RECYCLING
TEXTILES & PLASTICS

CENTEXBEL-VKCINFO

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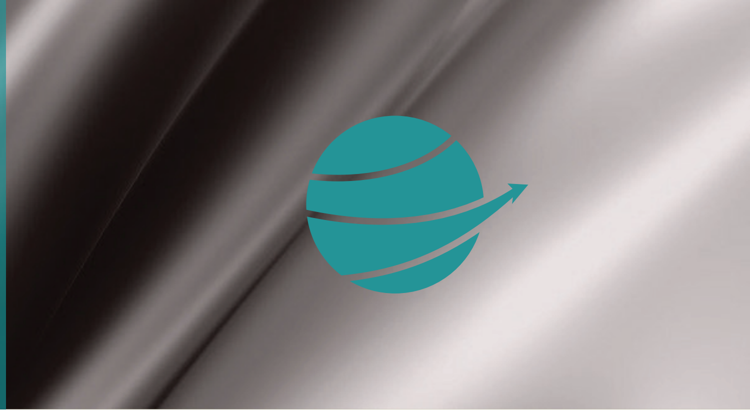
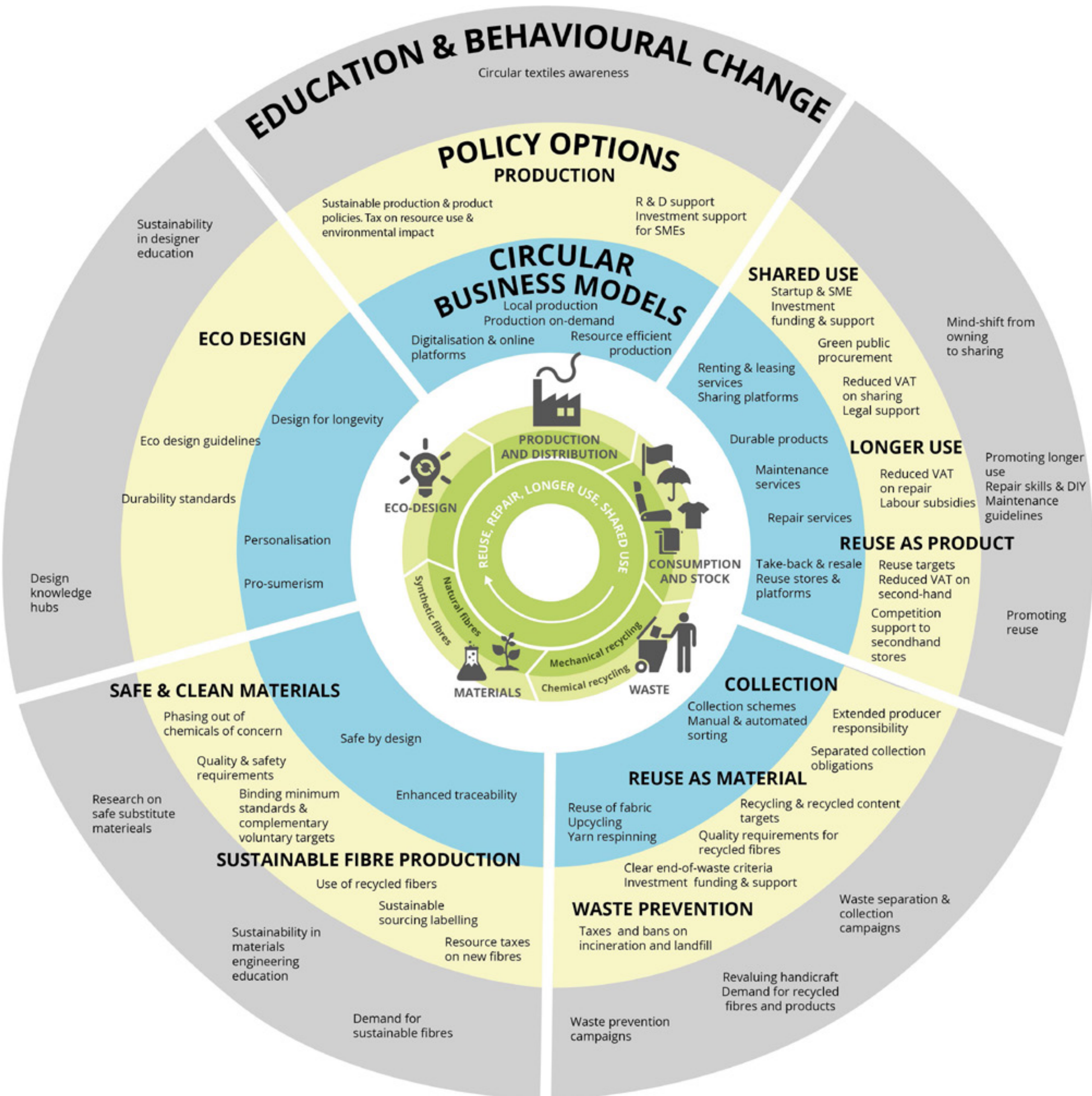
REDUCE
REUSE
RECYCLE



In 2019, the European Commission identified (plastic) packaging and textiles as priority product categories for the circular economy in ***Sustainable products in a circular economy - Towards an EU product policy framework contributing to the circular economy***[1]. Furthermore, Ursula von der Leyen, President of the European Commission, announced in ***My agenda for Europe***[2] that she will propose a new circular economy action plan focusing on sustainable resource use, especially in resource intensive and high-impact sectors, such as textiles and plastic packaging.



1 https://ec.europa.eu/environment/circular-economy/pdf/sustainable_products_circular_economy.pdf

2 https://ec.europa.eu/commission/sites/beta-political/files/political-guidelines-next-commission_en.pdf

Priority product category: textiles

Textiles such as garments, textile parts of footwear, and home interior textiles including carpets, are sold worldwide. Textiles are also used in many industrial applications including construction, automotive and other sectors. The EU is both a major producer and consumer of textiles.

The European textile and clothing industry employs 1.5 million people and generates a turnover of EUR 149 billion. The EU exports to the rest of the world represent more than 30% of the world market. While the EU remains a net importer of textiles and clothing, with annual imports over €80 billion, exports increased faster than imports in recent years. The EU is also one of the world's largest carpet producers. For example, around 65% of EU demand for carpets is fulfilled by EU-based manufacturing (high compared to other textile products), creating jobs in the EU.

Sustainability aspects of textiles

The production of some natural fibres, such as cotton and wool, requires much water and other agricultural inputs, while synthetic fibres and yarns used for the production of textiles are mainly fossil-based and also have plastics related issues such as a microfibre or microplastic discharge. The production of textiles emits CO_2 and other compounds to air and/or water. Apparel and footwear account for 8% of global GHG emissions worldwide, and the emissions are expected to increase, in a business as usual scenario. Textile production often involves the use of chemicals (e.g. for colouring) that can have negative environmental and health impacts. The fast-changing fashion in clothing means their first use is often short. Once discarded, textiles are in some cases collected for reuse or recycling, often by charities or other non-profit organisations, contributing to an extended use of clothing. However, much textile material is not dealt with in a circular way: it has been estimated that a full truck of textiles is sent to incineration or landfill every second, worldwide. Recycled materials used in textile production account for only about 1%. The situation in the EU is slightly better, with infrastructure for the collection, reuse and recycling of textiles in place or being developed in a number of Member States. However, even in the EU, collection rates are estimated to be as low as 25%, though large differences between Member States exist.

Recycling

Recycling of textiles takes place to a limited extent and when it takes place, it is often a matter of downcycling where the recycled material is of lower quality and functionality than the original material. There is limited knowledge of the feasibility of recycling of a number of fibres in mixtures, from an economic and environmental point of view. **Challenges include the complex combinations of materials in garments and the presence of hazardous 'legacy' substances, such as flame-retardants in carpets that were authorised at the time of production but are (soon to be) subject of restictions at the time of recycling.**

In the case of clothing, in particular, there is no urgent incentive for a better reuse, repair and recycling because of the very low price of new clothes and their often very poor material quality.

Sustainable business models

To ensure the uptake of more sustainable business models, the value of products, materials and resources must be preserved in the economy while minimising the generation of waste and technological innovation needs to be fostered.

Some EU policy instruments are in place, addressing impacts during production, use and end-of-life. However, no instrument exists to set up design and durability criteria for textiles.

Because of the large amounts of textiles on the EU market in combination with a relatively low performance of the circular economy loops such as reuse and recycling, there is a large margin for improvement. For example, an increase in duration of first use, reuse and repair of garments resulting in a reduction in production and sales of new garments by just 5%, is estimated to deliver a sustainability benefit equivalent of 20.000 kg of CO_2 emissions. The accompanying economic impact of an increased reuse and repair in terms of value and job creation was projected to be positive as well (though harder to quantify).

Priority product category: packaging

The increasing usage of polymeric materials and growing range of requirements in product design lead to the combined use of more than one material in the same product, the so-called multi-material products. Unfortunately, these technically excellent products complicate conventional recycling processes even more.

The main problem in recycling polymeric multi-material products is related to the difficulty in separating their components. The large variety of resins, polymers and formats used to create flexible packaging challenges efficient collection, separation, recycling and resale of this material. While new innovations and systems have been created to address single polymer materials, limited options for the end-of-life management of multi-materials flexible film packaging continues to challenge these types of packages.

Current compositions of multi-material flexible packaging vary from three layers up to nine and even more. Because there is no standard composition, and different resins are utilized across the various layers, there is no program anywhere across the globe to provide for the recovery of these materials. With an estimated 40 billion pf packages produced from multi-material films annually in the U.S., finding solutions to collect, sort and recover these materials is becoming of increasing interest to packaging and waste communities, as well as, consumers across the globe.

