Impact of Impurities in the Mechanical Recycling of Mixed Fiber Textiles

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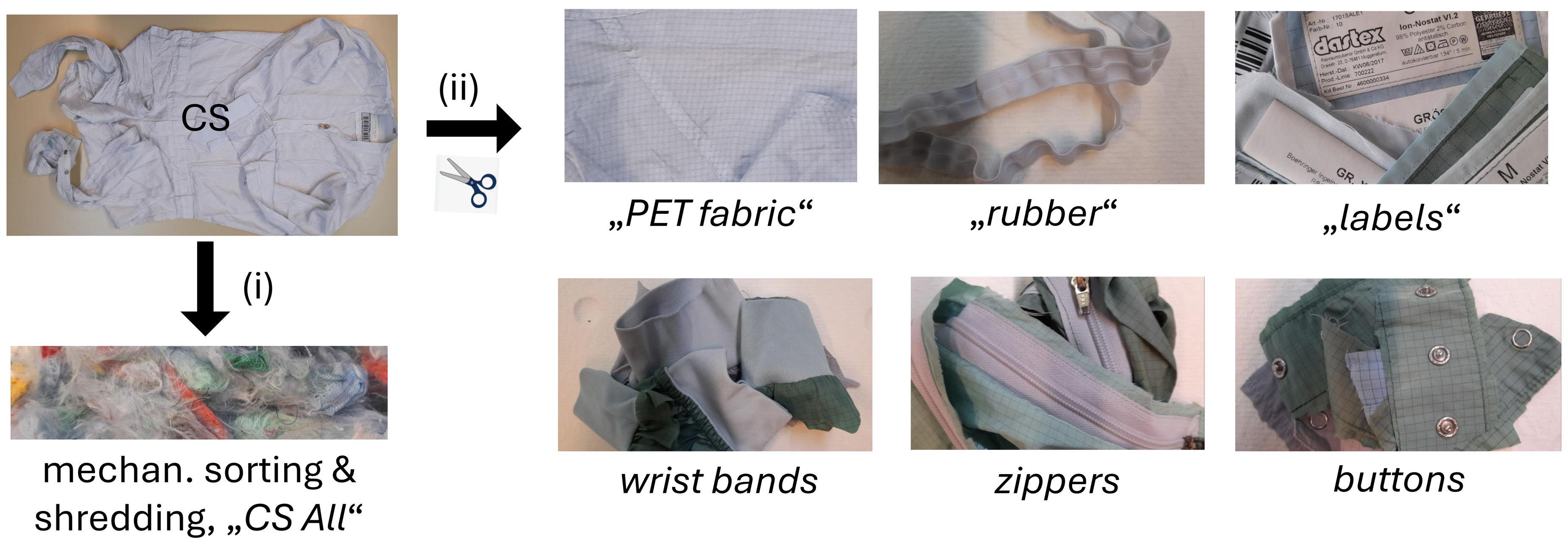
Recycling of Mixed Textiles

Only 0.5% of post-consumer textile waste is recycled and most textile waste ends up in landfills or incineration. Direct thermo-mechanical recycling of mixed textiles, i.e. polycotton, is challenging because of fundamental differences in the structure and constitution of cotton and polyester, which require completely different approaches for their reprocessing. Mechanically separating fibers yields reasonably pure material streams, alas, impurities and contaminants as well as residues from the other fiber type(s) have to be accepted. Specifically, minor elements of apparel (e.g. rubber, labels), are frequently not completely rejected. The aim of this study is to identify potential impurities present in mixed fiber textile apparel and to evaluate their impact onto the mechanical performance of recovered polymers from mechanical recycling.

Model System for identifying Disruptors

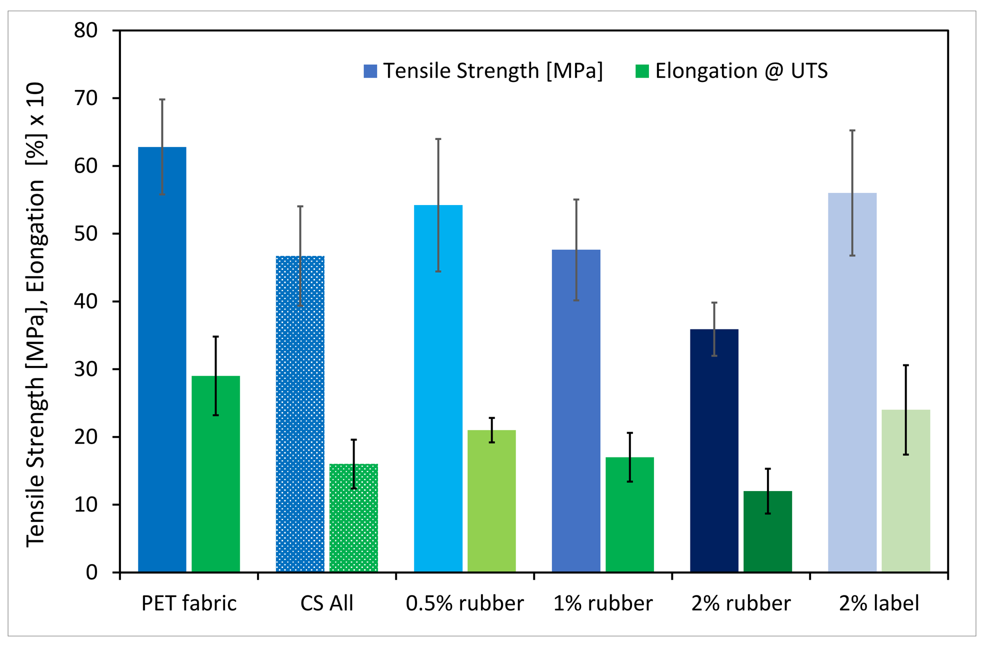
Pure polyester Clean Room Suit (CS).
CS was pre-treated

