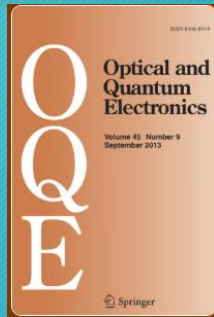


M. Erdoğan, K. Ozel, A. Atilgan, **A. Yildiz**, Y. Erdogdu
 Interfacial electron injection and structure-performance relationships of
 plant-derived sensitizers in TiO₂-based dye-sensitized solar cells



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Interfacial electron injection and structure-performance relationships of plant-derived sensitizers in TiO₂-based dye-sensitized solar cells

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Abstract

In this study, natural dyes extracted from *Cotinus coggygia* (CC), *Prunus padus* (PP), and *Prunus cerasifera* (PC) were evaluated as sensitizers for TiO₂-based dye-sensitized solar cells (DSSCs). A systematic set of photophysical, electrochemical, photovoltaic, and impedance measurements was performed under identical fabrication and testing conditions to clarify the structure-performance relationships of the three extracts. Among the investigated sensitizers, the PC-based device delivered the best performance, with a short-circuit current density of 2.87 mA cm⁻², an open-circuit voltage of 0.52 V, and a power conversion efficiency of 0.99%. Electrochemical impedance spectroscopy further showed that the PC-sensitized cell exhibited lower charge-transfer resistance and more favorable charge-transport behavior. The observed correlation between electron-injection driving force and photocurrent density indicates that interfacial electron injection is the dominant parameter governing device performance. This study therefore provides a controlled comparison of Anacardiaceae and Rosaceae-derived sensitizers prepared using the same fabrication route and demonstrates that anthocyanin-rich Rosaceae extracts offer more consistent and efficient sensitization. The results provide practical guidance for the selection and optimization of plant-based sensitizers in sustainable DSSC technologies.

Keywords Natural dye-sensitized solar cells · Anthocyanin sensitizers · Electrochemical impedance spectroscopy · Plant-based photovoltaic materials

E B Yurdakul, E Adak, K Ozel, A Atilgan, N Akdogan, Y Erdogdu **A. Yildiz**, A Disli Engineering tetrazole-anchored azo sensitizers for enhanced charge transfer and photovoltaic performance in dye-sensitized solar cells



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Engineering tetrazole-anchored azo sensitizers for enhanced charge transfer and photovoltaic performance in dye-sensitized solar cells

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Keywords: dye-sensitized solar cells, tetrazole anchoring groups, azo dyes, DFT/TD-DFT calculations, photovoltaic performance
Supplementary material for this article is available [online](#)

Abstract

Herein, we report the design and comprehensive investigation of a series of newly synthesized tetrazole-anchored azo dyes (denoted as O1Y–O4Y) to elucidate the role of donor substituents in governing interfacial charge-transfer processes in dye-sensitized solar cells (DSSCs). Combined experimental characterization and density functional theory (DFT)/TD-DFT analyses reveal that tetrazole anchoring significantly strengthens electronic coupling with TiO₂, enabling highly favorable electron injection ($\Delta G^{inject} = -1.34$ to -1.39 eV) while effectively suppressing recombination. Among the series, the thioether-substituted O1Y dye delivers superior performance ($J_{sc} = 4.59$ mA cm⁻², power conversion efficiencies (PCE) = 1.75%), whereas halogen-substituted analogs exhibit diminished efficiency due to unfavorable energetic alignment and increased reorganization losses. Notably, O4Y exhibits a 3.02-fold ($\approx 202\%$) enhancement in PCE compared to its nitrile-anchored counterpart (O4). Unlike conventional studies focusing on donor or π -spacer modification, this work provides a direct and systematic evaluation of anchoring-group engineering, offering new mechanistic insight into how tetrazole anchoring modulates interfacial charge-transfer processes in DSSCs.

A. Akkus, K Ozel, M. Erdogdu, A. Atılgan, **A. Yildiz**, Y. Erdogdu
Electrolyte-dependent photovoltaic performance of *Parthenocissus quinquefolia* natural dye in dye-sensitized solar cells



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Electrolyte-dependent photovoltaic performance of *Parthenocissus quinquefolia* natural dye in dye-sensitized solar cells

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ABSTRACT

In this work, natural dye-sensitized solar cells (N-DSSCs) sensitized with *Parthenocissus quinquefolia* L. (PQ) extract were fabricated using three distinct redox electrolyte systems (EL1, EL2, and EL3) to examine electrolyte effects. The device containing EL3 exhibited the highest power conversion efficiency of 0.72%, with improved fill factor and recombination resistance due to suppressed charge recombination and extended electron lifetime. Our findings highlight the critical role of electrolyte engineering in enhancing anthocyanin-based N-DSSC performance.

