Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 11 (13): 2421-2425, 2011
ISSN 1812-5654 / DOI: 10.3923/jas.2011.2421.2425

Biotechnology in Biofuels-A Cleaner Technology

Kenthorai Raman Jegannathan, Eng-Seng Chan and Pogaku Ravindra
Centre of Materials and Minerals, School of Engineering and Information Technology,
Universiti Malaysia Sabah, 88999 Kota Kinabalu, Malaysia

Abstract: The issues of global warming and greenhouse gas emissions are increasingly becoming one of the major technological, as well as and also important societal and political challenges. With increasing gap between the energy requirement of the industrialized world and inability to replenish such needs from the limited sources of energy like fossil fuels, ever increasing levels of greenhouse pollution from the combustion of fossil fuels in turn aggravate the perils of global warming and energy crisis. One quarter of the world's CO_2 emissions are created by the transport sector which accounts for some 60% of the world's total oil consumption. Biofuel made from biomass has the potential to reduce greenhouse gas emissions compared to fossil fuels. By using cleaner technology, it is possible to enhance economic growth in industries all over the world while at the same time saving water, energy, raw materials and waste to minimize the environmental footprint. The cleaner technology involves the use of enzymes in an industrial process. Enzymes can be used to make fuels and chemical intermediates in more sustainable, environmentally friendly ways. The development of new enzymes, including through the production and purification of enzymes from genetically modified organisms, is a major driving force in the commercialization of cleaner technology products and processes.

Key words: Biofuels, biotechnology, cleaner technology, bioethanol, biodiesel, enzymes

INTRODUCTION

The development and application of cleaner technologies offer multiple benefits such as: reduced emissions, less waste and cost savings from reduced energy and resource use during production as well as due to improved systems of recycling and waste management (Dovi *et al*., 2009). The world is rapidly embracing the implantation of renewable energy production and biofuels that will slow down or reduce the effect of global warming and the resulting deterioration of the environment. Renewable energy sources are indigenous and can therefore contribute to reducing dependency on oil imports and increasing security of supply.

Biofuels-liquid or gaseous fuels derived predominantly from biomass are able to provide an alternative source of energy that is both sustainable and without serious environmental impact (Jegannathan *et al*., 2009). Biodiesel and bioethanol are the primary biofuels and have each experienced tremendous development in terms of industrial-scale production and quality. The increase in global production levels of these two fuels are shown in Fig. 1 (Licht, 2006). The substitution of biofuels for petroleum-based fuels for transport purposes is also emerging as an important policy strategy in many countries. The biofuel policy aims to promote the use in transport of fuels made from biomass, as well as other renewable fuels. Biofuels provide the prospect of new economic opportunities for people in rural areas in oil importer and developing countries. The central policy of biofuel concerns job creation, greater efficiency in the general business environment and protection of the environment (Demirbas, 2008).

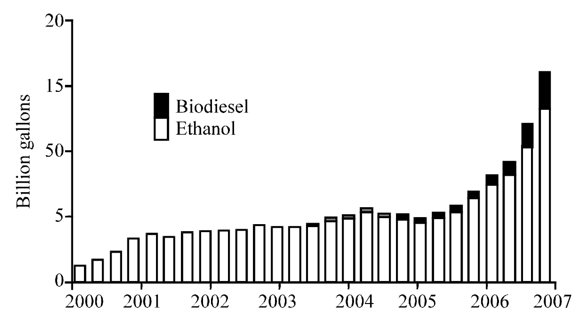

Fig. 1: Global ethanol production

Biofuels are conventionally produced using chemical catalyst processes, in the near future when the demand for biofuels increases, the use chemical catalysts involved in the biofuel production process could create

Corresponding Author: Pogaku Ravindra, Centre of Materials and Minerals, School of Engineering and Information Technology, Universiti Malaysia Sabah, 88999 Kota Kinabalu, Malaysia

environmental pollution problems. Thus it is an important to implement cleaner technologies in biofuel production. This review study, emphasis the availability and implantation of green technology in biofuel production.

