Enhance mechanical and thermal properties of recycled Poly ethylene terephthalat (PET) from used bottle

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ABSTRACT

Plastics have a special part in modern life. Polyethylene terephthalate belong to polyesters and have various applications especially in packaging industries. For decrease the negative effect of plastic in the environment, PET waste recycled. During recycling some of the PET properties decreased. In this article, polycarbonate used for improve the properties of Recycled polyethylene terephthalate. Different level of Polycarbonate used for this mixing from 20% to 50%. Polycarbonate improved the mechanical and thermal properties of polyethylene terephthalate, which decreased during recycling process. Increasing the amount of polycarbonate decreased the brittleness of Recycled polyethylene terephthalate, and improved the thermal resistance. Alloying the recycled Polyethylene terephthalate with Polycarbonate improved the properties of Polyethylene terephthalate matrix and usability of recycled polyethylene terephthalate increased for various applications, because Polycarbonate has high impact strength. Differential scanning calorimeter (DSC) done for thermal analysis of alloy. Melting point and crystallization of recycled PET/Polycarbonate increased, so polycarbonate enhances the mechanical and thermal properties of alloys.

Key words: Polyethylene terephthalate, recycling, environment, mechanical properties, Dsc, thermal properties.

Introduction

Recycling is the best way for reduce plastic solid waste in the environment. Plastic waste could see everywhere, because microorganisms don’t have a necessary enzyme for consume them.

Pet used in various applications like food container, bottle, plastic fibers, toys, wrapping materials, films and resins. Poly ethylene terephthalat is one of the highly requested plastic in the world. Poly ethylene terephthalat(PET) is thermoplastic polyester [4].

PET has a good electrical insulating properties, Low water absorption, high hardness and strength. Plastics used highly in daily life, because plastic are flexible and cheap and have a many application. Despite all of the plastic benefits they remain in the environment. Plastic waste can be seen everywhere because plastic not biodegradable and remain in the environment for many years. Because of slow degradation of plastic materials they caused a problem in landfills and also make problem in collection of solid waste. There are ways for solve the plastic waste problem like source reduction and recycling. Recycled plastic has a low performance because their properties reduce during recycling process. Recycling is a best way for reduce the amount of solid waste. Before recycling process PET should be separated from other waste.

PET recycling has a two form: Mechanical and chemical process. Mechanical process is most common way of PET recycling. In this method bottles and other PET base material must be washed and grinded. The resulting flaks blend with virgin PET in various percent according to future applications.

Most industries consider recycle PET as a good row material due to its chemical properties, good thermal resistance.PET Molecular weight reduced because moisture absorption, biological contamination, oxidation, thermal degradation and high temperature. During recycling process chemical and mechanical [2]. Degradation occurred Degradation of PET waste has an impact on mechanical properties of recycled PET [3]. Chemical resistance and melt viscosity recycled of PET are less than virgin PET. Factors that could decrease physical, mechanical, chemical and rheological properties of recycled PET also causing brittleness of this recycled polymer. This factor also leading to loss of melting elasticity behavior of recycled PET.

Polycarbonate is a thermoplastic polymer has a many applications [1]. Polycarbonate is though and
transparent. Polycarbonate has a good thermal resistance and impact resistance.

Polymer alloying is suitable technique for production and development of new materials. In this method two or more polymer combined together and alloy have excellent properties more than primal polymer. This method not expensive and will give a result in short time. The blending of two or more polymer is a way to improve application of primary polymers.

In this article recycled PET blended with polycarbonate to improve mechanical properties of blend. Recycled PET prepared from used bottle.

**Experimental:**

**Material:**

Waste Poly ethylene terephatalat (R-PET) obtained from used bottle and washed to remove pollutant. Recycled PET was grind to prepare flakes. Flakes washed again. Polycarbonate obtained from BASF Company. Ethylene Acrylate Terpolymer used as a compatibilizer obtained from Dupont Company.

**Method:**

Materials dried in oven for 16 hours at 110°C. Alloy prepared in twin-screw extruder with 150 rpm at 260°C.

The tensile properties were measured by instron 6025 testing machines. Morphological observation was done by Oxford Instruments INKA Penta FET×3 scanning electron microscope at voltage 20 KV. Samples fractured in liquid nitrogen, then sputter coated with gold 18 carat.

A METTLER-TOLEDO differential scanning calorimeter (DSC) was used for Thermal analysis.

**Result and discussion**

Recycled PET was alloyed with various amount of polycarbonate. The amount of polycarbonate are 0% with virgin recycled PET, 20% with 80% R-PET, 40% with 60% R-PET, 50% with R-PET.