Sertaç Oruç, Mehmet Salih Türker, Ali Ulvi Galip Şenocak, **Bülent Yeşilata**
 Projection of Heating and Cooling Degree Days in Ankara Under
 Climate Change Using ERA5-Land and Bias-Corrected CMIP6
 Models: A Multi-Threshold Approach



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Article

**Projection of Heating and Cooling Degree Days in Ankara Under
 Climate Change Using ERA5-Land and Bias-Corrected CMIP6
 Models: A Multi-Threshold Approach**

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Abstract

Climate change is shifting building thermal demand from heating toward cooling, yet quantitative, design-relevant projections for semi-arid continental cities remain scarce. This study projects heating and cooling degree days (HDDs and CDDs) for Ankara, Türkiye, using ERA5-Land as the reference, and a quantile delta mapping (QDM) bias-corrected CMIP6 ensemble under SSP2-4.5 and SSP5-8.5, across eight base temperatures (HDD 15–18 °C; CDD 23–26 °C) to 2100. By the far future, HDD18 decreases by 23–37% whereas CDD24 increases by +205 to +498 °C·day/year (with wide inter-model spread), and the heating degree days factor declines from 0.984 to 0.765, marking a shift toward cooling within the degree-day budget; the cooling season extends from 25 to as many as 106 days. In a deterministic −1 to +2 °C local-temperature-offset test, the direction of change persists, and the cooling design dry-bulb temperature rises by up to +7.3 °C, raising peak cooling loads. Independent 2020–2022 station observations support the HDD projections (CDD projections were not independently validated). Because a single grid cell and station cannot resolve urban canyon or local climate zone contrasts, the conclusions apply to the campus vicinity. Overall, the study translates the climate signal into HVAC-sizing and retrofit-relevant metrics for a warming semi-arid capital.

Keywords: climate change; heating degree days; cooling degree days; CMIP6; ERA5-Land; bias correction; building energy demand; Ankara

Furkan Soysal, Sıtkı Kocaoğlu, Kaan Berk Çelik, Ruhi Can Dürü, Mustafa Çelik, Ömer Önder Erat, Bülent Yeşilata

Design of a Microcontroller-Based Automatic Water Discharge Mechanism for Feeding a Pelton Turbine in Micro-Hydroelectric Systems



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Design of a Microcontroller-Based Automatic Water Discharge Mechanism for Feeding a Pelton Turbine in Micro-Hydroelectric Systems

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Mikro-Hidroelektrik Sistemlerde Pelton Türbinini Beslemek İçin Mikrodeneleyici Tabanlı Otomatik Su Tahliye Mekanizmasının Tasarımı

Furkan SOYSAL¹, Sıtkı KOCAOĞLU², Kaan Berk ÇELİK³, Ruhi Can DÜRLÜ⁴, Mustafa ÇELİK⁵,
Ömer Önder ERAT⁶, Bülent YEŞİLATA⁷

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Abstract

This study presents the design and laboratory-scale validation of a microcontroller-based accumulate-and-release discharge mechanism developed to condition irregular and low-flow building drainage streams for impulse turbine feeding. The system is formulated as a hybrid hydraulic-control architecture integrating continuous accumulation dynamics with event-triggered state transitions. A threshold-based control law is implemented to regulate the transition between accumulation and discharge states, ensuring that water is released only when sufficient hydraulic head and volume are available to generate impulse-compatible outflow conditions. The framework is experimentally validated using a laboratory-scale prototype configured to operate under repeatable and isolated conditions with clean water, allowing the intrinsic performance of the control architecture to be assessed independently of fluid variability. Experimental results from 20 consecutive discharge cycles demonstrated a mean discharge duration of 5.00 s with a standard deviation of 0.03 s, a repeatability index of $RI = 0.994$, and a hydraulic pulse stability index below 0.3%, confirming that state-driven control can effectively decouple inflow irregularity from turbine excitation requirements. The results demonstrate the feasibility of converting intermittent drainage flows into repeatable discharge pulses under controlled laboratory conditions. The findings indicate that intelligent, state-based flow conditioning offers a preliminary framework for building-integrated micro-hydropower systems, while remaining specific to the hardware configuration evaluated in this study.

Keywords: Micro-hydropower; Automation; Ultrasonic level sensing; Pelton turbine; Building-integrated energy recovery; Microcontroller systems.

