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Editorial

Biofuel and Bioenergy Technology

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1. Introduction

Biomass is considered as a renewable resource because of its short life cycle, and biomass-derived biofuels are potential substitutes to fossil fuels. When biomass grows, all carbon in biomass comes from the atmosphere and is liberated into the environment when it is burned. Therefore, biomass is thought of as a carbon-neutral fuel. For these reasons, the development of bioenergy is an effective countermeasure to elongate fossil fuel reserves, lessen greenhouse gas (GHG) emissions, and mitigate global warming and climate change. Biomass can be converted into biofuels through a variety of routes such as physical, thermochemical, chemical, and biological methods. The common and important biofuels for bioenergy include charcoal, biochar, biodiesel, bioethanol, biobutanol, pyrolysis and liquefaction bio-oils, synthesis gas (syngas), biogas, and biohydrogen, etc. On account of the merit of bioenergy for environmental sustainability, biofuel and bioenergy technology plays a crucial role for renewable energy development. This Special Issue aims to publish high-quality review and research papers, addressing recent advances in biofuel and bioenergy. State-of-the-art studies of advanced techniques of biorefinery for biofuel production are also included. Research involving experimental studies, recent developments, and novel and emerging technologies in this field are covered. The particular topics of interest in the original call for papers included, but were not limited to:

- Novel and unexploited biomass resources for biofuel and bioenergy production
- New emerging technologies for biofuel and bioenergy production
- Development of thermochemical conversion routes for biofuel and bioenergy produciton
- Advanced biorefinery processes for biofuel and biochemicals production
- Bioreactors or microbial fuel cell for bioenergy and power production
- State-of-the-art review in the progress of biofuel and bioenergy technology

This Special Issue of *Energies* on the subject of “Biofuel and Bioenergy Technology” contains the successful invited submissions [1–27]. A total of twenty-seven technical papers which cover diversified biofuel and bioenergy technology related researches have shown critical results and contributed significant findings in biomass processing [1,2], bio-oil and biodiesel [3–11], syngas [12–14], biogas/methane [15–19], bioethanol and alcohol-based fuels [20–22], solid fuel [23–25] and also microbial fuel cell [13,26,27] developments.

2. Statistics of the Special Issue

The response to our call had the following statistics:

- Submissions (46);
- Publications (27);

- Rejections (19);
- Article types: research articles (25); review articles (2).

The authors' geographical distribution (published papers) is:

- Taiwan (8);
- Korea (4);
- Czech Republic (3)
- Australia (3);
- USA (2);
- China (1);
- Malaysia (1);
- Mexico (1);
- Pakistan (1);
- Poland (1);
- Spain (1);
- The Netherlands (1).

Published submissions are related to the most important techniques and analysis applied to the biofuel and bioenergy technology. In summary, the edition and selections of papers for this special issue are very inspiring and rewarding. We thank the editorial staff and reviewers for their efforts and help during the process.

3. Brief Overview of the Contributions to This Special Issue

Table 1 provides some of the key information, including the research type, field of study, final product as well as the key findings. As observed, a majority of the publications (twenty-three papers) focus on experimental work to improve or explore novel technologies for energy-products synthesis, while three papers focus on modelling studies and two papers focus on literature review studies. The following discussion highlights and groups the research findings in accordance to the corresponding research field or work.

As the initial step in most synthesis routes, biomass processing can enhance the substrate's quality for other synthesis processes. Thus, commonly, these are treated as pretreatment to enhance the characteristics of the biomass. In two research works [1,2], the combination of physical treatment (ball milling) and chemical treatment (ethanol organosolv) showed improved glucan digestibility. Three different biomasses such as giant miscanthus, corn stover and wheat straw were pretreated with ball milling and ethanol organosolv and the overall biomass size was reduced as a result of the prolonged pre-treatment [1]. Due to the improved physicochemical characteristics resulting from the pre-treatment, a maximum of 91% glucan digestibility could be achieved. A parametric study on combined ball milling and organosolv was performed as well to optimize the glucan digestibility [2]. It was determined that at 170 °C, with reaction time of 90 min and ethanol concentration of 40% and liquid/solid ratio of 10, the pretreatment process achieved the best results. Thus, the biomass processing method could be beneficial in generating desired products.

