

RecyClass

Science behind Recyclability



*Laminating
Adhesives*



RecyClass



3-11 June 2023

#EUGreenWeek
PARTNER EVENT

RecyClass



Science behind Recyclability

Laminating adhesives used in plastic packaging

08 June 2023

Fabrizio Di Gregorio, Technical Director, Plastics Recyclers Europe
Jean-Emile Potaufoux, Technical Advisor, Plastics Recyclers Europe
Marc Defoin, Flexible Lamination R&D Director, Bostik

RecyClass

A stylized, light teal graphic on a dark teal background. It features a chemical structure on the left, consisting of two fused hexagons with internal lines representing bonds. To the right of the chemical structure is a large Erlenmeyer flask, also in a light teal outline, containing a wavy line representing liquid. The overall theme is scientific and related to chemistry or materials science.

RecyClass Test Campaigns

RecyClass Science behind Recyclability, 08 June 2023

- Tests of one or more packaging features according to RecyClass Sorting and/or Recyclability Evaluation Protocols.

- Understand the effect of different features on plastic packaging recyclability by generating fact-based data.
- Use this knowledge to update the [Design for Recycling Guidelines](#).

- Support from Members and non-members for sample provisions.
- Support from RecyClass Recognized Testing Facilities to carry out the tests.

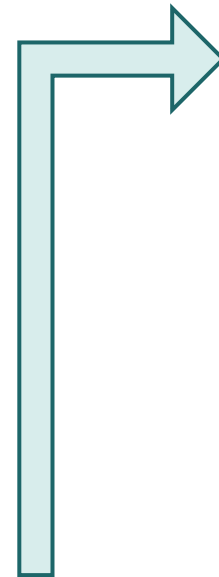


RecyClass | Test Campaigns: Process

	YES - FULL COMPATIBILITY	CONDITIONAL - LIMITED COMPATIBILITY	NO - LOW COMPATIBILITY
MATERIAL COMPOSITION (TOTAL AMOUNT OF PE & AMOUNT OF PP ATTACHMENTS IN THE PACKAGING)	A > 95%, B > 90% and all packaging features are FULLY compatible with recycling	C > 70% and all packaging features are FULLY compatible with recycling	D > 50%, E > 30%, F < 30% and all packaging features are FULLY compatible with recycling
DESCRIPTION (TEST PROTOCOL)	Materials that passed the testing protocols with no negative impact OR materials that have not been tested (yet), but are known to be acceptable in PE recycling	Materials that passed the testing protocols if certain conditions are met OR materials that have not been tested (yet), but pose a low risk of interfering with PE recycling	Materials that failed the testing protocols OR materials that have not been tested (yet), but pose a high risk of interfering with PE recycling
DESCRIPTION (METHODOLOGY)	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from A to B or from B to C	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from C to D	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from D to E or from E to F
MATERIAL (METHODOLOGY)	D, PE-LD, PE-HD	Multilayer PE/PP with PP < 5%	Multilayer PE/PP with PP > 5%; Any other polymer (e.g. PET, PVC, etc.)
COLORS	Light colours; translucent colours	NIR-detectable dark colours (Sorting test)	Non NIR-detectable dark colours
SIZE	> A4 or > 50 x 50 mm once compacted	< A4 format or between 20 x 20 and 50 x 50 mm once compacted (Sorting test)	< 20 x 20 mm
PRODUCT RESIDUES (EASY TO EMPTY INDEX)	A if the index is < 5%; B if the index is < 10%	C if the index is < 15%	D if the index is < 20%; E if the index is < 25%; F if the index is > 25%
BARRIER	Barrier in the polymer matrix; and AOCs without additional coatings	< 5% EVOH (in polyolefinic combination film); metallized layers without coatings; barrier layer PVC, PVDC; any other barrier layer; foaming agents used as expanding chemical agents; aluminium	> 5% EVOH (in polyolefinic combination film); Any other PA; barrier layer PVC, PVDC; any other barrier layer; foaming agents used as expanding chemical agents; aluminium
ADDITIVES	Additives that do not increase the density higher than 0,97 g/cm³	Bi-/oxo-/photodegradable additives; Additives that do increase the density higher than 0,97 g/cm³ (CaCO ₃ , talc, glass fibers, etc.)	Bi-/oxo-/photodegradable additives; Additives that do increase the density higher than 0,97 g/cm³ (CaCO ₃ , talc, glass fibers, etc.)
CLOSURE SYSTEM LINERS, SEALS AND VALVES	D, PE-LD, PE-HD	PP	Metal, aluminium, PVC, PET, PETG, PS, PLA, non PO or foams with density < 1 g/cm³
OTHER COMPONENTS	D, PE-LD, PE-HD	PP, removable aluminium lidding	Metal, aluminium, PVC, PET, PETG, PS, PLA, foiled paper, non PO or foams with density < 1 g/cm³
RISKS	D, PE-LD, PE-HD	PP	Metal, aluminium, PVC, PET, PETG, PS, PLA, paper, foams with density < 1 g/cm³
LABELS	Non-bleeding inks compliant with EuPIA Exclusion Policy	Inks that bleed; Inks non-compliant with EuPIA Exclusion Policy	Inks that bleed; Inks non-compliant with EuPIA Exclusion Policy
ADHESIVES FOR LABELS	Water soluble or water-releasable at less than 60°C	PP, paper labels without fibrous	Metallized labels, any other: paper labels with fibrous
DIRECT PRINTING	Laser marked print; Printed production or expiry date; printing covering < 50%**	Printing covering > 50%**	Adhesives non-soluble in water or non-releasable in water at less than 60°C

RECYCLED CONTENT: No change in the recyclability assessment. A separate 'Recycled Plastic Traceability Certification' based on a Chain of Custody approach is available with RecyClass
 ** Temporary solution

Last update: June 2021



REPORT AST-22-079-part1-EN/2
AST-22-079

AIMPLAS
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PETITIONER:
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SUBJECT
Recyclability study of LDPE laminated films

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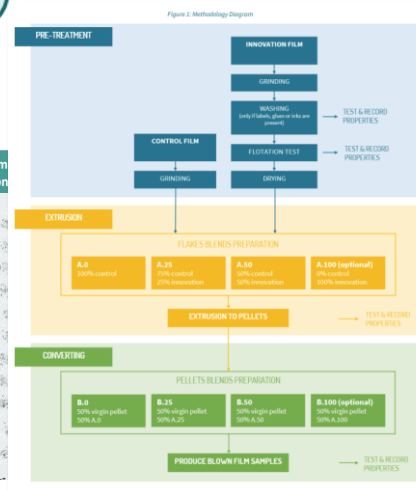
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Laboratory results
reviewed within
RecyClass TC

DfR Guidelines updated
with findings of the test
campaign

Ex: No information on **Laminating Adhesives**

#	Solvent	Isocyanate type	Polyol type	NCO/OH termination	NCO:OH ratio	Free-m con
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						



