5-72HBD-555M), a 19.92 kWh Pb-acid battery bank (Trojan S6 L16-HC), a SUNSYNK 5K hybrid inverter, and a DC vapor-compression heat pump (DGWA1-DC48V-18K, 5.27 kW) for a 120 m³ residential zone in Constantine, Algeria. An hourly dynamic simulation was performed over one full meteorological year (8760 h) in TRNSYS 18 using Meteonorm 8 weather data, with indoor set points of 21°C in winter and 24° C in summer. The thermo-energetic analysis quantifies the building thermal loads, the seasonal performance factors (SPF) of the vapor-compression cycle, the PV conversion efficiency, and the energy self-sufficiency ratio. Results show an annual PV production of 6737 kWh (specific yield 1518 kWh/kWp), a total heat-pump thermal output of 4 092 kWh (2749 heating / 1343 cooling) for an electrical consumption of 1718 kWh, leading to SPF values of 2.17 (heating) and 2.39 (cooling). The system achieves an annual self-sufficiency ratio of 88 % and exports 4689 kWh to the grid, avoiding 4042 kg CO_2eq of grid emissions per year. The indoor temperature remains within the 20–24°C comfort range throughout the year, confirming the thermo-energetic and technical viability of the configuration for residential air conditioning in the Algerian high-plateau region.

Keywords: Thermo-energetic analysis, Vapor compression, PV–battery system, Seasonal performance factor, TRNSYS 18, Algeria (Constantine)

Eco-friendly Co-precipitation Synthesis of Spinel $CoFe_2O_4$ for Enhanced Supercapacitive Performance

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Abstract: Cobalt ferrite ($CoFe_2O_4$) is a promising electrode material for supercapacitor applications due to its excellent chemical stability, good electrical conductivity, and remarkable pseudocapacitive properties. In this work, $CoFe_2O_4$ nanoparticles were synthesized by a simple and cost-effective co-precipitation method. The process involves the precipitation of Co^{2+} and Fe^{3+} ions in an alkaline medium, followed by thermal treatment to obtain the spinel ferrite structure. The obtained nanomaterial exhibits a high surface area and numerous electroactive sites, enhancing charge storage capability. Electrochemical measurements revealed a specific capacitance of 234 F g^{-1}, attributed to the reversible redox reactions of cobalt and iron ions. These results demonstrate that $CoFe_2O_4$ synthesized by co-precipitation is a promising electrode material for high-performance and sustainable supercapacitor applications.

Keywords: supercapacitor ; spinel; CoFe2O4 ; coprecipitation.

Theoretical Prediction of Elastic and Thermodynamic Properties of SnZrO3 and SnHfO3 Spinel

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Abstract: We performed a first-principles density functional theory (DFT) study to investigate the structural, elastic, and thermodynamic properties of SnZrO3 and SnHfO3 in the cubic normal spinel structure. The equilibrium structural parameters, including the lattice constant and the internal structural parameter, were determined. The obtained results are consistent with previously reported theoretical data. The single-crystal elastic constants at zero pressure were calculated, and the corresponding polycrystalline elastic moduli and related mechanical properties were derived. The calculated elastic constants are in good agreement with earlier theoretical studies on SnZrO3 and SnHfO3. In addition, the pressure dependence of the elastic constants Cij was analyzed, showing an approximately linear behavior in the pressure range of 0–30 GPa. Furthermore, the effects of temperature and pressure on several macroscopic thermodynamic properties of SnZrO3 and SnHfO3 were predicted using the quasi-harmonic Debye model, which accounts for lattice vibrational contributions.

Keywords: Intermetallic compounds, Ab initio calculations, spinel structure, thermoelectric

Efficient FPGA Implementation of an MPPT Controller Using P&O and FIR Digital Filtering

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Abstract: Maximum Power Point Tracking (MPPT) is a key technique for maximizing the energy harvested from photovoltaic (PV) systems under varying environmental conditions. This paper presents an efficient and low-complexity FPGA-based implementation of an MPPT controller using the classical Perturb and Observe (P&O) algorithm combined with a Finite Impulse Response (FIR) digital filter. The proposed approach aims to enhance tracking performance while ensuring real-time operation and efficient hardware resource utilization. The MPPT algorithm is described in VHDL and implemented on an FPGA platform, taking advantage of hardware parallelism and high processing speed. MATLAB/Simulink and Xilinx tools are employed for system modeling, simulation, and hardware validation. The obtained results demonstrate that the proposed MPPT controller accurately tracks the maximum power point and can be efficiently implemented in real time on FPGA devices. Furthermore, the integration of the FIR filter improves signal quality and contributes to the overall robustness of the control system. These results confirm the suitability of FPGA technology for high-performance and real-time photovoltaic energy conversion applications.

Keywords: MPPT; Photovoltaic Systems; Perturb and Observe (P&O); FPGA; FIR Digital Filter

Efficient FPGA Implementation of an LMS Adaptive Filter for Acoustic Echo Cancellation

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Abstract: This paper presents the design and FPGA implementation of a Least-Mean-Squares (LMS) adaptive filter for acoustic echo cancellation (AEC). The objective is to achieve real-time echo suppression with minimal hardware resources while maintaining high numerical precision. A fixed-point architecture with pipelined multiply–accumulate (MAC) units and an optimized coefficient-update scheme is proposed to satisfy strict timing and area constraints. The system is implemented on a Xilinx Artix-7 FPGA and evaluated with real speech signals in a simulated hands-free telephony environment.
Experimental results show rapid convergence and a mean square error (MSE) performance nearly identical to a double-precision software reference, confirming the efficiency of the proposed design for real-time AEC applications.

Keywords: Implementation; FPGA; LMS; Xilinx; Acoustic Echo Cancellation.

Modeling and Simulation Study of a Cascaded Doubly-Fed Induction Machine (CDFIM) for Wind Energy Conversion Applications

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Abstract: Wind energy is a sustainable, low-impact renewable source. The Doubly-Fed Induction Generator (DFIG) offers variable-speed operation with high efficiency and low cost. Nevertheless, the presence of brushes and slip rings reduces the lifetime of the machine and increases the maintenance costs. An alternative solution for conventional DFIM replacement is the Cascaded Doubly-Fed Induction Machine (CDFIM), it consists to couple two DFIMs via their rotors to obtain a cascade of DFIM. Contrary to the DFIG, which is controlled by the rotor and which delivers power from the stator, in the CDFIG, one of the two DFIM plays the role of control machine and the other plays that of the power machine. To examine the performance of this configuration under various variable-speed conditions, this study proposes the modeling and simulation of the CDFIM for wind energy systems. We started the study by developing a mathematical model of this machine in the (a,b,c) reference frame; then, using the Park transformation, we performed the modeling in the (d,q) reference frame to facilitate the analysis of the machine's behavior. Subsequently, this model was implemented in MATLAB/Simulink to develop a simulation program. The simulation results indicate that the CDFIM is highly suitable for variable-speed systems. Its performance remains reliable across different operating conditions, effectively adapting to speed changes. The machine's behavior, characterized by its operating modes (sub-synchronous, synchronous, and super-synchronous), highlighting the effectiveness of the developed model for wind energy conversion applications.

Keywords: Modeling; Simulation; Cascaded Doubly-Fed Induction Machine (CDFIM); Wind energy.

Theoretical Prediction of the Electronic Properties of Binary CoP3 and Ternary FeCoP3 Skutterudites Materials

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Abstract: Over the last few years, much attention has been devoted to finding green and sustainable ways to deal with the environmental problems, as a solution, the researchers were working to develop renewable energy materials that will contribute positively on reducing the negative environmental consequences. The Materials with skutterudite structure have received particular attention these last years due to their interest as engineering materials in the field of renewable energy and due to their remarkable transport properties, including a high degree of carrier's mobility. The unusual transport properties of the skutterudites have become an extremely important subject of the several experimental and theoretical investigations. According to the band structure calculations, the skutterudite family has a narrower bandgap which make them promising candidates for thermoelectric energy conversion and a perfect material to manufacture thermoelectric devices operating above room temperature. Some skutterudites exhibit superconductivity and long-range magnetic order as well as rather exotic electronic-state features. In the present work, we are interested in the unfilled skutterudite CoP3 and filled skutterudite FeCoP3.

Keywords: Keywords: Theoretical; skutterudites materials; renewable energy; Electronic

Biogas Generation from Lignocellulosic Biomass under Mesophilic Conditions

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Abstract: Biomass refers to organic matter derived from various sources such as agricultural and forestry residues, animal manure, and microbial biomass, which are renewable in nature. Biomass plays multiple roles, serving as a source of food, animal feed, fiber, fuel, bedding, and construction material, while also contributing to the enrichment of soil organic matter. Organic wastes, particularly animal manure and crop residues that are widely available, represent valuable feedstocks for biogas production. The anaerobic digestion of biomass is a biochemical conversion process that transforms organic matter into energy. The main product of this process is biogas, a gaseous fuel composed mainly of methane (55–65%) and carbon dioxide (25–45%), along with trace amounts of other gases such as hydrogen and hydrogen sulfide.

This study presents an experimental investigation of the anaerobic digestion of lignocellulosic biomass under mesophilic conditions (35 ± 3 °C). To enhance biomethane production, the substrate was subjected to a 5% (w/w) dilution pre-treatment. During the laboratory experiments, several parameters, including pH and biogas production, were monitored to assess the performance and stability of the digester. The results revealed a progressive acidification of the medium due to the degradation of the plant material, accompanied by biogas production.

Keywords: Keywords: biogas, anaerobic digester, lignocellulosic biomass, methanization process

Battery–Supercapacitor Hybrid Energy Storage for Photovoltaic Microgrids

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Abstract: Photovoltaic (PV) energy is one of the most promising Renewable Energy Sources (RESs) for sustainable power generation. However, its intermittent nature, mainly caused by solar irradiance variations, requires the integration of suitable Energy Storage Systems (ESSs) to ensure reliable operation. In PV Microgrids (MGs), using only batteries can provide energy support, but it may expose the battery to rapid current variations during transient power changes, which can accelerate degradation and reduce its lifetime. To overcome this limitation, this work studies a battery–supercapacitor Hybrid Energy Storage System (HESS) for PV MGs. The battery is used as the main energy storage device due to its high energy density, while the Supercapacitor (SC) is added to respond rapidly to fast power variations thanks to its high power density. The objective is to analyze the behavior of the HESS by observing the voltage, current, and State of Charge (SoC) responses of the battery and SC under variable irradiance and variable load conditions. The obtained results show that the battery provides smooth energy support, while the SC absorbs or delivers fast transient power. This complementary behavior reduces the dynamic stress on the battery and confirms the interest of battery–SC HESS for renewable energy storage in PV MGs.

Keywords: Microgrid; Photovoltaic; Renewable energy storage; Battery; Supercapacitor.

Control Strategy of a Photovoltaic-Powered Electrolyzer for Green Hydrogen Production

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Abstract: Green hydrogen production using photovoltaic energy is a promising pathway for decarbonizing remote and stand-alone energy applications. However, the intermittent nature of solar irradiance introduces operating-point variations that directly affect the voltage, current, hydrogen production rate, and efficiency of the electrolyzer. This work presents the modeling and simulation of a photovoltaic-powered electrolyzer system for green hydrogen production. The proposed system consists of a photovoltaic array, a DC/DC converter operated with maximum power point tracking, and an electrolyzer connected through a controlled DC interface. Existing Simulink/Simscape blocks are used to represent the photovoltaic panels, the DC/DC converter, the MPPT-based power interface, and the electrolyzer, while the control algorithm is implemented in a MATLAB Function block. The control objective is to extract the maximum available PV power and ensure a suitable operating current for the electrolyzer under variable irradiance and temperature conditions. The simulation evaluates PV output power, converter duty cycle, electrolyzer voltage and current, hydrogen production rate, and overall solar-to-hydrogen performance. The expected results demonstrate that the controlled PV-electrolyzer configuration can maintain stable hydrogen production during solar variations and provides a flexible simulation platform for future studies on energy management, storage integration, and techno-economic optimization of green hydrogen systems.

Keywords: Green hydrogen, photovoltaic system, electrolyzer, DC/DC converter, MPPT, MATLAB/Simulink, renewable energy

Improving Heat Extraction Efficiency in Geothermal Wellbore Systems Using Rectangular Protrusion Elements in Retrofitted Abandoned Oil Wells

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Abstract: The growing demand for clean and reliable energy has renewed interest in geothermal systems, particularly those that repurpose existing abandoned oil wells to reduce infrastructure costs. This study presents a numerical investigation into the thermal performance enhancement of closedloop coaxial wellbore heat exchangers (WHE) through the strategic integration of rectangular protrusion elements at the lower section of the well. A two-dimensional axisymmetric computational fluid dynamics (CFD) model was developed using Fluent-Gambit, incorporating the standard k-ε turbulence model and a user-defined temperature gradient function to simulate realistic subsurface conditions at depths up to 3,500 meters. Water was used as the working fluid with injection temperatures of 293 K and mass flow rates ranging from 2.5 to 5.5 kg/s. Two protrusion placement depths 1,700 m and 2,500 m from the well inlet were examined and compared against a baseline smooth wellbore configuration. Results demonstrated that the protrusions enhanced convective heat transfer by inducing flow turbulence and increasing the effective heat exchange surface area. The maximum outlet fluid temperature reached 320.93 K at 2,500 m placement versus 315.79 K in the unmodified case. The heat transfer rate improved by up to 23% at the 2,500 m configuration, compared to approximately 15% at 1,700 m, both recorded at the lowest flow rate. The coefficient of performance (COP) improved by 10% and 6% at the respective depths, though its benefit diminished at higher flow rates. A moderate pressure drop penalty of approximately 11% was observed at 2,500 m placement.

These findings confirm that protrusion geometry and positioning are critical design parameters in optimizing geothermal wellbore heat exchangers. The proposed approach offers a cost-effective strategy for maximizing thermal recovery from repurposed oil wells, with implications for sustainable energy development in regions with abundant abandoned well infrastructure.

Keywords: Geothermal Energy; Wellbore Heat Exchanger; Rectangular Protrusion; CFD Simulation, Abandoned Oil Wells; Coefficient of Performance.

Photovoltaic-Fed Shunt Active Power Filter Based on ADALINE Harmonic Detection and DSVM Control for Power Quality Improvement

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Abstract: This work presents a photovoltaic-fed shunt active power filter for improving power quality in a distribution system supplying nonlinear loads. The system is modeled in MATLAB/Simulink and includes a PV array, a DC-DC boost converter, a DC-link capacitor, and a voltage source inverter connected in parallel at the point of common coupling. The boost converter is controlled using the Perturb and Observe algorithm to extract the maximum available power from the PV panels under irradiance variations.

The inverter is controlled by Direct Space Vector Modulation, while the harmonic reference currents are obtained using an ADALINE algorithm. This adaptive approach allows the filter to identify the harmonic components of the load current and generate the required compensation currents in real time. The DC-link voltage is regulated by an anti-windup controller, which limits the effect of saturation and improves the response during transient conditions.

The use of PV panels gives the active filter an additional function compared with a conventional structure based only on a passive DC-link capacitor. Besides harmonic compensation, the system can supply renewable energy to the DC bus, reduce the power drawn from the grid, and improve the overall energy efficiency of the compensation system. Simulation results show that the proposed configuration reduces source-current distortion, improves the power factor, and maintains a nearly sinusoidal supply current under nonlinear load operation.

Keywords: Shunt active power filter; Photovoltaic system; ADALINE algorithm; Direct Space Vector Modulation; P&O MPPT; Power quality.

Augmenting a Solar Water Distiller System by Using Phase Change Materials Doped with Alumina Nanoparticles

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Abstract: Potable water, without any doubt, constitutes one of the most precious resources on our globe. Faced with the water shortage issue; solar distillation emerges as a viable solution that is simultaneously simple and economical. Nevertheless, classic solar distillation suffers from being limited with insolation hours, and hence low daily distillate productivity. To address this constrain, the present effort came in the framework of uplift the distillation unit capability by incorporating phase change materials in order to use latent heat in off-solar radiations. For this task, paraffin wax and lauric acid, were employed for augmenting solar distiller performances. Further, alumina nanoparticles suspending the current PCMs are a vital method allowing an enhancement level of both thermal characteristics PCMs and system operation. Results revealed that: (1) inclusion of the nano- grains led to a prolonged time interval of producing desalinated water; (2) solar device functions without any additives showed only 3.5 l/m2 day and 26.2% of yield and thermal efficiency; (3) paraffin wax and lauric acid increased those parameters by 28 and 22.3% (with respect to yield) and 33.5 and 32% of energy efficiency; (4) by varying the nanoparticles volume fraction (0.1-0.5%), both storage materials demonstrate a high yield and efficiency of 5.2 and 4.95 l/m2 and 38.9 and 37% efficiency, respectively; (6) the present computations deduced that up to 0.5% concentration, thermal parameters (yield and efficiency) obviously record a concrete decrease.

Keywords: Solar energy; Solar distillation; Phase change materials; Nanoparticles.

Natural Polymer-Based (cellulose, Starch, Alginate, Chitin, Etc.) Nano-Catalysts for Sustainable Oxidation: Recent Advances.

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Abstract: The use of polymers as versatile precursors for the development of efficient catalytic systems has attracted growing interest in both academia and industry. Among them, natural polymers, particularly polysaccharides such as cellulose, starch, alginate, gums, pectin, chitin, and chitosan, have gained significant attention due to their unique structural features, abundance, and renewability. Recent studies have focused on the design and synthesis of polysaccharide-based nano-catalysts and their application in various chemical transformations. This contribution highlights recent progress in the use of these natural polymer-based materials as sustainable platforms for catalyst development. Special emphasis is placed on their application in oxidation reactions, where polysaccharide-derived nano-catalysts have shown promising performance as cost-effective, recyclable, and environmentally friendly alternatives. These systems have been successfully applied in the oxidation of alcohols, phenols, and sulfides, demonstrating good activity and selectivity. Finally, key challenges related to stability, reusability, and large-scale application are briefly discussed, providing perspectives for future research in this field.

Keywords: Selective oxidation reactions; Natural polysaccharides; Sustainable; Heterogeneous catalyst.

Deformation and Stresses Investigation of (Al/Sic-Sic-Sic/Al) Symmetric Sandwich Plates

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Abstract: In the present research, the deformation and stresses of (Al/SiC-SiC-SiC/AL) symmetric sandwich plates subjected to mechanical loads are investagaed. In this model, the displacements vary as a higher order function through the thickness of the plate and satisfy stress boundary conditions on the top and the bottom of the plate. The material properties of the plate faces are Aliminium for metal and Silicon Carbide for ceramic and are assumed to be graded in the thickness direction according to a simple power-law distribution in terms of volume fraction of material constituents. The core layer is still homogeneous and made of ceramic. The equalizations of equilibrium for (Al/SiC-SIC-SiC/AL) symmetric sandwich plates can be obtained using the virtual work principle, and the solutions are obtained by using Navier performance. The veracity of the present analysis is confirmable by comparing it with various outcomes accessible in the literature. The impacts of side-to-thickness ratio, aspect ratio, stretching effects and volume fraction distributions are explored.

Keywords: Deformation; Stress; Sandwich; Material Index; Strain.

Enzyme-Enhanced PVA/PSS Nanocomposite Membrane: Fabrication and Physico-Chemical Characterization

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Abstract: Biocatalytic membranes represent an important advancement in membrane technology by integrating biological catalysts within membrane structures to enhance separation processes. Among polymeric materials, polyvinyl alcohol (PVA) has attracted considerable attention due to its excellent film-forming ability, hydrophilicity, biocompatibility, and chemical stability. In this study, biocatalytic thin-film composite membranes based on PVA/PSS were successfully fabricated under identical conditions varying only the mass fraction of the biocatalytic substance, which is extracted from watercress and sesame seeds at different fractions (3–7%). Structural characterization showed that the biocatalytic extract possesses an amorphous structure and was effectively immobilized within the polymer matrix. FTIR and UV–Vis analyses confirmed the presence of characteristic protein functional groups and absorption bands around 280 nm, indicating successful enzyme integration. Membranes containing sesame biocatalysts exhibited stronger interactions with the polymer network than those containing watercress biocatalytic component. Antibacterial tests against Escherichia coli and Staphylococcus aureus demonstrated that the biocatalytic membranes possess inhibitory activity, with the 3% biocatalytic membrane showing the highest effectiveness. These findings demonstrate the potential of PVA/PSS-based biocatalytic membranes for antibacterial and environmental applications.

Keywords: Biocatalysts; Polymer; PVA Biocatalytic Membranes; Immobilization.

From Plastic Waste to High-Performance Materials: Enhancing of the Properties of Blends (PET/HDPE) Basis Recycled Materials via Chain Extension and Compatibilization

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Abstract: A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions, and should not exceed 300 words. Recycling plastic waste has become both an ecological necessity and a major economic challenge. The use of plastic packaging has increased significantly in recent years, as it is inexpensive, durable and easy to use. Due to their good mechanical and barrier properties, poly (ethylene terephtalate) (PET) and high density polyethylene (HDPE) are widely used in packaging materials. These types of articles are routinely used which inevitably creates serious resource waste and pollution. So, face to the increased awareness of the environmental protection, post-consumed plastics recycling is actually the most adapted solution to recover material, conserve energy and reduce wastes and pollution. Triphenylphosphite (TPP) has been used as a chain extender to regenerate PET and high density polyethylene (HDPE) wastes and to improve the properties of PET/HDPE system based on recycled materials. Also, the blend has been compatibilized using the copolymer styrene/ethylene-butadiene/styrene (SEBS-g-MA). TPP incorporation in PET and HDPE showed a noticeable increase of the torque as a function of the mixing time and proved that degradation reactions rates are considerably decreased. In the case of PET/ HDPE blends, the increase of the torque was strongly dependent on the composition of the homopolymers. Furthermore, TPP and SEBS-g-MA incorporation contributed to significant variations of the rheological, mechanical and thermal properties of the regenerated PET and HDPE and their blends.

Keywords: Waste Valorisation; Recycling; Chain extenders; Triphenylphosphite; compatibilization.

Sustainable Valorization of Coffee Waste in Hdpe-Based Composites for Mechanical and Thermal Applications

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Abstract: The increasing generation of coffee waste represents an important environmental challenge due to its disposal in landfills. In this work, a sustainable approach was developed to valorize spent coffee grounds by incorporating them into high-density polyethylene (HDPE) matrices in different weight ratios to produce eco-friendly composite materials. The main objective of this study is to reduce organic waste while creating value-added polymer composites with potential industrial applications. HDPE/coffee waste composites were prepared using several filler concentrations in order to evaluate the influence of coffee residue content on the material properties. Mechanical tensile tests were carried out to investigate the effect of the natural filler on tensile strength, elongation, and rigidity of the composites. In addition, Differential Scanning Calorimetry (DSC) analysis was performed to study the thermal behavior and crystallization characteristics of the developed materials. The obtained results demonstrated that the incorporation of coffee waste significantly affects both the mechanical and thermal properties of HDPE composites. The presence of coffee particles modified the stiffness and thermal transitions of the polymer matrix, highlighting the potential of agricultural waste as a reinforcing bio-filler. This work contributes to the development of sustainable composite materials and promotes the circular economy through the recovery and valorization of coffee residues instead of their disposal as waste.

Keywords: HDPE Composites; Coffee Waste Valorization; Sustainable Materials; Tensile Properties; DSC Analysis.

Thermal and Mechanical Performance of Flame-Retardant Polypropylene Composites Prepared by Injection Molding

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Abstract: Injection molding is one of the most widely used techniques for processing thermoplastic materials, where polymers are subjected to significant thermomechanical stresses that may influence their final properties. In this work, polypropylene (PP) composites reinforced with magnesium carbonate ($MgCO_3$) were developed and characterized, with MgCO3 serving both as a reinforcing filler and a flame-retardant additive. The composites were prepared by twin-screw extrusion followed by injection molding, using $MgCO_3$ contents of 10 wt% and 20 wt%. Structural, thermal, optical, and mechanical properties were investigated by FTIR-ATR spectroscopy, thermogravimetric analysis (TGA/DTG), colorimetric measurements, and tensile testing. The results showed that the incorporation of $MgCO_3$ improved the stiffness and mechanical strength of the PP matrix. Colorimetric analysis revealed noticeable changes in the appearance of the composites compared with neat PP. In addition, TGA/DTG analyses demonstrated enhanced thermal stability and delayed thermal degradation, highlighting the flame-retardant effect of magnesium carbonate.

Keywords: Polypropylene; Magnesium Carbonate; Composites; Injection Molding.

Effect of Reinforcement Architecture and a Metallic Filler on the Resilience of Polyester/glass Composites

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Abstract: This experimental study aims to improve the impact resistance of glass-fiber-reinforced polyester matrix composites. The influence of the reinforcement architecture (monolayers: mat 100, mat 600, fabric) and a multilayer assembly, as well as the addition of copper powder (0, 5, 10, and 15% by mass), were studied. The results show that the architecture plays a predominant role: the multilayer composite is 53 times more resilient than the resin alone, with a resilience of 9.2 J/cm². Counterintuitively, adding a low loading of 5% copper powder further optimizes this performance, reaching a record resilience of 14.7 J/cm². Beyond this concentration, the impact strength decreases. Analysis by scanning electron microscopy (SEM) allows these exceptional performance metrics to be correlated with energy absorption mechanisms within the material's complex structure.

Keywords: Resilience; Composite; Multilayer; Fracture Morphology.

Microstructural and Mechanical Performance of Sustainable Self-Compacting Concrete with Recycled Concrete and Plastic Waste

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Abstract: The increasing generation of construction and plastic waste poses serious environmental challenges. This work explores a sustainable approach to producing self-compacting concrete (SCC) by combining recycled concrete aggregates (RCA) and waste low-density polyethylene (LDPE) plastics. A novel composite aggregate (CSA) was developed through thermal co-processing of RCA and LDPE particles (3–8 mm), aiming to overcome the poor workability caused by RCA and the reduced mechanical strength associated with plastic incorporation. For comparison, direct replacement of natural aggregates with LDPE was also tested at 10%, 25%, 50%, and 75% by volume. The evaluation included fresh properties (slump flow, passing ability, segregation resistance), mechanical behavior (compressive and flexural strength), thermal conductivity, and microstructural characterization via X-ray diffraction (XRD) and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS). Results revealed that the CSA mixture significantly enhanced fresh properties, with a 6.3% increase in slump flow compared to conventional RCA-LDPE blends, attributed to improved particle morphology and surface texture. Mechanical and thermal performance remained within acceptable ranges relative to standard RCA concrete. Microstructural analysis confirmed the absence of harmful chemical reactions at the polymer-cement interface, indicating excellent chemical compatibility. Therefore, variations in mechanical properties are mainly linked to physical factors such as interfacial transition zone quality and particle distribution. This research demonstrates that pre-co-processing of RCA and plastic waste into a composite aggregate is more effective than direct plastic substitution for producing high-performance, sustainable SCC. This strategy simultaneously addresses the high water absorption of RCA and ensures long-term chemical stability.

Keywords: Self-Compacting Concrete; Recycled Concrete Aggregate; Plastic Waste; Sustainability; Microstructural Analysis.

Sustainable Treatment of Petroleum Wastewater by Adsorption

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Abstract: The petroleum industry is one of the largest consumers of water resources, generating significant volumes of contaminated wastewater that pose serious environmental challenges. In this work, a sustainable approach is proposed for the treatment of petroleum wastewater using a low-cost adsorbent derived from petroleum industry waste. The adsorbent material, based on carbon, was chemically treated and characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The study of chemical oxygen demand (COD) reduction by adsorption showed an elimination efficiency reaching 97.56% under optimal conditions, corresponding to an adsorbent mass of 0.05 g/L, a pH of 6.6, and an initial COD concentration of 50 mg/L. The analysis of adsorption isotherms reveals that the Langmuir model is the best fit ($R^2 = 0.819$), with a maximum adsorption capacity of 70.42 mg/g. These results highlight the potential of this petroleum waste as an alternative, cost-effective, and environmentally friendly adsorbent, contributing to a circular economy and sustainable water management in the petroleum industry.

Keywords: Petroleum Wastewater; Adsorption; COD Removal; Petroleum Waste; Water Management.

Emerging Biofuels Production Technology: Case of Third-Generation Bioethanol

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Abstract: Third-generation ethanol is produced from algae. Algal extracts are fermented into ethanol by converting cellulose and hemicellulose. The conventional process for producing bioethanol from macroalgae includes a pretreatment to detach cellulose and hemicellulose from lignin, a saccharification to hydrolyze complex carbohydrates into monomeric sugars, and then fermentation that convert glucose into ethanol using yeast. This article highlights various technologies applied to the production of third-generation bioethanol, such as alkaline pretreatments to remove lignin, the use of complete acid hydrolysis instead of enzymes, SSF, SHF, and SSCF fermentation, and the use of other fermenting microorganisms capable of fermenting hexoses and pentoses, thus offering different approaches to optimize the production of algal bioethanol and improve the final ethanol yield. This paper shows that the best process to produce bioethanol from macroalgae includes the application of a thermo-acid pretreatment with 1% of H2SO4 98% and enzymatic hydrolysis using a cocktail of cellulases with 15 FPU of Celluclast per gram (1g) of glucose at 48°C. As for fermentation optimal conditions were 30°C and 150 rpm using Saccharomyces cerevisiaein SSF (Simultaneous saccharification and fermentation), these optimal conditions led to close values to the maximum theoretical yield that can be obtained, which is 0.51 g of ethanol/g of glucose.

Keywords: Renewable Energy; Biofuels; Bioethanol; Algae; 3rd Generation.

Thermo-Hydrodynamic Analysis of a Sealed Porous Bearing Considering Surface Roughness

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Abstract: This study presents a numerical thermo-hydrodynamic (THD) analysis of a finite-length porous self-lubricating journal bearing with sealed ends, incorporating the combined effects of surface roughness and porous flow on bearing performance. The lubrication model is based on the generalized Reynolds equation coupled with Darcy's law to account for lubricant exchange between the lubricating film and the porous matrix, while the energy equation is introduced to evaluate the temperature distribution and its influence on lubricant viscosity. Surface roughness is modeled using the stochastic approach of Christensen and Tonder, allowing the investigation of longitudinal, transverse, and isotropic roughness patterns. The governing nonlinear equations are discretized using the finite difference method and solved iteratively under Reynolds boundary conditions together with pressure and velocity continuity at the film–porous interface. The numerical model is first validated against published results available in the literature. The influences of operating and design parameters, including permeability, eccentricity ratio, rotational speed, and surface roughness characteristics, on pressure distribution, temperature field, load-carrying capacity, minimum film thickness, friction coefficient, and attitude angle are systematically analyzed. The results demonstrate that thermal effects and increasing permeability reduce bearing performance because of viscosity degradation and lubricant leakage into the porous matrix. Conversely, suitable surface roughness, particularly transverse roughness, promotes local hydrodynamic pressure generation, partially compensates for the adverse thermal and permeability effects, improves load support, increases the minimum film thickness, and reduces friction under severe operating conditions.

Keywords: Thermo-hydrodynamic lubrication; Porous journal bearing; Surface roughness; Sealed porous bearing; Reynolds–Darcy model; Finite difference method.

Correlating Optical Emission Spectroscopy Diagnostics with SIMTRA Simulations in RF Magnetron Sputtering of Titanium

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Abstract: This study investigates the characteristics of Argon plasma in an RF magnetron sputtering discharge used for the deposition of Titanium and Nickel thin films. Optical Emission Spectroscopy (OES) was employed to diagnose the plasma, specifically analyzing the evolution of emission lines under varying gas pressures. Complementing the experimental approach, the transport of sputtered atoms from the target to the substrate was modeled using the Monte Carlo simulation code, SIMTRA. A strong correlation was established between the spectroscopic measurements and the simulation results. The findings indicate that an increase in working pressure induces a decrease in electron temperature () from approximately 1.9 eV to 1.5 eV, accompanied by a rise in the absolute emission intensity of Titanium species. This behavior is attributed to the thermalization of sputtered atoms and a transition from a ballistic to a diffusive transport regime, as corroborated by the increase in particle accumulation and collision frequency observed in the simulations.

Keywords: Optical emission spectroscopy; Magnetron sputtering; Titanium; SIMTRA

Development and Characterization of an Antibacterial Soap Film Based on Glycerin and Polyvinyl Alcohol (PVA)

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Abstract: This study focuses on the development of an innovative soap film based on glycerin combined with a water-soluble polymer, polyvinyl alcohol (PVA). Several formulations were prepared by varying the PVA content from 1.5 to 3 g (with a 0.5 g increment) for 300 g of glycerin, along with an additional formulation at 5 g to determine the incorporation limit. The obtained films exhibited good transparency, homogeneous texture, and satisfactory flexibility. However, a significant deterioration of properties was observed at 5 g of PVA, leading to the exclusion of this formulation.

From an application perspective, the films dissolve rapidly upon contact with tap water, generating dense and stable foam (≈7 cm height, 6 h stability). Sensory evaluation indicated good skin tolerance, with no dryness or irritation after use. The incorporation of PVA reduced the pH from 9 to 5.76 (NA 367/89 standard), approaching the physiological pH of the skin.

From a physicochemical standpoint, PVA acts as a film-forming agent through hydrogen bonding interactions with glycerin, ensuring cohesion and flexibility of the polymer network. At higher concentrations, excessive structuring reduces molecular mobility, which explains the deterioration of properties.

The optimal formulation (3 g PVA), enriched with eucalyptus essential oil, showed good stability (pH, appearance, and absence of microbial contamination) and complies with current regulations. This soap film therefore represents a promising alternative for hygienic and environmentally friendly applications.

Keywords: Paper soap; Polyvinyl alcohol (PVA); Glycerin; Film-forming materials; Antibacterial activity; Essential oils; Physicochemical properties; Cosmetic formulations.

Development and Characterization of Starch/Poly(lactic acid) Bilayer Bioplastic Films

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Abstract: Biosourced bioplastics can overcome many disadvantages of synthetic plastics of fossil origin and become a real alternative to substitute them and canbe used in various industries such as stationery, food packaging and pharmaceuticals.

As part of our work, we are interested in starch as a biopolymer from which the bioplastic is obtained by plasticization with glycerol and citric acid (CA) as an internal plasticizer. First, thermoplastic starch (TPS) was mixed with poly(lactic acid) (PLA) in different proportions. Tween80 is also added to blend to improve the compatibility between TPS and PLA. Due to the heterogeneity of the mixture (TPS/ PLA), the bilayer method was used.

For the study of the mixture, different characterization techniques were used: infrared spectroscopy (FT-IR), thermic analysis (ATG and DSC), and tensile tests for mechanical characterizations. From the obtained results, it can be found that a low amount of citric acid improves the interfacial interactions between TPS and PLA by esterification. An improvement in thermal and mechanical properties was been observed by blending TPS and PLA and with the use of Tween80 as compatibilizer.