Öz

Bu çalışma, düzensiz ve düşük akışlı bina drenaj akışlarını darbe türbinini beslemesi için şartlandırmak üzere geliştirilen mikrodeneleyici tabanlı bir biriktirme ve boşaltma mekanizmasının tasarımını ve laboratuvar ölçekli doğrulamasını sunmaktadır. Sistem, sürekli biriktirme dinamiklerini olay tetiklemeli durum geçişleriyle entegre eden hibrit bir hidrolik kontrol mimarisi olarak formüle edilmiştir. Biriktirme ve boşaltma durumları arasındaki geçişi düzenlemek için eşik tabanlı bir kontrol yasası uygulanmıştır. Bu sayede su, yalnızca darbe uyumlu çıkış koşulları oluşturmak için yeterli hidrolik basıncı ve hacim mevcut olduğunda boşaltılır. Sistem, temiz su ile tekrarlanabilir ve izole koşullar altında çalışacak şekilde yapılandırılmış bir laboratuvar ölçekli prototip kullanılarak deneyler olarak doğrulanmıştır. Bu da kontrol mimarisinin içsel performansının akışkan değişkenliğinden bağımsız olarak değerlendirilmesine olanak tanır. 20 ardışık boşaltma çevrimi üzerinden elde edilen deneysel sonuçlar, ortalama boşaltma süresinin 5.00 s ve standart sapmasının 0.03 s olduğunu, tekrarlanabilirlik indeksinin $RI = 0.994$ seviyesine ulaştığını ve hidrolik darbe kararlılık indeksinin %0.3'un altında kaldığını göstermiştir. Bu bulgular, durum tabanlı kontrol yaklaşımının giriş akışındaki düzensizlikleri türbin uyarım gereksinimlerinden etkin bir şekilde ayırtılabildiğini doğrulamaktadır. Sonuçlar, aralıklı drenaj akışlarını kontrollü laboratuvar koşulları altında tekrarlanabilir boşaltma darbelerine dönüştürmenin fiizibilitesini göstermektedir. Bulgular, akıllı, duruma dayalı akış koşullandırmasının, bu çalışmada değerlendirilen donanım konfigürasyonuna özgü kalmakla birlikte, binaya entegre mikro-hidroelektrik sistemleri için öncü bir çerçeve sunduğunu göstermektedir.

Anahtar Kelimeler: Mikro hidroelektrik; Otomasyon; Ultrasonik seviye algılama; Pelton türbin; Binaya entegre enerji geri kazanımı; Mikrodeneleyici sistemleri.

Okan Şen, Obed N. Onsomu, **Bülent Yeşilata**

AI-based visual analysis of photovoltaic panels for fault detection and maintenance support



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AI-based visual analysis of photovoltaic panels for fault detection and maintenance support

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Okan Şen, Obed N. Onsomu & Bülent Yeşilata

As the global transition toward renewable energy accelerates, ensuring the operational reliability of photovoltaic (PV) systems has become increasingly critical. Manual inspection procedures remain labor-intensive and economically inefficient, particularly in large-scale solar installations. This study proposes an automated diagnostic framework for classifying anomalies associated with PV panels using deep learning approaches built on the EfficientNet as a backbone, techniques such as Fine-tuned Transfer Learning (FTL), Deep Feature Extraction + Classifier (DFE-C), and Alternative Fine-tuning Setup (AFS) are applied and their efficacy in detecting various defect categories is evaluated. Furthermore, the analysis focuses on a comprehensive evaluation of these strategies in terms of robustness and accuracy regarding classification capabilities. The approaches are evaluated under a consistent data partitioning strategy derived from the same PV image dataset, enabling a systematic comparison of their classification accuracy, robustness, and consistency. The results indicate that FTL enhances domain adaptability, while DFE-C exhibits the greatest overall stability and performance under limited and variable data conditions. The AFS approach provides a balanced trade-off between flexibility and convergence. The experimental framework incorporates structured training pipelines, hyperparameter control, and performance benchmarking using accuracy, macro F1-score, and fold-based stability analysis. Specifically, the DFE-C approach achieved a superior overall accuracy of 94.05%, demonstrating near-perfect diagnostic capability in critical categories such as physical damage (100%) and snow coverage (96%). In short, the proposed framework provides a comparative evaluation methodology for automated PV inspection and offers useful insights for the development of more reliable AI-based diagnostic systems for PV energy applications.

Keywords Photovoltaic defect classification, EfficientNet, Transfer learning, Cross-domain evaluation, Multi-dataset validation, Deep feature extraction

Obed N. Onsomu, Okan Şen, **Bülent Yeşilata**

Comprehensive Evaluation of Hybrid Utilization of DT and Virtual Power Plant Platforms for Distributed Energy Resource Management



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Comprehensive Evaluation of Hybrid Utilization of DT and Virtual Power Plant Platforms for Distributed Energy Resource Management

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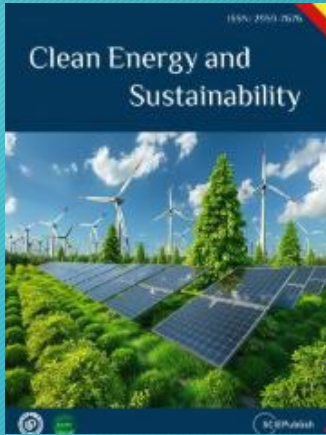
Keywords: asset management | digital twin | optimization | renewable energy resources | virtual power plant

ABSTRACT

As the global energy sector seeks to reduce dependence on fossil fuel-based generation and mitigate carbon emissions, there is an increasing need to evaluate advanced enabling platforms that support sustainable energy integration. Technologies, such as digital twin (DT) and virtual power plant (VPP), provide enhanced capabilities for detailed modeling, monitoring, and optimization of modern power systems with high penetration of renewable energy sources (RESs). This study proposes an integrated DT-VPP framework for effective management of distributed energy resources (DERs), particularly photovoltaic (PV) systems, while also presenting a wind turbine (WT) simulation case using distributionally robust optimization (DRO) to improve grid stability under uncertainty. The proposed framework enables real-time asset monitoring, operational optimization, and enhanced decision-making to mitigate technical constraints such as power losses, capacity limitations, and renewable intermittency. Furthermore, the study highlights the role of artificial intelligence (AI)-driven strategies in improving predictive analytics, system reliability, and resilience of future smart grids. The findings demonstrate that the integration of DT, VPP, and AI-based optimization techniques can significantly enhance grid stability, operational flexibility, and sustainable energy management.

