Characterization of Lignin Particles

Mikayla McKenna-Pettit[1], Niloufar Manafi[1], Dr. Neda Nazemifard[1]
[1]Department of Chemical and Materials Engineering, University of Alberta

Introduction

Background

- Lignin is an organic compound found in the support tissues of trees, and it is similar to the more commonly known organic compound cellulose.
- Lignin's structure and aromaticity give it a lot of potential to replace other toxic aromatic compounds in industrial and chemical processes.
- Characterization is necessary for experiments being done with lignin. Knowing properties such as the zeta potential and particle diameter allow researchers to determine reactivity and other qualities of the compound.

Purpose

- The purpose of this experiment was to characterize lignin particles and to compare the accuracy of the Zetasizer Nano ZSP and the Image J software.

a) b)

Figure 1a: Extracted lignin in solid powdered form, the state in which it is used for our experiment.
Figure 1b: A common chemical lignin structure.

Methods

Image J

- Image J is an image processing software.
- Lignin is naturally fluorescent, allowing us to use a fluorescence microscope to take images of the particles at the micrometer (µm) scale.
- Using ImageJ, fluorescent images can be analyzed to measure the diameter of individual particles.

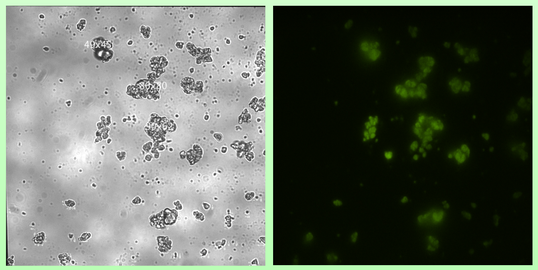

Figure 2: White (left) and green (right) fluorescence microscopy images of lignin particles.

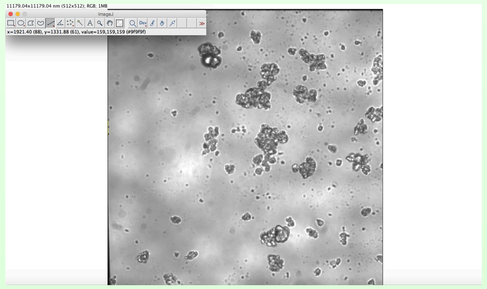

Figure 3: Screen capture of the ImageJ software, including a white fluorescence microscopy image, which is magnified 100x.

- To measure the diameter of particles with ImageJ, known distance and the measurement scale (nm, µm, etc.) are needed.

Zetasizer Nano ZSP

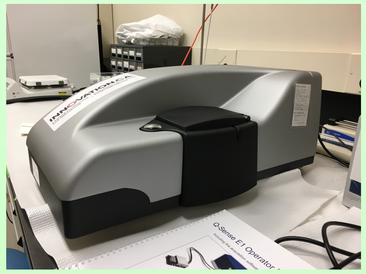

Figure 4: The Zetasizer Nano ZSP.

- The Zetasizer Nano ZSP is a device used to measure properties of particles. For this experiment, zeta potential and particle diameter were measured.
- Zeta potential is the value of electrical charge that exists on particles dispersed in a liquid. The higher (+/-) the zeta potential value, the more stable the particles are.
- The concentration of particles in the dispersant have a significant effect on the results the Zetasizer produces. The concentration can neither be too high or too low, or else the results become inaccurate.

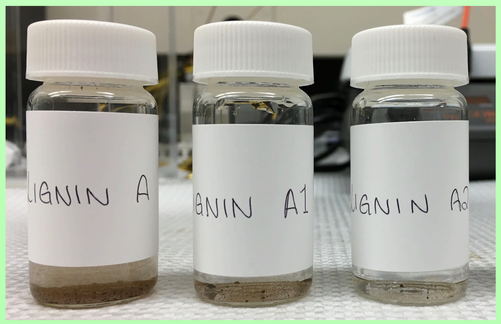

Figure 5: Various concentrations of lignin dispersed in water. The darker the color, the higher the concentration of lignin.

