Development of a Sulfur-Free Delignification Process for Softwood Biorefineries

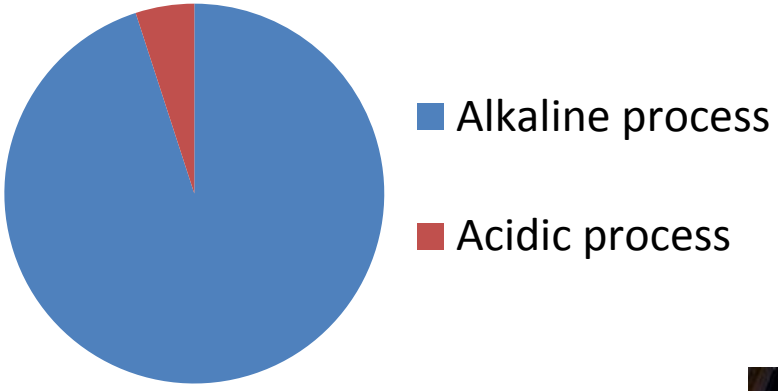
Claire Monot, Christine Chirat
Grenoble INP-Pagora / LGP2

58th SWST International Convention
June 9, 2015

Funded by

The cellulose industry

- Worldwide annual production of **cellulosic fibers** produced via a chemical way: 135 million tons, using about **300 million tons of wood** (as dry weight)



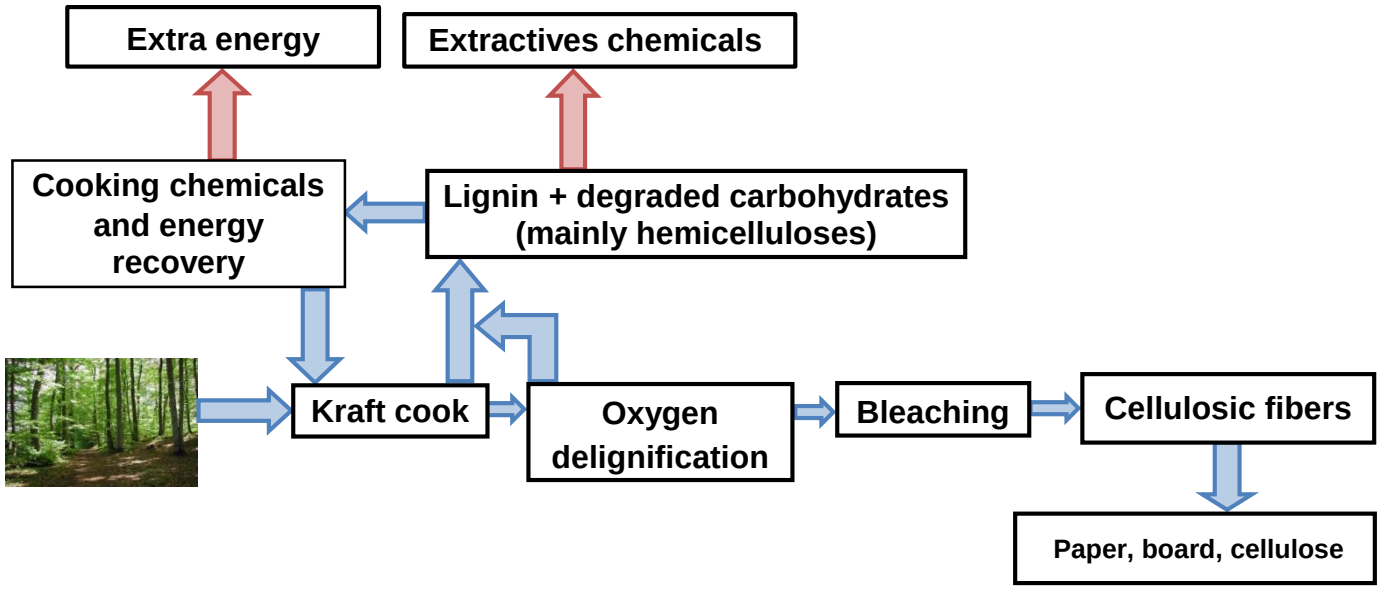
- Pulp industry: the **biggest player in wood chemistry** (working as biorefineries for more than 100 years)
  Example: the Borregaard mill in Norway



The kraft pulp mill

- Wood composition
  - Cellulose (40-45%) ⟶ main valorized product: paper and board
  - Lignin + hemicelluloses (55-60%) ⟶ solubilized and degraded in the effluent: combustion
- Kraft pulp mills: net producers of energy

