Correlation of Dynamic Dielectric Properties to Reaction Kinetics and Changing Mechanical Properties of Epoxy Resins During Cure

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Abstract

The principal objective of this paper is to describe how complex impedance, obtained from frequency dependent dielectric sensing technique, can be used as an effective diagnostic tool for insitu real-time investigation in the fabrication of thermoset structures.

Two epoxy systems (Pr500 from 3M and My720 from Ciba Geigy) with different functionality are characterized in terms of their dielectric, thermal, and rheological behavior. It is observed that there is a one to one relationship between Tg and conversion which is independent of cure temperature. The chemical kinetics of the reaction is satisfactorily described by an autocatalyzed reaction mechanism. The chemical rate constant has the usual Arrhenius form, whereas the diffusion rate constant is assumed to be given by a modified form of the Williams-Landel-Ferry (WLF) equation. The overall reaction rate constant is modelled by a combination of the chemical rate constant and the diffusion rate constant. The ability of the frequency dependent dielectric sensing technique to monitor the progress of curing reaction, build up in glass transition temperature, viscosity and to detect the time of occurrence of gel during thermoset cure are explored. The temperature dependence of the dielectric relaxation time, ionic conductivity and viscosity are described by the modified WLF equation. This approach provides a common frame work for describing and comparing different related properties.