4th Energy, Efficiency and Environmental Sustainability Conference 2023

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Keynote Speakers

Dr. Rafael Ramírez

Professor at The Center for Research and Advanced Studies of the National Polytechnic Institute, CINVESTAV-IPN, in Querétaro. MEX.

Keynote: "Semiconductor nanostructures and nanocomposites for environmental applications"

Dr. Belén Villacampa

Professor at the Department of Condensed Matter Physics, University of Zaragoza, Spain, and the Institute of Nanoscience and Materials in Aragón (INMA- CSIC-UZ).

Keynote: "The Revival of DSSCs, is it possible without a commitment to sustainability?"

Dr. Marcela Vazquez

Professor at the National University at Mar del Plata in Argentina and a Staff member of the National Research Council (Principal Researcher), CONICET, ARG.

Keynote: "Challenges and opportunities while preparing chalcopyrites and kesterites for photovoltaic applications by non-vacuum techniques"

November 29th - December 01st | 2023
Hotel Club La Serena - Avenida del Mar 1000

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FONDECYT 1231376
Development of a photocatalytic coating based on bifunctional catalysts of semiconductor oxides with hierarchical structures for environmental and antimicrobial

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PROGRAM AND ABSTRACT BOOK

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ESSS

Welcome from Vicerrector de Investigación y Postgrado de la Universidad de La Serena

La Universidad de La Serena (ULS), busca siempre cumplir con las exigencias de la sociedad y una de las demandas que más se han evidenciado en los últimos años son el problema energético y la escasez hídrica. En este contexto, las políticas institucionales en materia de investigación científica fundamental, investigación aplicada y formación de especialistas conducentes a la generación y desarrollo de energías limpias y tecnologías no contaminantes, son un eje de relevancia para la Universidad. Evidencia de aquello es la creciente productividad científica en el área y la creación de programas de Diplomados, Magister y Doctorado en temáticas de energías renovables y Sustentabilidad.

Desde un punto de vista global, el planeta está sufriendo un alza de temperatura con consecuencias graves para los sistemas biológicos y sus equilibrios naturales. Es así como uno de los objetivos principales de la Agencia Internacional de la Energía (AIE), compuesta por 30 países, es mantener el calentamiento global por debajo de los 2 grados centígrados, siendo para ello absolutamente necesario realizar una transición a energías limpias y reducir de forma sostenible la emisión de gases con efecto invernadero. Según la AIE, el escenario de desarrollo sostenible acordado por 193 países en el año 2015, para mantener los objetivos de París, considera la necesidad de producir al menos 300 GW de nuevas capacidades de energías renovables por año hasta el 2030. Por otro lado, muchos países comienzan a acordar reducir sus emisiones a tal punto de volverlas neutras. En el caso de Chile, se ha anunciado un ambicioso plan para convertir al país en carbono neutral al año 2050, proyectando para ello el cierre de todas las centrales energéticas basados a carbón y el potenciamiento de la generación de energías renovables. Ante este nuevo escenario, las nuevas tecnologías deben ser direccionadas a la consecución de los objetivos climáticos a largo plazo, siendo el desarrollo y acceso libre a la electromovilidad y la optimización de los sistemas de almacenamiento de energías obtenidas mediante fuentes renovables los desafíos que se avecinan para lograr un avance real en la transición energética y desarrollo sostenible de las naciones.

Para aportar al cambio en la matriz energética que requiere el país, es necesario enfrentar el problema que conlleva el cambio climático. En el año 2014 la ULS comenzó con un programa de investigación en la temática de energías renovables mediante un Proyecto de Mejoramiento Institucional financiado por el Ministerio de Educación, que luego dio origen a los programas de Diplomado en Eficiencia Energética y Energías Renovables No Convencionales, y Magíster en Energía y Medio Ambiente. En el año 2017, se creó el Programa de Doctorado en Energía, Agua y Medio Ambiente, y la Universidad organizó el primer congreso sobre energía, eficiencia y sustentabilidad ambiental (CEES-2017). Este tercer Congreso en Energía, Eficiencia y Sustentabilidad Ambiental 2019 es una muestra clara de la consolidación institucional que ha tenido la temática de Energía y Sustentabilidad. En ella, queda reflejado el esfuerzo de los investigadores de nuestra institución y su interés por promover la interacción con investigadores de otros centros para conversar, discutir y compartir experiencias e investigaciones que den respuestas a los desafíos que nos demanda la sociedad actual y del futuro. Este tercer congreso también favorece la formación de estudiantes nacionales e internacionales que actualmente cursan programas de Magister y Doctorado en áreas de Energía, Eficiencia y Sustentabilidad Ambiental.

Invito a los lectores a conocer las actas del congreso 2023, que sintetizan el esfuerzo de quienes realizaron tan valiosos aportes. Esperamos que el próximo año sigamos recibiendo más contribuciones y que esta iniciativa siga contribuyendo a un tema tan relevante como es la Energía, Eficiencia y Sustentabilidad Ambiental.

Cordialmente,

Eduardo Notte
Vicerrector de Investigación y Postgrado
Universidad de La Serena, Chile

Welcome from the Executive Comittee President

Estimados asistentes al Cuarto Congreso en Energía, Eficiencia y Sustentabilidad Ambiental (CEES 2023).

La Universidad de La Serena (ULS) se ha transformado en un referente no sólo regional, sino que también nacional en las temáticas de Eficiencia Energética, Energías Renovables y Sustentabilidad Ambiental. Prueba de ello, es la adjudicación del Plan de Mejoramiento Institucional PMI 1401, en Eficiencia Energética y Sustentabilidad Ambiental, cuyo periodo de ejecución estuvo comprendido entre los años 2015-2018. Adicionalmente, el año 2018 comienza el primer año del programa de Doctorado en Energía, Agua y Medio Ambiente, y el año 2019 se suma la primera versión del Magister en Energía y Sustentabilidad Ambiental. Lo anteriormente expuesto, demuestra el firme compromiso de la institución en dichas temáticas. La organización del IV Congreso Internacional en Energía, Eficiencia y Sustentabilidad Ambiental (CEES), consolida a la Universidad de la Serena como referente en estas temáticas, e internacionaliza su alcance. Todo lo anterior, dentro de un contexto de preocupación mundial por el cambio climático, el uso eficiente de los recursos, tratamiento y reutilización de las aguas, y los diversos temas que permitan lograr un verdadero desarrollo sustentable.

El Congreso Internacional en Energía, Eficiencia y Sustentabilidad Ambiental, tiene como finalidad promover la generación y difusión del conocimiento científico con alcance internacional. El congreso estará bajo la organización de La Universidad de La Serena (ULS), con apoyo de la Universidad de Concepción, Universidad Nacional Autónoma de México, Universidad del Bío-Bío, Universidad de La Frontera, Universidad de Zaragoza y la Universidad Nacional de Mar del Plata.

La última versión del Congreso realizada en 2021, permitió la participación de cerca de 120 asistentes, entre académicos e investigadores de diversas instituciones nacionales e internacionales. También se contó con la presencia de alumnos de pre y postgrado. Entre los países presentes, se destacan la participación de investigadores de Argentina, Colombia, España y Turquía. Se presentaron alrededor de 40 ponencias orales en modalidad online.

Los programas de Doctorado en Energía, Agua y Medio Ambientes y de Magister en Energía y Sustentabilidad Ambiental han puesto a disposición del comité organizador el recurso humano necesario para la correcta ejecución del congreso. Finalmente, es mi deseo manifestar mi más profundo reconocimiento y agradecimiento a todas las instituciones nacionales e internacionales, así como a los invitados, ponentes y asistentes cuya colaboración y apoyo fue vital para la organización de esta cuarta versión del congreso CEES.

En nombre del comité científico y el comité organizador esperamos que disfruten de este Congreso, teniendo la certeza que su participación en el mismo, es de trascendencia para Chile y para el mundo.

Cordialmente,

Luis Silva Llanca, Ph.D.
Académico
Instituto de Investigación Multidisciplinario en Ciencia y Tecnología
Departamento de Ingeniería Mecánica
Universidad de La Serena, Chile

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Scientific program

Wednesday 29/11: Afternoon sessions

14:00	Registration	
15:00	Welcome	
16:00	Keynote (Elqui 3): Rafael Ramirez-Bon	
	Room Elqui 1	Room Elqui 2
	Chair: N. Moraga	Chair: A. Jaramillo
17:00	ESS01	SED01
17:20	ESS02	SED02
17:40	ESS03	SED03
18:00	ESS04	SED04
17:40	Coffee Break	

Thursday 30/11: Afternoon sessions

	Room Elqui 1	Room Elqui 2
	Chair: R. Cabrales	Chair: F. Jure
14:30	ESS10	OM03
14:50	ESS11	OM04
15:10	ESS12	
15:30	Coffee Break/Poster Session	
17:00	TEC01	IT01
17:30	TEC02	IT02
18:00	TEC03	
20:00	Conference Dinner	

Thursday 30/11: Morning sessions

	Room Elqui 1	Room Elqui 2
	Chair: D. Carvajal	Chair: A. Alfonso
09:00	ESS05	REC01
09:20	ESS06	REC02
09:40	Keynote (Elqui 3): Belén Villacampa	
10:40	Coffee Break	
11:10	ESS07	REC03
11:30	ESS08	OM01
11:50	ESS09	OM02
12:10	(Elqui 3) Award for Excellence Ceremony	
13:00	Lunch	

Friday 01/12: Morning sessions

	Room Elqui 1	Room Elqui 2
	Chair: M. García	Chair: M. Abreu
09:30	ESS13	SEC01
09:50	ESS14	SEC02
10:10	WMU01	SEC03
10:30	Coffee Break	
09:30	WMU02	SEC04
09:30	WMU03	
11:40	Keynote (Elqui 3): Marcela Vázquez	
12:40	Conference end	
13:00	Lunch	

ESS: Energy Systemas and Simulation
OM: Other Materials for Energy Conversion and Environmental Decontamination
REC: Renewable Energy Conversion
SEC: Semiconductor Materials for Energy Conversion
SED: Removal of Water and Air Pollution by Semiconductors
WMU: Water Managment and Sustainable Water Usage

Contents

Keynote Presentations

KN1:
Semiconductor nanostructures and nanocomposites for environmental applications

Rafael Ramírez Bon
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Herein, we describe the processing of different types of semiconductor nanostructures and nanocomposites and their application to environmental issues such as the water pollution due to organic contaminants in sewage. Among the semiconductor nanostructures, metal oxide semiconductor nanofibers (NFs) produced by the electrospinning technique have enhanced photocatalytic properties due to their large surface area to volume ratio. On the other hand, semiconductor nanocomposites constituted by the mixture of semiconductor nanostructures in different types of matrixes, such as zeolites, also represent excellent photocatalytic materials. In these nanomaterials, the large surface area to volume ratio of the semiconductor nanostructures and the synergy with the matrix materials result in outstanding photocatalytic properties. In this talk, we describe the procedure to achieve some of such photocatalytic nanomaterials based on metal oxide semiconductors. Furthermore, we present the result of photocatalytic experiments to degrade organic dye molecules, such as methylene blue and rhodamine from aqueous solutions. The activation of the photocatalytic materials is produced by natural sunlight, which represent an additional advantage because the reduced energy budget.

Biography

Rafael Ramírez is a professor at CINVESTAV-IPN in Querétaro. He has degrees in Physics and has conducted research in the fields of semiconductor, metallic and ceramic coatings, as well as semiconductor electronic devices. He has been the Principal Investigator in 15 projects and has published 215 papers in peer-reviewed journals with over 2,400 citations. Dr. Ramirez has also directed more than 120 theses at the undergraduate and graduate levels. He has held various positions such as the President of the Mexican Vacuum Society from 1997 to 1998, a Member of the Mexican Academy of Science since 1996, and an Investigator Level 3 of the Mexican System of National Investigators since 2002. Dr. Ramirez is also a Fullbright Scholar at the University of Texas at Dallas between 2017 and 2018.

KN2:
The Revival of DSSCs, is it possible without a commitment to sustainability?

Belén Villacampa[1,*],
D. Barrios[1], C. Carrera[3], I. Duerto[2], E. García-Bordejé[3], M.-J. Blesa[2]

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Dye-sensitized solar cells (DSSCs), also known as Grätzel cells [1] that is known for their potential sustainability benefits compared to other photovoltaic devices. They typically use thin films of TiO_2 coated with a dye and a liquid electrolyte. It has been usual to highlight some DSSCs advantages: the use of less and typically less toxic material compared to traditional silicon solar cells, facilitating recyclability and reducing the environmental impact; the fabrication process is less energy-intensive and may not require the high-temperature processing steps involved in traditional solar cell production; DSSCs can be manufactured locally, reducing the carbon footprint associated with shipping over long distances. However, DSSCs have lower efficiency compared to traditional solar cells or even other emergent devices and their long-term stability and durability can be issues [2].

It is now generally accepted that DSSCs remain promising for certain uses. They can be made flexible and semi-transparent, which makes them suitable for applications such as building-integrated photovoltaics and wearable technology; other attractive features of DSSCs are their response in low light conditions and the versatility to modulate their response spectral range.

In order to consider DSSCs for a sustainable energy solution it is essential to evaluate their performance, durability, and overall environmental impact within the specific context and application. Research is being carried out in our group to address some of the aforementioned challenges and to improve the sustainability of DSSCs [3]. Some of the strategies undertaken will be presented, focusing mainly on photo-anodes sensitized with new organic metal-free dyes, designed and developed to have an optimized response in broader illumination spectral ranges, in addition to showing improved stability. On the other hand, some results related to the use of carbon-based materials for counter electrodes will be exposed.

Acknowledgments

Financial support from Spanish AEI (PID2019-104307GB-I00 and PID2019-104272RB-C51) and Gobierno de Aragón-Fondo Social Europeo (E47-23R and T03-23R) is acknowledged. I.D. and C.C. acknowledge the Gobierno de Aragón-Fondo Social Europeo predoctoral contracts and D.B. the Santander-2018 program PhD studentship. The contributions of the members of the Photoactive π-Functional Materials Group are warmly appreciated.

