UNIVERSIDAD DE LA SERENA

LA SERENA CHILE

Energy, Efficiency and Environmental Sustainability Conference

22ND TO 24TH NOVEMBER 2017

HOTEL CLUB LA SERENA AVENIDA DEL MAR 1000

KEYNOTE SPEAKERS

Dr. **Dionysios D. Dionysiou**

University of Cincinnati, Ohio, USA.

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Plenary conference: Treatment of Cyanotoxins and Contaminants of Emerging Concern in Water Using Advanced Oxidation Processes.

Dr. **Jean-Luc Delplancke**

Université libre de Bruxelles, Brussels, Belgium.

-

Plenary conference: Fuel cells and hydrogen: flexible devices for the production of sustainable electricity.

Dr. **Jesús Fidel González Rouco**

Universidad Complutense de Madrid, Spain.

-

Plenary conference: Wind variability: a climatological perspective through model-data comparison.

Organizing Committee

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BOOK OF ABSTRACTS

1 ENERGY, EFFICIENCY

AND ENVIRONTMENTAL SUSTAINABILITY CONFERENCE

22, 23 y 24 de Noviembre de 2017

Hotel Club La Serena, La Serena, Chile

Welcome from the Ineergias Executive Director

Chile ha experimentado un progreso sin precedentes durante las últimas décadas, movilizado por la aspiración de ser un país desarrollado. La pobreza ha disminuido sustancialmente, la esperanza de vida se ha elevado hasta sobrepasar el nivel promedio de los países de la OCDE, el acceso a la vivienda, el consumo y a la educación superior se han expandido de manera notable. Estos indicadores de progreso material y de bienestar de la población han mostrado avances que parecían imposibles para nuestro país hace algunas generaciones.

El crecimiento económico no sólo trae beneficios, sino que también establece nuevos desafíos y responsabilidades que exigen un mayor estado de conciencia y, por cierto, de acción frente a los desafíos de nuestra sociedad, especialmente aquellos desafíos de carácter global.

Los ciudadanos comunes de todo el mundo y muchos de sus gobiernos están cada vez más preocupados del cambio global, siendo el más conocido el cambio climático y sus efectos en el orden económico y social. Organizaciones Multilaterales, como IPCC, la Convención Marco de las Naciones Unidas sobre el Cambio Climático entre muchos otros, no sólo expresan esa inquietud, sino que definen una ruta para los países. Chile y sus universidades no han estado ajenos a ello. Es así como la Universidad de La Serena con el apoyo del Ministerio de Educación ha apostado por el desarrollo de un Programa de Mejoramiento Institucional en Eficiencia y Sustentabilidad, denominado INEERGIAS, que implica abordar un interesante camino de evolución en su gestión sustentable como corporación, impulsando estos conceptos como sello de la formación de los profesionales universitarios, en la instalación de capacidades científicas especializadas en estos temas y en generar vínculos estables con los agentes económicos, sociales y educativos del territorio regional, nacional e internacional, para construir una agenda de codesarrollo en el marco de estas temáticas, la cual hoy lleva tres años de ejecución y que se proyecta con muy buenas perspectivas hacia el futuro.

Como Universidad regional y del Estado de Chile, estamos convencidos de que las ciencias, las tecnologías y la innovación son, sin duda, claves para elevar la productividad de nuestro territorio, impulsar nuestro crecimiento y bienestar material. Sin embargo, también reconocemos que son caminos para la creación de valor en el ámbito social, en la generación de bienes públicos, en la conservación del medio ambiente y ciertamente fundamentales en la comprensión de nuestros mundos y su transformación. Es por eso que agradecemos la respuesta de cada uno de los académicos, estudiantes y profesionales que respondieron con alto interés a nuestra convocatoria y que han decidido compartir sus avances en la generación de conocimiento en esta conferencia denominada **ENERGY, EFFICIENCY AND ENVIRONMENTAL SUSTAINABILITY**.

Sabemos que no es fácil cambiar paradigmas y aún más complejo es fundar unas nuevas arquitecturas para un desarrollo sustentable, sin embargo, ya comenzamos con este primer paso de muchos que se vienen por delante, en que esperamos –ciertamente- contar con todos ustedes.

Cordialmente,

César Espíndola Areyano
Director de Estudios Institucionales y Planificación
Universidad de La Serena Director Ejecutivo PMI-ULS 1401 INEERGIAS-
Universidad de La Serena, Chile

Welcome from the Organizing Comitte

Estimados asistentes al Primer Congreso en Energía, Eficiencia y Sustentabilidad Ambiental (CEES 2017). Como representante del comité organizador de este evento académico, debo comentar en primer lugar que este evento nació en el año 2015 en la Universidad de La Serena y bajo el alero del Plan de Mejoramiento Institucional PMI 1401: Eficiencia Energética y Sustentabilidad Ambiental-Ineergias. En dicha ocasión, se realizó bajo el nombre de Seminario en Energía, Eficiencia y Sustentabilidad: Economía Circular. Y en el año 2016 fue realizado con el nombre de Seminario Internacional en Energía, Eficiencia y Sustentabilidad (SIEES), abordando temáticas relacionadas con Materiales y Procesos para Energía y Descontaminación Ambiental.

Con la organización de este Primer Congreso en Energía, Eficiencia y Sustentabilidad Ambiental, más de 100 investigadores nacionales y extranjeros disponen a consideración de la comunidad científica, académica y empresarial el resultado de sus investigaciones y proyectos en curso, para promover la creación de lazos de cooperación multidisciplinaria y la generación de redes de intercambio de conocimientos teóricos- prácticos, ideas y experiencias, que contribuyan con el desarrollo tecnológico y permitan dar respuesta a los desafíos actuales en el ámbito de la Eficiencia Energética y Sustentabilidad Ambiental.

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. Quiero de forma personal proporcionar 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 este Congreso. En nombre de la Universidad de la Serena, el Programa Ineergias, el comité científico y el comité organizador esperamos que disfruten de este Congreso 2017, teniendo la certeza que su participación en el mismo, es de trascendencia para Chile y para el mundo.

Cordialmente,

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Scientific program

Wednesday, November 22			
Time	**Salón Elqui 1**	**Salón Elqui 2**	**Salón Elqui 3**
14:00-15:00			Registration
15:00-15:30			Inauguration
15:30-16:30			Plenary 1
16:35-17:05	CT1	WT1	
17:05-17:35	CT2	WT2	
17:35-18:05	CT3	WT3	
18:05-18:35	Coffee break		
Thursday, November 23			
Time	**Salón Elqui 1**	**Salón Elqui 2**	**Patio Tololo**
9:00-9:30	CT4	WT4	
9:30-10:00	WT7	WT5	
10:00-10:30	WT8	WT6	
10:30-11:00	MT1	PL1	
11:00-11:30	Coffe break		
11:30-12:00	MT2	PL2	
12:00-12:30	MT3	PL3	
12:30-13:00	MT4	PL4	
13:00-14:30	Lunch		
14:30-15:30	Plenary 2		
15:30-16:30	Poster session/Coffee break		
16:30-17:00	MT5	SM1	
17:00-17:30	MT6	SM2	
17:30-18:00	MT7	SM3	
18:00-18:30	MT8		
20:00	Conference dinner		
Friday, November 24			
Time	**Salón Elqui 1**	**Salón Elqui 2**	**Salón Elqui 3**
9:00-10:00	Plenary 3		
10:00-10:30	Coffee break		
10:30-11:00	EN1	SM4	
11:00-11:30	EN2	SM5	
11:30-12:00	EN3	EL1	
12:00-12:30	EN4	EL2	
12:30-13:00	EN5	EL3	
13:00-13:30			Closing ceremony
13:30			Lunch

Sessions names
CT: Catalysis
WT: Water management
MT: Materials
PL: Policy
SM: Simulation
EN: Energy
EL: Electricity

Plenary conferences

P1:	Dionysios D. Dionysiou *University of Cincinnati, USA*	Treatment of Cyanotoxins and Contaminants of Emerging Concern in Water Using Advanced Oxidation Processes
P2:	Jean-Luc Delplancke *Ecole Polytechnique de Bruxelles, Belgium*	Fuel cells and hydrogen: flexible devices for the production of sustainable electricity
P3:	Jesús Fidel González Rouco *Complutense university, Spain*	Wind variability: a climatological perspective through model-data comparison

Contents

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Plenary Conferences

Treatment of Cyanotoxins and Contaminants of Emerging Concern in Water Using Advanced Oxidation Processes

Dionysios (Dion) D. Dionysiou

Advanced Oxidation Processes (AOPs) are gaining popularity for the removal of contaminants of emerging concern, especially for applications in the purification of drinking water, treatment of wastewater effluent (i.e., for discharge or reuse applications), decontamination of industrial effluents, and remediation of groundwater. Homogeneous and heterogeneous AOPs are currently intensively explored, modified, and optimized for applications as stand-alone technologies or integrated with other processes in the overall treatment train. Several new AOPs demonstrating promising results have been developed in recent years. While most of these technologies are based on hydroxyl radical as oxidizing species, some AOPs involve other radical species such as sulfate radical and superoxide anion radical, which are also more selective. While less efficient for destruction of organic contaminants, superoxide anion radical can play a significant role in water disinfection by solar light. Recent interest has also spurred in reductive pathways of AOPs for application in reduction of metals, nitrate, bromate and other species of importance in water quality. More recent studies have also delved into mechanistic insights of AOPs, including identification of reaction intermediates, unveiling reaction pathways, determination of treated solution toxicity, and the role of water quality on the reaction mechanisms and reaction kinetics. Recent progress in nanotechnology also propelled new advances in the field of heterogeneous AOPs. The use of solar light by some of these processes (i.e., solar photocatalysis, solar photoelectrocatalysis, solar disinfection) has expanded potential application in parts of the world that have plenty of sunlight but also have critical needs in water quality and energy generation. In this presentation, Professor Dionysiou will overview mechanistic transformation pathways of treatment of cyanotoxins and other contaminants of emerging concern in water using AOPs. Emphasis will be given on UV and Solar-based Advanced Oxidation Processes such as TiO2-based photocatalysis (UV and visible) (i.e., a heterogeneous AOP) and UV/H2O2 process (i.e., a homogeneous AOP). Details will be presented on the degradation of cyanotoxins and other selected contaminants. Most emphasis will be placed on the oxidative pathways for the degradation of microcystin-LR and cylindrospermopsin. Transformation kinetic rates and reaction intermediates formed by OH radical attack and other reactive oxygen species on specific sites of the target contaminants will be presented and the detailed reaction pathways will be discussed. Discussion will also be provided when oxidation takes place by other radicals such as sulfate radicals and superoxide anion radicals under certain modifications of the proc esses described above. The role of water quality parameters such as natural organic matter, alkalinity and pH will be discussed, considering also the chemistry of the target contaminants and, in the case of heterogeneous AOPs, the role of the catalyst nano-interface

Biography

Professor Dionysiou was born on the Island of Cyprus. He is currently a UNESCO Chair Professor on “Water Access and Sustainability” and a Herman Schneider Professor of Environmental Engineering at the University of Cincinnati where he teaches courses on drinking water quality and treatment, advanced unit operations for water treatment, advanced oxidation technologies, and physical-chemical processes for water quality control. His research interests include treatment of water contaminated by harmful algal blooms with conventional and advanced technologies, advanced technologies for water treatment, advanced oxidation technologies, transition metal-based chemical oxidation, and nanotechnology.

Dr. Dionysiou is the author or co-author of over 315 refereed journal publications, 86 conference proceedings, 32 book chapter publications, 28 editorials, and more than 600 presentations. He has edited/co-edited 6 books on water quality, water reuse, ferrates/ferrites, and photocatalysis. He is currently co-editing a book on harmful algal blooms. Dr. Dionysiou’s work received over 14,000 citations with an H factor of 67. He has currently numerous national and international collaborations. Dr. Dionysiou

has received funding from NSF, US EPA, NASA, NOAA/CICEET, USGS, USDA, Ohio Sea Grant, USAID, Cyprus Research Foundation, and DuPont. He is currently one of the editors of Chemical Engineering Journal (Elsevier), Editor of the Journal of Advanced Oxidation Technologies, and Special Issue Editor and Associate Editor for the Journal of Environmental Engineering (ASCE). He is a member of the Editorial Boards of more than ten other journals. He has previously served as Associate Editor of Water Environment Research (WEF) (2006-2011) and as member of the Editorial Board of Environmental Progress (now renamed as Environmental Progress and Sustainable Energy) (AIChE) (2003-2009). Dr. Dionysiou is a fellow of the American Chemical Society (ACS). He is currently chair-elect of the Environmental Chemistry Division of ACS and is a member of many committees of several professional societies (i.e., ACS, AEESP, AWWA, WEF, IWA). Dr. Dionysiou has been featured in several international symposia, professional meetings, and scientific publications, including an interview on “Cleaning up water” published on July 5, 2011 in the Chemistry World magazine of the Royal Society of Chemistry.

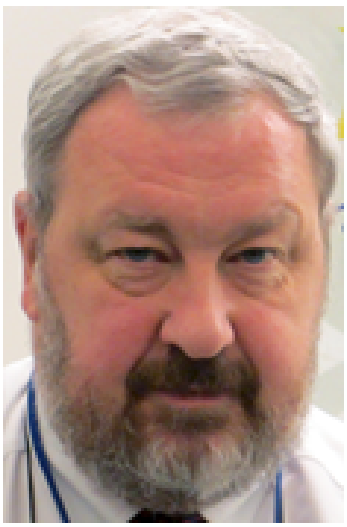
Fuel cells and hydrogen: flexible devices for the production of sustainable electricity

Jean-Luc Delplancke

Fuel cells, discovered by Schönbein and Grove in 1838 correspond to an old technology with a very complex history. They are efficient electrochemical generating power devices invented more than 40 years before the classic dynamo generators, the combustion engines or the gas turbines. But they were more or less completely forgotten until the launch of the NASA Gemini and Apollo development programmes in the sixties. There is today a renewed interest for this technology generated by the concept of «Hydrogen Economy» and sustainable growth.
A fuel cell is a static and compact electrochemical device transforming a fuel (natural gas, biogas, hydrogen...) and an oxidizer (oxygen or air) into electricity, heat and pure water. Fuel cells allow a very efficient use of fossil or renewable energy sources, do not generate green house gases (if powered by hydrogen), NOx, SOx, particulates or noise and are highly modular with power ranging from 1 W to tens of MWs. The list of fuel cell applications includes portable applications like the replacement of batteries for cellular phones, laptop... transport applications like passenger cars, delivery vehicles, buses, trains, boats... electricity micro-generation for distributed residential use or off-grid locations, medium power plant for co-generation, industrial processes, malls, hospitals, airports and large power plant (largest power plant in 2016 located in South Korea - 59 MW).
Hydrogen is not only the most abundant element in the universe but is also an essential energy carrier, should mankind target to limit climate global warming and to achieve the ambitions of multiple international agreements like the COP21. Hydrogen may be stored for long durations and offers a clean, sustainable and flexible solution for a low-carbon economy when produced by water electrolysis and renewable energy sources (RES). These renewable energy sources are not evenly distributed throughout the world. Hydrogen transport at scale and over large distances, e.g., from are as with a high potential for renewable power generation to areas with high demand of energy may become an economically attractive option for emerging countries.
The objective of this presentation is to highlight the potentials of hydrogen generation from renewable energy sources in combination with electricity and drinkable water production by means of fuel cells for the local and international sustainable development of developed and emerging countries.

Biography

Dr. Jean-Luc Delplancke, Chemical and Metallurgical Engineer, is presently a Scientific Co-worker in the 4MAT Department (Materials Engineering, Characterization, Synthesis and Recycling Department) of the Université Libre de Bruxelles (Belgium). He got, from the Université Libre de Bruxelles, his Master Degree in Chemical Engineering in 1981, his Master Degree in Metallurgical Engineering in 1983 and his Ph.D. in Materials Science in 1987. After a scientific career at the National Fund for Scientific Research of Belgium (FNRS), he became Professor of Materials Science in the Engineering Faculty of the Université Libre de Bruxelles in 1996. He mas nominated Full Professor and Director of the Materials Science and Electrochemistry Department in 1998. In 2004 he joined the European Commission where he was appointed in 2011 Head of the Program Unit for the Fuel Cells and Hydrogen Joint Undertaking, a Public/Private Partnership dealing with the research and development programs of fuel cells and hydrogen technologies in Europe. He retired from the Commission in 2016 and is now an independent expert (RES non verba) in renewable energy sources.



