Biofpr Biofuels Bioproducts & Biorefining

Lignin Bioproducts to Enable Biofuels

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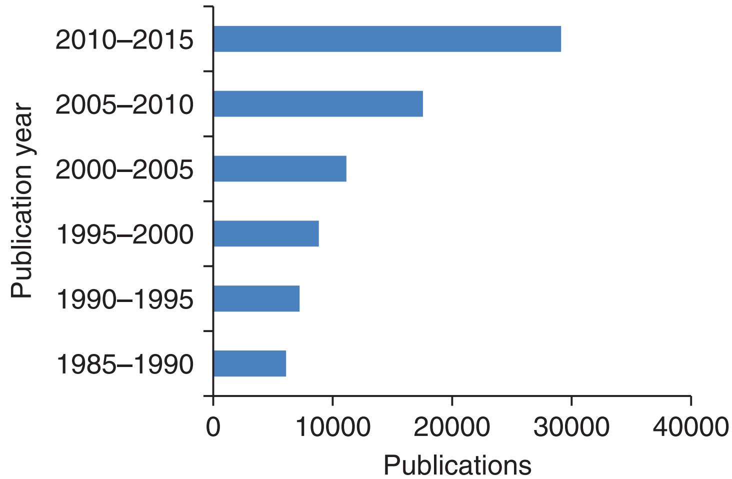
Over the past few years, the biofuels industry has 'quietly' reached a significant milestone as synergistic private and government investments have brought on-line a series of commercial cellulosic ethanol plants that are delivering important products; creating value for agricultural residues, cellulosic waste materials, and/or energy crops; and addressing climate change, rural development, and renewable energy security issues.[1,2] Many of these facilities have opted to use the biological technology platform to convert cellulosic biomass to fuels, an impressive challenge is that these facilities only derive high value from ~65-75% of the bioresource. Lignin, nature's dominant aromatic polymer, is found in most terrestrial plants in the approximate range of 15 to 40% dry weight to provide structural integrity. Traditionally, most large-scale industrial processes that use plant polysaccharides burn lignin to generate the heat and power needed to productively transform biomass. However, because lignin is wet and has a lower energy content than coal, its value in this role is limited to well under $50/dry ton, and higher value use could enhance overall biorefinery competitiveness. The advent of biorefineries that convert cellulosic biomass into liquid transportation fuels will generate substantially more lignin than is necessary to power these operations and efforts are critically needed to transform it into higher value products.

Bioengineering to modify lignin and/or adding atypical components has shown promise

Table 1. Lignin related publications.



Today's and tomorrow's biofuels production facilities could benefit tremendously from increasing the value from the large amount of lignin that results from biofuels operations. Certainly, the scientific community, and biofuels industry has begun to recognize the challenges and opportunities associated with lignin as highlighted in Table 1.

The valorization of lignin is not a new challenge, as the forest products industry has championed trying to address this need in the past, and some commercial products for lignin have been established.[3] However, its diverse structure, difficulties in isolation, and complex chemistry has hindered widespread utilization. One of the key challenges over the past decade that will change this historical perspective is to advance lignin bioengineering in combination with novel lignin separation technologies. Bioengineering to modify lignin structure and/or the incorporation of atypical components has shown promise toward facilitating recovery and chemical transformation of lignin under biorefinery conditions. The flexibility in lignin monomer composition has proven useful for enhancing extraction efficiency. Both the mining of genetic variants in native populations of bioenergy crops and direct genetic manipulation of biosynthesis pathways have produced lignin feedstocks with unique lignin properties for co-product development. Advances in analytical chemistry and computational modeling can provide details of the structure of the modified lignin and direct bioengineering strategies for targeted properties. Novel biomass pretreatment technologies have further facilitated lignin recovery and enable catalytic modifications for desired chemical and physical properties. Novel biological approaches show promise for converting lignin fractions into valuable products that can contribute to enhancing overall process revenues for biological conversion and catalytic upgrading of sugars to biofuels. These novel technologies promise to relegate the old saying that "You can make anything out of lignin except money" to the history books.

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