

Xylan from Bleached Hardwood Kraft Pulp – New Opportunities

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Business from technology

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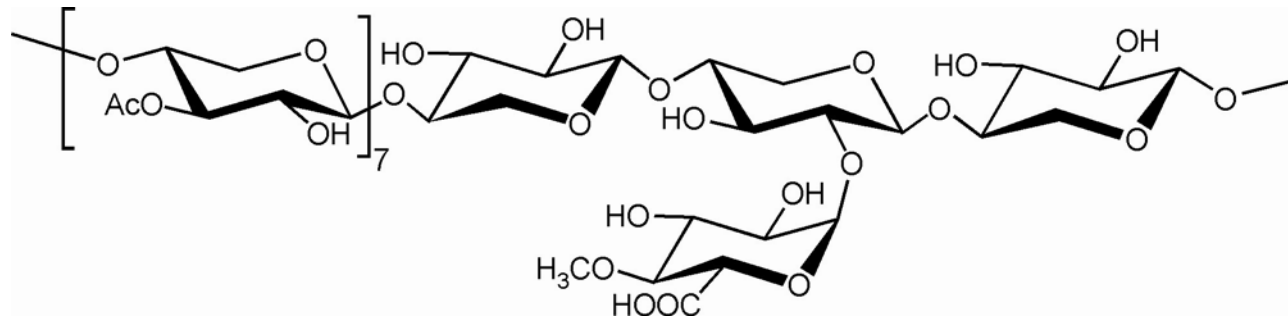
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1. Introduction

- Expanding the use of renewable and biodegradable raw materials is highly desirable today
- Research has mostly focused on lignin, however, lately also the hemicelluloses have gained attention
- Low heat value of hemicelluloses, i.e. 14 MJ/kg compared to 25 MJ/kg for lignin, is in favor of their utilization as a chemical feedstock

Structure and utilization of xylan

- Xylan, the most common hemicellulose, is as such a high-molar-mass charged polymer



- So far, xylan has been mainly utilized for the production of furfural and xylitol

Raw materials and ways to isolate xylan

Xylan can be isolated from

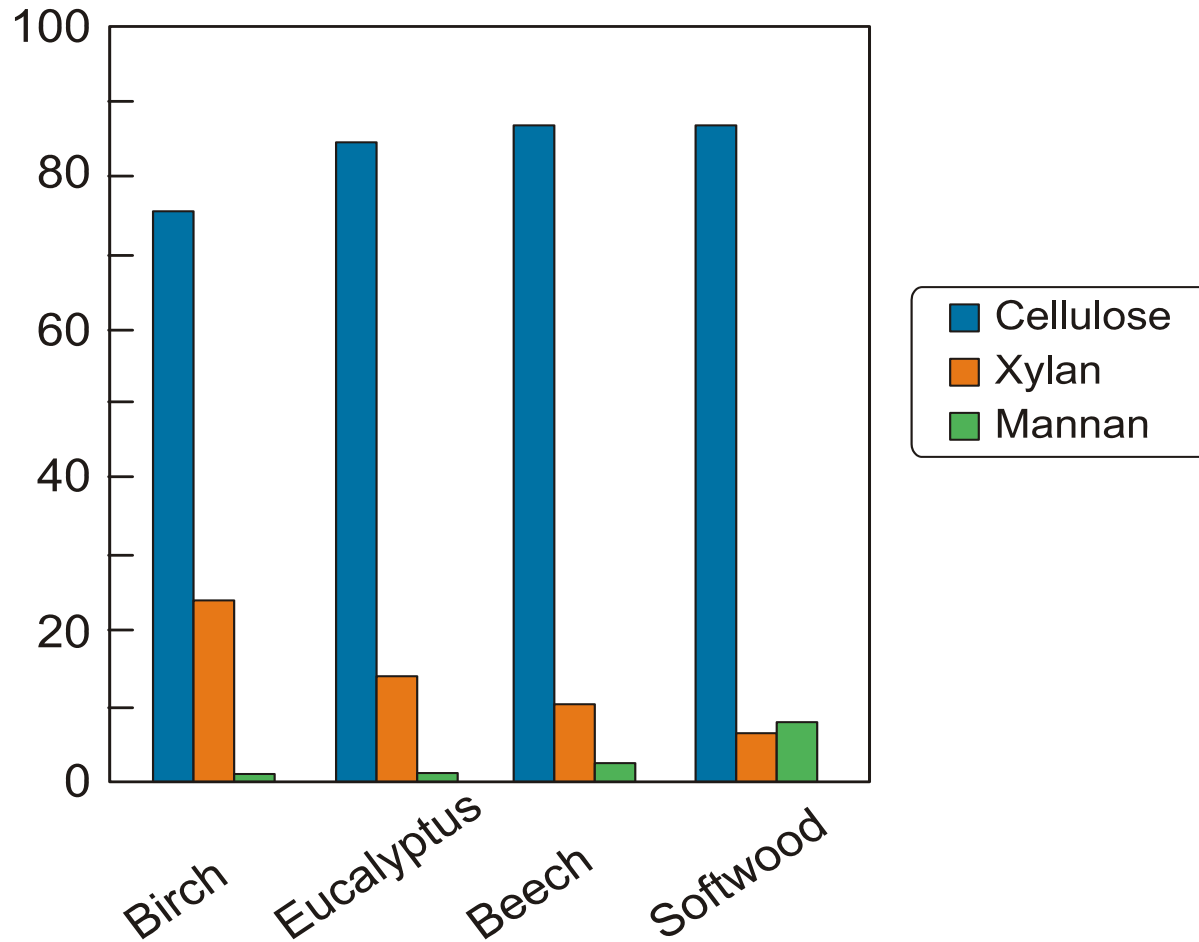
- Low-cost agricultural residues, e.g. cereal husks
- Wood waste or chips by alkaline or near-neutral extraction
- Black liquor by ultrafiltration and precipitation



For a pure xylan product several purification stages are needed for removal of lignin etc.