Wind variability: a climatological perspective through model-data comparison

J. Fidel González Rouco[1,a] J. Navarro Montesinos, E. García Bustamante
E. Lucio Eceiza & C. Rojas

The variability of the wind at regional and local spatial scales entails many interesting scientific questions related to the reliability of observations representing surface winds, to our ability to model wind fields with statistical and/or dynamical downscaling approaches or to understand the processes that provide a balance between the driving large-scale circulation and local effects like topography or thermal contributions. The very local character of (complex) topography or land use poses challenges for high resolution regional modeling and model-data comparison.
This presentation will discuss uncertainties in wind surface wind observations and analysis of long term (interanual to multi-decadal and centennial) wind variability using regionalization and statistical and dynamical downscaling approaches. Uncertainties in model evaluation strategies will be discussed.

Biography

Dr. J. Fidel González Rouco is presently an Associate Proffessor at the Department of Astrophysics and Atmospheric Sciences at the University Complutense of Madrid. He is a member of the Institute of Geosciences (IGEO), a mixed center between the University Complutense (UCM) and the Consejo Superior de Investigaciones Científicas (CSIC). JFGR finished his Ph.D. in 1997 on the application of statistical downscaling models to precipitation in Iberia in present and future climate change scenarios. Between 1988 and 2001 he was a Postdoc at the GKSS research center (now Helmholtz Zentrum Geesthacht, Hamburg) where he extended his research interests to problems related with the simulation and analysis of climate variability and change in the last millennia. During this time he was involved in the first General Circulation Model simulations of the last millennium. In 2004 he obtained a tenure track Ramón y Cajal position, promoted to permanent in 2009 and finally to Associate Professor in 2011. He was contributing author for WG1 IPCC AR4 in 2007 and leading author for IPCC AR5 in 2013. JFGR focuses his research in climate variability and change problems that involve model-data comparison at different spatial and temporal scales, thus addressing uncertainty in observations and in models. At large spatial and long time scales he is interested in problems addressing the simulation and reconstruction of the climate of the last millennia. At regional and local scales he is interested in addressing the realism of regional models in high resolution applications where the interactions with complex terrain and data availability and observational uncertainty are important.

Oral Presentations in Catalysis

Application of natural and modified zeolites in a heterogeneous catalytic ozonation process for wastewater treatment

Hector Valdés[1,a], F.R. Tardón[2] & C.A. Zaror[2,b]

In this work, the influence of active surface sites of natural and modified Chilean zeolite on the catalytic ozonation of methylene blue (MB) contaminated waters is analysed. A Chilean natural zeolite was acid-treated using HCl (2.44 M). Acid-treated zeolite was chemically and physically characterised by N_2 adsorption at 77 K, X-ray fluorescence, acidimetric-alkalimetric titration, and by NH_3 and CO_2 temperature-programmed desorption methods. Fourier transform infrared spectroscopy of pyridine adsorption was used to elucidate the nature and strength of acidic sites resulting from the acid treatment of natural zeolite. Experimental results obtained here are kinetically modelled using a set of two homogeneous and three heterogeneous surface reactions. Moreover, the quantitative effects of single ozonation, adsorption and coupled treatment on MB removal rate, together with the effect of pH and the presence of radical scavengers are analysed. Brønsted acid sites in the form of proton-donating OH groups (Z-OH) of acid-treated zeolite are claimed here to play an important role on the catalytic ozonation of MB in water, acting as active sites for the adsorption of reacting species. The higher catalytic activity is observed at pH above the pH of point of zero charge (pH_{PZC}) and could be related to the presence of surface hydroxyl groups in the deprotonated form.

Keywords: *catalytic ozonation, methylene blue, ozone, surface hydroxyl groups, surface properties, zeolite.*

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Degradation of organics from sythetic slaughterhouse wastewater by anaerobic digestion follow by solar photoelectro-fenton process.

Ricardo Salazar[a], Jorge Vidal & César Huiliñir

Wastewater of slaughterhouse is very complex mixture of chemical and biological components as blood, proteins, fats, carbohydrates such as glucose and cellulose, and generally detergents and disinfectants. Moreover, these waters have a significant content of pathogenic microorganisms and produce strong odors towards the environment [1]. In this sence, different technologies are being studied and applied in order to eliminate all types of substances producing a treated wastewater withot pollutants and microorgnisms (coagulation, aerobic digestión, UV-radiation, etc). In the present work, the treatment of 2.5 L of synthetic slaughterhouse wastewater with two different initial concentration (1700 and 3500 mg COD/L, sample A and B, respectively) in a UASB reactor (Upflow Anaerobic Sludge Blanket) was performed. After 15 days of continuous Anaerobic Digestion (AD), with a hydraulic retention time (HRT) of 10 h, the removal of chemical oxygen demand (COD) reached 90% for sample A and 60% for sample B. COD decay is due to the action of anaerobic microorganisms that convert the organic compounds into CH4 and CO2. The formation of CH4 was determinate too. After biological treatment, the effluent was treated by Solar photoelectro-Fenton (SPEF) process in a pilot plant to remove the bio-resistant substances. The pilot plant contains an electrochemical filter press cell with a dimensionally stable anode (DSA-type) and an Air-difussion cathode coupled to solar photoreactor. After 4 hours, a complete mineralization was achieved due to the action of hydroxyl radicals generates by Fenton reaction and the action of solar radiation. A complete mineralization of organics was obtained by the combination of AD and SPEF [2]. The formation of ions (nitrate and ammonia) and carboxylic acids was followed. And finally, an evaluation of cost was realized.

Keywords: *slaughterhouse wastewater, anaerobic digestión, solar photoelectro-Fenton process, hydroxyl radical*

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Evaluation of the improve of landfill leachate quality after advanced oxidation processes and adsorption process.

Rodrigo Poblete[1,a]

Landfill leachate (LL) is a complex wastewater resulting from the disposal of solid municipal and residential wastes, which need to be submitted to advanced treatment to protect the environment [1]. LL may contain large amounts of dissolved organics, xenobiotic organic compounds, ammonia, heavy metals, as well as other toxic substances [2]. In the present study, advanced oxidation processes (AOPs) based on ozonation were tested for the complete treatment of a specific LL. An adsportion process was carried out as post-treatment using a natural zeolite. The application of UVsolar/O_3/H_2O_2 achieved elimination of 56 and 17 % of color and COD, respectively, requiring 140 minutes of irradiation time and a consumption of H2O2 of 0.67 g/L. When adding persulfate to the system (UVsolar/O_3/H_2O_2/$S_2O_8^{-2}$), 29% and 77% elimination of color and COD was obtained, respectively, with a concentration of 0.2 g/L of $S_2O_8^{-2}$) requiring 250 minutes of irradiation time. Adsorption post-treatment using natural zeolite produced a reduction of 36% of COD, 99% of ammonium and 18% of chloride.

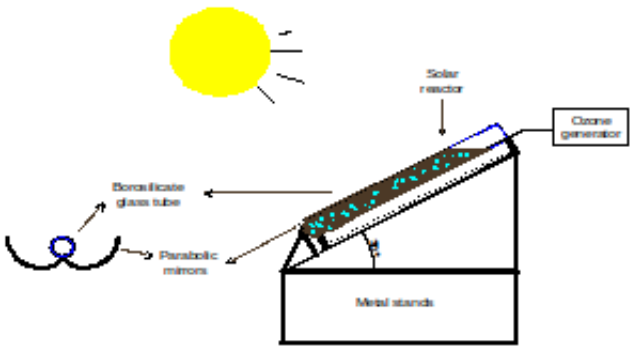

Figure 1: UVsolar/O_3/H_2O_2 pilot plants. Left: solar reactor cross-section.

Keywords: *Landfill leachate, solar reactor, oxidants, toxicity.s*

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BiOBr and BiOI Microspheres for decontamination of wastewater and air

Adriana Mera[1,2,a*]

Nowadays environmental decontamination is receiving much attention, due to the increase of environmental and health problems, caused by pollutants present in water and air. The design of materials with potential application clean water using solar radiation currently is relevant to improve environmental quality. BiOI and BiOBr microspheres have potential application in heterogeneous photocatalysis for decontamination of water and air under visible light or solar radiation.
In this work, different nanostructured materials of BiOI and BiOBr were obtained using a solvothermal and microwave method in the presence of ethylene glycol and KX (X=Br or I). Optimal conditions were determined for the synthesis of these materials. The photocatalytic efficiency of materials was calculated utilizing the rate constants obtained during gallic acid and methyl orange (MO) degradation in aqueous solution and photo-oxidation reaction of NO in gas phase under simulated solar radiation and visible irradiation, respectively.
One of water pollutant selected for this study is gallic acid a phenolic structure commonly presents in several agricultural wastewater as wine processing industries. This model compound confers a refractory character to agricultural effluents and it is responsible the inhibitory effects on microbial activity in biological treatment systems. The other pollutant used was methyl orange, this was selected in this study as a target organic pollutant representative of anionic dyes normally present in wastewater from textile manufacturing industry, where around 50% of dyes are discharged directly into industrial sewage systems. On the other hand, NOx are responsible for the formation of acid rains and the photochemical pollution results in diseases of the human can cause very serious respiratory problems.
Nanostructured materials obtained were characterized by XRD, SEM, BET, DRS and others techniques. This work shown that the factor that strongly influences in the solvothermal synthesis of the BiOI and BiOBr is the temperature. The materials synthesized using microwave method show that photocatalytic activity for NO removal can be associated with synergetic effects of many factors.
In addition, semiconductors prepared by solvothermal and microwave method showed a higher efficiency than TiO_2 *Evonik* P-25 under simulated solar radiation and visible light irradiation. The materials obtained are potential photocatalysts for practical applications in environmental decontamination of wastewaters and air.

Keywords: *BiOI, BiOBr, microspheres, solvothermal, microwave, efficiency.*

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Oral Presentations in Water Treatment

Evaluation of pilot system for treatment of urban waste water in La Serena City

J. Barraza[1,a], J. Illanes[2,b], G. Merino & R. Orrego

Present project validates the implementation of a new Japanese technology for treatment of domestic waste water in a pilot scale, this validation is determined for the analysis of biological oxygen demand (BOD), total suspended solids (TSS), and Chilean regulation n^{o} 1333 of water quality for irrigation use, project is implemented in a fixed bed system, it alternates aerobic and anaerobic phases during its process and without sludge generation. A collaborative work between Chile and Japan allowed the transfer of this technology for implementation of a prototype parallel to underwater outfall of La Serena City, at the beginning this was in order to treat a flow of 5 m^3/ day, afterwards treated flow was increased until 10 m^3/ day; samples of BOD and TSS was taken once a week for a period of 4 months, monitoring treated flow remotely and an realizing experimental analysis of hydraulic retention time, for subsequence analysis of the samples in a spectrophotometer was used rhodamine B as dye. In addition, 3 analysis of Chilean regulation n^{o} 1333 was made and the study is complemented realizing a microbiological analysis to detect Escherichia coli and mesophilic aerobic bacteria present in the pond. A water replacement over 90% of water is calculated after 24 hours of operation. Besides, a reduction over 91% of the BOD and TSS concentration is obtained in average of all the analysis, and a compliance over 70% for the demanded parameters of Chilean regulation n^{o} 1333 and analyzed bacteria reduction in 3 magnitude orders. From the achieved results, a stable system is obtained, this system is able to withstand an overload od the double of the original treatment flow keeping its stable parameters and without sludge generation, this means a simplification of the operation in comparison with others treatment systems, this become the system in an economical and environmentally friendly alternative.

Keywords: *wastewater, treatment, sludge, experimental study, biological treatment, anaerobic system.*

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Modeling snow cover evolution for two contrasting years (2014-2015), La Laguna watershed, Elqui Valley, Chile

M. Réveillet[1,a], S. MacDonell[1], S. Gascoin[2], C. Kinnard[3], N. Schaffer[1] & A. Hammann[1]

In the semiarid Andes of Chile, farmers and industry in the cordillera lowlands depend on water from snowmelt, as annual rainfall is insufficient to meet their needs [1]. Despite the importance of snow cover for water resources in this region, there is currently a limited understanding of snow depth distribution and mass balance. Whilst the effect of wind on the snow cover patterns distribution has been assessed [2], the relative importance of melt and sublimation to total ablation has only been studied at the point-scale [3]. Analyzing relative ablation rates are critical for understanding snow depth sensitivity to climate variations and simulating the evolution of the snow pack over a larger area and over time [3]. This study aims to quantify melt and sublimation rates over a catchment during two contrasting years to determine the impact of El Niño and La Niña climatic modes on snow distribution and ablation. In this study, we model the snow cover evolution using a distributed snowpack model (SnowModel [4]) in the instrumented watershed of La Laguna (3150–5630 m above sea level, 30° S), over two hydrologically contrasted years, 2014 and 2015. The model is calibrated and forced with meteorological data from seven Automatic Weather Stations (AWS) located in the watershed, and modeled WRF and MicroMet results [4]. Temporal evolution of the simulated snow depth is validated using the snow depth measured at each AWS. The snow duration and snow cover extend are compared to MODIS and selected SENTINEL-2 images. Model results have been used to quantify the relative contribution of melt and sublimation, and identify remnant spring snow patches as ideal locations for installing snow fences to enhance natural snow accumulation.

Keywords: *dry Andes, water resources, snow modeling, climate change.*

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Snow fence effectiveness evaluated with automatic cameras and terrestrial LIDAR, dry Andes, Chile

Nicole Schaffer[1,a], Coco Antonissen[1], Shelley MacDonell[1], Marion Réveillet[1]
Robinson Godoy[1], Andrés Hevia[1] & Eduardo González[1]

In the dry Andes, the most arid part of the cordillera [1], annual rainfall is insufficient to meet the needs of farmers and industry in the lowlands who rely on snowmelt, and to a lesser extent glacier runoff, when precipitation rates are low [2]. However, a significant proportion of accumulated snow sublimates, which means that not all fallen snow is available to augment streamflow, and the remaining snow cover only lasts 1 to 2 months after the last winter snowfall [2]. As the region is experiencing an increase in water demand, and an average decrease in supply, there is a need to develop a set of complementary solutions to aid future water management decision-making. Within this context, this study aims to evaluate the use of a relatively low-cost solution, snow fences, to accumulate and extend the preservation of snow on the ground in the semiarid Andes. Snow fences act as wind-breaks and facilitate snow accumulation by decreasing wind speed, thereby causing the deposition of wind-transported snow [3, 4]. They also prolong the duration of snow cover by causing preferential accumulation, and decreasing sublimation rates [3, 4]. Whilst snow fences have been installed in other sites in Chile, their effectiveness has not been assessed. To achieve this aim, we investigate the usefulness of such snow fences in the dry Andes at two sites in the Limari watershed. The precise volume of snow adjacent to fences installed at each site is measured by differencing three dimensional images of the terrain with and without snow cover derived from a terrestrial LIDAR. Volume estimates are also obtained from camera images of a set of stakes installed adjacent to each snow fence. Daily variations in snow depths recorded at an automatic weather station are compared to snow depths derived from camera images to obtain a multi-source record of snow variability and the duration of snow cover.

Keywords: *dry Andes, snow fence, terrestrial LIDAR, automatic camera*

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Glaciers in the Coquimbo Region, Chile-working towards a regional glacier management plan

S. MacDonell[1,a], F. Pellicciotti[2], J. McPhee[3], E. González[1], M. Réveillet[1], & N. Schaffer[1]

During the last century, northern and central Chile have experienced difficulties with water availability. This situation is related to both the decrease in precipitation during this period, and the increase in the demand for water from various sectors, including agriculture, mining and for domestic use. At present, there is limited information available to quantify hydrological contribution from different natural water sources (snow, glaciers, rock glaciers, rain, fog, and dew) to the local hydrological system. The contribution and importance of each of these elements varies annually due to climate variability [1], which is largely driven by ENSO cycles. In this context, we know that the primary water source comes from the cordillera [1], and that snow is the dominant source [2]. However, as shown in Central Chile, during the summer months, and periods of drought, glaciers play an important role, especially for maintaining basal flow [3].

