Could plastic grow on trees?

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Chemists have pulled off a sweet trick to help create biorefineries, reports Roger Highfield

A major step towards creating "biorefineries" that can turn plants and trees into plastics and petrol has been reported by chemists.

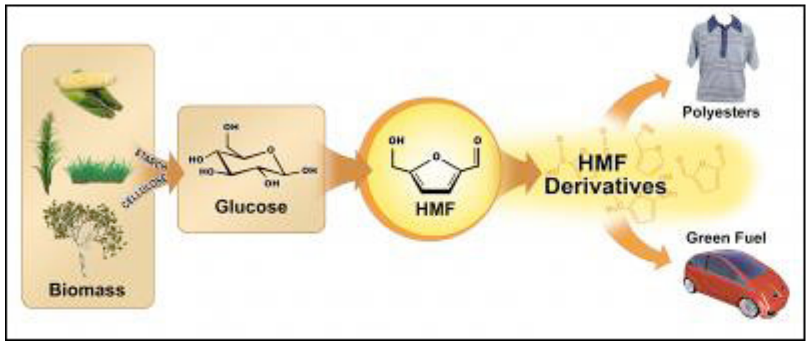

Diagram illustrating the chemical process

The advance in renewable energy comes as Colin Campbell of the Oil Depletion Analysis Centre, based in London and Aberdeen, warns that global production of oil is set to peak in the next four years before entering a steepening decline, though the centre itself believes the decline could begin any time until 2015.

For years, chemists have quested for the elusive goal of finding a way to sidestep the use of crude oil as the root source of chemicals for plastic, fuels and scores of other industrial and household chemicals, aiming to replace it with inexpensive, nonpolluting renewable plant matter instead.

Today, there is a concerted global effort to identify ways of converting plant-derived molecules, especially cellulose, into replacements for petrochemical feedstocks. In that way, biorefineries would be used for the production of fuels, chemicals and plastics instead of traditional (petro)chemical processing.

Now American scientists announce in the journal Science that they have discovered the most effective method yet to convert glucose, which is found in plants worldwide and nature's most abundant sugar, to a chemical building block that can be turned into components for products now made from petroleum, notably the polymers used in plastics, and fuels.

In other words, they have found a way to turn sugars that are ubiquitous in nature to an alternative source for those chemical products that make oil so valuable.

"What we have done that no one else has been able to do is convert glucose directly in high yields to a primary building block for fuel and polyesters," said Conrad Zhang, senior author who led the research and a scientist with the Pacific Northwest National Laboratory in Richland, Washington.

That building block that can be derived from plants, as an alternative to those traditionally made from petroleum is called HMF, which stands for hydroxymethylfurfural, and is viewed as a promising surrogate for petroleum-based chemicals that are used at the moment.

Glucose, in plant starch and cellulose, is nature's most abundant sugar. The problem has been turning into HMF in an efficient way. "But getting a commercially viable yield of HMF from glucose has been very challenging," Zhang said. "In addition to low yield until now, we always generate many different byproducts," making product purification expensive and uncompetitive with petroleum-based chemicals."

Working with Haibo Zhao, John Holladay and Heather Brown, Zhang was able to obtain HMF yields upward of 70 percent from glucose and nearly 90 percent from the plant sugar fructose while leaving only traces of impurities.

To achieve this, the team experimented with a novel catalysts - substances that speed chemical reactions - in a solvent capable of dissolving cellulose. The solvent is a liquid salt - think of a version of table salt that melts at low temperature - that is called an ionic liquid.

Zhang and his team discovered that in this ionic liquid a particular metal derivative - chromium chloride -

was by far the most effective at converting glucose to HMF with few impurities and, as such reactions go, at low temperature, 100°C.

His next step is to tinker with the catalyst and solvent to improve the yield of HMF while reducing separation and purification cost. "The opportunities are endless," Zhang said. However, he admits that the chemistry that makes the transformation possible is a mystery.

"This, in my view, is breakthrough science in the renewable energy arena," said Prof John White at the University of Texas. "This work opens the way for fundamental catalysis science in a novel solvent."

However, a British ionic liquid expert, Prof Ken Seddon of The Queen's University of Belfast, commented yesterday: "I am always wary of miracle cures, and I am particularly wary of large scale "green" processes based on toxic metals such as chromium."