

Editorial

Special Issue: Green Sustainable Chemical Processes

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Sustainable chemical process engineering results from applying the principles of green chemistry or sustainable chemistry to chemical process engineering. Its objective is the development of chemical processes that reduce or eliminate the production of harmful products or waste and maximizing energy efficiency in relation to conventionally established processes. It is an objective that must be sought in the development of any new chemical process from an environmental point of view but also from an economic point of view. From the first line of fire, researchers must thus work under this premise to later transfer it to production systems and teachers must introduce it from the first years of science and engineering studies. All this will undoubtedly be necessary if we want to achieve true sustainable development that does not endanger our natural resources and our environment.

In the call for papers, we invited contributions that promote the design green chemical process engineering including renewable resources, alternative solvents, biofuels, process intensification, biocatalysis, nanotechnology and environmental technologies. All contributions were peer-reviewed according to the usual high standards of this journal. Our thanks go to authors and highly qualified and thorough referees that helped us accept high quality twenty papers (16 original article and 4 review papers). In the following, a brief overview and summary of the individual contributions are given:

Original Articles:

The first contribution in this issue from G. Di Moarcoberardino et al. (Politecnico de Milano, Italy) is entitled "Life cycle assessment and economic analysis of an innovative biogas membrane reformer for hydrogen production." [1] This work investigates the environmental and economic performances of a membrane reformer reactor for hydrogen production from biogas. Palladium membranes in the reforming reactor allows simultaneous hydrogen production and separation. The system was simulated with Aspen and considered two different biogas compositions, biogas produced by landfill and by anaerobic digestion. This technology was compared against conventional hydrogen production processes based on steam reforming, water gas shift reactors and a pressure swing adsorption unit. LCA analysis shows that the new system performs better than reference systems when biogas becomes a limiting factor for hydrogen production to satisfy market demand. On the contrary, when biogas is not a limiting factor for hydrogen production, the innovative system can perform either similar or worse than reference systems. Economic results showed that hydrogen production cost was lower value with respect to the reference cases (4 €/kg_{H2} vs. 4.2 €/kg_{H2}) at the same hydrogen delivery pressure of 20 bar.

The paper by R.X. Alberico et al. (State University of Montes Claros, Brazil) is entitled "Characterization of the Primary Sludge from Pharmaceutical Industry Effluents and Final Disposition" [2] These authors have performed the physicochemical characterization of primary sludge from pharmaceutical industry effluents including: total fixed and volatile solids, moisture, chemical oxygen demand, corrosivity, reactivity and toxicity. Based on this study, the authors propose anaerobic digestion as a treatment for sewage sludge and their subsequent use as a biofertilizer.



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The paper entitled “Prediction of CO₂ solubility in ionic liquids based on multimodel fusion method” by C. L. Xia et al. [3] (Zhejiang University of Technology, China) propose a multimodel fusion modeling method to predict the solubility of CO₂ in ionic liquids. The performance of the fusion model is verified by the test set. The results show that the prediction effect of the linear fusion model is better than other single submodels.

M.E. Zappi et al. (University of Louisiana at Lafayette, USA) contribute to this issue of the journal with their paper “Evaluation of the Methane Production Potential of Catfish Processing Wastewater Using Various Anaerobic Digestion Strategies” [4]. This work evaluates the potential of anaerobic digestion as an alternative to the currently used aerobic biotreatment of catfish processing wastewater. The results showed that nutrient amendment was the most suitable strategy for improving the digestibility of the catfish processing wastewater varying the methane yield from 4 m³ /ton (U.S.) COD input to 121–236 m³ /ton (U.S.) COD input.

The next contribution in this issue from Y. Xi et al. (Kunming University of Science and Technology, China) is entitled “Kinetics of Arsenic Removal in Waste Acid by the Combination of CuSO₄ and Zero-Valent Iron.” [5]. The authors have investigated the kinetics of arsenic removal from waste acid by the combination of zero-valent iron (ZVI) and CuSO₄. The results showed that after the arsenic removal reaction, As₂O₃ and magnetite phases were detected on the surface of ZVI. The arsenic removal process was described by the shrinking core model.

