Stability of ARPRO 5134 RE after several recycling loops

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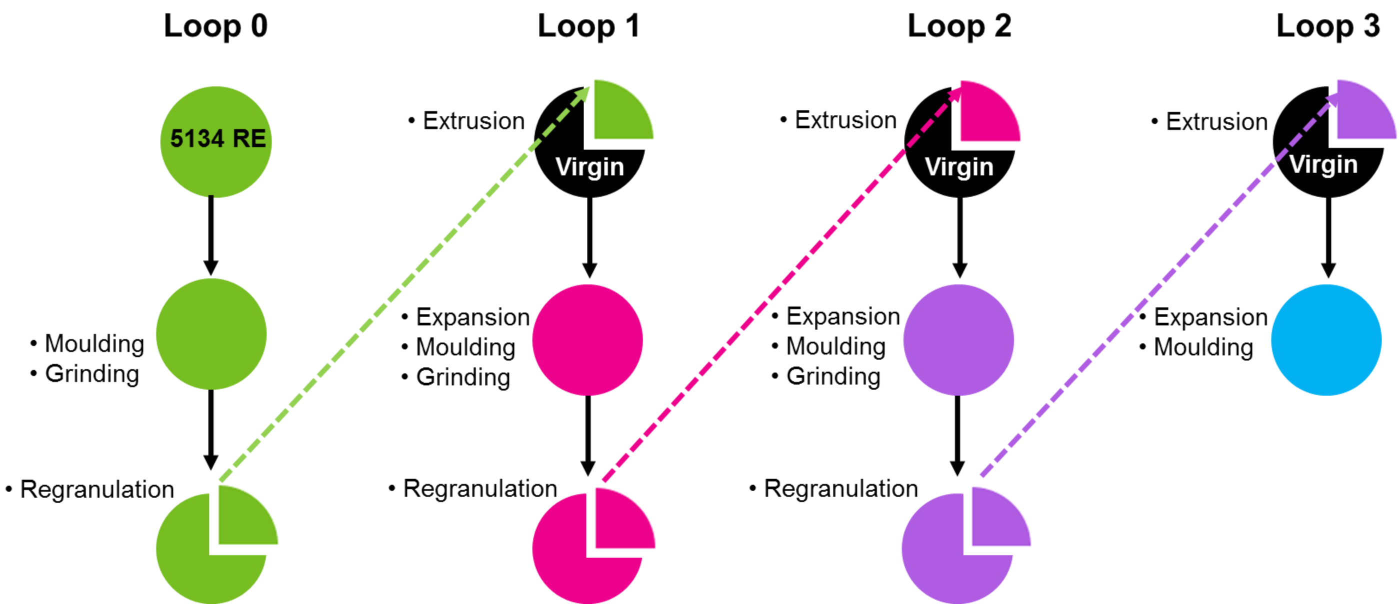
Mechanical recycling of EPP is the most efficient way to save resources and reuse waste material. However, thermoplastics are sensitive to thermal degradation that might cause reduced mechanical properties. Thanks to an excellent additives package and a well-controlled recycling loop, the stability test performed on ARPRO 5134 RE doesn´t highlight any difference between virgin ARPRO and ARPRO with 25% of the recycled content in terms of moulding behaviour and final mechanical properties.

Test objective: Evaluate the impact of several loops of recycling on the final properties of ARPRO Recycled grades.

Test method:
The objective of this study is to assess the performance of ARPRO Recycled grades after several complete loops of recycling. A complete recycling loop of end-of-life ARPRO parts is defined as the process including the following steps: Extrusion, Expansion, Moulding, Grinding and Regranulation.

As a start, ARPRO 5134 RE taken from standard production was moulded into several 1,200*800*50mm planks. A plank was kept as reference for properties evaluation and all other planks were grinded and regranulated thanks to an extruder dedicated to the recycling of ARPRO. The regranulated material was reincorporated at 25% into the material formulation in order to expand a new ARPRO 5134 RE. This new ARPRO 5134 RE followed then the same process, so that the overall process was replicated three times as summarised in the diagram below:



Results:

Conclusion:

ARPRO 5134 RE was recycled via three consecutive loops of recycling which include all steps from extrusion to expansion, moulding, grinding and finally regranulation. After these three loops of recycling, moulding behaviour and mechanical properties of ARPRO are not impacted.