i. in a mechanical sorting & shredding facility, removing zippers and buttons.
ii. manually cut into the separate fractions (main *PET fabric*, *rubber*, *labels*, etc.) – „*CS All*“.



RESULTS

Mechanical Properties
→ *Tensile Strength / Strain*

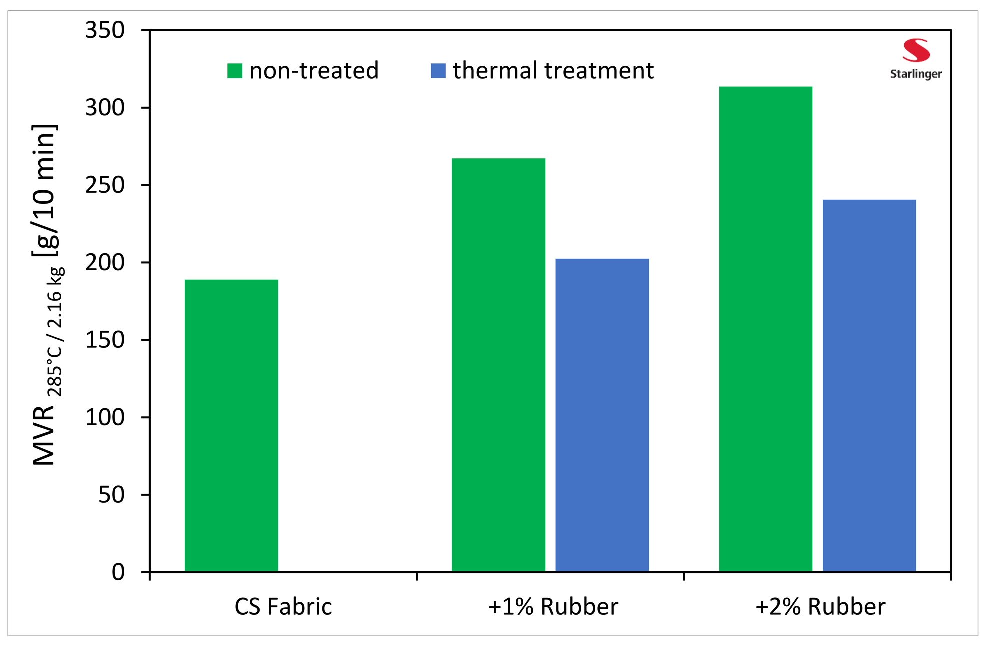


Tensile Strength & Strain

- Pure CS: typical values for PET
- „*CS All*“: significantly reduced
- *Labels*: certain Impact
- *Rubber*: huge Impact
  → 1% ≈ „*CS All*“

→ Degradation of *Rubber* @ 260 °C?