The paper by A.A.M. Elgharbawy et al. (International Institute for Halal Research and Training (INHART), Malaysia) is entitled “Natural Deep Eutectic Solvent-Assisted Pectin Extraction from Pomelo Peel Using Sonoreactor: Experimental Optimization Approach” [6]. In this study, Natural Deep Eutectic Solvent (NADESs) were used for pectin extraction from pomelo (*Citrus grandis* (L.) Osbeck) peels using a sonoreactor. Choline chloride–malonic acid and choline chloride–glucose–water yielded 94% pectin.

The paper by K.M. Rahman et al. (Birmingham City University, UK) is entitled “Determination of the Potential Impact of Domestic Anaerobic Digester Systems: A Community Based Research Initiative in Rural Bangladesh” [7]. These authors examines the potential impact of domestic anaerobic digester (AD) systems adopted in Bangladesh and similar developing countries. Cattle dung and poultry litter feed stocks were specifically investigated. These results showed that small scale AD can offer a positive impact upon rural lifestyles.

The paper entitled “On the Selective Transport of Nutrients through Polymer Inclusion Membranes Based on Ionic Liquids” by Z. Baicha et al. (University of Murcia, Spain) analyzed the transport of nutrients (calcium chloride and sodium hydrogen phosphate) through polymer inclusion membranes based on different concentrations of methyltriocetylammmonium chloride [8]. The results show very low permeation values for CaCl₂. The higher permeation of Na₂HPO₄ respect to CaCl₂ involves that these membranes could be used for the selective transport of nutrients such us Na₂HPO₄ and CaCl₂.

Z. Lentz et al. (North Carolina State University, USA) contribute to this issue of the journal with their paper “Valorization of swine manure into hydrochars” [9]. The objective of this research was to convert manure slurry into hydrochars via hydrothermal carbonization and their chemical-physical characterization. The parameters (i.e., temperature) involved in the reaction was studied, pH, energy contents and thermal and oxidation kinetic parameters. Different uses of hydrochars were studied.

The next contribution in this issue from H.S. Kharal et al. (University of Engineering and Technology, Lahore, Pakistan) is entitled “Environment-Friendly and Efficient Gaseous Insulator as a Potential Alternative to SF₆” [10]. Authors evaluate the refrigerant R152a as a potential alternative for SF₆ (global warming potential (GWP) of 22,800 times compared to CO₂) in electrical insulation systems. R152a gas has a significantly reduced value of GWP (140) and is a cheap insulation medium as compared to SF₆. From this study, R152a/CO₂ gas reveals good dielectric properties, and insulation performance can reach up to 96% of SF₆.

The paper by V. Martín-Dominguez et al. (Complutense University, Spain) is entitled “Kinetic modelling of the coproduction process of fumaric and malic acids by *Rhizopus arrhizus* NRRL 1526” [11]. This work investigates the biotechnological fumaric and malic acid production via fungi of the *Rhizopus* genus. The authors found that the production of the organic acids is mainly non-associated with fungal growth.

The paper by M. Magni et al. (Università degli Studi di Milano, Italy) is entitled “Green corrosion inhibitors from agri-food wastes: The case of *Punica granatum* extract and its constituent ellagic acid. A Validation Study” [12]. These authors studied corrosion inhibition effect induced by a methanolic extract from wastes of fermented *Punica granatum* and by its main component the ellagic acid.