Today's kraft pulp mill

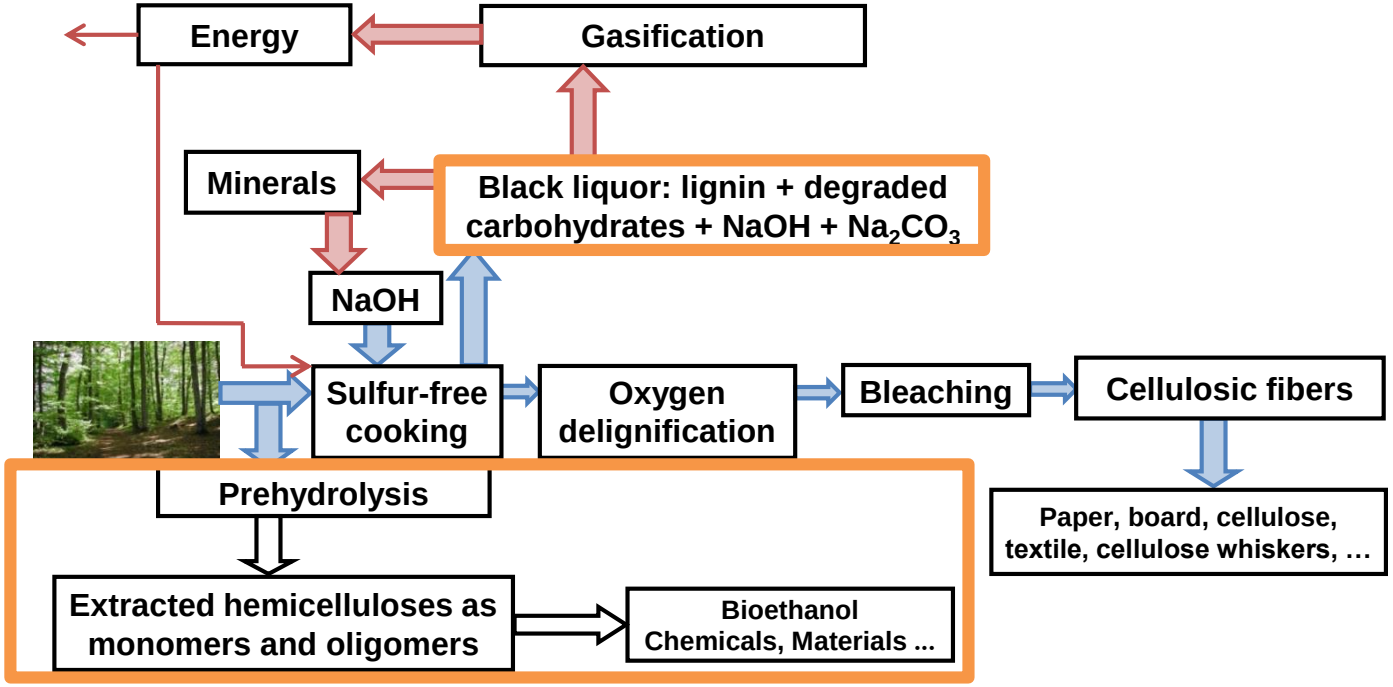


Tomorrow's lignocellulosic biorefinery

- Prehydrolysis: extraction of hemicelluloses for valorization, which facilitates delignification

Goal of this project: to develop a sulfur-free cooking after a prehydrolysis step to allow black liquor gasification

