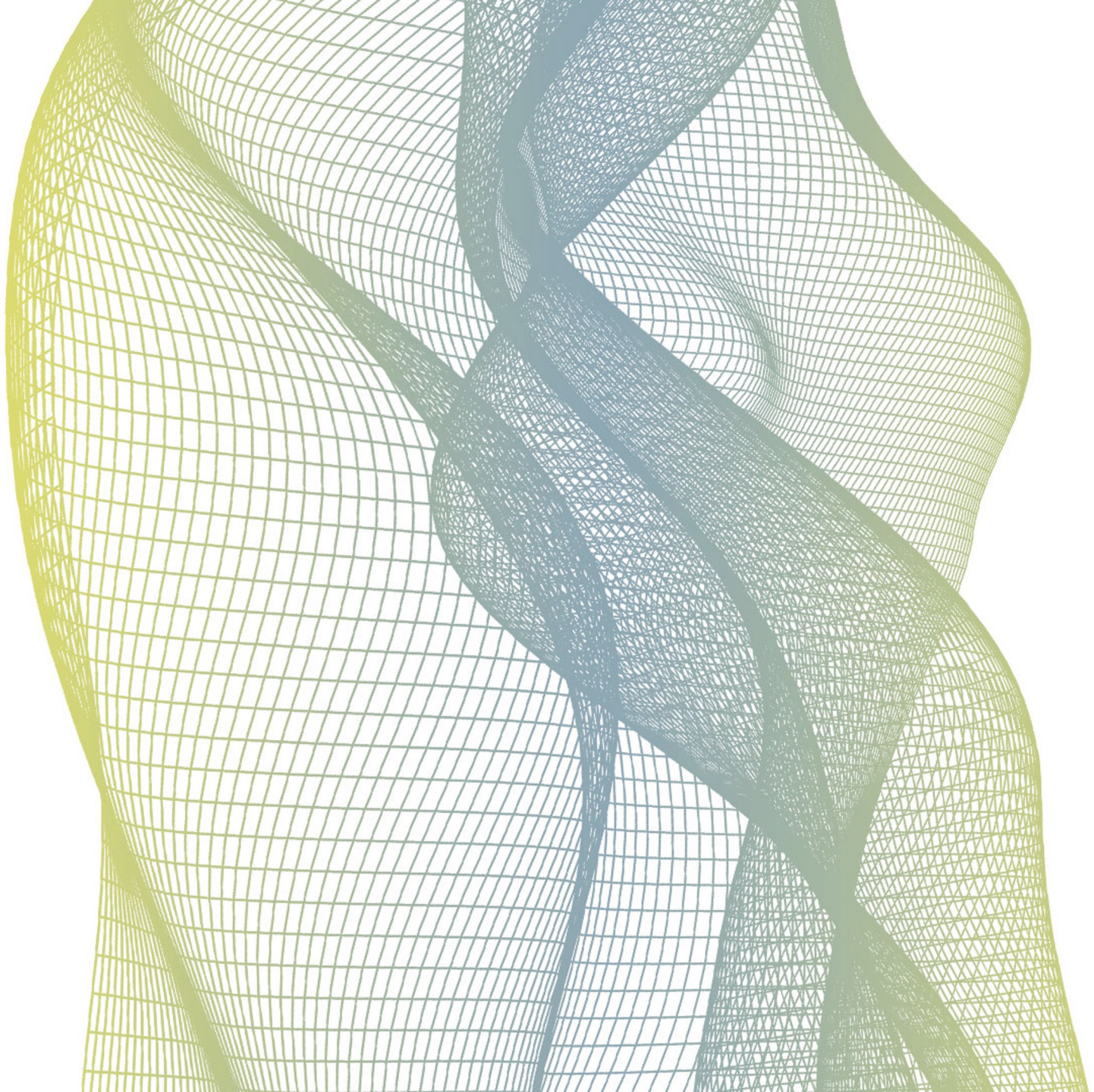

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REACT

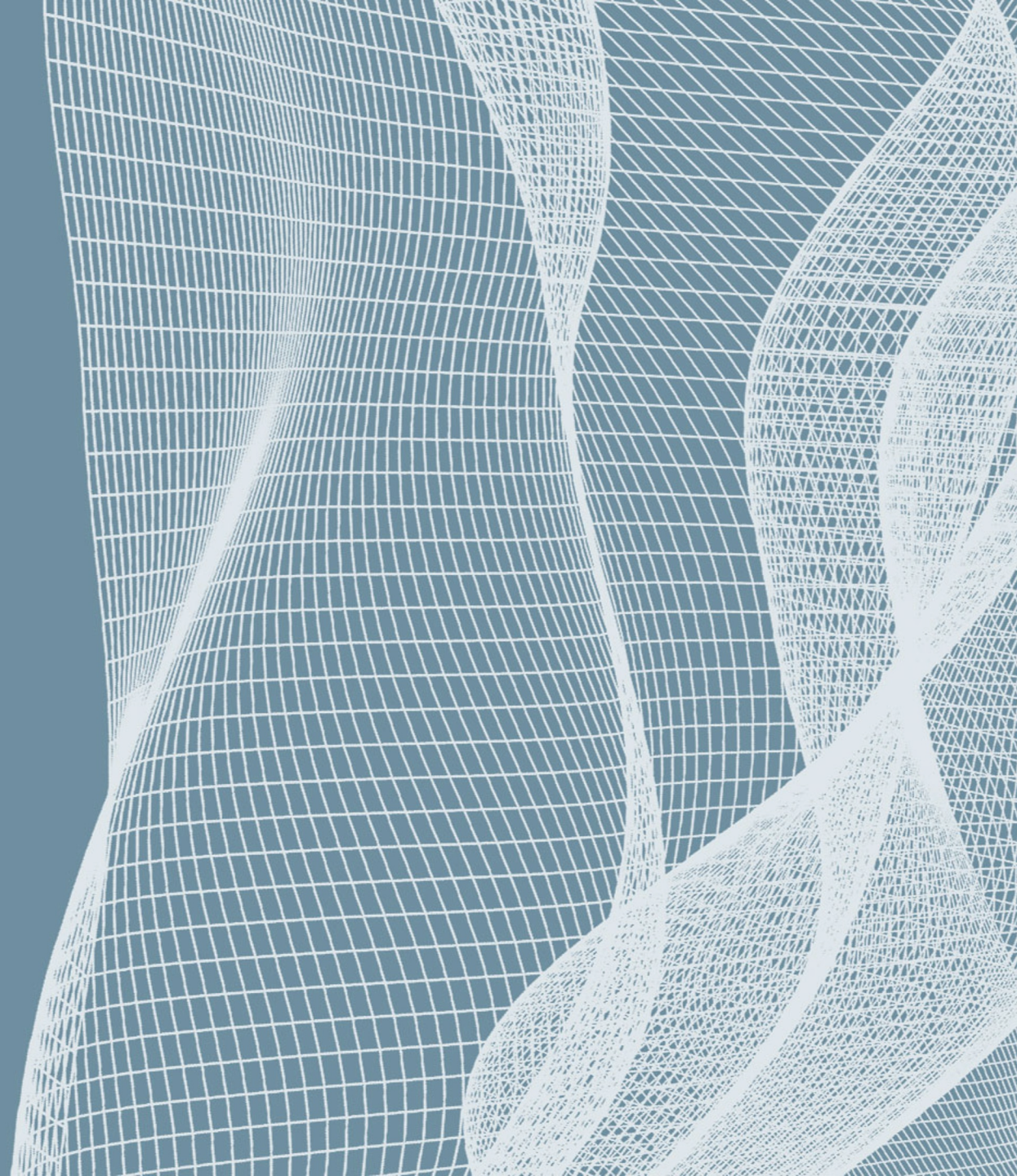
REMOVING HARMFUL FINISHES TO RECYCLE WASTE ACRYLIC TEXTILES

Brecht Tomme

Valentina Trovato, Jozefien Geltmeyer, Giuseppe Rosace, Daniele Piga, Barbara Ferrari, Andrea Cataldi, Steven De Meester, Karen De Clerck

The Fiber Society 2022 Spring Conference, 01/06/2022

THE REACT PROJECT