Quite often, when any new material is introduced into the marketplace, recycling is one step behind. The cycle of innovation requires that as needs arise and markets grow, investment into solutions will advance. This dynamic relationship between demand, innovation and economics is what created our existing recycling systems in the first place. Many of the materials accepted by public recycling systems today were established during wartime when demand for resources was high. The government and military contractors relied on the re-use of materials and invested in systems for their sorting and processing. While there is increasing support for innovation in material recovery systems, establishing the economics of end markets, collection and demand still remain beyond the direct control of those seeking solutions. Market economics always has, and will, continue to play a role in driving sustainable recovery systems.

When we examine the history of material recycling, a common pattern emerges, regardless of the material type. A new material is identified and developed for consumer use, collaboration occurs to identify solutions for recycling, investments are made to scale up technological solutions and end markets are identified or created. Once cost-effective processing solutions and viable end markets can be established, materials will gain acceptance into public collection systems.

Common Process	Common Challenges
• Identification of technologies and best practices to process materials. • Identification of cost-effective collection systems. • Regulatory approvals and legislative support granted (as needed). • End markets develop over time as a result of economics, regulatory, and manufacturer support.	• Consumer education and participation in collection to ensure adequate recovery rates tend to occur over a long time period. • End market development takes time and may be influenced by global economics.

Initiatives to find effective recycling solutions for multi-material flexible packaging have tackled some, or all, of these challenges. Some projects and pilots have identified solutions to specific challenges, but the key to addressing all aspects of the recovery system is still elusive. Yet, as we know from the history of recovery, solutions are dynamic; innovations and understandings will continue to develop and amend over time.

A particularly challenging case is the presence of legacy chemicals in plastic packaging used for food and beverages, (partly) composed of recycled plastics. This packaging is designed based on strict requirements that are aimed at increasing food shelf life while retaining high degree of quality, safety and hygiene.

Commission Regulation (EU) No 10/2011[1] sets out criteria for the composition of new plastic materials coming into contact with food.

However after these materials have been used, they do not comply anymore to the plastic Regulation, as they may have been contaminated with other substances. Therefore, a separate Regulation exists to control the recycling processes: **Commission Regulation (EC) No 282/2008[2] on recycled plastic materials and articles intended to come into contact with foods.**

1 Click link to Regulation 10/2011 for further reading

2 Click link to Regulation 282/2008 for further reading

By 2030, all plastic packaging will have to be reusable or recyclable in an economically viable manner.

Frans Timmermans , Executive Vice-President European Commission

https://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf

Recycling

There is an urgent need to tackle the environmental problems related to the production, use and consumption of plastics. The millions of tonnes of plastic litter that end up in the oceans every year are one of the most visible and alarming signs of these problems, causing growing public concern.

Rethinking and improving the complex plastics value chain requires efforts and greater cooperation by all its key players, from plastics producers to recyclers, retailers and consumers. It also calls for innovation and a shared vision to drive investments in the right direction. The plastics industry is very important to the European economy. Increasing its sustainability can bring new opportunities for innovation, competitiveness and job creation.

In December 2015, the Commission adopted an EU Action Plan for a circular economy, in which it identified plastics as a key priority and committed itself to 'prepare a strategy addressing the challenges posed by plastics throughout the value chain and considering their entire life-cycle'. In 2017, the Commission confirmed it would focus on plastics production and use and work towards the goal of ensuring that all plastic packaging is recyclable by 2030.

A vision for Europe's new plastics economy[1]

A smart, innovative and sustainable plastics industry, where design and production fully respect the needs of reuse, repair, and recycling, brings growth and jobs to Europe and helps cut EU's greenhouse gas emissions and dependence on imported fossil fuels.

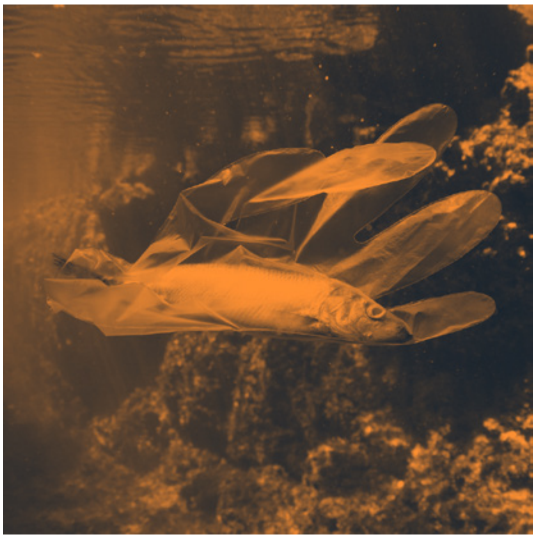
- Plastics and products containing plastics must be designed to last longer to be reused and allow high-quality recycling. By 2030, all plastics packaging placed on the EU market must be reusable or recyclable in a cost-effective manner.
- Changes in production and design must enable higher plastics recycling rates for all key applications. By 2030, more than half of plastics waste generated in Europe must be recycled.
- EU plastics recycling capacity must be significantly extended and modernised. By 2030, sorting and recycling capacity must be increased fourfold since 2015, leading to the creation of 200 000 new jobs, spread across Europe.
- The export of poorly sorted plastics waste must be phased out by improved separate collection and investment in innovation, skills and capacity upscaling. Recycled plastics must become an increasingly valuable feedstock for industries, both at home and abroad.
- The plastics value chain must be better integrated, and the chemical industry must work closely together with plastics recyclers to help them find wider and higher value applications for their output. Substances hampering recycling processes must be replaced or phased out.
- The market for recycled and innovative plastics must be successfully established, with clear growth perspectives for a larger number of products with recycled content. Demand for recycled plastics in Europe has grown four-fold, providing a stable flow of revenues for the recycling sector and job security for its growing workforce.
- More plastic recycling will help to reduce Europe's dependence on imported fossil fuel and cut CO_2 emissions, in line with commitments under the Paris Agreement.
- Innovative materials and alternative feedstocks for plastic production must be developed and used where evidence clearly shows that they are more sustainable compared to non-renewable alternatives.

1 https://ec.europa.eu/environment/waste/plastic_waste.htm

Economics and quality of plastics recycling

Boosting the recycling of plastics may lead to significant environmental and economic benefits. To achieve higher levels of plastic recycling, plastics and plastics articles must be produced and designed differently. Plastics manufacturers, converters, public and private waste management companies must work together to:

- improve design and support innovation for an easier recycling
- expand and improve separate plastic waste collection
- ensure quality inputs to the recycling industry
- expand and modernise the sorting and recycling capacity
- create viable markets for recycled and renewable plastics.



Design for recyclability

Plastics are made from a range of polymers and are highly customised, with specific additives to meet functional and/or aesthetic requirements. This diversity can complicate the recycling process, make it more costly, and affect the quality and value of recycled plastic. Specific design choices, some of which are driven by marketing considerations (e.g. the use of very dark colours) can also negatively affect the value of recyclates.

Plastics packaging is a priority area when it comes to design for recyclability. Today it accounts for about 60 % of post-consumer plastic waste in the EU, and product design is one of the keys to improve recycling levels. It has been calculated that design improvements could halve the cost of recycling plastic packaging waste.

Construction and the automotive, furniture and electronics sectors are also important applications for plastics use and are a significant source of plastics waste that could be recycled. For these applications, lack of information regarding the possible presence of chemicals of concern (e.g. flame retardants) creates a significant obstacle to achieving higher recycling rates.

The European Commission is committed to developing, where appropriate, product requirements under the Ecodesign Directive that take account of circular economy aspects, including recyclability. This will make it easier to recycle plastics used in a wide variety of electrical appliances and electronic goods.

Boosting demand for recycled plastics

Weak demand for recycled plastics is another major obstacle to transforming the plastics value chain. In the EU, uptake of recycled plastics in new products is low and often remains limited to low-value or niche applications. Uncertainties concerning market outlets and profitability are holding back the investment necessary to scale up and modernise EU plastics recycling capacity and boost innovation. Recent developments in international trade, restricting key export routes for plastics waste collected for recycling, make it more urgent to develop a European market for recycled plastics.

One of the reasons for the low use of recycled plastics is the fear of many product brands and manufacturers that recycled plastics will not meet their needs for a reliable, high-volume supply of materials with constant quality specifications. Plastics are often recycled by small and predominately regional facilities, and more scale and standardisation would support smoother market operation. The European Commission is committed to working with the European Committee for Standardisation and the industry to develop quality standards for sorted plastic waste and recycled plastics.

The chemical composition of recycled plastics and their suitability for the intended uses can also act as a barrier in some instances. Incidental contamination or lack of information about the possible presence of chemicals of concern is a problem for various streams of plastics waste. These uncertainties can also discourage demand for recycled plastics in a number of new products with specific safety requirements. The Commission's work on the interface between chemicals, waste and product policy is set to address some of these issues and will therefore contribute directly to increased uptake of recycled plastics. The EU will finance research and innovation projects on better identification of contaminants and on decontamination of plastic waste through Horizon 2020.

Volumes and quality alone, however, do not fully explain the small market share held by recycled plastics today. Resistance to change among product manufacturers and a lack of knowledge of the additional benefits of closed-loop recycled plastics have also emerged as barriers to the higher uptake of recycled content.

Growing concerns over microplastics

Microplastics are intentionally added to certain product categories (such as cosmetics, detergents, paints), dispersed during the production, transport and use of plastic pellets, or generated through wear and tear of products such as tyres, paints and synthetic clothes.