İrem Seyda Uğuz, **Ömer Önder Erat**, **Bülent Yeşilata**

Evaluation of University Students' Perspectives on the Relationship Between Sustainability and Energy



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Article

Evaluation of University Students' Perspectives on the Relationship Between Sustainability and Energy

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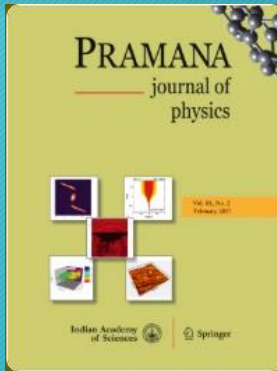
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ABSTRACT: Narrowing the gap between energy demand and supply, while improving the efficiency of energy consumption, has become one of the central sustainability challenges addressed in global policy agendas. Implementing energy management systems in public institutions and organizations is important for achieving this balance. University campuses can be considered small cities, as they serve as living spaces for students. Therefore, since establishing an energy management system is a long-term process, its timely implementation and the creation of an effective system can only be achieved if the students actively using the campus understand and take ownership of the concept. This study explores the role of students as active participants in campus energy management, with a particular focus on integrating the ISO 50001 Energy Management System into higher education environments. A mixed-methods approach was used at Ankara Yıldırım Beyazıt University's (AYBU) Etlik Campus, combining longitudinal building energy consumption data (2019–2023) with a face-to-face survey of 201 students from nine departments within the Faculty of Engineering and Natural Sciences. The survey assessed students' knowledge, attitudes, and willingness to participate in energy efficiency and sustainability initiatives. The findings suggest that while students are generally aware of sustainability concepts, their technical familiarity with standards such as ISO 50001 and units such as ton of oil equivalent (TOE) remains limited. Notably, Energy Systems Engineering (ESE) students tended to report higher awareness and stronger support for forming volunteer, student-led energy management units. Based on the findings, student-led energy management units may serve as a participatory mechanism to improve energy-data transparency, strengthen operational energy literacy, and support sustainability-oriented campus practices. This approach offers a repeatable framework for higher education institutions seeking to align operational energy performance with student-led sustainability actions.

Keywords: Energy Management System (EnMS); ISO 50001; Energy performance; Energy consumption; Energy efficiency; Energy policy; Energy target; Significant Energy Uses (SEU); Energy Performance Indicator (EnPI); Continuous improvement

Metin Aktas, Biswanath Rath, Ramazan Sever

Generalized approach to applications of quantum time-dependent harmonic oscillator model with variable mass and frequency via dynamical invariant formalism



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Generalized approach to applications of quantum time-dependent harmonic oscillator model with variable mass and frequency via dynamical invariant formalism

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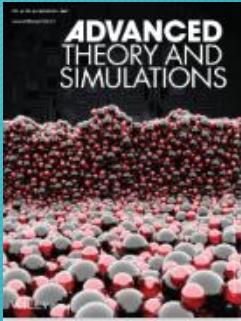
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Abstract. This article offers complete analytical solutions to the one-dimensional time-dependent Schrödinger equation for an explicit frequency-dependent factor with time-varying mass and frequency by implementing the Lewis-Riesenfeld (LR) dynamical invariance procedure. The present approach proposes a dynamically quantum-invariant phase factor for the wave function of the time-dependent harmonic oscillator model. In this context, a time-dependent system is often transformed into a time-independent one via an integral of motion under appropriate unitary transformations. Various cases of oscillatory systems involving time-dependent mass and frequency forms are also examined algebraically. As a result, the corresponding analytical solutions of the Pinney equation can be employed in nonlinear configuration analyses of such systems.

Keywords. Time-dependent harmonic oscillator; invariant operator; dynamical invariance formalism; Pinney's equation.

Aysenur Gencer, Ahmet Aydogan, **Ozge Surucu**, Gokhan Surucu

Exploring X_2BH_6 ($X = Li, Na, \text{ and } K$) Double Perovskite Hydrides for Solid-State Hydrogen Storage Applications



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RESEARCH ARTICLE OPEN ACCESS

Exploring X_2BH_6 ($X = Li, Na, \text{ and } K$) Double Perovskite Hydrides for Solid-State Hydrogen Storage Applications

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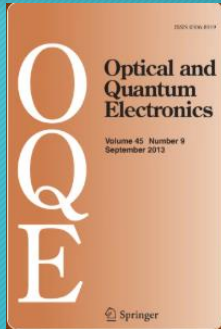
Keywords: density functional theory | double perovskite hydrides | electronic properties | hydrogen storage | mechanical properties | phonon stability

