RecyClass

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The RecyClass HDPE and PP Technical Committees (TCs) in collaboration with the SPICE[1] initiative investigated the impact of Thermoplastic Elastomers (TPE)[2], more specifically Thermoplastic Polystyrene Elastomers (TPS), on the recyclability of HDPE and PP rigid containers. TPS products consist of at least a triblock copolymer of styrene and a specific diene, where the two end segments, i.e. the hard segments, are polystyrene and the internal soft segment is a polydiene or hydrogenated polydiene. The styrenic block copolymers tested were of two different types, styrene-ethylene-ethylene-propylene-styrene (SEEPS) and styrene-ethylene-butylene-styrene (SEBS) grades blended with HDPE and PP grades at a concentration of 10 %. Tests were carried out following the procedures described by both RecyClass Recyclability Evaluation Protocols for HDPE and PP containers[3].

The TPS grades were provided by Wittenburg. A specific focus on the hardness of the grades was considered, trying to cover as much as possible the extreme cases and the representativeness of grades available on the market. Blends of 10 % TPS and 90 % HDPE and PP were extruded and considered as the initial material (referred to as the "innovation").

The samples were tested at Interzero, a RecyClass recognised testing facility located in Slovenia. The control materials used for the tests corresponded to one-time processed HDPE and PP blow moulding resins. The TPS grades evaluated are described in Table 1. Grades 1 to 6 were tested in combination with PP, whilst grades 1 and 2 were also tested in HDPE.

**TABLE 1. DIFFERENT TPS GRADES TESTED.**

| TPS Code | Styrenic Block Copolymer | Hardness [Shore A] | Oil Content [%] | Remark |
|---|---|---|---|---|
| 1 | SEBS | 30-40 | 50-60 | Low hardness SEBS grade |
| 2 | SEBS | 70-80 | 30-40 | High hardness SEBS grade |
| 3 | SEBS | 30-40 | 40-50 | Optimized formulation for packaging |
| 4 | SEBS | 80 | 0 | Oil-free formulation |
| 5 | SEEPS | 30-40 | 50-60 | Low hardness SEEPS grade |
| 6 | SEEPS | 70-80 | 30-40 | High hardness SEEPS grade |

[1] https://open-spice.com/

[2] For nomenclature purposes of TPEs, please refer to the ISO 18064 definition.

[3] RecyClass Recyclability Evaluation Protocols

For all the tested samples, the extrusion process was not affected by the presence of the TPS. The process ran steadily over 30 minutes at a melt temperature of 220 °C, without any increase of the pressure and any sign of build-ups in the filter. The extruded pellets, namely blends A.0 (control material), A.25 (25 % of innovation) and A.50 (50 % of innovation), were all natural in colour and did not show any sign of thermal degradation (see Annex 1). The properties of the pellets were within the benchmark recommendations for all the samples.

Each pellet sample obtained by the extrusion process was injection moulded into tensile test bars and test plaques without any dilution with virgin material (see Annex 1). The plaques were natural coloured without inclusions or black spots. The tensile properties of the injection moulded specimens were within the recommended benchmarks for all the TPS in combination with PP. However, specific deviations were noted, particularly for samples A.50 when TPS were in combination with HDPE. A decrease in the flexural and tensile modulus beyond recommended limits (25 % decrease) was recorded. Whilst PP samples were only injection moulded as conversion step; HDPE samples were further tested via blow moulding for the production of bottles.

For this latter test, the extruded pellets were mixed with virgin material to obtain blends B.0 B.25 and B.50. Sample B.25 and B.50 contain 12.5 % and 25 % of the innovation, respectively. The blow moulding process was performed without any problem. All the bottles had a clear aspect without defects. The bottle dimensions and mechanical properties were within the benchmark recommendations except for the top load measurements for the B.50 samples, which exceeded the allowable deviation (10 % decrease vs. B.0).

Based on the test results, the RecyClass HDPE and PP Technical Committees have issued the following Design for Recycling recommendations:

- For PP containers: TPS grades are **fully compatible** with PP recycling when used at a concentration of up to **10 % wt**.
- For HDPE containers:
    - TPS grades are **fully compatible** with HDPE recycling when used at a concentration of up to **5 % wt**.
    - TPS grades are **limited compatible** with HDPE recycling when used at a concentration between **5 % and 10 % wt**.


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Given the notable deviations in flexural and tensile modulus and top load observed for samples A.50 and B.50, it is indeed recommended to limit the concentration of TPS in HDPE to 5 % wt to ensure full compatibility.

The insights provided by these tests contributed to the development of RecyClass Design for Recycling Guidelines for HDPE and PP containers.

