ENVIRONMENTAL CHALLENGES AND OPPORTUNITIES OF LIGNIN
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WHAT ABOUT LIGNIN?

• Lignin is the most abundant bio-polymer on earth
  • Glues hemicellulose and cellulose together
  • Provides stiffness to the stem of plants and trees
• Can be extracted from side streams in biorefineries and pulp mills
  • Is today mainly used for internal energy use
• Has many possible applications
  • For example as a raw material for chemical production or as a fuel precursor
WHY THE INTEREST IN LIGNIN?

• The LIBRE project aims to produce carbon fibers from lignin
  • Carbon fibers are usually produced from polyacrylonitrile
• We soon noticed that little work had been done on how to assess lignin using LCA
  • We also noticed that the choice of allocation method affect the final results for the carbon fiber significantly
  • We decided look into how lignin is best assessed using LCA
  • How do you assess a material with an emerging market?
AIM OF THIS STUDY:

• To assess and illustrate how different allocation methods in life cycle assessment affect the resulting environmental impacts for lignin and the final application
SCOPE OF THE STUDY

• Functional unit: 1 kg of lignin from Kraft pulping in Sweden
• System boundary: Cradle-to-(pulp mill) gate
• Impact category: Climate impact
SCOPE OF THE STUDY: INVENTORY DATA

- Inventory for lignin production is from Culbertson et al. (2016)
  - Adapted to fit Swedish conditions
  - Outputs are:
    - Pulp
    - Lignin
    - Soap
    - Heat
WE ASSESSED THE FOLLOWING ALLOCATION METHODS

• Main product bears all burden (as described by Sandin et al. 2015)
• System expansion by substitution (as described by Sandin et al. 2015)
• Mass allocation
• Economic allocation
RESULTS: DIFFERENT ALLOCATION METHODS GIVES DIFFERENT RESULTS

Lignin is the main product

The price of lignin is higher due to increased demand

Main product bears all burden
System expansion by substitution
Mass based allocation
Economic based allocation

Climate impact

kg CO2 eq./kg lignin

kg CO2 eq./kg lignin

kg CO2 eq./kg lignin

kg CO2 eq./kg lignin

kg CO2 eq./kg lignin

kg CO2 eq./kg lignin
RESULTS: WHAT DOES THIS MEAN IN PRACTICE?

-10%  0%  10%  20%  30%  40%  50%  60%  70%  80%  90%

Relative Climate impact

Material that can be replaced by lignin

1 kg of phenol based tert-butyl catechol (Montazeri & Eckelman 2016)

Lignin impact: Lignin carries no burden

Lignin impact: Lignin carries all burden

Lignin impact: System expansion by substitution

Lignin impact: mass based allocation

Lignin impact: Lignin is cheap

Lignin impact: Lignin is expensive

Other processing impacts

Economic based allocation
CONCLUSIONS AND LIMITATIONS

• The choice of allocation method has a large influence on the environmental impact of lignin and on the impact of the end product

• The drivers of the system changes also has a large influence
  • These could change and vary with time

• Limitations:
  • These results are for one specific process—More data are needed!
  • It is difficult to predict what is going to happen in e.g. the future
  • What are good substitutions?
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REFERENCES


