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Recovery of post-consumer textile waste garments from a new and environmentally-friendly approach: method and properties

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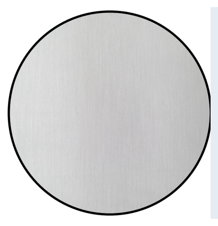
PROBLEM ENCOUNTERED

- Necessity of the recovery of post-consumer textile waste, from an economic and environmental point of view.

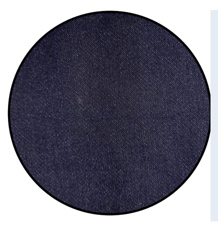
PROPOSED SOLUTION

- Development of a viable strategy to reduce the environmental impact of the textile industry;
- Selective removal of polyester from post-consumer polyester (PET), cotton (CO), and elastane (EL) waste garments, using alkali solutions with different cosolvents at distint temperatures, allowing an efficient recovery of the CO fibers to be reincorporated into the industry.

MATERIALS AND METHODS

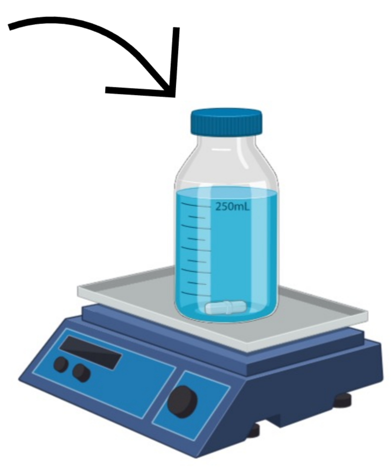


PCS
PET/CO/EL: 75/23/2



SQUASH
CO/PET/EL: 84/14/2

Fabric: 5 g uncut

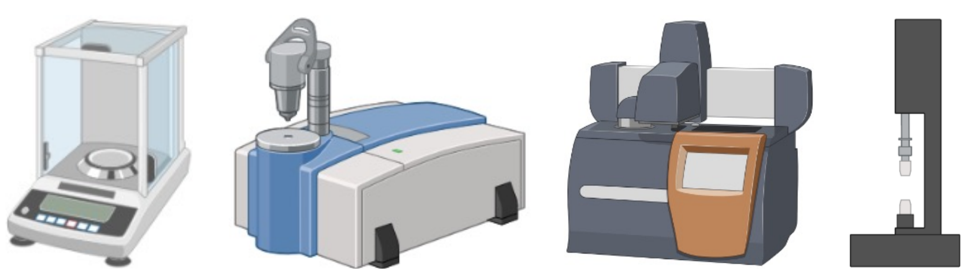


System
i) NaOH 2M: DMSO 1:1
ii) NaOH 3M: isopropanol 1:1

Temperature
a) 50 °C, 24h
b) 70 °C, 24h

Bath Ratio textile: solvent = 1:50 (g/mL)

CHARACTERIZATIONS

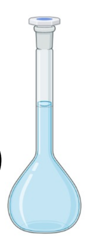


Yield, composition, thermal and tensile properties

PET REMOVAL EFFICIENCY

Recovered fabric → Recovered PET

Dissolution of CO + EL



H_2SO_4 75% (v/v)

23 ± 2 °C, 2h
Bath Ratio = 0.1/10 (g/mL)

Table 1. Results and conditions used for the PET removal process

Fabric	System	T (°C)	% PET before system	% PET after system	% Removal Efficiency
PCS	i)	a)	75	1.15	98.47
	ii)			51.30	31.60
	i)	b)		0.00	100.00
	ii)			0.00	100.00
SQUASH	i)	a)	14	5.97	57.32
	ii)			13.18	5.85
	i)	b)		0.00	100.00
	ii)			0.00	100.00

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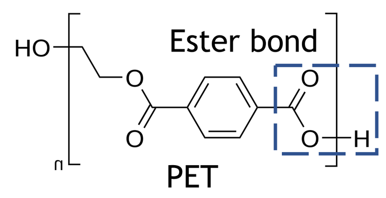
RECOVERED FABRIC COMPOSITION: FTIR-ATR SPECTROSCOPY



Disappearance of the C=O stretching signal at 1713 cm^{-1}, characteristic of the PET fiber

