Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 44 (2012) 1384 – 1386

Procedia Engineering

www.elsevier.com/locate/procedia

Euromembrane Conference 2012

[P2.088]

Adsorption to improve filtration performance in treatment of wood-based hydrolysates

E. Koivula*[1], M. Kallioinen[1], T. Sainio[1], S. Luque[2], M. Mänttäri[1]
[1]Lappeenranta University of Technology, Finland, [2]University of Oviedo, Spain

Introduction

An autohydrolysis of wood produces hemicellulose-rich solutions, which also contain lignin and wood extractives.[1] Ultrafiltration of wood hydrolysates is a possible way to recover, fractionate and purify hemicelluloses. Different fractions can be used e.g. as a barrier materials or raw materials for fermentation processes. However, some other dissolved components, such as lignin or wood extractives [2,3], increase the membrane fouling leading to higher costs. This study aimed to improve the fluxes during ultrafiltration of wood hydrolysates by removing possible foulants from the feed solution with polymeric adsorbents.

Methods

Two different wood hydrolysates were used in this study, birch hydrolysate and eucalyptus/pine hydrolysate. Both hydrolysates were made with water from wood chips under high temperature and pressure.

Two commercial polymeric adsorbents were used: Amberlite XAD16 and XAD7HP from Rohm and Haas. XAD16 is hydrophobic, uncharged adsorbent, which surface is aromatic. XAD16 is applicable for adsorbing hydrophobic molecules from polar solvents, e.g. organic substances of relatively low to medium molecular weight. XAD7 is uncharged and its surface is aliphatic. XAD7 can be used to adsorb non polar compounds from aqueous systems, e.g. plant extracts and organic pollutants, and, polar compounds from non polar solvents. Adsorption was conducted at 60 ^{o}C for 3 h, with five different adsorbent-hydrolysate ratios in the range of 0.005 – 0.150. After adsorption, phases were separated by vacuum filter and solution was collected to filtration experiments.

Two different ultrafiltration membranes were used: for birch hydrolysate UH004P (PES, 4000 g/mol) membrane from Microdyn-Nadir and for eucalyptus/pine hydrolysate UFX5 pHt (PSu, 5000 g/mol) from Alfa Laval.

Both hydrolysates were filtrated with lab-scale stirred filter cells: for birch hydrolysate Amicon 8400 filter cell (membrane surface area 0.0040 m^2, 5.5 bar, 60 ^{o}C, VRF value 2) was used and for eucalyptus/pine hydrolysate Amicon 8050 filter cell (membrane surface area 0.0013 m^2, 2 bar, initial temperature 45 ^{o}C, volume reduction factor (VRF) value 2) was used. Amicon 8050 filtration equipment did not include heating, so the temperature of the solution inside the cell was decreasing towards room temperature as the filtration went on. Pure water fluxes were measured before and after filtration. Filtration samples, as well as samples taken during adsorption, were analyzed with UV spectrophotometer at 280 nm to observe changes in amount of UV absorbing matter (lignin and extractives).

Results and discussion

According to the filtration test, the use of polymeric adsorbent improved the flux of the wood hydrolysate drastically compared to the flux of the original hydrolysate. This happened both when birch hydrolysate was filtered with the UH004P membrane (Fig. 1, left picture), and, when eucalyptus/pine hydrolysate was filtered with the UFX5 pHt membrane (Fig. 1, right picture). With birch hydrolysate and UH004P membrane, the filtration without adsorbent pretreatment was impossible to carry on to the expected VRF value. Pretreatment with adsorbent improved the flux of birch hydrolysate making it possible to continue the filtration up to the VRF value of 2.

doi:10.1016/j.proeng.2012.08.796

With birch hydrolysate, XAD7 adsorbent increased the flux more than XAD16 adsorbent. With eucalyptus/pine hydrolysate and UFX5 pHt membrane even the filtration of original hydrolysate could be continued to the expected VRF value, however, the flux was low and also in this case the improvement on flux caused by adsorbent treatment was remarkable. With eucalyptus/pine hydrolysate XAD16 adsorbent was slightly more effective in increasing flux than XAD7 adsorbent.

