Safety assessment of the process Poly Recycling, based on recoSTAR PET FG technology, used to recycle post-consumer PET into food contact materials

EFSA Panel on Food Contact Materials, Enzymes and Processing Aids (CEP), Vittorio Silano, José Manuel Barat Baviera, Claudia Bolognesi, Andrew Chesson, Pier Sandro Cocconcelli, Riccardo Crebelli, David Michael Gott, Konrad Grob, Alicja Mortensen, Gilles Rivière, Inger-Lise Steffensen, Christina Tlustos, Henk Van Loveren, Laurence Vernis, Holger Zorn, Vincent Dudler, Maria Rosaria Milana, Constantine Papaspyrides, Maria de Fátima Tavares Poças, Alexandros Lioupis and Evgenia Lampi

Abstract

The EFSA Panel on Food Contact Materials, Enzymes and Processing Aids (CEP) assessed the safety of the recycling process Poly Recycling (EU register number RECYC173) using the recoSTAR PET FG technology. The input is hot washed and dried poly(ethylene terephthalate) (PET) flakes originating from collected post-consumer PET containers, mainly bottles, with no more than 5% PET from non-food consumer applications. The flakes are heated and crystallised in a continuous first reactor under inert gas flow and then heated in a second continuous reactor under inert gas flow before being extruded into pellets. Having examined the challenge test provided, the Panel concluded that the drying and crystallisation (step 2) and the drying of the crystallised flakes (step 3) are the critical steps that determine the decontamination efficiency of the process. The operating parameters to control the performance of these critical steps are temperature, residence time and gas flow rate. It was demonstrated that this recycling process is able to ensure that the level of migration of potential unknown contaminants into food is below the conservatively modelled migration of 0.1 µg/kg food. Therefore, the Panel concluded that the recycled PET obtained from this process is not considered of safety concern, when used at up to 100% for the manufacture of materials and articles for contact with all types of foodstuffs for long-term storage at room temperature, with or without hotfill. Trays made of this recycled PET are not intended to be used in microwave and conventional ovens and such use is not covered by this evaluation.

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Keywords: recoSTAR PET FG, Poly Recycling AG, food contact materials, plastic, poly(ethylene terephthalate) (PET), recycling process, safety assessment

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Question number: EFSA-Q-2018-01002
Correspondence: fip@efsa.europa.eu
Panel members: Vittorio Silano, José Manuel Barat Baviera, Claudia Bolognesi, Andrew Chesson, Pier Sandro Cocconcelli, Riccardo Crebelli, David Michael Gott, Konrad Grob, Evgenia Lampi, Alicja Mortensen, Gilles Rivière, Inger-Lise Steffensen, Christina Tlustos, Henk Van Loveren, Laurence Vernis and Holger Zorn.

Note: The full opinion will be published in accordance with Article 10(6) of Regulation (EC) No 1935/2004 once the decision on confidentiality, in line with Article 20(3) of the Regulation, will be received from the European Commission. The text and table on the operational parameters (Appendix C) have been provided under confidentiality and they are redacted awaiting the decision of the Commission.

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

Recycled plastic materials and articles shall only be placed on the market if they contain recycled plastic obtained from an authorised recycling process. Before a recycling process is authorised, EFSA’s opinion on its safety is required. This procedure has been established in Article 5 of Regulation (EC) No 282/2008 of the Commission of 27 March 2008 on recycled plastic materials intended to come into contact with foods and Articles 8 and 9 of Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food.

According to this procedure, the industry submits applications to the Member States Competent Authorities, which transmit the applications to the European Food Safety Authority (EFSA) for evaluation.

In this case, EFSA received, from the Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, Germany, an application for evaluation of the recycling process Poly Recycling, European Union (EU) register No RECYC173. The request has been registered in EFSA’s register of received questions under the number EFSA-Q-2018-01002 EFSA-Q-2018-00897. The dossier was submitted on behalf of Poly Recycling AG, Switzerland.

According to Article 5 of Regulation (EC) No 282/2008 of the Commission of 27 March 2008 on recycled plastic materials intended to come into contact with foods, EFSA is required to carry out risk assessments on the risks originating from the migration of substances from recycled food contact plastic materials and articles into food and deliver a scientific opinion on the recycling process examined.

According to Article 4 of Regulation (EC) No 282/2008, EFSA will evaluate whether it has been demonstrated in a challenge test, or by other appropriate scientific evidence, that the recycling process Poly Recycling is able to reduce the contamination of the plastic input to a concentration that does not pose a risk to human health. The poly(ethylene terephthalate) (PET) materials and articles used as input of the process as well as the conditions of use of the recycled PET make part of this evaluation.