ABSTRACT

Solid-state hydrogen storage in lightweight hydrides represents a promising pathway toward a sustainable hydrogen economy. In this work, we employ density functional theory to systematically investigate the structural, electronic, mechanical, dynamical, and hydrogen storage properties of X_2BH_6 ($X = Li, Na, \text{ and } K$) hydrides. All hydrides exhibit negative formation energies, confirming their thermodynamic stability. The gravimetric hydrogen storage capacities are remarkably high: 19.71, 9.64, and 6.37 wt% for Li_2BH_6 , Na_2BH_6 , and K_2BH_6 , respectively, all surpassing the 2025 U.S. Department of Energy target of 5.5 wt%. Electronic band structure analysis reveals metallic character for all hydrides. Evaluation of Born mechanical stability criteria reveals that Li_2BH_6 and K_2BH_6 are mechanically stable, whereas Na_2BH_6 is mechanically unstable. Phonon dispersion calculations demonstrate that only K_2BH_6 is dynamically stable, while Li_2BH_6 and Na_2BH_6 exhibit imaginary phonon modes. Combining all stability criteria, K_2BH_6 emerges as the most promising candidate, possessing simultaneous thermodynamic, mechanical, and dynamical stability alongside a gravimetric capacity of 6.37 wt% and a hydrogen desorption temperature of 308.00 K that falls within the DOE operating target. These findings suggest K_2BH_6 as a potential candidate for solid-state hydrogen storage and provide theoretical guidance for future experimental synthesis.

Neslihan Gokcek, Aysenur Gencer, Gokhan Surucu, **Ozge Surucu**

ScBr₂/AlSe: a magnetic dihalide/non-magnetic chalcogenide van der Waals heterostructure from first principles



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ScBr₂/AlSe: a magnetic dihalide/non-magnetic chalcogenide van der Waals heterostructure from first principles

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Abstract

Combining intrinsic 2D ferromagnetism with a broadband optoelectronic response within a single van der Waals (vdW) architecture remains an open design challenge. Here, first-principles density-functional-theory calculations are used to investigate the ScBr₂/AlSe vdW heterostructure, representing the first coupling of a magnetic transition-metal dihalide with a non-magnetic group-III chalcogenide. The low lattice mismatch ($\delta \approx 2.17\%$) yields three energetically near-degenerate stacking configurations within PBE+D3 accuracy; the heteroB stacking is adopted as the representative geometry and its dynamical, thermal and mechanical stability is confirmed through phonon dispersion, machine-learned-force-field-accelerated ab-initio molecular dynamics at 300 K, and Born-stable elastic constants. HSE06 calculations yield a direct gap of 0.57 eV with clear Type-II band-edge character, and the ScBr₂ magnetic moment is preserved at 1.0 μ_B per Sc atom. The optical response shows strong absorption across the visible and ultraviolet regions with in-plane isotropy. These results establish the transition-metal-dihalide/group-III-chalcogenide class as a promising design space for multifunctional magnetic–optoelectronic vdW heterostructures.

Keywords Density functional theory · Van der Waals heterostructure · 2D ferromagnetic semiconductor · Type-II band alignment · Machine-learned force field · Scandium dihalide

Emircan Turgut, Sefer Bora Lisesivdin, Aysenur Gencer, **Ozge Surucu**, Gozde Altuntas, Bulent Bostan, Fatih Himmet, Gokhan Surucu

WSi₂N₄/XSe and WSiGeN₄/XSe (X=Al, Ga, and In) heterostructures for photocatalytic water splitting: a DFT investigation



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WSi₂N₄/XSe and WSiGeN₄/XSe (X=Al, Ga, and In) heterostructures for photocatalytic water splitting: a DFT investigation

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The research for an effective photocatalyst is ongoing, and this study considers the WSi₂N₄/XSe and WSiGeN₄/XSe (X = Al, Ga, and In) heterostructures for photocatalytic water splitting using Density Functional Theory. The heterostructures are constructed using a 7 × 7 × 1 supercell for the WSi₂N₄ and WSiGeN₄ monolayers and 2 × 2 × 1 supercell for the XSe monolayers. The structural optimizations reveal that the heterostructures with the InSe monolayers have positive binding energy, which reveals their structural instability. The WSi₂N₄/XSe and WSiGeN₄/XSe (X = Al and Ga) heterostructures have been further considered for their mechanical and thermodynamic stabilities, where all the heterostructures are structurally, mechanically, and thermodynamically stable. The electronic properties of WSi₂N₄/XSe and WSiGeN₄/XSe (X = Al and Ga) heterostructures are studied in detail using PBE and HSE methods. The WSi₂N₄/AlSe, WSi₂N₄/GaSe, and WSiGeN₄/AlSe heterostructures have band gaps as 1.83 eV, 1.66 eV and 1.69 eV, respectively, that satisfy the band gap requirement for photocatalytic water splitting. In addition, the valence band and conduction band levels are determined that must satisfy the redox potential. This analysis reveals that the WSi₂N₄/AlSe and WSi₂N₄/GaSe heterostructures have an S-scheme mechanism, while the WSiGeN₄/AlSe heterostructure has a type-II mechanism. Furthermore, the optical properties and solvent effect are investigated to reveal the performance of these heterostructures further. The present study determines the stability of WSi₂N₄/XSe and WSiGeN₄/XSe heterostructures and examines their photocatalytic water splitting potential in detail. It is therefore posited that the results presented in this study will serve as a guide to inform future studies and pave the way for new research in this field.

