Bio-Perform: Finishing and surface embellishment of cellulosic bio-based materials that are compatible with circular systems

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\Background

This research foregrounds the recently completed interdisciplinary project ‘All Cellulose Composite’ that enhanced the structural and surface properties of woven fabrics made from Piñayarn® using a patented mono-composite technology to simplify end of life solutions.

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DR RAQUEL PRADO

PROFESSOR MICHAEL RIES

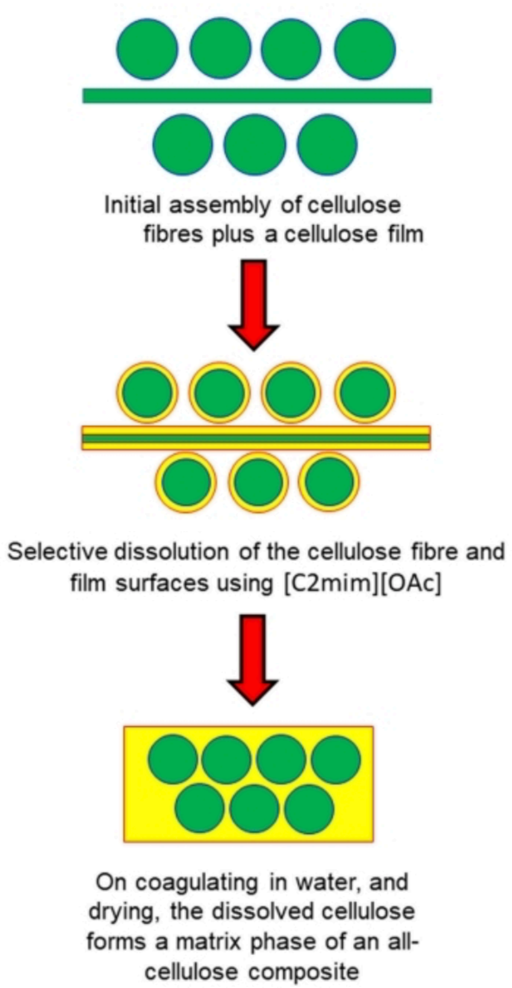
JUNE SWINDELL

DR HELEN PAINE

PROFESSOR KATE GOLDSWORTHY

SOPHIE FIELDS

\ All-Cellulose Composite Process



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1. Assembly of cellulosic materials (with/without cellulose film)

2. Soaking of cellulose materials in Ionic Liquid/DMSO solution (80:20)

3. Hot press (10mins 2MPA) followed by water soak and air drying

\All Cellulose- Project Outcomes

37 Woven Piñayarn® fabrics exploring different stitch types and fabric flexibilities

A full dataset of woven and composite samples testing fabric elongation, tensile strength and pilling.

Over 100 mono-composite samples created demonstrating varying degrees of flexibility for potential application in luxury hospitality, automotive and accessories markets.

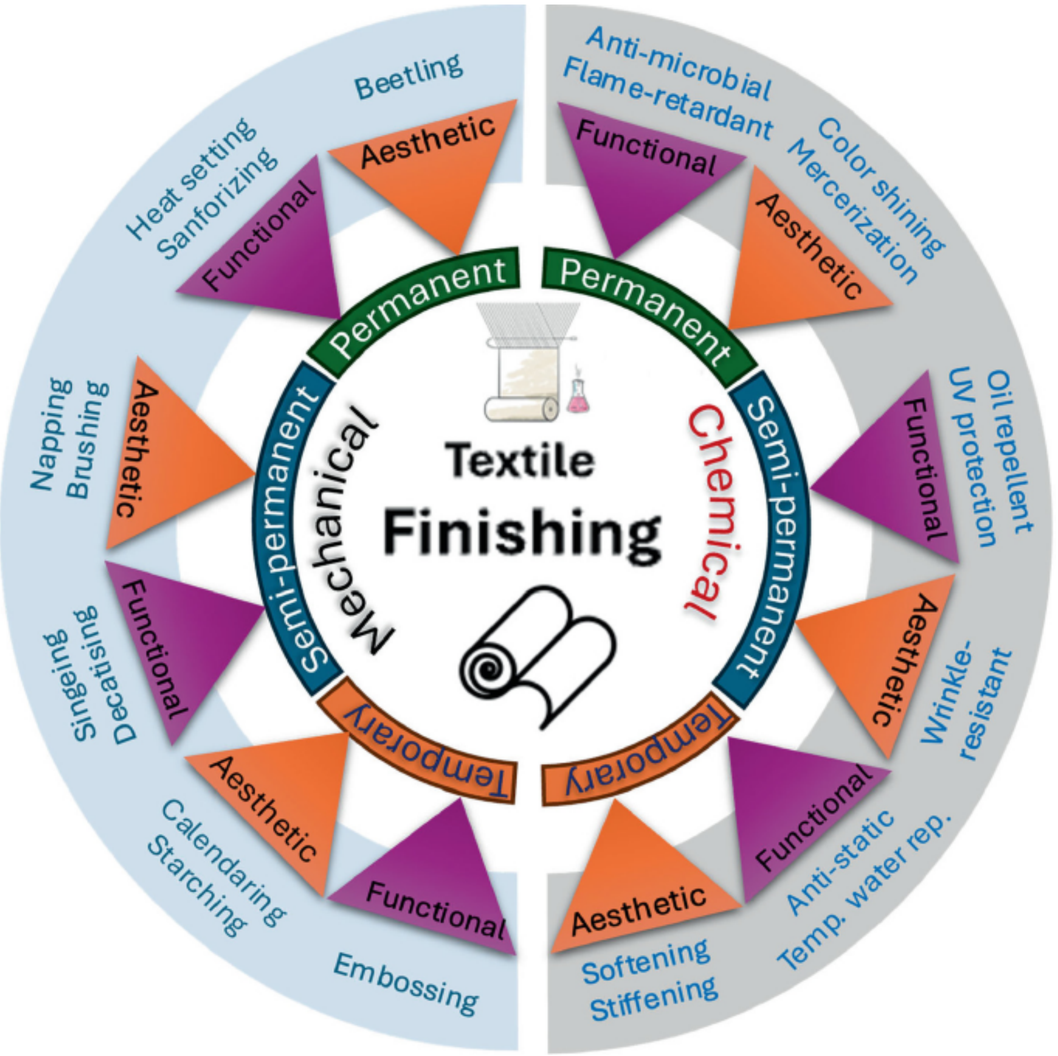
Gradle-to-gate LCA study indicating hotspots for process improvement

Textile finishing encompasses chemical, physical, and mechanical treatments applied after dyeing to enhance a fabric's aesthetic qualities, functionality, and performance.’

