Thermal Properties of Blend of PP/RPET with PP-g-MAH as Compatibilizer

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Abstract

Polyethylene terephthalate is a clear, strong, and lightweight plastic that is widely used for packaging foods and beverages, especially convenience-sized soft drinks, juices and water. PET is too valuable to only be used once and it need to be recycled. One of recycle technique is blending polymers to generate a composite with improved properties, such as enhancement in thermal stability. Thermoplastic polymer such as polypropylene (also known as PP) is one of the most versatile polymer. The blending between PP and RPET gives more benefits as RPET is rigid than PP at higher temperature while PP could crystallize RPET by heterogeneous nucleation. However with maleic anhydride-grafted polypropylene (PP-g-MAH), as an addition compatibilizers that can diminish the Tg (glass transition) which the polymer can withstand at low temperature that is good than virgin PP. This experiment is to study between blending RPET and PP on thermal properties such as glass transition, crystallization and melting point. However, due to the several factors the result could not be achieved same as the previous studies. The glass transition temperature should be increase following the previous studies, however in this study, the glass transition have been decrease. The few factor that affect the result are the compounding ratio, moisture content and viscoelastic.

Keywords: **PET, PP, PP-g-MAH, Thermoplastic**

1. Introduction

The production of plastic in Malaysia has been increasing from time to time. This is because of the increasing market and demand from the industry. The average of waste that produced in Malaysia estimated about 19,000 tonnes of solid waste per year and 24% from the solid waste is representing the plastic waste (Asmuni, Hussin, Khalili, & Zain, 2015).

Polypropylene (PP) is classified as a thermoplastic polymer that can be blend with other polymer and also can be recycled. This production and recycled polymer are widely used worldwide for example, such as food packaging industry, plastics, components in automotive and also for textiles industry (Mohd Khairof Fais Bin Abd Raop, 2007).The most common type of plastic the industries use is polyethylene terephthalate (PET). The PET is widely used for consumer product containers for foods and beverages. It is also used in fibrefill for winter coat, sleeping bags and life jacket (Kwabena, Berko-boateng, & Ama, 2017).

There are two types of plastic waste according to the National Solid Waste Management Department, Malaysia (JPSPN) which are thermoplastics and thermosets. The plastics that can be recycle called thermoplastics, while the plastics that cannot be recycle called thermosets. In order to reduce the amount of solid waste, the ideas of recycling PET is proposed. It is not only can harm the environment but it is also can give the negatives side effects to human when the amount of solid waste is higher. It can cause long term damage to the ecosystem. The PET need long period of time to decompose. It will take about 400 to 1000 years for PET in a landfill to be degrading . People nowadays threw their PET waste such as plastic bottle into the rivers and waterways. It is supposedly cannot be happen because it can harm the aquatic life and can cause the pollution of river. So, as for the conclusion, community should recycle the PET to reduce energy consumption, lower cost, and reduced the environmental impact (Mwanza & Mbohwa, 2017).

Polymer compounding is one of the way to improve the mechanical properties and also increase the immiscibility of the polymers blending (Potiyaraj, Tanpichai, & Phanwiroj, 2012). Polypropylene (PP) is a polymer that has great properties which has low density, good surface hardness and good abrasion resistance (Pivsa-Art et al., 2016). Other than that, it is also started that PP has very low cost, simple in production, the production is covered all around the world, they burning of PP does not produce toxic, and lastly can be recycled (Pivsa-Art et al., 2016). PP is the most suitable polymer to be used because molding material is produced with very high tensile strength (Mohd Khairof Fais Bin Abd Raop, 2007).

The purpose of this project is to study about the characteristics of blending between RPET and PP with maleic anhydride-grafted polypropylene (PP-g-MAH) as an addition compatabilizer. This polymers blending is carried out to study about the effect of polymers blending with additive and its effect on thermal properties.

Thus, by adding the aditive which we used Maleic-anhydride-grafted in polypropylene (PP-g-MAH) is added. The aditive added act as a compatibilizer, to support interfacial adhesion and acts as a bridge between two components (I hoi, Kwon, Kim, Bae, & Kim, 2013). To achieve this process, it is commonly used in blending of the immiscible polymer .