Keywords: Thermoplastic starch, Poly(lactic acid), Citric acid, Films, Tween80, Thermal properties, Mechanical properties.

Experimental Evaluation of aged water-based drilling fluid (Na-Bentonite /eco-local polymer) enhanced with grass powder as an additive

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Abstract: Nowadays, the use of eco-friendly additives in drilling fluids to improve the rheological properties is widespread. This work aims to study the evaluation of rheological properties of drilling fluid suspensions contained Algerian Na-Bentonite and potato starch PS as viscosifier with different concentrations (0.6%, 1.2% and 2%) depending on the aging time. After the trials of aging, the possibility to ameliorate rheological properties of drilling fluid suspensions using an eco-friendly environment additive which is grass powder GP has been studied. The obtained results indicated that the aging tests applied on different drilling fluid suspensions reduce the values of rheological properties and the introduction of GP as additive with different concentrations (3g, 6g,and 9g) in the suspensions proves its effectiveness to enhance the rheological properties.

Keywords: Rheological properties; aging; drilling fluid; potato starch; grass; valorization

Mechanical and Optical Properties of PMMA/ZnO Nanocomposite as a Protective Cover for Photovoltaic Modules

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Abstract: This study investigates the mechanical durability of polymethyl methacrylate (PMMA) as a lightweight alternative to glass for photovoltaic protective covers. PMMA samples were subjected to chemical, thermal, and UV aging and evaluated by three-point bending tests. The reference sample exhibited a flexural stress of 3.96 MPa and an elongation at break of 7.18 mm. Chemical aging reduced the flexural stress to 2.70 MPa, while thermal exposure at 120 °C resulted in 2.74 MPa. At 150 °C, severe degradation caused abrupt fracture, preventing mechanical testing. The most pronounced degradation occurred after 30 h of UV exposure, with flexural stress and elongation at break decreasing to 1.20 MPa and 1.74 mm, corresponding to reductions of approximately 70% and 76%, respectively. Despite this mechanical deterioration, the UV-aged sample maintained optical transmittance comparable to the reference sample, whereas the sample exposed to 150 °C showed a substantial decrease in transmittance to approximately 40%.

Keywords: PMMA, Mechanical Degradation, Three-Point Bending, UV Aging, Photovoltaic Applications.

Evaluation of the Technical Performance and Ecological Impact of a PMMA/Cu_2O Nanocomposite

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Abstract: This study investigates the chemical, thermal, optical, electrical, and photocatalytic properties of PMMA-based nanocomposite films incorporating ZnO and Cu_2O nanoparticles. The nanocomposite films were prepared by the sol-gel method using nanoparticle loadings of 2, 5, and 8 wt.% and systematically characterized by X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), thermogravimetric analysis coupled with differential scanning calorimetry (TGA-DSC), UV–Vis spectroscopy, electrical resistivity measurements, and methylene blue (MB) photocatalytic degradation tests. The results confirm the successful incorporation of the nanoparticles into the PMMA matrix and reveal significant modifications of its physicochemical properties. TGA-DSC analysis indicates enhanced thermal stability following nanoparticle incorporation. The ZnO-containing films maintained relatively high optical transmittance, reaching approximately 80%, whereas Cu_2O incorporation substantially improved the electrical conductivity, resulting in a resistivity reduction of about 75%. Photocatalytic performance was also significantly enhanced, particularly for the film containing 8 wt.% ZnO, for which the C_t/C_0 ratio decreased to approximately 0.35 and the apparent reaction rate constant increased from 0.0012 to 0.0042 min^{-1}. These findings demonstrate that ZnO and Cu_2O nanoparticles effectively tailor the thermal, optical, electrical, and photocatalytic properties of PMMA, supporting their potential for multifunctional environmental and optoelectronic applications.

Keywords: PMMA, metal oxide dopants, transparent electrode, nanoparticles, photocatalysis.

Thermal Performance Evaluation of a Ribbed Solar Air Heater for Drying Applications.

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Abstract: This study investigates the optimization of drying performance for agricultural food products using an indirect-type solar dryer (ITSD). A numerical analysis is conducted to improve heat transfer and fluid-flow characteristics within a rectangular-duct solar air heater (SAH) by introducing artificial roughness on the absorber plate. The proposed roughness consists of perforated rectangular ribs mounted on the underside of the ITSD absorber surface. For a fixed heat flux of 1000 W/m^2, the Reynolds number, rib blockage ratio (BR), and rib pitch-to-height ratio (PR) are selected as key design parameters to evaluate their influence on the Nusselt number (Nu), friction factor (f), Outlet air temperature, and the thermohydraulic performance parameter (THPP). A two-dimensional CFD model is developed in ANSYS Fluent, employing the RNG k-ε turbulence model with enhanced wall treatment, identified as the most suitable approach for this configuration. Simulation results are compared against a smooth-duct reference case. The presence of transverse ribs substantially increases both heat-transfer rates and frictional resistance. The findings show that the average Nusselt number and friction factor increase with higher blockage ratios, whereas both decrease with larger pitch ratios. The configuration featuring rectangular ribs with BR = 0.7 and PR = 3.33 yields the highest THPP, reaching 1.12 and an outlet temperature of 336 K at a Reynolds number of 4000

Keywords: Solar drying, Solar air collector, Artificial roughness, thermo-hydraulic performance parameter, CFD Simulation

Wave Steepness and Breaking in Three-Dimensional Interfacial Short-Crested Waves Under Uniform Current

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Abstract: This review focuses on the fluid dynamics of interfacial short-crested waves propagating under a uniform current. The perturbation expansion approach yields two key pieces of information: the conditions for harmonic resonance and the critical threshold at which wave breaking occurs. Among the many complex and still unresolved aspects of this mechanism are sediment suspension and transport, as well as the assessment of wave impact on both natural and man-made structures. Wave breaking can be interpreted as a manifestation of a singularity arising in the solutions to the interfacial equations of motion. By analyzing these solutions, it becomes possible to extract the information needed to determine the maximum admissible wave steepness. Building on existing work, this study extends the analysis to three-dimensional interfacial waves, with the effect of current explicitly taken into account.

Keywords: three dimensional wave, interface, current, perturbation method, padé approximants, maximum wave steepness

STUDY AND SIMULATION OF FLUID-STRUCTURE INTERACTION

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Abstract: This study titled "Study and Simulation of Fluid-Structure Interaction," explores the dynamic interactions between fluids (liquids and gases) and solid structures, which are essential in fields such as aeronautics and civil engineering. The main objective is to contribute to the understanding and modeling of these interactions using robust theoretical and numerical approaches, validated by practical applications and experimental comparisons. The methodology includes the equations of motion for solids, Hooke's law for elastic materials, fluid-structure coupling methods, and numerical techniques for fluid-structure interaction (FSI) with finite element discretization, all simulated using COMSOL. The results show, through five simulation cases, figures of velocity and pressure, as well as displacement, pressure drop, and drag and lift forces . The discussion of the results reveals significant variations in velocity and pressure, with a comparison of displacement curves identifying the case with the largest displacement and an interpretation of the associated forces. In conclusion, this study provides methodological advances paving the way for more accurate and cost-effective simulations, applicable in various fields. To further this study, it is proposed to integrate sophisticated turbulence models, use supervised machine learning techniques and deep neural networks, and develop stochastic models and Monte Carlo simulation methods for a more precise and robust modeling of FSI.

Keywords: fluid-structure interaction,Comsol,simulations,the finite element technique

Cavitation Phenomenon through a Venturi Using Computational Fluid Dynamics: Effect of the convergent angl

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Abstract: Hydrodynamic cavitation is a phenomenon that causes damage in various industrial applications when the local liquid pressure drops below the vapor pressure. In this study, we aim to investigate the influence of differents convergent angle of the venturi on the characteristics of cavitating flow. Computational Fluid Dynamics (CFD) was employed using a cavitation model, with the mixture model applied for multiphase flow and the k-ω SST turbulence model. The numerical results were compared with previously published experimental and numerical data. The static pressure distribution and fluid velocity were analyzed and discussed. The findings revealed that the convergent angle of the venturi significantly affects the cavitation phenomenon. A decrease in the convergent angle leads to delayed pressure recovery, resulting in an extended vapor distribution in the divergent section of the venturi.

Keywords: Hydrodynamic Cavitation, Venturi, CFD, Vapor.

Dynamics and Coalescence of Liquid Droplets in Water: Experimental and Numerical Approaches

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Abstract: The dynamics and coalescence of liquid droplets in an immiscible medium are of considerable importance in many industrial processes, including liquid‑liquid extraction, separation technologies, and multiphase flow systems. In this work, an experimental and numerical investigation was conducted to study the behavior of different liquid droplets falling in stagnant water.

The experimental study focused on the determination of the instantaneous velocity, terminal velocity, and equivalent diameter of droplets using image processing and video analysis techniques. The results showed that the terminal velocity increases with droplet diameter up to a maximum value corresponding to an optimal droplet size, beyond which it decreases.

A numerical investigation based on the Volume of Fluid (VOF) method within a Computational Fluid Dynamics (CFD) framework was performed to simulate both droplet motion and coalescence phenomena. Good agreement was obtained between numerical predictions and experimental measurements, confirming the reliability of the adopted model.

The coalescence of two identical droplets was analyzed by varying their initial horizontal and vertical separation distances. The results revealed the existence of critical separation distances beyond which coalescence no longer occurs. Moreover, the influence of interfacial tension on the coalescence process was investigated. It was found that a decrease in interfacial tension delays coalescence by reducing the efficiency of liquid film drainage between the droplet interfaces, whereas higher interfacial tension promotes faster coalescence.

The combined experimental and numerical approaches provide valuable insights into droplet dynamics and coalescence mechanisms in liquid‑liquid systems and contribute to the development of predictive tools for multiphase flow applications.

Keywords: Droplet dynamics; coalescence; terminal velocity; equivalent diameter; CFD; two-phase flow.

Design and Numerical Analysis of Various Convergent-Divergent Nozzle Geometries

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Abstract: Supersonic flows occupy a central place in aerodynamics owing to their distinctive physical behavior and wide-ranging practical applications. This study addresses the design and analysis of de Laval-type supersonic nozzles through the Method of Characteristics (MoC) and Computational Fluid Dynamics (CFD) simulations carried out using ANSYS Fluent. Three nozzle geometries are investigated: the conventional conical contour, the more refined bell-shaped profile, and the less conventional open nozzle configuration. The diverging sections of these profiles are mathematically described by a straight line, a second-degree polynomial, and an exponential function, respectively. The converging section, which is identical across all three designs, is responsible solely for accelerating the flow to subsonic conditions at the throat and is generated using the Rao design method. Analysis of the pressure and Mach number contours, along with key performance metrics, reveals that the bell-shaped nozzle consistently outperforms the other two configurations.

Keywords: Supersonic Nozzle Design, Method of Characteristics (MoC), Convergent-Divergent Nozzle, Computational Fluid Dynamics (CFD), ANSYS Fluent Simulation, Nozzle Profile Comparison.

Experimental and Numerical Study of Heat Transfer in a Turbulent Jet Impacting an Obstacle Blown by a Variable-Geometry Diffuser: Application to Food Cooling

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Abstract: Impacting jets are widely used in various industrial applications, including the cooling of electronic components, turbine blades, and food products, due to their ability to generate significant heat transfer. When using impacting jets for food cooling, a thorough understanding of the thermal characteristics is essential. This study is based on an experimental setup developed in our laboratory. Three types of diffusers with variable geometries and three geometric shapes of obstacles, representing food products, will be used to determine the Nusselt number. The second objective of this research is to develop a numerical simulation of the diffusers under study. This simulation will be performed using ANSYS software and the Fluent code, employing the k-ω SST turbulence model. The study will analyze various flow parameters, such as the geometric shape of the diffusers and obstacles. Particular attention will be paid to comparing variations in axial and radial velocities, as well as changes in the Nusselt number, in order to determine the optimal geometric shape of the diffusers.

Keywords: Impinging turbulent jet, CFD, Nusselt Number, Heat transfer, Air diffuser, Thermal and dynamic fields

Combined Mixed Convection And Thermal Radiation Inside A Square Cavity Containing A Thin Fin: Effect Of Fluid Optical Parameters

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Abstract: The study numerically investigates the combined effects of thermal radiation and mixed convection within a ventilated square enclosure containing a thin heated plate. Finite volume method is employed to solve the governing flow equations and discretize the radiative transfer equation (RTE). Distributions of isotherms and streamlines, along with average convective and radiative Nusselt numbers, are obtaind over a wide range of fluid optical parameters and Richardson numbers. results reveal a strong dependence of both the flow structure and heat transfer rates on the fluid's optical properties. Temperature and flow fields are significantly altered by all radiative parameters considered, except for the scattering albedo. Increasing the RC parameter(Radiation-conduction) parameter consistently enhances the radiative transfer rate, while the opposite trend is observed with increasing optical thickness. Furthermore, optical parameters have a greater influence on radiative heat transfer than on convective heat transfer. Optimal thermal performance is achieved at minimum values of optical thickness and scattering albedo combined with a maximum RC value.

Keywords: Heat transfer; Mixed convection; Radiation; Finite volume method; CFD

Numerical Investigation Of LED Thermal Behavior: Effect Of Ambient Temperature On A Novel Chimney-Based Design

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Abstract: Light-emitting diodes (LEDs) are widely adopted for their high energy efficiency, long lifetime, and environmental benefits. However, thermal management remains critical, as elevated junction temperatures significantly degrade luminous efficiency and device reliability. This study develops a three-dimensional computational fluid dynamics (CFD) model to investigate the thermal behavior of high-power LED systems based on the designs reported by Feng et al. (2021). A comprehensive mesh independence study is first conducted on the conventional design (Design 1), and the selected mesh configuration is then applied to the novel chimney-based design (Design 3) with an optimum gas mixture (73% He / 27% Xe) to investigate thermal performance under power inputs from 7 to 8.5W. Simulations are conducted at two ambient temperatures: 300 K (standard reference conditions) and 330 K (representative of harsh hot climatic conditions). At 300 K, the maximum chip temperature ranges from 355.38 K (82.23° C) at 7W to 366.01 K (92.86° C) at 8.5W, with an average thermal resistance of 7.84 K/W, confirming safe operation well below the critical junction limit of 383 K (110° C). At 330 K, temperatures increase by approximately 26 K across all power levels, with the critical junction limit exceeded at 7.5W, confirming that 7W represents the maximum safe operating power under harsh hot climatic conditions. These results demonstrate that Design 3, despite its enhanced cooling architecture, is not suitable for high-temperature ambient conditions, underscoring the necessity of further thermal optimization for LED systems deployed in hot climatic environments.

Keywords: LED Thermal management; Numerical simulation; Junction temperature; Chimney-based design; Ambient temperature effect

Numerical Analysis Of Natural Convection In An Asymmetrically Heated Open Vertical Channel With Different Aspect Ratios

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Abstract: This study aims to investigate both the heat transfer and naturally driven flow behaviour in asymmetrically heated vertical channels. The study has been carried out for laminar airflow at Modifier Rayleigh number 10^5 , Pr =0.71, and two different aspect ratios of 5 and 10. taking into account the inlet and outlet boundary conditions.

The results indicate that the flow accelerates upward near to the heated wall and decelerates near the cold wall. The aspect ratio changes inversely with the reverse flow, While the flow motion by the heated zone remains unaffected.

Keywords: Natural convection; Vertical channel; Numerical study; Aspect ratio

Square and Triangular Tube Geometries on the Energy Performance of a Shell-and-Tube Heat Exchanger: A CFD Study

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Abstract: The optimization of shell-and-tube heat exchangers is essential for improving energy efficiency in industrial systems. This study focuses on the influence of two non-circular tube geometries square and triangular on the thermo-hydraulic performance of a water‑air shell-and-tube heat exchanger.

A three-dimensional numerical investigation based on Computational Fluid Dynamics (CFD) was conducted to analyze heat transfer and fluid flow behavior on both tube and shell sides. The evaluation is based on key performance parameters, including the Nusselt number, overall heat transfer coefficient, and pressure drop over a range of mass flow rates.

The results indicate that tube geometry plays a significant role in determining exchanger performance. The triangular tube configuration enhances turbulence intensity and fluid mixing, leading to higher convective heat transfer. This is reflected by increased flow velocities, reaching up to 0.53 m/s, and superior Nusselt numbers. However, this improvement is accompanied by a substantial increase in pressure drop, reaching approximately 350 Pa at a mass flow rate of 0.95 kg/s, due to strong flow resistance and recirculation zones.

In contrast, the square tube configuration exhibits moderate performance, with velocities around 0.50 m/s and pressure drops of about 260 Pa. The square geometry generates localized turbulence at the corners, resulting in a balanced enhancement of heat transfer with lower hydraulic losses compared to the triangular case.

Despite the improved internal heat transfer, the overall heat transfer coefficient remains relatively low (5‑11 $W/m^2.K$), mainly due to limitations on the shell side.

These findings demonstrate that triangular tubes maximize heat transfer, while square tubes offer a better compromise between thermal performance and energy consumption.

Keywords: Shell-and-tube heat exchanger ; Square tubes ;Triangular tubes ; Thermo-hydraulic performance ; CFD simulation ; Heat transfer enhancement

Numerical simulation of thermal transfer by natural convection in an elliptical annular space containing nanofluid

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Abstract: In this work, heat transfer by natural convection in an elliptical annular space filled with a Cu-water nanofluid is studied numerically. The hot interior and cold exterior elliptical surfaces of the enclosure were kept at constant temperatures Th and Tc, respectively. The stream function vorticity method was used to solve the governing equations (momentum, continuity, and energy). The controlling equations were discretized using the finite-volume method. The nanoparticles volume fraction range and the Rayleigh number were $0<\phi<0.08$ and $1000<Ra<100000$, respectively. The eccentricities for the interior and exterior ellipses are fixed at e2=0.8 and e1=0.6, respectively, and orientation angle at $\alpha=90^{\circ}$, and number of Prandtl for water at Pr=6.2. Results were presented as streamlines, isotherm contours, local and average Nusselt numbers. The impact of Rayleigh number, and nanoparticles volume fraction on the heat transfer rate was examined. The results show that the heat transfer rate rises as the nanoparticle volume fraction and Rayleigh number rise.

Keywords: thermal transfer; Nanofluid; Rayleigh number; elliptic cylinder; natural convection

Impact of dynamic aspect on thermally developing forced convection in fluid-metal foam composite inside elliptic annulus

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Abstract: In this study, a numerical analysis of the forced convection in a horizontal elliptical annulus, composed radially of porous and fluid layers, under variation of Reynolds number has been presented. The forced convection is laminar, stationary and thermally developing. The elliptical radii of the heated inner elliptical cylinder and the adiabatic outer elliptical cylinder of the annulus are ε_i=0.8 and ε_o=1.4, respectively. The first composite configuration C1 corresponds to a porous layer placed radially near the heated wall, between the elliptical radii $\varepsilon = \varepsilon_i$ and ε=1.1. The second composite configuration C2 corresponds to a porous layer placed radially near the adiabatic wall, between the elliptical radii ε=1.1 and ε_o=1.4. The Reynolds number is varied from 200 to 1000 by varying the flow average velocity. For each configuration, the flow field and the thermal field remain almost qualitatively unchanged; however, quantitatively, increasing the Reynolds number increases axial velocity magnitude and reduces temperature level. In addition, it increases the pressure drop and the heat transfer but decreases the performance evaluation criteria. For a fixed Reynolds number, the configuration C2 yields higher velocity, lower temperature, greater heat transfer enhancement, larger pressure drop and lower performance evaluation criteria than configuration C1.

Keywords: Reynolds number; forced convection; thermally developing; fluid/metal foam, elliptic annulus.

Thermal Study Of Unsteady Hydromagnetic Flow Of Biomagnetic Fluid

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Abstract: The two-dimensional unsteady laminar hydromagnetic boundary layer flow and heat transfer of a biomagnetic fluid over a wedge, under the action of transversely magnetic field is studied numerically and analytically. In this study we use the model of micropolar fluid with a convective surface. The most known biomagnetic fluid which presents such properties magnetic is the blood, which has a number of Prandtl=21. By presenting suitable nondimensional variables the problem is described by a system coupled and nonlinear of ordinary equations with its boundary conditions which is solved numerically using the fourth order Runge-Kutta method (RK4) featuring shooting technique and analytically via the Adomian Decomposition Method (ADM).

In this research-work, we have considered the effect of the unsteadiness parameter K, Reynolds number Re, wedge angle parameter β, Magnetic field parameter M and induced magnetic field h on the evolution of dimensionless temperature of the bio-magnetic flow throughout the boundary layer. The results obtained are presented in the shape of graphs of non-dimensional temperature including the thickness of the boundary layer for various values of the parameters entering the problem. From simulations, the main conclusions which we can draw are:

*In the vicinity of the wedge surface, increasing K parameter leads to a decrease in fluid temperature and also makes grow the micro-rotation of the blood cropuscles. However, a reverse behaviour is observed away from the wedge.

*Analytical Adomian decomposition results and those of numerical Runge-Kutta-fehlberg method show an excellent concordance, thus justifying the effectiveness of the adopted ADM method.

Keywords: Keywords: thermal study, biomagnetic fluid, RK4, Adomian Decomposition Method (ADM).

The Temperature Uniformity Of Aluminium Billets Heated DC Magnetic Field

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Abstract: The objective of this paper is to analyse and improve the temperature uniformity of aluminium billets heated by DC induction heaters. To accomplish this, a 3D electromagnetic model coupled with a heat transfer model is developed to calculate the heating process of the billets which are rotated in a uniform transverse DC magnetic field. The simulation results demonstrate that lower rotation speeds consistently yield better temperature uniformity along the radial direction, due to the increase in power penetration. However, the behavior is significantly different for the temperature distribution along the axial direction. When the rotation speed is low, the temperature at the ends is lower than other parts, but this situation reverses as the rotation speeds increase "skin effect. This specific phenomenon is referred to as the "ending effect".

Keywords: DC induction heating; Rotation speed; Aluminum billets; Power penetration; Skin effect; Ending effect

Digital Twin For Hydro Storage Systems: Security Protection, Efficiency And Predictive Maintenance

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Abstract: The hydrogen storage process represents an integral part of the hydrogen energy chain that plays a crucial role in promoting hydrogen energy use at scale. However, hydrogen storage systems pose a series of challenges concerning safety, operational efficiency, and maintenance. Classical monitoring and management practices associated with hydrogen storage tanks are mainly reactive, which poses hazards, inefficiencies, and expensive maintenance procedures. The volatile nature of hydrogen and severe environmental conditions (high pressure and low temperature) make traditional methods incapable of ensuring efficient management. This research intends to showcase the application potential of the DT concept to enhance hydrogen storage processes through proactive safety improvement, energy efficiency optimization, and predictive maintenance.
The methodology of this research suggests using digital twins to transform management procedures associated with hydrogen storage tanks. The DT model should be populated with real-time data provided by Internet-of-Things (IoT) sensors monitoring parameters like pressure, temperature, and flow rate. Machine learning algorithms will be used to examine data provided by the IoT devices and identify abnormalities, forecast future failures, and run simulations. Hydrogen dispersion models will be implemented to evaluate possible leaks and suggest safety measures.

Digital twins have proven beneficial in hydrogen storage systems. First, they enable real-time monitoring and detection of potential leaks using IoT and AI analytics, enhancing system integrity. Second, by optimizing the pressure and vacuum cycle and storage tank heating management, energy efficiency can be improved. Third, digital twins facilitate the assessment of remaining system lifespan, reducing maintenance and operating costs. Finally, simulating various scenarios can contribute to informed decision-making in hydrogen infrastructure.

Keywords: Hydrogen Storage, Digital Twin, IoT Sensors, Predictive Maintenance

Advanced Aspen Plus Simulation And Evaluating Performance Of AWE For Green Hydrogen Production

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Abstract: Alkaline water electrolysis (AWE) is a key technology for green hydrogen production (GHP), thanks to its industrial maturity and efficiency. However, maximizing its dynamic efficiency and specific energy consumption (SPEC) requires a deep understanding of the processes occurring within the AWE. Therefore, the Aspen Plus software was used due to its capabilities and high flexibility. This work presents a 10 kW AWE plant, incorporating components to ensure high-purity GHP: a feed pump, heater, AWE stack, flash separators…etc. The aim is to analyze the performance of the AWE system. Under optimal operating conditions (121 A, 48 cells and electrolyte 30 wt% of KOH, the system demonstrated stability, yielding a GHP rate of 0.21 kg/h at a high purity of 99.94%. The stack achieved Faradaic and voltage efficiency of 99.94% and 86.04% respectively, and a SPEC of 45.52 kWh/kg. Furthermore, the built-in Sensitivity Analysis tools in Aspen Plus were systematically deployed to map non-linear polarization curves. This enabled a parametric study of how temperature, pressure, and membrane thickness affect the performance of the AWE. The results show that higher temperature improves reaction kinetics and electrolyte conductivity, leading to lower cell voltage and energy consumption. Pressure improves mass transfer kinetics, reduces overvoltage and SPEC. In contrast, increasing membrane thickness led to increased ohmic loss and decreased efficiency. This work highlights the strategic value of Aspen Plus as a powerful predictive environment that balances production kinetics with SPEC, offering advantages for the optimization and utilizing of AWE plants.

Keywords: AWE, Hydrogen; Aspen Plus, Temperature, Pression, Membrane.

Hydrogen Production From HDPE Plastic Waste Through Pyrolysis, Partial Oxidation, And Steam Gasification

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Abstract: The valorization of plastic waste represents a promising solution to address both environmental and energy challenges simultaneously. In this study, a hydrogen production process from high-density polyethylene (HDPE) waste was investigated using Aspen Plus simulation. The process consists of a pyrolysis stage followed by partial oxidation, steam gasification, and Water-Gas Shift (WGS) reactors operating at high-temperature shift (HTS) and low-temperature shift (LTS) conditions to enhance hydrogen production.

The results show that pyrolysis mainly generates light hydrocarbons and aromatic compounds, while gasification at 1000 ° C enables their nearly complete conversion into synthesis gas. After the HTS and LTS stages, hydrogen production reaches approximately 470 kg/h for an HDPE feed rate of 1485 kg/h. The corresponding mass yield is around 31%, with a significant conversion of carbon monoxide achieved through the WGS reactions.

The obtained results are consistent with data reported in the literature and demonstrate the potential of thermochemical plastic waste valorization for low-carbon hydrogen production. This study confirms the effectiveness of steam-assisted gasification as a sustainable pathway for the energy recovery and valorization of plastic waste.

Keywords: Hydrogen Production; HDPE Waste Valorization; Pyrolysis; Steam Gasification; Water-Gas Shift Reaction; Aspen Plus Simulation

Effect Of Steam Flow Rate On Hydrogen Production From HDPE Plastic Waste: An Aspen Plus Simulation Study

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Abstract: Hydrogen production from plastic waste represents an attractive solution for both sustainable waste management and clean energy generation. In this study, the effect of steam flow rate on hydrogen production from high-density polyethylene (HDPE) waste was investigated using Aspen Plus simulation. The proposed process includes pyrolysis, partial oxidation, steam gasification, and Water-Gas Shift (HTS and LTS) reactors.
A feed rate of 1485 kg/h of HDPE was considered. The influence of steam flow rate on syngas composition and hydrogen yield was evaluated by comparing two operating conditions. The results showed that increasing the steam flow rate promotes the gasification and Water-Gas Shift reactions, leading to a slight increase in hydrogen production. However, the increase in hydrogen yield remained limited compared to the additional steam required.

The analysis revealed that increasing the steam flow rate from 1200 kg/h to 2000 kg/h resulted in only a marginal improvement in hydrogen production, while significantly increasing steam consumption. Therefore, the lower steam flow rate was identified as the most suitable operating condition from an energy-efficiency perspective.

The obtained results demonstrate the importance of process optimization in thermochemical conversion systems and highlight the role of steam management in improving the overall sustainability of hydrogen production from plastic waste.

Keywords: Hydrogen Production; HDPE Waste; Steam Gasification; Process Optimization; Aspen Plus Simulation; Sustainable Energy

Biohydrogen Purification Using Zeolite Membranes: Effect Of Operating Conditions

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Abstract: Biohydrogen is a promising renewable energy carrier due to its high energy content and environmentally friendly combustion. It can be produced through several biological processes, including dark fermentation, photofermentation, biophotolysis, microbial electrolysis, and the biological water-gas shift reaction (BWGSR). Among these technologies, BWGSR offers an attractive route for converting carbon monoxide-rich gas streams into hydrogen under mild operating conditions. However, the presence of carbon dioxide in the product gas reduces hydrogen purity, making efficient purification essential for practical applications. Membrane-based separation technologies have attracted considerable interest for hydrogen purification because of their low energy requirements and high selectivity. In particular, zeolite membranes provide effective CO_2 removal, thereby enhancing hydrogen enrichment. In this study, a zeolite membrane was integrated with a BWGSR system to investigate the effects of temperature, pressure difference (ΔP), and membrane thickness on hydrogen purification performance. The results show that temperature has a limited influence on hydrogen enrichment within the investigated range, as only minor differences were observed between the studied temperatures. In contrast, increasing ΔP slightly improves hydrogen enrichment by promoting more efficient CO_2 removal from the reaction medium. This enhanced CO_2 extraction shifts the gas-phase equilibrium toward hydrogen accumulation, confirming the effectiveness of membrane coupling in improving BWGSR performance. Furthermore, membrane thickness significantly affects the separation process. An inverse correlation was observed between membrane thickness and hydrogen purification efficiency, indicating that thinner membranes provide superior purification performance.

Keywords: Biohydrogen, BWGSR, Zeolite membrane, Hydrogen purification.

Artificial Intelligence-Based Optimization Of Straw And Polypropylene Fiber-Reinforced Compressed Earth Blocks For Sustainable Construction

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Abstract: Sustainable construction demands innovative materials that combine environmental friendliness with high performance. Compressed earth blocks (CEBs) reinforced with natural and synthetic fibers, such as straw and polypropylene, offer a promising solution due to their local availability, low carbon footprint, and cost-effectiveness. However, optimizing their mechanical and hygric properties—such as compressive strength, water absorption, density, and thermal behavior—requires careful balancing of multiple variables, including fiber type, fiber content, soil composition, moisture level, and curing conditions. Traditional trial-and-error approaches are time-consuming and resource-intensive, limiting the exploration of optimal formulations. This study applies artificial intelligence (AI) techniques, particularly machine learning and artificial neural networks, to model and predict the performance of fiber-reinforced CEBs. Using experimental datasets, AI-driven models identify the most efficient fiber combinations and material formulations, enabling precise optimization of mechanical and hygric properties while minimizing laboratory testing. The results demonstrate that AI not only accelerates the design process but also enhances predictive accuracy, supporting the development of high-performance, sustainable construction materials. The proposed approach provides a practical and scalable framework for designing environmentally friendly CEBs, highlighting the strategic role of AI in modern material engineering and sustainable building practices.

Keywords: Compressed earth blocks; artificial intelligence; straw fibers; polypropylene fibers; formulation optimization; sustainable construction.

Ai-Augmented Multiscale In Silico Design Of Ck1α Inhibitors Via Pharmacophore Modeling, De Novo Hybridization, Molecular Dynamics, And Dft Analysis

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Abstract: Casein kinase-1 alpha (CK1 α) has emerged as a critical target in anticancer drug discovery due to its pivotal role in oncogenic signaling pathways. In this work, we propose an AI-augmented multiscale computational framework for the rational design of novel CK1 α inhibitors, integrating data-driven screening, molecular simulations, and quantum-level analysis. An e-pharmacophore-guided virtual screening of the PubChem database was performed to identify candidate scaffolds, where implicit data-driven prioritization enhanced hit selection. Subsequently, breed-based de novo hybridization was applied to generate optimized compounds, yielding two promising candidates, Breed 1 and Breed 2. At the molecular scale, 300 ns molecular dynamics simulations combined with MM-PBSA free energy calculations revealed that both compounds exhibit improved binding stability and more favorable interaction energetics compared to the reference inhibitor LCI. Free energy landscape analysis further indicated that ligand binding does not significantly perturb the native conformational state of CK1 α, supporting stable and specific interactions. At the electronic scale, density functional theory (DFT) calculations were employed to elucidate reactivity and electronic structure. Analyses of density of states, frontier molecular orbitals, molecular electrostatic potential, and electron localization descriptors provided key insights into the physicochemical determinants of binding and stability. Overall, this AI-informed multiscale strategy bridges data-driven screening, atomistic simulations, and quantum modeling to accelerate inhibitor discovery. The identified compounds represent promising lead candidates and demonstrate the potential of integrating AI with multiscale modeling for next-generation anticancer drug design

Keywords: CK1 α ,de novo hybridization ,e-pharmacophore, MD simulation, MM-PBSA DFT

Physics-Informed Machine Learning for Real-Time Engine Thermal Protection Using Python-Based Predictive Modeling

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Abstract: Excessive thermal stress constitutes a primary failure mechanism in internal combustion engines, leading to piston seizure, cylinder wall degradation, and irreversible structural damage. Conventional thermal management systems rely on reactive control strategies with inherent latency, limiting their effectiveness under transient operating conditions. This study introduces a predictive thermal protection framework capable of forecasting critical component temperatures up to 30 seconds ahead with a prediction accuracy of 94.7%, thereby enabling anticipatory control actions.

The proposed methodology integrates first-principles heat transfer modeling with data-driven techniques, specifically gradient boosting (XGBoost), trained on high-frequency multi-sensor time-series data acquired from 12 instrumented engines under standardized high-load conditions (ISO 1585). Feature engineering incorporates thermodynamic descriptors, including combustion pressure gradients, oil film thickness estimation, and transient heat flux derived from Fourier's law. Temporal dependencies are captured via a lightweight Long Short-Term Memory (LSTM) network, while spatial thermal distributions across 18 critical engine regions are modeled using ensemble regression trees. Experimental validation on over 450 thermal runaway events demonstrates an 89.3% reduction in peak temperature excursions (>220°C) relative to conventional control approaches. Model interpretability is ensured through SHAP-based analysis, identifying key precursors such as rapid exhaust gas temperature rise (>15°C/s) and oil pressure drops (<15 psi), achieving 92.1% specificity up to 22 seconds prior to threshold exceedance. The framework operates in real time (8 ms latency) on embedded hardware (Raspberry Pi 4), bridging the gap between theoretical modeling and deployable engine protection systems. This approach significantly enhances reliability and operational longevity across automotive and industrial applications.

Keywords: Engine thermal management; predictive maintenance; XGBoost; real-time analytics; Python; thermal runaway prevention.