THE REACT PROJECT

- Horizon 2020 project (European Commission)
- 7 partners from 4 European countries

CENTROCOT Innovation experience

CETI CENTRE EUROPÉEN DES TEXTILES INNOVANTS

TEMPOTEST ITALIAN PERFORMANCE FABRICS

GHENT UNIVERSITY

soft chemicals

Ják Spinning

MARTEL innovate

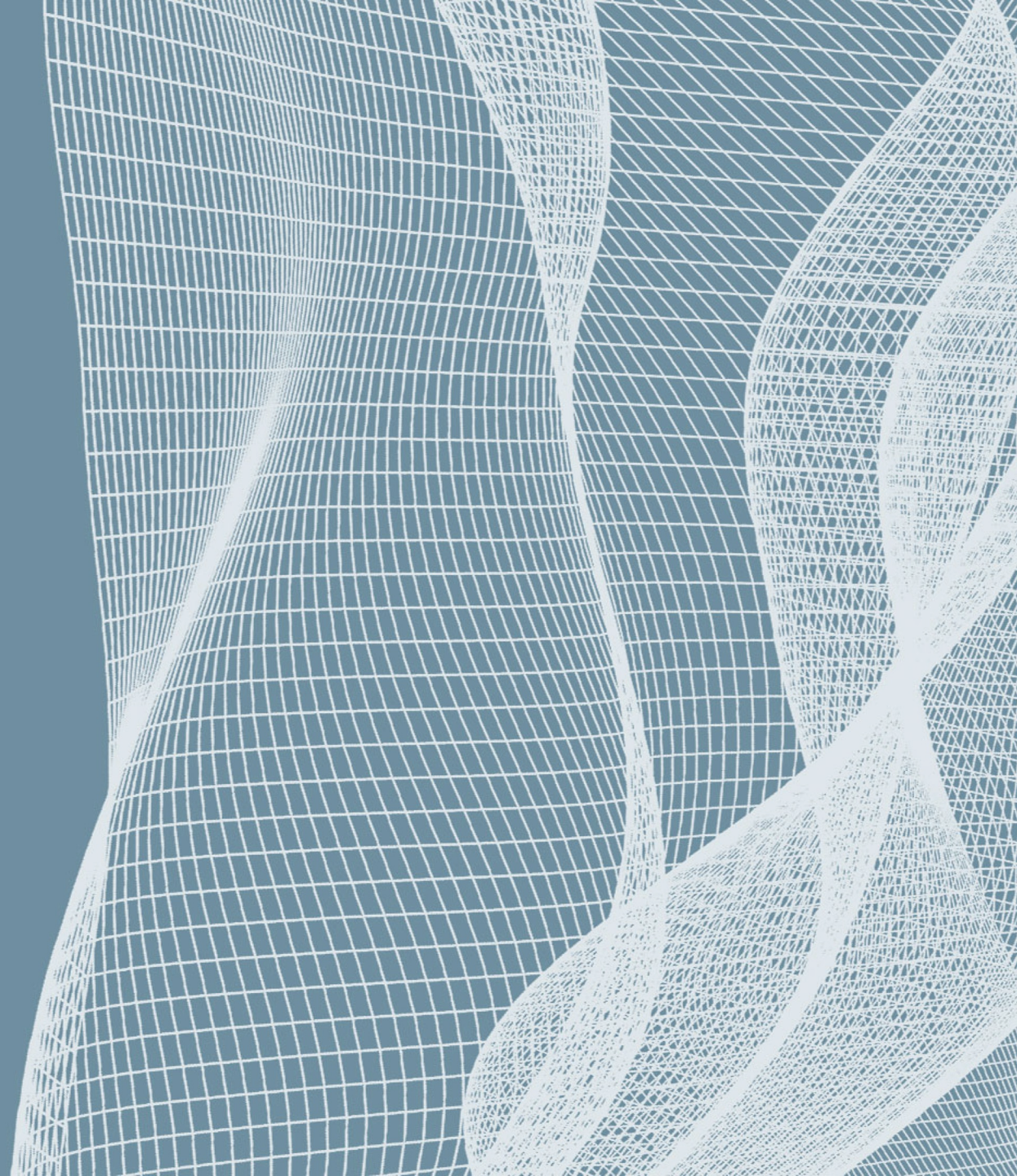
- REcycling of waste ACrylic Textiles
  - Mechanical recycling down to the fibre level

