Textile recycling technologies

destex

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MATERIALLY

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Introduction

Textile fiber recycling may be performed via mechanical or chemical recycling, the latter being less commonly used since it still represents a scenario under development: available solutions may require further perfecting, or not be economically convenient, or suitable, yet, for XL volumes, as the market may require.

Recycling processes via thermomechanical means frequently results in a loss of mechanical properties and overall performances, however they still represent the most frequently adopted recycling solution, even though chemical recycling leads to higher quality outcomes.

Mechanical recycling represents the basal process for recycling textile materials and consists in deconstructing the fabrics mechanically to obtain reusable fibers and material in an effective way. In the case of natural fibers, the resulting process outcomes are ready to be used to manufacture new yarns or new textile products, however they exhibit reduced quality features due to the fact that the fibers are shortened and damaged during the shredding process, and may require blending with additional fibers in order to create durable resulting fabrics.

Chemical recycling processes transform waste textile materials by means of specific chemical processes and enable the production of new fibers featuring properties that are equivalent to those of the initial fibers, or may be even better. Since these technologies are based on chemicals, they should rely on their re-use in order to be environmentally sustainable from the point of view of the process itself.

More uniform and homogenous materials featuring low to zero amounts of colorants, dyes, finishes, prints and toxic substances have greater chances to be returned to a cycle, but blends and chemicals do not represent the only obstacle to effective and efficient recycling procedures. In the case of finished garments, deconstruction and recycling procedures are complicated and decelerated by sewing threads featuring different compositions than the garment's material, as well as by buttons, zippers, closures, studs and further rigid components.

Keywords

textile recycling, mechanical recycling, chemical recycling, textile life cycle, end-of-life, closed loop, textile design for longevity

Goals

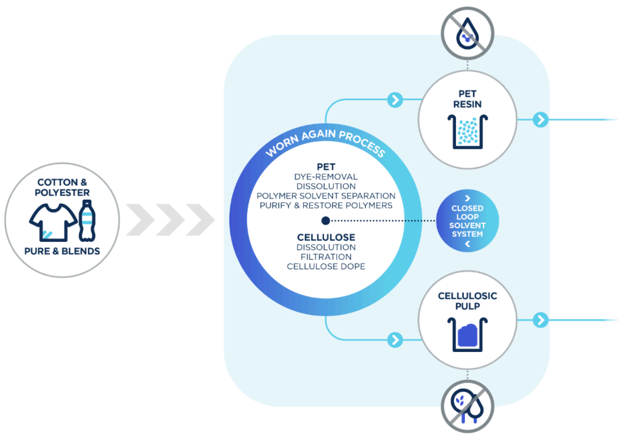
The OER aims are to provide students knowledge about advanced textile recycling technologies. In order to illustrate the state of the art of chemical textile recycling technologies, a selection of case studies of commercially available products and processes has been evaluated.