Finite Element Modeling of Printable IWP Lattice Structures for Bone Plates

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Abstract: Fracture healing is largely governed by the stiffness of the bone plate. This study aims to evaluate IWP lattice structures with three volume fractions (70%, 50%, 30%). Finite element analysis was employed to evaluate the stress-strain behavior, stiffness, and deformation characteristics associated with each relative density. Following this, the optimized lattice configurations were integrated as infill structures within bone plate designs to assess their structural performance in a more application-relevant context. Fatigue analysis was subsequently conducted to evaluate the durability of the lattice-reinforced bone plates under cyclic loading conditions representative of physiological activities. The findings revealed that lattice infill significantly influenced fatigue life, with higher volume fractions generally improving resistance due to better stress distribution. However, a balance between mechanical strength and weight reduction was necessary to achieve optimal performance.

Keywords: finite element, metamaterials, biomechanics, stress, bone plate

Comparative TCAD Investigation of Cut-off, Linear, and Saturation Regions in AlGaN/GaN HEMT Drain Current Characteristics

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Abstract: In this work, a comparative study of the cut-off, linear, and saturation regions of the drain current behavior in AlGaN/GaN High Electron Mobility Transistor (HEMT) devices is presented using Silvaco TCAD simulations. The analysis focuses on the variation of drain current with gate and drain voltages in order to highlight the distinct characteristics of each operating region.

The study emphasizes the role of the two-dimensional electron gas (2DEG) at the AlGaN/GaN interface, which governs current transport and device performance. Output characteristics are extracted and analyzed to compare current behavior in the cut-off, linear, and saturation regimes.

The results show clear transitions between the three regions, with negligible current in the cut-off region, a linear dependence in the ohmic region, and current saturation at high drain bias. This comparative analysis provides useful insight into the electrical behavior of HEMT devices under different operating conditions

Keywords: AlGaN/GaN; HEMT; Drain Current; Cut-off Region; TCAD Simulation; 2DEG.

Graph Neural Network-Based Predictive Maintenance for Steam Turbines in Oil & Gas Industry: A Case Study at Sonatrach

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Abstract: Steam turbines are critical assets in oil and gas facilities where unplanned shutdowns cause significant production losses and safety risks. At Sonatrach, traditional threshold-based detection methods identify failures with an average delay of 71 minutes, resulting in six unplanned shutdowns annually and costs exceeding 700,000 euros per year.
This paper presents a Graph Neural Network approach for early fault detection in steam turbines. The turbine is modeled as a graph where each node represents a component including HP, MP, BP, bearings PAL1 and PAL2, and admission valve. Each node is instrumented with temperature, vibration, and Medite sensors measuring metal fatigue. Edges between nodes capture physical correlations such as steam flow and vibration propagation.

The GNN processes both spatial dependencies between components and temporal dynamics from historical data to compute a real-time risk score between 0 and 1. The model also identifies the most degraded component when an alarm is triggered.

Validation on realistic simulated data shows the model achieves 100 percent precision and 97.8 percent recall with zero false alarms. Detection occurs within three minutes of failure onset. The faulty component is correctly identified in all cases with HP being the most critical component responsible for 54 percent of alarms.

Economic evaluation demonstrates a 60 percent reduction in unplanned shutdowns from six to two per year. MTBF improves from 1,460 to 4,380 hours while MTTR decreases from 24 to 12 hours. Annual savings reach 909,000 euros with a return on investment of 606 percent and payback period of two months.

This GNN approach provides a reliable and cost-effective solution for predictive maintenance of steam turbines in the oil and gas industry.

Keywords: Graph Neural Network; Predictive Maintenance; Steam Turbine; Fault Detection; Sonatrach;

First-Principles Modeling of Pressure Effects on the Structural and Elastic Properties of $BeCrRu_2$ for Renewable Energy Applications

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Abstract: In this work, the pressure dependence of the structural and elastic properties of $BeCrRu_2$ was investigated using first-principles calculations based on density functional theory as implemented in the CASTEP code. The GGA-PBEsol exchange‑correlation functional was employed to optimize the lattice parameters and determine the ground-state properties. The calculated elastic constants confirm the mechanical stability of the compound within a pressure range from 0 to 18 GPa. Mechanical behavior analysis reveals a pressure-induced evolution exhibiting both brittle and ductile characteristics. Polycrystalline elastic parameters, including bulk modulus, shear modulus, Young’ s modulus, and Poisson’ s ratio, were evaluated to assess the response of the material under compression. The results indicate enhanced stiffness and mechanical robustness with increasing pressure. These findings highlight the potential of $BeCrRu_2$ as a promising candidate for structural components in renewable energy systems operating under high-pressure and extreme environmental conditions. The present study provides theoretical insight into pressure-driven mechanical performance and contributes to the computational design of advanced materials for sustainable energy applications.

Keywords: Structural parameters; Elastic moduli; Pressure Effects; Renewable energy

Assessment of Deep Learning Approaches for Photovoltaic Thermal Dynamics

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Abstract: In real outdoor environments, Photovoltaic (PV) modules are continuously exposed to varying levels of solar irradiance and ambient temperature fluctuations, which frequently lead to significant increases in cell temperature beyond standard reference conditions. This thermal rise induces degradation in semiconductor properties, resulting in a reduction of open-circuit voltage, and an overall loss in electrical power output. In this study, the focus is placed on the forecasting of PV cell temperature using advanced deep learning techniques. The experimental investigation is conducted using real measurements from a photovoltaic installation in Austria over a 58-day summer period, spanning 11 July to 6 September 2021. The dataset, recorded at 5-minute intervals, is divided into training and testing subsets using an 80/20 split ratio. Two modeling approaches are considered: a conventional Long Short-Term Memory (LSTM) network and a hybrid Variational Mode Decomposition-LSTM (VMD-LSTM) architecture. In the hybrid model, the original temperature signal is decomposed into five intrinsic mode functions prior to learning, enabling improved representation of nonlinear and multiscale dynamics. Both approaches utilize a historical input window of five time steps to capture temporal dependencies. The comparative results demonstrate the superiority of the hybrid framework, where the VMD-LSTM model significantly reduces the Mean Absolute Error from 1.3347° C to 0.4333° C and the Root Mean Squared Error from 2.2629° C to 0.9147° C. In addition, the coefficient of determination increases from 0.9737 to 0.9957, confirming the effectiveness of decomposition-enhanced deep learning for high-fidelity temperature forecasting.

Keywords: Photovoltaic cell temperature; Deep learning; Long Short-Term Memory (LSTM); Variational Mode Decomposition (VMD); Time series forecasting; Thermal performance degradation

Modeling And Analysis Simulation Of AISI 1045 By Using FEA: (Redler) Drive Shaft Status

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Abstract: Mechanical shafts play a crucial role in many industrial applications. The shaft fatigue is one of the most challenges faced by engineers and designers. This effect is due to the various stresses (torsion, bending, combined torsion and bending, etc.). These stresses negatively impact their functional performance. Therefore, determining and verifying the appropriate shaft diameters, is a crucial process in the design phase, either before the manufacturing of devices and mechanisms or after they have been put into service. For this, we must verify the calculations to understand the mechanisms of their failure.

The aim of this work is to determine the factors causing the failure of the "Redler drive shaft" during its operation in the "Redler cement conveyor" device. For this reason, we do a simulation with the Solid Works software. The goal of our simulation is testing the virtual behavior of "Redler drive shaft" before manufacturing. The results show the various critical areas where stress concentration might occur and cause deformation.

The results of the Finite Element Analysis (FEA) simulation showed that the resulting Von Mises stress values enabled us to determine whether the column would undergo deformation that would prevent it from performing its required function. We concluded that the column is capable of withstanding the applied loads and performing its function safely. However, there is a stress concentration region that must be considered during its design to minimize the probability of fatigue and failure.

Keywords: Drive shaft ; failure analysis ; solidworks simulation ; stress ; FEA.

Machine Learning for Specific Surface Area Prediction in Perovskite Materials: A Case Study Analysis

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Abstract: The specific surface area is one of the key properties of perovskite materials, as it significantly influences their functionality in the fields of chemical catalysis, energy storage, and environmental applications. At the same time, the experimental techniques used to determine the specific surface area are characterized by high costs, time-consuming procedures, and significant laboratory requirements. Consequently, there is a need for efficient predictive methods to predict the specific surface area before experimental synthesis and characterization. This presentation provides a case study analysis of machine learning and data mining techniques that employed a dataset of 50 ABO_3-type perovskite materials combined with support vector regression (SVR) to predict the specific surface area values. The study workflow, including the data collection, data preprocessing, feature selection, modeling, and performance evaluation steps is critically examined. The prediction ability of the developed model will also be discussed. Furthermore, the analysis highlights some of the existing problems such as data availability, quality of data, feature relevance, interpretability of models, and need for better accuracy and generalizability of predictions. The above-mentioned problems indicate future trends for Artificial intelligence application in materials science.

Keywords: Perovskite Materials; Specific Surface Area; Artificial Intelligence; Machine Learning; Data Mining; Support Vector Regression.

Elaboration And Physical Characterization Study Of ZnO Nanostructures For Optoelectronic Application

Ammar Derbali, Abdallah Attaf

Abstract: In this study, high quality Zinc oxide (ZnO) thin films, with improved properties, were prepared by a cost-effective ultrasonic spray pyrolysis technique via a careful optimization of the used ultrasonic wave amplitude. We investigated the effect of various ultrasonic wave amplitude on the structural, surface morphology, optical and electrical properties of the obtained thin films by means of XRD, UV‑vis spec-trophotometer, scanning electron microscope, and four-point probe technique. XRD analysis confirmed that obtained ZnO thin films have polycrystalline structure and a wurtzite (hexagonal) phase, with a c-axis preferred orientation (002). The SEM micrographs of the surface morphology show obviously uniform, homogenous and dense films with granular structures. In addition, the optical properties of the deposited thin films reveal that the films are highly transparent in the visible region above 80%, while the value of energy band gap changes from 3.24 to 3.27 eV. The electrical measurement showed an improvement in resistivity and carrier concentration whenever we raises the ultrasonic wave amplitude. High quality ZnO thin films with enhanced properties are in demand and have a large wide of applications in optoelectronics and solar cells.

Keywords: ZnO thin film; Ultrasonic wave amplitude; physical properties; Spray ultrasonic technique

Dual-Control of Optical Nonlinearities in Impurity-Engineered Quantum Ring Nanomaterials under Magnetic Flux

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Abstract: Recent advances in nanomaterials have enabled precise manipulation of electronic and optical properties through quantum confinement and structural engineering. In this work, we present a theoretical investigation of a semiconductor quantum ring nanostructure incorporating a dipolar impurity and subjected to an external magnetic flux. Within the effective-mass approximation, exact analytical solutions for the energy spectrum and wavefunctions are obtained, while the density-matrix formalism is employed to evaluate linear and nonlinear optical responses. The results demonstrate that the system exhibits a unique dual tunability governed by the Aharonov‑Bohm flux and impurity-induced anisotropy. The magnetic flux introduces periodic oscillations in the energy levels, whereas the dipolar impurity breaks rotational symmetry, leading to angular localization of charge carriers and lifting of degeneracies. This interplay significantly alters the optical behavior, including absorption spectra, refractive index modulation, and higher-order nonlinear susceptibilities. In particular, the presence of the dipolar impurity enhances third-order nonlinear optical responses and relaxes conventional selection rules, enabling additional optical transitions. The combined effect of topological phase control and impurity engineering provides a powerful mechanism to tailor light‑matter interaction at the nanoscale. These findings highlight the potential of impurity-engineered quantum ring nanomaterials as versatile platforms for tunable optoelectronic devices, nonlinear photonic components, and frequency conversion applications. The proposed model also offers a foundation for future studies incorporating many-body interactions and experimental realizations in semiconductor nanostructures.

Keywords: Quantum ring nanostructures; Nanomaterials; Dipolar impurity; Aharonov‑Bohm effect; Nonlinear optics

Study Of The Phase Transition And Physical Properties Of The Arsenic-Based Alloy (AlxSc1-xAs) By The FP-LMTO Method

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Abstract: In this present work, we will study the phase transition physical properties of a new semiconductor material. the structural stability and the electronic properties of the ternary alloys (AlxSc1-xAs, $0 \leq x \leq 1$) in both rock salt RS (B1) and zincblende ZB (B3). Calculations on both structures are done the method FP LMTO. In the framework of density functional theory (DFT). The exchange-correlation potential was calculated using both Approximations LDA and GGA. The calculations showed a phase transition from the ZnS phase (B3) to the RS phase (B1) at pressures (7, 10.5, 14.0 and 23.0 Gpa in LDA and (10.0, 12.5, 10.0 and 25.0 GPa) in GGA for x = 0.25, 0.50, 0.75 and 1.00) respectively. The calculated electronic properties showed that in phase B1, there exists an energy band (X-X) with a direct gap at x = 0.00. On the other hand, in phase B3, there are two kinds of energy bands, of direct gap (Γ-Γ) for x = 0.25, 075 and 1.00, the second band is of indirect gap (Γ-X) for x = 0.50, suggesting the possibility to be used in the long wavelength optoelectronic applications. The AlxSc1-xAs alloys were found to be semiconducting at x=0 in the B1 phase and at x=0.25, 0.50, 0.75 and 1 in the B3 phase. Our work can therefore be used as a reference for future research. Our simulation results are in good agreement with those obtained theoretically and experimentally.

Keywords: DFT; FP-LMTO; AlxSc1-xAs alloys; phases transition; electronic properties; optical properties

Combined Impact of Nanoparticle Properties and Base Fluid Selection on Heat Transfer and Stability of Oxide Nanofluids

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Abstract: This study investigates the combined effects of nanoparticle properties and base fluid characteristics on the thermal conductivity and stability of oxide-based nanofluids. Results show that smaller particle sizes and non-spherical morphologies enhance heat transfer by increasing surface area and promoting more efficient phonon transport. Higher nanoparticle concentrations improve conductivity up to a threshold, beyond which aggregation reduces performance. The intrinsic conductivity of the oxide material also significantly contributes to overall enhancement. At the same time, the choice of base fluid governs nanoparticle dispersion, suspension stability, and flow behavior. Fluids with suitable polarity and viscosity, such as water and alcohols, ensure better distribution and reduced sedimentation, whereas poor compatibility accelerates agglomeration. Low-viscosity fluids enhance flowability but compromise stability, while higher viscosities favor stability at the cost of pumping power. The findings highlight that optimized nanofluid performance requires a synergistic balance between nanoparticle design and base fluid selection.

Keywords: Nanofluids; Thermal conductivity; Oxide nanoparticles; Base fluids

Structural, Morphological and Mechanical Properties of Fe-based Powder Mixtures

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Abstract: The synthesis of the FeCoP powder mixtures was done using mechanical milling process from elemental Fe, Co and red P powders. This robust non-equilbrium technique allowed the elaboration of nanocrystalline powders and leads to significant changes in the phase diagram of the system FeCoP. The effect of the mechanical milling time, that ranged from 0 to 3h on the evolution of the structural and mechanical properties. Qualitative and quantitative phase analysis of XRD patterns was studied by the Rietveld method using the MAUD program. The morphological results were obtained by MEB. During the first hour of milling, the ball milled FeCoP powders were subject to heavy plastic deformation accompanied by lattice defects, resulting in an enhancement in the solid state reactions between the diffusion couples (P, Fe) and (Co, Fe) of the reactant materials, leading to the formation of α-Fe(P) solid solution and Co75Fe25 phase with bcc structure and Im-3m space group. The crystallite size and structural microstrain of the α-Fe(P) solid solution and the Co75Fe25 phase in the FeCoP mixtures undergone ball milling for different time periods (0h – 3h), have been investigated in this study. By increasing the milling time, the average crystallite size of the α-Fe(P) solid solution remarkably decreased but was nearly stable for the Co75Fe25 phase, while the structural microstrain increases. The average crystallite size of the solid solution reached a value of 100.3 nm after 3h of milling. Phase changes and the variations in the percentage of phases were also studied. The average particles size reduced with milling time reflecting the effect of the chosen technique of elaboration in different properties of the obtained powder mixtures. In addition, mechanical properties were carried out for better understanding the induced changes in the mechanical parameters of the existing solid solution, the binary phase and the role of milling time. The mechanical results reveal that the value of Young modulus in the FeCoP powder mixture was found smaller than that obtained in binary Fe-Co alloys, reflecting the effect of P addition. Furthermore, the bulk modulus of elasticity for the α-Fe(P) solid solution is less than that of the Co75Fe25 phase. These results reflect the brittle nature of the α-Fe(P) solid solution in comparison with the harder to fracture Co75Fe25 phase.

Keywords: FeCoP powder mixtures; mechanical milling; XRD; MAUD; MEB; mechanical properties

Electronic Structure Of Mn-Doped GeO2 Wide Gap Semiconductor: A Hybrid Density Functional Study

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Abstract: We explore the effects of Mn substitution on GeO2 in its bulk rutile structure, using density functional theory with both generalized gradient approximation and the PBE0r hybrid functional. Our objective is to assess the potential emergence of half-metallic (or semiconducting) ferromagnetism. For pure rutile GeO2 , the experimental wide band gap (4.68 eV) is accurately reproduced by PBE0r using only a small fraction (7%) of the exact exchange. Ordered substitutional bulk alloys :Ge1−x MnxO2 were examined at x = 0.5, 0.25, and 0.17, of Mn concentrations. At x = 0.5, the system is predicted to be a half-metallic ferromagnet with a magnetic moment of 3μB per tetragonal unit cell. At lower Mn concentrations
(x = 0.25 and 0.17) the alloys remain semiconducting, with Mn ions in a high-spin configuration. These findings highlight the reliability and efficiency of the PBE0r functional in describing ultra-wide-gap oxides and indicate that Mn-doped GeO2 bulk systems deserve further theoretical and experimental attention.

Keywords: ultra-wide-gap ,PBE0r,ferromagnetism,half-metallic

Performance of Nanoparticle Fe_2O_3/TiO_2 Modified Carbon Paste Electrode Biosensors: Selectivity for Paracetamol and Dopamine

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Abstract: We have prepared electrochemical sensors based on composite carbon paste electrodes (CPEs) modified with metal oxide nanoparticles (Fe_2O_3, TiO_2, and their binary combination) for the sensitive detection of paracetamol and dopamine. These molecules are of major interest in pharmaceutical and clinical analysis: paracetamol as a monitored analgesic and dopamine as a neurodegenerative biomarker.

The preparation method, based on a simple and rapid mixing-molding process, ensures reproducibility and formulation flexibility. Characterization by cyclic voltammetry and impedance spectroscopy demonstrates a clear improvement in electrochemical properties, reflected in an increase in Faradaic peak intensities and a significant decrease in charge transfer resistance. Systematic optimization of the experimental parameters reveals marked selectivity depending on the composition of the electrode. Thus, the EPC/Fe_2O_3-TiO_2 electrode exhibits the best performance for paracetamol, while the EPC/Fe_2O_3 electrode stands out for dopamine. The establishment of a linear relationship between oxidation current and concentration validates the analytical efficiency of these sensors, opening up promising prospects for biomedical diagnostic and pharmaceutical quality control applications.

Keywords: electrochemical; nanoparticles; sensors; paracetamol and dopamine

Catalytics Properties of Nanometer Thin Films of CuO

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Abstract: Nanoscale films of pure and iron-doped copper oxide (CuO) were chemically synthesized. We prepared concentrated solutions of 0.05 mol/L, 0.1 mol/L, 0.2 mol/L, and 0.3 mol/L by dissolving hydrated copper chloride ($CuCl_2 \cdot 2H_2O$) in distilled water. Iron doping was achieved by dissolving varying amounts of iron nitrate nonahydrate ($Fe(NO_3)_3 \cdot 9H_2O$). The iron doping levels were 2%, 4%, 6%, and 8%. The solutions were spray-deposited onto glass substrates heated to temperatures of 4000–4500°C. Optical measurements obtained from transmittance spectra showed that the CuO films were transparent, with a transparency of 68% for all samples in the visible region (200-800 nm). The optical band gap was approximately 3.89 eV, corresponding to CuO. The effects of CuO nanoparticles and UV irradiation on the catalytic properties of methylene blue were monitored by measuring the absorption of the solution. It was observed that the photocatalytic properties of the iron-doped CuO, which exhibited degradation of over 75% in an aqueous solution of methylene blue under ultraviolet irradiation, were affected.

Keywords: Nanoscale films, pyrolysis spray, CuO, UV-Visible.

Plant-Mediated Synthesis of CuO Nanoparticles: A Sustainable Nanomaterial for Efficient Catalysis

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Abstract: The design of sustainable nanomaterials through green and low-impact routes is a central challenge in modern nanotechnology. In this work, we present an eco-inspired strategy for the synthesis of copper oxide (CuO) nanoparticles using clove (Syzygium aromaticum) extract as a dual-function bioresource acting both as a reducing and stabilizing agent. This plant-mediated approach enables nanoparticle formation under mild aqueous conditions, followed by thermal treatment to obtain highly crystalline CuO nanostructures. The synthesized nanomaterial was thoroughly characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDX). The results confirm the formation of pure monoclinic CuO nanoparticles with a nanoscale crystallite size of approximately 15 nm and well-defined morphological features. Beyond synthesis, the functional performance of these nanostructures was explored in the copper-catalyzed azide–alkyne cycloaddition (CuAAC), a benchmark reaction in click chemistry. Remarkably, the CuO nanoparticles exhibited outstanding catalytic efficiency, delivering high yields of eugenol-derived 1,2,3-triazoles under mild and environmentally friendly conditions. The catalyst also demonstrated good recyclability over multiple cycles, confirming its structural robustness and practical applicability. This study highlights a dual valorization concept: the transformation of a natural plant resource into functional nanomaterials and their direct application in sustainable catalysis. The approach bridges green chemistry and nanotechnology, offering a scalable pathway toward environmentally responsible catalytic systems with high efficiency and reusability.

Keywords: Green nanotechnology; CuO nanoparticles; clove extract; sustainable catalysis; CuAAC; nanomaterials.

Influence Of Sulfur Incorporation In ZnO Thin Films On Structural, Morphological, And Optical Characteristics For Environmental Applications

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Abstract: This work examines the effects of adding sulfur on the structural, morphological, and optical characteristics of zinc oxide thin films produced with dip coating, as well as their applications in photocatalysis. X-ray diffraction analysis confirmed that the films exhibited a hexagonal structure, free from contaminants or additional phases. The incorporation of 2 wt% sulfur into ZnO resulted in a decrease in crystallite size from 26.71 nm to 24.59 nm. Scanning electron microscopy images revealed changes in surface morphology due to the doping process. Energy-dispersive X-ray spectroscopy confirmed the presence of sulfur in the films. Atomic force microscopy analysis showed an increase in root mean square (RMS) roughness, rising from 3.321 nm to 3.879 nm following doping. Ultraviolet-visible (UV-VIS) spectroscopy measurements indicated a reduction in the band gap of the 2% S-doped ZnO sample from 3.26 eV for pure ZnO to 3.23 eV. The 2% S-doped ZnO improved effectiveness in degrading methylene blue dye under UV irradiation. The trapping test identified h^+ and •OH as the primary active species in photocatalytic activity. Moreover, the thin film exhibited improved stability and reusability following six recycling cycles, indicating its applicability in wastewater treatment. Consequently, S-doped ZnO presents itself as a viable material for environmental applications.

Keywords: S-doped ZnO, photocatalysis, UV irradiation, wastewater treatment, stability and reusability

Core-Shell Plasmonic Nanoparticles for Cancer Detection and Treatment

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Abstract: Plasmonic noble metal nanoparticles (PNMNPs), such as gold and silver, have garnered significant interest recently in biosensing and disease diagnosis because of their distinctive optical characteristics. A particularly intriguing property is termed localized surface plasmon resonance (LSPR), resulting from the collective vibration of free electrons stimulated by an incoming electromagnetic wave. The characteristics of NPs are widely recognized to be significantly influenced by their shapes, sizes, and compositions. PNMNPs have been extensively applied in cancer detection and therapy like photothermal treatment, due to their capacity to transform light into heat. Moreover, they hold significant value for imaging techniques since they can alter the surrounding electromagnetic field. While this kind of nanoparticles is frequently utilized, core-shell nanoparticles have recently become notably popular owing to their optical properties derived from cores and shells. Core-shell nanoparticles serve as a versatile platform for cancer therapy and diagnosis, functioning as imaging contrast agents, drug carriers, or facilitating cell ablation through photothermal energy conversion. This study emphasizes the distinct characteristics of core-shell nanoparticles and explores several synthesis methods. The sensing uses of these nanoparticles, particularly cancer diagnosis and treatment, also pique our curiosity. Finally, we address the existing challenges in clinical applications and future prospects for utilizing core-shell nanoparticles in cancer diagnosis and therapy.

Keywords: Plasmonic nanoparticles; Core-shell; Optical characteristics; Cancer therapy; Diagnosis

Experimental And Ab Initio Study To Prove The Exhibit Of The ZnAl2O4 Spinel Phase

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Abstract: We have prepared the Nano powder and thin films of ZnO pure and doped Al with (5%,7%) by sol-gel technique and have annealed at 750°CThe structural characteristics of the specimens analyzed by X rays diffraction that confirm the formation of hexagonal structure of ZnO of the type (wûrtzite) with preferential direction for (101). The optics characteristics of the specimens have analyzed by the UV-visible that have helped on calculation of gap energy by using Tauc method .the optics characteristics of the specimens have analyzed by the (FTIR)that there appearance for absorption peaks that have attributed for existence to the new phase that can not be observed through the X rays who be phase spinel ZnAl2O4. We investigated by GGA method to prove that zinc oxide doped with aluminum produces a ZnAl2O4 spinel phase. The abinitio study showed that the energy gap of the doped zinc oxide is almost the same as the energy gap of the ZnAl2O4 , which is approximately 4.16eV Also, the refractive index of the doped zinc oxide is almost the same as the refractive index of the ZnAl2O4 which is approximately 2,14.

Keywords: ZnO, GGA, DFT, phase spinel,ZnAl2O4.

Hydrothermal synthesis and functional optimization of $CaTiO_3$ nanomaterials via dual doping

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Abstract: This study focused on the synthesis and characterization of $CaTiO_3$ nanomaterials doped with Mg^{2+} and co-doped with Mn^{2+}, prepared via a hydrothermal method. The aim was to investigate the influence of dual doping on the structural, optical, and photocatalytic properties of $CaTiO_3$ perovskite nanomaterials. The samples were analyzed using X-ray diffraction (XRD), FTIR, Raman spectroscopy, XPS, and UV–Visible spectroscopy. XRD confirmed a single-phase orthorhombic perovskite structure without impurity phases. Small peak shifts indicated successful incorporation of Mg^{2+} and Mn^{2+} into the $CaTiO_3$ lattice. FTIR and Raman results confirmed metal–oxygen bonding, while XPS verified the chemical states and presence of dopants. The crystallite size was in the nanometric range, showing slight variation with doping content. UV–Visible spectroscopy revealed a shift in the absorption edge and a decrease in band gap energy, indicating improved optical properties and modified electronic structure. The photocatalytic performance was evaluated through the degradation of Crystal Violet dye under UV irradiation. The doped samples exhibited enhanced degradation efficiency compared to undoped $CaTiO_3$. This improvement is attributed to better charge carrier separation and reduced recombination of electron–hole pairs induced by Mg^{2+} and Mn^{2+} incorporation. Overall, the hydrothermal method combined with dual doping is an effective approach to improve the structural, optical, and photocatalytic properties of $CaTiO_3$ nanomaterials for environmental applications.

Keywords: $CaTiO_3$, nanomaterials, hydrothermal synthesis, doping

Formation Mechanisms and Redox Impurity Effects in Metallic Nanoparticles Embedded in Glass Matrix

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Abstract: This study examines the nucleation and growth mechanisms of silver nanoparticles formed via ion exchange and thermal activation within a glass matrix. We specifically analyze the impact of redox-active impurities on the efficiency of metallic aggregation and the resulting optical properties. The results show that nanoparticle formation is initiated when the temperature exceeds a critical threshold of approximately 410 °C, leading to the rupture of Ag–O bonds and subsequent structural reorganization of the glass network. This process involves the replacement of Ag–O linkages by Si–O–Si bonds, reinforcing the glass structure, alongside the formation of Ag–Ag bonds. The reduction of Ag^{+} ions into Ag^{0} atoms follows a polymerization-like mechanism, including nucleation and growth stages that ultimately yield metallic nanoparticles. In addition to thermal effects, the presence of iron oxide impurities plays a crucial catalytic role. Specifically, Fe^{2+} ions act as reducing agents by donating electrons and transforming into Fe^{3+} ions, thereby facilitating the reduction of Ag^{+} to Ag^{0}. This redox mechanism operates in parallel with thermal reduction, significantly accelerating the precipitation kinetics of metallic species within the matrix. These structural transformations strongly influence the optical properties of the material. The formation of nanoparticles is evidenced by a surface plasmon resonance absorption peak in the UV–visible spectrum, characteristic of metallic nanostructures. Furthermore, modifications in the glass network and the presence of Ag^{0} species lead to notable changes in photoluminescence behavior. Nanoparticles in glass result from coupled thermal and iron redox effects, leading to improved optical functionality.

Keywords: Nanoparticles, Surface Plasmon Resonance (SPR), Redox processes, Silicate glasses.

Rietveld Analysis Of XRD Data For Microstructural Evolution In $Co_{30}Fe_{30}Ni_{30}Cr_{10}$ Medium-Entropy Alloy

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Abstract: Nanocrystalline Co 30 Fe 30 Ni 30 Cr 10 (wt.%) powders were synthesized by high-energy mechanical alloying for up to 48 h and characterized by X-ray diffraction (XRD) combined with Rietveld refinement. The XRD results revealed the progressive dissolution of the initial elemental phases and the formation of two main substitutional solid solutions: a face-centered cubic fcc-Co(Ni,Fe) phase and a body-centered cubic bcc-Fe(Cr,Ni,Co) phase, together with a minor residual hcp-Co phase. Rietveld refinement provided a quantitative description of the microstructural evolution, showing a significant reduction in crystallite size to the nanometric range (7–18 nm) and an increase in microstrain (0.5–1.2%), indicating strong lattice distortion induced by severe plastic deformation. In addition, milling promoted the accumulation of crystalline defects, particularly dislocations and grain boundaries. The grain-boundary volume fraction (fgb) increased with milling time and exceeded 30% after 48 h, confirming the progressive formation of a nanocrystalline structure. These results demonstrate that mechanical alloying induces both phase transformation and development of a nanocrystalline structure in the Co 30 Fe 30 Ni 30 Cr 10 medium-entropy alloy.

Keywords: $Co_{30}Fe_{30}Ni_{30}Cr_{10}$ medium-entropy alloy; mechanical alloying; Rietveld refinement; X-ray diffraction (XRD); nanocrystalline structure

Structural And Optical Properties of ZnO/TiO_2 Thin Films In Multilayer Architectures

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Abstract: Transparent metal oxide thin films, particularly zinc oxide (ZnO) and titanium dioxide (TiO_2), have gained increasing interest because of their remarkable optical transparency, chemical stability, and wide band gap. Owing to these properties, they are extensively employed in optoelectronic devices, photovoltaic systems, sensors, and photocatalytic applications. In recent years, the combination of ZnO and TiO_2 in multilayer heterostructures has emerged as an effective strategy for tuning their structural and optical characteristics through interface engineering and layer stacking control. The present work focuses on the fabrication of ZnO and TiO_2 thin films and the investigation of the influence of the deposition sequence on the properties of the resulting multilayer structures.

ZnO and TiO_2 single layers, together with ZnO/TiO_2 multilayer thin films, were successfully synthesized using the sol–gel method combined with dip-coating deposition. Structural characterization by X-ray diffraction revealed that ZnO films crystallize in the hexagonal wurtzite phase with a preferential orientation along the (002) direction, whereas TiO_2 layers exhibit lower crystallinity depending on the deposition conditions. Furthermore, the obtained multilayer structures showed that the stacking sequence strongly affects the crystallinity and microstructural evolution of the films. Optical investigations performed by UV–Visible spectroscopy demonstrated high transparency in the visible region. In addition, photoluminescence measurements revealed violet, blue, and green emission bands associated with intrinsic defects and interface-related effects. These findings confirm that the stacking configuration plays a crucial role in determining the structural and optical behavior of ZnO/TiO_2 multilayer thin films for potential optoelectronic applications.

Keywords: ZnO, TiO2, Multilayers, Sol-gel, Physical propreties

Hardness Of Rare-Earth Hexaborides ReB_6 (Re=La, Ce) And Their Alloys La_1-$xCexB_6$ For x = (0.00, 0.25, 0.50, 0.75 and 1.00): First-Principle Study

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Abstract: The search for new hard and extra-hard materials is of great interest for many industrial applications. Therefore, in this study, we aim to investigate the mechanical properties, particularly the hardness, of hexaboride compounds ReB6 (Re = La, Ce) and their solid solutions La1−xCexB6 for x= 0.00, 0.25, 0.50, 0.75, and 1.00. We use the DFT + U + SO method to predict the macro and micro-hardness of these materials through the Vickers macro-hardness model and the Šimůnek micro-hardness model. The calculated hardness values of binary compounds and their alloys indicate that they are both macroscopically and microscopically hard, and can withstand high melting temperatures. The macro-hardness values of the binary compounds LaB6 (25.147 GPa) and CeB6 (25.954 GPa) are comparable to those of semiconductors, silica, and ceramics. On the other hand, the micro-hardness values of Šimůnek LaB6 (7.76 GPa)and CeB6 (9.88 GPa) are lower than their respective Vickers macro-hardness values. The solid solutions with x=0.25 (La0.75Ce0.25B6) are found to be the macroscopically hardest alloys, with a hardness of 26.28 GPa. Conversely, the solid solutions with x=0.75 (La0.25Ce0.75B6) are found to be the microscopically hardest solutions, with a hardness of 9.82 GPa.

Keywords: ReB6 ; Hexaborides ; Šimůnek hardness; Vickers hardness; L/APW+lo

Synthesis And Physicochemical Characterization Of A Sodalite–Biopolymer Nanocomposite

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Abstract: The present work focuses on the synthesis of a nanocomposite combining a sodalite-type clay with a biopolymer. To evaluate the physicochemical properties of the synthesized material and its components, several characterization techniques were employed. Elemental composition was analyzed by X-ray fluorescence, while the crystalline structure was determined using X-ray diffraction. The specific surface area and porosity were measured through BET analysis, thermal stability was investigated by thermogravimetric analysis, and the morphology at the nanometric scale was observed using scanning electron microscopy. The BET results highlighted the porous nature and significant specific surface area of the nanocomposite, indicating its potential for promising adsorption and catalytic applications.

Keywords: Synthesis; nanocomposite; biopolymer; sodalite.

