

BIOFUELS

- Biofuels are renewable liquid or gaseous fuels made by and/or from living organisms or the wastes that they produce.
- Microbes play a crucial role in the production of sustainable biofuels.
- The European Commission Renewable Energy Directive (2009) states that 10% of transport fuel should be from renewable sources such as biofuels by 2020.

WHY DO WE NEED BIOFUELS?

Sustainable biofuels are essential to ensure a constant, secure supply of energy for individuals and industry. Advanced biofuels will reduce our dependency on fossil fuels and limit our impact on the environment. It is also argued that investing in biofuel production may boost the economy of developing countries.

CURRENT BIOFUELS

Bioethanol and biodiesel are the two main types of biofuel that are currently commercially produced. These can replace, or be used in combination with, petrol, diesel and aviation kerosene as transport

fuels. Biodiesel is currently produced by extracting the oil from crops such as soybean (USA), oilseed rape and oil palm (Europe), and converting it to biodiesel. Bioethanol is produced from sugar beet, sugar cane and corn. The sugars are fermented to ethanol by the micro-organism yeast. Biofuels that are produced from edible crops are called traditional, or 'first-generation' biofuels. These biofuels are considered to be less sustainable than more advanced biofuels, as the feedstocks they use represent energy that can be used by humans or other animals.

NEW APPROACHES TO BIOFUELS

'Second-' and 'third-generation' biofuels are generated from non-food crops. Microbes play a key role in the development of these biofuels. They are more sustainable than first-generation biofuels as they produce higher yields, reduce greenhouse gas production and do not compete with crops grown for food. Two major areas of research are lignocellulosic biofuels and algae.



Cells of the algae *Chlamydomonas*. Power and Syred/Science Photo Library

LIGNOCELLULOSIC BIOFUELS

Lignocellulosic biofuels are produced through the breakdown of carbohydrates (celluloses) locked in the cell walls of plants, which can then be fermented by yeast or other micro-organisms.

Lignocellulosic biomass makes up about half of the total biomass in the world and represents the non-edible parts of crops such as stalks, chaff, sawdust and wood chip. Approximately 430 million tons of plant waste is produced from farmland each year, which could be recycled in biofuel production.

Lignocellulose is designed to be strong and resistant to degradation. This means it is very difficult to release it from the cell walls and to break down the celluloses into sugars for microbial fermentation. Microbiologists are working to find microbes that produce an enzyme complex called cellulase that breaks down celluloses into sugars. Microbes that naturally produce cellulase have been identified in diverse environments such as the stomachs of cows and termites and in volcanic soil. Microbiologists are using genetic techniques to improve the production of cellulase in two ways; by improving the yields from cellulase-producing microbes or by transferring microbial cellulase genes into standard strains of bacteria used in industry, to enable large-scale production of cellulase.

Once the celluloses are broken down, the sugars can be fermented by yeast or other micro-organisms. New strains have been identified that are suitable for fermentation in industry; for example, heat-loving (thermophilic) bacteria that can ferment sugars into ethanol very efficiently at high temperatures, making the process more cost-effective.

If lignocellulose in cell walls can be released and converted to ethanol efficiently, bioethanol could eventually be commercially produced from wood, straw and waste materials. If all cell wall

sugars were readily accessible to fermenting microbes, 5 kg of wood could theoretically produce up to 2.5 litres of ethanol.

ALGAE

Algae are a diverse group of photosynthetic micro-organisms. They use the energy from sunlight and carbon dioxide to produce biomass including oil, which can be converted into biodiesel.

Algal-based biofuels have several advantages. Microalgae have the potential to produce up to 100 times more oil per acre than any terrestrial plant. Also, algae do not compete with food crops for land as they can be grown on non-productive, non-arable land using a variety of water sources. The development of algal biofuels is at an experimental stage and production is currently very costly due to a limited knowledge of scale-up possibilities. At present, industrial-scale production of biodiesel from algae costs at least 10–30 times more than making traditional biofuels.

Algal biofuels can also be produced by processing algal biomass. This is similar to lignocellulosic processing, where the end product is sugars that can be fermented to alcohol by microbes.

CURRENT RESEARCH

Microbiologists are currently working in a number of areas to make biofuel production more efficient. These include:

- Scaling-up the production of microbial cellulase that will break down celluloses into fermentable sugars.
- Engineering yeast to tolerate higher concentrations of alcohol to increase bioethanol production.
- Genetically modifying micro-organisms to ferment sugars more efficiently to increase bioethanol yields.
- Optimizing microbial strains that will convert sugars into biobutanol as an alternative to bioethanol.
- Finding algae that produce high yields of oils or are otherwise well-adapted for biodiesel production.

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