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Characterization of polyester composites from recycled polyethylene terephthalate reinforced with empty fruit bunch fibers

Chiachun Tan, Ishak Ahmad *, Muichin Heng

Polymer Research Centre (PORCE), School of Chemical Science and Food Technology, Faculty of Science and Technology, Universiti Kebangsaan Malaysia 43600 Bangi, Selangor, Malaysia

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ABSTRACT

Unsaturated polyester resin (UPR) was synthesized from recycled polyethylene terephthalate (PET) which acted as a matrix for the preparation of UPR/empty fruit bunch fibers (EFB) composite. Chemical recycling on fine pieces of PET bottles were conducted through glycolysis process using ethylene glycol. The unsaturated polyester resin (UPR) was then prepared by reacting the glycolysed product with maleic anhydride. FTIR analysis of glycolyzed product and prepared UPR showed that cross-links between unsaturated polyester chain and styrene monomer occurred at the unsaturated sites which resulted in the forming of cross-linking network. The preparation of UPR/EFB composite was carried out by adding EFB into prepared UPR matrix. The effects of surface treatment on EFB with sodium hydroxide solution (NaOH), silane coupling agent and maleic anhydride (MA) were then studied. The experimental results showed that treated EFB have higher values of tensile and impact strength compared with untreated EFB. The best results were obtained for silane treatment followed by MA and NaOH treatments where the tensile strength was increased by about 21%, 18% and 13% respectively. SEM micrographs of the tensile fracture surfaces of UPR/EFB composite also proved that treatment on EFB has increased the interfacial adhesion between the fiber and UPR matrix compared to the untreated UPR/EFB composite.

1. Introduction

Polyethylene terephthalate (PET) is widely used in the manufacturing of food packaging industry, especially soft-drink bottles due to its high tensile and impact strength, chemical resistance, clarity, transparency, and good thermal stability [1]. The production of PET bottles in large number has created a very large environmental problem, as most of these bottles do not decompose. The effective solution to deal with this problem is through recycling of used PET bottles. There are two methods to recycle waste PET. The first method is through physical recycling to produce PET flakes and reuse it with PET resins. The second method is chemical recycling by depolymerization of waste PET [2]. Glycolysis process involves the entry of diol into the PET chains with the presence of zinc acetate as catalyst to generate oligomers or bis(2-hydroxyethyl terephthalate) (BHET). BHET is widely used in the synthesis of polymer materials. Xi et al. [3] conducted a research on the depolymerization of waste polyethylene terephthalate (PET). The monomer bis(2-hydroxyethyl terephthalate) (BHET) was obtained with high purity and significant yield by depolymerization of waste PET.

For sustainable development, natural fibers are often used as reinforcement in polymer matrix composites. The function of fiber surface characterization with either physical or chemical surface treatment is to improve the bond strength between filler and polymer matrix [4]. Chemical treatments by using sodium hydroxide (NaOH) and acrylic acid (AA) were carried out by Vilay et al. [5] to modify the properties of bagasse fibers. AA treated fiber composite showed better mechanical properties compared to NaOH treated fiber composite. NaOH and AA treatment destroyed the cell structure of fiber, thereby reducing the void content of fiber. Ismail et al. [6] studied the effects of silane coupling agent on the mechanical properties of bamboo fiber filled natural rubber composite. The mechanical properties of the composite such as tensile strength, tear strength, hardness and tensile modulus were improved with the addition of silane. This is because silane coupling agent improves the adhesion between fiber and matrix which eventually increase the mechanical properties of composite.

In this study, recycled product of waste PET is used as a matrix, with empty fruit bunch (EFB) fiber used as a reinforcing agent for the preparation of UPR/EFB fiber composite. The objective of this study is to investigate the effects of fiber surface treatment on the mechanical properties, thermal decomposition properties, and morphology of UPR/EFB composites based on recycled PET.

* Corresponding author. Tel.: +60 3 89215424; fax: +60 3 89215410.
E-mail address: gading@ukm.my (I. Ahmad).

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