How do we repurpose a mechanical pulp mill (newsprint) as a pretreatment "front end" for a potential wood based biorefinery?

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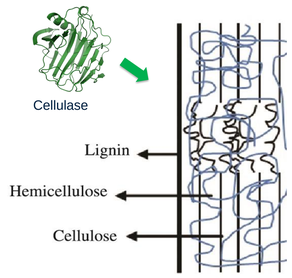
Introduction

- The >50% decrease in demand for newsprint over the past decade has provided a considerable motivation to assess the possible "re-purposing" of Canada's existing thermo-mechanical refining/pulping (TMP) infrastructure as the "front-end" of an enzyme/ microbial based biorefinery.

- Mechanical refining-based pretreatment:

Size reduction from chips to pulp, virtual complete recovery of the cellulose and hemicellulose in the solid fraction, making use of all of existing utilities etc.

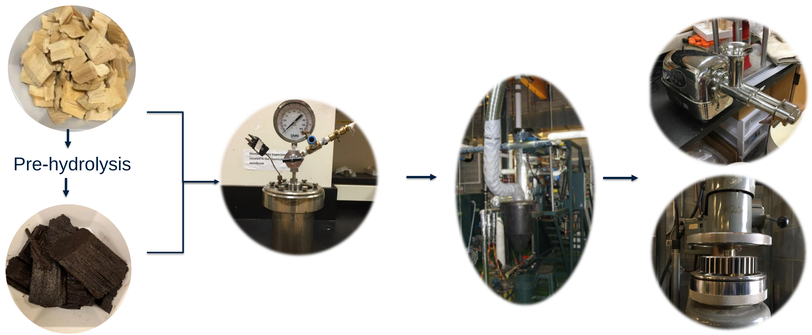
Retention of lignin:
- Prevents accessibility to cellulose
- Restricts substrate swelling
- Non-productively binds cellulases
- Expensive to remove



The approach

Rather than removing lignin, the integration of alkali-oxygen step into the TMP process of hardwood wood chips will result in enhanced recovery of the carbohydrate components in the water-insoluble fraction. Selective lignin oxidation will enhance enzyme accessibility and cellulose hydrolysis.

Pretreatment process



- **Raw Chips**
- **Pre-hydrolyzed Chips**

→ **Alkali-oxygen Impregnation (AO)** → **Pre-steaming** • **190/130°C** • **15 min** → **Mechanical Refining**

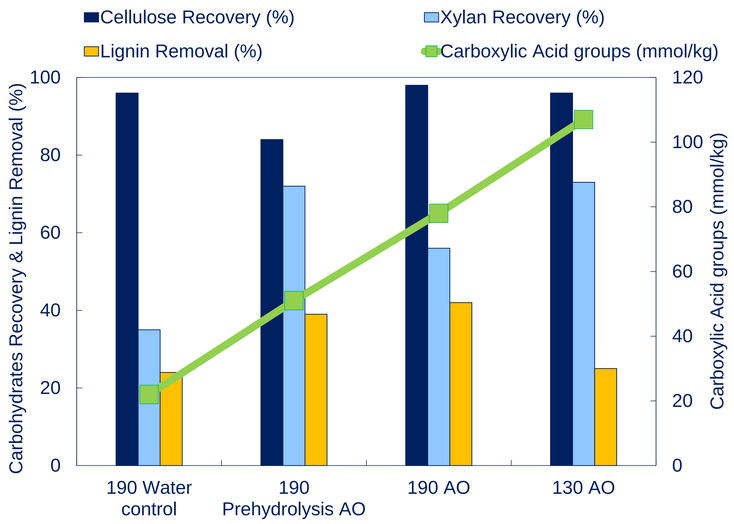
Pre-hydrolysis:
- 170 °C, 1 hour
- Solubilizes >50% xylan

- Fortifies carboxylic acid groups on to the lignin
- ↑ fiber swelling
- ↑ hydrophilicity & negative charges of lignin
- ↓non-productive binding of enzymes to lignin

- Fiber separation
- Fiber fibrillation
- ↑ cellulose accessibility

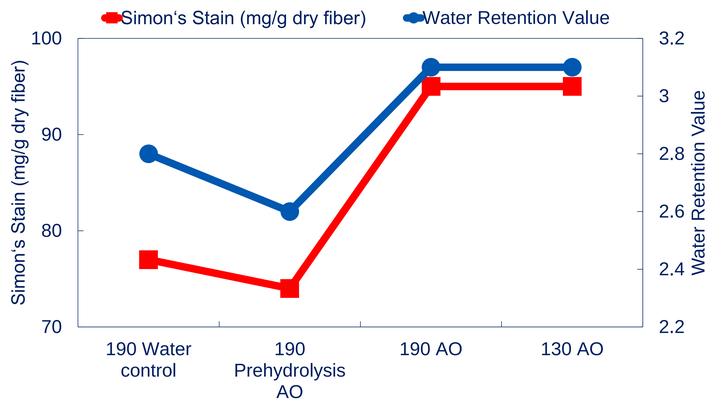
Results & discussion

Carbohydrates recovery, lignin removal & modification (acid groups)



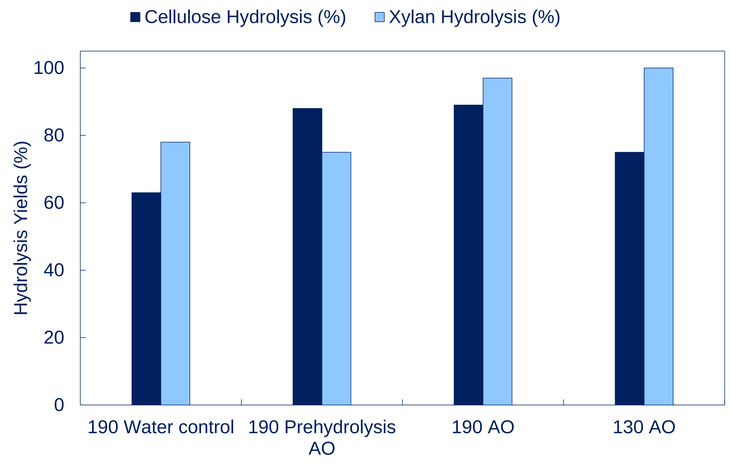
- 190°C AO ↑ xylan recovery from the water-insoluble fraction compared to traditional steam pretreatment
- Initial pre-hydrolysis further ↑ total recovery of xylan
- Lower steaming temperature to 130°C ↓ lignin removal, ↑ lignin modification

Substrate swelling & cellulose accessibility



- Water Retention Value indicates substrate swelling
- Simon's Stain indicates increased accessibility to cellulases
- One-pot AO pretreated substrates are more swollen/accessible to cellulases

Substrates' susceptibility to enzymatic hydrolysis



Enzymatic hydrolysis of pretreated substrates using 15mg cellulase +5mg xylanase g[1] cellulose at 10% solids for 72 hours

- AO Pretreated substrates could be readily hydrolyzed when a commercial cellulase mixture was supplemented with xylanases

Conclusions

- Rather than recovering the xylose from inhibitor-rich pre-hydrolysate solution, alkali-oxygen (AO) treatment at 130°C retains >70% of the xylan in the water-insoluble fraction.

- The highly swollen, more accessible cellulose can be readily hydrolyzed at low enzyme loadings, due to selectively lignin modification.

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