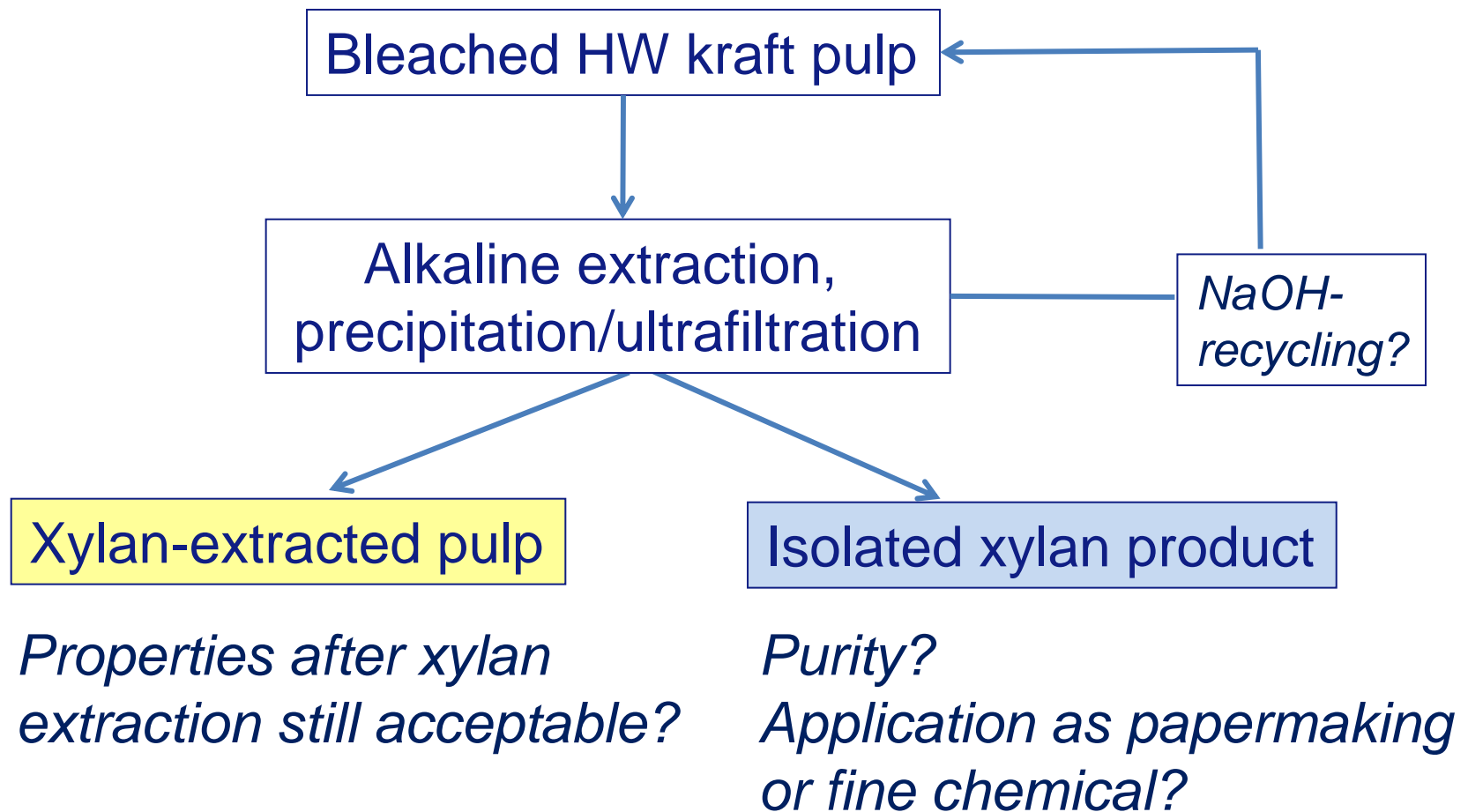
Xylan content especially high in birch

Bleached kraft pulp, w-%



Janzon et al. Holzforschung 60 (2006)

2. Isolation of xylan – the process





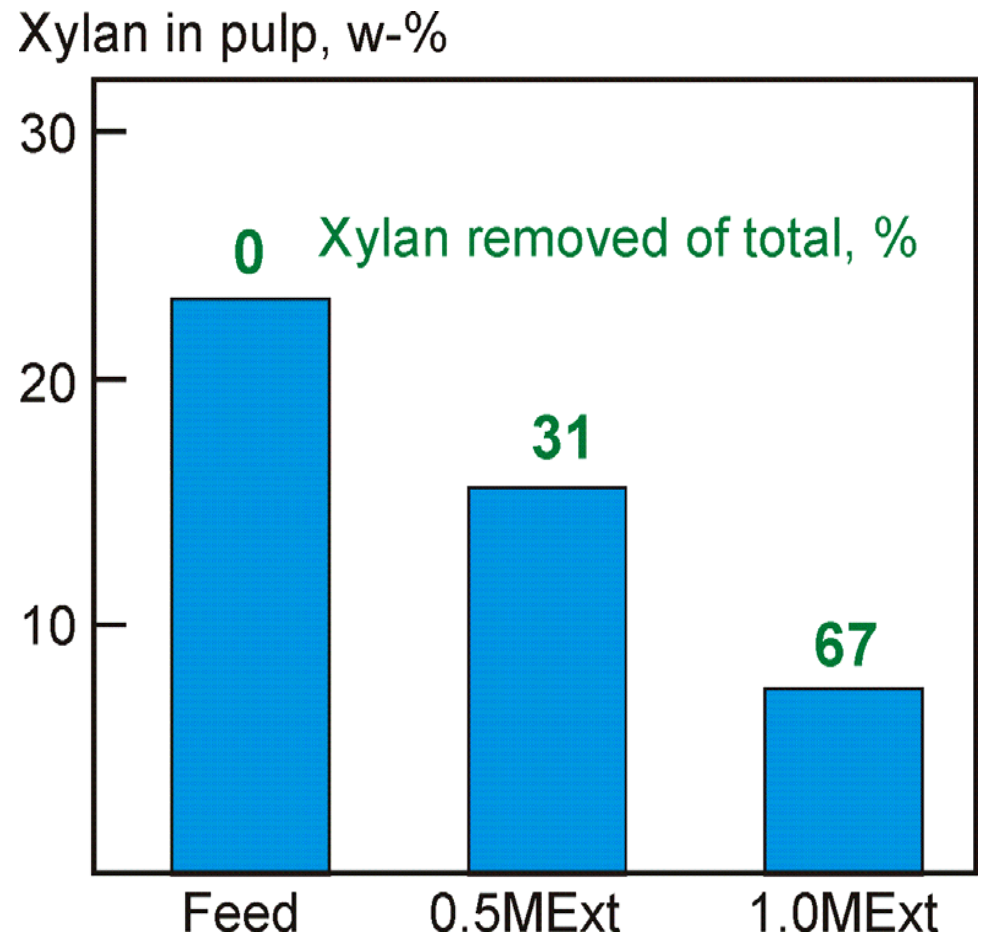
Objectives



- To extract polymeric xylan from bleached birch kraft pulp simply using NaOH
- To test the xylan product as a papermaking chemical for utilization as a wet-end chemical and a surface sizing agent
- To evaluate the effects on the extracted pulp

Alkaline NaOH-extraction of xylan - procedure

- Extraction of bleached birch mill pulp with 0.5 and 1.0 M NaOH-solutions, 60 min at 23°C
- Xylan removed:
0.5 M NaOH: 70 kg/t pulp
1.0 M NaOH: 160 "
- NaOH recirculated in the process

