Mechanical Properties of PP/RPET Blends

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Abstract

Environment is in critical condition state as many plastic waste such as polyethylene terephthalate (PET) waste are being disposed into landfills. PET is formed by combining two monomers called modified ethylene glycol and purified terephthalic acid and categorize as thermoplastic material which can be recycle. A study has been conducted on observing the effect on mechanical properties of Polypropylene and Recycle PET blend which was prepared using a single screw extruder and an injection molding. Recycle PET (RPET) with the composition of 5%, 10% and 15% are blend together with PP and their characteristic is investigated through tensile and flexural test. From the results obtained the tensile and flexural strength decreased with the increased of RPET content. Based on previous study, such behaviour is due to the lack of immiscibility and poor interfacial adhesion. This may be overcome by adding a compatibilizer material.

Keyword: Polypropylene(PP), Recycle Polyethylene Terephtalate (RPET), PP/RPET Blend

1. Introduction

Nowadays plastic consumption have become integral part in lives. Plastic is mainly made by a non-renewable source and very useful for worldwide users as it is made prodigiously as the growth of modern industries. With the rising of environmental awareness throughout the world, the application and development of environmental friendly materials have been made such as polypropylene (PP) by using recycle polyethylene terephthalate (RPET) as a filler (Ghunavathy A/P Thaomadaran, 2011).

One of the ways to reduce the waste of PET are through the blending method. PET blends can be typically prepared by five techniques: graft copolymerization, melt solution, latex blending, partial block and synthesis of interpenetrating networks. Melt blending is a simple mechanical process of creating a homogeneous mixture of two or more polymers. The major advantage of melt blending is the absence of any solvents that might be required in other methods of polymer blending (Y. Srithep 2011). The purpose of mixing PP and RPET fibers are to enhance the mechanical properties of PP/RPET blend (Marcincin A., 2001).

Polypropylene is made from the monomer propylene, durable and unusually resistant to many chemical solvents, bases and acids. In addition to its superb physical and chemical properties, propylene is widely used because of its ease of fabrication and ability to endure high continuous operating temperatures. Polypropylene is versatile thermoplastic material and is compatible with many processing techniques such as injection molding, blow molding, extrusion, blown, cast film and thermoforming. Polypropylene also has excellent moisture and oxygen barrier. Therefore this polymer are very suitable in this process compared to other polymer (Mohd Khairof Fais Bin Abd Raop, 2007).

Polyethylene terephthalate or commonly called as PET is the common type of thermoplastic polymer resin of polyester family. It is beneficial and used in many things such as containers for liquids and foods, fibers for clothing and in combination with glass fibers for engineering resins but the majority of the world's PET production is for synthetic fibers in excess of 60% with bottle production accounting for about 30% of global demand (Ji Li Na, 2013). No chemical and mechanical changes if being heated or cooled several times (Baeurle SA, Hotta A, Gusev AA 2006).

This study onl investigate on the reinforced polypropylene with RPET as a filler. The main objective of this research i to in estigate the effect of the RPET content on the mechanical properties of PP/RPET blend. The reason for using RPET as a filler is because of high feedstock as it being used for plastic bottle (Ghunavathy A/P Thaomadaran, 2011). PP is used as a matrix because it endure high continuous operating temperatures and reducing the effect to the environment.(Mohd Khairof Fais Bin Abd Raop, 2007). This project will involve few mechanical test such as tensile strength and flexural test. Tensile strength will clarify the maximum force of PP with RPET can overcome while being pulled or stretched before breaking. Flexural test will show about the flexibility of the material.

2. Methodology

2.1 Pr paration of Raw Material

Raw material for this study which is RPET and PP is supplied by University Teknologi Malaysia's Faculty Of hemical Engineering.

2.2 Hopper Dryer

The RPET was dried in the oven for 24 hours at 80°C to remove the moisture of the RPET.

2.3 Extruder and Pelletizer o RPET

The RPET is inserted into a single screw extruder machine. Then, it produced a long and hot chain of RPET until the feed is fully consumed. The product then flowed on a conveyor belt while being cooled with an industrial fan. The cooled solid chain of RPET then moved to a pelletizer. Pelletizer cuts the long and cooled solid chain into a pallet to eases the next process involving PP.