Structure of the OER

1. Worn Again Technologies
2. Carbios
3. Circulose®
4. Osomtex®
5. Texloop™
6. Infinited Fiber technology

1. Worn Again Technologies

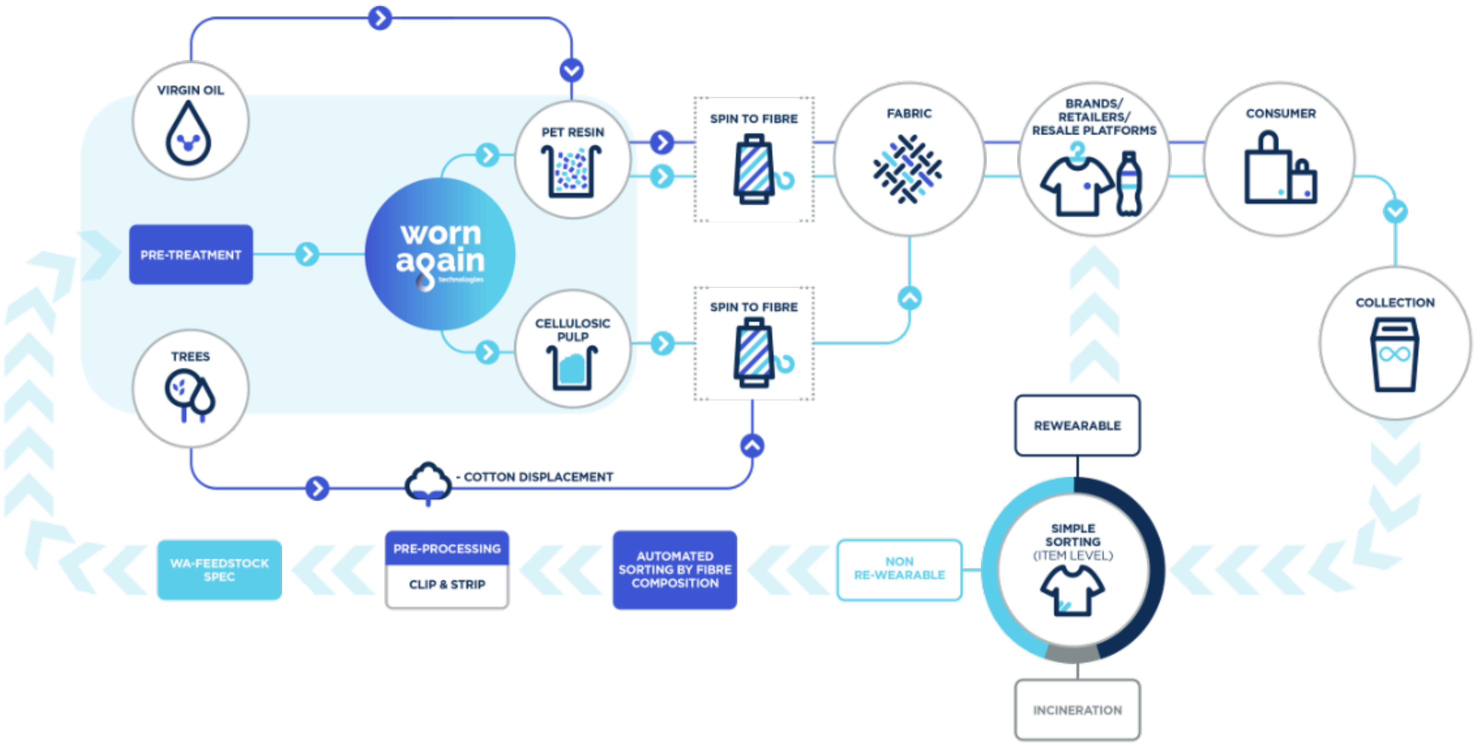
Worn Again Technologies advanced chemical recycling process turns non-reusable products - such as blended polyester and cotton clothing and textiles, PET plastic bottles and packaging - into virgin equivalent raw materials ready to be put back into production supply chains. Conventional recycling methods are unsuitable for polycotton blended textiles, which make up most textiles and require to be separated back into polyester and cotton. This advanced recycling technology is able to strip out dyes and finishes and separate, decontaminate and extract polyester and cellulose (from cotton) from non-reusable textiles and polyester bottles and packaging to produce dual PET and cellulose outputs. The resulting decontaminated and recaptured raw materials - polyester pellets and cellulosic pulp - can be turned into clothing like a virgin product through an environmentally friendly, closed-loop process. Compared with virgin raw materials, end products resulting from th quality and aim to be competitive in price.



Worn Again Technologies
https://wornagain.co.uk/

Status

In 2018, Worn Again Technologies was awarded a grant to become the first chemical recycling technology to be Cradle to Cradle (C2C) certified, as well as being named one of the LAUNCH Circular Innovators for 2018. In January 2020 the company has announced the launch of its pilot R&D facility as a major step forward in its development process and plans to launch its first industrial demonstration plant in 2021.



Worn Again Technologies

https://wornagain.co.uk/

2. Carbios

Carbios Biorecycling is an enzyme-based recycling process based on the use of enzymes, which can be considered “highly specific biological tools”. This innovative approach enables the specific de-polymerization of a single polymer (e.g., PET) contained in the various plastics to be recycled. This de-polymerization process results in monomers that are purified in order to be re-polymerized, thus enabling a perpetual recycling process. If plastic residues occur that are not degraded during the first stage, they are de-polymerized in a second stage by means of the same process, but by applying a different enzyme that will de-polymerize other polymers in the same way as in the first stage.

