Green Machine:
Using Hydrothermal Technology to Separate and Recycle Polyester and Cotton Blends

For ITMF Awards 2022

The Hong Kong Research Institute of Textiles and Apparel (HKRITA)

Executive Summary

The quest for full circularity within the fashion industry has been growing rapidly. The world is looking for practical solutions to recycle textile wastes along the fashion value chain and make them into quality textile materials that can be reused in textiles and apparel application.

Mixed colour and blended materials are the two pain points in textile recycling. They affect the quality and consistency of the recycled material, lowering their value and limiting their application. Green Machine has adopted the world's first hydrothermal separation and decolouring technology developed by HKRITA. Through hydrothermal treatment, effective separation of PET from PET-cotton blend, which is the most common textile blend used in the industry, can be achieved. Under hydrothermal conditions, the reclaimed PET materials swell, allowing the dispersed dyes to be released from the fibres with the aid of crosslinked polystyrene (PS) beads and activated carbon (AC) particles to achieve decolourisation, accomplishing over 95% colour removal of disperse dyes.

With major fashion brands pledged to use only sustainable and recycled material by 2030, Green Machine would provide an extra source of recycled PET (rPET) supply and achieve full circularity of PET material within the industry by recovering PET from blended textile waste. It provides an alternative source of rPET such that the fashion industry can avoid competition with bottle and packaging industries for plastic bottles, as well as China's ban on solid waste import that further limits the supply.

The achievement will serve as a tangible technology solution for textile & apparel and recycling industry partners, no matter in major textile production regions or high consumption regions.

Biography

Established in 2006, The Hong Kong Research Institute of Textiles and Apparel (HKRITA) is funded by the Innovation and Technology Commission of the HKSAR government, and hosted by The Hong Kong Polytechnic University.

HKRITA has achieved research deliverables over the years around our research clusters targeting in industry 4.0, sustainability, and social benefits through our centre-owned research teams and laboratories as well as collaborations with industry partners and institutions.

Our vision is to be the leading centre of excellence in research, development and technology transfer in fashion and textile industry.

Our mission is to be a Hong Kong based world renowned research institute for the textiles and clothing industry by concerted and focused R&D efforts to enhance the economic development of the HKSAR, mainland China and overseas. And by facilitating technologies transfers of R&D results, in pursuance of continual development technologies to enhance the competitiveness of the industry locally and internationally.

Achievements

HKRITA provides advanced textile technologies which are available for industry partners globally. By April 2022, HKRITA has 122 IP granted, 98 IP filed, 57 licensees, and 75 license signed. Since its establishment in 2006, we have also received 91 awards recognising our efforts in promoting textile innovation, fashion sustainability, and industrial design. One highlight of our achievements is winning a total of 61 awards in the International Exhibition of Inventions of Geneva, including 27 Gold Medals. Centre's award details are available on https://www.hkrita.com/en/our-innovation-tech/achievement/awards

Green Machine has received 3 awards for its technological innovation and sustainable upcycling of post-consumer textiles, including the Gold Medal in the 46th International Exhibition of Inventions of Geneva (2018).

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Exceptional Achievements

Focusing Aspect

Green Machine focuses on a primary problem in the textile industry: waste. An estimated 92 million tonnes of textile waste are created annually while <1% of clothing is recycled due to difficulty in recycling PET-cotton blended fabrics.

Green Machine is an innovation to recover PET from PET-cotton blended textile wastes and to reduce petro-based raw materials consumption. It is also related to a new solution for cotton farming and bio-based products manufacturing.

Challenges

Blended materials and mixed colours are the two pain points in textile recycling. Green Machine takes the challenges on (1) separation of PET-cotton blended textile and recovery of PET material, and (2) PET decolouring.

Methodical Approach

The achievement is related to a process. Green Machine uses HKRITA's hydrothermal technology with heat, water, pressure, and biodegradable green chemical to separate PET fibres and turn cotton into cellulosic powders. First, cotton-PET blended textile wastes shredded in pieces are put into the reactor with green chemicals. The temperature of the reactor is raised to required temperature; after that, reaction with agitation for 0.5-2 hours. PET fibres and cotton cellulosic powder are recovered by filtration. PET fibres remain intact without depolymerisation, while cotton is converted into cellulosic powders and further collected for re-spinning.

For textiles to be reused or re-dyed, PET fibres are decoloured. PET fibres swell under hydrothermal conditions, allowing the the dispersed dyes to be released from the fibres with the aid of crosslinked polystyrene (PS) beads and activated carbon (AC). PS beads contain a high density of hydrophobic groups, and so are able to adsorb and trap hydrophobic dyes. While AC has a high degree of micro-porosity, providing a large surface area, and so aids the adsorption of dye molecules. Unlike tradition decolourisation that relies on using large amount of chemical solvent, this hydrothermal-related decolourisation is more environmentally-friendly and cost-effective. The recycled fibres can thus be re-spun into new yarn and further made into fabrics.

The hydrothermal separation process is a highly efficient and green separation process with over 98% recovery of polyester, using 95% reusable water and less than 5% organic acid. Through PET decolouring, over 95% of colour removal can be achieved on recovered PET, improving the reusability and versatility of the recovered PET material.

The cellulosic powders can be used as raw materials in regenerated cellulosic yarn and PFC-free water-repellent textile finishing. They can also be further processed to become superabsorbent polymer for cotton plantation.