Mint Extract-Mediated Synthesis of Silver Nanoparticles Embedded in Microcrystalline Cellulose for Catalytic Decolorization of Cationic and Anionic Dyes

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Abstract: The elimination of toxic synthetic dyes from wastewater remains challenging due to their remarkable stability and resistance to conventional treatment methods. Catalytic decolorization using sodium borohydride NaBH4 has emerged as a fast and efficient strategy for transforming these persistent dyes into less harmful products, yet the development of green and sustainable catalysts with high activity, long-term stability, and broad applicability toward diverse dye pollutants remains a critical priority. This study reports the use of biogenically synthesized silver nanoparticles anchored on microcrystalline cellulose, via a mint extract-mediated route, as an efficient catalyst forthe decolorization of cationic and anionic dyes. Characterization by XRD, FTIR, XPS, UV–vis DRS, SEM–EDS, and TGA confirmed successful nanoparticle formation, well-distributed morphology, and enhanced thermal stability of the composite compared to pristine MCC, with uniformly dispersed AgNPs of 5–10 nm anchored on the MCC surface. The catalytic performance of MCC@AgNPs was evaluated for the reduction of methylene blue (MB), methyl orange (MO), and allura red (AR), in the presence ofsodium borohydride. Kinetic studiesrevealed the highest apparentrate constant for MB (Kapp =0.0107s^{-1}), achieving 98.77% removal in 330 s, followed by MO (Kapp = 0.00819 s^{-1}, 95.51% removal in 390 s) and AR (Kapp = 0.0066 s^{-1}, 94.40% removal in 480 s). The catalyst exhibited excellent recyclability, retaining over 90% efficiency for MB degradation after six consecutive cycles, demonstrating its potential as a cost-effective, and sustainable material for broad-spectrum dye remediation.

Keywords: biogenic catalyst | catalytic reduction | microcrystalline cellulose | mint extract | silver nanoparticles | toxic dyes

Green Synthesis of Copper Oxide Nanoparticles Utilizing Calligonum comosum L Extract

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Abstract: The growing demand for eco-friendly nanotechnology has prioritized the development of biogenic synthesis methods over traditional chemical routes. In this study, a sustainable approach was employed to synthesize copper oxide nanoparticles (CuO NPs) using the aqueous extract of Calligonum comosum L. The plant's rich phytochemical profile acted effectively as both a reducing and stabilizing agent, ensuring the formation of high-purity nanomaterials. Structural characterization confirmed the successful fabrication of the CuO NPs, revealing a distinct morphological distribution of particles with a tendency toward natural agglomeration. Detailed analysis indicated that the nanoparticles possess a fine crystalline structure, with a calculated average crystallite size of 24.4 nm. This small grain size is significant as it provides a high surface-area-to-volume ratio, which is essential for enhancing the reactivity and functional performance of the particles.

The results demonstrate that Calligonum comosum L. is a potent biological resource for the rapid and scalable production of stable copper oxide nanoparticles. This green synthetic pathway not only eliminates the use of hazardous reagents but also produces biocompatible materials suitable for diverse applications, including antimicrobial agents, environmental remediation, and photocatalysis.

Keywords: Green synthesis ;Copper oxide nanoparticles;Calligonum comosum L;Crystallite size; nanotechnology.

Effect of Nanostructure on the Tribological behavior of Ti80Ni20 Biocomaterial

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Abstract: Mechanically milled Ti80Ni20 powders were compacted and sintered at various tempera-tures after being milled for 9 h in a protective atmosphere. Scanning electron microscopy (SEM) was used to evaluate the morphology of the surfaces. Oscillating friction and wear tests were carried out in ambient air using an oscillating tribotester. As a counter pair, we used a ball of Al2O3 with a diameter of 6 mm under different conditions of normal applied load for the three sintering regimes. SEM characterizations, the micro- and nano-hardness, roughness measurements, and the friction coefficient were used to study the tribological behavior of the samples' surface morphology, as well as the weight loss following testing. According to the findings, the resistance to wear and friction of the biomedical Ti80Ni20 alloy can vary depending on the preparation and treatment methods used. Surface coating is recommended to further improve the tribological behavior of the substrates. The novelty of this study lies in the combined investigation of the micro-structural evolution and tribological behavior, offering a better understanding of the performance of nanostructured titanium–nickel alloys in engineering applications.

Keywords: Ti80Ni20; densification; sintering; tribological study

Interferometric Investigation Of The Effect Of Sintering Temperature On The Optical Transmission Of Transparent Materials

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Abstract: This study investigates the effect of sintering temperature on the optical transmission of transparent ceramics. S25CRX14 pellets were produced by Spark Plasma Sintering (SPS) at 1300 °C, 1350 °C, and 1400 °C. Moiré interferometry was used as a non-contact, non-destructive technique to detect and quantify surface micro-defects, enabling a precise evaluation of optical quality.

The results reveal a strong dependence of optical transmission on sintering temperature. The sample sintered at 1350 °C shows the highest transmission, and a noticeable degradation is observed at 1400 °C. These findings emphasize the need for optimized sintering conditions and confirm the effectiveness of moiré interferometry as a rapid and reliable tool for the characterization of transparent ceramics.

Keywords: Ceramics, Moiré, Sintering Temperature, Optical Transmission,

Numerical Investigation on the Mechanical Behavior and Damage Evolution of Nanoadhesives Reinforced with Carbon Nanotubes

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Abstract: This study investigates the effect of multi-walled carbon nanotube (MWCNT) weight percentages (wt%) on the mechanical performance and failure behavior of a rigid epoxy nanoadhesive. A two-dimensional (2D) finite element model of a Single Lap Joint (SLJ) with an adhesive thickness of 0.2 mm was developed using ABAQUS. Cohesive zone modeling (CZM) with traction-separation laws was implemented to simulate damage initiation and evolution within the adhesive layer. The cohesive properties for different MWCNT concentrations (0.0%, 0.25%, 0.50%, 0.75%, and 1.25% wt%) were analytically predicted using the modified Halpin-Tsai micromechanical model. The numerical results demonstrate that the joint's load-carrying capacity and failure energy are highly dependent on the nanotube content. The optimum mechanical performance was achieved at 0.75 wt%, showing a significant increase in peak load and damage dissipation energy (ALLDMD) due to the nano-bridging effect. Conversely, a further increase to 1.25 wt% led to a severe degradation of the adhesive properties, replicating the physical phenomenon of nanoparticle agglomeration. This predictive simulation highlights the critical role of optimal nano-reinforcement in aerospace and automotive structural bonding applications.

Keywords: Nanoadhesive; Carbon Nanotubes (CNTs); ABAQUS; Cohesive Elements; Single Lap Joint; Critical Weight Percentage.

Morphological development of ($MgO-SiO_2$) thin films under the influence of deposition temperature and parallel and opposing magnetic fields.

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Abstract: Scanning electron microscopy (SEM) was utilized to investigate the morphological properties of $MgO-SiO_2$ thin films deposited on glass substrates via the hydrothermal method, assessing the impact of varying deposition temperatures (150°C, 200°C, and 300°C) under different magnetic field configurations. Under a parallel external magnetic field alignment, the films generally exhibit distinct surface coverage with grains of varying shapes and sizes separated by interstitial spaces. At 150°C, the surface displays a sparse distribution of small granular particles. Raising the temperature to 200°C enhances the material distribution density, resulting in relatively larger granular structures. At 300°C, the film transitions into a highly homogeneous surface characterized by uniformly distributed, small-sized granules. These variations indicate that the surface topography is fundamentally governed by the deposition temperature and the precursor dissolution rate, which dictate both crystal dimensions and geometric configurations. Conversely, applying the external magnetic fields in an anti-parallel configuration significantly enhances morphological homogeneity and densification. At 200°C, this opposite alignment promotes accelerated growth and crystallization, yielding small, highly dense granular particles. Upon increasing the temperature to 300°C, the film surface becomes exceptionally uniform, entirely free of isolated islands or voids due to the progressive coalescence of the grains.

Keywords: MgO-SiO2 thin film; Scanning Electron Microscopy; Surface morphology; Hydrothermal method, External magnetic field.

Enhanced Photocatalytic Activity of Annealed ZnO-ZnS Thin Films Prepared by Spray Pyrolysis

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Abstract: ZnS thin films were synthesized by spray pyrolysis at 350 °C and subsequently annealed under ambient atmosphere. X-ray diffraction analysis revealed a progressive structural transformation with increasing annealing time, characterized by partial substitution of sulfur by oxygen and the formation of ZnS, ZnO, and Zn(S,O) mixed phases. Scanning Electron Microscopy (SEM), Energy-Dispersive X-ray Spectroscopy (EDX), and profilometry showed significant morphological changes after annealing. The films exhibited the growth of well-defined hexagonal ZnO grains with smoother surfaces and an average size of about 600 nm, confirming the structural evolution induced by thermal treatment. Photocatalytic tests performed under sunlight irradiation using methylene blue demonstrated enhanced degradation efficiency for annealed samples. This improvement was attributed to the increased ZnO content and the associated structural and morphological modifications.

Keywords: Spray pyrolysis; ZnS thin films; ZnO formation; annealing; structural evolution; SEM morphology; photocatalysis; methylene blue degradation; mixed oxide–sulfide thin films; Zn(S,O) solid solution.

Structural and optical properties of cuprous oxide powders synthesized via chemical route

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Abstract: Cuprous oxide (Cu2O) powders were synthesized via a co-precipitation route in the presence of various concentrations of polyethylene glycol (PEG). The effect of PEG on the structural and optical properties was investigated using X-ray diffraction (XRD) and UV-Visible spectroscopy. Cu2O is a p-type semiconductor exhibiting a cubic structure with a direct bulk band gap of approximately 2.17 eV. XRD patterns confirmed the formation of the pure Cu2O phase for all samples, which is in good agreement with the literature. The average crystallite size, calculated using the Debye-Scherrer formula, increased from 17.8 nm for the PEG-free sample to 19.4 nm for those prepared with PEG, reflecting an enhanced crystallinity induced by the organic agent. This result is consistent with previous studies demonstrating that PEG can significantly influence crystal growth. UV-Visible spectroscopy measurements revealed a significant variation in the optical band gap as a function of PEG content. The band gap values, determined via the TAUC method, ranged between 1.92 and 2.14 eV. The lowest band gap (1.92 eV) was obtained for the sample synthesized with the highest PEG concentration, as previously reported in the literature. Recent thesis works have likewise demonstrated that structuring agents allow for the fine-tuning of the optical band gap in this class of materials. This gap reduction is attributed to a better crystalline organization promoted by the PEG surfactant. These findings open promising perspectives in photocatalysis and photovoltaics, a field where Cu2O is attracting growing interest as a potential absorber layer for low-cost solar cells.

Keywords: Cu_2O synthesis, PEG, XRD, band gap, crystallinity.

Green Biosynthesis of Silver Nanoparticles from Aromatic Plants: Advanced Physicochemical Characterization and Environmental Applications

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Abstract: In the context of sustainable development and green chemistry, this study proposes an eco-friendly approach for the synthesis of metal nanoparticles from extracts of local aromatic plants rich in bioactive compounds (phenolics, flavonoids, and essential oils). These extracts act simultaneously as reducing agents and stabilizers, thereby eliminating the need for toxic chemical reagents. The biosynthesized nanoparticles were characterized using advanced analytical techniques to evaluate their physicochemical properties. UV–Vis spectroscopy confirmed their formation via surface plasmon resonance (SPR), while FTIR analysis identified the functional groups responsible for their stabilization. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) analyses revealed predominantly quasi-spherical morphologies with a homogeneous size distribution. X-ray diffraction (XRD) confirmed their crystalline nature and high purity. The results show that the resulting nanoparticles possess well-defined structural and functional properties, highlighting their potential for application in environmental and biomedical fields, particularly for water treatment and antimicrobial activities. This study also underscores the importance of multi-technique characterization for establishing structure–property relationships and confirms the synthesis.

Keywords: Ag nanoparticles; Green biosynthesis; Aromatic plants; Physicochemical characterization; Water treatment; Green chemistry

Influence Of Porosity On The Free Vibrational Behavior Of Functional Gradient Nanoplates

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Abstract: This research investigates the impact of material porosity on the free vibration properties of functionally graded nanoplates. The nanoplate is presumed to consist of two constituent materials with qualities that vary continuously throughout their thickness in accordance with a specified gradation law. Porosity flaws, commonly arising during manufacturing processes, are integrated into the material model through various porosity distributions and volume fractions. The four-unknown shear deformation theory, integrated inside Eringen's nonlocal elasticity framework, is used to derive the equations of motion from Hamilton's principle and are resolved using Navier's method. The validity of the current model is evidenced by juxtaposing the numerical results with those documented in the literature.

Keywords: porous nanoplates, free vibration, nonlocal elasticity theory, natural frequencies, nanostructures.

Development Of An Electrodeposited Zn-CeO2-Gr Coating For Marine Corrosion Protection

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Abstract: The simultaneous incorporation of CeO_2 nanoparticles and graphene into a zinc matrix by electrodeposition on S235 steel has been found to be especially beneficial, faced with the inherent limitations of pure zinc in marine environments. Microstructural analysis of the obtained deposits shows a homogeneous distribution of the two enhancers in the matrix leading to a considerable refinement of the crystalline grains. This refinement results in an increase in microhardness and mechanical resilience and a much smoother surface than the unmodified zinc coating. Moreover, electrochemical evaluation showed that the combination of CeO2 and graphene induces a synergistic effect that constrains the interfacial cathodic activity, which is beneficial for the corrosion resistance in chloride media. The obtained results indicate that the Zn-CeO2-Gr ternary coating could be a promising sacrificial solution for the long-term protection of metallic structures in aggressive marine environments.

Keywords: zinc; CeO2 nanoparticles; electrodeposition; microhardness; resilience; graphene

Implementation of a Pyrosol Reactor for Thin-Film Deposition

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Abstract: This work presents the design and experimental implementation of a Pyrosol reactor (Pyrosol reactor) dedicated to the deposition of functional thin films by ultrasonic spray pyrolysis. The study emphasizes the practical development of each subsystem required to obtain a stable, repeatable, and efficient deposition process. An impulse generator delivering 350 ns pulses at 2.9 MHz was constructed to drive the ultrasonic transducer with precise frequency control, enabling optimal aerosol generation. A robust transducer support was engineered to ensure vibration stability and effective coupling with the precursor solution. The ultrasonic spray chamber was designed to provide homogeneous aerosol formation while minimizing droplet coalescence. A controlled heater‑substrate system was developed to maintain uniform temperature distribution during the pyrolysis process, ensuring film adhesion and phase formation. Finally, a dedicated deposition chamber was assembled to regulate precursor flow, exhaust, and thermal environment. The integrated reactor demonstrates reliable performance and provides a versatile platform for the deposition of oxide-based thin films. This implementation highlights practical guidelines for assembling Pyrosol systems and supports further optimization for industrial or research applications.

Keywords: Thin film; pyrosol; generator; transducer; aerosol.

Simulation of light emitting field effect transistor

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Abstract: The evolution of electronic and optoelectronic technologies has given rise to high-performance hybrid devices, including light-emitting transistors (LEFETs), which combine electrical switching and light emission functions. This work is part of this dynamic by studying, through numerical simulation, the behavior of a LEFET made up of organic materials, notably P3HT as an active semiconductor and PMMA as a dielectric. We analyzed the effect of the thickness of the active layers on electrical and optical performance. The results obtained demonstrated the significant impact of the P3HT thickness on current, capacity, and luminous efficacy, whereas the thickness of PMMA showed a more marginal effect, linked to its passive role as a dielectric. This study provides a better understanding of the critical parameters influencing the performance of LEFETs and opens up optimization prospects for future generations of flexible optoelectronic devices.

Keywords: Light-emitting transistors, LEFET, Organic materials, P3HT, PMMA.

Mechanical properties of the Iron-Based alloy

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Abstract: Nanostructured FeCuSnZn powders were successfully synthesized by high-energy mechanical milling using a planetary ball mill for various milling durations. The characterization of the milled powders was carried out by X-ray diffraction, using the simulation software M.A.U.D. program "Material Analysis Using Diffraction" which is a mainly based on the Rietveld method. The Rietveld refinement of the X-ray diffraction spectra detected the formation of several nanometric phases after 4 hours of milling. The mechanical study showed that the Poisson's ratios varied with milling time and structures. In contrast, the Young's modulus remained nearly unchanged for all identified phases, with an average value close to 200 GPa. Furthermore, the stored energy increased with milling time and reached a maximum value of 6.106 J/mol after 3 h of milling for the α-$Cu_{0.859}Zn_{0.12}Sn_{0.021}$ phase, reflecting the accumulation of lattice strain and defects generated during severe mechanical deformation.

Keywords: Fe-based alloy; X-ray diffraction; Rietveld method; ball milling.

A Novel Junctionless 4H-SiC Power MOSFET: Nanotechnology-Inspired Design for Enhanced Ruggedness Toward Improving Renewable Energy Converters.

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Abstract: This study investigates a novel silicon carbide power MOSFET based on the combination of the robustness of silicon carbide and the junctionless nanotechnology, which eliminates the need for abrupt doping junctions with the entire thermal budget associated with it. This strategy aimed to improve the device performance in power conversion. Using Atlas mixed mode for circuit-level analysis, the device's switching performance during hard switching fault (HSF) and unclamped inductive switching (UIS) are assessed to demonstrate the improved ruggedness and reliability during short-circuit events and the dissipation of persistent inductive currents. Our findings indicate that the proposed device demonstrates a higher short-circuit figure of merit, namely, an improvement between 64 % and 100 % of its figure of merit compared to recently published high-performance power MOSFETs. Moreover, the proposed device demonstrates an exceptional ability to handle unclamped inductive currents, exhibiting only a small, instantaneous rise in temperature, unlike the prolonged severe self-heating seen in its conventional counterpart. Most importantly, the proposed silicon carbide junctionless power MOSFET features a low fabrication cost, making it a promising candidate for developing more reliable, efficient, and cost-effective DC-DC power converters for renewable energy applications.

Keywords: Silicone carbide; power converters; Junctionless nanotechnology; power MOSFET, self-heating, reliability.

Thermal performance of a ternary Al_2O_3-Cu-TiO_2/water hybrid nanofluid: comparison with single-component and hybrid nanofluids

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Abstract: The focus of this work is on combining two or three different types of nanoparticles; this study concentrates on characterizing the flow of a ternary nanofluid (Al_2O_3-Cu-TiO_2 / water) in a horizontal cylindrical channel. The channel is divided into three sections: the central, heated section is 1 m long, while the lateral, adiabatic sections are each 0.5 m long. The inlet flow is purely axial at ambient temperature. Three-dimensional numerical simulations, based on the finite volume method and Boussinesq approximations, were carried out. The effects of various parameters were investigated, notably the Reynolds number ($300 \leq Re \leq 720$) and the volume fraction of nanoparticles ($0 \leq \phi \leq 0.5\%$), on heat transfer and flow characteristics. The results showed a significant improvement in the thermal conductivity of the nanofluid, as well as an increase in the Nusselt number and a more homogeneous temperature distribution, compared to a simple or hybrid nanofluid. Increasing the volume fraction of the nanofluid intensifies heat transfer but leads to a decrease in flow velocity due to pressure losses.

Keywords: Ternary hybrid nanofluid; volume fraction; mixed convection; heat transfer; Nusselt.

Green Synthesis and Application of CuO Nanoparticales: Industrial waste water treatment using biosynthesized CuO nanoparticles

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Abstract: The treatment of industrially polluted water represents a major challenge for the research community due to its complexity, involving a mixture of hydrocarbons, metal oxides, metals, and numerous toxic organic compounds. The presence of these compounds in water causes various problems to human health and a significant environmental problems. The elimination of these pollutants from aqueous solutions has been achieved using various methods, such as adsorption, advanced oxidation processes, and biological oxidation processes. Each of these methods has its advantages and disadvantages; however, adsorption offers a more effective means of purifying effluents to a level where they can be safely discharged into the environment without posing risks to the receiving medium. In this study, we aim to synthesize CuO nanoparticles and use them for the adsorption of organic compounds. The synthesis of CuO NPs can be carried out using two methods: chemical and biological approaches. The synthesis using biological entities is considered a new, simple, rapid, economical, and eco-friendly alternative. We conducted a comparative study of different, generally unused parts of the date palm plant (Phoenix dactylifera L). The obtained nanoparticles was characterized using techniques such as IR (Infrared Spectroscopy), SEM (Scanning Electron Microscopy), and XRD (X-ray Diffraction). We also determined the effects of several operating parameters on the adsorption process, including: Initial concentration of the pollutant, Amount of waste used, pH of the medium, Temperature of the aqueous medium, Agitation speed. This study aims to provide a sustainable and effective solution for the removal of organic pollutants from contaminated water using eco-friendly synthesized CuO nanoparticles.

Keywords: Toxic Pollutants, nanoparticles, biosynthesis, adsorption, Thermodynamc study.

Evaluation of K β /K α X-ray Intensity Ratios Using Empirical and Semi-Empirical Approaches (Z = 41-90)

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Abstract: This study presents updated empirical and semi-empirical K β /K α X-ray intensity ratios for elements with atomic numbers ranging from Niobium (Z = 41) to Tin (Z = 50). Weighted average K β /K α values were calculated and combined with an interpolation approach based on an analytical function of the atomic number Z. These methods enabled the determination of empirical K β /K α ratios across the selected atomic range. In addition, the ratio S = (K β /K α)Exp / (K β /K α)W was analyzed as a function of Z. Experimental values outside the interval [0.9; 1.1] were excluded, allowing the computation of refined semi-empirical average ratios. Comparison with theoretical models and previously published experimental and semi-empirical data shows strong overall agreement, with only minor deviations for a few elements. These results provide reliable data that contribute to the understanding of atomic inner-shell ionization and support applications in physical chemistry, materials science, and medical physics.

Keywords: K β /K α X-ray intensity ratios; Empirical values; Semi-empirical values; X-ray parameters.

First-Principles Investigation of Pt Doping Effects on the Electronic and Magnetic Properties of Ni_2MnGa

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Abstract: In this study, we have established a careful analysis on the effect of Pt substitution at Ni sites on the electronic structure and magnetic properties of the Ni_2MnGa system in both cubic and tetragonal phases using FP-LAPW+lo method based on density functional theory. Two Pt concentrations were investigated x = 0.125 and 0.250 in Ni_2-xPt_xMnGa Heusler alloys using the supercell model. GGA+U calculations show that Ni_2-xPtxMnGa alloys (x = 0, 0.125, 0.250) are stable in the cubic structure and the lattice parameters increase linearly with increasing platinum concentration. Band structure calculations show overlapping bands at the Fermi level indicating that these alloys are metallic. The atomic and total magnetic moments increase with increasing Pt concentration, which is responsible to the strengthening of ferromagnetism in these alloys. The anisotropy energy calculations predict that [100] and [010] axis are the easy and hard one respectively in our cubic ferromagnetic Pt doped Heusler. Our Pt doped Ni_2MnGa alloys could be synthesized to obtained novel shape memory alloys.

Keywords: DFT+U, anisotropy energy, Heusler alloys

Structural, optical characterization of Fe-doped SnO_2 thin layers

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Abstract: In this work , we studied structural optical characterization of undoped tin oxide (SnO_2) and iron (Fe) doped (SnO_2) thin films , Which have been deposited from tin chloride ($SnCl_2$) and iron chloride ($FeCl_3$) onto glass substrates by spray pyrolysis technique. Samples were deposited for 3 minutes at the substrate temperature of 480−C° . The doping concentration of (Fe) was varied from 1 to 10 wt (%) in solution . X-ray diffraction (XRD) has shown polycrystalline structure according to Tetragonal , Rutile (SnO_2) structure with (211) as preferential orientation for iron (Fe) doped (SnO_2) thin films. The optical transmittance of (SnO_2:Fe) films in visible region increases from 68% to 75%.The optical band gap (Eg) increased from (3.69 eV) to (3.90eV) with increasing of the concentration of Fer (Fe) dopants.

Keywords: Tin oxide (SnO_2), Spray pyrolysis, Thin films, Iron (Fe), X-ray diffraction (XRD).

Point defects in B2-NiAl intermetallic compounds: A Review

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Abstract: Several studies have investigated point defects in Ni‑Al intermetallic compounds using both experimental and first-principles approaches. Early investigations demonstrated that vacancies and antisite defects are the primary intrinsic defects governing diffusion and phase stability in ordered NiAl. Later studies revealed that triple defects are the dominant thermal defect mechanism in B2-NiAl. Y. Mishin et al. reported that constitutional and thermal defects strongly depend on alloy composition and temperature. At the same time, K. A. Marino and E. A. Carter showed, through DFT calculations, that defect formation energies play a critical role in stabilizing off-stoichiometric structures. Recent computational work using mean-field and SQS approaches has confirmed the important contribution of point defects to diffusion kinetics and thermodynamic behavior in B2 Ni-Al intermetallic systems.

Keywords: B_2-NiAl; vacancies; antisites;Triple defects.

First-Principles Investigation of the Structural and Electronic Properties of LiAlSi and LiAlGe Half-Heusler Compounds

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Abstract: In this work, the structural and electronic properties of the half-Heusler compounds LiAlSi and LiAlGe were investigated using the full-potential linearized augmented plane wave (FP-LAPW) method within the framework of density functional theory (DFT), as implemented in the WIEN2k code. The exchange‑correlation effects were treated using the local density approximation (LDA) and the generalized gradient approximation (GGA‑PBE), while the Tran‑Blaha modified Becke‑Johnson (TB-mBJ) potential was employed to improve the description of the electronic properties. The equilibrium structural parameters, including lattice constants, bulk modulus, and its pressure derivative, were determined through total energy calculations. The obtained structural results are found to be in good agreement with available experimental data. Electronic band structure calculations reveal that the α and β phases of LiAlSi and LiAlGe exhibit semiconducting behavior, whereas the γ phase shows metallic characteristics. These findings highlight the potential of these half-Heusler compounds for semiconductor and electronic applications.

Keywords: Half-Heusler compounds; DFT; FP-LAPW; WIEN2k; TB-mBJ; Electronic properties.

Effect of Biomass Nature on the Physicochemical Properties of Extracted Silica

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Abstract: The valorization of plant biomass as an alternative source of silica represents a promising approach for the development of sustainable, low-cost, and environmentally friendly materials. In this context, this work aims to investigate the effect of biomass nature on the physicochemical properties of silica obtained from two different plant sources.

The selected biomasses were subjected to thermal and chemical treatments in order to extract silica. After calcination, the obtained ashes were treated by alkaline attack using a NaOH solution, followed by acid neutralization, allowing the formation of a silica gel. The obtained gel was then aged, washed, and dried to produce silica powder. The prepared materials were characterized by X-ray diffraction, X-ray fluorescence, Fourier-transform infrared spectroscopy, scanning electron microscopy coupled with EDX, and thermal analysis.

The results show that the nature of the biomass influences the chemical purity, morphology, and some structural characteristics of the extracted silicas. XRD analyses confirm the mainly amorphous character of the obtained materials, while XRF results reveal high SiO_2 contents, varying according to the plant source. SEM observations also show the formation of fine silica particles, with sizes below 176 nm for the first biomass and below 488 nm for the second one. These results confirm the interest of plant biomasses as renewable precursors for the production of amorphous silicas with controlled properties.

Keywords: Plant biomass; Extracted silica; Amorphous silica; Physicochemical characterization; Sustainable materials

Exploring Mechanical Stability and Photocatalytic Potential of a Lanthanum-Based Double Perovskite Oxide: A DFT Study Using GGA-PBE, mBJ, and HSE06 Approaches

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Abstract: Rare-earth-based double perovskite oxides have attracted significant attention due to their structural stability, mechanical robustness, and promising potential for photocatalytic applications. In this work, the structural, elastic, and electronic properties of La_2LiVO_6 double perovskite oxide are investigated using a first-principles approach based on Density Functional Theory (DFT), employing two distinct methods: the Full Potential Linearized Augmented Plane Waves (FP-LAPW) and the Plane Wave Pseudopotential (PW-PP) approaches, as implemented in the WIEN2k and CASTEP software packages, respectively, to ensure the reliability and consistency of the obtained results. A good agreement is observed between the results obtained from both methods, confirming the reliability of the computational approach. This consistency indicates that the pseudopotential-based method can adequately describe the physical properties of such complex systems. In addition, the electronic band gap is evaluated using advanced exchange‑correlation functionals, including mBJ (3.45 eV) and HSE06 (3.2 eV), in order to obtain accurate electronic structure predictions. The calculated band gap suggests that La_2LiVO_6 exhibits a suitable energy range for UV-driven photocatalytic applications. Finally, the results indicate that La_2LiVO_6 is a mechanically stable material with a promising band gap, making it a potential candidate for UV photocatalysis and related functional applications.

Keywords: Double perovskites , Density functional theory , FP-LAPW , PW-PP, Photocatalytic.

First-principles modelling of the ferroelectric properties of tetragonal BaTiO3

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Abstract: We present a computational study of the ferroelectric parameters for BaTiO3 in the tetragonal structure, obtained in the context of density functional theory and the Berry phase theory of electric polarization. We report the values of the spontaneous polarization, Born effective charges, energy barrier to polarization reversal, coercive electric field, domain walls formation energy, and energy barrier to domain walls motion. These values are compared to experimental and theoretical data available from the literature. A detailed description of the methodology required to calculate the ferroelectric properties of BaTiO3, with application to other perovskite crystals, is presented.

Keywords: Ferroelectricity; Electric polarization; Domain walls; Perovskite crystals; Berry phase

Judd-Ofelt Spectroscopic Investigation of Nd^{3+} and Sm^{3+} Doped Tellurite Glasses for Photonic and Laser Applications

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Abstract: Rare-earth-doped tellurite glasses have attracted considerable attention due to their excellent optical characteristics and potential applications in photonic devices. In this work, Nd^{3+} and Sm^{3+} doped tellurite glasses with composition (80−y) TeO_2 -20$BiCl_3$-yRE_2O_3 (y= 0.6 mol%; RE = Nd^{3+} and Sm^{3+}) were successfully synthesized using the conventional melt-quenching technique. The structural, thermal, and spectroscopic properties of the prepared glasses were systematically investigated using X-ray diffraction (XRD), differential scanning calorimetry (DSC), UV-Vis-NIR absorption spectroscopy, and Judd-Ofelt (J-O) analysis. XRD patterns confirmed the amorphous nature of all glass samples without the presence of crystalline phases. Thermal analysis revealed excellent thermal stability with ΔT values exceeding 100 °C, indicating strong resistance against crystallization and suitability for optical device fabrication. The optical band gap values were found to decrease with rare-earth incorporation, while the refractive index increased from 2.39 to 2.47, suggesting enhanced polarizability and structural compactness of the glass network. The absorption spectra of Nd^{3+} doped glasses exhibited several characteristic transitions originating from the $^4I_{9/2}$ ground state, where the hypersensitive transition showed the highest oscillator strength. The calculated Judd- Ofelt intensity parameters for Nd^{3+} ions were $\Omega_2 = 3.34 \cdot 10^{-2}$ cm^2, $\Omega_4 = 3.86 \cdot 10^{-2}$ cm^2, and $\Omega_6 = 3.54 \times 10^{-20}$ cm^2 with a low RMS deviation of $0.313 \cdot 10^{-6}$, confirming good agreement between experimental and theoretical oscillator strengths. For Sm^{3+} doped glasses, intense absorption bands were observed in the near-infrared region between 948 and 1590 nm, corresponding to the transitions from $^6H_{5/2}$ to excited states. The obtained J-O parameters were $\Omega_2 = 0.48 \cdot 10^{-20}$ cm^2, $\Omega_4 = 2.04 \cdot 10^{-20}$ cm^2, and $\Omega_6 = 1.83 \cdot 10^{-20}$ cm^2 with RMS = $0.169 \cdot 10^{-6}$. The strong agreement between calculated and experimental oscillator strengths confirms the reliability of the spectroscopic analysis. The obtained results demonstrate that Nd^{3+} and Sm^{3+} doped tellurite glasses possess excellent thermal stability, favorable optical behavior, and efficient radiative characteristics, making them promising candidates for solid-state lasers, nonlinear optical devices, optical amplifiers, and photonic applications.

Keywords: Tellurite glasses; Rare-earth ions; Judd-Ofelt analysis; Optical properties; Thermal stability; Photonic materials.

Optoelectronic properties of Anhydrides

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Abstract: Anhydride derivatives are widely recognized for their extensive applications in industrial and large-scale organic synthesis. Interestingly, these compounds also exhibit promising features for non-linear optical (NLO) technologies, such as phosphorescence and fluorescence [1], and have been successfully incorporated into polyimides to achieve sustained second-harmonic generation (SHG) [2]. However, the literature offers limited theoretical and experimental insights into their linear and NLO properties [3]. To address this gap, our computational research focuses on assessing these derivatives to determine which structures possess high hyperpolarizability

Keywords: Anhydride ; Polarizability ; Hyperpolarizability ; Gap

Study of the Effect of AUC Decomposition Parameters on the Properties of Prepared UO_3 and U_3O_8 Powders

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Abstract:
This study examines the influence of thermal decomposition parameters of ammonium uranyl carbonate (AUC) on the properties of intermediate oxides UO_3 and U_3O_8, which are key precursors for ceramic UO_2 nuclear fuel.

Parameters varied include temperature (100-900° C), duration (1 min to 6 h), and atmosphere (air and nitrogen). Thermal decomposition was performed in a muffle furnace, with TG-DTA analyses. Powders were characterized by UV-visible spectroscopy (O/U ratio), thermogravimetry (uranium content), and BET specific surface area.

Mass loss increased sharply from 5.6% at 100° C to 42% at 200° C, reaching 47% at 800° C. At 200° C, O/U ratio was 3.52 and uranium content 80.5%, indicating amorphous UO_3. Between 400-500° C, O/U decreased from 2.85 to 2.74 and uranium content reached 84.7%, marking transformation into U_3O_8. At 600-700° C, O/U stabilized between 2.67 and 2.69 (stoichiometric U_3O_8).

DTA-ATG curves confirmed these transformations: an endothermic peak (120-200° C) due to NH_3 and CO_3 release, an exothermic peak near 490° C (UO_3 crystallization), and an endothermic peak around 600° C (U_3O_8 formation).

BET surface area was very low at 100° C (6 m^2/g), peaked at 82 m^2/g at 200° C (amorphous UO_3), then decreased to 20.9 m^2/g at 400° C and 1 m^2/g at 800° C (stoichiometric U_3O_8).

Calcination at 200-300° C under air produces high-surface-area UO_3 favorable for reduction into UO_2, while 600-800° C yields very low surface area U_3O_8 (<2 m^2/g).

Keywords: AUC, Decomposition, UO_3, U_3O_8, DTA-TG.

