Printing inks and Plastic Recycling – Q & A

1. Are your inks recyclable?

The recyclability of printed packaging or publication print is primarily determined by the main structural material (e.g. paper, plastic, glass, metal). Therefore, the recyclability has to be assessed for the final printed product. From a recycling perspective, the key requirement for printing inks is to not interfere with the recycling process of the substrate and ensure sufficient quality of the recyclates.
Various institutes and associations have published guidelines to evaluate recyclability, including CEFLEX with its D4ACE-Guidelines, RecyClass (an initiative of Plastic Recyclers Europe, PRE), Cyclos HTP, 4evergreen for fibre-based packaging and many others. These guidelines aim to harmonize Design for Recycling (DfR) principles in line with the recyclability goals of the Packaging and Packaging Waste Regulation (PPWR). Where printing inks are mentioned, the requirements can be summarized as the following:

Printing inks should comply with the EuPIA exclusion policy.

The guidelines recommend applying as little ink as possible resp. limit the share of ink to <5% by weight for easy recyclability.

There is a preference for lighter shades.

2. Can you provide inks with lighter shades only?

Printing ink manufacturers can provide ink for almost every application and packaging design, in every colour density and colour shade. However, it is not the ink manufacturer who decides on the packaging and print design. The packaging designer decides if the packaging is made with light or strong colour shades. Consequently, the packaging, which requires strong or dark colours, and which is fully printed on the surface may not be well designed for recycling. Nevertheless, it is important to note that there are differences between rigid packaging, which may carry a printed separable sleeve and a flexible packaging film forming the packaging as such.

3. What can you state about heat stability of inks/components of inks in the temperature range between 200 – 270°C?

At temperatures above 160°C, nictrocellulose (NC) becomes thermally unstable. Therefore, when NC-based inks are present in plastics processed in extruders at temperatures exceeding 200 °C, degradation can occur. This may lead to VOC emission during the extrusion process, unpleasant odours, and discoloration of the recycled material. For this reason, printing ink manufacturers already offer commercially available NC-free ink systems that enable the design of high-performance, recyclable flexible packaging solutions.Other ink components, such as certain azo-pigments, may also degrade at temperatures exceeding 200°C. While this can pose challenges for food-contact applications, it generally has no significant impact on the properties of the recycled material in non-sensitive applications, apart from slight discoloration, which nevertheless makes it acceptable for the coloured stream.A known critical issue arises when inks contain polyvinyl chloride (PVC) resin, which decomposes above 200°C, releasing hydrochloric acid, which then possibly corrodes the metal parts of the extruders and decreases recyclate qualities by formation of black specs. Guidelines are now specifying PVC containing inks as incompatible with recycling and many customers and brand-owners are already adapting to these requirements with PVC-free inks.

4. Why do we observe gassing during mechanical recycling?

Mechanical recycling typically involves an extrusion process, which either produces pellets from the sorted and washed post-consumer plastic waste or directly produces films from recycled plastics. In order to melt the recycled plastics and achieve good flow characteristics temperatures above 200°C are applied for polyolefines,.

Given the fact that the plastic waste material to be extruded usually contains coatings, inks and adhesives, in addition to the substrate polymer, also these materials are subjected to these high temperatures. It is a matter of fact that some of the ingredients in inks are not stable under these conditions and start to degrade. Nitrocellulose (NC) is the most common binder in inks for flexible packaging, it starts disintegrating at 160°C by forming nitrous gases, which then would be observed as gassing phenomenon. The more NC is available, the more gassing is observed. Gassing could interfere with the film-forming process; however, problems could be avoided when using extruders with degassing units.

In contrast to NC other binders are known to be stable as evaluated within recyclability testing from RecyClass and CEFLEX, for example inks based on polyurethanes, acrylates, PVB (Polyvinyl butyral) and others.

5. Why does PCR (Post Consumer Recyclate) show black to brown colour stain?

The brown colour stain observed in mechanically recycled polyolefins can be attributed to the presence of pigments in the printing inks, if there is no deinking step before extrusion, which can still impart colouration even in a small amount to a transparent film. Additionally, the thermal decomposition of some printing ink ingredients, like for instance NC binders indicated in the questions above, may result in brownish substances which contribute to the overall colour of the PCR material.

6. Do printed black surfaces prevent from proper sorting?

Most plastic sorting systems use Near-Infrared (NIR) spectroscopy to distinguish between polymer types and direct them into appropriate recycling streams. However, when the NIR beam hits areas colored with Carbon Black (Pigment Black 7), the light is absorbed rather than reflected. This lack of reflected signal prevents the system from identifying the plastic, making accurate sorting — and thus recycling — impossible. In most cases this means that the plastic is incinerated with thermal energy recovery, which potentially wastes some of the recyclates value. However, it is very unusual for packaging to be 100% covered with black ink and studies show that limited print areas below 50% and small features like barcodes or text are less problematic, because there is still enough NIR reflection for the sorting equipment to identify and correctly sort the plastic. To support recyclability without sacrificing design flexibility, also carbon-black-free ink solutions are available. These include CMY-based black, which is achieved by combining standard process colors cyan, magenta, and yellow, as well as tailor-made spot inks that use customized pigment blends to achieve deep black tones without carbon black. Both approaches are compatible with NIR sorting systems, helping brand owners meet recyclability targets while maintaining high visual and print quality. When plastic packaging is mass-coloured with Carbon Black pigment, it reflects too little NIR radiation for sorting systems to identify the polymer type. For this there are also alternative approaches for colouration, which are transparent to NIR allowing effective sorting.

