processes

Editorial

Emerging Technologies for Biorefining, Food and Environmental Applications

Roberto Castro-Muñoz

Tecnologico de Monterrey, Campus Toluca, Avenida Eduardo Monroy Cárdenas 2000, San Antonio Buenavista, Toluca de Lerdo 50110, Mexico; food.biotechnology88@gmail.com or castromr@tec.mx

Several emerging technologies, such as membrane technologies, biofermentation, oxidation processes, among others, are currently attracting interest in different areas of biotechnological and chemical engineering. Such technologies offer the possibility of biorefining several products and by-products from traditional transformation processes (e.g., food, biotechnology, petrochemical factories). Additionally, these technologies provide relevant insights into reducing hazardous wastes, representing a promising alternative to environmental issues. Therefore, this Special Issue highlights the importance of emerging techniques for biorefining, food, and environmental applications. The papers compiled in this Special Issue can be read as a response by the research community according to the current needs and challenges. In the field of food technology, Tahir et al. [1] constructed and evaluated the performance of a smokehouse system for smoking fish by integrating a biomass furnace, heat exchanger, cyclone separator, and a smoking chamber. The authors concluded that the system worked efficiently for smoking fish using a temperature in the smoking chamber from 70 to 108 °C.

Towards environmental approaches, membrane technologies, such as membrane bioreactors, are one of the main tools for domestic wastewater treatment and reuse. In this regard, Thejani Nilusha et al. [2] developed the optimization and stable operation of an anaerobic ceramic membrane bioreactor. Interestingly, a flux rate over 70% of the initial membrane flux was successfully stabilized by in situ permeate backwashing, which in fact contributed to reduce the membrane fouling. Additionally, this investigation evidenced important variables to reduce the cost of widely applied chemical reagents for backwashing and chemical cleaning of ceramic membranes. The anaerobic treatment is also a powerful alternative to treat wastes and concurrently produce biogas. The efforts have been focused on evaluating the performance of anaerobic digestion by adding different metal ions within the enzymatic activity of five types of enzymes. In this Special Issue, Ale et al. [3] studied the effect of Barium (Ba^{2+}) usage on the hydrolytic enzymatic activity in food waste degradation at anaerobic conditions. They use a lab-scale anaerobic semi-continuous hydrolytic reactor that was operated for 171 days. After experimentation, it was observed that Ba^{2+} promoted β-amylases activity by 76%, and concurrently inhibited endoglucanases and α-amylases activity by 39 and 20%, respectively. The work provided by Ale and co-workers served as a pioneering work to understand the mechanism of Ba^{2+} on the physiological processes of cellulose and starch biodegradation under anaerobic conditions. With the aim of reducing the food wastes, Ghinea and Leahu [4] monitored the fruit and vegetable waste composting operation by analyzing the relationship between microorganisms and physicochemical parameters. In fact, it was noted that the microbial communities were constantly varying through the composting process. In a different study, Contreras-Cisneros et al. [5] applied biodrying of orange peel together with mulch and sugarcane bagasse. At this point, the researchers were mainly focused on studying the relationship of moisture and temperature to the concentration of O_2 and CO_2. Such a biodrying process (from beginning to 35 days) was governed by the combination of microbial heat, convection, and solar irradiance; while at the end of the processes (after

check for updates

Citation: Castro-Muñoz, R. Emerging Technologies for Biorefining, Food and Environmental Applications. *Processes* **2021**, *9*, 668. https://doi.org/10.3390/pr9040668

Received: 8 April 2021
Accepted: 8 April 2021
Published: 10 April 2021

35 days), the drying process was mainly done by convection and solar irradiance, allowing to attain piles with a moisture content between 12–14%. In the same line of environmental issues, Malvic et al. [6] performed the geological risk calculation to assess the safety of geological environment storage in deep wells, in which regionally distributed lithologies were considered for nuclear waste disposal purposes. All this was done considering petrophysical values, water saturation, recent weathering, and tectonic activity.

A study of the ozonation process combined with ultraviolet radiation was proposed by Prasetyaningrum et al. [7]. Their core aim was to establish an efficient photochemical oxidation process of copper (Cu) from electroplating wastewater. In this work, the authors evaluated different process variables, such as Cu concentration, ozone dosage, UV irradiation intensity, and pH value. Thanks to the high production rate of HO• radicals, this integrated system revealed high performance on Cu removal. At this point, it is likely that the integration of different processes is a feasible way to reach the intensification of processes and thus highly efficient technologies. For instance, Osuna-Laveaga et al. [8] also proposed the combination of ozonation and enzymatic hydrolysis of sugarcane bagasse. Herein, a lab-scale fixed bed reactor was utilized for ozonation evaluating different ozone doses (50, 75, and 100 mg O_3/g bagasse), particle size (420, 710, and 1000 µm), and moisture content (30, 45, and 60% w/w). The overall integrated process allowed obtaining glucose and xylose yields as high as 45 and 38%, respectively. In addition, the authors confirmed that used operating conditions contributed to an efficient ozone utilization (<2% unreacted ozone) with a yield of 0.29 g sugars/g bagasse. According to the current trend in the field of wastewater treatment, the removal of heavy metals, such as Ni^{2+} and Zn^{2+}, from aqueous solutions can be performed by biosorption. This was evidenced by Morales-Barrera et al. [9] during the evaluation of the biosorption capacity of *Lemna gibba* plant. The results declared that the plant displayed a higher affinity towards Zn^{2+} ions compared to Ni^{2+} ions. According to the authors' findings, hemicellulose and cellulose are the responsible compounds for the biosorption of the metal ions, which was confirmed and validated by several analyses.

