Extractives in Douglas-fir: Tracking Extractives through Biofuel Production and Assessing their Effects on Saccharification

Karl R. Oleson and Daniel T. Schwartz
Chemical Engineering, University of Washington, Seattle, Washington 98195, USA

Abstract

Douglas fir (Pseudotsuga menziesii) has been investigated as a feedstock for biofuel processes due to its abundance in western North American timberland. Diverse extractive compounds make up 5% to 25% of the dry weight for different tissues of Douglas fir [1], but are rarely accounted for in biofuel studies. These components are commonly lumped into a lignin, or Klassen lignin, category and this category is known to bind to cellulases and obstruct the saccharification step in biofuel production. Extractives may be some of the key culprits of this inhibition. In this work, we identify extractives that are likely to be present in key biofuel process streams and analyze how extractives in the stream to saccharification inhibit cellulases.

Extractives in Biofuel Process Streams and Effluents

Types of Extractives

- Proanthocyanidin and phlobaphenes
- Flavonoids
- Waxes
- Phytosterols
- Terpenes
- Condensed Tannin
- Triglyceride
- Dihydroquercetin
- α-Pinene
- Pseudotsuga menziesii

Aspen Simulation of Sulfite/Bisulfite Process including Extractives

An Aspen simulation was assembled that simulates a sugar depot in order to track what streams extractives end up in. Common biofuel steps such as Pretreatment, Pressing, Saccharification, and Sugar Concentration (Evaporator) are included.

Experimental Results

48 Hour Glucose Yields from Saccharification

- α-Pinene has no noticeable effect
- Dihydroquercetin inhibits saccharification while α-pinene has no noticeable effect

4BMF, 1CBH, 1EG1, 4BD

Methods for Analyzing Cellulose-Extractive Interactions

Saccharification Experiments

Saccharification experiments with individual extractives added

- Extractives: Dihydroquercetin and α-Pinene
- Substrate: Sigmacell Cellulose
- Saccharification time: 48 hours

Cellulase-Extractive Binding Simulations

Cellulose from Trichoderma Reesei simulated

Experimental Results

Stable site near/α catalytic area

Stable site on non-catalytic area

α-Pinene binding to a non-catalytic site of Endoglucanase I

Conclusion

- Certain extractives such as dihydroquercetin inhibit saccharification, while other such as α-pinene are relatively inert
- Dihydroquercetin binds to the catalytic module of the three enzymes examined here. On the catalytic module, they can bind to both catalytic areas and non-catalytic parts of the enzyme.
- α-Pinene also is stable when placed in the catalytic area for two of the enzymes. However, experimental results imply it is unlikely to travel into the catalytic site in the first place

References


Acknowledgements

We would like to thank the Pfandner Research group at the University of Washington for help with the cellulose-extractive simulations, specifically Kyle Spriniger, Vance Jaeger, and Jim Pfandner. Also we would like to thank NARA 2015 Summer Intern Barbara Wolfin for her contributions.

This work made possible by the USDA-NIFA subgrant.

Photosynthesis: the reaction of carbon dioxide and water to form glucose and oxygen in plants, algae, and cyanobacteria. It is the primary source of energy for all trophic levels on Earth and the basis for many commercial products and industries.