SPIRE PROJECT

multicycle

AT MID-TERM

Defining and Specifying Sustainable Recycling Processes to recover Plastic-based Multi-materials

One of the first technical tasks in the project was to produce an up to date review of the technical and patent literature dealing with recycling processes for MultiCycle's target multi-materials and established the specifications for the different processes involved in material recovery and reprocessing, providing an understand of the requirements of converters and end users in terms of properties, price etc. for the resulting secondary raw materials produced.

A review of the relevant literature and industry trends has been assembled which offers a broad view of the current state of play with respect to plastic waste generation and the current state of the art in recycling technology.

The regulatory drive to establish higher recycling targets means that the recycling sector must be developed in the coming years, however the current options for the **MultiCycle** target materials are limited: both multi-material/multi-layer flexible packaging and reinforced plastics in End of Life Vehicles (ELV) are predominantly sent for fuel/energy recovery.

In view of their limited recycling options, the growth of the Fibre Reinforced Plastics (FRP) market in both carbon and glass fibre reinforced materials, does not help in meeting the goals of the ELV Directive. This presents an opportunity for **MultiCycle**, and especially the **CreaSolv®** selective material recovery technology at the heart of the project, which has the potential to increase the recycling volume of multi-layer packaging and FRP, and to do so producing high quality recovered polymeric and other materials including fibres.

The regulatory drive to establish higher recycling targets combined with limited current recycling options for the relevant target materials presents an opportunity for MultiCycle.

Consideration of the solvent-based **CreaSolv®** process requirements has shown that these have a large share in the selection of the respective technical components. With the help of the installed pilot plant, the entire plant technology is being up-scaling to Technology Readiness Level (TRL) 7. Critical process parameters that may influence the stable operation of the plant have been identified, and initial information provided on possible monitoring systems, and on which components of a motor vehicle can be used within the framework of the project to increase the recycling quota of ELVs.

Pilot Separation Process and Monitoring Systems

Technical work to obtain and evaluate a wide selection of waste material streams representing the variety of material types which the **MultiCycle** pilot plant might be expected to handle, and to identify from this a broad window of suitable waste stream requirements within which economic and practical processing could take place has been carried out.

Using their reach into the relevant supply and value chains, partners such as Arkema, Bond Laminates, FARPLAS, and Amcor have secured numerous samples of both industrial scrap and post-consumer wastes and sent these back to a hub location at Fraunhofer IVV, the Fraunhofer Institute for Process Engineering and Packaging. Both laboratory characterization and experimentation on an existing **CreaSolv®** small-scale pilot plant have been used to parameterize the **MultiCycle** process, and to inform the design of a 25 kg/h scale, continuous pilot plant concept, including suitable monitoring systems for plastic waste composition tracking and process control developed by IRIS Technology Group.

Trials at this stage is dealing with representative, tailor-made samples of up to around 100 kg of targeted waste streams, processed over multiple batches to allow testing of process stability and multiple use of recovered solvents. This will also enable the quality of recovered target polymers to be assessed and will provide samples for post-processing.

Examples of the diverse materials being evaluated in MultiCycle

Pilot Reprocessing of Recovered Plastics and Fibres

Materials recovered from treated waste are being characterized with respect to their application in plastic packaging, textiles and composites. This involves effort from across the consortium, but particularly Centexbel.

A wide range of virgin film extrusion and composite grade thermoplastic polymers have been assesed for their rheological and thermal behaviour. The values associated with these properties serve as reference points which can be compared with the plastics recovered by the **CreaSolv®** process. A number of recovered thermoplastics have already been extensively characterized, and several more are on their way. In addition to thermal and rheological properties, the composition and purity of the recovered materials is being thoroughly investigated via spectroscopy and extraction techniques.

Recycled carbon and glass fibres are being analysed for their mechanical and surface properties and compared to their primary manufactured counterparts by Centexbel and ELG respectively. Although the initial fibre samples were too short for mechanical characterization, it is expected that the **CreaSolv®** pilot plant will be able to retain larger fibre lengths.

Waste to new materials – treatment of end of life flexible film and automotive scrap yield both high purity mono-polymers and recovered reinforcing fibres

The residual sizing on the fibres (an important contributor to optimal fibre matrix adhesion) is also being determined. It is hoped that, with conditions suitably tuned, the **CreaSolv®** process will be able to selectively partly maintain the sizing on the fibres.

