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The effect of residual polyethylene on mechanical and rheological properties of recycled Polypropylene

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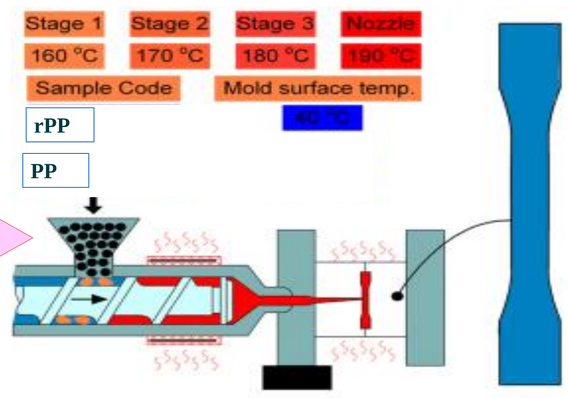
Introduction

Due to the per capita increasing demand for high quality and lightweight plastic parts, the recycling of polymeric materials becomes essential in industry and scientific studies. Based on a report, there is approximately 360 million tons plastic parts manufactured globally. Among the wide variety of thermoplastic materials, polyolefins, polystyrene, and poly ethylene terephthalate (PET) are largely used to produce aforementioned polymeric parts. Around 89 % of plastics used worldwide are hydrocarbon materials such as polypropylene (PP) and polyethylene (PE). Polyolefins are in high demand in various applications such as pipes, containers, bags, wrappings, films, and automotive parts owing to their unique processability, affordability and mechanical properties. Up to 90 % of plastics used for recycling are a member of the polyolefins [1]. PP is mainly used in automotive industry where high quality and light weight are prominent factors in making different polymeric parts for vehicles. Literature reports that the highest demand in Europe is for PP with over 10 million tons sold in 2019 [2]. However, certain economical and technical factors must be taken into consideration to evaluate the feasibility and the benefits of recycling plastics such as PP. More specifically, polymer degradation time, temperature, and degradation behavior along with possible contaminations come to material during recycling. The mentioned critical parameters can lead to manufacturing faults and finished products with inferior properties [3].

Materials & Methods

Recycled polypropylene (rPP)
(Skyplen 04KC0, PreZero, Austria)
MFR (230 °C, 2.16 kg) = 8 g/10 min,
density = 0.93 g/cm3

Homopolymer polypropylene (PP)
(HE125Mo, Borealis, Austria),
MFR (230 °C, 2.16 kg) = 12 g/10min,
density = 0.908 g/cm3



Injection molding (Allrounder 470 A (1000-400), Arburg GmbH, Germany)

Characterization Tests

- **Differential Scanning Calorimetry**
- **Rotational Rheometer**
- **Thermogravimetric Analysis**
- **Charpy Impact test**

Results & Discussion

PP is a semi-crystalline polymer, which make it prone to different behavior regarding the crystalline content. Different PP microstructure (homopolymers, block copolymers, etc.) shows dissimilar crystalline content and behavior. So collection and separation methods in recycling section, leads to a recycled polymer which consist of different microstructure of a same polymer and contaminations from other polymers. It is reported that various amounts of polyethylene (PE) residues can be found recycled PE and vice versa.

This type of residue in recycled polymers is a prominent factor that limits the recyclates' applicability. DSC method widely used for measuring this kind of contamination based on melting enthalpies.

DSC

- **Second endothermic peak** appeared at **~ 125 °C** is melting temperature (Tm) of PE residue, **PE residue ~ 3 - 6 %**
- **Crystallinity content (Xc) of PP ~ 2x rPP**