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[2] Sharma et al. Nanoscale Research Letters (2018) 13-381. b) Rahman et al. RSC Adv. (2023) 13, 19508-19529
[3] Duerto et al. Dye. Pigm. (2020), 173, 107945. b) Duerto et al. Dye. Pigm. (2022) 203, 110310

Biography

Dr. Belen Villacampa received her PhD from the University of Zaragoza in 1993 and carried out postdoctoral research in the Molecular and Quantum Electronics Department of the Centre National d'Etudes des Telecommunications. Her research has focused on nonlinear optical (NLO) properties of organic materials and optimization of photovoltaic devices, particularly Dye Sensitized Solar Cells. She has collaborated with several Spanish and foreign universities and has published over a hundred scientific papers. Dr. Villacampa is also involved in projects and activities for the dissemination of science and has taught several courses on General Physics and more advanced courses in the Physics Degree. She has held various management and academic positions, including PhD Coordinator of the International Excellence Campus Iberus.

KN3:
Challenges and opportunities while preparing chalcopyrites and kesterites for photovoltaic applications by non-vacuum techniques

Marcela Vazquez
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Chalcopyrites and kesterites describe families of minerals containing sulfur. The most representative two compounds, $CuInS_2$ (CIS) and Cu_2ZnSnS_4 (CZTS), are promising p-type semiconductors suitable to act as absorber layers in solid-state photovoltaic devices. Besides combining excellent optical properties (α 105 cm^{-1}) and a direct band gap value that matches well the solar spectrum (1.4$\leq E_{gap} \leq$ 1.5 eV), these materials do not contain toxic elements such as selenium or cadmium. They are being intensively studied for developing highly efficient and environmentally friendly terrestrial solar cells. For this kind of application, low-cost and large area processing technologies are crucial. To reduce production costs, it is key to avoid deposition techniques that require high vacuum. Among them, solution methods such as electrodeposition, spray pyrolysis and successive layer deposition have been explored. These techniques involve moderate temperatures and atmospheric pressure. They have additional advantages since they can be used for big and irregular geometries and even on top of flexible substrates. One drawback associated to films deposited from aqueous solutions is that at room temperature their crystalline degree is not high enough. It becomes mandatory to include a subsequent annealing process, where recrystallization leads to a considerable reduction of defects. During the annealing stage, an oxygen-free atmosphere is necessary to avoid formation of oxides within the film. Results will be shown for films prepared using a variety of solution-base deposition techniques, aiming at identifying the main challenges found along this road.

Biography

Marcela Vazquez is a full professor at the National University at Mar del Plata in Argentina and a Staff member of the National Research Council (Principal Researcher), CONICET, Argentina. She holds a Bachelor's degree in Chemistry and a PhD in Chemical Sciences from the same university. Dr. Vazquez conducted post-doctoral studies at Pennsylvania State University and the University of Liverpool. Her research focuses on electrochemistry and corrosion, and she has published numerous papers in prestigious journals. Dr. Vazquez has also supervised seven PhD theses and collaborated with international researchers from Chile, the United Kingdom, Uruguay, South Africa, The Netherlands, among others.

ESS: Energy Systems and Simulation

ESS: Oral Presentations

ESS01:
Tessellation algorithms used in the design of systems composed of microchannel applied to thermal control of photovoltaic cells

Fabián Alquinta Galarce, Pablo Pacheco Pérez, Benjamín Peralta Tapia, Cristian Chávez Toro*
Departamento de Ingeniería Mecánica, Universidad de La Serena, Chile
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The work deals with the use of tessellation algorithms applied to the design of matrices composed of microchannel networks for thermal control of photovoltaic cells. Currently, industry and academia are focused on finding technological solutions that allow the efficient use of solar energy. This work proposes to improve the efficiency of photovoltaic cells through thermal control by microfluid flow. The method consists of designing random configurations of microchannels whose lengths, diameters and nodes are located within the surface of a standard-sized solar cell. The design is tessellated in an algorithm programmed in Python then transported to a computational fluid mechanics simulation process programmed in Fortran, where the variation effects of the fluid velocity, microchannels dimensions, tessellated network geometry, and the type of fluid are studied. The study fluids are R1234ze(E) and R1234yf with low potential to affect global warming. The computer programs used have been developed by the authors and are open source. The results are presented in temperature distributions and pressure drops. When the number of microchannels increases, the pressure drops and heat transfer intensity increase. The uniform distribution of the flow throughout the entire tessellated array is a relevant parameter in the design of devices that allow improving the efficiency of a solar cell. The project idea allows us to design cooling systems using algorithms with a reduced calculation time, which is why it is suggested to use this computational tool in future design projects.

Acknowledgments

The authors acknowledge ANID for the financial support in the project FONDECYT 1200572, and for the doctoral scholarship fund to Diego R. Rivera (2021).

ESS02:
Thermal simulation of a house with a PCM-modified envelope located in the south of Chile

Adriano Cabrera Bobenrieth[1], Diego Vasco Calle[1,*], Natalia Osorio Álvarez[1]
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This work evaluates the improvement of the thermal envelope of a house by incorporating phase change materials (PCMs) in the walls. The PCM incorporated is InfiniteRPCM21C, which has a melting temperature of 21°C close to thermal comfort and adequate for heating purposes [1]. The base case corresponds to a house in Coyhaique, whose indoor temperatures are available in the National Monitoring Network [2]. The construction information and occupational variables were taken from the OGUC [3], and the meteorological information from the SCCY station. The chosen house as the base case (Fig. 1) was computationally simulated using DesignBuilder v6.1.5.002, and the PCM was incorporated in the walls of the two rooms with higher thermal stress hours and occupancy. Using the PCM gave place to an annual decrease of 270 kWh (5 %) in heating consumption (Fig. 2), avoiding the emission of 155 $kgCO_2$eq/year and an increase in thermal comfort hours of 171 h. These results may be the starting point for the assessment of using PCMs with other heating systems and even district heating.

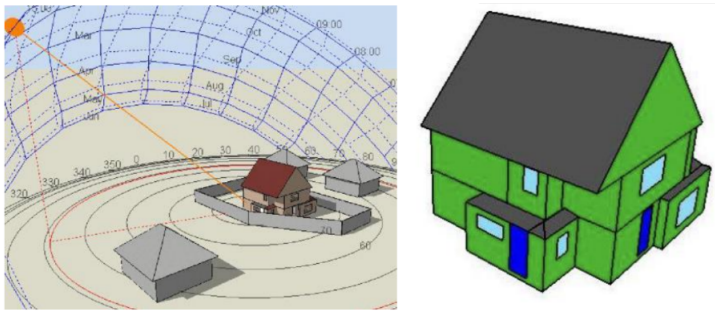

Figure 1: Schematization of the base case.

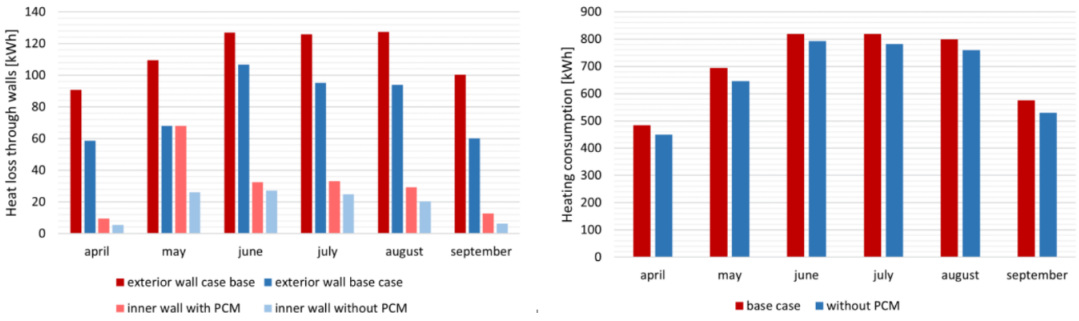

Figure 2: Left: Heat loss of the main bedroom during winter, with and without PCM. Right: Comparison of heating consumption in winter for the base case (red) and the house with PCM (blue).

Acknowledgments

The authors acknowledge the support provided by Proyecto FONDECYT N° 1201520, Agencia Nacional de Investigación y Desarrollo, ANID Chile.

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ESS03:
Aquaponics: A sustainable alternative for efficient use of water and energy in the production of trout and lettuces in a semiarid region

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Nowadays, the world's population faces challenges related to food security, availability of water and energy resources. Two techniques that respond to these requirements are hydroponics and aquaculture. Aquaculture focuses on the production of animal protein, lowering its environmental impact through technologization, and hydroponics, which is efficient in the use of water and nutrients applied, by replacing the substrate with water, being efficient in terms of spatial configurations and land use. The combination of both techniques, which is the focus of this study, is Aquaponics. The present study analyzes Aquaponics from a technical, water use and food production perspective, based on mathematical modeling, finite volume simulations and experiments performed in prototypes for lettuce and trout growth. This combined analysis, which coupled experimental results and data obtained through mathematical models, with findings on product quality, is the first time it has been reported. The results show that different hydraulic and operational configurations, with emphasis on reducing energy consumption: changing the water pumping - reuse strategy and thermal insulation of the system, would generate competitive commercial quality products at a lower cost. This finding opens a possibility to optimize the operating conditions of these systems, prior analysis of the optimal requirement of the species and modelling the subsystems.

Acknowledgments

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ESS04:
Modelling the effect of design parameters on the performance of a thermal energy storage dryer with a phase change material at a semi-arid climate zone

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This work investigates four key design parameters to improve the thermal efficiency and operation time of Solar Air Heaters (SAH) with a phase change material (PCM) used in food drying. The design parameters studied are the length of the SAH; the thickness of the PCM; the selection of a thermal insulation system for single and double glass, and the inclusion of aluminium fins in the latent heat thermal storage material to increase the heat transfer rate between the absorber plate and the PCM. A total of 32 configurations are studied by finite volume simulations of fluid mechanics and heat transfer and evaluated by energy and exergy analyses. The thermal performance of each system is investigated for a characteristic day-night cycle (24 hours) of a typical summer day in the south hemisphere (December) at Vicuña, Chile (semi-arid climate). The atmospheric conditions of solar irradiation, air temperature, and wind speed used in the physical-mathematical model include their variation in time. The results obtained indicate that the most efficient SAH configuration is a phase change thermal energy storage system with a 2 m length, double glass system, aluminium fins, and 4 cm of paraffin wax as the suitable PCM. This system extends the operation time up to 8.6 hr and requires an additional energy of 2.5 kWhr, with an average daily energy and exergy efficiency of 2.2 (η_I=43.2%) and 1.6 ($\bar{\eta}_{II}$=2.48%) times higher than the base case of SAH (2 m; without double glass, fins, and PCM).

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ESS05:
Evaluation of decision-making on the energy efficiency of data centers

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The increasing demand for data centers worldwide has led to a significant increase in energy consumption of these systems, posing challenges related to efficiency and operational sustainability. This research presents a thermodynamic first law-based approach to assess the effect of decision-making on the energy efficiency of a conventional Data Center (DC). To this end, a modular thermodynamic model was developed to represent the energy interaction between the different cooling system components. Simulations were conducted using the Engineering Equation Solver (EES) software, considering different operation scenarios, and the results were compared to those obtained from a real DC consumption data. The results revealed that decision-making based on the subjective experience of operators can have a significant impact on the energy efficiency of the DC. It was observed that the strategic selection of cooling setpoints according to the climatic conditions and thermal loads of the DC can significantly reduce energy consumption. This highlights the need for informed decision-making backed by scientific evidence in the management of DCs. These findings are relevant for organizations that seek to optimize their energy consumption and reduce their environmental impact, while maintaining optimal performance in their cooling infrastructure.

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ESS06:
Use of Chilean salts and metallic foams for sustainable energy storage in thermal accumulators at extreme climates

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Chile is endowed with a large amount of solar radiation and reserves of metals and salts, having a high potential in terms of generation, storage and transport of electric energy based on a sustainable technology. This work describes fluid mechanics and heat transfer in transient thermal energy storage utilizing lithium nitrate ($LiNO_3$) and a salt composed of 40 wt % of KNO_3 and 60 wt % of $NaNO_3$ as phase change materials (PCMs) to storage solar energy at Vicuña and Coyhaique (Chile). The objectives of this study are: (i) to compare the energy storage capacity of a thermal accumulator with different types of salts under controlled conditions, (ii) to improve this energy storage capacity incorporating diverse porous media; (iii) to evaluate the performance of a thermal accumulator in two zones with extreme climatic conditions. The methodology includes physical-mathematical modeling, solving the unsteady transport equations for fluid and heat flows with radiation and heat convection time-dependent boundary conditions by a finite volume solution procedure with a novel pressure-correction algorithm. The analysis considers thermal energy stored at daytime by fusion and supplied at night by solidification. The results describe the evolution of temperature and velocity in the phase change material, time of melting and solidification of the salts in the porous media, and thermal energy efficiency. The conclusion is that the use of appropriated salts as PCM materials with suitable porous media allows to improve the energy storage capacity of a thermal accumulator at the Vicuña and Coyhaique in Chile.

Acknowledgments

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ESS07:
Numerical Analysis of Exergy Destruction in Microchannels of Generalized Newtonian Fluids under Laminar and Turbulent Regimes

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This study numerically evaluates the Exergy Destruction in microchannels with different pin configurations when utilizing Newtonian and non-Newtonian nanofluids in laminar and turbulent regimes. The aim is to identify the rheological effects of the fluid on the Exergy Destruction and, consequently, on the device performance. The analyzed problem involves a rectangular cross-sectional microchannel with a length of 19.5 mm and 67 pin fins organized in a staggered pattern. Two modifications are proposed to this base design: incorporating vortex generators on the microchannel walls and utilizing shear-thinning fluids. Numerical simulations were performed for Reynolds numbers ranging from 200 to 1200. Under laminar flow conditions, the Exergy Destruction remains relatively constant along the channel. However, more Exergy is destroyed due to the dissipative effects that appear from the transition to turbulence. A strong dependence is observed between the rate of Exergy Destruction and the non-Newtonian power-law index, n. Shear-thinning fluids exhibit lower Exergy Destruction than shear-thickening fluids. This study offers novel insights into the dynamics of microchannels involving complex fluids through CFD simulations. The analysis of the Exergy Destruction emerges as a valuable metric for optimizing microfluidic systems where shear-thinning or shear-thickening fluids hold significance.

