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Preface

Bioresource technology for bioenergy, bioproducts & environmental sustainability

A B S T R A C T

The 3rd International Conference for Bioresource Technology for Bioenergy, Bioproducts & Environmental Sustainability (BIORESTEC) was held online from 17 to 19 May 2021. More than 120 participants from all over the world participated in this conference. The conference was studded with nine plenary lectures, ten invited lectures as well as more than 50 oral presentations along with several poster presentations. The purpose of the conference was to foster the exchange of knowledge and ideas among researchers in academia and industry as well as policymakers working on various aspects of biorefinery to discuss the progress made during the inter-vening three years and the latest trends in biotechnology, bioenergy, and biobased products. Biorefinery is winning over petrol refinery due to its sustainable nature and is the major driving force to a positive push to World's bioeconomy. Biorefinery enables us to obtain cascades of products by using biomass; including bio-energy, platform chemicals and various other bioproducts. Most of the talks during the conference dealt with sustainable practices for producing or synthesizing biomolecules via microorganisms. Bacteria, fungi as well algae were presented as bio machinery to convert the waste residues into value-added products including bio-energy and other biomolecules. This virtual special issue includes a selection of papers presented at the BIO-RESTEC conference, which contribute to environmental sustainability and give a strong message on sustainable technologies through developing bioproducts in order to overcome environmental issues.

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1. Lignocellulosic biorefinery developments

Lignocellulosic biomass is cheap, abundant and globally available resource for transformation of energy. There has been a recent increase in public interest in the recovery of materials and energy from waste biomass and the development of sustainable substitutions to fossil fuel-based resources in the last few decades. More recently, lignocellulosic biorefineries are blooming with the need for current technology advancement for the production of renewable chemicals and energy. Moreover, commercial biorefineries are still facing critical challenges for process optimisation. For instance, feedstock type, preconditioning, pre-treatment, chemical composition, enzyme doses are major cost barriers in conversion processes. Therefore, Singhal et al. (2021) in their report demonstrated the basic washing paraments on the chemical composition of empty fruit bunches of palm oil for pre-treatment. They demonstrated that prewashing could lead to the increase in poly-saccharide concentration and remove ash while removing 82–98% Cl, 64–80% S, 38–77% K, 34–67% ash, and 24–63% N, respectively, from oil palm at laboratory and pilot scale at the optimum condition of 1:15 S:L ratio at 50 °C. Furthermore, to improve the conversion efficiency and applicability of washing pre-treatment for combustion, pyrolysis and gasification, they further demonstrated a novel pretreatment approach using multi-step washing with fresh water and wastewater recirculation could help in further removal of K (<68%), Cl (<99%), S (<80%), N (<58%), and ash (<52%), while reducing fouling, slagging and corrosion propensity of wheat straw and empty fruit bunches of oil palm biomass and could be adopted for large scale biorefinery applications.

For a commercial biorefinery, low-cost pretreatment is highly desirable. Hydrothermal liquefaction has recently gained interest for conversation of wet or high moisture content waste biomass to fuels and chemicals. In view of this, a research article published under this SI by Saengsuriwong et al. (2021) demonstrated the effect of hydrothermal liquefaction of food waste for the production of bio-oils varying different temperatures ranging from 280–340 °C ad 1:3 to 1:7 sample to water ratio for 30 min reaction time in high throughput reactor. They found that at the optimized condition of 340 °C and 1:7 mixture ratio, a maximum of 40% (w/w) bio-oil could be yielded with 70% energy recovery. Moreover, chemical analysis showed that fatty acids, amides, N-containing compounds and cyclic ketones were major chemical components of bio-oils. This research paper provides the opportunity for the commercial development of hydrothermal liquefaction technology for fuels and chemical production.

Enzymes play a critical role in overall hydrolysis and are a determinant factor. Interestingly this SI also covers some new aspects of repeated fed-batch study for industrial production of lactulose and lactulose containing prebiotic mixtures with immobilized β-galactosidase in semi-continuous operation with AO β-gal covalently immobilized in glyoxyl-agarose support stands. Ramirez and co-authors investigated the feed flow rate in the fed state and varied the ratio of fructose to lactose for maximum lactulose production and selectivity of transgalactosylation (Ramírez et al., 2021). β-Galactosidase is a well-known enzyme for the synthesis of non-ionic surfactants, i.e., alkyl-(poly)glycosides (AGs) from lactose. In general most of the carbohydrates (i.e., lactose, glucose and galactose) are preferentially soluble in the aqueous phase and butyl-β-galactoside (BβG) is evenly distributed in both phases of the reaction medium. Therefore, in an advanced approach, Muñoz et al. (2021) demonstrated the partitioning performance of butyl-β-galactoside synthesis with Aspergillus oryzae β-galactosidase. They demonstrated that the partition coefficient of the donor substrate (lactose) and the reaction products (glucose, galactose and butyl-β-galactoside) at 30 to 50 C resulted in 130 and 30-fold solubility in the organic phase compared to lactose and the monosaccharides, respectively. They concluded that the interfacial properties of BβG suggest could be employed as a building block in organic chemistry or as a hydrotropic agent.