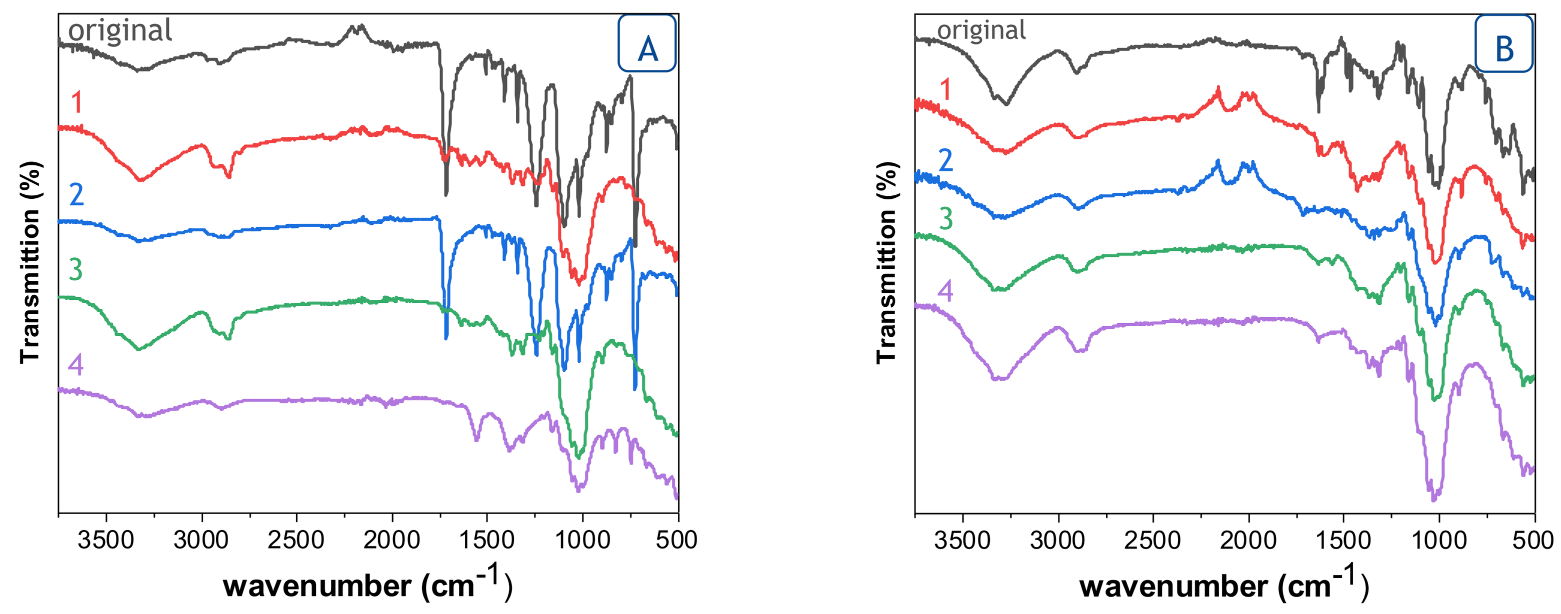
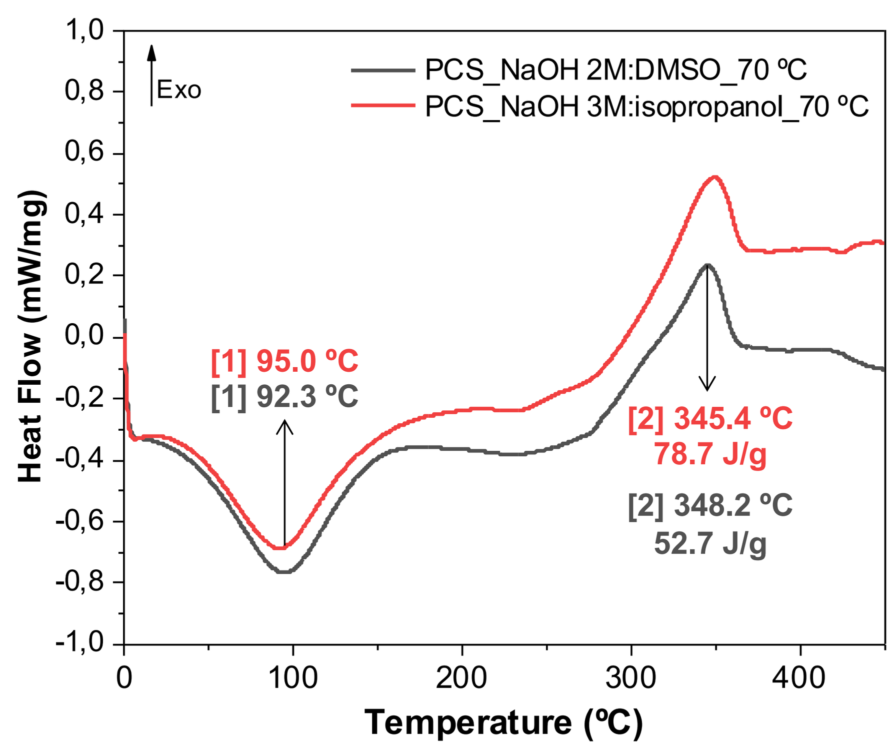
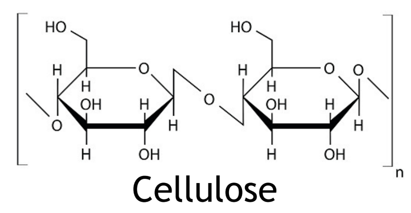


Figure 1. FTIR analysis of recovered samples: (A) PCS and (B) SQUASH, using (1) NaOH 2M:DMSO, 50 °C; (2) NaOH 2M:isopropanol, 50 °C; (3) NaOH 2M:DMSO, 70 °C; (4) NaOH 3M:isopropanol, 70 °C.