On December 27th, 2019, The Guardian[1] wrote: **"Revealed: microplastic pollution is raining down on city dwellers" - Exclusive: London has highest level yet recorded but health impacts of breathing particles are unknown**

> *Microplastic pollution is raining down on city dwellers, with research revealing that London has the highest levels yet recorded.*
> *The health impacts of breathing or consuming the tiny plastic particles are unknown, and experts say urgent research is needed to assess the risks.*
> *Only four cities have been assessed to date but all had microplastic pollution in the air. Scientists believe every city will be contaminated, as sources of microplastic such as clothing and packaging are found everywhere.*
> *Recent research shows the whole planet appears to be contaminated with microplastic pollution. Scientists have found the particles everywhere they look, from Arctic snow and mountain soils, to many rivers and the deepest oceans. Other work indicates particles can be blown across the world.*
> *The level of microplastic discovered in the London air surprised scientists. "We found a high abundance of microplastics, much higher than what has previously been reported," said Stephanie Wrightfrom Kings College London, who led the research. "But any city around the world is going to be somewhat similar."*
> *"I find it of concern – that is why I am working on it," she said. "The biggest concern is we don't really know much at all. I want to find out if it is safe or not."*
> *[…] The serious health damage caused by the pollution particles emitted by traffic and industry are well known. A comprehensive global review earlier in 2019 concluded that air pollution may be damaging every organ and virtually every cell in the human body. But the potential health impacts of inhaling plastic particles from the air, or consuming them via food and water, are unknown. People eat at least 50,000 microplastic particles per year, according to one study.*
> *Plastics can carry toxic chemicals and harbour harmful microbes, and the limited research done to date has shown harm to some marine creatures. The only assessment of microplastic in human lungs, published in 1998, found inhaled fibres were present in cancerous lung specimens.*
> *"These studies showing just how much plastic is in the air are a wake-up call," said Steve Allen, at the EcoLab research institute near Toulouse, France, and whose own work has shown microplastic air pollution in remote mountain areas. "The [London research] is a very well done study showing incredibly high numbers of airborne microplastics.*
> *"Currently we have very little knowledge on what effect this airborne pollution will have on humans," he said. "But with what we do know it is pretty scary to think we are breathing it in. We need urgent research."*

Microplastics intentionally added to products represent a relatively small proportion of all those in the environment. However, since they are relatively easy to prevent and in response to public concern, several countries have already taken action to restrict their use, while the cosmetic industry has also taken voluntary action. Bans are under consideration or planned in several Member States and this may lead to fragmentation in the single market. In line with the REACH procedures for restricting substances that pose a risk to the environment or health, the Commission has therefore started the process to restrict the use of intentionally added microplastics, by requesting the European Chemicals Agency to review the scientific basis for taking regulatory action at EU level.

More research is needed to improve our understanding of the sources and impacts of microplastics, including their effects on the environment and health, and to develop innovative solutions to prevent their dissemination. This can include ways to improve the capture of microplastics in waste water treatment plants, as well as targeted measures for each source.

For its part, the Commission will consider measures such as labelling and specific requirements for tyres, better information and minimum requirements on the release of microfibers from textiles, as well as measures to reduce plastic pellet losses.

Extended producer responsibility schemes can also be envisaged, where relevant, to cover the cost of remedial action. Microplastics also need to be monitored in drinking water, where their impact on human health is still unknown.

1 https://www.theguardian.com/environment/2019/dec/27/revealed-microplastic-pollution-is-raining-down-on-city-dwellers
https://www.theguardian.com/environment/2019/jun/05/people-eat-at-least-50000-plastic-particles-a-year-study-finds

2nd International conference

CIRCULAR ECONOMY FOR TEXTILES & PLASTICS

The Ellen MacArthur Foundation states:

Looking beyond the current take-make-waste extractive industrial model, a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system.

Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles:

- *Reduce waste and pollution through design*
- *Extend the life of products and materials*
- *Regenerate natural systems*

The 2nd International Conference on "Circular Economy for Textiles & Plastics" addresses the approach and efforts of the textile and plastics industries as well as key research themes to translate these three principles of the circular model into concrete actions and policies.

CALL FOR PAPERS

Join the international team of expert speakers from the industry, government and research world on the transition from a linear textiles and plastics value chain to a circular one.

Submit your abstract to adg@centexbel.be

before March 15, 2020

CENTEXBEL VKC

June 23 & 24, 2020

PROVINCIEHUIS BOEVERBOS - BRUGES

www.centexbel.be/en/agenda/2nd-international-conference-circular-economy-textiles-and-plastics

$scCO_2$ Extractor

ecologic extraction of legacy additives from recyclates

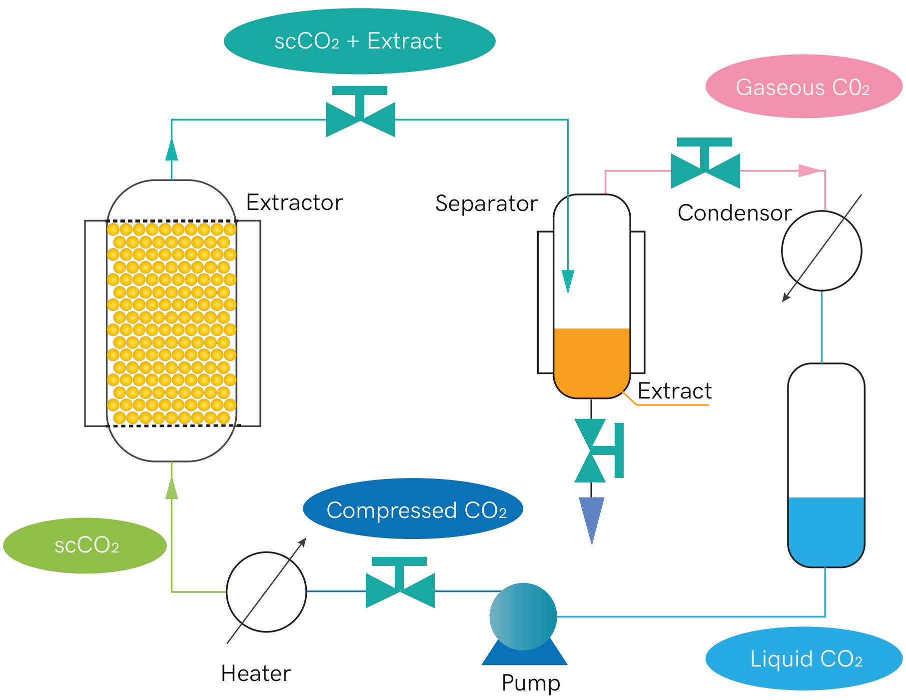
Supercritical CO_2 ($scCO_2$) is a phase of CO_2 with very interesting physical properties. The CO_2 is not strictly in the liquid or gas phase but somewhere in between: the supercritical phase. In this phase the CO_2 exhibits both the properties of a gas (high diffusivity and low viscosity) and the properties of a liquid (high density), making $scCO_2$ a very interesting extraction medium.

The $scCO_2$ extractor is a useful addition to our platform and testing equipment:

i. The **$scCO_2$ extractor** is used to perform extractions up to 150°C and 700 bar. In addition, a co-solvent pump allows to add other - more conventional - solvents, to influence the solubility properties of $scCO_2$, and allows us to research the extraction of **legacy additives from recycled plastics** in the framework of the European H2020 projects **CREAToR** and **REMADYL.**

ii. The interest in the use of $scCO_2$ as a **green solvent for textile dyeing** has grown in recent years.

iii. The **$scCO_2$ extractor** also serves as a showcase to guide plastic converting companies, desiring to increase the recycled content in their products, and recycled plastics suppliers, desiring to market purified recyclates, in selecting an efficient technology to remove undesired chemicals.



The equipment has been acquired in the framework of the EFRO GTI project

EFRO
EUROPEES FONDS VOOR REGIONALE ONTWIKKELING

More info

Tom Vercoutere | tov@vkc.be

https://www.centexbel.be/en/brochures/scco2-extractor

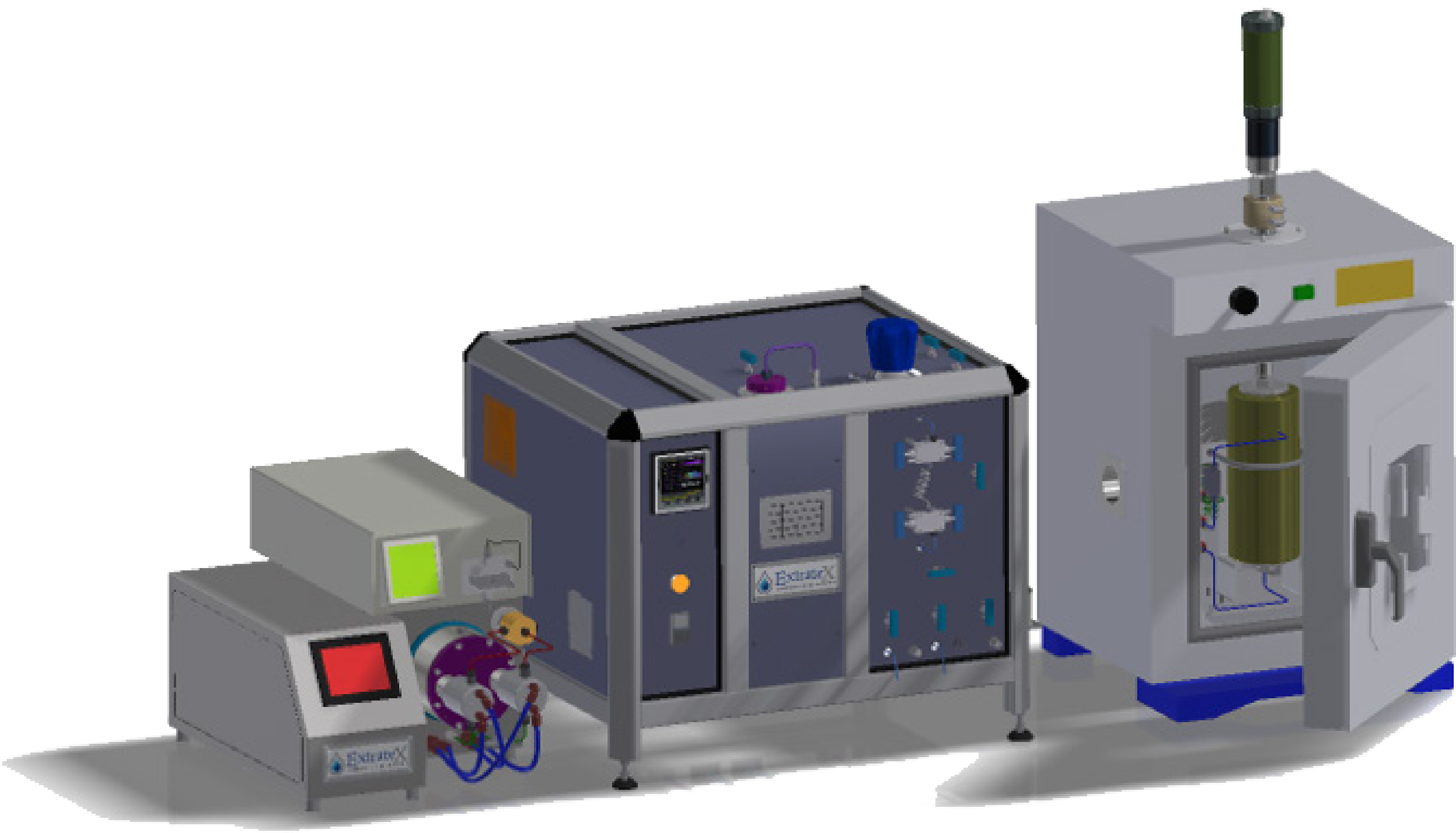
$scCO_2$ Extractor

technical data

The SFE is a versatile "multi-solvent" extraction equipment with precise control of process parameters for analytical purposes:

