Book of Abstract

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10th International Congress on Energy Efficiency and Energy Related Materials (ENEFM 2024)

8-11 October 2024

10th International Congress on Energy Efficiency and Energy Related Materials

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10th International Congress on Energy Efficiency and Energy Related Materials

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PLENARY PRESENTATION

Id-553

High-performance Membranes for Energy Efficient Air Cooling

A. ABDALA

Chemical Engineering Program, College of Science and Engineering, Hamad Bin Khalifa University, Doha, Qatar

*Corresponding Author: ahabdalla@hbku.edu.qa

Abstract: Space cooling is the fastest-growing category of energy consumption in residential and commercial buildings in hot and humid regions. This demand increase has significant implications for energy sustainability and environmental impact. The US Department of Energy recently identified membrane dehumidification-based air cooling as a leading alternative to conventional vapor compression cooling due to its superior energy efficiency and the elimination of environmentally hazardous hydrofluorocarbons (HFCs). However, the development of viable membrane dehumidification processes faces several challenges. These membranes must exhibit exceptionally high-water vapor permeance (WVP), high water/air selectivity, fouling resistance, durability, and cost-effectiveness. In this presentation, we discuss our recent research on developing high-performance air-dehumidification membranes. We focus on three types of membranes: i) graphene oxide (GO) membranes, ii) polyimide thin film composite membranes, and iii) mixed matrix membranes. We will explore the correlation between membrane structure and performance, discussing how molecular-level modifications can lead to significant improvements in efficiency. Additionally, we will present a techno-economic and life cycle analysis of air cooling based on these optimal air-dehumidification membranes compared to conventional air-cooling methods. This analysis aims to highlight the potential environmental and economic benefits of adopting advanced membrane technologies for space cooling.

Keywords: Air-cooling, Air-dehumidification, Graphene oxide membranes, Mixed matrix membranes, Thin film composite membranes.

INVITED PRESENTATION

Id-554

Techno-Economic Analysis of Hydrogen Production and Transportation

A. AJANOVIC*, M. SAYER

Technische Universität Wien – TU WIEN, Institute of Energy Systems and Electrical Drives, Energy Economics Group (EEG), Gußhausstraße 25 – 29 / E370-03, 1040 Vienna, Austria

*Corresponding Author: ajanovic@eeg.tuwien.ac.at

Abstract: The transition to a hydrogen-based energy system is widely seen as an important step towards achieving global decarbonization goals. Currently, key hydrogen production technologies are steam methane reforming with or without carbon capture and storage, and electrolysis using renewable energy sources. This paper presents a comprehensive techno-economic analysis of different hydrogen production and transportation options, examining the viability, costs, and technological challenges associated with different production methods and transportation choices. Of special interest is hydrogen transport via pipelines and ships from North Africa to Europe. The total costs of different supply chains are calculated considering hydrogen production, transportation and other process costs. Each supply chain is assessed in terms of infrastructure requirements, energy efficiency, and overall cost-effectiveness. The analysis also considers the impact of economies of scale, geographic factors (e.g. possible number of full-load hours), and technological advancements on the overall feasibility of hydrogen supply chains.

Our findings indicate that while electrolysis from renewable energy presents the most sustainable option from an environmental point of view, corresponding hydrogen costs are currently significantly higher compared to steam methane reforming with or without carbon capture and storage. However, anticipated advancements in electrolyzer efficiency and reductions in renewable energy costs could make green hydrogen competitive in the future. For transportation, our analysis indicates that pipeline transport is generally cheaper and preferable for hydrogen transport over long distances.

An important finding of this paper is that hydrogen production in Europe, as well as hydrogen import from North Africa, may be relevant for the achievement of the European decarbonization goals. However, the emphasis should be on green hydrogen – hydrogen produced through the electrolysis of water using electricity generated from renewable energy sources. If blue hydrogen, derived from natural gas

via steam methane reforming with carbon capture and storage, is under consideration, it is important to also address the frequently overlooked methane emissions upstream. Finally, policy support for the development of hydrogen infrastructure, including subsidies for green hydrogen production, investment in research and development, and the establishment of regulatory frameworks to ensure safety and efficiency in hydrogen supply chains, is essential for the broader production and use of hydrogen.
Keywords: Green Hydrogen, Blue Hydrogen, Hydrogen Transport, Costs, Policy.

INVITED PRESENTATION

Id-568

The Reuse of End-Of-Life Home Materials (EoLHM) in Buildings' Energy Harvesting

E. R. di SCHIO*, V. BALLERINI, P. VALDISERRI

Department of Industrial Engineering DIN, Alma Mater Studiorum – University of Bologna, Viale Risorgimento 2, 40136 Bologna, Italy

*Corresponding Author: eugenia.rossidischio@unibo.it

Abstract: A key aspect of this research is supporting sustainable development, as advocated by the United Nations in one of its 17 goals. This goal encompasses reducing inequalities, improving health and education, and protecting the environment. Europe faces the significant challenge of energy poverty, where many people cannot afford adequate heating, cooling, and lighting, leading to disease, death, and social isolation. The reuse of waste materials, such as surgical masks, or textile waste materials, or the development of new materials, is particularly beneficial. It enables individuals in disadvantaged communities to self-produce and install panels in their homes, thereby improving indoor comfort and enhancing human capital. The study's findings highlight new applications for End-of-Life Healthcare Materials (EoLHMs), particularly focusing on innovative materials derived from textile waste. The research aims to achieve two main objectives: first, to explore novel methods for promoting the circular economy by repurposing EoLHMs in the building sector; second, to refurbish buildings with a special focus on homemade panels, thereby benefiting disadvantaged communities. Many different materials were tested, and their thermal conductivity was measured in accordance with the ISO 8301 standard. Additionally, the relationship between thermal conductivity and density will be examined. The results will highlight which EoLHMs display a thermal conductivity in the range that is typical for insulating materials commonly used in refurbishment applications.

Keywords: EoLHMs, Reuse, Textile Materials, Surgical Masks, Thermal Conductivity.

INVITED PRESENTATION

Id-585

Solar Photovoltaic Soiling Loss: Quantification, Measurement and Monitoring

B. GUO

Mechanical Engineering Program, Texas A&M University at Qatar, Doha, Qatar

*Corresponding Author: bing.guo@qatar.tamu.edu

Abstract: Soiling of solar photovoltaic modules refers to the accumulation of contaminants, most commonly dust particles, on the module surface. Soiling can cause significant loss of electricity production due to the accumulated dust reducing the solar radiation that reaches the photovoltaic cells. In dusty regions around the world, it is economically justified to actively clean the modules in a solar photovoltaic power plant. For module performance assessment purpose, knowledge of a solar photovoltaic module's soiling loss is essential. Soiling loss may be quantified by using power output or the short-circuit current of a module. Measurement of soiling loss is typically done by comparing a module subject to soiling and a clean module. Alternatively, soiling loss can be measured using various soiling sensors. The effect of solar incidence angle comes into play when interpreting the readings of a soiling sensor. Soiling monitoring in conjunction with module health monitoring is an active area of technological development.

