UPLIFT
sUstainable PLastIcs
for Food & drinks packaging indusTry

H2020 Work Programme

D1.5 – Position paper with recommendatios for policy makers

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1. Executive summary

Deliverable 1.5 *Position paper with recommendations for policy makers* is oriented to introduce the technology that has been developed during the execution of the UPLIFT project, with special emphasis on the economic, environmental, and social advantages of its implementation.

In addition, this position paper reinforces the UPLIFT technology as a tool to contribute to reduce the environmental impact derived from the inefficient management of plastic waste, intensified by the high demand of plastics in sectors such as Food&Drink packaging.

Finally, UPLIFT is aligned with the main European strategic plans in relation to the circular economy, raising issues to be taken into account by policy makers so that the future of UPLIFT technology and other similar technologies is not slowed down and is strengthened so that in the not too distant future it can be a reality at the level of market maturity.

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2. Introduction

Over time, the need to valorize waste to transform it into high value-added products has increased. This is due to the exponential rise in the impact of climate change, which demands strategies from society to mitigate it.

In the plastic sector, the demand to valorize complex waste has led to the emergence of **chemical-biological recycling strategies**, which complement traditional mechanical recycling techniques. Chemical Recycling is defined as the set of strategies or technologies capable of breaking down polymers into their basic structural units.[1] Unlike traditional mechanical recycling where the chemical structure of the polymer is not altered chemical recycling strategies involve structural modification. This allows the degradation products to be reused to obtain new polymers or different high value-added chemicals, positioning these technologies as highly versatile. Chemical recycling is divided into three main categories:[2]

- **Chemical recycling mediated by solvents: solvolysis.** This type of chemical recycling strategy is based on the use of solvents that break down the initial polymer chain to obtain the starting monomer. This monomer can then be repolymerized to obtain a recycled polymer with properties very similar to the virgin polymer. Additionally, this technology allows for partial depolymerization, yielding intermediate oligomers instead of the starting monomer, which gives the final repolymerized product specific properties.
- **Chemical recycling using temperature.** In this case, the cracking of the polymer chain occurs because of temperature on the initial polymer chain. There are two types of strategies: pyrolysis (when there is no oxygen present in the reaction medium) and gasification, when cracking occurs in the presence of a certain amount of oxygen.
- **Biological recycling**. Biological recycling includes those recycling strategies mediated by either a whole microorganism or parts of it, such as enzymes.

Of the categories detailed above, the **UPLIFT technology is based on** the principles of **biological recycling**. During the implementation of the UPLIFT technology, biological depolymerization alternatives have been investigated to produce eco-plastics, as shown in Figure 1. The main objective of UPLIFT is the development of a circular plastic packaging value chain in the F&D sector by applying novel eco-design strategies and biochemical upcycling technology routes.

1 Elgegren, M., Tiravanti, G. J., Ortiz, B. A., Otero, M. E., Wagner, F., Cerrón, D. A., & Nakamatsu, J. (2012). Reciclaje químico de desechos plásticos. Revista de la sociedad química del Perú, 78(2), 105-119.

2 Fernández Codina, R. (2023). Métodos actuales de revalorización de plásticos por medio del reciclaje químico (Master's thesis, Universitat Politècnica de Catalunya).

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They are summarized below:

- To combine bio-depolymerization of plastics and bio-based building blocks to obtain smarter and renewable plastic materials, which will enable the effective upcycling of plastic packaging waste streams.

- To fully integrate the bio-chemical upcycling technologies within already existing and more mature recycling processes and fermentation processes. All these prototype materials and processes will be evaluated in a relevant operational scale close to expected performance (TRL 6)

