Decolorizing recycled polyester

Evelyn Lempa*[1]

[1]Niederrhein University – Germany

Abstract

Introduction
Fiber-to-fiber recycling of polyester is a key bottleneck in the circular textile economy: polyester accounts for _˜54% of global fiber production (_˜63.3 Mt in 2022), yet textile waste remains largely excluded from high-value recycling. Conventional decolorization relies on water- and energy-intensive reductive or oxidative chemistry, hazardous auxiliaries, and risks fiber degradation. New EU rules diverting bottle-grade rPET from fiber use, plus mandatory textile waste collection from 2025, add urgency to fiber-to-fiber solutions.
This work investigates supercritical carbondioxide (scCO2) as a water-free decolorization route for disperse-dyed polyester. Building on a proof-of-concept for selective dye extraction without aqueous chemistry or fiber damage, we present a systematic multi-parameter study across industrially relevant disperse dyes and dyeing methods. The central novelty is correlating dye molecular properties - chromophore, size, molecular weight, pH stability, fastness type - with scCO2 extraction efficiency for jet- and thermosol-dyed polyester, a structure-performance relationship not yet reported. A two-phase approach first sets optimal parameters on defined substrates, then applies them to post-consumer waste with unknown dye histories.

Materials & Methods
100% PES woven fabric (210 g/m^2) and 100% PES knitted fabric (120 g/m^2) was dyed by jet (130–135∘C, 30–45 min) and pad-thermosol (190∘C/90 s), followed by reductive clearing. scCO2 extraction: 350 bar, 130∘C, 75 min, ethanol co-solvent, CO2 flow 25 mL/min. Decolorization was assessed by colorimetry (Lab*, K/S, ΔE*), laser confocal microscopy, and ISO fastness testing after dyeing, de-dyeing and re-dyeing.

Results & Discussion
Proof-of-concept trials confirm substantial, reproducible color removal without aqueous steps or hazardous chemicals. Ongoing experiments show a clear dependence of extraction efficiency on dye molecular structure, indicating which dye classes suit scCO2 decolorization best. Full results will be presented at the conference.
Conclusion
scCO2 decolorization offers a closed-loop-compatible, water-free pathway for polyester recycling, eliminating aqueous effluent and hazardous auxiliaries. Linking dye structure to process performance, this work provides process intelligence for industrial implementation, supporting EU EPR schemes and the EU Textile Strategy. Conducted within a German-Dutch Interreg VI-A consortium, integrating textile chemistry, process engineering, LCA and industrial demonstration.

*Speaker

Keywords: Recycling, decolorizing, PES, supercritical carbondioxide