- Extraction with supercritical CO_2 at pressures up to 700 bar and temperatures up to 150°C allowing very high-pressure extraction over a very wide range of operating parameters and more opportunities to use supercritical CO_2 as non-flammable, non-toxic and environment-friendly solvent.
- High pressure and subcritical water extraction up to 400 bar and 250°C.

Components	Description
CO_2 pump	Variable flow rate from 0 to 100 g/min Variable pressure from 0 to 700 bar
Extraction vessel	200 ml
Oven	Used to heat the extraction vessel
Separator	For extract separation / collection of extracts and CO_2 recycling
Pressure Control	Back pressure regulator to control the pressure
Control board	Display and record process value



Centexbel expands its lab equipment to characterize recyclates or to assess the recyclability of materials

More information:
Eddy Albrecht | ea@centexbel.be

Freezer Mill:
Grinding and homogenizing recyclates

SPEX Cryomill 6875D is a high-throughput, dual chamber, cryogenic grinder with automatic fluid nitrogen feed. The samples are chilled in liquid nitrogen and then pulverized with a magnetically driven rapidly moving impactor. In contrast to the majority of cryogen grinding techniques, there is no contact between the fluid nitrogen and the sample material.

The Cryomill set up at Centexbel is equipped with accessories to grind samples in the 0.1-gram to 100-gram range.

The Cryomill also allows to homogenize the materials, which is especially interesting to characterize recyclates, and to "dilute" materials containing functional additives by adding virgin materials.

Dynamic Headspace GCMS:
Assessing the presence of VOC/SVOC

This finely ground material can then be further analyzed in the newly installed Gerstel dynamic headspace GCMS, on the presence of VOC and SVOC in textiles and plastics (e.g. REACH compliancy) in a fully robotized manner.

By grinding the compact plastics, the diffusion factor is no longer hampering the analysis and allows us to reach results much faster and to gain information about heavier and/or more polar substances.

The apparatus has been equipped with a large volume Dynamic HeadSpace (DHS) sampler in view of analyzing recyclates which allows us to go beyond the normal sample dimension of 20 mg (which is irrelevant for recyclates) to 10 g.

On the next pages we will discuss several ongoing collective R&D projects dedicated to recycling related themes:

A. *Removal of legacy chemicals from (multi-material) plastic waste*

   A.1 - REMADYL
   A.2 - VALBREE
   A.3 - CREATOR

B. *Recycling of multi-layered or multi-material products*

   B.1 - REFOIL
   B.2 - MULTICYCLE

C. *Recycling of coated and laminated multi-materials*

   C.1 - RECYCOAT
   C.2 - DECOAT

D. *Optimizing waste management*

   D.1 - URBANREC

E. *Circular/closed loop approach*

   E.1 - CIRCTEX
   E.2 - RETEX

For an updated list of ongoing projects, consult: https://www.centexbel.be/en/projects

A. Removal of legacy chemicals from (multi-material) plastic waste

A.1

PVC is one of the most widely used polymers in the world and Europe's third most popular plastic, with an anual global production of about 37 million tonnes of PVC (5.5 million tonnes in Europe). PVC is light, strong, fire resistant, has excellent insulating properties and low gas permeability.

PVC products are also durable: they need minimal maintenance and their life-span can range from 30 to even 100 years in the case of cables, pipes and window profiles. The current PVC waste stems from production runs from decades ago and and contains **legacy additives**, including lead (compounds) for preventing degradation under influence of heat or UV light and DEHP as phthalate plasticizer for flexibility. These **legacy substances (LS)** will be abundant in PVC waste for at least another 30 - 50 years given the long lifetime of PVC and the use of Pb (up to 2008) and of DEHP (up to 2015).

To create a circular PVC materials stream containing LS, the 'old PVC' with LS has to be up-cycled to 'new PVC' that is fully REACH compliant. The PVC industry will have to meet the recommendations published in the European Strategy for Plastics in a Circular Economy. To increase PVC recycling rates, also post-consumer 'old PVC' will need to be recycled. But therefore we need to develop a method to remove LS from PVC.

REMADYL will therefore develop a commercially viable technique to detect and extract legacy additives. The automatic identification of the LS substances under consideration (DEHP and lead) is highly challenging but mandatory for their actual recycling. Based on state of the art technologies, we will optimize the hardware and software for PVC monitoring to identify target LS that will faciliate the presorting of PVC waste. The presorted PVC will be the starting material for further LS extraction steps.

The REMADYL consortium will research and develop a continuous extraction technique to remove legacy additives from the PVC matrix of both soft and rigid PVC. We will investigate two systems:

i. metal scavengers in combination with melt filtration and
ii. continuous polymer extraction techniques in combination with processing aids such as $scCO_2$.

We will try to boost the efficiency of both techniques by use of innovative co-solvents. When the LS have been successfully extracted, subsequent procedures for the safe handling and processing of these LS will be defined. These novel techniques will form the basis for our REMADYL demonstration of circular use of post-consumer PVC.

The research performed in REMADYL, is supported by industrial and regulatory partners who monitor the viability and feasibility of the used technologies, to allow further upscaling and industrial implementation.

More information: https://www.centexbel.be/en/projects/remadyl

The REMADYL project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 821136.

A.2 Waste of electrical and electronic equipment (WEEE) such as computers, TV-sets, fridges and cell phones is one the fastest growing waste streams in the EU, with some 9 million tonnes generated in 2005, and expected to grow to more than 12 million tonnes by 2020.

Interreg France-Wallonie-Vlaanderen

UNION EUROPÉENNE EUROPESE UNIE

VALBREE

VALBREE: Valorisation of plastic waste electric and electronic equipment containing brominated flame retardants

Brominated flame retardants (BFRs) are used to reduce the risks of ignition and propagation of fire in a large product range: electrical and electronic equipments, textiles, wirings, etc.

BFRs comprise several families, including Polybromodiphenylethers (PBDE). These BFRs are widely used as additives in polymeric resins and plastics. Because of their "PBT" properties (persistence, aptitude for bio-accumulation and toxicity), the use of brominated flame retardants is restriced in the European Union and other countries. Therefore, plastic waste with brominated flame retardants cannot be recovered without prior treatment to ensure their elimination.

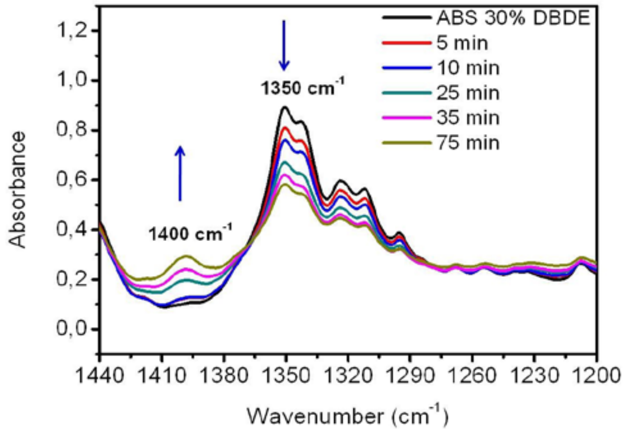
As PBBs and PBDEs are simply added to plastic materials and not chemically bound to them, they migrate into the environment if disposed in landfills. PBBs and PBDEs released into the environment do not degrade easily and can be absorbed and ingested by plants and animals, and therefore accumulate and persist in the food chain. The potential effects of these products vary primarily with the amount absorbed into the bloodstream, the duration and route of exposure. Exposure to polybrominated flame retardants may result in a significant risk of cancer.

Incineration of PBBs and PBDEs is not an option either, as it forms hazardous by-products, such as dioxins and furans.

The presence of hazardous components in WEEE is a major problem of waste management.

VALBREE aims to support the recycling of plastics from WEEE to increase the proportion of recycled plastic by deploying a polymer "debromination" treatment technology without any significant impact on its properties of use. In particular, the VALBREE consortium develops a concept technology patented by CREPIM and UMET/CNRS to eliminate brominated additives in their prohibited forms contained in plastic waste.

Broad-spectrum UV-visible light induced degradation processes were successfully applied on brominated plastic samples (ABS, PC, PP) in the form of granules of diameter of less than 2mm and in the form of films. The experimental parameters included radiation energy, exposure time, and concentration of the initial toxic species.The radiative effect of the pollutant/polymer system was monitored according to the time of exposure to artificial radiation by means of a UV-visible source. This allowed to investigate a number of corresponding parameters (irradiation dose, distance UV-sample source, temperature, intensity and power of the UV-visible lamp), to increase the efficiency of the photodegradation. The infrared spectroscopy technique was applied to characterize products before and after irradiation under UV-visible light.



