Refined method to convert lignin to nylon precursor

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A new study from the Energy Department's National Renewable Energy Laboratory (NREL) demonstrates the conversion of lignin-derived compounds to adipic acid, an important industrial dicarboxylic acid produced for its use as a precursor to nylon, plasticizers, lubricants, polyesters, and other popular products and chemicals.

The demonstration is an important step toward the goal of garnering more uses from lignin, which could be crucial for the economic success of the biofuels industry. It also shows that adipic acid can be produced from a renewable resource, which might have important ramifications for mitigating greenhouse gases.

Published in *Energy & Environmental Science*, the research in "Adipic acid production from lignin" demonstrates how lignin-derived compounds can first be converted to muconic acid via a biological process. Muconic acid can then be separated from the biological culture and catalytically converted into adipic acid. A patent application has been filed on this research, and the NREL Technology Transfer Office will be working with researchers to identify potential licensees of the technology.

The potential impact of this study is revealed by a quick review of the production numbers of adipic acid. Approximately 2.5 million tons of adipic acid are produced each year, mainly as a precursor for the production of nylon, and this global demand is expected to increase by up to 3.5% annually. Nylon is one of the most abundant materials in the

world, used in everything from carpet and ropes to clothing and toothbrushes. With more than 4 million metric tons of nylon manufactured annually around the world, capitalizing on the production of adipic acid from lignin-derived aromatic molecules could one day have a significant impact on the bottom line of lignocellulosic biorefineries.

"The current industrial pathway to produce adipic acid involves oxidation of cyclohexanol and cyclohexanone with nitric acid, which is a harsh process that produces nitrous oxide that must be cleaned up," said Gregg Beckham, senior engineer at NREL and a co-author of the study. "The development of a new process toward converting renewable lignin feedstocks to adipic acid could potentially provide positive economic benefits and greenhouse gas offsets, but, certainly, major technology improvements must still be made."

Lignin is one of the most abundant organic materials on Earth (second only to cellulose), and it potentially offers a vast, renewable source for the sustainable production of fuels, chemicals, and materials. Valorization of lignin has been shown by techno-economic analysis conducted at NREL to be essential to the development and success of the biofuels industry. However, because it is inherently difficult to remove from biomass, lignin is currently underutilized in fuel and chemical production.

"While our research is still in the concept stage, this gets us one step closer to improving the technology to expand the slate of molecules that can be viably produced from lignin," Beckham said. "As more lignocellulosic biorefineries come on line, large quantities of lignin will be generated, and valorization of these waste streams could eventually play a key role for the economic viability and environmental sustainability of biorefineries."

More information: "Adipic acid production from lignin" *Energy Environ*. Sci., 2015,8, 617-628 DOI: 10.1039/C4EE03230F

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