The Role of Catalysis for the Energy-Transition
DGMK Petrochemistry Conference October 5-7, 2022, Ludwigshafen

Sodium Methoxide as a Low-cost Glycolysis Catalyst for Chemical Recycling of Post-consumer PET Waste

S. Javed, J. Fisse, D. Vogt
Laboratory of Industrial Chemistry, TU Dortmund University

Abstract

Glycolysis of post-consumer polyethylene terephthalate (PET) waste is a promising chemical recycling technique, back to the monomer, bis(2-hydroxyethyl terephthalate) (BHET). This work presents sodium methoxide (MeONa) as a low-cost catalyst for this purpose. It was shown, not surprisingly, that PET conversion increases with the glycolysis temperature. At a fixed temperature of 190 ^{o}C, the response surface methodology (RSM) based on the Box-Behnken design was applied. Four independent factors, namely the molar ratio of PET: MeONa (50-150), the molar ratio of ethylene glycol to PET (EG: PET) (3-7), the reaction time (2-6 h), and the particle size (0.25-1 mm) were studied. Based on the experimental results, regression models as a function of significant process factors were obtained and evaluated by analysis of variance (ANOVA), in order to predict the depolymerization performance of MeONa in terms of PET conversion. The coefficient of determination, R^2 of 92%, indicated the adequacy of the predicted model. Afterward, the regression model was validated and optimized within the design space. The regression model suggested the influence of various interacting parameters on glycolysis performance. A Van 't Hoff plot confirmed the endothermic nature of the depolymerization reaction. The ceiling temperature was calculated from Gibbs' free energy. Kinetic investigations revealed that depolymerization reaction follows a pseudo-first-order reversible reaction. The reaction enthalpy of the glycolysis reaction was found to be 109 kJ·mol^{-1} and the activation energy for MeONa was estimated as 130 kJ·mol^{-1}. The catalytic depolymerization efficiency of MeONa was compared to that of zinc and cobalt acetate. All compared catalysts gave virtually complete conversion. However, sodium methoxide is advantageous because it is much cheaper and environmentally benign than heavy metal salts. These findings will undoubtedly provide insight into the economical upscaling of PET recycling to meet future recycling demands of a circular economy.