2.4 The Ratio of RPET And PP

Three formulations with different compositions of polypropylene and RPET are used in this experiment as shown in Table 1. All the materials were weighed by using a weighing machine. The total mass for each formulation is 2kg.

Table 1. The ratio of PP and RPET

Formulation	Polypropylene (wt%)	Recycle PET (wt%)
1	95	5
2	90	10
3	85	15

2.5 Extruder and Pelletizer of Materials

Both RPET and PP was well mixed before poured into the feed of the extruder. It was then produced the same long and hot semi solid shape. After it has been cooled, it formed a cooled solid shape which then proceeds to shredding process. The pelletizer produce pellets of reinforced RPET with PP according to ASTM D4101, 2014.

2.6 Drying the Materials

After the process of pelletizer, the products were stored in an oven for 24 hours at 80°C to prevent moisture in the material.

2.7 Injection Molding

The mixed product for each formulation is inserted into the top feed of the injection molding machine. The semi-auto process produce a white solid plate for mechanical test which 30% of the product is used in a tensile, flexural and impact test respectively using ASTM Standard F2389, 2007.

2.8 Mechanical Test

2.8.1 Tensile Strength Test

A fundamental materials strength test in which a sample is subjected to a controlled tension until failure. Ultimate tensile strength, maximum elongation and reduction in area are directly measured properties via a tensile test. A standardized sample cross-section is called a tensile specimen. It has two shoulders and a gauge in between. The shoulders which is large can be readily gripped, while the gauge has a smaller cross-section so the deformation and failure can occur in this area (ASTM Standard F2389, 2007).

2.8.2 Flexural Test

Flexural test are generally used to determine the flexural modulus or flexural strength of a material. The material is laid horizontally over two points of contact and then a force is applied to the top of material through either one or two points of contact until the sample fails. The flexural strength of that particular sample is the maximum recorded force (ASTM D7264, 2017)

3. Results and Discussion

3.1 Tensile Test

PP which acts as a matrix was mixed with RPET in the volume composition of 5% to 15%. The tensile properties were verify using five samples for each formulation to investigate the effect of PP fiber volume composition to tensile properties. Figure 1 shows the effect of RPET content on tensile strength of PP/RPET blends. The figure shows the decreasing trend of tensile strength value with addition of RPET content in PP/RPET blends. Based on (Mohd Haikal bin Mustafa, 2009), the behaviour of PP/RPET blend has significant due to its properties which is immiscibility and poor interfacial adhesion. It is observed that the RPET gives a slight effect on the tensile strength of PP. Tensile strength on sample 1 is slightly decrease than pure PP (100%) which its pure PP tensile strength is about 27.52 MPa (Noor et al., 2008).

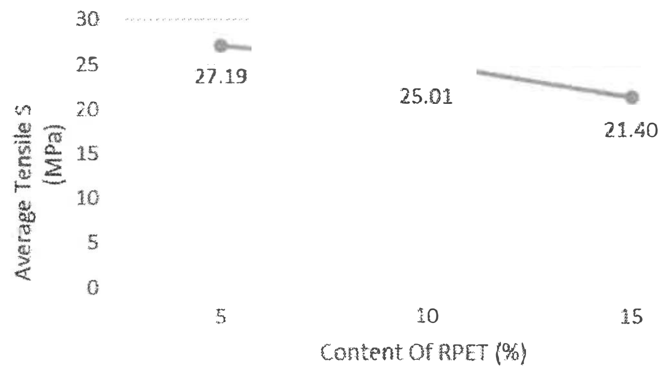

Figure 1: Effect of RPET content (%) on the average tensile strength (MPa) of PP/RPET blends.

Figure 2 portrays the influence to maximum load within the increasing presence of RPET in the PP. The figure below shows the decreasing trend on the maximum load value along with the increasing content of RPET in PP/RPET blends. The increase volume of RPET in PP/RPET blend dramatically decreases the strength of material and be more brittle (Noor et al., 2008).

