RecyClass

c/o Plastics Recyclers Europe
Avenue de Broqueville 12
1150 Brussels, Brussels

Phone: +32 2 786 39 08
info@recyclass.eu
www.recyclass.eu

RECYCLASS TECHNICAL REVIEW

Brussels, 24 January 2023
Revised : 28 January 2025

The RecyClass PO Films Technical Committee investigated laminating adhesives on recycling of PE films. This campaign was coordinated with the support of a pool of laminating adhesive Working Group experts regrouping Bostik, Coim, Dow, Henkel, and Sun Chemical, and started in July 2020. After more than 2 years, 3 rounds of testing and tens of samples tested according to different methods, the RecyClass PO Films Technical Committee managed to deliver the first set recommendations on the compatibility of laminating adhesives with PE flexible packaging recycling.

Two main objectives were targeted with this test campaign: 1) Discriminate the laminating adhesives compatibility with PE films recycling depending on their chemistry, 2) Develop a quick test procedure to test the impact of future laminating adhesives on the PE film stream. With that in mind, the first round of testing gathered around 50 samples analysed via thermogravimetric analysis (TGA) but did not lead to conclusive results. From that 50 samples, 12 laminating adhesives were selected, representing most of the chemistries (solvent-based/solvent-free, aliphatic/aromatic and polyester/polyether polyurethanes (PU)) used on the European market from various producers, as illustrated in Annex 1. All laminates were prepared using 2 layers of Dow 310E (50 µm), and the same PE grade was used as control material in order to ignore the impact of the PE grades. Solvent-based adhesives were representing 2.5wt% of the total weight of the laminate while solvent-free were representing 1.8wt%.

For the second round of testing, all samples were successively extruded without dilution. Obtained pellets were used to produce 500 µm plates via injection moulding as well as cast films with a targeted thickness of 50 µm. These tests enabled to observe different behaviors in terms of yellowing of the pellets, pressure evolution during extrusion and gels & specks. At that time, the Working Group agreed that solvent-based and solvent-free samples with a similar polyurethane chemistry would give similar results. An extensive yellowing of aromatic-based polyurethanes compared to aliphatic ones was also highlighted.

Finally, in order to confirm previous results, 6 of the 12 previous samples were selected to be analysed using the RecyClass Recyclability Evaluation Protocol for PE Films for the third round of testing. The selected laminating adhesives were representing 6 different chemistries that showed very different results over the past analyses. There, a focus was made on extrusion process, pellets yellowing and films gels & specks to discriminate the different laminating adhesives. Results confirmed previous

findings on origins of the yellowing as well as equivalency of solvent-free and solvent-based laminating adhesives. Note that the results were totally aligned with the results of the second phase, and confirmed that some specific laminating adhesives led to poor-quality films made after reprocessing and converting steps.

Overall, the outcome of this test campaign was that laminating adhesives could show different compatibilities with the PE film recycling depending on their chemistries. The main discrimination criterion was the isocyanate chemistry (aliphatic or aromatic) which showed a significant impact on the yellowing of the recycled pellets. Moreover, in order to discriminate the laminating adhesives that showed poor results in terms of gels increase, the experts of the Working Group decided to call for testing those laminating adhesives specially developed for high thermal applications above boiling and/or for high chemical resistance.

As a summary and according to the results that were obtained from the Recyclability Evaluation Protocol, the RecyClass PO Films Technical Committee defined the compatibility of the laminating adhesives with the PE recycling stream as following:

For PE film transparent stream:

- Full compatible: Laminating adhesives approved as fully compatible by RecyClass
- Limited compatible: Aliphatic PU < 2.5wt% of the total weight of the film; Laminating adhesives approved as limited compatible by RecyClass
- Low compatible: Aliphatic PU >2.5wt% of the total weight of the film; Aromatic polyurethanes & water-based acrylics; Laminating adhesives specifically designed for PET and/or Aluminium in combination with PE; Any other laminating adhesives (Epoxy, etc.)

For PE film coloured stream:

- Full compatible: PU and water-based acrylics <3wt% of the total weight of the film
- Limited compatible: PU and water-based acrylics 3-5wt% of the total weight of the film
- Low compatible: PU and water-based acrylics >5wt% of the total weight of the film; Laminating adhesives specifically designed for PET and/or Aluminium in combination with PE; Any other laminating adhesives (Epoxy, etc.)

It is important to highlight that these recommendations are given for films not containing any barrier material. Based on RecyClass expertise, additional issues may be observed when laminating adhesives

c/o Plastics Recyclers Europe
Avenue de Broqueville 12
1150 Brussels, Brussels

Phone : +32 2 786 39 08
info@recyclass.eu
www.recyclass.eu

are combined with barrier materials others than EVOH and metallisation. While some combination already obtained positive results through recyclability evaluations, more data will need to be gathered in order to provide clear recommendations for such combinations with barrier materials.

The PO Films Technical Committee would like also to emphasize that these new recommendations on laminating adhesive can be challenged through Recyclability Approval process, in order to obtain product specific Approval Letters. Finally, the Working Group on laminating adhesive will continue to work on the development of a simplified assessment for laminating adhesives.

Revision - January 2025:

Following the test campaign performed by the RecyClass PO Films TC on water-based acrylic laminating adhesives, Design for Recycling recommendations for the transparent PE films were reconsidered. It was observed that, through the test campaigns, acrylic-based laminating adhesives led to a more intense yellowing of the recyclate compared to aliphatic polyurethanes. With the validation of acrylic-based laminating adhesives as limited compatible with transparent PE films recycling, the PO Films TC decided to reconsider aliphatic PU as full compatible up to 2.5 wt% of the total weight of the packaging. Therefore, the outcome of the recyclability investigations on polyurethane-based laminating adhesives was reconsidered as follows:

For PE film transparent stream:

- Full compatible: Aliphatic PU < 2.5wt% of the total weight of the film; Laminating adhesives approved as fully compatible by RecyClass
- Limited compatible: Laminating adhesives approved as limited compatible by RecyClass
- Low compatible: Aliphatic PU >2.5wt% of the total weight of the film; Aromatic polyurethanes; Laminating adhesives specially developed for high thermal applications above boiling and/or for high chemical resistance; Any other laminating adhesives (Epoxy, etc.)

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

Follow the latest news on RecyClass channels: LinkedIn | Twitter | YouTube

Contact : Jean-Emile.Potaufeux@plasticsrecyclers.eu, www.recyclass.eu

RecyClass

c/o Plastics Recyclers Europe
Avenue de Broqueville 12
1150 Brussels, Brussels

Phone: +32 2 786 39 08
info@recyclass.eu
www.recyclass.eu

Annex I

Table 1: Laminating adhesive chemistries used for the test campaign

#	Solvent	Isocyanate type	Polyol type	NCO/OH termination
0	LDPE 310E			
1	SB	ALIPHATIC	Polyester	OH
2	SB	AROMATIC	Polyester	NCO
3	SB	AROMATIC	Polyether	NCO
4	SF	ALIPHATIC	Polyester	OH
5	SF	HYBRID ALIPH/AROM	Polyester/ether	NCO
6	SF	AROMATIC	Polyether	NCO
7	SF	AROMATIC	Polyether	NCO
8	SF	AROMATIC	Polyester	NCO
9	SF	AROMATIC	Polyester/ether	NCO
10	SF	AROMATIC	Polyester/ether	NCO
11	SF	AROMATIC	Polyether	NCO
12	WB	Acrylic		