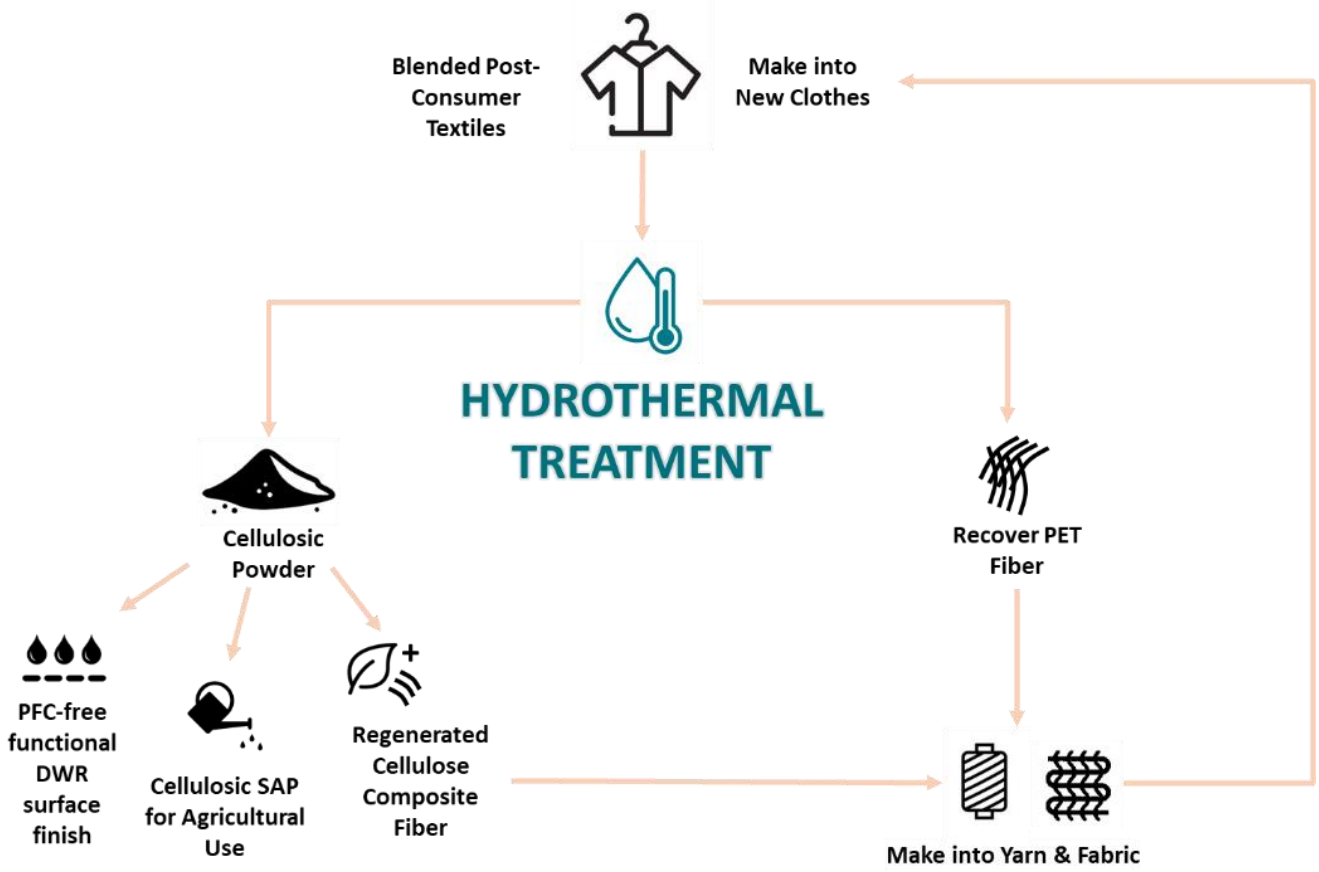

Fig. 1 Hydrothermal separation & recycling using Green Machine

Industrial Achievements & Benefits of Green Machine

Green Machine has been successfully upgraded to industrial scale. The first Green Machine is built at PT Kahatex which is an established vertically integrated textile manufacturer in Indonesia. Within a 400 m^2 area, it has the recycling capacity of PET-cotton blended fabrics of 210 kg per batch scale. That means capacity of over 1.5 tonnes daily or 450 tonnes annually could be achieved. Its recycled PET fibres have a purity value of average 98% for re-spinning. Besides, fashion brand Monki has started using textile materials made from Green Machine.

Life-cycle assessment shows that using 100% recycled fibres from Green Machine can save approximately 20% CO_2 emission and 50% of the waste to landfill compared to using virgin PET fibres. We are aiming at developing a 2-times higher recycling capacity system as 900 tonnes annually.

The technology of Green Machine responds to two of United Nations Sustainable Development Goals: Industry, innovation and infrastructure (SDG 9) and responsible consumption and production (SDG 12).

In addition to recycling textile waste, it has added value to build a sustainable cotton farming. Cotton fibres are decomposed into cellulosic superabsorbent polymer (C-SAP), which can highly retain soil moisture. For rain-fed farming areas, cotton yields could still be guaranteed even under drought, ensuring farmers a more stable yield. Environmentally, C-SAP could relieve soil degradation; while socially, it increases income security to farmers with higher crop yield.

Fig. 2 Green Machine in PT Kahatex, Indonesia

Read More on Green Machine

https://www.planetfirst.one/greenmachine

https://www.hkrita.com/en/our-innovation-tech/projects/34

https://www.hkrita.com/en/our-innovation-tech/projects/31