Since the materials with which we are working may have undergone some degradation during their previous working life (the **CreaSolv®** process itself does not lead to further downgrading), it is assumed that a degree of property "tuning" will be required if recycled thermoplastics are to be used for new applications via compounding. Optimal additive approaches are being developed by AIMPLAS to i) protect polymers during compounding and processing and during their lifespan, ii) improve their processing behaviour, iii) increase melt strength and molecular weight, and iv) improve specific functional properties related to their end use. Wherever possible additives, additional compounds or fillers recovered from the **CreaSolv®** process, will be considered for these roles, closing further material recovery and reuse loops. In the initial stages of this work, AIMPLAS has been working on adaptations to their compounding lines in preparation for preliminary trials with a reference film extrusion grade.

MultiCycle Pilot Plant Demonstration

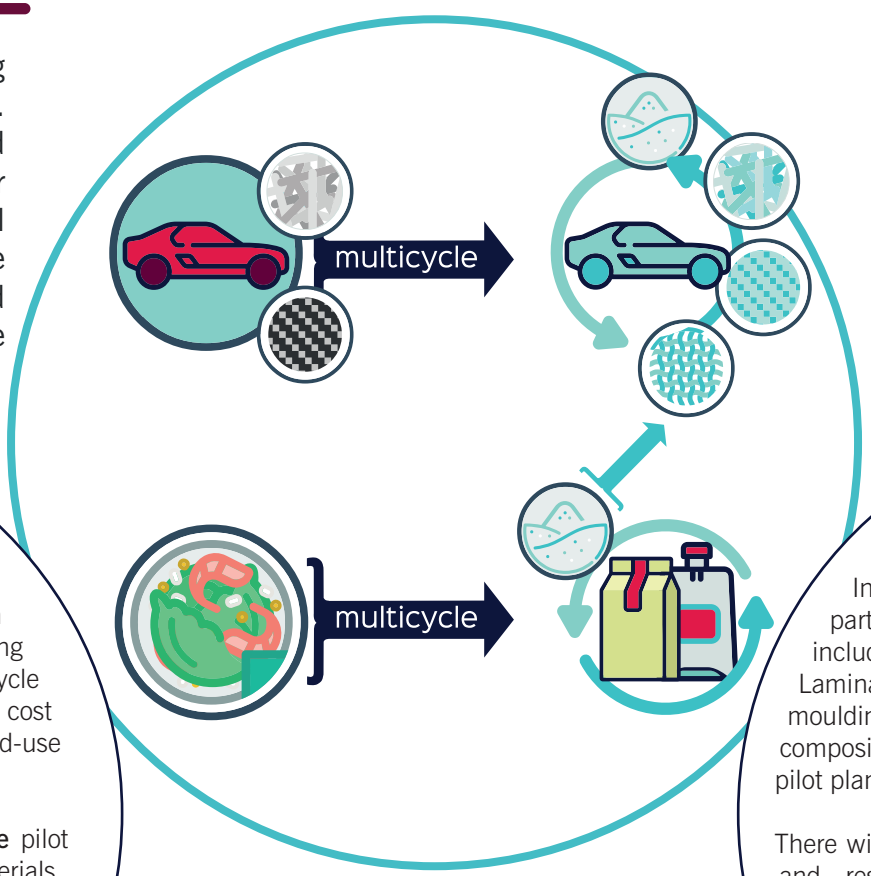
At the heart of **MultiCycle** is the engineering, installation and commissioning of a **CreaSolv®** pilot plant, and the demonstration of its performance under optimal operation. The pilot plant is designed to handle both composites and multilayer packaging found in currently non-recycled plastic waste mixed streams, recovering high quality recycled polymers and polymer free fibres in good yield for re-use in high end applications.

LÖMI GmbH have brought together their own expertise in high-quality and innovative process engineering systems and inputs from key technology partners, in particular Fraunhofer IVV and IRIS to integrate all the critical hardware engineering (rigs, pumps, filters, piping etc.) and software systems (PAT advanced sensing and monitoring) into a coherent whole process installed and comprehensively commissioned to relevant ATEX, CE and ISO standards.

As the pilot plant enters its operational phase in the autumn of 2020, larger scale representative waste streams reflecting the output from best, average and worst-in-class sorting systems practice across Europe will be treated both to validate the broad potential of the **MultiCycle** recycling pilot plan and to provide extensive large scale demonstration of the **MultiCycle** pilot recycling process for both multilayer packaging and fibre-reinforced composites.

Demonstration of Recovered Materials

MultiCycle is not just about demonstrating impressive new processing technology. Setting up the initial value chains, and raising industry acceptance and demand for more sustainable materials are also crucial to success, and this process begins with the demonstration of the potential of recovered materials in packaging and automotive applications.



Materials for Packaging Applications

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

The properties of materials arising from the **MultiCycle** pilot plant will be assessed relative to virgin benchmark materials. We will be producing single- and multi-layered packaging materials from the recovered plastics to evaluate their functional performance, once again in comparison to virgin-supply produced products, to validate their quality for food and non-food packaging applications, and confirm their usability relative to applicable legislative and industrial requirements.