Over the last decade, both scientific and public interest in the existence and role of glaciers in the Chilean Andes has increased, leading to the initial development of legislation aiming to give protection to ice bodies along the length of Chile. The development of this legislation has run parallel to a strengthening of the Environmental Impact Assessment system, which as of 2013 includes specific clauses relating to glacier evaluation. Due to the relatively recent awareness of glacier processes in the Norte Chico, there is currently limited information and available methods to analyze the role and behavior of glaciers, especially rock glaciers, in this area. The aim of this presentation is to outline a strategy to develop a glacier management plan for the Coquimbo Region, by diagnosing the current state of information, and methodologies available, before outlining steps required to address current knowledge gaps. Finally, we will outline the steps required to design a management plan in order to efficiently manage glaciers in the region, as a social-economic resource.

Keywords: *sry Andes, water resources, environmental impact assessment, climate change*

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The Role of Upstream Wetlands in Modulating Runoff in the Semi-Arid Andes

Andrés Hevia[1,a] & Shelley MacDonell[1,b]

In the semi-arid Andes of the Region of Coquimbo, Chile (30°S), the Elqui River Basin collects water from altitudes exceeding 6000*m* a.s.l. towards its outlet in the Pacific Ocean where the city of La Serena is located. The waters of the Elqui River sustain most of the agricultural production, industry and domestic consumption in the region. The main contribution of water to areas with the greatest demand comes from precipitation in the form of snow deposited at high elevations in winter [1]. One of the main tributaries of the Elqui River is the Estero Derecho sub-basin, whose head is near 3800 m a.s.l., draining the southern part of the basin. Erosive dynamics have shaped the morphology of the upper section of the main valley, so that there are a series of stepped levels, which constitute reservoirs or "natural dams" where the profuse presence of "bofedales" or "vegas" (wetlands) leads to a dispersion of the draining channels, consequently decreasing the runoff speed.
In a context of increasing water demand, this work aims to characterize the wetland's hydrological dynamics. We present conductivity and streamflow data, a stratigraphic description of a sediment core and of sedimentary deposits surrounding the wetlands, and a detailed map of the landforms that affect the dynamics of the river. This background information is used to construct a conceptual model that describes the dynamics of water in the wetlands. The catchment is a conservation area owned by a local agricultural community that depends extensively on the water and vegetation of these wetlands. Understanding the hydrology of the wetlands is a critical step towards mitigating the possible effects of climate change on these sensitive ecosystems.

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Structure and functioning of aquifers using geophysics

R. Valois[1,a], Y. Cousquer[2], A. Hevia[1], S. Lun[2], A. Pryet[3],
M. Schmutz[3] & J.M. Vouillamoz[4]

Inhabitants of Elqui and Limari catchments are clearly dependent on available water resources since agriculture is the main activity in these catchments and because water renewability is limited to low amount of liquid precipitation in winter and spring snow melt in such arid and semi-arid environments [1]. Thus, assessing water resources and its renewability is a key issue, especially because there are strong interannual variations in precipitations that can affect the all-region [2]. Since 80 % of precipitation falls in winter and that almost all snow cover melt in summer [2], the only water storage between two winters to be considered are glaciers, dams and aquifers. Aquifers are the only natural reservoirs that can store large volumes of water during at least one year, because the glacier contribution to annual riverflow seems to be negligible at the river catchment scale, despite its role is still important for streamflow at the seasonal scale when snowmelt is nearly over. Therefore, aquifers structure and functioning need to be characterized in order to quantify the number of "dry" years that they could mitigate.
Aquifer structure could be delineated with the use of Transient Electro-Magnetics (TEM) combines with Electrical Resistivity Tomography (ERT) and pumping tests in boreholes, as shown in the example in Cambodia where reserve maps could be assessed [3]. In the Elqui valley, these methods will allow the identification of the interface between alluvial deposits and the bedrock, which should play a significant role in the hydrogeological functioning [4]. The second objective is to identify the origins of the recharge and quantify its fluxes by using geochemical analysis to discriminate water sources and Self-Potential methods for quantifying stream-aquifer exchanges that is expected to be the dominant process. A numerical and field study in France is presented to illustrate the methodology. Quantifying the available volume and its renewability will be very useful to know the amount of water that could be used in a sustainable way and how many "dry" years the aquifers could mitigate in a context of climate change.

Keywords: *geophysics, hydrogeology, Elqui, Stream aquifer exchanges, hydrology*

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Water recovery of a solar drier process of brine

Rodrigo Poblete

The reject brine from desalination process can produce environmental damage due wastewater discharges to the marine environment [1, 2]. Solar drying is a viable alternative for the waste management that allows reducing the mass and also transportation and landfilling costs [3], promoting faster drying than open sun drying, with lower costs than artificial drying [4]. However, the vapor generated in the drying process, is sent to the air surrounding the dryer, as a loss of the process, especially in places that suffer to water scarcity. The aim of this study was investigate the potential to recover water present in the moisture produced in the dried process of brine and study the quality of this water. The results showed that the amount of water recovered depends on the operational process and the environmental conditions, being possible to obtain up to a 55% of the water from the vapour, see Fig. 1. The specific energy consumption to obtain this water was 6.8 kWh/kg. The quality of the water obtained was enough to use in irrigation systems due the absence of pollutants, complying with the normative rules of irrigation.

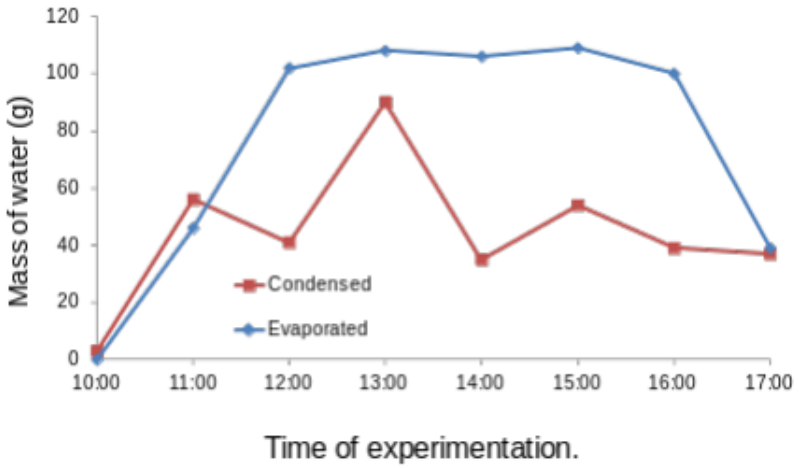

Figure 1: Mass of water produced in the experimentation.

Keywords: *water recovery, heat exchanger, operational conditions, water quality.*

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Passive dew water collection in chile

D. Carvajal[1,a], V. Meléndez-Vejar[2] & J. Bravo-Castro[3]

The availability of fresh water has become a serious problem in arid and semiarid areas of the world. Dew water collection can be a partial solution for water scarcity in arid and semi-arid areas. Passive dew condensers do not require external energy and its environmental impact is very low [1].
In this work, the results of the second year of the research project entitled "Experimental assessment and predictive modeling of rooftop dew collection for water supply in Chile" (Fondecyt 11140863, CONICYT, Chile) are presented. The overall objective of this project is to assess the dew water collection by passive radiative cooling at ten locations in the north and central area of Chile (Quillagua, Antofagasta, Paposo, Caldera, Copiapó, Coquimbo, El Sarco, Combarbalá, Paihuen and Valparaíso). At each place are set 1 m^2 dew condensers based on galvanized steel sheets coated with paint containing infrared emitting minerals and a non-soluble surfactant (manufactured by OPUR, France). Each condenser was provided with instrumentation for recording dew yields and surface temperature (every 15 min.). Each location has a meteorological station as well as a standard fog collector to record fog events. Dew, fog and rain water samples are collected and analyzed to determine their physical-chemical properties. The collectors started to operate at different times between October 2015 and January 2016. The implementation works, water yields and chemical characterization are presented and discussed. Daily average dew yields of 142 mL/m^2 (Valparaíso), 65 mL/m^2 (Paihuen) and 11 mL/m^2 (Combarbalá) were obtained in the first months. The first dew water samples from Valparaíso showed that the physical-chemical parameters comply with the OMS standards for drinking water.

Acknowledgments

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Oral Presentations in Materials

Optimization of magnetite nanoparticles supported on activated carbon for the treatment of waste water from oil industry and energy production.

Laura Acosta E.[1,a], Maria A. Causil, Camilo A. Franco & Farid B. Cortés

Discharging water from oilfields has become one of the major environmental issues related to the oil industry due to the large amounts of water contaminated with emulsified crude that are generated during oil and gas recovery operations and to the Complexity and costs associated with its treatment . This work presents a study about the adsorption of crude on magnetite nanoparticles supported in activated charcoal synthesized from the coffee residues and their subsequent catalytic decomposition in order to recover byproducts with a good calorific value and to regenerate the supported material. The magnetite nanoparticles were synthesized by the co-precipitation method and were used in the functionalization of activated carbon prepared from coffee residues. The characterization of the obtained products was carried out by analysis DRX, FTIR, SEM. The adsorbed amount of crude was determined by adsorption isotherms and packed bed. Thermogravimetric analysis and FTIR were used in the characterization of by-products obtained after the application of the pyrolysis process to the supported saturated nanoparticles of crude oil. A synergistic effect was observed between magnetite nanoparticles and activated carbon. In addition, the supported magnetite nanoparticles exhibited an efficiency greater than 10% of hydrocarbon removal compared to pure activated carbon; Besides a good catalytic capacity for the desorption of the emulsified crude.

Keywords: *magnetite nanoparticles, activated carbon, coffee residue, adsorption, catalysis*

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Evaluation of extracts of Cynara scolymus L. encapsulated as a corrosion inhibitor

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The corrosion protection of metal substrates is an area of active and relevant research in the field of materials science and industry. Anodic inhibitors or passivants such as chromates (oxidant anion) have been questioned primarily because of their toxicity. In contrast, green inhibitors that use products derived from plant extracts are a biodegradable and economical alternative. Organic inhibitors are highly conjugated molecules that contain heteroatoms in their structures, such as nitrogen, oxygen, sulfur. These atoms favor the adsorption of the compounds on the metal surface and prevent the production of the corrosion. On the other hand, phenolic compounds containing heteroatoms would have the ability to interact with highly oxidant molecules that produce corrosion and could be adsorbed on the metal by inhibiting the process. Artichoke (Cynara scolymus L.) has a high antioxidant capacity due to its high content of polyphenols, so its extracts have the potential to be organic type corrosion inhibitors. To make better use of resources, the extracts are prepared from vegetable waste from free trade shows in the V region. On the other hand, with the purpose of having a controlled and prolonged release of inhibitor on the surface of the metal, the idea of encapsulating the artichoke extract in silica meosporous nanoparticles (NPMs) arises.
The artichoke extract was obtained by extraction with ethanol-water. The total phenolic content was determined in triplicate by Folin-Coicalteu procedures. The content of flavonoids was obtained by an adaptation of the Dowd method. Antioxidant activity was measured using a DPPH method and by the ORAC-Fluorescein assay. The NPMs were synthesized according to Rahsepar et al, ethanol and deionized water briefly mixed, TEOS was added gradually and stirred for 10 min. The CTAB and NH4OH surfactant was added and stirred. The mixture was then centrifuged, washed with ethanol and dried overnight. The surface of the NPMs was visualized by SEM. The extract, NPMS and a mixture of NPMS-extract was evaluated by UV-Visible, and compared to find changes in the absorption spectrum. The interaction between extract and NMP was evaluated by IR.
To evaluate the protective effect of the efficacy of the particles associated with the extract, the following techniques were used: mass loss test in the presence of HCl as a corrosive agent, SEM analysis and electrochemical tests as potentiodynamic polarization curves

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Keywords: *infrared spectroscopy, antioxidants, natural extracts.*

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A photochemical proposal for the preparation of mixed oxides and the evaluation of its optical properties

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Mixed-metal oxides play a very important role in many areas of chemistry, physics and materials science. They exhibit metallic, semiconducting or insulating character due to their differences in electronic structures. In particular, mixed-metal oxide-based host matrices for lanthanide (Ln^{III}) ions have been studied extensively due to their optical and photochemical properties and their wide range of applications in solid-state lightning and display technologies.

Among these mixed oxides, spinel (AB_2O_4) and perovskite (ABO_3) materials are of great interest for a number of technical applications due to their chemical and physical properties originating from the fact that various cations of different charges and sizes can be accommodated in the crystalline structure. Some difficulties in the preparation of these mixed-oxide materials include (i) achieving chemically homogenous and phase-pure specimens, (ii) obtaining a narrow size distribution of particles, and (iii) the low crystallization and sintering temperatures of the materials. In this context, various methods of synthesis have been proposed for the preparation of mixed-oxide materials.

In recent years, we have developed a photochemical method based on the use of UV light for the deposition of a variety of metal oxide thin films in order to study their photoluminescent characteristics. In general, the procedure for this method involves several steps: (i) choosing suitable coordination complex precursors, and coating solutions of the precursors onto substrates using the spin-coating technique, (ii and iii) irradiation of the spin-coated films with light of proper wavelength to decompose the coordination complexes to form new metal or metal oxide films, (iv) elimination of organic residues from the films using proper solvents and post-annealing of the photodeposited films (see Fig. 1).

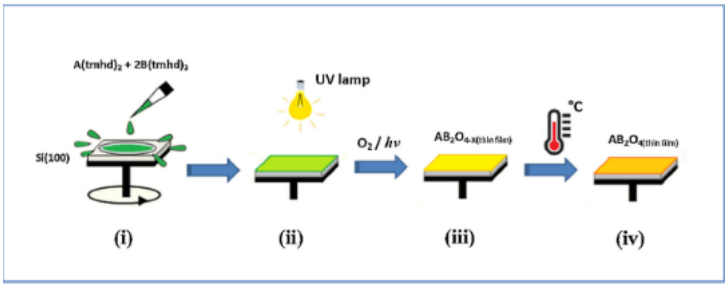

Figure 1: Schematic sequence of the photo-deposition process

In this work, we report a photochemical synthesis as an alternative method for the preparation of ternary metal oxide thin films of $NiGa_2O_4$ doped with Eu(III) ions and $BaTiO_3$ doped with Pr(III) ions and the study of their optical properties as photoluminescent materials.

Keywords: *photo-deposition, thin films, optical properties, photoluminescence*

Cathodic and anodic electrodeposition of PbCoSn thin films as electrocatalyst of the oxygen evolution reaction

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Oxygen evolution reaction (OER) is an anodic reaction present in several industrial processes such as copper or zinc electrowinning and water electrolysis for hydrogen generation. Lead-based alloys have been widely used as anodes for OER because of their favorable cost/useful life relationship, good electrical conductivity associated with low-dissipative energy, and low corrosion rate [1]. However, the major disadvantage of these alloys is the high overpotential for the OER. In this sense, electrodeposited Pb-Co coatings are promising low-cost electrocatalyst materials for oxygen evolution reaction that also exhibit lower degradation rate than the conventional Pb-Ca-Sn anodes [2]. In the same way, our working group has developed Pb-Co-Sn coatings cathodically electrodeposited that act as still better catalyst for OER because not only decrease the overpotential but also considerably increase the current densities of the systems [3]. The disadvantage of this coating is that easily dissolved in acid media so industrial use is not possible.

In this work we present an anodically electrodeposited Pb-Co-Sn coating that has identically good behavior than the cathodic one and excellent stability in acid media. The relationship between electrocatalytic behavior and morphology, microstructure, chemical composition and element's distribution is analyzed. Additionally, by comparing the performance of the cathodically and anodically electrodeposited Pb-Co-Sn coatings, the mechanisms of reactions in the first states of oxidation during service is analyzed and discussed. As conclusion it is possible to say that specific oxidation states of the three elements in the coating as well as the nanostructered nature of the coating makes possible it electrocatalytic activity in the OER.

