All-Cellulose Composites: Fast Fashion to Smart Materials

Ashley Victoria
University of Leeds Centre for Doctoral Training in Molecules to Product
bgy2mve@leeds.ac.uk

Introduction

Our efforts in recycling have made considerable improvements over the last 20 years to the way we manage waste, but there is still a large amount of un-recycled waste, destined for landfill or incineration. The reasons for this depend on the type of waste being discarded, and the viability of the recycling route which can vary among product types.

The growth of fast fashion has led to more clothing being discarded, sometimes after being worn only a handful of times. Although it is possible to recycle end-of-life clothing, the process of breaking down fabrics back into fibres can be energy intensive and disruptive, leading to recycled fibres with a loss in strength and quality. This means that they are often 'down-cycled' to lower grade products. It is therefore necessary to look to alternative solutions for dealing with textile waste.

With an increased need to reduce global warming and environmental impacts, it is vital that eco-design measures can be developed that are fit for circularity, and the commercialisation of new and innovative technologies can be achieved with these objectives in mind.

Recycling

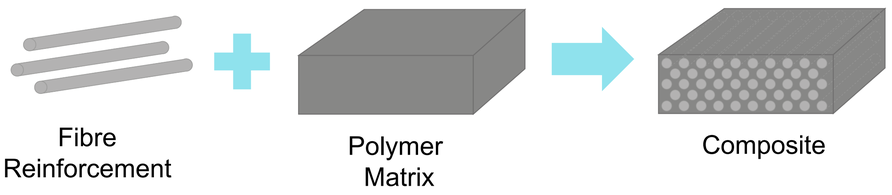
For products to be recycled, they have to be broken down into their constituent materials, and this is easier for some materials than others. Although many plastics can be recycled with relative ease, there are some polymer based materials that don't recycle as easily.

Some materials such as fibre-reinforced plastics have additional components added to improve their properties.

This is an example of a **composite** material.

Composites

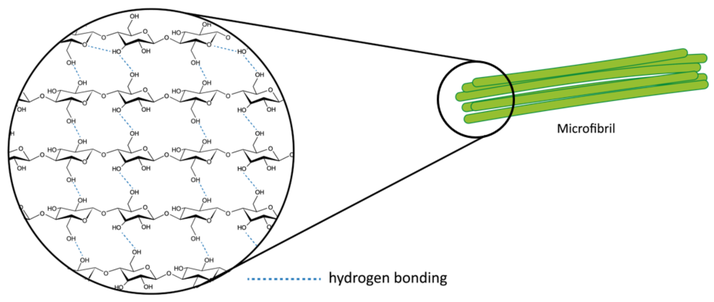
Composites are materials produced from two or more dissimilar components that remain separate within the composite structure as a matrix, and a reinforcement phase.



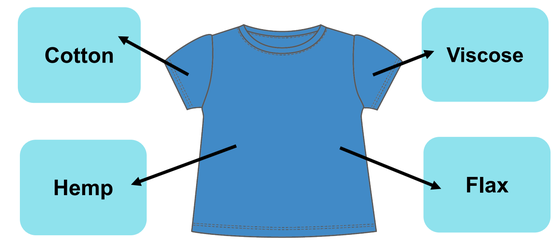
Recycling composites involves separating the different components within them and this can make the process complex and costly.

Cellulose

A large amount of fabrics used to make clothing are made from cellulosic fibres such as viscose, hemp, flax, and one of the most prevalent fibres used in clothing, cotton.



This biopolymer has the potential to bring strength to materials and has been used in the development of all-cellulose composites.

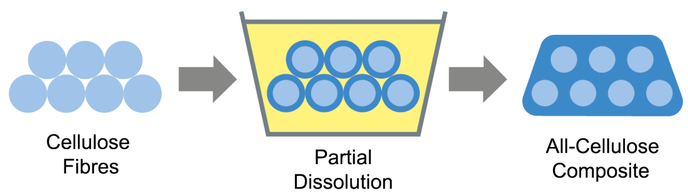


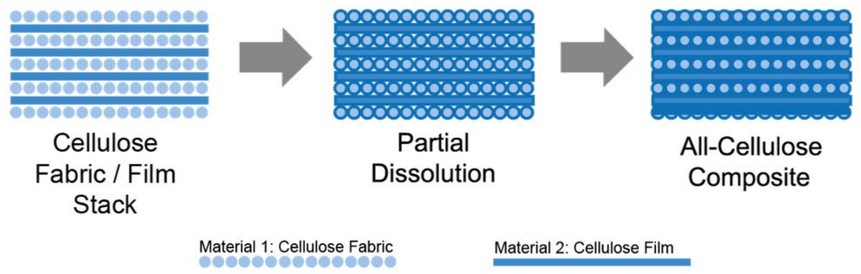
Cellulose is a biopolymer that originates from plants, bacteria, and algae, and is used to make fibres for clothing.

Strong hydrogen bonds between the cellulose units lead to the formation of microfibrils which have been found to have excellent tensile properties that can match that of steel.

All-Cellulose Composites

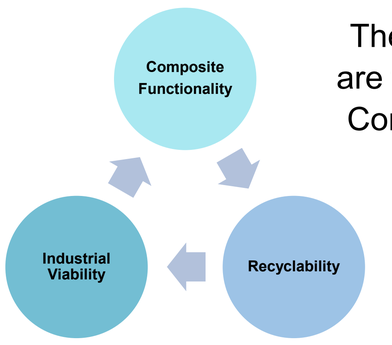
In all-cellulose composites, both matrix and reinforcement phases are formed from cellulosic material, resulting in a composite made from components that are chemically identical, making them easier to recycle than traditional composites.





Using this principle, layers of cellulosic material in fabric and film forms can assembled into a layered stack and dissolved in ionic liquid to create thicker materials that can be formed into three-dimensional shapes.

Aims & Objectives



The aims & objectives of this project are focused around three key themes: Composite functionality, recyclability, and industrial viability.

Can these materials make suitable alternatives to those harder to recycle?

- Investigate the influence of weave structure on the mechanical performance of ACCs.
- Study the influence of cellulose source on dissolution behaviour.
- Assess recycling potential and optimisation for commercial recycling.
- Optimise the process for commercialisation within industry.
- Assess the environmental impacts of the process and minimise.

Sustainability Development Goals

This project aligns with Goals 12 and 13 of the **United Nations Sustainable Development Goals.**

Goal 12 relates to using natural resources more responsibly, and reducing waste generation through recycling and reuse. By understanding the full life-cycle of a product and designing for circularity, materials can be designed to remain in a circular economy.

Goal 13 relates to tackling climate change. By assessing the environmental impacts of new technology, we can design processes with reduced carbon emissions and protect our Earth from global warming.

Summary

ACCs have the potential to provide sustainable alternatives to many man-made materials used in the consumer products industry that cannot be recycled easily. This work will build on existing knowledge and provide additional insight into the structure and functionality of these materials, allowing the development of economically and environmentally sustainable process routes. This will make use of clothing waste, reduce the amount of virgin material required to make new products, and move us forward in the development of a circular economy.

Acknowledgments:
Centre for Doctoral Training in Molecules to Product
Supervisory team: Michael Ries, Peter Hine, Richard Hodgett

References:
1. *Y. Ma, L. Rosson, X. Wang and N. Byrne, The Journal of The Textile Institute, 2019, 111, 630-638.*
2. *United Kingdom Pat., WO2020016583, 2020.*
3. *A New Textiles Economy: Redesigning fashion's future, Ellen MacArthur Foundation 2017.*