Evaluation of high-quality post-consumer recyclate (PCR) and virgin polyethylene blends for cable jackets

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ABSTRACT

This paper evaluates various PE jacket compounds made of post-consumer recyclate (PCR) and virgin materials. It shows how properties of the compounds and cables made of them, e.g., environment stress crack resistance (ESCR), tensile properties, weather resistance, pressure deformation, etc. are impacted by the ingoing components, as well as the choice of the PCR and virgin materials. It indicates the potential of using those compounds for cable jackets and suggests that, for a minimum carbon footprint, blending a PCR with a base resin produced from renewable based feedstocks, e.g. a polymer based on ethylene from second generation of renewable feedstock, could be a beneficial solution.

KEYWORDS

Polyethylene, PCR, cable jacket, ESCR

INTRODUCTION

In the EU27+3, 29.5 million tons' post-consumer plastic waste (PCW) was collected, of which 10.2 million tons were sent for recycling to generate 5.5 million tons' post-consumer plastic recyclate (PCR) in the year 2020. Specifically, for packaging plastic waste, the recycling rate is 32% according to the new calculation method in Directive (EU) 94/62/EC. Significant improvement is needed to reach the 55% recycling target for post-consumer plastics packaging waste by 2030[1].

Polyolefins (PO), in particular, polyethylene (PE) and polypropylene (PP) are increasingly consumed in large amounts in a wide range of applications, including packaging, fibers, automotive components, and a great variety of manufactured articles. It is reported that, in 2021, about 50% of the converters' plastics demand went to polyolefins in the EU27+3, with 30% for PE and 20% for PP[2]. Polyolefins were largely used for packaging applications. Improving the recycling rate of polyolefins is crucial to achieving the EU target and contributes greatly to the circular economy.

Generally, recycled PE made of PCW in the market is mainly contaminated by PP and vice versa. It may be further cross contaminated with non-polyolefin polymers, or non-polymeric substances like wood, paper, glass or aluminium. Presence of those contaminants has great impact on the properties of recyclates[3, 4]. Highly contaminated recyclates are only used in low-cost, non-demanding applications, e.g. in construction or in outdoor furniture. On the other hand, in the markets of more demanding applications, e.g., wire and cable (W&C), skin-care product packaging, automotive, etc, there is a strong interest in PCR based materials. It is essential to select PCR of high purity and/or to blend PCR with virgin polymers to address the needs in such markets. The virgin polymers can be produced from "second generation renewable feedstock", thus further increasing the sustainability without compromising on the required virgin polymer properties.

EXPERIMENTAL

Materials

Virgin PE (vPE)

Table 1 summarises the virgin PE materials used in this work, including two black materials containing carbon black (CB) and four natural materials. vPE05 was produced in a pilot PE polymerization plant; whereas the other virgin materials are commercial grades.

Table 1: Summary of virgin PE

	vPE01	vPE02	vPE03	vPE04	vPE05	vPE06
MFR2 (g/10min)	0.5		0.55	0.05		0.7
MFR5 (g/10min)	1.9	0.25	2	0.25	0.16	3
Density (kg/m^3)	960	960	946	950	954	936
Color[a]	B	B	N	N	N	N

[a]Color: B for black, N for natural

Recycled PE (rPE)

The recycled PE materials used in this work are all PCR and summarized in Table 2. rPE03 was produced in a pilot recycling plant and pelletized with antioxidants; whereas the other recycled materials are commercially available.

Table 2: Summary of recycled PE

	rPE01	rPE02	rPE03	rPE04	rPE05
MFR2 (g/10min)	0.8	0.55	0.39	0.56	0.8
MFR5 (g/10min)	3.6	2.7	1.7	2.2	2.6
Density (kg/m^3)	983	957	962	930	930
NMR C2 content (wt%)	87.4	91.9	98.2	93	93
NMR PP content[a] (wt%)	11.5	6.9	1.5	1.2	1.7
TGA ash content (wt%)	2.7	0.8	0.8	0.8	0.4
Color[b]	M	M	M	T	T
Stabilization[c]	N	N	Y	N	N

[a]NMR PP content: the content of continuous C3 measured by NMR

[b]Color: M for mixed color; T for translucent

[c]Stabilization: N: stabilizers not added; Y: stabilizers added