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Low Emission Biorefineries and Side-Stream Valorization

Recovery and Characterization of Low-Molecular-Weight Lignin from Ultrafiltered Kraft Black Liquor

Mariona Battestini Vives[1], Omar Abdelaziz[1], Johan Thuvander[1], Anders Arkell[2], Christian Hulteberg[1], and Frank Lipnizki[1]

[1]*Lund University, Lund, Sweden,*
[2]*RISE Innventia AB, Lund, Sweden*

Corresponding author: Lukas Almhofer <l.almhofer@wood-kplus.at>

Abstract

Kraft lignin is an aromatic polymer found in black liquor, a side stream of the kraft pulping industry. Usually, lignin is burned in the recovery boiler of the pulp mill as a fuel for energy generation. However, lignin has great potential as a raw material for the production of fossil-free fuels, chemicals, and materials. Membrane filtration has been studied in the last decades as a key separation method to recover lignin from black liquor. Further studies to concentrate lignin using membrane filtration are required, as well as characterization of the resulting lignin fractions for the development of molecular tailored lignin-based applications.

In the present work, nanofiltration (NF) was used to concentrate and recover the low-molecular-weight lignin obtained from the permeate of ultrafiltration of kraft black liquor. The concentration was performed using a NF090801 polymeric NF membrane (SolSep) with a molecular weight cut-off of 350 Da. A transmembrane pressure of 25 bar and 50 °C during the filtration increased the lignin content from 27 to 52 g/l, whereas a transmembrane pressure of 15 bar and 70 °C gave an increase from 18 to 45 g/l in lignin content. The lignin fraction recovered in the retentate of the NF step was analyzed by size-exclusion chromatography to ascertain the molecular weight of the lignin. Moreover, Fourier transform infrared spectroscopy and thermogravimetric analysis were carried out to evaluate the thermal properties and functionalities of the obtained fractions.

Recovery and characterization of low-molecular-weight lignin from ultrafiltered kraft black liquor

M. BATTESTINI VIVES[1], O. ABDELAZIZ[1], J. THUVANDER[1], A. ARKELL[2], C. HULTEBERG[1] AND F. LIPNIZKI[1]
[1]DEPARTMENT OF CHEMICAL ENGINEERING, LUND UNIVERSITY, LUND, SWEDEN; [2]RISE AB, LUND, SWEDEN

Introduction

Kraft lignin is an aromatic polymer found in black liquor, which is usually burned in the recovery boiler for energy generation. Lignin has great potential as a raw material for the production of fossil-free fuels and chemicals. Membrane filtration is a key separation method to recover different lignin fractions.

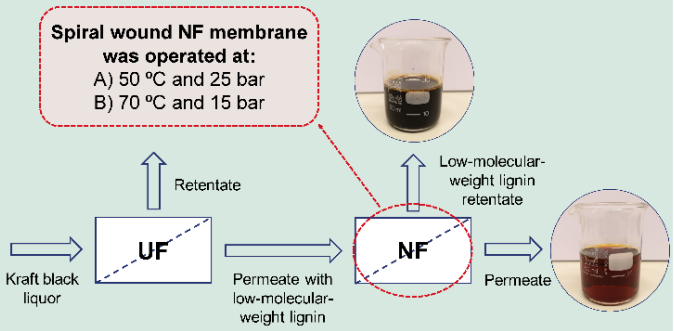
Further studies to scale up the concentration of lignin using membrane filtration are required, as well as characterization of the lignin fractions.

Aim

Concentrate ultrafiltered kraft black liquor by nanofiltration at pilot scale, and characterize the resulting lignin fractions.

Materials and methods

- The membrane used was a NF090801 (SolSep BV) in spiral wound configuration with a molecular weight cut-off of 350 Da.
- The membrane area was 1.8 m^2.
- The filtration was run at a pulp mill with a 400 L initial volume of ultrafiltered kraft black liquor.



Results

- A volume reduction (VR) of 80% and a lignin retention of 82% was achieved for both conditions *(Figure 1)*.
- Condition *B* had a higher average flux, 47 L/m^2h, compared to *A*, 35 L/m^2h.
- As expected, the lignin content increased, due to the feed being concentrated by recycling it over the membrane *(Table 1)*.

Table 1: Lignin content for initial and final VR at conditions *A* and *B*.

Lignin content	VR 0%	VR 80%
Condition A	27 g/L	52 g/L
Condition B	18 g/L	45 g/L

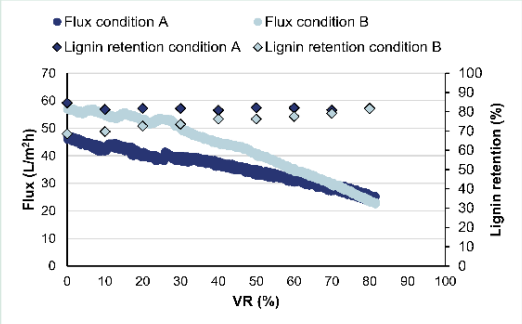


Figure 1: Flux and lignin retention vs VR for spiral wound membrane at conditions *A* and *B*.

- Lignin was separated between 100 to 1000 Da, and 1000 Da to 10 kDa, with condition *B* showing a more clear division compared to condition *A (Figure 2)*.

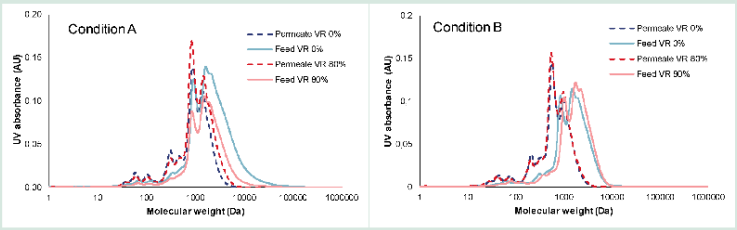


Figure 2: Molecular weight distribution for the permeate and feed samples taken at VR 0% and VR 80% at conditions *A* and *B*.

Conclusions

- The spiral wound NF membrane used in this study can successfully separate the low-molecular-weight lignin fractions.
- Lignin was similarly concentrated under both operating conditions due to a high membrane retention.

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Contact: **Mariona Battestini Vives**, PhD student, Department of Chemical Engineering, Lund University, Box 124, 221 00, Lund, Sweden, **mariona.battestini_vives@chemeng.lth.se**