2C2T Centre for Textile Science and Technology
Universidade do Minho Escola de Engenharia
P2.077
Frontiers in polymer science
29 May - 1 June 2023 | Gothenburg, Sweden
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Development of Sustainable Techniques for Cellulose Recovery from Leftovers and Cellulose-containing Garments

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INTRODUCTION

Textile and clothing industry is one of the most polluting industries in the world, with high impact on water and land consumption. Approximately 5.8 million tons of textiles are discarded in Europe, and only 1% is fiber-to-fiber recycled.

Cotton-based waste products are usually mechanically recycled. This recycling method decreases the mechanical properties of the cotton fibres, due to the shredding, opening and carding processes. The quality of the new products is, therefore, compromised.

Through chemical recycling, it is possible to regenerate the cotton fibres from waste and produce new value-added products.

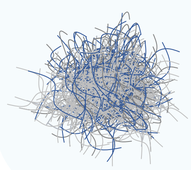
OBJECTIVES

- Optimize the cellulose recovery without compromising its physicochemical properties;
- Create value-added products with the recovered cellulose.

METHODOLOGY

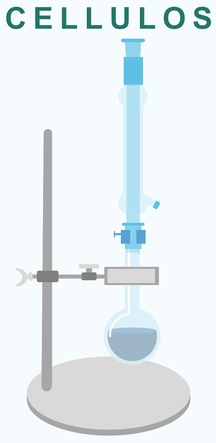
1 WASTE COLLECT

Post-consumer textile waste



Carding textile waste

2 CELLULOSE RECOVERY

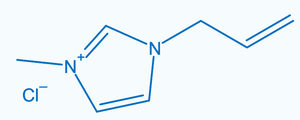


Pre-treatment with enzyme (5%, 10%, and 20%) 24 h at 25 °C

+

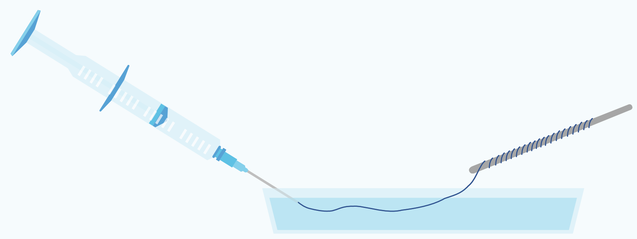
Reflux with HNO_3 (1 M) 3 h at 100 °C

3 PRODUCTION OF VALUE-ADDED PRODUCTS



1-allyl-3-methylimidazolium chloride

Cellulose dissolution in AmimCl with stirring at 25 °C



Wet spinning in distilled water bath at 25 °C performed at a rate of 20 mL/min

RESULTS AND DISCUSSION

CRYSTALLINITY INDEX

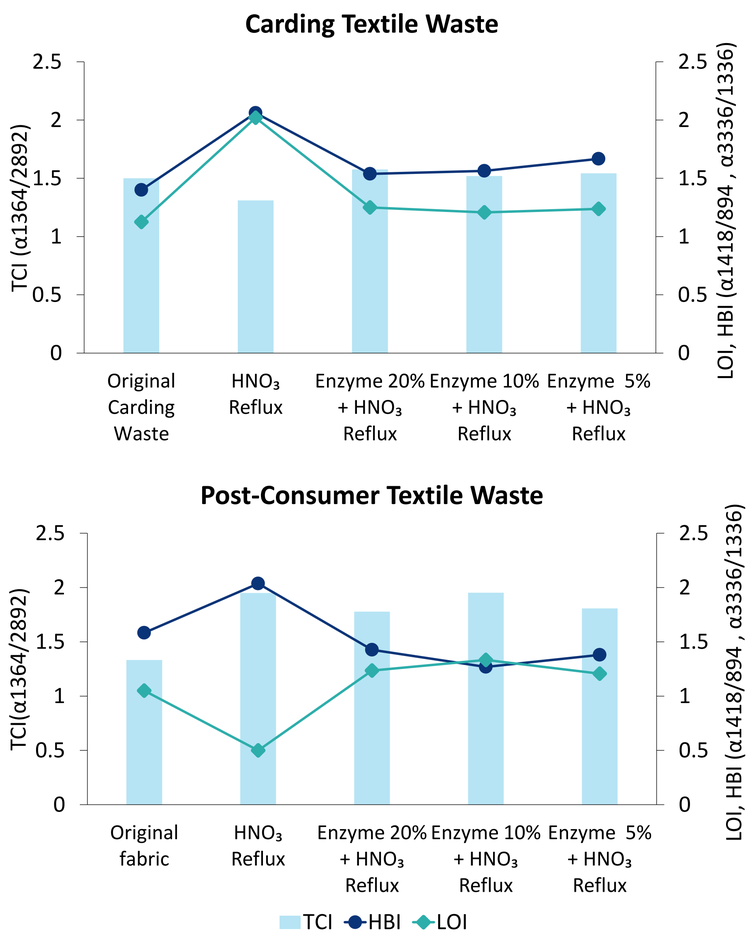


Figure 1 – Total Crystallinity Index (TCI), Hydrogen Bond Intensity (HBI), and Lateral Order Index (LOI) of regenerated cellulose.

