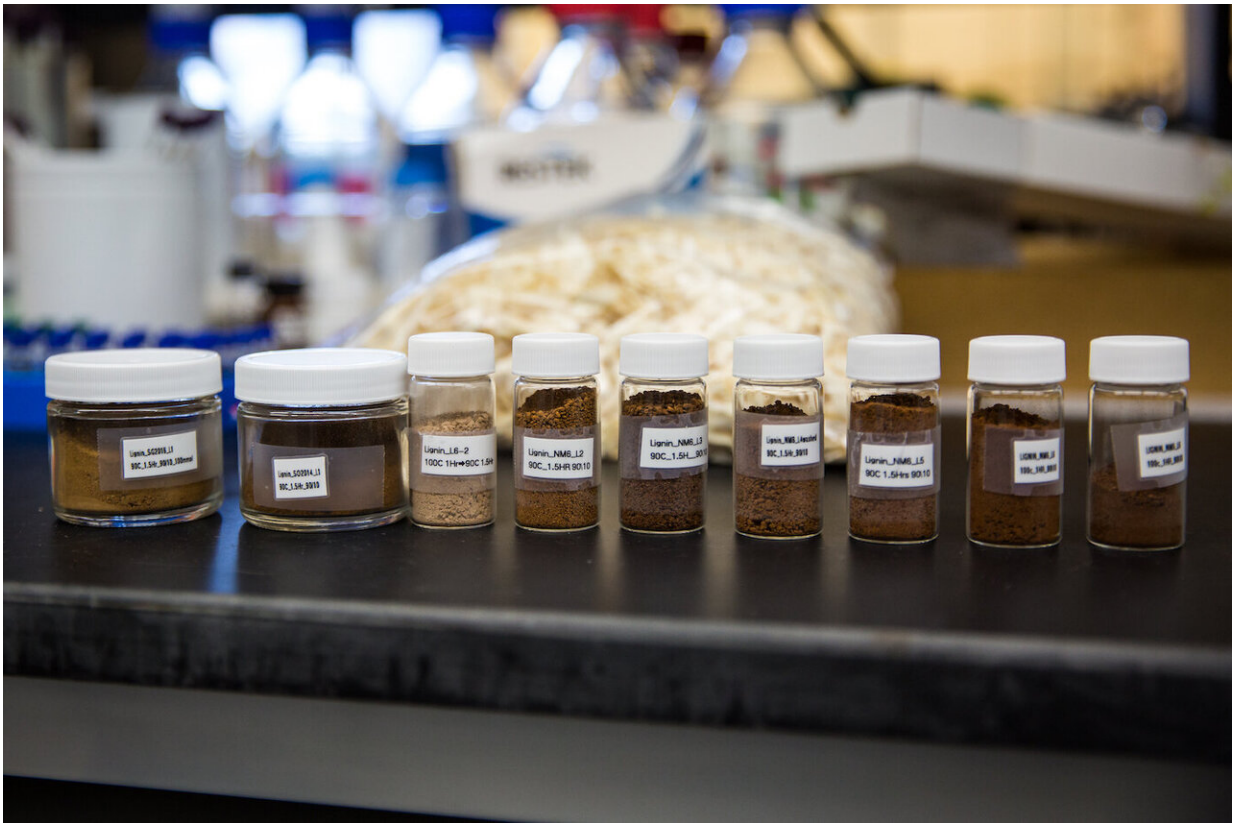
Relieving two headaches with one process

July 2 2019, by Jill Sakai



Pictured here are lignin samples in the lab at the Wisconsin Energy Institute. Credit: Chelsea Mamott

With a new method to synthesize a popular pain-relieving medication from plants rather than fossil fuels, researchers at the Great Lakes Bioenergy Research Center have found a way to relieve two headaches at once.

A team led by John Ralph, a professor of biochemistry at the University of Wisconsin–Madison, has been awarded a patent for a method to synthesize acetaminophen—the active ingredient in Tylenol—from a natural compound derived from plant material. The approach offers a renewable alternative to the current manufacturing process, which uses chemicals derived from coal tar. It also creates a useful product from an abundant but difficult-to-manage component of plant cell walls called lignin.