Keywords: *electrocatalytic anodes, oxygen evolution reaction, electrochemistry.*

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Synthesis of benzotrithiophene-based small molecules and their applications as electron donor in planar heterojunction solar cells

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Organic solar cells (OSCs) have attracted great attentions due to the potential advantages such as low cost, flexibility, simple architecture, among others. In contrast to the widely studied polymer based OSCs, small molecular organic solar cells (SM-OSCs) demonstrated many outstanding advantages, such as well-defined structure, solid-state compact packing, and thus little batch-to-batch variation. Recently, the power conversion efficiency (PCE) of 10% [1] has been achieved for SM-OSCs, indicating that the PCE of SM-OSCs could be indeed comparable with that of polymer solar cells [2] and even higher PCEs could be expected for SM-OSCs through combination of delicate molecule design and device optimization. The PCE of OSC is determined by three parameters: open circuit voltage (V_{OC}), short circuit current density (J_{SC}) and fill factor (FF). Generally, SM-OSCs have a high V_{OC} and FF over 50% have also been achieved for many SM-OSCs. So, to improve the J_{SC} without sacrificing the Voc and FF is one of the effective strategies to get high PCE for OSCs. There are many methods to improve the Jsc, such as active layer morphology controlling by adding additives and modification of buffer layer [3]. In fact, the direct and fundamental strategy to improve the Jsc is to design new donor compounds with broad light absorption range and high harvest efficiency.
In order to extend the light absorption range and cause an efficient solid-state packing herein, we designed a molecule that has an asymmetrical benzotrithiophene (BTT) unit as the central core and three electron (donor and acceptor) groups using a new organic synthetically process: Direct (Hetero)arylation. As expected, the final compounds exhibit broad and red shift solar absorption in contrast to core by itself. Initial PCEs of 2.02% were achieved for the molecule TPA-BTT with fullerene (C_{60}) as acceptor.

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Keywords: *Renewable Energies, Energy Efficiency, Organic Solar Cells, Organic Synthesis.*

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Optimization of deposition time in ZnS thin films grown by means of non-toxic chemical bath deposition

C.A. Rodríguez[1,a], M. Flores[2,b] & C. Carrasco[3,c]

Zinc sulphide (ZnS) thin films have been under intense investigations due to its excellent properties as an optical material [1, 2]. Among the different application of the ZnS, it has shown a great potential to be used as a buffer layer in thin films solar cells (TFSC). The high optical transmission, wide band gap, less–toxicity and lower cost, have made of this material the best choice to replace the CdS, which is the most used buffer layer in TFSC [3].
There are several methods to deposit ZnS thin films; however, chemical bath deposition (CBD) rise up because it is a simple and inexpensive technique for deposition of semiconductor materials to be used in TFSC devices. It is known that the initial growth stages of the reaction solution determine the evolution of different stages during the CBD process [4] affecting the morphological, chemical and optical properties of the film. In this sense, it would result useful to analyses the film formation as the time proceed in order to optimize the properties of the film.
In order to optimize the deposition time of ZnS films for applications as buffer layer in TFSC, the obtained samples were characterized by atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS) and UV-Vis spectroscopy. From AFM analysis, it was observed a homogeneous and compact sample after 20 min of deposition time. Besides, from XPS data, all the deposited samples were sulfur deficient and the maximum sulfur content was obtained at 20 min of deposition time. Finally, from the optical characterization all the grown samples exhibited a high optical transmission (> 80 %) for wavelength higher to the absorption edge and wide band gap value. From the results detailed above, it is clear that ZnS thin films grown during 20 min is an excellent candidate to be used as a buffer layer in solar cells devices.

Acknowledgements

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Keywords: *ZnS thin films, non-toxic solution, chemical bath, buffer layer, thin films solar cells.*

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Influence of doping with aluminum on CdS thin films for use in solar cells

M.G. Sandoval-Paz[a] & M.J. Cortés Burgos

Cadmium sulfide (CdS) is one of most promising materials for photovoltaic application due its relatively wide band gap (2.4 eV), which makes it useful as a window material along with other semiconductors such as CdTe and $CuInSe_2$, with efficiencies of up to 18-20% [1, 2]. However, some efforts have focused on replacing the CdS with other materials with a wider band gap such as $Cd_{1-x}Zn_xS$ or ZnS in order to reduce the window absorption losses and thereby improve the solar cell performance [3, 4]. In the same sense, in this work CdS thin films doped with different concentrations of aluminum were obtained by means of the chemical bath deposition technique. The influence of aluminum concentration in the reaction bath on the optical and structural properties of CdS films and on the efficiency of PbS/CdS type solar cells was studied. It was observed that the band gap of CdS thin films increases with higher concentration of aluminum used, from 2.40 eV to 2.60 eV, for CdS without doping and with R=0.10, respectively. Additionaly it was found that the introduction of aluminum in CdS films produces a structural disorder in the CdS lattice. Finally, the efficiencies of PbS/CdS type solar cells varied between 0.29 and 4.54%. The best solar cell parameters were obtained for solar cells by using CdS without aluminum: J_{SC}=49.02 mA/cm^{-2}, V_{OC} = 355.25 mV, FF = 0.26 and efficiency 4.54%.

Keywords: *cadmium sulphide, chemical deposition, thin film solar cells.*

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Applications of Phase Change Materials in Buildings.

Diego A. Vasco C[1,a], Tomás Venegas B[1,b] & Gaspar Ugarte

Energy performance of buildings has increasingly gained worldwide attention, due to its significant energy consumption and electrical peak power demand. In this scenario, the building sector in Chile also exhibits a significant share of nationwide energy consumption reaching a 21% of the final energy consumption. For these reasons energy efficiency measures have been encouraged.
Chiller plants used in commercial buildings are usually designed oversized in relation to their average load conditions, and this issue would certainly lead to higher cooling capacities and higher energy consumption. One possible way to reduce the power consumption and to redistribute the energy usage is through the integration of latent heat thermal energy storage systems (LHTES) with the cooling system of the building [1]. In the present work, a LHTES system based on ice is implemented along with a conventional chiller system of a commercial building located in Santiago de Chile. Different strategies of operation in a design day are assessed and the best strategy is evaluated through a computational simulation using EnergyPlus for a summer week. The effects of the LHTES over the building cooling load are obtained, the energy savings by using an ice tank are evaluated, and it is found that the use of LHTES may lead to reductions in the energy consumption of the cooling plant.
Another area of interest to reduce the energy consumption of buildings and dwellings is to improve the thermal performance of their envelope [2]. The use of phase change materials (PCMs) has gained attention, because they can be used to enhance the thermal inertia of light building materials. Usually, the thermal envelope of a dwelling in Chile is made of brick or wood along with other light building materials. The experimental part of this work deals with the thermal characterization of an organic PCM (Hexadecane), which has a relative low phase transition temperature. The characterization involved the measurement of density, thermal conductivity and heat capacity as a function of temperature, and the determination of phase change temperature and latent heat. These thermal properties were implemented in a set of thermal simulations with EnergyPlus of a dwelling located in Santiago de Chile and Puerto Montt. The numerical results in terms of heat storage and temperature profiles in the envelope, and heating and cooling demands are shown for different insulation levels. The results show that the level of thermal insulation influences the energy storage performance of the PCM.

Keywords: *PCM, buildings, thermal envelope, numerical simulation.*

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Oral Presentations in Policy

The growth of household PV exports with energy efficiency and the opportunity for battery storage systems

Sebastian Oliva H.

A growing range of energy efficient consumer technologies combined with extraordinary declines in photovoltaics system (PV) prices has seen household electricity demand fall whilst an increasing proportion of the remaining load is provided by household self-generation. Australia is a particularly interesting example of these developments, with one in five households now possessing a PV system while per-capita household demand has also fallen markedly. However, existing retail electricity tariffs and regulatory arrangements can create mixed incentives for households contemplating both PV and energy efficiency options. This is certainly the case in Australia with net metering arrangements that value self-consumption of PV far more than PV exports to the grid. Falling household demand can considerably reduce the financial value of a PV system. Meanwhile, the continuously falling cost of battery storage systems has encouraged more PV customers to contemplate storing PV exports in order to maximize self-consumption. The addition of battery systems can significantly change the financial benefits of residential PV and energy efficiency (EE), and only limited studies on this effect area available. In this work we use real household load and PV data from Sydney households to assess the financial interactions between PV, energy efficiency and battery storage installed in combination. Our results highlight how poorly designed feed-in tariffs may reduce the value that energy efficiency and PV offers to households, as well as the opportunities that battery storage can offer to maximize the value of the household energy investment portfolio.

Keywords: *distributed energy, net metering, energy policy*

Are non-state forms of environmental governance an alternative to state-centric governance?

Marco Antonio Tricallotis

Traditional or "state-centric" environmental governance, usually based on command-and-control regulations and economic instruments, has not been sufficient to address the negative environmental effects caused by a range of anthropogenic activities worldwide. Command-and-control approaches, for example, have frequently lacked credible enforcement mechanisms to make companies to comply with state laws and regulations (Gunningham and Sinclair 2002). This work explores how - and why in some contexts-non-state governance instruments have performed to address sustainability issues as compared with traditional state approaches. Methodologically, I draw on a mix of social research approaches that have studied the phenomenon of "global environmental governance", including Tikina and Innes' (2008) effectiveness approach applied in the forest industry as well as extensive reviews from the political economy and policy networks literature (e.g. Gale and Haward 2011). This review shows that in the early 1990s new forms of environmental governance emerged to address a number of global sustainability issues, e.g. deforestation, fisheries depletion and climate change. They encompassed a number of industry self-regulation initiatives, grouped under the concept of "corporate social responsibility (CSR)", of which "non-state market driven (NSMD) governance" (Cashore et al. 2007) has apparently performed better than traditional policy options. Examples include the Forest Stewardship Council (FSC) and the Marine Stewardship Council (MSC) as certification schemes in the forest industry and in fisheries, respectively. In the forest industry, the empirical evidence shows that NSMD governance has proved a more effective policy instrument to address sustainability issues - including deforestation and social conflicts – than public policies alone (Heilmayr and Lambin 2016, Tricallotis 2017). However, NSMD governance requires the existence of appropriate public policies as both forms of governance interact with each other in a hybrid governance arrangement.

Keywords: *environmental governance, sustainability, self-regulation, non-state governance, certification.*

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Insatiable cities: Management of these greedy energy sinks

Vanessa Weinberger[1,2,5,a], Joseph Burger[3], Cristóbal Quiñinao[4] & Pablo Marquet[1,5,6,7,8,b]

All populations, including humans, are sustained by fluxes of energy and materials from a finite environment. Physical constraints on biological design result in ubiquitous and predictable "allometric scaling laws", pervasive in ecological theory. However, unique to the human species is its capacity to harness *extra-metabolic* energy in the form of renewables and fossil fuels to power the development of more complex societies, from agricultural and industrial to modern technological lifestyles. We use ecological theory to compare variation in densities and individual energy use in human societies (varying in societal complexity) to other land mammals. We show that societal complexity (from hunter-gatherers to modern cities) not only associates to greater energy fluxes (both per capita and at a population scale), but also allows escaping from ecological laws. Moreover, densest cities across the globe flux greater energy than net primary productivity on a per area basis, becoming *sinks*. This condition poses formidable challenges for establishing a sustainable relationship on a finite planet. In an attempt of evaluating sustainable conditions of such demands, we developed a mathematical model, coupling human population growth, the benefits they obtain from the natural system or "ecosystem services" and technological development. In our model, high population numbers attaining basic standards of living can only be sustained under "clean technology". Otherwise, those numbers signify the establishment of societies attaining less than basic standard of living conditions or the acceptance of inequalities. Modern societies urge a rapid shift to clean technology, more than ever.

Keywords: *macroecology, extra-metabolic energy, energy sinks, cities, hyper-density.*

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Groundwater vulnerability assessment of a volcanic system in a chilean andean valley through fuzzy logic as a tool for dealing with data scarcity

Denisse J. Duhalde[1,a], José L. Arumí[2], Ricardo A. Oyarzún[1] & Diego A. Rivera[2]

Determination of the intrinsic vulnerability of an aquifer is a process that requires a large quantity of information regarding the structure and geology of the aquifer. Therefore, data scarcity is often a factor that complicates and/or impedes the acquisition of vulnerability indices for a sector under study. In light of the foregoing, this study presents a proposal for input data uncertainty management using a fuzzy system approach to the assessment and maps generation (GIS maps) of the vulnerability of a groundwater system adapting the traditional DRASTIC[1], GOD [2] and EKv [3] methods. The area of the study is Las Trancas Valley (the closest town to the main tourism spot in the Bio Bio Region), located in the Nevados del Chillán volcanic complex where there are no public sewage and drink water system and the people take water from springs.
The fuzzy system has been used in diverse areas of study related to polluted aquifers. In this study for the application of the fuzzy theory was employed the Mamdani system [4] and was carried out using the MATLAB Fuzzy Logic Toolbox [5]. It allowed the degree of uncertainty involved in the study, due the parameters exhibiting data scarcity (related to depth of the water table and vadose zone) to be specified and managed. Mamdani is employed fuzzy systems in the resolution of problems using fuzzy logic. In addition, despite the data scarcity, the vulnerability of the aquifer was evaluated by the traditional methods using only the available data in order to compare the results with the fuzzy method.
The results of this proposal show that the vulnerability index maps generated through a geographic information system (GIS) with the fuzzy system and traditional vulnerability index methods exhibit general agreement. However, changes in the vulnerability ranges of similar zones are generated due to management of the input data uncertainty with the fuzzy method. Thus the approach could be useful when the vulnerability of the aquifers is assessed under data scarcity and provide additional useful information for making spatial planning decisions.

Keywords: *aquifer vulnerability, data scarcity, fuzzy logic*

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Oral Presentations in Simulation

Numerical modeling and simulation of snow-accumulation behind porous fences

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The main water reserve in the region is snow, which a large percentage returns to the atmosphere due to the sublimation process. An innovative solution to this problem is the use of snow fences, whose function is to capture the snow and distribute it in mounds to reduce its sublimation rate [1, 2]. The objectives of this work are to evaluate the use of mathematical models and to describe the fluid mechanics of air/snow mixture turbulent flows and the accumulation of snow due to the interaction of the wind with barriers. It is proposed a physical-mathematical model to solve the continuity, linear momentum and volume fraction equations through the Finite Volume Method (FVM) [3], using ANSYS Fluent software, obtaining results of stream lines, turbulence intensity and mass of deposited snow. The analysis includes the study of two models of turbulence, two multiphase models and different types of barriers. The results indicate that as the complexity of the model used increases, greater CPU times are required for each iteration, which indicate higher accuracy with fewer number of iterations. When the type of barrier is modified it is necessary to propose different meshing strategies to determine the optimal discretization in relation to computational costs and precision. The methodology used has allowed the design of snow fences, which have been installed and proven to operate efficiently in different sectors of the Andes Mountains in the Coquimbo region of Chile. This pioneer experience in the region allows to accumulate snow in winter for use in summer when there is water shortage.

Acknowledgment

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Keywords: *snow fence, water, mathematical modeling, turbulence simulations.*

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Recovering wasted heat from concentrated photovoltaics: optimization of an organic rankine cycle through model predictive control

Manuel Araya [1], Carolina Ponce[1,a] & Luis Silva-Llanca[2,b]

Fossil fuel dominates as the power generation source around the globe, and will remain as such in foreseeable future, due to the economic and political difficulties inherent in replacing these—sometimes outdated—technologies with reliable alternatives. In recent years, renewable energy generation has emerged as a competitive market, to the extent that some developed countries aggressively move toward fossil fuel independence (Germany, Denmark, Spain). Energy efficient practices that make renewable generation more economically viable, became of great importance in today's worldwide situation, especially when considering climate change and air pollution in large cities. The recovery and reuse of heat that otherwise vanishes into the environment appears as one of the viable options. A type of Heat Engine known as the Organic Rankine Cycle (ORC) converts low temperature waste heat into electricity. Thanks to technological advances in the past decades, this technique gained competitiveness as an energy efficiency strategy. This work presents a thermodynamic analysis of an ORC which uses the excess heat from concentrated solar photovoltaics as an energy source. The ORC utilizes Ammonia as the working fluid and comprises four heat exchangers, a turbine and a pump. The system was modeled using Matlab Simulink coupled with the software RefProp to obtain the thermodynamic properties at each cycle state. The model assumes that the heat exchangers dominate the transient response, since the rest of the ORC components time scale is negligible in comparison. The system was designed to maintain optimum operating conditions through Model Predictive Control (MPC), using linear (ARIX) and nonlinear models (Takagi-Sugeno Fuzzy Model). The control strategy's objective is to maintain the system functioning at its highest thermal efficiency against varying input conditions. By modifying the pump's operation (Pressure jump, mass flow rate), we found that the ORC's thermal efficiency strongly depended on flow conditions entering the turbine. The control strategy maintained optimum thermal efficiency against a transient heat input associated with the variation in the daily thermal radiation load. Our work demonstrated that by applying the right control strategy, these energy efficient applications approach economic viability.