Table 1. Key Information of the Publications Submitted to Special Issue.

Research Work	Research Type			Technology/ Field of Work	Product	Key Findings
	Experimental	Modelling	Review			
Anwar et al., 2018 [5]	x			Blending	Biodiesel blend of papaya seed oil	• Reduction in brake power, torque and brake thermal efficiency. • Significant effect on brake specific fuel consumption.
Anwar et al., 2018 [6]	x			Alkali-catalysed transesterification	Australian native stone fruit biodiesel	• Optimisation with response surface methodology. • Maximum biodiesel yield of 95.8%. • Met ASTM D6751 and EN14214 standards. • Potential second-generation biodiesel.
Bidabadi et al., 2018 [25]		x		Mathematic asymptotic technique	-	• Oxidizer and fuel Lewis number were between 0.4 and 1, the maximum flame temperature was ~1860 K. • Per unit of fuel Lewis number, the minimum thermophoretic force was -1.48×10^{-8} N. • Per unit of oxidizer Lewis number, the minimum thermophoretic force was -1.53×10^{-8} N. • Per unit of porosity factor, the minimum thermophoretic force was -1.28×10^{-8} N.
Brunerová et al., 2018 [24]	x			High-Pressure Densification	Bio-Briquette Fuel	• Low ash content for bamboo fibre (1.16%) and sugarcane skin (8.62%). • Satisfactory mechanical durability for bamboo fibre (97.80%) and sugarcane skin (97.70%). • These products can be used for bio-briquette fuel production.

Table 1. *Cont.*

Research Work	Research Type			Technology/ Field of Work	Product	Key Findings
	Experimental	Modelling	Review			
Černý et al., 2018 [15]	x			Biogas study with DNA analysis	Biogas (Hydrogen)	• Occurrence of potentially harmful microorganisms such as *Clostridium novyi* was detected at higher ratio (65.63%) in the population of the bioreactor.
Chein et al., 2018 [12]	x			Tri-Reforming Process	Syngas (hydrogen)	• First-Law Efficiency increased with increased reaction temperature for higher hydrogen and carbon monoxide yields. • Second-Law Efficiency decreased with increased reaction temperature due to more complete chemical reaction.
Chen et al., 2018 [3]	x			Pyrolysis	Pyrolytic Oil	• Optimisation with Taguchi Method. • Maximum pyrolytic oil yield of 10.19%. • Synthesis conditions: 450 °C, 60 min, 10 °C/min and nitrogen flow of 700 mL/min.
Chen et al., 2018 [26]	x			Microbial Fuel Cell	-	• Hydrodynamic boundary layer of 1.6 cm (thin layer) showed maximum voltage of 22 mV and charged transfer resistance of 39 Ω.
David et al., 2018 [18]	x			Thermophilic anaerobic digestion	Methane	• Food wastes (corn stover, prairie cordgrass and unbleached paper) undergone thermophilic anaerobic digestion. • Highest methane yield of 305.45 L/kg was achieved after 30 days of incubation at 60 °C at 100 rpm.

