Title: Upcycling, design and material innovation

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Upcycling: adding value through design
Textile designers have a natural affinity with reusing materials – they are interested in how textiles look, behave and feel. Through working with materials in a hands-on context, textile designers for centuries have reused material as a matter of economic need and aesthetic appeal. From making patchworks to unravelling knitwear, a body of tacit knowledge has grown amongst those that work closely with materials.

It was no surprise then, that in 2004 as the research according the future of sustainable fashion textiles in the UK began for the Crafts Council’s Well Fashioned exhibition, that some of the best work would be in the innovative reuse of old clothing. A series of projects enabled the team to focus on pushing this innovation even further; inspired by Cradle-to-Cradle thinking [1] in 2005 the creation of a set of principles that would guide designers towards ‘upcycling textiles’ began [2]. The driver was to add value to the material and/or product through textile design; to improve the economic potential for upcycling in the sector. After much work in the field, 10 years later in 2015, the team embarked on the Trash-2-Cash (T2C) project, an EU-funded Horizon 2020 consortium project with 18 partners across 10 countries.

Global context
As a result of population growth, improved standards of living and the increasingly sophisticated desires of developing nations, the global demand for textile fibers is rapidly increasing. In the near future, due to the area of land required for farming and the amount of water needed for irrigation, the textile industry will be simply unable to grow enough cotton to satisfy this demand. We have reached ‘Peak Cotton’. Therefore, sustainable alternatives are required.

Polyester, the world’s most common textile fiber, is easily recycled but non-biodegradable. Man-made from crude oil – a polluting, finite, rapidly-dwindling natural resource – enough polyester has been produced to serve us indefinitely, most of which ends up in landfill. Each year we throw away over 3 million tons of textiles in the EU-28 countries. As a result, the one resource that is becoming ever more abundant is waste. Cotton and polyester, both of which are used for industrial applications and the upcycling of post-consumer textile waste into products is challenging to scale.

What is T2C and how does it address these issues?
Trash-2-Cash aims to progress us towards the sustainable textile industry of the future, one that benefits both people and the planet. It proposes a new, innovative model where paper and textile waste is recycled with environmentally benign chemicals, creating new regenerable fibers, textiles and products, which are the same quality as virgin materials, from pre-consumer and post-consumer waste. Trash-2-Cash is developing mass-producible circular...
fibers: cellulosic fibers from recycled paper and card production waste and closed loop recycled polyester fibers from used clothing. These fibers will be ‘technical nutrients’ that can be recycled indefinitely within a closed-loop, cradle-to-cradle system without any loss of quality.

In this unique collaboration between designers, scientists and manufacturers, the project is developing state-of-the-art fiber recycling methods and creating new high-performance fibers, high-quality textiles and product prototypes from waste, offering the fashion, interiors, automotive and other luxury goods industries new eco-fiber options.

Designers, design researchers, scientists, raw material suppliers and product manufacturers from across Europe make up a cross-disciplinary consortium representing the whole product supply chain. We are working together over a three-and-a-half-year period to address the challenge of designing high quality industrial materials from waste. The first phase was cross-sectoral, with the whole group designing a wish list of fiber properties, then describing a vision for how the novel recycled materials will be used. In the second phase, material scientists produced samples of the new recycled cellulosic and polyester materials, and designers and industry produced material prototypes, based on consumer insights. 3 of the final products are being shortlisted using new tools that assess ‘success’ potential from the perspective of each partner. These will undergo full LCA testing and will then be further developed to market readiness.

Design driven material innovation

In addition to the development of new fibers and products, the project also hopes to influence how all novel materials are developed in the future through a collaborative Design Driven Material Innovation (DDMI) methodology by demonstrating its effectiveness. The process is being led and refined by the academic partners to facilitate collaboration between science and design experts.

DDMI aims to bridge different approaches in order to create new recycled materials that are informed by, as well as drive, the market for new sustainable products.

The process of developing the methodology works like a road map and is crucial to the workshops attended by the partners. Tools to support the methodology include physical workshop activities based on interactive charts, card games and score sheets, all designed to evolve the knowledge exchange and ideation process. These sessions are carefully coordinated to make breakthroughs, resolve challenges, refine innovation and generally to manage and direct the expertise and insights within the project. This new way of working will outline how science, design and industry can input into the process from beginning to end. During the last phase academics will reflect on the new DDMI methodology, drawing upon their observations from the entire project.

Design and life-cycle thinking from fiber to fabric

Design approaches drive the consortium work and include academic partners’ reviews, tests and assessments of the scientific output, looking specifically at the potential for viable, marketable, new product concepts where scalability is possible. Specifically designed life-cycle charts are being developed in conjunction with strict life cycle assessment processes for the analysis, and together form a communication bridge to industry enabling the creation of design prototypes with ‘accountability’.

