DE-FOA-0001615: REQUEST FOR INFORMATION: CELLULOSIC SUGAR AND LIGNIN PRODUCTION CAPABILITIES

Response from Lawrence Berkeley National Lab
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Category 2: Lignin

If you currently operate a facility that produces lignin that you are willing and able to sell or otherwise make available to the research community, please provide information in response to the following questions. You may respond to as many or as few questions as you wish. The questions are intended to provide the research community with useful information when looking for a supplier of lignin. **BETO is requesting NON-PROPRIETARY information only.**

2.1. To which types of research entities are you willing and able to sell or otherwise provide your lignin? (e.g., university researchers, national laboratories, industry/private sector)? Are there any types of research entities to whom you are not willing and able to sell your lignin?
Same as 1.1. We do not sell lignin, but can provide them to any type of research entity on a cost recovery basis or through a collaboration in a federal or state funded project. The general approach we take with our collaborators include, scoping the project, performing deconstruction, and providing lignin coupled with process data including mass balance. We are also able to investigate any particular research question in lignin production at the lab and large scale.

2.2. What are the maximum and minimum quantities of lignin that you are willing and able to sell (kg)?
We are able to produce anywhere between 50 g to 6 kg lignin, which is depending upon the pretreatment technology.

2.3. In what units do you sell your lignin and is it packaged (e.g., super sacks), or sold in bulk?
We provide lignin on a dry weight basis, g or kg. The lignin samples are packaged in polypropylene bottles either solid, thick slurry, or liquid form.

2.4. How do you ship lignin?
In polypropylene bottles.

2.5. What is the lignin concentration in your product?
The lignin concentration can vary between 35-80% (w/w) as measured by Klason lignin tests. As such, the lignin samples may possess some carbohydrate residues, humins and pseudo-lignin.

2.6. What type(s) of biomass do you use in your process?
Same as 1.6. The specific feedstocks we tested thus far are listed below:
Switchgrass, corn stover, eucalyptus, bagasse, loblolly pine, energy cane, wheat straw, and municipal solid waste (MSW) blends with lignocellulosic feedstocks.

2.7. What process do you use that produces lignin (dilute acid, ammonium fiber expansion (AFEX), hot water, organosolv, etc.)?
Same as 1.7. We are technology agnostic and are only limited by the configuration of our reactor: a Hastelloy 10L reactor (working volume: 3-6L) that can operate at maximum 200˚C, two C20 10L reactors (working volume: 3-6L) with maximum operation temperature at 300˚C, and one 210L

thermochemical reactor (working volume: 30-100L) customized from Andritz with maximum operation temperature at 200˚C. As such, we can utilize a range of catalysts suspended in an aqueous phase (primarily water) for pretreatment and enzymatic hydrolysis. We can perform two-stage chemical treatments, i.e. saccharification with a chemical (acid or imprinted inorganic silicates, etc.) instead of an enzyme.

These catalysts include: Dilute and concentrated acid, dilute and concentrated alkalis, hot water (hydrothermal), ionic liquids, aqueous ammonia (Soaking Aqueous Ammonia), urea (NaOH/urea mixtures), solid acid catalysts, imprinted inorganic silicates, and all enzymes including cellulases, xylanases, pectinases etc. We typically perform pretreatment 10-30% (w/w) solids loading and enzymatic hydrolysis 5-20% (w/w) solid loading.

2.8. What details of the scale of your process are you willing to share (e.g. batch and/or continuous or volumetric productivity)?

Same as 1.8. The largest pretreatment reactor at the ABPDU is a batch reactor with a volume of 210L volume. Due to the low bulk density of biomass (<150 kg/m^3), we are able to operate a maximum of 75 kg at 30% (w/w) solids loading. We can increase the total mass of slurry to 100 kg if we reduce solid loading. Also, during high temperature and/or pressure reactions, it is necessary to provide headspace to allow for the expansion of water and catalyst.

After enzymatic hydrolysis, we separate solid residue from liquid stream via simple filtration with 2-5 µm filter and wash with water to remove sugar residues. We can perform ultrafiltration with molecular weight cut offs down to 200 – 300 kDa. We could also perform liquid-liquid extraction with solvent that can extract sugars out of lignin-rich stream.

2.9. Do you measure the typical composition of your lignin? If so, what method do you use? How consistent is the composition of your lignin?

We use NREL Laboratory Analytical Protocols (LAP002, LAP005) to determine the composition of the lignin-rich solid residue. The composition is consistent when the same process/conditions are repeated. We can perform HPLC to identify low molecular weight lignin molecules.

For a quick measurement of overall lignin in solid-residue, we calibrated the lignin concentrations with energy density measurements of the solid-residue sample from IKA bomb calorimeter. This allows us to compare the efficacy of a deconstruction and/or conversion process through energy balance[1] and is especially useful when studying a complex feedstock such as soluble lignin to multiple biofuel molecules, such as mixed alcohols.

[1] Gardner J, He W, Li C, Wong J, Sale KL, Simmons B, et al. Calorimetric Evaluation indicates that Lignin Conversion to Advanced Biofuels is Vital to improving Energy Yields. RSC Advances. 2015.