# Fuel from Cellulose

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Independence from fossil fuel exporting nations, a reduction in the release of greenhouse gases, conservation of dwindling resources: there are any number of reasons to stop the use of fossil fuels.

Hydrogen technology and solar energy will very probably provide the solution to our global energy problem—in the long term. For an initial quick remedy we may look to bioenergy. Biomass can be used to generate alternative carbon-based liquid fuels, allowing the continued use of current automotive combustion engine technology and existing infrastructure. At the same time, the chemical industry would continue to be supplied with the carbon compounds it requires as raw materials for plastics, textiles, etc.

Mark Mascal and Edward B. Nikitin at the University of California, Davis (USA) have now developed an interesting new method for the direct conversion of cellulose into furan-based biofuels. As they report in the journal *Angewandte Chemie*, their simple, inexpensive process delivers furanic compounds in yields never achieved before.

Atmospheric carbon dioxide is viewed as the ultimate carbon source of the future. It is most efficiently “harvested” by plants via photosynthesis. Currently, biofuel producers primarily use starch, which is broken down to form sugars that are then fermented to give ethanol. Cellulose is however the most common form of photosynthetically fixed carbon. The problem is that the degradation of cellulose into its individual sugar components, which could then be fermented, is a slow and expensive process. “Another problem is that the carbon economy of glucose

fermentation is poor," explains Mascal, "for every 10 g of ethanol produced, you also release 9.6 g CO2."

Could we avoid the breakdown of cellulose and fermentation? Mascal and Nikitin demonstrate that we can indeed. They have developed a simple process for the conversion of cellulose directly into "furanics", which are furan-based organic liquids. Furans are molecules whose basic unit is an aromatic ring made of one oxygen and four carbon atoms. The main product the researchers obtain under the conditions they have been developing is 5-chloromethylfurfural (CMF).

CMF and ethanol can be combined to give ethoxymethylfufural (EMF), and CMF reacts with hydrogen to give 5-methylfurfural. Both of these compounds are suitable as fuels. EMF has previously been investigated and found to be of interest in mixtures with diesel by Avantium Technologies, a spin-off of Shell.

"Our method appears to be the most efficient conversion of cellulose into simple, hydrophobic, organic compounds described to date," says Mascal. "It also surpasses the carbon yields of glucose and sucrose fermentation. Furanics could be established as both the automotive energy source and chemical starting material of the future."

Citation: Mark Mascal, Direct, High-Yield Conversion of Cellulose into Biofuel, *Angewandte Chemie International Edition*, doi: 10.1002/anie.200801594

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