@project_react

company/react-project

WWW.REACT-PROJECT.NET

ACRYLIC FIBRES



ACRYLIC FIBRE APPLICATIONS

- Relatively small but not unimportant market
  - Production: 2 million tonnes per year (total synthetic fibres: 50 million tonnes) [1]
  - Market of €5 billion predicted by 2026 [2]
- Applications [3]
  - 75% apparel
  - 20% home furnishings
  - 5% industrial end uses

[1] M. Yang Qin, "Global fibres overview", Pattaya, May 2014.
[2] Future Market Insights, "Acrylic fibre market: Global industry analysis and opportunity assessment", Oct 2013.
[3] M. Niaounakis, Management of marine plastic debris. Amsterdam: Elsevier, 2017, pp. 1-55.

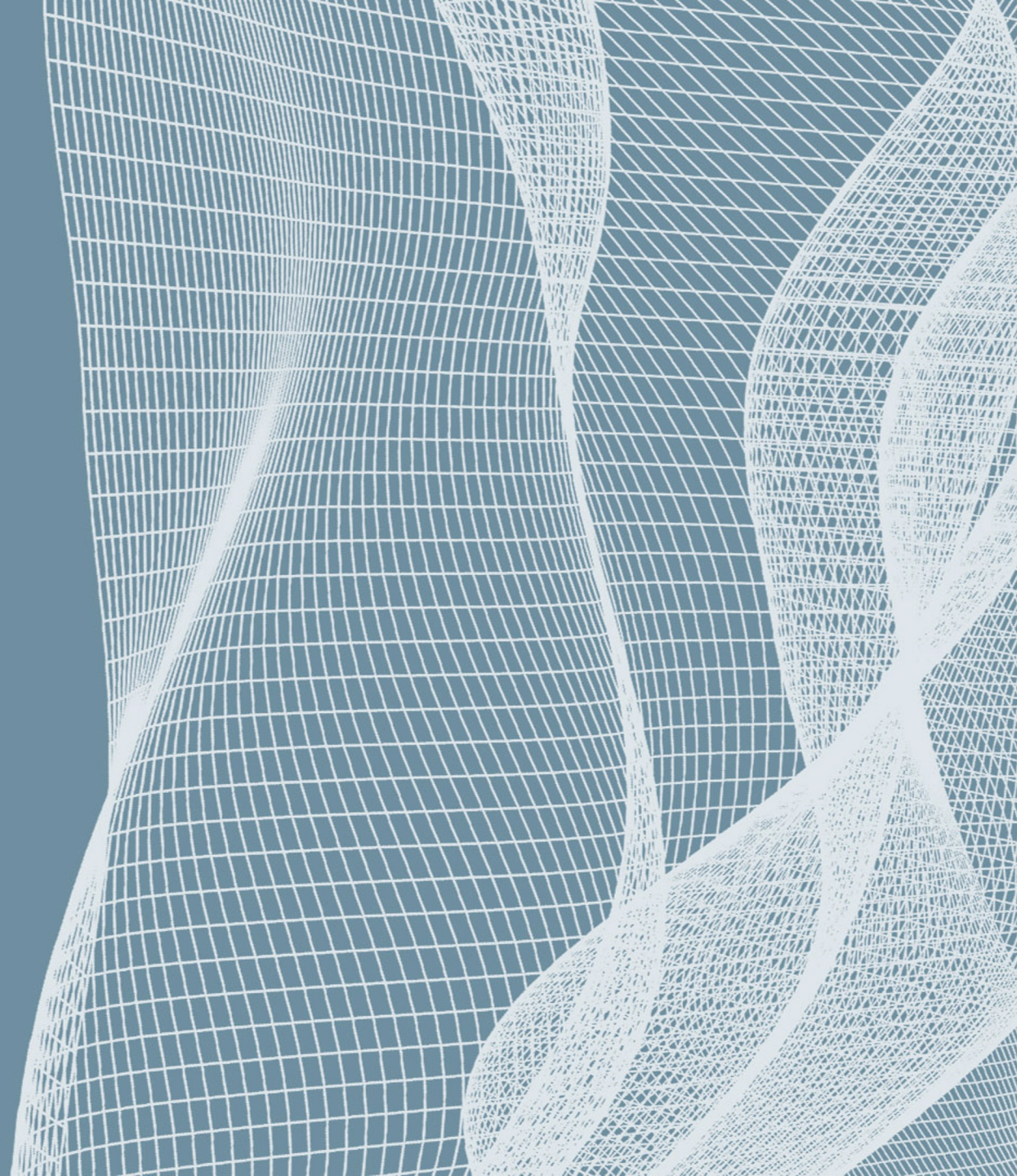
RECYCLING WASTE ACRYLIC TEXTILES

- Are the fibres worth recycling?