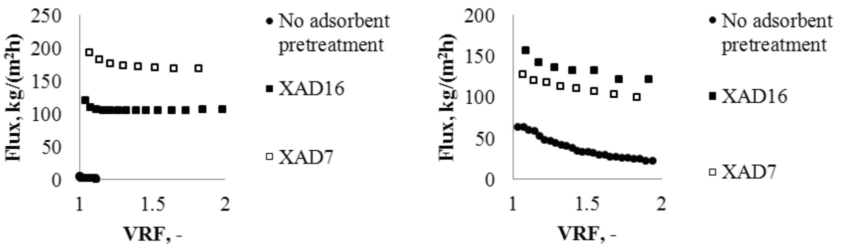

Figure 1. Filtration of birch hydrolysate with UH004P membrane at 5.5 bar and 60 °C (left) and eucalyptus/pine hydrolysate with UFX5 pHt membrane at 2.0 bar and 45 °C (initial temperature) (right).

With both hydrolysates, XAD16 adsorbent decreased the UV (280 nm) absorption of the hydrolysate more than XAD7 adsorbent (Table 1). On the contrary, XAD7 adsorbent decreased the PWF reduction more than XAD16 in both cases (Table 2). According to the pure water flux (PWF) reductions, both adsorbents reduced fouling of the both membranes.

Table 1 UV (280 nm) absorbances of the untreated and with the highest phase ratio treated hydrolysates.

	UV (280 nm), -		
	Untreated	**XAD16**	**XAD7**
Birch	350	90	162
Eucal./pine	83	29	42

Table 2 PWF reductions of the untreated and with the highest phase ratio treated hydrolysates.

	PWF reduction, %		
	Untreated	**XAD16**	**XAD7**
Birch, UH004P	90	6	-2
Eucal./pine, UFX5 pHt	36	10	1

Conclusion

Adsorption prior to filtration of both used hydrolysates and membranes increased the flux remarkably. With both hydrolysates XAD16 adsorbent was more efficient in decreasing the UV absorbance and XAD7 adsorbent in decreasing the PWF reduction, although, differences in PWF reductions with these two adsorbents were quite negligible. With birch hydrolysate, XAD7 adsorbent increased the hydrolysate flux more than XAD16 adsorbent, and with eucalyptus/pine hydrolysate, it was the other way. This difference might result from differences in the structure and amount of lignin and wood extractives in different wood species (birch, and, eucalyptus and pine), and differences in the characters of the adsorbents. Also because some part of the lignin is linked with polysaccharides, the amount of hemicelluloses might affect the amount of potentially adsorbable lignin, and thus, also the residual lignin.

Acknowledgements

The authors wish to thank Ms. Susanna Pulkka, M.Sc Massoud El Mansour El Jastimi and M.Sc Enrique Antón Rodríguez for their valuable contribution to this study, and Dr María Jesús González-Muñoz, from the University of Vigo in Orense (Spain), for the preparation of the eucalyptus/pine hydrolysate. The authors are also grateful to the Future Biorefinery Research Program FuBio for financial support.

References

1 Leschinsky M., Weber, H. K, Patt, R. and Sixta, H., Formation of insoluble components during autohydrolysis of eucalyptus globulus, Lenzinger Berichte 87 (2009) 16-25.

2 Maartens, A., Jacobs, E.P., Swart, P., UF of pulp and paper effluent: Membrane fouling prevention and cleaning, J. Memb. Sci. 209(2002), 81-92.

3 Puro, L., Tanninen, J., Nyström, M., Analyses of organic foulants in membranes fouled by pulp and paper mill effluent using solid-liquid extraction, Desalination 143(2002), 1-9.

Keywords: Pretreatment, Wood hydrolysate, Fouling