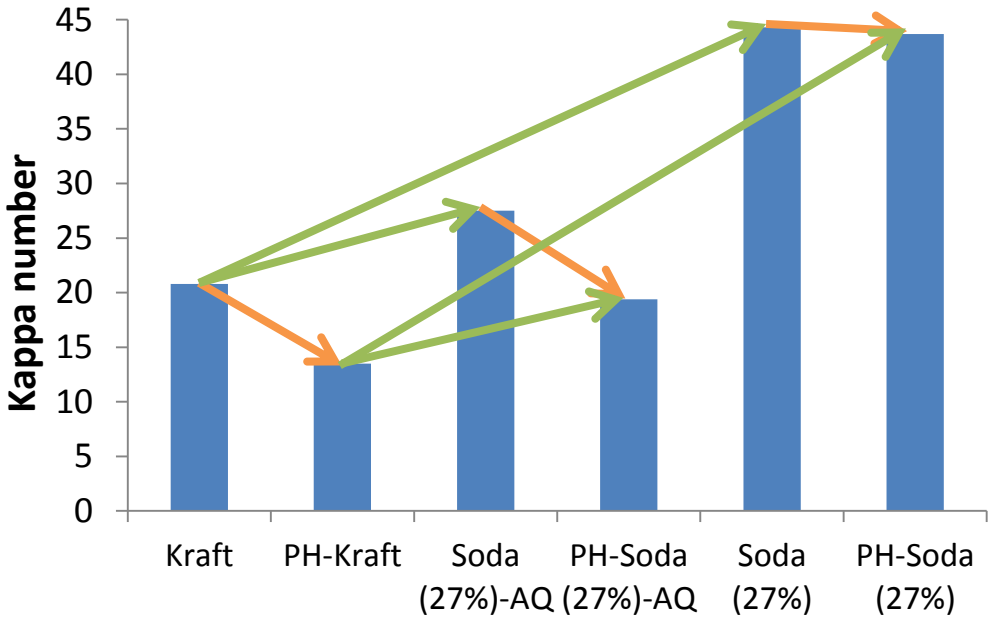
- Nowadays, the effluent of pulp and paper mills - black liquor - is burnt in a boiler: gasification would give better energy yields
- Sulfur is an inhibitor of gasification and is corrosive for the gasifier



Prehydrolysis (PH)

- Sulfur-free cooking is more difficult than kraft cooking
- PH removes part of hemicelluloses from wood
- Higher amount of lignin in PH wood (33% versus 28% in control wood)

PH pulps have lower or equal lignin contents after cooking despite a higher initial lignin content ⟶ PH facilitates delignification
Hypothesis: cleavage of lignin-carbohydrates linkages during PH?[1]

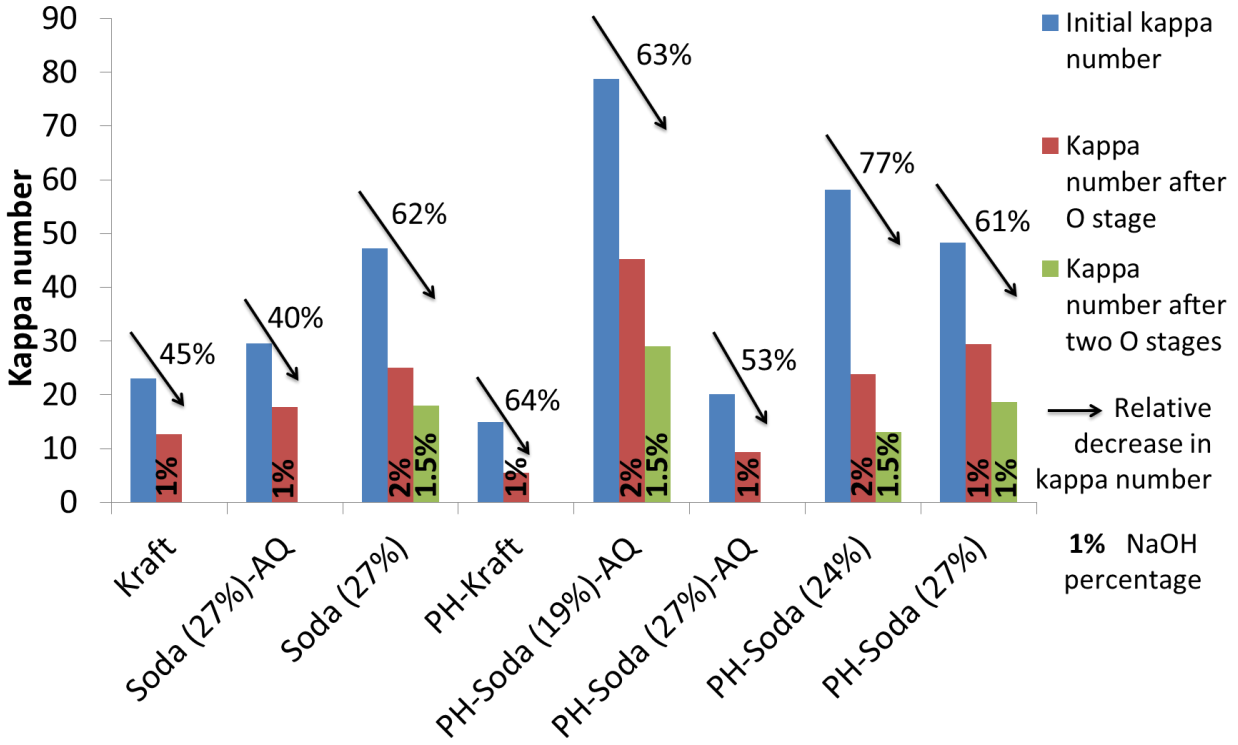


1. Monot, C. et al, 2014, Relationship between lignin-carbohydrate complexes (LCC) from chips and pulps and their delignification and bleaching ability, International Pulp Bleaching Conference, Grenoble