  - Energy yield/savings per kg is predicted to be 19.4 MJ vs. 2.4 MJ for incineration [4]
  - Acrylic fibres have the 4th highest Recycling Potential Index (after PET, PP, PE) [4]
- Mechanical recycling is ideal to avoid re-extrusion of the fibres
  - Solution spun using toxic and carcinogenic solvents such as DMF and DMAc

- Why does recycling not occur?
  - Finishes and coatings on the fabrics cause complications during the recycling process and reduce the quality of the recycled product

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

FINISH REMOVAL



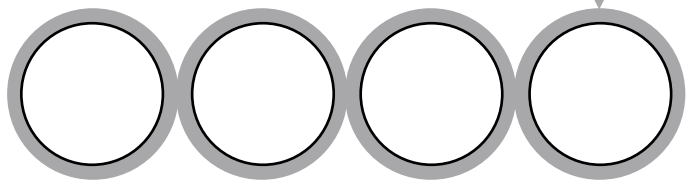
IDENTIFICATION OF FINISHES & COATINGS

1. Awning finish
2. Coating
3. Furnishing finish

IDENTIFIED CHEMICAL FINISHING COMPOUNDS

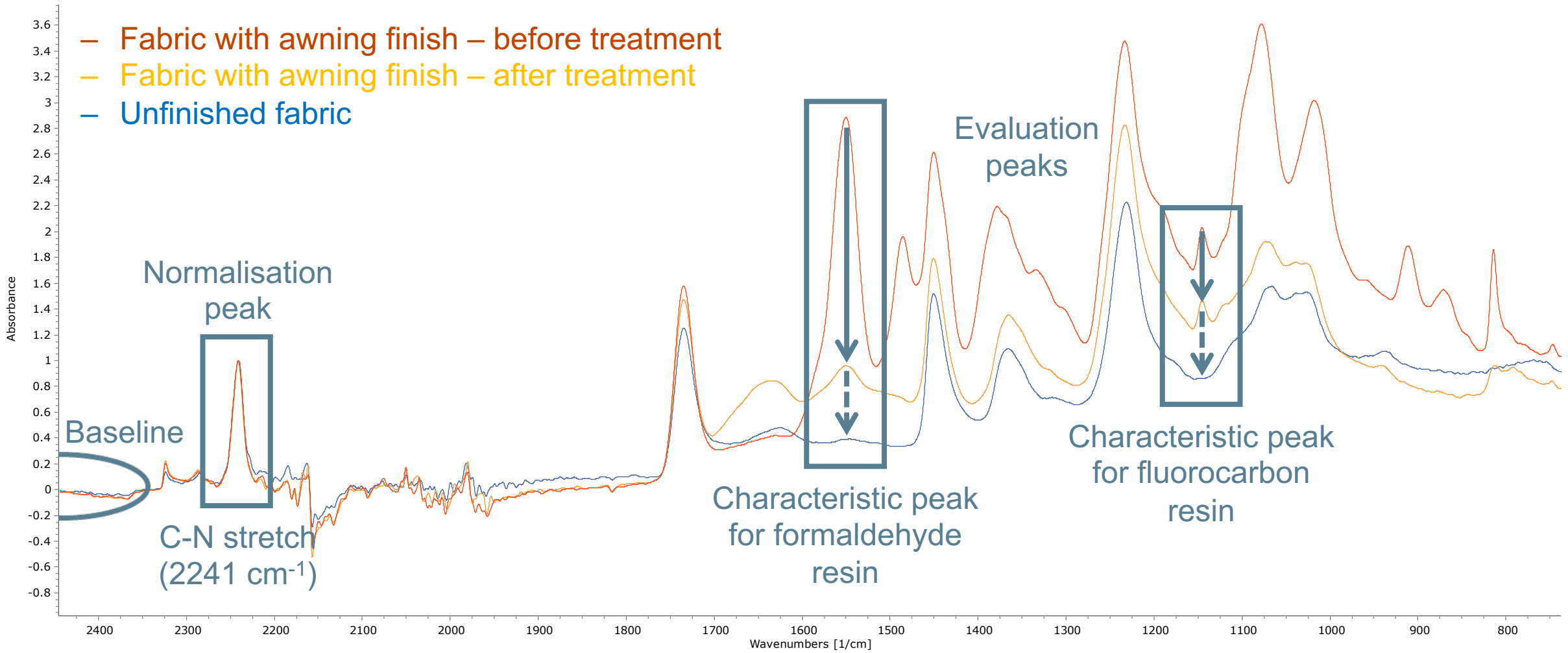
- Awning finish:
  - Formaldehyde resin
  - Fluorocarbon resin