The paper entitled “Discovering low toxicity ionic liquids for *saccharomyces cerevisiae* by using the agar well diffusion test” [13] by F. Missoun et al. (University of Murcia, Spain) studied the toxicity of a wide range of ionic liquids towards *S. cerevisiae* using the agar well diffusion test. Through this methodology, nine fully biocompatible ILs toward *S. cerevisiae* were identified, including: [Bmim⁺][NO₃⁻], [HOPmim⁺][NO₃⁻], [Bmim⁺][NTf₂⁻], [N_{8,8,8,1}⁺][NTf₂⁻], [S_{2,2,2}⁺][NTf₂⁻], [EMPyr⁺][NTf₂⁻], [BMPi⁺][NTf₂⁻], [Moxa⁺][MeSO₄⁻] and [Chol⁺][H₂PO₄⁻]. Beside the qualitative toxicity-structure relationship is also analyzed, which could help to select the more suitable ionic liquids for designing sustainable biocatalytic processes.

T. Havelt et al. (Bonn-Rhein-Sieg University of Applied Sciences, Germany) contribute to this issue of the journal with their paper “Characterisation of bioactive ingredients in extracts of fresh and dried coniferous trees for the development of sustainable packaging materials.” [14]. This work aims to characterize the antioxidant and light-absorbing properties and ingredients of different coniferous wood extracts with regard to different plant fragments and drying conditions. They conclude that coniferous woods are a promising renewable resource for preparation of sustainable antioxidants and photostabilizers. Besides, after extraction, the biomass can be fully valorized by incorporation in paper packaging.

The next contribution in this issue from L. Xia et al. (Zhejiang University of Technology, China) is entitled “Prediction of the solubility of CO₂ in imidazolium ionic liquids based on selective ensemble modeling method.” [15]. A selective ensemble modeling method has been developed and applied by author to the prediction of the solubility of CO₂ in imidazolium ionic liquids. The model was also validated against CO₂ solubility experimental data. This work not only provided an effective modeling method for the prediction of the solubility of CO₂ in ionic liquids, but also provided an effective method for the discrimination of ionic liquids for CO₂ capture.

The last original article in this special issue is from S. Bougarrani et al. (University Med V, Morocco) and is entitled “Improving the imazapyr degradation by photocatalytic ozonation: A comparative study with different oxidative chemical processes.” [16]. In this work, the degradation of imazapyr (commercial herbicide) was investigated. This study shows that the association of two oxidation processes, ozonation and photocatalysis, improve oxidation efficiencies for water treatment under optimal conditions.

Review papers:

Samuel Morales-Navarro et al. (Universidad Santo Tomás, Chile) have published a review paper entitled “Theoretical and Experimental Approaches Aimed at Drug Design Targeting Neurodegenerative Diseases” [17]. They review how green chemistry and computational approaches have been used to develop new compounds with the potential application against neurodegenerative diseases/disorders and the challenges and new directions of the drug development multidisciplinary process

Other review is related with the topic energy and specifically describes the development of textile-based supercapacitors. They analyze materials, methodology to prepare textile materials and applications supercapacitors. This paper is entitled “Flexible energy storage system—An introductory review of textile-based flexible supercapacitors” and it is authored by C.Y. Hui et al. (The Hong Kong Polytechnic University, China) [18].

Nanotechnology and particularly nanoemulsions (NEs) have gained increasing interest throughout the years. For that the review paper entitled “Nanoemulsions: Factory for food, pharmaceutical and cosmetics” has been included in the special issue [19]. This paper is authored by N.A.N. Azmi et al. (International Institute for Halal Research and Training (INHART), Malaysia) and the review includes components, properties, formation and applications of nanoemulsions. Applications of NEs are described in three main areas: food, cosmetics and drug delivery.

The last review paper presents an interesting systematic and detailed summary of the contemporary metabolic engineering approaches employed for L-tryptophan production. It is entitled “Metabolic engineering and fermentation process strategies for L-Tryptophan production by *Escherichia coli*” and it was presented by L. Liu (School of Life Science and Food Engineering, China) [20].

The collection of works in this special issue constitutes one more step forward in the race for the development of desired, greener, more sustainable chemical processes. We are confident that much more advancements in this field will be seen in the coming years. These advancements will bring great research opportunities and excitement to researchers and practitioners working in this field and will in the same time make our living environment safer and more pleasant. We hope that you find these papers interesting and wish you much success in your research in the field of green chemical engineering process.

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