	YES - FULL COMPATIBILITY	CONDITIONAL - LIMITED COMPATIBILITY	NO - LOW COMPATIBILITY
MATERIAL COMPOSITION (TOTAL AMOUNT OF PE & AMOUNT OF PP ATTACHMENTS IN THE PACKAGING)	A > 95%, B > 90% and all packaging features are FULLY compatible with recycling	C > 70% and all packaging features are FULLY compatible with recycling	D > 50%, E > 30%, F < 30% and all packaging features are FULLY compatible with recycling
DESCRIPTION (TEST PROTOCOL)	Materials that passed the testing protocols with no negative impact OR materials that have not been tested (yet), but are known to be acceptable in PE recycling	Materials that passed the testing protocols if certain conditions are met OR materials that have not been tested (yet), but pose a low risk of interfering with PE recycling	Materials that failed the testing protocols OR materials that have not been tested (yet), but pose a high risk of interfering with PE recycling
DESCRIPTION (METHODOLOGY)	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from A to B or from B to C	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from C to D	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from D to E or from E to F
MATERIAL (METHODOLOGY)	PE-LD, PE-LD, PE-HD	Multilayer PE/PP with PP < 5%	Multilayer PE/PP with PP > 5%; Any other polymer (e.g. PET, PVC, etc.)
COLORS	Light colours; translucent colours	NIR-detectable dark colours (Sorting test)	Non NIR-detectable dark colours
SIZE	> A4 or > 50 x 50 mm once compacted	< A4 format or between 20 x 20 and 50 x 50 mm once compacted (Sorting test)	< 20 x 20 mm
PRODUCT RESIDUES (EASY TO EMPTY INDEX)	A if the index is < 5%; B if the index is < 10%	C if the index is < 15%	D if the index is < 20%; E if the index is < 25%; F if the index is > 25%
BARRIER	Barrier in the polymer matrix; and AOCs without additional coatings	< 5% EVOH (in polyolefinic combination film); metallized layers without coatings; barrier layer PVC, PVDC; any other barrier layer; foaming agents used as expanding chemical agents; aluminium	> 5% EVOH (in polyolefinic combination film); Any other PA; barrier layer PVC, PVDC; any other barrier layer; foaming agents used as expanding chemical agents; aluminium
ADDITIVES	Additives that do not increase the density higher than 0,97 g/cm³	Bi-/oxo-/photodegradable additives; Additives that do increase the density higher than 0,97 g/cm³ (CaCO ₃ , talc, glass fibers, etc.)	Bi-/oxo-/photodegradable additives; Additives that do increase the density higher than 0,97 g/cm³ (CaCO ₃ , talc, glass fibers, etc.)
CLOSURE SYSTEM LINERS, SEALS AND VALVES	PE-LD, PE-LD, PE-HD	PP	Metal, aluminium, PVC, PET, PETG, PS, PLA, non PO or foams with density < 1 g/cm³
OTHER COMPONENTS	PE-LD, PE-LD, PE-HD	PP, removable aluminium lidding	Metal, aluminium, PVC, PET, PETG, PS, PLA, foiled paper, non PO or foams with density < 1 g/cm³
RISKS	Non-bleeding inks compliant with EuPIA Exclusion Policy	Inks that bleed; Inks non-compliant with EuPIA Exclusion Policy	Inks that bleed; Inks non-compliant with EuPIA Exclusion Policy
LABELS	Water soluble or water-releasable at less than 60°C	PP, paper labels without fibrous	Metallized labels, any other: paper labels with fibrous
ADHESIVES FOR LABELS	Laser marked print; Printed production or expiry date; printing covering < 50%**	Printing covering > 50%**	Adhesives non-soluble in water or non-releasable in water at less than 60°C
DIRECT PRINTING	Laser marked print; Printed production or expiry date; printing covering < 50%**	Printing covering > 50%**	Adhesives non-soluble in water or non-releasable in water at less than 60°C

RECYCLED CONTENT: No change in the recyclability assessment. A separate 'Recycled Plastic Traceability Certification' based on a Chain of Custody approach is available with RecyClass
 ** Temporary solution

Last update: June 2021

RecyClass TC defines the
scope of the **test campaign**

3

4

RecyClass

The background features two large, light teal line-art graphics. On the left is a chemical structure of a benzene ring with a side chain. On the right is a large Erlenmeyer flask containing a wavy line representing a liquid.

Laminating Adhesives in Flexible PE Packaging

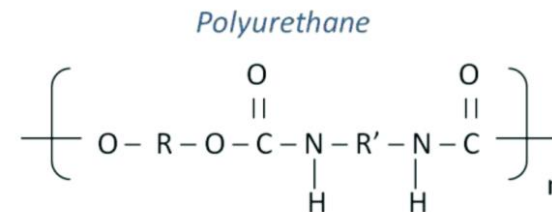
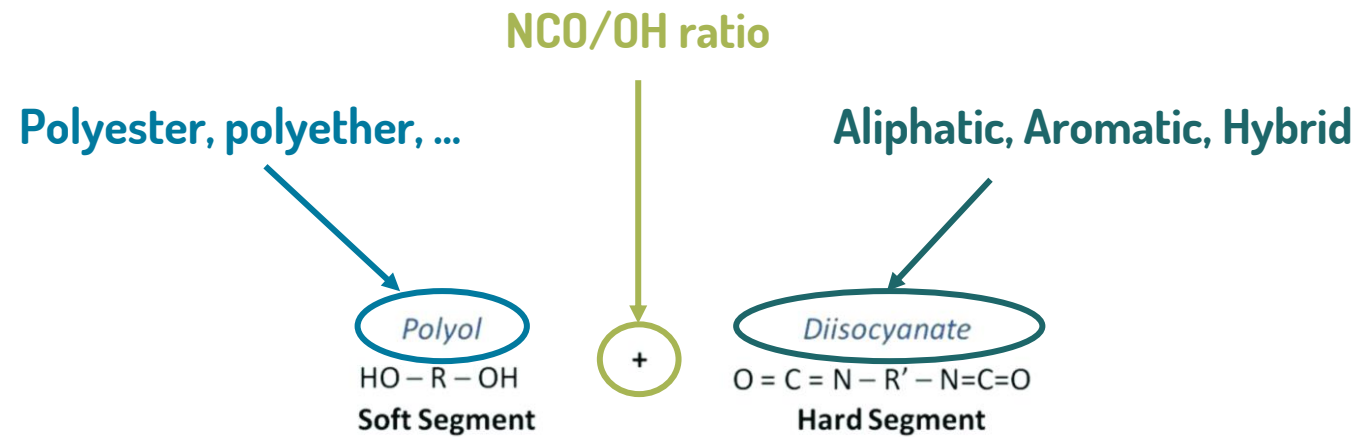
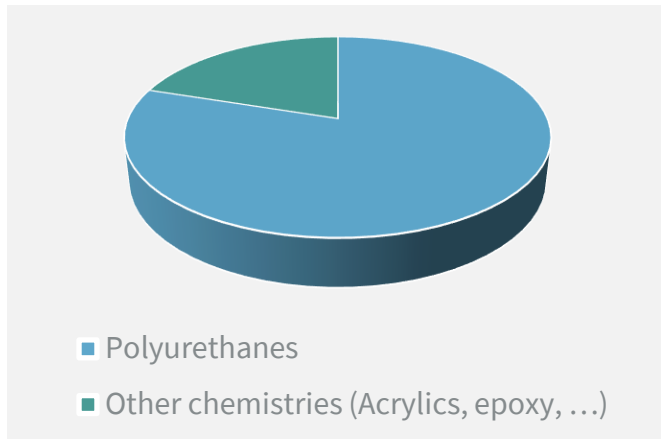
RecyClass Science behind Recyclability, 08 June 2023

RecyClass | RECYCLASS LA WG

STRUCTURE OF THE LAMINATING ADHESIVE WORKING GROUP (LA WG):

- ❑ Working Group launched in 2021 with 4 laminating adhesives producers
- ❑ Now composed of 8 RecyClass members, producers of Laminating Adhesives
- ❑ **Objectives:**
 - ❑ Assessed the impact of LA on flexible packaging
 - ❑ Discriminate the impact of LA on recyclability based on their chemistries and wt%
 - ❑ Develop a quick test method to evaluate LA based on their impact on recycle