7. Do printed metallic surfaces prevent from proper sorting?

Metallic inks, which contain reflective pigments such as aluminum or other metal-based compounds, can significantly interfere with Near-Infrared (NIR) sorting. These pigments act as microscopic mirrors, scattering and reflecting NIR radiation in unpredictable ways. As a result, the NIR signal from the underlying plastic substrate is attenuated or distorted, making it difficult or impossible for sorting systems to correctly identify the polymer type beneath the printed surface. Although printing inks typically form a thin layer and contribute minimally to the overall packaging weight, large-area coverage with metallic inks has been shown to negatively impact NIR detection, similar to the effect of Carbon Black pigments. However, partial coverage below 50% of the surface area — such as small printed elements, logos, or text — has been shown to allow sufficient NIR reflection for successful polymer identification. This means that limited use of metallic inks does not necessarily compromise recyclability, provided the unprinted areas remain detectable.

8. Can we get rid of inks before recycling?

Yes, ink removal is possible and increasingly important for improving the quality of recycled plastics. Two main approaches are being explored: washable inks and deinking. Washable ink solutions are already commercially available, particularly in the label segment for PET bottles. Deinking, on the other hand, is gaining relevance for polyolefins—especially rigid packaging—but is still in the early stages of broader market adoption.

Currently, existing deinking facilities rely on standard aqueous caustic solutions, which perform well with defined packaging waste qualities, ideally from post-industrial sources. However, to make deinking universally applicable and economically viable, further development is needed to ensure consistent results across various printed plastic materials.

In support of this, EuPIA emphasizes deinking as a key enabler for high-quality recycling and circularity in packaging. We advocate cross-industry collaboration and the development of standardized, non-proprietary deinking technologies to efficiently remove inks from post-consumer plastic waste and facilitate broader implementation.

9. Is there a contribution of hazardous components from inks, which would interfere with intended uses of PCR material?

The answer depends strongly on the ink system used in the post-consumer feedstock, but also on the definition of hazardous components and the intended uses of PCR.

Concerning hazardous components, EuPIA members formulate inks in accordance with EuPIA Exclusion Policy, therefore CMR cat 1 substances along with substance classified as Acute tox cat 1, 2, 3, STOT RE 1, STOT SE 1 are not used. Since long time, the raw material selection process of EuPIA members also ensures that toxic heavy metals (Hg, Pb, Cr, Cd) stay below 100 mg/kg in printing inks.

Non-sensitive applications, for example the ones requiring compliance with RoHS and Toy Safety Directive, appear non problematic, because the residual printing inks in the PCR are not an obstacle for this compliance, due to the known low content of toxic heavy metals and the general absence of polybrominated compounds from printing ink formulations.

On the contrary, sensitive applications, e.g. where PCR materials are intended to be used as food contact materials (FCM) are regulated today by Commission Regulation (EU) No 2022/1616, whilst so far there is mostly authorization for processes on post-consumer recycled PET. Further legislative updates on other PCR plastic materials are expected to come.

Depending on the ink technology, different substances may be generated by thermal decomposition. To date, the exact mechanism of thermal decomposition of printing inks raw materials is not completely known and other conclusions may be drawn thanks to further investigations. Here are some examples based on current information:

1. The thermal stability of binders differs considerably throughout the technologies and so vary the potentially cleaved substances. Some of them, like nitrocellulose and PVC binders 3may decompose, were already mentioned in the above sections. For other binder system, the following considerations can be offered:
    a. PVB-binders can create some unsaturated derivatives because of water elimination. The toxicology of these components is mainly not well reported.
    b. Polyurethanes (PU) have different thermal stability depending on composition: aliphatic PU are expected to have higher thermal stability, whereas aromatic PU could more easily undergo thermal decomposition. The resulting decomposition of products depends on the chemical environment in which the decomposition happens.
    c. Polyesters are expected to be quite thermally stable and survive the temperature of the recycling process, unless in strong acidic or alkaline environment, which could promote cleavages.
    d. The same consideration as for polyesters applies for polyamides, which in the condition mentioned above could cleave in substances not fully characterized (an example could be caprolactam).
    e. Styrene-Acrylates and pure acrylic binders could undergo thermal decomposition, yielding a variety of unsaturated components and aromatic compounds. For most of the substances potentially developed no toxicological data is available, although for very few (styrene, acrylic acid and respective esters) more data are available.

2. Some pigments (e.g. PY 13) could thermally cleave in a complex substance mixture creating potentially hazardous components like primary aromatic amines (PAAs) and NOx-containing aromatic components.

10. What is the average ink contribution (in % of weight) on printed plastics?

The total amount of printing ink depends on ink coverage (i.e. grams per square meter applied), the ink type applied and the film thickness of the substrate. But, as general rule, a maximum amount of ink between 2-4 % in weight can be taken into consideration. According to current design for recycling guidelines a total of < 5wt% for the ink system is acceptable.

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