EuPIA position paper on deinking of plastic packaging waste

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1. Executive Summary

The printing ink industry supplies inks and coatings to the packaging value chain. A relevant proportion of these products are applied on flexible plastic packaging films and on rigid plastic packaging. Flexible packaging films are either surface or lamination printed. On rigid plastic packaging, the inks and coatings are either directly printed or are applied on shrink sleeves or on labels attached to the rigid plastic body.

EuPIA supports the EU Commission's goal to foster circularity of packaging and reduce packaging waste. The upcoming EU regulation on packaging and packaging waste provides measures to achieve this goal, among which, specific stipulations for the use of recycled material.

Besides legal requirements, the key to enable the widespread use of recycled materials is the technical performance of the recyclates, including factors such as mechanical properties, colour, transparency, odour, safety for intended uses and, if applicable, legal compliance. Printed layers of inks and coatings could potentially impact these critical aspects, especially when considering impacts of the currently predominant mechanical recycling of plastic waste.

In order to avoid any potential adverse effects, a good cooperation of the plastic packaging value chain at all stages is vital. One effective route to improved recyclate quality is the introduction of an additional step, the removal of the printing ink, prior to the actual recycling process. This step is called "deinking".

EUPIA member companies have already developed solutions for deinking of printed Plastics. They are continuing to work towards even better and more efficient solutions, together with the recycling industry, to enable the recovery of plastic material and to achieve circularity for plastic packaging.

2. Conclusion

This position paper focuses on deinking of plastic packaging waste. To this end:

- Deinking of post-consumer plastic waste is recognized as the preferred route to enhance circularity of printed plastic materials.

- To foster deinking of plastic waste and ensure technological advancements on its cooperation with recyclers and other interested stakeholders is needed.

- Deinking of post-consumer plastic waste would be beneficial to achievement of a circular plastics economy as a recognized pathway in D4R guidelines of various industrial initiatives, as well as in the CEN guidelines currently being elaborated.

- Ongoing initiatives of stakeholders (incl. ink manufacturers) on the establishment of non-proprietary deinking specifications under the frame of national standardization bodies (like German DIN) are a key enabler for implementation of deinking.

3. Considerations and recommendations

3.1 Inks and coatings in mechanical recycling

Mechanical recycling is the predominant recycling technology for plastic packaging waste. Generally, pre-sorted waste fractions based on polymer type undergo a washing step to reduce contaminants. Cold washing is currently most prevalent, but there is a trend towards installing more hot washing units due to their improved efficiency in removing contaminants. Hot washing can be regarded as a significant move in the direction of deinking, since the hot washing unit can also be leveraged as an efficient deinking unit. Following the washing and subsequent drying step, the cleaned plastic flakes are subjected to an extrusion process. The temperatures required for extrusion vary depending on the type of plastic, but typically range from above 200°C up to 270°C in the case of PET.

Inks and coatings can have various effects on the quality of the extruded recyclates . If ink and coating layers are not removed via mechanical separation (e.g. with a separable label or sleeve) or during the hot washing (via deinking), these printed layers will become part of the recycled plastic.

EuPIA, in its declaration on "Inks and Coatings for High-Temperature Applications", has clearly stated that elevated temperatures in excess of 100°C increase the risk of decomposition and breakdown reactions of ink components, with temperatures of more than 200°C drastically increasing these effects.[1]

This means that when the printing ink layer is not removed prior to extrusion, these decomposition and breakdown reactions can lead to discoloration, formation of gel particles, and odour, as well as an impairment of the technical properties of the plastic material, which hinders its subsequent conversion and application performance.

This reduction in quality creates difficulties in securing regulatory approvals for contact-sensitive applications, particularly for food packaging, and in utilizing the recyclate from printed waste in other high-quality segments. As a result, the stream is often down-cycled into less demanding applications such as garbage bags, construction film, and plastic decking.

Even under the theoretical assumption that ink components resistant to thermal decomposition are used, there would still be discoloration of the recyclates because of the pigments and potential other quality impairments, like gel particles because of different melt-flow characteristics of ink components and substrate polymers.

As demand for recyclates increases due to the new requirements of the planned Packaging and Packaging Waste Regulation (PPWR) and the packaging sector's direct exposure to end-consumer pressure, significant cross-industry initiatives (e.g. RecyClass, CEFLEX),[2-3] as well as the European Committee for Standardization (CEN),[4] have started defining the so-called Design-for-Recycling (D4R) Guidelines which will eventually be referenced in the PPWR.

Currently, the testing methodologies used for the D4R guidelines for plastic packaging consider only two potential pathways that the inks and coatings can take during plastic recycling: mechanical separation via labels/sleeves (for rigid containers) or incorporation into the recycled plastic (for flexible packaging)[5]. Deinking is currently not considered. This is primarily driven by the guidelines orienting themselves at current recycling practices, which ignore the capabilities, risk minimization effects, and market potentials that deinking of plastic waste can offer.

3.2 Inks and coatings in chemical recycling

While still in the early stages, chemical recycling offers a promising solution for addressing the challenges posed by hard-to-recycle plastics, including printed flexible packaging waste. The term 'chemical recycling' encompasses a wide range of methods capable of transforming plastic waste into building blocks that can regenerate virgin-quality polymers. These methods could complement existing mechanical recycling processes, as long as they prove capable of treating waste types that are currently unsuitable for mechanical recycling at acceptable cost and without negative environmental impact.

