Wood fractionation by deep eutectic solvent systems

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Deep eutectic solvents

- Main constituents of DESs are high melting temperature solids with strong hydrogen bond interactions
  - Typically a salt + non-charged hydrogen bond donor
  - If mixture has low melting point → DES

- Most studied DES:
  - Choline chloride-urea
  - Choline chloride-ethylene glycol
  - Choline chloride-glycerol

![Cholinium chloride : urea](image)

**Components** → **Deep eutectic solvent**
DETs and ionic liquids in comparison

- Common properties:
  - Low volatility (no solvent emissions), excellent solvent properties, high viscosity, good chemical and thermostability

<table>
<thead>
<tr>
<th>Deep eutectic solvents</th>
<th>Ionic liquids</th>
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<tbody>
<tr>
<td>Cheap raw materials</td>
<td>Expensive</td>
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<tr>
<td>Low toxicity</td>
<td>Toxic</td>
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<tr>
<td>Easy to prepare by mixing</td>
<td>Prepared by synthesis</td>
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<tr>
<td>Low cellulose and wood solubility</td>
<td>Powerfull cellulose and lignocellulose solvents</td>
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DESs in biomass modification

- Generally not as powerful biomass solvents as ILs

- DESs good solvents for lignin and hemicellulose
  - Little known about DESs as cellulose solvents

- Application potential:
  - Feedstock pretreatment in biofuel production
  - Fibrillation and pulping of fibre materials
  - Fractionation of lignocellulose
Objective: Wood fractionation and fibrillation by DES treatment

- Task: fractionate/fibrillate softwood saw dust by cooking in DESs

- VTT approach:
  - Use unit operations, chemicals and equipment compatible to industrial processes
  - Interaction with industrial partners
  - Combine scientific and engineering disciplines mastered in-house
  - Molecular modelling to understand fundamental DES interactions
  - Both academic and technical excellence targeted in project
Fractionation trials - experimental

- Reactor $T = 75 \, ^\circ\text{C}$, stirring speed 100 rpm, cooking time 16 h
- Cooking step followed by particle size fractionation through sieving accompanied by water washing

Tornado Plus Overhead Stirring System with 6 seat reactor carousel
Fractionation trials - results

- Finest material enriched in lignin
- Fraction composition analyses currently under way
Enzymatic lignocellulose hydrolysis in DES solutions

- Ionic liquids (ILs) have been used for lignocellulose pretreatment prior to hydrolysis in biofuel and -chemical production
  - ILs inactivate enzymes used in biomass saccharification
  - Potential to use DESs instead of ILs
- Enzyme-compatibility of biomass-dissolving DESs not well known

- Stability in DES of polysaccharide hydrolysing enzymes studied in this project
Stability of polysaccharide hydrolases in DES solutions - results

- Cellulase and xylanase stability tested in three DESs (85 w-% conc.) with the IL [EMIM]AcO and buffer as references.
- DESs clearly more stabilizing than [EMIM]AcO.
- DESs can enable new pretreatment methods for biomass in biofuel production.
Conclusions

- Wood fractionation and fibrillation with DES appears promising

- The choice of DES is crucial for process efficiency
  - More understanding of processing parameters is needed
  - More understanding of the physico-chemical interactions between DES and lignocellulose components is needed

- DES technology very interesting for use in enzymatic processes
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