Table 1. *Cont.*

Research Work	Research Type			Technology/ Field of Work	Product	Key Findings
	Experimental	Modelling	Review			
Dziekońska-Kubczak et al., 2018 [20]	x			Nitric acid pretreatment for enzymatic hydrolysis and fermentation	Bioethanol	• Jerusalem artichoke stalks were converted into bioethanol with nitric acid as catalyst. • Nitric acid pretreated hydrolysates led to 30% improvement in ethanol yield (77–82% of theoretical yield).
Encinar et al., 2018 [7]	x			Transesterification with base-catalysed reactions	Biodiesel	• Ultrasonic accelerated rate of biodiesel transesterification reactions. • Reaction followed a pseudo-first order kinetic model.
Eri et al., 2018 [14]		x		Equilibrium constants modelling	-	• Simulations were performed with two different models (with and without tar). • The simulations were validated by experimental data.
Fernedas et al., 2018 [13]	x	x		Gasifier-Specific Solid Oxide Fuel Cell System	-	• Validation data showed good agreement between experimental and simulation data. • System efficiencies were estimated to be 33.7–34.5%.
Kim et al., 2018 [10]	x			Photobioreactor with coal-fired flue-gas	Microalgal biodiesel	• M082 strain showed maximum lipid content (397 mg fatty acid methyl ester (FAME)/g cell) with good tolerance to high temperature. • FAME produced met the international standards.

Table 1. *Cont.*

Research Work	Research Type			Technology/ Field of Work	Product	Key Findings
	Experimental	Modelling	Review			
Kim et al., 2018 [1]	x			Ball milling and ethanol organosolv	-	• Combined pretreatment on giant miscanthus, corn stover and wheat straw show varied results (increased of glucan content for giant miscanthus, removal of cellulose for corn stover). • Enzymatic digestibility was improved with 91% glucan digestibility.
Kim et al., 2018 [2]	x			Ball milling and ethanol organosolv	-	• Pretreatment was performed using a 30 L bench-scale ball mill reactor. • Pretreatment conditions were varied: room temperature to 170 °C, time from 30 to 120 min, ethanol concentration from 30% to 60%, liquid/solid ratio from 10 to 20. • Highest glucan digestibility was performed at 170 °C, reaction time to 90 min, 40% of ethanol concentration and L/S = 10.
Kuan et al., 2018 [8]	x			Transesterification	Biodiesel	• Acid-catalysed synthesis by 0.6 M sulphuric acid at 70 °C for 20 h yielded 111% of FAME. • Base-catalysed synthesis by 1.0 g/L of sodium hydroxide at 70 °C for 10 h yielded 102% of FAME. • Direct transesterification shortened the reaction time and improved FAME yield.

Table 1. *Cont.*

Research Work	Research Type			Technology/ Field of Work	Product	Key Findings
	Experimental	Modelling	Review			
Längauer et al., 2018 [4]	x			Simultaneous Extraction and Emulsification	Emulsified bio-oil	• Emulsified ratio (bio-oil to emulsifier, B/E ratio) at 1 showed higher solubility of 66.48 wt %. • At higher temperature, higher solubility was also observed. • Methanol as co-surfactant also improved better solubility from 58.83 to 70.96 wt %.
Li et al., 2018 [21]	x			Electrochemical Hydrogenation using polymer electrolyte membrane reactor	Isopropanol	• Polymer electrolyte membrane fuel cell was used to produce isopropanol as main product and diisopropyl ether as byproduct. • High selectivity and (>90%) and high current efficiency (59.7%) were observed at mild conditions of 65 °C and at atmospheric pressure.
Musa et al., 2018 [19]			x	Anaerobic Membrane Bioreactors (AnMBRs)	-	• Anaerobic digestion technologies were critically reviewed. • Factors on membrane fouling, microbial environment conditions as well as parameters on the operations of AnMBRs were discussed. • Microfiltration as the mean to reduce energy and water usage in the AnMBRs was suggested.
Nguyen et al., 2018 [11]	x			Liquid Lipase Catalyzed Esterification	Biodiesel	• Optimisation with Response Surface Methodology • Superadsorbent polymer (SAP), as water removal agent, was used in esterification. • The polymer improved the conversion to 96.73% at 35.25 °C, methanol to oleic acid molar ratio of 3.44:1, SAP loading of 10.55% and enzyme loading of 11.98%.

