29 October 2019

EuRIC position on chemical recycling

EuRIC's summarized position

- **CHEMICAL RECYCLING CAN COMPLEMENT MECHANICAL RECYCLING IN ACHIEVING A CIRCULAR ECONOMY**

The well-known issues surrounding end-of-life disposal of plastics and the more recent setting of higher recycling targets for plastic products, favors the emergence of new technology solutions to recover materials and extract value from waste plastics such as Chemical Recycling (CR), which describes a range of such potential solutions. Representing the mechanical recycling industry, EuRIC agrees that chemical recycling could effectively complement mechanical recycling in achieving a circular economy, as it would represent an interesting solution to address plastic waste streams that are not currently recycled.

- **CHEMICAL RECYCLING PROCESSES ARE STILL IN THEIR INFANCY AND CANNOT BE CONSIDERED AS THE SILVER BULLET SOLUTION**

However, EuRIC wishes to underline that chemical recycling cannot be considered as the silver bullet solution as such. It covers a large number of different technologies, in some cases at early stages of industrial development and with different abilities to recycle complex waste plastic streams of mixed polymer types. Those different processes will most likely be hampered by the same waste-specific issues that the mechanical recycling is facing. Besides, some of the technologies understood as CR are actually producing fuel from plastics and as such not complying to the definition of recycling as stated in the Waste Framework Directive.

- **REGULATORY FRAMEWORK DEFINING RECYCLING ACTIVITIES HAS TO REMAIN UNCHANGED**

As the growth of CR will be dependent upon both successful technological development, but also on a favorable EU regulatory framework, EuRIC underlines that the regulatory framework defining recycling activities has to remain the same, and allow level playing field between mechanical and chemical recycling. For instance, displacing existing definition boundaries between energy recovery and recycling would be unjustified.

- **DEMAND FOR RECYCLED MATERIALS HAS TO INCREASE TO BENEFIT BOTH MECHANICAL AND CHEMICAL RECYCLING**

Issues that CR is facing are the same for the whole industry, EuRIC promotes solutions that could help recycling in general, including the more mature mechanical recycling industry, such as boosting the demand for recycled materials.

I. Policy context underlying the drafting of a position paper

New recycling objectives have been set at EU level, favoring the development of new industrial solutions to comply with regulatory recycling objectives. The revised Waste Framework directive (Directive 2008/98/EC) has set ambitious objectives regarding the preparation for reuse and recycling targets: 55 % to be achieved by 2025, 60 % by 2030 and 65 % by 2035. Similarly, the revised Packaging and Packaging Waste Directive introduces a new plastic packaging recycling target of 55% to be achieved by 2030.

Similarly, at EU level private and public stakeholders involved in the plastics value chains, gathered in the Circular Plastics Alliance, have committed in September 2019 to recycle 10 million tons of plastics by 2025[1]. The global challenge of plastic litter, especially marine litter, has also raised awareness about the opportunity of plastic recycling.

Representing the already well-established mechanical recycling industry, EuRIC is committed to those objectives, and welcomes the developments of new industrial solutions hereafter designed as “chemical recycling”.

[1] See Circular Plastics Alliance pledge

II. Chemical recycling is complementarity with mechanical recycling

A. What is chemical recycling?

It is first necessary to better define the term "chemical recycling" (CR), which covers multiple processes (Crippa et al., 2019), including:

1- **solvent-based extraction**, where the plastic is dissolved, and the initial polymer is extracted. It addresses pure fraction of PVC, PS and polyolefins;
2- **depolymerization**, where the bond between certain types of polymers can be broken by heat to go back to the monomer blocks forming the polymer. It addresses pure fractions of PET, PU, PA, PLA, PC, PHA and PEF;
3- **feedstock recycling**, where the plastic is heated in the presence of oxygen (gasification) or without oxygen (pyrolysis). The plastic waste is turned back into the different molecules forming hydrocarbon chains. Both techniques address mixed plastics.

The Figure 1 illustrates the different processes used in chemical recycling, and at what stage plastic production these processes recycle polymers.