Keywords: Dust, Soiling Loss, Soiling Ratio, Photovoltaic Module, Performance Ratio.

INVITED PRESENTATION

Id-588

Thermal and Energy Efficiency Solutions for Natural Gas Compression Using Industrial Automation

A. MITRU

Romanian Research and Development Institute for Gas Turbines COMOTI, Blv. Iuliu Maniu, No 220D, Bucharest, Romania

*Corresponding Author: andrei.mitru@comoti.ro

Abstract: The dry screw compressor, developed in the late 1940s and widely adopted in the 1960s for plant air services, is joined by the single-screw compressor introduced by Zimmern in the 1950s. In today's era of escalating carbon emissions and environmental challenges, improving energy efficiency is crucial for mitigating these issues. The industrial landscape has witnessed significant advancements in automation and control systems, revolutionizing the operational efficiency and reliability of complex machinery and processes. Within this realm, screw electro-compressors have emerged as vital components in various industrial sectors, facilitating the compression of gases and playing a crucial role in ensuring seamless operations. As the reliance on these electro-compressors continues to grow, the need for robust and intelligent automation software to improve thermal and energy efficiency has significantly increased. The presentation strives to shed light on the remarkable progress made in advancing automation software by providing as results a PID function developed for the cabinet PLC used to protect a screw compressor from its thermal energy and a complex algorithm developed for ensuring energy efficiency. The operating mode of an electro-compressor can be imposed as manual mode or automatic mode and can be selected from a developed HMI screen. The algorithm behind both manual mode and automatic mode will be analyzed in the presentation. Manual mode involves the user setting of an operating speed for the electric motor that drives the electro-compressor. Automatic mode has behind a custom developed control loop algorithm. It involves to set a lower suction pressure threshold and an upper suction pressure threshold. Depending on the evolution of the suction pressure and the configuration of these two thresholds, the speed of the main electric motor evolves linear, therefore involving energy efficiency. In the presentation, data taken from the parameter records of a electro-compressor will be interpreted. The efficiency of energy consumption will result from the variation analysis of the current consumption

by the main electric motor that drives the compression unit. The oil temperature evolution will also be analyzed from the parameter records, which is kept under control from a thermal point of view by a custom parameterized PID function. It will be detailed in the presentation how this custom parameterization of the PID function was performed and what the implications are from the point of view of the thermal efficiency on the electro-compressor. Therefore, the presentation contributes to the collective knowledge base in the field of complex automation, optimizing electro-compressor performance, enhancing productivity, and ensuring a sustainable industrial process.

Keywords: Energy efficiency, Electro-compressor, Automation software, Thermal, Algorithm.

INVITED PRESENTATION

Id-592

EV Battery Sustainability: Diagnostic Techniques, Safety Challenges, and Circular Economy Solutions

M. AHMEID

School of Engineering, Newcastle University, Newcastle upon Tyne NE1 7RU, UK

*Corresponding Author: mohamed.ahmeid1@ncl.ac.uk

Abstract: As the number of electric vehicles (EVs) continues to rise, the end-of-life management of lithium-ion batteries (LiBs) has become increasingly critical for sustainability. This presentation explores a comprehensive approach to addressing the challenges associated with retired EV batteries. A practical method for accurately sorting these batteries based on their remaining capacity is introduced, validated on Nissan Leaf modules, which is essential for determining whether they should be repurposed or recycled. The impact of battery orientation on ageing and degradation patterns is also examined, revealing that different orientations can lead to non-uniform wear, affecting both initial use and second-life applications. Furthermore, the potential for second-life applications, such as stationary energy storage systems, is discussed, with an emphasis on the need for robust diagnostic techniques to ensure safety, longevity, and performance. Advanced methodologies like incremental capacity analysis and infrared thermal techniques are presented as tools to more accurately predict the "real" end-of-life of these batteries. The safety aspect is further explored through research on thermal runaway under various abuse conditions, uncovering significant hazards at both low and high states-of-charge (SOC), including a newly identified risk of vapor cloud explosions. These finding challenges existing safety perceptions and underscores the importance of improved safety protocols. Finally, the presentation situates these findings within the broader context of a circular economy for LiBs, emphasizing the necessity of automated disassembly and innovative recycling methods to manage the growing volume of retired batteries. The session concludes by reviewing cutting-edge recycling technologies and proposing strategies to achieve zero-waste outcomes, contributing to a sustainable and circular battery economy.

Keywords: Electric Vehicles (EVs), Lithium-Ion Batteries (LiBs), End-of-Life (EoL).

INVITED PRESENTATION

Id-594

Developing Key Components of Energy-Independent Wearables: Human Body Energy Harvesting and Self-Powered Sensors

J. BLUMS

Riga Technical University, Faculty of Natural Sciences and Technology, 7-321 P.Valdena Str., Riga, Latvia LV1658

*Corresponding Author: Juris.Blums@rtu.lv

Abstract: The energy, both the movement and heat offered by the human body, is theoretically large enough to ensure the work of wearable electronic devices, eliminating the need to charge or replace external power elements; in practice, when creating wearable electronic systems that use only harvested human body energy, developers face several challenges, for example, energy collection, transformation, and storage. When developing such wearables, several factors that are an integral part of human existence must be taken into account: the irregular nature of movements place additional demands on storage devices, the flow of heat from body parts to the surrounding environment strongly depends on the temperature difference, etc. Combining different energy sources is a perspective technique for ensuring a stable energy flow. On the other hand, the energy consumed to operate wearable systems can be significantly reduced if the sensors integrated into the clothing are electro-active and self-powered, i.e., they immediately transform the external effect that needs to be measured into an electrical signal. In our research, we apply the energy harvesting and self-powered sensors concepts to reach the energy independence of wearable electronics by integration into apparel devices, which can extract energy from the human body energy, both motion and heat flow and transform it into usable electric energy as well as information. By combining an electromagnetic motion energy harvester and a thermoelectric heat flow energy harvester, we have proposed a completely energy-independent system for measuring the physiological parameters (temperature, humidity) of the wearer and for data transfer to the remote observer, as well as have shown, that knitting technology can be applied for the creation of electroactive fully textile triboelectric sensors, which transfers the external impact to the electrical pulse, which parameters (amplitude, energy) depends on the impact strength. Such knitted structures can be completely integrated into clothes and used, for example, motion sensors.

Keywords: Wearable Electronics, Human Energy Harvesting, Thermoelectricity, Triboelectricity.