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Ali Deveci, Mehmet Ali Erkan, İhsan Tolga Medeni, **Tunç Durmuş Medeni**
A Novel Framework for Next Word Prediction Using Long-Short Term
Memory Networks



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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

**A Novel Framework for Next Word Prediction Using Long-Short Term Memory
Networks**

**Sonraki Kelime Tahmini İçin Yeni Bir Yöntem: Uzun-Kısa Süreli Bellek Ağlarını
Kullanma**

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Abstract

Natural Language Processing (NLP) has become a cornerstone in various fields, revolutionizing how machines interpret and process human language. Among its diverse applications, next-word prediction emerges as a highly practical and impactful example of generative AI. This research focuses on the use of Long Short-Term Memory (LSTM) models—an innovative class of Recurrent Neural Network (RNN)—for predictive text generation. LSTMs excel in capturing sequential and contextual information, making them ideal for language tasks. While transformer models dominate accuracy benchmarks, this work addresses the critical need for efficient alternatives in resource-constrained deployment scenarios. This study presents a novel LSTM-based framework enhanced with hybrid architecture and advanced regularization techniques, trained on a carefully curated dataset of 15,000 English sentences. The proposed model achieves superior performance with 84.2% training accuracy, 79.6% test accuracy, and a perplexity score of 2.41, significantly outperforming traditional approaches. The methodology addresses overfitting through dropout regularization, batch normalization, and adaptive learning rate strategies while effectively capturing long-term contextual dependencies. This research contributes to the advancement of neural language modeling by providing a robust framework that bridges the gap between computational efficiency and prediction accuracy in real-world NLP applications.

Anahtar Kelimeler: NLP, Next Word Prediction, LSTM, Deep Learning, Text Generation

Salma Sadek Jetlawei, Mohamed Ali Mohamed EL-sseid, **Tunç Durmuş Medeni**, İhsan Tolga Medeni, Mansour Essgaer, Abdulgader Alsharif

Systematic Mapping Study (SMS) on Energy Outcome Loss Caused by Dust Deposition on Photovoltaic Panels Due to Climate Change in North Africa



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Systematic Mapping Study (SMS) on Energy Outcome Loss Caused by Dust Deposition on Photovoltaic Panels Due to Climate Change in North Africa

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Keyword	Abstract
Photovoltaic soiling; Dust deposition; Climate change adaptation; North Africa; Systematic mapping; Renewable energy resilience; PV	Photovoltaic (PV) energy systems in North Africa are increasingly recognized as pivotal to regional decarbonization and energy security. However, the accelerating impacts of climate change including intensified aridity, desertification, and altered wind patterns are exacerbating dust deposition on PV modules, leading to significant and often unquantified energy yield losses. This paper presents the first systematic mapping study to comprehensively categorize, analyze, and visualize the state-of-the-art literature addressing the nexus between climate-induced dust accumulation and PV performance degradation across North Africa. Following the Kitchenham and Petersen protocols for systematic reviews in engineering, this research analyzed 87 peer-reviewed studies published between (2000 and 2026). This mapping reveals critical research gaps in long-term field data, standardized soiling measurement protocols, and region-specific predictive modeling under future climate scenarios. This research further identify emerging mitigation technologies and policy frameworks, proposing

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Ali Deveci, Mehmet Ali Erkan, İhsan Tolga Medeni, **Tunç Durmuş Medeni**, Ali Uzkaşalı, Ahmet Özkan

Enhancing IDS Through Multi-Objective Optimization: A Focus on Attack Graph under Worst-Parent Attack



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Enhancing IDS Through Multi-Objective Optimization: A Focus on Attack Graph under Worst-Parent Attack

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ABSTRACT

This study focuses on the evolution of network security models for RPL based LLNs under worst-parent attack. The multi-objective optimization approach integrates additional metrics: i) The amount of change in the maximum path length within the graph (ΔL) and ii) the amount of change in the number of nodes connected to the attacker node (ΔW) alongside the conventional accuracy criterion. The analysis of these metrics plays a crucial role in the development of Intrusion Detection Systems (IDS), particularly through the examination of attack graphs. Attack graphs are small, distinct network substructures used to model potential attacks on the network. Analyzing these graphs is considered essential for identifying security vulnerabilities in the network and determining the spread and impact of attacks. The findings of the study demonstrate a progressive improvement in model performance across tasks, starting from a single-objective task and advancing towards multi-objective tasks. This improvement signifies the effectiveness of integrating additional metrics in enhancing predictive accuracy and understanding network structure and resilience.