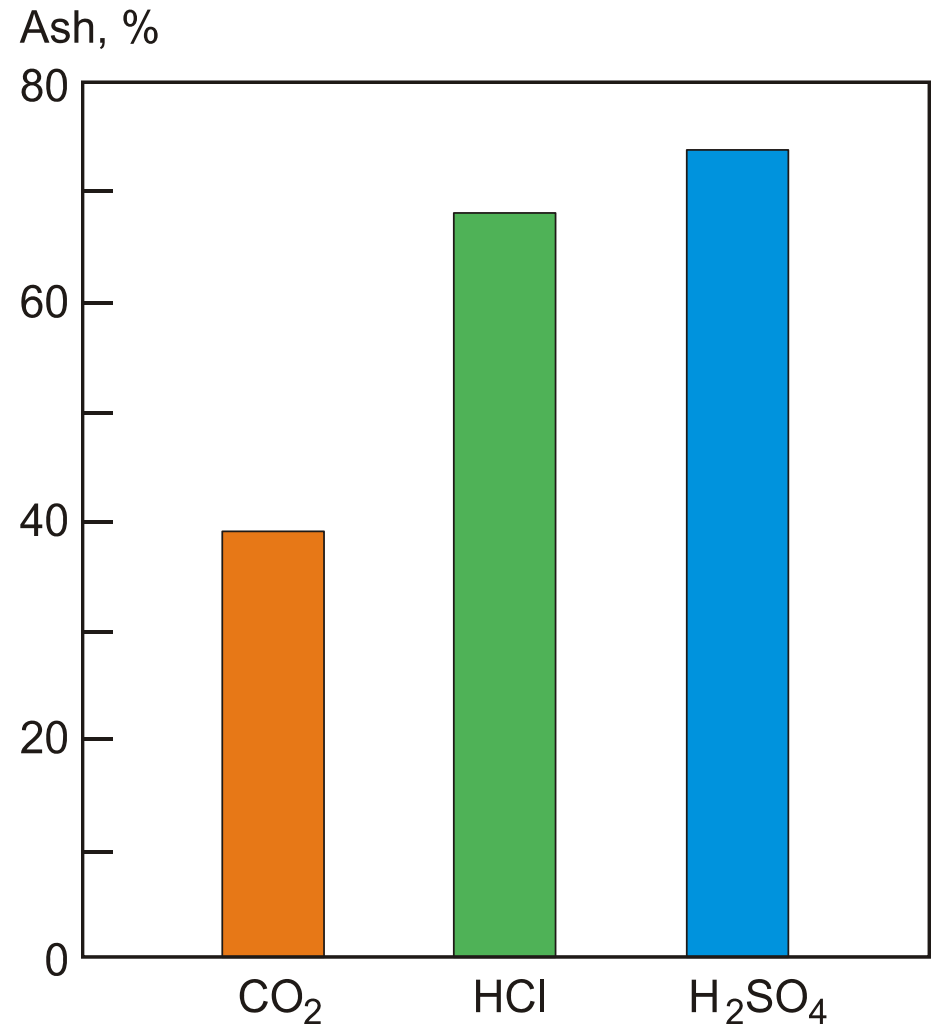


Isolation of xylan from the extraction liquor

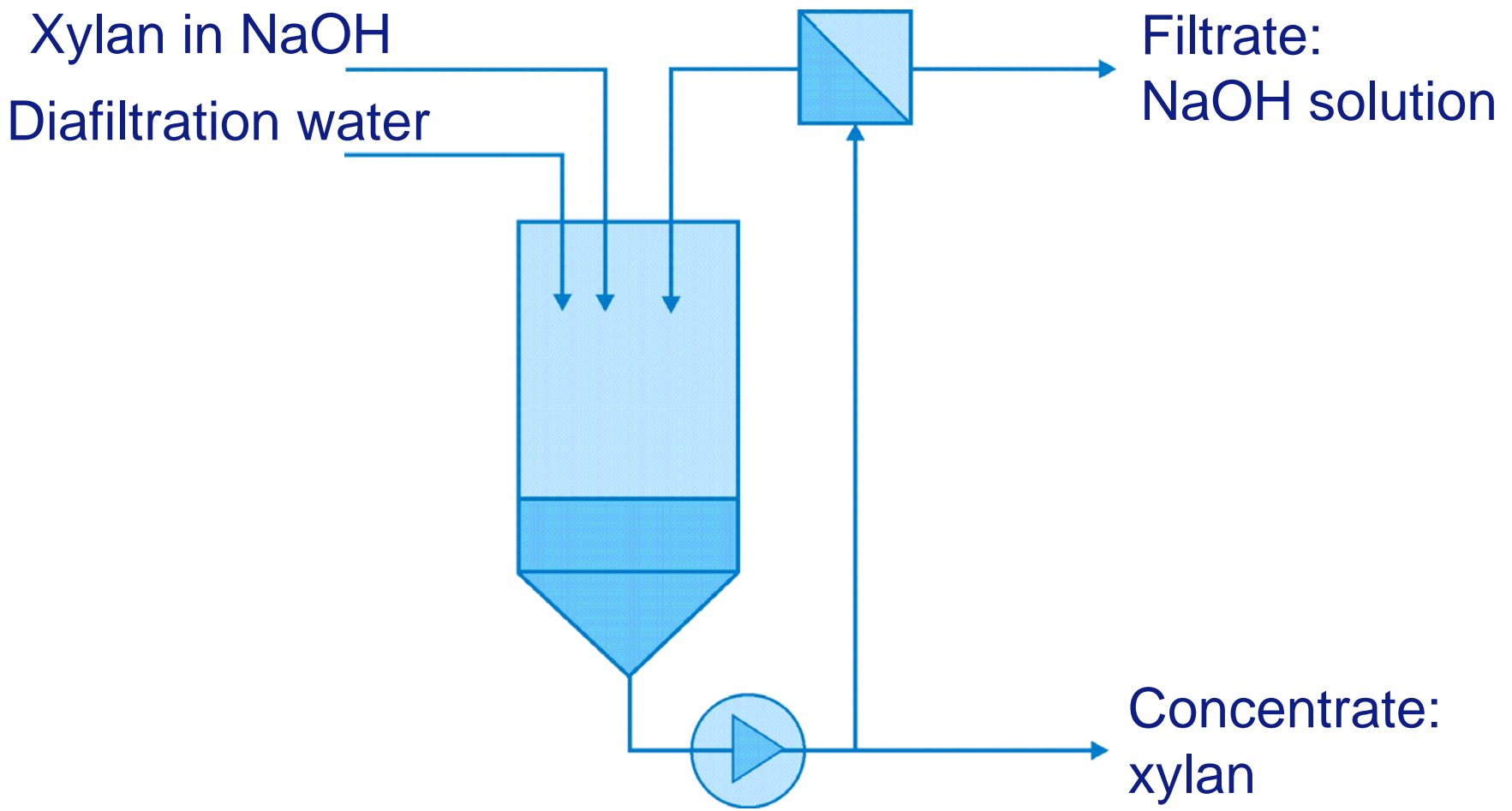
- Organic solvents: e.g. ethanol, isopropanol
- Precipitation by lowering pH using organic acids e.g. acetic acid, CO_2 , or inorganic acids such as HCl and H_2SO_4 for precipitation
- Ultra- and diafiltration for concentration and isolation by molar mass of the substances

Isolation of xylan from the extraction liquor

- Precipitation at pH 9 -10 using CO_2 increased ash content less than HCl and H_2SO_4
- Dialysis possible for desalting close to tap water level