INVITED PRESENTATION

Id-597

Perspectives of Energy-efficient Superconducting Computer

V.M. KRASNOV

Department of Physics, Stockholm University, AlbaNova University Center SE-10691 Stockholm, Sweden

*Corresponding Author: krasnov@fysik.su.se

Abstract: Transition to sustainable development is a global challenge facing our society. Effective utilization of electrical energy is the key factor for the decarbonization of the economy. Resistive losses are one of the main sources of energy waste. Furthermore, resistivity creates the principal limitations for the further improvement of modern semiconductor-based electronics. The high resistance, R, of silicon transistors and narrow interconnections creates the challenging problem of heat management in very-large-scale-integration (VLSI) circuits. It also impedes the operation speed, limited by the RC time constant (C-is the capacitance). Superconducting (SC) electronics can revolutionize future computation techniques. Examples of the supremacy achievable by SC quantum computers have been recently demonstrated [1]. However, at present, practical calculations are made on classical computers and the demand for digital computation capacities will continue to grow. Large computation facilities, such as big data centers and supercomputers, have become major energy consumers. For example, the power budget of the Meta data center in Lulea (north of Sweden) exceeds 100 MW. Similar numbers are relevant for other supercomputer facilities. It has been argued that a small fraction of this power (~MW) would be sufficient for cooling down the processor unit to cryogenic temperatures, suitable for superconductors [2]. Recent advances in dry cryogenic techniques have enabled a relatively simple construction of large cryogenic facilities. Therefore, building and maintaining a cryogenic supercomputer is a realistic task. Since there is (almost) no resistance, R = 0, the RC time constant is not the major limiting factor for a SC computer. The maximum operation frequency is determined by the SC energy gap. For many SCs, it is the THz range and can exceed 10 THz for unconventional high-temperature SC. This has to be compared to a few GHz in modern semiconductor-based computers. Consequently, for large data facilities, the shift from semiconductors to superconductors could provide drastic improvements both in the power efficiency (by an order of magnitude) and in computation speed (by 2 orders of magnitude). Such

perspectives have led to renewed interest in the development of a classical (digital) SC computer [2]. In this talk, we present an overview of historical development and the current state of the art in the superconducting digital electronics and will present recent results on the development of novel vortex-based superconducting electronics [3], which could allow miniaturization to nm scale and drastic reduction of access energy/per operation to below 0.1 aJ.

Keywords: superconducting electronics, Cryogenic computing, Energy efficiency, Vortex-based technology.

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INVITED PRESENTATION

Id-598

Work Function and Photo/electrochemistry of Oxide Semiconductors (SnO_2 TiO_2 and ZnO)

L. KAVAN

J. Heyrovsky Institute of Physical Chemistry, Czech Academy of Sciences, Dolejskova 3, 18223 Prague 8, Czech Republic

*Corresponding Author: kavan@jh-inst.cas.cz

Abstract: Experimental and theoretical studies in this field have primarily been conducted in aqueous electrolyte solutions [1, 2], but aprotic media aree needed for applications in energy storage and conversion, such as lithium batteries and dye-sensitized solar cells [3, 4]. Optimizing these technologies requires detailed information about the electronic structure near the conduction band minimum (CBM), which can be quantified by the work function, among other factors [5]. However, analyzing the CBM structure is challenging and sometimes fundamentally impossible [4-6]. Investigations spanning various materials, from macroscopic single crystals with different face orientations to polycrystalline and quasi-amorphous thin films on various substrates, in both aqueous and acetonitrile electrolyte solutions, have provided self-consistent data while also revealing some issues [4]. Notable challenges include: (i) Determining flatband potential and donor concentration using Mott-Schottky analysis, particularly for nanotextured materials. There is a significant spread in flatband potentials for TiO2, SnO2, and ZnO, and overestimated concentrations of majority charge carriers, which could lead to incorrect predictions of degenerate semiconductors [2]; (ii) Calculating work functions and band edges via DFT, often neglecting the effects of sample environment and/or defects in real crystals [4, 7]; (iii) Measuring work functions and band edges using only a single experimental technique (e.g., photoelectron spectroscopy, Kelvin probe, or electrochemistry), despite the inherently poor reproducibility of values from each individual method [4, 6]; (iv) Transposing these problematic theoretical and experimental data into discussions on water splitting, solar fuel generation, solar cells, and lithium-ion batteries [4]; (v) Applying the Gärtner-Butler model for carrier dynamics in a semiconductor photoanode without considering the gradient of electrochemical potentials as the driving force for electron-hole separation [4, 8].

Keywords: Titanium Dioxide, Tin Dioxide, Zinc Oxide, Mott-Schottky Analysis; Photoelectrochemistry, Photocatalysis, Water Splitting, Dye-Sensitized and Perovskite Solar Cells, Li-Batteries.

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INVITED PRESENTATION

Id-601

Novel Liquids for Increasing the Mobility of Aqueous Solutions for Low Permeable and Ultra-Low Permeable Oil Formations

A. S. USHAKOVA[1,*], V. V. ZATSEPIN[2]

[1]INEOS RAS, Vavilova st, 28, 119991, Moscow, Russia

[2]"Argentum-Energy" LLC, Mramornaya st, 10-167, 142116, Podolsk, Moscow region, Russia

*Corresponding Author: paravoz-s@yandex.ru

Abstract: It is known that polymer aqueous solutions at ultra-low concentrations of less than 1% can act as surfactants and reduce surface energy at the interface, which ensures a more complete displacement of oil from a porous medium. Such systems are characterized by lower adsorption on the rock surface in comparison with surfactant solutions and can be used for low-permeable reservoirs.

The conducted studies have shown the mechanism of locking filtration in low-permeable core samples during multilayer adsorption. The solution to the problem, as preliminary studies have shown, can be the use of mutual solvents [1-2] and/or the use of specially designed mixture of block-copolymers of low concentration in aqueous solvent of certain mineralization [3-4]. Chemical composition of aqueous solvent strongly depends on the oilfield properties and is unique for all the considered oilfields. Filtration results, as well as pilot tests have shown great efficiency in relative permeability increase [1-2]. Some chemical compositions are already successfully applied at the oilfields and have shown their efficiency in additional oil recovery and water cut decrease. This effect is stable for about 1-2 years after solvent injection, so we can conclude about rather good efficiency of chemical composition. This is probably based on the effect of chemical components' adsorption on the porous media. Analysis of the chemical compositions and some theoretical explanations of the solvents' efficiency are also considered in this work. Investigation of the mobility of aqueous solutions depending on the permeability of a porous medium was done.

The research is based on previously conducted theoretical studies, studies of filtration of surfactant solutions, polymers and mutual solvents in low-permeable reservoirs, and on the results of pilot tests of compositions based on block-copolymers (commercial name is "SFW technology") in the oilfields of Kazakhstan in 2018-2023.

Keywords: Oil Recovery, Surfactants, Block-Copolymers, Mutual Solvent, Surface Energy, Adsorption, Permeability.