This recycling bioprocess for plastics enables to recycle plastics to infinity by returning to the original monomers which can be used in all applications in which the original material was used, as well as recover the same level of performance displayed by the original materials in the recycled materials. Among plastic waste, this enzymatic technology is particularly suitable for polyesters (PET, PLA, etc.) and polyamides (PA).

Carbios
https://carbios.fr/en/technology/biorecycling/

These polymers feature monomers chains that are easily identifiable by the enzymes, and are therefore easier to de-polymerize. In addition to textile waste, this technology is suitable for plastic bottles and containers (water, milk, sodas, cosmetics, etc.), packaging and films. At the beginning of 2020 the company announced its new step forward in the development of its enzymatic depolymerization process in order to make it suitable for PET polyester fibers from textile waste.

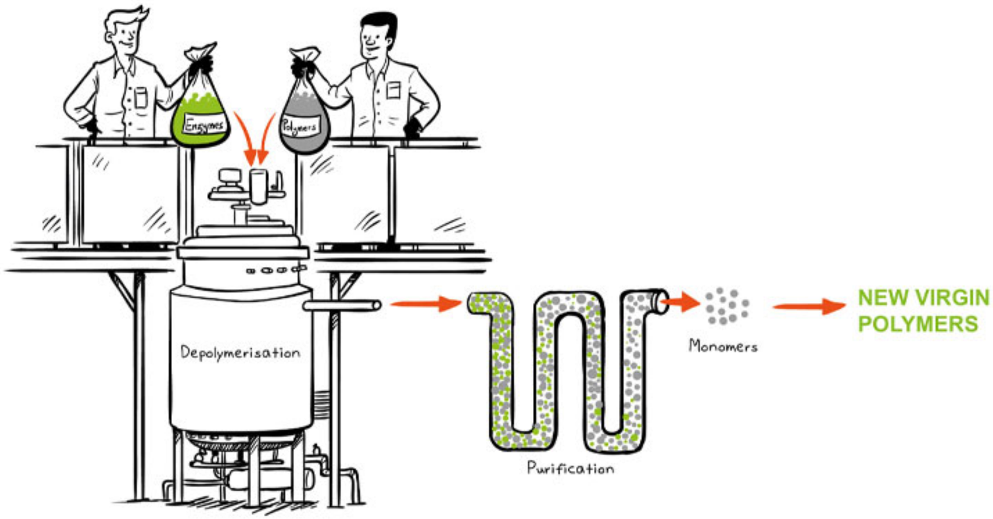
The process is based on an improved PET hydrolase that ultimately achieves, over a period of 10 hours, a minimum of 90% PET depolymerization into monomers, with a productivity of 16.7 grams of terephthalate per litre per hour (200 grams per kilogram of PET suspension, with an enzyme concentration of 3 milligrams per gram of PET). This highly efficient, optimized enzyme is claimed to outperforms all PET hydrolases reported so far, including an enzyme from the bacterium Ideonella sakaiensis strain 201-F6 (even assisted by a secondary enzyme) and related improved variants that have attracted recent interest. Biologically recycled PET exhibits the same properties as petrochemical PET, but can be produced from enzymatically depolymerized PET waste. Polyester is classified as today's single-largest-volume fiber produced globally, taking about a 50% share of the overall fiber market.

Carbios
https://carbios.fr/en/technology/biorecycling/

Status

After the successful demonstration that enzymatic depolymerization applied to PET plastics enables the virtuous cycle of a return to a virgin PET, CARBIOS opens a new major market by depolymerizing 100% PET textile waste fibers into their original monomers: PTA (terephthalic acid) and MEG (mono ethylene glycol).

The key objective of this new process developed with CARBIOS academic partners (INRA/TWB/LISBP) and supported by ADEME Auvergne Rhône-Alpes, is to provide: the recycling industry, a competitive solution to upcycle post-consumer PET polyester fabrics; and the textile industry, the ability to use recycled PET fibers that can fully replace those made from fossil resources.



Carbios
https://carbios.fr/en/technology/biorecycling/

3. Circulose®

Circulose® is a patented recycling technology by Re:newcell AB that transforms high cellulosic waste into pure, natural dissolving pulp, called Circulose® pulp.
This efficient chemical process does not use any solvents, but sustainable chemicals (exact recipe is a trade secret) that are recycled in the process, and was developed in response to the issue of waste generated by the fashion industry and allows for the closed-loop recycling of cellulosic textiles by reusing discarded textiles to create reduced environmental impact, new textile products.

