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

Climate impact

kg CO₂ eq./kg lignin

Main product bears all burden
System expansion by substitution
Mass based allocation
Economic based allocation
RESULTS: WHAT DOES THIS MEAN IN PRACTICE?

- 1 kg of phenol based tert-butyl cathecol (Montazeri & Eckelmann 2016)
- Other processing impacts
- Material that can be replaced by lignin
- 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

Relative Climate impact
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?
ACKNOWLEDGEMENT

• This project has received funding from the Bio Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 720707.
REFERENCES