(Choudhury , 2017)

Dornbusch, Germany (2016)

\Categorization of Textile Finishing

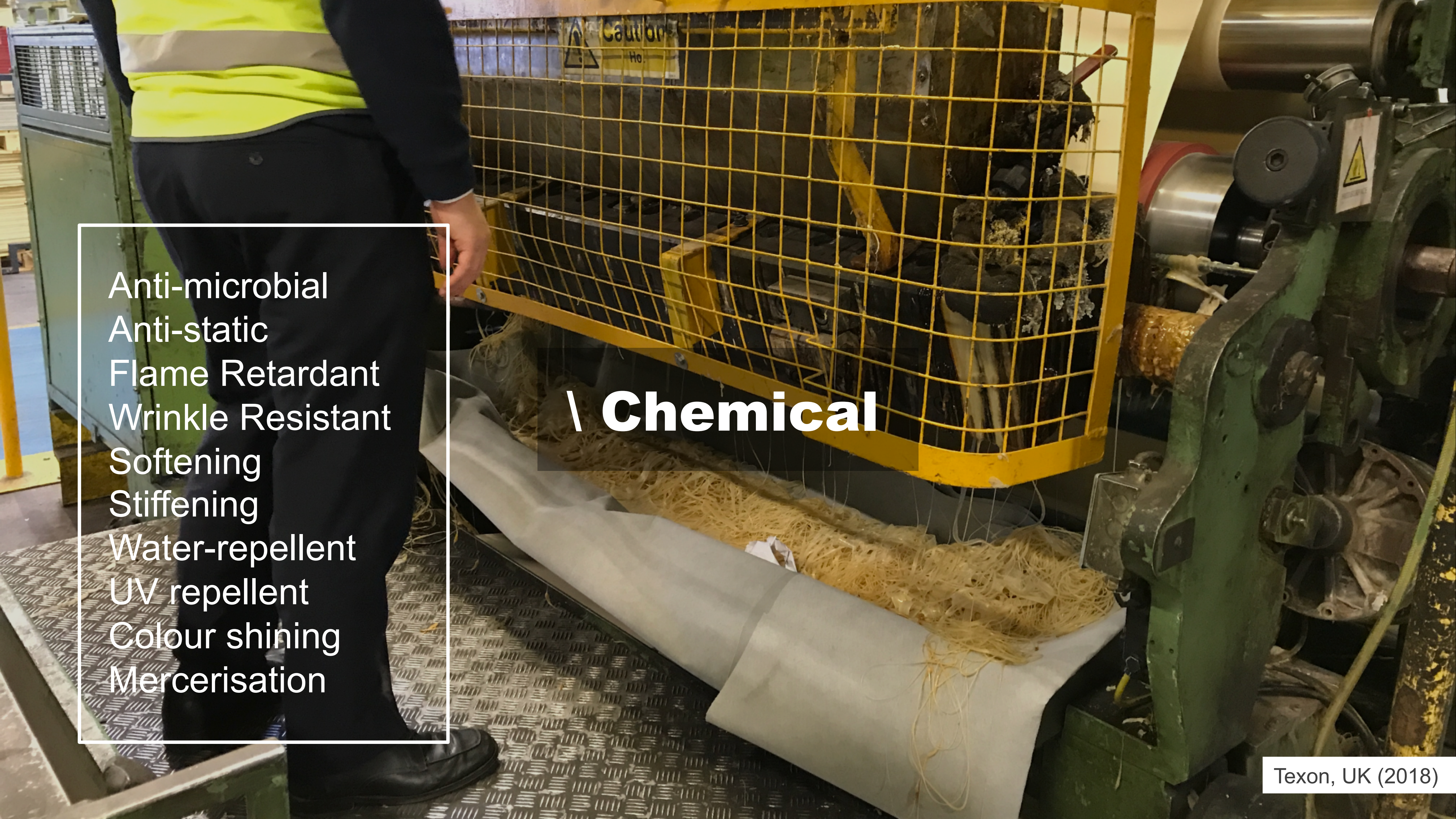


Morshed, M.N. (2025)

Mechanical (Dry Finishing): uses application of physical principles such as friction, temperature, pressure, tension etc.

Chemical (Wet Finishing): Chemical treatments are used to create durable finishes that change the properties (function and/or aesthetic) of the fabric

Dornbusch, Germany (2016)


Anti-microbial
Anti-static
Flame Retardant
Wrinkle Resistant
Softening
Stiffening
Water-repellent
UV repellent
Colour shining
Mercerisation
\ Chemical
Texon, UK (2018)

PU Droolings - Industrial Waste from a Boot Factory (Design Museum, 2021)

\ Impacts of Chemical Finishing

Release of toxic substances: carcinogens, endocrine disruptors & heavy metals

Contamination of water & soil

Occupational hazards to workers

Health risk to consumers through dermal contact or inhalation

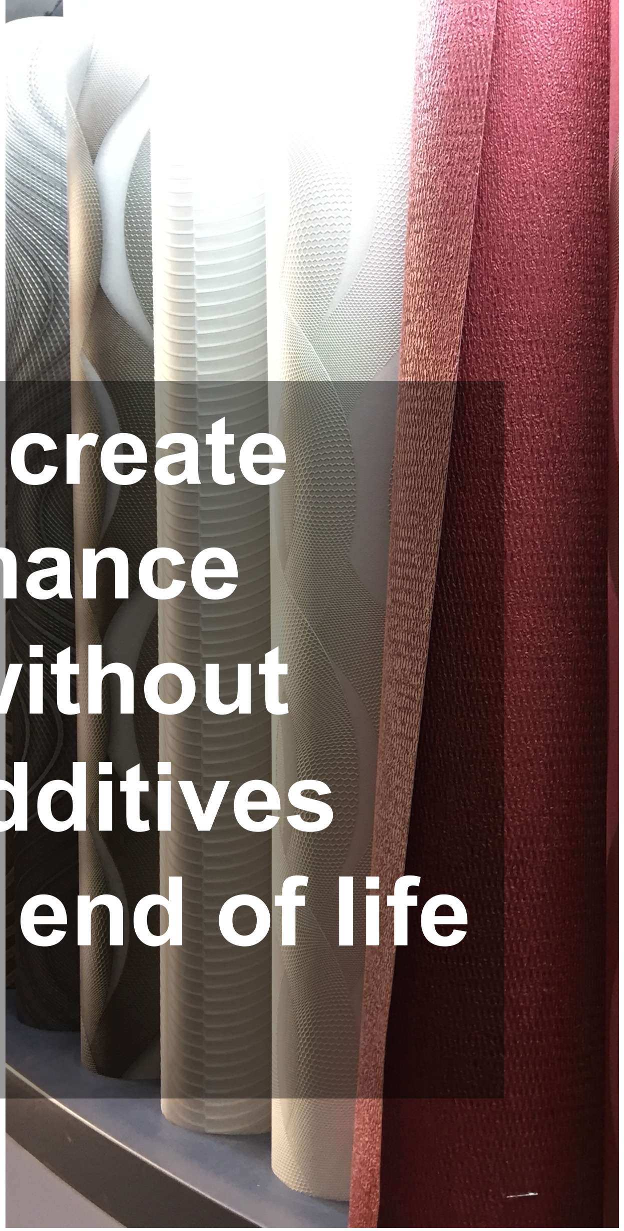
Polyfluoroalkyl substances (PFAS) are of particular concern