The need for biofuels: Several compelling issues drive a national effort to develop and improve technology to make biofuels. Our dependence on petroleum for fueling the transportation sector threatens our energy security, affects our environment and weakens our economy. Developing the technology to produce and use biofuels will create transportation fuel options that can positively impact these issues and establish safe, clean, sustainable alternatives to petroleum (Neufeld, 2000).

Fuels made from biomass: The word biomass refers to all the Earth's vegetation and many products and coproducts that come from it. Biomass is the oldest known source of renewable energy-humans have been using it since we discovered fire-and it has high energy content. Domestic biomass resources include agricultural and forestry residues, municipal solid wastes, industrial wastes and terrestrial and aquatic crops grown solely for energy purposes. Biomass is an attractive energy source for a number of reasons. First, it is renewable as long as it is properly managed. It is also more evenly distributed over the Earth's surface than are finite energy sources and may be exploited using more environmentally friendly technologies. Biomass provides the opportunity for increased local, regional and national energy self sufficiency across the globe. The energy in biomass can be accessed by turning the raw materials or feed stocks into a usable form (Demirbas, 2008).

Biofuels on the market: Currently, ethanol and biodiesel are commercially available. Ethanol made from starch crops is available in some countries country and is commonly used as a fuel oxygenate. Biodiesel is being used by some municipal fleets around the country and privately in situations where petroleum diesel is detrimental. As knowledge of the economic, energy security and environmental benefits of biofuels spread through our country, demand for these sustainable fuels will increase. To meet the demand and provide fuels that are competitive with petroleum fuels, research around the world focuses on improving technology for converting biomass to fuels. This will decrease costs and increase the kinds of biomass that can be converted to fuels, allowing for a sustainable supply of resources from which to make fuel. The biofuels program around the world strives to realize the large-scale use of environmentally sound, cost competitive, biomass-based transportation fuels by adopting and commercializing the best technologies. To accomplish this, the program works with industry to research, develop, demonstrate and facilitate the commercialization of technologies to develop clean fuels for transportation, leading to the establishment of a major biofuels industry (Neufeld, 2000).

Cleaner technology: Enzymatic processing of biofuels offers more sustainable way of processing than using chemical agents and significant savings can be achieved by switching to an enzyme-catalyzed alternative. The use of enzymes in the biofuel industry is a mature and proven technology. Nonetheless, there is still great potential in the use of enzyme technology to further optimize and improve the production of biofuel production.

Bioethanol production process: Bioethanol is an alcohol derived from biological feedstock that contains appreciable amounts of sugar or materials that can be converted into sugar by fermentation. The production of bioethanol involves three processes. The first process is the hydrolysis of higher sugars to glucose. The second is the fermentation of glucose to produce ethanol and carbon dioxide. The third process is thermo-chemical, where the dilute ethanol is distilled to produce absolute ethanol (Balat *etal*., 2008). When lignocellulosic biomass is used as feedstock, a pretreatment step of either chemical or enzymatic hydrolysis is carried out to remove the lignin present within it (Sanchez and Cardona, 2008). Chemical hydrolysis uses acid to break down the higher sugar molecules in the feedstock, whereas enzymatic hydrolysis uses various enzymes to achieve this (though it is also possible to use microorganisms instead of enzymes). Each process has its advantages and disadvantages. Chemical hydrolysis is a well-developed technology that is more efficient than its enzymatic counterpart. Due to the availability of the acid used, the process is also less costly. Chemical pretreatment requires little time and high levels of conversion can be obtained. However, this process also has serious drawbacks in that it requires high temperatures and the waste water produced is toxic, requiring costly treatment. This method of hydrolysis also leads to land pollution and the ethanol produced contains traces of acid, making the resultant fuel corrosive (Jegannathan *et al*., 2009).