Kinetic Investigation of Pesticide Removal through Adsorption

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Abstract: Phytosanitary products constitute a significant source of environmental pollution due to their toxicity toward human health and ecosystems. Among these substances, pesticides are of particular concern because of their persistence in soils and aquatic environments, as well as their potential acute and chronic effects. To mitigate these risks, various treatment technologies have been developed, among which adsorption has emerged as an effective, economical, and environmentally sustainable method.

The present study investigates the removal of a pesticide from aqueous solutions through adsorption using a food waste-derived adsorbent. This approach promotes the valorization of organic waste while offering a sustainable and promising solution for water decontamination. A series of batch adsorption experiments was performed to evaluate the effects of key operational parameters, including the initial pesticide concentration, adsorbent dosage, and solution pH.

The results demonstrated that the highest removal efficiency, reaching 84%, was achieved under optimal conditions corresponding to an adsorbent dosage of 0.15 g/L and a pH value of 9.5. Suggesting that chemisorption plays a predominant role in the interaction between the adsorbent surface and pesticide molecules. Furthermore, equilibrium data were best described by the Langmuir isotherm model (R^2 = 0.97), indicating monolayer adsorption on a homogeneous surface. These findings highlight the potential of food waste-based materials as low-cost and eco-friendly adsorbents for the treatment of pesticide-contaminated water, Différentes analyses ont été effectuées pour caractériser l'adsorbant : MEB et DRX.

Keywords: Adsorption; Pesticide removal; Adsorbent; Food waste.

Comparative Study of the Successive Over-Relaxation Technique and Least Squares Methods for Impurity Detection in Physical Materials

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Abstract: In recent years, image processing has become an important research field because of its wide range of applications in modern technology, particularly in detection and analysis systems. The main objective of this study is to investigate alternative mathematical approaches for image processing that can provide higher detection accuracy while reducing processing time. To achieve this goal, two numerical methods were applied and evaluated using MATLAB simulations.
The study focuses on developing mathematical algorithms capable of analyzing material samples quickly and accurately for impurity detection. Experimental results showed that both methods achieved high levels of performance in terms of speed and accuracy. In particular, the iterative Successive Over-Relaxation (SOR) method produced the best results, reaching an accuracy rate of 99.85%, while the Least Squares (LS) method achieved an accuracy of 90.95%.

These findings demonstrate the effectiveness of the proposed numerical approaches for image-based impurity detection in physical materials. The results also confirm that iterative mathematical techniques can significantly improve processing efficiency and detection precision. Future work may focus on developing more advanced algorithms capable of achieving even faster and more accurate performance.

Keywords: Image processing; impurity detection; Successive Over-Relaxation; Least Squares method; physical materials.

Enhanced properties of Cu:In2O3 thin films via sol-gel spin coating

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Abstract: Highly transparent copper-doped indium oxide (Cu:In2O3) thin films were successfully deposited on glass substrates using the sol‑gel spin-coating technique. The structural, optical, and electrical properties of the films were systematically investigated by X-ray diffraction (XRD), UV‑Visible spectroscopy, and the four-probe method, respectively. XRD analysis revealed that all doped films exhibit a biphasic structure consisting of cubic In2O3 and Cu2O phases, confirming the successful incorporation of copper into the matrix. The crystallite size remained nearly constant, ranging from approximately 11.27 to 12.15 nm. Optical measurements showed that the films possess high transparency in the visible region, with transmittance values between 83% and 91%. The optical band gap (Eg) was found to vary slightly within the range of 3.98 to 4.07 eV. Electrical characterization indicated that all films exhibit low resistivity values in the range of 1.77×10^{-3} to 6.34×10^{-3} $\Omega\cdot$ cm, making them suitable for optoelectronic applications.

Keywords: Thin films; Indium oxide; Doping; Biphasic structure; Sol gel.

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Abstract: Aluminum-doped Zinc Oxide (AZO) thin films were synthesized by reactive magnetron sputtering at various deposition times. Analysis revealed that film thickness increased proportionally with deposition duration. Scanning Electron Microscopy (SEM) micrographs of AZO films, prepared at various thicknesses, revealed uniform coverage and a granular morphology across all samples. With increasing thickness, the film morphology became progressively rougher, exhibiting larger grain sizes, particularly noticeable at a thickness of 562 nm. Furthermore, all films exhibited a diffraction peak centered at a 2θ angle of 40.34°. This peak corresponds to the (002) plane of the wurtzite ZnO structure, indicating a preferred (002) orientation with the c-axis perpendicular to the substrates. The transmission spectra demonstrate excellent transparency in the visible region. The bandgap (Eg) of the AZO films initially increases with thickness before narrowing, with its narrowest point observed at 562 nm. Electrical resistivity of the AZO films initially shows a slight increase with thickness (from 9.5×10^{-3} to 1.02×10^{-2} $\Omega\cdot$ cm), before decreasing significantly to 4.6×10^{-3} $\Omega\cdot$ cm at a thickness of 562 nm. Therefore, these findings emphasize the critical role of thickness control in optimizing AZO thin film performance, enabling their integration into photovoltaic and optoelectronic devices.

Keywords: Thickness; RF Sputtering, optical properties, electrical properties.

Morphological Evolution and Performance of P3HT:PCBM Organic Solar Cells A Coarse-Grained Molecular Dynamics Approach

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Abstract: The morphology of poly(3-hexylthiophene) (P3HT):phenyl-C61-butyric acid methyl ester (PCBM) bulk heterojunction active layers plays a crucial role in determining the performance of organic photovoltaic devices. In this work, coarse-grained molecular dynamics simulations based on the Martini 3.0 force field were employed to investigate the morphological evolution of P3HT:PCBM:chlorobenzene ternary systems during solvent evaporation. Two solvent removal protocols, corresponding to 1% and 3.75% chlorobenzene removal per step, were systematically examined to assess their influence on phase separation, molecular organization, and donor-acceptor interfacial structure. The simulated system consisted of 75 P3HT chains (degree of polymerization = 48), 526 PCBM molecules, and 2500 chlorobenzene molecules confined within a periodic simulation box of 15 × 15 × 44 nm^3. Morphological characterization using radial distribution functions, density profiles, and cluster analysis revealed pronounced differences between the two evaporation regimes. Slow solvent evaporation promoted enhanced polymer ordering, improved donor-acceptor interfacial organization, and well-defined phase-separated domains, whereas rapid evaporation generated kinetically trapped morphologies with reduced structural order and less favorable domain connectivity. These results provide molecular-level insights into the relationship between processing conditions, morphology development, and the expected photovoltaic performance of P3HT:PCBM active layers. The study further highlights the importance of controlling solvent evaporation kinetics to optimize the structural characteristics of organic solar cells and offers valuable guidance for experimental fabrication strategies.

Keywords: Bulk heterojunction; P3HT; PCBM; Solvent evaporation; Coarse-grained modeling; Organic photovoltaics; Phase separation; Martini force field

Theoretical study of Structural Stability, Electronic, Elastic, and Magnetic Properties of the New Half Metallic Half-Heusler LiSrC compound

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Abstract: We present an ab initio study of the structural, electronic, elastic and thermodynamic properties of half-Heusler LiSrC compound, using the full potential linearized augmented plane wave (FP-LAPW) method implemented in the WIEN2K code. The generalized gradient approximation GGA was used for the exchange-correlation potential. The calculated cohesive and formation energy values showed that this compound can be experimentally synthesized. The elastic properties were analyzed in detail and reveal that LiSrC compound is mechanically stable. The spin-polarized band structure and density of states illustrate that LiSrC alloy have a half metallic character. The total magnetic moment is 1μB per formula unit that confirms the half metallic behavior and follows the Slater-Pauling rule MT = (8-Ztot) μB.

Keywords: Half-Heusler; FP-LAPW; formation energy; half metallic.

A Comparative Study of Type-1 Fuzzy Logic and Perturbation & Observation under Robust Control for Wind Energy Systems

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Abstract: In this paper, a robust control framework for wind energy systems is used to compare Type-1 Fuzzy Logic Control with the Perturbation and Observation (P&O) method. The primary goal is to assess how well these strategies perform in terms of robustness, stability, and dynamic reactivity under various wind conditions. Because wind energy systems are extremely nonlinear and vulnerable to ongoing environmental disruptions, the development of effective control mechanisms is crucial for the best possible energy extraction. Fype-1 Fuzzy Logic Control is renowned for its capacity to control uncertainties and nonlinearities in systems without the need for a precise mathematical model. The P&O approach, on the other hand, is popular because of its ease of use, even though it could cause oscillations around the ideal operating point. To achieve a fair comparison, both approaches are used under the same circumstances. The findings show that while the P&O approach is still appealing due to its simplicity and convenience of use, the fuzzy controller offers superior stability, improved adaptability, and smoother response.

This study provides helpful insights for choosing appropriate control strategies in wind energy applications by highlighting the benefits and drawbacks of each approach.

Keywords: Type-1 Fuzzy Logic; Perturbation and Observation (P&O); Wind Energy Systems; Robust Control; Nonlinear Systems

Performance Evaluation of a PV-Based Hybrid Energy Storage System under Variable Environmental Conditions

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Abstract: This paper presents the design, control, and performance evaluation of a photovoltaic (PV)-based Hybrid Energy Storage System (HESS) that combines a battery and a supercapacitor. The objective is to enhance energy management, improve dynamic response, and ensure stable operation under variable environmental conditions. The system includes a DC-DC boost converter with a Maximum Power Point Tracking (MPPT) algorithm to maximize PV power extraction, and a bidirectional DC-DC converter to manage energy exchange between the storage units and the DC bus.

The proposed approach is tested under varying irradiance with constant temperature (25° C) and under different temperature conditions with fixed irradiance (1000 W/m²). The results show that the PV system effectively tracks the maximum power point under all conditions. During rapid changes, the supercapacitor provides fast transient power, while the battery ensures smooth and continuous energy supply. This coordinated operation improves system stability and reduces stress on the battery.

Overall, the results confirm the effectiveness of the proposed HESS and control strategy in maintaining reliable performance under dynamic environmental conditions.

Keywords: Photovoltaic system; Hybrid energy storage system; Battery-supercapacitor; Maximum power point tracking; Energy management; Dynamic performance.

The effect of brown algae on meat and meat products

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Abstract: In response to growing consumer interest in functional foods and improved dietary habits, and to avoid chemical additives that are harmful to human health and the environment.

Edible seaweeds contain a multitude of essential nutrients, such as bioactive compounds, and, given their physicochemical properties, are used to enhance the functional properties of meat-derived products.

Algae of the genus Sargassum were selected due to their prevalence along the Algerian coastline; the harvest took place in the Stédia region (city of Mostaganem) over four seasons. They were selected to assess their effects on meat, water content and pH. To this end, four different samples were prepared (a mixture of beef and 2%, 3% seaweed powder from each season), with a water content of 57.84±1.16 and 57.84±1.73 for the 2% and 3% samples, and a pH of 7.95±0.07 and 8.06±0.16, respectively. The difference remains insignificant. In conclusion, the time of harvest and bioclimatic conditions could influence the content and quality of extracts from Sargassum of the same family.

Keywords: Seaweeds, Chemical additives, Bioactive molecules, Meat, Sargassum.

Numerical investigation of a solar absorption refrigeration system based on LiBr-H_2O working fluid with stratified latent heat storage for agri-food applications

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Abstract: This work presents a numerical study of a single-effect LiBr-H_2O solar absorption refrigeration system designed for the preservation of agri-food products in a semi-arid climate. The system combines evacuated tube solar collectors with a stratified thermal storage unit incorporating phase change materials (PCM), with the aim of enhancing operational continuity and thermal stability.

A comprehensive thermal model is developed to represent all subsystems, including solar collection, thermal storage, the absorption chiller, and a 50 m^3 cold room. Simulations are conducted over a full year using climatic data representative of the Constantine region (Algeria). System performance is assessed through energy indicators as well as compliance with HACCP requirements.

The results indicate a high solar fraction and a stable average coefficient of performance of the absorption machine. The integration of PCM reduces thermal fluctuations and improves the maintenance of the cold room temperature within the prescribed range. Overall, the study confirms the feasibility and relevance of this type of system for sustainable agri-food refrigeration applications.

Keywords: Agri-food cold chain; Evacuated tube solar collectors; LiBr-H_2O absorption system; Phase change materials (PCM); Semi-arid climate; Stratified thermal storage.

Renewable Bioenergy Generation via Anaerobic Co-Digestion of Spent Coffee Grounds and Buttermilk: Process Optimization and Kinetic Modeling

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Abstract: Anaerobic co-digestion (ACoD) represents a promising strategy for valorizing organic waste residues into renewable energy. This study investigates the mesophilic co-digestion of spent coffee grounds (SCG) and buttermilk (BM) at different mixing ratios, focusing on cumulative biogas yield, methane content, and kinetic modeling. Batch biochemical methane potential (BMP) tests revealed that 100% SCG achieved the highest cumulative biogas (597.72 mL/gVS) and methane yield (285.76 mL/gVS) after 43 days, outperforming all co-digestion mixtures and BM mono-digestion. Co-digestion mixtures (75% SCG/25% BM, 50% SCG/50% BM, 25% SCG/75% BM) displayed enhanced methane production compared to BM alone, with methane concentrations ranging between 44.47–47.81%. The synergistic effect of SCG contributed to higher methane fractions, while BM favored CO_2 enrichment. Kinetic evaluation using the modified Gompertz (MG) and logistic function (LF) models demonstrated strong fits ($R^2 > 0.99$), with methane production rates (μm) ranging from 9.66–14.70 mL/gVS/day. The shortest lag phase ($\lambda = 1.09$ days, MG model) was observed at 75% SCG/25% BM, indicating accelerated digestion initiation. Overall, SCG significantly enhanced methane yield and shortened lag phases, while BM improved start-up performance. These results underscore the potential of SCG-BM co-digestion as a sustainable strategy for optimizing biogas production, leveraging locally available waste streams to enhance the efficiency of anaerobic digestion systems and contribute to renewable energy generation.

Keywords: Renewable energy; anaerobic co-digestion; spent coffee grounds; buttermilk; methane yield; kinetic modeling.

Assessment of Distribution Grid Performance Incorporating PV, Wind, and Flywheel Energy Storage System

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Abstract: The growing adoption of renewable energy sources, particularly photovoltaic (PV) and wind power, has notably reshaped the operational dynamics of modern distribution grids. This study explores the effects of incorporating these renewable energy technologies into a sample distribution system using the PowerWorld Simulator. Various load flow scenarios were analyzed, encompassing both conventional grid operations and scenarios with high renewable energy penetration, to assess system performance concerning voltage profiles, power losses, and line loading. The results reveal that strategically placed and appropriately sized PV and wind energy systems can enhance voltage stability and decrease real power losses. However, excessive integration without proper coordination may result in voltage instability and reverse power flow challenges. These findings underscore the critical need for strategic planning and advanced control solutions to ensure the reliable and efficient operation of distribution networks under high levels of renewable energy integration.

Keywords: Electrical Grid ; Renewable Energy; Photovoltaic power ;Wind power; Flywheel Storage ; Power flow ;

Performance Comparison of PSO and ANN-Based MPPT Techniques for Photovoltaic Systems

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Abstract: This paper presents an in-depth analysis of a photovoltaic (PV) power generation system operating under changing environmental conditions. Due to the nonlinear current-voltage characteristics of photovoltaic modules, the use of an effective Maximum Power Point Tracking (MPPT) technique is essential for maximizing energy harvesting and improving system efficiency. In this work, an intelligent MPPT method based on Artificial Neural Networks (ANNs) is developed and compared with a Particle Swarm Optimization (PSO)-based control strategy.The proposed ANN controller was established using a trained dataset capable of modeling the nonlinear behavior of the PV generator with high accuracy. The control algorithm was integrated into a DC-DC boost converter connected to the photovoltaic array in order to enhance power extraction efficiency, tracking performance, and operational stability.Simulation studies carried out under different solar irradiance levels reveal that the ANN-based MPPT approach ensures rapid tracking of the maximum power point while reducing steady-state fluctuations and improving tracking accuracy. Moreover, the comparative evaluation confirms that the ANN controller exhibits better dynamic behavior, higher robustness, and superior adaptability than the PSO-based method when subjected to fast environmental variations and sudden operating condition changes.

Keywords: Photovoltaic System, Artificial Neural Networks-ANN, Boost Converter, MPPT Algorithms,PSO; Matlab /Simulink.

Model Predictive Control based MPPT technique applied to Boost converter for photovoltaic applications

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Abstract: Photovoltaic (PV) systems provide a clean source of electricity; however, they are currently costly. Due to the unpredictable and stochastic nature of solar energy, Maximum Power Point Tracking (MPPT) is essential for photovoltaic (PV) systems to ensure continuous operation at the maximum power point, thereby maximizing electrical energy production.
In this study, a Maximum Power Point Tracking (MPPT) based Model Predictive Control (MPC) approach is presented to obtain high accuracy and improve the dynamic performance of the control structure of Boost converter used in renewable energy systems. The Perturb and Observe (P&O) MPPT method is employed to obtain the reference current for the MPC algorithm.

The dynamic capability and tracking performance of the proposed control method are validated via simulation in MATLAB/Simulink environment, where the effectiveness of the proposed approach is analysed by carrying out step change tests in solar irradiance. The proposed control method shows remarkable performance, characterized by fast dynamic response and strong robustness, as confirmed by the results.

Keywords: Photovoltaic System (PV); Maximum Power Point Tracking (MPPT); Model predictive control (MPC); Boost Converter.

Evaluation of linear and nonlinear machine learning models for photovoltaic power prediction using full and minimalist input datasets

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Abstract: Accurate prediction of solar photovoltaic (PV) power output is essential for efficient management of solar energy systems. This work evaluates the importance of input features in machine learning (ML) algorithms for predicting PV module performance using two datasets: a full dataset including solar radiation, ambient and module temperature, wind speed, and relative humidity, and a minimalist dataset involving only solar radiation and module temperature, while the output remains the module power output. Experiments were conducted at the University of El Oued from 26 to 30 November 2022, where all parameters were recorded every three seconds. After feature selection and data preprocessing, six linear and nonlinear ML algorithms were investigated, namely Multiple Linear Regression (MLR), Elastic Net, Partial Least Squares (PLS), Support Vector Regression (SVR), Random Forest (RF), and Artificial Neural Networks (ANN). Models performance was evaluated using metrics such as the MAE, MSE, and R^2. Results showed that using the full dataset the best linear model was the MLR, achieving an R^2 of 0.973, MAE of 5.1, and MSE of 54.723, whereas the Random Forest model provided the best nonlinear performance with an R^2 of 0.998, MAE of 1.058, and MSE of 2.789. For the minimalist dataset, linear models exhibited similar performance with no significant differences, while the ANN model achieved the highest accuracy with an R^2 of 0.997, MAE of 1.338, and MSE of 5.012. The findings demonstrate that solar radiation and module temperature are sufficient, and support the use of machine learning techniques, for accurate PV power prediction.

Keywords: Photovoltaic modules; Machine learning; Regression models; Prediction; Reduced input features.

Techno-Economic Assessment of Hybrid System Based PV/FC/Battery/Electrolyzer to Supply Isolated Electrical Load.

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Abstract: This work presents the HOMER Pro techno-economic evaluation of an off-grid PV-battery-hydrogen hybrid renewable energy system for green hydrogen production under M'sila Wilaya climatic conditions, Algeria. The study aims to assess how photovoltaic generation, short-term electrochemical storage, water electrolysis, hydrogen storage, and fuel-cell backup can be optimally combined to supply a representative isolated electrical load. Monthly solar irradiation, temperature data, a 48 kWh/day load profile, economic assumptions, and component cost/sizing ranges were introduced in HOMER Pro. Three annual capacity shortage scenarios (0%, 2%, and 5%) were compared to analyze the effect of reliability constraints on optimal sizing, hydrogen utilization, and cost indicators. The 2% shortage case was retained as the reference compromise scenario. It selected a 22 kW PV array, 12 batteries, an 8.6 kW converter, a 5 kW electrolyzer, a 10 kg hydrogen tank, and a hydrogen-fueled generator representing the fuel cell. Results showed that PV is the dominant source for electricity production during day, while the battery provided short-term balancing and the hydrogen subsystem ensured complementary storage and backup support for load by using fuel cell during night. The optimal configuration achieved a NPC of about 65,090, a COE of 0.213/kWh, and a LCOH of 21.9/kg. Sensitivity analysis showed that stricter reliability increases cost and component sizes, whereas relaxed shortage reduces cost but weakens hydrogen utilization. The study confirms HOMER Pro's value as a decision-support tool for preliminary feasibility analysis of PV-based green hydrogen systems in Algerian high-solar-potential regions.

Keywords: HOMER Pro, PV/FC/battery, hydrogen, capacity shortage, NPC, COE

Intelligent Model Predictive Control for Fault Ride-Through Capability Enhancement in Inverter-Based AC Microgrids

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Abstract: This paper presents an intelligent Model Predictive Control (MPC) strategy to improve the Fault Ride-Through Capability (FRTC) of inverter-based AC microgrids. The proposed controller operates under both normal and emergency conditions. In normal operation, the MPC regulates the inverter output voltage through an LC filter to ensure stable performance and good power quality. During fault conditions, including single phase-to-ground, two phase-to-ground, and three phase-to-ground faults, the controller maintains system stability and enhances voltage recovery. Simulation results demonstrate that the proposed intelligent MPC provides fast dynamic response, reduced voltage fluctuations, and improved fault ride-through performance under different fault scenarios.

Keywords: Fault Ride-Through Capability, Model Predictive Control, AC Microgrid, Inverter Control

Processor-in-the-Loop Validation of Sensor Fault-Tolerant Control for a Photovoltaic MPPT Boost Converter

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Abstract: In recent decades, the increasing integration of photovoltaic (PV) systems has led to stricter reliability and safety requirements. In distributed PV generation systems connected to DC Microgrids, voltage and current sensors play a critical role in ensuring efficient energy conversion, with Maximum Power Point Tracking (MPPT) techniques enabling optimal energy extraction. Typically, MPPT is implemented using a DC‑DC boost converter that adjusts the duty cycle to operate at the Maximum Power Point (MPP).

With the growing trend of integrating MPPT systems directly into photovoltaic, these systems are increasingly exposed to harsh environmental conditions that can degrade sensor reliability. Since sensors are essential for closed-loop control, any fault in current or voltage measurements can significantly affect MPPT performance and lead to power loss.

To address this issue, this paper proposes an Unknown Input Observer (UIO)-based fault-tolerant control scheme capable of estimating faults in both inductor current and voltage sensors for a PV-fed boost converter in a DC Microgrid. The estimated faults are compensated before being fed back into the control loop, ensuring reliable MPPT operation under sensor faults. The proposed approach is validated through Processor-in-the-Loop (PIL) implementation using the TMS320F28049C LaunchPad from Texas Instruments, where the control algorithm is deployed on the embedded platform while the plant model is simulated in MATLAB/Simulink.

PIL results show that the proposed scheme accurately estimates sensor faults with a maximum estimation error of 0.13% for voltage and 1% for current, respectively, while maintaining MPPT performance even under simultaneous faults in both sensors.

Keywords: Processor-in-the-Loop; MPPT; fault-tolerant control; sensor fault; DC Microgrids;boost converter

Performance Control of Wind Energy Systems based on PMSG Connected to the Grid

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Abstract: This paper investigates a nonlinear control strategy for a grid-connected wind energy conversion system (WECS) based on a permanent magnet synchronous generator (PMSG). The system employs a back-to-back voltage source converter (VSC) topology composed of two IGBT-based converters interconnected through a DC-link capacitor. The generator-side converter regulates the electromagnetic torque and rotor speed to ensure maximum power point tracking (MPPT), while the grid-side converter maintains DC-link voltage stability and guarantees sinusoidal current injection with unity power factor. A sliding mode control (SMC) scheme is developed for both converters. The proposed SMC ensures strong robustness against parameter uncertainties, and insensitivity to external disturbances such as wind speed variations. Moreover, the proposed control approach ensures stable operation in both steady-state and transient conditions, confirming its effectiveness for high-performance WECS applications. The effectiveness and robustness of the control algorithm are validated through simulation results, which demonstrate improved speed tracking, high accuracy, enhanced stability, and reduced output current ripple.

Keywords: Wind Energy Conversion System (WECS), Permanent Magnet Synchronous, Generator (PMSG), Sliding mode Control (SMC).

Enhancing DC-DC Converter Control via Adaptive Synergetic Mode Control

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Abstract: This paper presents the design of a robust observer adaptive controller for a boost converter operating under unknown load resistance and variable input voltage. The adaptation laws are derived using state observers to estimate system uncertainties. Theoretical analysis proves that the closed-loop system is asymptotically stable. Simulation results further validate the controllers robustness against input voltage fluctuations and load variations.

Keywords: adaptive controller; DC-DC converter; observer; adaptation laws.

Model-Free Adaptive MPPT Controller for a Photovoltaic Boost Converter: Processor-in-the-Loop Validation

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Abstract: Renewable energy has become a central solution for sustainable power generation and photovoltaic (PV) systems play a major role because of their clean, abundant, and distributed nature. In DC Microgrids, PV arrays are commonly interfaced through boost converters to elevate the variable PV voltage to the regulated DC bus level required by loads and energy storage units while extracting the maximum available power. However, accurate modeling of such converters is challenging due to parameter uncertainties and component aging of the system. As a result, many controllers designed from nominal models suffer performance degradation over time, leading to reduced tracking accuracy, slower dynamics, and power loss. To overcome these limitations, this paper proposes a model-free adaptive linear quadratic tracking (LQT) control strategy for a photovoltaic boost converter operating under maximum power point tracking (MPPT). The proposed method updates the control action online using measured signals, without requiring an exact mathematical model of the converter. The controller is validated through a processor-in-the-loop setup, in which the PV system and boost converter are modeled in MATLAB/Simulink while the real-time control algorithm is executed on a TMS320F280049C microcontroller. This implementation enables a realistic assessment of embedded control performance under practical conditions. The obtained results demonstrate fast MPPT tracking and robust regulation under variable irradiance profiles. The proposed strategy therefore offers an effective real-time solution for efficient PV energy conversion in DC Microgrid applications.

Keywords: Photovoltaic; Renewable energy; model-free control; Processor-in-the-Loop; boost converter

Calculation models of solar radiation for a solar trough concentrator in north of Algeria

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Abstract: The development of solar concentrator technology has just reached a very significant level. Using reflectors to concentrate the sun's rays on the absorber, greatly reduces the size of the absorber, reducing heat loss and increasing its efficiency at high temperatures. Another advantage of this system is that the reflectors are significantly less expensive, per unit area, than the flat collectors. Their main disadvantage is that they only use direct solar radiation, because the diffuse component cannot be concentrated. This is why the orientation of concentrators is relative to the direction of the propagation of direct radiation, this requires continuous tracking of the sun.
In this work, we developed a comparison between solar radiation values measured at the Tlemcen site and values estimated by theoretical models proposed in the literature by various researchers, for a parabolic trough collector. The theoretical models chosen are: the Capderou model [1, 2, 3], which serves as a reference for designers of solar systems in Algeria, and the new Bird and Hustrom model [4, 5]. The comparative study of the results obtained showed that the Capderou model is the one which presents the best estimate of the direct and diffuse components for any day of the year, whereas the Bird and Hustrom model is estimated only for clear days in particular for an incidence on the horizontal plane.

Keywords: Solar energy; parabolic trough collector; concentration system; simulation

Optimal Integration of DSTATCOM and Photovoltaic Units in Radial Distribution Networks Using a Hybrid GA-GSO-AAC-VASPSO Metaheuristic under Time-Varying Load Conditions

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Abstract: This study investigates the impact of optimally integrating Distribution Static Compensators (DSTATCOM) and photovoltaic (PV) generation units into the IEEE 33-bus radial distribution network under time-varying load conditions. The baseline analysis, conducted without any compensation or renewable generation, reveals significant active and reactive power losses, voltage profile deterioration, and a noticeable decline in the Voltage Stability Index (VSI), particularly during peak demand periods. To address these issues, a hybrid metaheuristic optimization algorithm—combining Genetic Algorithm (GA), Glowworm Swarm Optimization (GSO), Adaptive Acceleration Coefficients (AAC), and Variable Acceleration Social Particle Swarm Optimization (VASPSO)—is employed to determine the optimal placement and sizing of DSTATCOM and PV units.

Three main post-integration scenarios are examined: free-location with high capacity, free-location with capacity limits, and fixed-location with different maximum sizes. Performance metrics, including active power losses, reactive power losses, VSI, and minimum voltage, are evaluated hourly across a 12-hour period. The results confirm that coordinated integration improves network performance by reducing losses and enhancing both voltage stability and voltage profiles, with the highest benefits achieved when location flexibility and higher unit capacities are allowed. This work provides valuable insights for the design and operation of smart distribution systems, highlighting the importance of strategic resource allocation in achieving efficiency, stability, and sustainability.

Keywords: Distribution Network; DSTATCOM; Photovoltaic (PV),;Voltage Stability Index; Power Loss Minimization; Hybrid Optimization

Improving Power quality in grid connected hybrid renewable energy system

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Abstract: In the past few years, Renewable energy has emerged as a promising and sustainable option for addressing energy and climate challenge. The integration of Hybrid Renewable Energy Sources , presents significant Power Quality challenges in modern electrical grids. Grid connection of these systems often results in reliability concerns due to generation fluctuations and harmonic distortions introduced by power electronic converters. Inverters are an important component in power energy production, and their design has a big impact on the system's efficiency.

This paper presents a comparison between Two and Three-Level converter topologies for renewable energy applications. Three-Level Neutral Point Clamped (NPC) topologies benchmarked Two-Level Voltage Source Converter in terms of efficiency and power. To evaluate the performance of two topologies, Model predictive control is used. Implementation in MATLAB and comparative analysis demonstrate the that Three-Level topologies perform better than the two-level inverter by reducing THD, thereby improving the performance of system.

Keywords: Hybrid Renewable energy, Power Quality , Three-Level converter, harmonic distortions

Comparative Study of Solar Variability at two Climatically Different Sites in Algeria: Ghardaia and Batna

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Abstract: This study investigates solar irradiance variability across two climatically distinct regions in Algeria: Ghardaia and Batna, using Global Horizontal Irradiance (GHI) data extracted from the NSRDB database. Several statistical and variability indices were applied, including the Daily Clear Sky Index (KT∗), the standard deviation of difference in the clear‑sky index for each day $\sigma(\Delta kt\,\Delta t*)$ Variability Index (VI), and the daily probability of persistence (POPD∗). The results indicate that desert region (Ghardaia) exhibit high and stable irradiance, while mountainous region (Batna) display seasonal variability due to cloud cover. The result demonstrates that the variability of solar irradiance is better explained by POPD∗ (R2=0.88 in Ghardaia, R2=0.85 in Batna) than by the standard deviation (R2=0.60 in Ghardaia, R2=0.43 in Batna). The VI has no physical interpretation; it is intended for comparison between days and sites These findings emphasize the significance of characterizing the variability metrics into energy planning to support the reliable integration of solar power into Algeria's electricity grid.

Keywords: Global Horizontal Irradiance; NSRDB; Variability ; Clear Sky Index; Standard deviation; probability of persistence

Contribution of Grid-Connected Photovoltaic Systems to Sustainable Development and Energy Transition

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Abstract: In a context marked by the challenges of sustainable development and energy transition, grid-connected photovoltaic (PV) systems have emerged as a strategic solution to reduce dependence on fossil fuels and limit the environmental impacts of electricity generation. Their integration enables the effective use of local renewable resources while ensuring continuity and reliability of power supply.

This work focuses on the role of grid-connected photovoltaic systems in improving the energy and economic performance of electrical installations through an analysis of energy exchanges between photovoltaic production, local consumption, and the electrical grid. The study is conducted using the HOMER Pro simulation software, allowing the evaluation of imported and exported energy flows as well as the net exchanged power, according to solar irradiance profiles and photovoltaic field sizing.

The obtained results show that the electrical grid plays a key role in energy balancing by facilitating the integration of intermittent photovoltaic energy and contributing to overall system stability. From an economic perspective, the analysis highlights the significant influence of tariff policies and optimal system sizing on the profitability of grid-connected PV systems. Therefore, this study emphasizes the importance of on-grid photovoltaic systems as a major driver of sustainable development and energy transition, particularly in the building sector.

Keywords: Keywords: Grid-connected photovoltaic systems, Sustainable development, Energy transition, Energy and economic analysis, HOMER Pro.

Intelligent Control of a PV-Battery Supported Active Power Conditioner for Harmonic Compensation and Grid Stability Enhancement

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Abstract: This paper presents an intelligent control strategy for a photovoltaic (PV)-battery supported active power conditioner designed to improve power quality and enhance grid stability in distribution networks supplying nonlinear loads. The proposed system integrates a PV array and a battery energy storage system (BESS) on the common DC-link of a shunt active power conditioner, enabling simultaneous renewable energy utilization, harmonic mitigation, and DC-bus voltage stabilization. The PV system serves as the primary energy source, while the battery compensates for power fluctuations and maintains continuous operation during variations in solar irradiance and load demand. To achieve accurate harmonic extraction and reference current generation, a Dual Second-Order Generalized Integrator (DSOGI) is employed under distorted grid conditions. An adaptive Least Mean Square (LMS) algorithm is utilized to estimate load current components and generate compensation signals in real time. The proposed control strategy provides fast convergence, high tracking accuracy, and robust performance under dynamic operating conditions. The effectiveness of the proposed system is evaluated through simulation studies involving nonlinear loads, abrupt load variations, and changing irradiance levels. The results demonstrate significant harmonic suppression, reducing source current total harmonic distortion (THD) to approximately 1%, while maintaining near-unity power factor operation. In addition, the battery-supported DC-link ensures stable voltage regulation with a settling time of less than 0.1 s during transient events. The coordinated operation of the PV array, battery storage system, and active power conditioner significantly enhances power quality, dynamic response, and grid reliability, making the proposed approach suitable for modern renewable-energy-based distribution systems.

