

biosphere circulation project

designed by  Spiber

Introduction

Spiber Inc.

Spiber is more than just a material company...

We are **Committed** to tackling pressing social needs

We **Craft** and provide innovative solutions

We **Contribute** to sustainable human well-being

Brewed Protein™

biosphere circulation project



Introduction

Fashion & textile waste stats

We must **transition** from a linear "take-make-use-dispose" model to a sustainable and circular "take-make-use-reuse" model

Under **1%**

of used textiles are recycled for new textile applications today ¹

73%

of garments across the globe end up in landfill ¹

\$100 billion

USD worth of materials are lost each year at current rate ¹

1. Ellen MacArthur Foundation, "A new textiles economy: Redesigning fashion's future", (2017, <http://www.ellenmacarthurfoundation.org/publications>).

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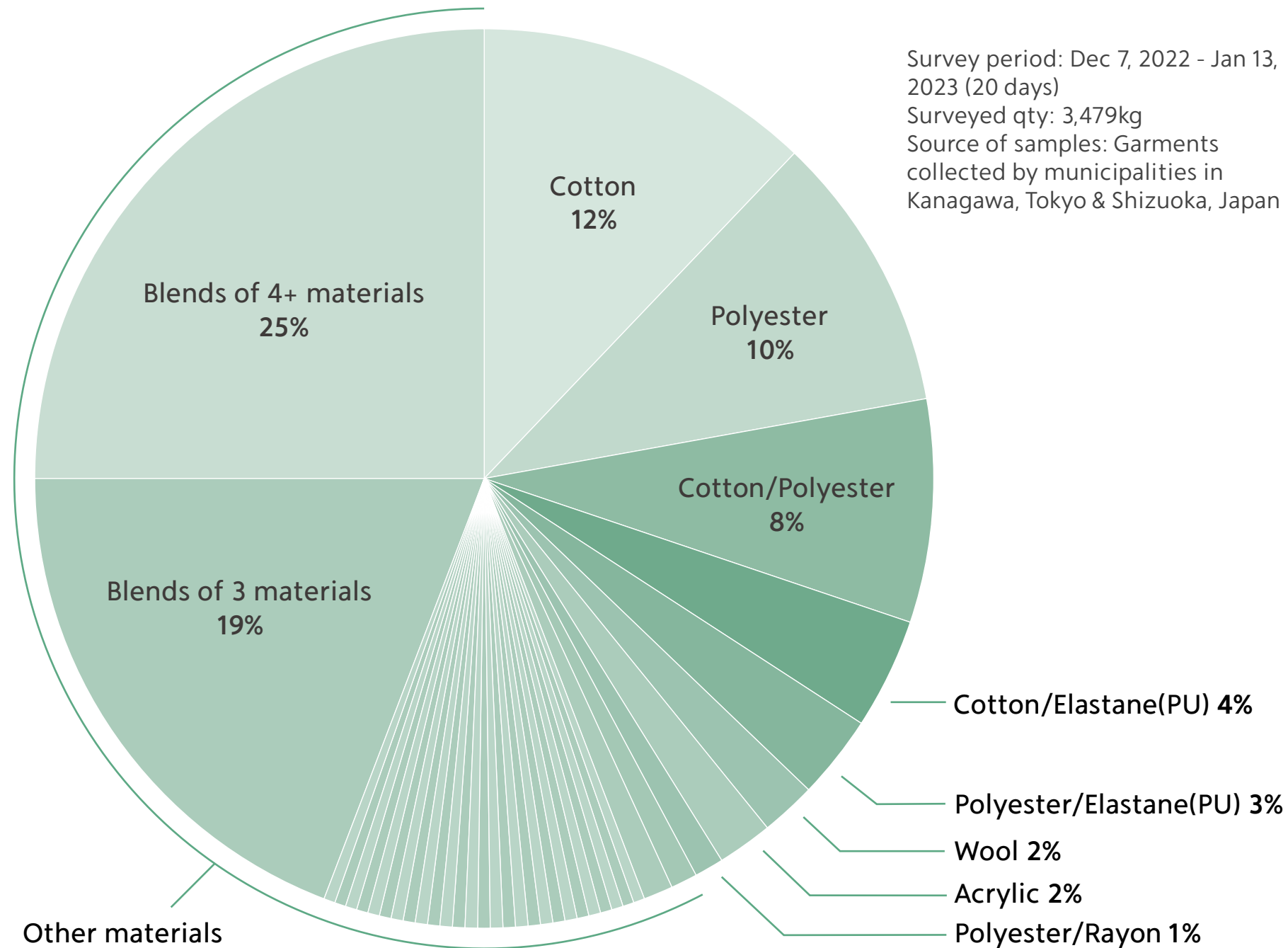
Fashion & textile waste compositions