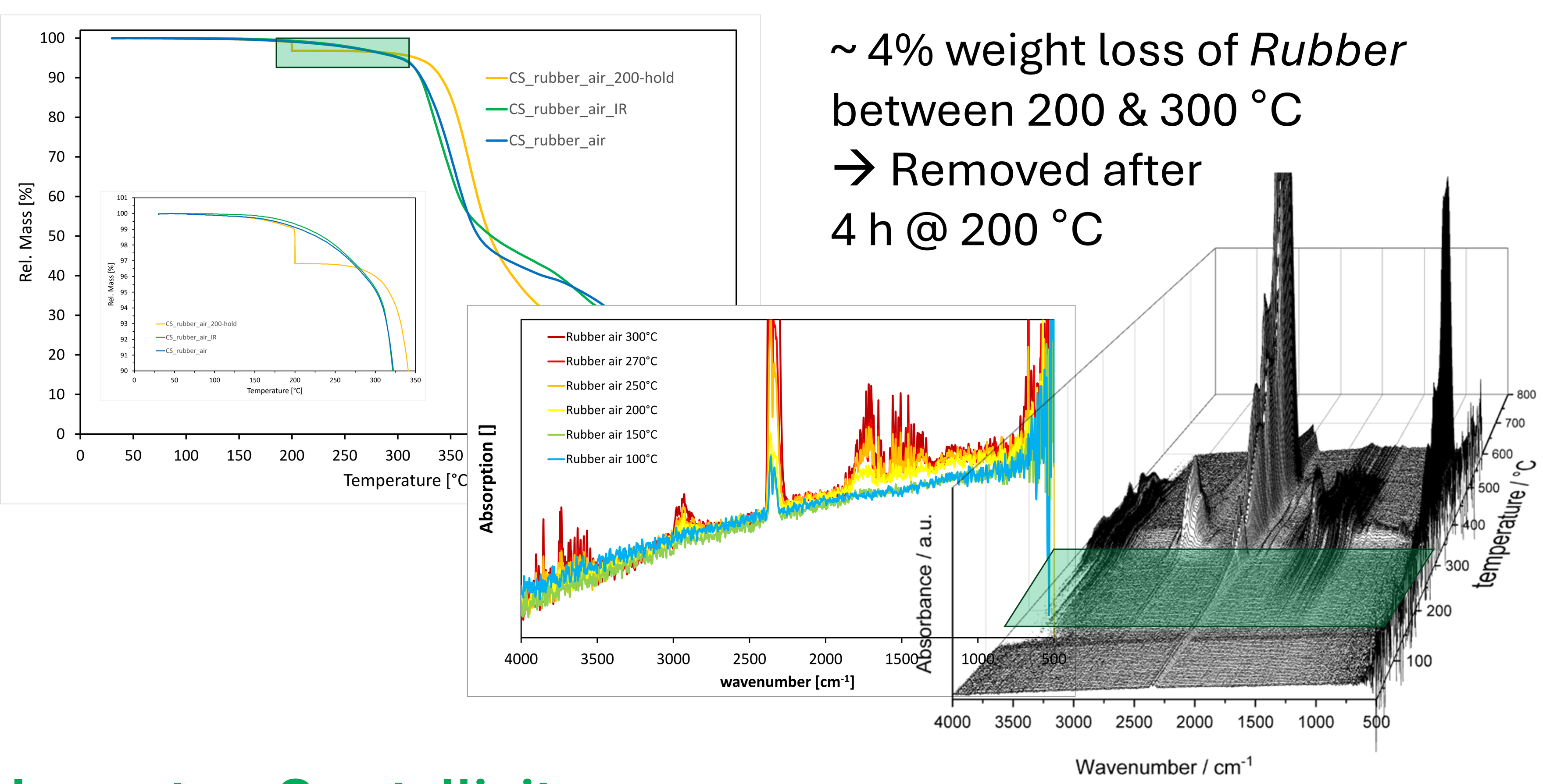
Reduction of *Molecular Weight*
→ *Melt Volume Rate (MVR)*



Increase of *MVR* by ~ 30%

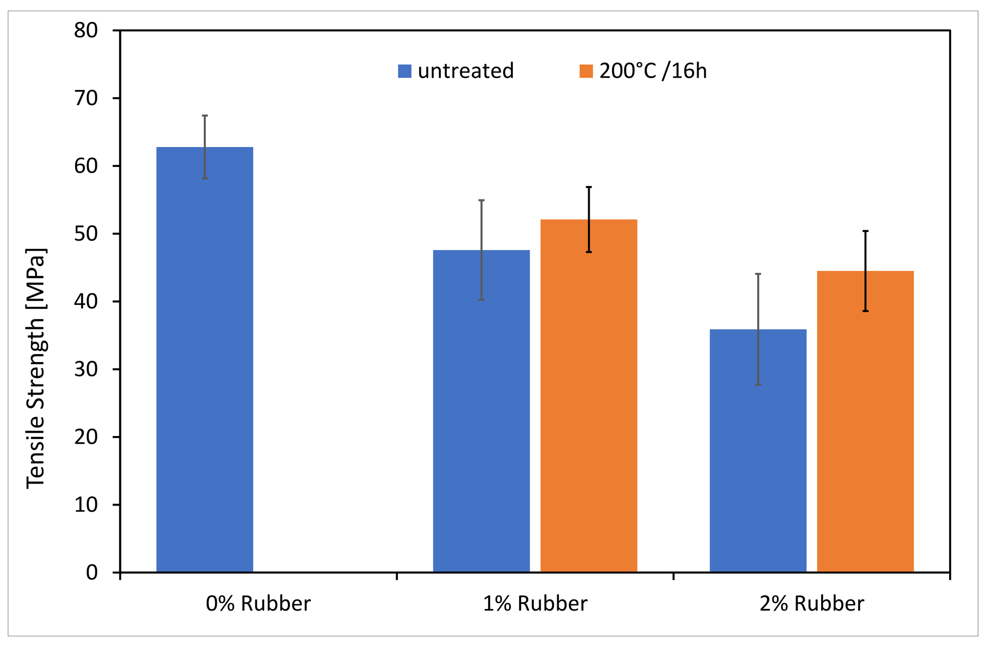
Thermal pre-Treatment of *Rubber*: 16 h @ 200 °C → MVR recovered