Oxygen delignification

- Oxygen delignification is more efficient on prehydrolysed wood than on control wood
- Sulfur-free cooking of prehydrolysed wood gives interesting results

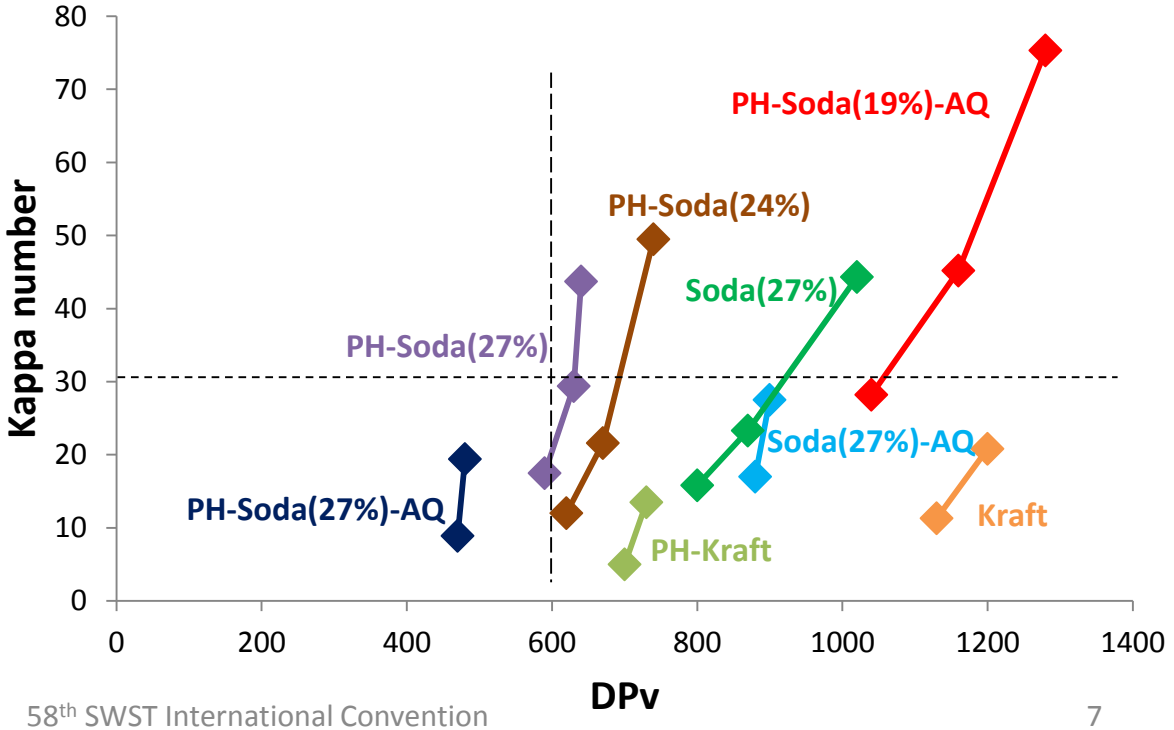
Although sulfur-free cooking of PH wood gives high kappa numbers,
further oxygen delignification being more efficient, the relative decrease in kappa number is higher than without PH



Cellulose characteristics

- Reduction of the degree of polymerisation (DP) after prehydrolysis for each type of cooking
- To obtain:
  - Acetate: DP above 800-1000
  - Viscose: DP above 600

Solution to improve the DP for a given kappa number: stop the soda cooking at a high kappa number (apply a lower alkali) and then apply a strong oxygen delignification stage



Conclusion and perspectives

- Prehydrolysis improves **pulp delignification** (cooking and oxygen stage), which would make it possible to apply a **sulfur-free cooking**

- Prehydrolysed pulps have lower DPs than control pulps: to improve the DP a **mild soda cooking** should be applied followed by a **strong oxygen delignification** (in one or two steps)

- Bleaching sequences should be applied on pulps to confirm that the characteristics of PH sulfur-free pulps are compatible with **viscose production**

Thank you for your attention