2. Data and methodologies

2.1. Data

The applicant has submitted a dossier following the ‘EFSA guidelines for the submission of an application for the safety evaluation of a recycling process to produce recycled plastics intended to be used for the manufacture of materials and articles in contact with food, prior to its authorisation’ (EFSA, 2008). Applications shall be submitted in accordance with Article 5 of the Regulation (EC) No 282/2008.

Additional information was sought from the applicant during the assessment process in response to a request from EFSA sent on 25 June 2019 and was subsequently provided (see ‘Documentation provided to EFSA’).

The following information on the recycling process was provided by the applicant and used for the evaluation:

- General information:
  - general description,
  - existing authorisations.

- Specific information:
  - recycling process,
  - characterisation of the input,
  - determination of the decontamination efficiency of the recycling process,
  - characterisation of the recycled plastic,
  - intended application in contact with food,
  - compliance with the relevant provisions on food contact materials and articles,
  - process analysis and evaluation,
  - operating parameters.
2.2. Methodologies

The principles followed for the evaluation are described here. The risks associated with the use of recycled plastic materials and articles in contact with food come from the possible migration of chemicals into the food in amounts that would endanger human health. The quality of the input, the efficiency of the recycling process to remove contaminants as well as the intended use of the recycled plastic are crucial points for the risk assessment (see guidelines on recycling plastics; EFSA, 2008).

The criteria for the safety evaluation of a mechanical recycling process to produce recycled PET intended to be used for the manufacture of materials and articles in contact with food are described in the scientific opinion developed by the EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (EFSA CEF Panel, 2011). The principle of the evaluation is to apply the decontamination efficiency of a recycling technology or process, obtained from a challenge test with surrogate contaminants, to a reference contamination level for post-consumer PET, conservatively set at 3 mg/kg PET for contaminants resulting from possible misuse. The resulting residual concentration of each surrogate contaminant in recycled PET ($C_{res}$) is compared with a modelled concentration of the surrogate contaminants in PET ($C_{mod}$). This $C_{mod}$ is calculated using generally recognised conservative migration models so that the related migration does not give rise to a dietary exposure exceeding 0.0025 µg/kg body weight (bw) per day (i.e. the human exposure threshold value for chemicals with structural alerts for genotoxicity), below which the risk to human health would be negligible. If the $C_{res}$ is not higher than the $C_{mod}$, the recycled PET manufactured by such recycling process is not considered of safety concern for the defined conditions of use (EFSA CEF Panel, 2011).

The assessment was conducted in line with the principles described in the EFSA Guidance on transparency in the scientific aspects of risk assessment (EFSA, 2009) and considering the relevant guidance from the EFSA Scientific Committee.

3. Assessment

3.1. General information

According to the applicant, the recycling process Poly Recycling is intended to recycle food grade PET containers to produce recycled PET pellets using the recoSTAR PET FG technology. The recycled pellets are intended to be used up to 100% for the manufacture of recycled materials and articles that are intended to be used in direct contact with all kinds of foodstuffs for long-term storage at room temperature, with or without hotfill.

3.2. Description of the process

3.2.1. General description

The recycling process Poly Recycling produces recycled PET pellets from PET containers, coming from post-consumer collection systems (kerbside and deposit systems and mixed waste collection).

The recycling process is composed of the four steps below. Step 1 may be performed by a third party or by the applicant.

**Input**

- In step 1, the post-consumer PET containers are processed into hot caustic washed and dried flakes.

**Decontamination and production of recycled PET material**

- In step 2, the flakes are preheated in a continuous reactor under inert gas flow and the material is crystallised.
- In step 3, the flakes are heated in a continuous reactor under high temperature and inert gas flow.
- In step 4, the material is extruded and pellets of recycled PET are produced.

The operating conditions of the process have been provided to EFSA.

The recycled pellets, the final product of the process, are checked against technical requirements, such as intrinsic viscosity, colour and black spots. They are intended to be converted by other companies into recycled articles used for hotfill and/or long-term storage at room temperature. The
recycled pellets may be used for bottles or sheets, which are thermoformed to make food trays. They are not intended to be used in microwave and conventional ovens.

3.2.2. Characterisation of the input

According to the applicant, the input material for the recycling process Poly Recycling consists of hot washed and dried flakes obtained from PET containers, mainly bottles previously used for food packaging, from post-consumer collection systems (kerbside and deposit systems as well as mixed waste collection). A small fraction may originate from non-food applications. According to the applicant, the amount of this non-food container fraction depends on the collection system and will be below 5%.