Clothing waste is composed of many types of materials and blended materials

All fractions of the pie chart are resources that need to be circulated at end-of-use

Products should be designed using combinations of materials that have solutions for circularity

Figure 1. Percentage of discarded clothing by material composition



Other materials (single material & blends)							
Rayon	Cotton/Nylon	Paper	Lyocell/Wool	Viscose/Wool	Polyester/Tencel	Nylon/Polyurethane	Wool/Linen
Cotton/Acetate	Cotton/Rayon	MMCF (Plant-based recycled fiber)	Rayon	Acrylic/Rayon	Acetate/Polyester	Synthetic Leather/Polyester	Wool/Rayon
Cotton/Acrylic	Cotton/Silk	Cupra	Rayon/Acetate	Acrylic/Linen	Polyacetate/Cashmere	Silk	Wool/Cupro
Cotton/Cashmere	Cotton/Tencel	Cupra/Polyester	Rayon/Nylon	Polyester/Acrylic	Nylon	Silk/Cotton	Wool/Polyurethane
Cotton/Wool	Hemp	Lyocell	Rayon/Polyurethane	Polyester/Nylon	Nylon/Wool	Silk/Polyester	Pashmina
Cotton/Hemp	Hemp/Rayon	Lyocell/Cotton	Tencel	Polyester/Linen	Nylon/Acrylic	Wool/Cashmere	
Cotton/Linen	Hemp/Cupro	Lyocell/Nylon	Tencel/Nylon	Polyester/Lexe	Nylon/Polyester	Wool/Silk	

Figure 1. This pie chart is adapted based on the "Sustainable Fashion" report produced by the Japanese government. (Original data retrieved from the website of the Ministry of Economy, Trade and Industry. Data is based on a study by the Ministry of Environment with support from Nakano Corp.) https://www.meti.go.jp/shingikai/mono_info_service/resource_recycling/pdf/002_02_00.pdf

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Spiber's activities

Clothing waste is composed of many types of materials and blended materials

All fractions of the pie chart are resources that need to be circulated at end-of-use

Products should be designed using combinations of materials that have solutions for circularity

Spiber's technology can utilize metabolic recycling, where biological components of "wastes" (e.g. agricultural residues, natural fibers such as cotton contained in discarded textile products, etc.) can be broken down into "nutrients" (sugars, amino acids, etc.) for fermentation to produce new materials including Brewed Protein™ fibers.