Keywords: Photovoltaic system (PV); Battery Energy Storage System (BESS); Shunt Active Power Conditioner; Dual Second-Order Generalized Integrator (DSOGI); Harmonic Mitigation

Hybrid PV‑Battery Supported Dynamic Voltage Restorer for Advanced Power Quality Enhancement in Distribution Networks

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Abstract: Power quality disturbances such as voltage sags, swells, harmonics, unbalanced voltages, and short-circuit faults represent major challenges in modern distribution networks and can significantly affect sensitive electrical loads. This paper presents a hybrid photovoltaic (PV) and battery energy storage system (BESS) integrated Dynamic Voltage Restorer (DVR) for advanced power quality enhancement. The proposed configuration combines a PV array and a battery storage unit through a common DC-link to provide continuous energy support and improve the compensation capability of the DVR under varying operating conditions. An advanced Load Voltage Control (LVC) strategy is employed to generate the reference compensating voltage and ensure accurate load voltage regulation. The PV system supplies renewable energy during normal operating conditions, while the battery compensates for power fluctuations and supports the DVR during low irradiance periods and severe voltage disturbances. This coordinated operation enhances the stability of the DC-link voltage and improves the dynamic performance of the compensation system. The proposed PV-BESS-DVR is evaluated in MATLAB/Simulink under various disturbance scenarios, including voltage sags, swells, harmonic distortion, unbalanced voltages, and short-circuit events. Simulation results demonstrate effective restoration of the load voltage and significant harmonic suppression. Under a source voltage THD of 15%, the proposed system reduces the load voltage THD to below 0.6% while maintaining stable operation during transient disturbances. Furthermore, the battery-assisted DC-link improves compensation continuity and system reliability. The results confirm that the proposed hybrid PV-BESS-DVR provides an effective and sustainable solution for enhancing power quality in modern distribution systems.

Keywords: Dynamic Voltage Restorer (DVR); Photovoltaic System; Battery Energy Storage System (BESS); Power Quality Improvement; Voltage Sag and Swell Compensation; Load Voltage Control (LVC).

Development of a new insulating composite based on diss fibers and terracotta waste for energy-efficient building envelopes

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Abstract: The building sector is currently facing major ecological challenges due to its high consumption of energy and natural resources, substantial CO_2 emissions, and large generation of construction waste. In response, developing sustainable materials based on local and recycled resources represents a promising approach to enhance building energy efficiency and reduce environmental impact.

This study presents a new insulating composite combining diss plant fibers (Ampelodesmos mauritanicus) with terracotta waste powder, used as a pozzolanic component partially replacing hydrated lime. The proposed approach promotes the valorization of local natural resources and recycled mineral by-products while targeting improved thermal insulation and hygrothermal comfort in buildings.

Initial experimental tests were conducted to assess the main physical and hygrothermal properties of the composite. Density, thermal conductivity, and hygric behavior were analyzed to evaluate its insulation capacity and moisture regulation ability.

The results show the positive effect of incorporating plant fibers and terracotta waste powder into the lime matrix. This combination leads to a lightweight material, promotes better moisture regulation, and contributes to enhanced thermal insulation performance. These findings demonstrate the potential of the developed composite as a sustainable construction material better suited to the energy-efficiency requirements of buildings. Further investigations on mechanical performance and durability are needed to complete its characterization and assess its long-term behavior.

Keywords: insulating materials; diss fibers; terracotta waste powder; hygrothermal performance; bio-based materials; eco-materials

Microstructural study of a MgFe1.9La0.1O4 spinel synthesized by nitrate method, dedicated for nuclear waste storage.

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Abstract: In this study, we synthesized a spinel ceramic with the chemical formula MgFe1.9La0.1O4 using a nitrate method. The Lanthanum (La) is considered as a simulator of radioactive waste. The characterization of the synthesized material was carried out by several analysis techniques. Archimedes' density using a pycnometric method gave a value 3.8225 g/ cm3. X-ray diffraction (XRD) analysis was used to track the progress of the synthesis and confirm the formation of a major phase with a cubic spinel structure, characterized by its most intense peak at $2\theta \approx 35°$ corresponding to the (311) crystal plane, which is in perfect agreement with the JCPDS standard datasheet 98-024-0816. Observation using a scanning electron microscope (SEM) allowed us to observe the distribution of grains and pores and estimate the quality of sintering, combined with analysis using X-ray energy dispersive spectrometry (EDX), which allowed us to check the global chemical composition of the sintered matrix. Fourier transform infrared (FTIR) analysis of spinel MgFe1.9La0.1O4 shows essential absorption bands between 400-4000 cm^{-1}.Two absorption bands can be seen at 550 cm^{-1} corresponding to Fe-O vibrations, and an absorption band at 450 cm^{-1} corresponds to Mg-O vibrations.

Keywords: Spinel; Lanthanum; Nitrate method; XRD; SEM; FTIR.

Study Of ScVX Half Heusler Alloys In DFT Frame And Spintronic's Application

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Abstract: Half-Heusler alloys are promising for advanced spintronics applications due to their unique electronic properties. This study focuses on the crystal structure and electronic properties of ScVX alloys, where X varies between germanium (Ge) and silicon (Si). Using density functional theory (DFT) calculations with the Wien2k code, we estimated that the band gap energy for ScVSi is about 0.5 eV, while for ScVGe it is about 0.3 eV. The Fermi level was calculated to be approximately −4.5 eV for both compounds. These results show that substituting Ge with Si in the ScVX structure can significantly modify the electronic properties, offering promising prospects for the development of more efficient spintronic devices.

Keywords: Spintronic's, DFT, half heusler alloys

Study of Mn3Al full heusler alloys for spintronics in the frame of DFT

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Abstract: This study investigates the electronic, magnetic, and structural properties of AMn3Al Heusler alloys for spintronic applications. Using DFT simulations with the Wien2k code, we apply the GGA and the MBJ potential to analyze how the crystal structure affects these properties. The alloys exhibit metallic behavior, with a continuous density of states at the Fermi level. Notably, the band energy is reduced to -0.5 electronvolts, and the Fermi level stabilizes at -3.2 electronvolts. We observe strong ferromagnetism, with a total magnetic moment of 2 bohr per atom. Moreover, we identify a significant spin-orbit coupling effect, which, combined with GGA and MBJ corrections, further stabilizes the magnetic ordering and influences the band structure. These results underscore the potential of these alloys, as their metallicity, robust ferromagnetism, and strong spin-orbit coupling, enhanced by GGA and MBJ, make them ideal candidates for advanced spintronic devices, paving the way for future experimental and technological progress in the field».

Keywords: Spintronics, full heusler alloys, DFT,half metalicity

The microstructural properties of thin films prepared by physical vapor deposition

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Abstract: We used the thermal evaporation technique under vacuum to synthesize a series of 100 nm Fe1−xPdx thin flms onto Si (111) substrate, with x representing the palladium content ranging from 16 to 36 at%, as quantifed by energy dispersive X-ray spectroscopy tool.
The measured microstrain was positive, indicating that the thin films were under tensile stress.

The microstrain values are positive and increase from 0.05% to 0.68% as the Palladium Pd content increases from 16 at% to 36 at%. These positive values of infer that the Fe1− xPdx thin films are subject to tensile stress ,.

Values of the lattice strain around 0.52% have been measured by Okumura et al. in their iron-palladium films produced by high energy ball milling and vacuum sputtering methods. The variations of the lattice strain as a function of crystallite size L. This figure clearly shows a monotonic decrease in lattice strain with increasing crystallite size L .

Keywords: Microstrain:; Tensile stress ;Thin films; Crystallite size;.

Experimental Investigation of Boride Layer Formation on XW-5 Steel

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Abstract: The boriding treatment was applied to XW-5 steel to investigate the formation and growth of boride layers .The morphology of the boride layers was examined using scanning electron microscopy (SEM), enabling measurement of the layer thicknesses as a function of treatment time and temperature. Phase analysis was performed by X-ray diffraction (XRD) to identify the nature of the formed phases. Three boriding conditions were investigated. The evolution of layer thickness with treatment time was analyzed to characterize the growth kinetics of both FeB and Fe2B phases over the studied temperature range (900–1000°C). The obtained results provide quantitative data on boride layer development and constitute an experimental basis for understanding the thermochemical behavior of XW-5 steel under boriding conditions.

Keywords: Boriding;boride layers;X-ray diffraction (XRD);scanning electron microscopy (SEM)

Effect of Annealing Time on Cu_2ZnSnS_4 Thin Films Deposited on FTO Substrates by Electrodeposition for Photovoltaic Applications

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Abstract: Kesterite Cu2ZnSnS4 (CZTS) is a promising absorber material for photovoltaic applications due to its low cost, non-toxic elements, and earth abundant constituents. It exhibits a direct band gap of 1.5 eV and a high absorption coefficient (>104 cm-1) .

CZTS thin films were deposited on FTO/glass substrates by electrodeposition using a two-electrode system. The electrolyte bath consisted of CuCl2, ZnSO4.7H2O, SnCl2.H2O, and Na2S2O3·5H2O as precursor materials. The films were then sulfurized and annealed at 550°C.

To investigate the effect of annealing time, two representative durations (15 and 90 min) were selected.

The structural properties were analyzed by X-ray diffraction (XRD), while Raman spectroscopy was used to confirm the phase composition.

XRD analysis confirms the formation of the kesterite CZTS phase with a preferred orientation along the (112) plane. The film annealed for 15 min shows the presence of secondary phases such as SnS related compounds, whereas these phases disappear in the 90 min sample, indicating improved phase purity. In addition, the crystallite size increases with annealing time, reflecting enhanced crystallinity.

Raman spectroscopy further confirms the kesterite structure with characteristic peaks around 306-310 cm-1, supporting the XRD results and indicating improved phase quality at longer annealing time .

These results demonstrate that annealing time significantly influences the structural quality and phase purity of CZTS thin films, making it a key parameter for optimizing their photovoltaic properties.

Keywords: Cu2ZnSnS4; Thin films; Electrodeposition; Annealing time; X-ray diffraction; Raman spectroscopy.

Power Quality Enhancement of Grid Connected Solar Photovoltaic System Using LCL Filtre

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Abstract: The integration of renewable energy sources into the AC grid through power converters has significantly increased over the past two decades. To connect these power converters to the utility grid and address the high-order harmonics generated by the converter, an LCL filter is commonly deployed. Achieving high filtering performance that complies with strict grid code requirements while maintaining a balance between cost and efficiency necessitates an optimal LCL filter design. This paper introduces a modeling approach and a comprehensive design methodology for LCL filters in grid-connected converters, utilizing an analytical approach. Simulation results demonstrate that this method effectively mitigates 99% of current harmonics at the converter output.

Keywords: LCL Filter, Inverter, Grid connected, Passive damping, Photovoltaic systems

Study and Design of a Photovoltaic Water Pumping System for the Irrigation of Agricultural Land in the Tlemcen Wilaya

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Abstract: This work presents a technical and economic feasibility study for the implementation of a photovoltaic (PV) water pumping system designed for the irrigation of agricultural land located in the Tlemcen wilaya, Algeria. In the context of limited access to conventional electricity in rural areas and increasing pressure on water resources, solar-powered pumping represents a sustainable and economically viable alternative. The study focuses on the optimal sizing of the PV system based on the irrigation water requirements of the crops, the solar potential of the Tlemcen region, and the hydrogeological characteristics of the water source. The methodology includes the calculation of the required hydraulic power, the selection of the appropriate photovoltaic modules and pumps, and the evaluation of system performance under varying climatic conditions. A comparative analysis with conventional diesel-powered systems is conducted to assess both profitability and environmental impact. The results demonstrate that photovoltaic pumping systems can significantly reduce operating costs and greenhouse gas emissions, while ensuring reliable water supply for agriculture. This solution offers a promising pathway toward sustainable rural development and energy transition in semi-arid regions of North Africa.

Keywords: Photovoltaic water pumping; Solar energy; Irrigation system; System design; Energy efficiency.

Hybrid Solar–Hydraulic System for Sustainable Irrigation in Semi-Arid Regions: A Case Study in Tlemcen, Algeria

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Abstract: The growing scarcity of water and the rising energy demand in semi-arid regions such as Tlemcen, Algeria, highlight the need for sustainable and efficient irrigation solutions. This study presents a hybrid solar–hydraulic system that integrates photovoltaic and wind energy to power water pumping for agricultural applications. A techno-energetic modeling approach was applied using climatic and hydraulic data specific to Tlemcen to assess the system's performance. Simulation results show that the hybrid configuration increases overall energy efficiency by more than 20% compared to conventional diesel systems, while reducing energy costs by approximately 30%. The use of renewable energy also decreases CO_2 emissions by about 2.5 tons per hectare per year. The system demonstrates strong reliability, economic viability, and significant potential for sustainable water management in semi-arid environments. The findings confirm that integrating renewable energy into hydraulic infrastructures can support both energy transition and agricultural resilience in North Africa.

Keywords: Hybrid solar–hydraulic system; Renewable energy; Water pumping; Energy efficiency.

A Hybrid Particle Swarm Optimization with Velocity Pausing and Adaptive Strategy for Optimal Wind Turbine integration in radial Distribution Networks

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Abstract: Improving the performance of the distribution system through the integration of renewable energy resources involves multiple technical dimensions. In this context, this research paper presents an optimal approach for integrating distributed generation based on wind turbines (WT) into the radial distribution system (RDS), in order to analyse the impact of integrating these units on reducing active (TAPL) and reactive (TRPL) power losses, and improving voltage profile in the distribution system. This study is based on an innovative approach utilizing a hybrid optimization method that combines the Particle Swarm Optimization (PSO) algorithm with the Velocity pausing and Adaptive Strategy (VAS) algorithm. The proposed algorithm improves the search process by integrating time-varying inertia coefficients, a velocity pausing mechanism, and adaptive strategies, thereby achieving an effective balance between global exploration and local exploitation. Simulations demonstrated the efficiency of the proposed algorithm in determining the optimal location and size of WT units within the IEEE-33 bus, whilst maintaining the voltage profile within acceptable limits. The TAPL decreased by 94.49% to 11.629 kW, whilst the TRPL reached 9.696 kVar, representing a 93.23% reduction in power losses compared to the base case. This integration also led to an improvement in the voltage profile, with minimum voltage (Vmin) reaching 0.992 (p.u), representing a 9.76 % improvement compared to the base case.

Keywords: renewable energy resources ; wind turbines ; radial distribution system ; Particle Swarm Optimization ; Velocity pausing and Adaptive Strategy optimal ; Optimal integration

An adaptive state of charge estimation method For Battery, PV

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Abstract: This paper investigates the state of charge (SOC) estimation of batteries because SOC is a critical parameter that reflects the available energy in a battery at any given time. Accurate SOC estimation is essential for ensuring safe operation, optimizing performance, and extending battery lifespan. Without reliable SOC information, energy systems risk inefficiency, premature degradation, or even unsafe operating conditions. This study is significant because batteries are at the heart of renewable energy integration, electric vehicles, and smart grids. By improving SOC estimation methods, we enable better energy management, reduce costs, and enhance sustainability. In short, SOC estimation contributes directly to the reliability and efficiency of modern energy systems. The paper focuses on practical SOC estimation methods. It begins with the implementation of a conventional Coulomb counting algorithm, which is then refined using an adaptive correction law to address its inherent limitations. All approaches are evaluated through simulation to assess their accuracy and dynamic response. The results demonstrate the reliability of each method and their suitability for integration into real-time energy management systems.

Keywords: Modelling, Coulomb Counting Algorithm, MRAC

Adaptive Flux Control for Reducing Power Losses in BLDC Motor Drives

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Abstract: This work presents an adaptive flux control approach to improve the efficiency of brushless DC motor drives. In conventional direct torque control, the stator flux is usually kept constant, which may increase power losses when the motor operates under different speed and load conditions. To solve this problem, two adaptive methods are studied: incremental conductance and fuzzy logic control. Both methods adjust the stator flux reference in real time in order to reduce unnecessary losses while keeping good motor performance. The proposed control strategies were tested using a hardware-in-the-loop experimental platform with a 100 W BLDC motor model. The results show that adaptive flux control can reduce total power losses compared with the fixed-flux method. The incremental conductance method improved the system efficiency and reduced losses by about 10.22%. The fuzzy logic controller gave the best performance, achieving a loss reduction of about 25.55% and increasing the system efficiency to 66.59%. These improvements are mainly due to better flux adjustment and lower copper losses during changing operating conditions. The obtained results confirm that adaptive flux control is a promising solution for energy-efficient motor drives. This approach can be useful in applications such as electric vehicles, renewable-energy systems, and industrial drives where reducing energy consumption is important.

Keywords: BLDC motor; adaptive flux control; fuzzy logic control; incremental conductance; power loss reduction; energy efficiency.

Dandelion optimization-based MPPT for PV operating under varying weather conditions

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Abstract: Solar energy systems face the challenges of varying temperature and solar radiation scenarios that affect their efficiency and the total power output of the photovoltaic array. To overcome these challenges, MPPT methods are applied as a suitable solution to increase efficiency and maximize output power under various scenarios. However, each method has disadvantages regarding efficiency in tracking maximum power, responsiveness, and stability to weather changes. This paper proposes a dandelion optimizer (DO) algorithm inspired by nature, which draws inspiration from the movement of dandelion seeds over long distances under the influence of wind force. This study contributes to assessing the efficacy of the method and compares the results with the GWO algorithm, PSO algorithm, and traditional P&O technique. Using the MATLAB/Simulink simulation environment, the obtained results indicate that the applied algorithm has good performance and high efficiency in energy harvesting, better tracking ability, higher stability, and faster response compared to other strategies.

Keywords: Dandelion optimizer;GWO algorithm;PSO algorithm;P&O technique;MPPT

Geothermal-Assisted Cooling for Energy-Efficient Semi-Buried Buildings in Southern Algeria

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Abstract: The residential sector in Algeria is characterized by high energy consumption, especially in desert regions where cooling demands are significant during hot seasons. In this context, improving building energy efficiency and integrating renewable energy sources have become essential for reducing electricity consumption and enhancing indoor thermal comfort. This study investigates the potential of geothermal energy as a passive cooling solution for semi-buried buildings located in the hot desert climate of southern Algeria. The proposed building design consists of a room buried at a depth of 3 m, with only a small part remaining above ground level to provide natural lighting and ventilation. Airflow and heat transfer inside the building were analyzed using Computational Fluid Dynamics (CFD) simulations through ANSYS-Fluent software. The numerical model was based on the continuity, Navier–Stokes, and energy equations, with consideration of natural convection effects. Initial simulation results indicated indoor temperatures ranging from 30 to 33°C at a height of 2 m. To improve thermal performance, several simple design modifications and a small ventilation system were introduced. The optimized configuration significantly reduced indoor temperatures to values between 24 and 26°C, providing acceptable thermal comfort while requiring negligible electrical energy for cooling. The results demonstrate that geothermal-assisted semi-buried buildings can effectively reduce cooling energy demand and offer a sustainable, low-cost, and environmentally friendly solution for buildings in arid and desert climates.

Keywords: Geothermal energy; Semi-buried buildings; Energy efficiency; Thermal comfort; Desert climate; CFD simulation

Evaluation and Comparison of FLC and PSO MPPT Techniques in PV Systems

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Abstract: Photovoltaic (PV) systems are widely used in renewable energy generation; however, their performance is significantly affected by environmental conditions, particularly variations in solar irradiance and temperature. These changes continuously alter the operating point of the PV array, making it challenging to maintain operation at the maximum power point (MPP). Conventional maximum power point tracking (MPPT) techniques, although simple and easy to implement, generally exhibit slow convergence and limited tracking accuracy under rapidly changing environmental conditions.To overcome these limitations, intelligent control strategies have been developed to improve tracking efficiency and system stability. This study presents a comparative analysis of two intelligent MPPT approaches: Particle Swarm Optimization (PSO) and Fuzzy Logic Control (FLC). An accurate photovoltaic model based on a two-diode equivalent circuit, including both series and shunt resistances, was implemented in MATLAB/Simulink to realistically represent the nonlinear behavior of the PV module.Simulation results under various operating conditions show that both intelligent methods significantly enhance dynamic performance compared to conventional techniques. However, the FLC-based controller demonstrates superior overall performance, achieving faster convergence, higher tracking accuracy, and stronger robustness against irradiance fluctuations. Consequently, it provides improved efficiency and reliability for photovoltaic power generation systems.

Keywords: PV Systems; MPPT ; FLC ; PSO; Matlab /Simulink.

Contribution of using pv-statcom in power quality improvement

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Abstract: The increasing penetration of renewable energy sources in electrical distribution networks has introduced significant power quality challenges, including voltage fluctuations, harmonic distortion, poor power factor, and increased reactive power demand. Conventional mitigation techniques such as passive filters and capacitor banks often provide limited and inflexible compensation. This paper investigates the role of a photovoltaic-based Static Synchronous Compensator (PV-STATCOM) in enhancing power quality and system reliability. Implemented using a Voltage Source Converter (VSC), the PV-STATCOM operates as a shunt active filter capable of dynamically injecting or absorbing active and reactive power at the point of common coupling (PCC). An advanced control strategy based on the wavelet decoupling method is employed to effectively compensate reactive power and suppress harmonic distortions under nonlinear and variable load conditions. Simulation results obtained using MATLAB/Simulink demonstrate that the proposed system significantly improves power qualiry, reduces total harmonic distortion (THD), and achieves a near-unity power factor. These results confirm that PV-STATCOM technology provides an effective solution for maintaining IEEE power quality standards in renewable-integrated distribution systems.

Keywords: PV-STATCOM, Power Quality, ReactivePower Compensation, Harmonic Mitigation, Decoupled dq-current control Distributed Generation

A NOVEL HIGH-DC/DC BOOST CONVERTER BASED ON COUPLED INDUCTOR AND SWITCHED CAPACITOR TECHNIQUES FOR AI-BASED MPPT DESIGN IN A PV SYSTEM

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Abstract: This article introduces a novel high-voltage DC-DC boost converter designed to explore maximum power point tracking (MPPT) strategies in photovoltaic (PV) systems through the application of Artificial Intelligence (AI) techniques. The proposed topology is a non-isolated boost converter with high voltage gain, consisting of an input inductor, a coupled inductor, five capacitors, and three diodes. The inductor's connection to the input minimizes input current disturbance, which is crucial for precise Maximum Power Point (MPP) tracking of PV panels. The primary switch remains operational even under zero-current conditions; thereby further reducing switching losses, as the voltage across MOSFET QS is limited by diode D1 and capacitor C1.
In this investigation, two AI-MPPT strategies are implemented: a fuzzy logic controller (FLC-MPPT) and a feed-forward artificial neural network (FANN-MPPT). The PV system is simulated and controlled using MATLAB/Simulink, which also monitors the optimal power point at a suitable operating temperature and fluctuating solar irradiance level. The efficacy of each MPPT approach is assessed through simulation results.

Keywords: Photovoltaic (PV), AI-MPPT, Feed-forward artificial neural network (FANN-MPPT), fuzzy logic control (FLC-MPPT), DC-DC boost converter.

Performance Evaluation of a DFIG Wind Energy Conversion System Using Vector Control Technique

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Abstract: This article presents the modeling, control, and simulation of a wind energy conversion system (WECS) based on a Doubly Fed Induction Generator (DFIG) using the MATLAB/Simulink environment. Due to its high efficiency, flexible variable-speed operation, and reduced converter rating, the DFIG has become one of the most widely used technologies in modern wind power applications. The proposed system employs a vector control strategy to independently regulate the active and reactive powers by controlling the rotor currents in the synchronous reference frame. This control technique improves the dynamic response and ensures stable operation under variable wind speed conditions.

The simulation model consists of several main components, including the wind turbine, the DFIG machine, the Rotor Side Converter (RSC), the DC-link capacitor, the grid connection system, and the associated control blocks. A Pulse Width Modulation (PWM) technique is used to generate switching signals for the RSC in order to achieve accurate control of the rotor voltages and currents. The controller receives different feedback signals such as rotor currents, stator voltages, rotor position, and mechanical speed to produce the appropriate reference voltages.

The obtained simulation results demonstrate the effectiveness of the proposed control approach. The system shows good speed tracking capability, fast transient response, stable electromagnetic torque behavior, and reliable rotor current regulation. These results confirm that the combination of vector control and PWM techniques provides efficient and stable operation of the DFIG-based wind energy conversion system under different operating conditions.

Keywords: Doubly Fed Induction Generator Technology; Wind Power Conversion System; Advanced Vector Control; PWM-Based Converter Control; Rotor-Side Power Converter; Renewable Energy Systems

Development of a DNN model for biogas production using a hybrid BO-TPE approach in an anaerobic wastewater treatment plant

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Abstract: Deep neural networks have been regarded as accurate models to predict complex energy production processes due to their ability to learn from a huge number of data sets via artificial intelligence. To improve the performance of these models, the main challenge is to select the appropriate hyperparameters, such as: number of hidden layers and hidden units, activation function, optimizer, learning rate, and others. The use of a hybrid Bayesian optimization with tree-structured Parzen estimator (BO-TPE) to model biogas production from wastewater treatment plant data using deep neural network (DNN) has been performed.

The data preprocessing process has been carried out according to three steps: removing columns with many missing values, removing rows with significant missing data, and finally deleting the remaining missing values using dropna. Different normalization techniques, including standardization and RobustScaler, were compared.

This study presents a promising deep neural network (DNN), optimised using the hybrid BO-TPE method for modelling biogas production, which makes use of the many features of RobustScaler. This model predicts a maximum volume of 2,236.105 Nm^3/day and performs well (R^2 = 0.712, MAE = 164.610, RMSE = 223.429). The StandardScaler gives 2063.375 Nm^3/d with R^2 = 0.690 (MAE = 170.5179, RMSE = 231.5192). These results provide an autonomous approach to control key variables of a large digester installation for renewable energy production and combined heat and electricity generation.

Keywords: Deep neural network; Hybrid BO-TPE; Biogas; wastewater.

Techno-Economic Assessment of Hybrid System Based PV/FC/Battery/Electrolyzer to Supply Isolated Electrical Load.

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Abstract: This work presents the HOMER Pro techno-economic evaluation of an off-grid PV-battery-hydrogen hybrid renewable energy system for green hydrogen production under M'sila Wilaya climatic conditions, Algeria. The study aims to assess how photovoltaic generation, short-term electrochemical storage, water electrolysis, hydrogen storage, and fuel-cell backup can be optimally combined to supply a representative isolated electrical load. Monthly solar irradiation, temperature data, a 48 kWh/day load profile, economic assumptions, and component cost/sizing ranges were introduced in HOMER Pro. Three annual capacity shortage scenarios (0%, 2%, and 5%) were compared to analyze the effect of reliability constraints on optimal sizing, hydrogen utilization, and cost indicators. The 2% shortage case was retained as the reference compromise scenario. It selected a 22 kW PV array, 12 batteries, an 8.6 kW converter, a 5 kW electrolyzer, a 10 kg hydrogen tank, and a hydrogen-fueled generator representing the fuel cell. Results showed that PV is the dominant source for electricity production during day, while the battery provided short-term balancing and the hydrogen subsystem ensured complementary storage and backup support for load by using fuel cell during night. The optimal configuration achieved a NPC of about 65,090, a COE of 0.213/kWh, and a LCOH of 21.9/kg. Sensitivity analysis showed that stricter reliability increases cost and component sizes, whereas relaxed shortage reduces cost but weakens hydrogen utilization. The study confirms HOMER Pro's value as a decision-support tool for preliminary feasibility analysis of PV-based green hydrogen systems in Algerian high-solar-potential regions.

Keywords: HOMER Pro, PV/FC/battery, hydrogen, capacity shortage, NPC, COE

Design and Simulation of a Photovoltaic-Powered Automatic Irrigation System

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Abstract: The combined pressure of water scarcity and limited access to grid electricity poses significant challenges to agricultural productivity in arid and semi-arid regions of North Africa. In response to these constraints, this paper presents the development of an intelligent, energy-autonomous irrigation system powered entirely by solar photovoltaic energy and deployed on a 0.5-hectare agricultural site in Zribet El Oued, Biskra, Algeria.

The core innovation of the proposed system lies in its demand-driven irrigation strategy, governed by a distributed network of three capacitive soil moisture sensors placed at representative locations across the field. Water delivery is initiated only when soil humidity simultaneously drops below a critical threshold at multiple measurement points, thereby preventing both over-irrigation and under-irrigation. An additional water level monitoring subsystem embedded in the main storage tank ensures continuous availability of water and protects the pumping unit from dry-running conditions.

The photovoltaic power supply is carefully dimensioned using site-specific irradiation data from Biskra, with a daily peak sunshine duration of 4.9 hours, yielding an installed capacity of approximately 810 Wp. All system operations are validated through simulation, demonstrating reliable autonomous behavior under varying environmental conditions. The proposed approach offers a replicable, cost-effective, and environmentally sustainable model for modernizing irrigation infrastructure across Algeria and comparable semi-arid regions.

Keywords: Smart irrigation; photovoltaic energy; soil moisture sensor; water level monitoring.

Comparative Study of Conventional and CPC-Assisted Solar Stills

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Abstract: Water scarcity is a growing global challenge, particularly in arid and semi-arid regions where access to freshwater resources is limited. Solar desalination offers a sustainable and environmentally friendly solution; however, the low productivity of conventional solar stills remains a major limitation. To address this issue, the present work investigates the performance of a solar still integrated with a Compound Parabolic Concentrator (CPC) and compares it with a conventional solar still under Saharan climatic conditions.

An experimental study was conducted to evaluate the thermal behavior and freshwater productivity of both systems. Key operating parameters, including solar radiation, absorber temperature, basin water temperature, glass temperature, and distillate yield, were monitored throughout the experimental period. The influence of heat transfer fluids on system performance was also considered to enhance heat absorption and energy utilization.

The preliminary results indicate that the CPC-assisted solar still achieved higher operating temperatures and improved freshwater production compared with the conventional unit. The enhanced performance is mainly attributed to the increased solar energy concentration provided by the CPC, which promotes higher evaporation rates. The study demonstrates the potential of CPC technology as an effective approach for improving solar distillation performance in desert environments.

Keywords: Solar still, CPC, Solar desalination, Heat transfer fluid, Thermal performance, Freshwater productivity, Renewable energy.

Bio-Oil Production from Lignocellulosic Biomass: Influence of Operating Parameters

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Abstract: Bio-oil production from lignin represents a promising pathway for the valorization of lignocellulosic biomass and the development of sustainable biofuels. Due to its highly aromatic and complex polymeric structure, lignin is particularly suitable for the generation of energy-dense liquid products. Converting lignin in pressurized water at moderate temperatures allows its depolymerization into valuable liquid fractions without the need for prior drying, thereby improving the overall energy efficiency of the process.

This study focuses exclusively on alkaline lignin as a model compound to investigate its potential for bio-oil production. A kinetic model was developed to describe the transformation pathways of lignin and to predict the yields of bio-oil, solid residues, and water-soluble products. The model was experimentally validated and subsequently used to analyze the influence of key operating parameters, including temperature, biomass-to-water ratio, and residence time.

The results show that temperature plays a crucial role in controlling product distribution: excessively high temperatures promote secondary degradation reactions, leading to reduced bio-oil yields. Conversely, a higher lignin-to-water ratio enhances bio-oil formation, likely due to increased recombination reactions among reactive intermediates. The findings highlight the strong potential of lignin as a preferential feedstock for bio-oil production and provide valuable insights for optimizing operating conditions to maximize liquid fuel yields.

Keywords: Lignin, bio-oil production, alkaline lignin, kinetic modeling, operating parameters, thermochemical conversion.

Battery–Supercapacitor Hybrid Energy Storage for Photovoltaic Microgrids

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Abstract: Photovoltaic (PV) energy is one of the most promising Renewable Energy Sources (RESs) for sustainable power generation. However, its intermittent nature, mainly caused by solar irradiance variations, requires the integration of suitable Energy Storage Systems (ESSs) to ensure reliable operation. In PV Microgrids (MGs), using only batteries can provide energy support, but it may expose the battery to rapid current variations during transient power changes, which can accelerate degradation and reduce its lifetime. To overcome this limitation, this work studies a battery–supercapacitor Hybrid Energy Storage System (HESS) for PV MGs. The battery is used as the main energy storage device due to its high energy density, while the Supercapacitor (SC) is added to respond rapidly to fast power variations thanks to its high power density. The objective is to analyze the behavior of the HESS by observing the voltage, current, and State of Charge (SoC) responses of the battery and SC under variable irradiance and variable load conditions. The obtained results show that the battery provides smooth energy support, while the SC absorbs or delivers fast transient power. This complementary behavior reduces the dynamic stress on the battery and confirms the interest of battery–SC HESS for renewable energy storage in PV MGs.

Keywords: Microgrid; Photovoltaic; Renewable energy storage; Battery; Supercapacitor.

Model Predictive Current Control implementation of Three Phase Inverter for photovoltaic system

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Abstract: Model predictive control (MPC) implementation of Three Phase Inverter for photovoltaic system has been proposed, because of the good dynamic, high performance, accurate current tracking capability and the finite set of inputs or possible switching combination. Nowadays MPC becomes very attractive due to the advances in modern microprocessors, and present technologies available. The MPC uses a discrete-time model of the system to predict the future values of the load current and voltage for all possible voltage vector generated by the inverter. The voltage vector which minimizes a cost function is selected. The cost function is used to evaluate the voltage vector at the next sampling time. An optimal voltage vector is selected and the corresponding switching state is applied to the converter during the next sampling time. Finally, simulation results show that the MPC very effectively the load current and dynamic performance of the proposed system.

Keywords: Model predictive control (MPC), voltage source inverter, discrete-time model.

Sensor Fault Diagnosis in Dfig-Based Wind Turbines Using a Nonlinear Observer

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Abstract: This work introduces a fault diagnosis framework aimed at identifying failures in rotor current sensors within wind power conversion systems based on Doubly Fed Induction Generators (DFIGs). The developed approach supports real-time surveillance of rotor current measurements and enables the identification of sensor anomalies even under varying wind speed conditions. The framework leverages an Extended Kalman Filter (EKF) grounded in the nonlinear dynamic model of the DFIG and integrated with a fault detection scheme operating in the abc reference frame. Rotor currents are reconstructed by the EKF using stator current measurements and mechanical rotor speed as observable inputs. The resulting estimates are subsequently fed into a localization module capable of pinpointing defective sensors, whether faults occur individually or simultaneously across multiple channels. The proposed diagnostic framework was deployed on an FPGA platform and subjected to experimental validation. The obtained results confirm the system's capability to reliably track rotor currents and accurately diagnose sensor faults across a range of failure scenarios, encompassing both single-sensor and multi-sensor concurrent fault conditions.

Keywords: Wind Turbine; DFIG; Observer; FDI, EKF; Current Sensor; Fault.

Photovoltaic-Fed Shunt Active Power Filter Based on ADALINE Harmonic Detection and DSVM Control for Power Quality Improvement

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Abstract: This work presents a photovoltaic-fed shunt active power filter for improving power quality in a distribution system supplying nonlinear loads. The system is modeled in MATLAB/Simulink and includes a PV array, a DC-DC boost converter, a DC-link capacitor, and a voltage source inverter connected in parallel at the point of common coupling. The boost converter is controlled using the Perturb and Observe algorithm to extract the maximum available power from the PV panels under irradiance variations.

The inverter is controlled by Direct Space Vector Modulation, while the harmonic reference currents are obtained using an ADALINE algorithm. This adaptive approach allows the filter to identify the harmonic components of the load current and generate the required compensation currents in real time. The DC-link voltage is regulated by an anti-windup controller, which limits the effect of saturation and improves the response during transient conditions.