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Moulding steps:

The initial ARPRO 5134 RE and the material produced from each recycling loop was moulded at a density of around 60g/l thanks to a 400*300*80mm block tool. Moulding parameters are presented in the table below. In order to evaluate the potential recycling impact on moulding cycle time, foam pressure sensors were used for all mouldings with a fixed demoulding pressure at 0.5bar.

Considering the usual variation experienced during the production of such ARPRO blocks, we observed no significant change in the moulding behaviour in between the different recycling loops. Actually, the same filling/back pressures (3.0/2.5 bar) and same steam pressures were used between the three loops which demonstrates the stability of the moulding performance even after three recycling loops.
In addition, no difference was noticed in terms of the visual aspect between all moulded parts after each recycling loop.

	Moulded density (g/l)	Cycle time (s)	Shrinkage (%)
5134 RE from Loop 1	63	123	1.7
5134 RE from Loop 2	63	116	1.9
5134 RE from Loop 3	63	115	1.9

Mechanical properties:

On the initial ARPRO 5134 RE and after each following recycling loop, the material mechanical properties were assessed in order to evaluate the impact of multi-recycling loops on final properties. As exhibited in the graphs and table below, there is no impact on the mechanical properties which remain in line with ARPRO Black typical values, even after three loops of recycling.

ARPRO

Test name	Test method	Unit	Average and single result on ARPRO at 60g/l			
			Initial 5134 RE	5134 RE Loop 1	5134 RE Loop 2	5134 RE Loop 3
Tested density	ISO 845	kg/m^3	58 *58; 59; 57; 59; 58* *Standard deviation = 1*	64 *65; 64; 64; 63; 64* *Standard deviation = 1*	63 *64; 63; 63; 63; 63* *Standard deviation = 0*	60 *60; 60; 60; 59; 59* *Standard deviation = 0*
Compression Set 25% strain, 24h	ISO 1856-C	%	10.5 *10; 11; 10; 11; 10* *Standard deviation = 0.5*	11.0 *10; 11; 11; 10; 11* *Standard deviation = 0.5*	11.0 *10; 11; 11; 11; 11* *Standard deviation = 0*	11.0 *11; 11; 11; 11; 11* *Standard deviation = 0*
Stauch-Härte 4th cycle @40%	ISO 3386	kPa	170 *172; 170; 166 171; 171* *Standard deviation = 0*	195 *197; 195; 194; 194; 194* *Standard deviation = 3*	192 *191; 190; 197; 193; 190* *Standard deviation = 8*	185 *187; 183; 185; 187; 183* *Standard deviation = 4*
Tensile strength	ISO 1798	kPa	1,021 *1,054; 1,045; 1,000; 1,003; 1,003; 1,022* *Standard deviation = 32*	1,167 *1,148; 1,187; 1,096; 1,160; 1,160; 1,252* *Standard deviation = 51*	1,044 *1,009; 1,085; 1,055; 1,047; 1,022; 1,047* *Standard deviation = 26*	1,018 *1,024; 1,045; 1,024; 965; 1,040; 1,009* *Standard deviation = 29*
Tensile elongation	ISO 1798	%	32 *34; 32; 29; 30; 31; 36* *Standard deviation = 3*	27 *24; 29; 24; 28; 25; 31* *Standard deviation = 3*	27 *23; 29; 29; 28; 24; 27* *Standard deviation = 3*	29 *28; 33; 27; 27; 28; 28* *Standard deviation = 2*
Compressive strength	ISO 844	kPa				
25% strain			338 *336; 344; 332; 333; 343* *Standard deviation = 6*	406 *412; 406; 407; 400; 407* *Standard deviation = 4*	391 *395; 388; 389; 389; 394* *Standard deviation = 3*	358 *366; 361; 358; 354; 352* *Standard deviation = 6*
50% strain			459 *455; 466; 450; 455; 468* *Standard deviation = 8*	539 *537; 540; 544; 534; 539* *Standard deviation = 4*	519 *523; 515; 519; 514; 524* *Standard deviation = 4*	473 *478; 473; 469; 472; 474* *Standard deviation = 3*
75% strain			1,006 *968; 998; 945; 1,022; 1,096* *Standard deviation = 58*	1134 *1,085; 1,156; 1,175; 1,144; 1,111* *Standard deviation = 36*	1114 *1,130; 1,091; 1,135; 1,074; 1,141* *Standard deviation = 29*	963 *949; 925; 914; 994; 1,031* *Standard deviation = 49*
Burn rate	ISO 3795 12.5mm thick	mm/min	41 *39; 38; 43; 43; 41* *Standard deviation = 2*	39 *38; 41; 38; 41; 38* *Standard deviation = 2*	40 *42; 40; 42; 39; 35* *Standard deviation = 3*	42 *45; 45; 41; 35; 44* *Standard deviation = 4*