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INVITED PRESENTATION

Id-602

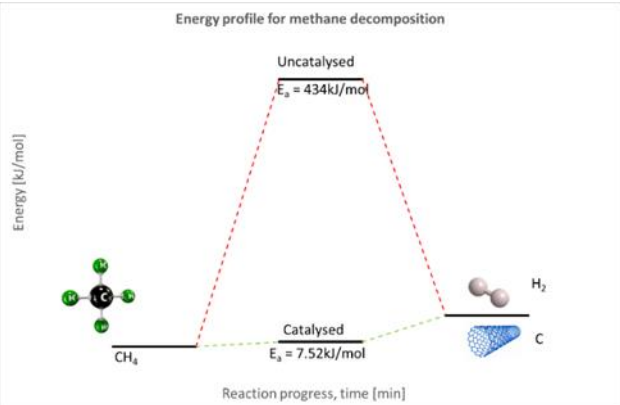
Thermo-Catalytic Decomposition of Methane to Hydrogen and Carbons – Kinetic Studies for A Novel Perovskite Catalyst

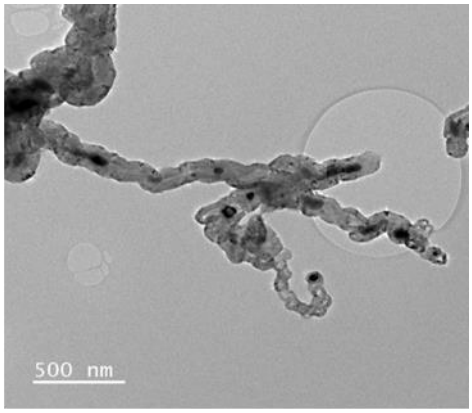
A.M SWARTBOOI*, Z. DUMA

HySA&CCU, Centre for Nanostructured and Advanced Materials, Chemicals Cluster, CSIR, Meiring Naude Road, Brummeria, Pretoria, South Africa

*Corresponding Author: aswartbooi@csir.co.za

Abstract: Hydrogen is seen as one of the most promising energy vectors and it plays a key role in many industrial applications. The current production methods of hydrogen are undesirable due to huge CO2 emissions associated with the production methods, i.e. coal gasification and steam methane reforming. For these reasons, many efforts are being made to produce cleaner hydrogen with zero to low CO2 footprint via water electrolysis powered by renewable energies. However, to meet short term needs and near-term net-zero targets, the continued use of fossil fuels will still be required [1]; alternatively renewable and sustainable sources of carbon will need to be sourced. Methane pyrolysis offers a cleaner production method for producing low-carbon hydrogen and solid carbon [2], [3]. Solid carbon offers easier sequestration options but can also be sold as a value-added product. In this study, we have developed a perovskite catalyst with high methane conversions to hydrogen which was sustained over long term operation on stream [4]. This work will discuss catalyst development and optimization studies, as well as touching on carbon product formation.





Keywords: Catalysis, Hydrogen, Methane, Thermos-Catalytic Decomposition, Carbon Nanotubes.

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INVITED PRESENTATION

Id-603

Shunt Active Power Filter as Energy Efficiency Solution

M. GAICEANU*, S. EPURE, R. SOLEA, R. BUHOSU

Dunarea de Jos" University of Galati, Domneasca Street no. 47, 800008 Galati, Romania

*Corresponding Author: Marian.Gaiceanu@ugal.ro

Abstract: Due to global environmental issues, policy makers around the world have focused on taking concrete steps to reduce greenhouse gases. The European Union has established a set of climate objectives for the period 2030-2050 [1]. One of the priorities of the European Union is the decarbonization of the energy sector. This can be achieved by increasing energy efficiency. The modernization of electrical equipment is carried out by introducing static power converters that modulate the electrical energy received from the network to meet the load requirements. These become non-linear loads in the structure of a power supply system. Due to the switching of power electronics from modern industrial equipment, from transport, energy production, but also from domestic consumers, this equipment has become sources of harmonic currents that worsen the power factor and efficiency of the conversion system [2]. The current harmonics lead to the increase of the current absorbed from the energy source, and the losses through the Joule effect increase with the square of the current, hence the reduced efficiency of the conversion. By reducing the harmonic content of the supply current, losses through the Joule effect are reduced. Therefore, the harmonic content control methods applied at the common load connection point led to an increase in energy efficiency. One of these methods is the dynamic control of harmonic content and power factors by means of active power filters. This presentation shows the control of the power factor and the harmonic content of the supply current in the PCC by means of an active power filter prototype mounted in the common coupling point (PCC) for a system that supplies a non-linear consumer. The prototype was made through the project at the Dunarea de Jos University of Galati [3,4]. In this paper, mathematical modeling, the developed control and the simulation results of an electrical system with active power filter of parallel type will be presented. This method leads to an increase of the power factor, the elimination of current harmonics leading to an increased energy efficiency and to the increase of the reliability of energy

conversion systems. Also, the experimental results obtained on the active power filter prototype will be presented.

Keywords: Shunt Active Power Filter, DC Bus, Voltage Control, Power Quality; Current Harmonics, Power Factor.

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ORAL PRESENTATION

Id-559

Risk-Informed Defense-in-depth Strategy for Nuclear Power Plant

Q. LIU*, Y. WU, D. YAO, G. WANG, C. YANG, C. WANG, Y. LU

China Nuclear Power Engineering Co., Ltd, Beijing 100840, China

*Corresponding Author: liuqwb@cnpe.cc

Abstract: As one of the basic safety design principles, defense-in-depth (DiD) concept has been proven effective for ensuring the safety of nuclear reactors by safety operation of hundreds of units for decades. The classic defense-in-depth concept containing five defense levels is built on mainstream light-water cooled reactor (LWR). After the Fukushima nuclear accident, improvements of the DiD concept were proposed by IAEA and WENRA, including adding sublevel for additional Design Extension Condition (DEC), and emphasizing the independence between defense levels. However, several problems are exposed during the practical application of the current DiD concept, such as over-protection, resulting to complex systems and cost burden; or neglected weakness, and misunderstanding of the goal for different defense levels. Besides, the current DiD concept based on deterministic method has limitations for innovative design or advanced technology application, and no longer appropriate for non-light water reactor designs because it evolved from LWR type and earlier deterministic hypothesis. How to develop a more comprehensive, holistic, and technology-inclusive DiD strategy for nuclear power plant is explored in this study. A risk-informed (RI) method is adopted to improve the DiD strategy. Firstly, the critical steps or elements in the top-down DiD design for a NPP are recognized, and which steps exist problems that could be optimized using risk insights are analyzed. Then, considering the gradual development of risk assessment methods and tools and acceptance process of risk insight for nuclear industry, a progressive risk-informed DiD strategy is proposed, including three RI solutions with different optimized steps or elements. The optimized steps or elements could be implemented through an integrated risk-informed DiD design process balancing between deterministic and risk perspectives. The process is iterative and guides the overall NPP design. Furthermore, the DID adequacy evaluation of resulting design can be reasonably conducted by taking the above process with data obtained in each risk-informed DiD step or elements. It is noted that the RI-DiD strategy for NPP is a hybrid approach that

integrates the deterministic principle of traditional DiD concept with the quantitative risk assessment of how much defense is needed, neither to abandon deterministic safety requirement, nor to just rely on probabilistic risk assessment (PRA). The RI-DiD strategy for NPP aims to make up the limitations of current DiD strategy and allocating resources to weakness that might be overlooked. Taking an advanced PWR with combined active and passive feature as an example, this paper presents a simplified configuration using RI insight meeting current DiD requirements, and the main elements that need to be considered in the specific design are illustrated in the design of secondary residual heat removal system.