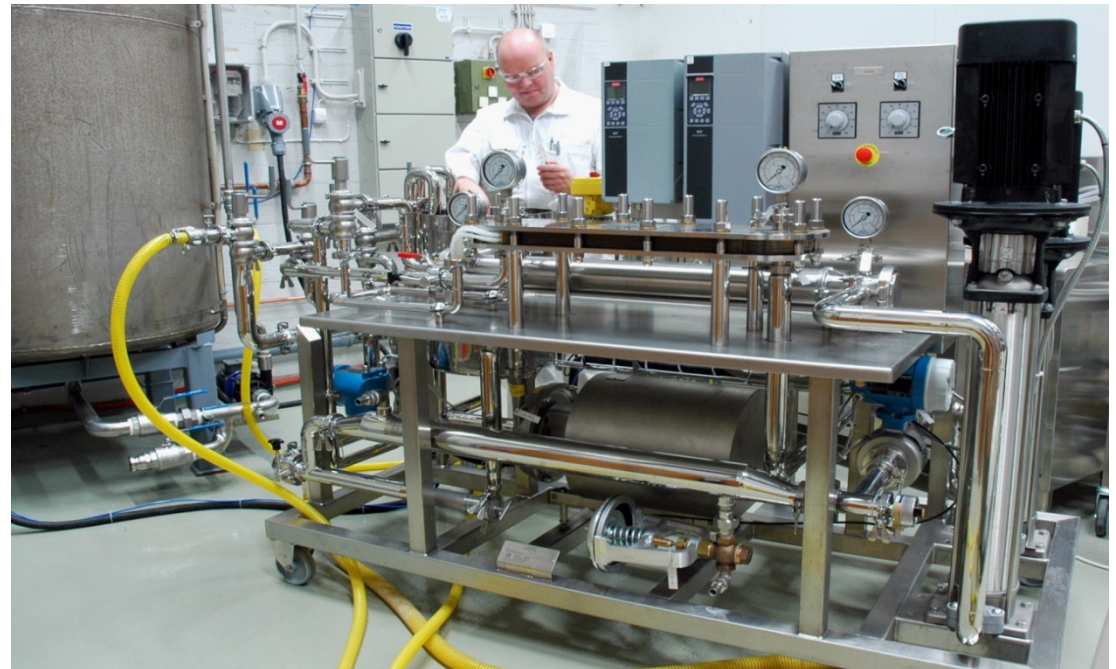
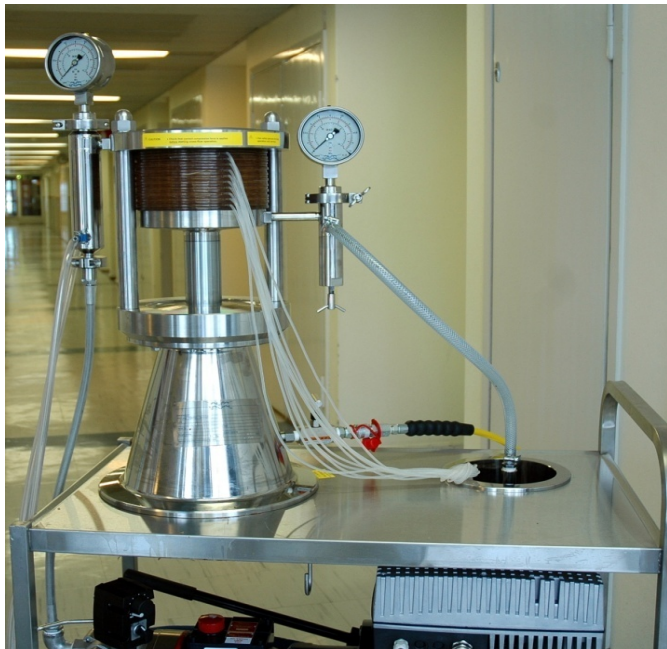


Separation by ultrafiltration – no additional chemicals needed, distinct molar mass cut off



Ultrafiltration results so far (cut-off 1 kD)

- Alkali-resistant membranes found i long-term runs
- Retention of xylan 91%, 82% of NaOH reusable

