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Chemical transformation of pet waste through glycolysis

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ABSTRACT

PET bottle grade material makes up a significant portion of the feedstock in plastics recycling. Theoretically, there are many end users however there are few applications for less purified grades of recycled PET. The current work is aiming to investigate the transformation of recycled PET into its chemical building blocks using glycolysis to produce unsaturated polyester resin. In this regard, PET waste has been collected from different sources, mainly, beverages and bottled water. Chemical transformation has been achieved through degrading glycolysis reaction with different glycols namely, propylene glycol, diethylene glycol, triethylene glycol and mixture of diethylene glycol with propylene glycol or triethylene glycol in equal amounts. The glycolized products have been converted into unsaturated polyester (UP) after the reaction with maleic anhydride. Finally, styrene was added as a crosslinker and the obtained UP has been characterized. Factors affecting the curing process of the obtained unsaturated polyester resin have been investigated.

1. Introduction

Polyethylene terephthalate (PET) is an important material which is used largely in the production of soft drinks and mineral water bottles. During such production processes some of PET is converting into industrial waste that cannot be reused feasibly in the same applications due to the possible thermal degradation during reprocessing at elevated temperature. Therefore, conversion of PET waste into curable unsaturated polyester (UP) and secondary value-added materials [1] useful in different applications such as polymer concrete was targeted [2,3]. Much attention has been devoted to glycolysis by ethylene glycol and the effect of different parameters on the reaction rate has been investigated [4–7]. Depending on the glycol choice, glycolysis can be conducted either at atmospheric pressure or performed under pressure. PET glycolyzates find applications in the manufacture of polymer concrete resins for unsaturated polyesters [8–10] and polyurethane foams and epoxy resins [11–13].

The effective utilization of PET waste attracts much attention. It has been considered significant from commercial and technological point of view due to its huge consumption worldwide. PET waste may be utilized in different ways such as conversion into extruded or molded articles after repelletization or it may be depolymerized to yield raw materials for resin synthesis as well [14]. Blending of segregated waste in small quantities with virgin monomer may be a possible way for recycling of PET although it often lowers the quality of the final product [15]. Also, PET waste can be converted into other polymeric materials that can be useful in different applications such as alkyd resins [16,17]. Another way for recycling is to break down the polymer into oligomers [18,19]. It is more economic to convert PET into low molecular weight oligomers by hydrolysis [14,20] or glycolysis with different alcohols [16,21,22] in presence of trans-esterification catalyst [14,23,24]. In addition, degrading aminolysis of PET leads to good results and bisterephthalamide derivatives such as N-hydroxyethyl terephthalamide have been formed [25]. Different oligomers obtained from glycolysis of PET can be used in the synthesis of UP by reaction with an unsaturated anhydride [26–29]. Thus, PET waste can be converted into commercial value-added products and into terephthalic acid (TPA) based UP without difficulties experienced during processing by the use of plain TPA.

Beside the low cost of UP resins, they are commercially important for the reinforced plastics markets hence they can be tailormade to meet specific requirements by proper choice of their building blocks [30–34]. Several articles have appeared in the literature concerned with recycling of PET [35–37].

This paper deals with the chemical transformation of PET through glycolysis with different glycols used to depolymerize waste PET into smaller building blocks and higher oligomers. Conversion of the glycolized products into value-added unsaturated polyester (UP) by treatment with maleic anhydride and addition of styrene as a crosslinking agent is the main target. Thus, the obtained intermediate can be used as building blocks to synthesize other polymers with higher economic value such as polyurethane foams and unsaturated polyesters applied as polymer concrete and mortar materials.

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