Pyrolysis, the prevailing chemical recycling technology, converts polyolefin (PO) plastic packaging waste into a liquid product that can be processed in steam crackers to produce light olefins, effectively closing the loop towards new virgin plastics. Despite its potential, there are still substantial safety and operational challenges associated with using pyrolysis oils derived from plastic waste as compared to conventional, fossil-based feedstocks. The main issue stems from the high concentration of contaminants found in these plastic waste-derived oils, which can significantly contribute to corrosion, fouling and catalyst poisoning in industrial steam cracking plants.

Recent research indicates that the concentration of several contaminants in pyrolysis oils produced from plastic waste, such as nitrogen, oxygen, metals, and particularly halogens, greatly exceed the specifications typically set for conventional feedstocks.[5]

This discrepancy necessitates further purification steps, like hydrotreatment, which are currently being explored within the chemical industry.

By their chemical nature, printing ink binders and pigments can be expected to contribute to the generation of nitrogen, chlorine, oxygen and metals in pyrolysis oils. As such, deinking as a pre-treatment strategy, emerges as a potential tool to improve the purity and yield of pyrolysis oil, and consequently, supporting the growth of the chemical recycling sector.

3.3 The way to high quality recyclates

Besides legal requirements, the key to enable the widespread use of recycled materials is the technical performance of these recyclates, including factors such as mechanical properties, colour, transparency, odour, safety for intended uses and, if applicable, legal compliance. As set out in the previous chapter, printed layers of inks and coatings potentially impact these critical aspects, especially when considering the currently predominant mechanical recycling of plastic waste.

Deinking of post-consumer plastic waste, when applied prior to any further conversion step during its recycling, offers a solution to all the aforementioned issues by fully removing the ink/coating layers.

Demonstrated by state-of-the-art laboratory-scale trials, pilot plant operations at ink manufacturers, commercial recycling processes, and the first industrial-scale initiatives at converter facilities with dedicated equipment to treat and recover post-industrial printed plastic film waste, deinking technologies based on aqueous washing solutions have proven their efficacy. These methods successfully deink a wide variety of inks and coatings while producing fully transparent recyclates.

These deinked recyclates are of higher value, enabling a wider range of uses, in line with the goals set out by the EU's Action Plan for a fully circular economy.

As with all new technologies, the parameters and chemistry of the deinking process, including the corresponding ink technologies, will undergo continual optimisation to increase economic viability.

To address the lack of standardized measurements and procedures in the field an industry-wide effort has been launched to establish an objective, repeatable testing procedure for measuring deinking efficiency on plastic films. This initiative, currently being finalized under the German National Standardisation body (DIN),[6] mirrors the established practices within the graphic paper recycling industry.[7] This is an important step towards establishing a common language within the industry, providing auditors with the right tools to certify deinkability and giving the recycling industry the necessary information and confidence to invest in deinking technologies.

The following subchapters provide a detailed overview of existing deinking solutions on the market-place:

3.3.1 Examples for deinking of post-industrial waste

Ink removal and the corresponding wastewater treatment are now focal points for several companies involved in the development and installation of washing and drying facilities for plastic waste. Two examples of this trend are Sorema S.r.l. and KEYCYCLE GmbH, a member of EREMA Group. Both companies offer complete turnkey deinking plants, primarily targeting post-industrial waste[8].

The implementation of such deinking units has already been realized by several major converters and recyclers. For instance, the French company Reborn established a deinking line with an annual capacity of 4000 tons and has announced plans for a second installation.[9] In the UK, Coveris has launched a significantly larger deinking line capable of processing 5,000 tons per year.[10] And company Selene has also taken strides in this direction by setting up an industrial-scale deinking unit on their site in Italy focusing on closed-loop recycling of post-industrial heavy-duty sack waste produced at ExxonMobil Chemical's facilities in Europe.[11]

These successful examples demonstrate the technical viability of ink removal within alkaline hot washing processes at industrial scale. At present, these practices are predominantly employed in the treatment of post-industrial waste due to the limitations in sorting technologies for flexible packaging.

Advances in waste sortation for post-consumer waste, including artificial intelligence, digital watermarking (e.g., Holy Grail 2.0 proejct), and tracers, coupled with the growing capacity for hot washing at recycling facilities, strongly suggest that the deinking of post-consumer waste is an imminent and logical progression.

3.3.2 Examples for deinkable shrink sleeves in the PET value chain

In the case of post-consumer waste, the PET value chain, specifically within the segment of PET bottles fitted with shrink sleeves, has been at the forefront of deinking implementation. This is primarily attributed to the well-established alkaline hot wash infrastructure integral to the PET bottle-to-bottle recycling process.

Currently, most shrink sleeves are removed prior to the hot washing phase. However, brand owners and recyclers view deinkability as a crucial attribute of crystallizable PET (c-PET) shrink sleeves. This feature guarantees that even if some printed material gets mixed with the bottle flakes, the ink will not contaminate the PET recyclates; instead, the ink will be removed during the hot alkaline wash phase. As the market share of deinkable sleeves expands, this holds potential to eventually make it possible to discontinue the sleeve removal process and enable the co-recycling of the deinked c-PET sleeve material with the PET bottles, greatly increasing the availability of high quality recycled PET and avoiding the loss to incineration or landfill of a significant quantity of plastic material.

The majority of these initiatives have been underway in the United States, where the Association of Plastic Recyclers (APR) (see: APR Design Recognition Program) has issued certifications to a diverse set of stakeholders for deinkable c-PET shrink sleeve technologies. The certificates have also been issued to certain ink manufacturers, members of EuPIA; PET resin producers like Eastman Chemicals; and converters including Klöckner Pentaplast, Bonset America, ShrinkFlex, Fuji Seal Packaging, and Smyth Companies. This broad spectrum of industry participation underscores the collaborative effort and potential in advancing the deinking of shrink sleeves.

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