Sandia National Laboratories

# Biofuels: Increasing the Value of Lignin

*Discovering effective methods of depolymerizing lignin will improve economics of biorefineries and create a renewable resource for chemicals*

## Lignin Valorization

Current lignocellulose biomass conversion to biofuels requires the breakdown of lignin to liberate sugars that can be converted into advanced fuels. The process results in a significant amount of lignin waste product that could be utilized for other byproducts improving the economics for biorefineries. Sandia researchers are discovering new depolymerization methods for lignin that convert this polymer into simple monomers that can be used to create high value chemicals from a renewable source.

Depolymerization methods currently being investigated by Sandia researchers are also overcoming a major barrier in lignocellulosic biomass conversion, the recalcitrant nature of lignin. These methods eliminate the use of specialized equipment and the need for thermo-chemical processes that require combinations of high temperatures and pressures, diluted acids or alkalis, and high energy inputs.

## High value chemicals derived from renewable lignin depolymerization process include:

- Benzene
- Toluene
- Xylene
- Styrene
- Biphenols
- Cyclohexane
- Syringaldehyde
- Vanillin and vanillic acid

## Biochemical, Chemical And Thermochemical Routes To Lignin Depolymerization

Chemical routes use the versatility of ionic liquid solvents to extract lignin from biomass and depolymerize the macromolecules at lower temperatures than conventional thermochemical routes. The ionic liquids derived from biomass conversion have also been used to depolymerize lignin, which greatly enhances the renewable value for this method.

Thermochemical routes include a hydrogenation route that uses a hydrogen donor solvent, rather than gaseous hydrogen for tandem depolymerization and hydrogenation of lignin to smaller molecules. The approach results in higher yields of small molecules and monomers that create products that more easily integrate into conventional petrochemical refinery streams.

Sandia researchers have also established a proof of concept for using metal organic frameworks (MOFs) to depolymerize lignin. MOFs resemble molecular scaffolding, consisting of rigid organic molecules linked together by metal ions. The components produce nano porosity that can be filled with guest molecules. As with ionic liquids a vast array of potential MOFs exists and can be tuned to target specific lignin linkages.

## Accelerating Innovation At JBEI

The Joint BioEnergy Institute (JBEI) is a U.S. DOE BioEnergy Research Center in Emeryville, California that is investigating the efficient conversion of lignocellulosic biomass into fuels. Sandia joined Lawrence Berkeley, Lawrence Livermore and Pacific Northwest national labs, the UC Campuses of Berkeley and Davis and the Carnegie Institution of Science in the formation of JBEI. Currently, Sandia researchers lead the deconstruction division that is focused on liberating sugars from biomass.

# Partnership Opportunities Available

Sandia has a variety of current lignin depolymerization processes available for license. Research is continuing with ongoing testing opportunities including development of methods and utilization of greater variety of feedstocks.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
BIOENERGY TECHNOLOGIES OFFICE

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