DEGREE OF POLYMERIZATION (DP)

SAMPLE	DP
Original Carding Waste	1197.74
HNO_3 Reflux	322.38
Enzyme 20% + HNO_3 Reflux	250.00
Enzyme 10% + HNO_3 Reflux	307.14
Enzyme 5% + HNO_3 Reflux	360.00
Original Post-Consumer Waste	619.05
HNO_3 Reflux	222.86
Enzyme 20% + HNO_3 Reflux	229.20
Enzyme 10% + HNO_3 Reflux	215.71
Enzyme 5% + HNO_3 Reflux	241.43

MICROSCOPY

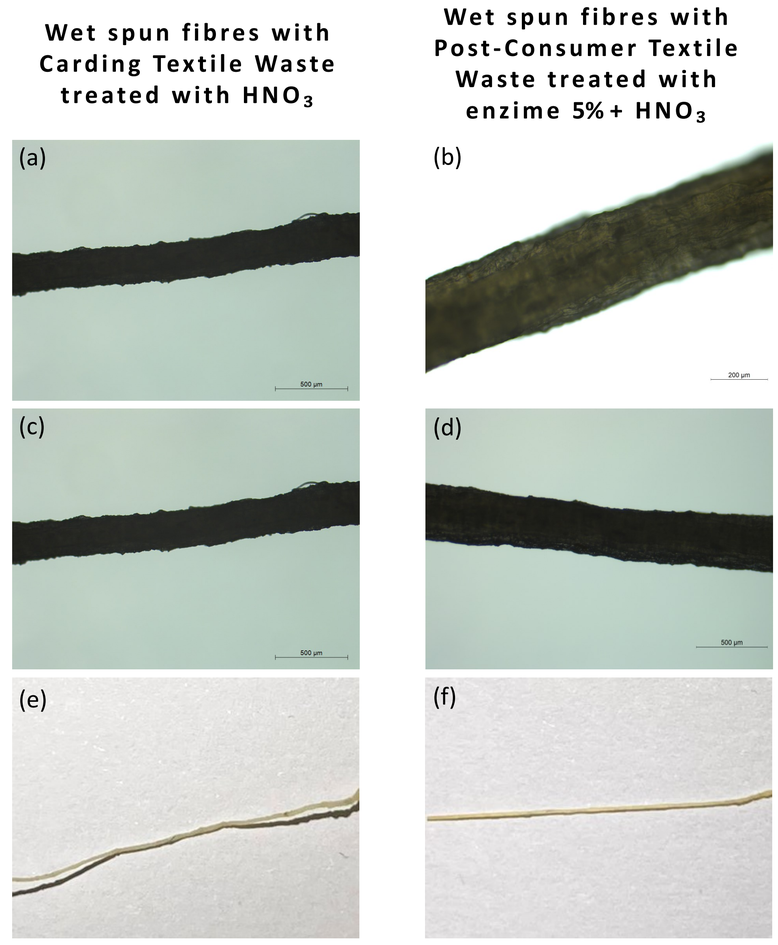


Figure 2 – Microscope images of the wet spun fibres with (a), (c), and (d) 4x, and (b) 10x magnification. Macro images of the wet spun fibres (e) and (f).

- Cellulose treated with HNO_3 presents high crystallinity index (high TCI and high HBI);
- On the contrary, the presence of HNO_3 lowers the degree of polymerization;
- A lower degree of polymerization leads to increased brittleness thus lowering the production of wet spun fibres.

CONCLUSIONS

- The process was optimized. It is now possible to regenerate cellulose in less time, by adding an enzymatic treatment;
- It is possible to produce new products through cellulose regeneration, such as wet spun fibres and cellulose acetate;
- The production of new value-added products needs to be optimized.

ACKNOWLEDGEMENTS

This research was funded by FEDER funds through the Operational Competitiveness Program–COMPETE, under the project POCI-01-0247-FEDER-047124, and by National Funds through Fundação para a Ciência e Tecnologia (FCT), under the project UID/CTM/00264/2020.

Talita Nicolau and Cátia Alves acknowledge FCT, MCTES, FSE and UE PhD grants 2022.15386.BD and 2022.10454.BD, respectively.