Technical data for the hot washed and dried flakes are provided, such as information on physical properties and on residual contents of moisture, dust, poly(vinyl chloride) (PVC), polyolefins, other plastics and metals (see Appendix A).

3.3. recoSTAR PET FG technology

3.3.1. Description of the main steps

The general scheme of the recoSTAR PET FG technology, as provided by the applicant, is reported in Figure 1. In step 1, not reported in the scheme, post-consumer PET containers, are processed into hot washed and dried flakes.

- Drying and crystallisation in a continuous reactor (step 2): The flakes are introduced into a continuous reactor where high inert gas flow and high temperature are applied for a predefined residence time. These process conditions favour the vaporisation of possible contaminants and crystallisation of PET flakes.
- Heating of the crystallised flakes in a continuous reactor (step 3): The crystallised flakes are continuously fed into a reactor under high temperature with preheated inert gas for a predefined residence time.
- Extrusion (step 4): The flakes continuously coming from the previous reactor are melted in the extruder. The molten material is either pelleted (e.g. strand, under-water or eventually under-water with in-line crystallisation) or used for in-line production (e.g. thermoforming sheet, injection moulding).

Figure 1: General scheme of the technology (provided by the applicant)

The process is operated under defined operating parameters of temperature, gas flow rate and residence time.

3.3.2. Decontamination efficiency of the recycling process

To demonstrate the decontamination efficiency of the recycling process Poly Recycling, a challenge test was submitted to EFSA that was performed at laboratory scale.

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3 In accordance with Art. 9 and 20 of Regulation (EC) No 1935/2004, the parameters were provided to EFSA and made available to the applicant, the Member States and the European Commission (see Appendix C).
PET flakes were contaminated with toluene, chlorobenzene, chloroform, methyl salicylate, phenylcyclohexane, benzophenone and methyl stearate, selected as surrogate contaminants in agreement with the EFSA guidelines and in accordance with the recommendations of the US Food and Drug Administration. The surrogates include different molecular masses and polarities to cover possible chemical classes of contaminants of concern and were demonstrated to be suitable to monitor the behaviour of PET during recycling (EFSA, 2008).

Conventionally recycled post-consumer PET flakes were soaked in a mixture of surrogates and stored for 7 days at 50°C with periodical agitation. The contaminated PET flakes were washed and the concentrations of the surrogates in these flakes determined.

The first continuous reactor was filled with washed and dried contaminated flakes only (step 2), which were then continuously fed to the second reactor. The flakes were analysed after each step for their residual concentrations of the applied surrogates.

The decontamination efficiency of the process was calculated taking into account the amount of the surrogates detected in washed contaminated flakes before the drying and crystallisation reactor (before step 2) and after the heating reactor (step 3). The results are summarised below in Table 1.

### Table 1: Efficiency of the decontamination by the recoSTAR PET FG technology in the challenge test

| Surrogates         | Concentration of surrogates before step 2 (mg/kg PET) | Concentration of surrogates after step 3 (mg/kg PET) | Decontamination efficiency (%) |
|--------------------|------------------------------------------------------|-----------------------------------------------------|--------------------------------|
| Toluene            | 260.9                                                | 3.5                                                 | 98.7                           |
| Chlorobenzene      | 452.7                                                | 7.0                                                 | 98.5                           |
| Chloroform         | 401.5                                                | 6.8                                                 | 98.3                           |
| Methyl salicylate  | 575.6                                                | 8.7                                                 | 98.5                           |
| Phenylcyclohexane  | 356.7                                                | 12.8                                                | 96.4                           |
| Benzophenone       | 535.7                                                | 22.2                                                | 95.9                           |
| Methyl stearate    | 525.6                                                | 11.9                                                | 97.7                           |

PET: poly(ethylene terephthalate).

As shown in Table 1, the decontamination efficiency ranged from 95.9% for benzophenone to 98.7% for toluene.

### 3.4. Discussion

Considering the high temperatures used during the process, the possibility of contamination by microorganisms can be discounted. Therefore, this evaluation focuses on the chemical safety of the final product.

Technical data, such as information on physical properties and residual contents of PVC, polyolefins, other plastics and metals, were provided for the input materials (washed and dried flakes, step 1). These are produced from PET containers, previously used for food packaging collected through post-consumer collection systems. However, a small fraction may originate from non-food applications such as bottles for soap, mouth wash or kitchen hygiene agents. According to the applicant, the collection system and the process are managed in such a way that in the input stream, this fraction will be lower than 5%, as recommended by the EFSA CEF Panel in its ‘Scientific opinion on the criteria to be used for safety evaluation of a mechanical recycling process to produce recycled PET intended to be used for manufacture of materials and articles in contact with food’ (EFSA CEF Panel, 2011).

