DES for the Extraction of Lignin from Biomass

Thomas Potolicchio, Senthil Subramaniam and Xiao Zhang.
NARA-SURE Program. Bioproducts, Sciences and Engineering Laboratory, Washington State University, Richland

Introduction

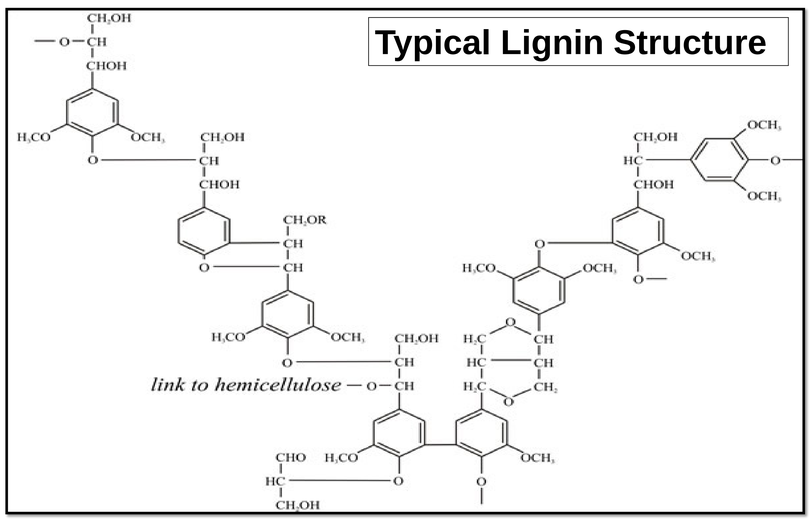
The three primary components of plant cells are cellulose, hemicellulose and lignin. Cellulose is the most desirable component and it has many uses from paper to biofuel. Currently lignin is primarily seen as a byproduct of pulp mills and biomass refineries. Lignin content percentages vary depending on which type of plant material is used. Refining biomass without using the lignin leaves a portion unused. In wood biomass that can be a significant amount, up to 40%.

The benefit of biofuels is that they are renewable. Paper and pulp mills plant more trees than they cut. As much of the biomass as possible needs to be used for production to see the most profit. Uses for lignin as a value added material are being researched.

Lignin can be extracted by several methods, but the focus of this research is using deep eutectic solvents (DES) . DES is considered to be a “green” solvent and therefore better for the environment than using highly acidic or basic solvents for example. Use of other chemicals can produce negative side effects so finding a biodegradable, non-reactive and safe solvent is a priority in the biofuel industry.

In this project DES is formed by mixing two salts, choline chloride and lactic acid, which form a homogeneous liquid when mixed. The biomass and DES are mixed and heated. The temperatures used experimentally have been relatively low, ranging from 90 to 145 degrees Celsius. The mixture was observed for varying periods of time and then filtered to separate the lignin, DES and the cellulose.

The results in the lab have been promising. Large scale production has not been achieved at this time. I have been working with Aspen Plus to get a simulation of the experiment. Once the simulation is complete for the small scale, it can be scaled up.