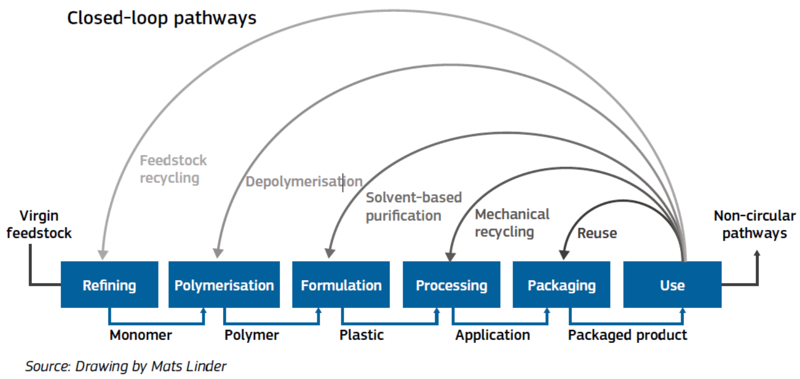

Figure 1: Overview of different loops for plastics in a circular economy (Crippa et al., 2019)

Given the diversity of those processes and their different positions on the polymer production stages (as shown in Figure 1), it would be difficult to define a unique circularity potential for CR, and therefore a unique position in the waste hierarchy.

B. What could be the waste streams addressed by chemical recycling?

Only about 30% of waste plastics is collected for recycling in the EU (European Commission, 2019), meaning that there is an opportunity to address large plastic waste streams that cannot be recycled by existing mechanical technologies. This include most notably low-quality waste plastic fractions that are too much soiled or mixed.
By cleaning waste material at the molecular level, CR could remove of additives and contaminants and help produce food grade recycled plastics. A Life Cycle Assessment (LCA) study from CE-Delft (Bergsma, 2019) has found CR to be a sustainable alternative for plastic waste not addressed by mechanical recycling in the case of:

- PET-trays, undergoing magnetic depolymerization;
- mixed plastic waste[2] undergoing hydro-pyrolysis.

Polyester textile fibers could also be chemically recycled for example.
One should note however that concerning mixed plastic waste, mechanical recycling and chemical recycling have been compared in the abovementioned LCA study. It proves that mechanical recycling still has a better carbon footprint than CR. Theoretically, if the different processes understood as CR (solvent-based extraction, depolymerization, gasification etc.) were to be introduced in the waste hierarchy as such, it is clear that CR should be inserted below mechanical recycling and above energy recovery.

[2] DKR 350 : other plastic waste stream according to Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe mbH (DKR) standard

III. Chemical recycling also entails economical - technical challenges

A. Chemical and mechanical recycling actually share issues specific to waste processing

1. Low density of low value waste to collect

As mechanical recycling now, the development of CR might be hindered by the low value of the waste. Indeed, as put by Crippa et al. (2019) "*the lack of incentives for chemical producers to buy geographically dispersed and relatively small volumes of chemically recycled feedstock is a barrier*". Since plastic waste are lightweight and geographically scattered, their transportation cost can turn out to be prohibitive. This might be challenging if the CR plants require large inputs to be economically and technically viable.

2. Poor quality of waste input mix also degrades the quality of recycling output in chemical recycling

Poor quality of the input plastic mix and used processes can lead to the formation of substances of concern (SoC) in CR as well, which will need to be further purified, e.g. dioxins and PAH formed in pyrolysis process (Crippa et al., 2019), but also in gasification (Delavelle and De Caevel, 2015).
CR also has to tackle legacy substances. For instance, the Vinyloop plant in Ravenna, recycling soft PVC from cables and films by solvent based extraction, had to face the issue of now restricted phthalates, which were not economically removable from the input plastic. The plant had to close in June 2018.