Blending between recycled polyethylene terephthalate (RPET) and polypropylene (PP) is one of the best solutions to increase the effectiveness in thermal properties. It is stated that at higher temperature, the stiffness of PP can be enhance by RPET. Both polymers which are polyolefin can lead the PET to crystallize due to heterogeneous nucleation in order to increase the blending stiffness. Other than that, the characteristics of PET which is has lower permeability towards oxygen and water vapour can help and great in packaging material utilization (Cazan, Cosnita, & Duta, 2017). The objective of this study is to improve the thermal properties in term of glass transition, crystallization temperature and melting temperature of virgin polypropylene by blending RPET with PP by using PP-g-MAH as the compatibilizer. The weight percentage of RPET and PP will be manipulated to get the best compositions that bring the maximum result.

3. Methodology

3.1 Sample Preparation

(RPET) are weighed to 10wt%, 15wt%, and 20wt% respectively. Then, the (RPET) must be dried in the oven about (80°C) for a day to avoid moisture that can affect the filament. Drying is a necessary preparative step to prevent this defect. Only then, the (RPET) is inserted into the extruder by using single screw extruder. As for pelletizing process, it is using pelletizer (PE7020). In the end, the (RPET) will be in the form of pellets. The (PP) are weighed accordingly by 80wt%, 85wt% and 90wt%. However, the additive, (PP-g-MAH) is 10part per hundred, constant for all samples. Then, the (PP) and (PP-g-MAH) is mixed before proceed to the extrusion process. The steps are repeated from the extruder process to pelletizing process.This experiment has been conducted at The Faculty of Polymer, UTM Skudai.

3.2 Thermal Testing

Then, for the thermal testing, Differential Scanning Calorimetry (DSC) is being used to study about the glass transition temperature, crystallization temperature and the melting point. Three samples have been prepared for the testing. The DSC is been set up for heating-cooling-heating process starting from -50°C to 300°C and back to -50°C. This testing is run with the scanning rate 10°C/min.

Operating Condition

Heating: -50°C to 300°C
Cooling: 300°C to 50°C
canning rate: 10°C/min

ample 1: 80% PP, 20%RPET 10phr PP-g-MAH	Sample 2: 2: 85%PP, 15%RPET, 10phr PP-g-MAH	Sample 3: 90%PP, 10%RPET, 10phr PP-g-MAH

4. Results and discussion

Based on the study, transitional glass temperature has been observed in order to achieve the low transition glass. The result has shown a significant difference in the temperature of the transition glass. Table 1 illustrated the differences between the blending of RPET and PP with the virgin PP.

Table 1

Virgin PP	Sample 1	Sample 2	Sample 3
Tg_{PP} = -20.00 °C	Tg_1 = -43.75 °C	Tg_2 = -47.83 °C	Tg_3 = -45.00 °C
Tc_{PP} = 120.00 °C	Tc_1 = 120.00 °C	Tc_2 = 122.73 °C	Tc_3 = 122.50 °C
Tm_{PP} = 165.00 °C	Tm_1 = 165.00 °C	Tm_2 = 162.42 °C	Tm_3 = 164.56 °C

It is showed in the figure 1, which is sample 2 is the lowest glass transition temperature between all while both crystallization temperature and melting point are almost the same as the properties of virgin PP. It still maintained the properties form the virgin PP except for the glass transition.

To compare between blending PP with RPET and virgin PP, we can see that blending PP with RPET is the best way to improve the glass transition temperature. The transition glass for virgin PP is decrease which is from about -20°C to -47.83°C.

PP is a polymer that has lower glass transition while RPET is a polymer that brittle and hard and has a higher glass transition temperature. As the result that achieve, the final results showed the lower temperature for glass transition are recorded. Based on the theory and study from the other journal, the results are completely opposite. The error in this final result may occur due to few factors (Jadhav, Gaikwad, Nair, & Kadam, 2009).

First of all, the result might be influenced by the compounding ratio. The ratio of PP with RPET for this three samples was 1:4, 3:17 and 1:9. The higher weight percentages of PP allowed to bring down the glass transition temperature of that compounds. Due to the small amount of RPET used, the properties of the compound towards RPET does not clearly see (Nonato & Bonse, 2016).