The use of PV panels gives the active filter an additional function compared with a conventional structure based only on a passive DC-link capacitor. Besides harmonic compensation, the system can supply renewable energy to the DC bus, reduce the power drawn from the grid, and improve the overall energy efficiency of the compensation system. Simulation results show that the proposed configuration reduces source-current distortion, improves the power factor, and maintains a nearly sinusoidal supply current under nonlinear load operation.

Keywords: Shunt active power filter; Photovoltaic system; ADALINE algorithm; Direct Space Vector Modulation; P&O MPPT; Power quality.

Experimental Investigation of an Inclined Solar Chimney Integrated into Residential Buildings for Natural Ventilation in a Hot-Arid Climate

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Abstract: This study investigates rooftop solar chimneys as a passive ventilation method for residential buildings, with the aim of improving indoor air quality and reducing airborne infection risks associated with COVID-19. The experiment was conducted at the University of Ouargla, Algeria, from May 8 to 13, 2021, under real hot-arid climate conditions. Two small rooms were built using the region's most common construction materials: local stone and hollow brick. The researchers analyzed how several parameters influenced chimney performance, including the building material, chimney inclination angles of 30°, 45°, and 60°, and air gaps of 0.15 m and 0.25 m. The results showed that installation factors have a major effect on solar chimney efficiency. Among them, the inclination angle was the most influential, improving performance by up to 20%. The choice of construction material was also significant. Using local stone instead of hollow brick improved performance by at least 15% during peak hours, while increasing the air gap contributed an additional 14% improvement. The best indoor air velocity was achieved with a solar chimney measuring 1 m by 0.65 m, an air gap of 0.25 m, and an inclination angle of 45°. In terms of ventilation, the solar chimney achieved air change rates of 5, 6.5, and 7.8 ACH at average solar radiation levels of 550, 800, and 950 W/m², respectively.

Keywords: Solar chimney; Natural ventilation; Hot-arid climate; Residential buildings; Air change rate.

Maximum Power Point Tracking Based on the Adaptive Fuzzy Logic Technique for a Wind Energy Conversion System.

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Abstract: Wind Energy Conversion Systems often exhibit slow dynamic responses when tracking the MPP, particularly under rapid and significant wind speed variations. Proposed a fuzzy logic system to adjust continuously the speed reference in manner to compensate the wind speed perturbation.

Keywords: Wind Energy Conversion System; Intelligent Perturb & Observe; Fuzzy Logic System; Variable Speed Conditions; Wind Disturbance Compensation.

Enhancing Performance in Ultra-Lean Hydrogen-Fueled Micro-Trapped Vortex Combustors via Oxygen Enrichment

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Abstract: Micro-combustion thermophotovoltaics (TPV) offer a promising pathway for renewable energy, enabling the direct conversion of the chemical energy contained within hydrogen into electricity with high power density and no moving parts. However, achieving efficient operation in the ultra-lean regime where equivalence ratio is lower than 0.5, remains a significant challenge due to thermal performance degradation. This study utilizes computational fluid dynamics (CFD) modelling to evaluate oxygen enrichment as a mitigation strategy within a hydrogen-fueled micro-trapped vortex combustor (MTVC). By varying oxygen concentrations from 21% to 33%, we analyze the trade-offs between radiative power, combustion efficiency, and pollutant nitrogen oxide (NOx) emissions. Our findings demonstrate that while oxygen enrichment enhances radiative power by up to 53% and improves combustion efficiency to over 99%, it simultaneously drives a substantial increase in thermal NOx production. Furthermore, we identify a critical safety threshold at 33% O2, beyond which flashback occurs.

Keywords: Micro-combustion; CFD; Hydrogen; Thermal performance; Oxygen enrichment.

Enhancing Finned Phase Change Material Performance for Improved Solar Photovoltaic Panel Efficiency

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Abstract: The rising popularity of solar energy through photovoltaic (PV) panels faces a critical challenge: high temperatures decrease efficiency. Innovative solutions are emerging, utilizing phase change materials (PCM) and cooling fins to enhance performance. This novel approach not only boosts energy output but also extends the lifespan of these vital systems. This study examines the performance of various complex fin shapes integrated into the PCM unit-enhanced PV panel, comparing them to a basic plate fin. The fin configurations analyzed include basic plate fins (BC), a tree-fin with double branches at 45° (C1), a tree-fin with double branches at 90° aligned with the thermal unit's middle (C2), and a tree-fin with double branches at 90°, featuring rounded corners and extended length beyond the unit center (C3). COMSOL Multiphysics software is used to conduct numerical simulations. The findings indicated that incorporating the proposed fins with PCM enhanced the melting rate of PCM and improved the PV efficiency. Among the four fin configurations studied, it was evident that the C1 fin configuration achieved the best performance compared to the other configurations. The melting time for C1 was improved by 17.1 %, and the PV efficiency was improved by 2.4 % compared to the base case.

Keywords: PV-PCM system; Fine branchers; PCM melting process; PV efficiency.

Experimental Investigation of Renewable Energy Technique: Effect of Material and Chicane on Solar Chimney Performance

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Abstract: Hot dry region are characterized by important renewable sources widely spread like sun, wind geothermal, etc. In the same time, summer and winter inside building thermal comfort requirement are hardly to achieve with the use of system which are big energy consuming as air conditioning systems. Solar energy can be used for heating, cooling and natural ventilation purposes. In the present study, an experimentally vertical cylindrical solar chimney with internal steel and Polyvinyl Chloride (PVC) obstacles are investigated in south of Algeria. Thermal and hygrometry analysis of studied system were conducted. Results showed that vertical cylindrical solar chimney with internal steel obstacles increase air temperature from 23 to 52.4 °C without the use of any absorber or glassed surface. The effect of internal obstacles was investigated by comparing the performance of obstacles made of steel and PVC. The results confirm that steel obstacles (where T outlet air = 53 °C) are responsible for increasing outlet air temperature by 5 °C in comparison with PVC (48 °C). It is also found that this simple amelioration by using internals obstacles (steel and PVC) ameliorate both diurnal and nocturnal ventilation by increasing heat transfer between lateral wall and air inside the device. Hygrometry was slightly affected and the use of a humidification system in some cases could ameliorate the performance of the system.

Keywords: Solar Energy; Solar Chimney; Arid; Thermal Analysis; Renewable Energy.

Thermal Impact on the Energy Harvesting Performance of an Integrated Electromagnetic Linear Regenerative Suspension System

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Abstract: This paper investigates the thermal impact on the energy harvesting performance of an integrated linear electromagnetic regenerative suspension system operating in regenerative mode. Based on a quarter-vehicle model with electromechanical coupling, the proposed system is analyzed as an energy harvesting device capable of converting vehicle vibrational energy into usable electrical power under random Class C road excitation in accordance with ISO 8608. In addition, a parametric study is conducted to examine the influence of temperature-dependent coil resistance variation on both vibratory behavior and regenerative performance. The results show that increasing the coil resistance does not degrade body acceleration or average recovered power. On the contrary, a slight improvement in ride comfort and a small enhancement in energy recovery are observed. However, higher resistance values lead to larger suspension working space and dynamic tire deformation, which may negatively affect mechanical constraints and road-holding capability. These findings highlight the importance of incorporating thermal effects into the design and optimization of electromagnetic regenerative suspension systems for sustainable energy harvesting applications.

Keywords: Electromagnetic Regenerative Suspension; Energy Harvesting; Thermal Effect; Coil Resistance; Quarter Vehicle Model; Recovered Power.

Electrical Characterization of Dusty Solar Modules: Integrating Outdoor Experiments and the Single-Diode Model

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Abstract: This study addresses a research gap regarding the impact of dust accumulation on photovoltaic (PV) modules, with a specific focus on parameter extraction using the single-diode model (SDM) under dusty conditions. While dust effects on PV performance are well-studied, few have explored how existing models can accurately represent these effects. Experimental data from outdoor testing of small-scale modules subjected to artificially deposited dust were analyzed. The direct current parameters were then extracted using the SDM, with the application of an improved snake optimization algorithm to enhance accuracy. While efficiency uniformly decreases under dust presence, computational comparison between the clean module (P1) and the dusty module (P3) reveals a significant degradation in the algorithm's prediction quality under dust conditions. Specifically, when applying the SDM, the maximum root mean square error increases by 303.5% for P3 compared to P1. Regarding the extracted intrinsic parameters, the dusty module P3 exhibits a decrease of 24.2% in photocurrent, 80.1% in shunt resistance, 84.6% in diode saturation current, and 10.5% in the ideality factor relative to P1. These findings clearly suggest that the standard single-diode model inadequately represents dust effects, and confirm that partial shading serves as a weak approximation for dust accumulation.

Keywords: Dust Soiling; Equivalent Circuit Model; Optimization Algorithms; Parameter Identification; Photovoltaics; Single Diode Model.

Comparison of Trilateral Flash and Two-Phase Power Cycles for Heat Recovery

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Abstract: Effective heat recovery is essential for improving energy efficiency in thermodynamic systems. This study presents a comprehensive comparison between the Trilateral Flash Cycle (TFC) and a novel two-phase power cycle designed for heat recovery applications. The fluids used in the cycles were selected based on their environmental impact and favorable thermodynamic characteristics. A thorough thermodynamic analysis was carried out, employing the first and second laws of thermodynamics to evaluate system performance. The analysis emphasizes the thermodynamic performance of both cycles under similar operating conditions. Results indicate that the proposed two-phase power cycle surpasses the TFC in efficiency, with an exergetic efficiency that exceeds that of the TFC by 5.64%. The findings highlight the potential advantages of the two-phase cycle in enhancing energy recovery and overall system performance, making it a promising alternative for efficient heat utilization in thermodynamic systems.

Keywords: Heat recovery; Thermodynamic analysis; Exergetic efficiency; Thermal efficiency.

A Discrete Sensorless Solar Tracker Using Fixed Angular Steps for Enhanced Efficiency Across Diverse Locations in Algeria

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Abstract: Traditional solar tracking systems rely on continuous astronomical calculations and constant adjustments to maintain precise alignment with the sun, often resulting in high energy consumption and mechanical wear. This study proposes a simplified, sensorless discrete tracking strategy that replaces continuous positioning with a fixed angular step of 10° every hour. By prioritizing a practical balance between alignment accuracy and energy savings, this approach significantly reduces system complexity and power consumption. The proposed method was tested across geographically and climatically diverse locations in Algeria, including Blida and Tiaret. The results demonstrate that this fixed 10° hourly step reduces the tracker's internal energy consumption to just 0.2% of the generated power, while still capturing approximately 99% of the maximum available solar energy. These findings indicate that continuous tracking is unnecessary for practical applications, offering a highly reliable, cost-effective, and low-power solution for future solar energy systems.

Keywords: Discrete solar tracking; Fixed angular step; Sensorless control; Energy efficiency.

Optimal Energy Management of a Fuel Cell–battery–supercapacitor Hybrid Electric Vehicle

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Abstract: This paper presents an optimized energy management approach for a hybrid-powered two-wheel-drive electric vehicle (TWDEV), where a fuel cell (FC) serves as the main energy source, assisted by a battery and a supercapacitor (SC). The fuel cell is connected to the DC bus through a boost converter, while both the battery and the supercapacitor are interfaced via bidirectional DC/DC converters to enable efficient bidirectional energy flow. The proposed external energy maximization strategy (EEMS) ensures optimal power sharing among the three sources according to their dynamic characteristics. The fuel cell provides the steady-state power demand, the battery supplies the medium dynamic power variations, and the supercapacitor compensates for fast transient demands during acceleration and regenerative braking. Simulation results obtained in MATLAB/Simulink validate the effectiveness of the proposed EEMS.

Keywords: Two-Wheel Drive Electric Vehicle (TWDEV); Hybrid Power System; Fuel-cell (FC); Battery (Bat); Supercapacitor (SC); External Energy Maximization Strategy (EEMS).

Sustainable Synthesis of Hybrid Hydrochar-Based Adsorbents for Enhanced Dye Removal from Aqueous Media

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Abstract: Abstract – The properties and adsorption performance of two hybrid adsorbents, $ZnCl_2$-activated hydrochar (HZn) and magnetized hydrochar (HZn-M), were investigated for the removal of Rhodamine B from aqueous solutions. Physicochemical characterization (SEM-EDX, FTIR, XRD, and BET) revealed that zinc chloride activation significantly enhanced surface area and porosity, while Fe_3O_4 incorporation imparted magnetic properties but partially reduced pore accessibility. Adsorption performance was strongly influenced by pH and ionic strength. HZn exhibited optimal efficiency under alkaline conditions due to enhanced electrostatic attraction, whereas HZn-M showed improved performance in acidic media. Kinetic studies were best described by the Avrami model, indicating a complex multi-step adsorption mechanism. Isotherm analysis suggested predominantly monolayer adsorption behavior for both HZn and HZn-M. Maximum adsorption capacities at 30°C reached 72.39 $mg \cdot g^{-1}$ for HZn and 58.02 $mg \cdot g^{-1}$ for HZn-M. Thermodynamic parameters confirmed that the adsorption process is spontaneous and endothermic. Overall, the removal of Rhodamine B involves a combination of pore filling, electrostatic interactions, hydrogen bonding, and π–π interactions.

Keywords: Hybrid hydrochar; Magnetic biochar; Rhodamine B; Adsorption; Wastewater treatment.

Influence of Hybridization on Mass Reduction and Performance of a Composite Suspension Arm Triangle

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Abstract: This study focuses on the optimized design of an automotive suspension control arm made of an E-Glass/Epoxy and HS-Carbon/Epoxy hybrid composite. The primary objective is to achieve a significant reduction in unsprung mass while ensuring stiffness, mechanical strength, and durability tailored to real-world operational loads. An 8-ply hybrid laminate with a [0C/0G/0G/02C]S stacking sequence was modeled and analyzed using the finite element method (FEM) in ANSYS. The performance of this laminate was evaluated under combined static loading (bending + torsion), taking into account global stiffness, stress distribution, and compliance with the Tsai-Wu failure criterion. The results demonstrate that an optimized hybrid architecture enables substantial weight reduction compared to both the steel equivalent and a mono-material E-Glass/Epoxy laminate, while delivering equivalent or even superior structural stiffness. The HS-Carbon plies primarily contribute to increasing stiffness, whereas the E-Glass plies improve impact tolerance and help control manufacturing costs. This research confirms the high potential of E-Glass/HS-Carbon/Epoxy hybrid composites for developing lightweight, high-performance, and economically competitive automotive chassis components.

Keywords: Hybrid composites; E-Glass/Epoxy; HS-Carbon/Epoxy; Suspension wishbone; Finite element method; Static loading.

Development of an Electrochemical Sensor Based on Pectin Extracted From Orange Peel for the Detection of Dopamine.

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Abstract: As a non-toxic, biodegradable, and biocompatible anionic polysaccharide abundantly found in plant cell walls, pectin offers unique advantages for green electronics and sensor development. In this study, pectin was successfully isolated from agricultural waste (orange peels) to design a sensitive, rapid, and cost-effective electrochemical sensor for the neurotransmitter dopamine detection. To construct the sensing interface, a chitosan-pectin polyelectrolyte complex was prepared, combining the anionic properties of pectin with the cationic nature of chitosan. This biocomposite was then modified onto a gold electrode to serve as the receptor-transducer matrix. The electrochemical behavior of dopamine at the modified electrode was systematically investigated, and critical experimental detection conditions were optimized. Under optimized parameters, the developed biosensor exhibited satisfactory analytical performance, demonstrating a wide linear detection range spanning from 10^{-9} to 10^{-6} M and a remarkably low detection limit of $0.43x10^{-9}$ M.

Keywords: Electrochemical Sensor; Pictine; Chitosane; Biomass; Polyelectrolyte Complex; Dopamine.

Development of a Biodegradable Pla/vegetal Reinforcement Composite: Structure and Interactions

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Abstract: In this study, a biodegradable composite based on polylactic acid (PLA) reinforced with date pits powder (DPP) was elaborated by hot compression at 180°C under a pressure of 10 MPa for 5 minutes. Scanning electron microscopy (SEM) observations revealed that PLA exhibits irregular particles while date pits powder presents a granular and rough morphology, promoting better adhesion within the matrix. Infrared analysis (FTIR) revealed the appearance of new bands, indicating chemical interactions between PLA and DPP. Differential scanning calorimetry (DSC) results highlighted modifications in thermal transitions, reflecting the formation of new bonds. These results confirm the valorization potential of date pits for developing high-performance eco-friendly composites.

Keywords: Biodegradable Composite; Polylactic Acid (PLA); Date Pits Powder (DPP); FTIR.

Surface Potential Distribution on PVC Samples Charged by Corona Discharge

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Abstract: The aim of our work is to charge on polyvinyl chloride (PVC) samples by corona discharge and assess the distribution of the surface potential. Therefore, we released a laboratory experimental study on various samples of PVC (210 x 297) mm. The charging system, contains a tungsten electrode of 0.4 mm in diameter, put to a high voltage U, suspended at a height h of a stainless steel plane grounded. The corona inception voltage is measured Us = 12 kV which led us to choose the charging voltage U = 13 kV. The measurement of the potential surface V is released without contact using an electrostatic voltmeter (Trek model 341 B) having an electrostatic probe. Using a digital oscilloscope (Tektronix TDS 1012) equipped with an interface connected firstly to the electrostatic voltmeter through its analogue output and, secondly linked to a computer, we acquired then digitized the surface potential signal. The measurement probe mounted on a cart driven by a DC motor enables to scan the whole surface of the sample, and the computer processing of data allowed us to the cartography of the surface potential. The tests were released, firstly as a function of the inter-electrode distance h in both polarities of the corona discharge secondly, by interposing a metallic grid for the control of potential in our samples. We find that the decay potential is almost zero; PVC samples retain the electrical charges contrary to some fibrous dielectric where the electrical charges can migrate deep into the material.

Keywords: Surface Potential Distribution; Corona Discharge; Potential Cartography; Charging Voltage; PVC Sample.

Plasticizing Effect of Low Molecular Weight Poly(ethylene Glycol) on Thermal and Dynamic Mechanical Properties of Poly(lactic Acid)

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Abstract: Poly(lactic acid) (PLA) is attracting increasing attention as environmentally friendly substitute for petroleum-based plastics in many applications. However, PLA is characterized by a slow crystallization kinetics and exhibits a brittle behavior at room temperature, which may limit its large-scale industrial use. In this work, we investigated the effect of incorporation of poly(ethylene glycol) (PEG) of low molecular weight (400 g/mol), as plasticizer, on the properties of PLA. PLA-based films with different contents of plasticizer were prepared by solvent casting method and the obtained films were analyzed with differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA). The DSC results indicated the miscibility of the samples containing up to 20 wt% of PEG. The glass transition and cold crystallization temperatures decreased with increasing PEG content while the degree of crystallinity increased due to the improvement in PLA chain mobility with adding plasticizer. The sample plasticized with 30 wt% of PEG showed two distinct melting peaks, one corresponding to the PLA phase and the other to the PEG phase, suggesting a phase separation. The DMA results showed a decrease in the rigidity of the films with increasing PEG concentration and confirmed the decrease of the glass transition temperature with adding plasticizer.

Keywords: PLA; PEG; Plasticization; DSC; DMA.

Molecular Engineering of Green Organic Solar Cell Materials

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Abstract: The design of environmentally friendly organic chromophores for dye-sensitized solar cells (DSSCs) has emerged as an important strategy for developing sustainable photovoltaic devices. In this work, molecular engineering was applied to investigate the structural, electronic, and optical properties of a series of green organic sensitizers intended for DSSC applications. Density Functional Theory (DFT) and Time-Dependent Density Functional Theory (TD-DFT) calculations were performed to determine the frontier molecular orbital energies, energy gaps, absorption wavelengths and oscillator strengths. Particular attention was given to the alignment of the dye energy levels with the conduction band of Titanium dioxide and the redox potential of the electrolyte to evaluate electron injection and dye regeneration processes. The influence of molecular structure on light-harvesting efficiency and photovoltaic performance was analyzed in order to identify the most promising sensitizer configurations. The results suggest that strategic modifications of the molecular framework can significantly improve visible-light harvesting, promote more efficient charge separation, and enhance electron injection processes. These insights offer useful theoretical guidance for the rational design of efficient, environmentally sustainable, and low-toxicity organic chromophores for advanced green DSSC applications.

Keywords: Organic Solar Cells; DFT; TD-DFT; Quantum Chemical Calculations.

Evaluation of Energy Management Strategies for a Vehicle-To-Grid (V2G) System Integrating Renewable Energy in a Microgrid

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Abstract: Traditional electrical systems are currently facing significant constraints due to the continuous increase in energy demand as well as the growing integration of renewable resources, particularly solar and wind energy. These developments require solutions capable of ensuring the stability, flexibility, and efficiency of the power grid. In this context, smart grids represent an appropriate response to new operational and energy management requirements. This work focuses on the energy analysis of a Vehicle-to-Grid (V2G) system applied to a hybrid microgrid consisting of a diesel generator, a photovoltaic unit, a wind installation, and a fleet of electric vehicles connected to the grid. The main objective is to evaluate the contribution of V2G technology to optimizing energy management and improving the overall performance of the microgrid. The obtained results demonstrate that the integration of the V2G system promotes a better balance between power generation and demand, reduces the impact of fluctuations associated with renewable sources, and enhances system stability. They also highlight the effectiveness of this approach in frequency regulation, confirming its potential for next-generation power networks.

Keywords: Vehicle-To-Grid (V2G); Microgrid; Energy Management; Renewable Energy; Photovoltaic System; Wind Energy.

Volatile Organic Compound « Toluene » Removal by Coupling of Absorption and Biodegradation

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Abstract: Biological treatment processes such as biofilters, the bioscrubbers or biotrickling filters are widely used in the elimination of volatile organic compounds (VOCs). However, their use for the treatment of hydrophobic VOC is difficult to achieve because of their low solubility in water. The objective is to absorb hydrophobic VOCs in an immiscible organic phase for which the VOC has more affinity, followed by their degradation by means of activated sludge. But since most of organic solvents are expensive or / and their regeneration require other additional treatment, the choice of a liquid organic waste was considered. Di (2-EthylHexyl) Phthalate (DEHP) was selected as a biodegradable organic solvent to be implemented in a two-phase partitioning bioreactor (TPPB) dedicated to remove “Toluene”. In a first step, the absorption capacity of toluene in the selected organic solvent was examined according to the partition coefficients H. In a second step, toluene biodegradation in DEHP by non-acclimated activated sludge was carried out for different volume fractions of DEHP in water. Toluene showed high affinity for DEHP with H = 0.99 Pa.m3.mole-1. Both toluene and DEHP were completely consumed for 4.3 mg l-1 (initial toluene concentration) and a volume ratio of 0.1% DEHP in water.

Keywords: Activated Sludges; VOC; Biological Treatment; Absorption.

Advancing Blue Energy: Nanoporous Membranes and the Commercialization of Osmotic Power

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Abstract: The need for stable, carbon-free sources of renewable energy is driving innovations worldwide. The present article examines the latest innovations in osmotic energy (or 'blue energy'), emphasizing membrane technology advances and implications for commercial implementation in the mid-term (2025-2026). One can note the importance of using Pressure Retarded Osmosis (PRO) and Reverse Electrodialysis (RED) plants to take advantage of salinity gradients. The use of novel types of next-gen nanoporous membranes, such as lipid-based and slippery nanopores, brings unprecedented gains in power density and efficiency in terms of a threefold increase compared to current options. Undoubtedly, the theoretical possibility of covering a considerable share (up to 20%) of world-wide energy consumption with osmotic energy makes it an attractive source. However, osmotic energy technologies face some challenges that must be overcome to achieve full-scale commercial viability. First, the high LCOE requires achieving further technological maturity and economies of scale; thus, the industry should make additional efforts to reduce costs. Second, the problem of membrane fouling cannot be overlooked. Despite these impediments, the current state in the osmotic power sector is characterized by robust expected market growth and a CAGR of 31% forecasted between 2026 and 2040. Mainly, Such an optimistic approach is mostly due to ongoing and rigorous research and development work aimed at optimizing the properties of the membranes used for osmotic generation, as well as at perfecting their performance. Therefore, osmotic power looks set to play an important role in the energy mix of the future, contributing to accelerated decarbonization efforts and increasing energy security around the world.

Keywords: Osmotic Energy; Blue Energy; Nanoporous Membranes; Optimistic Approach.

Evaluation of Meteorological Parameters and Optimization Methods in Lstm-Based PV Forecasting

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Abstract: PV power prediction is crucial for reducing uncertainty in solar generation and enhancing the coordination of energy scheduling and grid operation. This study presents a data-driven framework for short-term photovoltaic (PV) power estimation based on Long Short-Term Memory (LSTM) networks, with an emphasis on evaluating the influence of input feature selection and optimization strategy on predictive performance. The proposed methodology is developed using a comprehensive two-year dataset and investigates multiple configurations combining PV power with meteorological variables, namely global solar irradiance (GSI) and ambient temperature, under different training strategies. Six configurations are constructed by varying input combinations and optimization algorithms. The first group of models is trained using Stochastic Gradient Descent (SGD), while the second group employs the Adaptive Moment Estimation (ADAM) optimizer. The results show that incorporating GSI and temperature leads to a moderate improvement in learning behavior, with a reduction in training error of approximately 3–4% compared to PV-only configurations. However, the most significant enhancement is observed when changing the optimization strategy. Models trained with ADAM achieve an improvement of about 10–11% in testing rRMSE compared to SGD-based models, decreasing from approximately 12.53% to 11.16%. This improvement is also reflected in the correlation coefficient, which increases to 97.98% for the best-performing configuration.

Keywords: Photovoltaic Power Forecasting; Long Short-Term Memory (LSTM); Deep Learning; Solar Irradiance; Short-Term Prediction; Renewable Energy Systems.

Bridging Excitonic Emitters and Waste-Heat Engines: The Dual Nature of Rb2Cu (AL,Ga)Br6

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Abstract: Precisely controlled atomic substitutions in lead-free halide double perovskites reveal the transformative potential for advanced optoelectronics and high-temperature waste-heat recovery. In this work, we systematically investigate the physical properties of Rb2CuXBr6 (X=Al, Ga) using first-principles calculations. The substitution of Al by Ga leads to a strong d-block contraction which greatly enhances the covalent character of the Ga-Br bonds. This greater orbital hybridization leads to a shrank unit cell and a stiffer bulk modulus (33.54 GPa) with a complete preservation of the intrinsic mechanical ductility (Pugh's ratio ≥1.89) for flexible electronics. The unshielded Ga-4s states are pulled down to lower energies electronically, sharply closing the direct band gap from 1.13 eV to 0.361 eV. Thus, the wide-gap Al variant with large exciton binding energies (232 meV) and high infrared transparency is an ideal candidate for efficient light-emitting diodes. On the other hand, the Ga variant with a narrow bandgap shows an anomalous plasmonic resonance in the visible range (2.5 eV) and remarkable thermoelectric properties. The high-temperature lattice thermal conductivity is limited to ~0.4 W/(m K) due to strong anharmonicity in bonding (γ=1.694) and a "phonon-glass electron-crystal" mechanism. In contrast, a strongly localized Cu-3d valence band gives the large density of states required for an excellent p-type Seebeck coefficient without compromising Γ-point mobility ($m^* \approx 0.20$). The Rb2CuGaBr6 with an optimized p-type doping of 1021 cm^{-3} reached a world-class Figure of Merit (ZT) of 2.0 at 800 K, providing a definitive blueprint for next generation energy conversion devices.

Keywords: Lead-Free Double Perovskites; First-Principles Calculations; Electronic & Mechanical Properties; Thermoelectrics; Optoelectronics.

Cascade Green Biorefinery of Cucurbitaceae Waste: Enzyme-Assisted Extraction of Bioactive Compounds Coupled to Bioethanol Production

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Abstract: This study proposes a cascade green biorefinery for the sustainable valorization of waste from Citrullus lanatus 'Crimson Sweet', Cucumis melo subsp. melo, and Cucurbita pepo sourced from Bejaia. The strategy integrates enzyme-assisted aqueous extraction of bioactive compounds from fruit peels with the subsequent conversion of the depleted residue into bioethanol . Carbohydrates, proteins, lipids, fibers, and total polyphenols were quantified using anthrone, Bradford, Folch, gravimetric, and Folin-Ciocalteu methods, respectively. Antiradical activity using DPPH and antioxidant activity using ABTS were evaluated to determine the antioxidant activity of different extracts. Nutritional characterization revealed comparable profiles among the three species. C. lanatus showed the highest carbohydrate content (7.2%) and lowest lipid content (0.22%), C. pepo was richest in proteins (0.8%), while C. melo presented the highest fiber content (0.53%). Enzyme-assisted extraction in water, significantly enhanced total polyphenol recovery from peels compared to conventional methods. The extracts demonstrated strong antioxidant activity by DPPH and ABTS assays. The valorization of the residual biomass, after extraction, through anaerobic digestion and fermentation is currently under investigation. This step aims to evaluate whether the cascade approach can improve material and energy efficiency while reducing final waste volume compared to direct digestion of raw waste. These results clearly demonstrate that cucurbit waste constitutes a highly promising sustainable raw material. It can yield both high-value biomolecules and green biofuels, perfectly aligning with the objectives of a circular economy and renewable energy.

Keywords: Cucurbitaceae; Valorization; Antioxidants; By-Products; Extraction; Bioethanol.

Bridging Heritage and Sustainability: Passive Energy Solutions in Constantine's Traditional Housing

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Abstract: The growing demand for energy-efficient buildings has renewed interest in traditional architectural solutions that were developed in harmony with local climatic conditions. Vernacular houses in the historic city of Constantine, Algeria, provide valuable examples of passive design strategies that ensure thermal comfort while minimizing energy consumption. This study investigates the thermal performance of traditional Constantine houses and highlights the role of their bioclimatic features in enhancing energy efficiency. Particular attention is given to the central courtyard, thick masonry walls, natural ventilation systems, compact urban morphology, and the use of local building materials. These elements contribute to reducing indoor temperature fluctuations and improving occupant comfort throughout the year. The research is based on an architectural and environmental analysis of selected traditional dwellings, supported by a review of previous studies on vernacular architecture and passive thermal regulation. The findings demonstrate that these traditional design principles offer effective and sustainable responses to contemporary environmental challenges. They also reveal the potential for integrating vernacular knowledge into modern architectural practices to support energy transition and sustainable development. The study emphasizes the importance of preserving and reinterpreting traditional architectural heritage as a source of innovative solutions for low-energy and climate-responsive buildings.

Keywords: Vernacular Architecture; Thermal Performance; Passive Design; Energy Efficiency; Traditional Housing; Constantine; Sustainable Development.

Applied the Voltage Oriented Control (VOC) of Three Phase Source PWM Rectifier in Power Distribution Grids

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Abstract: Power quality is becoming very important for demand for efficient and clean power distribution electricity producers. PWM rectifiers are increasingly becoming an attractive means of connection to the electrical grid for several industrial applications, including high-performance electric drives, thanks to their ability to reduce the amplitude of harmonic currents on the electrical grid and ensure bidirectional power transfer, and their rapid response. This paper presents the performance analysis of control strategy called voltage oriented control (VOC) for a three-phase PWM rectifier. Theoretical principle of this method is presented. The VOC is based on coordinate transformation between stationary α-β and synchronous rotating d-q reference systems. This strategy guarantee fast transient response and high static performance via an internal current control loops. The objective of this paper is controlling the DC Link voltage, absorbing sinusoidal currents and controls the power factor. The control techniques presented in this paper are implemented and verified by simulation using the Matlab/Simulink. Results have proven excellent performances and verify the validity of the presented strategy.

Keywords: Voltage Oriented Control; Three Phase PWM Rectifier; DC-Link Voltage; Power Factor.

Electronic Structure and Collinear Magnetism in the Heusler Alloy NiPtMnGa

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Abstract: The effect of Pt substitution on the structural and magnetic properties of NiPtMnGa alloys was investigated using ab-initio calculations. For ordered systems, FM structure was found to be the most stable among competing magnetic ones. However, the calculated magnetic moment of 4.13 μ B was significantly overestimated compared with the experimental value of 2.2 μ B. This spin rearrangement was unable to reproduce the experimental magnetic moment. To solve this problem, the effect of disorder was also studied. Five magnetic configurations, namely Ferromagnetic (FM), Anti-ferromagnetic (AFM-1), Anti-ferromagnetic (AFM-2), Ferrimagnetic (FiM), and Antisite ferrimagnetic (AS) phases, were investigated and compared. FM phase remained the most stable with an overestimated magnetic moment of the order of 4.174 μ B. However, FiM and AS phases were found to accurately reproduce the experimental magnetic moment value. Calculations show that FiM is better suited for the NiPtMnGa alloy comparing to the AS phase, exhibiting a more stable equilibrium energy and a magnetic moment of 2.068 μ B.

Keywords: L/APW+lo Method; DFT; Electronic structure; magnetic properties; Heusler

Elaboration And Physical Characterization Study Of ZnO Nanostructures For Optoelectronic Application

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Abstract: In this study, high quality Zinc oxide (ZnO) thin films, with improved properties, were prepared by a cost-effective ultrasonic spray pyrolysis technique via a careful optimization of the used ultrasonic wave amplitude. We investigated the effect of various ultrasonic wave amplitude on the structural, surface morphology, optical and electrical properties of the obtained thin films by means of XRD, UV‑vis spec-trophotometer, scanning electron microscope, and four-point probe technique. XRD analysis confirmed that obtained ZnO thin films have polycrystalline structure and a wurtzite (hexagonal) phase, with a c-axis preferred orientation (002). The SEM micrographs of the surface morphology show obviously uniform, homogenous and dense films with granular structures. In addition, the optical properties of the deposited thin films reveal that the films are highly transparent in the visible region above 80%, while the value of energy band gap changes from 3.24 to 3.27 eV. The electrical measurement showed an improvement in resistivity and carrier concentration whenever we raises the ultrasonic wave amplitude. High quality ZnO thin films with enhanced properties are in demand and have a large wide of applications in optoelectronics and solar cells.

Keywords: ZnO thin film; Ultrasonic wave amplitude; physical properties; Spray ultrasonic technique

Valorization and chemical treatment of Cynodon fiber using sodium hydroxide/unsaturated polyester

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Abstract: The composite was prepared using Cynodon fibers a s a reinforcement of the unsaturated polyester matrix and marble as an additive, the aim of this study is to improve the mechanical properties of this composite. Vegetable fibers are characterized by high physical and chemical properties that are abundant in nature light weight biodegradability and low cost these properties made vegetable fibers competitive with synthetic fibers in the preparation of composites, to improve the surface of the Cynodon fibers we treated them with benzoyl, permanganate 0.1 %, alkali treated 6 % for 24 h and placed in the microwave for 15 min. The results obtained from the tests conducted on the composite and fiber showed that the treatment with NaOH at a concentration of 6 % for 24 h had an effect in improving the mechanical properties of the composite and the fibers compared to the untreated fibers Other treatments also proved that the added marble had a significant effect in improving the mechanical behavior. Among the diagnostic tests used in this study are infrared spectroscopy, tensile test.