Keywords: *energy efficiency, waste heat recovery, organic rankine cycle, predictive control.*

Numerical study of improved solar energy storage efficiency for buildings with phase change material in trombe wall

Nelson Moraga[1,a], Roberto Cabrales[2,b] & Luis Rojas[1]

A current trend in energy efficiency to achieve a sustainable comfort temperature of air inside buildings located in arid zones is the use of phase change materials (PCMs) to store the abundant daily solar energy. Mathematical modeling and the finite volume method can be used to characterize the evolution of air temperature inside a building during a day/night cycle of 24 hours. The mathematical model is formed by continuity, Navier-Stokes and energy unsteady equations describing fluid mechanics and convective heat transfer in air coupled with transient heat diffusion in the Trombe wall with liquid-solid phase change in the PCMs. Numerical solutions of this problem are obtained by using the finite volume method, the PISO algorithm, suitable convergence criteria for velocity and temperature, using a 110x100 nodes staggered grid and a time step of 1s. The case investigated includes the attenuation of indoor air temperature by a Trombe wall improved with the paraffin wax as PCM. External boundary conditions consider the evolution of irradiation, ambient temperature and heat convection losses during the 24 hours day-night cycle investigated. Results obtained include the evolution of the air velocity and temperature inside the room, along the variation of temperature in the Trombe wall with phase change in t he paraffin wax. Simulations for natural convection of air inside the room with a Rayleigh number Ra = 10^7 reveal that a daily variation of 4 °C can be obtained with the use of a Trombe wall with phase change of paraffin wax. The energy stored inside the Trombe wall with a phase change material during daytime can be used to attenuate the variation of air temperature during the cycle day and night in both, winter and summer months, reducing energy consumption by fossil fuels for air heating and cooling in locations with available solar radiation.

Acknowledgements

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Keywords: *energy efficiency, passive systems, mathematical modeling, numerical simulations.*

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Efficient and sustainable cooling through convective evaporation using l ow global warming potential refrigerants in microchannels

C.A. Chávez[a] & N.O. Moraga[b]

The present paper concerns a study on convective evaporation inside a microchannel array heat sink. Experimental results for two-phase pressure drop, heat transfer coefficient, and exergy analyses were acquired for the hydrocarbons R600a (isobutane), R290 (propane) and R1270 (propylene). These fluids present low Global Warming Potential (GWP) and null Ozone Depletion Potential (ODP). The cooling performance of these hydrocarbons was evaluated for a copper heat sink containing fifty parallel microchannels. The microchannels were rectangular with cross section of 123×494 μm^2, 15 mm length and a footprint area of 15×15 mm^2. The experiments were performed for heat fluxes up to 400 kW/m^2, mass velocities from 165 to 823 kg/m^2s, degrees of liquid subcooling at the test section inlet of 5, 10 and 15 °C and saturation temperatures of 21 and 25 °C. The experimental data were carefully analyzed and discussed focusing on the effects of the fluid on the heat sink thermal hydraulic performance. Curves of pressure drop and heat transfer coefficient were obtained by gradual increasing of the heat flux up to a value prior to a critical heat flux (CHF) and then the continuous decreasing to a null value. Additionally, an exergy analysis was performed to evaluate the refrigerant efficiency during convective evaporation. Subsequently, the parametric effects and performance of hydrocarbons were compared with previous results for refrigerant R134a obtained in the same test facility and under the same experimental conditions. The refrigerant R290 provided heat transfer coefficients higher than R600a and R1270. However, R290 needed a degree of wall superheating for the onset of nucleate boiling (ONB) higher than R1270. Based on the exergy analysis it was concluded that the irreversibility associated to the heat transfer process is predominant compared to the irreversibility due to the pressure drop. According to the Second Law analyses it was also concluded that R290 is the fluid with the best performance.

Acknowledgments

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Keywords: *thermal efficiency, microsystems cooling, exergy, hydrocarbon refrigerants.*

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Development of a series of four energy efficient solar racing cars with a suitable li-ion battery cooling system at Universidad de La Serena

Nelson Moraga, Pablo Pacheco[a] & Ricardo Araya

The development of cars driven by solar energy has to main limitations: speed and efficient system for energy storage in batteries. The objective of this paper is to describe the development of a series of four solar racing cars with a suitable Li-ion battery cooling system that was undertaken at Universidad de La Serena. The strategy followed was based on the reduction of of frontal area and drag forces acting on the cars by a sequentially improved aerodynamic design. Fluid mechanics of air turbulent flow around each car was investigated by using numerical simulations with the finite volume method and the standard $k - \epsilon$ turbulent model for the two first three wheeled cars, models 2011 and 2012/13. The third 2014/15 and fourth 2017 model were designed with four wheels and the cockpit moved from the center towards one side of the cars. Aerodynamic design of the two later models was improved by using the SST Transitional four equations turbulence model with the analysis of the effect of frontal and lateral wind on drag and lift forces [1]. A high efficient cooling system based on a conjugate mathematical model of mixed heat turbulent convection and internal heat generation in the Lithium-Ion batteries, solved by the finite volume method, was designed and used in the last two models of solar racing cars [2]. The use of the computational modeling allowed the design of a series of four cars with significant reductions of frontal area and drag coefficients, with increments on speed from 80 up to 120 km/hr, lift forces and thermal efficiency of the lithium batteries by the cooling system designed. As a result, the two first models of solar cars won the international competition Atacama Solar Challenge, Chile in 2012 and in 2013, with the second model located in the second place in the World Solar Challenge in Australia, 2013 while the third model finished in second place in Atacama Solar Challenge in 2014.

Keywords: *energy efficiency, solar cars, mathematical modeling, numerical simulations.*

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Oral Presentations in Energy

A combined pyrolysis-gasification study to increase syngas production yield from brewers spent grain (BSG)

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Extensive resources and efforts have been dedicated to evaluate opportunities for using locally available biomass to produce energy, reduce CO2emissions, and lower reliance on petroleum. The use of lignocellulosic biomass is promising since it is readily available in vast amounts and there are processes for converting different biomass sources to useful products of particularly interest in liquid transportation fuels.[1]
Brewer's spent grain (BSG) is a major by-product of the beer industry, representing around 85% of the entire by-products produced [2]. BSG can be classified as bio-waste [3] and has been studied for several uses in the food industry [4], sustainable and might be utilized for energy and biogas production. One promising technology that has gained interest in the past few years is pyrolysis and gasification [5]. The core objective of this research is to study the influence of pyrolysis and gasification spent grain from brewers' waste to improve syngas production. Biochar produced from the biomass pyrolysis was used to obtain compounds with higher carbon content to subsequent undergo a gasification process.
Brewers waste was pyrolyzed under a nitrogen environment in different operating conditions; heating rates, reaction times, and pyrolysis temperatures. Pyrolysis at 300 °C produced a 56% yield of biochar, then the biochar was gasified 850 °C and 1 atm. of pressure for two hours using water as oxidizing agent in a fluidized bed reactor. This process leads to higher concentrations of syngas (60% of H2 and 20% CO) produced during gasification of the waste biomass studied. Finally, the combined processes applied to brewers' waste, allows to obtain products with higher added value, making possible the production of synthesis gas from the gasification of solid compounds obtained from pyrolysis of beer bagasse waste. These studies lay the groundwork for longer-term efforts aimed at using waste biomass as a sustainable way to add value to solid waste biomass.
These studies lay the groundwork for longer-term efforts aimed at using waste biomass as a sustainable way to add value to solid waste biomass.

Keywords: *biomass, gasification, pyrolysis, syngas, ChemCad.*

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Study of life cycle (lca) of biodiesel production plant from wild thistles, in Papudo, Chile

E. Soto[1,a] & F. Vergara[1,b]

All industrial activity consumes raw materials in order to generate a product or service, which satisfies the needs of people. The application of management tools allows the reduction of negative impacts, which are not only the area of production, but also in each and every one of the stages in which the product reaches its life cycle. This study is based on the application of ISO 14044/2006, whose objective was to analyze and identify the environmental impacts generated in each one of the stages of biodiesel production from wild thistles. The life cycle study (LCA) is carried out at a biodiesel plant located in the commune of Papudo, in the province of Petorca, Valparaíso region (Chile), which has 100,000 m^2 of land. The methodology according to ISO 14044 requirements consisted of: defining the overall objectives, the purpose of the study, the product to be studied, the intended recipients and scope of study. Inventory of input and output data in relation to the system studied. To conclude with the impact assessment it provides additional information in order to help evaluate the results of the life cycle inventory. Considerations: 3 thistles per square meter, with 5 flowers in average per thistle, an amount of 150,000 kg per month is obtained, the oil percentage by weight is 22.84% for each thistle, based on these values, were made balances of matter and energy, associated with the transesterification process. The energy consumption and CO_2 emissions of the biodiesel production plant has been calculated from the cradle (sowing and harvesting) to the finished product (biodiesel). Carbon dioxide emissions to the atmosphere in the sowing and harvesting process have been determined to be 2.3 [t CO2 / L biodiesel] throughout this process. In turn, the energy required for the correct operation of the plant on a daily basis generates 28 [kgCO_2 / kWh]. The application of the life cycle analysis showed that not only are carbon dioxide emissions generated during biodiesel production, but also in the transesterification process it is possible to quantify the emission of liquid industrial waste (RIL) Generated, which mostly contain methanol (considered as transesterification agent). In this sense, the country needs to increase bioenergy research and development in order to improve competitiveness and increase participation in the energy matrix.

Keywords: *thistles, biodiesel, valorisation, solid waste.*

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Sensitivity analysis of expected wind extremes over the northwestern sahara and high atlas region

Elena García-Bustamante[1,a], Jorge Navarro1[1], J. Fidel González-Rouco[2,b] & Jorge Conte[3,a]

A robust statistical framework in the scientific literature allows for the estimation of probabilities of occurrence of severe wind speeds and wind gusts, but does not prevent however large uncertainties associated with the particular numerical estimates [1]. An analysis of such uncertainties is thus required [2]. A large portion of this uncertainty arises from the fact that historical observations are inherently shorter that the timescales of interest for the analysis of return periods. Additional uncertainties stem from the different choices of probability distributions and other aspects related to methodological issues or physical processes involved. The present study is focused on historical observations over the Ouarzazate Valley (Morocco) and in a high-resolution regional simulation of the wind in the area of interest. The aim is to provide extreme wind speed and wind gust return values and confidence ranges based on a systematic sampling of the uncertainty space for return periods of up to 120 years.

Keywords: *wind speed, wind gust, extreme values, uncertainty, probabilistic return values.*

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Design of an optimized hybrid solar/wind system for a village in the semiarid Elqui valley, Chile.

Jorge Cortez[1,a], Sonia Montecinos[1], Kay Ohnmeiß[2], Frank Sehnke[2] & Martin Felder[2]

The use of renewable energy in the world has grown considerably in recent years. Chile has not been the exception, due to his huge potential for non-conventional renewable energy. The north of Chile is known for his high solar radiation. In the Coquimbo Region, the longitudinal valleys and mountains areas have higher solar radiation than coastal zones [1] and hence a great potential for generation of photovoltaic energy. Coquimbo Region also has a high wind potential, with the 67% of the installed wind power of the country. Due to the complex terrain, the wind speed presents high variability [2], and the wind potential must be evaluated locally.

In this work we shown the solar and wind potential and present a conceptual design of a hybrid renewable energy system that supply local energy demand of Diaguitas (30.02° S and 70.63° W) located in the Elqui Valley, 60 km east of La Serena, Coquimbo Region. The village consists of 428 houses and the economic activities spin around to agriculture and beer production (Granja Agro-Acuicola and Cervecería Guayacán).

The optimized system was designed using one-year time series of offer and demand energy. For this purpose, a theoretical 30-min interval demand curve was built using the information available about the demand energy in the village. The energy production was estimated from the meteorological information measured in Vicuña (6 km west of Diaguitas) during the year 2015. The optimum solar and wind power also considered installation cost, land use and geological hazards of the area.

We found that the total demand of the village was 1.45 GWh/year (including household consumption, public lighting, companies and water pumping). The capacity factor of the wind turbines and for photovoltaic cells (PV) is 6% and 19%, respectively. This, together with a high correlation between solar radiation and wind speed, the lower initial investment for a solar farm than for a wind farm, wind energy thrown out from the hybrid energy system. In order to have a night supply of energy, Lithium-Ion batteries should be included, increasing the initial investment considerably. With 100% self-supply scenario, 2.1 MW of solar power and batteries for 3.1 MW is required, meanwhile for a 70% scenario, the system requires 0.9 MW in PV cells and 1.5 MW in batteries. Another alternative is to design the PV farm without batteries so that the system produces 100% of the energy demand of the year, so that the missing / excess energy is bought / sold to the grid. In this case, if the goal is a PV system of 0.9 MW is required.

Acknowledgment

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Keywords: *solar energy, wind energy, hybrid energy system, local suitable energy.*

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Wind energy forecast in the semi-arid Coquimbo region in Chile

Sonia Montecinos[1,a], Omar Cuevas[2], Martin Felder[3], Ignacio Salfate[1] & Bartolomé Manobel[1]

The participation of wind as a clean energy source is growing in importance at global and local level in Chile. Because of the variation of wind speed, the energy generated by wind farms experiences important fluctuation. Consequently, to have a good wind energy forecast system is an important issue.
The goal of this work is to generate hourly wind energy forecasts of up to 120 hours ahead. The methodology is based on Artificial Neural Networks (ANN), which have proven to be effective at forecasting the power of wind turbines [1]. The algorithm was applied to the Totoral wind farm, located at the coast of the semi-arid Coquimbo Region in Chile (31°19' S, 71° 36' W).
For the training of the ANN, historical meteorological forecast is needed. For this purpose, the numerical model WRF (Weather Research and Forecasting) was validated in the Coquimbo Region, and historical weather forecasts up to 5 days ahead (120 hours) for the Totoral wind farm were generated. Other inputs for the ANN training are time series of current meteorological data (wind speed, wind direction, temperature and pressure) as well as the latest wind power generation of the wind farm. We use multiple Deep Neural Networks (DNN) with state-of-the-art training algorithms to compensate for the variation of statistical properties of the forecasts over the forecast horizon.
DNN training was performed at the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), using specialized software running on graphics card servers. The operational application of the forecast models can be performed on any regular desktop PC.
We performed wind energy forecast for the Totoral wind park in the period January 2015 to October 2016, and found that the normalized root squared mean error at 5 days ahead was 17

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Keywords: *wind energy forecast, artificial neural network, arid zones.*

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Oral Presentations in Electricity

Life cycle environmental sustainability of electricity generation in Chile

Carlos Gaete[a], Alejandro Gallego-Schmid[b], Laurence Stamford[c] & Adisa Azapagic[d]

The present study evaluates the life cycle environmental sustainability of electricity generation in Chile using life cycle assessment as a tool. The following technologies contributing to the national electricity mix are considered: coal, oil, natural gas, biomass, biogas, hydropower, solar photovoltaic (PV) and onshore wind. The study has been carried out following the ISO 14040/44 standards [1, 2]. The following environmental impacts have been estimated: global warming potential (GW), abiotic depletion potential (ADP), human toxicity potential (HTP), acidification potential (AP), eutrophication potential (EP), ozone depletion potential (ODP), photochemical oxidants creation potential (POCP) and freshwater, marine and terrestrial eco-toxicities.

The results reveal that coal power is environmentally the least sustainable option for most of the impacts. For instance, freshwater aquatic eco-toxicity is 30 times higher for coal power (308 g DCB eq./kWh) than for natural gas electricity (11 g DCB eq./kWh), and more than 300 times greater than for hydropower (0.8 g DCB eq./kWh). In the case of GWP, the impact of coal power (1039 g CO2 eq./kWh) is 64% greater than for natural gas (648 g CO_2 eq./kWh) and at least 130 times higher than wind (8 g CO_2 eq./kWh) and hydropower (2 g CO_2 eq./kWh). AP and EP of coal power are 10 times higher than for natural gas and 20 times higher than for solar PV. However, for ODP and POCP, oil power has the highest values (ODP: 108 μg R11 eq./kWh; POCP: 425 mg C_2H_4 eq./kWh) and solar PV for ADP (1168 μg Sb eq./kWh). The latter can be explained due to the use of scarce elements in the production of silicon-based solar panels, such as, tellurium, silver and copper, while the release of halogenated compounds used as fire suppressant in the oil pipelines is responsible for the high value of ODP. Finally, the combustion of oil produces emissions of NO_x and SO_2 that contribute to POCP.