- Furnishing finish:
  - Fluorocarbon resin
  - Softeners



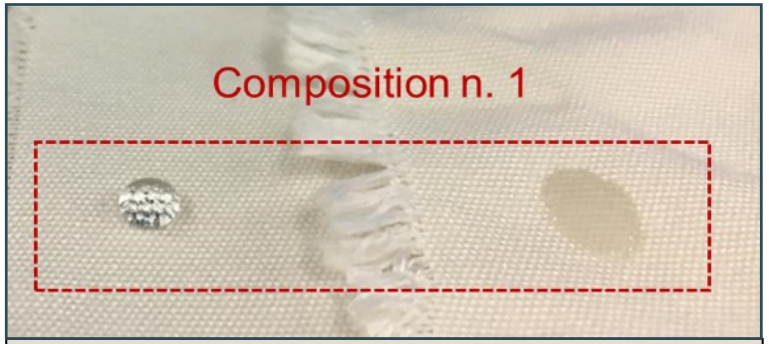
- Coating:
  - Formaldehyde resin
  - Fluorocarbon resin
  - Acrylic resin

EVALUATING REMOVAL EFFECTIVENESS (FTIR-ATR)

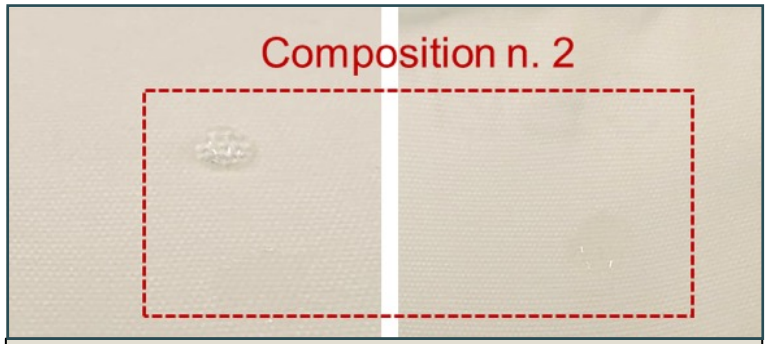


EVALUATING REMOVAL EFFECTIVENESS (OIL-REPELLENCY)

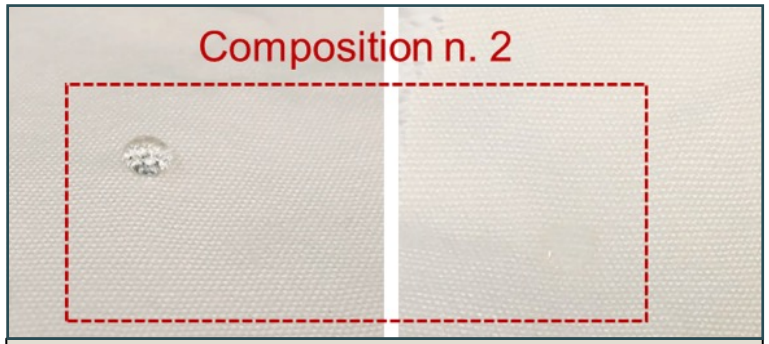
- Evaluation of fluorocarbon resin removal
- AATCC 118-2013