Keywords: Attack graphs, eccentricity, multi-objective optimization, RPL, worst parent attack

Meryem Sena AKKUŞ

DFT Investigation of the Electronic and Catalytic Effects of Ni–Co–V Alloy Structures on the Theoretical Hydrolysis of NaBH₄



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Research Article

DFT Investigation of the Electronic and Catalytic Effects of Ni–Co–V Alloy Structures on the Theoretical Hydrolysis of NaBH₄

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Abstract: This study presents a density functional theory (DFT) investigation of Ni–V, Co–V, and Ni–Co–V alloy clusters (Ni₇V₂, Co₈V₂, Ni₆Co₄V₂, and Ni₄Co₄V₄) toward sodium borohydride (NaBH₄) hydrolysis for hydrogen generation. The catalytic behavior was analyzed by comparing bare clusters and their NaBH₄ + H₂O adsorbed reaction complexes. Structural optimizations reveal pronounced B–H bond elongation and metal–metal bond flexibility upon adsorption, particularly on Ni-rich surfaces. Electronic structure analyses indicate a systematic reduction in the HOMO–LUMO energy gap following NaBH₄ adsorption, confirming enhanced surface reactivity. Löwdin population analyses show significant charge transfer from borohydride to the metal framework, accompanied by a loss of hydride character and effective activation of hydrogen atoms. Thermodynamic calculations demonstrate that all reaction complexes are highly stable in aqueous media, with strongly negative enthalpy and Gibbs free energy values, indicating spontaneous and exergonic complex formation. Overall, Ni-rich and synergistic Ni–Co–V clusters exhibit superior electronic adaptability and structural stability, making them promising candidates for efficient NaBH₄ hydrolysis.

Keywords: DFT, HOMO–LUMO, NaBH₄ hydrolysis, Ni–Co–V alloys, Surface interactions

Musaria Karim Mahmood, Mohammad Abdullah Abbas

Explainable Artificial Intelligence Framework for Sustainable Energy Management and Data-Driven Decision Making



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Research Article

Explainable Artificial Intelligence Framework for Sustainable Energy Management and Data-Driven Decision Making

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ABSTRACT

In today's world with the considerable rise in the energy consumption of Energy Systems, the necessity to intelligent and sustainable management of energy has surfaced as a key requirement for energy efficiency and effective data-driven decision making. In recent years, AI and ML techniques have proven to be a promising way to predict energy consumption patterns, yet most of the existing solutions are black-box models, which lack interpretability. This limitation reduces trust in the users and lowers the likelihood of implementing AI solutions in the energy sector that promote sustainability. This study suggests an Explainable Artificial Intelligence Framework for Sustainable Energy Management and Data-Driven Decision Making to offer correct and clear energy analysis, combining machine learning based prediction with Explainable AI techniques. The proposed framework compares the performance of three models of machine learning namely Random Forest (RF), Extreme Gradient Boosting (XGBoost) and Artificial Neural Network (ANN) with an energy consumption dataset that features environmental and operational parameters. The performance of the models implemented are assessed using Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and coefficient of determination (R^2) of regression. Two methods of explaining the contribution of features and individual prediction results, namely, SHAP (SHapley Additive exPlanations) and LIME (Local Interpretable Model-Agnostic Explanations) are embedded to explain the individual prediction outcomes and feature contribution in an enhanced transparency of the model. The results of the experiments confirm that the developed models have a good prediction performance, with the XGBoost model being the most successful approach for forecasting. Moreover, the explainability analysis reveals the most influential factors on energy consumption and gives valuable insights for optimization of sustainable energy. The proposed framework aims to balance predictive accuracy with interpretability of the models by converting traditional AI-based energy prediction models into transparent decision support models. The developed approach can help the energy manager and stakeholders to understand the consumption pattern, optimize the operational of the system and contribute in taking the initiatives for sustainable consumption.

Ali Rachini, **Musaria Karim Mahmood**

Deep Learning-Based Cybersecurity Framework for Proactive Intrusion Detection on the CSE-CIC-IDS2018 Dataset



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Research Article

Deep Learning-Based Cybersecurity Framework for Proactive Intrusion Detection on the CSE-CIC-IDS2018 Dataset

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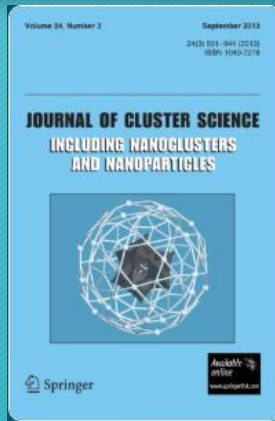