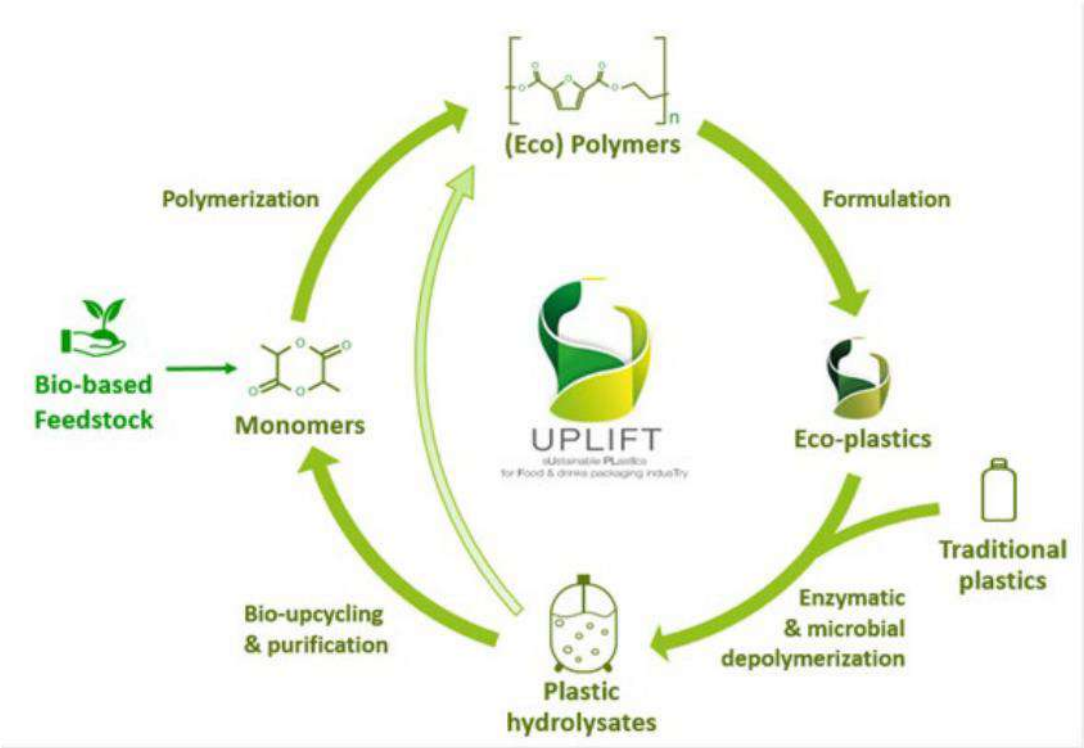

Figure 1. Overview of the UPLIFT technology

The advantages of biological recycling in general, and UPLIFT technology in particular, are diverse (as detailed in the Strengths Weaknesses Opportunities Threats study in deliverable 1.4.)
These are summarized below:

A. Environmental advantages

Biological recycling strategies mitigate the environmental impact with respect to conventional recycling processes as biological processes typically require less energy than traditional chemical or mechanical recycling methods, resulting in lower greenhouse gas emissions. In addition, use microorganisms like bacteria and enzymes, reduces dependencies on solvents and toxic chemicals.

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B. Economic advantages

From an economic perspective, new biological recycling strategies allow for the development of new market niches that demand sustainable products. In the case of UPLIFT, the development of its technology will drive the evolution of the use of enzymes in plastics recycling, the production of value added products including biodegradable packaging from waste in the medium to long term. Furthermore, in the specific case of UPLIFT, cascade depolymerization will reduce downstream costs. These economic advantages make biological recycling an attractive option not only from an environmental perspective but also economically, providing short and long-term benefits for businesses, governments, and society at large.

C. Social advantages

In the medium to long term, new bio-recycling technologies will increase social awareness of the climate crisis and plastics recycling.

However, biological recycling technologies are currently the least advanced in terms of TRL compared to other chemical recycling techniques like pyrolysis or solvolysis. This is why the public administration has a vital role to play in promoting the development of this type of recycling strategy by implementing solid legislative and regulatory frameworks that reinforce it.

3. UPLIFT solution : from waste to high value-added materials

The world is currently facing the challenge of minimizing the carbon footprint of the different value chains, to minimize as much as possible, the environmental impact derived from it. In particular, the food and beverage sector require enormous quantities of plastics for packaging. In 2022, global plastics production reached 400.3 million tons.3 A large part of this amount is destined for food packaging. In the case of Europe, 40 % of the plastic produced goes to packaging manufacturing.4

In Europe, demand for plastics for food packaging remains high, despite pressures to reduce the use of plastics due to environmental concerns and stricter regulations. In 2020, for example, the food and beverage industry in Spain has seen continued

3 https://gestoresderesiduos.org/noticias/400-millones-de-toneladas-esta-es-la-cantidad-de-plastico-que-producimos-al-ano

4https://www.eea.europa.eu/media/infographics/nearly-40-percent-of-plastic/view#:~:text=Nearly%2040%20percent%20of%20plastic,plastic%20packaging%20%E2%80%94%20European%20Environment%20Agency&text=Do%20something%20for%20our%20planet,millions%20of%20people%20do%20it!