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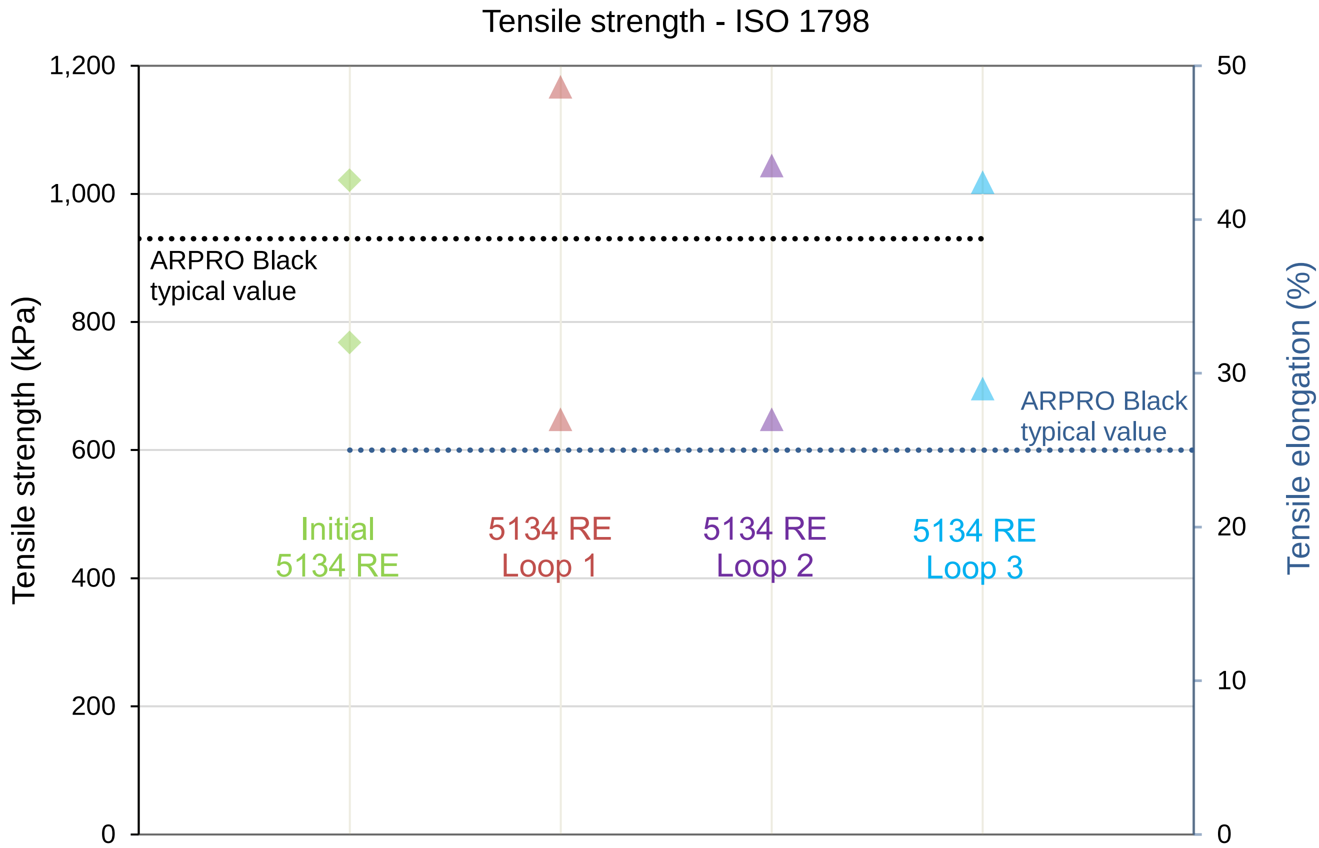
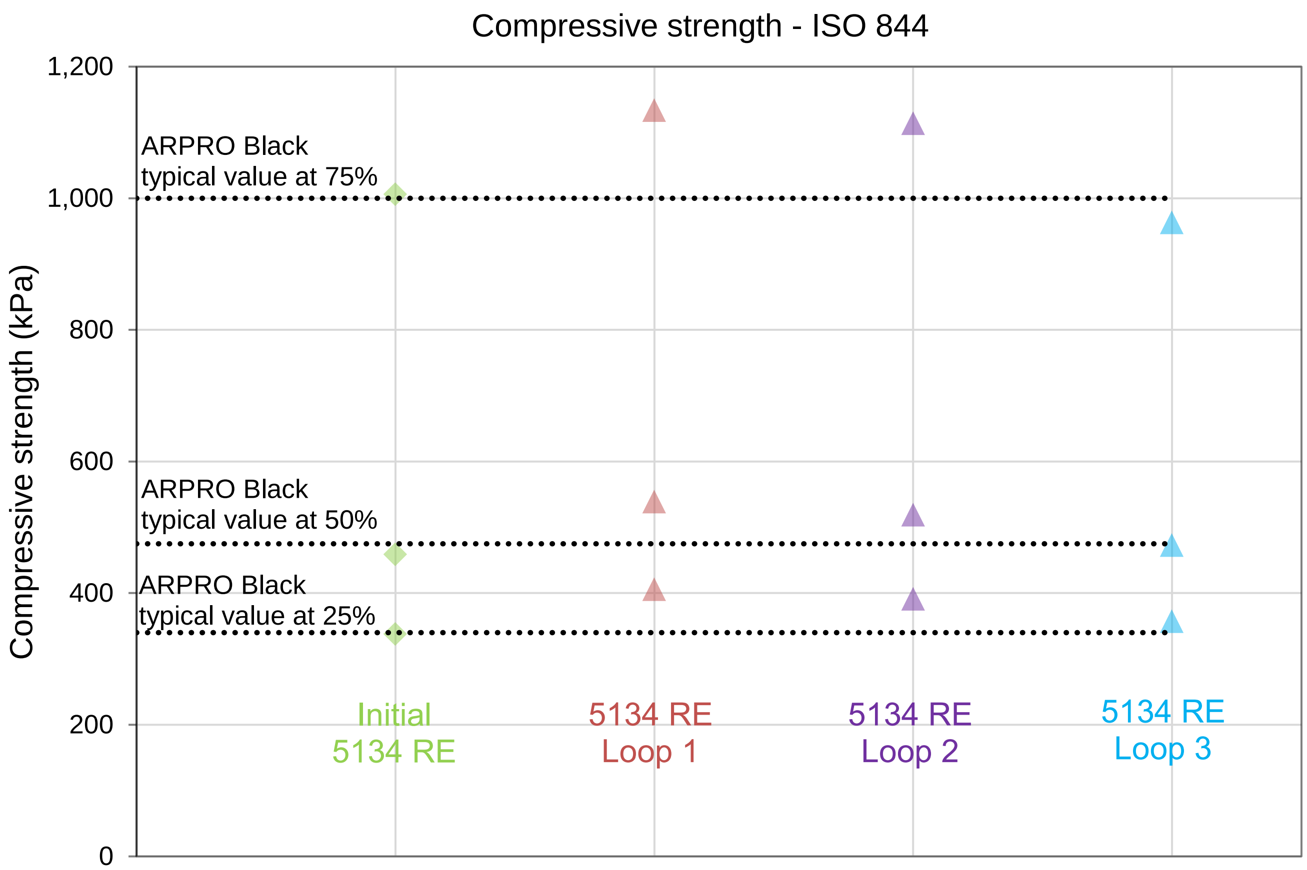

Tensile strength - ISO 1798
1,200
1,000
800
600
400
200
0
50
40
30
20
10
0
Tensile strength (kPa)
Tensile elongation (%)
ARPRO Black
typical value
ARPRO Black
typical value
Initial
5134 RE
5134 RE
Loop 1
5134 RE
Loop 2
5134 RE
Loop 3


Compressive strength - ISO 844
1,200
1,000
800
600
400
200
0
Compressive strength (kPa)
ARPRO Black
typical value at 75%
ARPRO Black
typical value at 50%
ARPRO Black
typical value at 25%
Initial
5134 RE
5134 RE
Loop 1
5134 RE
Loop 2
5134 RE
Loop 3

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