Awning finish	
Before treatment	After treatment



Coating	
Before treatment	After treatment

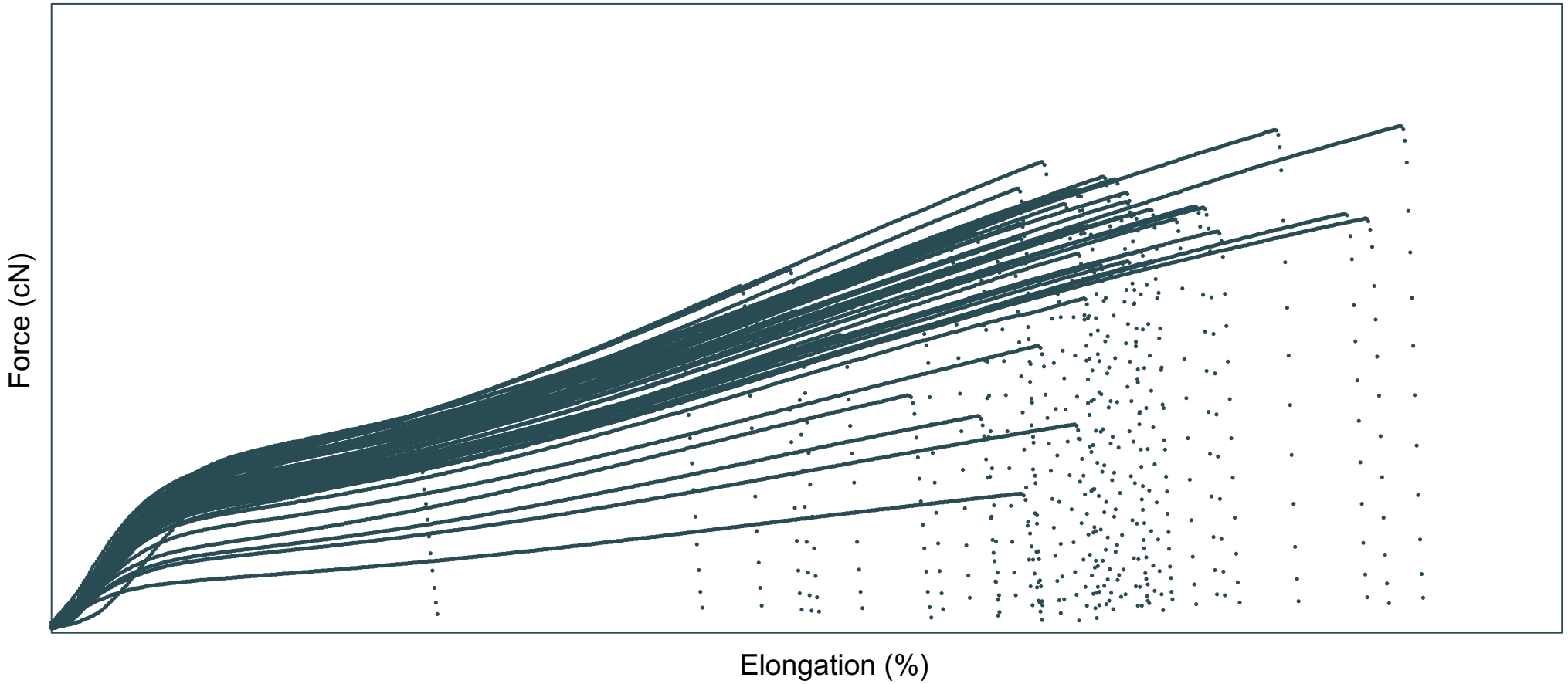


Furnishing finish	
Before treatment	After treatment

- More quantitative alternative: contact angle measurements

ARE OUR PROCESSES DAMAGING TO THE FIBRES?

- Fibre-level tensile tests (FAVIMAT+)



IDENTIFIED CHEMICAL FINISHING COMPOUNDS

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- Furnishing finish:
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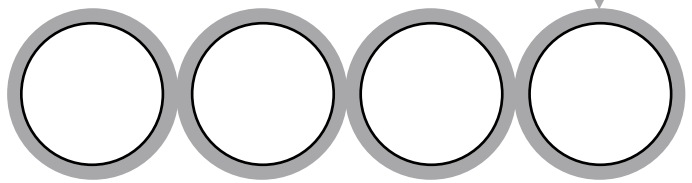
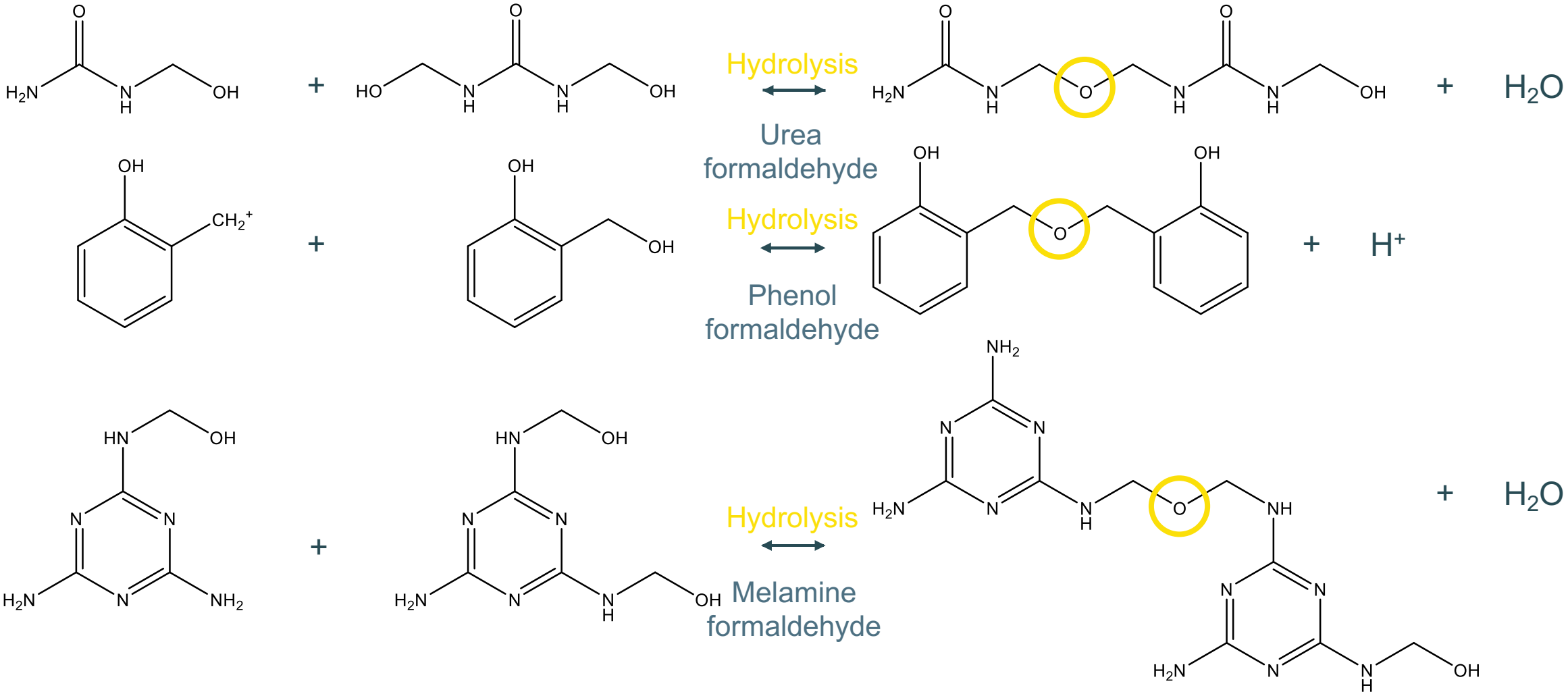