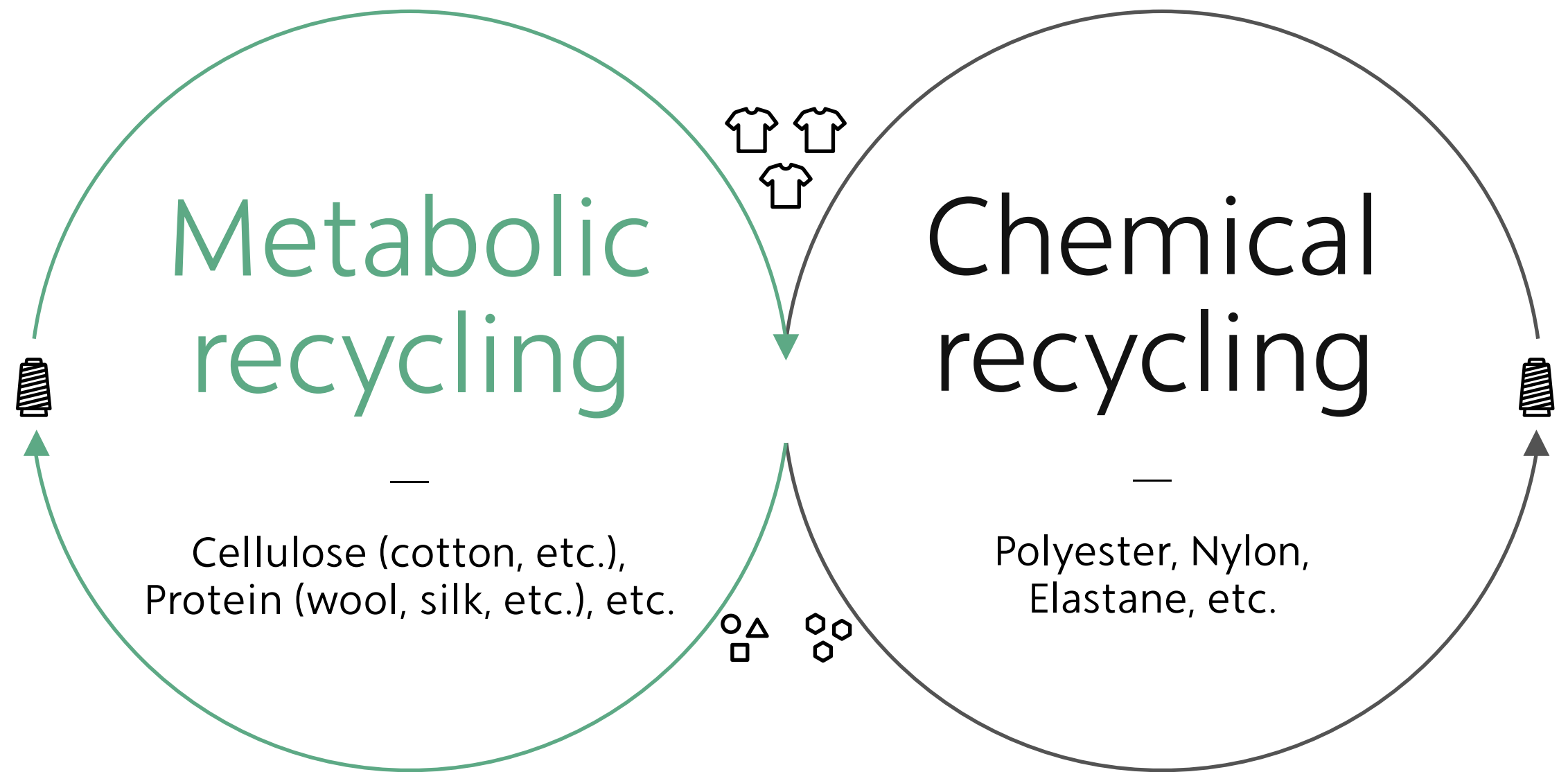
We envision metabolic recycling to play a key role in a circular future where all mainstream products, including those combining bio-based and synthetic materials, are designed to be fully recycled at end-of-use.

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The project vision

All fractions of the pie chart are resources that need to be circulated at end-of-use

Through partnerships with chemical recycling technologies, we aim to enable a network of circularity solutions for the full utilization of both bio-based and chemical-based components of blended textile waste streams that are composed of various combinations of materials.