Use of hazardous chemicals is regulated by legislation (e.g. ZDHC, COSHH, UK REACH)

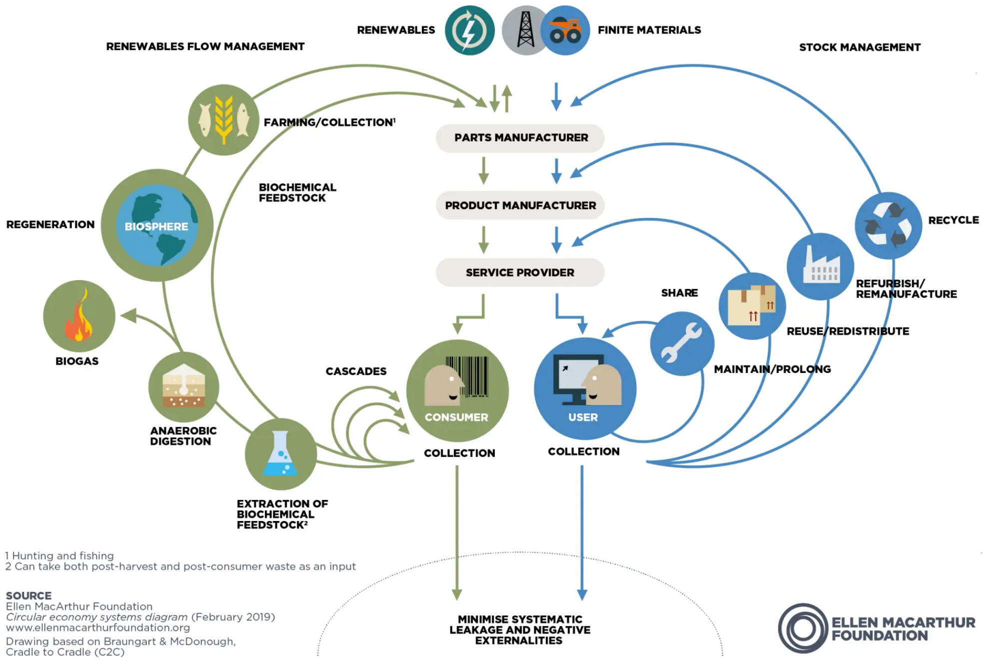
COMPLIANT · COMPLIANT · COMPLIANT · REACH

ZDHC

\ Move to Renewables



How can we create high performance cellulosics without petroleum additives and simplify end of life solutions?

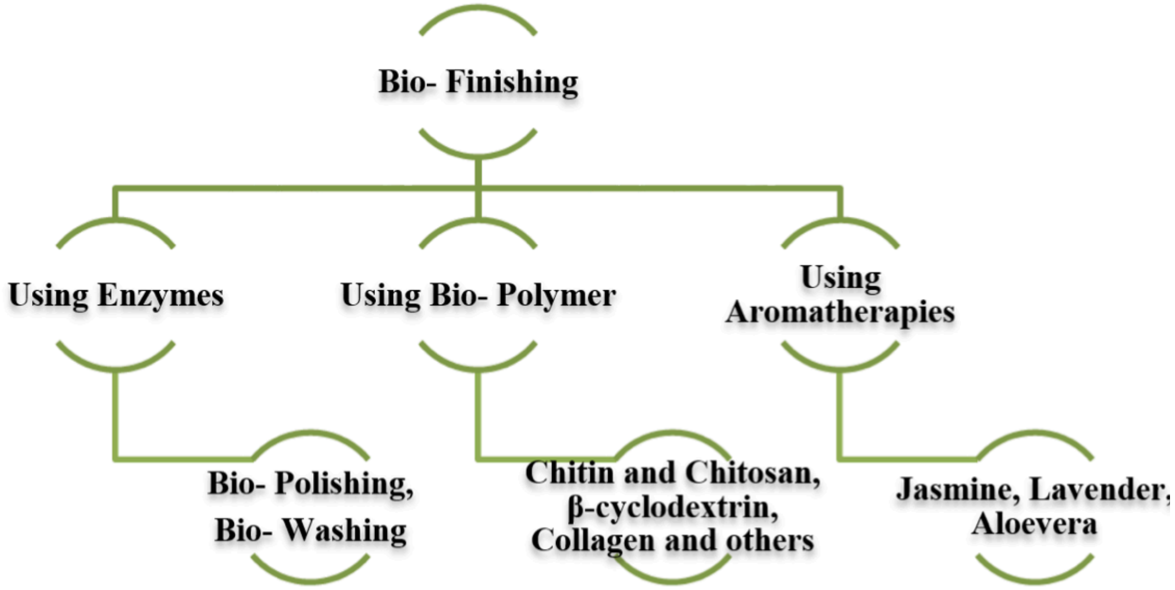


(Butterfly Diagram, 2012)

Monstrous Hybrids

(McDonough, Braungart, 2002)

