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RECYCLING OF WASTE ACRYLIC TEXTILES

D2.4: Report on Red-Ox removal – Executive summary

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Abstract	One of the challenges of the REACT project is the removal of chemical finishes from waste acrylic textiles. Three types of waste acrylic textiles were examined: fabrics finished for awnings, coated fabrics and fabrics finished for furnishings. Several effective

	removal processes were developed for the removal of specific or all finishing components, at laboratory scale.
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** R: Document, report (excluding the periodic and final reports)*

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

OTHER: Software, technical diagram, etc

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PU	Public, fully open, e.g. web	✓
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EXECUTIVE SUMMARY

Introduction

Every year, within Europe, 7700 tonnes of acrylic textiles are disposed of by landfill or incineration. Recycling this waste would conserve over 8 times the energy regained from incineration [1]. In addition, acrylic fibres are predominantly solution spun using toxic and carcinogenic solvents such as dimethyl formamide, so mechanically recycling these fibres would avoid the need for re-extrusion using these solvents, thus providing a benefit to health.

Currently, acrylic fabrics for outdoor use are not recycled. One crucial reason for this is the presence of finishing chemicals on the fibre substrate, which complicate the recycling process and remain in the recycled product, thus limiting its application potential and remaining a health risk. One of the main challenges of the REACT project is the removal of these chemical finishes from waste acrylic textiles.

Three types of waste acrylic textiles were examined: fabrics finished for awnings, coated fabrics and fabrics finished for furnishings. These finishes contain a total of four significant finishing components: thermosetting resin, fluorocarbon resin, resin for waterproof properties and softeners. Different strategies for the removal of these finishes at laboratory scale were followed within the REACT project: chemical removal (Task 2.1) and red-ox removal (Task 2.2). The work performed within the scope of these two tasks was strongly linked and all results were obtained via an intensive collaboration between the partners. Therefore, the executive summaries are identical for these two tasks and thus deliverables D2.2 and D2.4.

Materials and methods

The acrylic fabrics used for this research were industrial waste and post-consumer samples, upon which three finishes were identified: an awning finish (containing a thermosetting resin and a fluorocarbon resin), a coating (containing the awning finish underneath a thicker resin for waterproof properties) and a furnishing finish (containing a fluorocarbon resin and softeners).

Various single step and sequential processes were used to treat these fabrics and their finish removal effectiveness was evaluated. The processes include acid and alkaline hydrolysis, reduction and oxidation treatments, washing and UV irradiation treatments. The hydrolysis, redox and washing treatments were performed at lab scale in aqueous baths with control of temperature, treatment time, stirring speed and solid-to-liquid ratio.

The results of the finish removal treatments were evaluated by Fourier-transform infrared spectroscopy via attenuated total reflection (FTIR-ATR), by judging the change in intensity of the peaks characteristic to unique bonds in the finishing components. Additionally, fluorocarbon resin removal was evaluated by the standardised oil-repellency test *AATCC 118-2013* and via liquid chromatography coupled with mass spectroscopy (LC-MS).

After the removal treatments, mechanical tests were carried out to investigate whether physical damage was done to the acrylic fibres during these treatments, using the *Textechno FAVIMAT*, a single-fibre tensile bench that works according to the principle of constant rate of extension.

The decolourisation experiments were performed on unfinished fabrics and fabrics finished for awnings. The different processes used for decolourisation were swelling, oxidation and dissolution. The decolourisation effectiveness was evaluated via UV-Vis spectroscopy, by comparing the reflectance spectra prior to the treatment and after the treatment with the spectrum of an uncoloured sample.

Results

Several **effective removal processes** were developed **for the removal of specific or all finishing** components, at laboratory scale:

- Pure acid hydrolysis is capable of removing all thermosetting resin and is mostly harmless to the mechanical properties of the acrylic fibres (**focus of deliverable D2.2 and D2.3**).
- A sequential treatment consisting of acid and alkaline hydrolysis, a UV treatment and a washing step is capable of entirely removing all finishing components (**focus of deliverable D2.4 and**

D2.5). The ultraviolet irradiation, however, has a negative impact on the mechanical properties of the acrylic fibres, and may be less straightforward to perform industrially.

- Sequential treatments consisting of a combination of alkaline and acid hydrolysis performed at varying temperatures resulted in a sufficient or complete removal of all finishing components (**focus of deliverable D2.4 and D2.5**). The mechanical testing results show that the removal processes as such do not damage the mechanical properties of the fibres.

These removal processes were very promising at laboratory scale and were very useful for the investigation of the removal processes on pre-industrial scale. The laboratory scale tests allowed to choose the best conditions for scale-up without introducing processes that are difficult to carry out on an industrial scale.

Additionally, several other removal processes were evaluated but did not show to be effective for the removal of the finishing components: single step alkaline hydrolysis (**focus of deliverable D2.2 and D2.3**), alkaline hydrolysis combined with an oxidative treatment (**focus of deliverable D2.2 and D2.3**) and redox treatments (**focus of deliverable D2.4 and D2.5**).

Several **effective removal processes** were evaluated on **post-consumer (PC) fabrics** for the removal of specific or all finishing components, at laboratory scale (**focus of deliverable D2.4 and D2.5**):

- Sequential treatments consisting of acid hydrolysis, alkaline hydrolysis and washing (whether or not combined with a UV treatment), resulted in the total removal of finishing from postconsumer fabrics, although changes in the chemical structure of acrylic fibres (in particular for post-consumer awning fabrics) were observed due to the long-lasting exposure to sunlight.
- Singular acid hydrolysis was proven efficient for the removal of finishing only from the post-consumer awning fabrics.

Intensive testing and analysis has been performed to **decolourise** the acrylic fabrics, ranging from swelling over oxidation to complete dissolution of the fibres to remove the pigments (**focus of deliverable D2.2 and D2.3**). Although interesting results were obtained, a sound solution was not found. This was, however, not one of the main goals of the REACT project, since the fibres can still be used for mechanical recycling.

Conclusion

Several effective removal treatments were developed resulting in a **sufficient, more than 90%, or complete removal of all finishing components**. These removal treatments were demonstrated to be **very promising at laboratory scale** and were very useful for the investigation of the removal processes **on pre-industrial scale**. This will enable subsequent recycling of the fibre substrate.

References

[1] Muthu, S. S., Li, Y., Hu, J. & Mok, T. P. Y. (2012). Recyclability Potential Index (RPI): The concept and quantification of RPI for textile fibres. Ecological Indicators, 18, 58-62.