New process helps overcome obstacles to produce renewable fuels and chemicals

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(Phys.org) —There's an old saying in the biofuels industry: "You can make anything from lignin except money." But now, a new study may pave the way to challenging that adage. The study from the Energy Department's National Renewable Energy Laboratory (NREL) demonstrates a concept that provides opportunities for the successful conversion of lignin into a variety of renewable fuels, chemicals, and materials for a sustainable energy economy.

"Lignin Valorization Through Integrated Biological Funneling and Chemical Catalysis" was recently published in the *Proceedings of the National Academy of Sciences*. The NREL-led research project explores an innovative method for upgrading lignin.

The process for converting glucose from biomass into fuels such as ethanol has been well established. However, plants also contain a significant amount of lignin – up to 30 percent of their cell walls. Lignin is a heterogeneous aromatic polymer that plants use to strengthen cell walls, but it is typically considered a hindrance to cost-effectively obtaining carbohydrates, and residual lignin is often burned for process heat because it is difficult to depolymerize and upgrade into useful fuels or chemicals.

"Biorefineries that convert cellulosic biomass into liquid transportation fuels typically generate more lignin than necessary to power the operation," NREL Senior Engineer and a co-author of the study Gregg Beckham said. "Strategies that incorporate new approaches to transform

the leftover lignin to more diverse and valuable products are desperately needed."

Although lignin depolymerization has been studied for nearly a century, the development of cost-effective upgrading processes for lignin valorization has been limited.

In nature, some microorganisms have figured out how to overcome the heterogeneity of lignin. "Rot" fungi and some bacteria are able to secrete powerful enzymes or chemical oxidants to break down lignin in plant cell walls, which produces a heterogeneous mixture of aromatic molecules. Given this large pool of aromatics present in nature, some bacteria have developed "funneling" pathways to uptake the resulting aromatic molecules and use them as a carbon and energy source.

This new study shows that developing biological conversion processes for one such lignin-utilizing organism may enable new routes to overcome the heterogeneity of lignin. And, that may enable a broader slate of molecules derived from lignocellulosic biomass.

"The conceptual approach we demonstrate can be applied to many different types of biomass feedstocks and combined with many different strategies for breaking down lignin, engineering the biological pathways to produce different intermediates, and catalytically upgrading the biologically-derived product to develop a larger range of valuable molecules derived from lignin," Beckham said. "It holds promise for a wide variety of industrial applications. While this is very exciting, certainly there remains a significant amount of technology development to make this process economically viable."

A patent application has been filed on this research and NREL's Technology Transfer Office will be working with researchers to identify potential licensees of the technology.

In addition, researchers from NREL participated in a recent review on lignin valorization published in *Science* Magazine. This review highlighted the broad potential for manufacturing value-added products from lignin, including low-cost carbon fiber, engineering plastics and thermoplastic elastomers, polymeric foams and membranes, and a variety of fuels and chemicals all currently sourced from petroleum.

More information: Jeffrey G. Linger, Derek R. Vardon, Michael T. Guarnieri, Eric M. Karp, Glendon B. Hunsinger, Mary Ann Franden, Christopher W. Johnson, Gina Chupka, Timothy J. Strathmann, Philip T. Pienkos, and Gregg T. Beckham. "Lignin valorization through integrated biological funneling and chemical catalysis." *PNAS* 2014 ; published ahead of print August 4, 2014, DOI: 10.1073/pnas.1410657111 Lignin Valorization: Improving

"Lignin Processing in the Biorefinery." Arthur J. Ragauskas, et al. *Science* 16 May 2014: Vol. 344 no. 6185. DOI: 10.1126/science.1246843

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