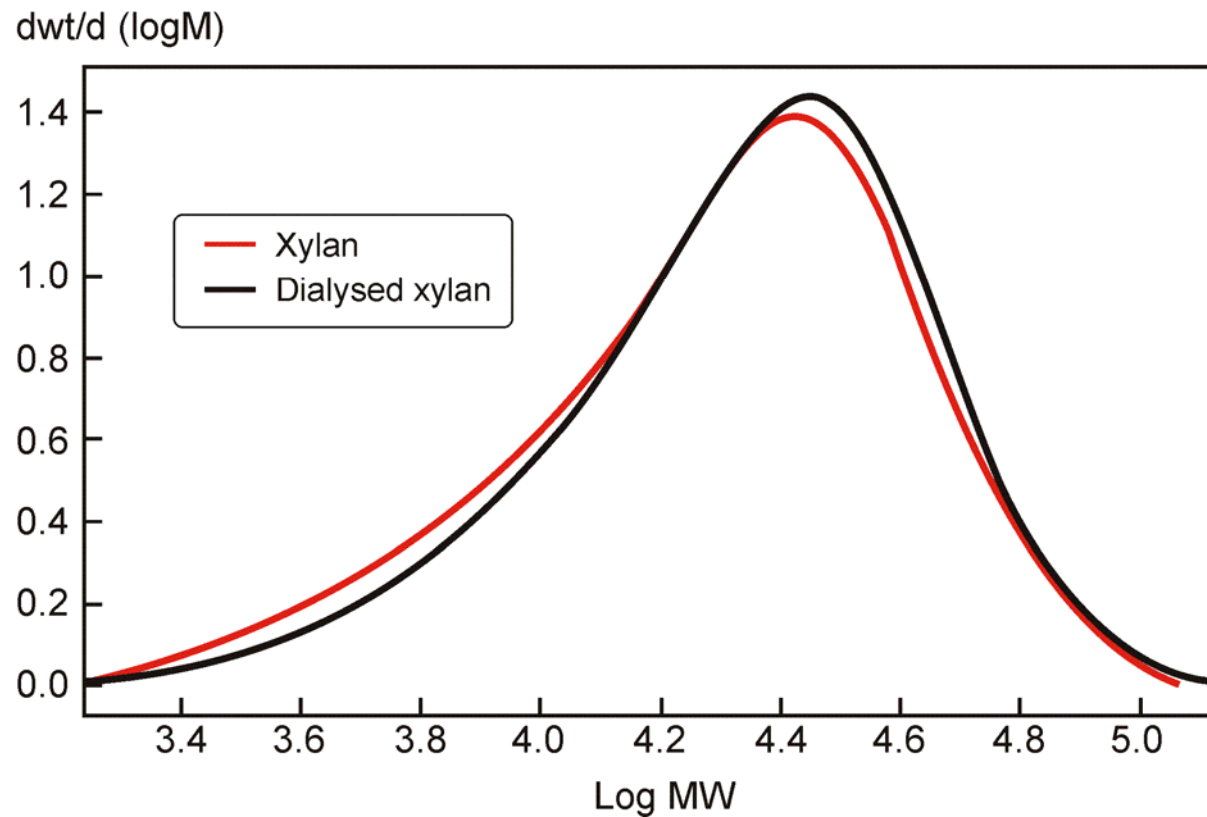


3. Quality of the isolated xylan product

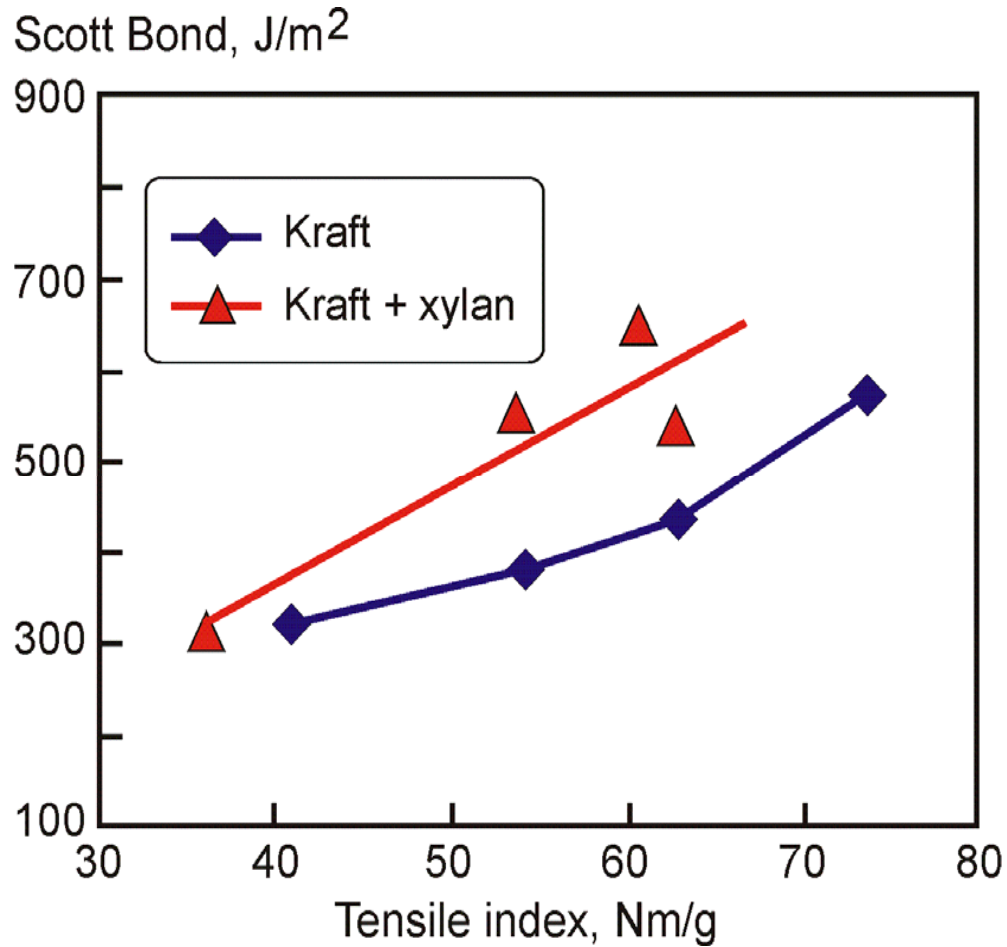
- Xylan is obtained as a white milky or creamy compound
- 98-99% of the precipitated carbohydrates is xylan
- However, TOC values indicate also other organic substances present, probably degradation products, e.g. organic acids



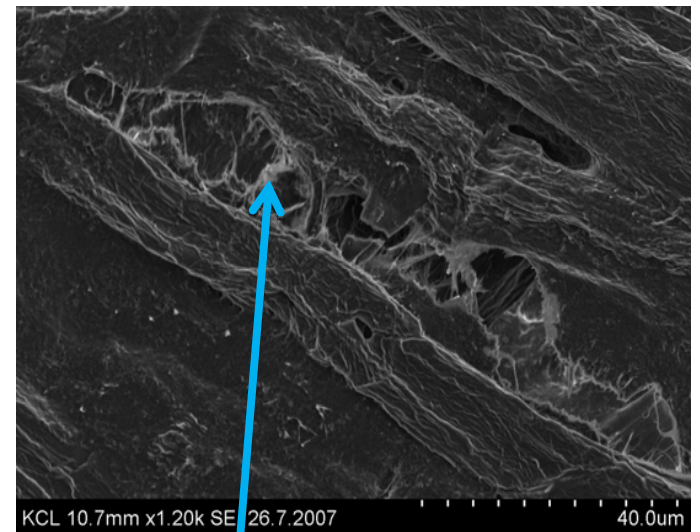
Molar mass distribution of isolated xylan by SEC – high-molar mass, Mm ca. 26,000 D