Keywords: Defense-in-Depth, Limitations, Risk-informed, Integrated decision-making.

ORAL PRESENTATION

Id-562

Recyclable Composites Based on Natural and Waste Materials for Thermal Insulation Applications: An Example of "Deep Materials Sustainability"

V. LUGHI

University of Trieste, Department of Engineering and Architecture, Trieste, Italy

*Corresponding Author: vanni.lughi@dia.units.it

Abstract: True (or "deep") sustainability of materials is obtained if all phases of the material's life cycle are sustainable: sourcing, manufacturing, use, End-of-Life. While there are multiple and complex metrics for sustainability, good proxies are the energy usage or the CO2 emissions at each of these stages. Here, we discuss an example of a "deeply sustainable" material. We co-developed a highly efficient thermal insulation foam [1] (ensuring energy and CO2 credits in the use phase) along with its recycling process [2]; the foam material is a composite consisting of an alginate matrix and recycled fiber glass as the filler – i.e. a combination of renewable and recycled materials, ensuring minimum impact at the sourcing stage. At the end of life of the insulating foam – e.g. when the highly porous microstructure starts degrading, leading to a decrease of the thermal insulation performance – the composite can be recycled through a process that exploits the reversibility of the molecular assembly mechanism in the ion-assisted gelification of alginate, which is the first step in the fabrication of our material. A chelation agent is utilized to sequestrate the ions and disassemble the matrix, enabling the full recovery of the initial material source. Reversing chelation by changing the pH enables re-gelification and successively re-creation of the foam; this process can be repeated multiple times, and the new foam shows unaltered thermal insulation properties, as assessed via thermofluximetry and calorimetry. SEM and micro-computed tomography are used to characterize the microstructure of the foams, and a Life-Cycle Assessment is also carried out, showing a rather promising environmental footprint. This work shows the feasibility of a deeply sustainable material: a foam based on a natural source, incorporating waste material, fully recyclable, and that is an effective thermal insulator – simultaneously addressing, in the spirit of circular economy, the issue of energy efficiency, of sustainable materials sourcing, and the material end-of-life.

Keywords: Natural-based materials, Waste-based materials, Recycling, Thermal Insulation, Sustainability.

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ORAL PRESENTATION

Id-563

Deposition of Luminescent and Hydrophobic Coating for Efficiency Improvement of Si Solar Cells

T. S. ATABAEV*, D. GOPONENKO, K. ZHUMANOVA

Nazarbayev University, Department of Chemistry, Astana, Kazakhstan

*Corresponding Author: timur.atabaev@nu.edu.kz

Abstract: Solar cells are playing an important role in global efforts to minimize reliance on conventional energy sources. These technologies not only help to reduce greenhouse gas emissions, but they also provide the potential to boost energy availability in rural or hard-to-reach regions. Despite well-established manufacturing technology, solar panels still face significant challenges that limit their efficiency, stability, and durability. In particular, spectral mismatches between solar cells' absorbance and solar radiation cause thermalization effects and partial loss of high energy (UV) and low energy (IR) photons [1]. On the other hand, ultraviolet (UV) radiation has a substantial impact on solar cells by damaging their active layers and, as a result, lowering their efficiency over time. Potential solutions include the blocking of UV light (which can reduce the power output of solar cells) or converting UV photons into visible light using down-conversion optical materials. In this work, we propose a novel hydrophobic coating based on a polydimethylsiloxane (PDMS) layer with embedded red emitting Y2O3:Eu3+ (quantum yield = 78.3%) particles for UV radiation screening and light conversion purposes. The favorable features of the PDMS-Y2O3:Eu3+ coating were examined using commercially available polycrystalline silicon solar cells, resulting in a notable increase in the power conversion efficiency (PCE) by ~9.23%. The chemical and UV stability of the developed coatings were assessed by exposing them to various chemical conditions and UV irradiation. It was found that the developed coating can endure tough environmental conditions, making it potentially useful as a UV-protective, water-repellent, and efficiency-enhancing coating for solar cells.

Keywords: PDMS, Y2O3:Eu3+, UV protection, hydrophobic coating, Si solar cells.

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ORAL PRESENTATION

Id-604

PEDOT:PSS/Laser-induced graphene composites: Preparation and Thermoelectric Characterization

F. KOCAMAN KABIL[1,*], N. AYDEMİR[1], A. Y. ORAL[2]

[1]Institute of Nanotechnology, Gebze Technical University, Gebze, Kocaeli 41400, Turkey

[2]Department of Materials Science and Engineering, Gebze Technical University, Gebze, Kocaeli 41400, Turkey

*Corresponding Author: fatmanurkocaman@gtu.edu.tr

Abstract: Poly(3,4-ethylenedioxythiophene)(styrenesulfonate) (PEDOT:PSS) is widely recognized as one of the most effective polymer materials for thermoelectric (TE) applications. Traditional methods to enhance its TE performance have involved treatments with high-boiling solvents, acids, or bases. However, recent advancements have shifted toward composite materials that integrate organic polymers with inorganic substances or carbon nanostructures to improve electrical conductivity, flexibility, and processability. Among these carbon nanomaterials, graphene stands out for its remarkable thermoelectric properties, high electrical conductivity, flexibility, lightweight structure, and non-toxicity. In this study, we developed composite thermoelectric materials based on laser-induced graphene (LIG) and PEDOT:PSS. Flexible electronics based on functionalized LIG offer significant potential for a wide variety of applications, such as sensors, energy harvesting, and energy storage systems. LIG, produced through a rapid, scalable, and cost-effective process, holds great promise for flexible electronics applications, including sensors, energy harvesting, and energy storage systems. We fabricated graphene powders using a CO2 laser to scribe directly on polyimide (PI), followed by scraping the LIG film from the PI surface. These powders were combined with PEDOT:PSS to create conductive inks, which were coated on glass via drop casting for performance measurements. To evaluate the thermoelectric properties of the composite, we measured electrical conductivity and Seebeck coefficients, demonstrating the impact of LIG as a filler in enhancing PEDOT:PSS's performance. Our findings underscore the potential of this composite material for flexible and wearable thermoelectric devices, paving the way for future research and development in sustainable energy technologies.