Enzymatic hydrolysis may be carried out in two ways: using either soluble enzymes or immobilized enzymes. The use of soluble enzymes for hydrolysis is the conventional method but the recent development of immobilization-where an enzyme may be reused, thereby decreasing the cost-has shown promising results in many industries. More research is needed on the various

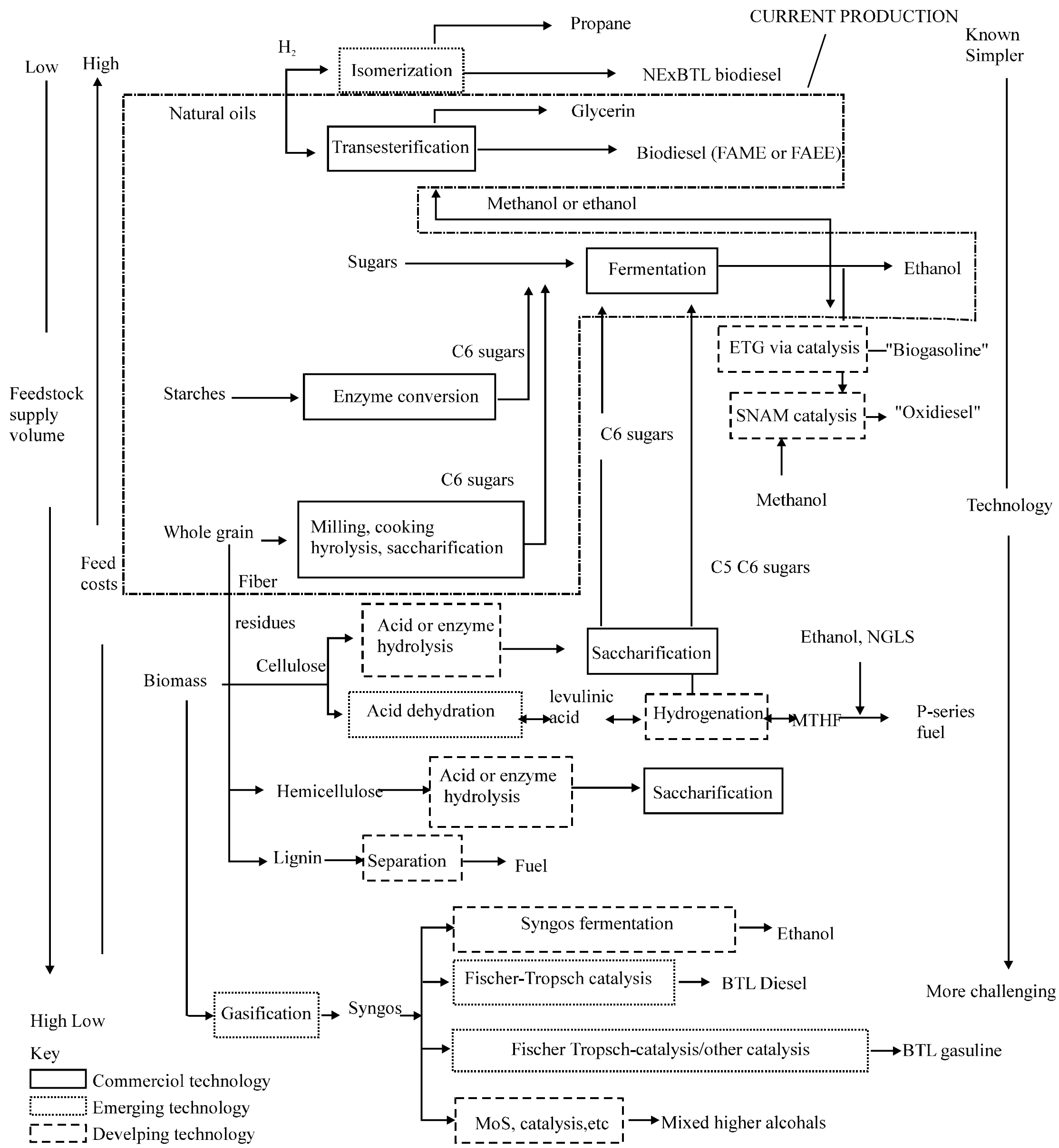

Fig. 2: Technological routes for the production of biofuels (Nexant, 2006)