4. Xylan as a papermaking chemical - increasing of fiber bonding



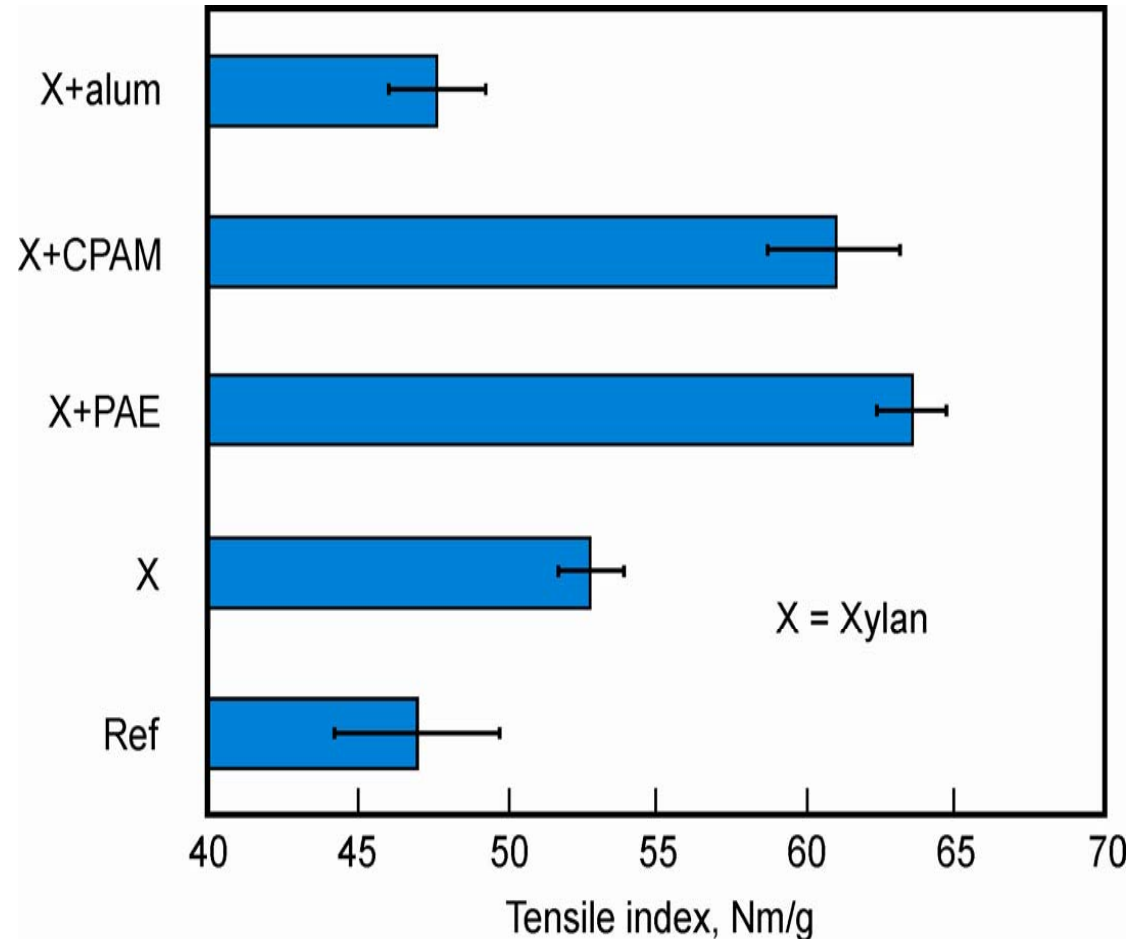
0, 250, 500, and PFI 1000 revolutions



Glue-like xylan bonds

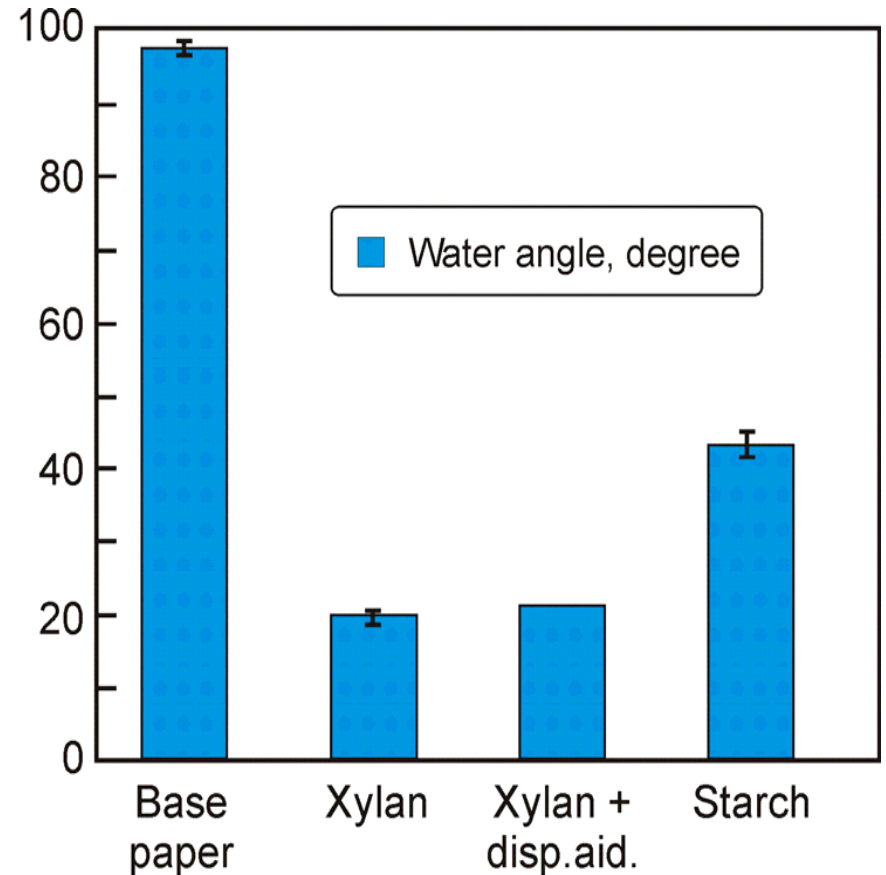
Xylan as strength improving chemical in the wet-end – sheet tests

- Using CPAM or PAE fixation chemicals xylan retention was improved from 82-89% to 94-100%
- Paper properties improved:
 - tensile index by 40%
 - Z-strength by 65%
 - stretch by 56%



Xylan as a surface sizing material

- Increased surface hydrophilicity due to lower water contact angle
- Formed a hard surface layer which resists bending of the sheet
- Good picking resistance, hard but brittle - needs plasticizer

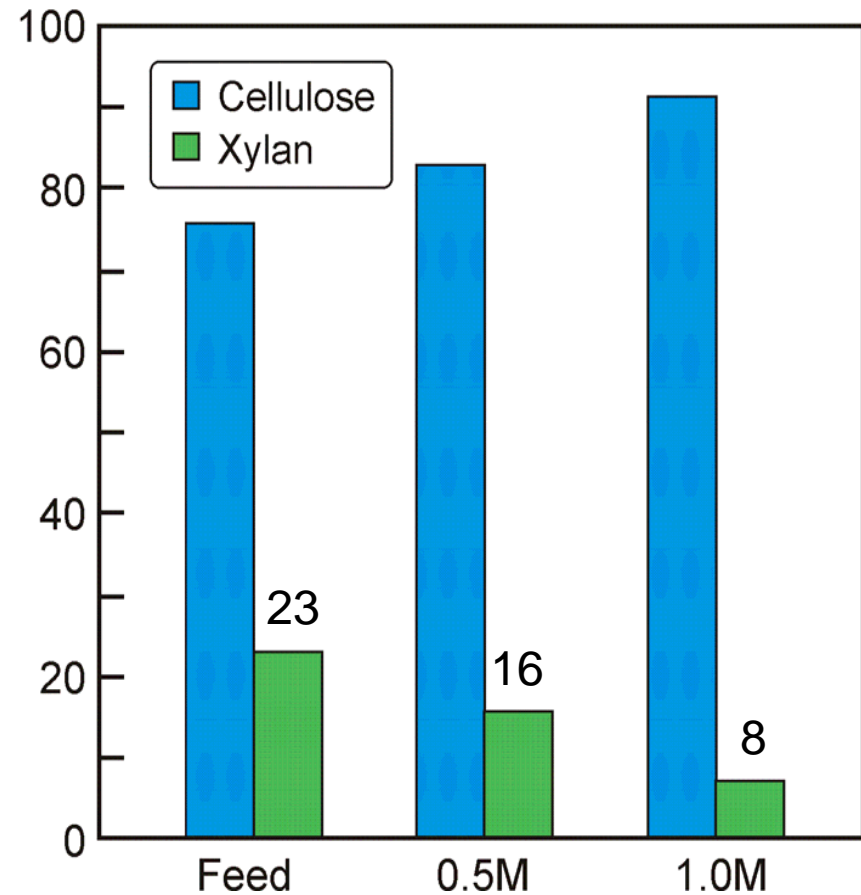


5. Properties of the extracted pulp

Evaluation of the effects of decrease of xylan in birch pulp performed:

