DEGRADATION INDUCED BY RECYCLING PROCESS OF POLYPROPYLENE

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Abstract

During the recycling process the material undergoes various operations that bring out several modifications in the molecular structure. As a matter of fact, the mechanical properties of the recycled products and their structural organization are quite different compared to those composed of virgin material [1].
Also, particular attention is attached to the relationship and several consequent changes in the mechanical properties.
The aim of this work is to study some properties and structural aspects of recycled polypropylene in particular through the analysis of degradation by infra red spectroscopy.
Moreover, the mechanical properties in terms of traction and impact were carried out on films obtained from virgin and recycled material and binary blends of them.
These mixtures were analyzed as a function both of blend composition and of the number of reprocessing of the recycled fraction.
The results of infra red spectroscopy of virgin and the reprocessing polypropylene were correlated with the mechanical properties.

Introduction

Plastic materials are considered as extremely important candidate to recycling for their increasing demand in daily life and thus a necessary need to reduce their space in disposal capacity and lower emissions from landfills and incinerators.
The possibility to reuse the recycled material by injecting it in the manufacturing chain of relatively good quality product depend of the resulting mechanical and rheological properties
The objective of the present paper is to study the possibility to reuse the recycled polypropylene by injecting it in the manufacturing chain. To achieve this objective, the effect of reprocessing of polypropylene and blending of the recycled and virgin polypropylene on mechanical properties was carried out. In addition, melt flow index and FTIR spectroscopic study were investigated.

Material and methods

1. Material

Commercial polypropylene homopolymer (PP) PPH 4060 from ATOFINA TOTAL PETROCHEMICALS with a density of 0.905 and a MFI of 3 was used.

2. Equipments

Extrusion: Controlab 08 FE extruder with a screw of L/D ratio=20 and D= 25mm.
Operating conditions are: Temperature (Metering zone: 200°C, Mixing zone: 240°C and Die zone: 240°C); Screw speed: 50 rpm. Moulding: An hydraulic press with electric heating and hydraulic opening.
Operating conditions are: temperature: 210°C, closing pressure: 200psi

3. Testing

- Infra red spectroscopy on spectrometer NEXUS and ATR (Attenuated Total Reflection more adapted to the opacity of the specimens)
- MFI ASTM 1238 with 2.16Kg
- Tensile test on ADAMEL-LHOMARGY DY 22 with a cell 500 daN and a tensile speed of 50 mm/mn (ISO1798-1983 (F)
- Impact test (charpy) on specimen of 1x100x15 mm^3

4. Preparation of specimen

First PP is extruded, ground, moulded and then tested (fig 1).

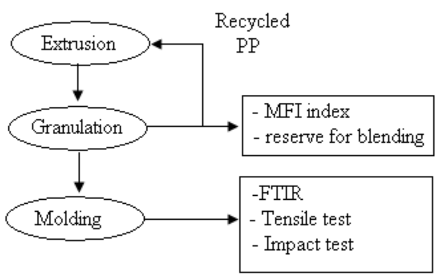

Figure 1: Schema of recycling

Table 1: composition of the different formulations
Ri; R: recycled i: number of extrusion undergone

Compo.	25% recycled +75% virgin PP	50% recycled + 50% virgin PP	75% recycled + 25% virgin PP	100% recyclats
Design.	BR1 25	BR1 50	BR1 75	R1
	BR2 25	BR2 50	BR2 75	R2
	BR3 25	BR3 50	BR3 75	R3
	BR4 25	BR4 50	BR4 75	R4
	BR5 25	BR5 50	BR5 75	R5

The recyclats are obtained by several looping of (extrusion +granulation) and the blends (recyclat+virgin PP) table.1 are passed trough the loop

The re extrusion is stopped at the fifth one because the aspect of the extrudate is yellow and makes drops due to advanced degradation.

Result and discussion

1. ATR-FTIR

ATR-FTIR spectra of the virgin PP and its recyclats: V, R1, R2, R3, R4 and R5 show an increasing development of peaks in the two regions of 2700-3000 cm-1(figure2) attributed to the methyl **[1]** group C (sp3)-H due to chain scission and 1600-1800cm-1 attributed to the C=C bound which may be due to the combination termination of the degradation reaction. In the regions of the three major groups of carbonyl (C=O) 1705, 1735 and 1770cm-1 in absorbance, an increase of the peaks indicate a thermo-oxidative degradation **[2].**

When incorporating virgin PP in the recyclats at different ratios, it is noted an improvement indicating a decrease of the quantities of the methyl and carbonyl groups and the C=C bound.

2. MFI

Comparing the MFI of the virgin PP and its successive recyclats (figure3), it is noticed that flow index increases as number of cycles increases. This is due to the increase of quantity of small chains due to thermo-oxidative degradation by chain scission decreasing the overall molecular weight. The blends of virgin PP and its recyclats show an important change only in the case of the recyclat R5, where a decrease of MFI indicates an increase in molecular weight due to the incorporation of the virgin PP with its long chains **[3].**

3. Tensile test

The Young strength and the strength at break show a decrease as the number of cycles increases. While the elongation at break show an increase as the number of cycles increases (figures 4). This is due to the degradation by chain scission undergone during successive extrusions, decreasing the molecular weight and the quantity of entanglements which give strength and elasticity to the bulk **[4].** The incorporation of virgin PP in the recyclats improves all the tensile properties due to the longer chains of virgin PP.

4. Charpy impact test

As the number of cycles increases, the PP shows a decrease in the charpy impact strength (figure 5). This is due to the increase in short chains (chain scission) which are the concentrates of impact energy causing fracture. It is noticed that the incorporation of virgin PP increases the impact strength as its ratio increases

Conclusion

The flow and mechanical properties of polypropylene show a drastic decrease due to several degradations undergone in the extrusion processes. The incorporation of virgin polypropylene in the recyclats ameliorates these properties, without a complete recovery of them. Consequently, following the tolerances, these blends may find use in a second life.

References

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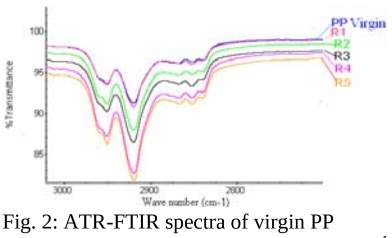

Fig. 2: ATR-FTIR spectra of virgin PP and its recyclats in the region 2700-3000cm^{-1}

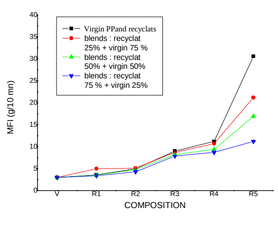

Fig. 3: MFI of virgin PP, its recyclats and blends of virgin PP with recyclats

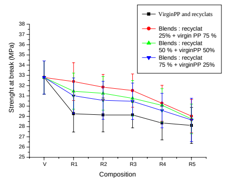

Fig.4: Strength at break of virgin PP, its recyclats and blends of virgin PP with recyclats.

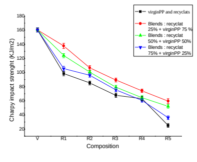

Fig.5: Charpy impact strength of virgin PP, its recyclats and blends of virgin PP with recyclats