Catalytic reductive fractionation of lignocellulose

EFFECTS OF ACIDIC/ALKALINE ADDITIVES

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Classic *vs.* lignin-first: a cascade

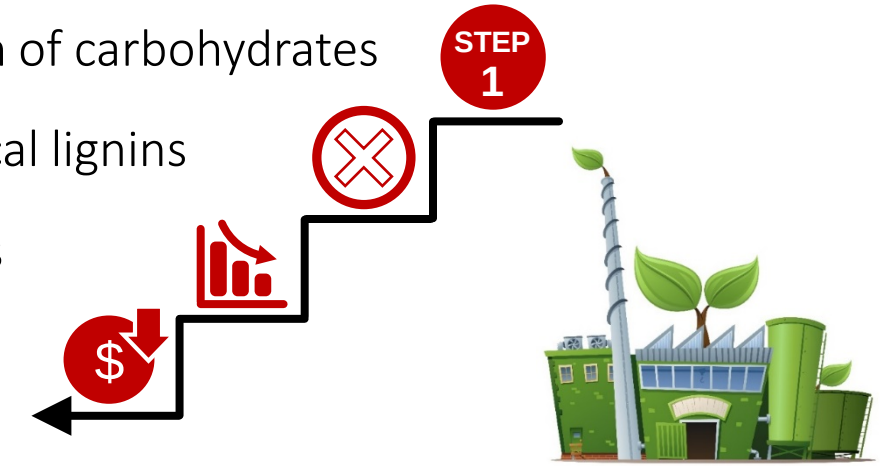
Classic: Lignin valorisation is a secondary objective

Focus on valorisation of carbohydrates

Degradation: technical lignins

Low monomer yields

Low added-value



Classic *vs.* lignin-first: a cascade

Classic

Focus on valorisation of carbohydrates

Degradation: technical lignins

Low monomer yields

Low added-value

Lignin-first: Lignin valorisation is a primary objective

Focus on valorisation of native lignin

Prevention of degradation

High monomer yields

Increased added value

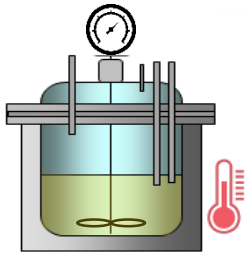
The CRF-biorefinery

Lignocellulose
e.g. poplar, birch, pine, switchgrass

Catalyst + H_2
e.g. Pd/C, Ru/C, Ni/SiO_2

Solvent
e.g. MeOH, EtOH, iPrOH, EtGly

Operating conditions
473 – 523 K
40 – 120 bar



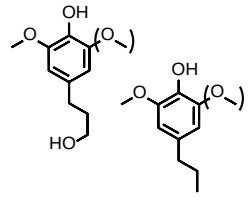
Elementary steps
Step 1: Solvolytic extraction
Step 2: Depolymerization