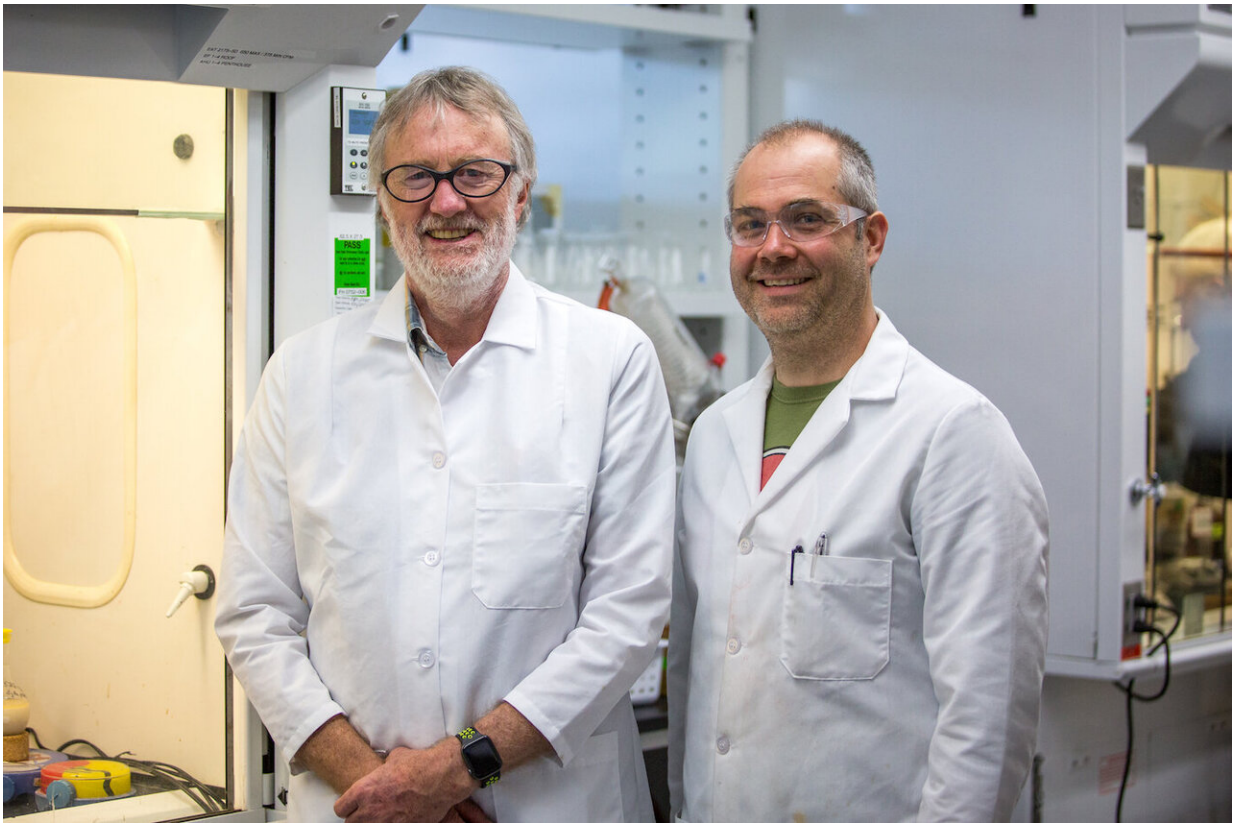
"Lignin is an extremely complex, messy polymer. No two molecules in a plant are exactly the same," Ralph says. "It's very effective for providing structure and defense for the plant, but it's challenging for us to break down into usable materials."

The lignin in bioenergy crops, such as poplar, can create a headache for bioenergy researchers due to its recalcitrant tendencies, Ralph says. Once plant sugars are used to produce biofuels, the lignin that remains is typically burned for energy.

The patent application, filed by the Wisconsin Alumni Research Foundation, describes a way to convert a molecule found on lignin into acetaminophen. It was awarded in May to Ralph, Steven Karlen of UW–Madison, and Justin Mobley, a former GLBRC postdoctoral fellow who is now at the University of Kentucky.

Structurally, acetaminophen is a relatively simple compound: a six-carbon benzene ring with two small chemical groups attached. Poplar trees naturally make a very similar structure, called p-hydroxybenzoate, attached to lignin.

"Although lignin itself is a challenge to break down, the p-hydroxybenzoate is fairly easy to clip off as a quite pure stream," Ralph says.



A team led by John Ralph (left), a professor of biochemistry at the University of Wisconsin–Madison, and research scientist Steve Karlen has been awarded a patent for a method to synthesize acetaminophen—the active ingredient in Tylenol—from a natural compound derived from plant material. Credit: Chelsea Mamott

From there, the researchers devised a short series of chemical reactions to convert the molecule into acetaminophen. The method is inexpensive and builds on a biomass pretreatment process previously developed at GLBRC.

In addition to charting a way to synthesize acetaminophen from a renewable, sustainable source material, the newly patented process

improves the overall bottom line for biorefining—that is, producing fuels and other industrial materials from plants.

"Making money off any side product helps drive the economics of the biorefinery," Ralph explains. "In many cases, these products are even more valuable than the fuel."

Steve Karlen, research scientist at UW–Madison, prepares a sample in John Ralph's lab at the Wisconsin Energy Institute building in Madison, Wis., Thursday, June 27, 2019. Credit: Photo by Chelsea Mamott

The plant material also offers the chemical advantage of starting from a molecule that already has some of the desired structure. More complex petrochemicals must first be stripped down to basic molecular backbones before being built back up into the desired compounds.

"As industries prepare to shift away from a fossil-fuel-based economy, having biomass-based pathways at the ready will be an essential piece of that process," Ralph says. "Here is an opportunity to make a high-demand, 'green' pharmaceutical from plants rather than from fossil fuels."

Acetaminophen and related molecules are also useful as commodity chemicals, the industrial building blocks used to make products including other pharmaceuticals, plastics and fuels.

The researchers are now working on refining the process to improve the yield and purity of the plant-derived acetaminophen.

Provided by University of Wisconsin-Madison

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