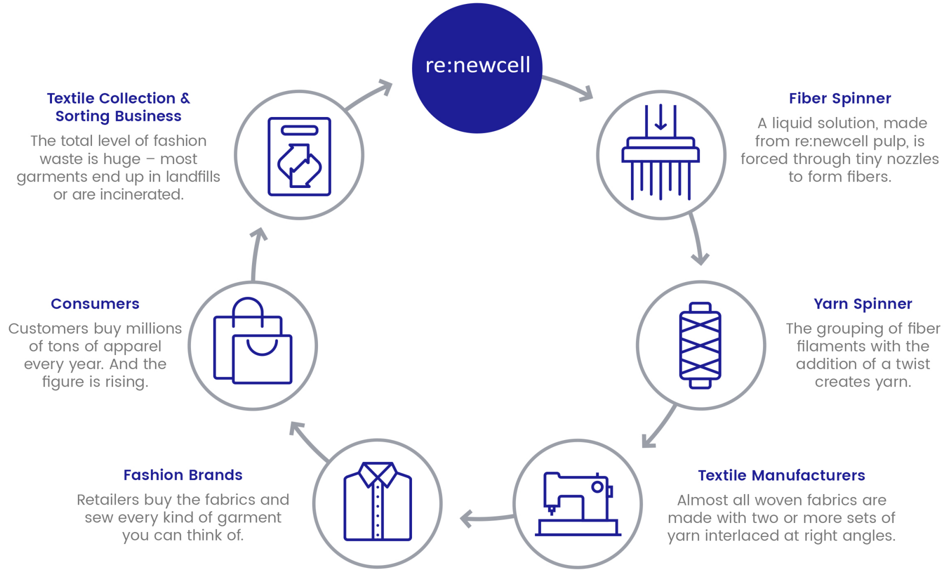
The process begins with collecting pre-consumer fabric scraps and post-consumer garments with a high cellulosic content (cotton and viscose) and reuses chemicals to dissolve the natural fibers. The resulting mixture is dried to produce a new, biodegradable pulp raw material, which is packaged into bales and fed back into the textile production cycle. The resulting material is certified organic, biodegradable, recyclable, and offers similar characteristics to conventional cotton fibers.

This recycling system uses less water and chemicals, emits less CO2 than existing conventional processes used to manufacture clothing fibers. While several initiatives are experimenting with new circular materials, this manufacturer claims that theirs is the first solution to work on a larger scale. Applications include textiles for apparel, footwear, accessories, furniture, and automotive upholstery, and stationery.

Re:newcell AB
https://circulo.se/

Renewcell works with brands, manufacturers, collectors and sorters to find large volumes of waste that are suitable for recycling. The company recycles high volume (5 metric tons or more), high cotton content (98%+) and consistent waste fractions with regular and predictable delivery terms (e.g. semi-monthly) and does not have the capacity to receive or sort waste directly from the public.

Renewcell takes in unresoldable garments, preferably cotton clothes because of their high cellulose content. The clothes are shredded, de-buttoned, de-zipped, de-colored and turned into a slurry, while contaminants like polyester or other plastics are taken out, leaving only cellulose. The slurry is dried to produce sheets of pure Circulose®, which are packed into bales and shipped to be made back into natural textile fibers. Garments and accessories manufacturers design new clothes using Circulose® fibers.



Re:newcell AB

https://circulo.se/

Status

The plant in Kristinehamn, Sweden produces around 7,000 tons of pulp per year. This allows the company to get the experience that will lead to the design of full-scale plants, each meant to produce approximately 30,000 tons of pulp per year. The first production unit certification audits and LCA measurements will be performed of actual production in 2020.

The Kristinehamn Plant is powered by 100% green energy from wind and water and the process conforms to all relevant Swedish environmental regulations, including REACH. Renewcell collaborates with selected retailers. Available from July 2020 as part of the Levi's® Wellthread™ line 2020, Levi's® has launched a jeans garment made with organic cotton and Circulose®.