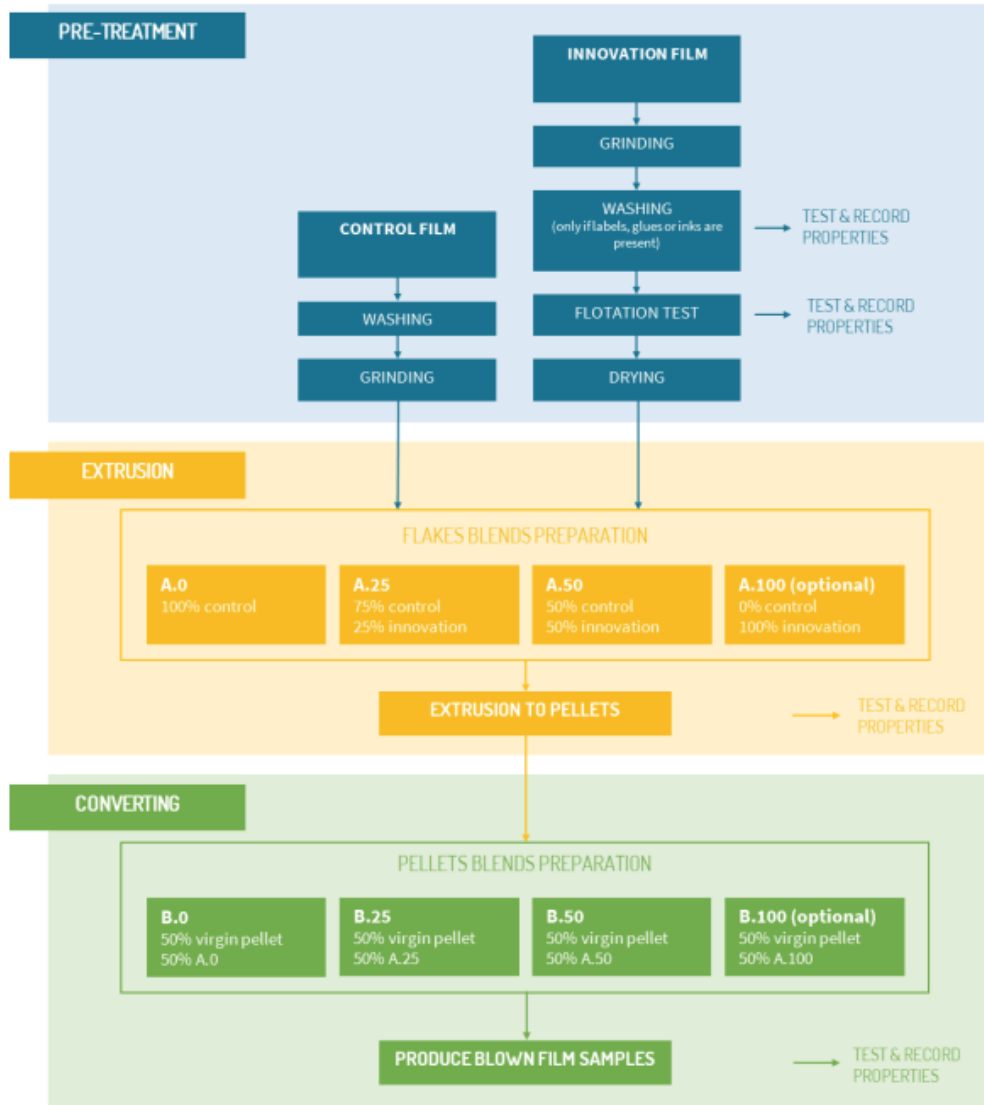
RecyClass | WHAT ARE LAMINATING ADHESIVES ?



Other parameters:

- Solvent-based, solvent-free, ...
 - Free monomer content
 - ...

RecyClass | RECYCLABILITY ASSESSMENT



Complexity of laminating adhesive

+

Complexity of RecyClass protocol

=

Difficult to perform full test on a significant number of laminating adhesive to deliver general guidelines

Focus on the more sensitive parameters:

- Pressure
- Build up on filter
- TGA
- MFI
- Yellowing
- Gels & speck

RecyClass | STARTING POINT

Pre-screening



FIRST OBJECTIVE:

- ☐ Definition of a quick test procedure to characterize the impact of LA on recyclability of PE films

WORKPLAN:

- ☐ About 50 samples tested by members of the WG
- ☐ Thermogravimetric analyses (TGA) performed on PE//PE laminates
- ☐ TGA also performed on cured adhesives

CONCLUSION:

- ☐ Too simplistic approach to discriminate the LA depending on their chemistries
- ☐ Necessity to replicate recycling process to observe differences

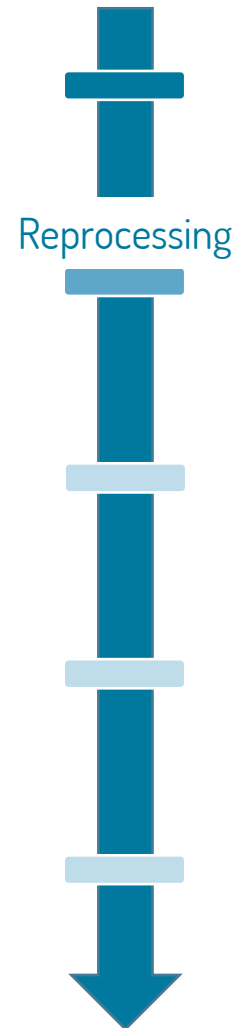
RecyClass | STEP 2 – REPROCESSING



#	Solvent	Isocyanate type	Polyol type	NCO/OH termination	NCO:OH ratio	Free-monomer content
0	LDPE 310E					
1	SB	ALIPHATIC	Polyester	OH	0.2	<0.5%
2	SB	AROMATIC	Polyester	NCO	1.6	2-5%
3	SB	AROMATIC	Polyether	NCO	1.3	2-5%
4	SF	ALIPHATIC	Polyester	OH	0.55	<0.2%
5	SF	HYBRID ALIPH/AROM	Polyester/ether	NCO	2	16%
6	SF	AROMATIC	Polyether	NCO	2	35%
7	SF	AROMATIC	Polyether	NCO	1.2	23-26%
8	SF	AROMATIC	Polyester	NCO	1.35	21-23%
9	SF	AROMATIC	Polyester/ether	NCO	1.3	23-26%
10	SF	AROMATIC	Polyester/ether	NCO	1.5	32%
11	SF	AROMATIC	Polyether	NCO	2	0.1%
12	WB	Acrylic				

For **SB (Solvent Based)**: 2.5wt% of LA For **SF (Solvent-Free)**: 1.8 wt% of LA

RecyClass | STEP 2 – REPROCESSING



Sample 0

#	Solvent	Isocyanate type	Polyol type	NCO/OH termination	NCO:OH ratio	Free-monomer content	Yellowing
0	LDPE 310E						0
1	SB	ALIPHATIC	Polyester	OH	0.2	<0.5%	3.8
2	SB	AROMATIC	Polyester	NCO	1.6	2-5%	6.9
3	SB	AROMATIC	Polyether	NCO	1.3	2-5%	5.5
4	SF	ALIPHATIC	Polyester	OH	0.55	<0.2%	5.0
5	SF	HYBRID ALIPH/AROM	Polyester/ether	NCO	2	16%	9.2
6	SF	AROMATIC	Polyether	NCO	2	35%	8.9
7	SF	AROMATIC	Polyether	NCO	1.2	23-26%	9.5
8	SF	AROMATIC	Polyester	NCO	1.35	21-23%	12.0
9	SF	AROMATIC	Polyester/ether	NCO	1.3	23-26%	14.8
10	SF	AROMATIC	Polyester/ether	NCO	1.5	32%	12.2
11	SF	AROMATIC	Polyether	NCO	2	0.1%	12.8
12	WB	Acrylic					12.6

Table 5. Pellet properties

Sample	Melt flow rate (g/10 min)
Sample 0	0.58
Sample 1	0.79
Sample 2	0.96
Sample 3	1.07
Sample 4	1.06
Sample 5	0.92
Sample 6	1.03
Sample 7	1.06
Sample 8	1.00
Sample 9	1.01
Sample 10	1.12
Sample 11	1.14
Sample 12	1.08