immobilization techniques and the production of a versatile immobilized enzyme is crucial for achieving high conversion. In direct comparison to chemical hydrolysis, soluble enzymatic hydrolysis has certain advantages. Unlike chemical hydrolysis, only mild reaction conditions are needed and the resulting ethanol product is of higher quality, is less corrosive and requires less investment in waste water treatment. Also, simultaneous saccharification and fermentation is possible (Saxena, *et.al*., 2009). However, enzymatic hydrolysis also lacks some of the attractive features of chemical hydrolysis: the enzyme is expensive, it cannot be stored for long due to its lower usage period and its use may vary depending on the feedstock used. Additionally, the enzymatic process takes longer to complete and product inhibition decreases the activity of the enzyme.

Biodiesel production process: Biodiesel is a nearly colorless liquid made from the transesterification of vegetable oils or animal fats with alcohol and has properties similar to petroleum-based diesel (Fig. 2).

Table 1: Clean technology Biofuels companies in Europe

Company	What they do	Product status	Based
Biogasol	Bioethanol based fuels from organics	Development	Denmark, Lyngby
Choren Industries	Turns biomass into tar-free synthetic gas	Shipping	Germany, Freiburg
KiOR	Converts biomass into bio-crude	Development	Netherlands, Hoevelaken
Green Biologics,	Advanced microbial technologies to convert biomass	Development	UK, Abingdon
Inetec	Turns food waste into energy	Shipping	UK, Brigend
Orchid Environmental	Converts household waste into energy	Shipping	UK, Lancashire
Regenastar	Biofuel conversion systems for diesel engines	Development	UK, Oxford
TMO Renewables	Next generation biofuels using micro-organisms	Development	UK, Guildford
SweTree	Specialist breeding technologies for trees	Development	Sweden, Umea

Presently, the industrial production of biodiesel is a chemical process based on the methanolysis of various oils using alkaline or acid catalysts. However, recent laboratory-scale research has aimed to develop enzymatic production techniques; for example, lipase enzyme can be used as a catalyst for the transesterification of vegetable oil to methyl ester (Fukuda *et al*., 2001). The only obstacle to the extension of enzymatic production to large industrial scales is the cost of the enzyme but this may be overcome with the use of immobilized lipase which can be reused several times to decrease costs. As an alternative to the use of lipase as a catalyst in biodiesel production, some studies have also used an immobilized-whole cell of *Rhizopu oryzae* (Tamalampudi *et al*., 2008) and have demonstrated promising results, achieving equal methyl ester conversion equal to enzymatic catalysts.

Emerging new processes: Researchers are employing various processes to improve the quality and economical viability of biofuel. New approaches are being tested starting from the raw material to the refining of the product. Among them micro algae (Chisti, 2007) and jatropha (Kumar and Sharma, 2008) are studied as a potential source of oil for biodiesel production. These sources in no way influence food crops, thereby are prime raw materials for biodiesel production. Similarly, supercritical extraction employing CO_2 (Machmudah *et al*., 2008) and ionic liquids (Keskin *et al*., 2007) are becoming familiar separating agents in extractive distillation for dehydration of ethanol from aqueous solutions. Further, hydrothermal reaction could be a prominent method for the treatment of organic wastes in bioethanol and biogas production (He *et al*., 2008). Diesterol, a mixture of fossil diesel fuel, biodiesel and bioethanol is also emerging as a new environment-friendly IC engine fuel (Rahimi *et al*., 2009). Developments in aspects of ecological phytochemistry can induce defence pathways in plants to control pests, diseases and weeds (Pickett *et al*., 2007).