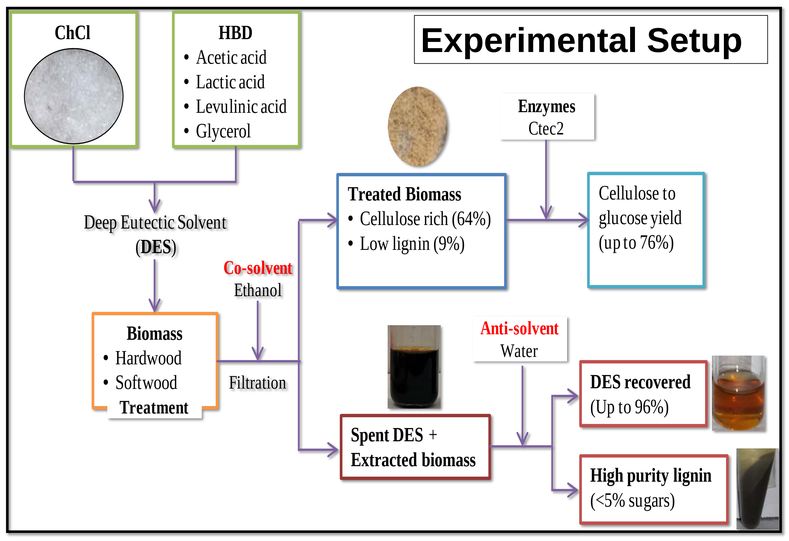


Background

DES is formed by mixing two salts which are solid at room temperature, but form a liquid when mixed. Another name for this type of solvent is low transition temperature mixture (LTTM). The two salts, usually solid at room temperature, form the homogeneous solvent because one is a hydrogen bond donor (HBD) and one is a hydrogen bond acceptor (HBA). DES are cost effective since they are less expensive than ionic liquids which and easier to clean up when the process is complete. The solvents are safe and biodegradable.

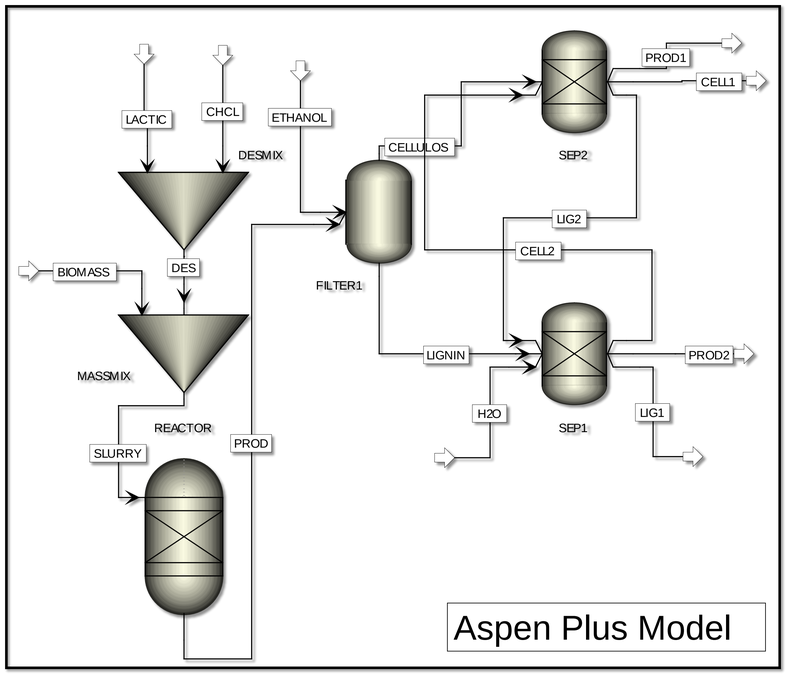
Aspen Plus is a chemical engineering software which is used to simulate chemical reactions. In my research I learned how to use Aspen Plus and worked with modeling the extraction of lignin from a wood biomass with the used of a DES and a low temperature reactor (90 degrees Celsius). The software was not designed to run this type of reaction so there were obstacles that I worked to overcome. My final results are showing perfect conditions instead of real world results.

Experiments at the lab scale have been collected and the process works at that level. There is interest in scaling up the process to see how well it works for industry. I am working towards a goal of perfecting the simulation and then increasing the scale. Aspen Plus can also calculate the costs of equipment, power consumption and other factors.



Procedure

- DES is mixed from choline chloride and lactic acid at a 2:1 ratio. Other HBD can be used instead of lactic acid.
- The DES is added to a wood biomass at a 6:1 ratio and then sent to a reactor.
- The lignin and cellulose are separated by filters. Ethanol is used to help with the separation.
- The residual hemicellulose and DES are washed from the lignin using water.
- A portion of the DES can be recovered for reuse and the end of the procedure.



Results

	Aspen Simulation	Experimental Result
Temperature (degrees C)	90	145
Lignin Extracted	80%	70%
DES Recovered	80%	96%

Conclusions

- DES made from choline chloride and lactic acid has successfully separated lignin from wood biomass at low temperature in lab scale experiments.
- DES is safe, biodegradable easy to make at a high purity and cost effective when compared to other solvents such as ionic liquids.

Recommendations

- Conversion of a portion of the cellulose into the ethanol used in the separation process would make the process more self-sustaining.
- Further research into increasing the scale of the procedure should be a priority.
- Pulp mills which separate lignin as a byproduct should be approached with the proposal to work together to use their lignin. New and better extraction methods can be shared with them.

Acknowledgements

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