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Editorial

Processes for Bioenergy and Resources Recovery from Biowaste

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1. Introduction

The increasing quantity of biowaste generation and the requirements governing their ultimate disposal are of serious economic and environmental concern [1]. Our existing waste management facilities continue to experience the challenge of balancing population growth and sustainable biowaste management practices that meet regulatory limits. As many countries across the world set goals to reduce waste landfilling, there has been growing attention to developing reliable technologies for converting biowaste to biofuels and other value-added bioproducts, thereby building sustainable waste infrastructures [2]. The most widely researched biological and thermochemical approaches for bioenergy and resource recovery from biowaste include anaerobic digestion [3], microbial fermentation [4], gasification and pyrolysis [5,6].

Anaerobic digestion is arguably the most widely adopted bioenergy process for various biowastes, including sewage sludge, organic fraction of municipal solid waste, and agricultural and livestock waste. Biogas produced from the process can be utilized for heat and electricity generation. Biogas can also be upgraded to renewable natural gas. Despite anaerobic digestion being a matured biowaste-to-energy process, there are several challenges related to process kinetics and stability that need to be addressed to improve digester economics further [7]. Pre-treatment of feedstock prior to anaerobic digestion has been explored and adopted in full-scale anaerobic digestion facilities [8], while further research is required for process optimization. Moreover, in recent years, amending conductive materials in digesters [7], integrating anaerobic digestion with microbial electrochemical systems has also been demonstrated to be a potential approach to overcome process kinetics and stability issues faced in conventional digesters [9]. However, most of these emerging ideas have only been demonstrated on the lab-scale.

Anaerobic microbial fermentation for carboxylic acid production from organic waste has received significant attention due to its potential application in biofuels and production of various green chemicals [4]. For instance, anaerobic fermentation of sludge has been adopted by many wastewater treatment plants to produce organic acids to supplement exogenous electron donors to the biological nutrient removal process [10]. However, increasing product yields has been and continues to be of great interest to researchers. Combustion, pyrolysis, and gasification are major thermochemical conversion processes studied for conversion of waste to various value-added resources, such as syngas, biochar, and bio-oil [11]. The thermochemical conversion of waste biomass differs from conventional coal gasification. Notably, the higher moisture content, lower energy density, non-uniformity of waste biomass can significantly influence process performance [12]. Thus, efficient and economically viable thermochemical conversion processes for various waste streams are yet to be developed. The growing research interests in the aforementioned areas drew inspiration in compiling this Special Issue.

2. Statistics of the Special Issue

The Special Issue showcases ten full-length original research articles [13–22], one short communication [23], and one review article [24] covering different aspects of various processes for bioenergy and resource recovery from biowaste. Specifically, the accepted manuscripts covered a range of essential topics in the areas of anaerobic digestion, microbial fermentation, and thermochemical conversion targeting various value-added resources, including biogas, syngas, bio-oil, and organic acids (Figure 1). The authors' geographical distribution (published articles) is:

- China (7)
- Canada (2)
- USA (1)
- Indonesia (1)
- Sweden (1)

