How to recycle more WEEE plastics

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Introduction

Every production process generates waste, even the processes within recycling facilities that treat plastic to turn it into secondary raw materials. The mechanical recycling core activity of these facilities is to sort different plastics. Any sorting has a target fraction, the reusable material, and a waste fraction, the "real waste" that won't be recovered. Within Waste from Electrical and Electronic Equipment (WEEE), this fraction can reach up to 50% of the input. Finding a process to reduce this volume is essential to achieve higher recycling rates.

Part of a plastics recycler's job is to sort out the valuable materials, repair their damaged mechanical properties, and release a safe secondary raw material on the market. This last point is crucial in the recycling process. It leads to the most significant generation of waste since WEEE contains plastics created with legacy additives listed under the European **Persistent Organic Pollutants** (POP) and **REACH legislation**. Recyclers must separate plastics compliant with the REACH legislation, which are safely reusable, from the non-compliant plastics. To correctly execute this step, the processed stream is separated from the main stream by means of density sorting to preserve the safe-to-reuse plastic from the remaining fraction.

The launch of the **European plastics strategy** is a milestone for sustainability and it expresses the belief of the Commission that businesses can drive the circular economy forward within their processes. On the recycler side, this strategy promotes innovation to find collaborative solutions to recover more plastic. Regarding waste treatment, two major roads are possible: (1) reducing the amount of waste fraction in the production process, and (2) finding a new purpose for the waste fraction.

The waste fraction

At the time of the first **Stockholm Convention on POPs** in 2001, the plastics inside WEEE were mainly polyolefins (PO) and styrenics. Over the past two decades, we have witnessed a growing variability in this fraction. We see a growing number of new technical plastics types, elastomers, foams and plastronics. It is crucial to innovate the sorting processes to treat and recover as many plastics as possible from the input.

Figure 1: Picture of the waste fraction containing the technical and contaminated plastics

Plastics formulated with Substances of Concern (SoC) are removed from the main stream by a density separation process at 1.10g/cm^3 – a process that separates polymers based on their intrinsic density. For example, PO can be separated from all the other rigid plastics with clear water since PO will float (density < 1.0 g/cm^3). In comparison, the remaining plastic will sink (density > 1.0 g/cm^3). Adding substances, called additives, in the production of virgin plastics in order to improve their performances, like e.g. brominated flame retardants (BFRs), often increases the material density. Recyclers use this property to separate plastic with SoC from plastics without SoC via density baths at 1.10 g/cm^3. This process ensures that the recycled plastics released on the market are safe and POP and REACH compliant. However, the recent use of technical plastics to produce Electrical and Electronic Equipment (EEE), has increased the waste fraction volume during recycling since their density overlaps the density of plastics made with SoC. Technical plastics such as polyamide (PA), polycarbonate (PC) and Polybutylene terephthalate (PBT), have a density above 1.15 g/cm^3 and fall directly into the waste fraction although they are valuable materials to recover. This overlap of density makes this process unsuitable to separate technical plastics, and makes it impossible to separate polymers containing SoC from technical plastic. The result is turning valuable technical plastics into waste material. To stop this waste of valuable and reusable plastics, it is therefore essential to find new recycling methods that use other parameters than density.

This issue is the heart of our research at **Coolrec** and the EU project **CREAToR**, where we are committed to finding a solution.

Innovation in recycling

The CREAToR is an EU funded project focused on the development and demonstration of a process to remove hazardous, and restricted, bromine-containing flame retardants from waste streams through continuous purification. The purification technologies are supercritical CO_2 and cost-effective solvent-based processes that use natural deep eutectic solvents (NADES) in twin-screw extruders.

CREAToR plans to cover the whole value chain, starting from the collection of thermoplastic waste streams. The project implements ways to collect secondary raw materials, identify hazardous flame retardants, remove these contaminants from the materials and, finally, reuse the materials. As case studies, the resulting secondary raw material is reused for automotive interior application and producing 3D printed parts for aerospace applications. To further improve the economic feasibility of this approach, an optimized logistic concept and a harmonized material quality classification scheme are developed and applied within this project.

Actions

The processes developed during the CREAToR project work in combination with the current state-of-the-art mechanical processes. Following this path will drastically reduce the implementation time and costs as follows:

1. **Reduce the waste produced in the production process by the implementation of a novel sorting system.** The first studied strategy is to remove all the clean and compliant materials from the waste fraction and recover them via a mechanical recycling process. A sorting system plans to target and sort the technical plastics out of the waste stream. Some requirements for this system highlighted (i) the need of an automated system to obtain an economically viable recovery process; (ii) the identification of black plastics as most plastics from the EEE are black or dark, thus cannot be identified with current industrial sorting systems; (iii) the polymer specific detection including the technical plastics; (iv) a good ratio between the purity of the output fraction and efficiency of the sorting process. The two technologies studied within the CREAToR project are the laser-induced breakdown spectroscopy (LIBS), intended to sort on elemental composition and the mid-wave infrared (MWIR), based on polymeric detection. Both technologies fulfil the requirements mentioned above.