The process is adequately described. The washing and drying of the flakes from the collected PET containers (step 1) are conducted in different ways depending on the plant but, according to the applicant, this step is under control. The following steps are those of the recoSTAR PET FG technology used to recycle the PET flakes into decontaminated PET flakes: drying and crystallisation (step 2), heating the crystallised flakes (step 3) and extrusion (step 4). The operating parameters of temperature, gas flow rate and residence time for the steps 2 and 3 have been provided to EFSA.

A challenge test to measure the decontamination efficiency was conducted at laboratory scale on process steps 2 and 3. The Panel considered that the challenge test was performed correctly according to the recommendations in the EFSA guidelines (EFSA, 2008) and that steps 2 and 3 are critical for the decontamination process.

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4 Conventional recycling includes commonly sorting, grinding, washing and drying steps, and produces washed and dried flakes.
decontamination efficiency of the process. Consequently temperature, residence time and gas flow rate parameters of steps 2 and 3 should be controlled to guarantee the performance of the decontamination. These parameters have been provided to EFSA.

The decontamination efficiencies obtained for each surrogate contaminant from the challenge test, ranging from 95.9% to 98.7%, have been used to calculate the residual concentrations of potential unknown contaminants in PET (C_{res}) according to the evaluation procedure described in the ‘Scientific opinion on the criteria to be used for safety evaluation of a mechanical recycling process to produce recycled PET’ (EFSA CEF Panel, 2011; Appendix B). By applying the decontamination percentages to the reference contamination level of 3 mg/kg PET, the C_{res} for the different surrogates was obtained (Table 2).

According to the evaluation principles (EFSA CEF Panel, 2011), the dietary exposure must not exceed 0.0025 μg/kg bw per day, below which the risk to human health is considered negligible. The C_{res} value should not exceed the modelled concentration in PET (C_{mod}) that could result in a migration giving rise to a dietary exposure exceeding the 0.0025 μg/kg bw per day, after 1 year at 25°C. Because the recycled PET is intended for general use for the manufacturing of articles containing up to 100% recycled PET, the most conservative default scenario for infants has been applied. Therefore, the migration of 0.1 μg/kg into food has been used to calculate C_{mod} (EFSA CEF Panel, 2011). The results of these calculations are shown in Table 2. The relationship between the key parameters for the evaluation scheme is reported in Appendix B.

### Table 2: Decontamination efficiencies from the challenge test, residual concentrations of the surrogates in the recycled PET (C_{res}) and calculated concentrations of the surrogates in PET (C_{mod}) corresponding to a modelled migration of 0.1 μg/kg food after 1 year at 25°C

| Surrogates       | Decontamination efficiency (%) | C_{res} (mg/kg PET) | C_{mod} (mg/kg PET) |
|------------------|--------------------------------|---------------------|---------------------|
| Toluene          | 98.7                           | 0.04                | 0.09                |
| Chlorobenzene    | 98.5                           | 0.05                | 0.10                |
| Chloroform       | 98.3                           | 0.05                | 0.10                |
| Methyl salicylate| 98.5                           | 0.05                | 0.13                |
| Phenylcyclohexane| 96.4                           | 0.11                | 0.14                |
| Benzophenone     | 95.9                           | 0.12                | 0.16                |
| Methyl stearate  | 97.7                           | 0.07                | 0.32                |

PET: poly(ethylene terephthalate).

As the residual concentrations (C_{res}) of all surrogates in the decontaminated PET are below the corresponding modelled concentrations in PET (C_{mod}), the Panel concluded that the recycling process using the recoSTAR PET FG technology is able to ensure that the migration of unknown contaminants from the recycled PET into food is below the conservatively modelled value of 0.1 μg/kg food, at which the risk to human health is considered negligible.

### 4. Conclusions

The Panel considered that the process Poly Recycling using the recoSTAR PET FG technology is adequately characterised and that the main steps used to recycle the PET flakes into decontaminated PET pellets have been identified. Having examined the challenge test provided, the Panel concluded that the drying and crystallisation (step 2) and the heating of the crystallised flakes (step 3) are critical for the decontamination efficiency. The operating parameters to control its performance are temperature, residence time and gas flow rate.

The Panel concluded that the recycling process Poly Recycling is able to reduce foreseeable accidental contamination of post-consumer food contact PET to a concentration that does not give rise to concern for a risk to human health if:

- i) it is operated under conditions that are at least as severe as those applied in the challenge test used to measure the decontamination efficiency of the process;
- ii) the input of the process is washed and dried post-consumer PET flakes originating from materials and articles that have been manufactured in accordance with the EU legislation on food contact materials containing no more than 5% of PET from non-food consumer applications.