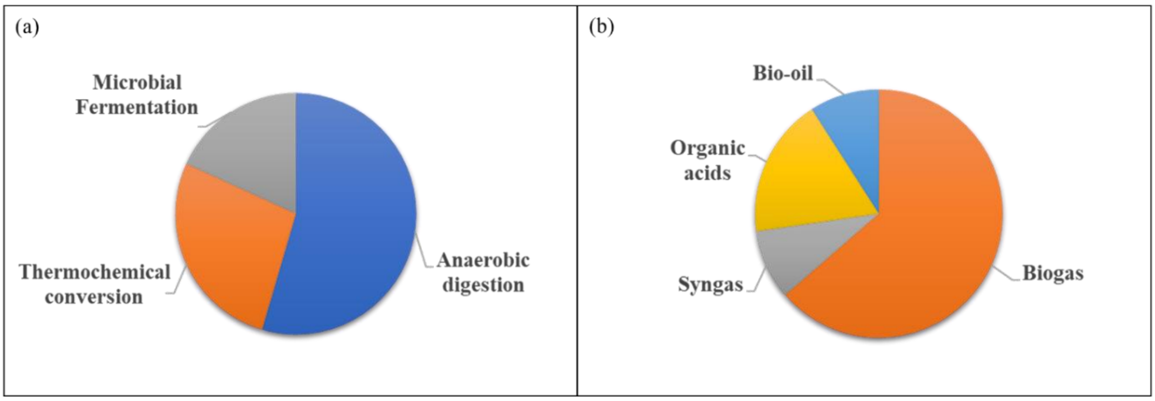

Figure 1. (**a**) Processes, and (**b**) target value-added products covered in this Special Issue.

3. Overview of the Contributions

Among the published articles, multiple articles presented different fundamental and applied aspects of anaerobic digestion for biogas production. Liu et al. [22] proposed the co-supplementation of ethylenediaminetetraacetic acid (EDTA) and Fe^{2+} to improve methane yield and process stability in anaerobic digestion of kitchen waste. Their results suggested that EDTA-Fe^{2+} could stimulate enzymatic activity by improving Fe bioavailability. Chowdhury et al. [13] proposed a two-stage anaerobic digestion process combining high-solid anaerobic digestion followed by ultrasonication of digestate and wet-type anaerobic digestion for effective biomethane recovery from the organic fraction of municipal solid waste. Dong et al. [19] presented a Computational Fluid Dynamics (CFD) simulation on hydrodynamic characteristics of anaerobic granule swarms with various voidages in an internal circulation (IC) anaerobic reactor. Moreover, Wang et al. [18] presented another CFD study on the understanding of flow behaviors of gas–liquid inside the vertical riser inside the IC anaerobic reactor. These simulation results would be useful in the optimization of the design and operation of IC anaerobic bioreactors. Last but not least, Anukam et al. [24] reviewed recent advances towards improving the anaerobic digestion process. Their review also highlighted emerging techniques, including the application of conductive materials and microbial electrochemical systems.

Two articles in this Special Issue showcased approaches for improving anaerobic microbial fermentation for value-added carboxylic acid production from organic wastes. Yu et al. [21] demonstrated enhanced caproate productivity and kinetics achieved via applying anion-exchange resin to mixed-culture caproate fermentation process. Notably, the application of strong base anion-exchange resin could alleviate feedback inhibition of caproate, which can potentially provide a simple solution compared to other approaches previously reported in the literature, including electrodialysis. Kakar et al. [20]

investigated temperatures and retention times for the application of the thermal hydrolysis process as a feedstock pretreatment method for improving fermentative volatile fatty acid synthesis from source-separated organics. Based on their results, the temperature used in thermal hydrolysis was the most important factor influencing the yield of volatile organic acids from anaerobic fermentation. Moreover, the authors commented that pretreatment conditions could be adjusted to manipulate product spectrums for target applications, including biological nutrient removal, biopolymer synthesis, and so on.

The articles in this Special Issue also highlighted fundamental insights into the effects of temperature and waste composition on thermochemical conversion processes. Gu et al. [16] presented a feasibility study on municipal solid waste (MSW) gasification under medium temperatures. Their results provided interesting insights into how temperature and oxygen content influence syngas quality and process efficiencies under medium temperatures. Supramono et al. [17] investigated how the feed composition could influence heat transfer, product yield, and composition of the non-polar fraction of bio-oil produced by co-pyrolysis of biomass and polypropylene.

The articles in this Special Issue unfolded several exciting aspects of developing efficient biowaste processes for bioenergy and resource recovery, but further research is still needed. We sincerely hope that this Special Issue will be useful to researchers, practitioners, and others interested in bioenergy and resource recovery processes from biowaste.

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