European Commission

Science for Environment Policy

Biorenewable chemicals: a review of technologies and feedstocks

Growing demand for biorenewable chemicals could lead to conflicts with food production and unwanted environmental impacts. Against this context, this study investigated different types of feedstock and conversion technologies. The authors recommend use of only non-edible feedstock alongside green and carbon neutral conversion technologies, such as algal fermentation.

Concerns over dependence on fossil fuels alongside increasing levels of CO_2 in the atmosphere have led to a global drive for renewable energy. Biomass (e.g. dry plant matter) can be converted to fuels and therefore some consider it an alternative to petroleum, able to meet the needs of the energy sector while reducing CO_2 emissions. As a result, governments around the world subsidise the production of biofuels from edible crops.

This has both benefits and downsides for the environment. There are also economic ramifications. The rapid pace at which edible crops were diverted to produce biofuels caused the price of some crops to rise sharply. For example, after corn was deviated for biofuel production in the US, corn prices shot up by a margin of over 100% from 2005–2007[1].

As well as for fuel, biomass can be used to produce chemicals for the pharmaceuticals, cosmetics, solvents, detergents, paints and biodegradable plastics industries. Profit from the biorenewable chemicals industry is higher than biofuels and is projected to grow at a compounded annual growth rate of 22%, and to account for almost half of the chemicals produced in the US by 2025[2,3]. This can be attributed to increasing environmental awareness among manufacturers, and a need to reduce dependency on scarce and expensive petroleum.

In this review, researchers considered some of the environmental concerns and benefits associated with different sources of feedstock and different conversion technologies. The authors describe three categories of biofuels, based on the type of raw material that is used to produce them. First generation biofuels are produced from edible sources, such as starch from corn, or triglycerides from fats and oils. As these are edible, their use leads to concerns about the impact on both food availability and prices. Lignocellulose (the woody material in plants) is a second generation feedstock, which is non-edible (although it can be extracted from edible sources). Although it is an alternative to first generation feedstock, converting plant dry matter into a useful form (simple sugar units) is expensive. Lignocellulose production is also limited because land is a finite resource.

Third generation feedstock – algae – provide a high yield of fat molecules, are able to grow on non-arable land, and can survive on a wide range of carbon sources. However, the costs associated with the conversion of algal feedstock are higher than other forms, and new technologies are needed to allow this type of feedstock to compete with the price of petroleum products.

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Biorenewable chemicals: a review of technologies and feedstocks *(continued)*

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Generations can also be defined based on the conversion technology used to produce them. Biological conversion technologies include the production of chemicals by microbes, one of the 'greenest' technologies available. A range of chemicals have been produced by microbial organisms, which can convert sugar or starch into useful products by fermentation. Although environmentally friendly, most commercial chemicals are not produced in this way on a large scale because of higher costs.

More common chemical technologies encompass physical, thermochemical and chemical conversion processes. Although there are well-established methods for processing edible biomass, methods for processing non-edible or waste biomass are less developed and generally more expensive.

Integrating both can overcome their individual shortcomings and has thus become a popular approach in industry. An example of a biorenewable chemical that has been produced using integrated techniques is succinic acid, which has an estimated market value of $63 million. Companies in the US are already producing succinic acid, and other commercially important chemicals derived from it, for applications including detergents and cosmetics. However, integrated conversion processes remain in their early stages and several challenges remain, including impurities found in biomass that can negatively impact microbial systems and maintaining catalyst stability under high temperatures.

In sum, the authors suggest that biorenewable chemicals should be produced entirely from non-edible feedstock in order to avoid conflict with food production. As the technologies used to convert non-edible feedstock into a useful form are still expensive, they say research organisations should work to develop affordable means of producing biorenewable chemicals from non-edible materials. In terms of policy, the researchers suggest decision makers should promote green technologies, such as the fermentation of sugars by algae to oil and biomass, which can then be converted into biofuels and biochemicals — potentially a carbon neutral or even positive technology.