Applying novel natural solvents to the delignification of lignocellulosic biomass

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Abstract

Lignocellulosic biomass is considered an important non-fossil and non-food resource for sustainable chemicals and fuels.[1], [2] Lignin, one of the three main biopolymers present in lignocellulosic biomass, inhibits most valorisation routes for the other two biopolymers, cellulose and hemicellulose.[3], [4] Current biomass treatments that incorporate lignin removal are generally energy consuming or environmentally challenging.[5]

An alternative biomass treatment is the selective extraction of lignin with a solvent specifically designed for that task. Ionic Liquids (ILs) have proven to selectively extract lignin from biomass[6–8]. Encouraged by these developments, Low Transition Temperature Mixtures (LTTMs) and Deep Eutectic Solvents (DESs) were examined for the selective extraction of lignin from biomass at mild conditions. LTTMs do not require complicated synthesis routes, but can be easily prepared by mixing solid hydrogen bond donors and acceptors without the need for further purification.[9], [10] LTTMs exhibited high lignin and negligible cellulose solubility, implying a high extraction selectivity towards lignin.[11]

Experiments at mild conditions show that the lack of lignin accessibility in the biomass limits the extraction performance, despite the shown potential of high and selective solubility. Nevertheless, the extraction efficiency could be improved by changing the extraction conditions and tuning of the solvent by varying the types and ratios of its constituents. If the amount of extracted lignin can be driven towards the maximum lignin solubility, LTTMs offer a new, cheap and environmentally benign lignocellulosic biomass treatment.

References

[1] C. O. Tuck, E. Pérez, I. T. Horváth, R. A. Sheldon, and M. Poliakoff, Science, vol. 337, no. 6095, pp. 695–699, 2012.
[2] C. Somerville, H. Youngs, C. Taylor, S. C. Davis, S. P. Long, and others, Science, vol. 329, no. 5993, pp. 790–792, 2010.
[3] N. Mosier et al., Bioresource technology, vol. 96, no. 6, pp. 673–686, 2005.
[4] Y. Zeng, S. Zhao, S. Yang, and S.-Y. Ding, Current Opinion in Biotechnology, vol. 27, pp. 38–45, 2014.
[5] G. Brodeur, E. Yau, K. Badal, J. Collier, K. Ramachandran, and S. Ramakrishnan, Enzyme research, vol. 2011, 2011.
[6] S. H. Lee, T. V. Doherty, R. J. Linhardt, and J. S. Dordick, Biotechnology and bioengineering, vol. 102, no. 5, pp. 1368–1376, 2009.
[7] A. Pinkert, D. F. Goeke, K. N. Marsh, and S. Pang, Green Chem., vol. 13, no. 11, pp. 3124–3136, 2011.
[8] E. Achinivu, R. Howard, G. Li, H. Gracz, and W. Henderson, Green Chemistry, 2013.
[9] M. Francisco, A. van den Bruinhorst, and M. C. Kroon, Angewandte Chemie International Edition, vol. 52, pp. 3074–3085, 2013.
[10] Q. Zhang, K. D. O. Vigier, S. Royer, and F. Jérôme, Chemical Society Reviews, 2012.
[11] M. Francisco, A. van den Bruinhorst, and M. C. Kroon, Green Chemistry, vol. 14, pp. 2153–2157, 2012.