Polycarbonate and recycled PET have different polar characters are compatible with each other. During the melt alloying sterification reaction take place. Sterification reaction between Polycarbonate and recycled PET cause enhance in recycled PET properties. With increasing the amount of polycarbonate properties such Transparency, impact resistance and tensile strength improved.

Mechanical properties of recycled PET/Polycarbonate alloys were shown in figure 1 to 3. As it shown in figure 1, Elongation of break decreased with increasing polycarbonate. This can be explained the polycarbonate is though materials so has a low elongation at break. Recycled PET has a lower tensile strength in comparison with Polycarbonate; Polycarbonate has a two phenyl aromatic cycle in this chain that cause a higher tensile strength than recycled PET. As it shown in figure 2, increasing the Polycarbonate content in recycled PET matrix has a positive effect on tensile strength. Virgin recycled PET has a lower and R-PET/PC (50/50) has a higher tensile strength.

Polycarbonate improves the tensile strength of recycled PET/Polycarbonate alloys. The maximal elasticity modulus and tensile strength belong to R-PET/PC (50/50) blend. With increase the amounts of polycarbonate elasticity modulus increase significantly, that shown in figure 3. These observations agreed with other researchers [2].

PET properties decreased after recycling process, so usage of polycarbonate could be a good solution for that problem. So for enhance the tensile strength, Toughness in low temperature and high thermal stability.

![Fig. 1: Elongation of break of recycled PET/Polycarbonate alloy.](image-url)
Fig. 2: Tensile strength of recycled PET/Polycarbonate alloy.

![Tensile strength graph]

The tensile strength of the recycled PET/Polycarbonate alloy increases with the amount of polycarbonate added. The graph shows a clear trend where the tensile strength improves as the proportion of polycarbonate increases.

Fig. 3: Elasticity modulus of recycled PET/Polycarbonate alloy.

![Elasticity modulus graph]

The elasticity modulus also increases with the addition of polycarbonate. The modulus values for different compositions are as follows:

- Recycled PET (100/0): 1.0 GPa
- R-PET/PC (80/20): 1.5 GPa
- R-PET/PC (70/30): 1.8 GPa
- R-PET/PC (60/50): 2.0 GPa
- R-PET/PC (50/50): 2.5 GPa

The modulus values show a significant improvement with the addition of polycarbonate, indicating enhanced mechanical properties.

Fig 3 shows the scanning electron micrograph (SEM) of recycled PET/Polycarbonate alloys. With decreasing radius of the particle, adhesion between the surface increases. Hence, distribution of polycarbonate particle in PET matrix improved. Recycled PET and polycarbonate has a close crystallization temperature. Because of compatibility between Recycled PET and polycarbonate didn’t use any compatibilizer. If compatibilizer used the dispersed phase particle size will be smaller. With decrease particle radius the adhesion between the surfaces of two martial increases. Distribution of polycarbonate particle in the main phase of PET improved.

According to table 1, with increasing the amount of polycarbonate Crystallization temperature increased. Polycarbonate enhances the melting point of recycled PET/Polycarbonate alloys, so have a positive effect on thermal properties. There are two particles in the alloy so cause a increasing in crystallinity of alloy.

**Conclusion:**

PET has a various application but it’s not degradable in environment. Recycling is the best way for reduce PET solid waste. During recycling process some of the mechanical and thermal properties of recycled PET decreased. Alloing Recycled PET and polycarbonate improved the properties that decreased during recycling process. With increasing the amount of poly carbonate thermal properties and Crystallization temperature of recycled PET/Polycarbonate increased. Adding polycarbonate has a positive effect on crystallization behavior.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Melting temperature (Tm)</th>
<th>Crystallization temperature (Tc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled PET(R-PET)</td>
<td>255</td>
<td>132</td>
</tr>
<tr>
<td>R-PET/PC (80/20)</td>
<td>253</td>
<td>137</td>
</tr>
<tr>
<td>R-PET/PC (70/30)</td>
<td>255</td>
<td>150</td>
</tr>
<tr>
<td>R-PET/PC (60/50)</td>
<td>255</td>
<td>152</td>
</tr>
<tr>
<td>R-PET/PC (50/50)</td>
<td>256</td>
<td>152</td>
</tr>
</tbody>
</table>
Fig. 3: Scanning electron micrograph (SEM) of recycled PET/Polycarbonate with different amount, (a) R-PET/PC (80/20), (b) R-PET/PC (70/30), (c) R-PET/PC (60/50), (d) R-PET/PC (50/50).

Acknowledgment

This paper result of research project prepare and study of recycled PET/Polycarbonate alloys that granted by research fund of Damavand branch, Islamic Azad University.

References