TURNING LAWN INTO JET FUEL

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What do you think of when you see grass? A cow? Football? Grass-type Pokémon? Nowadays, it is also possible to relate grass to a jet or, more precisely, jet fuel.

Fossil fuels are made from carbon compounds that originate from plants and animals that died millions of years ago. When dead organisms are buried, they decompose in the absence of oxygen. Depending on the time and conditions, such as the temperature and pressure at which they are decomposed, different fossil fuels (for instance petroleum, natural gas and coal) can be formed. The formation of fossil fuel takes millions of years, which is also why they get the name 'fossil'; however, this process can be assimilated and accelerated under controlled engineering conditions.

Currently, the fuels that we are using in our transport are refined from fossil fuels. As fossil fuels are not infinite, and as global warming is increasing greenhouse gases (such as carbon dioxide) in the atmosphere, there is an urgent need to turn to renewable energy and resources. This is where the biorefinery approach comes in.

'Biorefinery' is a conceptual model for future biofuel production, where both fuels and high-value co-product materials are produced. It attempts to apply the conventional petroleum refining methods to biomass, incorporating biological processes. A biorefinery can get its feed from dedicated crops, either from agriculture or from forestry.

Getting dedicated crops from agriculture to feed biorefinery, however, is a contentious issue because it is seemingly in conflict with the demands of food production as the world population is expanding exponentially. Thus, waste biomass can be used as an alternative feedstock.

Plants like grass are rich in cellulose, and if you break down the cellulose, you can utilise its sugar. Some bacteria are able to consume these sugars and convert them to other compounds such as lactic acid, a three-carbon compound that can often be found in your muscles, as well as in yoghurt and dairy products. Other bacteria can make caproic acid, a six-carbon oily compound found in goat milk fat. While it would take too long to form fuels through microbial processes alone, electrochemistry can be applied to assist the process.

Electrochemistry is not unfamiliar in everyday life; it involves a reduction and oxidation reaction between materials—for example, in the rusting of iron. When iron comes into contact with oxygen and water, iron is oxidised into iron oxide, which we see as rust, while the oxygen is reduced to water. By applying electrochemistry, caproic acid can be reduced to decane, a 10-carbon, energy-dense, liquid hydrocarbon fuel commonly used in aviation.


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Our research makes use of these natural microbial actions, and adds spices of an engineering approach to achieve a process that would otherwise take years to accomplish. We aim to produce hydrocarbon fuel directly from grass. First, we feed grass to bacteria to obtain lactic and caproic acids, and then we apply electrochemistry to convert these microbial oils into fuel.

The next phase is a feasibility study and upscaling of the process. While industrial plants that convert grass into methane gas (which is similar to natural gas for energy generation) have already existed, it is also of prime interest to produce liquid biofuels that are more compatible with combustion engines.

With minimal nutrient requirements, grass can grow almost anywhere, except in the coldest region of the Arctic and Antarctica. If it is left unattended, grass will grow and wilt, decompose by bacteria into carbon dioxide, and finally be absorbed again by new grass, forming a cycle. Here, we intercept the cycle and produce a useful product, while still keeping the cycle closed, and without introducing more carbon dioxide into the system. In this way, we can reduce the reliance on fossil fuels and hence curb the emission of carbon dioxide into the atmosphere.

As grass normally grows by spreading across a great area instead of being packed into a small space, one of the biggest challenges is the efficient harvesting and collection of grass. Apart from that, as fragile-looking as grass is, in reality it is a tenacious organism, both in terms of vitality and structure.

Considerable energy investment is required to break down the biomass to improve its biodegradability. This increases the process cost and optimisation required to attain a prospective economic outlook. But considering the sheer volume of grass worldwide, it is very worthwhile to investigate how its potential can be fully exploited.

Way Khor will be speaking at the 17th International Biotechnology Symposium (IBS 2016).