Optimization of a sustainable solvent-based process for elastane separation and recycling from blended textiles

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Textile recycling often requires the separation of elastane (EL), a segmented polyurethane fiber also known as spandex or LYCRA®, to enable recyclability. Elastane, typically used in small amounts (1–5 wt%) in cotton or wool fabrics and up to 20 wt% in polyester or polyamide textiles, enhances stretch and comfort in products such as sportswear and medical textiles. Despite representing only about 1% of total fiber production, elastane poses significant challenges in recycling processes. Indeed, its elastic properties can clog filters, disrupt cutting machines, and create defects in recycled fabrics. Effective EL separation methods are critical to making many elastane-containing textiles recyclable. Unlike thermal or mechanical methods, that can damage the entire textile matrix or create processing issues like unwanted strings, selective solvents target elastane more effectively. However, using non-hazardous solvents is crucial for environmental and safety reasons. Indeed, to date, only few studies have investigated EL separation from textile wastes and the main approach used was the extraction using hazardous organic solvents, such as N, N-dimethylformamide and tetrahydrofurfuryl alcohol. However, the usage of these solvents is undesired at industrial scale and a significantly shorter process time than 4 hours would be essential for a large-scale implementation.

This study aimed at optimizing a solvent-based process for selectively separating elastane from blended textiles. A non-toxic organic solvent, dimethyl sulfoxide (DMSO), was identified as the best option based on a thorough comparison of literature data and theoretical models, including Hansen Solubility Parameters. Experimental tests demonstrated that DMSO could selectively dissolve EL in just 1 hour at around 120°C, starting with cotton-based fabrics. The recovered EL retained its original properties, as confirmed by thermal analyses, ensuring no degradation during the process. Additionally, the recovered EL underwent mechanical recycling and was extruded with a brittle polymer matrix to enhance its mechanical properties. To tackle contaminants like dyes left in DMSO after processing, a photocatalytic method was implemented. This approach successfully achieved over 98% removal and mineralization of impurities. Then, the DMSO was efficiently recovered through distillation, maintaining its original solubility efficiency towards EL for reuse. By allowing the solvent to be recycled and reused, the process became more sustainable. This optimized method presents a promising, eco-friendly solution for recycling elastane-containing textiles, paving the way for broader adoption of elastane recycling.

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