Strategies of recovery sample sugar from textile waste in agreement with the circular economy policies

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This paper reviews several strategies used in the processes of pre-treatment and hydrolysis of cotton waste for their reuse as a raw material for new productions. The processes illustrated hereafter have been selected according to either their high yields or their low environmental impact.

Today, the textile industry is one of the most polluting sectors in the world. According to Gupta et al. 2022, manufacturing fashion is the second most polluting industry for agricultural land, which leads to various adverse impacts on the environment after the oil industry (Gupta et al. 2022).

With the advent of fast fashion, the amount of waste produced by the textile industry has been increasing. Most of the purchases which are made in fast fashion stores determine the exploitation of huge amounts of water, raw materials, energy and the production of goods with low quality, intended to a short life before becoming waste (Niinimäki et al. 2020). World textile production almost doubled between 2000 and 2015 (Ellen MacArthur Foundation. 2017) and the consumption of clothing and footwear is expected to increase by 63% by 2030, from 62 million tonnes in 2019 to 102 million tonnes in 2030 (Manshoven et al. 2019). Moreover, approximately 75% of global textile waste is disposed in landfills, 25% is reused or recycled, and less than 1% of all textile is recycled back into clothing (Ellen MacArthur Foundation. 2017). The textile waste landfilled or incinerated causes the production of toxic fumes and solid pollution, including high amounts of microplastics, which are toxic for all ecosystems (Šajn 2019).

In this panorama, several lines of research have been created to transform the linear process model followed by the textile sector into a more circular one, in order to reuse the textile waste and obtain new garments or other high-value-added products (Subramanian et al. 2022, Shirvanimoghaddam et al. 2020).
Most commonly, textile waste is composed of cotton consisting of 90% cellulose, and polyethylene terephthalate (PET). The fabric reuse processes usually require a pre-treatment and hydrolysis of cellulose step to obtain simple sugar, which is a good starting point for many productions (Kaabel et al. 2022; Subramanian et al. 2022).

This work aims to identify the most convenient ways to carry out these two steps at the base of the circularity of the process, placing a strong focus on the yield of the processes and their life cycle assessment (LCA)(Subramanian et al. 2020).

Pre-treatments aim to process cotton with the purpose of obtaining cellulose with higher accessibility for hydrolysis, to increase the hydrophilicity, to remove the surface impurities, and to reduce the structural compactness of textile materials (Kassim et al. n.d.). The yield of pre-treatment influences all the other process steps' yield. This is the reason why studying different initial treatments appears so promising. The nature of pre-treatments can be physical, chemical, or chemical-physical. Physical treatments involve the material chopping to increase the surface area. Chemical treatments instead use various reagents to remove lignin and hemicellulose. Those treatments are often carried out with the use of inorganic acids and bases that determine high yields, but also a high environmental impact. Other ways are therefore preferred, sought such as the use of organic acids (Sahu and Pramanik 2018; Kaabel et al. 2022).

Similarly, the hydrolysis process also appears to be an important step to study, because it is a common passage between a big range of textile waste re-using processes. The hydrolysis may be carried out by enzymes, microorganisms, and inorganic compounds (Subramanian et al. 2022; Lei et al. 2020). As previously seen for the pre-treatment phase, here again, we try to choose the higher yield process with less environmental impact.

The various studies carried out to identify a good process of pre-treatment and hydrolysis of cotton show a very large range of alternatives (Yang and Wyman 2008; Ranjithkumar et al. 2017; Sahu and Pramanik 2018).

The review has not defined a method that is absolutely the best to treat textile waste, but it describes different techniques by evaluating their yield in product formation, the cost of the reagents used, and the environmental impact of the process.

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