3. Chemical recycling will also face the issue of low virgin material prices

Mechanical recycling has been facing for long the cyclical problem of low virgin materials price, limiting the demand for recycled plastics. Low oil prices are related to a reduced demand for recycled plastics as plastics are cheaper to produce from virgin materials. This could also harm the profitability of CR.
In the case of potential large-scale plastic plants integrating plastic waste from pyrolysis, it has been estimated that plastic-waste based feedstocks would be competitive with virgin based feedstock above a crude oil price of 65-75 US$/barrel (Hundertmark et al., 2018). Over the last five years, oil prices have not been high above this range.

B. Chemical recycling still has specific limitations

1. The easiest way for chemical recycling could be to turn waste into fuel, i.e. not to recycle

- Pyrolysis and gasification are the most suited way to treat mixed-plastic waste

As previously mentioned, CR entails diverse processes, and in most of those processes, a homogenous mix of plastics is actually needed. Indeed, feedstock recycling processes (gasification, pyrolysis) are the main way to treat mixed plastic waste. As streams of mixed plastic waste contain a lot of impurities (e.g. Pb or phthalates in PVC), the easiest way get value from the resulting fuel or syngas is to turn it into fuel, instead of new plastic material.

This might be a problem for a large part of the plastics likely to go through a CR process. Polyolefins are the most used polymers by volume, representing in total about half of the plastic demand in the EU-countries (for PP, PE-LD and PE-HD on Figure 2). Polyolefins cannot be depolymerized to produce raw material directly suitable for polymerization, and require requires additional refining steps.

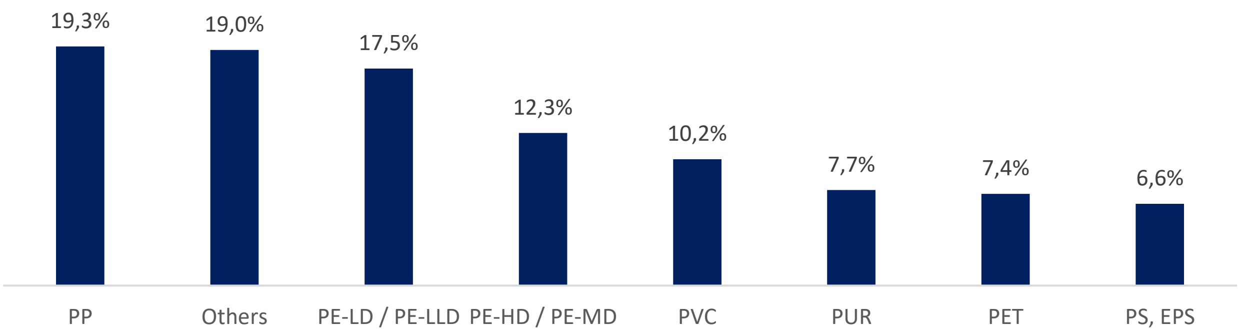

Figure 2: Demand by polymer type in the EU in 2017 (Plastics Europe, 2018)

Other resins such as PS, PMMA or Nylon, (Delavelle, De Caevel, 2015) or PET (Crippa et al., 2019) can undergo depolymerization processes enabling to recover the monomer forming the polymer.

- Pyrolysis and gasification may also require pre-sorted waste streams

However, even pyrolysis and gasification processes are not exempt of advanced pre-sorting of individual polymer materials for them to allow material recovery. Indeed, the majority of low-value, mixed plastic waste streams those processes could treat contain multiple polymer types; both as individual items (e.g. PET bottle) and combined in complex multi-layer flexible films (e.g. laminated food sauce pouches). In order for the molecular break-down process to be able to deliver an end-product - gas or liquid - that is viable for use to re-manufacture new plastic molecules, the infeed stream also has to be carefully sorted to remove all traces of unwanted plastic: in the case of pyrolysis for instance, PET should preferably be sorted out of mixed PE / PP polyolefin streams[3].

Besides, in the case of gasification, the presence of impurities in the syngas from mixed waste plastics can harm conventional catalytic converters. After the gasification step, chemical building blocks from waste will need catalytic conversion to form monomers, alongside virgin materials. However, catalytic converters are designed for virgin materials, not for waste materials (Forsgren, 2019)[4]. Impurities could therefore hinder this process (Delavelle et De Caevel, 2015).