ABSTRACT

Network infrastructure has become more complex and the amount of cybersecurity challenges has grown with the introduction of cloud computing, the Internet of Things (IoT) and next-generation communication technologies. The known attack and known signatures are the reasons why traditional IDSs fail to detect sophisticated and new attacks; they are signature-based and programmed by hand. To overcome these drawbacks, this work presents a deep learning-based cybersecurity framework for proactively detecting the intrusion in CSE-CIC-IDS2018 benchmark dataset. The proposed system combines spatial and temporal features of network traffic using a hybrid Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) network architecture with a systematic data preprocessing pipeline. In the preprocessing stage, data quality and learning efficiency are enhanced by data cleaning, handling missing data, removing duplicate data, encoding labels, normalizing features, and splitting the data into training and testing sets. The CNN part is used to automatically learn discriminative spatial features, and the LSTM was used to learn the sequential traffic dependencies to see the relation between the sequential sequence and attack detection capability was improved. Experiments were carried out on Python, TensorFlow, Keras and Google Colab with GPU support. The proposed framework was evaluated according to the accuracy, precision, recall, F1-score, and ROC-AUC and the results were found to be 98.64%, 98.41%, 98.18%, 98.29%, and 99.12%, respectively, which are considered to be excellent classification results and strong discrimination ability. Moreover, the framework demonstrated good computational efficiency with an average inference time of 2.8ms per network flow and a moderate use of GPU memory. Results of comparative analysis with the latest deep learning-based intrusion detection methods also validate the competitiveness and applicability of the proposed framework. The results highlight the efficiency, reliability, and effectiveness of the hybrid CNN-LSTM framework in proactively detecting network intrusions in contemporary cybersecurity settings.

Bengü Getiren Sevinç, Salih Açıl, **Furkan Soysal**, Zafer Çıplak, Atila Yıldız & Nuray Yıldız

Sustainable Design of LrGO-Ag-Au-Cu_xO Hybrid Nanocomposites with Superior Catalytic and Photocatalytic Efficiency in Aqueous Pollutant Degradation



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ORIGINAL PAPER



Sustainable Design of LrGO–Ag–Au–Cu_xO Hybrid Nanocomposites with Superior Catalytic and Photocatalytic Efficiency in Aqueous Pollutant Degradation

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Abstract

Cetraria islandica (L.) Ach. lichen extract was employed as a bioinorganic reducing and stabilizing agent for the single-step green synthesis of a quaternary LrGO-Ag-Au-Cu_xO nanocomposite integrating lichen-reduced graphene oxide (LrGO), silver (Ag), gold (Au), and copper oxide (Cu_xO). XRD Rietveld refinement confirmed the coexistence of four crystalline phases – Ag (56.9 wt%), Au (28.9 wt%), CuO (7.5 wt%), and Cu₂O (6.7 wt%) – Alongside the LrGO matrix, while XPS established the zero-valent states of Ag and Au and the formation of CuO/Cu₂O heterojunctions. TEM analysis revealed a narrow nanoparticle size distribution with an average of 6.03±2.61 nm, and BET analysis yielded a specific surface area of 11 m² g⁻¹. The dual functionality of the nanocomposite was evaluated through two model reactions. In the catalytic reduction of 4-nitrophenol (4-NP) to 4-aminophenol (4-AP) using NaBH₄, the LrGO-Ag-Au-Cu_xO (1:1:1) nanocomposite exhibited an apparent rate constant of 0.0078±0.0003 s⁻¹ at a catalyst loading of 0.172 mg mL⁻¹, maintaining stable activity over 11 consecutive cycles. Under visible LED irradiation, the nanocomposite achieved a methylene blue (MB) degradation efficiency of 97.67±1.15% within 180 min, with a rate constant of 0.0219±0.00265 min⁻¹. Radical trapping experiments identified •OH and •O₂⁻ as the dominant reactive species. These results establish *Cetraria islandica* extract as an effective green synthesis medium for the fabrication of multifunctional quaternary nanocomposites with competitive dual catalytic and photocatalytic performance.

Keywords Green synthesis · Nanocomposites · Catalytic performance · Photocatalytic degradation

Seymanur Baslik, Omur Akyazi

A novel adaptive Gaussian FOPID controller design for automatic voltage regulator system



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A novel adaptive Gaussian FOPID controller design for automatic voltage regulator system

Seymanur Baslik^{1,3} & Omur Akyazi^{2,3}✉

The fundamental aim of a power system is to deliver electricity to consumers in a secure, continuous, and reliable manner. Achieving this goal requires maintaining the overall stability of the power system. Stability is a multifaceted concept that encompasses components such as voltage, frequency, and rotor angle; this study focuses on voltage stability. Within synchronous generators, automatic voltage regulator (AVR) systems are essential for sustaining voltage stability. To improve the dynamic performance and robustness of the AVR system, this study proposes a new control method called Gaussian-based fractional-order PID (GFOPID) controller. The controller parameters for the proposed GFOPID structure are optimized using the Jellyfish Search (JS) optimization algorithm. In the optimization phase, we employed several well-known error metrics as performance criteria: the integral of absolute error, the integral of squared error, the time-weighted integral of absolute error, the time-weighted integral of squared error, and the user-defined Zue Lee Gain (ZLG) objective function. The performance of the JS-GFOPID controller in the AVR system was assessed through analyses of time-domain response, robustness, reference signal change, disturbance rejection, and nonlinear effects. The GFOPID controller was compared with fractional-order PID (FOPID) controllers, which have gained considerable acceptance in recent years when used with different metaheuristic algorithms. Under reference-changing inputs, the proposed GFOPID/ITAE controller provides between 25–73% improvement in IAE, 2–63% in ISE, and 21–57% in ITAE when compared with benchmark FOPID-based strategies.

Keywords A novel adaptive controller, Gaussian FOPID, AVR system, Jellyfish search algorithm, Voltage stability