Sample 1



Sample 2



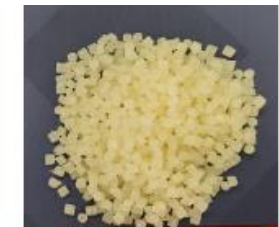
Sample 3



Sample 7



Sample 8



Sample 9



Sample 4



Sample 5



Sample 6



Sample 10



Sample 11



Sample 12

RecyClass | STEP 2 – CAST FILMS

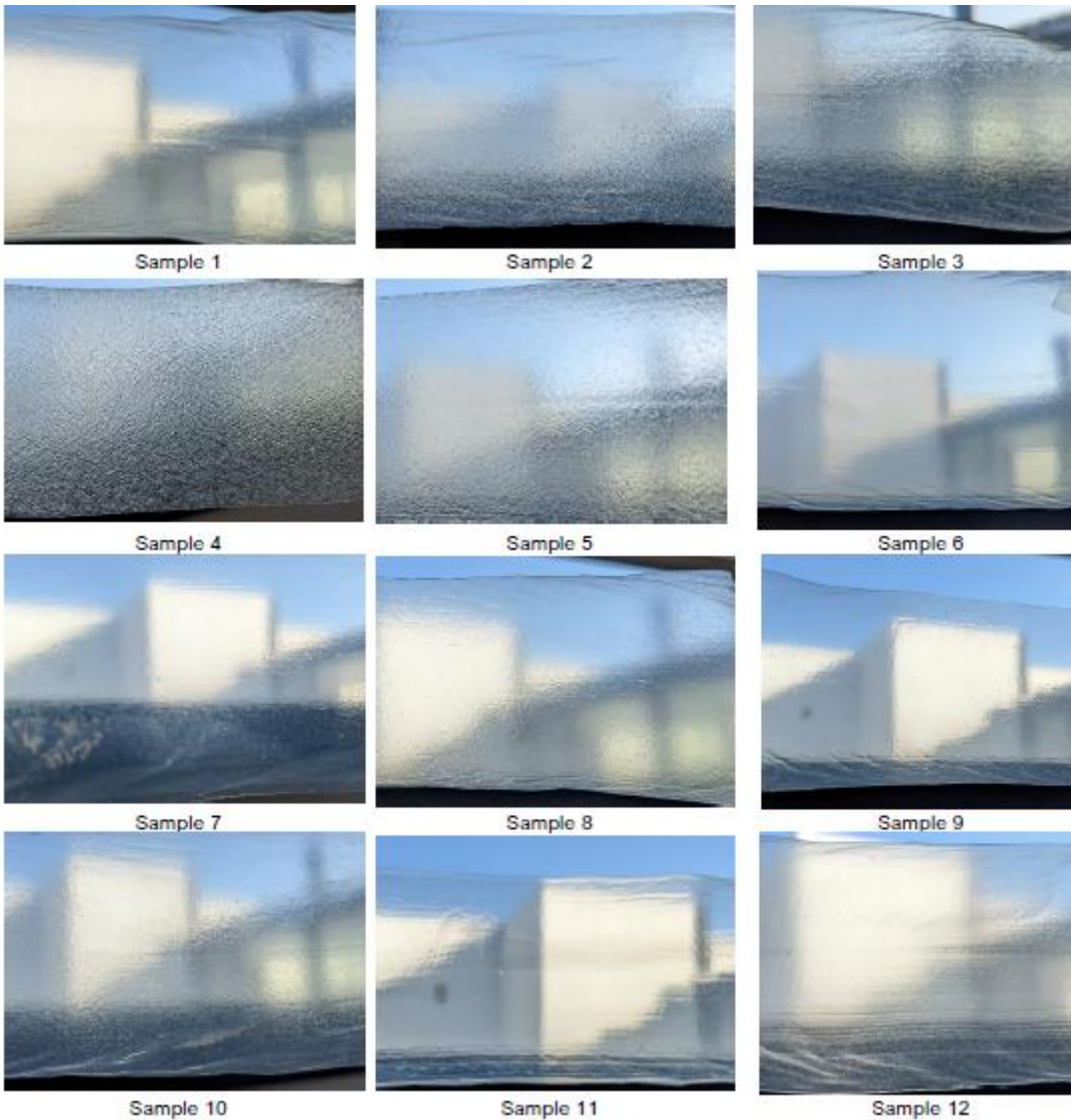


Figure 7. Films aspect

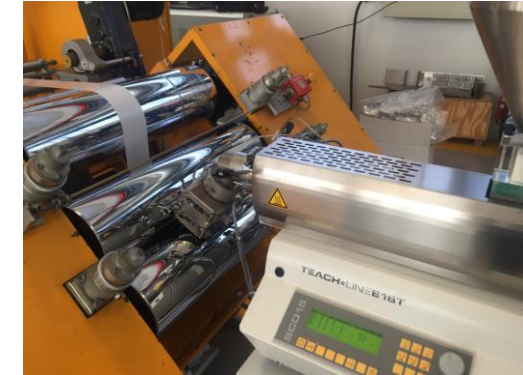


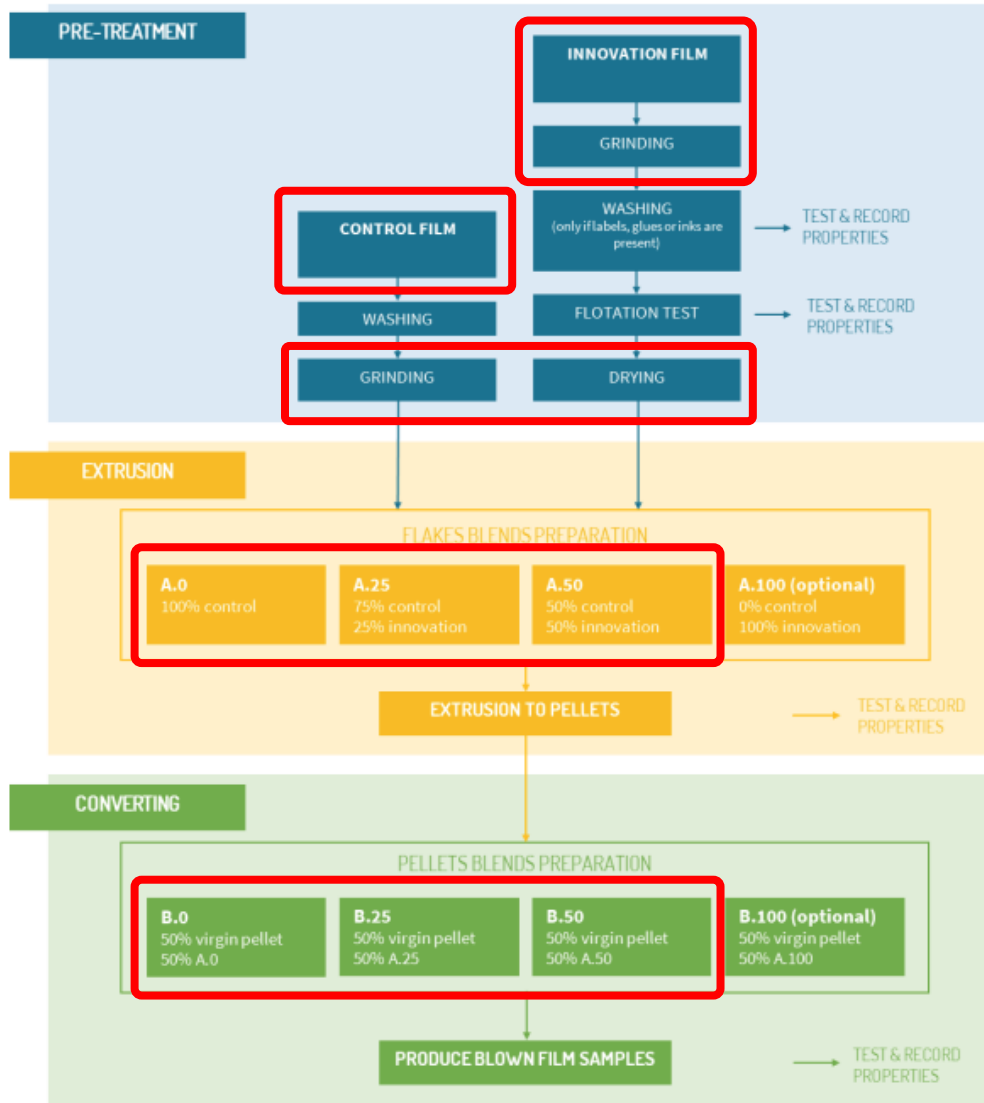
Table 4. Film properties

N° Sample	Sample	N° of Gels/Specks
AST-21-332-01-00-01	Sample 0	26 ± 3
AST-21-332-02-00-01	Sample 1	879 ± 15
AST-21-332-03-00-01	Sample 2	4686 ± 74
AST-21-332-04-00-01	Sample 3	4318 ± 185
AST-21-332-05-00-01	Sample 4	5365 ± 116
AST-21-332-06-00-01	Sample 5	4230 ± 78
AST-21-332-07-00-01	Sample 6	960 ± 19
AST-21-332-08-00-01	Sample 7	450 ± 39
AST-21-332-09-00-01	Sample 8	415 ± 26
AST-21-332-10-00-01	Sample 9	468 ± 27
AST-21-332-11-00-01	Sample 10	1243 ± 84
AST-21-332-12-00-01	Sample 11	938 ± 43
AST-21-332-13-00-01	Sample 12	49 ± 7



#	Solvent	Isocyanate type	Polyol type	NCO/OH termination	<i>NCO:OH ratio</i>	Free-monomer content	Yellowing	Gels & Specks	
0	LDPE 310E						0	26	
1	SB	ALIPHATIC	Polyester	OH	0.2	<0.5%	3.8	879	
4	SF	ALIPHATIC	Polyester	OH	0.55	<0.2%	5.0	5365	
	6	SF	AROMATIC	Polyether	NCO	2	35%	8.9	960
	7	SF	AROMATIC	Polyether	NCO	1.2	23-26%	9.5	450
	8	SF	AROMATIC	Polyester	NCO	1.35	21-23%	12.0	415
11	SF	AROMATIC	Polyether	NCO	2	0.1%	12.8	938	

RecyClass | RECYCLABILITY ASSESSMENT



Focus on the 4 more sensitive parameters :

- Pressure
- Build up on filter
- Yellowing
- Gels & speck

RecyClass | STEP 3 – RESULTS



Figure 13. Control film flakes. Division in millimetres.