Other thing that may affect this study is might be because of the moisture content. One day before the testing, the samples have been dried in an oven for a day with the temperature 80°C. But after that, when the testing is about to start, the samples are exposed to the environment about one hour before been place for the testing. During that time, some of the polymers have already absorbed the moisture from the environment. Air holes are occurs due to the oxidations that happened at the surface of the polymers. This has affected for this study and gives a different pattern of the final result (Dos Santos, De Sousa, & Gregorio, 2013).

Viscoelastic is the nature of polymer, and it has the relation with the glass transition temperature. It caused the elastic modulus decrease and failure strains are increase because of the moisture content in polymer. The changed of b haviour in stress strain will make a brittle state of polymer to become more ductile and rubbery state (Smith, Parks, Hyjek, Downey, & Gall, 2009).

Glass transition occurs in amorphous materials which are form to glass state from hard state during the increasing temperature. Amorphous is the condition when the chains in polymer is just spread away freely, not is crystal arrangement or not even in solid arrangement. However, glass transition is definitely different from melting. Melting is the transition that happen during crystallization process. It occurs due to the falls out of the polymer chain from the structure. It will finally become a liquid state. One same polymer can have both in melting temperature and glass transition because there are some amorphous are present in crystalline polymer. However, it is already stated that glass transition only can occurs for the amorphous materials while melting only can occurs for the crystalline materials (Zhang, Bai, Cheng, & Liu, 2017).

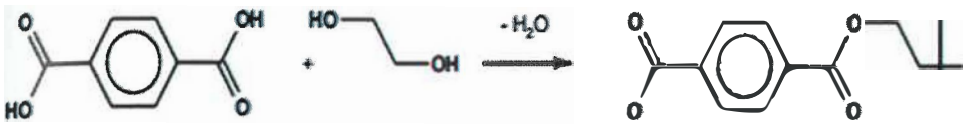
However, based on a journal that been referred, it stated that the melting point will reduce due to the thermal decomposition. However, from this result, it shows just small changes for the melting point between all the three samples. This may happen due to the moisture that have been absorbed by the polymer or maybe due to the sensitivity of the DSC sensor (Potiyaraj, Tanpichai, & Phanwiroj, 2012). Other than that, it is also stated that the aditive that been used does not affect the melting temperature (Pivsa-Art et al., 2016).

Glass transition is used in many types of application. From that, there will be some applications that need higher glass transition and also some applications that need lower glass transition. Basically, for the applications that need to be used in extremely low temperature, low glass transition is needed.

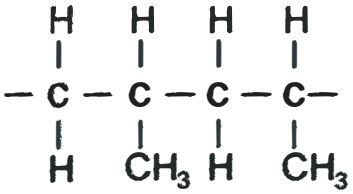
5. onclu ion

A for the conclusion, the compounding between PP and RPET with the PP-g-MAH as the compatibilizer have been done successfully although there are some properties that does not accurate. But the main objective is not been achieve completely which is to increase the glass transition temperature.. Heating, cooling and preheating process are being used to get and record the new glass transition, crystallization temperature and melting point of this compound. The results have shown that the transition glass temperature have been decreased from the virgin PP. The result might be affected by the compounding ratio and also by the moisture content in the samples. After all, the result of compounding between PP and RPET is clearly illustrated. This study came is prove that additive in this study, which is PP-g-MAH is just act as a compatibilizer and not affect the thermal properties(Zhou, Yu, Lin, & Chen, 2013).This blending process gives a very significant reading for the transition glass while it does not have any significant changes for the melting point because of the present of additive. For overall, lower glass transition is best for extremely low temperature and not easily to crack or break down due to the low glass transition temperature. For the improvement, other types of additive should be used in order to make a different for the melting point. Next, other techniques such as pulverization or injection molding can be used to enhance the strength and stiffness of the compound. For the improvement, the polymer should be dried before the testing. The sample can't be exposed to the atmosphere for a long period of time.

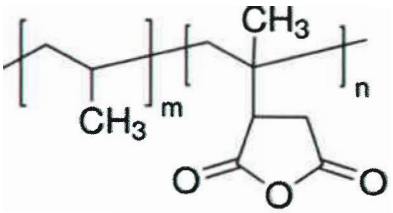
6. Appendix



terephthalic acid ethylene glycol PET



Polypropylene (PP)



(PP-g-MAH)