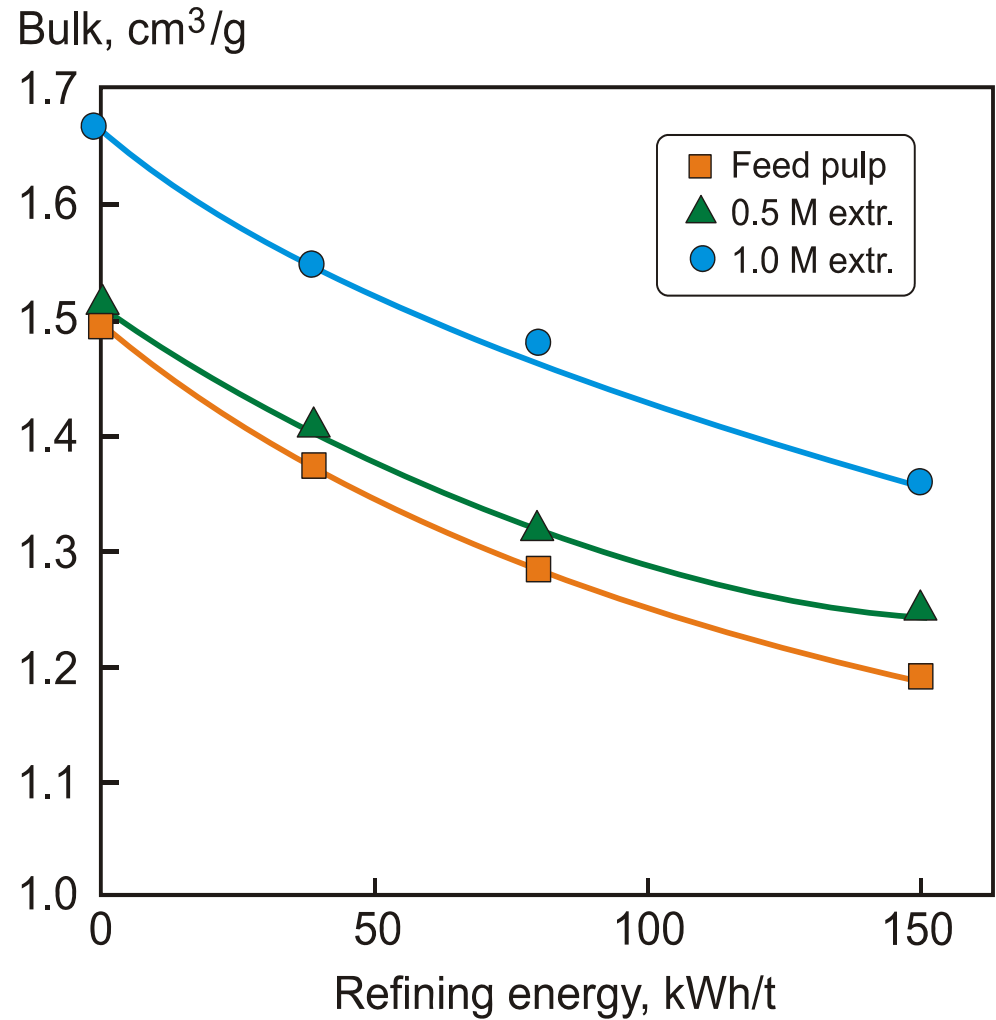
- need for refining
- bulk
- fiber bonding
- strength properties
- drainability
- brightness stability
- hornification in drying

Cellulose and xylan in pulp, %

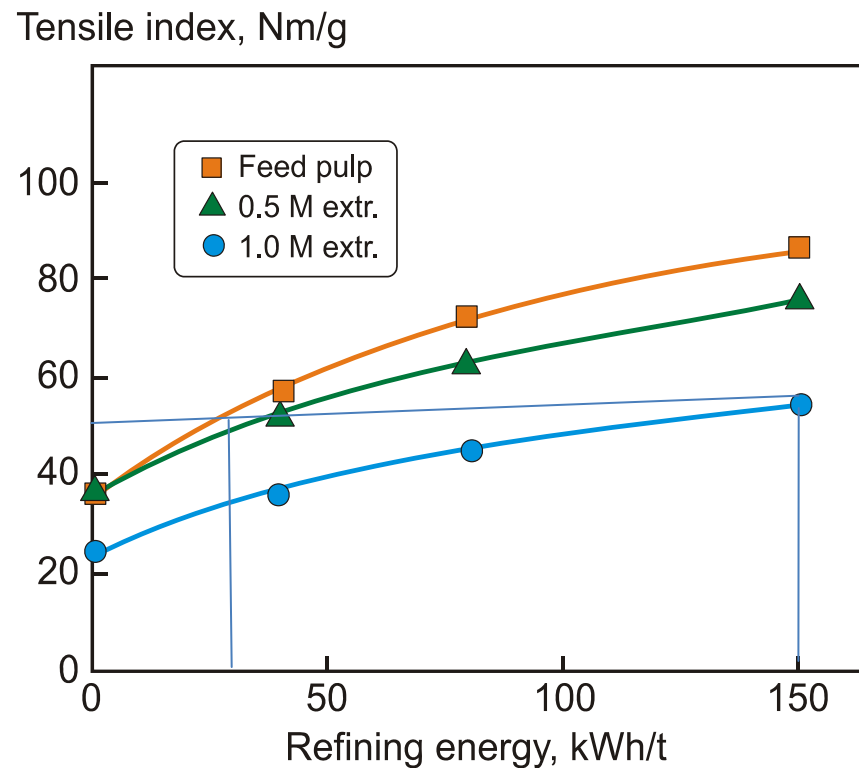
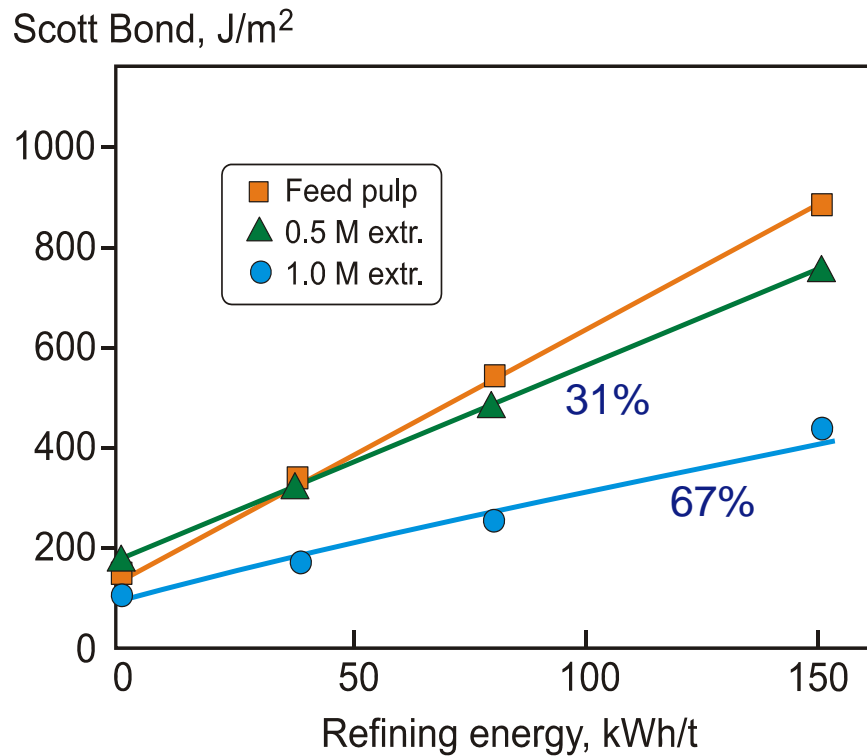


Increased brightness and bulk after extraction

- Brightness unrefined
Feed 89.5 %
0.5 M extr. 90.5
1.0 M extr. 92.0
- Improved brightness stability
- 50% less extractives
- High bulk - 1.0 M extracted pulp