Spectral evolution (FTIR) of ABS loaded with DBDE (30 wt%), as function of exposure time

The distance between the UV-visible source and the plastic is another factor that influences the efficiency of the process. Generally speaking, the shorter this distance, the more effective will be the radiation treatment. However, if the distance between the UV-visible source and the shred is too small, there is a risk of degradation of the plastic material. Thus, the distance between the UV-visible source and the plastic sample is chosen to allow effective deactivation of the brominated compounds while avoiding any degradation of the plastic material.

More information: https://www.centexbel.be/en/projects/valbree

Université de Lille UMET Unité Matériaux Et Transformations Crepim CNRS CENTEXBEL MATERIA NOVA Materials R&D Centre

Project funded by

Interreg France-Wallonie-Vlaanderen UNION EUROPÉENNE EUROPESE UNIE

Wallonie AGENTSCHAP INNOVEREN & ONDERNEMEN Vlaanderen is ondernemen Vlaanderen verbeelding werkt

Research and innovation

More info

www.interreg-fwvl.eu @InterregFWVL

The programme is co-financed by the European Regional Development Fund

Collection of raw materials, Removal of flame retardants and Reuse of secondary raw materials

A.3 A Europe-wide consortium aims to create a circular economy by removing hazardous flame retardants from plastic waste and re-using the purified material in high-value applications. High volumes of plastic waste – for example from construction and demolition, aeronautics and electronics – pose a huge economic and environmental challenge. While the best option would be to recycle and reuse, the cost of collecting, sorting and purifying these materials is often too high, so they are disposed of via combustion or landfill, or via "downcycling", i.e. reuse in low-value products.

One specific problem is that many plastic materials contain hazardous flame retardants, such as bromine. These flame retardants were used in a myriad of products from the 1970s onward, but have since been banned throughout the EU, because they can remain in the environment for years, accumulating to toxic levels.

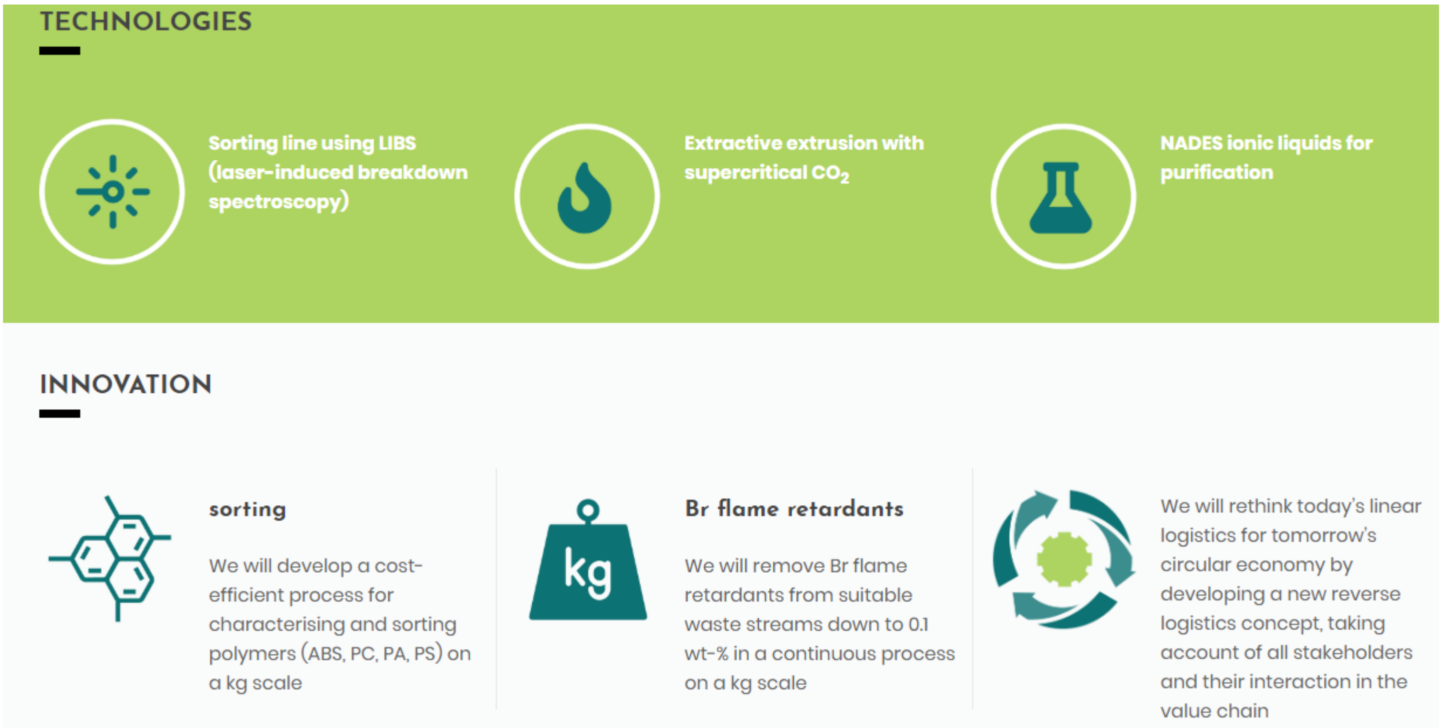
Over the next three years, the partners in CREAToR will develop a new purification process for waste material, using so-called continuous extraction technologies (supercritical CO2 and eutetic solvents in twin-screw extruders). To ensure that this process is transferred from the laboratory to real-life application, the consortium will also work at every stage of the value chain, developing a logistics process for the collection of materials, new characterization technologies for sorting and quality control, modification of the purified material (e.g. the introduction of new, non-hazardous flame retardants) and specific case studies for its re-use in similar applications to its original markets and also in other applications, for example in the automotive industry.

This will turn waste products into valuable raw materials, generating profits for waste collection and sorting companies and recyclers, and reducing the quantity of plastic waste in the environment. The project partners, including industrial recyclers and re-users, stand to benefit directly through the expected commercialization of the results within the next five years. Besides this, numerous European industries will benefit from the possibility to valorize and re-use waste material.

More information

https://www.centexbel.be/en/projects/creator

https://www.creatorproject.eu



CREATOR
COLLECT • PURIFY • REUSE

what does CREAToR do?

- **Collection** of raw materials
- **Removal** of flame retardants
- **Reuse** of secondary raw materials

THE PROCESS

- collection of waste
- separation of polymer parts
- continious extraction for removal of Br flame retardant
- labelling of Br free material
- modification for reuse

DEVELOPMENT OF INTEGRAL LOGISTIC CONCEPT

INNOVATION

A new, cost-effective approach

Consideration of the **whole value chain** for various **polymers ABS, PC, PA, PS**

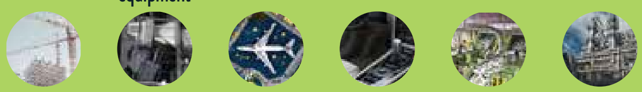
Chracterisation and sorting of large polymer parts containing bromined flame retardancies at **kg scale**

Removal of Br-FR down to **0,1 wt-%** in continuous process at kg scale

MARKET INTEGRATION

CREAToR delivers solutions to various steps of the production chain

construction & demolition	electrical & electronic equipment	aeronautics industry	automotive industry	recyclers	polymer parts manufacturers
waste source	waste source	waste source	end-product re-use	characterisation in the sorting and removal of hazardous components	labeling and re-additivation
end-product re-use	end-product re-use	end-product re-use			



TECHNOLOGIES

- Sorting line with LIBS technology (**Laser-Induced Breakdown Spectroscopy**) for characterisation
- Extractive extrusion with **super critical CO_2 and NADES ionic liquids** for the purification
- **Re-additivation** for the re-use (new flame retardants, processing additives)
- **Labeling** of the material to ensure hazardous flame retardant content **< 0,1 wt-%**

THE CONSORTIUM

RECYCLING

RE-USE

LCA • DISSEMINATION • LEGAL

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 820477

B. Recycling multi-layered or multi-material products

ReFOIL

B.1 Apparently 'simple' trays and films for food packaging often consist of several layers of different polymer materials, each contributing its own functionality to the packaging. These various layers are physically joined together, so that the constituent polymers can no longer be separated after use and must be recycled as a mixture.

The aim of the REFOIL research was to examine the possibility for open loop recycling of a post-industrial multi-layered waste stream, to study the effect of different compatibilizers, and to determine and develop a suitable application or demonstrator for the multilayered waste through the principle of 'design from recycling', a material-driven design approach.

To this end, we studied four industrially relevant cases of multilayer waste streams composed of the most common plastic packaging materials (PE, PP, PET, PA, EVOH).

We analysed the strengths and weaknesses of the available material streams in terms of material properties, upgraded the waste streams with additives and studied their suitability for different processing techniques.

We then identified the opportunities based on the properties, which generated many ideas in the search for suitable products. In order to make sure that the project results may be implemented rather quickly by the participating companies, it is needed that the products be manufactured by using industrially available processing methods.

The knowledge acquired during the lab-scale research was translated into various selected applications on a (semi)-industrial scale. This resulted in the development of a technical demonstrator per case that contains all relevant knowledge about the complex recycling issue.

Result: One of the participating companies is already applying the results. The other companies expect to be able to apply the results within a year of the end of the project, or see this possible in the future with company-specific research.

One of the case studies involves the analysis and characterisation of a two layered tray and foil consisting of PET and PE, initially used for sliced meat packaging.

The waste is melt-blended with different percentages of compatibilizers and elastomers to improve both mechanical and rheological properties as well as reprocessability. Afterwards, we have evaluated open-loop recycling into a multifilament extrusion application and a tape extrusion application.

