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Pilot scale production of 2G ethanol utilizing rice straw: an integrated bio-refinery approach

The global energy demand has been continuously increased from past decades that caused a scarcity in the supply of crude oil. Globally, research has been shifted from conventional sources to alternative clean and sustainable energy sources. In general, the atmospheric carbon-dioxide was fixed by plants to carbohydrates via photosynthesis and considered as a most abundant lignocellulosic biomass on earth that has significant potential for biofuels generation. The exploitation of lignocellulosic biomass for biofuels production is one of the viable options compared to conventional energy sources such as fossil fuels that ultimately help to reduce the burden on fossil fuels utilization and greenhouse gas emission. Current situation demands the production of cellulosic biofuels to control the energy crisis for betterment of societal needs. The production status of rice straw indicated that approximately 731 million tons of rice straw produced per year globally. The distribution data in Asia is 667.6 million tons, 20.9 million tons in Africa, and 3.9 million tons in Europe. The total carbohydrate content of rice straw was reported to be 49 % and lignin content of 14 %. It is one of the largest lignocellulosic biomass feedstock's having the capacity to produce 730 billion liters of bioethanol from 731 million tons of rice straw. Major proportion of the rice straw is burnt in the field itself. In practice, rice straw was burned in the open fields that led to air pollution and release of the particulate matter into the atmosphere. In India, surplus amount (23 %) of rice straw is produced every year that constitute 0.05% greenhouse gas emissions through open burning in the field. Thus, rice straw represents one of the viable feedstock candidates for biofuels generation owing to its carbohydrate content that can be converted to fermentable sugar and in turn ethanol. Biomass is the only foreseeable renewable feedstock for sustainable production of biofuels. The main technological barrier to more widespread utilization of this resource is the lack of low-cost technologies to overcome the recalcitrance of the cellulosic structure. Three major biological events occur during conversion of lignocellulose to ethanol via processes featuring biomass pretreatment, enzymatic hydrolysis and fermentation of hexose and pentose sugars. Consolidated biomass processing (CBP) is gaining increasing recognition as a potential breakthrough for low-cost biomass processing. A fourfold reduction in the cost of biological processing and a twofold reduction in the cost of overall processing are projected when a mature CBP process is substituted other fermentation processes. To increase product yields and to ensure consistent product quality, key issues of industrial fermentations, process optimization and scale up are aimed at maintaining optimum and homogenous reaction conditions minimizing microbial stress exposure and enhancing metabolic accuracy. For each individual product, suitable strategies have to be elaborated by a comprehensive and detailed process characterization and identification of the most relevant scale-up parameters influencing the product yield. In the present work, consolidated processing of rice straw of 25Kg batch was carried out for ethanol production. Maximum ethanol 3.01 % (v/v) in liquid broth was obtained whereas, 1.77 % (w/w) was recorded in fermented solid biomass. SEM analysis indicated changes in the surface characteristics. Biomass crystallinity and energy density studies further support the outcome of the process. Techno-economic analysis of the process suggests that if the residual biomass from rice straw is utilized for biomethane and biomanure generation then the process will result a net profit upon per ton of biomass processing.

Recent Publications

1. Banerjee R, Chintagunta AD, Ray S (2017) A cleaner and eco-friendly bioprocess for enhancing reducing sugar production from pineapple leaf waste. Journal of Cleaner Production http://dx.doi.org/10.1016/j.jclepro.2017.02.088.
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4. Gujjala LKS, Bandyopadhyay TK, Banerjee R (2016) Kinetic modelling of laccase mediated delignification of Lantana camara. Bioresource Technology, 212, 47-54.
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Biography

Rintu Banerjee, Ex-MNRE- Chair-Professor, Indian Institute of Technology, Kharagpur has created a niche of her own in the area of Biomass Deconstruction/Biofuel Production/Enzyme Technology. In the process of her innovative development, she was granted 8 Indian, 3 International (US, Japanese and Chinese) patents. She has published more than 150 papers in peer-reviewed national/international journals, guided 27 (17 continuing) Ph.Ds, 3 MS, 71 (3 continuing) M.Techs, 50 (2 continuing) B.Techs. She is the Editorial member of many Journals. She has written 24 book chapters and authored a book on "Environmental Biotechnology" published by Oxford University Press. She is recipient of various awards/honours given by both government/non-government organizations.

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