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REMOVAL OF HAZARDOUS FINISHES TO ENABLE MECHANICAL RECYCLING OF WASTE ACRYLIC FABRICS

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ABSTRACT

For ecological, economic, and health reasons, it is important to mechanically recycle waste acrylic fabrics originating from outdoor applications. These are not currently recycled due to the presence of harmful finishes on the waste fabrics, that interfere with the recycling process, reduce the quality of the recycled product, and pose health risks.

Through a combination of washing with a detergent, acid/alkaline hydrolysis and UV irradiation treatments, all of the finishing chemicals on waste, outdoor acrylic fabrics can be removed by at least 90%, thus enabling the mechanical recycling process.

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. These include hazardous formaldehyde- and fluorine-containing resins, which complicate the recycling process and remain in the recycled product, thus limiting its application potential and remaining a health risk. It is clear that these finishes must be removed at the start of the recycling process, which is one of the goals of the European REACT (Recycling of Waste Acrylic Textiles) project.

MATERIALS AND METHODS

The acrylic fabrics that were used for this research were industrial waste samples provided by Parà SpA (Viale Monza 1, Sovico, Italy). Three finishes were identified: an awning finish (containing a formaldehyde resin and a fluorocarbon resin), a coating (containing the awning finish underneath a thicker acrylic resin coating) and a furnishing finish (containing a fluorocarbon resin and softeners).

A combination of sequential processes was used to treat these fabrics. The investigated processes include washing with a detergent, acid and alkaline hydrolysis, and ultraviolet light (UV) irradiation. All chemicals used in these processes were provided by Soft Chemicals SRL (Via 11 Settembre, Marnate, Italy). The washing and hydrolysis treatments were performed in aqueous baths with control of temperature, treatment time, stirring speed and solid-to-liquid ratio. The radiation treatment was

performed with UV generating lamps.
The results of the finish removal treatments were evaluated by Fourier-transformed infrared spectroscopy via attenuated total reflection (FTIR-ATR) and fluorocarbon resin removal was also evaluated by the standardised oil-repellency test AATCC 118-2013.

RESULTS AND DISCUSSSION

The first investigated finish removal process was a single-step acid hydrolysis. After optimising this process for formaldehyde resin removal from awning fabrics, FTIR-ATR revealed that more than 90% of the formaldehyde resin was removed. As a cheap, easy process, this was very promising, though it was only partially able to remove fluorocarbon resins and softeners, and was not able to penetrate the acrylic coating in the coated fabrics; see Table 1. No statistically significant mechanical damage was caused to the fibres by this hydrolysis.
To improve the treatment, alkaline hydrolysis and detergent washing processes were added. The order of the three processes was optimised, resulting in a finish removal treatment capable of partially removing all components of the coating, in addition to improving the formaldehyde resin and softener removal in the non-coated fabrics; see Table 1.
To finally increase the removal of the fluorocarbon resins, UV radiation treatments were performed after the previous sequential treatments. The optimal process then yielded an above 90% or even complete removal of all the finishing components; see Table 1. This was confirmed by the oil-repellency test, with the fabric no longer displaying any oleophobic behaviour.

Table 1. Finish removal percentages as evaluated by FTIR-ATR, on each identified waste fabric type.

		Formaldehyde resin removal (%)	Fluorocarbon resin removal (%)	Acrylic resin removal (%)	Softener removal (%)
ACID HYDROLYSIS	Awning fabric	> 90	50 - 80	-	-
	Coated fabric	< 30	< 30	< 30	-
	Furnishing fabric	-	50 - 80	-	50 - 80
WASHING + ACID/ALKALINE HYDROLYSIS	Awning fabric	~ 100	50 - 80	-	-
	Coated fabric	50 - 80	50 - 80	50 - 80	-
	Furnishing fabric	-	50 - 80	-	~ 100
WASHING + ACID/ALKALINE HYDROLYSIS + UV RADIATION	Awning fabric	~ 100	> 90	-	-
	Coated fabric	~ 100	~ 100	~ 100	-
	Furnishing fabric	-	> 90	-	~ 100

CONCLUSION

A combination of sequential treatments, including washing with a detergent, acid and alkaline hydrolysis, and UV irradiation was developed and optimised, capable of removing more than 90% of all the chemical components present in waste acrylic fabrics from outdoor applications. While further alternatives are being researched, these proposed laboratory-scale processes are ready for scale-up and will enable subsequent recycling of the fibre substrate.

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