\ Classification of Bio-Finishing

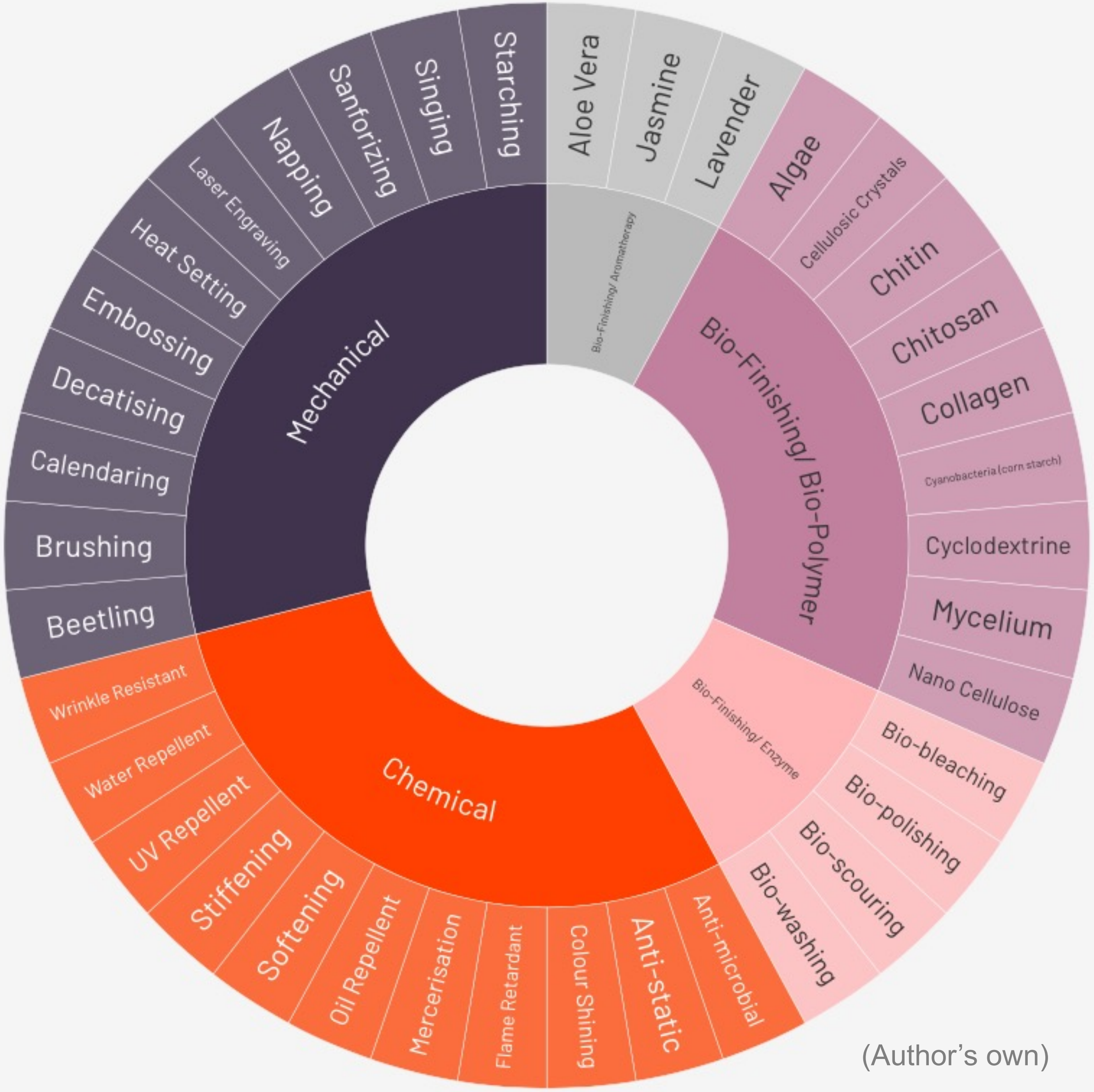


(Grover et al., 2022)

'Bio-finishing can be defined as a biological way of giving wet treatment to the textiles. It includes enzymatic desizing, bio-scouring, bio-bleaching, bio-washing, bio-polishing, finishing using biopolymers, aromatherapy and speciality finishes like wrinkle free effect, antimicrobial finish, deep sleep finishing etc by using some or the other biological means.'

(Bhala et al., 2012)

Classification of Mechanical and Bio-Finishing for Textiles



(Author's own)

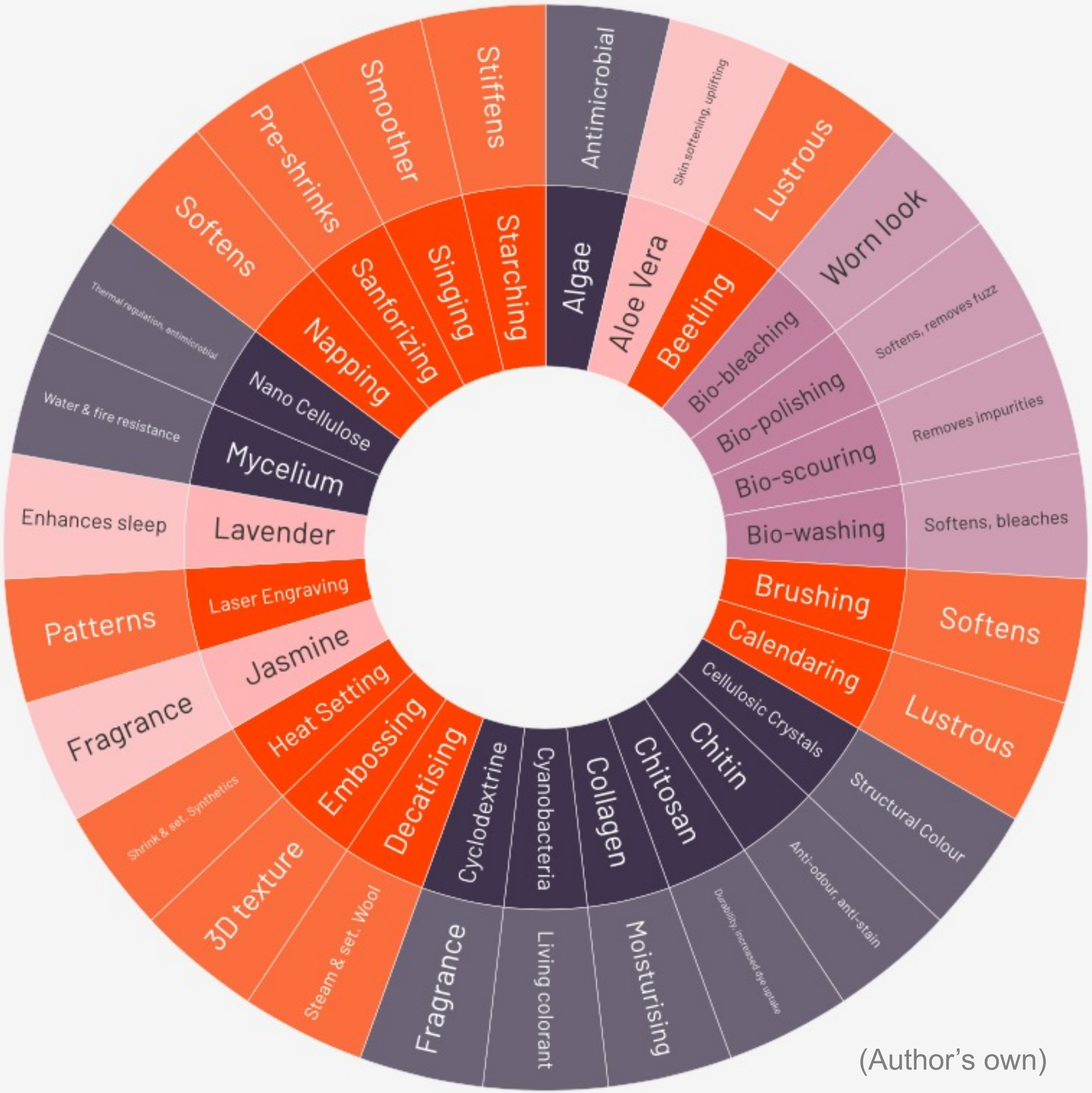
\ Classification of Bio, Mechanical Finishing and Effects