Materials for Automotive Applications

In parallel to the work on packaging applications, partners aligned to the automotive value chain, including 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.

There will be work carried out to validate both the processability and resulting performance of the recycled materials in automotive applications when compared to the use of virgin materials, to confirm their usability for a range of industrial automotive applications. This will require upscaling of compounding process, and production and characterisation of textile nonwovens for the car interior, carbon and glass-fibre reinforced composite materials, and structural/semi-structural automotive parts.

People, planet, profit – ensuring the sustainability of the Multicycle process

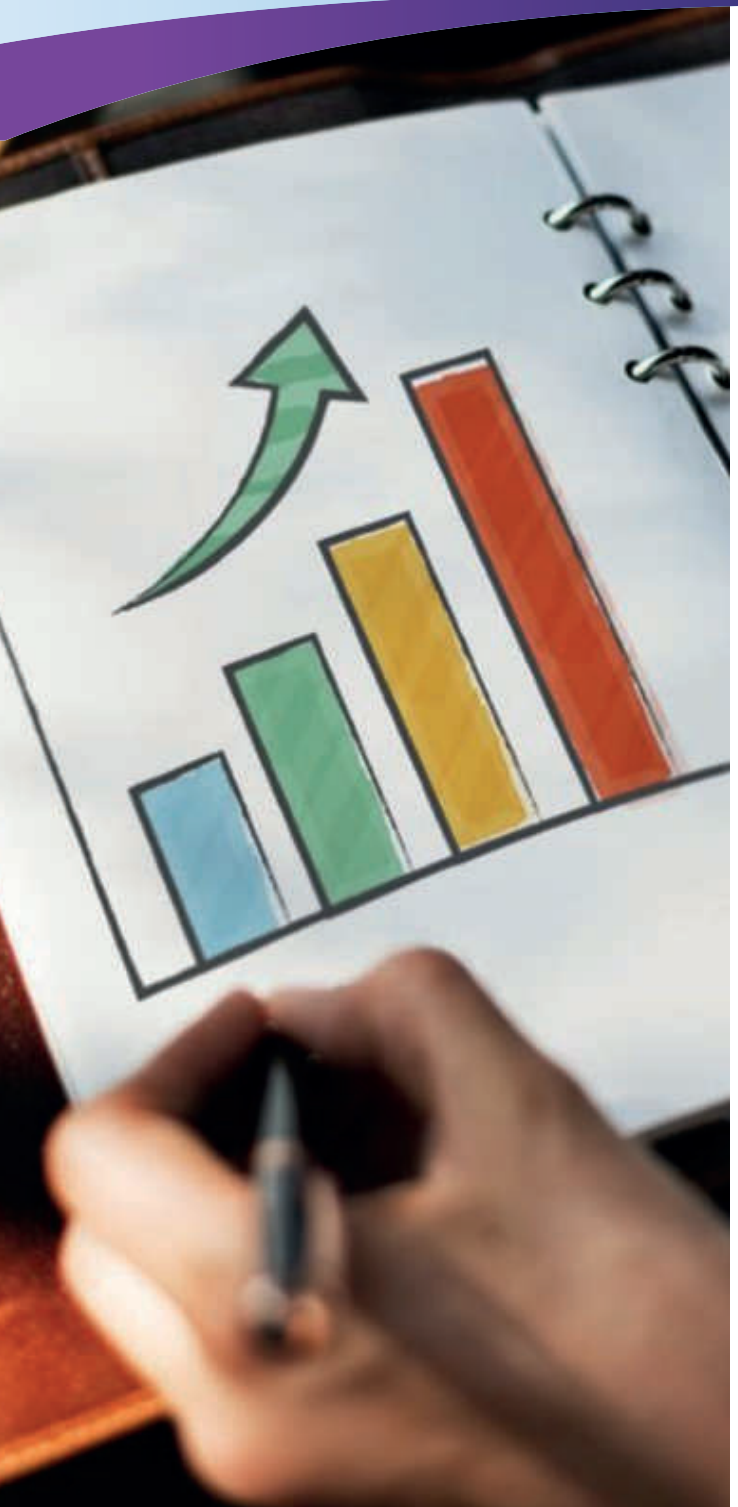
The emerging **MultiCycle** proposition will be thoroughly evaluated, not just at the technical level, but for its sustainability in development and implementation across the board.