Table 1. *Cont.*

Research Work	Research Type			Technology/ Field of Work	Product	Key Findings
	Experimental	Modelling	Review			
Poudel et al., 2018 [23]	x			Torrefaction	Torrefied Biomass	• Wood waste was torrefied at 200–400 °C and 0–50 min. • 300 °C as the optimal temperature for torrefaction based on Van Krevelen diagram.
Rahman et al., 2018 [22]			x	Bio-hydrocarbon Production in Bacteria	-	• Bioenergy products (alcohols and *n*-alkene hydrocarbons (C_2 to C_{18}) as produced by engineered microorganisms showed promising energy potential. • The review discussed the complexity of metabolic networks to obtain these bio-hydrocarbon products.
Roubík, et al., 2018 [16]	x			Biogas Plant Study	Biogas (methane)	• Biogas composition was measured for 107 small-scale biogas plants, respectively. • Mean compositions as follows: For plants younger than 5 years, CH_4 was 65.44% and CO_2 was 29.31%; for plants older than 5 years, CH_4 was 64.57% and CO_2 was 29.93%.
Su et al., 2018 [9]	x			Two-step acid-catalysed transesterification	Biodiesel	• Soursop (*Annona muricata*) seeds were used to produce bio-oil (29.6% (*w*/*w*)). • Bio-diesel with highest of 97.02% was produced under acid-catalysed conditions of 65 °C, 1% sulphuric acid, reaction time of 90 min and methanol: oil ratio of 10:1 and under base-catalysed conditions of 65 °C, 0.6% NaOH, reaction time of 30 min and methanol: oil ratio of 8:1. • Produced biodiesel met the EN14214 and D6751 requirements.

Table 1. *Cont.*

Research Work	Research Type			Technology/ Field of Work	Product	Key Findings
	Experimental	Modelling	Review			
Valero et al., 2018 [17]	x			-	Biomethane	• Biochemical Methane Potential (BMP) showed that the addition of granular activated carbon (GAC) improved the methane yield by 34% for instance testing and 54% for 10 days of GAC biofilm development. • Addition of GAC can improve digester's anaerobic digestion performance.
Wu et al., 2018 [27]	x			Microbial Fuel Cell	-	• Different calcination temperatures (500–900 °C) of iron oxide ($F_{e2}O_3$) were tested to investigate their photocatalytic properties within the cathodic chambers. • Calcinated $F_{e2}O_3$ improved the bio-electro-Fenton microbial fuel cell (Bio-E-Fenton-MFC) on degrading oily wastewater. • Within one hour, oily water was best-degraded up to 99.3% with electrode material synthesised at 500 °C with maximum power density of 52.5 mW/m^2.

Bio-oils can be synthesized from sewage sludge by using pyrolysis techniques [3]. Taguchi optimization suggested the best pyrolysis was performed at 450 °C, 60 min and 10 °C/min, which also showed consistency with other research work. Nonetheless, under most conditions, pyrolytic oil/bio-oil requires further processing or upgrading for use as biodiesel. To maintain the stability of bio-oil, blending with emulsifier resulted in high solubility (58.83–70.96 wt %) [4]. These findings suggest that simple blending could improve the properties of biodiesel or bio-oil tremendously, which is worthy of further investigation. Aside from using bio-oil as a precursor for biodiesel [3], biodiesel could be directly synthesized using other oil materials such as Australian native stone fruit oil [6], rapeseed oil [7], *Rhodotorula glutinis* [8] and soursop seed oil [9] via transesterification techniques. Transesterification of Australian native stone biodiesel showed a high yield of 95.8% with the response surface methodology optimization and its quality fulfilled the ASTM D6751 and EN14214 requirements [6]. Kuan et al. [8] investigate both direct acid and base-transesterification on *Rhodotorula glutinis* biomass which gave 111% yield of FAME and 102% yield of FAME, respectively, which were regarded as of good biodiesel quality. Another research work by Su et al. [9] used soursop seed to produce bio-oil which was eventually upgraded to biodiesel using a two-step acid catalyzed transesterification. The biodiesel produced met both EN14214 and D6751 standards. Encinar et al. [7] performed rapeseed transesterification with KOH catalyst as well as with the aid of ultrasound whereby the kinetic behavior obeyed a pseudo-first order trend. Liquid lipase-based esterification was attempted and optimized using RSM to enhance the usage of water removal agent in the system [11]. In Anwar et al's, [5] work, it was found that by blending papaya oil biodiesel with varying contents (5–20%) with diesel could improve the engine testing properties. Microalgal biodiesel was generated using photobioreactor with coal-fired flue gas from three strains (M082, M134 and KR-1) [10]. Among the strains, M082 generated high lipid value of 397 mg/g which was regarded to be a suitable feedstock for biodiesel production.