More information:

https://www.centexbel.be/en/projects/refoil

AGENTSCHAP INNOVEREN & ONDERNEMEN

Vlaanderen is ondernemen

TETRA project van 2017 tot 2019 met steun van Vlaanderen Agentschap Innoveren & Ondernemen Nr. HBC.2017.0056

KU LEUVEN

UNIVERSITEIT GENT

VKC

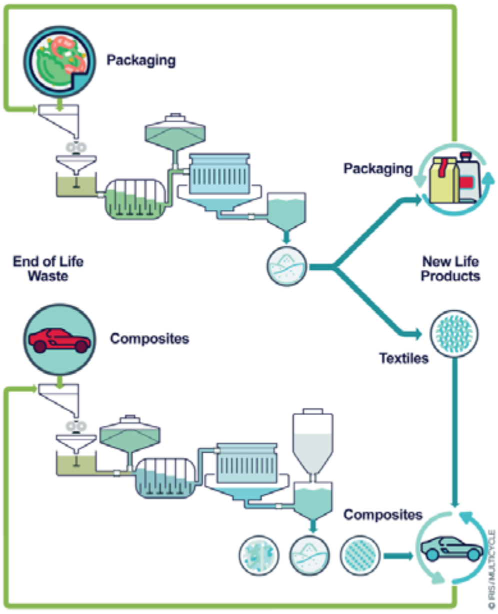
B.2 MultiCycle will create an industrial recycling pilot plant for thermoplastic multilayer packaging and fibre-reinforced composites using a novel solvent-based selective extraction process, CreaSolv®, developed by Fraunhofer IVV[1], to recover pure plastics and additives in mixed wastes for their subsequent reprocessing in value-added applications.

In the meantime, the project partners have defined and specified **sustainable recycling processes**, of which they have established the specifications.

Centexbel has characterized materials recovered from treated waste with respect to their application in plastic packaging, textiles and composites. The rheological and thermal behaviour of a wide range of virgin film extrusion and composite grade thermoplastic polymers have been assesed. These values will be benchmarked against the values of plastics recovered by the CreaSolv® process. In addition to thermal and rheological properties, the composition and purity of the recovered materials is being thoroughly investigated by means of spectroscopy and extraction techniques. We also analyse the mechanical and surface properties recycled of carbon and glass fibres that will be compared to their primary manufactured counterparts by project partner ELG. The residual sizing on the fibres (an important contributor to optimal fibre matrix adhesion) is also being determined.

Materials for Packaging Applications

A group of partners led by Amcor with substantial input from Fraunhofer will be focusing on the use of recycled plastics in new, easy-to-recycle packaging designs, based on material performance, cost and relevant regulatory considerations including food-use compliance.



Materials for Automotive applications

FARPLAS, Tofaş, SILON, Centexbel, and Bond Laminates will be producing a variety of parts - injection mouldings, textile nonwovens, carbon fibre reinforced composites - from the materials recovered by the MultiCycle pilot plant.

The processability and performance of recycled materials in automotive applications will be validated and compared to virgin materials, to confirm their applicability in a range of industrial automotive products.

More information

https://www.centexbel.be/en/projects/multicycle
http://multicycle-project.eu

Project partners

From waste to new materials - treatment of end-of-life flexible films and automotive scrap yield high purity mono-polymers and recovered reinforcing fibres

1 https://www.ivv.fraunhofer.de/en/recycling-environment/recycling-plastics.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 820695

C. Recycling of coated and laminated multi-materials

The recently published European Strategy for Plastics states that it is crucial to recycle many more plastics and textile materials with a commitment from the plastics industry to achieve a recycling quota of 50% by 2040[1]. Despite very high needs and targets, today only 6% of new plastic products are made from recycled materials[2]. Also in the textile industry the use of recycled material is limited: for clothing only 1% is used in a closed loop system and 12% in a downcycling system or cascade recycling[3]. We are working hard to improve this, paying attention to the technical, economic and logistic aspects.

Eco-design : an asset to increase recycled content

Eco-design means that the product is designed for optimal use and lifetime, while also taking into account the end of life and recycling possibilities. This is possible, for example, by manufacturing the object from a single thermoplastic material that can easily be remelted after the end of life and - with or without the addition of a fraction of virgin material - can be used in the production of new materials and objects.

However, many textile or plastic objects are coated or laminated to obtain certain functionalities (such as colour and barrier properties). These layers complicate or prevent the recycling process so that these objects are usually incinerated or converted into RDF pellets after use. In order to increase the recyclable fraction, it must be possible to separate these layers from each other. Ideally, the subsequent separation process should already be taken into account when designing multilayer materials.

In the European Ecometex project we developed a method to separate the secondary backing of a carpet by immersing the carpet in boiling water. After 30 seconds, the separation process was completed.

recycling coated materials

C.1

This heat triggered separation process (with additives in the adhesive layer) was further investigated in the Flemish Catalisti project Recycoat to assess whether the concept is also valide for other objects with different adhesive layers.

During the Recycoat project, we have been investigating the possibility of separating the layers of conventional, commercially available objects (and therefore not designed according to the rules of eco-design) by selectively dissolving one of the layers in "green" solvents.

1 https://www.plasticsconverters.eu/single-post/2018/01/16/European-Plastics-Industry-works-towards-50-plastics-waste-recycling-by-2040
2 https://ec.europa.eu/commission/sites/beta-political/files/plastics-factsheet-industry_en.pdf
3 https://www.ellenmacarthurfoundation.org/circular-economy/concept

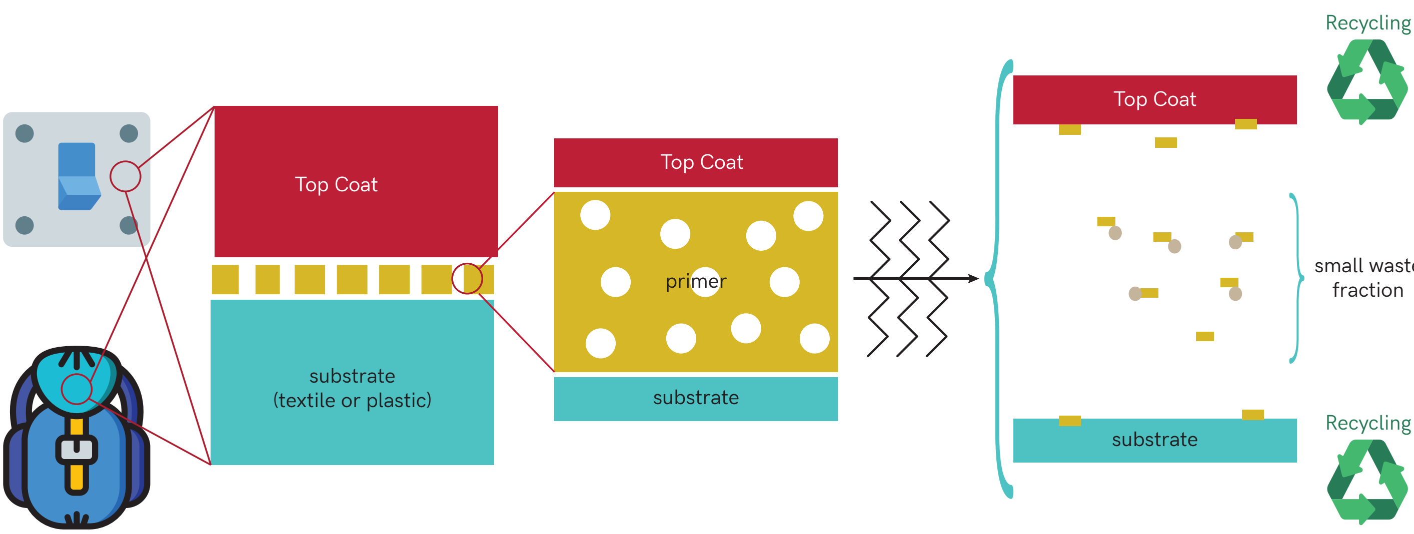
Recycling of coated and painted textile and plastic materials

C.2

In the ongoing European Decoat project we are further studying the “triggered separation” of textile and plastic objects. Whereas only commercially available additives were used in Recycoat, we are now developing additives that are specifically aimed at separating the different layers that make up an object and that are “triggered” by heat, steam, moisture or microwaves. They are added into the adhesive layer or coating (if no adhesive layer is present).

In addition to fine-tuning the separation process, we are also developing a method to optically sort the waste in order to guide the waste equipped with a specific trigger to the correct recycling flow.

The prototypes are first developed on a lab scale. Subsequently, we validate the concept on a pilot line where demonstrators (plastic and textile) are created that go through the entire recycling process.



Acknowledgements

ECOMETEX — This project has received funding from the European Union’s FP7-NMP-2011-SMALL-5 under grant agreement No 280751 (01/05/2012-30/04/2015)

RECYCOAT — Speerpuntcluster / VIS project in transitieprioriteiten - circulaire enonomie - nr. HBC.4017.0686. Gesteund door VLAIO - ingediend door Catalisti (01/03/2018 - 29/04/2020)

DECOAT — This project has received funding from the European Union’s Horizon 2020 H2020-NMBP-ST-IND-2018 - Smart plastic materials with intrinsic recycling properties by design (CE-NMBP-26-2018) - under grant agreement No 814505 (01-01-2019 - 31-12-2022)

D. Optimizing waste management

D.1

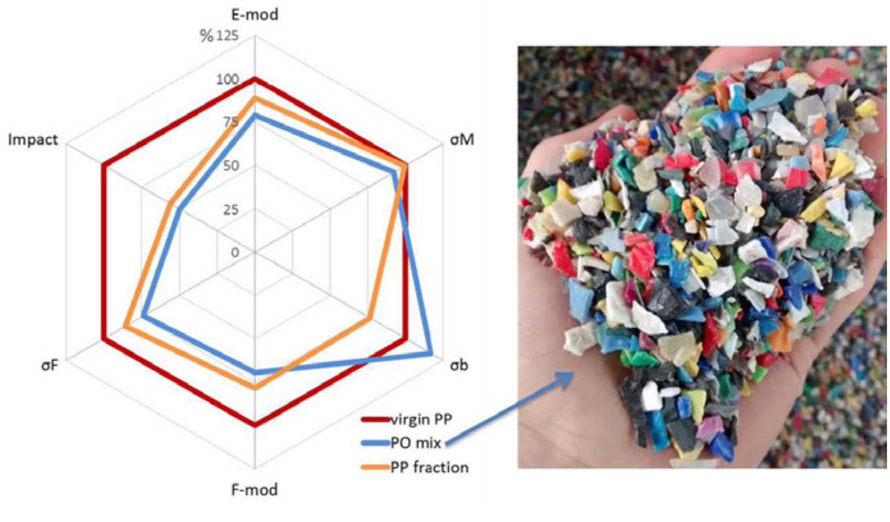
The URBANREC project aims to develop and implement an eco-innovative and integral bulky waste management system and demonstrate its effectiveness in different EU regions.