Degradation Products of Rubber @ Processing
→ *Thermogravimetry / IR-spectrosopy*



~ 4% weight loss of *Rubber* between 200 & 300 °C
→ Removed after 4 h @ 200 °C

Rubber Pre-Treatment 16 h at 200 °C
→ *Mechanical Strength*?

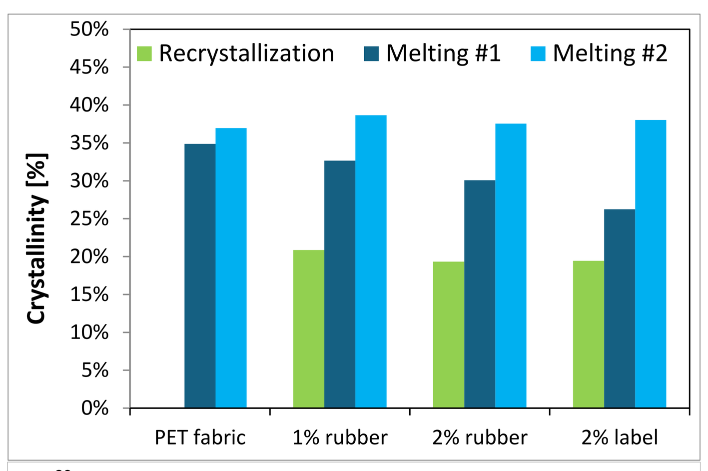


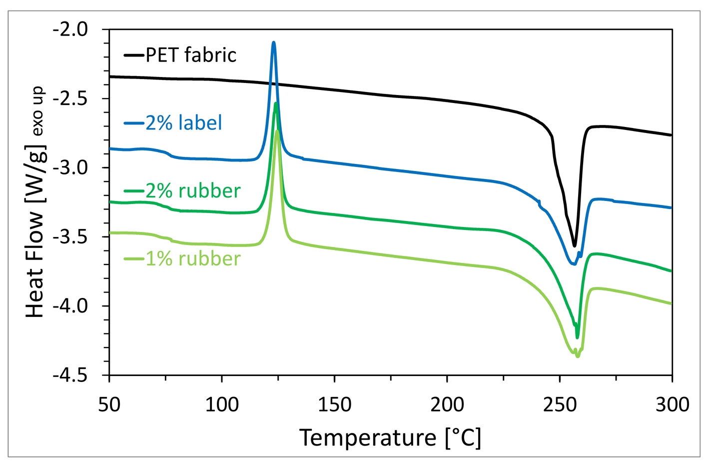
Only slight improvement by pre-Treatment

→ other effects?

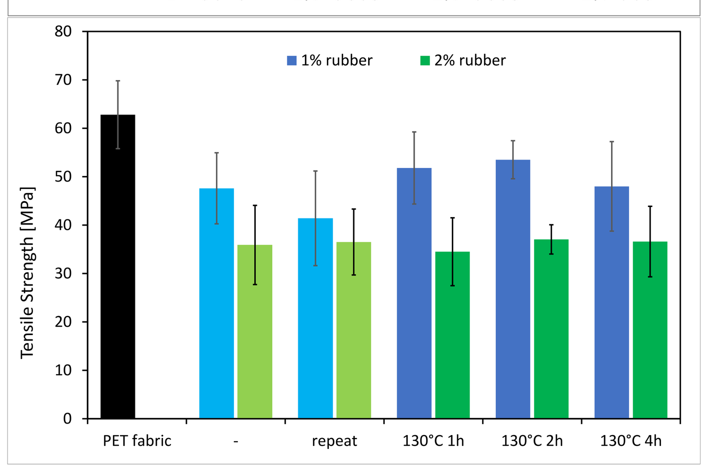
Impact on Crystallinity
→ *DSC*

CS: no Recrystallization
Disruptors: significant Recrystallization
→ Impact on Crystallization Behaviour
→ post-Treatment @ 130 °C





Slight im-provement by post-Treatment



Conclusions

- *Labels*: limited influence on mechanical properties
- *Rubber*: strong impact already <1%
- Degradation of M_W caused by the presence of *Rubber*
- Hypothesis: degradation products of *Rubber* @ processing temperature are the real problem
- Removal of degradation products prior to processing
- Influence onto the crystallization behaviour, too

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