Led by specialists in the field at Vertech Group, environmental, social and economic assessments are being undertaken using recognized best practice approaches: Environmental Life Cycle Assessment (LCA) to ISO 14040/14044 guidelines, Social LCA (S-LCA) for social and socio-economic aspects, and Life Cycle Cost Analysis (LCC) of both capital and operations. Life Cycle Assessment has been initiated by conducting a preliminary assessment based on laboratory scale data. The initial results are promising regarding the carbon footprint and energy efficiency of the MultiCycle process compared to current production routes for polymers/fibres and their end-of-life treatment. As energy use is the primary contributor to the impact, the main recommendation drawn at this stage is to improve the energy efficiency of the process. Some key parameters that will be defined later in the project (the quality of the recovered products, and energy requirement for pre- and post-treatment) as well as the collection of demonstration scale data will help fine tune these results and draw conclusions on the optimal context for maximizing the environmental benefits of the MultiCycle process.

An integrated evaluation of the techno-economic-environmental feasibility of the proposed process and plant evaluated, will generate recommendations for future up-scaling and help inform policy recommendations.

To help overcome the challenge of complexity in multilayer plastics and fibre reinforced composites and stimulate steps towards a Circular Economy model, a strategic approach is required to improve recycling and foster reuse. A whole value chain based decision support tool will be developed by AXIA Innovation based on an advanced multicriteria optimization model allowing

- Development of efficient networks depending on plastic waste properties and characterization
- Local circular business model opportunities and logistics strategies to be identified
- Informed decision making about which circular paths to pursue based on simulating materials over several life cycles and trade-offs between amounts recovered and performance.



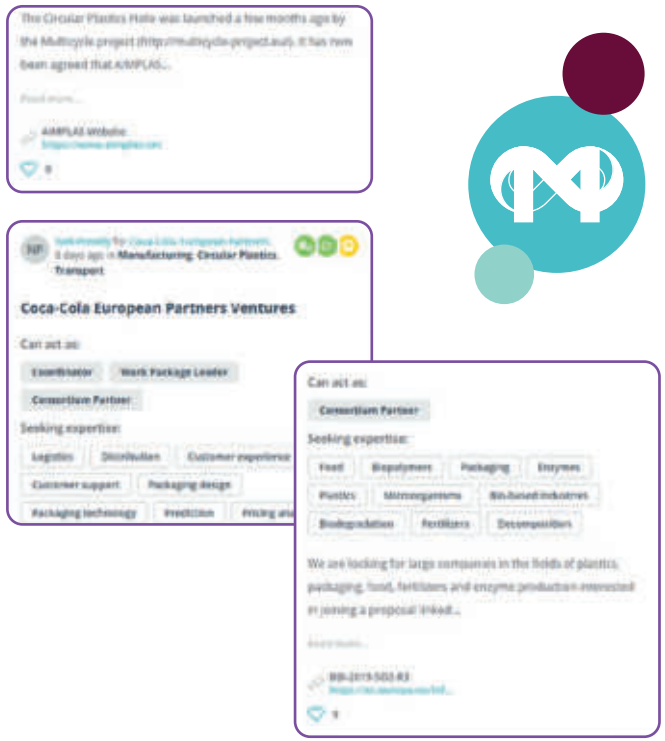
Promoting Impact and Exploitation

In order to realise MultiCycle's vision of leading the transition towards a sustainable post-petroleum society in the plastic sector and assist Europe in the transition towards a Circular Economy the consortium partners are working towards carefully planned post-project exploitation pathways.

Our aim is to reach the broadest audience possible, primarily though not exclusively across the EU, at both project level and at the relevant programme level. Communication and dissemination activities, led by Britest, and exploitation planning led by AXIA Innovation will be a catalyst for impact, with a strong emphasis upon commercial exploitation of the results arising as well as building momentum for the broader transformation towards a circular plastics economy for Europe.

MultiCycle has established a primary communication and dissemination vehicle in the shape of the Circular Plastics Helix as part of the broader CrowdHelix network, an Open Innovation network of more than 2,200 users supported by a technology platform which is open to applications from any organisation, of any size, anywhere in the world, that can demonstrate a strategic commitment to collaborative research and innovation. As well as disseminating the project's results, the Helix aims to create a self-sustainable research and innovation community around the circular economy and plastics – taking in sustainable plastic value chains, circular economy, renewably sourced plastics, recycling and end of life valorisation – that will continue beyond the end of the project.

To find out more about the Circular Plastics Helix and how to join it please contact multicycle@crowdhelix.com.



As well as disseminating technical results and recommendations for further upscaling, MultiCycle is a delivering a training and capacity building programme for the current and future workforce in plastics recycling, and producing decision support systems and policy recommendations promoting waste management and resource efficiency improvements (through ISWA) for the target packaging and automotive applications.

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