The project intends to improve the separation and disassembly of bulky waste, implementing advanced fragmentation techniques to obtain high quality raw materials. Innovative valorisation routes are also promoted, especially for those fractions that are considered more problematic (PUR foam, mixed hard plastics and mixed textiles), and are currently not being recycled due to a lack of eco-innovative cost-effective solutions.

Together with **Vanheede Environment Group** and **Procotex s.a.** - two Belgian companies - Centexbel proceeded with the industrial manufacturing and validation of short fibre reinforced PP composites (FRC) from bulky waste. Vanheede cleaned up the rigid plastics fraction from bulky waste and Procotex prepared the textile fibres by controlled fractioning to obtain fibre lengths of 1 to 6 mm. Fibre granulation tests were carried out to supply better dosable fibres. Centexbel performed compounding trials to optimize the FRC composition.

Clean-up of the recycled plastics fraction

A fraction of the separate collection of bulky waste in Belgium, is composed of mixed rigid plastics. This is a mixture of different polymer types (including PP, PE, PVC, ABS, PS, PA, PC, PMMA, etc.) and different production types. Moreover, the mixture is also contaminated with metals, wood, stones, etc. and needed a further clean-up. In a first step, the mixed rigid plastic fraction was sorted into different polymer grades. Then the materials were cut into pieces of ca 10-15 cm. The presorting resulted in 71% polyolefin (PO) materials of which the different fractions were further processed in the recycling line for PO plastics. The treatment includes size reduction, washing and flotation, removal of different metal fractions (ferro and non-ferro), regrinding and dedusting. The PO injection moulding fraction (PO mix) is a blend of PP and PE which could already be used in plastic processing. However the mix was further purified to a 98% PP fraction in order to increase the material value. The start mix and sorted PP fraction of the PO injection moulding grade were processed via melt filtration to remove any residual non-melting impurities that could damage the pilot scale equipment and/or would impair the FRCs mechanical properties.



Radar plots comparing the mechanical properties of recycled plastics to virgin PP (left) and illustration of the recycled PO mix regrind.

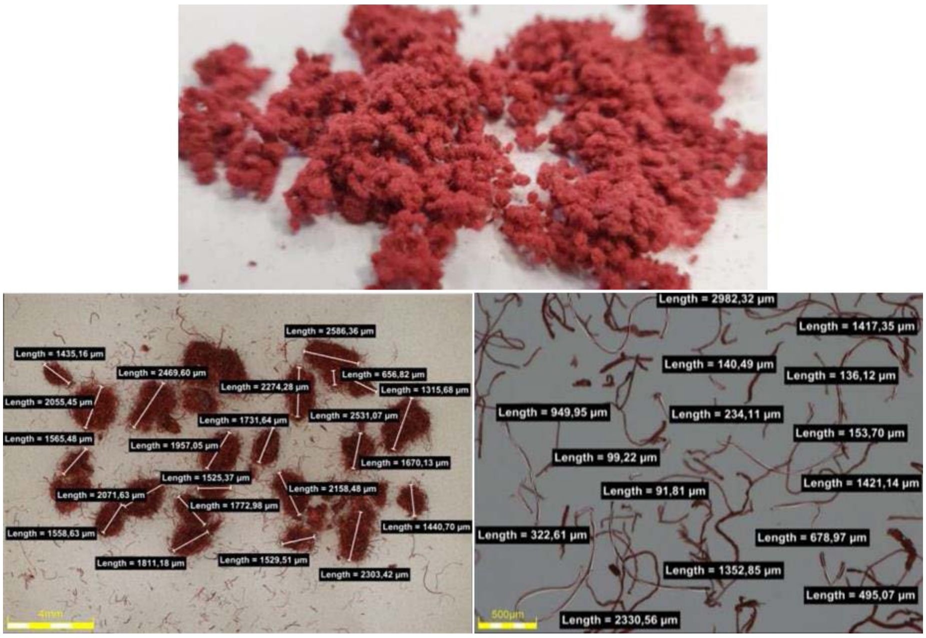
The recycled plastics show a 10-20% lower tensile and flexural stiffness compared to the virgin PP grade used as a reference. Moreover, much lower impact strengths were obtained which was expected as the selected virgin PP grade is a high impact grade. Interestingly, compared to the virgin PP grade, both recycled fractions show similar tensile strength but lower flexural strength, while the PO mix fraction has a higher fracture strength.

Fibres from post-producer and post-consumer bulky textile waste

PROCOTEX used a milling machine to precisely cut post-producer waste (cotton, polyamide (PA) and polyester (PES)) and post-consumer waste (mattress textile) to 2 or 4 mm fibres. A set of minimum specifications to which the raw material had to conform for FRC production was then defined. The chemical composition of the mattress textile waste materials was determined:

- Post-producer from Delax: >90% PES
- Post-consumer from Ecofrag: 90% PES/cotton + PA
- Post-consumer from Vanheede: 90% PES/cotton + wool

By means of optical microscopy the fibre morphologies and actual lengths were evalutated. To improve the fibre dosing on a pilot scale compounding equipment, Procotex prepared granules of different types of fibre fluff (PES, cotton, jute, aramid) using a fiber compacting machine. These granules were inspected using a microscope with camera and image processing to examine the granule size, fibre length and to assess whether the fibres were still intact after compacting.



Images of the PES fibres granulated by Procotex including the determination of the granule size and fibre length.

Development of short fibre-reinforced composite demonstrators

Centexbel performed small and pilot scale compounding trials by submitting standard test samples were to injection moulding with the aim of optimizing the FRC formulation. Varying fibre types and amounts were added to a PP matrix. A range of additives (compatibilizers) was tested to improve the fibre/matrix interaction.

Tensile, flexural and impact properties were determined and compared to glass fibre reinforced composites (GFC) and wood plastic composites (WPC). The results show that the stiffness (i.e. tensile and flexural moduli), fracture and flexural strength as well as the impact resistance were improved by adding cotton fibres. Increasing fibre concentrations resulted in further enhancement of elastic modulus and strength. The addition of the 2 mm mattress textile fibres also resulted in increased elastic and flexural moduli and thus in materials with an increased stiffness. ECOFRAG fibres induced a slightly higher fracture and flexural strength, comparable to the cotton FRCs. However, a reduced impact resistance was obtained, whereas the DELAX compound showed increased impact strength but decreased flexural and tensile strength.

The varying properties for the different FRCs are likely to be caused by a combination of different fibre/matrix interactions, fibre properties, and morphologies. In terms of stiffness, the developed FRCs are outperformed by the GFC to a great extent. However, they are comparable or even superior to the WPC material. An ice bucket demonstrator was produced from the PP-Delax FRC compound.

We further replaced virgin PP by recycled plastics obtained by Vanheede from which we produced some rulers as demonstrators. By adding cotton fibres and a compatibilizer it was possible to considerably improve the mechanical properties. The tensile and flexural moduli and strengths even exceeded the ones of the virgin PP grade.

We then proceeded to compound and produce a final demonstrator in the form of a storage box by means of injection moulding.

To do so, we selected mattress textile fibres recycled by Vanheede as actual specimens of post-consumer bulky waste. We compared the properties of the 2 mm mattress fibre-FRCs with the GFC and WPC samples as well as with a commercial Curver® box. As was to be expected, the GFC vastly outperformed the FRCs, whereas the WPC showed a better overall performance.

Nevertheless, FRCs containing a compatibilizer are definitely suitable to produce storage boxes as their stiffness, flexural and impact properties are superior to the ones of a commercial Curver® box, while having a similar tensile strength.

We will now proceed to determine the mechanical properties of the storage box demonstrators, to further adjust the injection moulding parameters to optimize the product properties.

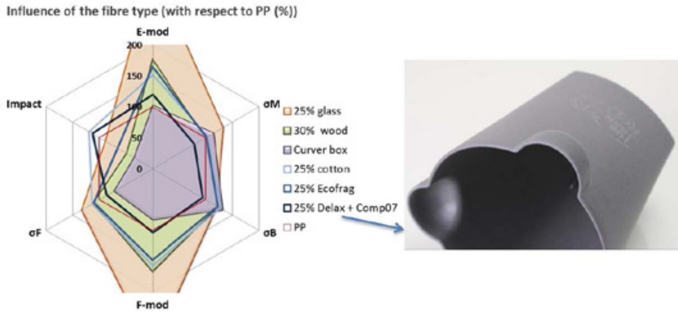
The compounding step will be upgraded to an industrial scale to evaluate the homogeneous fibre distribution by using large-scale extruders.

Finally, the developed demonstrator(s) will be submitted to a life cycle analysis, in view of selecting an ecolabel.

