Research uncovers potential sustainable refining method for lignin

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Lignin, used as a renewable resource to produce high-value products, has presented both production and economical challenges for biorefinery operations.

However, a Texas A&M AgriLife Research scientist suggests the use of an extraction method, plus other refining processes to produce multiple lignin streams.

Dr. Joshua Yuan, chair of Synthetic Biology and Renewable products at Texas A&M University, has published his research findings in *Green Chemistry*, the peer-reviewed journal of the Royal Society of Chemistry.

Sustainable biorefinery heavily depends on the generation of value-added products, particularly from lignin. Despite considerable efforts, the production of fungible lignin bioproducts is still hindered by the poor fractionation and low reactivity of lignin, according to the journal article, which is featured on the cover.

Yuan proposes the use of selective organic solvent extraction, also known as SOFA, a process that uses different conditions such as pH and temperature to derive lignin with different chemistry.

"This process is used so that a variety of lignin particles with different features can be produced," he said. "This will allow different functionality. It is an important consideration for applications like drug delivery and nanocomposites."

As a result, he said, tailoring the lignin chemistry using SOFA provides a sustainable means for upgrading the low-value lignin and thus contributes to the profitability of biorefineries.

"Lignocellulosic biomass can be used to produce second-generation biofuel, or advanced biofuel, which will be a sustainable and alternative solution to traditional fossil fuel," Yuan said. "Basically, grass-like sorghum and switchgrass can be grown to fix carbon dioxide and processed into ethanol for fuel.

"Considering the high yield of energy sorghum, energy cane and other feedstock, the productivity per acre is much higher than corn ethanol. This will reduce carbon balance and improve the energy output of biofuel. For perennial feedstock like switchgrass and energy cane, it also promotes soil and water conservation as well as biodiversity."

Yuan said the problem is that lignin is the waste in this biorefinery process, which negatively impacts the economics and sustainability of the biorefinery. He said the utilization of lignin for high-value products will improve biorefinery cost-effectiveness and sustainability significantly.

"Lignin nanoparticle is a high-value product that could achieve this, when it is used for bulk products like slow-release fertilizer," he said. "Another very important aspect is that lignin is generally considered safe and biocompatible. And lignin nanoparticle can be used for drug delivery."

Yuan said one of the most important challenges in biorefinery, specifically lignocellulosic biorefinery, is to utilize lignin for high-value products, Yuan said.

"Most of the current biorefinery configuration focuses on ethanol as the single product, which brings limited value to the output," he said. "If you look at the corn ethanol biorefinery, they have distillers grains and corn oil as the byproducts to add value, so that the refinery can make money. In the same way, the petroleum biorefinery industry utilizes every bit of feedstock to produce different (preferably higher value) products.

"Lignocellulosic biorefinery needs to use complete feedstock to produce different products and if possible, high-value products, to make the refinery economically feasible. This requires new biorefinery processes like SOFA."

Yuan said a plant cell wall has three major components: cellulose, hemicellulose and lignin. Both cellulose and hemicellulose are sugar-based, and can be used for ethanol fermentation.

"But lignin is an aromatic polymer, and we need to find good use for it. This paper provides one of the solutions. My lab has been focused on this, and we have developed routes to produce high quality carbon fiber, nanoparticles, asphalt binder modifier, bioplastics and biodiesel from lignin. This research was supported by the Department of Energy Bioenergy Technology Office."

More information: Zhi-Hua Liu et al. Defining lignin nanoparticle properties through tailored lignin reactivity by sequential organosolv fragmentation approach (SOFA), *Green Chemistry* (2018). DOI: 10.1039/C8GC03290D

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