Reaction pathway analysis and kinetics on the solvothermal degradation of epoxy resins in carbon fiber reinforced plastics

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Abstract

In this study, we showed the results of the degradation experiments of epoxy resins in sub-critical benzyl alcohol with or without K_3PO_4 catalyst using a batch-type reactor in order to understand degradation behavior of epoxy resins contained in carbon fiber reinforced plastics. A test piece of epoxy resin (50 mm in length, 10 mm in width, and 2 mm in thickness) was used as a starting material, benzyl alcohol (BZA) as a reaction media, and K_3PO_4 as a reaction catalyst in this study. First of all, fixed amount of benzyl alcohol and K_3PO_4 catalyst were loaded in the small-sized batch-type reactor (internal volume: 8.8 mL) with a piece of epoxy resin test sample, sealed and then inserted to the electric furnace which was maintained at the desired temperatures (250 – 350°C) to initiate the reaction. As a result, the epoxy resin was perfectly solubilized for 1 h in the presence of K_3PO_4 catalyst, while it takes 2 h to reach 100 % solubilization of epoxy resin in the absence of the catalyst. Time course of the weight change of epoxy resin was also investigated with or without the catalyst at 300°C. In the absence of K_3PO_4 catalyst, the weight of the solid sample was increased at 0.5 h and then decreased with increasing treatment time. This indicates that benzyl alcohol was dissolved into epoxy resin and then degradated to its lower molecular weight fractions. Comparison of product distributions at various operating conditions concluded that the existence of bisphenol A (BPA), which is a monomer of epoxy resin, with small peaks of BZA and its oxidized components were confirmed by GC/MS analysis of the BZA soluble fraction obtained after 2 h treatment at 300oC in the absence of K_3PO_4 catalyst. In contrast, several components of BPA and its derivatives were confirmed on the GC/MS chromatograms for the BZA soluble fraction obtained after 1 h treatment in the presence of K_3PO_4 catalyst at 300°C. This indicates that products were tunable on the solvothermal degradation of epoxy resin enough to the application to chemical recycling of the resin. Kinetic analysis for epoxy resin degradation in sub-critical BZA was also investigate based on the experimental results.

Keywords: *Polyethylene terephthalate; Cyclic oligomers; Solvothermal; Benzyl alcohol; Batch-type reactor.*