Evaluation of Acidic Deep Eutectic Solvent Treatment for Hemp Fiber Processing

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Abstract

Developing sustainable alternatives to conventional alkaline degumming is important for reducing the environmental impact of lignocellulosic fibre processing. Deep eutectic solvents (DESs) offer a potentially lower-impact approach, but their effectiveness in bast-fibre treatment and the process parameters governing their performance remain poorly understood. Here, we evaluated a ternary acidic DES for hemp-fibre treatment using a full factorial design that examined the effects of temperature, treatment time and water content. Treatment performance was assessed by compositional analysis using the d-AIR method, supported by Fourier-transform infrared spectroscopy, scanning electron microscopy and colourimetry. Sodium hydroxide treatment was included as a conventional benchmark. DES treatment produced only minor changes in cellulose (65.08±1.55%) and lignin (10.41±0.67%) contents, while selectively altering the hemicellulose, starch and extractive fractions. Analysis of variance identified water content as the principal factor governing compositional changes, whereas temperature and treatment time had no significant effects within the investigated range. Microscopic and spectroscopic analyses indicated partial disruption of the surrounding non-cellulosic matrix and a cleaner fibre surface, while the lignin-containing structural framework remained largely intact. DES treatment also increased fibre brightness, potentially owing to greater surface heterogeneity and enhanced light scattering. These findings demonstrate that, under the investigated conditions, the acidic DES acted primarily as a selective extraction medium rather than as an effective delignifying or comprehensive degumming agent. The results identify DES water content as a key determinant of treatment performance and provide mechanistic insight to guide the development and computational screening of more effective DES formulations for sustainable bast-fibre processing.

Keywords: Hemp Fibers, Deep Eutectic Solvents (DES), Sustainable Degumming

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