THERMAL PROPERTIES: DIFFERENTIAL SCANNING CALORIMETRY



Test conditions: heating rate 10 °C/min



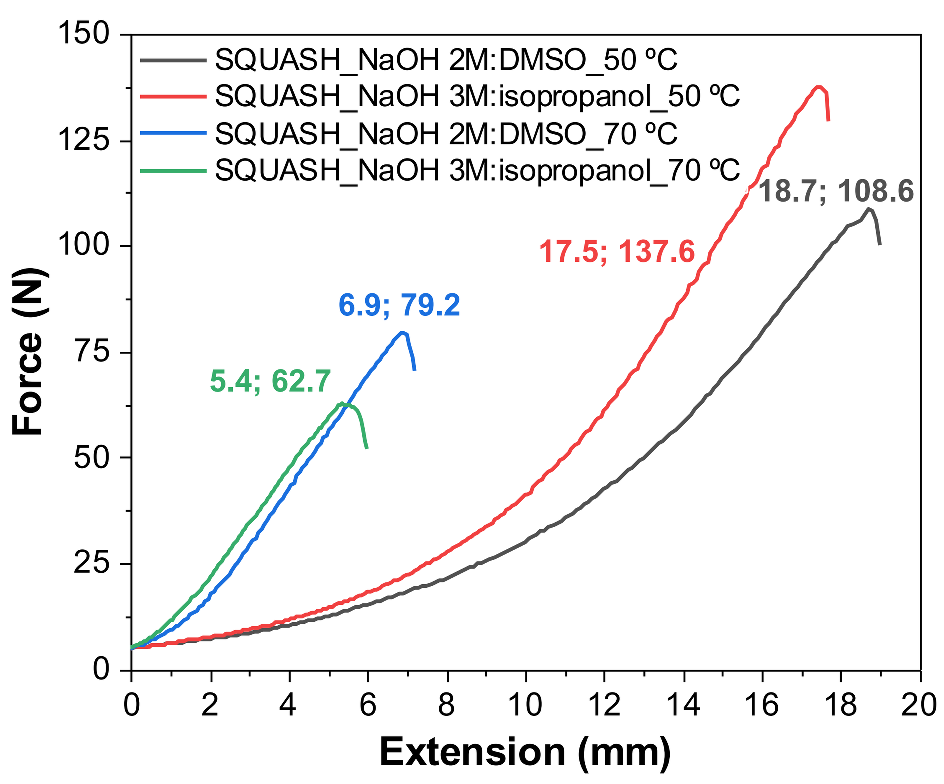
Cellulose

[1]: Evaporation of water and volatilization of low molecular weight compounds (such as residual solvents)

[2]: Decomposition of cellulose polymeric chains

Figure 2. DSC analysis of recovered PCS samples using DMSO and isopropanol cosolvents at 70 °C.

TENSILE PROPERTIES: DYNAMOMETER



Test conditions followed the standard ASTM D5035. Specimens 7.5 cm long and 1.5 cm wide were cut from the fabric and were tested in the weft direction. The gauge length was established at 6 cm. The crosshead speed was 100 mm/min and the selected load cell was 250 N, used with a pre-load of 5 N. Experiments were performed at 23 ± 2 °C.

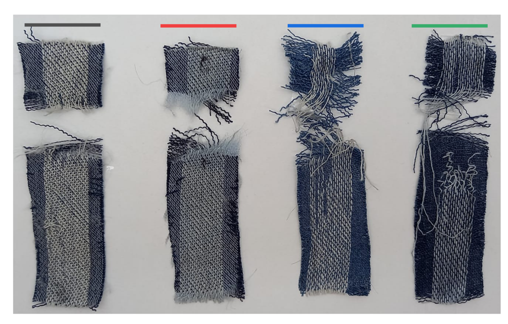


Figure 3. Tensile properties of SQUASH samples and respective specimens.

- SQUASH fabrics subjected to alkali solutions at 70 °C lost all the PET fibers resulting in lower break strength and extension at break values, than those at 50 °C;
- Use of NaOH 3M: isopropanol 1:1 at 50 °C was inefficient in removing the PET fibers resulting in higher break strength and lower extension values, than the use of NaOH 2M: DMSO 1:1 at 50 °C.

CONCLUSIONS

The results prove that environmentally-friendly approaches can be successfully used in post-consumer textile waste, allowing the **removal of PET** in high yields and **recovery of CO** with good properties.