More information:

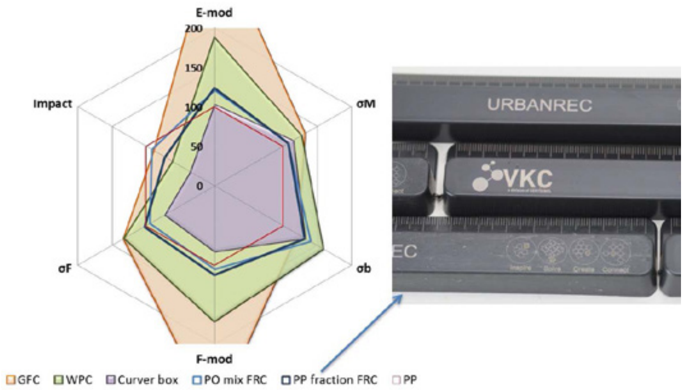
https://urbanrec-project.eu
https://www.centexbel.be/en/projects/urbanrec

Project partners:



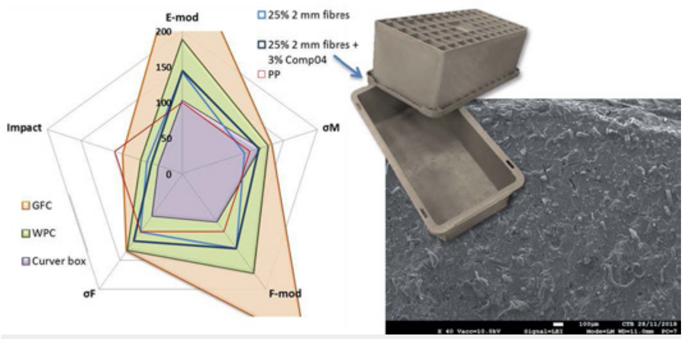
Left: radar plot comparing the mechanical properties of the FRCs with cotton, Ecofrag and Delax fibres to virgin PP

Right: ice bucket demonstrator produced from PP-Delax FRC



Left: radar plot comparing the mechanical properties of the recycled plastics FRC's to unfilled, virgin PP and to virgin WPC and GFC

Right: demonstrators produced from the PO mix FRC



Left: Radar plot comparing the mechanical properties of the 2 mm mattress fibre-FRC's to unfilled, virgin PP and to virgin WPC and GFC.

Right: final demonstrator and SEM image of the fracture plane of the FRC illustrating the homogeneous distribution of the fibres.

URBANREC - agreement no. 690103 - is a European research project within the Horizon 2020 programme's framework

E. Circular/closed loop approach

E.1

Industrial clothing is the ideal starting point for circularity in the textile industry. Because reuse is prohibited, this sector is completely dependent on new materials. The quality requirements as well as the impact of use are higher than in other textile sectors. The results obtained in CIRCTEX will therefore be applicable in the other textile sectors.

Interreg North-West Europe CircTex
European Regional Development Fund
EUROPEAN UNION

Collection and sorting systems will be tested and developed in a closed process chain, in which the effects of use are also analysed. Results of CircTex are actively communicated in the NWE textiles industry to increase knowledge and the amount of SME's and enterprises that actively work towards circularity in textiles. To ensure a long-term effect, CIRCTEX will set up an innovation network, actively involving stakeholders in the whole NWE. An international standard for circular textiles will be initiated to stimulate further development of the circular process chain for other textiles and textile products.

CIRCTEX will provide a proof-of-concept for fully recyclable workwear by developing technologies for large-scale processing of PET workwear, which will be validated and demonstrated in a closed chain pilot.

Optimizing the integration of these technologies and process steps is essential to ensure recyclability. The workwear sector is the ideal starting point for an industry-wide innovation, as it is used to working with (inter)national standards and public tenders that demand more and more circularity in their specifications.

More information:

https://www.centexbel/en/projects/circtex

E.2

The goal of RETEX - a project financed by Interreg France-Wallonie-Vlaanderen - is simple: reduce textile waste and stimulate innovation.

Interreg France-Wallonie-Vlaanderen
UNION EUROPEENNE EUROPESE UNIE
GoToS3 RETEX

Textile recycling in plastics processing is key to concrete and profitable value chains.

Centexbel carried out tests on the recycling of polyester textiles. Some fabrics in this product category contain fibres that are too short to be mechanically recycled into textile yarn, but they are suitable for thermoplastic recycling. Centexbel carried out tests with thermal granulation on different types of end-of-life products, such as blankets and fleece, protective suits (Clean Air Suits) and calendered non-woven. Industrial waste including edges of weaving strips and waste from spinning and carding were tested, as well as products that did not pass the quality controls, velvet fabrics, seat belt straps or non-woven for filtration.

Centexbel submitted each type of product to an initial protocol of mechanical and thermal recycling: preparation, fraying, or compression and thermal granulation for extrusion or injection moulding. Ideally, multi- and monofilament yarn could be extruded into 100% recycled polyester. For other yarns, only 25% of the regenerated secondary raw material could be integrated to obtain a product that met market expectations. Injection test were also largely positive. In some cases, the presence of additives or dyes proved to have an influence on the quality of the products.

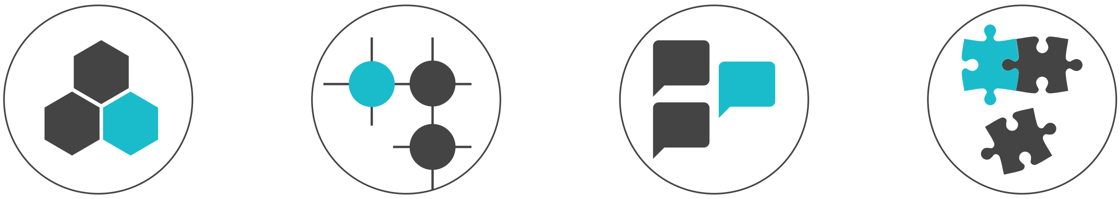
For every situation, the process parameters have to be adjusted. These laboratory tests complement the mechanical recycling tests carried out last year by the Retex partners on an industrial scale with hospital uniforms. This test case made it possible to process 10 tonnes of clothing into 70% polyester/30% cotton into a 100% recycled 40 dtex yarn. Again, each step of the process was validated and evaluated to determine the costs (removal of hard elements, transport) and the solutions to optimise the process, particularly in terms of eco-conception.

A set of Life Cycle Inventories (LCI) is created to set-up a database for each identified value chain. These inventories will cover all phases (collection, removal of hard elements, manufacturing, etc.) and will be available on the project website.

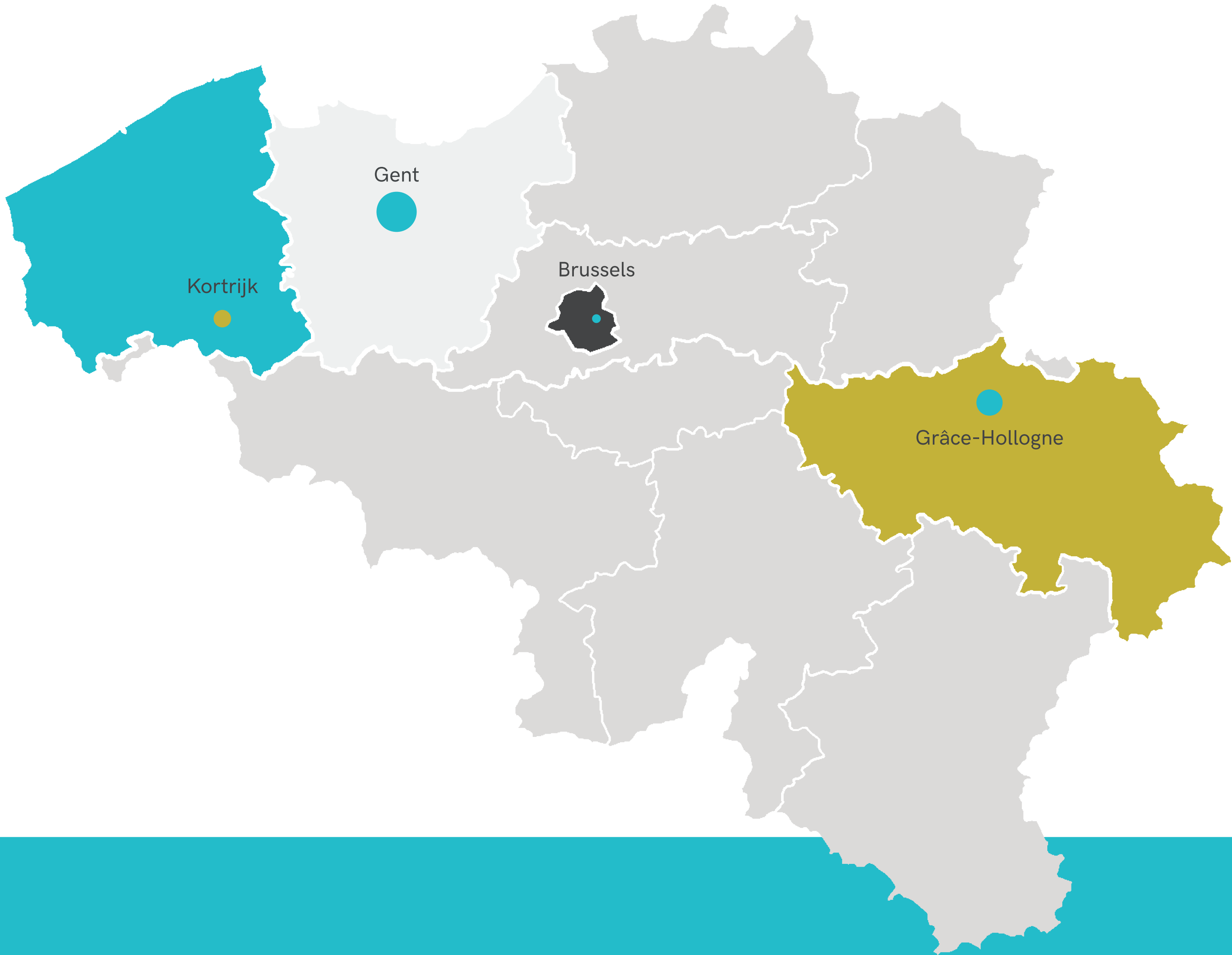
More information

https://www.dotheretex.eu/

https://www.centexbel.be/en/projects/retex



CREATE CONNECT INSPIRE SOLVE



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