MATERIAL CYCLES and WASTE MANAGEMENT RESEARCH

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Abstracts

【Special Issues: Recent Developments in the Bio-refinery using Waste Biomass Materials】

1. Current Status and Perspectives Surrounding Bio-refinery: Procurement of Raw Materials for Bio-refinery and Related Issues

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Abstract

Bio-refining is the production process of general-purpose chemicals and fuels using biomass as a raw material. Bio-refineries were initially expected to become an alternative to petroleum refineries to cope with the rapid increase in oil prices. Thereafter, the carbon-neutral characteristics of bio-refining came to the fore and when the SDGs (Sustainable Development Goals) were adopted at the United Nations Summit in 2015, bio-refining was seen to support and help to achieve several of the goals.

In addition, through the use of biodegradable plastics, bio-refining has recently been effective in alleviating the problem of marine pollution caused by microplastics. Although it has various advantages, bio-refining has not been widely utilized, except for in bioethanol production from edible crops that compete with foods such as sugar cane and corn. For widespread bio-refining, it will be essential to procure large quantities of inexpensive raw materials and develop cost effective conversion processes. This study examines the procurement of three raw materials for bio-refinery: resources that have been unutilized, resources prepared for production of energy and materials, and waste materials. Finally, the paper investigates some problems associated with the use of these materials.

Keywords: bio-refinery, resources, waste, conversion technology

2. Research Trends and Future Prospects for Bioethanol

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Abstract

The use of bioethanol, produced from biomass, is seen to be one of the most promising gasoline blending agents for reducing CO_2 emissions from gasoline vehicles in the transportation sector. Bioethanol is produced mainly from sugarcane molasses and corn starch in Brazil and USA, respectively. Other countries have also increasingly been adopting bioethanol blending with gasoline, however, overuse of bioethanol production from sugarcane molasses and corn starch may lead to catastrophic issues such as food scarcity/competition and drastic land-use changes. Hence, the R&D for bioethanol requires production must come from non-edible cellulosic feedstock such as agricultural residues and herbaceous biomass.

In this review, research trends in bioethanol production processes from non-edible biomass are surveyed in terms of cost-competitiveness and reduction of GHGs, especially CO_2 for mitigating global warming. In addition, the paper outlines recent research into the technology of bioethanol production from variable biomass wastes through synthetic gas and novel microorganisms, as a way to produce bioethanol to substitute chemical components such as ethylene, propylene, and other chemicals, including jet fuel by ATJ (Alcohol to Jet Fuel) catalytic process. Such technologies can be combined with carbon recycling schemes to further reduce CO_2 emissions and eventually realize a carbon neutral society by 2050.

Keywords: bioethanol, non-edible biomass, gasoline blend, biochemical feedstock

3. Expansion of First Generation Biodiesel Fuel to Next Generation Biofuel

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Abstract

As a result of heightened environmental awareness about issues such as global warming and solid waste treatment, many countries are looking to manufacture biodiesel fuel from biomass materials as a developing technology that recycles resources. In Japan, a biodiesel fuel conversion project comprised of research on production of fatty acid methyl esters (FAME) from waste cooking oil is being promoted as an example of domestic biomass utilization. This article describes recent trends in the development of biodiesel fuel both domestically and internationally. It includes a history of the application of FAME as a first generation biodiesel fuel in Kyoto City and the development of a second generation biodiesel fuel with properties equivalent to hydrocarbon fuel.

Keywords: biodiesel fuel, fatty acid methyl esters (FAME), hydrocarbon fuel,
sustainable aviation fuel, waste cooking oil

4. Recent Development in Research and Application of Biomethane and Biogas

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Abstract

The utilization of biomass is becoming more important for the realization of a decarbonized and recycle-oriented society. Recently, biomethane production by methane fermentation and biogas power generation have been attracting attention. In this paper, to summarize the research trends on biogas production, we first summarized the annual publication status of research papers on biogas utilization based on the Web of Science database. Then, the various enhancement technologies (pretreatment, additives, and co-digestion) applied to the methane fermentation to improve the efficiency and stability of the process are reviewed. The authors also introduced their recent co-digestion studies of municipal waste biomass (food waste, sewage sludge, and paper waste). Finally, several representative examples of methane fermentation plants that have been running in Japan are reviewed.

Keywords: biogas, methane fermentation, food waste, sewage sludge, waste paper

5. Utilization of Cellulose Nanofibers as an Approach towards a Decarbonized Society

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Abstract

Cellulose nanofibers (CNFs) are a fundamental component of plant cell walls, and fibers of 4 to 20 nm width can be obtained by simple disintegration of pulp obtained from wood and bamboo, as well as agricultural and industrial biomass wastes. Since the nanofibers are made of semi-crystalline extended cellulose chains, they exhibit high elasticity (approximately 140 GPa), high strength (approximately 3 GPa), and low thermal expansion (approximately 0.1 ppm/K), with a density of 1.5 g/cm^3. Because of these excellent mechanical properties and their high specific surface area, the utilization of CNFs has gained increasing attention across the world. In this paper, the characteristics of CNFs and their utilization is discussed based on seven keywords: 1) high performance; 2) varied raw materials; 3) diverse applications; 4) cost and performance; 5) time; 6) decarbonization; and 7) sustainability.

Key words: cellulose nanofibers, CNFs, woody biomass, materials, decarbonized society

6. Production of Liquid Feed (Eco-feed) by Hydrothermal Reaction

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Abstract

Liquid feed (eco-feed) holds many advantages for the environment, livestock farmers, pigs, etc. Here, production of liquid feed from organic resources using hydrothermal reaction is introduced as a recycling technology. Although this method requires more energy and has higher installation costs when compared to conventional methods, it is able to utilize various organic resources and produce high-value-added liquid feeds. In addition, it is expected to become one of the disruptive innovation technologies in response to recent improvements in sustainability and awareness of environmental issues within society.

Keywords: liquid feed, hydrothermal reaction, high-added value, digestibility, digestive inhibitor