Several improvements are proposed to improve the environmental sustainability of the electricity sector in Chile. In the short term, the reduction of the impacts caused by coal is the main objective. For example, Santa Maria coal power plant has the worst performance out of the 18 coal power plants in Chile and should be targeted for improvements. The use of coal from Australia contributes to ODP due to the shipping while mining contribute to high EP, HTP and eco-toxicities. Therefore, the use of coal from Colombia or USA should be prioritized. In the medium term, the use of natural gas should be favoured instead of coal and oil. Finally, in the longer term, greater implementation of renewables should be a priority. For solar PV, the depletion of scarce elements can be reduced up to 30% by using thin film technologies. These solar panels, despite having lower efficiency, use significantly less raw materials in their thin layers and, therefore, consume less scarce elements per kWh produced.

Keywords: *Climate change, environmental impacts, fossil fuels, renewable energy, abiotic resource depletion.*

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The role of the distributed generation to achieve in a sustainable way the 70% of ERNC in 2050

Carlos Maldonado

Chile has signed off on a new energy strategy in which sets a goal of generating 70% of national electricity generation from renewable sources by 2050 [1].
However, achieving such an objective is not easy because Chile imports 65% of its energy needs and some 97% of its petroleum and the generation of electric energy is assumed entirely by private companies [2].
The Chilean energy strategy aims at the development of energy efficiency and particularly as far as electricity generation and transmission.
The current economic model of the electric system does not allow citizens to independently manage and pay for their energy and thus contribute to real sustainable development. A sustainable option is to be able to generate our own energy and consume it directly (self-consumption).
In Chile, the law 20.571, known as the Law of Distributed Generation (DG), establishes net billing for systems that generate less than 100 kW. The net billing scheme for domestic PV users, allowing them to sell their energy back to the grid, but energy injections are valued at a lower cost than the purchase price, becoming a barrier to its development [3].
The small-scale PV market in Chile is in its infancy, and the obvious missing system of this DG model is energy storage.
The implementation renewable DG increasing energy security and contributes to competitiveness, economic growth reducing local environmental and social externalities and reduce the cost of electricity for a country as a whole.
The role of DG is discussed in order to achieve the goals proposed for agenda 2050.
Keywords: *distributed generation, law 20.571, self-consumption, micro-grid.*

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Life cycle inventory of the electricity production and distribution in Chile over 1995-2015: the evidences of the time effect

Mabel Vega[1,a] & Claudio Zaror[1,b]

The electricity production is well-known as a key engine for economic development, and also a source of environmental impacts. Therefore, there is a permanent need to assess electricity production under an environmental perspective. In Chile, the electricity market has experienced significant changes over the last two decades, having huge investments in electricity generation infrastructure, changing drastically the generation technological profile.
The electricity generation in Chile is provided mainly by two interconnected grids, namely the Northern Interconnected System (SING) and Central Interconnected System (SIC). Both account for nearly 99.9% of installed capacity, and covers a territory of around 2.800 km, from the northern to the insular territory of Chiloé in the south. SING matrix was mostly based on thermal sources, such as coal and natural gas; however, in recent years it has developed large investments in solar PV technologies. On the other hand, the SIC matrix has a significant contribution from hydropower and an increasing share of wind power and biomass-based plants. A constraint for the hydropower has been the presence of periodic droughts, associated to La Niña southern oscillation phenomena, being strongly related to macro-climatic events. Within this context, was developed this study on the environmental profile of electricity generation in Chile over the last two decades, ie. 1995 – 2015, following a cradle-to-gate life cycle approach, and considering previous assessments [1].
The methodology is based on the ISO 14.040-44:2006 standards, with a functional unit of 1 kWh distributed at high voltage (HV), and includes all the electricity generation technologies associated to the SING and SIC networks. The process stage include fuels extraction and import to Chilean ports, internal fuel transport, construction materials, also the infrastructure-and thermal efficiency are included, based on primary data [2].
The results indicate that changes in water availability, commercial constrains in natural gas supply, explosive investment in solar PV technology, among others, have led to significant changes in the environmental profile along time. Energy conversion in thermal plants accounts for a large fraction of environmental burdens; on the other hand, construction stage and production of the plant construction materials dominate burdens in the case of plants based on renewable sources. These results will serve as a base line for future comparisons as new project and the announced next connection of both matrix will imply changes in overall burden along the value chain of electricity dependent economic activities.

Keywords: *electricity generation, life cycle inventory, Chile, environmental burdens.*

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Poster Presentations

Photocatalitic degradation and mineralization of gallic acid

Alejandra Pereira Araya[1,a], F.J. Jamett[1] & A.C. Mera[2,b]

In this last period, a worldwide concern for the contamination of the planet has been evidenced, as well as the search for different ways to minimize the impact of different chemical agents used in large industries. One of the main problems is produced when industries discharge their wastes in to surface waters withoof receive environmental previous treatment to mitigate the environmental impact.
This research seeks to achieve the photocatalytic mineralization and degradation of gallic acid, a model compound presents in waste water generated by the wine industry.
To do so, heterogeneous photocatalysis1 was used comparing two semiconductors: TiO_2 and BiOCl. Percentages of degradation and mineralization were analyzed using techniques such as UV-visible, HPLC and COD. In addition, the influence of pH and the concentration of each semiconductor during the photocatalytic process using simulated solar radiation were evaluated.
The statistical model provided that the optimum conditions for obtaining the maximum degradation and mineralization of the phenolic compound are: pH of 8 and 632 ppm of TiO_2 *Evonik* P-25. In addition, the optimum conditions for BiOCl are: pH of 5,5 and 683 ppm of photocatalyst.
Results obtained her shown that heterogeneous photocatalysis is a technique promising using BiOCl for the pretreatment of wastewater containing phenolic compounds2

Keywords: *photocatalysis, degradation, contaminants, environment.*

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Fog collection and its relation with local meteorology in a semiarid zone in chile

Andrea Torrejón[1,a], Sonia Montecinos[1] & Pilar Cereceda[2]

Fog is considered an important alternative source of water, especially in places where p recipitation is scarce. The Humboldt Current and the Pacific anticyclone that characterize the North of Chile promote the formation of Stratocumulus along the coastline, which are transported inland by trade winds and land-sea circulations. When these clouds intercept the prominent coastal topography, advection fog can be observed [1]. Because of these characteristics, patches of diverse fog-dependent plant communities can be observed along the Coast Range in the North of Chile, as for example the Fray Jorge Biosphere Reserve (30^oS).

The goal of this research is to characterize the fog collection in a year, and its relation with local environmental variables registered in El Sarco (29.51^oS, 71.27^oW and 700 m a.s.l.) situated in the Coast Range of the semi-arid Coquimbo Region. The site is equipped with a meteorological station and a Standard Fog collector (SFC) [2]. The fog water (FW) collected by the SFC is measured by a rain gauge. The results shown in this presentation are based on data collected in one-year period.

We found that the FW collection was greater in winter the in the summer months, and mainly occurred with SW and NE winds. For a fixed wind speed, it ranged between zero and a maximum value which increaseds with wind speed. The mean daily temperature amplitude was larger in winter than in summer, meanwhile the relative humidity achieved the minimum values in winter. The Fog Index (FI) was defined as the percentage of foggy-days per month, for which the water collected is greater than 1 liter. We found that FI follows the same trend as the monthly collected water and decreases with the mean monthly daily temperature amplitude. This fact can be explained because wet air cools and heats more slowly than dry air and fog prevents both, cooling by radiation during the night and attenuates the incident solar radiation.

Acknowledgments

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Keywords: *fog water collection, meteorology, arid zones.*

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Wind speed simulations for Totoral wind farm: I evaluation

Carla Meyer[1,a], Omar Cuevas[1,b], Sonia Montecinos[2,c], Julio C. Marín[3,d], Bartolomé Manobel[2,e] & Ignacio Salfate[2,F]

The energy production from wind farm depends strongly of the wind speed, but due to the largely variable nature of these, it is complex to estimate the energy production in short time. To estimate the wind speed over wind farm a WRF meteorological model was used using three parameterizations of the planetary boundary layer (PBL): MYNN, MYNN3, QNSE. The simulations were made in 2013 and 2014 years over Totoral wind farm and were compared with in situ observations. The main objective is to determine which WRF scheme simulate the wind speed with better performance compared with the observations.
The WRF model was configured with four nested domains and results from the innermost domain (d04 at 1 km horizontal resolution), every one hour and centered at the Totoral wind farm was used in the study. To evaluate the WRF performance with observations the RMSE, BIAS and linear correlation were used. The results show that WRF-QNSE has better performance and low error compared with the other WRF configurations used in this work. The WRF-QNSE will be used in a second step to evaluate the wind speed forecast at 120 hrs.

Acknowledgment

This project have been financed by CONICYT-CHILE through FONDEF ID14I10016 project.

Keywords: *Wind speed, Meteorological simulations, WRF*

Environmental assessment of farmers' market waste revalorization alternative via a life-cycle analysis (lca) in Chile

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This study is a preliminary environmental assessment of two processes for biomass conversion to energy (pyrolysis and anaerobic digestion) from farmers' market waste (FMW) in the Metropolitan Region of Santiago, Chile. The aim of this research was to stablish which alternative was the most environmentally sound and compare those results with the current landfill disposal system and its impacts on the environment, through the implementation of a Life Cycle Assessment (LCA) tool to analyze all the emissions of each system studied, based on specific amount of electricity produced, expressed in kilowatt-hour (kW-h).
The Life Cycle Impact Assessment (LCIA) shows the impact of ten categories selected for the study, corresponding to global warming (GW), formation of particulate matter, photochemical smog formation, and depletion of fossil fuels, among others. Results show that the best option to implement corresponds to the anaerobic digestion of FMW due to the low environmental emissions. By changing the raw material with forestry waste, the best Waste-to-Energy (WtE) alternative to implement corresponds to the fast pyrolysis process, because it generates less impacts than FMW, due to the low moisture content (<10%). Finally, identifying all the problems of the different impacts associated with each waste revalorization system is possible to determine the critical points that generate these impacts, and optimize their processes to mitigate their effect on the environment.

Keywords: *life cycle assessment, pyrolysis, anaerobic digestion, landfill, ecobase, farmers market waste.*

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A techno-economic study on the utilization of brewers spent grain (bsg) through gasification

C. A. Correa[1], R. A. Barrientos[2] & R. A. Garrido[1,a]

The present report constitutes an analysis of the techno-economic pre-feasibility for the valorization of the brewers spent grain (main solid waste generated by the brewing industry), through gasification process.
The aim of this study is to determine the technical and economic feasibility of the gasification process on the selected biomass to generate products with added value.
It is for this reason that several actions were carried out to accomplish the objectives: characterization of the biomass, experimental gasification process of brewers spent grain, design the simulated process through the establishment of a calculation basis, and finally the evaluation of the results to determine its feasibility.
The simulation of the gasification process for the production of methane and methanol was done using ChemCad software, which showed the technical feasibility for a 2,000 ton/day of biomass facility. For the economic viability will be based on the calculation of analysis indicators for projects, such as the NPV (Net Present Value) and the IRR (Internal Rate of Return) showing a value of 472,60 US$ Million and 44% respectively.
Finally, with this study it was determined that it is possible to execute the recovery procedure considered to treat brewer spent grain to produce methane and methanol on an economical and technical way and increase the knowledge of this waste-to-energy technologies suitable for the Chilean energy matrix.

Keywords: *biomass, gasification, syngas, chemcad.*

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Evaluation of the process of heterogeneous photocatalysis in the treatment of waste water with presence of pesticides, using BiOI microspheres under simulated solar radiation

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Currently there is an increasing concern about the indiscriminate use of chemicals in agriculture, primarily for pest control. The Region of Coquimbo presents an extensive area dedicated to fruit and vegetable production, and in order to protect the production of crops, it is necessary to use chemical compounds that are very toxic to human health [1] and the environment.
In most agricultural areas, after the application of phytosanitary products, pesticide residues that remain in the application machines are diluted with water and discharged into the adjacent areas to the crops, leading to environmental pollution.
Considering the above, the heterogeneous photocatalysis process is presented as a pre-treatment alternative for these residues. This corresponds to an autonomous technique with low cost of installation and unlike other treatments, allows the degradation and non-selective mineralization of pollutants by oxidation reduction reactions, catalyzed by a semiconductor and stimulated by solar radiation.
The present study proposes the use of BiOI semiconductor microspheres, obtained by solvotermal method [2], as catalyst for the degradation and mineralization of two model pesticides (profenofos and linuron) under simulated solar radiation, by experiments with a Batch reactor. Adjusting pH (3 – 10) and BiOI concentration (0,1 – 1,0 g/L)
The determination of the optimum photocatalytic conditions (pH and amount of BiOI) using RSM methodology will allow the generation of an alternative for the pre-treatment and the possibility of reuse or the adequate disposal of waste water with the presence of pesticides generated daily in horticultural companies.

Keywords: *BiOI microspheres, photocatalysis, pesticides, Linuron, Profenofos.*

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Mesoporous materials for glyphosate degradation in water through catalytic wet air oxidation

E. Vaschetto[a], V. Elías, S. Casuscelli & G. Eimer

In recent decades, pollution of water resources has grown mainly due to inadequate treatment of industrial waste and excessive use of agrochemicals [1]. Currently the world consumption of agrochemicals is 4.6 million tons per year. In Argentina, herbicides account for 64% of the total agrochemicals market. Within them, glyphosate is a broad-spectrum herbicide and it is the main active ingredient in commercial formulations. The great solubility of this substance in water causes that, when they are applied on the ground, they can diffuse towards groundwater generating a severe contamination. In this context, the advanced oxidation processes, among them "catalytic wet air oxidation", are proposed as an alternative of degradation of glyphosate in aqueous media [2]. They are based on the formation of reactive chemical species, such as hydroxyl radicals, which are oxidizing agents capable of degrading the most resistant molecules. Although there are reports that employing this type of oxidation process, the use of high pressures and high temperatures are reported in most works [3]. In this context, mesoporous materials such as SBA-15 and MCM-41 substituted with transition metals appear as very promising catalytic supports because of their structure, high specific area and pore volume, which make it suitable for use in degradation of pollutants. Thus, in this work the use of nano-structured mesoporous solids modified with iron and aluminum is proposed to degrade glyphosate in aqueous solutions by catalytic wet air oxidation process. Fe-SBA-15 and Al-MCM-41 [4] materials with a Si/Fe or Al molar ratio = 20 and the pure siliceous matrix were catalytically evaluated in a fixed-bed reactor at room temperature and pressure. An aqueous solution of glyphosate of 15 ppm at a contact time of W/F = 40 gh/mol (g of catalyst on glyphosate feed rate) was fed with a TOS (time on stream) of 15 min. The reaction samples were analyzed by ion chromatography (Thermo Scientific ICS-1100 Dionex). The obtained results showed an 80% of glyphosate degradation, obtaining phosphate, nitrate and nitrite ions when the Fe-SBA-15 material was used. When Al-MCM-41 and pure siliceous matrix were evaluated, there was no degradation of glyphosate. Thus, these materials could be considered as not catalytically active for the tested reaction. Meanwhile, by replacing the Si by Fe in the material (Fe-SBA-15) the degradation of the pollutant molecule could be achieved. Thus, adding an iron source in the synthesis gel, an active material was developed. So, employing a solid catalyst such as Fe-SBA-15 for the catalytic wet air oxidation the degradation of glyphosate was achieved at soft reaction conditions resulting in lower environmental impact and operating costs and increasing the sustainability of the process.

