Methods of Lignin Treatment and Use

Dennis Fong
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Contents of Presentation

- Background - Pretreatment Methods
- Lignin/Biomass Properties
- Lignin Usage - Four Main Methods
- Conclusion/Biofuel Opinion
Background: Biomass to Biofuel

Main Steps in the Biochemical Process

- Pretreatment
- Cellulose Hydrolysis
- Sugar to Ethanol Conversion

Importance of Pretreatment

- Feedstock contains lignin, hemicellulose, cellulose
- Required to break down and remove lignin and hemicellulose
- Four main methods of pretreatment: physical, physicochemical, chemical, biological electrical
Background: Pretreatment

Physical Method
- Communition of Biomass
- Pyrolysis

Physicochemical Method
- Steam Explosion
- Ammonia Fiber/CO2 Explosion

Chemical Method
- Ozonolysis
- Acid/Alkaline Treatment

Biological/Electrical Method
- Biological
- Electrical
**Lignin**

**Properties**
- Complex polymer of alcohols
- Accounts for 25-30% of biomass
- Readily available and cheap, but hard to deal with

**Current Use**
- Burned off as a fuel source

**Potential Use**
- Elimination via genetics
- Target for conversion to fuel
- Conversion to similar compounds such as phenols
Lignin: Fuel Source

Burning
- Major components of lignin are alcohols
- Burn readily, good source of fuel
- Used to power pretreatment plants
- Combustion heat of 26.6 kJ/g compared to EtOH of 30 kJ/g

Dennis et al.

Qin et al.
Lignin: Elimination

Gene Expression/Regulation

- One approach research labs are taking
- Decrease lignin amount or change the structure to allow for easier processing of the lignin-cellulose material
- Target are enzymes used in the polymerization of lignin.
- Downregulation of PAL, HCT, C3H, CCoAOMT, CCR, and CAD enzymes shown to impact composition and amount of lignin
- Not necessary to decrease lignin amount either
Gene Expression/Regulation

- Plants may not grow as well if lignin is weakened or reduced.
- Use fast growing plants such as weeds for the increased production of lignin if necessary.
- Another advantage: increased carbohydrate content in plants with decreased lignin content, consequence of mass balance.
- Implication: genetically modify plants with very low lignin content to altogether eliminate pretreatment step.
- Much more research is needed in this area.

Vanholme et al.
Lignin: Base Material

Conversion to Phenols

- Currently, 5% total petroleum output used for chemical production, rest is used for fuels/energy
- Lignin conversion to phenols for chemical processing industry use
- Higher value, used in bio-polymers
- Process involves a one step conversion developed by Kleinert et al. from lignin to liquid
- Both depolymerization and removal of oxygen by formation of water occur in a single step
conversion to phenols continued

- GC-MS of product crude oil derived from strong acid hydrolysis lignin

- Other methods of treating lignin provided similar results

- Separation can be achieved by short silicon chromatography between aliphatic compounds and phenols

- Yield is ~25%-35% phenols from original lignin starting material

- Moderately costly - does require heat and formic acid, as well as pretreatment, but reaction time within 35 min
Lignin: Conversion to Fuel

Chemical Conversion - Kleinert

- Used a liquefaction process to depolymerize lignin in one step
- More cost effective, but the product is less pure and requires more refining

Chemical Conversion - Shatabi, Zmierczak

- Lignin, via base catalyzed depolymerization, and chemical conversion, yielded gasoline-like product
- Product high quality, but more costly given the multi stage process
- Can be blended with gasoline products to achieve higher octane products
Summary

Elimination of Lignin

- Use as a fuel source for combustion - most common method today
- Reduce lignin content or decrease durability of lignin via genetic modification

Use of Remaining Lignin for products

- Conversion to fuel
- Degradation to form chemical compounds used in biopolymers
Thoughts on Ethanol/Biofuel

Advantages
- Most readily available method today in the field of alternative fuels/energy
- Large government subsidies and research dedicated to biofuels
- Greater public environmental awareness

Disadvantages
- Energy negative
- Not the best solution when compared to other alternative fuel sources

Overall - YES
- World still largely dependent on fossil fuels
- We will still continue to increase the efficiency of obtaining fossil fuels from the earth
- Use of fossil fuels does not bring greater awareness or funding to alternative energy
- Biofuel is a readily available solution today, slow integration would be best
- Any other alternative energy solutions are too costly to implement or not ready for mass production
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