Advancing Circularity in Textiles: Evaluating the Recyclability of Commercial Crosslinked Lyocell and Recycled Cotton Fibres

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Abstract

Driven by the growing demand for more circular and lower-impact textile solutions, fibre recycling has gained significant attention as a key pathway towards a sustainable circular economy. This includes the interest for more environmentally sustainable and biodegradable fibres, as is the case of man-made cellulosic fibres (MMCFs). Whereas cotton chemical recycling has been widely explored as a source of cellulosic fibres, the recyclability of Lyocell remains less understood, particularly due to surface modifications that may hinder dissolution and regeneration. In this study, two fibre streams were investigated: recovered cellulose from pre-consumer cotton waste, and commercial-grade Lyocell fibres, with or without crosslinking finishing treatments. Cotton residues were subjected to alkaline pre-treatments to decolourise and remove finishing agents, yielding purified cellulose suitable for reprocessing. Equivalent alkaline pre-treatments were applied to improve dissolution efficiency of commercial-grade Lyocell fibres. These materials showed good performance at laboratory-scale dissolution and wet spinning, allowing the preparation of stable cellulose dopes and regenerated fibres blended with virgin Eucalyptus globulus pulp.
In lab-scale dissolution trials, 5 % cellulose dopes were prepared using N-Methylmorpholine-N-oxide (NMMO) solvent, incorporating the treated fibres in both pure and blended configurations. The wet spinning process was subsequently upscaled to pilot level using 10 % cellulose dopes in NMMO. The obtained fibres were characterised in terms of mechanical properties, and molecular weight distribution, providing a comprehensive assessment of their structural and performance-related features.

Filaments containing up to 50 % of recycled Lyocell fibres showed mechanical performance comparable to those produced with 100 % virgin pulp (tenacity of 3.2 cN/dtex, elongation of 9 %). In addition, knitted fabrics were produced from the regenerated fibres to evaluate

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their suitability for downstream textile applications and to assess performance in a realistic end-use context.

This study confirmed the feasibility of recycling both cotton waste and commercial-grade Lyocell into regenerated cellulose fibres. This work therefore supports the development of closed-loop recycling routes and contributes to more sustainable and resource-efficient textile manufacturing.

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