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ORIGINAL RESEARCH

Benign and ecofriendly depolymerization of polycarbonate wastes into valuable diols using micro- and nano-TiO_2 as the solid supports

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Abstract

Hydroglycolysis of polycarbonate (PC) wastes received from optical (CDs) and digital optical discs (DVDs) to the diols derivatives of bisphenol-A (BPA), namely, bis(4-hydroxybutyl hydrogen carbonate) of BPA (DHB–BPA), mono(4-hydroxybutyl hydrogen carbonate) of BPA (MHB–BPA), and BPA itself as the major and oligomeric minor products were developed under mild and convenient conditions. Experiments were performed with the mixture of green solvents, including 1,4-butanediol and water in the presence of nanoparticles TiO_2 (NPs-TiO_2) and microparticles TiO_2 (MPs-TiO_2) as the solid supports, and sodium hydroxide as the catalyst under simple heating method and the obtained results were compared with together. In the developed procedure, DHB–BPA achieved and selectively converted into the MHB–BPA and BPA, respectively, when left in the moisturized environment. In these reactions, the effects of various parameters such as concentration of sodium hydroxide, the role of water as co-solvent, and nano-solid support on reaction progress are considered. The obtained results showed that by increasing the amount of water (0 up to 30 pbw based on total solvent weights) and catalyst as well (0 up to 2 pbw based on total solvents and PC wastes weights), the depolymerizing reaction was performed in high yields. In the meantime, DHB–BPA was recovered in 80% yield, using NPs-TiO_2 as the solid support in the 30 pbw aqueous 1,4-butanediol. The depolymerization reaction time shortened in using NPs-TiO_2 as the solid support when the data compared with the experiments performed by MPs-TiO_2. Finally, the recyclability and efficiency of the NPs-TiO_2 were studied and the data showed the usability of this solid support for four cycles. The recovered products were characterized using ^{1}H NMR, ^{13}C NMR, Fourier-transform-infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), and gas chromatography–mass spectrometry (GC–MS) methods.

Keywords Polycarbonate wastes · TiO_2 nano-solid support · Diols · Ecofriendly depolymerization · Bisphenol-A · Green chemistry

Introduction

Polycarbonate (PC) as an engineering plastic and because of its excellent characteristics has a variety of applications such as medical, bottles, automotive, optical (CDs), and digital optical discs (DVDs), etc. On the other hand, increased PC wastes has become a serious problem in many societies because of its high production capacities and usages and the developing of a green, ecofriendly, and economic chemical recycling method is essential for its recycling and recovering of valued intermediates. In this area, several studies have been conducted in the past decades. For example, PC wastes recycled under high-temperature and high-pressure conditions [1]. In another report, products such as bis(hydroxyethyl) ether of bisphenol-A (BHE–BPA) as the valued monomer for preparing of polyesters, mono(hydroxyethyl) ether of bisphenol-A (MHE–BPA) and bisphenol-A (BPA) were achieved during chemical recycling of PC in the presence of sodium hydroxide (NaOH) as the catalyst, ethylene glycol (EG), and ethylene carbonate (EC) as the solvent and reagent, respectively [2]. In addition, PC can be chemically recycled to monoglycerol ether of

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