- Coating:
  - Formaldehyde resin
  - Fluorocarbon resin
  - Acrylic resin

REMOVAL OF FORMALDEHYDE RESINS



HYDROLYSIS 1

Design of experiments → Statistical model → Optimised parameters

	Formaldehyde resin removal (%)	Fluorocarbon resin removal (%)	Acrylic resin removal (%)	Softener removal (%)
Awning fabric	> 90	50 - 80	-	-
Coated fabric	< 30	< 30	< 30	-
Furnishing fabric	-	50 - 80	-	50 - 80

- Excellent removal of formaldehyde resin
- Coating and fluorocarbon resin are hard to remove
- Mechanical tests confirm there is no significant damage to the fibres

HYDROLYSIS 1 & 2 + WASHING

- Sequential treatments to improve removal of fluorocarbon and acrylic resins

	Formaldehyde resin removal (%)	Fluorocarbon resin removal (%)	Acrylic resin removal (%)	Softener removal (%)
Awning fabric	~ 100	50 – 80	-	-
Coated fabric	50 – 80	50 – 80	50 - 80	-
Furnishing fabric	-	50 - 80	-	~ 100

- Better removal of acrylic resin and softeners
- Fluorocarbon resin is still difficult to remove (validated by oil-repellency tests)
- Mechanical tests confirm there is no significant damage to the fibres

HYDROLYSIS 1 & 2 + WASHING + PHYSICAL TREATMENT

- Extra physical treatment to improve removal of fluorocarbon resin

	Formaldehyde resin removal (%)	Fluorocarbon resin removal (%)	Acrylic resin removal (%)	Softener removal (%)
Awning fabric	~ 100	> 90	-	-
Coated fabric	~ 100	~ 100	~ 100	-
Furnishing fabric	-	> 90	-	~ 100

- Near complete removal of all finishing components
- Fabric is no longer water- or oil-repellent, as proven by oil-repellency tests
- Some issues with upscalability of the physical treatment, and mechanical tests show increase in elongation and loss of stiffness

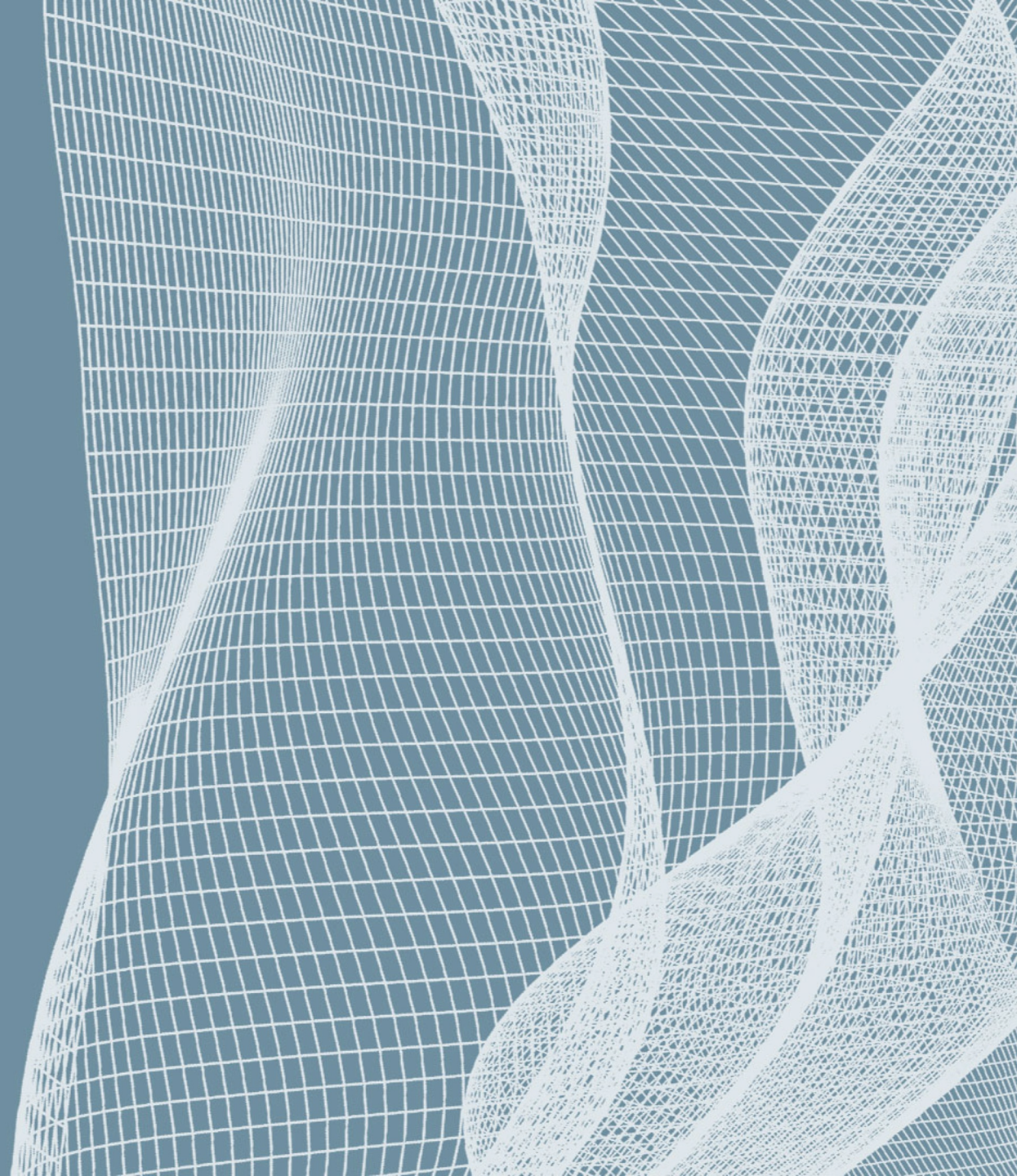
HYDROLYSIS 1 & 2 AT HIGHER T + WASHING

- Higher temperature hydrolysis decreases the surface tension of the solution → easier penetration of fluorocarbon and acrylic resins

