Biofuel Research Journal 7 (2015) 253

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Biofuel
Research Journal

Journal homepage: www.biofueljournal.com

Editorial

# The status of biofuels...

Four main types of biofuels are in use: fuel alcohols such as ethanol and butanol obtained via fermentation of sugars; biogas, a mixture of methane and carbon dioxide, obtained by anaerobic digestion of organic matter; biodiesel derived from various biological oils; and dry biomass residue of crop production for combustion. Articles in this issue address aspects of biodiesel production from oils of Jatropha, Kapok and microalgae. In addition, production of bioethanol via syngas fermentation is reviewed.

Biofuel researchers typically overlook the attributes of a feedstock which determine whether it could ever be used for the intended purpose. Just because a vegetable oil can be converted to biodiesel does not make it a viable feedstock. The key questions to consider are the following: How much oil could be produced? At what cost? Does the feedstock have better alternative uses? How sustainable would be fuel production from it? What resources would be needed and can they be provided? What would be the social implications of its use?

A suitable biodiesel feedstock oil must meet at least the following criteria: it should not be a food oil such as oils of soybean, canola, corn and oil palm; its production should not take agricultural land away from production of food and fodder crops; its production should not cause deforestation or loss of other critical habitat; its cost of production should be no more than of palm oil; its yield per hectare per year should at least equal the best possible yield for palm oil, but preferably should be much greater; its production should require minimum inputs in terms of fertilizers, pesticides, labor and water; and its production should be socially sustainable. These criteria are not easily met.

Kapok (*Ceiba pentandra*) a large evergreen tropical tree has been suggested as a source of biodiesel. Kapok seeds contain about 20–28% oil by weight. The oil is similar to cottonseed oil. Kapok grows rapidly to become productive in 4 to 5 years. Under suitable conditions the tree may yield up to 1,160 kg of seeds per hectare per annum. Assuming 25% oil in seeds, the best expected oil productivity is 290 kg per ha per year, or about 315 L per ha per year. This is only 5% of the oil productivity of oil palm, one of the most productive crops. The oil productivity of kapok is roughly 70% of the oil productivity of soybean.

Jatropha (*Jatropha curcas*) is a drought-resistant perineal tropical shrub. A native of Central America, but now grown in many tropical regions. The plant becomes productive within 12-months of planting, but can take up to 3-years to achieve high yields. Jatropha remains productive for nearly 40 years. It grows on poor soils, but fertilization greatly improves productivity. Jatropha seeds may contain between 20% and 40% oil by weight. The oil and the plant are nonedible. The maximum oil productivity is a relatively high 1,870 L per ha per year, although less than 30% of the productivity of oil palm. Oil productivity may vary a lot, depending on the growth conditions and this translates into a high level of uncertainty and a substantial financial risk. Jatropha plantations have attracted a lot of investment, but many ventures have failed. Substantial effort is needed to domesticate Jatropha as a commercial crop. Depending on sustainable yield, oil production from Jatropha plantations for biodiesel is potentially economically viable.

Microalgae may be viewed as primitive microscopic plants. They offer potential opportunities for a sustainable production of biofuels. Fuel oils, biogas, biohydrogen, and bioethanol may be produced, but commercialization remains elusive. The hurdles to economically viable and environmentally sustainable production of algal fuels are many and substantial. The biomass productivities are low; the biomass recovery from a dilute broth of algae is expensive; the recovery of oils from the biomass is challenging; the demands on resources are overwhelming for production on any meaningful scale; the net energy capture in the form of a useable fuel can be minuscule. These seemingly insurmountable problems are opportunities for new thinking. How nitrogen and phosphorous resources can be recycled? What can genetic and metabolic engineering of microalgae contribute to enhancing the capture of sunlight, simplifying the harvesting of the biomass, and easing the release of the oil from the biomass? How can cheap carbon dioxide be made available in sufficient quantity and at a suitable concentration? What can technology do to minimize the energy demands of the biomass and fuel production processes? These and many similar questions need to be satisfactorily addressed for any future sustainable production of algal fuels. To be useful, algal fuels must be produced sustainably and with a much reduced carbon footprint than of a comparable fossil fuel. If these criteria are met, algal fuels may reasonably command a certain price premium over fossil fuels and still be accepted. Commercialization of algal fuels will not be easy and will certainly require years of research.

Syngas, a mixture of hydrogen and carbon monoxide, can be used to make fuel alcohols and other products via fermentation as well as chemical processes. Syngas can be made from low-value renewable biomass by various catalytic and noncatalytic thermal treatments. Some of these biomass-to-syngas processes are already commercial. Biomass to fuel alcohols via syngas, may perhaps be the best option for making biomass-derived renewable fuels. Syngas fermentation to potential fuel alcohols is being commercially operated and new production facilities are being built.

Commercial viability of production is of course an insufficient criterion for basing production decisions. Some biofuels have proven commercially sustainable. Examples include bioethanol from sugarcane and biodiesel from palm oil. Whether they are environmentally sustainable in the long run, is debatable. Arguments for production of fuel alcohols from corn, cassava and wheat are unconvincing.

With a few exceptions, biofuels are controversial. Respected bodies such as Greenpeace and Food and Agriculture Organization of the United Nations (FAO) have suggested that biofuels actually deepen poverty and accelerate climate change. Whether biofuels will be sustainable and make any significant contribution to our energy supply, remains to be seen. Only well thought out, long term and multifaceted research is likely to produce biofuel successes.

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Please cite this article as: Chisti, Y. The status of biofuels... . Biofuel Research Journal 7 (2015) 253. DOI: 10.18331/BRJ2015.2.3.2