*About RecyClass*

RecyClass is a non-profit, cross-industry initiative advancing recyclability, bringing transparency to the origin of plastic waste and establishing a harmonized approach toward recycled plastic calculation & traceability in Europe. RecyClass develops Recyclability Evaluation Protocols and scientific testing methods for innovative plastic packaging materials which serve as the base for the Design for Recycling Guidelines and the RecyClass Online Tool. RecyClass established Recyclability Certifications for plastic packaging, Recycling Process Certification and Recycled Plastics Traceability Certification for plastic products.

RecyClass – Plastic Future is Circular

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Annex I

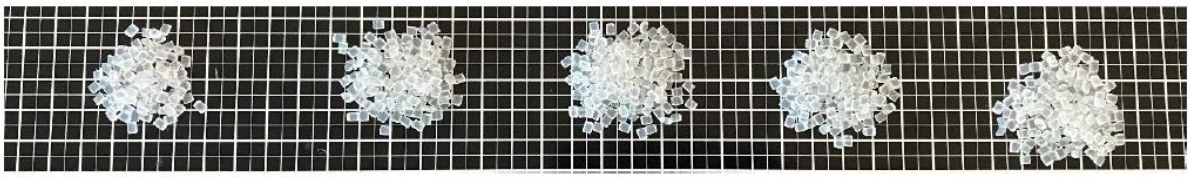

**FIGURE 1. PELLETS PRODUCED AFTER EXTRUSION (PP) (A.0, A1.25, A1.50, A2.25, A2.50 FROM LEFT TO RIGHT)**

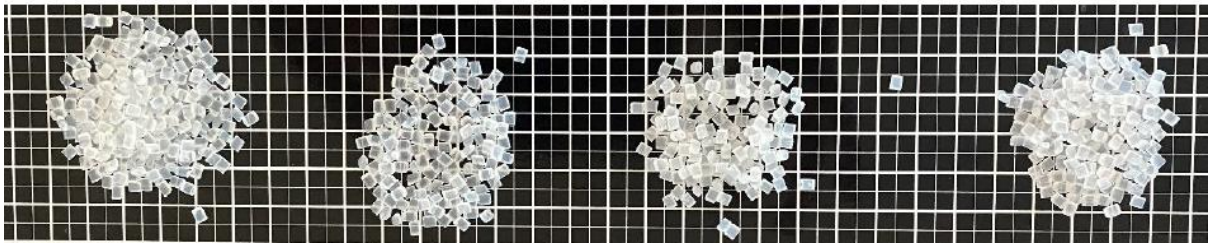

**FIGURE 2. *PELLETS PRODUCED AFTER EXTRUSION (PP) (A3.25, A3.50, A4.25, A4.50 FROM LEFT TO RIGHT)***

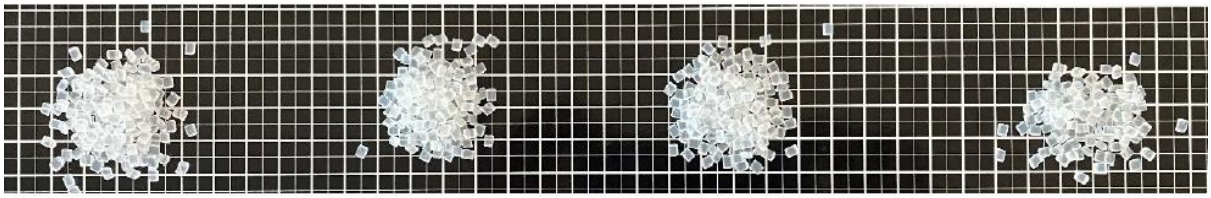

**FIGURE 3. *PELLETS PRODUCED AFTER EXTRUSION (PP) (A5.25, A5.50, A6.25, A6.50 FROM LEFT TO RIGHT)***

**FIGURE 4. *PELLETS PRODUCED AFTER EXTRUSION (HDPE) (A.0, A1.25, A1.50, A2.25, A2.50 FROM LEFT TO RIGHT)***


**FIGURE 5. *INJECTED PLAQUES PRODUCED BY INJECTION MOULDING (PP) (A.0, A1.25, A1.50, A2.25, A2.50, A3.25, A3.50 FROM LEFT TO RIGHT)***

**FIGURE 6.** ***INJECTED PLAQUES PRODUCED BY INJECTION MOULDING (PP) (A.0, A4.25, A4.50, A5.25, A5.50, A6.25, A6.50 FROM LEFT TO RIGHT)***

**FIGURE 7.** ***INJECTED PLAQUES PRODUCED BY INJECTION MOULDING (HDPE) (A.0, A1.25, A1.50, A2.25, A2.50 FROM LEFT TO RIGHT)***

**FIGURE 8.** ***BOTTLES PRODUCED BY BLOW MOULDING (HDPE) (B.0, B1.25, B1.50, B2.25 AND B2.50 FROM LEFT TO RIGHT)***



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