Keywords: *nanostructured materials, catalytic wet oxidation, agrochemical pollution (Glyphosate).*

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Heterogeneous photocatalysis for the degradation and mineralization of caffeic acid present in wastewater of the wine and pisco industry

E. Espejo[1], F. Jammet[1] & A.C. Mera[2,a]

Heterogeneous photocatalysis is an advanced oxidation process (AOP) that is generally applied to degrade and mineralize recalcitrant contaminants present in wastewater, which are difficult to biodegrade.
This research focuses on the evaluation of photocatalytic activity of TiO_2 *Evonik* P-25 in the photocatalytic degradation and mineralization of caffeic acid. This model contaminant is present in wastewater generated in the wine and pisco industry.
Photocatalytic tests were carried out in a batch reactor, using a xenon lamp as a source of UV-visible radiation with a radiation in here range of 380nm to 900nm.
Optimum photocatalytic conditions (pH and amount of TiO_2) were determined using the RSM methodology. In order to develop the multivariate statistical model, pH ranges from 2.2 to 7.8 units were used, while the photocatalyst concentration range was 76 to 924 ppm.
The degradation percentage of caffeic acid was determined using Uv-Visible Spectroscopy and High Resolution Chromatography (HPLC). The percentage of contaminant mineralization was determined using Chemical Oxygen Demand (COD).
Statistical model provided the optimum conditions for obtaining the maximum degradation and mineralization of the phenolic compound caffeic acid: pH of 6.0 and 877 ppm of TiO_2 *Evonik* P-25.
Results obtained, allow to consider the heterogeneous photocatalysis as a pre-treatment alternative for wastewater generated in the wine and pisco industry.

Keywords: *photocatalytic activity, semiconductor, contaminant, degradation, mineralization.*

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Immobilization of pseudomonas fluorecens lipase in mesoporous materials to biodiesel production

Gabriel O. Ferrero[a], Edgar M. Sanchez-Faba & Griselda A. Eimer

The aim of this work is to design a catalyst for biofuels production from renewable raw materials by means of the immobilization of an enzyme on nano-structured solid supports [1, 2]. In fact, the main purpose is to immobilize the lipase of Pseudomonas fluorescens in the pure SBA-15 (Santa Barbara Amorphous) mesoporous material [3] and to compare their activity in the biodiesel production using vegetable oils, with that of the enzyme immobilized on materials SBA-15 modified with metals (Ca, Na, Fe, Cu, Al, K) [4]. The physicochemical properties of the synthesized mesoporous materials were determined by Small-angle X-ray scattering (SAXS), Transmission electron microscopy (TEM) and UV-visible. The enzyme was immobilized by physical adsorption, mixing each mesoporous material with an enzyme solution. The effective incorporation of the enzyme in the materials was confirmed determining the protein concentration in the soluble fraction after immobilization by the Bradford method. The optimal conditions of the biocatalyst activity were determined: oil / ethanol ratio, water percentage, amount of immobilized enzyme / mg of SBA-15 support, reaction time and activity of the biocatalyst respect to the metal impregnated in the solid used. Ca/SBA-15 material show the better activity as biocatalyst to biodiesel production using 400mg/g of lipase respect material, 1/4 oil/ethanol and 4 wt% of water respect oil.

The transesterification reaction of triglycerides with ethanol for the production of biodiesel catalyzed by the LPF / SBA-15 / Ca biocatalyst has high batch yields, does not produce soap, uses low temperatures of 37 ∘C and allows to separate the catalyst easily from the mixture.

Keywords: *biodiesel, enzymatic immobilization, SBA-15, mesoporous material.*

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Techno-Economical Assessment of the utilization of Brewers Spent Grain (BSG) for the production of energy through a combined Pyrolysis and Gasification process.

G.R. Sánchez[1], M.F. Valenzuela[1], R.A. Barrientos[2] & R.A. Garrido[1,a]

In recent decades, the solid waste management system has become one of the biggest problems in the world. This is why there is a constant search of what actions to take, to reduce the waste production and to provide the best possible disposal system, avoiding negatively damages in the environment.
This study focused on the revalorization of brewing bagasse, which is a residue generated from barley, to analyze the economic and technical feasibility on the use of brewer's spent grain from the brewing industry for the generation of electric energy, through a combined pyrolysis and gasification process using a process simulation software, CHEMCAD ©.
In the brewing industry, large amounts of residual biomass are generated, about 85% of the solid waste generated corresponds to the brewing bagasse. This study focuses on finding a way to use this residue more efficiently through chemical thermodecomposition processes, increasing its economic value to a residue that is considered a waste. The main products obtained through the combined processes of pyrolysis and gasification were syn gases (mainly H2 and CO) which were then processed and fed to an internal combustion reactor for the generation of electrical energy, producing 1770 TWh/yr of power. The technical prefeasibility of the process was checked using the CHEMCAD © software and the economic evaluation resulted in an IRR of 18% and a NPV of USD130.89 million.
This type of studies are of great importance to encourage the use of new non-conventional renewable energy sources in the future, with the objective of complementing the national energetic matrix, this work demonstrate that this technologies are technically and economically viable sources of energy and it should be further explored and improved

Keywords: *biomass, brewing bagasse, pyrolysis, gasification, technical/economic analysis, Chemcad.*

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Wind turbine power curve fitting based on gaussian processes and artificial neural networks.

Jorge Cortez[1,a], Bartolomé Manobel[1], Sonia Montecinos[1], Ignacio Salfate[1], Frank Sehnke[2], Martin Felder[2]

Wind energy has grown exponentially in recent years [1]. Currently, the installed power in Chile is near 1 GW, 67% of which are in the Coquimbo Region, and it is expected that it will continue to grow. A common problem in this industry is the inaccuracy in the prediction of production rates of wind farms due to the dependence of atmospheric conditions, which are variable [2], both spatially and temporally. The relation between windspeed and power output of a wind turbine is given by the power curve, which follow a cubic relation with the wind speed. Nevertheless, it also depends on other atmospheric variables such as temperature, atmospheric pressure, turbulence intensity, among other [3], and operational variables like unplanned curtailment and maintenances. Therefore, fitting the real curve from historical data is a complex issue.
The aim of this paper is to present a method to fit the power curve based on a pre-filtering gaussian process and artificial neural networks (ANN), which is able to eliminate outliers automatically before performing the ANN fitting.
The study was carried out with data registered in Totoral wind farm (31°16'S and 75°36'W), located at the coast of the Coquimbo Region, Chile. Totoral has 23 Vestas V90 wind turbines with a total nominal power of 46 MW. The analyzed data were wind speed and wind direction at 80 meters above ground level and turbines' power output from 2013 to 2016. Data were provided as ten-minute averages. We compared the results with traditional fitting of the manufacture power curve found in the literature. Results show that this procedure improves the standard ANN modeling and also improves the widely used IEC-61400 standard (International Electrotechnical Commission) and other parametric and non-parametric methods. There is a significant improvement about 25% in root mean square error of predicted power using our proposed model compared to standard methods currently applied.

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Keywords: *manufacture power curve fitting, artificial neural network, Gaussian process.*

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Calculating pv modules temperature from meteorological conditions

Jorge Cortez[1,a], Sonia Montecinos[1], & Martin Felder[2]

Solar energy has the highest potential for growth in northern Chile because it hosts the highest solar resources of the world. There are several factors that affect the performance of PV cells, being the most important the solar radiation. However, due that cells are semiconductors, they are sensitives to the temperature [1]. The electrical efficiency and thus the energy produced, decreases with the module temperature [2]. Most of the PV farms don't have a thermometer to determinate the module temperature but they usually have a meteorological station. For this reason, it is important to develop a methodology that allow calculating it from atmospheric records.
The goal of this study is to calculate the module temperature from meteorological registers (air temperature, solar radiation and wind speed). For this purpose, we used Artificial Neural Network (ANN) and compare the results with the standard approach and others methods found in the literature [1].
The methodology was applied to registers from Minera Los Pelambres (MLP) (31.7°S and 70.5°W) situated in the Andes Mountains, 210 km south east of La Serena in the Coquimbo Region, Chile. MLP has installed two PV solar farms with different panel types, a polycrystalline and a micromorph with nominal power of 3.8 kW and 5 kW, respectively. Each solar farm has a meteorological station which register air temperature, solar radiation and wind speed (wind speed is not available for the polycrystalline module) and also there are measurement of energy production and module temperature. The data provided were stored every 5 minutes in the micromorph plant and every 15 minutes in the polycrystalline plant for the period 2014 to 2016.
We found that, for both plants, the ANN was the best method. In the case of the micromorph plant we found that root mean square error (RMSE) for the fitting using ANN, standard approach and Kurtz's equation -the best of the classical method which included the wind speed in the calculations- was 2.9 °C, 5.1 °C and 3.0 °C, respectively. For the polycrystalline plant, for the same methods the RMSE was 3.3 °C, 4.6 °C and 4.1 °C.

Acknowledgment

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Keywords: *module temperature, neural network, semi-arid zone.*

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Development of an organic regenerator of soils based on natural zeolites and organic agricultural waste resources

M.L. Saavedra[1,a], R.Santoro[1], G. Díaz[1] & R.Garrido[2,b]

The natural or synthetic zeolite appears as a valid soil improvement option, which can contribute to the more efficient use of these two resources, water and nutrients, and has a high capacity of cation exchange and especially ammonium ion, it is possible to use it as a liberator of controlled-action fertilizers. Zeolites are highly crystalline hydrated aluminosilicates which, when dehydrated, develop a porous structure in the ideal crystal with pore diameters of at least 3 to 10 Å [1], have a crystal lattice made up of tetrahedra which are composed of $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$, which bind to each other, sharing their oxygen, to achieve a highly stable structure [1]. The molecular structure of zeolites give the ability to hydrate and dehydrate, which allows to improve the water balance in the soils, so that its use in soils of the north and in times of drought would be very useful for farmers [2].
This study is in the intermediate stage of development and focuses on generating products, based on agroindustry residues, to be used as a soil improver. For this purpose, it is essential to evaluate the agricultural and agroindustry activities, to characterize residues from massive crops such as cereals, forages, fruit trees and residues from horticultural plants, among others, that can be treated to be reused. It is considered to use the residues in mixtures with zeolite and polymeric HPs obtained from the residues as a binder. Therefore, the impact of applying these materials on crop soils, on the retention of ammonium and water has been studied.
The impact of applying natural zeolite type clinoptilolite (with the presence of modernite provided by Fertosa SA) on sandy loam soil (33°34′53.76″ S) has been studied, increasing the cation exchange capacity of the soil from 7.44 to 12 (meq / 100g) The soil ammonia volatilization tests with zeolite showed that the loss was reduced by 6.5% and water permeability tests showed that the coefficient of hydraulic conductivity was reduced by 18% (5% zeolite on soil).
On the other hand, cellulose acetylation (99% purity) extracted from agroindustrial wastes such as pineapple leaves, grape marc and oat straw was obtained, gaining the following degrees of substitution: 2.56 in pineapple leaves (PM: 62418.15 g / mol); 2.48 for grape marc (MW: 53293.77 g / mol) and 2.63 for oat straw (MW: 54986.18 g / mol).
Regarding the agroindustrial residues, the effect of the zeolite on the composting o f these is being investigated, that allows to formulate a procedure of management of these residues and the formulation of an organic regenerator, applicable to either soils of areas with water scarcity or as well as soil improver in other areas to reduce the use of artificial nutrients and improve irrigation yields

Keywords: *zeolite, composting.*

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Optical and electrical properties of silicon solar cells by wet chemical etching

Mauricio Arias[1,a], Mackarena Briceño[1], Aitor Marzo[2,3] & Antonio Zárate[1]

The minimization of reflection losses is of crucial importance in obtaining high photo-conversion in solar cells. The use of nanostructures such as porous silicon is suitable for use as an antireflection coating in solar devices. [1] Metal-assisted chemical etching (MACE) can be done without the use of vacuum processes, which can significantly reduce the manufacturing costs of solar cells. MACE techniques provide a method for obtaining various silicon nanostructures, such as Si nanowires and Si nano-pores with well-controlled morphological characteristics. [2]
We present a simple low-cost wet chemical etching process which is facilitated by the presence of silver metal clusters, and is applied to n-type (100) Si and commercial silicon solar cells. The sample processing is performed in two steps: firstly by controlling the formation of metallic particle via the immersion time in the metallic salt solution, and secondly by controlling the etching time. An increase in particle size at longer times with silver ion solution and an increase in depth at longer etching times are observed in the topological analysis. For the Si wafer and commercial silicon solar cells, the reflectance measurements results showed that the total reflectance is reduced at longer etching times. The optimum experimental conditions required in order to obtain the best efficiency in solar cells was achieved by using an immersion of 18 second in the silver salt acid solution and 30 second in the etching solution. And a decrease in the values of the photocurrent efficiency is observed in samples with longer etching time. The incorporation of Ag NP's produced a 0.6% increase in efficiency compared to reference solar cell under AM 1.5G illumination. This effect is attributed at an increase of the local electric field strength and the enhanced light scattering. These results suggest that this loss in efficiency is associated with the high depth of the pores on the solar cell due to the increased surface recombination associated with the increased surface area. Nevertheless, this procedure shows good potential to increase solar cell efficiency while minimizing manufacturing costs for these devices.

Acknowledgements

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Keywords:*metal-assisted chemical etching, photoconversion, nanopores.*

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Nanostructured mesoporous materials modified with nickel for alternative energy and environmental applications.

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Nickel modified mesoporous silicas with MCM-41 structure were prepared by direct hydrothermal synthesis with Si/Ni molar ratio = 20 and 60 in the synthesis gel and increased days of synthesis from 0 to 7 days. Various characterization techniques including XRD, N2 adsorption at 77 K, TEM, SEM, ICP-OES, UV-Vis DRS, TPR, FT-IR and adsorption of pyridine coupled to FT-IR spectroscopy were conducted in order to study the textural, structural and chemical properties of the materials. The effect of Ni loading on the textural, structural, adsorbing and catalytic properties of the materials was investigated.
The samples presented well-ordered hexagonal structure; however, the structural ordering appears to be slightly decreased when increasing the hydrothermal treatment days. A hydrothermal treatment time of 3 days appears optimum to obtain a good ordering and Ni species incorporation into the structure. Longer hydrothermal treatment times decreased the degree of ordering structural, giving account for the restructuration and reorganization of the network. Thus, combined characterization results indicate that the synthesis time has an important influence on the textural, structural and chemical properties of the nickel modified mesoporous silica [1].
Hydrogen adsorption capacity of Ni-containing mesoporous materials modified with nickel was measured at 77 K up to 10 bar. The results demonstrated that the sample with a molar ratio Si/Ni = 60 and without hydrothermal treatment presented the highest hydrogen adsorption, probably due to their SBET and the presence of highly dispersed nickel species on the support [2].
Besides, the mesostructured nickel-containing catalysts have been successfully proved in Atrazine degradation by the heterogeneous photo-Fenton process in aqueous solutions. As a result of this, the sample with nickel loading of 1.6 wt. % (Ni(60)0) allowed to reach values of the pollutant degradation about of 60.3 % [3].
In conclusion, the nickel incorporation into the mesoporous framework presents the option of developing materials versatile and efficient for to be employed in energy and environmental applications.

Keywords: *MCM-41, nickel, hydrogen storage, atrazine degradation.*

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Important decreasing of carbon deposition on Ni/Ce-La-Al_2O_3 catalysts by Rh addition in ethanol steam reforming reaction.

