

Reinforcing Cotton Recycled Fibers for the Production of High-Quality Textile Structures

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Summary: The textile industry is under increasing pressure to adopt sustainable practices due to the significant environmental impacts associated with fiber production, including high energy consumption, water usage, and substantial greenhouse gas emissions. The recycling of textile waste, particularly cotton, is a promising solution that has the potential to reduce landfill waste and decrease the demand for virgin fibers. However, mechanically recycled cotton fibers frequently demonstrate diminished mechanical properties compared to virgin fibers, which limits their potential for high-quality textile applications. This study explores the use of cross-linking agents (citric acid (CA) and sodium hypophosphite (SHP)), polymers (polyethylene glycol (PEG), chitosan (CH), carboxymethyl cellulose (CMC) and starch (ST)), and silicas (anionic (SA) and cationic (SC)) to enhance the mechanical properties of recycled cotton fibers. The treatments were then subjected to a hierarchical ranking, with the effectiveness of each treatment determined by its impact on enhancing fiber tenacity. The findings of this research indicate that the most effective treatment was starch (ST_50), which resulted in an enhancement of tenacity from 14.63 cN/tex to 15.34 cN/tex (+4.9%), closely followed by CA-SHP_110/110, which also reached 15.34 cN/tex (+4.6%). Other notable improvements were observed with CMC_50 (15.23 cN/tex), PEG_50 (14.91 cN/tex), and CA_50 (14.89 cN/tex), all in comparison to the control. In terms of yarn quality, the CA-SHP_110/110 treatment yielded the most substantial reductions in yarn irregularities, including thin places, thick places, and neps with decreases of 36%, 10%, and 7%, respectively. Furthermore, CA_50 exhibited moderate enhancements in yarn regularity, thin places (−12%), thick places (−6.1%), and neps (−8.9%). The results of this study demonstrate that combining CA with SHP, particularly when preceded by the heating of the solution before the addition of the fibers, results in a substantial enhancement of the structural integrity, strength, and overall quality of recycled cotton fibers. This approach offers a viable pathway for the improvement of the performance of recycled cotton, thereby facilitating its wider utilization in high-quality textile products.

Biography

Dr. Ana Catarina Silva (ACS) holds a PhD in Chemistry, with a specialization in Physical and Analytical Chemistry, and an Integrated Master's in Biological Engineering (Food branch), both from the University of Minho. Her research focuses on the valorization of organic waste, with expertise in material characterization, process optimization, and sustainability assessment. She has participated in several national and European-funded projects, including Res2ValHum, Res4ValOr, and the Lusitano project, addressing topics such as compost quality, contaminant adsorption, and textile recycling technologies. ACS has authored scientific publications, presented her work at national and international conferences, and supervised both undergraduate and graduate students. In addition to her research

activities, she plays an active role in science outreach and institutional promotion, particularly within the Innofiber Research Lab, part of the Centre for Textile Science and Technology (2C2T). She supports the organization of school visits, internal events, and public engagement initiatives that showcase the work developed at 2C2T and the Department of Textile Engineering. Passionate about sustainability and the circular economy, she combines scientific rigor with a strong focus on practical and environmental impact.

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