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ESS08:
Sustainable indoor comfort temperature control using ionic liquids as phase change material for solar energy storage

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This work describes transport phenomena in residential air conditioning processes by solar energy storage using phase change materials (PCM), based on an accurate description of fluid mechanics and heat transfer in transient thermal processes. Meteorological conditions of Vicuña (30°01'00"S 70°42'00"O) and Calama (22°27'45"S 68°55'38"O) are considered as the case studies. The specific objectives are: (i) to control indoor air temperature by a solar chimney (SC); and (ii) to evaluate the use of ionic liquids (ILs) as suitable PCMs. These objectives are achieved by computational simulations. Two problems of energy storage by fusion and heat release by solidification are studied: (i) the thermal behavior of brick walls including PCMs and ILs, and (ii) thermal energy storage in a SC using ionic liquids. The analysis considers a temperature-varying phase change liquid fraction model and a conjugate convection-conduction mathematical model for the unsteady process. The computational solution is accomplished by the finite volume method and the SIMPLERnP algorithm. The energy analysis includes 24 h studies for the day-night cycle, in summer and winter, at Vicuña and Calama, considering the time-variation of the environmental conditions. The results describe the time evolution of air velocity and temperature, together with the variation of the temperature distribution in the materials of a wall of a house and in a SC. The main conclusion achieved is that the use of ionic liquid as PCM allows to improve the energy efficiency of the air conditioning process of houses based on the use of the available solar energy.

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ESS09:
Energy released during water freezing in a convective air-cooling tunnel estimated by computational modelling: Effect of Reynolds and Richardson numbers

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One of the most common methods to decrease the temperature of foods and medicines is by the use of ice. However, the process of water freezing requires a large amount of energy to achieve the liquid to solid phase change. This research investigates the influence of the Reynolds (50<Re<400) and Richardson numbers (0.1<Ri<10) in the energy released by liquid water inside a metallic container while water freezes during the cooling process in a freezing tunnel. Continuity, linear momentum and energy equations for the surrounding airflow and water convective phase change are solved by the finite volume method, using alternatively the projection and the revised semi-implicit pressure-linked equations coupling algorithms. A transient conjugate airflow mixed heat convection, transient heat conduction in the walls of the metal water container and natural heat convective solidification in water allows to describe simultaneously the unsteady fluid mechanics and heat transfer in air and water. The results obtained indicates that the increment of the values of Reynolds and Richardson numbers increase the rate of vortex-shedding allowing to improve the frequency of the warm air removal from the rear side of the water container. This effect reduces the freezing times due to the enhance of the amount of energy released by water during the phase change from liquid to ice. Additionally, it is found a reduction of three-times in the computation time is achieved when the incremental projection method is used instead of the SIMPLER algorithm.

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ESS10:
Thermal and fluid dynamics characterization of non-Newtonian Al-Cu-Si alloys for high-temperature latent heat energy storage applications

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Studies on phase change by solidification or melting involving high-temperature phase change materials (PCMs) have increased considerably in recent years [1]. Using metals or alloys for this task is cost-effective since additional processes to improve thermal performance are not required [2]. Therefore, solar power plants, automotive and aeronautical industries employ Al-Cu-Si alloys due to their lightness, excellent moldability, and outstanding mechanical properties. However, using these alloys in Latent Heat Energy Storage (LHES) systems is at an early stage, and their good oxidation resistance properties at high temperatures have been demonstrated recently [3].
The main objective of this work is to characterize the thermal performance describing the heat transfer and fluid dynamics of two non-Newtonian Al-Cu-Si alloys with non-linear liquid phase change fraction, Al-6%Cu-1%Si and Al-27%Cu-5.25%Si, in a transient convective-diffusive solidification process at a high Rayleigh number (Ra$\geq 10^7$), based on a mathematical heat transfer model solved with the Finite Volume/SIMPLERnP scheme. The numerical approach is validated with experiments and numerical results found in the scientific literature [4]. The results show that the percentage of copper and silicon changes the key energy parameters: solidification time, cooling curves, maximum velocities, streamlines, fluid viscous behavior, and the latent heat energy released during the processes. These results are also affected by the constitutive parameters of the non- Newtonian rheological models, such as the power index (0.1$\leq n \leq$1.9) and restrictive yield stress (0$\leq \tau_0 \leq$50, Pa). The results show that increasing n and τ_0 changes the heat transfer mechanism, from convective to conductive-dominant, and are more significant for Al-27%Cu-5.25%Si, mainly due to the restrictive yield stress. Finally, we conclude that Al-6%Cu-1%Si increases the thermal energy released and the rate of solidification, which enhances the thermal performance for LHES applications.

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ESS11:
Energy Sustainability: A systematic literature review

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Energy is an essential resource for human development. Deploying accessible and clean sources of energy is a key challenge, one that has been established as one of the Sustainable Development Goals for 2030 by the United Nations. However, when referring to *Energy Sustainability*, there are several associated concepts that require clarity in their definition to promote work towards this goal through coordinated efforts among industry, academia, and civil society.
The purpose of this work is to study the use of *Energy Sustainability* and related concepts within the scientific literature through a Systematic Literature Review and analyse their potential to contribute to the achievement of this Sustainable Development Goal. 1992 articles were analysed by keywords and title, selecting a subset to evaluate at abstract and full-text level. Top cited keywords contain *Energy security, Building integrated photovoltaics, Renewable energy, Solar potential, Wind potential*, and *Climate change*. Finally, possible lines of research related to Energy sustainability are described where knowledge gaps still exist, including *Potential energy self-sufficiency; Potential of renewable energy hybrid systems; Whole energy lifecycle assessment; Energy return on energy investment; Net-zero energy systems; Climate change effects on renewable energy sources*; and *Energy sovereignty and community engagement*.

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ESS12:
Increased energy efficiency in three thermal food processes by computational simulations

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This work describes how to increase the energy efficiency of three relevant thermal food processes: convective drying with solar-preheated air, freezing of water in a baffle-modified tunnel, and sterilization of granulated canned food by mathematical modeling and numerical simulations. Fluid mechanics and convection-conduction heat transfer differential equations of the unsteady conjugated mathematical for the interaction between air and food processing were solved by the Finite Volume method with the SIMPLE algorithm. A series of numerical experiments were conducted to examine the impact of various parameters on energy analysis for each process. The aspect ratio of the food was studied during drying, while the incidence of the size and position of baffles was analyzed during freezing. In sterilization, the lethality curve of Clostridium botulinum was calculated at the slowest heating point to ensure compliance with food safety standards. The parametric studies have led to a reduction in the total processing time, resulting in improved productivity and energy efficiency of all related processes. The key findings were reducing the food thickness to 1/4 during drying increased drying speed by 32%; the use of deflectors during freezing resulted in an increased heat removed from 47.5 W to 108.9 W, and the sterilization process of canned tuna reached the lethality criterion at half the treatment time, with a 50% of energy reduction. These results that describes fluid and heat transport phenomena have important implications for improving food quality and energy efficiency.

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ESS13:
Effect of surface roughness on wind turbine wake length

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Computational Fluid Mechanics (CFD) has proven to be an instrumental tool in the study of wind behavior in wind farms. Most modeling studies focus on flat terrain, while complex terrain can impact wind development and power generation efficiency. In previous work, we found that surface roughness is a factor in wake length due to its influence on turbulence, turbulent entrainment, and wake recovery, in a actual wind farm. Yang et al. (2018) shows a proportionally relationship between surface roughness and wind farm performance, comparing two surface roughness height (order of centimeters).
This study investigates the intricate interplay between surface roughness and wake length for wind turbines in complex terrains. The aim is to establish a clear relationship between the characteristics of the ground and the wake length including a deep understanding of the physics phenomena.
We used the commercial software ANSYS Fluent^{TM} to model the fluid mechanics and the Actuator Disk model to represent the wind turbine under various surface roughness conditions. The research method involved meticulously altering the roughness of the terrain modeled by a sinusoidal function and measuring its impact on wake length. The novelty of this work is the focus on the terrain complexity, and the relationship between the interest variables considering the surface roughness in the order of meters. To the best of our knowledge, the latter is absent from the literature. Our findings reveal an inverse proportionality between the roughness of the ground surface and the wake length generated by the wind turbine.

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ESS14:
Enhanced energy efficiency of a convective freezer with PCMs and a salmon-fillet during charging, discharging and operating processes by conjugated CFD modelling

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The use of Phase Change Materials (PCMs) in refrigeration/freezing systems have demonstrated multiple benefits in energy efficiency and food preservation quality in recent years. However, their applications in the evaporator under scenarios with thermal loads (foods) and real operating conditions has not been investigated using accurate numerical models. In this work, we study through numerical simulations the effect that PCM-plates have on the heat transfer and energy efficiency of a domestic convective freezer-cabinet, with inlet/outlet airflows, and a salmon-fillet at its center. Two different PCMs, 19.5%wt NH4CL and PlusIce E-10, that are attached on the internal freezer walls are investigated under different scenarios in the processes of charging, discharging and operation. The air's fluid dynamics and heat transfer in the food/PCMs is described by a conjugated solid-fluid model, incorporating the k-ω SST model for turbulent flows, the net radiative method for thermal radiation, and the apparent specific heat and liquid fraction methods for liquid/solid phase change of the food and PCMs. The set of equations is solved using the Finite Volume Method in a structured staggered-grid with the SIMPLEC algorithm and the Bi-CGSTAB solver. The results indicate that PCM-plates originates small variations in the total heat transfer of the food, but delay the charging and discharging times in 0.2 and 6 hours, respectively. Consequently, the main conclusion achieved is that the energy efficiency of the operating process increases in 17% using the PCM-1 and 34% for PCM-2.

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ESS: Poster Presentations

P-ESS01:
Technological-environmental evaluation of potential hydrogen production in Chile from domestic sewage sludge

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The use of hydrogen as a clean fuel gas in the power generation sector is essential to reduce the environmental problems associated with the use of conventional fuels [1]. Sludge gasification with air is considered the most efficient technology for hydrogen production from wastewater [2]. Sewage sludge is difficult to neutralize, as it often has a high moisture content, contributes to numerous environmental problems, and direct contact with this waste can cause health problems [3]. This study explores the thermochemical gasification of sewage sludge using ASPEN Plus software to develop a complete steady- state equilibrium simulation model. The model was used to evaluate the hydrogen generation potential and identify optimal conditions for improving the Chilean wastewater gasification process. The potential of wastewater as a renewable energy source in Chile has been poorly explored. The efficiency of gasification also depends on the elemental composition of the sludge, so this process should be studied for Chilean wastewater conditions. An analysis of the configuration of the process stages was carried out in order to improve yields towards hydrogen production. A process was established contemplating a pyrolysis step for the decomposition of the material, an intermediate nitrogen elimination step (to avoid the formation of undesired compounds), followed by two gasification steps and finally the purification of the synthesis gas (see Figure 1). With this model we obtained an optimum production of 409 m^3 of hydrogen/kg of sludge in one year of production. In addition, through a cartographic analysis of water treatment plants in Chile, it was estimated that the national potential for hydrogen production by sewage sludge gasification in 2020 (138x106 m^3/year). The results will be accompanied by an economic and environmental assessment based on the model results, which will ensure a holistic evaluation of the proposed approach.

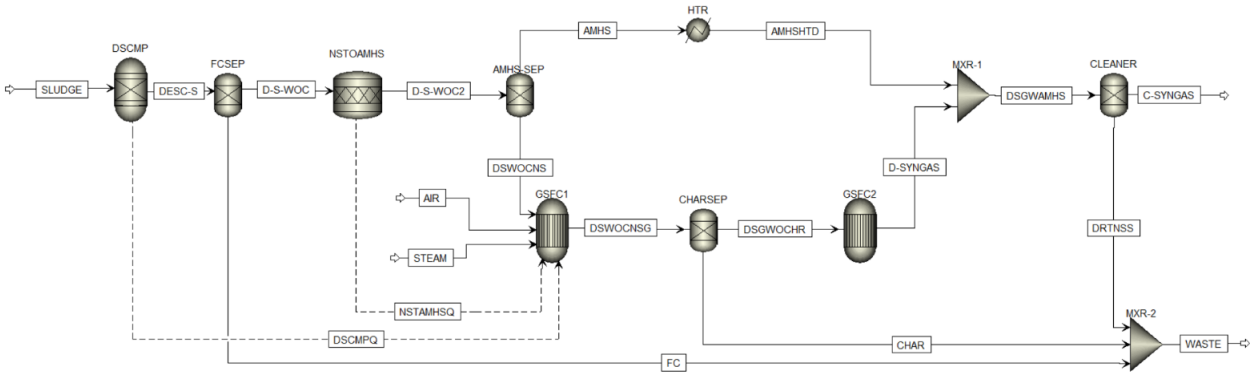

Figure 1: ASPEN Plus flow chart for domestic wastewater gasification system.

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P-ESS02:
Use of pig manure from the Chilean swine industry for the production of hydrogen through a dark fermentation process

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Hydrogen has a high specific energy content and its combustion, which produces water, does not form greenhouse gases. Currently, most of the hydrogen produced comes from steam reforming of fossil fuels, which calls for the development of renewable and sustainable hydrogen production [1]. Biological hydrogen production could fulfill this mandate, and a wide variety of microorganisms and metabolic pathways exist for biohydrogen production. Among them is dark fermentation, which can use various organic wastes to produce hydrogen and other by-products [2]. Among organic wastes, animal manure is an inexpensive and widely available renewable resource. Pig production has expanded during the last 10 years in Chile due to two factors: the increase in exports by 38% per year during 2014-2016, and the increase in consumption by 36% per year. Chile is the sixth largest producer in the world and the second largest in Latin America, after Brazil [3]. This has led to an increase in the amount of slurry, which is the main waste from the swine industry, drawing attention to this sector as a potential hydrogen producer in Chile. This study is the product of a collaboration between the University of Santiago de Chile and the Department of Environmental Engineering, Middle East Technical University, Turkey. The kinetics of the fermentation of swine manure together with mixtures of switchgrass and wastewater biosolids by the hyperthermophilic cellulolytic bacterium Caldicellulosiruptor bescii was studied. Under the fermentative conditions established at the experimental level in this work, a yield of 82.5 NmL/g biomass added was recorded, the highest yield recorded to date in dark fermentation studies with swine manure. With the data collected in the laboratory on the cell growth rate, the kinetic parameters were determined and a model was established based on the Monod equation, which was modeled in Aspen Plus, obtaining hydrogen production values similar to the experimental results (76.5 NmL/g biomass). This model is valid for sensitivity studies of various parameters within the process in future studies.