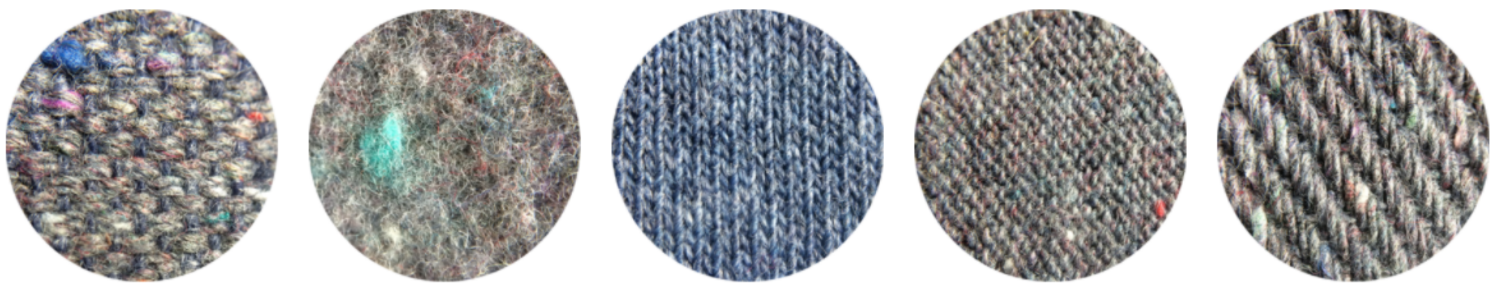
Re:newcell AB
https://circulo.se/

4. Osomtex®

Osomtex® by Upcycletex LLC is a patent-pending closed-loop manufacturing system for apparel that repurposes mixed discarded post-consumer and post-industrial textile products.

The resulting OSOMTEX® materials are upcycled yarns and fabrics composed of 70% post-consumer discarded clothing (average of 68% polyester, 27% cotton, and 5% other fabrics) and 30% polyester (or recycled polyester). The material is naturally flame-retardant and water-resistant due to the upcycled polyester content and is commercially tested for furniture and building applications. The upcycled yarn comes in several yarn counts from 8/1 to 20/1 (also available in 2, 3 and 4 ply). Fabrics are offered by weight, from a thick canvas to a light jersey fabric in a wide range of colors and different woven and circular knit constructions. It is also possible to customize the fabrics by material and the type of weave and color

WOVEN STRUCTURES



PLAIN WEAVE | FLEECE | BLUE CIRCULAR KNIT | GRAY CIRCULAR KNIT | TWILL

Upcycletex Llc
www.osombrand.com

The process recycles virtually all types of post-consumer garment and textile waste, without having to sort or cut buttons, zippers, tags, etc., by using state of the art technology that applies high-pressure air to separate fabrics from notions, preparing them for the subsequent mechanical process. It does not require any water, dyes and harsh chemicals, which leads to additional savings on water usage and greenhouse gas emissions.

Status

Upcycletex repurposes millions of pounds of discarded post-consumer and post-industrial textile waste per year. The manufacturer has started programs to collect directly from brands and companies, thus offering a completely closed-loop system from collection to upcycled yarn. Applications are for home, fashion, accessories, and furniture.

Socks are made of this upcycled yarn in Guatemala solar-powered and fair trade factories without changing the color of the yarn, which eliminates the need to use any harmful chemicals to dye the fabric.