Materials, technologies and partners

Ioncell-P technology, developed by project partner Aalto Chem and the University of Helsinki/Finland, is a chemical fiber recycling process that converts wood and other cellulosic materials into textiles without the use of harmful chemicals. It is an environmentally friendly alternative to water-intensive cotton production that also knowledge exchange and ideation process. These sessions are carefully coordinated to make breakthroughs, resolve challenges, refine innovation and generally to manage and direct the expertise and insights within the project.
has the potential to revolutionize the recycling of textile waste, turning waste cotton into upcycled, high-quality fibers. Ioncell-F is a new technology for producing man-made cellulose textile fibers using a novel, solvent, ionic liquid.

Currently, there are 2 main man-made cellulose fibers (MMCF) on the market: viscose and lyocell (Tencel®). Production of viscose requires the use of carbon disulfide, a very toxic chemical. The solvent applied in the production of Tencel® fibers, NMMO, also has an intrinsic shortcoming: its chemical and thermal instability, causing a risk of dangerous runaway reactions. The ionic liquid used in the Ioncell-F process is an environmentally friendly and inherently safe alternative to the solvents used in current MMCF production processes.

Recycled PET (polyethylene terephthalate) – the most common polyester – pellets and an innovative catalyst are driving sustainable developments in polyester recycling in Trash-2-Cash. There is a great need to convert material not qualified for reuse into high-value virgin textile fiber, thereby realizing the sustainable utilization of textile resources.

The key Trash-2-Cash partners involved in polyester recycling are Celanese Corp., Irving, TX/USA, and Swerea IVF in Sweden. Celanese are developing the recycled PET pellets and Swerea focus on the development of a catalyst that activates the breakdown of polyester at a low temperature.

The recycled pellets produced are used for both injection molding and melt mixing processes. Injection molding results in the production of composites, and melt mixing produces upcycled polyester yarn. Celanese are also directly involved in the melt mixing process, transforming recycled polyester in the form of fluff using advanced extrusion methods.

The polyester recycling approach, developed by Swerea IVF in Sweden, uses a mild chemical method to ‘depolymerize’ – breakdown long polymer chains of polyester into smaller, individual units of polyester molecules (monomers). This method is used on pure polyester as well as cotton/polyester blends. The obtained monomers are easily purified from dyes and finishes, and are subsequently suitable for use as raw materials for virgin polyester production.

Compared to polyester synthesized directly from crude oil, polyester made from a regeneration process consumes less energy and releases less CO₂ into the atmosphere. Taking this process forward means the fashion industry’s dependence on finite, polluting and unsustainable resources will decrease along with the raw material costs.

Contemporary recycling methods often produce poor quality products, particularly with thermoset composites. To resolve this problem, closed-loop recyclable thermoset composites are being developed, made with cotton and polyester waste textiles and epoxy or poly-urethane resins.

Trash-2-Cash partners Cidetec, San Sebastián/Spain, are responsible for the research and development of

Printed nonwoven material made from polyester fleece clothing (© Becky Earley)

T2C designers, scientists, engineers and industry experts working together at Prato Textile Museum
sustainable thermoset resins and composites, particularly with the future car industry in mind. These renewable composites are new generation, using different combinations of cotton and polyester waste fiber or fabric. 2 types of recyclable dynamic resin are produced: a polyurethane (PUR) resin and an epoxy resin. The PUR resin is combined with recycled PET fabrics to form flexible composite parts. The epoxy resin is combined with recycled PET or regenerated cellulose fabric using the resin transfer molding (RTM) manufacturing technique to form ridged composite parts. In order to make the products marketable, Cidetec apply decorative and functional finishes using different technologies to include lasering.

In addition to Cidetec’s main market, the automotive industry, the flexible composites are also being developed for innovative waterproof garments.

Rebecca Earley discussing design concept work with the T2C consortium (© Kate Goldsworthy)

Challenges faced
Several challenges face the consortium. There is a clear need for mechanical innovation to sort recycled textile fibers. A big challenge with recycling is processing blends. In order to create regenerated fibers from waste, the ability to separate the fiber at the recycling stage is imperative due to the different chemical processing requirements. Feasibility studies are being carried out to assess future market viability and to help analyze which innovations and processes realistically are best to progress. The studies take into account long-term circularity in the broadest sense.

Outcomes
In the latter stages of the project, research and innovation merge together to create a portfolio of final concepts. T2C will present the final prototypes at Dutch Design Week (October 2018) in Eindhoven/Netherlands. These will include circular prototypes for the fashion, car and technical textile industries.

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Centre for Circular Design (CCD)

After 21 years of Textiles Environment Design (TED) at Chelsea College of Arts (1996-2017), co-directors Professor Rebecca Earley and Dr. Kate Goldsworthy founded a new research center dedicated to design research for circular economies through practice-based and design-driven exploration of materials, models and mindsets. The Centre for Circular Design (CCD) will accelerate the development of design for circular futures where textiles and materials are envisioned, produced, used and disposed of in radical new ways. By bringing together academic and industry research concerned with designing textiles and textile products for the circular economy, it explores the design of new materials with approaches ranging from emerging technology, systems design, tools, user behavior and social innovation models.

References:

[1] Braungart and McDonough 2002 Please give full reference