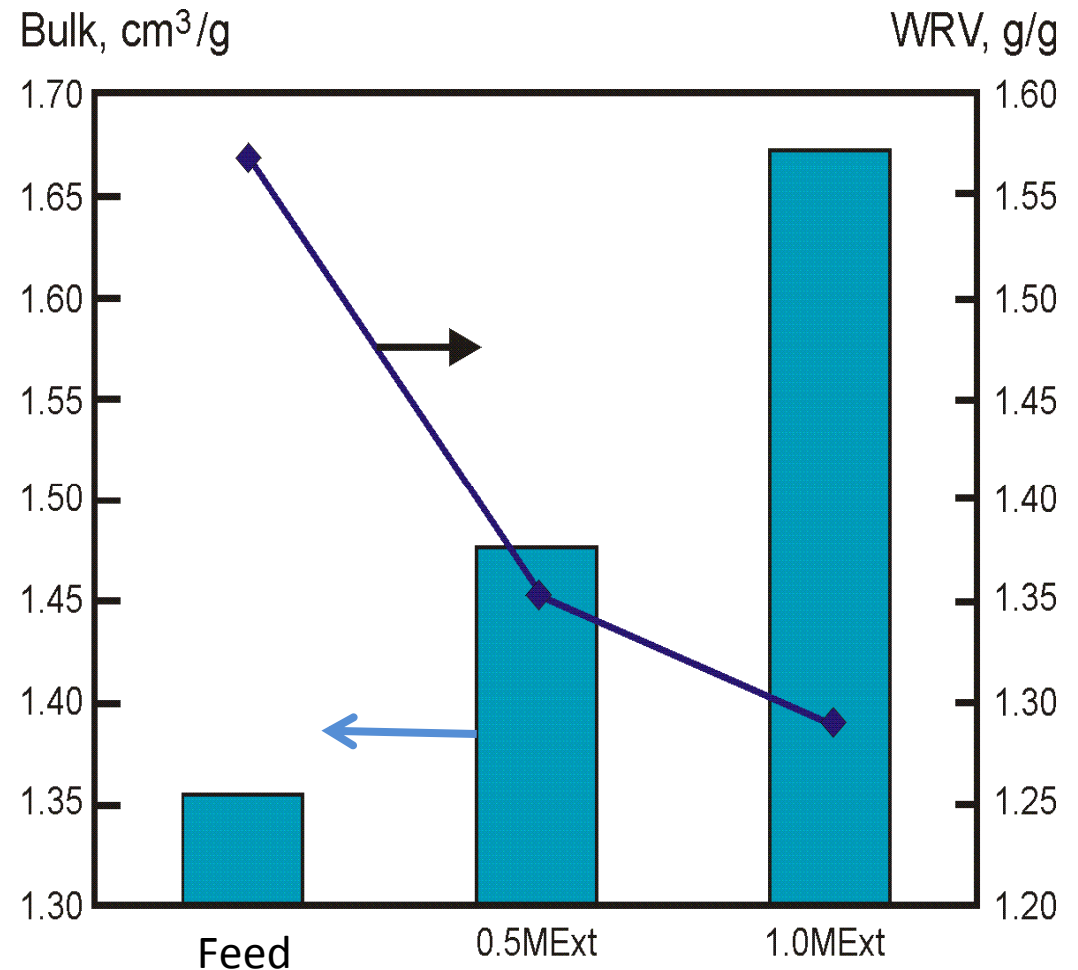


Removal of 67% xylan (1.0 M NaOH) - poor bonding -> poor tensile index/high refining energy



Pulp properties after drying prior to refining – positive indications of bulk and drainability

- Bulk of the extracted pulps remained more unaffected by drying compared to the feed pulp
- Lower water retention values – improved drainability



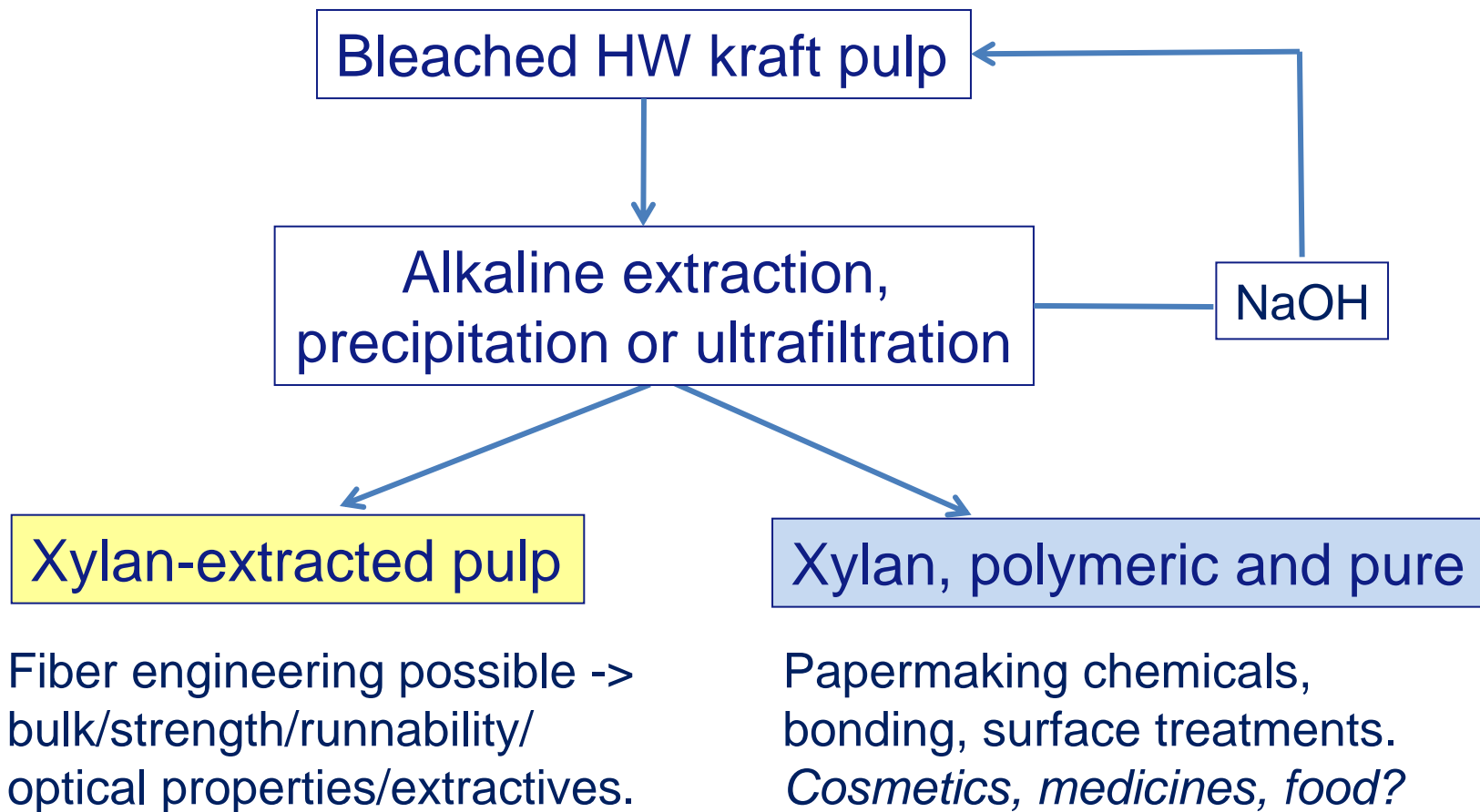
Conclusions

- Bleached birch kraft pulp contains 23-25% xylan
- 30-70 w-% of the xylan can be easily extracted from bleached birch pulp using 0.5-1.0 M NaOH-solution, i.e. 70-160 kg/t pulp
- Xylan can be isolated, and NaOH recirculated using ultra- and diafiltration
- Isolation can also be performed with CO₂ precipitation, however, the recirculation of NaOH is less complete

Conclusions...

- 98-99% of the carbohydrates is high-molar-mass xylan, and the color of the product is white
- In papermaking xylan acts as an excellent bonding material for various fiber materials
- Removal of xylan makes fiber engineering possible, taking into account product & process demands
- The properties of the extracted pulp can be widely varied depending on the amount of xylan removed or redeposited

Xylan isolation from bleached kraft pulp - new opportunities



Thank you for the attention!