Upcycletex Llc
www.osombrand.com

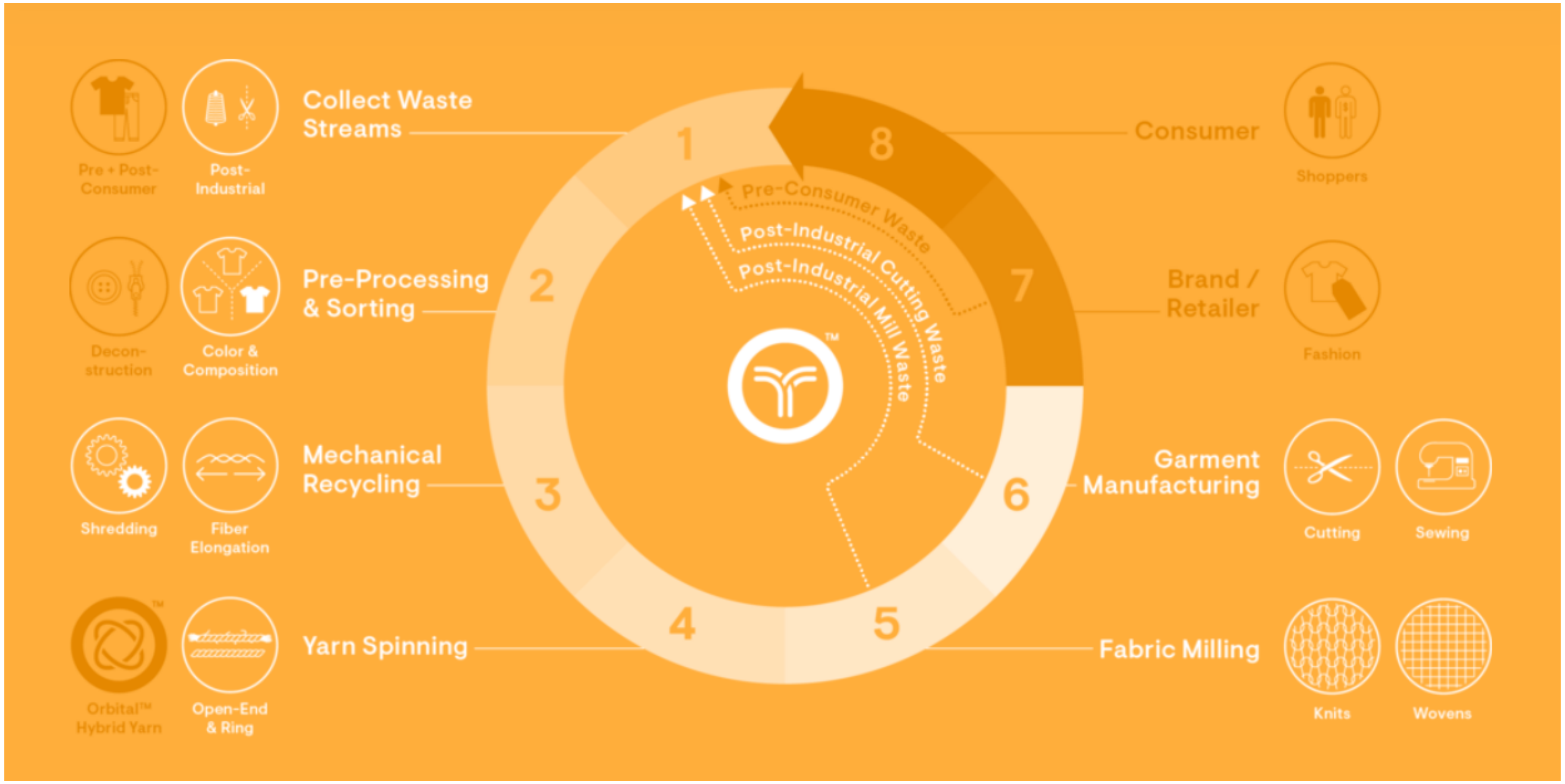
5. Texloop™

Texloop™ by Circular Systems is a processing system that converts pre- and post-consumer 100% synthetic and synthetic blend textile waste into recycled fiber, yarns, and fabrics. The technology is capable of managing complex blends, including stretch fabrics which are typically different to handle with conventional techniques, and fabrics featuring recycled polyester.

Finished fabrics come in all different constructions and in a variety of weights ranging from 53 gsm to 216 gsm (2 osy to 6 osy). With a maximum width of approximately 60 in (154 cm), fabrics are piece dyed or dyed with a waterless process to achieve custom colors.
Based on what the input is and their desired output, the company will set up a supply chain system to help facilitate the brand's recycling program. They have already established an end-to-end program in South East Asia. Their system is designed to achieve costs that are competitive with virgin polyester and is highly scalable. Applications include apparel, footwear, accessories, and upholstery.

Circular Systems
https://circularsystems.com/

Texloop™ RCOT Primo and Classic (post-industrial recycling process 1-6)



Circular Systems

https://circularsystems.com/

6. Infinited Fiber technology

Infinited Fiber Technology Company Oy's patented technology can turn textile, cardboard and agricultural waste into new natural fiber without any decrease in the quality of the fiber. Regardless of the raw material's origin (virgin or already recycled), the process may be performed not just once, or a limited number of times, but infinitely, while obtaining the same results in terms of output quality.

