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Title: *Extraction of Cellulose Nanocrystals via Sulfuric Acid Hydrolysis from Post-Consumer Cotton-Elastane Textile Blends with Elastane Recovery*

ABSTRACT OF RESEARCH

An estimated 92 million tons of textiles are discarded yearly, contributing to global environmental crisis. Cotton upcycling presents a promising alternative to landfills or incinerators; cotton can be converted into high-value, biodegradable nanocellulose forms with applications across industries. However, the widespread blending of cotton with elastane (spandex) complicates any reuse, as elastane becomes entangled in machinery during traditional recycling. This research develops a scalable, sustainable upcycling pathway for extracting cellulose nanocrystals (CNCs) from post-consumer cotton-elastane textile blends. First, the sample fabric undergoes selective dissolution of elastane using N,N-dimethylacetamide (DMAc). Through filtration, cotton is separated, DMAc is recovered, and elastane fibers are isolated in a form suitable for further recycling. Sulfuric acid hydrolysis is applied to the separated cotton, producing CNC yields of approximately 55%. Dynamic Light Scattering particle size analysis of the CNCs in suspension showed an average hydrodynamic diameter of 60.1nm, which aligns with CNCs from USDA Forest Products Labs. This pathway outperforms an experimental comparison method, where direct sulfuric acid hydrolysis without prior fabric separation yielded fewer CNCs (50.3%), failed to recover elastane, and produced smaller CNCs with an average size of 51.1nm. Based on current commercial facilities, the developed method of pre-separation and subsequent acid hydrolysis can save 1880 kg (about 11,000 t-shirts) of cotton-elastane waste per day. These findings support a scalable and sustainable route for upcycling cotton-elastane blends, which are otherwise challenging to recycle, advancing toward a circular economy.