Keywords: Laser-induced graphene, PEDOT:PSS, Thermoelectric.

POSTER PRESENTATION

Id-557

Cobalt-Iron-Phosphorus Catalysts for Hydrogen and Oxygen Evolution

E. NORKUS, H. AMBER, K. VJUNOVA, Z. SUKACKIENE, B. SIMKUNAITE-STANYNIENE, J. VAICIUNIENE, L. TAMASAUSKAITE-TAMASIUNAITE

Department of Catalysis, Center for Physical Sciences and Technology (FTMC), Sauletekio Ave. 3, LT-10257 Vilnius, Lithuania

*Corresponding Author: eugenijus.norkus@ftmc.lt

Abstract: Hydrogen production by water splitting is one of the low-cost green hydrogen production technologies. The challenge is to develop inexpensive, highly active catalysts. Herein, we present a strategy for fabricating flexible electrocatalysts based on cobalt-phosphorus (CoP) and cobalt-iron-phosphorus (CoFeP) coatings. The CoP and CoFeP coatings have been deposited on the flexible copper-coated polyimide (Cu/PI) surface using the low-cost and straightforward method of electroless metal deposition. The morphology, structure, and composition of CoP and CoFeP catalysts deposited on the Cu/PI surface have been studied by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and inductively coupled plasma optical emission spectroscopy (ICP-OES), while their activity was investigated for hydrogen evolution (HER) and oxygen evolution (OER) reactions in 1 M KOH using linear sweep voltammetry (LSVs) and chrono-techniques. The HER and OER data for the CoP/Cu/PI and CoFeP/Cu/PI catalysts in an alkaline medium are compared and discussed on the basis of electrochemical data.

Keywords: Cobalt, Iron, Phosphorus, Hydrogen Evolution, Oxygen Evolution, Electroless Metal Plating.

POSTER PRESENTATION

Id-558

Study of Oxygen Reduction and Evolution on Palladium-Modified Cobalt-Phosphorus and Cobalt-Iron-Phosphorus Coatings

H. AMBER, L. TAMASAUSKAITE-TAMASIUNAITE, K. VJUNOVA, Z. SUKACKIENE, D. SIMKUNAITE, J. VAICIUNIENE, E. NORKUS

Department of Catalysis, Center for Physical Sciences and Technology (FTMC), Sauletekio Ave. 3, LT-10257 Vilnius, Lithuania

*Corresponding Author: loreta.tamasauskaite@ftmc.lt

Abstract: This study presents the fabrication of palladium-modified cobalt-phosphorus (Pd-CoP) and cobalt-iron-phosphorus (Pd-CoFeP) coatings deposited on the copper surface by the electroless metal plating, followed by their modification with Pd crystallites, and their application for oxygen reduction (ORR) and evolution (OER). Scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and inductively coupled plasma optical emission spectroscopy (ICP-OES) were used to characterize the morphology, structure, and composition of the resulting catalytic materials, while the electrocatalytic activity of the catalysts for the ORR and OER in an alkaline medium was studied using the rotating disc electrode (RDE) method. The ORR and OER data for the Pd-CoP and Pd-CoFeP catalysts are presented. Modification of CoP and CoFeP coatings with Pd crystallites was found to significantly enhance their ORR and OER activities compared to unmodified CoP and CoFeP coatings.

Keywords: Palladium, Cobalt, Iron, Phosphorus, Oxygen Reduction, Oxygen Evolution, Electroless Metal Plating.

POSTER PRESENTATION

Id-560

Study of Contaminants Present in Industrial Water Used for Cooling Gases in The Pyrolysis Process

S. D. OSIPOVS*, A. I. PUČKINS

Institute of Life Sciences and Technology, Department of Applied Chemistry, Daugavpils University, Daugavpils, Latvia

*Corresponding Author: sergejs.osipovs@du.lv

Abstract: Pyrolysis promotes the breakdown of waste into valuable by-products, resulting in gas, liquid, and solid phases. Among the components in the gas mixture are tars. Water purification technology is used to purify pyrolytic gas. However, this approach has a drawback: tar components gradually accumulate in the water. Light heterocyclic aromatic compounds and heavy polyaromatic tar compounds, which are easily soluble, are particularly susceptible to such accumulation. Although the pyrolysis gas contains large amounts of some light aromatic tar compounds, their presence in the cooling and cleaning water is minimal. Consequently, as the pyrolysis cycles increase, the total tar content and the proportion of individual tar compounds in the cooling and purification water change, with a significant accumulation of the heaviest polyaromatic tar compounds. This accumulation creates problems for further purification and the use of the cooling and purification water itself. The cooling water collected from the scrubber was sampled at a pyrolytic gas temperature of 250 °C after 5, 10, and 15 pyrolysis cycles. The aqueous tar components were extracted with dichloromethane. In the extraction process, 4 ml of dichloromethane was added to 100 ml of water, shaken for 30 minutes, and the procedure was repeated three times with the same sample to improve the yield. The extracted compounds were then pooled, concentrated by rotary evaporation, filtered through syringe filters, and submitted for GC/MS analysis. The concentration of individual tar compounds in the cooling and treatment waters shows different growth patterns depending on the number of pyrolysis cycles. For example, poorly water-soluble light aromatic tar compounds such as benzene and naphthalene show only 1.69- and 1.57-times higher concentrations in cooling and cleaning water during triple pyrolysis. However, light heterocyclic aromatic tar compounds that are easily soluble in water, such as phenol, m-cresol, p-cresol, and 2,3-xylenol, show 2.54, 2.63, 2.48, and 2.74-fold increases in concentration, respectively, as the number of pyrolysis cycles increases threefold. Similarly, the

concentration of heavy polyaromatic tar compounds, which are poorly soluble in water, in cooling and cleaning water increases significantly more than light tar compounds. For example, in the triple pyrolysis cycle, the concentration of tar compounds such as pyrene, chrysene, and coronene in the cooling and cleaning water increases by 2.69, 1.91, and 2.52 times, respectively. When exposed to pyrolytic gas, the easily soluble light heterocyclic aromatic tar compounds and heavy polyaromatic tar compounds gradually accumulate in the cooling and cleaning water. Although the pyrolysis gas contains large amounts of some light aromatic tar compounds, their presence in the cooling and cleaning water is minimal. The pyrolytic gas purification process not only increases the total tar content of the cooling and cleaning water but also changes the ratio of individual tar compounds, especially the accumulation of heavier polyaromatic tar compounds. These changes create problems for further processing and the use of cooling and cleaning water.