The contributors of this Special Issue are also aware of the production of new materials and feedstock for promising applications. This is the case of the report provided by Tran et al. [10], who enhanced the astaxanthin biosynthesis by means of *Rhodosporidium toruloides* mutants. As it is well known, astaxanthin is a high-added-value compound that is potentially suggested in new food formulations as a natural colorant. In their study, Tran and co-workers investigated *Rhodosporidium toruloides* mutants for improved astaxanthin accumulation using ultraviolet (UV) and gamma irradiation mutagenesis, where gamma irradiation was found to be more efficient than UV for producing astaxanthin. By optimizing the medium compositions in terms of peptone, malt extract, and glucose concentration, it was highlighted that the maximum astaxanthin yield reached ca. 3021 µg/L, which was a competitive production yield compared with several reported works in the field.

According to the scarcity of fresh drinking water, seawater desalination and wastewater recycling have become an alternative to reach such water demand. Today, several technologies, such as electro-dialysis, multi-stage flash desalination, reverse osmosis, multi-effect distillation, and capacitive deionization, including membrane. In this matter, Botha and co-workers [11] analyzed the effect of slurry wet mixing time, thermal treatment, and method of electrode preparation on membrane capacitive deionization performance. Thus, different electrodes were fabricated showing superior desalination capacity. In desalination outcomes, it was demonstrated that the electrodes prepared from slurries mixed longer than 30 min exhibited a relevant reduction in the maximum salt adsorption capacity associated with the agglomeration of carbon black. Today, carbon-based materials are intensively applied in the enhancements of properties of other materials; for example, Rybarczyk et al. [12] have very recently documented that biomass-derived nitrogen functionalized carbon nanodots enhanced the antibacterial properties of composite materials. When incorporated in membranes, carbon nanodots promoted bacterial wall disruption of *Klebsiella oxytoca* and *Pseudomonas aeruginosa*. Moreover, the embedding of carbon nanodots into membranes also improved their hydrophilicity and surface charge without compromising the integrity.

To finalize, outstanding review papers were compiled in this Special Issue. Miralrio and Espinoza [13] reviewed the application of plant extracts as green corrosion inhibitors for different metal surfaces and corrosive media, paying particular attention to corrosion inhibitor—metal surface interactions. In this comprehensive literature review, the authors found out that electron-rich regions and heteroatoms are generally responsible for chemisorption on the metal surface, while physisorption can occur depending on the polar regions of the inhibitor molecules. Additionally, they revealed that the plant extracts mainly offer corrosion inhibition efficiencies over 60%, but most of the development works report efficiencies ranged from 80 to 90%. Another interesting review was released by Pérez-Guzmán and Castro-Muñoz [14], who elucidated the last five years' applications and development works on using zein as a potential biopolymer for tissue engineering and nanotechnological approaches. Zein constitutes between 44- 79% of the total protein content of the endosperm of maize. The review stated that such biopolymer has been majorly applied as scaffold support to the cells in the regeneration of different types of tissues including nerves, cartilage, tendon, ligaments, vascular functions, and skin, while its application in nanotechnology comprises as a wall material for encapsulating biologically active compounds that are sensitive to environmental changes. Additionally, the authors declared that the upcoming works using zein could deal with scaffold fabrication and design with the aid of 3D printing, as well as in drug delivery and controlled administration of drugs. Ultimately, Mbakop et al. [15] compiled the recent advances in the synthesis of nanocellulose functionalized–hybrid membranes and their application for the enhancements of water quality. Considering that such nanomaterials present interesting properties such as tuneable surface chemistry, mechanical strength, biodegradability, biocompatibility, etc., the researchers reviewed the different types of nanocelluloses, their established production protocols, and their influence in nanocellulose-based membranes for membrane filtration (e.g., micro, ultra- and nanofiltration, and membrane distillation). Over the course of this review, it was addressed that the use of nanocellulose in membranes enforced the separation efficiency of membranes (in terms of permeate flux and rejection rates) as a result of improving the relevant membrane properties such as hydrophilicity and mechanical features. Furthermore, the authors confirmed that nanocelluloses are representative materials to perform various types of chemical functionalization that may lead to the fabrication of membranes with unprecedented performance.