Keywords: Unsaturated Polyester, Composite, Cynodon, Tensile strength, Chemical treatment

Effect of H_2 Concentration in the Hot-Filament Chemical Vapor Deposition (HFCVD) Process

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Abstract: In this study, the concentrations of chemical species were calculated within the reaction chamber of an HFCVD reactor. Gas-phase homogeneous reactions were described using a simplified reaction mechanism. A two-dimensional model was employed to investigate the HFCVD reactor. The governing equations of heat, momentum, and mass transfer were solved numerically, and the simulations were performed using a program written in FORTRAN. The curves exhibit similar characteristics in terms of symmetry and show good agreement with respect to both the filaments and the substrate. The distributions of H2 species concentrations are similar at the filaments and also between the filaments. The comparison of H_2 concentration variations as a function of z at the filament for n = 3 and n = 4 shows that the H_2 concentration for n = 3 is higher than that for n = 4, with a difference of 1.64% at the vertical planes of the filaments. Between the filaments, H_2 concentrations for n = 4 exceed those for n = 3, with differences ranging from 3.34% to 3.78%

Keywords: Chemical vapor deposition, Fluid model, CH4/H2 gas mixture, Chemical reaction, Diffusion, Concentration.

Ultrasonic Monitoring of Concrete at Early Age: Effect of Mix Composition

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Abstract: This work investigates the effectiveness and sensitivity of ultrasonic techniques for assessing the influence of composition on concrete properties at early age. Two series of concrete specimens with distinct mix designs, referred to as compositions (A) and (B), were prepared in order to evaluate the ability of ultrasonic waves to detect and differentiate between variations in composition and their impact on the internal structure of concrete. Composition (A) corresponds to a previously defined formulation, while composition (B) was developed with different mixture parameters, including variations in the water-to-cement ratio and aggregate grading. Concrete samples were cast and monitored during early age using ultrasonic measurements with transducers operating at a nominal frequency of 54 kHz. To validate the ultrasonic results, a complementary destructive approach was adopted through compressive strength testing at maturation age. The combined use of non-destructive and destructive methods allowed for a comprehensive assessment of the evolution of concrete properties. The results show that ultrasonic parameters are highly sensitive to changes in composition, enabling clear differentiation between the two mixtures. These variations are directly related to differences in microstructural development, which also influence the mechanical strength of the material. This study highlights the capability of ultrasonic techniques as a reliable and efficient tool for monitoring concrete and detecting composition-related effects. It further demonstrates their relevance within the framework of physical chemistry of materials, providing valuable insight into the relationship between composition, microstructure, and macroscopic properties.

Keywords: Concrete, Composition,maturation age, ultrasonic technique, compression strength

Comparative Study of Conventional and CPC-Assisted Solar Stills

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Abstract: Water scarcity is a growing global challenge, particularly in arid and semi-arid regions where access to freshwater resources is limited. Solar desalination offers a sustainable and environmentally friendly solution; however, the low productivity of conventional solar stills remains a major limitation. To address this issue, the present work investigates the performance of a solar still integrated with a Compound Parabolic Concentrator (CPC) and compares it with a conventional solar still under Saharan climatic conditions.

An experimental study was conducted to evaluate the thermal behavior and freshwater productivity of both systems. Key operating parameters, including solar radiation, absorber temperature, basin water temperature, glass temperature, and distillate yield, were monitored throughout the experimental period. The influence of heat transfer fluids on system performance was also considered to enhance heat absorption and energy utilization.

The preliminary results indicate that the CPC-assisted solar still achieved higher operating temperatures and improved freshwater production compared with the conventional unit. The enhanced performance is mainly attributed to the increased solar energy concentration provided by the CPC, which promotes higher evaporation rates. The study demonstrates the potential of CPC technology as an effective approach for improving solar distillation performance in desert environments.

Keywords: Solar still, CPC, Solar desalination, Heat transfer fluid, Thermal performance, Freshwater productivity, Renewable energy.

Thermal Energy Storage with Phase Change Materials for Concentrated Solar Power: From Material Properties to System-Level Design and Future Prospects

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Abstract: Concentrated solar power (CSP) can deliver dispatchable renewable electricity, but its competitiveness relies on efficient, cost-effective thermal energy storage (TES). Sensible two-tank molten salt storage is commercially mature, yet its energy density is modest. Latent heat storage using phase change materials (PCMs) offers higher compactness, near-isothermal operation and potentially lower cost. This paper reviews the field following a materials-to-systems approach (Fig. 1): high-temperature PCM families (molten salts, metallic alloys, composites) and their main hurdles (low thermal conductivity, 0.2–0.7 $W \cdot m^{-1} \cdot K^{-1}$, corrosion, supercooling, volume expansion, limited cycling stability); encapsulation strategies (macro, micro, nano); thermal-conductivity enhancement (porous matrices, nanoparticles, fins); cascaded multi-PCM configurations and metallic PCMs; and numerical modelling using the Schumann packed-bed framework. A recent techno-economic comparison shows that cascade PCM systems reach a levelised cost of electricity (LCOE) of 14.35 USD/MWh, outperforming concrete storage (16.16 USD/MWh). Future directions include long-term stability beyond 10 000 cycles, corrosion mitigation, hybrid geometries, MW-scale demonstration and integration with supercritical CO_2 cycles.

Keywords: Keywords: Phase change materials; Concentrated solar power; Thermal energy storage; Encapsulation; Cascaded storage; Techno-economics

Porous-Medium-Assisted Mixed Convection of a Ternary Hybrid Nanofluid in a Horizontal Annulus

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Abstract : This study presents a numerical investigation of laminar mixed-convection heat transfer of a ternary hybrid nanofluid flowing through a horizontal concentric annulus partially filled with a porous medium under a uniform heat flux. The governing continuity, momentum, and energy equations are solved using the finite volume method. The effects of the Darcy number, Richardson number, and nanoparticle volume fraction on the hydrodynamic and thermal characteristics of the flow are systematically investigated. The numerical model is validated against previously published results, showing excellent agreement and confirming its reliability. The results indicate that increasing the Darcy number enhances fluid circulation and heat transfer by reducing the hydraulic resistance of the porous medium. Higher Richardson numbers strengthen buoyancy-driven convection, thereby promoting thermal mixing and enhancing heat transfer. Although the ternary hybrid nanofluid exhibits lower flow velocities due to its higher viscosity, it provides superior thermal performance owing to its enhanced effective thermal conductivity, resulting in higher Nusselt numbers compared with the base fluid. The combined effects of high Darcy and Richardson numbers lead to the most favorable thermal performance. Overall, the findings demonstrate the potential of ternary hybrid nanofluids for enhancing heat transfer in porous-media systems and improving the thermal efficiency of advanced heat transfer applications.

Keywords: Ternary hybrid nanofluid; mixed convection; porous medium; concentric annulus; heat transfer enhancement; Darcy number; Richardson number; Nusselt number.

Thermal Performance Analysis of a Solar Chimney Power Plant Using

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Abstract: This work presents a thermal analysis of a Solar Chimney Power Plant based on an energy balance approach. A numerical model was developed in C++ to investigate heat transfer and natural convection phenomena inside the solar chimney system under different operating conditions. The study focuses on the influence of key geometrical and environmental parameters, including chimney height, cavity width and solar radiation intensity, on the thermal behavior of the system. The proposed model evaluates the temperature evolution and airflow characteristics generated by buoyancy forces resulting from solar heating. Special attention is given to the effect of solar radiation on the thermal performance of the collector and the induced natural convection inside the chimney. The numerical predictions were compared with previously published experimental results available in the literature. A good agreement between the computed and experimental data was obtained, confirming the validity and reliability of the developed model. The obtained results demonstrate the potential of solar chimney systems as sustainable technologies for renewable energy applications and provide useful insights for the optimization of their thermal performance.

Keywords: Solar Chimney Power Plant; Natural Convection; Heat Transfer; Solar Radiation; Energy Balance; Renewable Energy

Production of a Cao-Based Heterogeneous Biocatalyst from Agro-Food Waste: Synthesis and Physicochemical Characterization

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Abstract: The valorisation of agro-food waste into high-value materials represents a sustainable approach aligned with circular economy principles. In this study, a heterogeneous biocatalyst based on calcium oxide (CaO) was successfully produced from an agro-food waste precursor through a controlled thermal transformation process. The objective was to develop an eco-friendly and cost-effective catalyst suitable for industrial applications. The obtained biocatalyst was evaluated through physicochemical analyses of the products generated during its application, including viscosity, density, drip point and acid value. The results revealed that these parameters comply with standard specifications, indicating the efficiency and stability of the synthesized CaO-based catalyst. The good catalytic performance can be attributed to the high basicity and active surface properties of the prepared material. Overall, this study demonstrates that agro-food waste can be effectively converted into a valuable heterogeneous biocatalyst, offering both environmental and economic benefits. This approach contributes to waste minimization and promotes the development of sustainable catalytic processes.

Keywords: Agro-food waste valorisation; Calcium oxide (CaO); Heterogeneous biocatalyst; Waste-derived catalyst; Physicochemical properties.

Solar EV Li-Ion Battery Management Combining CC–CV Charging Control and Kalman Filter for Soc Estimation

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Abstract: The main innovation for sustainable mobility is the integration of photovoltaics into the electric propulsion system for solar electric vehicles (SEVs). For optimal performance, efficient energy conversion and precise battery charge state estimation are required. This paper proposes an innovative and simulation-based methodology that includes a solar charging system with enhanced efficiency and the State of Charge (SOC) estimation technique for lithium-ion batteries. The proposed power conversion system utilizes a photovoltaic cell in combination with a Phase-Shifted Full-Bridge (PSFB) DC-DC converter and applies Zero Voltage Switching (ZVS) technique to reduce switching loss and achieve maximum efficiency. A constant current–constant voltage (CC–CV) charging scheme is employed to allow fast charging without damaging the batteries by protecting them from overcurrent and overvoltage conditions. In parallel with the power management system, accurate SOC estimation can be accomplished by adjusting the performance of the Extended Kalman Filter (EKF). With regard to the estimation algorithm, a first-order RC equivalent circuit model considering thermal dynamics and sensor noise is adopted for the simulations. The results show that the EKF provides smooth convergence and minimum steady-state errors

Keywords: Solar Electric Vehicles (SEVs); Lithium-ion batteries; State of Charge (SOC) estimation; Extended Kalman Filter (EKF); PSFB Converter; ZVS; CC–CV Control.

Modification and Characterization of Kaolinite Chitosan-Crosslinked Nanocomposite for Enhanced Adsorption of Methyl Orange

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Abstract: This study presents modification and characterization of a novel kaolinite-chitosan (K-Ch) composite for enhanced removal of methyl orange (MO) from aqueous solutions. The composite was prepared through intercalation techniques and comprehensively characterized using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and elemental analysis. XRD analysis revealed successful chitosan intercalation, evidenced by the expansion of kaolinite d (001) spacing from 9.97 Å to 10.5-11.0 Å. FTIR spectroscopy confirmed chitosan incorporation through characteristic absorption bands at 3350-3450 cm^{-1}, 2850-2950 cm^{-1}, and 1590-1600 cm^{-1}. Adsorption studies demonstrated superior performance with a maximum adsorption capacity of 216.92 mg/g, following the Langmuir isotherm model ($R^2 = 0.956$). The synthesized K-Ch composite represents a promising sustainable adsorbent for industrial wastewater treatment applications, effectively combining the advantages of both materials while mitigating their individual limitations.

Keywords: Kaolinite; Chitosan; Composite materials; Methyl orange; Adsorption; Water treatment; Anionic dyes; Intercalation.

Numerical Investigation of Delamination in Composite Laminates Under Impact Loading

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Abstract: This study investigates the effect of stacking sequence on delamination behavior through finite element (FE) analysis. Two composite laminates with different stacking sequences, $[0°]_{12}$ and $[0°/90°]_6$, were subjected to a 7 J impact. The results show that delamination in the $[0°]_{12}$ laminate was not completely absent, but it remained limited to a few localized zones and was relatively controllable. This behavior can be attributed to the uniform fiber orientation across the plies, which reduces the mismatch in stiffness between adjacent layers and limits the development of interlaminar stress concentrations. In contrast, the $[0°/90°]_6$ laminate exhibited more significant delamination damage. The presence of differently oriented plies creates stiffness mismatch at the interfaces, especially between 0° and 90° layers, leading to higher interlaminar stresses and stress concentrations under impact loading. As a result, delamination initiates and propagates more easily in the cross-ply laminate compared with the unidirectional $[0°]_{12}$ configuration. These findings are consistent with previous literature and highlight the important role of stacking sequence in controlling delamination damage and energy transfer mechanisms during impact events. Understanding this relationship is essential for designing impact-resistant composite structures, where the laminate layup must be optimized to reduce interlaminar failure while maintaining the required mechanical performance.

Keywords: Composite Material; Delamination; Low Velocity Impact; Finite Element Analysis.

Numerical Study of Heat Transfer Enhancement in a Tube with Al_2O_3–TiO_2 and Al_2O_3–TiO_2-CNT Hybrid Nanofluids under Magnetic Fields

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Abstract : This numerical study investigates the heat transfer and fluid flow characteristics of two hybrid nanofluids, namely Al_2O_3–TiO_2/water–ethylene glycol and Al_2O_3–TiO_2-CNT/water–ethylene glycol, under the influence of an applied magnetic field with two different orientations. The analysis is performed at a fixed Reynolds number of Re = 750 and Darcy number of Da = 0.01. The effects of the magnetic field orientation on the Nusselt number and friction factor are examined to assess the thermal and hydrodynamic performance of the considered nanofluids. The results indicate that the application of a magnetic field can significantly enhance heat transfer, with the magnitude of the enhancement depending on the magnetic-field orientation and the composition of the hybrid nanofluid. The findings highlight the potential of hybrid nanofluids, particularly CNT-enhanced mixtures, for improving the thermal performance of magnetohydrodynamic heat-transfer systems.

Keywords: Hybrid nanofluids; heat transfer; magnetic field; Nusselt number; friction factor.

Thermal, Optical, and Spectroscopic Investigation of Er^{3+}-Doped Tellurite Glass for Photonic Applications

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Abstract : TeO_2–K_2O–Na_2O–Nb_2O_5 (TKNN) tellurite glass has emerged as a promising host matrix for rare-earth ions owing to its high thermal stability, broad optical transparency, and favorable spectroscopic properties, making it suitable for near-infrared photonic applications. In this work, Er^{3+}-doped TKNN glass was prepared by the conventional melt-quenching technique and its thermal, structural, optical, and spectroscopic properties were systematically investigated. Differential scanning calorimetry confirmed the high thermal stability of the glass, while X-ray diffraction analysis confirmed its amorphous nature. The glass exhibited an optical transmittance exceeding 60% over the 175–3300 nm spectral range, and the direct optical band gap was determined to be 2.74 eV. The absorption spectrum revealed the characteristic absorption transitions of Er^{3+} ions, with the most intense band located at 524 nm ($^4I_{15/2} \rightarrow {}^2H_{11/2}$). Under 540 nm excitation, the photoluminescence spectrum exhibited an intense emission band centered at 660 nm, accompanied by weaker emissions at 860 and 978 nm. Judd–Ofelt analysis was employed to evaluate the radiative properties of Er^{3+} ions in the glass matrix. The resulting intensity parameters were used to determine radiative transition probabilities, branching ratios, radiative lifetimes, and stimulated emission cross-sections. The absorption cross-section was calculated to be 2.25×10^{-20} cm^2 at 521 nm, while the maximum stimulated emission cross-section reached 1.72×10^{-20} cm^2 at 1532 nm. This value exceeds the corresponding values reported for several Er^{3+}-doped tellurite, phosphate, and silicate glasses, highlighting its superior stimulated emission performance. Overall, the obtained optical and radiative parameters confirm that Er^{3+}-doped TKNN glass is a strong candidate for efficient near-infrared optical amplifiers and solid-state laser applications.

Keywords: Er^{3+}-doped tellurite glass; TKNN glass; optical properties; Judd–Ofelt analysis; photoluminescence.

OVERVIEW OF FTIR AND FOUR-POINT PROBE METHODS — APPLICATION TO NTD- SILICON

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Abstract: A non-destructive analytical technique called FTIR spectroscopy uses measurements of the sample's absorption of infrared light to describe the molecular structure and chemical interactions. It is highly useful for in giving information about the structures of molecules, as it gives the vibrational nature of atoms in the crystal lattice, analyzing semiconductor surfaces, and organic materials. In contrast to the latter, the Four-Point Probe technique is used to accurately determine the electrical resistivity or sheet resistance of conductive films and semiconductor materials. Because it employs distinct current and voltage electrodes, contact resistance mistakes are eliminated. When combined, the methods can yield complementary findings about the chemical makeup and electrical properties of materials. This two-fold technique offers the correct measurements of structural integrity and electronic performance which is vital in optimizing properties of semiconductors concerning power electronics, sensors, photovoltaics and dopant characterization, particularly in studies involving neutron transmutation-doped silicon.

Keywords: FTIR spectroscopy;Four-Point Probe; electrical resistivity; semiconductor; NTD Silicon,

Experimental Determination of the 141Pr(n, γ)142Pr Neutron Capture Cross Section

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Abstract: The neutron capture cross section for the 141Pr (n, γ)142Pr reaction at 0.0372 eV energy was measured by using the activation technique. The gold foils were used as neutron flux monitor via the 197Au (n, γ)198Au reference reaction . The irradiations were performed at horizontal Channel N04 of the ESSALAM nuclear research reactor. The γ -ray spectra from the irradiated samples were collected with a calibrated n-type high purity Germanium (HPGe) detector. The cross sections at this neutron energy are measured for the first time and the results show a good agreement compared with those evaluated in the JENDEL-4.0 and ROSFOND-2010 databases. The experimental results were corrected for thermal neutron self-shielding effects and gamma attenuation.

Keywords: Cross section, Activation technique, 0.0372 eV, Thermal neutron.

Structural Properties and Photocatalytic Performance in Methyl Orange Degradation

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Abstract: WO_3 thin films were synthesized via chemical bath deposition using sodium tungstate dihydrate ($Na_2WO_4 \cdot 2H_2O$) as the tungsten precursor and Oxalic Acid as the complexing agent. The deposition was carried out on cleaned FTO substrates under controlled heating conditions, followed by calcination at 500 ° C to obtain crystalline WO_3 structures. The photocatalytic performance of the films was evaluated using Methyl Orange (10 mg/L) as a model organic dye under UV irradiation. Adsorption-desorption equilibrium was established in the dark prior to illumination. Photocatalytic degradation was monitored by UV-visible spectrophotometry, with efficiency determined from the decrease in absorbance at the dye's characteristic wavelength. Results demonstrated that photocatalytic activity, particle size, and optical absorption properties are strongly influenced by the precursor concentration and the molar ratio between sodium tungstate and oxalic acid. The simplicity, cost-effectiveness, and scalability of chemical bath deposition highlight WO_3 thin films as promising candidates for environmental remediation and wastewater treatment applications.

Keywords: WO_3 thin films; chemical bath deposition; photocatalysis; Methyl Orange degradation; environmental remediation

Voltage Stability Enhancement Through Wind Power Integration: DFIG vs. PMSG Comparative Analysis

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Abstract: Wind energy integration into power grids introduces significant voltage stability challenges, particularly relevant to Algeria's ongoing renewable energy deployment program. This study investigates the steady-state voltage stability of the IEEE 9-bus test system under various wind penetration scenarios, simulated using PSAT 2.1.11 in MATLAB R2015b.

Bus 9, identified as the weakest bus, is selected as the wind injection point. Five scenarios are evaluated via Newton-Raphson Load Flow and Continuation Power Flow (CPF): base case (no wind), DFIG at 20% penetration (63.0 MW), DFIG at 30% (94.5 MW), DFIG at 30% with reactive power support (+20 MVAR), and PMSG at 30% (94.5 MW), on a 315 MW, 100 MVA, 60 Hz system. Results confirm that reactive power control is the dominant factor governing voltage resilience. The DFIG with reactive support (DFIG+Q) achieved the highest stability margin (λ _max = 2.501 pu), a +1.7% improvement over the base case (λ _max = 2.459 pu), with Bus 9 voltage rising by +0.66%. In contrast, the PMSG − operating at a fixed voltage setpoint − absorbed reactive power from the grid, reducing the stability margin by 2.6% (λ _max = 2.394 pu). A 30% DFIG without reactive support yielded only a marginal +1.0% gain.

These findings demonstrate that reactive power capability outweighs active power penetration level as a design criterion for wind farm integration − a key insight for Algeria's future transmission network planning.

Keywords: Voltage stability; DFIG; PMSG; IEEE 9-bus; continuation power flow; PSAT.

Design, Implementation, and Experimental Validation of a Solar Cooker Prototype

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Abstract: Solar energy offers a sustainable and environmentally friendly alternative to conventional energy sources for food preparation. This study presents the design, construction, and experimental evaluation of a low-cost solar cooker prototype built from readily available materials. The low cost cooker consists of two nested cardboard boxes insulated with newspaper to reduce heat losses, aluminum foil reflective surfaces to concentrate solar radiation and enhance solar energy collection. A double-glazed glass cover was incorporated to create a greenhouse effect, allowing solar radiation to enter while minimizing heat dissipation. The absorber plate and cooking pot were coated with matte black paint to maximize heat absorption. Experimental tests were conducted under natural sunlight conditions to assess the thermal performance of the prototype. The results demonstrated that the cooker was capable of reaching temperatures exceeding 144°C, which proved sufficient for cooking foods requiring extended heating periods, such as lentils. The findings confirm the effectiveness of the proposed design in harnessing solar energy for cooking applications and highlight its potential as a clean, renewable, and cost-effective solution for sustainable food preparation, particularly in regions with high solar irradiance.

Keywords: Renewable energy; solar energy; solar radiation; solar cooker; greenhouse effect; thermal performance

Evaluation of the Summer Performance of a Hybrid PV–Wind System in Adrar

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Abstract: This paper presents an experimental analysis and study of a Hybrid Photovoltaic-Wind Turbine Stand-alone System (HPVWT) installed in Adrar South West of Algeria. This town is located in desert area which is known by its hard weather conditions. The hybrid system can be very useful in remote area for farmer, companies…etc. The HPVWT is a stand alone system, it is composed from photovoltaic panels, converters, battery and load. Both wind turbine and PV system performances has been measured in real time under Saharan weather conditions in summer. The experimental results were presented and discussed. They proved a good system operation although the harsh conditions. This encourages to use Hybrid systems in Saharan regions to overcome environment and economic problems.

Keywords: Hybrid Photovoltaic; Wind Turbine; Stand-alone System (HPVWT); UDTS50; real time; measurement.

Process Safety in Carbon-Neutral Cement Manufacturing under High-Variability Conditions: A Full-Scale HAZOP and Energy Trace and Barrier Analysis Framework

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Abstract: The cement industry's transition toward carbon-neutral production has accelerated the substitution of alternative fuels and secondary raw materials beyond the original design basis of existing firing systems. This shift introduces persistent fluctuations in calorific value, moisture content, and chlorine–sulfur–alkali loading, which destabilize process boundary conditions faster than control systems can compensate. The resulting high variability drives buildup formation, combustion drift, and refractory stress that conventional steady-state risk models are not designed to capture.

The safety consequences of this transformation are severe and consistently underestimated in current practice. Hot material releases at temperatures approaching 1450°C constitute an inherent operational hazard rather than isolated events, and their frequency increases during manual interventions such as blockage removal, hot material handling, and refractory inspection. Existing sensing technologies cannot reliably track a dynamically migrating combustion zone under dust-laden conditions and material buildup, while current risk assessment approaches fail to integrate process variability, human and organizational limitations, and safety barrier degradation within a unified assessment framework.

This study develops an integrated risk assessment methodology combining Hazard and Operability (HAZOP) analysis with Energy Trace and Barrier Analysis (ETBA), structured around a formal accident model in which harm occurs when hot material reaches a target following loss of containment and/or barrier failure. The methodology is applied and validated on a full-scale operating cement plant.

Results identify sudden blockages and uncontrolled hot material releases as the dominant high-consequence scenarios, with validated escalation pathways to fire and explosion through unprotected structural zones. Barrier mapping reveals critical deficiencies in existing protection layers under high-variability conditions, and the framework is designed for direct transfer to cement facilities operating beyond their original fuel substitution design envelope.

Keywords: Cement; Alternative fuels, Process safety; HAZOP; ETBA

Study of Calcined Bentonite as a Functional Material for Bisphenol A adsorption: Correlation Between Structural Modifications and Performance.

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Abstract: This work falls within the field of functional material design for environmental protection, focusing on the link between the heat treatment of a natural clay and its adsorption properties. Bentonite, a phyllosilicate clay, was thermally treated (calcined) to optimize its retention capacity for bisphenol A (BPA), a major endocrine disruptor.

The physicochemical study shows that calcination profoundly alters the atomic structure and porosity of the material. The heat treatment induces dehydration and dehydroxylation of the layers, influencing the basal spacing and density of active sites on the surface. These structural modifications were correlated with macroscopic adsorption properties through batch tests.

Experimental results indicate that calcined bentonite exhibits a greater affinity for BPA compared to raw bentonite. Analysis of adsorption isotherms and kinetic models elucidates the interaction mechanisms (physisorption/chemisorption) at the solid-liquid interface. This study thus demonstrates the effectiveness of thermal processing in transforming a natural resource into a high-performance adsorbent material, offering a sustainable solution for treating water polluted by organic micropollutants.

Keywords: Bentonite, Calcination, Functional materials, Adsorption, Bisphenol A, Structure-Property Relationship.

A Comparative Analysis of SRR and CCR Technologies in Naphtha Reforming

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Abstract: Catalytic reforming is a key process in refineries for producing high-octane gasoline. There are two types, based on the catalyst regeneration method: semi-regenerative (SRR) and continuous (CCR).
The main difference lies in the need to shut down the unit for regeneration in the SRR. The system can use either fixed
bed or moving-bed catalysts.
The CCR process produces high-octane reformates even with low-quality feedstock. It ensures continuous hydrogen production, with high catalytic activity, a low recycle rate, and an operating pressure around 50 psig. Since the process requires a constant energy supply, integrating heat and mass can help optimize the system design.

Keywords: Catalytic reforming, Octane number, Catalyst regeneration, Continuous and semi-regenerative

Geometric parameter optimization in 1D phononic thin-film structures to maximize phononic bandgaps.

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Abstract: Phononic crystals are periodic nanostructured materials that control the propagation of acoustic and elastic waves by creating frequency bands (phononic bandgaps). This study examines one-dimensional (1D) multilayer phononic crystals with the aim of optimizing geometric parameters to achieve broad and stable phononic bandgaps, which are essential for applications involving the control of acoustic properties at the nanoscale. Simulations were carried out to analyze systematically three key parameters: (1) the number of layers N, (2) the layer thickness h, and (3) the lattice parameter a. The results reveal that increasing the number of bilayers enhances the attenuation within the bandgap, while the optimal layer thickness ratios determine the position and width of the Bragg band. The lattice parameter has a significant influence on the periodicity and must be carefully adjusted to maximize the coverage of the bandgap. Our results show that a carefully chosen configuration and periodicity can significantly improve the phononic bandgap characteristics.

These optimized multilayer one-dimensional structures can be applied in nano-acoustic devices, nano-sensors, and in the field of nanoelectronics at high frequencies. By optimizing the design parameters of phononic crystals with spectral gaps tailored to specific frequency ranges, we can contribute to the development of superphononic materials for next-generation nanotechnology applications.

Keywords: phononic crystals, 1D multilayers, bandgap optimization, geometric parameters, nano-acoustics.

Physics-Informed Machine Learning for Degradation-Aware Optimization of Lithium-Ion Battery Energy Storage Systems

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Abstract: The reliable and efficient operation of battery energy storage systems (BESS) is essential for enabling large-scale integration of renewable energy sources. However, conventional energy management strategies often neglect battery degradation mechanisms, resulting in reduced lifetime, higher operational costs, and compromised system performance. In this work, a physics-informed machine learning framework is proposed to achieve degradation-aware optimization of lithium-ion battery systems under realistic operating conditions. The approach integrates a physics-based aging model, capturing key degradation processes such as solid electrolyte interphase (SEI) growth and lithium plating, with a Gaussian Process Regression (GPR) surrogate model for rapid and accurate prediction of battery state-of-health (SOH). This surrogate model significantly reduces computational cost while preserving the physical consistency of electrochemical behavior. It enables efficient analysis of the effects of operating parameters, including charge/discharge rates, temperature, and cycling conditions. Based on this predictive capability, an optimization strategy is developed to determine optimal charge-discharge profiles that simultaneously minimize operational costs and degradation rates. The framework is validated under dynamic scenarios representative of renewable energy applications, including fluctuating generation and variable load demand. Results show that degradation-aware control significantly improves system performance, achieving up to 20-25% extension in battery lifetime and 10-15% reduction in operational costs compared to conventional strategies. Additionally, the method enhances energy utilization while maintaining stable system operation. Overall, this work demonstrates the effectiveness of combining physics-based modeling and machine learning for advanced energy storage management, providing a scalable solution for sustainable and resilient renewable energy systems.

Keywords: Battery energy storage systems; lithium-ion batteries; degradation modeling; state of health prediction; energy management optimization; renewable energy integration.

Machine Learning- Driven Optimal Energy Management for Renewable Microgrids

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Abstract: The increasing penetration of intermittent renewable energy sources, such as solar and wind, introduces significant challenges for reliable and efficient power system operation. This study proposes a machine learning- driven framework for optimal energy management in renewable-based microgrids integrating photovoltaic generation, wind turbines, battery storage, and diesel backup systems. The approach combines Long Short-Term Memory (LSTM) networks for accurate forecasting of load and renewable generation with a Deep Reinforcement Learning (DRL) agent for real-time energy dispatch optimization. The DRL agent learns optimal control policies by minimizing a multi-objective cost function that accounts for operational costs, carbon emissions, and system constraints, including power balance and battery state-of-charge limits. The proposed framework is validated on a benchmark microgrid under diverse weather and demand conditions. Results demonstrate significant performance improvements, achieving up to 18% reduction in daily operating costs and 22% reduction in CO_2 emissions compared to conventional rule-based strategies, while maintaining system stability and efficient energy utilization. The model also ensures robust battery management and enhanced renewable energy penetration. Overall, this work highlights the potential of combining predictive and decision-making machine learning models to enable intelligent, adaptive, and sustainable microgrid operation. The proposed framework provides a scalable pathway toward low-carbon, resilient energy systems and supports the transition to next-generation smart grids.

Keywords: sustainable energy; renewable microgrid; deep reinforcement learning; energy management optimization; carbon reduction; battery storage systems

TiO2 thin film deposition by sol-gel spin-coating method: effect of rotation speed and annealing temperature on optical, electrical and wettability properties

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Abstract : Titanium dioxide (TiO2) thin films were deposited on glass substrate using "sol-gel spin coating" technique. The effects of rotation speed and annealing temperature on the optical, electrical and wettability properties of TiO2 thin films were investigated. Four samples were deposited with different rotation speeds, 1000, 2000, 3000 and 4000 rpm and were annealed at two temperatures, 300 and 450°C. Photocatalytic efficiency was also assessed. For the characterization of the deposited samples, UV-Visible-NIR spectroscopy have been used for the optical characterization, the four-point technique have been used for the electrical characterization and the measurement of the contact angle have been used for the characterization of the wettability. The optical characterization shows that the transparency of the deposited films reaches 90%, the thickness of the films decreases while their refractive index increases when the speed of rotation increases. The Tauc optical gap varies slightly around 3.5 eV. Increasing annealing temperature has a similar effect on thickness and refractive index as increasing rotation speed. The measurement of the contact angle shows that the samples obtained after annealing at 300°C for one hour are hydrophilic. Exposing the samples to UV light renders the samples super-hydrophilic.

Keywords: Thin film, Titanium dioxide, TiO2, Sol-gel, Spin coating.

Effect of Cerium Doping on the Structural, Optical and Photocatalytic Properties of TiO_2 Thin Films Prepared by Dip-Coating

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Abstract: In this work, TiO_2 thin films were synthesized using the dip-coating technique with different concentrations of cerium (Ce) rare-earth dopant. XRD analysis revealed the formation of TiO_2 with a typical anathase crystal structure after annealing at 450°C. Furthermore, the incorporation of Ce induced an increase in the microdeformation (microstrain) of the crystal lattice, indicating the successful insertion of Ce ions into the TiO_2 structure and the generation of lattice distortions. UV–visible spectroscopy showed that the undoped TiO_2 films exhibited a transparency of 70–80% in the visible range. With increasing Ce concentration, a slight decrease in transparency to 60–70% was observed. The optical band gap, determined using the Tauc method, was found to be approximately 3.92 eV. Photocatalytic activity tests, performed through the degradation of methylene blue under UV irradiation, demonstrated that Ce doping enhances the photocatalytic performance of TiO_2 thin films, particularly at low Ce concentrations, leading to a higher photodegradation rate compared to undoped films. These results indicate that Ce incorporation modifies the structural and optical properties of TiO_2 and contributes to improved photocatalytic efficiency.

Keywords: TiO_2 thin films, Cerium doping, Microstrain, Optical properties, Photocatalysis.

Numerical Simulation of Mixed Convection Heat Transfer of Ternary Nanofluids in a Heated Horizontal Concentric Annulus: Effect of the Darcy Number

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Abstract: This study numerically investigates laminar mixed convection of a ternary hybrid nanofluid (TiO_2 + ZrO_2 + h-BN/PG–H_2O 50:50) in a horizontal concentric annulus filled with a porous medium. The governing equations of continuity, momentum, and energy are solved using the finite volume method (FVM), with a uniform heat flux applied at the heated wall. The numerical model is validated against published results. The effects of the Darcy, Richardson, Reynolds, and Hartmann numbers, as well as nanoparticle volume fraction, are examined. The results show that increasing the Darcy and Richardson numbers enhances fluid circulation and heat transfer. Despite its lower flow velocity due to higher viscosity, the ternary hybrid nanofluid provides superior thermal performance, achieving higher Nusselt numbers than the base fluid. The best heat transfer performance is obtained at high Darcy and Richardson numbers, highlighting the potential of ternary hybrid nanofluids for improving thermal system efficiency.

Keywords: Ternary nanofluids, Darsy number, annulus, laminar flow