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Spiber's activities to enable product design

Clothing waste is composed of many types of materials and blended materials

All fractions of the pie chart are resources that need to be circulated at end-of-use

Products should be designed using combinations of materials that have solutions for circularity

The biosphere circulation project aims to determine how to design products for the ecosystem of circularity solutions

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Product design principles: overview

Designing products for biosphere circulation

Principles

1

Design products using materials that have circularity solutions, and, avoid combinations of materials that do not

Each combination of materials needs to have an efficient, scalable & viable end-of-use solution for circularity

2

Ensure textile chemicals and colorants will not contaminate end-of-use processing

The effect of textile chemicals and colorants must be taken into account in the product design phase to ensure that they will not be contaminants to circularity solutions

3

Product composition data must be made available to enable circulation

Data on all items used to make products must be available for efficient sorting and directing to right end-of-use circularity solution

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Product design principles

1. Design products using materials that have circularity solutions, and, avoid combinations of materials that do not

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1

Is doing the research and development to provide solutions for as many types of textile waste as possible

2

Will make this information available to designers to enable product design for circularity

3

Will find a way to allow consumers to identify products made in accordance with these principles

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Product design principles

2. Ensure textile chemicals and colorants will not contaminate end-of-use processing

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1

Will test materials combined with key textile chemicals to understand what can be used as nutrients for fermentation

2

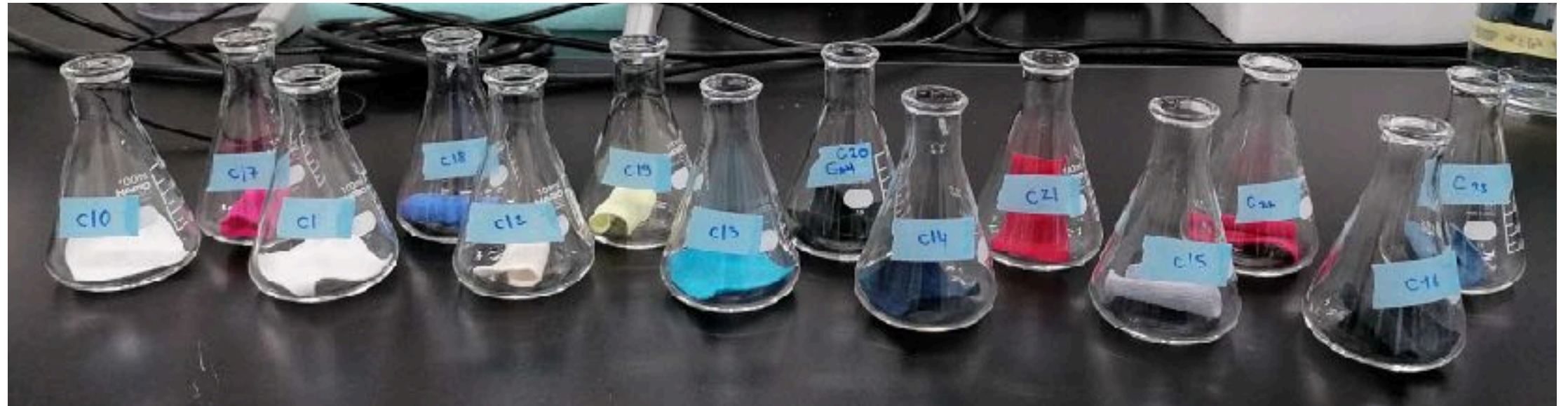
Will rate materials combined with textile chemicals for their ability to be used as nutrients, and will make this information available to the industry as a resource for product design

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Product design principles

Spiber has begun testing a variety of textile dyes to evaluate their impact on the ability of bio-based materials to be converted into nutrients

Early findings indicate that some dyes can cause a decrease in the ability of materials to be converted into nutrients



Sample fabrics before pretreatment



Samples after treatment to extract nutrients

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Product design principles

This database is a tool Spiber plans to publish on the web

It will disclose evaluation results of nutrient conversion efficiencies for various combinations of materials and chemicals

Figure 2.