In recent years, gasification also garners high interest due to its rapid processing step and high yield of syngas which could be directly used for combustion. One of the main constitutes of syngas is hydrogen which usually provides high calorific value. Based on Chein and Hsu's [12] work, the tri-reforming process could produce good quality syngas. In addition, it was also found that at higher reaction temperatures, more hydrogen and carbon monoxide were produced. In pilot plant study, the gasifier which was embedded with specific solid oxide fuel cell system in an industrial scale was investigated in details [13]. To further understanding the gasification process, a thermodynamic equilibrium constants derivation and modelling was performed for two cases, with and without tar. The simulated data were validated with experimental data [14]. These findings could serve as good guides for future development of gasification process.

Bio-digester or bioreactor could also be used for biogas production. Černý et al. [15] discovered that microorganisms such as *Clostridium novyi* were detected at higher ratio (65.63%) in the population of the bioreactor for the biogas production. Such detection could serve as an important reminder to seek ways to inhibit these harmful microorganisms in the system. In an investigation and survey of 107 biogas plants, it was also found that the younger plant (<5 years) produced higher CH_4 (65.44%) and CO_2 (29.31%) [16]. Addition of granular activated carbon (GAC) in the digestion system could also directly improve the methane production by more than 34% [17]. Thermophilic anaerobic digestion is another interesting field of research. David et al. [18] found that by co-digestion under such conditions, high yield of methane (up to 305.45 kg/L) could be achieved. Musa's work critically reviewed some of the more critical findings on anaerobic membrane reactors for biogas recovery especially on membrane fouling and parameters of operation [19].

The studies on alcohol-based biofuels are increasing due to its high energy-content and suitability as fuel products. Dziekońska-Kubczak et al. [20] report that nitric acid as a form of chemical pretreatment could enhance the bioethanol production up to 30%. A Polymer Electrolyte Membrane Fuel Cell was used to produce isopropanol from acetone for use as a biofuel [21]. The hydrogenation process consumes less energy and less chemical wastes compared to other techniques [21]. Bio-hydrocarbons (alcohol and alkenes) produced from bacteria and their synthesis mechanisms are reviewed by Rahman et al. [22], as well as future challenges and complexity.

High pressure densification and torrefaction are currently attracting attention among the research community as these methods can produce potential solid-based fuels which require no further upgrade and can be use directly. Both methods are usually applied in mild synthesis conditions which differ from common thermochemical conversion techniques like slow pyrolysis and fast pyrolysis. For example, biomass with low ash content (1.16–8.62%) and good mechanical durability (97%) such as bamboo fibre and sugarcane skin could be directly densified as bio-briquette fuel without any energy processing [24]. As for torrefaction, a form of mild pyrolysis, wood wastes could be converted into torrefied biomass as low as 300 °C [23]. As observed, both methods consume relatively lower energy requirement and are simpler in term of synthesis process. In a modelling study, *Lycopodium* particles were also simulated and modelled as biofuel and burned in air environment [25]. It was discovered that the particles of *Lycopodium* were greatly influenced by thermophoretic force. Microbial fuel cell studies were also being investigated thoroughly. The effect of the hydrodynamic layer thickness was found to be significant on the voltage and charged transfer resistance [26]. In another study, the calcination temperature on the cathodic chambers was studied and it was found that the electrode synthesized at 500 °C could degrade oily wastewater up to 99.3% [27]. Thus, the microbial fuel cell shows tremendous potential to be developed for other applications.

Conflicts of Interest: The authors declare no conflict of interest.

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