Keywords: Pyrolysis, Cooling and Cleaning Water, Extraction, Tar, Gas Chromatography.

POSTER PRESENTATION

Id-570

ICT For Smart and Energy Efficient Buildings

D. N. KARASTOYANOV

Institute of Information and Communication Technologies – Bulgarian Academy of Sciences, bl. 2, ac. G. Bonchev str., 1113 Sofia, Bulgaria

*Corresponding Author: dimikara@abv.bg

Abstract: The European Intelligent Building Group (EIBG) proposes an efficiency-based definition. EIBG considers smart buildings to be those designed to provide their users with the most efficient environment and for the building to use and manage resources as efficiently as possible, to minimize the costs of appliances and installations. Service-based definitions describe smart buildings in terms of the services and/or their quality provided by buildings. According to the National Sociological Institute, there are about 4,000,000 homes in Bulgaria, with approximately 66% of them located in cities. The largest percentage are brick buildings (about 80% with beams or reinforced concrete slab). According to the Ministries of Economy, Energy and Tourism, the potential of solar radiation on the territory of Bulgaria is significant. The average annual duration of insulation is about 2150 hours with annual total radiation ranging from 1400 to 1600 kWH/m2. According to the same sources, about 3% of the territory of the country can theoretically be used for photovoltaic energy. This makes the option of installing rooftop solar systems for home use attractive. Private properties and residential buildings are acquiring solar panels, aiming at a more ecological way of life and minimizing electricity costs. An innovative idea is the construction of a roof system (solar tiles) for energy-efficient construction and energy storage. Its adoption enables efficient and reliable roof constructions, reducing electricity costs and providing "green" energy. This structure is distinguished by its simultaneous functional purpose - the role of a roof and the creation of electrical energy. The innovativeness of the proposed solution consists in the use of solar tiles and creation of a complete smart system for energy management, which will not only record the energy produced, consumed or given away by the household, but will be able to learn itself and make a decision based on the machine learning concept. The temperature controller for types of solar collectors allows them to achieve maximum efficiency when using similar types of systems. The controller for the management of heating-cooling fluid systems is designed for the management of heating and cooling

systems with fluid circulation. Thermal energy storage systems can store heat or cold to be used later under different conditions such as temperature, location or power. Knowledge of the melting and freezing characteristics of phase change materials (PCM), their ability to undergo thermal cycling, and their compatibility with building materials is essential for evaluating the short- and long-term performance of latent heat storage systems. A typical heat storage system is a water storage vessel in which pipes filled with PCM. PCM used for heat storage are chemical substances that undergo a solid-to-liquid transition at temperatures in the desired heating and cooling range. PCM are special types of paraffins.

Keywords: Smart Buildings, Solar Tiles, Temperature Controller, Phase Change Materials.

POSTER PRESENTATION

Id-572

New Anthrone Derivatives as Light Emitting Substances

E.M. KIRILOVA[1,*], A. MALECKIS[2], R. FRIDMANS[1]

[1]Institute of Life Sciences and Technology, Daugavpils University, Daugavpils, Latvia

[2]Faculty of Materials Science and Applied Chemistry, Riga Technical University, Riga, Latvia

*Corresponding Author: jelena.kirilova@du.lv

Abstract: Solid-state luminescent dyes have always been of great interest as electroluminescent materials for light-emitting devices. The development of such materials involves the search for new p-conjugated donor–acceptor systems and a detailed study of their photophysical parameters. Anthracene derivatives (anthrone and anthraquinone dyes) are a special class of environmentally sensitive, photostable, bright luminophores. Therefore, many anthracene derivatives have found various applications for solving a number of important practical goals, in particular, to create highly efficient and inexpensive OLEDs [1,2]. In continuation of our research in the field [3,4], present work is focused on photophysical study of new anthrone derivatives with various substituents in aromatic core. During this study new preparation methods were designed for synthesis of emissive anthrone derivatives. The resulting derivatives with substituted amino and amidino groups have effective polarity sensitive fluorescence in organic solvents from 550 to 750 nm, and many of them also have solid-state emission. In present research, interesting results about substituents effects on physical properties of prepared dyes are obtained and discussed. The electroluminescent properties of selected solid-state emissive derivatives were investigated using single-layer (ITO/PEDOT:PSS(50nm)/Dye/LiF(1nm)/Al (130nm) structures, demonstrating emission at 620-650 nm and current efficiency at 2.0-2.5 cd/A. The obtained results indicate that further design of anthrone molecules could develop a variety of materials for organic electronics applications.

Keywords: Luminescent Dyes; Anthrone Derivatives; Synthesis; Fluorescence Spectroscopy, Electroluminescence.

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POSTER PRESENTATION

Id-580

Development of On-Board Charger and Solar Inverter Using Power Module Based on Wide Bandgap

Y. S. NOH, S. M. PARK, J. S. PARK AND J. H. KIM*

Korea Electronic Technology Institute, Power System Research Center, Bucheon, Korea

*Corresponding Author: yongsu.noh@keti.re.kr

Abstract: With the recent surge in interest regarding environmental pollution, the enhancement of power converter (i.e. electric energy conversion devices such as inverter and converter) has become increasingly important. Additionally, to use energy more efficiently, systems integrating batteries or renewable energy sources are being developed. Also, improving the efficiency of power conversion devices, extending the driving range of electric vehicles, and enhancing consumer convenience have led to demands for higher density and lighter power converter. Recently developed WBG (Wide Bandgap) devices can operate with lower switching and conduction losses compared to the widely used silicon-based devices. This allows for high-frequency operation, making high-efficiency and high-density power conversion devices possible. This paper addresses the development of an on-board charger (OBC) for electric vehicles and a solar inverter using power semiconductor based on WBG to achieve high density and efficiency in power converter. The OBC, which is installed inside electric vehicles, charges the vehicle's battery from the grid power. Integrating the OBC with the solar inverter allows for the efficient use of stored energy in the electric vehicle battery and renewable energy. The OBC structure consists of a boost converter for power factor correction (PFC) and a full-bridge LLC converter, with an output rated capacity of 7.2 kW. The power semiconductor of the OBC uses a power module composed of gallium nitride (GaN) devices, and the capacitor for the resonant tank is implemented with sub-modules based on MLLC devices. The solar inverter has an output capacity of 3kW and it is also adopted GaN based power module. The operation of the OBC and solar inverter was verified through PSIM simulations. Additionally, a laboratory prototype was built using WBG-based sub-modules and control board sub-modules to verify efficiency and performance.

Keywords: On-board Charger, Photovoltaic Inverter, Wide Bandgap, Sub-module, Intergration.