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growth in packaging use, reflected in increased food retail sales reaching $27.4 billion in 2021.5

In parallel, the production of recycled plastics has increased, reaching 35.5 million tons globally in 2022, representing 8.9% of total plastics production.6 This increase in recycling is crucial to reduce the environmental impact of the use of plastics, including those used in food packaging. However, we are still in a phase of awareness and development of technologies to increase recycling rates within the packaging sector, since:

- Enormous quantities of virgin materials are currently used (around 40 % of plastics and 50 % of virgin paper is used for packaging) with the environmental damage that this entails.
- In recent years, CO_2 emissions from processes related to packaging manufacturing have increased, as it is a growing sector. As most plastics are used, this has an enormous impact on the carbon footprint and a disproportionate increase in the use of fossil fuels.

In parallel, much of the packaging waste ends up in ecosystems such as the marine environment. In particular, the Mediterranean Sea is one of the most affected. In 2023, it was estimated to contain 7% of the world's microplastics, despite representing only 1% of the planet's water.[7] This is equivalent to 1.25 million plastic fragments per square kilometer. A significant percentage of this amount comes from F&D packaging sector.[8]

Thanks to advances in new recycling technologies, such as the UPLIFT technology, progress is being made towards the implementation of technologies that open up the end of life options for plastic recycling and thus increase the circularity of the impact of plastics from the packaging sector. Within the framework of UPLIFT, the valorization of waste from the F&D sector will be achieved through the following high value-added compounds:[9]

- **Monomers.** Basic structural unit of polymers.
- **Polymers.** Product of the union of several monomers
- **Co-polymers.** Macromolecule composed of two or more monomers or distinct repeating units, which are joined by chemical bonding.
- **Plasticisers.** Additives whose main function is to increase the flexibility, elasticity and fluidity of a given material (generally plastics and concrete).

[5] https://www.mordorintelligence.com/es/industry-reports/europe-plastic-packaging-market
[6] https://plasticseurope.org/es/knowledge-hub/plasticos-situacion-en-2022/
[7] https://www.20minutos.es/noticia/5123659/0/el-mediterraneo-camino-de-convertirse-en-una-sopa-de-microplasticos/
[8] https://www.worldwildlife.org/initiatives/plastics
[9] Reynoso, S. L. (2018). Los Polímeros Plásticos: Los Conceptos Básicos que debes conocer durante y al salir de la Universidad. Sara L Reynoso.

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In this way, **UPLIFT is attempting to valorize waste that ends up in landfills, damaging ecosystems and/or contributing to processes with high CO_2 emissions**. Therefore, **UPLIFT is demonstrating that it is possible to achieve a circular economy strategy within the F&D packaging waste sector, increasing resource efficiency.** In this way, UPLIFT can contribute to the achievement of climate neutrality by 2050, by favouring low CO_2 emission processes, reducing plastic waste entering the environment which is associated with biodiversity loss and producing recycled products than can be biodegraded.

4. UPLIFT alignment with European environmental strategies

UPLIFT is aligned with different European frameworks and objectives which are listed below:

- **Circular Economy Action Plan 2020.**[10] One of the main pillars of this plan is waste reduction, setting targets and measures to increase recycling rates. It also encourages the use of recycled materials in new products, supporting research and development of advanced recycling technologies and innovative solutions. UPLIFT is clearly aligned in this regard.
- Green Deal.[11] The green deal framework promotes the transition to a circular economy where products, materials and resources are kept in use for as long as possible, thus reducing the need to extract novel resources and minimizing waste. UPLIFT is therefore perfectly in line with this European strategy.
- Farm to Fork Strategy.[12] It is one of the key components of the European green deal, which aims to create a sustainable food system. To this end, it promotes improvements in waste management, increasing efficiency, improving waste management, and promoting the circular economy in the food system, including the reuse and recycling of by-products and waste. Specific to food packaging. UPLIFT is a tool fully aligned with this European strategy.

As discussed above, **it is of vital importance that the European public administration encourages recycling technologies such as UPLIFT** to move from the laboratory to the real world, promoting and favouring the process of industrialization of the technology.

Bioplastec: PHA (C8-PHA) que es el hydroxi octanoate, que es totalmente amorfo, pegajoso.
Co polimero del HPA—Láctico-Lactida (PLA) ((PLA/HPA))

[10] https://ec.europa.eu/commission/presscorner/detail/es/ip_20_420
[11] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_es
[12] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

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5. Industrialization of UPLIFT technology

The traditional linear economy model is based on the take-make-waste model. This model favours the accumulation of waste in landfills, which generates a high environmental impact. This is why, in a circular economy model, a given product is made from renewable materials, either by reusing or recycling materials that traditionally would have been considered as waste, forming a closed-loop system. According to this model, materials can be circulated almost indefinitely, reducing and avoiding excessive waste generation, especially in the plastics sector.

