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Viewpoint

Biorefineries: India's future option for energy and chemical feedstock

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Abstract

The search for renewable and alternative sources of energy demands an industrial revolution where biorefineries will be the leading industries using biomass as substrate in place of petrochemical refineries. Establishment of biorefineries using complex biomass like lignin and cellulose from waste biomass is preferred and need of the hour. Many countries of the world, including India, are favourable places for the establishment of biorefineries due to an abundance of the residual biomass. Native as well as designed microbes having capability to ferment the hexoses and pentoses released from biomass along with the steps of gasification of biomass are the two key processes in the operation of biorefineries. Biorefineries are interdisciplinary industrial units which are in the infancy stage and require tender support from government and research institutes to flourish in the future as an alternative source of energy and feedstock.

Keywords: Biorefineries, Biomass, Energy

Introduction

It is estimated that current global oil reserves will last up to 2030, as projected in 2006-2007 by IEA [1]. In India, demand for oil and energy is increasing due to the huge population and rapid growth rate of transportation and industrial sectors and the search for renewable and alternative sources of energy demands an industrial revolution. In this context, establishment of biorefineries can be a future option for energy and chemical feedstock in place of petrochemical refineries. The biorefinery is an overall concept of a processing plant where biomass feedstock is converted into a spectrum of valuable products [2]. A biorefinery is analogous to a petrochemical refinery producing a range of products including ethanol, biodiesel, biohydrogen, syngas etc. However, in the place of crude oil as the primary substrate as used in traditional refineries, substrate in biorefineries is plant biomass, whose potential is harnessed using microbes and chemical reactions to obtain a product line. Many countries of the world, including India, are favourable places for the establishment of biorefineries due to an abundance of residual biomass. The biorefineries serve two purposes, using plant biomass as a source of energy and feedstock is a process of carbon neutral cycle reducing greenhouse gas emissions and the other is by providing multiple product streams of fuels and chemicals.

To set up biorefineries in India, comparatively low labour and construction costs, coupled with abundance of biomass in the form of forest and agricultural residues are the encouraging factors. It may not be necessary to transport biomass over long distances as the biorefineries can be established on site of biomass abundance and these local biorefineries can select a plant species grown in that area. Grasses like sorghum and sugarcane are useful substrates for biorefineries in India and these biorefineries are categorized as biomass- producing – country type. Similar to the US, India also needs a "Biomass Technical Advisory Committee" having representatives from industry and energy sectors, which acts as an advisor to government for developing a strategy for future biorefineries. This committee should discuss the type of biomass suitable to Indian biorefineries, economic aspects, viability of the project and preferred locations for establishment. The committee should review and select the dedicated energy crops, trees or agricultural and forest residues as substrate for biorefineries without disturbing the natural ecosystems. The government should promote research and development to better understand plant biochemistry and genomic and metabolic data for many potential crops which can be used as substrate in biorefineries. Similar to Europe, India should also have a "Renewable Energy Law" and certain regulations regarding the substitution of non-renewable resources of biomass in biorefining/area of biofuels [3]. Goals must be set in this regard as to what percentage substitution of fossil fuels is possible by biomass based biorefineries in the coming years. All categories of biorefineries can be established in India, e.g. green biorefineries using wet biomass such as grass, immature cereal, lignocellulosic feedstock (LCF) biorefineries and whole crop biorefineries.

However, the major impact on energy and climate change in India is likely to come from the conversion of lignocellulosic materials to ethanol through LCF biorefineries. Establishment of biorefineries using complex lignocellulosic substrate is preferred. Biorefineries using lignocellulosic biomass as substrate will reduce competition with grain for food and feed and allow the utilization of material such as straw which would otherwise go to waste. Wild grasses can be grown on waste land or land which is less suitable for farming. These biorefineries are based on substrate like agricultural and forest residues, wood chips, straw and other waste biomass. Biorefineries which are based on grasses like wheat, maize, rye (wet biomass) etc. can also be planned in India, but diversion of food crops towards biorefineries may have serious implications in terms of scarcity of food grains along with competition for food and feedstock from the same land. For a strong foundation of biorefineries in India as well as in other parts of the world, it is mandatory to have long-term strategic research to use the abundant supply of pentose sugars from lignocellulosic biomass with the help of native or genetically engineered microbes.

As far as the operation of biorefineries is concerned, one major route is heating the biomass in an oxygen-free atmosphere (gasification) producing a wide variety of products, including syngas, that leads to methanol production. Methanol opens up the avenues for transformation of a variety of products by common chemical reactions [4], e.g. production of acetic acid, formic acid, methyl esters and ethylene etc., which are key intermediates for plastic manufacturing. At the same time, methanol has high potential for being used as an alternative fuel [5]. Integration of fermentation units and gasification processes for production of fine chemicals and biofuels is another key process step in biorefineries. Ethanol formed in biorefineries acts as a substrate and is used to obtain acetone, butanol, ethylene, ethylene glycol, ethyl bromide, propanol, succinic acid, glycerol and its derivatives by microbial processes as well as by chemical methods [6].