2. **As shown in figure 2, the input is screened via an elemental detection on cadmium, bromine, chlorine, chromium and lead with the LIBS device.** Those specific chemical elements were chosen because the bromine is related to BFRs, the chlorine to chlorinated flame retardant and the other are heavy metals restricted in the REACH and the POP regulation. The fraction containing those elements is then separated by polymer – namely polystyrene (PS) and acrylonitrile butadiene styrene (ABS), which represents respectively 8 and 15% of the waste fraction – using a MWIR system. The contaminated ABS and PS are forwarded to the purification process to remove the hazardous substances as they still contain SoC and, therefore, cannot be recycled without further purification. The remaining fraction, free of SoC, after the elemental detection is separated via the conventional density separation process, which allows to recover the PC/ABS (25% of the waste fraction) and the PBT due to their different densities. Further research has to be performed on the PA, as many different types of PA exist in the market, each with their own specific properties and applications (like PA6, PA6-10 or PA66).

The sorting process allows the material to be directed to the right treatment processes to be later recovered. The first tests have been conclusive on the feasibility of the sorting process.

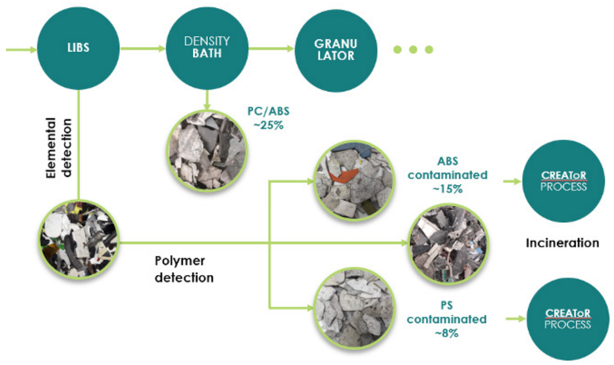

Figure 2 : Scheme of the process with the LIBS system (presentation at the Plastic Circularity Multiplier (PCM)-CREAToR project)

3. **Find a new purpose for the produced waste by using purification technologies.** The contaminated ABS and PS are unsafe for reuse, as they still contains SoC. Therefore they have to be purified. In the WEEE stream, the restricted BFRs are mainly found in the ABS and PS. Hence, the plastic matrix needs to be separated from the additive, the BFR in this case, to be recycled in new products. The CREAToR process investigates the possibility of purifying these specific contaminated plastics using supercritical CO2 and cost-effective solvent-based methods using natural deep eutectic solvents (NADES) in twin-screw extruders. The system is developed on a conventional twin-screw extruder, making this technology a cost-efficient solution, as the mechanical sorted plastic flakes already need to be processed in such an extruder (pelletized) anyway before being manufactured in new products. Consequently, it is an extension on equipment already available in the recycling process. No investment in an extra-process step is needed to obtain the final granulate.

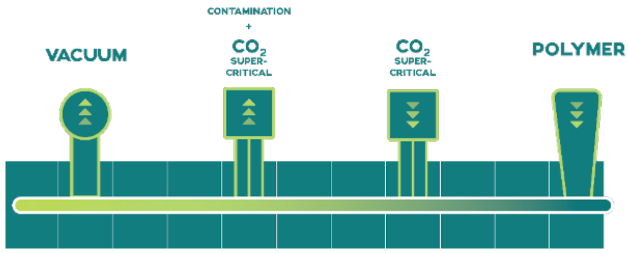

Figure 3 : Scheme of the purification process (presentation at the PCM-CREAToR project)

Conclusion

WEEE recycling means anticipating what the waste will look like in the next decades. This process should focus on foreseeing (i) the substances entering the legislation and (ii) the polymers that will enter treatment facilities, to ensure that the technologies developed today will work for tomorrow's feedstock. By screening the market today, it is possible to prepare next years' recycling processes as the plastics entering a WEEE plant are mostly 10 to 15 years old. Anticipating will switch the recycling industry from a reactive to a proactive one. With the technologies under development in the CREAToR project, we can lower the plastics' fraction waste from WEEE by 50%. On a European scale, this innovation can generate 75,000 extra tonnes of recycled plastics annually according to the **European Electronics Recyclers Association (EERA)**.

This set of processes ensures the legacy additives' correct disposal and maximizes the recycling of WEEE plastics. Offering more recycled technical plastics in the market will contribute to the European Plastics Strategy target of 10 million tonnes of recycled plastics on the European market by 2025. The compliance to the POP and REACH legislation is the center and highlight of the recycler's mission. This legislation is not hindering the plastics recycling; it instead promotes it by pushing recyclers to improve their way of working day by day. By doing so, the producers and consumers' opinion of recycled plastics will shift from considering them unsafe and low quality, towards safe and high performant secondary raw materials. This shift will boost the use of secondary raw materials in new applications and ensure that the EU lowers its dependencies from petroleum sources by implementing more circular models in its economy.

Setting the right thresholds for the prohibited substances is essential to ensure a safer recycling that doesn't hurt the existing processes. By gathering and sharing more data on recycled plastic, researchers, recyclers, and policymakers can cooperate in providing more sustainable and circular treatments of plastic.

The CREAToR project is part of the Plastics Circularity Multiplier initiative (PCM). Watch our presentation by following this link to the **PCM presentation**.

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