Over the course of this Special Issue, the editor has identified the great efforts of contributors in providing real cases of study and compelling analysis of the state of the art. The papers are not only oriented to the development of emerging technologies for biorefining, food, and environmental applications but also in exploring the potential of promising substrates and feedstock for the synthesis of new materials in chemical processes. This Special Issue has also evidenced that the application of membranes can cover from chemical separations to many processes and technologies in various fields, paving the way to their increasingly industrial exploitation.

Funding: This Special Issue received no external funding.

Acknowledgments: The editor acknowledges all the contributors to this Special Issue, thanking their efforts to prepare featured manuscripts.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Tahir, M.; Salengke, S.; Mrsalim; Metusalach; Caesarendra, W. Performance of smokehouse designed for smoking fish with the indirect method. *Processes* **2020**, *8*, 204. [CrossRef]
2. Nilusha, R.T.; Wang, T.; Wang, H.; Yu, D.; Zhang, J.; Wei, Y. Optimization of in situ backwashing frequency for stable operation of anaerobic ceramic membrane bioreactor. *Processes* **2020**, *8*.

3. Ale, F.; Castro-Muñoz, R.; Barragán-Huerta, B.E.; Rodriguez-Nava, O. Effect of Barium Addition on Hydrolytic Enzymatic Activities in Food Waste Degradation under Anaerobic Conditions. *Processes* **2020**, *8*, 1371. [CrossRef]
4. Ghinea, C.; Leahu, A. Monitoring of fruit and vegetable waste composting process: Relationship between microorganisms and physico-chemical parameters. *Processes* **2020**, *8*, 302. [CrossRef]
5. Contreras-Cisneros, R.M.; Orozco-Álvarez, C.; Piña-Guzmán, A.B.; Ballesteros-Vásquez, L.C.; Molina-Escobar, L.; Alcántara-García, S.S.; Robles-Martínez, F. The Relationship of Moisture and Temperature to the Concentration of O2 and CO2 during Biodrying in Semi-Static Piles. *Processes* **2021**, *9*, 520. [CrossRef]
6. Malvić, T.; Dinis, M.A.P.; Velić, J.; Sremac, J.; Ivšinović, J.; Bošnjak, M.; Barudžija, U.; Veinović, Ž.; Fernando Pedrosa e Sousa, H. Geological risk calculation through probability of success (PoS), applied to radioactive waste disposal in deep wells: A conceptual study in the pre-neogene basement in the northern Croatia. *Processes* **2020**, *8*, 755. [CrossRef]
7. Prasetyaningrum, A.; Riyanto, T.; Djaeni, M.; Widayat, W. Photochemical oxidation process of copper from electroplating wastewater: Process performance and kinetic study. *Processes* **2020**, *8*, 1276. [CrossRef]
8. Osuna-Laveaga, D.R.; García-Depraect, O.; Vallejo-Rodríguez, R.; López-López, A.; León-Becerril, E. Integrated ozonation-enzymatic hydrolysis pretreatment of sugarcane bagasse: Enhancement of sugars released to expended ozone ratio. *Processes* **2020**, *8*, 1274. [CrossRef]
9. Morales-Barrera, L.; Flores-Ortiz, C.M.; Cristiani-Urbina, E. Single and binary equilibrium studies for Ni2+ and Zn2+ biosorption onto lemna gibba from aqueous solutions. *Processes* **2020**, *8*, 1089. [CrossRef]
10. Tran, T.N.; Ngo, D.; Tran, Q.; Nguyen, H.; Su, C.; Ngo, D. Enhancing Astaxanthin Biosynthesis by Rhodosporidium toruloides Mutants and Optimization of Medium Compositions Using Response Surface Methodology. *Processes* **2020**, *8*, 497. [CrossRef]
11. Botha, E.; Smith, N.; Hlabano-Moyo, B.; Bladergroen, B. The effect of slurry wet mixing time, thermal treatment, and method of electrode preparation on membrane capacitive deionisation performance. *Processes* **2021**, *9*, 1. [CrossRef]
12. Rybarczyk, M.K.; Gontarek-Castro, E.; Ollik, K.; Lieder, M. Biomass-derived nitrogen functionalized carbon nanodots and their anti-biofouling properties. *Processes* **2021**, *9*, 1–14.
13. Miralrio, A.; Vázquez, A.E. Plant extracts as green corrosion inhibitors for different metal surfaces and corrosive media: A review. *Processes* **2020**, *8*, 942. [CrossRef]
14. Pérez-Guzmán, C.J.; Castro-Muñoz, R. A review of zein as a potential biopolymer for tissue engineering and nanotechnological applications. *Processes* **2020**, *8*, 1376. [CrossRef]
15. Mbakop, S.; Nthunya, L.N.; Onyango, M.S. Recent Advances in the Synthesis of Nanocellulose Functionalized–Hybrid Membranes and Application in Water Quality Improvement. *Processes* **2021**, *9*, 611. [CrossRef]