Innovation film 1



Innovation film 4



Innovation film 6



Innovation film 7



Innovation film 8



Innovation film 11

Figure 14. Innovation films flakes. Divisions in millimetres

RecyClass | STEP 3 – RESULTS – PROCESS

Table 8. Extrusion parameters.

Blends	Average Torque (%)	Average Pressure (Bar)	Average melt temperature (°C)	Pressure during first 5 minutes (bar)	Pressure during last 5 minutes (bar)	ΔP over run (%)	Observations (change of filters, odours, ...)
A.0 ^a	35,5	40,3	241	40	41	3	None
A.25.1	39	41	240	41	41	0	None
A.50.1	39	42	239	42	42	0	None
A.25.4	37,8	48,7	240	48	50	4	None
A.50.4	39,8	53,6	240	53,7	55	6	None
A.25.6	37,5	40,6	241	40	41	3	None
A.50.6	40	41,3	238	41	42	2	None
A.25.7	35,3	40	239	39	41	5	None
A.50.7	36,3	39,7	240	39	40	3	None
A.25.8	34,7	41	239	41	41	0	Some particles
A.50.8	33,7	38	239	38	38	0	Some particles
A.0 ^b	38,5	42,7	238	42	43	2	None
A.25.11	35	37	243	37	37	0	None
A.50.11	34,6	39	241	38	40	5	None

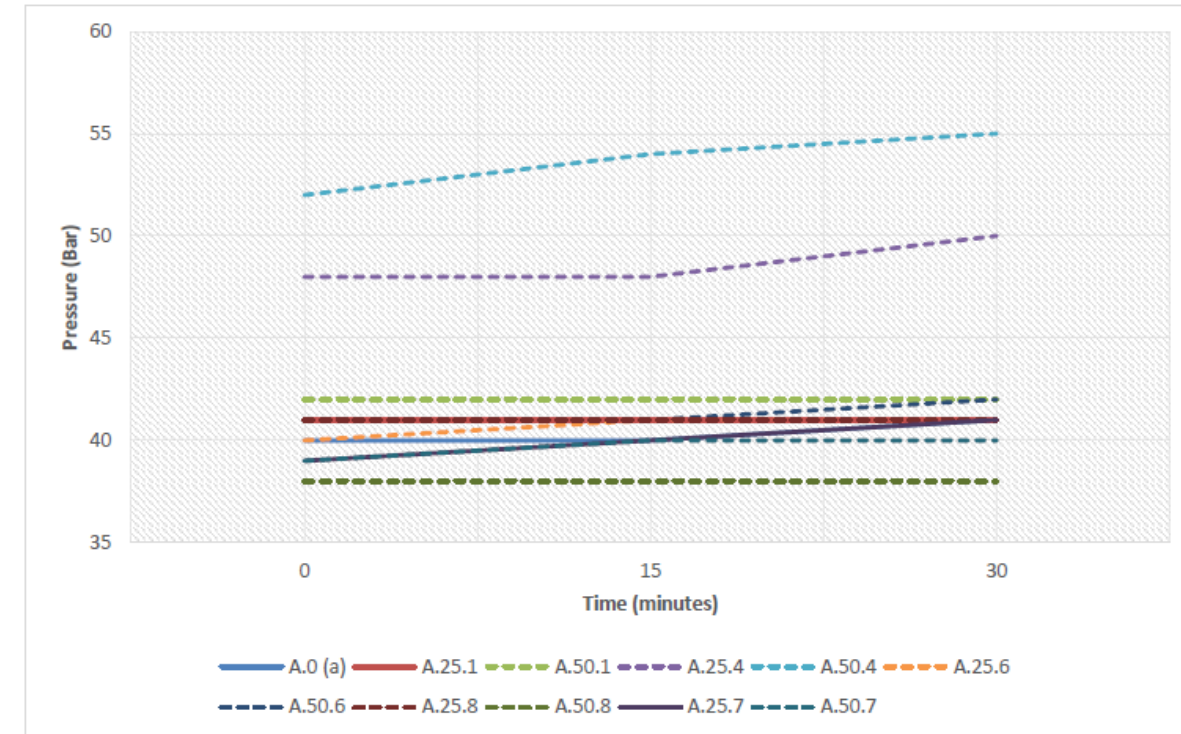
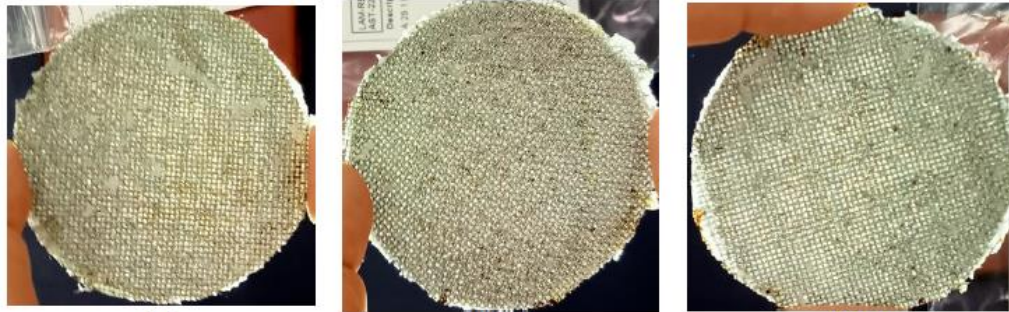


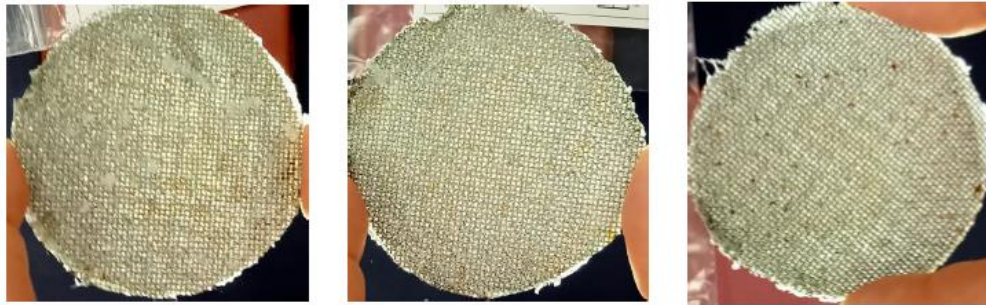
Figure 15. Pressure evolution over time for A.0a, A.25.1, A.50.1, A.25.4, A.50.4, A.25.6, A.50.6, A.25.7, A.50.7, A.25.8 and A.50.8, for a production of 8 kg/h.

RecyClass | STEP 3 – RESULTS – FILTERS



A.0 A.25.1 A.50.1

Figure 17. Screen pack visual inspection. Samples A.0, A.25.1 and A.50.1



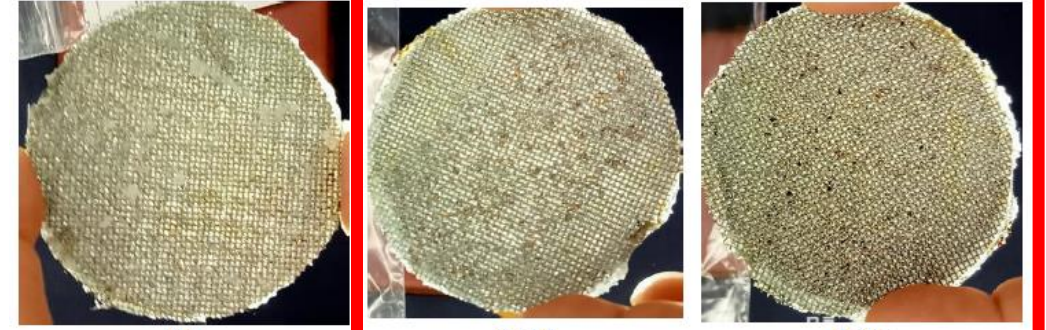
A.0 A.25.4 A.50.4

Figure 18. Screen pack visual inspection. Samples A.0, A.25.4 and A.50.4 (Control sample included for comparison)