Filtration

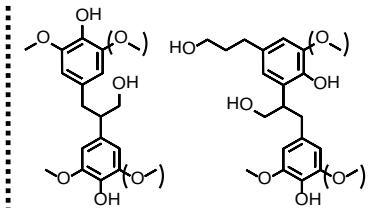
Bio-crude

Separation

Lignin oil

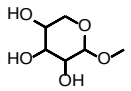


monomers

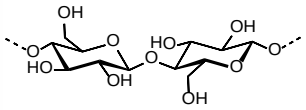


dimers + oligomers

Soluble carbohydrates

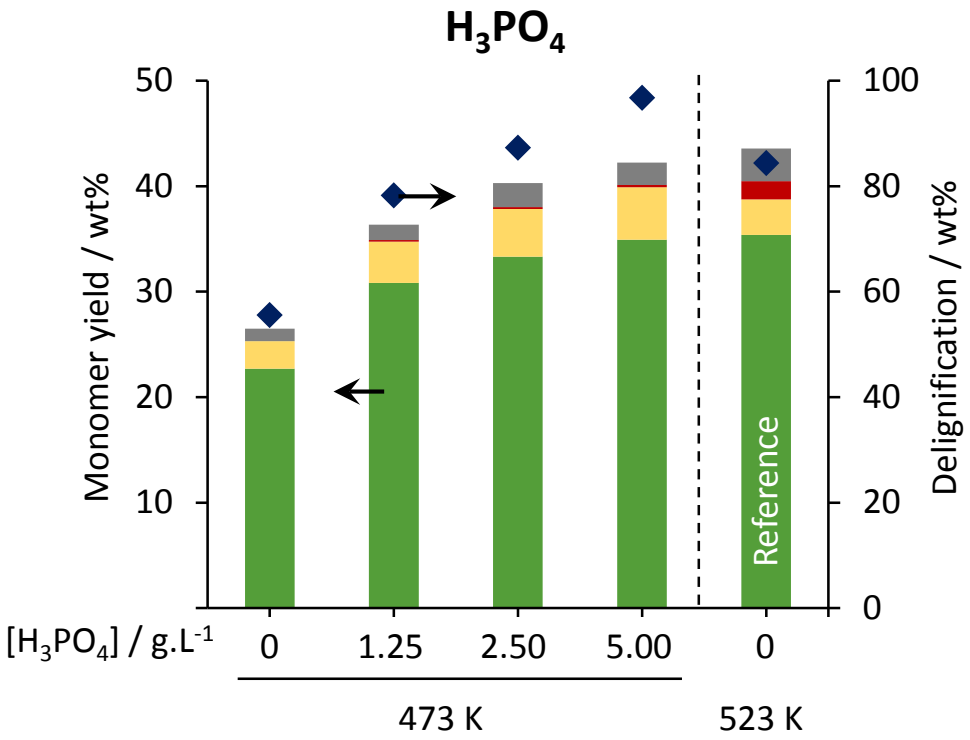


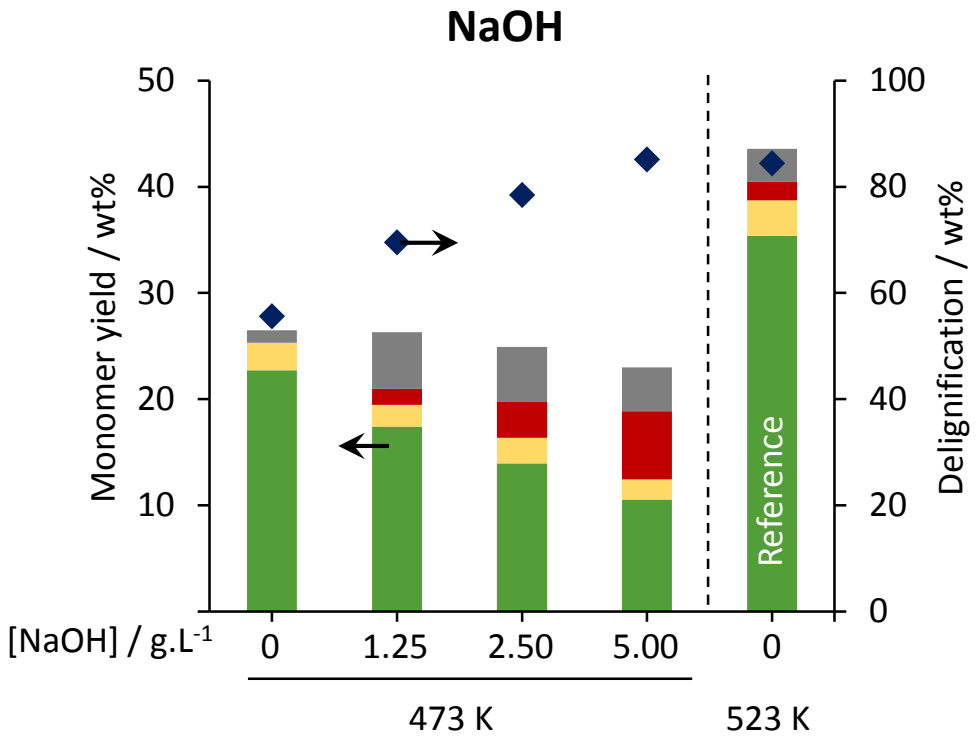
Carbohydrate pulp

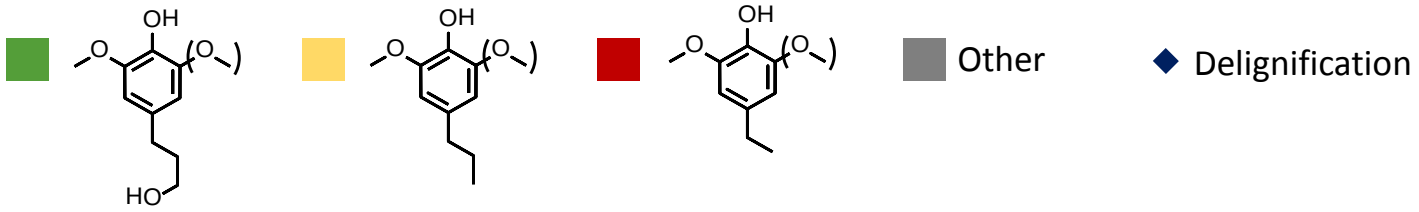


Pitfall: High temperatures (523 K), high pressure (120 bar).
Possible solution: Catalytic additives (**H_3PO_4, NaOH**)
Research question: What are the effects? Beneficial?