Acknowledgments

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P-ESS03:
Modelling thermal energy storage by convective melting of octadecane and paraffin wax in a porous medium

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This work describes the influence of Rayleigh number on the solid-liquid phase change in octadecane and paraffin wax as latent heat thermal energy storage by phase change materials (PCM) embedded in aluminum metal foam. The model incorporates one and two energy equations to describe the rate of change of internal energy, heat transfer by convection and conduction with and without metal foam for each PCM. The Darcy-Brinkman-Forchheimer model describes the equations of continuity, linear momentum for molten materials in the porous medium, and uses a phase change liquid fraction that varies linearly with temperature. The finite volume method allows to solve the equations that govern this conjugate thermal process using SIMPLERnP [1], a precise and robust P-v-T prediction-correction algorithm. The results indicate that the energy storage of paraffin wax is much more efficient compared to octadecane. A two- energy equation model must be used when the interstitial Nusselt number $Nu_i \leq 100$, due to the difference in thermal conductivity between the foam and the PCM. The melt volume fraction rate and the speed of solid to liquid phase transformation increase about 12% when the Rayleigh number Ra=108 compared to Ra=105. It is concluded that by increasing the value of Ra from 105 to 108 in the fusion process by natural heat convection, the thermal energy stored in the paraffin wax is 35% higher than when octadecane is used, and the melting time is reduced 60 times.

Acknowledgments

This work was partly supported by the National Agency of Research and Development (ANID) of Chile under grant FONDECYT N 3210768.

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P-ESS04:
Thermodynamic and environmental analysis of a pig manure gasification system to produce hydrogen as an energy potential in Chile

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A large amount of livestock manure is produced annually in Chile, which requires safe use to reduce environmental contamination and produce energy. Animal waste or manure has been associated with some hygienic and environmental problems, such as contamination of ground and surface water, soil and air, odors, greenhouse gases and ammonia emissions [1]. In recent years, supercritical water gasification (SCWG), a promising and pollution-free technology, can utilize pig manure with high moisture content to produce hydrogen [2]. The above is raised considering the increase in recent years in the growth of the swine industry in the country [3]. It should be noted that the configuration of the gasifier is also a key parameter for the optimization of the gasification process. For this purpose, an in-depth investigation of the plant behavior and operating conditions is required. This study provides, through process simulation, the optimal system configuration to obtain the best performance in hydrogen production. The simulation of coal gasification will be performed using Aspen Plus. According to the bibliographic information, an autothermal gasification system is proposed, which uses the heat generated in the partial oxidation of the fuel gas for gasification. Under these conditions, a considerable amount of 5,081 Nm^3/h of H_2 was produced. In addition, a sensitivity analysis has been performed where the best hydrogen production yields were obtained at 620°C and 25 MPa. The obtained model represents an opportunity to evaluate the hydrogen production potential and the environmental impact of the system through life cycle analysis.

Acknowledgments

This work was supported by the Anillo ACT210050 project of the Agencia Nacional de Investigación y Desarrollo in Chile.

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OM: Other Materials for Energy Conversion and Environmental Decontamination

OM: Oral Presentations

OM01:
Eco-friendly zeolite functionalization for environmental remediation: exploring the role of the active sites and surface characteristics

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In this study, three applications of functionalized zeolites are assessed to unveil the role of the physicochemical characteristics and the active sites. For this, a natural Chilean zeolite was modified to support copper and zinc oxides as photocatalytic materials. Therefore, new Brönsted and Lewis acidic active sites were created allowing ethylene adsorption involving π-cation interactions with metal sites. Furthermore, a synergistic remotion process including adsorption and photocatalysis was unveiled by DRIFTS operando experiments. Ethylene adsorption was increased to 200 μmol/g using copper-modified zeolite, meanwhile, photocatalytic degradation of 50% of ethylene was observed when both, zinc and copper oxides were deposited over the zeolite. In a second approach, a synthetic zeolite was modified to study the effect of the compensation cations on CO2 removal. For such purpose, acidic (Cu^{2+} and Zn^{2+}) and basic (Na^{+} and K^{+}) cations were transferred to the zeolite and compared to $NH4^{+}$ cations present in the original sample for CO_2 removal. Adsorption experiments were performed and modelled by Langmuir and Freundlich isotherms showing a preferent interaction of CO_2 with basic cations. Finally, those zeolites modified with copper compounds were investigated to verify their antifouling properties to inhibit the formation of bacterial biofilms. Bacterial inhibition analysis depicted that copper nanoparticles limit the growth of e-coli and other bacterial strains. Results depict the versatility of zeolites for environmental applications when correctly functionalized. The presence of basic cations could enhance CO_2 capture while copper cations could increase ethylene adsorption and photocatalysis also avoiding the growth of bacterial strains.

Acknowledgments

ANID/FONDECYT Postdoctoral Grant 3210158; ANID/Fondecyt Regular Project, Grant1231376.

OM02:
Bismuth oxyiodide (BiOI) and scallop shells waste for the removal of arsenic (III) in drinking water

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Arsenic (III) is a pollutant that can be naturally present in soils or produced as a by-product of industrial activities associated with mining. Consequently, As (III) can be readily detected in drinking water, and due to its toxicological characteristics, various techniques have been developed to eliminate it from water sources. One of the most promising methods involves heterogeneous photocatalysis using semiconductors, with titanium dioxide (TiO_2 P-25) being the most extensively studied semiconductor. Nevertheless, since its activation relies on ultraviolet radiation λ <390 nm), alternatives materials like BiOI have gained attention. BiOI can be activated by visible radiation, thus harnessing sunlight more efficiently. This study assesses the removal of As (III) from drinking water through heterogenous photocatalysis employing BiOI microspheres, followed by filtration with waste powder from scallop shells originating from northern Chile, specifically Tongoy Bay, with varying particle sizes. BiOI microspheres were synthesized using a solvotermal method, employing bismuth nitrate pentahydrate and potassium iodide as reactants, dissolved in ethylene glycol. This resulted in an experimental yield of 84,64%. The As (III) colorimetric quantification was performed using UV- Visible spectrophotometry, scanning a spectrum from 470 to 650 nm. The results indicate that employing a pseudo-first order kinetic model, BiOI microspheres removed approximately 56,4% of As (III) from drinking water through the photooxidation of As (III) into As (V). Subsequently, using different beds of scallop shells waste powder with varying grain size, higher percentage of As (III) was removed from drinking water in each case, where initial and final concentration (Ci- Cf/Ci) yielded similar removal rates (approximately 70%).

Acknowledgments

Authors gratefully acknowledge the financial support of DIDULS/ULS, through the projects PR21172 and PR2153857. Multidisciplinary R& D Project DIDULS FIULS 2030 N ID1953851.

OM03:
Corrosion of welded joints in Solar thermal storage systems

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High temperature thermal storage allows solar thermal power plants (CSP) to generate manageable electricity independent of the variability of the solar resource. The two-tank molten salt thermal storage system is the most common storage system in concentrated solar power plants. Solar salt (60% $NaNO_3$ + 40% KNO_3) is the most widely used energy storage material in solar thermal plants [1] [2].
It has been thermodynamically determined that concentrated solar power plants have higher performance at higher operating temperatures. Consequently, the materials in storage tanks will be exposed to increasingly severe corrosion conditions. The welded joints of solar thermal storage tanks represent a critical variable that must be controlled during the structural manufacturing process of this equipment.
This work explores the behavior of welded joints of different alloys, Stainless Steel (ASS) grade 316L and AISI 347 (Ni-Cr-Mo base alloys), exposed to a binary mixture, with 60% NaNO3 and 40% KNO3 (solar salt) at a constant temperature of 300°C, for a period of 200, and 400 hours of exposure.

Acknowledgments

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OM04:
Electrochemical CO_2 capture by ruthenium and rhenium polypyridine complexes.

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The threat of carbon dioxide emissions and global warming looms large, demanding urgent action for the sake of our planet's future. Given the unlikelihood of a short-term transition away from fossil fuels, carbon dioxide capture and storage (CCS) becomes essential. CCS involves capturing CO_2 from industrial processes, binding it to a sorbent, and storing it underground. In this study, we propose the use of ruthenium and rhenium coordination complexes as alternatives to the amines and metal carbonates commonly used as sorbents. The use of these complexes could pave the way for novel systems for capturing CO_2 driven by solar light. Here, we present the electrochemical study of a series of Ru and Re complexes of the type $[Ru(bpy)_2(Lig)]$ and $Re(CO)_3Cl(Lig)$, where (Lig) is 1,10-phenanthroline-5,6-dione or dipyrido[3,2- a:2',3'-c]phenazine-10,13-dione, and bpy is 2,2-dipyridyl (Fig.1). Their electrochemical behavior was evaluated under N2 and CO2 atmospheres using cyclic voltammetry. The results obtained are consistent with the formation of adducts between the reduced ligand Lig and CO_2 (Fig.2). We calculated the association constant for the adduct between CO_2 and the dianion of diones using the methodology described by Simeon. Additionally, we studied these systems using spectroelectrochemical techniques to probe the MLCT bands possessed by the complexes. These results were complemented with theoretical calculations using the DFT/B3LYP theoretical level, where the LanL2DZ basis was employed for the rhenium or ruthenium center and a 6-311G++(d, p) basis for all other atoms.

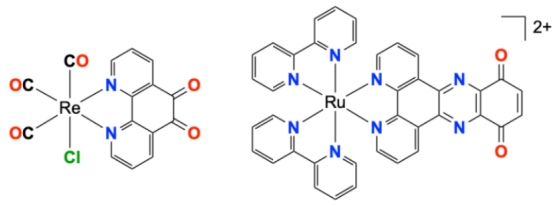

Figure 1: Re and Ru complexes.

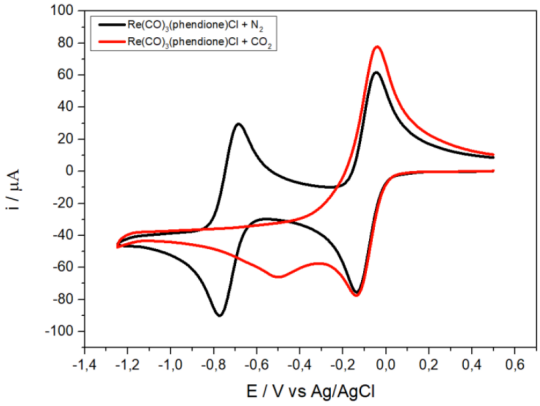

Figure 2: Electrochemical response $Re(CO)_3Cl(phendione)$ in N_2 (black line) and CO_2 (red line).

Acknowledgments

This work was supported by Fondecyt grant 1230179.

OM05:
Creating a composite material reinforced with scallop shell powder and an environmentally friendly solvent-dissolved expanded polystyrene matrix.

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Plastics, owing to their ease of distribution, are closely linked to modern consumption patterns, with the majority being utilized for single-use packaging. However, their decomposition is a slow process that poses significant harm to the environment. In 2018, global plastic production reached a staggering 359 million tons (Miranda, 2023). Among South American nations, Chile stands at the forefront in terms of waste generation, producing up to 25 thousand tons of plastic waste (The numbers behind waste generation in Chile, 2020).

One of the most environmentally detrimental plastic waste types, due to its considerable volume and lengthy degradation period of roughly 1,000 years (Zañartu, 2013), is expanded polystyrene. This research endeavor seeks to repurpose this single-use material by dissolving it with the organic solvent D-Limonene, a natural, biodegradable, and non-toxic substance. The aim is to utilize this dissolved material as a matrix for crafting a composite material reinforced with particles derived from the shells of northern Chilean scallops, which also pose a pollution concern as they often end up in landfills. The expected advantages are to make use of two waste materials using an organic solvent in the production of a completely sustainable composite material with structural applications, leading to a reduction in environmental pollution and promoting sustainable production and a circular economy.

The manufacturing process of this composite material requires a thorough understanding of the properties of each phase. Consequently, various properties, including the saturation point (Figure 1), drying temperature (Figure 2), and matrix-reinforcement ratio, have been determined. Subsequently, mechanical tests involving tension and flexion will be conducted to assess the practical utility of this composite material.

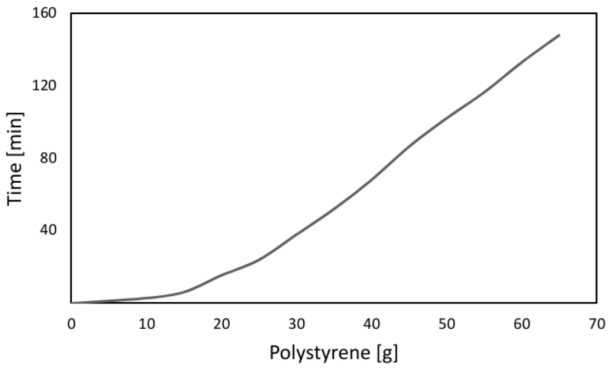

Figure 1: Saturation curve.

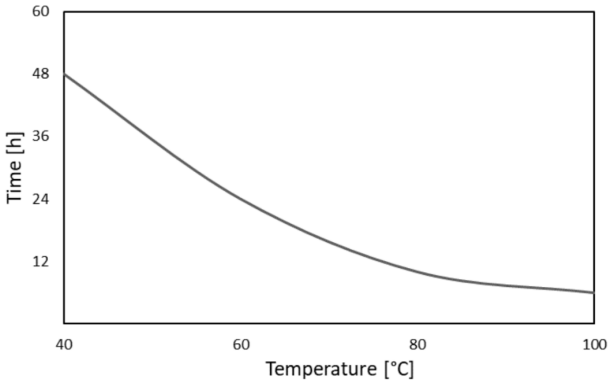

Figure 2: Drying temperature.

