Cure Reaction of Epoxy Resins catalyzed by Graphite-Based Nanofillers

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Abstract

A significant effort was directed to the synthesis of graphene stacks/epoxy nanocomposites and to the analysis of the effect of different graphene precursors on cure reaction of a model epoxy matrix. A comparative thermal analysis of epoxy resins filled with different carbon nanofillers (a high-surface-area graphite, HSAG and a graphite oxide GO), for different thermal histories, were conducted. The main aim was to understand the molecular origin of the influence of GO on the Tg of epoxy resins. The higher Tg values observed for low curing temperatures, for epoxy resins with graphite-based nanofillers, were easily rationalized by a catalytic activity of graphitic layers on the reaction between the epoxy and amine groups of the resin, which leads to higher crosslinking density in milder conditions. This hypothesis has been clearly supported by experiments showing catalytic activity of the considered graphite-based nanofillers on the epoxide ring opening reaction, for monofunctional epoxide and amine reactants. The considered nanocarbons exert a catalytic activity not only on reactions between primary amines and epoxide groups but also on reactions between secondary amines and epoxide groups, like those needed to crosslink epoxy resins. Starting from these results, a kinetic analysis of the cure mechanism of the epoxy resin associated to the catalytical activity of the graphite based fillers was also performed by isothermal DSC measurements. The DSC results showed that the addition of all graphite based fillers greatly increased the enthalpy of epoxy reaction and the reaction rate, confirming the presence of a catalytic activity of graphitic layers on the crosslinking reaction between the epoxy resin components (epoxide oligomer and di-amine). A kinetic modelling analysis, arising from an autocatalyzed reaction mechanism, was finally applied to isothermal DSC data, in order to predict the cure mechanism of the epoxy resin in presence of the graphite based nanofiller.