Chemical recycling of textile waste by oxidative liquefaction and solvolysis - from waste to sustainable fashion.

The fashion industry contributes significantly to environmental pollution as a result of ever-increasing production. Efforts to develop a more sustainable textile recycling process have become a focus for researchers. In 2018, total global textile production amounted to 105 million metric tonnes, of which up to 64% of the textile fibres produced come from the petrochemical industry. The rest of the fibres, 36%, are split between cotton 24%, cellulosic fibres, 6%, wool 1%, and natural fibres. Current research indicates significant challenges facing both mechanical and chemical recycling (pyrolysis, enzymatic hydrolysis, hydrothermal, ammonolysis, and glycolysis). Only 1% of textile waste, primarily white textiles, is recycled, resulting in low recycling rates. Spinning carded and blended yarn through a mechanical recycling process can transform textile waste into yarn, which can then be re-woven or knitted, according to research. On the other hand, it is difficult to recycle some, especially mixed and multi-component textiles, through chemical methods such as enzymatic hydrolysis.

Given the above and the strategy of a circular economy, environmental regulations and policies, and the long-term viability of a circular economy, it is critical to reduce the amount of this waste while developing a stable strategy for converting tactile waste in the future. Thermal methods of converting textile waste in the context of upcoming climate provisions appear to be inefficient, generating harmful emissions of microplastics, toxins, and greenhouse gases, so there is a need to develop new methods for its disposal.

The project will carry out studies of oxidative liquefaction and liquefaction using low-molecular-weight organic solvent mixtures of textile wastes, including textile wastes containing natural fibres (cotton and flax), fibres of natural origin (viscose, cellulose, and acetic acid esters), synthetic fibres (polyesters, polyamides, nylon, and elastane), and their mixtures. The project involves experimental studies of the liquefaction of various textile waste samples in subcritical water enriched with oxidative additives to improve the quality of the final product. Crucial for oxidative liquefaction is water under elevated pressure and temperature conditions (150–300 °C, 20–30 bar), which, together with the addition of an oxidizer, enables textile fibres to be converted to oxygenated organic compounds such as volatile fatty acids or to lower hydrocarbons. When using low-molecular-weight mixtures of organic solvents for liquefaction, it is crucial to carry out the process under the boiling conditions of the solvents. This process facilitates the degradation of components present in the textiles under study. Under these conditions, the process can obtain monomers and dimers formed by degradation, such as hydrolysis and de-esterification, by carrying out the process up to 200 °C in an inert nitrogen atmosphere with the possible addition of a catalyst.

In parallel, multivariate data analysis using chemometric methods will be implemented to identify recycled products with high market demand suitable for the production of alternative chemicals. All of the experimental research actions will be assessed and optimized environmental point of view using the Life Cycle Assessment (LCA). LCA allows to evaluate environmental burdens and benefits of any product or service, and the proposed project will be used to hopefully distinguish the sustainable method of the chemical recycling of textile waste.