EPEA Position Paper

Mechanical and chemical recycling of plastics

EPEA
The Cradle of
Cradle to Cradle

Review of arguments for mechanical and chemical recycling of polymer-based products

A hierarchy of recycling strategies underlies the European waste framework directive. It assumes that the more matter is recycled the better it is for the performance of material flow management (eco-efficiency). A driver for this hierarchy is the differential energy demand which is structurally lower for mechanical recycling than for chemical recycling. The **quality of recovered materials** and especially their capacity to substitute virgin materials as technical nutrients in a chemically defined way and without compromises **(eco-effectiveness)** plays in this hierarchy a subordinated role. As result, chemical recycling appears lower in this hierarchy than mechanical reprocessing.

At EPEA, we see that **the approach of the recycling hierarchy isn't differentiated enough, especially for polymer-based products: by not considering conditions for repeated reuses of one and the same material**, this hierarchy can introduce a bias leading to favour in the design phase plastic resins with a significantly lower long-term reuse performance, both in eco-efficiency and eco-effectiveness terms.

Mechanical recycling of plastics is applicable for a limited number of reuses of one and the same material because additives and contaminants are not removed and tend to accumulate in the recycled material, thus limiting the technical attractiveness and safety with number of reuse cycles increasing. As example, **contaminations with heavy metals and bioaccumulative fluorinated compounds can't be removed from carpet fibres via mechanical recycling.**
To partially overcome such a limit and to also compensate other limitations (e.g. the plastic resin chain shortage), mechanical recycling generally involves combination of recycled materials with virgin materials. This leads to diluting problematic chemicals of former uses in a volume increasing with each new reuse and to challenging the reusability of the whole volume after only a small number of reuse cycles.

However, **both the properties of the polymer and the formulation context in products must not be per se a bottleneck but can indeed represent opportunities for intelligent and adapted recycling technologies** with a subsequent high material reuse performance, both in eco-efficiency and eco-effectiveness terms.

In this view, some chemical recycling approaches (specifically depolymerization) represent a valuable solution when they enable to refine and separate easily additives formerly included in the formulation of the used products to be recycled.

However, such chemical recycling is not feasible for all polymers: for example, polyamide 6,6 (which is usable in a functionally equivalent way to polyamide 6), some polyesters and polyurethane do not offer the opportunity for a rational depolymerization process. In this view, there is indication to make use of polymeric materials recyclable via depolymerization rather than the ones feasible only for mechanical recycling and/or unspecific chemical recycling like pyrolysis.

Important steps have been taken in this direction. Indeed, **a virtuous example of chemical recycling rationale is the polyamide 6 depolymerization/ repolymerization. The performance of such a process, both in terms of eco-efficiency and eco-effectiveness, is so high** with polyamide 6 rich materials that there is a strong indication to increase the volume of polyamide 6 used in products comparable to textiles in terms of formulation structure and complexity.

The industrial feasibility of the polyamide 6 chemical regeneration has been already established with the industrial **ECONYL process of Aquafil S.p.A**. The striking potential of polyamide 6 depolymerization in both terms of eco-efficiency and eco-effectiveness is demonstrated in the following presentation:

Targeting high environmental performance of the recycling of polymer-based products. A methodological proposal of EPEA

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