Bio-Polymer

Enzyme

Aromatherapy

Mechanical



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\ Bio-Finishing: Enzymes

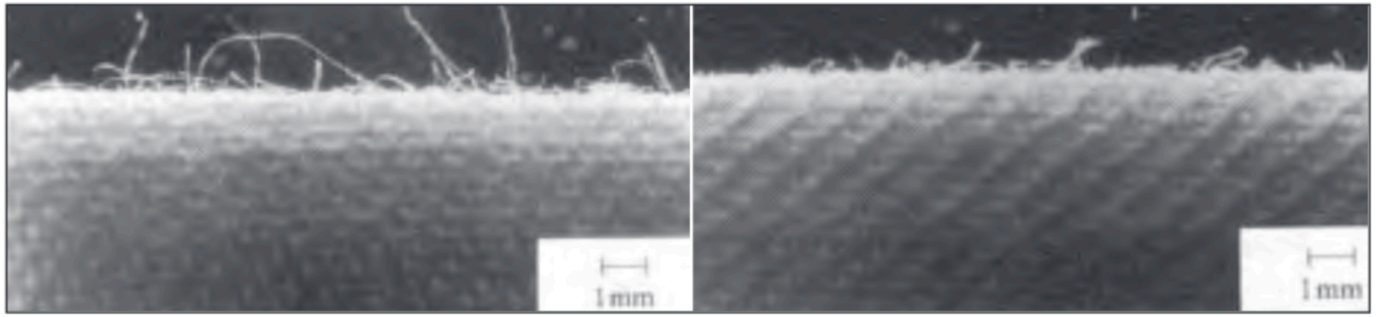


Fig 4 : Effect of bio-polishing : Before (left) and after (right) the enzyme treatment

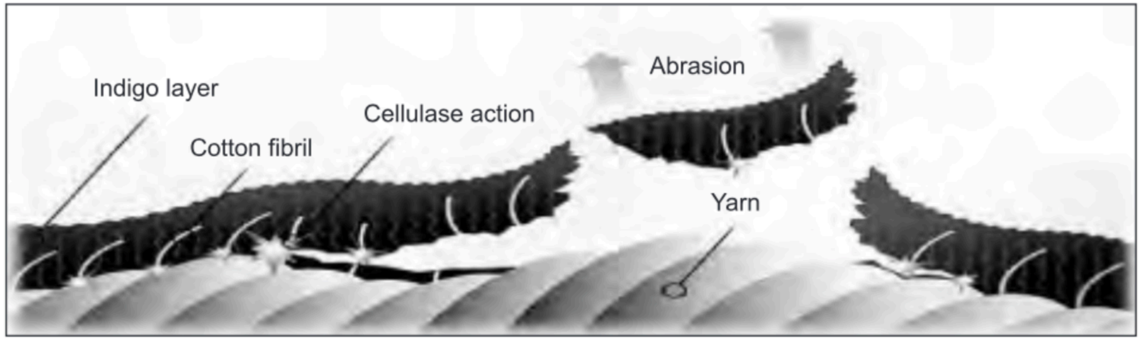


Fig 3 : Mechanism of cellulase enzyme action during denim washing

- Enzymes are bio-catalysts that are used to replace chemical wet processes, particularly in cellulosic fibres
- Commonly used enzymes: Cellulase, Amylase and Peroxidase.
- Bio-polishing/Bio-finishing: commonly used enzymatic process for cellulosic textiles to reduce pilling and create a smoother handle

(Bhala et. al, 2012)

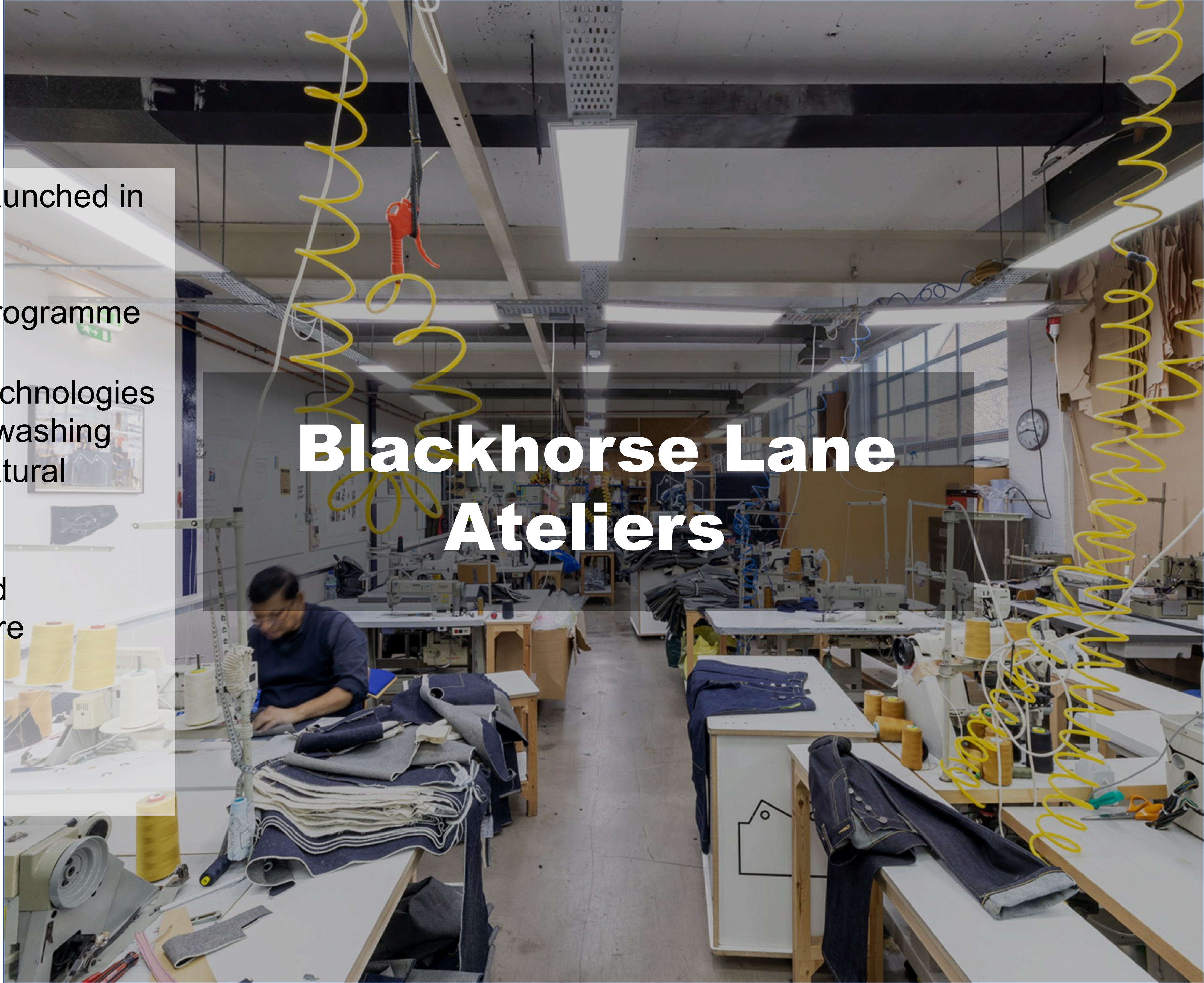
\ Bio-Finishing: Enzymes, Ozone & Mechanical

London’s first Denim Wash-Lab launched in 2023

Partnership with UAL via BFTT Programme

Sustainable finishing and wash technologies including laser engraving, ozone washing and bio-washing/polishing with natural enzymes

Open to to students, start-ups and established brands to explore more sustainable denim wash methods



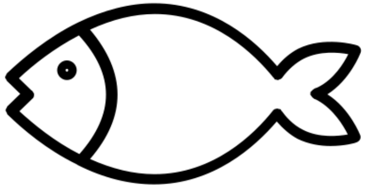
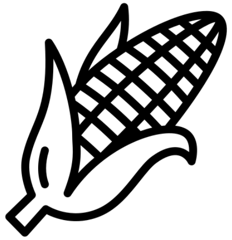
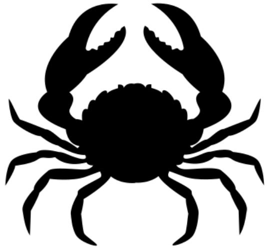
\ Bio-Finishing: Biopolymers

Biopolymers are green alternatives to petroleum based fibers directly produced by living organisms or derived from bio-based monomers. Biopolymers are sustainable, carbon neutral, biodegradable and renewable.