Base material	Chemical 1	Chemical 2	Chemical 3	Nutrient conversion rate
> Cotton fiber	> Black reactive dye [Type XXX]	> Chemical softener [Type XXX]	> Optical brightener [Type XXX]	> Excellent
> Silk fiber	> Blue acid dye [Type XXX]	> Chemical softener [Type XXX]	> Optical brightener [Type XXX]	> Good
> Linen fiber	> Red reactive dye [Type XXX]	> Chemical softener [Type XXX]	> Optical brightener [Type XXX]	> Bad
> Wool fiber	> Yellow reactive dye [Type XXX]	> Chemical softener [Type XXX]	> Optical brightener [Type XXX]	> Fair

This image is for illustration purposes only, the biosphere circulation compatibility database is currently under development

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Product design principles: overview

3. Product composition data must be made available to enable circulation

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1

Created a simple webpage sharing detailed composition information for a demo product developed by project member Goldwin

2

Will find a simple way for brands to share product composition information, to allow consumers to verify the product, and to enable product sorting and end-of-use circularity

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Product design principles

The project's demo product, the Basque shirt, produced by Goldwin, was designed to be able to be converted into nutrients for fermentation

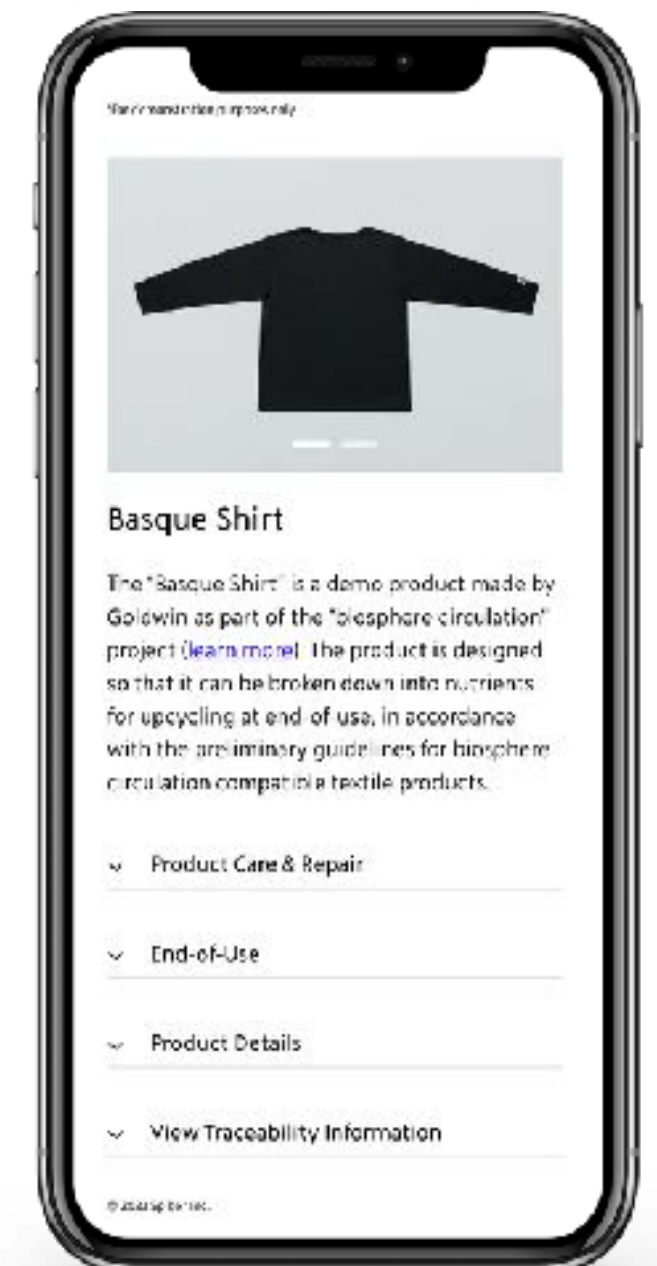
Full product composition information was uploaded to a simple webpage

[Read press release](#)

Images: Basque shirt, shirt sleeve with QR label



Figure 3. Product webpage



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Final statement

The “[biosphere circulation project](#)” is our approach to creating a new path for a more circular future

We believe in joining forces. By working together, we can tackle the challenges we face and realize this vision





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