Acknowledgments

The authors would like to thank the financial support of DIDULS/ULS, through the projects PR21172 and PR2153857. Acknowledges the financial support of DIDULS/ULS through the project FIULS 2030 grant number 18ENI2-104235 funded by the CORFO program "Nueva Ingeniería para el 2030 en Regiones—Etapa de Implementación", Multidisciplinary R& D Project DIDULS FIULS 2030 N_ ID1953851. FONDEQUIP EQM-160070 and FONDEQUIP 150109.

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OM: Poster Presentations

P-OM01:
Noise Analysis Of Impacts Caused By Wind Farm In The Xavier Community, Western Coastline Of The Of Ceara - Brazil.

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Wind energy emerged in Brazil in the 2000s. Since then, Ceará (CE) has received numerous wind farms, many located in areas of traditional communities. These developments bring strange characteristics to the natural environment, such as noise. This aspect is not already widely discussed in Brazilian legislation, which does not have parameters for noise from wind turbines. Therefore, this work aimed to investigate noise levels and how the residents of Xavier Community, Camocim-CE, perceive the noise of the towers. To carry out this work, bibliographical research was done alongside visits to the study area, noise measurement in the park's surroundings during day and night, questionnaire applications, and mapping. In the community, noise levels ranged between 34 and 57,2 dB(A) during the daytime and 46,2 and 60,4 at night. During the day, there was a decrease as the distance from the park increased. However, noise levels similar to those close to the towers in the daytime and night periods were found in the last houses, approximately 1 km away. This may indicate that the sum with the environmental factors has a greater contribution to determining the levels found. Despite this, 25% of respondents report discomfort due to noise. Although, no significant damage to the community customs and daily habits was identified concerning the noise presence. Understanding how tower noise dissipates into nearby communities and how it is perceived will help to build specific legislation for wind farm noise parameters.

Keywords: *Keywords: Noise. Perception. Wind Energy.*

Acknowledgments

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P-OM02:
Synthetic zeolite modification for CO_2s capture: On the role of the compensation cations

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In this study, a synthetic, ZSM-5 type zeolite was modified by an ion exchange procedure, to study the effect of the compensation cations on CO2 removal, also from a gaseous stream. For such purpose, acidic (Cu^{2+} and Zn^{2+}) and basic (Na^{+} and K^{+}) cations were transferred to the zeolite structure by an ion exchange procedure, as new compensation cations and compared to NH_4^+ cations present in the original zeolite for CO2 removal. The physicochemical characterization developed verified the modification of the chemical composition of the zeolites as a consequence of the ionic exchange process using nitrate salts. SEM-EDS and XRF studies revealed the incorporation of the new compensating cations without modifying the zeolite morphology. Besides, nitrogen adsorption experiments verified that the surface area and pore volumes remained without mayor modification. Additionally, FTIR experiments also confirmed that the zeolite functional groups remained after the modification process. Finally, preliminary dynamic adsorption experiments were performed to unveil the role of the compensation cations on the adsorption uptake showing a preferent interaction of CO_2 with basic cations increasing the CO_2 adsorption uptake when Na and K modified zeolites.

Acknowledgments

ANID/FONDECYT Postdoctoral Grant 3210158; ANID/Fondecyt Regular Project, Grant1231376.

P-OM03:
Reverse logistics and disposal of household pharmaceutical waste in Chile

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The expansion of medicines consumption, the generation of their waste, and the environmental impacts have driven the reverse logistics of pharmaceutical products in many countries. Reverse logistics establishes the responsibility of manufacturers and suppliers for the collection and treatment of particular or hazardous waste originating in the consumption chain. In Chile, the collection of household pharmaceutical waste is not regulated, and empirical information is scarce. Thus, this study aims to characterize the reverse logistics of medicines in Chile and their disposal, taking the city of La Serena as a case study. The data were obtained through a literature review and a semi-structured questionnaire applied through face-to-face interviews to a representative sample of 430 households in the city of La Serena randomly selected and stratified according to urban/rural location (Figures 1 and 2). It was observed that medicine collection is isolated and limited in the country's central region. These wastes are mostly disposed of in household garbage (78%) and the sewage system (13%). In addition, no information was found on the profile of this hazardous waste in the country, such as the main active ingredients and therapeutic groups. Thus, Chile must move towards regulating reverse logistics of medicines to offer the community environmentally sound alternatives for their disposal. Knowing the collection options and the management of household pharmaceutical waste supports the progress of environmental policies that reduce the impact of these emerging pollutants.

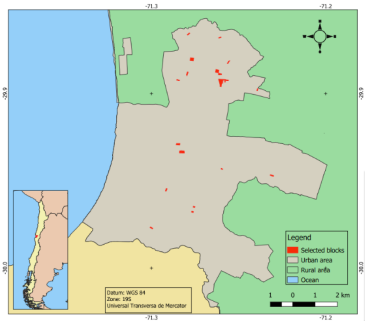

Figure 1: Study area in the urban zone of the La Serena commune. Note: selected blocks are highlighted in red and include the sectors of Centro, El Olivar, Las Compañías, La Florida, La Pampa, San Joaquín, and Barrio Universitario.

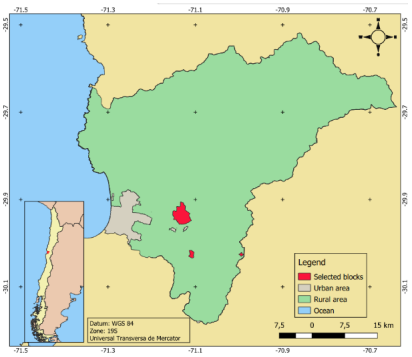

Figure 2: Study area in the rural zone of the La Serena commune. Note: the rural entities selected were El Romero, El Rosario, and Pelícana, which are highlighted in red.

Acknowledgments

This work was supported by the National Agency for Research and Development of Chile (ANID) - Subdirección de Capital Humano [Doctorado Nacional/ 2021-21210126].

P-OM04:
Photodegradation of dyes and bacterial disinfection by the action of AgO-doped $La_2Ti_2O_7$ films synthesized photochemically

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$La_2Ti_2O_7$ films doped with different concentrations (1.0, 3.0, and 5.0 mol %) of AgO were synthesized using a photochemical method employing β-diketonate complexes. The resulting photo-deposited films were characterized through XRD, XPS, and SEM analyses. The XRD analysis confirmed the emergence of the monoclinic phase of La2Ti2O7. Furthermore, the XPS analysis revealed two peaks located at 852.1 and 835.5 eV assigned to La 3d3/2 and La 3d5/2, respectively, indicating the presence of La(III). The Ti 2p band consisted of two signals at 458.2 and 464.0 eV, suggesting the presence of Ti(IV). On the other hand, the Ag 3d5/2 signal exhibited two sub-peaks at 368.2 and 367.2 eV, indicating the presence of Ag0 (45.9%) and AgO (54.1%), respectively. The O1s signal displayed four distinct contributions. The first two contributions at 528.9 eV and 529.5 eV were associated with lattice oxygen within $La_2Ti_2O_7$. The third contribution, observed at 530.8 eV was attributed to the presence of oxygen vacancies, providing evidence of discrete energy levels or defects within the material's band gap. Finally, the fourth contribution at 532.1 eV was attributed to the presence of weakly adsorbed oxygen. Photocatalytic activity assessments on water samples demonstrated a 25% degradation of Congo Red for the pure samples, contrasting with a 93% degradation for the doped samples. Additionally, antibacterial trials conducted against Staphylococcus aureus showcased a 99.9% inhibition efficiency in just 40 minutes of UV-visible illumination. Building upon these findings, a photocatalytic mechanism centered a type I heterojunction has been postulated (Fig. 1).

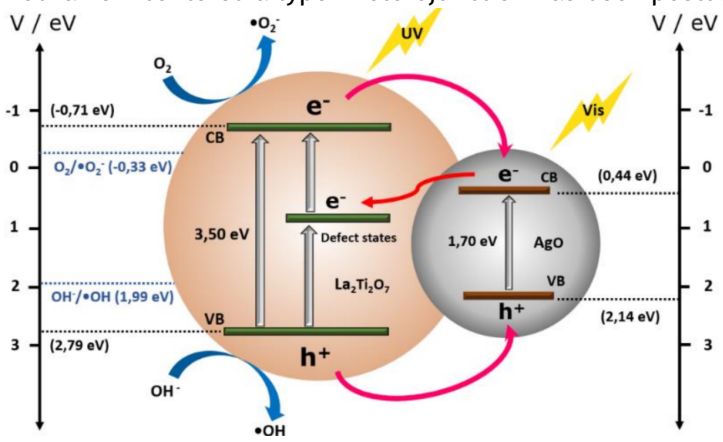

Figure 1: Proposed mechanism in the photodegradation of Congo red dye.

Acknowledgments

The authors would like to express their gratitude to the post-graduate office of the University of Bío-Bío (Program INES I+D 22-16) for their financial support in the execution of this study

P-OM05:
Manufacture of a composite material from expanded polystyrene and secondary lead slag.

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Expanded polystyrene (EP), known in Chile as Plumavit, is a material obtained from petroleum and has properties such as thermal insulation, moisture resistance and shock absorption. Despite its usefulness, it is important to mention that this material generates environmental problems, because it is not biodegradable and is difficult and expensive to recycle. On the other hand, secondary lead slag, which is generated in recycling processes of devices and equipment that have lost their useful life, is a waste categorized as non-hazardous considering its chemical composition. However, it can cause health problems for the people who handle it because it contains very tiny particulate material with a diameter of less than 2.6 µm. For this reason, companies dedicated to lead recycling seek to encapsulate this slag, so that it can be recycled without any type of inconvenience in the landfills.
To solve the environmental problems mentioned above, in this project a composite material (CM) was created to encapsulate the secondary lead slag, allowing its easy handling. At the moment, there are no reports in the literature of a CM based on EP, acetone and secondary lead slag. In this study a paste based on PE dissolved in acetone was used. The EP-acetone saturation curve was made using different proportions of PE and organic solvent. These tests showed that the best paste constituted by the plastic material with the solvent is achieved at a proportion of 5 g EP per 6 mL of acetone. In addition, it was experimentally determined that this mixture can hold up to 7 g of secondary lead slag.
The results obtained show that it is possible to encapsulate the slag with the fabrication of a PE and acetone-based CM, which will reduce the health damage caused by the migration of particulate material when this waste is handled in safety fillers. However, the mechanical and other properties of the CM obtained could not be determined because the material has a very heterogeneous structure due to the presence of a large number of holes resulting from the volatilization of acetone. In order to obtain scientific contributions, and to determine the future application of a CM based on the secondary lead slag, the acetone will be replaced by a green and less volatile solvent, such as d-limonene, wich is intented to obtain a homogeneous MC to determine physical, chemical and mechanical properties.

Acknowledgments

Proyecto DIDULS REGULAR PR2153857.

P-OM06:
Lessons learned during the evaluation of the MIG/MAG welding process of 316L steel with and without oscillation for Thermal Storage systems with molten salts.

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The two-tank molten salt thermal storage system is the most common storage system in concentrated solar power plants. Solar salt (60% $NaNO_3$ + 40% KNO_3) is the most widely used energy storage material in solar thermal plants [1]. However, there is still great uncertainty regarding the evaluation of solder joints in contact with molten salts at high temperatures.

Regarding the corrosion process of steels in contact with nitrate salts, some authors have reported that iron reacts with O_2, and generates products such as FeO, FeO_2, Fe_3O_4 and Fe_2O_3, which generates a metal oxide layer [1-3]. These operating conditions, plus the work at high temperatures of the storage systems with molten salts, make the welded area of the tanks of high scientific interest, of which there is no evidence on a pilot scale.

This work explores the lessons learned throughout the evaluation process of the welded joint samples of different grade 316L Stainless Steel (ASS) specimens, exposed to a binary mixture, with 60% $NaNO_3$ and 40% KNO_3 (solar salt) inside the thermal storage pilot plant of the University of Antofagasta.

The tests for the ternary mixture were carried out in a stainless-steel grade 316L tank of 0.83 m^3 and 203 kg weight. The tank was equipped with the commercial components detailed in Figure 1, where four electric resistances of 1.2 kW provided the heat to melt the salt. The system contains 15 temperature sensors type PT100 class B 3-wire with 316-L stainless steel sheaths that are located inside and outside the tank. A GVSO40/160A high-temperature vertical pump recirculated the fluid at a rate of 1 $m^3\ h^{-1}$.

As a novelty, the process (Figure 1 a) that the storage group has developed is proposed to carry out tests with specimens (Figure 1 b), made of 316-L stainless steel with 2 types of welding, to immerse them inside a tank of thermal storage at 400 °C. During this entire process there is a recirculation of the molten salts, which resembles the behavior of real systems where the stainless-steel materials are in contact with an agitated fluid due to the loading and unloading process of the storage systems.