A.0 A.25.6 A.50.6

Figure 19. Screen pack visual inspection. Samples A.0, A.25.6 and A.50.6 (Control sample included for comparison)



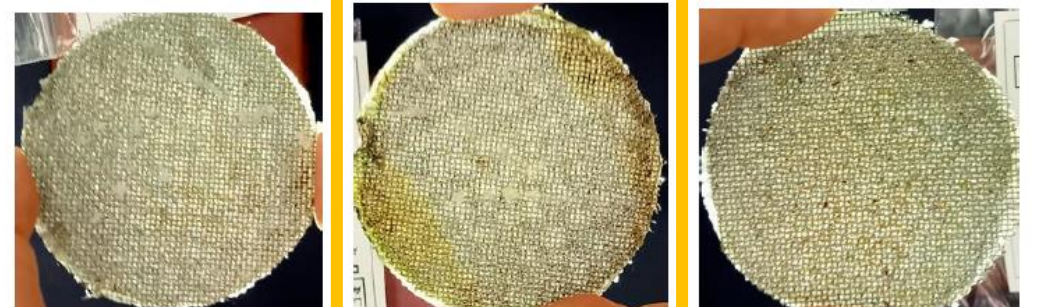
A.0 A.25.7 A.50.7

Figure 20. Screen pack visual inspection. Samples A.0, A.25.7 and A.50.7 (Control sample included for comparison)



A.0 A.25.8 A.50.8

Figure 21. Screen pack visual inspection. Samples A.0, A.25.8 and A.50.8 (Control sample included for comparison)



A.0 A.25.11 A.50.11

Figure 22. Screen pack visual inspection Samples A.0, A.25.11 and A.50.11 (Control sample included for comparison)

RecyClass | STEP 3 – RESULTS – PELLETS

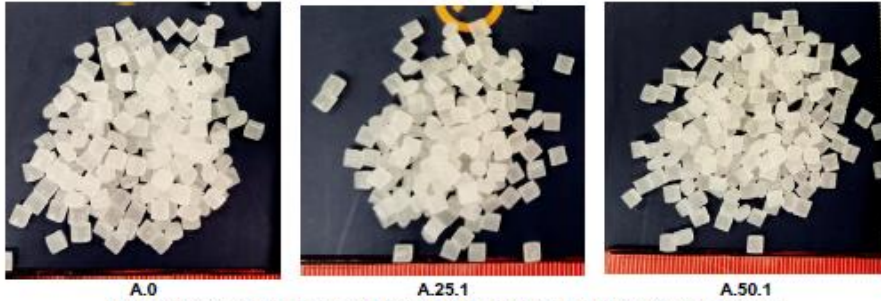


Figure 29. Pellets produced - Samples A.0, A.25.1, and A.50.1. Scale in millimetres.

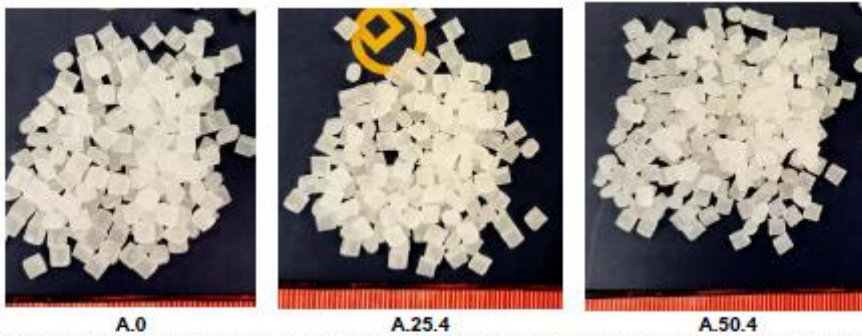


Figure 30. Pellets produced - Samples A.0, A.25.4, and A.50.4. Scale in millimetres. (Control sample included for comparison)

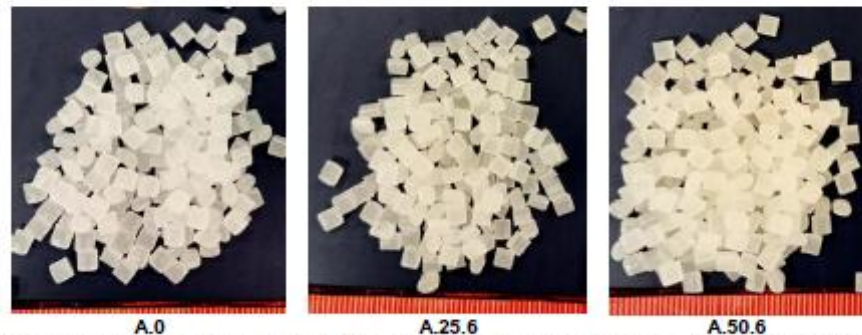


Figure 31. Pellets produced - Samples A.0, A.25.6, and A.50.6. Scale in millimetres. (Control sample included for comparison)

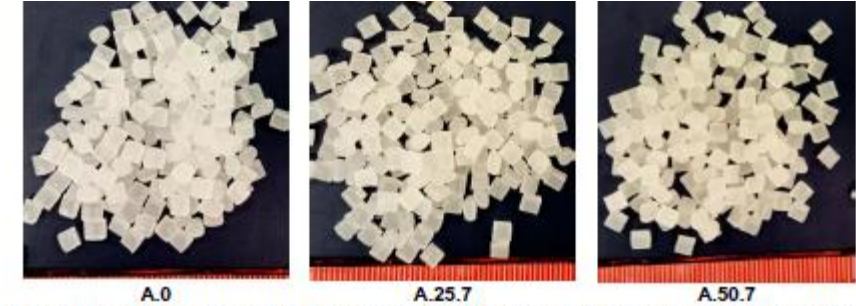


Figure 32. Pellets produced - Samples A.0, A.25.7, and A.50.7. Scale in millimetres. (Control sample included for comparison)

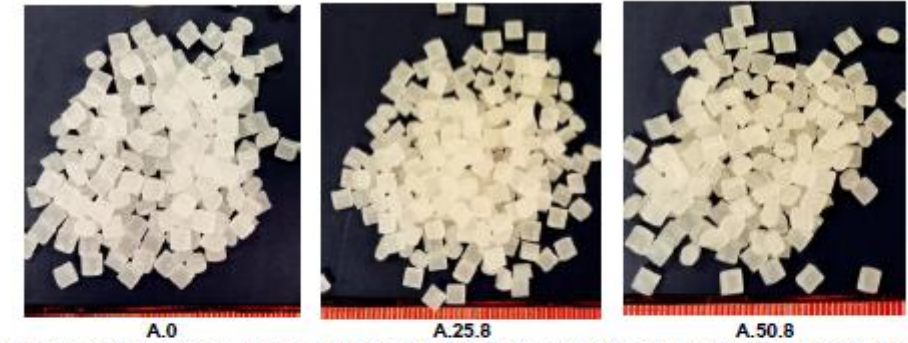


Figure 33. Pellets produced - Samples A.0, A.25.8, A.50.8. Scale in millimetres. (Control sample included for comparison)

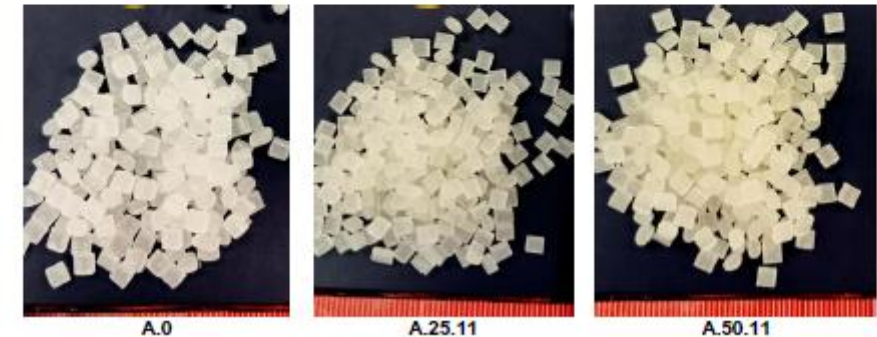


Figure 34. Pellets produced - Samples A.0, A.25.11 and A.50.11. Scale in millimetres. (Control sample included for comparison)