Impact

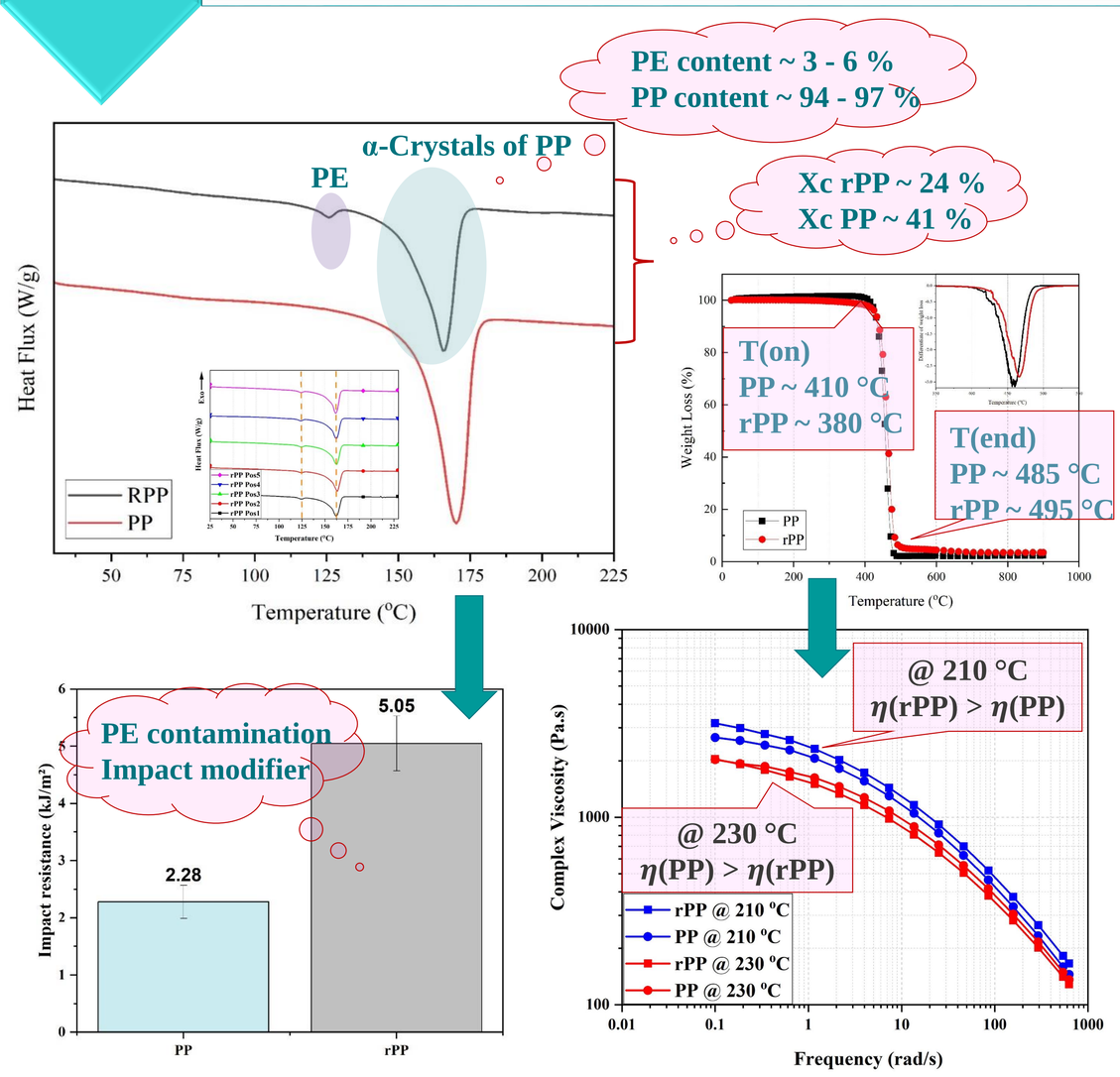
- Lower Xc and PE contamination affect the toughness
- **Impact resistance rPP > 2x PP**

TGA

- Onset thermal degradation **(T_{in}) rPP < T_{in} PP**
- End of thermal degradation **(T_{end}) rPP > T_{end} PP**
- **Degradation rate PP > rPP**

RMS

- **Lower temperature, (η) rPP > η PP**
- **Higher temperature, η rPP < η PP**
- rPP is thermally unstable at higher temperature



Conclusions

Recycled PP and virgin homopolymer PP were analyzed and found that 3 - 6% PE contamination present in rPP. Interestingly, the impact resistance of rPP is around 55 % higher than PP, which is due to the effect of PE residues in the sample. Furthermore, rPP showed higher thermal stability in lower processing temperature. Although, rPP is recycled material and contain different amount and types of microstructure of PP, it showed fine mechanical and processing properties, near and in some cases even higher than homopolymer PP.

References

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