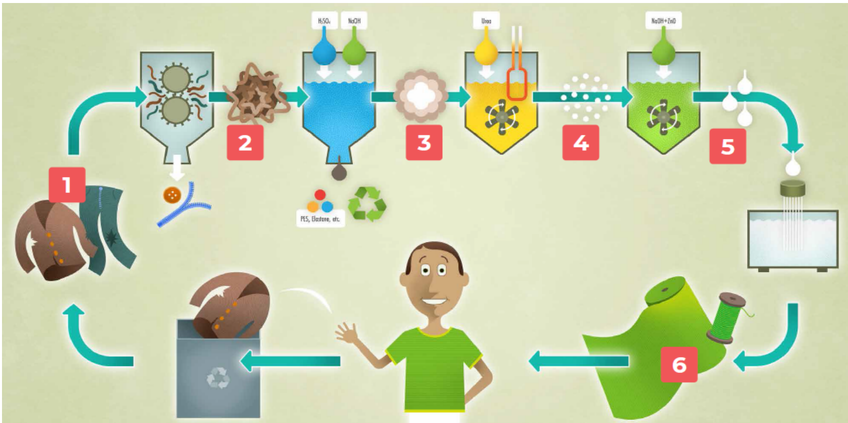
The core of the technology consists of three key processes: activation, dissolving, and fractioning. The technology offers significant economical and ecological advantages and may fit into any existing pulp and viscose fiber plant. The resulting high-performance fiber has a natural hand feel, similar to cotton, 30-40% higher color uptake, and natural antibacterial properties Key figures for a 1.3/40 fiber made from 100% textile waste includes a decitex (dtex) of 1.3, tenacity when dry of >22 cN/tex, tenacity when wet of >10 cN/tex, elongation when dry of 15-20%, and a length of 40 mm.

The new, chemically regenerated fibers are suitable for the fashion and technical textile industries and can replace viscose and cotton in several applications. Viscose production uses carbon disulfide (CS2), an environmentally and medically hazardous chemical, while cotton is regarded as a fiber whose availability does not meet the growing demand.

Infinited Fiber Technology
https://infinitedfiber.com/

This technology requires considerably less water for production than cotton, up to 5,300 gal (20K L) less water per lb (kg) than cotton, and 160K ha less forest needs to be harvested than viscose (30% of viscose comes from endangered and ancient forests).

1. SHREDDING: Clothes are shredded and non-textile materials like buttons and zippers removed; 2. FIBER SEPARATION: Cellulose based fibres are separated from other fibres like polyester and elastane. Colours and finishing chemicals are removed; 3. CONTACT WITH UREA: Urea is compressed into cellulose and heated. The cellulose carbamate is formed. Cellulose carbamate is a stabile powder that can be easily stored; 4. DISSOLVING: Cellulose carbamate is dissolved into honey like liquid in alkali solution. Dissolved dope is then filtered; 5. WET SPINNING: In wet spinning the filtered dope is pumped into acid bath through very small holes. Cellulose is crystallizing and orientated and a new fibre is born. Fibres form a tow called filament. Filament is then cut to needed length and fibres are washed, dried and baled; 6. PRODUCTS MANUFACTURED: Yarns, textiles and non-woven fabrics produced in different facilities.



Infinited Fiber Technology
https://infinitedfiber.com/

Status

The sale of the first licensed commercial plant with an estimated capacity of over 25,000 tons per annum is scheduled for 2020-2021. The first pilot plant started up production in March 2018 and is selling solutions to several leading global brands. The company is currently running its 50-ton per annum pilot plant next to its HQ in Espoo (Finland) and is going to build a second pre-commercial 500-ton per annum plant to start up in Valkeakoski by early 2020. IFC employs 11 people and its turnover in 2018 was EUR 1.5 million.

The business model of IFC is to license the Infinited Fiber technology for global fiber producers in textile and non-woven industries. The end-use applications include fashion, home textiles, disposable personal care products (e.g. wipes, diapers, pads) and technical products (e.g. automotive filters, dairy, construction applications). The production process is protected by several patents in key market areas.

Infinited Fiber Technology

https://infinitedfiber.com/

Visit http://destexproject.eu/ to see the rest of the intellectual outputs of the project

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