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Editorial: Recent Advancements in Algae-to-Biofuels Research: Novel Growth Technologies, Conversion Methods, and Assessments of Economic and Environmental Impacts

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Editorial on the Research Topic

Recent Advancements in Algae-to-Biofuels Research: Novel Growth Technologies, Conversion Methods, and Assessments of Economic and Environmental Impacts

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Biomass-derived fuels and chemicals provide an alternative to conventional petroleum-based feedstocks owing to their greater energy security, reduced environmental impacts, foreign exchange savings, and socioeconomic benefits (Demirbas, 2009). In the past two decades, there has been increasing research and technological development of biofuels and bioenergy by academia, industry, and other organizations (Brenan and Owende, 2010). Algae are one of the most studied potential sources of biofuels and bioenergy (Menetrez, 2012). Algal fuels are attractive to energy researchers, engineers, post-graduate and advanced undergraduate students, and others interested in pursuing research of bioenergy and bio-based products. Research into identification of productive algae species and conversion of algae into alternative fuels and other bioproducts is taking place in both public and private arenas. Although research has been conducted on algal strain selection, maintenance of pure species, growth and cultivation of algae biomass, there is still significant room for improvement in these areas (Hannon et al., 2010). Also, macroalgae (commonly known as "seaweed") have not been fully exploited as a biofuel resource. Minimizing land, water, and nutrient use is critical to sustainable algae production. Recycling of process water, nutrients, and energy is crucial to large-scale algae production (Darzins et al., 2010; Hannon et al., 2010). The downstream processing of algal components into fuel and high-value coproducts poses a different set of challenges. Through processing technologies such as anaerobic digestion, pyrolysis, gasification, catalytic cracking, and enzymatic or chemical transesterification, whole algal biomass or algal extracts can be converted into different fuels, including biogas, kerosene, ethanol, jet fuel, and bio-hydrogen (Chisti, 2007; Christenson and Sims, 2011; Jena and Das, 2011; Milledge et al., 2014). Other areas of interest include development of higher efficiency harvesting and dewatering technologies, improved high-value product extraction and downstream processing, and development of novel conversion methods suitable for wet algae.

In view of increasing efforts on algae biomass production and its conversion into energy and high-value products, this research topic covers important aspects of algal strain selection, culture systems, inorganic carbon utilization, lipid metabolism and quality, biomass harvesting, extraction of lipids and proteins, and thermochemical conversion of algal feedstocks into biocrude.

Most of the articles in this current Research Topic fit within the category of Recent Advancements in Algae-to-Biofuels Research, including novel growth technologies and conversion methods. For example, strategies for optimizing algal biology for enhanced biomass production have been reviewed and detailed by Barry et al. These include modification of photosynthetic light-harvesting antenna size to increase energy capture and conversion efficiency, as well as development of advanced molecular breeding techniques (Barry et al.). Novel design and construction of an internally lit air-lift photobioreactor for growing algae have been described and validated in a separate chapter (Hincapie and Stuart). Other topics include utilization of municipal wastewater for algal growth (Hiibel et al.) and use of carbon dioxide through conversion of industrial waste gases to produce algae biomass (Napan et al.; Stewart et al.). Several experimental efforts directed at producing algae-derived fuels and high-value products are also reported here. These include production of neutral lipids using geothermal microalgae consortia (Bywaters and Fritsen), hydrothermal liquefaction (HTL) of macroalgae (Díaz-Vázquez et al.), pyrolysis of algae into bio-oil (Vargas e Silva and Monteggia), solvent extraction and characterization of neutral lipids (Anthony and Stuart), and novel protein extraction and subsequent HTL into biocrude (Parimi et al.).

Along with a summary of relevant basic standard methods practiced in microalgae culture, harvesting, and processing, the current research topic presents an up-to-date overview of advancements in the still exciting field of algal biofuel research. Each chapter opens with fundamental explanations and goes on to provide experimental details and discuss the results. All chapters are supported by numerous clear, informative diagrams and tables.

We sincerely thank the authors of all the chapters for their cooperation and their willingness to revise the manuscripts in a timely manner. We also acknowledge the assistance of reviewers, who in spite of their busy professional activities, helped to evaluate the manuscripts and provide critical inputs to refine and improve the chapters. Finally, we warmly thank the team of Frontier Energy for their cooperation and communication in this effort.

AUTHOR CONTRIBUTIONS

UJ contributed to preparation and submission of the manuscript and was responsible for editing eight chapters in this research topic. SH contributed to editing two chapters in the current research topic.

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