Biopolymers can be used as biodegradable finishes for textiles to impart new functional and aesthetic properties

Biopolymers can be be categorized by origin: plant, animal, bacteria & microorganisms, agricultural waste, marine biomass

Biopolymer	Origin	Use in Textile Finishing
Chitin & Chitosan	Found in shells of crustaceans, insects & fungi	Wrinkle-free finish Antimicrobial finish Fragrance release finish Flame Retardancy
Cyclodextrins (CDs)	Starch	Functional fabrics – odor absorption, anti-microbial etc.) applied by spraying, printing, padding, grafting, surface coating, impregnation, inkjet printing or via sol gel
Collagen	Connective tissue of animals	Dyeing of cotton and leather

\ Bio-Finishing: Biopolymers

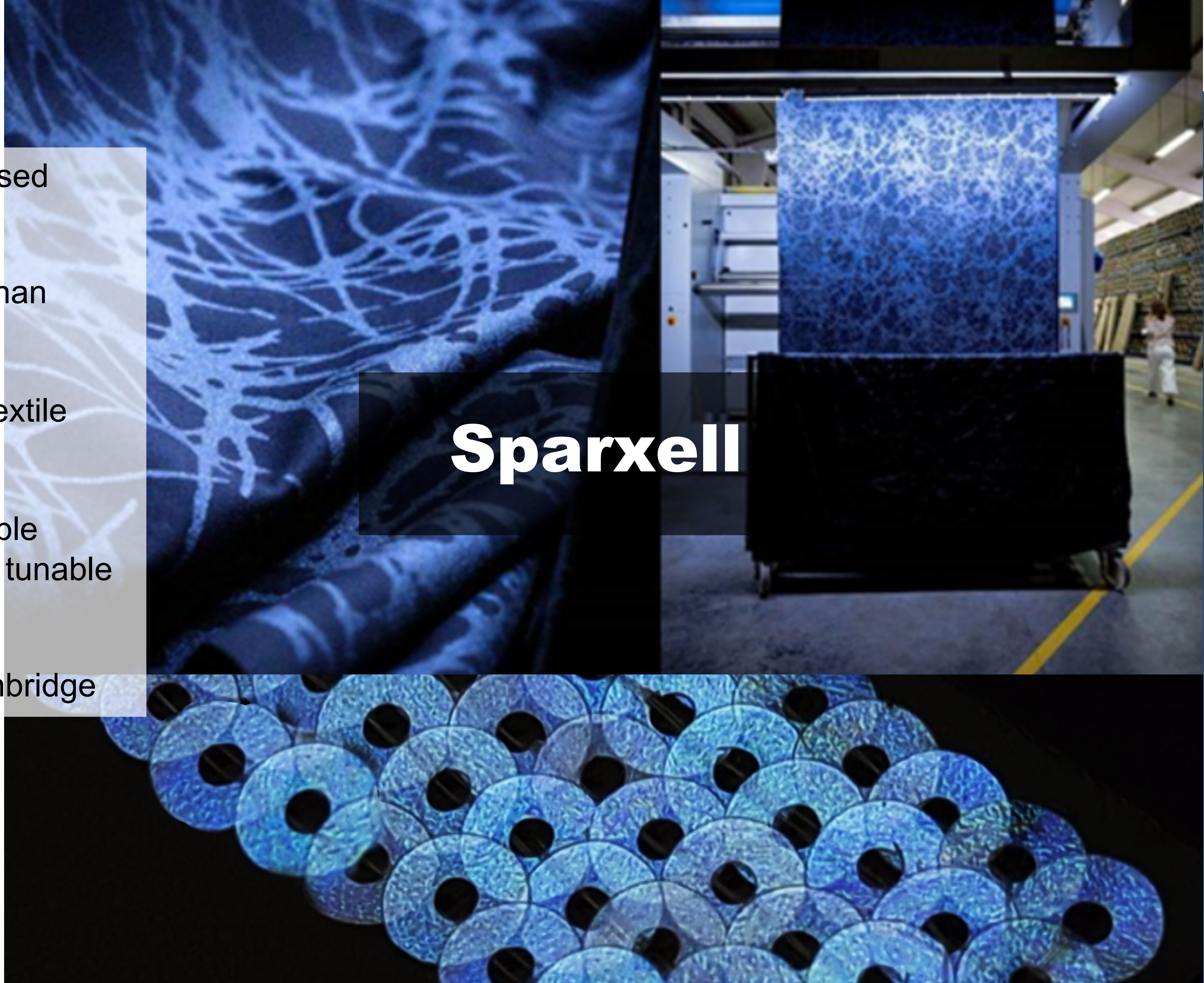
Derived from reflective plant-based cellulose crystals

Uses light manipulation rather than chemical dyes

A structural colour solution for textile finishing

Process can create biodegradable pigments, glitters and films with tunable appearance

Spin-out from University of Cambridge



\ Biopolymers: Carbon Negative

Photosynthetic coatings containing living microbes

Microbial pigmentation using soil dwelling bacteria

Technologies create zero-waste, carbon-negative finishes that produce oxygen while simultaneously reducing hazardous chemical use and capturing CO_2 from the air

Post Carbon Lab

\ Biopolymers: Recycled cellulosic powder

Innovative process that disintegrates cellulosics into powder using ionic liquid

Cellulosic powder can directly incorporated in manufacturing as a pigment for new fabrics reducing waste and extending the life cycle of materials

Technology can also be applied to cotton-synthetic blends

DyeRecycle: Cellulosics

Link here

\ Biopolymers: Nano-cellulose

MA Material Futures graduate: Jen Keane (2018)

Bacterial nanocellulose materials and coatings

K. Rhaeticus bacteria are fed with agricultural sugars to produce nanocellulose

Nanocellulose is grown around a cellulosic textile scaffold

Unique non-woven structure

Materials and finishes can be manipulated to create controlled aesthetics and finishes

Modern Synthesis

\ Biopolymers:
Cellulose sequins

Ellissa Brunato MA Material Futures graduate (2019) + RISE Research Institutes of Sweden – Founder of Radiant Matter