Iogen Corporation in Canada is the first large-scale bioethanol facility in that country and lists the priority biomass sources used [7]. Grasses have been given top priority and forest wood, bark given least priority as these are difficult to process. Among grasses, corn stover is a preferred source of biomass in the USA to support biorefineries due to its availability in large quantities [8]. In the year 2008, the US had its first cellulose substrate base biorefinery built by the Verenium Company. This biorefinery is expected to produce 1.4 million gallons of cellulosic ethanol a year. In India there is an abundance of cellulose substrates like grasses, along with left over agricultural and forest residues, bagasse etc., and these can be diverted towards biorefineries. However, the complexity of biomass due to its major components like cellulose, hemicellulose and lignin, demands a dedicated effort to develop pretreatment processes to convert this biomass to make it compatible with ethanol- producing microorganisms [9, 10, 11]. Pretreatment processes like acid/alkali/steam/enzyme hydrolysis increase the breaking of the lignocellulosic network and release sugars (pentoses and hexoses) to be used by fermenting microorganisms [12, 13].

For overall development of biorefineries in any part of the world, "effective separation of lignocellulosic feedstock into lignin, cellulose, hemicellulose via the best pretreatment systems in biorefineries, along with improvement in gasification procedures of biomass is necessary for enhanced microbial capabilities of degradation of cellulose, starch etc." [14]. The concept of the biorefinery should follow the principles of industrial ecology. To start a biorefinery, issues of substrate availability, cost and local factors play an important role. Harnessing the potential of biomass in biorefineries depends up on continuous R&D effort, economic subsidies and government support in this direction to prove its analogy to petro- chemical refineries, ignoring earlier failures or losses if any. The vision of total replacement of petrochemical refineries lies in restructuring the traditional fermentation industries into viable biorefineries with a close look at economics and viability of the 21st century technology [15, 16].

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References

1. Kjärstad, J. and Johnsson, F., Resources and future supply of oil. Energy Policy., 2009, **37**(2), 441-464.

2. Jorgenson, D., Wilcoxen, W. and Peter, J., (1997). Energy, environment and Economics (E3) Handbook,1st ed., U.S. Department of Energy, http://www.oit.doe.gov/e3handbok.

3. Ohara, H., (2003). Polylactate as an industrial plastic, Annual Meeting Japan Society for Bioscience, Biotechnology and Agrochemistry. 377.

4. Mousdale, D.M., (2008). Biofuels, Biotechnology, Chemistry and Sustainable Development. Handbook, 1st ed., CRC Press, Taylor and Francis Group.

5. Aishwarya and Syal, S., (2008). Time for methanol revolution, **Current Science**, **95**(10), 1383.

6. Fiedler, E., Grossmann, G., Kersebohm, D.B., Weiss, G. and Witte, C., (2005). Methanol, in Ullmann's Encyclopedia of Industrial Chemistry, e-edition, Wiley-VCH Verlag Gmbh & Co. KgaA, Weinheim.

7. Clark, J.H., (1999). Green chemistry: challenges and opportunities, **Green Chemistry**, **1**, 1-8.

8. Christoph, R., Schmidt, B., Steinberner, U., Dilla, W. and Karinen, R., (1999). Glycerol, in Ullmann's Encyclopedia of Industrial Chemistry, e-edition, Wiley-VCH Verlag Gmbh & Co. KgaA, Weinheim.

9. Kamm, B., Gruber, P. R., and Kamm, M., (Eds.) Tolan, J.S., (2006). Iogen's demonstration process for producing ethanol from cellulosic biomass, in Biorefineries – *Indusrial processes and products*. Volume1. *Status Quo and future directions*, Wiley-VCH Verlag, Weinheim Chap. 9

10. Galbe, M., and Zacchi, G., (2002). A review of the production of ethanol from softwood, **Applied Microbiology and Biotechnology**, 2002, **59**,618-628.

11. National Research Council (2000). Biobased Industrial Products, Priorities for Research and Commercialization [National Academic Press, Washington D.C., ISBN 0-309-05392-7(a) 74.

12. Sharma, S., Kalra, K. and Grewal, H., (2002). Enzymatic saccharification of pretreated sunflower stalks, **Biomass and Bioenergy**, **23**, 237-243.

13. Immanuel, G., Bhagavath, C., Raj, P., Esakkiraj, P. and Palavesam, A., (2007). Production and partial purification of cellulase by *Aspergillus niger* and *A. fumigatus* fermented in coir waste and sawdust, **The Internet Journal of Microbiology**, **3**.

14. Ohara, H., (2000). Zero emission is realized by polylactate. In United Nations (ed) Preprints of zero emission symposium, United Nations, Tokyo, (a), 81-89.

15. Ohara, H., (2000). Development of producing poly-L-Lactic acid as biodegradable plastics from kitchen refuse. In: Nickei Hall (ed) preprints of Japanese business leaders' conference on environment and development, Nikkei Hall, Tokyo, (b), 19-23.

16. Kadam, and McMillan., (2003). Availability of corn stover as a sustainable feedstock for bioethanol production, **Bioresource Technology**, **88**, 15- 25.