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Abstract

Ethanol steam reforming is a promising method for H2 production since it produces more H_2 per mole of reactant compared with other methods as the reforming of methane, in addition, is widely available and shows low toxicity. Since chemical nature of metal and support drastically affects products and catalyst stability in the reaction, a suitable selection of catalysts components is relevant to obtain a system with high selectivity towards H_2 production and low carbon deposition [1]. In this context, different paths have been studied in order to reduce the deposition of carbon in catalysts based on non-noble metals [2]. To overcome these drawbacks, supports participating in degassing of carbon of bimetallic catalysts are used. The main goal of this work was to study the effect of Rh addition over Ni catalysts supported on CeO_2-La_2O_3-Al_2O_3 and their selectivity to some reaction products and catalyst stability. CeO_2-La_2O_3-Al_2O_3 supports were prepared by successive impregnation of commercial γ-Al_2O_3 with $Ce(NO_3)_3{\cdot}6H_2O$ and $La(NO_3)_3{\cdot}6H_2O$ and 10%w/w of Ni and then, different amounts of Rh. The prepared catalysts were characterized by TPR, HR-TEM, DRX, XPS and TPO-TGA. The molar ratio of H_2O: Ethanol was 3:1 and reaction temperatures were ranged between 400-700 °C. All XRD diffractograms showed characteristic peaks of γ-Al_2O_3, CeO_2 and Ni°. HR-TEM micrographs of bimetallic catalysts showed larger size Ni particles than those observed for monometallic catalysts onto the same support, this latter was also concluded with XRD results. XPS measurements showed that rising the Rh content led a slight shift the Rh BE to high values, suggesting a possible interaction between metals. In addition, catalysts containing high Rh amounts displaced the BE of Ni^{2+} by 0.5 eV. At low temperature (400°C), catalysts showed similar selectivities following the next order H_2 »CH_4»CO_2»CO. Regarding bimetallic catalysts, it was clearly observed that even at Rh low amounts, the hydrogenation of the CH3 species were favored, given a high CH_4 selectivity. This could reduce catalyst deactivation by accumulation of CH_3 species. Increasing of CO_2 selectivity was observed in bimetallic catalysts suggesting that water gas shift reaction was favored. Moreover, for all bimetallic catalysts no ethylene was found at any temperatures, unlike Ni catalyst. Modification of Ni catalyst containing 0.75% and 1% of Rh improved stability of monometallic catalyst, since no C_2 species were observed and the carbon deposition dropped substantially. In the bimetallic catalyst with 1% Rh and 10% Ni the deposition of carbon decreased 10 times with respect to the Rh catalyst and 560 times with respect to Ni, showing clearly the advantages of the bimetallic catalyst.

Keywords: *ethanol steam reforming reaction, hydrogen production, supported metallic catalysts*

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Ionic liquids, the need of promoting them in the academy as solvents of the future and their undeniable contribution to the green chemistry

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The aim of this study is to publicize the interest that the Academy and especially the industry have shown in ionic liquids in place of conventional solvents. A brief overview is given regarding current health labor problems suffered by workers in permanent contact with common solvents and a documented observation is presented on ionic liquids as solvents of the future. Solvents are substances existing in our life and mostly in the industry. There are about 18 million considerably toxic substances, among them neurotoxic substances; and millions of workers are exposed to their consequences, such as alterations in short and long term memory, concentration, information processing and mood. However, all of these are difficult to detect at first, they have terrible ulterior consequences [1]. Solvents might be hazardous and they are being replaced by ionic liquids, which are liquid substances formed exclusively by ions, whose melting temperature is below 100°C. Some of the features of ionic liquids that make them attractive for the industry are: (i) low steam pressure in environmental temperature; (ii) low melting temperature; (iii) they might be optimized for specific reactions modifying cations and anions structures; (iv) they are considered non flammable; (v) suitable thermal stability; (vi) suitable chemical stability; (vi) they are recoverable and reusable; (vii) they have a wide range of solubility; (ix) they might be designed as non toxic. [2, 3]. These and other properties make ionic liquids a good alternative to permanently substitute organic volatile compounds, such as solvents, which would allow the development of the "Green Chemistry" [3]. The industry expects to design ionic liquids in the pharmaceutical and hydrometallurgical areas, which have been explored since only a couple of years ago [4, 5]. From the documented observation, it is possible to conclude the strong need to publicize in environmental and pharmaceutical scientific communities -among others- the use of ionic liquids as the solvents of the future and their undeniable contribution to the green chemistry.

Keywords: *ionic liquids, solvents of the future, green chemistry, toxicity.*

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Instalation of experimental snow fences in the Coquimbo region, Chile

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Water is a critical resource in the Coquimbo Region, as the regional economy depends on agricultural production and mining, which are two industries that rely heavily on a consistent water supply. Due to relatively low rates of rainfall, meltwater from snow in the highland areas provide the main source of the annual water supply in low-lying areas. However, up to 60-90% is sublimated due to the atmospheric conditions in the region, due to strong winds, high solar radiation, low relative humidity and relatively low temperatures. The aim of this study is to test the use of snow fences for retaining snow on the ground, and for reducing sublimation rates. We hypothesize that a snow fence could reduce the overall rate of sublimation by 30-40% by reducing the factors that cause it. A snow fence acts as a wind break, causing snow-bearing wind to lowers its speed as it passes through the barrier, therein causing suspended snow to fall and accumulate in a reduced area behind the barrier. By accumulating snow behind the fence, the volume of snow exposed reduces, therein reducing sublimation rates.
To test the effectiveness of snow fences, we installed four prototype snow fences in the Coquimbo Region, at altitudes ranging from 2300 to 3550 m a.s.l. and in different geographical settings. At each snow fence location we installed a meteorological station with real-time data transmission and an automatic camera which records daily pictures. The fences have shown to increase the volume of snow accumulated next to them, and to extend the days with snow on the ground in the storage area of the snow fence.

Keywords: *snow fence, experimental, sublimation, water resources.*

Effect the solution pH on the properties of ZnS thin films synthesized by a non-toxic chemical bath solution.

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ZnS films have shown great potential to be used as a buffer layer in thin film solar cells (TFSC) [1]. Even though, ZnS films have been grown using various techniques, it is the Chemical Bath Deposition (DBQ) method which achieves greater energy conversion efficiency in TFSC devices. However, the synthesis of this compound normally includes toxic and highly volatile elements, such as ammonia and hydrazine [2]. Accordingly, synthesis of ZnS thin films free of toxic precursors has been under intense investigation. In this work ZnS films were synthesized free of toxic precursors by means of chemical bath deposition method. The solution pH was varied from 9 to 11.5 by adding appropriate amount of KOH. The influence of the solution pH on the optical and morphological properties of the ZnS thin films were analyzed by means of UV-Vis spectrophotometry and scanning electron microscopy (SEM).
The films exhibited a higher percentage of optical transmission in the visible range (higher than 80 %). From the morphological studies, compact samples were observed with well-defined particles for pH values between 9.5 and 10.5. It was also observed that samples grown at pH 9 did not cover homogenously the substrate surface, and samples grown at pH values higher than 11, films exhibited a high density of cracks.
From the results mentioned above, it is clear that the samples grown at pH between 9.5 and 10.5 are the most suitable for thin films solar cells applications.

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Keywords: *thin films, semiconductors, chemical bath, optical properties.*

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Wind maps of the semi-arid Coquimbo region in Chile

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The electrical energy that can be generated by a wind park depends meanly on the wind speed. Because wind turbines are expensive, it is necessary to monitor the wind conditions for a period of time (at least one year). Wind maps are important tools that allow to choose the best places to install the meteorological station for this purpose.
The goal of this article is to generate wind maps of the semi-arid Coquimbo Region in Chile. We evaluated the mean meteorological conditions in a period of 16 years (1900 to 2005) using the KAMM model (Karlsruhe Atmospheric Mesoscale Model) [1]. The methodology was based in cluster analysis [2], which consists in grouping days with similar characteristics. For each cluster a representative simulation was carried out, which were averaged taking into account its statistical weight. This procedure was performed for each season separately, which were averaged to obtain the annual mean values. The simulated seasonal diurnal cycles of wind speed and wind direction were compared with data registered in 30 meteorological stations distributed in the entire region.
We found that the best wind conditions were located near the coast and in the high Andes Range. The proximity to the Ocean conduce to well-developed thermal winds, with wind speed higher during the day than in the night hours. The highest wind speed are presented in spring and summer, which could favored the use of wind speed for agricultural activities.

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Keywords: *wind energy, mesoscale models, arid zones.*

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Nano-structured catalysts applied to heterogeneous photo-fenton process to degrade herbicides in aqueous phase

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The Fenton (Fe^{2+}/H_2O_2) and photo-Fenton (Fe^{2+}/H_2O_2/UV-Vis) reactions appear as very promising options for the oxidation of a wide range of recalcitrant organic pollutants. The application of these processes to wastewater treatment has aroused great interest mainly due to the fact that Fe is a widely available and nontoxic element, and hydrogen peroxide is easy to handle and the excess decomposes to environmentally safe products [1]. Depending upon the phase, the Fenton and photo-Fenton reactions may be carried out under homogeneous or heterogeneous conditions. Nevertheless, it has been reported that the conventional homogeneous Fenton process based methods suffer from some drawbacks such as (i) the precipitation of soluble iron ions as hydroxide precipitate under neutral pH or alkaline conditions [2], (ii) the requirement of strict pH regulation around 2.8-3 [3], and (iii) the requirement of post-treatment prior to discharge, such as neutralization of the treated solutions [4]. Some of the drawbacks of the conventional Fenton process can be avoided by the use of a heterogeneous catalyst. Mesoporous materials have received widespread interest because of their good distribution of pore size/volume; this allows hundreds of molecules to effectively diffuse to internal active sites, increasing their activity per unit of volume [5]. In previous works, mesoporous materials have been modified like SBA-15 and KIT-6 with Fe showing excellent physical, optical and catalytic properties [6].
In the present work, mesoporous photocatalysts supporting Fe species on SBA-15 and KIT-6 were prepared, for their application in the photo-Fenton heterogeneous reaction for the degradation of the commercial herbicide (atrazine, ATZ) in water. The different mesostructures obtained were characterized by N2 adsorption-desorption at 77 K, TPR and UVVIS-RD. These iron-containing mesostructured materials have been successfully tested for the heterogeneous photo-Fenton degradation of ATZ aqueous solutions using UV-visible irradiation at room temperature and close to neutral pH. Depending on the dispersion and size of the different iron species, the nanocomposites showed different catalytic behaviors. The results showed that the Fe/SBA-15(10) and Fe/KIT-6(5) catalysts exhibited the highest activities. Thus, the high performance of these materials indicates that the heterogeneous via of photo-Fenton process can also be efficiently employed to treat wastewaters containing pollutants such as herbicides, in order to reduce them to simpler and less toxic molecules.

Keywords: *mesostructures, heterogeneous Photo-Fenton, herbicides, degradation.*

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Fe/SBA-15 mesoporous materials as photo-fenton catalyst for azo-dyes degradation

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The photo-Fenton processes are included in the Advanced Oxidation Processes (AOPs) which are efficient for the treatment of waste water affected by organic pollutants. This process involves the use of Fe ions as catalyst to activate hydrogen peroxide (H_2O_2) decomposition in order to generate hydroxyl radicals (OH^*) which are able to degrade organic molecules in aquatic systems under ambient conditions [1]. The Fe salts often used as the metal source are soluble in water, and the Fenton process is usually in homogeneous phase. Nevertheless, this process has the inconvenient of the low operation pH (3) and the difficulty for the recovery of Fe from the generated sludge that need further treatments. Then, the immobilization of Fe species on solids supports result as an attractive option to developed Fenton catalysts in heterogeneous phase. In this sense, materials with porous structures as SBA-15 silicates have attracted increasing interests as supports due to their high specific surface and pore volume [2].

In this work the SBA-15 support was modified with Fe by a simple method (wet impregnation) using a solution of $Fe(NO_3)_3.9H_2O$ in ethanol. After eliminate the solvent in a rotary evaporator the solid was calcined a 350 °C for 3 h. The metal concentration for the impregnating solution was chose in order to reach an Fe load of 2.5 % wt. The solid was test as catalyst for the Acid Orange 7 (AO7) degradation under UV-vis radiation and using a stoichiometric concentration of H2O2. Under the pH of operation (3.5) it was not observed a considerable Fe lixiviation, confirming that the process is under heterogeneous phase. An almost total AO7 and H_2O_2 degradation was observed after 5 h of radiation. For its part, a high mineralization was also observed (81 %) which indicate the efficiency for the tested catalyst.

From the solid characterization by XRD, UV-Vis DR, N2 physisorption and TPR, it was found that the high surface of the regular structured SBA-15 support was just slightly modified by the Fe presence, and a high dispersion of the metal was allowed. Thus, it could be concluded that the high dispersed Fe ions anchored in the SBA-15 surface are responsible for the activity and stability of the catalyst. Then, the catalyst was recovered from the aqueous medium an evaluated in a second catalytic cycle, reaching the same mineralization percentage. This result was other evidence of the high catalyst stability confirming that the process is in heterogeneous phase. Finally, this active catalytic reactivity for the synthetized solid, in addition with the observed stability, provide a great advantage for the proposed photo-Fenton process using a heterogeneous catalyst over the classic homogeneous Fenton process.

Keywords: SBA-15 silicates, photo-Fenton, Stability, Azo-Dyes, Degradation.

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Synthesis of an organic compound of low molecular weight as a potential organic photovoltaic cell and its structural correlation with the respective manganese metalocycle.

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The environmental current problematics has forced scientifics to create new technologies in order to be more sustainable and less pollutant. The use of solar cells is an alternartive to these not renewable energies. In this resume, was realized and synthesized a low molecular weight organic molecule (LMWOM) C20H10O2S2 obtained from the Sonogashira coupling between the p-phenylenediamine (PPD) and benzodithiazole, figure 1. Through 13C and 1H CPMAS RMN spectrometry, conventional spectroscopic technologies, and elementary analysis in dissolution and solid-state, were analyzed evidences that allowed to propose the molecular structure of the LMWOM. Finally were realized computational details for the geometry optimization of LMWOM with dipolar moment of 6.928 Debye. These results were compared with structures cyclic in where the electronic delocalization was major, the dipolar moment was 2.907 Debye and the electronic properties associated can suggest this structure as potential OPV, figure 3.

Characteristic vibrations are found: ν (=C-H) 2945 cm^{-1}, ν (-C-H) 2826 cm^{-1}, ν (C≡C) 2162 cm^{-1}, ν (C=C) 2111 cm^{-1}, v (C=O) 1648, ν (C-H ar) 1017 cm^{-1}, ν (C-S-C) 610 cm^{-1}, MeOH solvent in 3310 cm^{-1}. The assignments 1HRMN were: δ 9.89 (s, 1H), 7.69 (d, J=3.9 Hz, 2H), 7.56 (s, 3H), 7.34 (d, J=3.9 Hz, 3H), 7.26 (s, 5H), δ 9.89 (-CHO), δ 7.69, 7.56 (H hetero aromatic), δ 7.34 7.26 (H double bond aromatic).

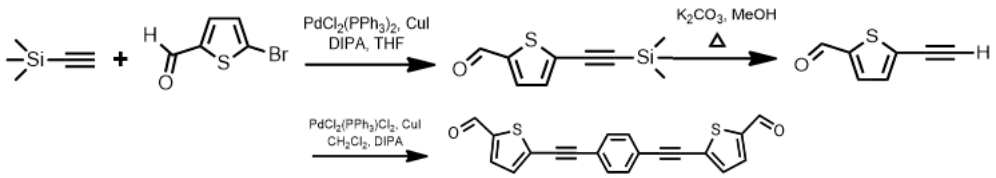

Figure 1: Synthesis of LMWOM

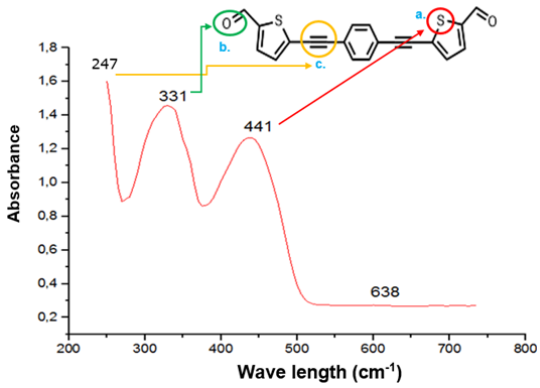

Figure 2: Electronic spectrum of LMWOM

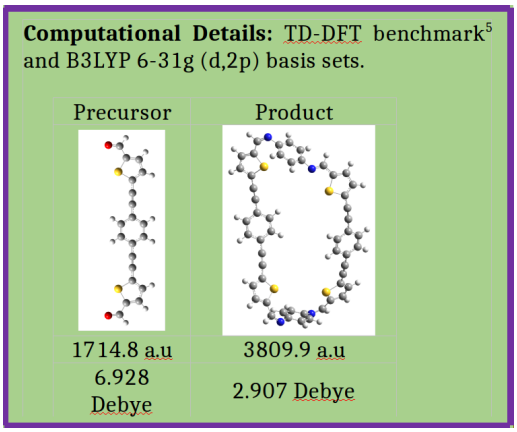

Figure 3: Optimized structures

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