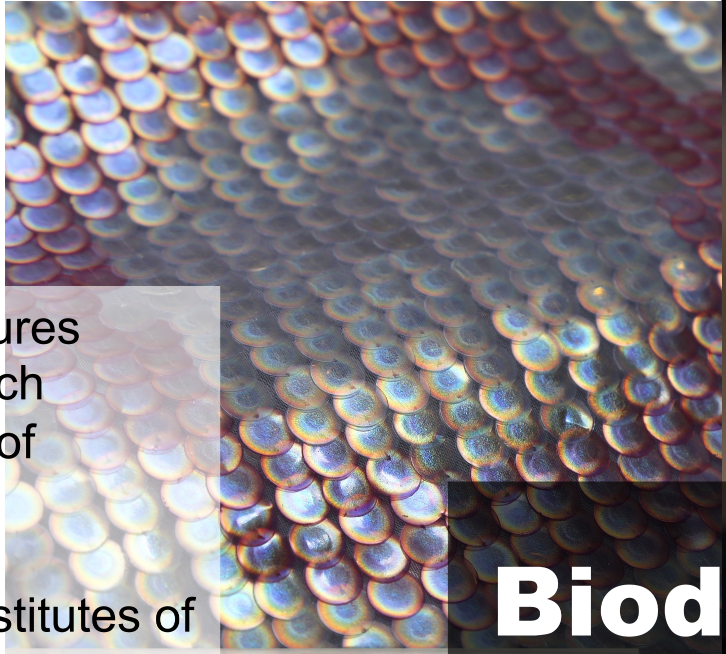
Working with RISE Research Institutes of Sweden

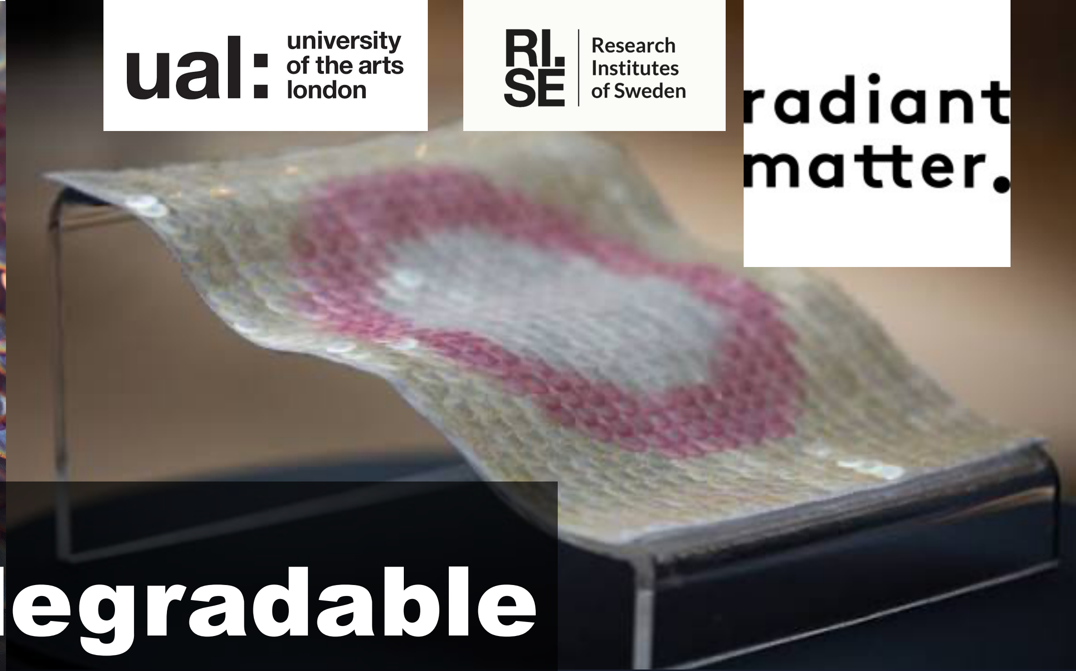
Biodegradable sequins made from wood cellulose

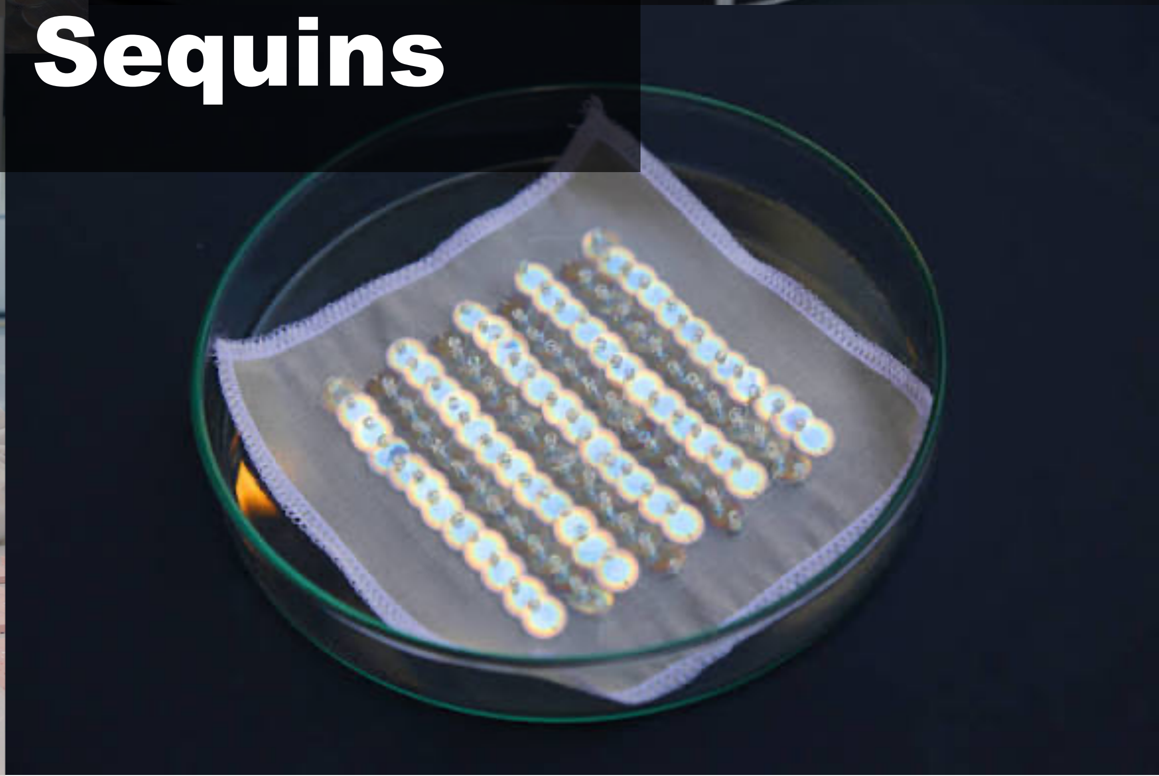
Iridescent colour created by their natural nanostructure – Structural Colour

Stella McCartney Collaboration - 2023

Biodegradable Sequins







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RISE Research Institutes of Sweden

radiant matter.