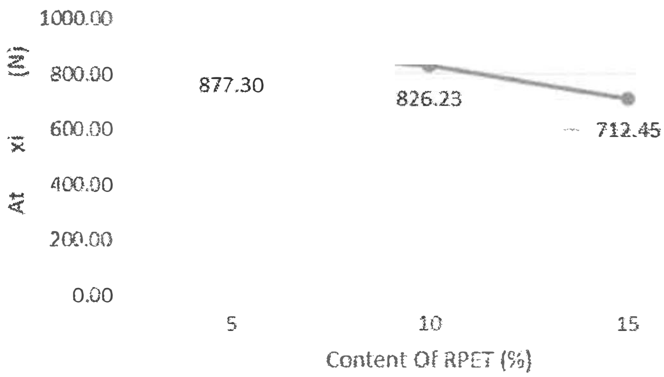

Figure 2: Effect of RPET content (%) on load at maximum (N) of PP/RPET blends.

3.2 Flexural test

The mechanical properties (flexural strength) of the blended PP/RPET matrix are presented in Figure 3. Generally, it is certain that uncompatibilized blends have inferior mechanical properties compared with the virgin polymers (Kuzmanović, Delva, Cardon, & Ragaert, 2016). The graph gives the decreasing trend of flexural strength value with the addition of RPET content in PP/RPET blends. Generally, the flexural strength on the 1st formulation portrays the highest average flexural strength (MPa) compared to the other two formulations. This results shows that RPET contributes an effect to the blended PP/RPET. The reasons for the gradually decrease amount of average flexural strength (MPa) mainly because of its low interaction and poor interfacial adhesion between PP and RPET phase. The increasing content of RPET in the blend also increases the viscosity thus lowered the flow of the blending in the extruder. The heat build-up causing the blend to degrade and indicate a decreasing rate in flexural strength (Noor et al., 2008).

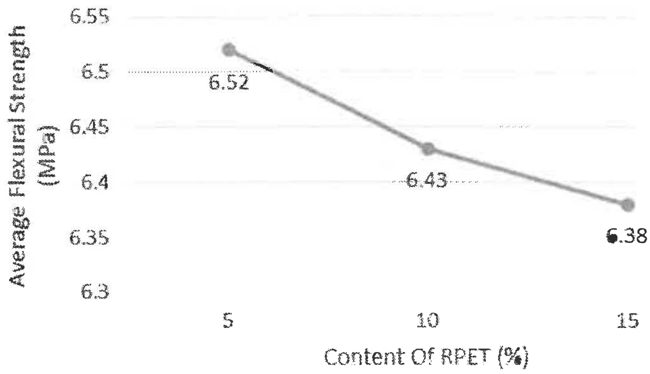

Figure 3: Effect of RPET content (%) on flexural strength of PP/RPET blends.

In figure 4, the graph shows the effect of maximum bending stress at maximum load. Mainly, the trend shown in the graph indicates the declining rate of maximum bending stress at maximum load (MPa). The reading slightly decrease from 34.12 MPa to 33.98 MPa. The decline may resulted from the immiscibility and low interfacial adhesion between PP and RPET phase (Noor et al., 2008).

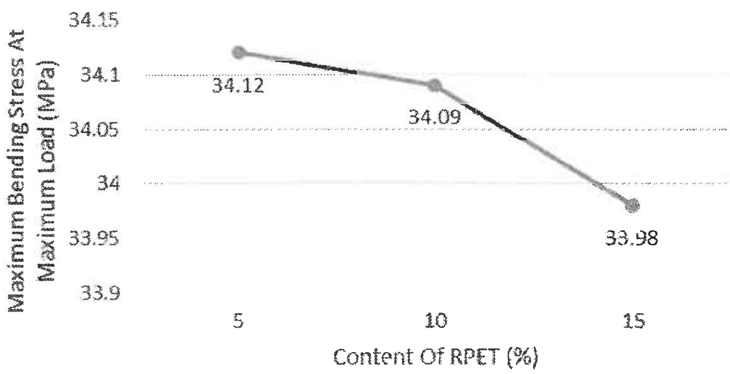

Figure 4: Effect of RPET content (%) on maximum bending stress at maximum load (MPa)

4. Conclusion

Tensile test and flexural test of PP/RPET blends decreased with increased of RPET content (%). The main factors contribute to this behaviour were the immiscibility and low interfacial adhesion between PP and RPET phase. Based on the study, RPET and PP are incompatible and are strongly immiscible. RPET can improve the mechanical properties of composites if it is present only in a small amount. If it is present in large amount, it will degrade the PP/RPET blend in the extruder thus resulting in lower reading of tensile and flexural test. In conclusion, the mechanical properties of PP/RPET blend varies with the increasing content of RPET.