Is Xanthan a Suitable Model Polymer for the Investigation of Hemicellulose Fouling Behaviour During Nanofiltration?

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Introduction

The production of viscose-type textile fibres from wood generates waste streams containing hemicellulose dissolved in caustic soda with concentrations up to 20 wt %. Hemicellulose is a collective term for polysaccharides, particularly 4-O-methylglucuronoxylan, that originate from the raw material wood and degradation products like sugar acids and hydroxycarboxylic acids. Caustic soda is usually recycled, however, the purification of these process liquors by nanofiltration is a challenge not only because of the high corrosiveness but also due to the high organic load of the solution. Fouling is a critical issue of this process that lowers permeate flux which need diligent choice of process conditions and rigorous cleaning procedures.

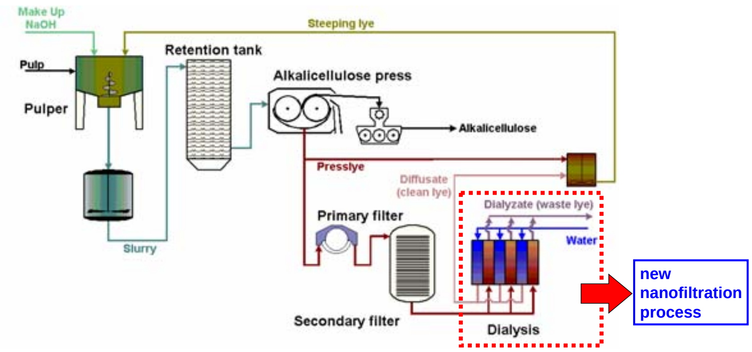


Figure 1: Alkalicellulose production (using diffusion dialysis) at Lenzing AG.

Properties of press lye & xanthan

It is known that the formation of hemicellulose aggregates in alkaline solution depends on alkali and hemicellulose concentration, shear stress, temperature and time. It is also known that hemicellulose may form gel layers during nano- and ultrafiltration [1].

The major goal of the present study was to find suitable oligo- or polymers to be used for nanofiltration fouling experiments which are well-defined, show similar gelation properties, and result in similar physical properties of the solution (e.g. viscosity, see figure 3) but do not need sodium hydroxide as a solvent. Xanthan was selected for this purpose (fig. 2).

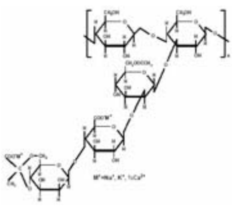
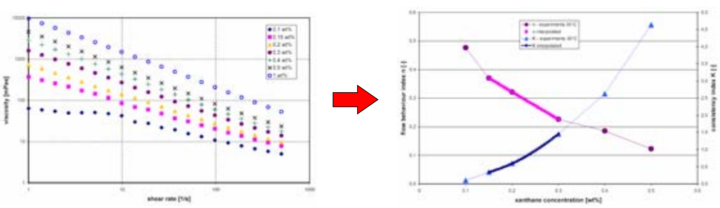


Figure 2: Molecular structure of xanthan.



Pseudoplastic flow behaviour: $\mu = K\dot{\gamma}^{(n-1)}$ **where:** $\dot{\gamma} = \frac{du}{dy}$

Figure 3: Viscosity model of dilute xanthan solutions.

The effect of the pseudoplastic flow behaviour of xanthan solution on the laminar flow profile in flat channels was investigated for a 0,1 wt% xanthan solution (fig. 4).

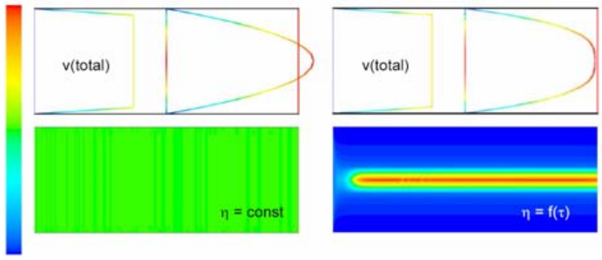
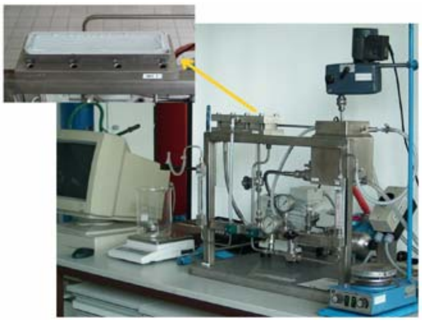


Figure 4: Flow profile of Newtonian fluid and pseudoplastic fluid (0,1 wt% xanthan solution).

Experiments & Results

All NF experiments were performed with a 80 cm² flat sheet lab-scale cross flow module at 30°C and feed pressures of 25 bar.

Figure 5: Membrane module and experimental apparatus.



Nanofiltration experiments were run at various feed concentrations and process conditions. Gelation could be gently induced by the addition of Fe^{3+}. At low concentration of Fe^{3+}, gelation only occurred in the concentration polarisation layer at the membrane surface and resulted in additional flux decrease when the threshold concentrations were reached (see figure 6). Gel layer model was applied (see figure 7).

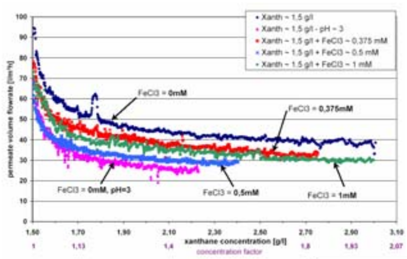
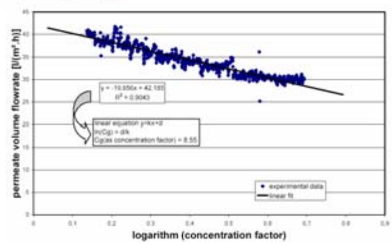


Figure 6: Permeate flowrate as function of concentration factor for different xanthan feed mixtures.

Gel layer model:

$$\frac{\dot{m}_P''}{\rho_F} = J = k_F \ln\left(\frac{c_g}{c_F}\right) = k_F \ln\left(\frac{w_{jg}}{w_{j1}}\right) = \frac{\Delta p}{\eta \cdot (R_m + R_g)}$$

Figure 7: Application of gel layer model to calculate the gelation concentration.



Current & Future Work

Comparison with nanofiltration results using presslye (and the same membrane & operating conditions) is ongoing. This is still needed for a better overall picture to answer the headline question.

References

[1] Schlesinger, R.; Götzinger, G.; Sixta, H.; Harasek, M.; Friedl, A.: Influence of hemicellulose aggregate and gel layer formation on flux and retention during nanofiltration of alkaline solutions. Conference on Fouling and Critical Flux, June 2004, Lappeenranta (Finland).

[2] Schlesinger, R.; Sixta, H.; Harasek, M.; Friedl, A.: Recovery of sodium hydroxide from industrial waste liquors by dialysis. Proceedings of the International Congress on Membranes and Membrane Processes (ICOM), 7-12 July 2002, Toulouse, France.

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