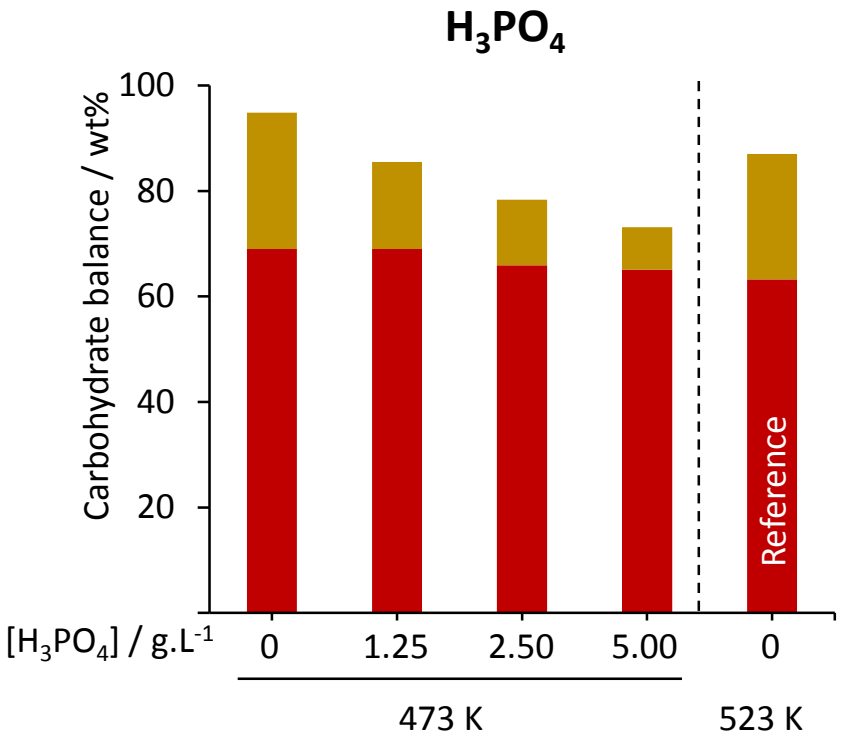
Effects on lignin

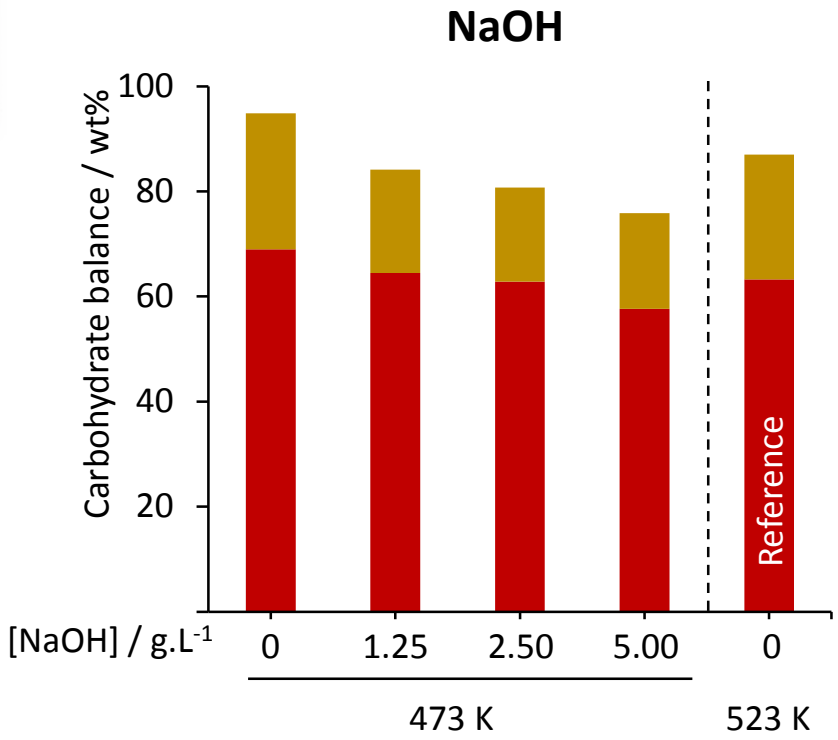


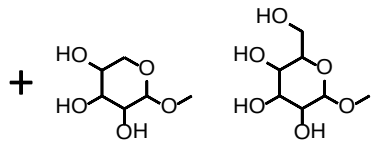




Effects on pulp







Soluble methyl sugars
(H_3PO_4 promoted alcoholysis)

Cellulose (pulp)

Hemicellulose (pulp)

Evaluation

H_3PO_4

Lignin
- Increased monomer yield
- Increased delignification
- → Higher lignin conversion at milder T
- → Similar outcome as high T reference

Pulp
- Removal of hemicellulose (alcoholysis)
- Effective preservation of cellulose
- → Cleaner cellulosic pulp

NaOH

Lignin
- Decreased monomer yield
- Increased delignification
- → Lower monomer selectivity (*cfr.* gap)
- → Hampered depolymerization by NaOH

Pulp
- Partial loss of hemicellulose
- Partial loss of cellulose
- → Degradation of released sugars

(1) Van den Bosch, S., Schutyser, W., Renders, T., Sels, B. F., *et al*., *Energy Environ. Sci.* 2015, 8 (6), 1748-1763.

(2) Renders, T., Schutyser, W., Van den Bosch, S., Sels, B. F., *et al*., *ACS Catal.* 2016, 6 (3), 2055-2066.