RecyClass | STEP 3 – RESULTS – YELLOWING

Sam ple #	Solvent/ Water based	Isocyanat e type	Polyol type	NCO/OH terminatio n	NCO:OH ratio	Free- monomer content	Blend	L*	a*	b*	b* step 2
0	LDPE 310E						A.0	65.34	-0.54	1.53	0
1	SB	ALIPHATIC	Polyester	OH	0.2	<0.5%	A.25	62.42	-0.71	4.03	3.5
							A.50	64.22	-0.93	3.51	
4	SF	ALIPHATIC	Polyester	OH	0.55	<0.2%	A.25	64.81	-0.61	2.48	2.3
							A.50	64.31	-0.66	2.71	
6	SF	AROMATIC	Polyether	NCO	2	35%	A.25	63.16	-0.70	5.02	8.4
							A.50	63.34	-1.02	6.41	
7	SF	AROMATIC	Polyether	NCO	1.2	23-26%	A.25	63.75	-0.79	4.56	9.1
							A.50	63.42	-0.82	6.05	
8	SF	AROMATIC	Polyester	NCO	1.35	21-23%	A.25	63.68	-0.80	6.33	12.0
							A.50	63.60	-0.97	7.94	
11	SF	AROMATIC	Polyether	NCO	2	0.1%	A.25	65.48	-0.97	6.07	12.4
							A.50	63.88	-0.97	7.81	

RecyClass | STEP 3 – RESULTS – FILM PROD



B.0

B.25.1

B.50.1

Figure 35. Blown film extrusion line –Visual inspection on haze for sample B.0, B.25.1 and B.50.1



B.0

B.25.4

B.25.4

Figure 36. Blown film extrusion line –Visual inspection on haze for sample B.0, B.25.4 and B.50.4

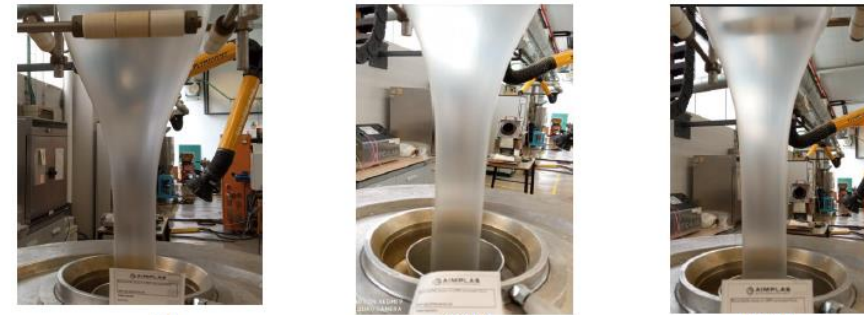


B.0

B.50.6

B.25.6

Figure 37. Blown film extrusion line –Visual inspection on haze for sample B.0, B.25.6 and B.50.6

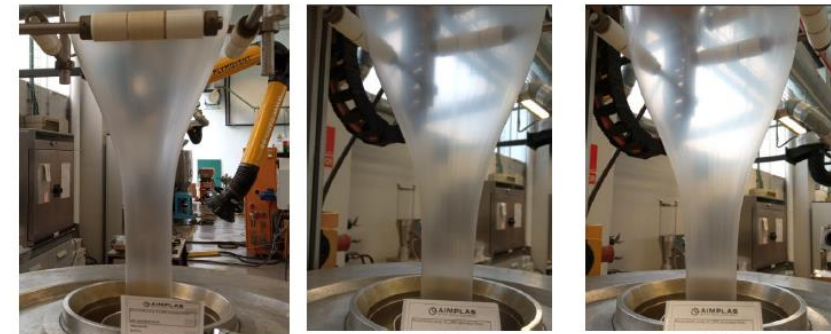


B.0

B.25.7

B.50.7

Figure 38. Blown film extrusion line - Visual inspection on haze for samples B.0, B.25.7 and B.50.7



B.0

B.25.8

B.50.8

Figure 39. Blown film extrusion line - Visual inspection on haze for samples B.0, B.25.8 and B.50.8



B.0

B.25.11

B.50.11

Figure 40. Blown film extrusion line - Visual inspection on haze for sample B.0, B.25.11 and B.50.11

RecyClass | STEP 3 – RESULTS – FILM CHARAC



B.0 B.25.1 B.50.1
Figure 41. Films obtained in the Converting stage. Samples B.0, B.25.1 and B.50.1



B.0 B.25.4 B.50.4
Figure 42. Films obtained in the Converting stage. Samples B.0, B.25.4 and B.50.4



B.0 B.25.6 B.50.6
Figure 43. Films obtained in the Converting stage. Samples B.0, B.25.6 and B.50.6



B.0 B.25.7 B.50.7
Figure 44. Films obtained in the Converting stage. Samples B.0, B.25.7 and B.50.7



B.0 B.25.8 B.50.8
Figure 45. Films obtained in the Converting stage. Samples B.0, B.25.8 and B.50.8



B.0 B.25.11 B.50.11
Figure 46. Films obtained in the Converting stage. Sample B.0, B.25.11 and B.50.11

RecyClass | STEP 3 – FILM CHARACTERIZATION

Sam ple #	Solvent/ Water based	Isocyanat e type	Polyol type	NCO/OH termination	<i>NCO:OH ratio</i>	Free- monomer content	Blend	Haze (%)	Gels & Specks	Gels & Specks Step 2
0	LDPE 310E						A.0	25.2	6	26
1	SB	ALIPHATIC	Polyester	OH	0.2	<0.5%	A.25	26.9	5	879
							A.50	26.5	6	
4	SF	ALIPHATIC	Polyester	OH	0.55	<0.2%	A.25	31	853	5365
							A.50	33	1144	
6	SF	AROMATIC	Polyether	NCO	2	35%	A.25	28.5	15	960
							A.50	28	23	
7	SF	AROMATIC	Polyether	NCO	1.2	23-26%	A.25	27	15	450
							A.50	26.6	18	
8	SF	AROMATIC	Polyester	NCO	1.35	21-23%	A.25	20.8	12	415
							A.50	19.9	5	
11	SF	AROMATIC	Polyether	NCO	2	0.1%	A.25	24	13	938
							A.50	22.6	8	

RecyClass | STEP 3 – RESULTS – SUMMARY

Sam ple #	Solvent/ Water based	Isocyanat e type	Polyol type	NCO/OH termination	NCO:OH ratio	Free- monomer content	Blend	b*	Gels & Specks	Extrusion Process
0	LDPE 310E						A.0	1.53	6	OK
1	SB	ALIPHATIC	Polyester	OH	0.2	<0.5%	A.25	4.03	5	OK
							A.50	3.51	6	
4	SF	ALIPHATIC	Polyester	OH	0.55	<0.2%	A.25	2.48	853	High Pressure
							A.50	2.71	1144	
6	SF	AROMATIC	Polyether	NCO	2	35%	A.25	5.02	15	Few specs
							A.50	6.41	23	
7	SF	AROMATIC	Polyether	NCO	1.2	23-26%	A.25	4.56	15	OK
							A.50	6.05	18	
8	SF	AROMATIC	Polyester	NCO	1.35	21-23%	A.25	6.33	12	Residues
							A.50	7.94	5	
11	SF	AROMATIC	Polyether	NCO	2	0.1%	A.25	6.07	13	Few specs
							A.50	7.81	8	

RecyClass | STEP 3 – CONCLUSION

- ❑ Results **aligned with the Step 2**
- ❑ Sample #4 showing the worst results with very high gels & specks
- ❑ No difference between **Solvent based and Solvent Free**
- ❑ Aromatic PU show **significantly higher yellowing**

Based on the results
→ Guidelines were updated with LA

Sample #	Solvent/ Water based	Isocyanate type	Polyol type	NCO/OH termination
0	LDPE 310E			
1	SB	ALIPHATIC	Polyester	OH
4	SF	ALIPHATIC	Polyester	OH
6	SF	AROMATIC	Polyether	NCO
7	SF	AROMATIC	Polyether	NCO
8	SF	AROMATIC	Polyester	NCO
11	SF	AROMATIC	Polyether	NCO



