BIOMASS
MAGAZINE

EPFL: Turning biofuel waste into wealth in a single step

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Lignin extracts with (L) and without (R) formaldehyde.
Alain Herzog/J. Luterbacher/EPFL

Reducing our reliance on fossil fuels means turning to plant-derived biofuels and chemicals. But producing them cost-effectively from plants and other organic matter—collectively referred to as biomass—is a major engineering challenge. Most biomass comes in the form of non-edible plants like trees, grass, and algae, which contain sugars that can be fermented to produce fuel. But biomass also contains lignin, a bulky, complex organic polymer that fills wood, bark, and generally gives plants rigidity. Because it is difficult to process, lignin is usually discarded during biofuel processing. EPFL scientists have now turned lignin from a nuisance to an important source of biofuel by simply adding a common chemical, converting up to 80 percent of it into valuable molecules for biofuel and plastics. The patent-pending method, which can be scaled up to industrial levels, is published in *Science*.

Complex, but energy-dense

Lignin is an enormously complex biopolymer, filling the hard wall that surrounds each plant cell. In fact, lignin makes up almost a third of plant biomass, and its molecular structure gives it an energy density 30% greater than that of the sugars that are traditionally processed into biofuel. The problem is that lignin is difficult to extract and transform. Due to its instability, lignin usually rapidly gets destroyed during its extraction and most researchers have failed to efficiently break it apart for upgrade into fuels or chemicals.

Now, an international team of researchers led by Jeremy Luterbacher at EPFL, has shown that they can easily break lignin apart simply by adding the chemical formaldehyde to the process. Formaldehyde is one of the most widely used chemicals in industry, and it is simple and cheap to produce. The researchers found that formaldehyde stabilizes lignin and prevents it from degrading, leading to high yields of building blocks that can be used to make substitutes for petrochemicals. These yields were 3-7 times higher than those obtained from lignin without formaldehyde.

Scaling up

“Depending on the wood used we get between 50 and 80 percent,” says Jeremy Luterbacher, who became known in 2014 for developing a method for extracting sugars from plants safely and cheaply (also published in *Science*). “The chemistry is relatively straightforward; the real challenge is actually finding investors for a pilot facility to demonstrate this.” The market, he says, is difficult for sustainable energy largely because of inconsistent political support and widely varying energy prices. Investors for such innovative platforms are hard to come by in an uncertain market, especially considering the competition of well-established fossil fuels.

“The technology looks really good,” says Luterbacher. “If the global political establishment sent a consistent message about moving away from fossil fuels, then investors would take notice. But I think Switzerland is a great place to get started. The Swiss have been unwavering supporters of clean energy and could help demonstrate new technologies, and so I’m quite optimistic about the future.”

This work involved a collaboration of EPFL’s Institute of Chemical Engineering (ISIC) with the University of Wisconsin-Madison, the US Department of Energy, and Purdue University. It was funded by the Swiss Competence Center for Energy Research (Biomass for a Swiss Energy Future), the Swiss National Science Foundation, EPFL, the US Department of Energy (Great Lakes Bioenergy Research Center; Center for Direct Catalytic Conversion of Biomass to Biofuels. EPFL has submitted a patent application based on this work.