POSTER PRESENTATION

Id-581

Phase Shift Modulation Method for Low Voltage-Light Load Area of Load Resonant Converter with Wide Output Voltage

D. M. JOO, H. G. YANG, J. S. PARK, J. H. KIM*

Korea Electronic Technology Institute, Power System Research Center, Bucheon, Korea

*Corresponding Author: kimjinhong@keti.re.kr

Abstract: Recently, an 800V battery system was developed to overcome the limitations of the 400V battery system with a long charging time at the same battery capacity. In the case of Hyundai's IONIQ 6,it is equipped with the 800V battery system, and it takes only 18 minutes to charge to 80%. Therefore, a DC fast charger should charge low voltage from 200V to high voltage 1,000Vdc due to the spread of both 400V and 400V electric vehicles. The LLC resonant converter topology is widely used for key topology of DC fast chargers because of its high-efficiency and soft switching characteristics of output diode. However, it acts as a voltage divider controlled by switching frequency, so it cannot regulate output voltage/current near no-load condition especially at low voltage. However, standard EV charging sequence requires low voltage-light load operation to check cable status. Therefore, other controlling methods should be applied to meet IEC 61851-23 charging standards. The Phase shift modulation method can be applied to conventional LLC resonant converter to reduce the input voltage of the resonance network. In this paper, this method is applied to a prototype of fast charger module.

Keywords: LLC Resonant Converter; Wide Voltage Range; DC Fast Charger; IEC 61851-23 Standard; Phase Shift Modulation.

POSTER PRESENTATION

Id-605

UV-Vis-NIR Absorption Spectroscopy as a Supporting Technique in Understanding the Electrical Conductivity Behavior of the PEDOT:PSS Films

B.Ş. AKDEMİR YILMAZ[1,*], N. KIZILDAG[1], A. Y. ORAL[2]

[1]Institute of Nanotechnology, Gebze Technical University, Gebze, Kocaeli 41400, Turkey

[2]Department of Materials Science and Engineering, Gebze Technical University, Gebze, Kocaeli 41400, Turkey

*Corresponding Author: vcaskan@gtu.edu.tr

Abstract: UV-Vis-NIR absorption spectroscopy deals with the optical properties of materials like absorption, transmission and reflection and uses lights having wide range of wavelengths from ultraviolet to the near-infrared. In ultraviolet and visible range, the incoming ultraviolet light energy is absorbed by the certain functional groups (chromophores) that contain valence electrons of low excitation energy whereas in infrared region, the incoming light is absorbed by the molecular bonds of the material. These behaviors give an insight about the optical and chemical properties of the tested material. Poly(3,4-ethylenedioxythiophene) (PEDOT), is an inherently conductive, insoluble polymer. It is blended with poly(styrene sulfonic acid) (PSS) in order to improve its solubility and processability. Due to the decreased overall electrical conductivity caused by the blending with PSS, some additional processes are applied to improve the electrical conductivity [1, 2, 3]. In this study, different organic solvents and their mixtures were used as dopants in the preparation of PEDOT:PSS solutions for film preparation [4]. Spin-coating was used in coating of the films onto the pre-cleaned glass substrate at 1000 rpm for 45 s. The spin-coatings procedure was repeated twice. Then the films were immersed into the organic solvents for further doping. The resistances of the films were measured by 4 point-probe method using Gamry Reference 3000 Potentiostat and then the electrical conductivity was calculated [5]. UV-Vis-NIR absorption spectroscopy was used to investigate the absorption properties of the PEDOT:PSS films. The electronic transitions of PEDOT and PSS were affected by the doping process and the type of the organic solvent used for doping. The electrical conductivity of the PEDOT:PSS films could be further improved by the application of a post-treatment using organic solvents..

Keywords: Doping, Electrical Conductivity, Optical Properties, PEDOT:PSS, Post Treatment, Secondary Doping, Spin-Coating, UV-Vis-NIR.

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SUBMISSIONS & TOPICS

TOPIC	TITLE
Solar Energy	Id 585 - Solar Photovoltaic Soiling Loss: Quantification, Measurement and Monitoring
Nuclear Energy	Id 559 - Risk-Informed Defense-in-depth Strategy for Nuclear Power Plant
Petroleum	Id 601 - Novel Liquids for Increasing the Mobility of Aqueous Solutions for Low Permeable and Ultra-low Permeable Oil Formations
Natural Gas	Id 588 - Thermal and Energy Efficiency Solutions for Natural Gas Compression using Industrial Automation
Efficient Consumption of Energy	Id 603 - Shunt Active Power Filter as Energy Efficiency Solution
	Id 580 - Development of on-board Charger and Solar inverter using Power Module Based on Wide Bandgap
	Id 581 - Phase Shift Modulation Method for Low Voltage-Light Load Area of Load Resonant Converter with Wide Output Voltage
Energy effEcient Buildings	Id 568 - The Reuse of End-of-Life Home Materials (EoLHM) in Buildings' Energy Harvesting
	Id 570 - ICT for Smart and Energy Efficient Buildings
Efficiency in Heating and Cooling	Id 553 - High-performance Membranes for Energy Efficient Air Cooling
Thermoelectrics	Id 594 - Developing key Components of Energy-independent Wearables: Human Body Energy Harvesting and Self-powered Sensors

	Id 604 - PEDOT:PSS /LIG Composites: Preparation and Thermoelectric Characterization
	Id 605 - UV-Vis-NIR Absorption Spectroscopy as a Supporting Technique in Understanding the Electrical Conductivity Behavior of the PEDOT:PSS Films
Batteries	Id 592 - EV Battery Sustainability: Diagnostic Techniques, Safety Challenges, and Circular Economy Solutions"
Photovoltaics and Solar Cells	Id 563 - Deposition of Luminescent and Hydrophobic Coating for Efficiency Improvement of Si Solar Cells
	Id 598 - Work Function and Photo/electrochemistry of Oxide Semiconductors (SnO_2 TiO_2 and ZnO)
Hydrogen Production and Fuel Generation from Renewables (Catalysis)	Id 554 - Techno-economic Analysis of Hydrogen Production and Transportation
	Id 557 - Cobalt-Iron-Phosphorus Catalysts for Hydrogen and Oxygen Evolution
	Id 558 - Study of Oxygen Reduction and Evolution on Palladium-modified Cobalt-phosphorus and Cobalt-Iron-Phosphorus Coatings
	Id 602 - Thermo-catalytic Decomposition of Methane to Hydrogen and Carbons – Kinetic Studies for a Novel Perovskite Catalyst
Light Emitting Materials	Id 572 - New Anthrone Derivatives as Light Emitting Substances
Materials for Energy Saving	Id 562 - Recyclable Composites Based on Natural and Waste Materials for Thermal Insulation Applications: an Example of “Deep Materials Sustainability”

	Id 597 - Perspectives of Energy-Efficient Superconducting Computer
Environmental Pollution & Management	Id 560 - Study of Contaminants Present in Industrial Water Used for Cooling Gases in the Pyrolysis Process