Thermo-mechanical Recycling of Multi-Component Outdoor Garments for Circular Textile Production

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Abstract

The transition towards circular textile production requires scalable recycling solutions capable of processing today's complex garment compositions. Thermo-mechanical recycling represents an option for closing material loops for synthetics, as it builds on existing polymer processing technologies while enabling material valorisation beyond energy recovery. This study examines suitable methods with which thermo-mechanically recycled textiles can fulfil end-product requirements in textile recycling.
This contribution presents results from thermoplastic recycling trials of outdoor garments. Three common compositions for outdoor trousers are studied: (1) 95 % polyester / 5 % elastane, (2) 60 % polyamide / 30 % polyester / 10% elastane, and (3) 95 % polyamide / 5 % elastane. Moreover, a (4) 100% polyester fabric serves as a point-of-reference. Prior to melt processing, garment pieces are characterised using optical microscopy to analyse textile structures, with the aim of linking structural features to melting and degradation behaviour.

Thermo-mechanical recycling is carried out using a lab-scale compounder, producing granules or monofilaments. Processability, melt stability, and homogeneity are assessed, while the use of different processing additives may be tested to counteract limit degradation and enhance filament spinnability. Granules are examined for injection moulding suitability, and extruded monofilaments are oriented and characterised in terms of e.g., uniformity, tensile properties and surface morphology.

Based on the performance, most promising composition will be further processed at pilot scale on VTT's cylindrical extruder MODIX to assess scalability within a circular production context. MODIX is a unique extruder capable of processing uncompacted and fluffy streams of thermoplastic materials. Demonstration is planned in injection moulded parts and filament-based applications. The recycled materials could potentially be developed further through natural fibre reinforcement or foaming to expand the application potential.
The study identifies key material barriers to circular thermo-mechanical recycling. The study aims to demonstrate that targeted formulation and process optimisation can significantly improve material quality. Overall, the study provides practical insights into how thermo-mechanical recycling may support circular textile production systems for selected material streams.

Keywords: Thermomechanical recycling, circular textiles, outdoor garments, polyester blends, polyamide blends, cylindrical extrusion, melt processing

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