2. Renewable feed stock exploration

Food waste is becoming a major environmental issue, with a projected annual production of 931 million tons. Recyclable and value-added goods such as biofertilizers, carbon-based polymers, and solid biofuel can be produced from food waste digestate (FWD), which has a wide range of environmental uses. Even though there is a wide range of feedstock sources for anaerobic digestion (AD) (each of which has its own unique characteristics), these existing studies fail to differentiate between them. This is a critical issue that affects the selection of subsequent valorization processes for a wide range of applications. As a result, Dutta and his colleague examined the various characteristics of FWD and the currently available treatment options. Microalgal culture and biofuel production both stand to benefit greatly from FWD as a fertilizer supply. It would be interesting to investigate the potential of new thermal conversion methods for converting FWD into high-value bioproducts like functionalized hydrochar with a wide range of uses. In order to maximize the use of resources and decrease carbon emissions, integrated AD facilities with consequent valorization amenities are extremely recommended (Dutta et al., 2021). A new and energy-efficient valorization method for high-moisture digestate, hydrothermal carbonization was shown to be a developing and viable option, bringing advantages in dewaterability, the production of useful carbon materials, and solid fuels. The resource loop may be closed and a circular economy actualized by combining anaerobic digestion of food waste with later valorization technologies (Dutta et al., 2021).

Due to the fact that microalgae can grow in wastewater, which generally contains nutrients such as nitrogen and phosphorus that are needed for microalgae development, there has been a surge in interest in utilizing microalgae to make biofuels. As a result of their presence in wastewater discharges, these chemicals may cause environmental harm such as eutrophication, which results in oxygen depletion, the loss of biological diversity, and a rise in the turbidity and toxicity of the water. As a result, Vargas-Estrada and his colleagues studied the feasibility of incorporating microalgae cultivation into treating wastewater as tertiary treatment to retrieve nutrients such as nitrogen and phosphorus. These findings indicate that microalgae cultivation may be used as a tertiary wastewater treatment method since nutrients can be recovered in the form of biogas (Vargas-Estrada et al., 2021). They came to the conclusion that microalgae grown in wastewater were capable of significant nutrient removal, with TP and NH^{4+} removal rates of 100% and 97.85%, respectively, when grown in wastewater. Consequently, the findings indicated that microalgae grown entirely from wastewater are more practical for biogas generation (Vargas-Estrada et al., 2021).

The removal of nitrogen (N) from wastewater is essential to reduce eutrophication induced by the misuse of chemical fertilizers. Conventional N removal strategies are comprised of a biological process that permits N to be transformed into nitrite, nitrate, and finally N gases. However, typical biological elimination procedures may contribute to climate change as a result of the generation of greenhouse gases. Muscarella et al. (2021) evaluated the suitability of zeolite as a suitable medium for ammonium adsorption, desorption, and recovery from wastewater in this direction, and they found that it was effective. A specific set of experiments was carried out using zeolite to investigate the effects of chemical treatment and contact time on adsorption and desorption of NH_4^+-enriched solutions in batch mode. Their findings concluded that treatments with NaCl resulted in greater and quicker NH_4^+ absorption than treatments with $CaCl_2$ and $MgCl_2$, independent of the pre-treatment (Muscarella et al., 2021).

Besides, the concept of the biorefinery is a dream without a cost-effective production of value-added products. Rigorous research is going on worldwide to bring down the cost of value-added products. Astaxanthin is a reported anti-inflammatory compound produced by *Haematococcus Pluvialis.* Yu and coworkers showed the production enhancement of omega-3 fatty acid and natural antioxidant astaxanthin in *Haematococcus Pluvialis* by the addition of calcium ions (Yu et al., 2021). The addition of calcium carbonate resulted in increased biomass and astaxanthin production nearly 178 and 522-fold respectively. The research output from this study signified the role of calcium ions for the upscaling of natural antioxidant production on the industrial level coupled with carbon sequestration is beneficial for the biorefinery concept. Carbon sequestering microorganisms are the future machinery for energy and chemicals production. Sewage sludge is an abundant source of carbon produced by the urban population and is increasing exponentially with increasing urbanization. Sewage sludge is a global problem that needs to be properly addressed. There are many sewage minimization techniques one of them is the bioconversion of sewage sludge into value-added products such as volatile fatty acids (VFA) using microorganisms. VFA production is highly dependent on the pH of sludge. Presti and coworkers extensively studied the role of pH and volatile solids on volatile fatty acid production using sewage sludge (Presti et al., 2021). The change in the microbial community before and after the start of batch reactors showed an increase in the dominance of proteobacteria and Bacteroidetes. Their study demonstrated the changes in the microbial community were in parallel with the production of volatile fatty acids. Volatile fatty acids can be further used for the production of value-added products such as polyhydroxyalkanoates (PHA). PHAs are produced by the microorganisms as an energy and carbon reserve for survival during stress conditions in nutrient limiting conditions. There are different types of PHAs produced naturally such as Polyhydroxybutyrate (PHB), polyhydroxy valerate (PHV), Polyhydroxybutyrate-co-valerate (PHBV) etc. Carbon sequestering autotrophs generally produce PHB using carbon dioxide. Sirohi and coworkers critically reviewed the production of Polyhydroxybutyrate (PHB) using carbon dioxide as substrate by autotrophs/microalgae (Sirohi et al., 2021). An improved understanding about the sequestration of carbon dioxide from flue gas and the advanced development of the carbon sequestering microorganism is essential for an efficient biorefinery.

3. Conclusions

Technological advancement in biorefinery process would lead to a sustainable future with reduction in carbon foot prints. The research articles published under Biorestec special issue would help technologists, scientific community and renewable industries to establish eco-friendly technologies for dissimilation of organic waste stream in to green chemicals and fuels in biorefinery approach.

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