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[3] Oxygen-containing PET would interfere with the pyrolysis process, that is normally done without the presence of oxygen.

[4] A polymer degradation process forming syn-gas (hydrogen gas and carbon monoxide) makes it possible to produce very clean chemicals but with the drawback of higher energy losses.

- Chemical recycling could then divert some plastic waste stream from material recovery to energy recovery

Such well-sorted streams of plastic are exactly what is needed for existing mechanical recycling plants. This fact severely limits the choice of waste feedstock streams that are suitable for the CR processing technology.

Given all these limitations to treat mixed plastics to recover material, plastic-to-fuel processes might be the easiest path for waste plastics treated by pyrolysis or gasification[5]. Besides, existing pyrolysis processes have already fuel as an output product, alongside naphtha (which can be used to produce secondary plastics) from plastic waste. Naphtha can represent up to 50% of the output of pyrolysis, leaving room for fuel production with the remaining output.

However, under the current regulatory framework, these plastic-to-fuel processes fall under the category of energy recovery, not of material recycling (see section IV).

[5] in the case of gasification "*there is a high likelihood that the output products would be used as fuel, as is the case nowadays*" (Crippa et al., 2019).

2. Chemical recycling has so far a poor track record of industrial scale processes

One of the few CR processes mature at industrial scale, the PVC recycling process of Vinyloop, had to stop in 2018 (Crippa et al., 2019). In France, despite important R&D efforts, no pyrolysis or gasification project had reached a mature development (Delavelle et De Caevel, 2015). In fact, efforts to set up large scale plants in the past years have not succeeded.
CR does not only require large investments in plants, it also requires to secure significant input of raw materials on a long-term basis, both in terms of price and quantity. In the recycling industry, this long-term visibility is so far limited, as EPR-scheme seldom give contracts for a period over 3 years (Forsgren, 2019). This was already acknowledged by TNO in a report written for the Commission about a project of industrial-scale plastic CR plant in Ludwigshafen: "*It seems that no agreement could be reached on a waste supply guaranteed in the long term for a gate fee that would be sufficient to cover the costs of a full-scale plant. Particularly due to the long mortgaging periods of such industrial installations, long-term commitments are essential to reduce the financial risks for the investor to reasonable levels*" (TNO, 1999). The difficulties encountered so far to set up industrial scale chemical recycling operations can obviously not prejudge the outcome of substantial investments made by the chemical and petrochemical industry in CR. Nevertheless, a cautionary approach should prevail against potential solutions that CR would provide in the future.

In comparison, mechanical recycling is a mature industry with years of experience. The Figure 3 illustrate the global share of mechanical recycling in the global distribution of polymers waste streams. If there is an obvious need for more recycling, mechanical recycling is responsible for the overwhelming majority of waste polymers recycling.