\ Mechanical: Beetling

Academic/Industrial partnership between UAL & William Clarke & Sons – Ireland's oldest surviving linen Mill

Last commercial beetlers in the World – pounding linen cloth to give a beautiful sheen

Project tested sustainable finishing products to provide water and soil repellent properties for new products

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William Clark SINCE 1736

\ All Cellulose Composite: Student Brief

Elanka Jiang

Bio-finishing and coloration of fabrics made from pineapple leaf fibres

Students explored natural dyeing, screen printing with natural pigment, mono-embroidery, applique, shibori and more

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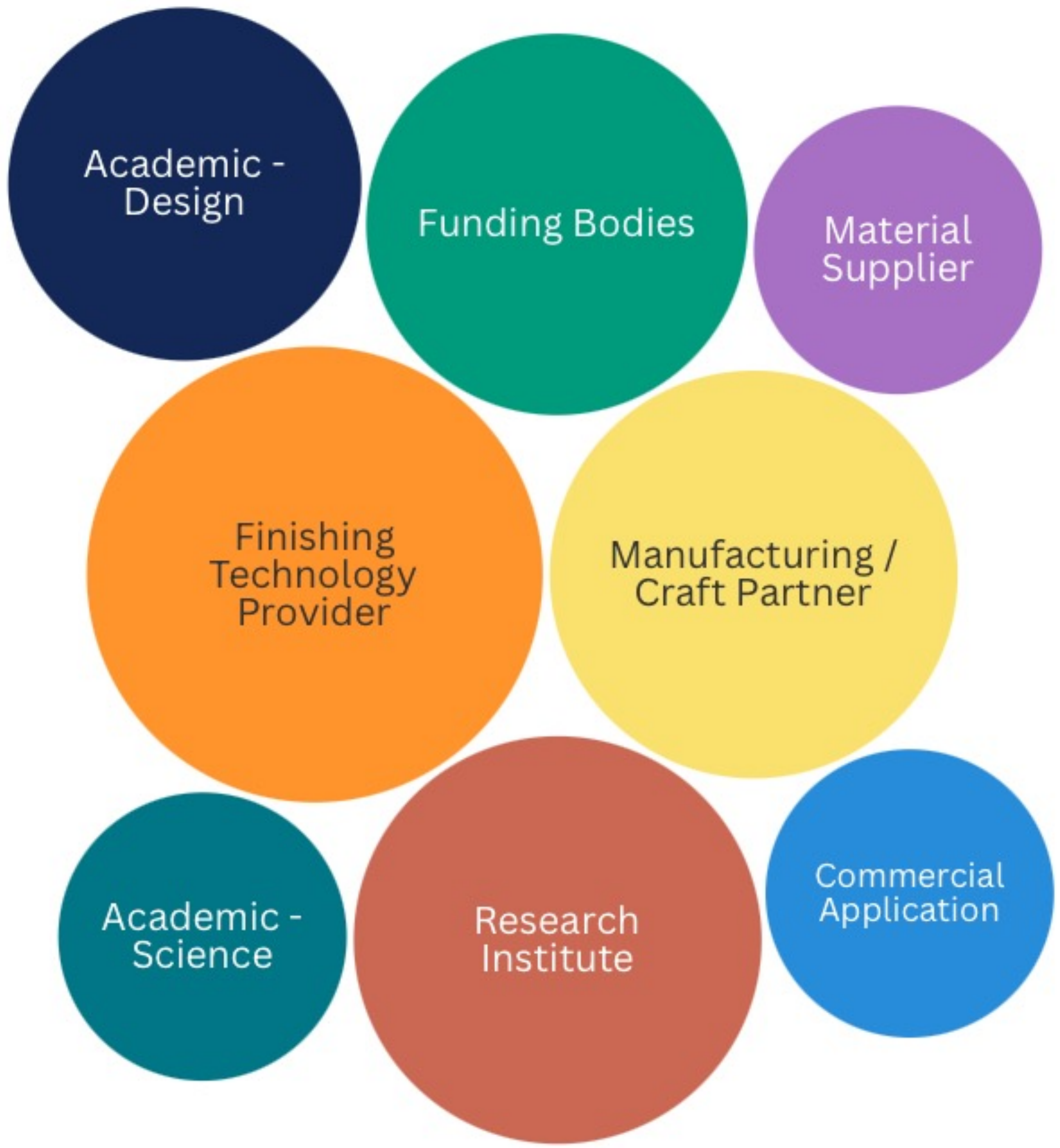
A proposal for interdisciplinary engagement with new Bio-finishing technologies that bridges across academic and industrial fields to have real systemic impact.



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London Doctoral Design Centre

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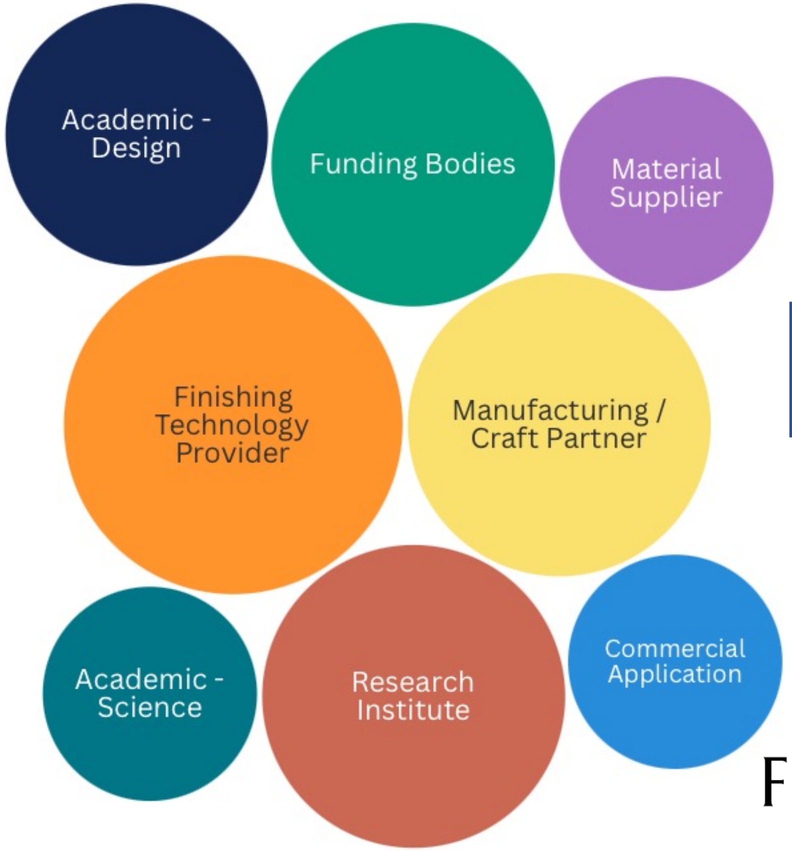
UKRI Arts and Humanities Research Council

The Business of Fashion, Textiles & Technology Partnership

Royal College of Art
Postgraduate Art & Design

TWI



UKRI Engineering and Physical Sciences Research Council

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Formen Werkzeuge Prüflehren

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Guilford performance textiles by LEAR

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