Acknowledgments

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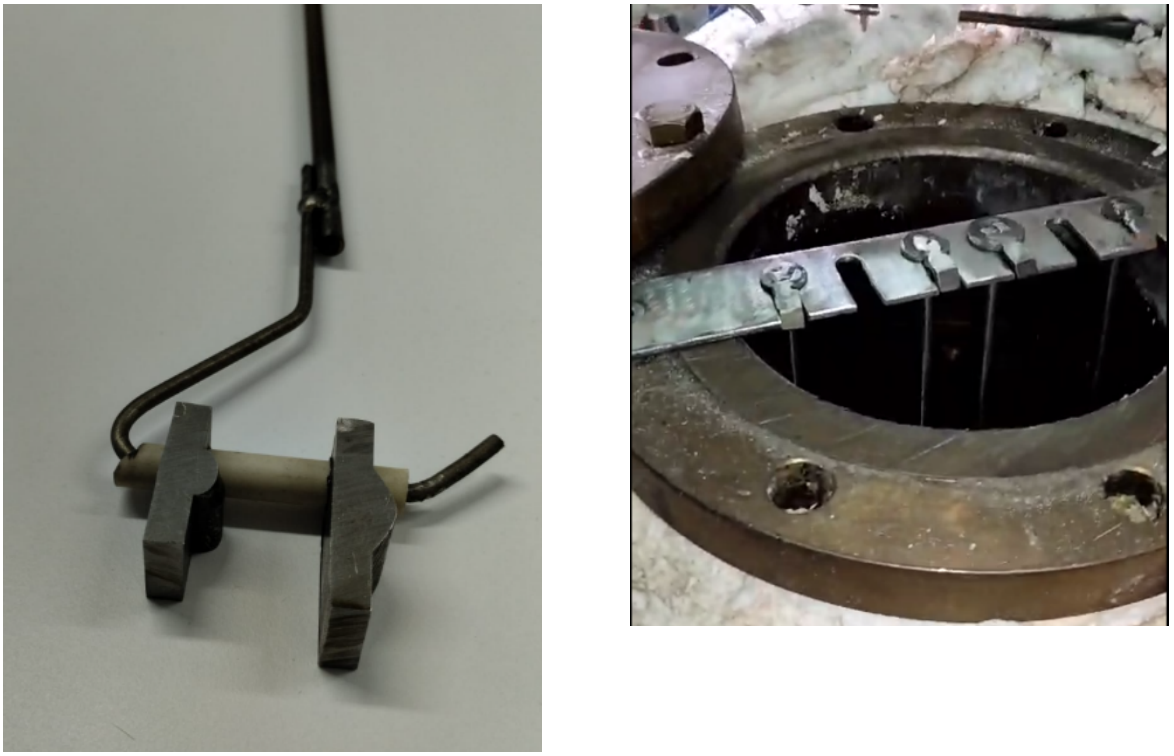

Figure 1: Welding process facilities. a) steel specimens inside the molten salt pilot tank. b) Steel specimens with oscillation and non-oscillation welding.

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REC: Renewable Energy Conversion

REC: Oral Presentations

REC01:
Assessing the influence of local renewable sources variability on the levelized cost of hydrogen

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Utilizing hydrogen for numerous carbon-based applications has emerged as a viable approach to mitigate greenhouse gas emissions. Currently, water electrolysis stands as the most suitable technology for hydrogen production. The required electricity can be sourced from both the power grid and renewable resources, such as solar and wind energies. Utilizing these renewable resources would hinge on the location resources' availability and complementarity, playing a crucial role in determining the levelized cost of hydrogen (LCOH). Nevertheless, the impact of the local solar and wind availability and complementarity on the levelized cost of hydrogen (LCOH) remains unclear. This study examines the influence of the local renewable resources on the LCOH. Our approach involves creating an optimization model for an PEM electrolysis-based hydrogen plant, identifying key factors and trends that relate the LCOH with the local renewable resources in different locations. The model utilizes hourly data on solar PV and wind generation from four locations in Chile, optimizing the capacities of onsite solar and wind generators, electrolyzers, storage tanks, and compressors. The analysis reveals that locations relying heavily on solar energy are significantly affected by the reduction of solar generation during the winter season, resulting in a substantial increase in the LCOH. Also, periods with low renewable generation could affect the LCOH by increasing the storage capacity and it would depend on the duration of the event. Finally, periods with low wind generation showed to increase the LCOH by around 10

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REC02:
A new design of solar racing car prototype: Energy improved by aerodynamic and suspension design

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In 1987 the World Solar Challenge (WSC) began, being the top competition for solar vehicles. The main objective is the development of energy efficient vehicles, considering a limited surface for the solar panels and the weight of the battery bank. Solar car INTIKALLPA VI (IK6) was designed for WSC, evolving from the previous prototype INTIKALLPA V (IK5) which successfully competed in WSC 2019. Energy efficiency of the solar car increases your range on the road, [1] point out that the design of the aerodynamic shape originates 80% of the energy consumption. For this reason, the IK6 prototype considers symmetrical wing profiles and aerodynamic additions to reduce the drag force of the vehicle. The aerodynamic design was accomplished by ANSYS Fluent, based on the finite volume method to calculate the fluid dynamics in addition to the k-ω SST turbulence model. The suspension system is an important aspect, because 15% of electrical consumption comes from tire-asphalt rubbing [2]. Pushrod type system was proposed to optimize stability and minimize weight, it was simulated in SOLIDWORKS using the finite element method. The main results are the 12% of improvement in energy efficiency related to electricity consumption, and the 5improved drag coefficient. The suspension has been reduced by 32% in space and 11compared to the previous version.

Acknowledgments

Authors gratefully acknowledge the support of Antakari Solar Car Project sponsors: Engineering Simulation and Scientific Software Ltda. (ESSS) and ANSYS for CAE and CFD software. Also, DISEGNO 3D S.P.A. and Dassault Systèmes for CAD software.

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REC03:
Combined Heat and Power potential using green hydrogen fuel cells as a source of CO2 emission mitigation in Chile

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In the global context of transition towards a sustainable energy matrix and less dependence on fossil fuels, Chile intends to be one of the primary producers of green hydrogen worldwide. This study examines the national scenario of thermal sources such as boilers and ovens in Chile to replace these sources with residual heat from a Fuel Cell. Using MINSAL and RETC databases, an analysis of the cadastre of the sectors and subsectors with the highest thermal demand in Chile, geographical location, and polluting emissions was carried out, which allowed a comparison to be made to simulate the cost and the change by cells of fuels. In addition, it was determined that at the national level, the highest thermal demand is in regions such as the Metropolitan, an economic center with crucial industrial activity, La Araucanía, and Los Lagos, specifically in their agricultural sectors. In an analysis by the subsector, the highest thermal demand comes from the food and beverage subsector. However, when performing an analysis by sector, the industrial sector has the highest demand, with 12,077.31 [MWt], among 2,179 companies, for which approximately 253,130 Fuel Cells must be used, which represents 23.4% of the total number of cells to replace in the country. In conclusion, the application of fuel cells is more favorable in specific industrial scenarios with high thermal and electrical demand due to the high costs of the Fuel Cells, which represent approximately USD$ 130,488 million, in scenarios applicable to 250 companies that meet the minimum requirements

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REC: Poster Presentations

P-REC01:
Development of an iron oxide/biochar composite for counter electrodes of dye sensitized solar cells.

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Activated carbon has proven to be a promising option to replace the traditional platinum catalyst of a DSSC, due to its properties and low cost. The brewing industry produces residual biomass in large quantities that can be transformed into a material with desired properties for the creation of catalysts that, together with transition metals, could allow improving the characteristics of a DSSC. In this research, an iron oxide/biocarbon composite was developed as a potential catalyst to be applied to counter electrodes in DSSC, where the composite was developed through thermochemical methods evaluating activation temperatures and FeCl3/biochar concentration. The composite was characterized through SEM, XRD, BET, FTIR. The developed catalyst in DSSC showed efficiencies of 1.026%. Moreover, the results demonstrated that the activation from two thermochemical methods allowed to obtain a composite with a good production yield by eliminating the volatile material and increasing the carbon content on its structure. The composite showed great porosity and surface area (643.078m^2/g) due to the catalytic action of iron chloride on the structure, which allowed the formation of pores, which is an important characteristic in a catalyst, in addition, adhered iron was identified in the form of hematite. This study allowed the validation of using residual brewing biomass for its use in a counter electrode which, when treated thermochemically, presented desirable properties to be used as a catalyst. The future work will be focused in to optimize the production and application of this new composite which could be a novel and eco-friendly material for improving the photovoltaic performance of DSSCs.

Acknowledgments

Authors would like to acknowledge: ANID BECAS/DOCTORADO NACIONAL 2021-21211394, Fondecyt Regular Project 1201865, Centro de Manejo de Residuos y Bioenergía Universidad de La Frontera and Nanostructured Materials for Photovoltaic Energy Group, ICN2.

P-REC02:
Evaluation of the mixture of bacterial pigments as sensitizers of photovoltaic solar cells (DSSC)

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Studies focused on the use of bacterial pigments in DSSC have shown that it is feasible to apply these pigments as sensitizers to produce electrical energy, where their performance depends directly on the type of pigment and the concentration applied. Considering this background, this research considered the option of evaluating the performance of DSSC from the mixture of bacterial pigments, where each pigment would provide an improvement in the range of absorption of sunlight at different wavelengths. Four pigments corresponding to Antarctic strains were evaluated. The pigments were characterized by UV-Vis, FTIR and photostability assays. The electrical characterization of the DSSC was carried out in a solar simulator under standard conditions (100mW/cm2,1.5AM,25ºC). The spectra of the pigments were maximum between 400-600nm corresponding to the visible spectrum. The DSSC presented efficiencies between 0.056-0.062

Acknowledgments

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SEC: Semiconductor Materials for Energy Conversion

SEC: Oral Presentations

SEC01:
Optimization of mesoporous triple stack solar cell structure infiltrated with perovskites

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Stable perovskite solar cells are a promising technology for new generation photovoltaics thanks to their impressive improvements in efficiency. Such stability issue is probably the main concern and currently this has been addressed by using additives and change of structure [1, 2]. The mesoporous triple-stack assembly is a structure approach that not only protect the perovskite against the environmental humidity but also enhance the transport and current by keeping high the area to volume ratio in the whole device. This is because the nanostructured architecture of all layers except the TiO2 blocking layer. The goal of this study was the optimization of this kind of structure using two perovskites for infiltration: $CsPbBr_3$ and Methylammonium lead iodide (AVA-MAPI) to be applied as photovoltaic device. Among the main results, we obtained a precise thickness of each layer in the screen-printed structure where the efficiency for both types of perovskites is maximum and closely related to the state of art efficiencies. The infiltration step was critical and a novel one step infiltration of $CsPbBr_3$ using one solvent allowed to maximize its efficiency. On the other hand, the AVA-MAPI was infiltrated using a state of art protocol as reference to tune up the screen-printed structure. Light soaking effect was critical to obtain better efficiencies in AVA-MAPI solar cells while this perturbation had no effect on the CsPbBr3 based solar cells. We concluded the mesoporous screen-printed structure has been optimized in thickness, $CsPbBr_3$ is less efficient but more stable in photovoltaic response compared with its organometallic AVA-MAPI counterpart. This also confirms the lack of an alternative method to measure efficiency, for instance the maximum power point tracking (MPPT) rather than the i-V characteristics. Efficiency, using a Solar simulator, and External Quantum Efficiency measurements were carried out regarding the effect of light soaking and storage time on these measurements.

Acknowledgments

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SEC02:
Development of a $LiFePO_4$/C cathode with a three-dimensional architecture for high-performance lithium-ion batteries

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One of the main limitations of using LiFePO4 (LFP) as a cathode in lithium-ion batteries (LIB) for electric vehicles (EVs) is its lower capacity and power at high current rates, which is due to the slow transport of lithium ions and electrons in its structure. To improve the tolerance of the LFP to fast charge and discharge, the architecture of the cathode material has been studied and a new electrode manufacturing alternative is proposed to accelerate the kinetics of lithium ions and electrons simultaneously during battery operation. This new route for obtaining LFP electrodes combined with carbon (LFP/C) involves hydrothermal synthesis to get textured LFP powders, screen printing and physical vapor deposition to deposit LFP and carbon films, respectively. The production of the cathode finishes with its exposition to a magnetic field to induce a rearrangement of LFP particles. The morphology and crystallinity of the obtained powders were characterized by Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD), respectively. The carbon films were analyzed by XRD and Atomic Force Microscopy (AFM) to study the presence of crystalline phases, topography, and thickness. The porosity in the LFP films was analyzed by light microscopy. The micro-nano structural analyses reveal a promising pathway for fabricating LFP/C cathodes with three-dimensional sandwich architecture, which involves simple and large-scale reproducible techniques. When comparing the electrochemical characteristics of the produced cathodes with those of conventional ones, it is verified that the new distribution of structures has notable changes in the kinetics of the material.

Acknowledgments

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SEC03:
Influence of solution pH on the structural and optical properties of CdS films by and ammonia-free deposition to be used as buffer layer in thin films solar cells

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The study of semiconductor materials has been a matter of great interest in the renewable energies field. In this context, the research in semiconducting materials has been focused in materials with tunable properties, that are abundant and with low manufacturing costs. Thus, cadmium sulfide (CdS) is presented as an attractive option, since it corresponds to a sulfur compound that can be obtained by economic synthesis methods. In the present work, CdS thin films were synthesized by chemical bath deposition at different pH values (from 11,47 to 12,16) to evaluate their use in thin film solar cells. Contact profilometry measurements showed a direct relationship between solution pH and film thickness. Structural characterization by X-ray diffraction (XRD) revealed that the CdS films have a cubic and/or hexagonal structure with preference in the (111) or (002) plane, respectively. From the optical characterization obtained by UV - Visible spectrophotometry, transmittance and reflectance spectra were measured, obtaining on average values between 90 and 30%, respectively. In addition, it was found that the bandgap values (Eg) increased from 2,51 to 2,61 eV when the pH of the solution increased from 11,47 to 12,16, which could be due to a structural change of the obtained CdS films. The results allow to identify the pH value for the optimization of the CdS films towards its use as buffer layer in thin film solar cells.

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SEC04:
Dye-sensitized solar cells based on bismuth oxychloride.

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Dye-sensitized solar cells are one of the most promising simple and low-cost production alternatives among emerging photovoltaic devices. Unfortunately, up to now, they have not exceeded an energy conversion efficiency of 14.3% reached when TiO_2 is used as the semiconductor material. The recombination processes associated with the reduced electronic mobility of TiO_2 are one of the main problems limiting the performance of these devices. In this sense, BiOCl is a semiconductor widely studied in photocatalytic applications. It is characterized by properties similar to those of TiO_2, but, in addition, it has an anisotropic structure in the (001) direction, which is responsible for the generation of an internal electrostatic field that favors the efficient separation of photogenerated electron-hole pairs.

In this work, BiOCl powder was obtained by co-precipitation method, from which a BiOCl film was obtained by screen printing using a sintering temperature of 400°C. The films obtained were morphologically, structurally and optically analyzed. Subsequently, the films were sensitized with N719 dye and BiOCl-based DSSCs were fabricated and characterized using an embedded solar simulator.

This work confirms the potential of BiOCl-based photoanodes for use in DSSCs and the need to obtain a film free of cracks and impurities to aim for higher energy conversion efficiencies.

