Scale-up of Polycotton Textile Waste Valorization toward EU Innovation Action

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Background

Building on the ongoing TÜBİTAK-1001 project entitled *"Valorization of Polycotton Textile Waste into Thermoformable Packaging Materials by Grafting Lactide onto Cellulose"*, this concept note explores the upscaling of the developed technology toward a Horizon Europe Innovation Action focusing on post-consumer blended textile waste.

Polycotton textiles represent one of the most challenging waste streams in the textile sector due to the intimate blending of polyester (PET) and cellulose fibers, which limits efficient recycling and leads to downcycling or disposal. While significant progress has been made at laboratory and pilot scale within the TÜBİTAK project—particularly in the selective separation of PET and cellulose and the conversion of recovered cellulose into a processable, biodegradable thermoplastic—there remains a clear need to demonstrate these solutions at higher TRLs and within an industrially relevant framework.

The Horizon Europe call on post-consumer blended textile waste provides a clear pathway to advance the technology from TRL 5–6 to TRL 6–7 through large-scale demonstration and industrial validation.

Objective

The overall objective of the proposed EU-scale project is to demonstrate and deploy an integrated, scalable solution for recycling and valorizing post-consumer polycotton textiles, enabling both fiber-to-material recycling and high-value material applications, while ensuring environmental safety and economic feasibility.

Conceptual Approach and Technical Scope

The proposed work builds directly on the validated outcomes of the TÜBİTAK project, shifting the focus from process development to demonstration, optimization, and industrial integration.

Post-consumer textile feedstock management and characterization

Post-consumer polycotton textiles (apparel and home textiles) will be collected and characterized in terms of fiber composition, additives, dyes, and contaminants. This step will support optimized process control and enable traceability across recycling cycles.

Fiber separation and purification

The single-step glycolysis–alkalization approach developed in the TÜBİTAK project will be demonstrated at a larger scale to efficiently depolymerize PET and recover reactive cellulose. The process will be optimized to ensure consistent cellulose quality, minimal degradation, and effective removal of non-textile components and contaminants.

Cellulose functionalization and material development

Recovered cellulose will be functionalized through ring-opening polymerization (ROP) of biodegradable monomers, producing melt-processable materials (e.g., lactide and caprolactone) suitable for compounding. Compared to conventional cellulose recycling routes, this approach enables higher-value applications and improved compatibility with thermoplastic processing.

Demonstration of industrial applications

The functionalized cellulose-based materials will be processed via extrusion and injection molding to demonstrate non-food packaging components (e.g., plastic caps or rigid packaging parts). Processing stability, mechanical performance, and reproducibility will be validated under industrial conditions. These activities build on existing pilot-scale production and industrial injection molding trials established within the TÜBİTAK-1001 project, enabling a realistic transition toward large-scale demonstration.

Recyclability limits and secondary use pathways

The project will assess how many recycling cycles the recovered fibers and materials can undergo without significant loss of performance. When fiber-to-fiber recycling is no longer viable, alternative material applications will be explored to extend material lifetime and value. This will enable the definition of practical recyclability limits and decision criteria for transitioning from fiber-to-fiber recycling to alternative material applications, in line with EU circularity requirements.

Sustainability, SSbD, and LCA/LCC assessment

A full life-cycle perspective will be applied to evaluate environmental and economic performance, including chemical safety, microplastic release, and resource efficiency. The Safe and Sustainable by Design (SSbD) framework will guide material and process choices throughout the project.

Expected Outcomes

Demonstration of a market-relevant recycling route for post-consumer polycotton textiles.

Production of high-quality secondary materials suitable for industrial polymer processing.

Advancement of the technology to TRL 6–7, enabling further commercialization.

Reduced reliance on virgin raw materials and fossil-based plastics.

Clear contribution to the EU circular economy and sustainable textile strategies.

Strategic Relevance

The proposed concept aligns closely with:

EU priorities on circular textiles and waste reduction, fiber-to-fiber and fiber-to-material recycling objectives, the Textiles of the Future partnership, the EU Green Deal, Zero Pollution Action Plan, and Circular Economy framework.

Importantly, it represents a natural continuation and scale-up of the TÜBİTAK-1001 project, translating validated scientific results into demonstrable industrial solutions within a European context.