As discussed in the previous sections, UPLIFT is a technology with a clear basis in the principles of the circular economy. The ascent of such a technology to a market TRL will depend on the resolution of different challenges.

The main challenges facing the industrialization of the technology are based on different aspects which are detailed below: i) economic aspects, ii) technology and process efficiency, and iii) regulatory aspects.

- **Economic aspects.** At the beginning of the implementation phases, large investment costs will be necessary to scale up the technology. Support from public funds will be critical to de-risk the scale up but this will also attract larger scale investments for higher TRL (8-9) implementation. Thus early stage public funds not only helps to accelerate technological development but also stimulates private investment for implementation.
- **Technology and process efficiency.** During the scale-up phase, it is possible that process efficiencies may be modified with respect to laboratory results. This is why human resources and innovation support will be needed to adapt the technologies to the new scales of operation.
- **Regulatory aspects.** The clear definition of concepts related to bio-recycling and their consideration in operating environments will not be possible without a clear regulatory framework in which the processes are standardized. In addition, support for such technologies may also come from tax exemptions that stimulate the uptake of these new recycling strategies.

The support of the European public administration is therefore vital to overcome the challenges discussed above and that will appear during the industrialization of UPLIFT technology. This is why a series of recommendations for policy makers in favour of UPLIFT are proposed below.

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6. Recommendations for public administration in favour of the UPLIFT technologies

Some recommendations to be considered by policy makers in favour of UPLIFT technology are discussed below:

- **Incentive and financial support through the design of calls for proposals aimed at promoting these new recycling technologies.** To frame public calls for research support towards this type of strategies. The execution of this type of projects allows:
  - Knowledge transfer between university entities/technology centers and companies promoting public-private collaborations. The knowledge generated in universities and research centers must be transmitted to the business fabric so that the end user benefits. The transfer process is enriching for all actors:
    - **A)** Business actors. Knowledge and technology transfer can become an important source of innovation and competitiveness.
    - **B)** Knowledge generation centers (universities and technology centers). The process of knowledge transfer makes research work gain added value and provides basic research with applications.
    - **C)** Society. The final beneficiary of the knowledge and technology transfer process is society in general, since it allows the retention of existing jobs and the creation of new jobs. It also promotes the development of a knowledge-based economy, which enhances the welfare of citizens.
  - The promotion of technologies even with TRLs far from the market. Research calls allow research and industrialization of processes that are not currently implemented in the market. This factor is vital for a novel recycling technology to have a real application in the market.
- **Establishment of solid legislative and regulatory frameworks that encourage the development of new recycling technologies.** An example is the new regulation 2022/1616 concerning recycled plastic materials and articles intended to meet food. It opens a new window to new recycling technologies, considered as novel recycling technologies, allowing the evolution of recycling techniques still at low TRLs with respect to the market, such as those proposed in UPLIFT. However, this is only the beginning, and the competent authorities need to continue to provide greater support for the new chemical and biological recycling technologies that have emerged in recent years.
  Stronger links between the circular economy and bioeconomy strategies are needed as often they are treated two separate concepts when in fact the bioeconomy is one half of the circular economy. UPLIFT shows that tools from the bioeconomy (microorganisms and enzymes) can be deployed in the technical half of the circular economy (waste plastic depolymerization and

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valorization) and the products arising from Uplift can be managed in the bioeconomy half of the circular economy (e.g. biodegradable plastics arising from the recycling of fossil based plastic waste).

- **Reach out to society through efficient dissemination strategies.** Such dissemination could be done by the public administration (use of digital media/Publications/Public events and workshops). Public administration initiatives to promote recycling and to imagine new futures can be promoted though Community groups, schools and competitions. Public private partnerships between the recycling industry and local public administrations are also vitally important to share knowledge and promote innovation.

7. Conclusions

These recommendations can help policy makers to design effective and sustainable policies that encourage the use of bio-recycling technologies, thus contributing to the mitigation of environmental impacts and economic development based on sustainability.

This requires a **joint work between the main actors: i) universities, ii) technology centers, iii) companies and iv) public administration** in order to:

- Clarify fundamental theoretical aspects definition of biological, microbiological and enzymatic recycling.
- Define the limits between chemical and biological recycling. Currently there are no clear definitions of chemical and biological recycling, so it is necessary to establish clear definitions of chemical and biological recycling processes, to distinguish them clearly.
- Encourage support at state and European level for the advancement of biological recycling technologies.
- EU policy should incentivize the transition to renewable materials as complementary to incentives regarding end of life of products to ensure circular products and boost a truly circular European economy.
  To promote and convince industry of the advantages of bio-recycling technologies and the benefits of investing in new technologies.

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