Acknowledgments

The authors acknowledge the Solar Energy Research Center (SERC) FONDAP project No. 15110019, ANID for grant Doctorado Nacional 21220791 and Fondecyt Regular 1230857

SED: Removal of Water and Air Pollution by Semiconductors

SED: Oral Presentations

SED01:
Usage of mine tailings in the removal of organic pollutants of winery wastewater by heterogeneous photocatalysis

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Mine tailings represent a severe environmental concern as they introduce toxic heavy metals into neighboring ecosystems. As the mining industry is the largest industry in Chile and the country's primary source of income, it becomes necessary to find new applications in which this kind of waste may be used.
At the same time, removing pollutants in wastewater via Heterogenous Photocatalysis (HP) using BiOI as a catalyst has gained importance in the last few years, as it allows for high degradation percentages of organic matter. However, recycling the HP semiconductor is not easy, as the catalyst's nanometric size requires dedicated microfiltration steps to be removed from the treated samples, making its recovery difficult.
Considering the above, this work focused on obtaining catalyst heterostructures that can be removed from the water using an external magnetic force. The magnetic material from two different tailings in the Coquimbo región in Chile (Tailing A and Tailing B) was separated and used to support the catalyst. The BiOI/Magnetic Material (A and B) heterostructures were synthesized via co-precipitation and characterized by XRD, SEM, BET, and DRS. Catalytic activity was determined by monitoring the degradation of caffeic acid under simulated solar radiation for 60 minutes and analyzing samples via UV-Vis and HPLC. The degradation percentage for BiOI/A and BiOI/B was 75.1% and 68.8%, respectively, comparable to those obtained from BiOI/magnetite (79.7%) and BiOI (74.4%). These results, therefore, prove that mine tailings may potentially be used as magnetic support on HP.

Keywords: *BiOI/magnetite, mine tailings, caffeic acid, heterogeneous photocatalysis.*

Acknowledgments

Proyecto CIP ULS 2253852 y DIDULS regular 2023. PR 2321510

SED02:
Sunlight-driven photocatalysis to remove pharmaceutical residues in wastewater effluents: Comparing the performance of Ag2O/TiO2 and BiOI

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Heterogeneous photocatalysis using narrow band gap semiconductors is considered as an alternative to remove recalcitrant pollutants from water under visible light irradiation. However, a limited number of studies has been performed to upscale this process from ideal conditions in the laboratory to more realistic schemes. In this work, we synthesized two photocatalysts, BiOI microspheres and Ag_2O/TiO_2, to degrade atenolol and carbamazepine in secondary effluent. The experiments were undertaken under summer sunlight irradiation in Tunisia, with a duration of 3 h. With an initial concentration of 1 mg/L of each compound, atenolol was completely degraded using both materials under sunlight irradiation. Still, the degradation was faster using the Ag_2O/TiO_2 heterostructure. On the other hand, high degradation of carbamazepine (90%) was achieved after 3 h of sunlight irradiation only when the heterostructure was used. Regarding mineralization, near 90% was achieved for atenolol, while only 54 and 23% were observed for carbamazepine using the Ag_2O/TiO_2 and BiOI materials, respectively. Some intermediates were identified using HPLC-MS/MS for both molecules. It was demonstrated that heterogeneous photocatalysis can be applied for water purification harnessing the high irradiation of North Africa regions.

Acknowledgments

Authors want to thank to Secretaría de Educación, Ciencia, Tecnología e Innovación de la Ciudad de México (SECTeI) for funding This work through project SECITI/047/2016.

SED03:
Photocatalytic degradation of antibiotics using immobilized Bismuth oxyiodide (BiOI) in thin Films.

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The inadequate management of urban wastewater leads to the release of antibiotics into the environment, imposing a severe ecological impact and a risk to human health due to the development of antibiotic-resistant pathogens. A promising solution to this issue is Heterogeneous Photocatalysis (HP), which employs the semiconductor Bismuth Oxyiodide (BiOI) and visible range radiation to achieve high efficiency in contaminant degradation. However, using BiOI in powder form poses difficulties in its recovery from treated water and subsequent reuse, increasing operational costs and the risk of secondary contamination. For this reason, this study investigated the immobilization of BiOI in thin films through the solution ionic layer adsorption and reaction method, using bismuth pentahydrate nitrate ($Bi(NO_3)_3x5H_2O$), potassium iodide (KI), and polyvinylpolypyrrolidone (PVP). The obtained films were characterized using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Diffuse Reflectance Spectroscopy (DRS). The photocatalytic degradation of the antibiotic Tetracycline in water was evaluated. Photocatalytic assays began by subjecting the films to a 30- minute dark period to achieve adsorption-desorption equilibrium. Subsequently, the films were irradiated for 60 minutes with simulated solar radiation. It was observed that while the crystalline structure and band gap affect degradation, the film's morphology is the dominant property for achieving higher photocatalytic efficiency. The best BiOI film was obtained using 33 cycles and 49 seconds of immersion time. Under these conditions, an average antibiotic degradation percentage of 18% was achieved. The results show that thin films obtained through chemical solution methods are a potential alternative for immobilizing the BiOI semiconductor, facilitating its recovery and reuse in the photocatalytic degradation of antibiotics on water.

Keywords: *Thin films, BiOI, Heterogeneous photocatalysis, Chemical solution, Antibiotics, Semiconductor immobilization.*

Acknowledgments

Proyecto: FONDECYT REGULAR 1230857 and FONDECYT REGULAR 1231376 ANID Chile.

SED04:
Synthesis of BiOI/Fe_3O_4 by co-precipitation method for photocatalytic removal of antibiotics from water.

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Recently, antibiotics have been detected in drinking water, groundwater, surface water, domestic sewage, and wastewater sources. The existence of these antibiotics in the aquatic environment poses a harmful threat to human health and ecosystems because these promote antibiotic-resistant bacteria. Ciprofloxacin (CIP) is one of the most widely prescribed fluoroquinolone antibiotics used worldwide to treat infectious diseases in humans and animals. Unfortunately, CIP is highly chemically stable, non-biodegradable, and remains in the environment for long. Considering the above, exploring and implementing efficient treatment technologies to remove CIP from the aquatic environment is essential. In this regard, heterogeneous photocatalysis (HF) is a promising technology for removing antibiotics from water.

The semiconductor BiOI is one of the most studied in HF due to its high photocatalytic efficiency under visible and solar-simulated radiation. However, one of its limitations is its nanometric size, which hinders its recovery from the treated wastewater for subsequent reuse. Considering the above, in this work, BiOI coupled to magnetite (Fe_3O_4) was obtained to remove CIP from water using an external magnetic force. The BiOI and BiOI/Fe_3O_4 photocatalysts were synthesized by co-precipitation method. The characterization of materials obtained was realized using different techniques: XRD, SEM, BET, and DRS. The photocatalytic activity was determined by following the removal of CIP in water under simulated solar irradiation for 240 minutes using UV-Visible spectroscopy and HPLC. The removal percentages obtained using BiOI and BiOI/Fe_3O_4 were 87.53% and 72.04%, respectively. These results are promising because they show that the BiOI/Fe_3O_4 heterostructure obtained by the co-precipitation method is a potential alternative for removing antibiotics from the waters.

Keywords:*Heterogeneous photocatalysis, ciprofloxacin, BiOI/Fe3O4.*

Acknowledgments

Proyecto CIP ULS 2253852 y DIDULS regular 2023. PR 2321510

SED: Poster Presentations

P-SED01:
Optimization of photocatalytic conditions for the degradation of phenolic compounds present in water using BiOI/magnetite heterostructures.

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The wine agro-industry plays a significant role in Chile's economy. However, the wastewater produced during wine production contains phenolic compounds such as caffeic acid and gallic acid, among others. These compounds challenge biological wastewater treatment processes, making it difficult to meet current environmental regulations.

To address this issue, heterogeneous photocatalysis (HP) processes have been employed as a solution. One commonly used semiconductor in HP is bismuth oxyiodide (BiOI). However, its nanometric size makes separating it from treated water for subsequent reuse complex when using micro membranes. This limitation hinders the widespread industrial application of HP. Magnetite (Fe3O4) is an excellent support for BiOI, allowing for the removal of the semiconductor from treated water using an external magnetic force. In this study, BiOI/Fe_3O_4 material was synthesized via the solvothermal route at a temperature of 147.7°C for 6.7 hours, with a BiOI to Fe_3O_4 ratio of 5:1.

The resulting BiOI/magnetite heterostructure was thoroughly characterized using XRD, SEM, DRS, FT IR, and BET analysis. The photocatalytic efficiency of the material was assessed through High-Performance Liquid Chromatography (HPLC), focusing on the degradation of caffeic acid under simulated solar radiation. The optimization of heterostructure concentration (ranging from 125 to 600 ppm) and pH levels (ranging from 3 to 7) was carried out using a CCD factorial design and RMS methodology with MODDE 13 Software. The BiOI/magnetite material exhibited approximately 23% degradation when exposed to 698 ppm of the heterostructure and pH 5 for 15 minutes under simulated radiation. This degradation rate increased to approximately 40% after 60 minutes of simulated radiation exposure.

The results demonstrate the potential of the BiOI/Fe_3O_4 heterostructure as a promising photocatalyst for treating wastewater generated in the wine industry. This study in the future will be completed with the evaluation of the material's magnetic properties obtained under optimized conditions.

Keywords: *BiOI/magnetite, Phenolic Compounds, Wine Industry*

Acknowledgments

Proyecto CIP ULS 2253852.

P-SED02:
Bismuth oxychloride heterostructures doped with copper for the photocatalytic degradation of Methyl Orange: on the process optimization and kinetic modeling.

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In this study, the photocatalytic degradation of methyl orange (MO) was assessed using a hetero- structured catalyst based on bismuth oxychloride doped with copper oxide (BiOCl/CuO). The investigation entailed an analysis of the impact of pH conditions and photocatalyst concentration on the photocatalytic degradation process and its temporal progression. Heterostructures of BiOCl with CuO were synthesized through a solvothermal method, optimizing CuO concentrations to enhance the photocatalytic activity. The optimal CuO concentration, at 0,6% relative to BiOCl, demonstrated a photocatalytic degradation of 40% within 60 minutes under UV-visible light exposure. As reported in scientific literature, SEM assays confirmed a distinctive morphology of BiOCl microspheres and CuO lamellar plates.

Additionally, Electron Dispersion Spectroscopy (EDS) and Fourier Transformed Infrared Spectroscopy (FTIR) studies confirmed the material composition and functional groups. The material's zero point of charge (BiOCl/CuO at 0,6%) was determined across a pH range of 2 to 12, revealing a trend for acidic pH values. The optimal experimental conditions were determined with eleven experiments; these were performed using a central composite design (CCD) under varying conditions. The optimal degradation of methyl orange was achieved at pH 4, coupled with a photocatalyst dosage of 0,8 g/L. Besides, kinetic experiments were fitted to a pseudo-second-order model for the contaminant degradation and the reaction byproducts (Figure 1). Finally, new details in the photocatalytic degradation of MO utilizing BiOCl/CuO were revealed, optimizing the photocatalytic operational conditions and unveiling its reaction kinetics exhibiting its practical applicability for the remotion of water contaminants.

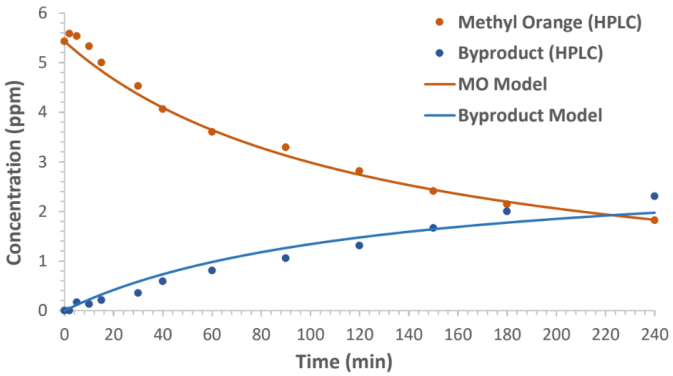

Figure 1: Pseudo-second-order kinetic modelling of methyl orange degradation and reaction byproduct detected by HPLC.

Acknowledgments

ANID/Fondecyt Regular Project, Grant1231376; ANID/FONDECYT Postdoctoral Grant 3210158

P-SED03:
Heterojunction of BiOCl-CuO by co-precipitation method for the remotion of environmental pollutants

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Heterogeneous photocatalysis (HP) allows the removal of organic dyes used in the textile industry to reduce the environmental impact caused by these little biodegradable substances. However, the semiconductors used present a high recombination process, which can substantially reduce the photocatalytic efficiency when using HP. For this reason, manufacturing a heterojunction is of interest in HP because it will facilitate the separation of the electron-hole pairs, increasing the photocatalytic efficiency.
A highly studied heterojunction is BiOCl-CuO, obtained using the solvothermal method. However, this method generates high energy costs and uses ethylene glycol, making the procedure more expensive. Therefore, this study synthesized the BiOCl-CuO heterojunction by co-precipitation method, using 0,3276g of $Bi(NO_3)_3$ in ethanol, and the mixture was added 0,006g of CuO. Then, was added dropwise a solution with 0,050g of KCl dissolved in deionized water. The final mixture was agitated and filtered, and the solids were dried at 60°C for 60 minutes. This synthetic route uses less energy and cheaper reagents than the solvothermal route. The materials were synthesized using two pH values: acidic and basic. The photocatalytic efficiency was determined by HPLC, using the degradation of the methyl orange dye under simulated solar radiation for 180 minutes.
Preliminary results show that the percentage of dye removal was 57.2% at pH 1.5 (acid) and 41.6at pH 8.4 (basic). These results encourage a study of optimization of synthesis variables, such as stirring time, pH, and CuO concentration in the heterojunction, to achieve maximum photocatalytic efficiency. In addition, the materials obtained will be characterized by various techniques to understand the relationship of the physical and chemical properties with their photocatalytic efficiency.

Acknowledgments

Fondecyt Regular N° 1231376.

P-SED04:
Catalytic degradation of dyes and bacterial disinfection in aqueous solutions using photochemically synthesized CeO2 and CeO2/Fe2O3 deposits.