PET recycling process Poly Recycling (recoSTAR PET FG)
Therefore, the recycled PET obtained from the process Poly Recycling intended to be used up to 100% for the manufacture of materials and articles for contact with all types of foodstuffs for long-term storage at room temperature, with or without hotfill, is not considered of safety concern. Trays made of this recycled PET are not intended to be used in microwave and conventional ovens and such use is not covered by this evaluation.

5. **Recommendations**

The Panel recommended periodic verification that the input to be recycled originates from materials and articles that have been manufactured in accordance with the EU legislation on food contact materials and that the proportion of PET from non-food consumer applications is no more than 5%. This adheres to good manufacturing practice and the Regulation (EC) No 282/2008, Art. 4b. Critical steps in recycling should be monitored and kept under control. In addition, supporting documentation should be available on how it is ensured that the critical steps are operated under conditions at least as severe as those in the challenge test used to measure the decontamination efficiency of the process.

**Documentation provided to EFSA**

1) Dossier ‘Poly Recycling’. April 2019. Submitted on behalf of Poly Recycling AG, Switzerland.
2) Additional information, July 2019. Submitted on behalf of Poly Recycling AG, Switzerland.

**References**

EFSA (European Food Safety Authority), 2008. Guidelines for the submission of an application for safety evaluation by the EFSA of a recycling process to produce recycled plastics intended to be used for manufacture of materials and articles in contact with food, prior to its authorisation. EFSA Journal 2008;6(7):717, 12 pp. https://doi.org/10.2903/j.efsa.2008.717

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EFSA CEF Panel (EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids), 2011. Scientific opinion on the criteria to be used for safety evaluation of a mechanical recycling process to produce recycled PET intended to be used for manufacture of materials and articles in contact with food. EFSA Journal 2011;9(7):2184, 25 pp. https://doi.org/10.2903/j.efsa.2011.2184

**Abbreviations**

bw body weight
CEF Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids
CEP Panel on Food Contact Materials, Enzymes and Processing Aids
C_{mod} modelled concentration in PET
C_{res} residual concentrations in PET
PET poly(ethylene terephthalate)
PVC poly(vinyl chloride)
Appendix A – Technical data of the washed flakes as provided by the applicant

| Parameter                                      | Value     |
|------------------------------------------------|-----------|
| Moisture                                       | < 2.5%    |
| Dust                                           | < 1.5%    |
| Metal content (aluminium, ferrous, others)     | < 200 mg/kg|
| PVC content                                    | < 200 mg/kg|
| Polyelefin content                             | < 100 mg/kg|
| Other plastics                                 | < 200 mg/kg|
| Amount of non-food application PET              | < 5%      |

PVC: poly(vinyl chloride); PET: poly(ethylene terephthalate).
Appendix B – Relationship between the key parameters for the evaluation scheme (EFSA CEF Panel, 2011)

PLASTIC INPUT
Assumption of reference contamination level

3 mg/kg PET

RECYCLING PROCESS WITH DECONTAMINATION TECHNOLOGY
Decontamination efficiency measured using a challenge test

Eff (%)

PLASTIC OUTPUT
Residual contamination in the recycled PET

\[ C_{res} = 3 \text{ (mg/kg PET)} \times (1-\text{Eff \%}) \]

MIGRATION IN FOOD
0.1 μg/kg food* calculated by conservative migration modelling related to a maximum potential intake of 0.0025 μg/kg bw per day

PLASTIC IN CONTACT
\( C_{mod} \) modelled residual contamination in the recycled PET

\[ C_{res} < C_{mod} \]

Yes
No

No safety concern
Further considerations

*Default scenario (infant). For adults and toddlers, the migration criterion will be 0.75 and 0.15 μg/kg food respectively. The figures are derived from the application of the human exposure threshold value of 0.0025 μg/kg bw per day applying a factor of 5 due to the overestimation of modelling.
Appendix C – Table on Operational parameters

| Parameter                  | Value | Description                  | Value | Description                  |
|----------------------------|-------|-------------------------------|-------|-------------------------------|
| Temperature (°C)           |       |                               |       |                               |
| Pressure (bar)             |       |                               |       |                               |
| Flow rate (L/min)          |       |                               |       |                               |
| Speed (rpm)                |       |                               |       |                               |
| Recovery rate (%)          |       |                               |       |                               |
| Yield (%)                  |       |                               |       |                               |
| Energy consumption (kWh)   |       |                               |       |                               |
| Emissions (kg CO₂eq)       |       |                               |       |                               |