Results

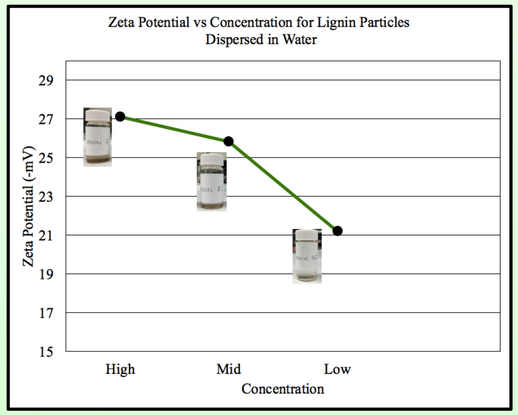

Figure 6: Graph relating the concentration of the lignin samples to their average zeta potential (-mV) values.

- For each concentration, multiple zeta potential measurements were done with the "zeta" function of the Zetasizer and averaged to get one value.

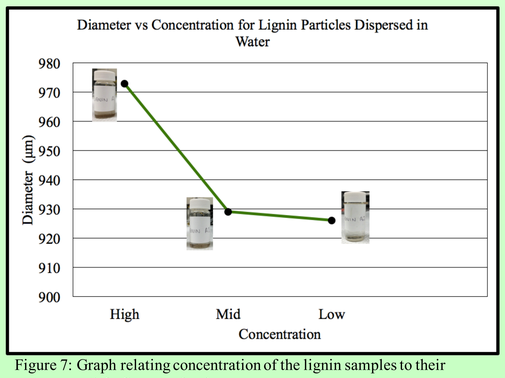

Figure 7: Graph relating concentration of the lignin samples to their average particle diameter (µm).

- Using the "size" function of the Zetasizer, the diameters of the particles for each concentration of lignin were measured. Multiple measurements were taken for each concentration and averaged to get one value.

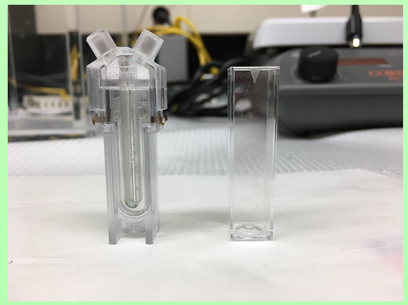

Figure 8: The zeta potential (left) and size (right) cells used for measurement in the Zetasizer. The amount of sample in each cell can only be 10-15mL.

Conclusion

- The characterization of lignin has much importance to biological and industrial studies.
- The viability of biofuel production would be greatly enhanced by the development of products derived from lignin.
- The use of fluorescence microscopy for imaging lignin content and composition is made easier by the natural fluorescence of lignin, as shown in Figure 2.
- When comparing the ImageJ processing software and the Zetasizer Nano ZSP, ImageJ is easier to use, however the results may not be accurate enough due to the possibility of human error.
- The Zetasizer Nano ZSP is the method that allows for the most accuracy in characterization, particle diameter and zeta potential.

Acknowledgements

The author would like to thank WISEST, International Paper, Canada Summer Jobs, and the TEKLab for allowing this research to be possible.

References

Albinsson B, Li S, Lundquist K & Stomberg R. The origin of lignin fluorescence. J. Mol.Struct., 1999,508: 19–27

Doherty, W.O.S., Mousavioun, P., Fellows, C.M., 2011. Value-adding to cellulosic ethanol: lignin polymers. Ind. Crops Prod. 33, 259–276.

"Lignin." *Wikipedia*, Wikimedia Foundation, 16 July 2019, en.wikipedia.org/wiki/Lignin.

Vangeel, Thijs, et al. "Perspective on Lignin Oxidation: Advances, Challenges, and Future Directions." *SpringerLink*, Springer International Publishing, 4 July 2018, link.springer.com/article/10.1007/s41061-018-0207-2.

"Zeta Potential." *Zeta Potential - an Overview | ScienceDirect Topics*, www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/zeta-potential.