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We propose the synthesis of pure CeO_2 and Fe_2O_3-loaded CeO_2 films at different concentrations (0.5, 1.0, 2.0, and 3.0 mol%) using a low-cost and easy-to-handle photochemical method. The photo-deposited films on silicon were annealed at 950 °C and subsequently characterized using surface analysis techniques such as XRD, XPS, SEM, EDS, and Raman spectroscopy. The results demonstrated uniform deposits and the presence of cerianite phases of CeO_2 along with hematite Fe_2O_3 for the loaded samples. Evaluation of the optical properties of the samples revealed a reduction in the band gap and a decrease in photoluminescent emission as the Fe_2O_3 loading on the CeO_2 matrix is increased. The evaluation of its photocatalytic properties was carried out using brilliant green and Staphylococcus aureus as a contaminant in aqueous solutions with a lamp UV- Vis as light source. The results showed that the CeO_2 films exhibited a degradation percentage of 78.87% towards Brilliant green dye compared to CeO_2/Fe_2O_3 films, where the degradation results reached 90.07% in samples loaded with 1.0 mol% of Fe_2O_3. The kinetic photodegradation curves are displayed in Fig.1 obtaining kinetic constant of 0.0076 min^{-1} for the 1 mol% Fe_2O_3-loaded CeO_2 sample. The results of the antibacterial study based on Staphylococcus aureus demonstrated that films Fe_2O_3-loaded CeO_2 significantly reduce the growth of this microorganism compared to pure CeO_2 films, making it a potential antibacterial control material.

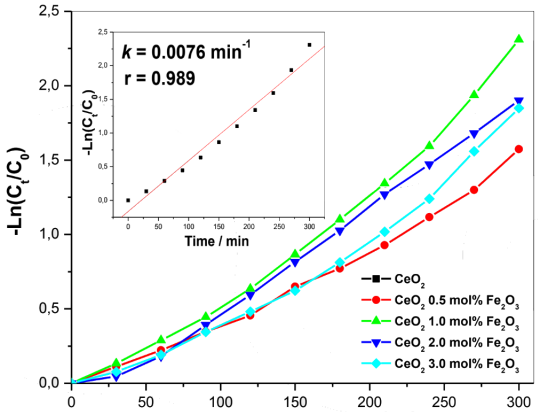

Figure 2: The plot -Ln (Ct/Co) vs time. Inset: Kinetics in the photodegradation of brilliant green over CeO_2 loaded with 1.0 mol% Fe_2O_3.

Acknowledgments

We are grateful to the post-graduate office at University of Bío-Bío (Program INES I+D 22-16)

WMU: Water Management and Sustainable Water Usage

WMU: Oral Presentations

WMU01:
Enhancing Water Security in an arid basin in north-central Chile: Effects of prioritizing water access to addressing scarcity and water demand coverage

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Ensuring consistent access to clean and ample water resources in an era marked by intensifying water scarcity and shifting climate patterns has grown paramount. Water security, encompassing reliable, safe, and equitable access to essential water resources, has emerged as a pivotal framework for analyzing and addressing challenges posed by water scarcity, climate dynamics, and equitable water distribution. Arid zone basins, characterized by scant rainfall and elevated evaporation rates, confront pronounced water scarcity issues due to their inherently limited water reservoirs. Consequently, applying water security principles in these regions assumes heightened significance to mitigate the detrimental impacts of water scarcity. This study undertakes a comprehensive assessment of water security dynamics across historical, mega-drought, and projected climate change scenarios, guided by the incorporation of priority access to water rights to alleviate water scarcity and vulnerability. We use indicators based mostly on subsistence activities and basic human needs water footprints, which are constrained by available water flow offers [1]. The research replicates water flows by employing flow modeling, capturing historical trends and anticipated climate-induced shifts. Our hypothesis suggests that implementing priority access to water resources would likely alleviate water scarcity and water demand coverage to human consumption, while also potentially amplifying these effects for agricultural activities. This work contributes to the ongoing discourse on water resource management, particularly in arid zones, informing policy decisions and broader sustainability discussions.

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WMU02:
Fog water collection in arid and semi-arid zones in Chile: how scientific knowledge and technological development can help alleviate freshwater scarcity in the context of climate change

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According to the World Resources Institute (2019), Chile ranks among the top 20 countries facing the most severe water stress globally. This situation is expected to worsen due to climate change, with projected future scenarios indicating rainfall reductions of between 5 and 15% across the regions from Atacama to Aysén (Ministry of the Environment, Chile, 2023). The decline in available surface and groundwater has sparked increased interest in utilizing unconventional water resources (UWRs) such as atmospheric water (e.g., fog, dew), seawater desalination, and greywater reuse. In Chile, seawater desalination has gained significant momentum in recent years among these UWRs, overshadowing the utilization of atmospheric water sources, which remain limited to small-scale applications in isolated areas. The aim of this work is to address the following question: Could atmospheric water resources in Chile gain greater significance in the upcoming years? The answer is affirmative for two reasons: the substantial availability of atmospheric water resources, especially fog water, and ongoing technological advancements that contribute to enhanced performance and reduced costs in water collection. Technological enhancements in fog water collection can be achieved through applied research utilizing tools such as computational fluid dynamics and laboratory experiments conducted in wind tunnels. This research has demonstrated that by enhancing the efficiency of aerodynamic fog collection and deposition, it becomes feasible to double the collection efficiency compared to conventional systems, while also improving water drainage. These advancements consequently lead to a reduction in the costs associated with such systems, thus extending their potential applications. This emerging approach holds great appeal for enhancing fog water collection technology, positioning it as a compelling alternative solution to alleviate freshwater scarcity within the context of climate change in Chile's arid and semi-arid regions.

Acknowledgments

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WMU03:
Effect of the upstream wind speed vertical profile on the aerodynamic efficiency of fog water collection.

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Fog, a geophysical and geographical phenomenon found in various world regions, has attracted a great deal of attention as a promising solution to combat water scarcity in arid and semi-arid areas. In this context, fog collectors have emerged as an attractive alternative, allowing water retention during fog events by the impaction of droplets, which coalesce and drip into a gutter for collection. This study aims to deepen the fundamental aspects related to the aerodynamic behavior of conventional fog collectors during fog capture. For this purpose, it developed a three-dimensional computational fluid dynamics model in which the collector mesh is represented as a porous medium, thus simulating a conventional two-dimensional double-layer configuration. The analysis includes a parametric study in which the wind velocity is characterized by a logarithmic type profile on surfaces with different roughness lengths (Zo). Among the most noteworthy findings of this research, it is observed that the aerodynamic efficiency would exhibit a variation of less than 1response to the increase in the magnitude of the wind speed, in a range between 2 and 10 m/s, contemplating different magnitudes of roughness length. These results are very useful to accurately determine the type of site for various applications inherent to this technology, such as agriculture or water supply to smaller communities, among others.

Acknowledgments

This work was supported by ANID/ FONDEF IDeA ID21I10374 grant.

WMU: Poster Presentations

P-WMU01:
Proposal for an eco-sanitation design for housing located in the "Scientific and Technological Pole" of the University of La Serena, Coquimbo

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Ecological sanitation systems, also known as ecosan, focus on treating wastewater generated in homes. These systems make it possible to reduce water consumption and ration this resource more efficiently. Ecosan is an alternative that provides a new opportunity for human waste by creating a separation for the management of these wastes from the starting point of the flow (the toilet) to the area where it will be stored, thus avoiding cross-contamination. These wastes can be considered as potential fertilizers in the case of human urine or of human feces. In this project, an ecological sanitation design was made for the houses located in the Scientific and Technological Pole of the University of La Serena. The first part of the design includes a dry ecological toilet with a human waste storage system as a secondary part, consisting of depositing feces in a chamber with ventilation, while urine will be deposited in a separate container. This storage will be done for a period of no less than 6 months to eliminate pathogens. In the third section, the feces are subjected to a biological treatment based on composting under controlled conditions, and the urine to fermentation, in the hope of obtaining compost and natural fertilizer for later use in green areas. This proposal was made using data submitted from one of the houses within the site. This will allow us to promote practical concepts of sustainable development within the university community.

Acknowledgments

Grupo de Investigación Multisdisclinar en Energía y Gestión Ambiental (GIMEGA), Universidad de La Serena, Chile.

P-WMU02:
Groundwater contamination by nitrates in the Puelche-Argentina aquifer.

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Groundwater serves as the primary source of freshwater for approximately two billion people globally. Nonetheless, its quality and quantity are facing a concerning decline, whether severe or incipient. This degradation is primarily attributed to overexploitation and inadequate pollution control measures. The main pollution source of anthropogenic origin from diffuse sources, mostly is linked to nitrates originating from agricultural activities and the infiltration of urban effluents.

Therefore, nitrates have become an environmental indicator of anthropogenic impact on subsurface aquatic systems worldwide. In this study, nitrate contamination was determined in the Puelche aquifer in the area of influence of the Matanza-Riachuelo basin. The Matanza Riachuelo Authority (Acumar) data taken from 2008-2018 correspond to the annual concentrations. Geostatistical methods (Arcgis v10.2) were used to analyze the concentrations and their spatial distribution, taking into account the environmental regulations in the Province of Buenos Aires. This aquifer has a low salinity (average of 585 mg/L). However, it is confirmed that the drinkability of water is only affected by the nitrate content, mainly of a diffuse nature in the urban area and of a specific nature in the rural region.

Urban pollution has degraded the aquifer to the extent that groundwater now mixes with surface water from the Río de la Plata to avoid exceeding the limit set by the drinking water quality standard of the Province of Buenos Aires (50 mg/L) in the urban area. The presence of nitrates affects over 10% of the Puelche's freshwater reserve. This underscores the pressing need to address this environmental impact through the implementation of awareness campaigns aimed at conserving and protecting water resources, as well as strengthening monitoring networks.

Keywords: *groundwater, nitrates, pollution, aquifers*

Acknowledgments

The authors thank the Faculty of Engineering at the Universidad Nacional de La Plata for within the context of the specialization in Ecohydrological Tools.

Technical and Invited Talks

Technical Talks

TECO1:
Desafíos en la investigación de la cosecha de agua de niebla

Pedro Hernández Pérez
Consultora Pedro Hernández Pérez EIRL

TECO2:
Simulación avanzada con ANSYS de cara a los desafíos de la gestión y el tratamiento de aguas

Carlos Olivares
Engineering Simulation and Scientific Software (ESSS)

TEC03:
Technical Talk

Grupo SIBI SPA

Invited Talks

IT01:
Innovations in nanotechnology for water purification

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One of the most serious problems currently facing the man kind throughout the world is freshwater scarcity. Millions of people including children lose their life annually due to water-borne diseases caused by the consumption of contaminated fresh water. Fresh water resources are predominantly polluted by effluents discharged from various industries that are toxic to aquatic environment and human beings. In addition, the accumulation of various synthetic organic compounds such as dyes, phenols, organochlorides, antibiotics and etc., are known to cause great harm to human health (carcinogenic, teratogenic and mutagenic) even when their concentration in water is less than 10-7 magnitude. Moreover, it is very difficult to mineralize the synthetic organic compounds wastes using the traditional treatment techniques, such as, adsorption, sedimentation, coagulation, evaporation, etc. due to their high solubility in water. Hence, problems related to water are expected to grow worse in the coming decades with freshwater scarcity occurring globally even in the regions currently endowed with fresh water-rich. Addressing these serious problems requires robust advanced nanotechnologies for purifying water polluted with synthetic organic compounds wastes in an economical way and with less energy consumption. Heterogeneous photocatalytic oxidation process with an aid of oxide semiconductor nanoparticles is of special interest, especially when visible portion of the solar light is used. The semiconductor nanomaterials as a catalyst facilitate large contact area on its surface for the adsorption of a greater number of target organic pollutant molecules. This ensures that the catalytic active sites can be effectively used for the degradation of organic pollutants. In view of the above facts, the current presentation will be discussed the state-of-the-art research activities and latest advancements in the design of different nanostructured materials via various strategies, including hydrothermal/solvothermal, high temperature gas phase methods and ect., To overcome the large band gap of nanostructured semiconductor materials and rapid recombination of photogenerated charge carriers, modifications are carried out to manipulate its electronic band structure, including transition metal doping, noble metal doping, non-metal doping and incorporating graphene as a two-dimensional (2D) catalyst support. The advancements made in these aspects are thoroughly examined, with additional insights related to the charge transfer events for each strategy of the modified nanostructured semiconductor materials. Finally, a summary and some invigorating perspectives on the major challenges and new research directions for future exploitation in this emerging frontier for various environmental applications.

IT02:
Chemical bath deposition of zinc oxide films for application as transparent and conductive windows in thin film solar cells

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The pursuit of cost-effective solar cells prompts the implementation of alternatives processing methodologies. In this work, the deposition on glass of zinc oxide films, unintentionally doped and doped with aluminium, was studied to be used as transparent windows in thin film solar cells. Chemical bath deposition (CBD) was chosen as the synthesis technique since it does not require vacuum, is simple and scalable to large areas. Furthermore, CBD temperatures are suitable for deposition on pre-deposited layers of the cell without damaging them. To promote heterogeneous nucleation during CBD, a seed layer of ZnO was deposited using spray pyrolysis. Then, CBD was carried out from a solution of ZnO powders dissolved in NH_4OH. For doping a solution with $Al(NO_3)_3$ and ammonium citrate was incorporated into the ZnO CBD solution. Finally, a post- treatment with UV light was implemented in order to improve the electrical conductivity of the ZnO films.
The optoelectronic properties were characterized by UV-VIS spectroscopy and the Van der Pauw method. The thickness of the films was obtained from profilometry. The chemical composition, morphology and microstructure were analysed by X-ray diffraction (XRD), Raman spectroscopy, scanning electron microscopy (SEM) and energy dispersive electron analysis (EDS). Macro- and microscopically uniform films with a transmittance greater than 80% in the visible range were obtained. The resistivity decreased by three orders of magnitude after the UV-treatment, reaching resistivities close to 10^{-2} Ω.cm. The deposition of ZnO was demonstrated by XRD and Raman, while the incorporation of aluminium as dopant could be confirmed through EDS.

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