OA04

Solvation effect of CO_2 on accelerating the curing reaction process of epoxy resin

Dong-dong Hu*, Jia-xun Lyu, Tao Liu, Ling Zhao*
State Key Laboratory of Chemical Engineering, East China University of Science and Technology, Shanghai 200237, China
* hudd@ecust.edu.cn - zhaoling@ecust.edu.cn

Supercritical carbon dioxide ($scCO_2$) is of interest as a promising green alternative to organic solvent attributed to its unique properties [1-2]. In polymer systems, $scCO_2$ is inert and presents advantages to assist polymerization and polymer processing. As a class of the most important thermosetting polymers, epoxy resins are widely applied as adhesives, electronic encapsulations and protective coatings because of their excellent mechanical and chemical properties such as chemical resistance and good thermal stability [3-4]. In the curing reaction of epoxy resin, the diffusion-controlled stage is an extremely important even a crucial step since the reaction system changes from a viscous liquid to a rubbery or glassy state and the situation of mass transfer changes significantly with the conversion, which is expected to be adjusted with solvent such as $scCO_2$.

The solvation effect of $scCO_2$ on the curing reaction process of epoxy resin was investigated by using the in-situ FTIR. The isothermal curing kinetic constant and activation energy of diglycidyl ether of bisphenol A (DGEBA) with m-xylylenediamine (MXDA) was calculated via Kamal autocatalytic model. The increased kinetic constant and reduced activation energy with the increasing CO_2 pressure, suggests that the plasticization effect of CO_2 eases the chain movement, promotes the curing of epoxy resin, and increases the final conversion at relatively low temperature. Then, an amended Kamal model involving the diffusion factor was applied to better describe the curing process, which suggests that the high pressure CO_2 plays an important role to reduce the mass transfer resistance and intensify the curing process. Meanwhile, the activation energy determined by the isoconversional method, also decreases with CO_2 pressure at the same curing degree, which further confirms the solvation effect of CO_2 accelerates the curing of epoxy resin.

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