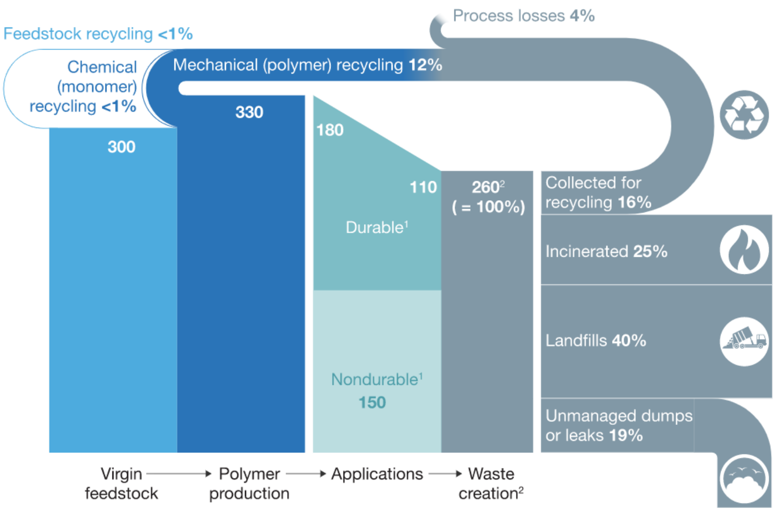

Figure 3: Global polymer flows, million metric tons per annum, 2016 (Hundertmark T., 2018). 1- Durable applications with an average lifetime >1 year will end up as waste only in later years; nondurable applications go straight to waste. 2- 150 million metric tons of mixed plastic waste from nondurable applications that end up as waste in same year, plus110 million metric tons of mixed plastic waste from production in previous years.

IV. Existing limitations of chemical recycling imply support by the policy framework

A. Existing waste framework legislation should not be substantially changed

The product of the gasification or pyrolysis of polymers can be used as a raw material (P2P, plastic-to-plastic), but also as a fuel (P2F, plastic-to-fuel). Given the now uncertain profitability of CR mentioned above, and the nature of some CR processes, this product is may end-up as fuel. Both the American Chemistry Council[6] and Chemical Recycling Europe[7] defines waste-to-fuel technologies as recycling. However, recovery activities consisting mainly of P2F shall not be defined as recycling, but as energy recovery, in accordance with the current EU waste legislation and its long-established waste hierarchy soundly based on treatment options' environmental impacts.

EuRIC express its disagreement to the inclusion of alternative fuels recovery in recycling activities. The recovery of fuels is clearly excluded from the definition set in the Waste Framework Directive (Directive 2008/98/EC), where recycling means "*any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations*" (art. 3.17). In that regard, a clear definition of CR should be established at EU level, without substantially changing the existing regulatory framework.
Besides, P2F solution are also not compatible with the Commission decision (Decision 2019/1004) on the rules for calculating recycling rate, which states that recycled plastics are measured as "*Plastic separated by polymers that does not undergo further processing before entering pelletisation, extrusion, or moulding operations. Plastic flakes that do not undergo further processing before their use in a final product*". This calculation point shall not be changed to include outputs used for fuel production.

Finally, unclear classification exists concerning "co-processing" of plastic waste. This process operates with both waste and end-of-waste feedstocks. If waste regulations do not apply appropriately to co-processing, a regulatory loop hole might arise.

B. To ensure a level playing field, funding available for chemical recycling shall equal those available for mechanical recycling

Mechanical recycling technologies still have huge potential for further technical innovation and process development. Therefore, funding should be available for mechanical recycling to the same extent as it would be available for chemical recycling. In fact, the awarding of funds to these new processes needs to look closely at the actual mass percentage yield of useful end-product, because many of the proposed CR methods create outputs at around half of the input mass flowrate, much lower than equivalent mechanical recycling options.

C. Common issues in recycling require similar policy measures

However, many technical-economical limitations of CR are also hampering recycling in general. Therefore, in addition to technological achievements, CR would need a favorable regulatory framework to bloom, (e.g. acknowledging the concepts of CR and mass balance approach). Consequently, regardless of the technology (mechanical or chemical recycling), EuRIC stresses the need for a boost in the demand for end-markets using recycled plastics from both mechanical and chemical recycling. Plastics recycling is affected by cyclical (low prices of recycled materials) and structural (lack of profitability) issues and the substantial environmental benefits it brings are not internalized in market prices. A higher demand (recycled content targets combined with industry pledges) would contribute to reduce that market uncertainty needed to de-risk investments.

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[6] "*The Chemical Recycling Alliance* [created by the American Chemistry Council] *works to: grow awareness of the benefits of chemical recycling technologies that convert post-use plastics into chemicals, fuels and other products*" (source)

[7] "*Chemical Recycling of polymer waste is defined as any reprocessing technology that directly affects either the formulation of the polymeric material or the polymer itself and converts them into useful products like monomers, basic-chemicals, alternative fuels and other value-added materials*" (Chemical Recycling Europe, 2019)

V. References

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