CONCLUSION

The new generation of clean technology-based biofuel processes is being driven to tile greatest extent by developments in industrial biocatalysts. In the past major problems for deploying enzymes have resulted from their fragility under conditions of industrial processing, their high cost and the requirement for large concentrations of water. Now, with the advent of genetic manipulation, artificial evolution and gene shuffling, rational manipulation of reaction conditions and enzyme presentation and the discovery of extremozymes the customisation of enzymes for an ever growing range of industrial requirements has become a reality. Several biofuel companies have emerged towards achieving the clean technology in Europe (Table 1). This clearly proves that clean technology is viable. Hence this technology can be implemented by all the countries to attain sustainable energy production by decreasing the carbon print.

REFERENCES

Balat, M., H. Balat and C. Oz, 2008. Progress in bioethanol processing. Prog. Energy Combust. Sci., 34: 551-573.

Chisti, Y., 2007. Biodiesel from microalgae. Biotechnol. Adv., 25: 294-306.

Demirbas, A., 2008. Biofuels sources, biofuel policy, biofuel economy and global biofuel projections. Energy Convers. Manage., 49: 2106-2116.

Dovi, V.G., F. Friedler, G. Huisingh and J.J. Klemes, 2009. Cleaner energy for sustainable future. J. Cleaner Prod., 17: 889-970.

Fukuda, H., A. Kondo and H. Noda, 2001. Biodiesel fuel production by transesterification of oils. J. Biosci. Bioeng., 92: 405-416.

He, W., G. Li, L. Kong, H. Wang, J. Huang and J. Xu, 2008. Application of hydrothermal reaction in resource recovery of organic wastes. Resour. Conserv. Recycl., 52: 691-699.

Jegannathan, K.R., E.S. Chan and P. Ravindra, 2009. Harnessing biofuels: A global renaissance in energy production. Renewable Sustainable Energy Rev., 13: 2163-2168.

Keskin, S., D. Kayrak-Talay, U. Akman and O. Hortacsu, 2007. A review of ionic liquids towards supercritical fluid applications. J. Supercrit. Fluids., 43: 150-180.

Kumar, A. and S. Sharma, 2008. An evaluation of multipurpose oil seed crop for industrial uses (*Jatropha curcas* L.): A review. Ind. Crops Prod., 28: 1-10.

Licht, F.O., 2006. Ethanol: World production, by country, table. World Ethanol and Biofuels Report Vol. 4, No. 16 (April 2006), pp: 365.

Machmudah, S., M. Kondo, M. Sasaki, M. Goto, J. Munemasa and M. Yamagata, 2008. Pressure effect in supercritical CO2 extraction of plant seeds. J. Supercrit. Fluids, 44: 301-307.

Neufeld, S., 2000. Biofuels for sustainable transportation. National Renewable Energy Laboratory, a DOE National Laboratory. DOE/GO-102000-0812, June 2000. http://www.nrel.gov/docs/fy00osti/25876.pdf.

Nexant, 2006. Prospectus liquid biofuels: Substituting for petroleum-a global techno economic and market evaluation. http://www.chemsystems.com.

Pickett, J.A., M.A. Birkett, T.J.A. Bruce, K. Chamberlain and R. Gordon-Weeks *et al*., 2007. Developments in aspects of ecological phytochemistry: The role of cis-jasmone in inducible defence systems in plants. Phytochemistry, 68: 2937-2945.

Rahimi, H., B. Ghobadian, T. Yusaf, G. Najafi and M. Khatamifar, 2009. Diesterol: An environment-friendly IC engine fuel. Renewable Energy, 34: 335-342.

Sanchez, O.J. and C.A. Cardona, 2008. Trends in biotechnological production of fuel ethanol from different feedstocks. Bioresour. Technol., 99: 5270-5295.

Saxena, R.C., D.K. Adhikari and H.B. Goyal, 2009. Biomass-based energy fuel through biochemical routes: A review. Renew Sus. Energy Rev., 13: 167-178.

Tamalampudi, S., M.R. Talukder, S. Hama, T. Numata, A. Kondo and H. Fukuda, 2008. Enzymatic production of biodiesel from Jatropha oil: A comparative study of immobilized-whole cell and commercial lipases as a biocatalyst. Biochem. Eng. J., 39: 185-189.