RecyClass | GUIDELINE UPDATE PROPOSAL

Coloured PE Flexible Films for Household and Commercial Packaging

	YES - FULL COMPATIBILITY	CONDITIONAL - LIMITED COMPATIBILITY	NO - LOW COMPATIBILITY
MATERIAL COMPOSITION (TOTAL AMOUNT OF PE & AMOUNT OF PP ATTACHMENTS IN THE PACKAGING)	A >= 95%, B >= 90% and all packaging features are FULLY compatible with recycling	C >= 70% and all packaging features are FULLY compatible with recycling	D >= 50%, E >= 30%, F <= 30% and all packaging features are FULLY compatible with recycling
DESCRIPTION (TEST PROTOCOL)	Materials that passed the testing protocols with no negative impact OR materials that have not been tested (yet), but are known to be acceptable in PE recycling	Materials that passed the testing protocols if certain conditions are met OR materials that have not been tested (yet), but pose a low risk of interfering with PE recycling	Materials that failed the testing protocols OR materials that have not been tested (yet), but pose a high risk of interfering with PE recycling
DESCRIPTION (METHODOLOGY)	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from A to B or from B to C	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from C to D	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from D to E or from E to F
MATERIAL	PE-LD, PE-LLD; PE-HD	Multilayer PE/PP with PP <= 5%	Multilayer PE/PP with PP > 5%; Any other polymer (e.g. PET, PVC, etc.)
COLOURS	Light colours; translucent colours	NIR-detectable dark colours (Sorting test)	Non NIR-detectable dark colours
SIZE	> A4 or > 50 x 50 mm once compacted	< A4 format or between 20 x 20 and 50 x 50 mm once compacted (Sorting test)	< 20 x 20 mm
PRODUCT RESIDUES (EASY TO EMPTY INDEX)	A if the index is < 5%; B if the index is < 10%	C if the index is < 15%	D if the index is < 20%; E if the index is < 25%; F if the index is > 25%
BARRIER***	SiOx and AlOx without additional coatings	<= 5% EVOH (in polyolefinic combination film); Metallisation; PVOH <= 1%; <= 15% PA 6/66 copolymer with melting temperature < 192 °C and incorporating >= 10% PE-g-MAH tie layers	> 5% EVOH (in polyolefinic combination film); Any other PA; PVOH > 1%; barrier layer PVC, PVDC; any other barrier layer; foaming agents used as expanding chemical agents; aluminium
ADDITIVES	Additives that do not increase the density higher than 0,97 g/cm³		Bio-/oxo-/photodegradable additives Additives that do increase the density higher than 0,97 g/cm³ (CaCO3, talc, glass fibers, etc.)
LAMINATING ADHESIVES	Polyurethanes and water-based acrylics <= 3%; <u>Laminating adhesives approved</u> as fully compatible by RecyClass; To be tested if in combination with a barrier material	Polyurethanes and water-based acrylics 3-5%; <u>Laminating adhesives approved</u> as limited compatible by RecyClass; To be tested if in combination with a barrier material	Polyurethanes and water-based acrylics >5%; Laminating adhesives specifically developed for PET and/or Aluminium in combination with PE; Any other laminating adhesives (Epoxy, etc.)

Laminating adhesive specially developed for high thermal applications above boiling and/or for high chemical resistance (to be tested)

Polyurethanes and water-based acrylics <= 3%;
Laminating adhesives approved as fully compatible by RecyClass;
To be tested if in combination with a barrier material

Polyurethanes and water-based acrylics 3-5%;
Laminating adhesives approved as limited compatible by RecyClass;
To be tested if in combination with a barrier material

Polyurethanes and water-based acrylics >5%;
Laminating adhesives specifically developed for PET and/or Aluminium in combination with PE;
Any other laminating adhesives (Epoxy, etc.)

RecyClass | GUIDELINE UPDATE PROPOSAL

Natural PE Flexible Films for Household and Commercial Packaging

	YES - FULL COMPATIBILITY	CONDITIONAL - LIMITED COMPATIBILITY	NO - LOW COMPATIBILITY
MATERIAL COMPOSITION (TOTAL AMOUNT OF PE & AMOUNT OF PP ATTACHMENTS IN THE PACKAGING)	A >= 95%, B >= 90% and all packaging features are FULLY compatible with recycling	C >= 70% and all packaging features are FULLY compatible with recycling	D >= 50%, E >= 30%, F <= 30% and all packaging features are FULLY compatible with recycling
DESCRIPTION (TEST PROTOCOL)	Materials that passed the testing protocols with no negative impact OR materials that have not been tested (yet), but are known to be acceptable in PE recycling	Materials that passed the testing protocols if certain conditions are met OR materials that have not been tested (yet), but pose a low risk of interfering with PE recycling	Materials that failed the testing protocols OR materials that have not been tested (yet), but pose a high risk of interfering with PE recycling
DESCRIPTION (METHODOLOGY)	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from A to B or from B to C	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from C to D	In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from D to E or from E to F
MATERIAL*	PE-LD, PE-LLD; PE-HD	Multilayer PE/PP <u>with PP <= 5%</u>	Multilayer PE/PP with PP > 5%; Any other polymer (e.g. PET, PVC, etc.)
COLOURS	Unpigmented; transparent	Light colours; translucent colours	Dark colours; black; carbon black
SIZE	> A4 or > 50 x 50 mm once compacted	< A4 format or between 20 x 20 and 50 x 50 mm once compacted (Sorting test)	< 20 x 20 mm
PRODUCT RESIDUES (EASY TO EMPTY INDEX)	A if the index is < 5%; B if the index is < 10%	C if the index is < 15%	D if the index is < 20%; E < if the index is < 25%; F if the index is > 25%
BARRIER***	SiOx and AlOx without additional coatings	<u><= 5% EVOH</u> (in polyolefinic combination film); <u><=15% PA 6/66 copolymer with melting temperature < 192 °C and incorporating >= 10% PE-g-MAH tie layers</u>	> 5% EVOH (in polyolefinic combination film); Any other PA; Metallisation; PVOH; barrier layer PVC, PVDC; any other barrier layer; foaming agents used as expanding chemical agents; aluminium
ADDITIVES	Additives that do not increase the density higher than 0,97 g/cm³		Bio-/oxo-/photodegradable additives Additives that do increase the density higher than 0,97 g/cm³ (CaCO3, talc, glass fibers, etc.)
LAMINATING ADHESIVES	<u>Laminating adhesives approved</u> as fully compatible by RecyClass; To be tested if in combination with a barrier material	Aliphatic polyurethanes <= 2.5%; <u>Laminating adhesives approved</u> as limited compatible by RecyClass; To be tested if in combination with a barrier material	Aliphatic polyurethanes >2.5%; Aromatic polyurethanes & Water-based acrylics; Laminating adhesives specifically developed for PET and/or Aluminium in combination with PE; Any other laminating adhesives (Epoxy, etc.)

Laminating adhesives approved as fully compatible by RecyClass;
To be tested if in combination with a barrier material

Aliphatic polyurethanes <= 2.5%;
Laminating adhesives approved as limited compatible by RecyClass;
To be tested if in combination with a barrier material

Aliphatic polyurethanes >2.5%; Aromatic polyurethanes & Water-based acrylics;
Laminating adhesives specifically developed for PET and/or Aluminium in combination with PE; Any other laminating adhesives (Epoxy, etc.)

KEY TAKEAWAYS

- ✓ RecyClass is now delivering recommendations on **Design for Recycling for laminating adhesives**
- ✓ **Cooperation and support of the main laminating adhesive suppliers** made this work possible
- ✓ **Approved adhesives** can be used for recyclable films
- ✓ Focus on the laminating adhesives, **the RecyClass testing protocols are robust** to prove laminating adhesive characteristics over recyclability
- ✓ Due to their complexity, **some laminating adhesives still needs to be tested prior to be approved (e.g. barrier films)**
- ✓ RecyClass is developing a **simplified testing procedure** for LA
- ✓ **New recommendations** for laminating adhesives used in **PP films** will be available **by end 2023**

RecyClass

The background features two large, light teal chemical structures. On the left is a benzene ring, and on the right is a flask containing a wavy line representing a liquid. These structures are faint and serve as a decorative backdrop for the text.

Questions & Answers

Use the Q&A box in the top-right corner of your screen

RecyClass

The background features two large, light teal chemical structures. On the left is a benzene ring, and on the right is a flask containing a wavy line representing a liquid. The entire graphic is set against a dark teal background.

Thank you for participating!

Sign up for the next session
5 July 2023

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