The whey to greener electricity

Using dairy waste as an alternative source of power.

IT MAY seem ridiculous, but in the hunt for sources of alternative energy researchers have come up with fuel cells which are powered by cheese—or at least whey, a by-product in cheese making. Usually fuel cells run on hydrogen, but the aim of the research is to allow factories to recover energy from waste products like whey by converting organic materials directly into electricity.

Whey is rich in lactose, a sugar which Georgia Antonopoulou, a biochemical engineer at the University of Patras, Greece, says can be consumed by cultures of bacteria contained within a fuel cell in order to generate an electric current. Microbial fuel cells, as they are known, are not a new idea but only in the past few years have they attracted attention as a way of both dealing with raw waste water and generating electricity at the same time.

The organic content of whey can pose an environmental hazard and many governments now impose strict regulations requiring factories to pay for its treatment before disposal. Whey constitutes about 70% of the volume of the milk used to make cheese, says Dr Antonopoulou. So, just one small feta facility will need to dispose of as much as 4,000 tonnes of whey in a single year, she says. Microbial fuel cells could help, and not just in the cheese-making industry. Breweries, pig farms, food-processing plants and even works dealing with domestic sewage could gain from the technology.

Traditional fuel cells work by using a catalytic material to oxidise a fuel, such as hydrogen, turning it into a positively charged ion and a negative electron. The positive ions are drawn to a second electrode, via a membrane or electrolyte that will not allow electrons to pass through. This forces the freed electrons to travel to the second electrode through a wire, creating an electric current.

Microbial fuel cells function in much the same way except that the catalytic reactions are carried out by bacteria contained within the fuel-cell chamber. Under anaerobic conditions (where oxygen is absent) they metabolise the fuel by feeding off it and in doing so produce natural chemical reactions that cause ions to be released, allowing a current to flow.

In theory microbial fuel cells can run on just about any kind of organic matter, says Chris Melhuish, head of the Bristol Robotics Laboratory, England. “All you have to do is match the microbial culture with the type of stuff you want to use as fuel,” he says. Dr Melhuish has spent some years trying to power robots on domestic waste water, but getting it right can be tricky. Ideally you would want to use cheap and nasty raw-waste products, he says. But traditionally the fuel cells work best when fed a refined fuel in the form of solutions containing synthetic sugars, such as glucose.

However, Dr Antonopoulou has now shown that, using a culture of bacteria obtained from her local waste water plant, it is possible to get almost as much power from raw whey as from refined fuel, provided the whey is diluted. The trouble is the power output still only amounts to milliwatts, barely enough to trickle-charge a cellphone. And working with raw waste water also presents challenges.

Initially Dr Antonopoulou and her colleagues found that the coulombic efficiency of their cells—a measure of how many electrons produced actually flow into a circuit—was particularly low, at around just 2%. This turned out to be because a second set of microbes, within the whey itself, was absorbing them. So, by sterilising the whey first to kill these other bugs they have now boosted the coulombic efficiency to around 25%. And they say that the total power of the

device should improve further with a new design within the fuel chamber that increases the surface area of the electrodes.

One of the biggest obstacles is a lack of investment to develop materials that would work with this kind of fuel cell. As things stand, researchers like Dr Antononpoulou and Dr Melhuish have to use electrodes designed with traditional fuel cells in mind. If the various hurdles can be overcome and the technology can be scaled up to industrial levels, then there is the potential for microbial fuel cells to start generating as much power as the anaerobic digesters that are beginning to be used by industry to produce gas from waste material. Given time, then, the technology can only mature; just like a good cheese.

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