	Formaldehyde resin removal (%)	Fluorocarbon resin removal (%)	Acrylic resin removal (%)	Softener removal (%)
Awning fabric	~ 100	~ 100	-	-
Coated fabric	~ 100	> 90	> 90	-
Furnishing fabric	-	~ 100	-	~ 100

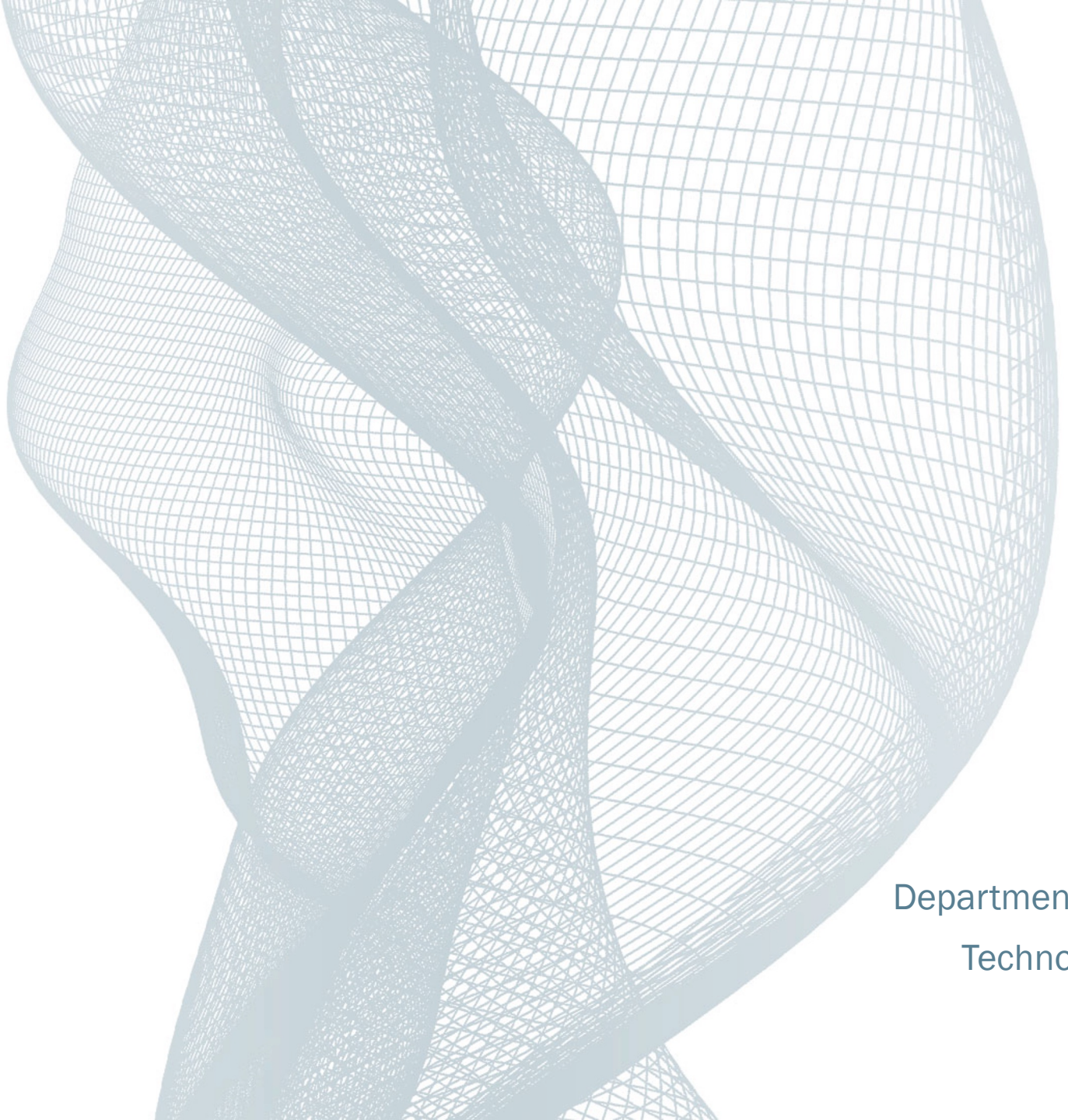
- Better removal of acrylic resin and softeners
- Fluorocarbon resin is still difficult to remove (validated by oil-repellency tests)
- Mechanical tests confirm there is no significant damage to the fibres

CONCLUSION



CONCLUSION

- Acrylic fibres for outdoor applications are not yet recycled even though they have a high recycling potential, due to finishing chemicals on the fibre surface
- Hydrolysis 1 & 2 at higher temperature + washing is an optimised, lab-scale series of treatments that can remove over 90% of all finish components from outdoor acrylic textiles
- First pre-industrial scale trials are successful and have led to umbrellas, pillows and a seat made of 100% recycled fibres



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THANK YOU FOR YOUR ATTENTION

Brecht Tomme
Brecht.Tomme@UGent.be

Centre for Textile Science and Engineering
Department of Materials, Textiles and Chemical Engineering

Technologiepark 70A, 9052 Zwijnaarde (Gent), Belgium

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 820869