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Effect of binder powders added to carbon fiber reinforcements on the chemoreology of an epoxy resin for composites

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Abstract

The growing use of reinforcement preforms during composite manufacturing requires resin soluble binders which significantly affect the properties of crosslinking thermosetting resins. In this study, for the first time the influence of an epoxy preforming binder on the curing kinetics and chemorheological behavior of a crosslinking epoxy matrix was studied. The results proved that the addition of the binder lead to a significant change of the curing behavior suggesting that the epoxy binder was an essential component needed to complete the stoichiometry of the resin-hardener mixture. The developed kinetic and chemorheological model of the experimental results could be used for process optimization.

Keywords: A. Thermosetting resin; B. Cure behavior; B. Rheological properties; D. Thermal analysis

1. Introduction

Liquid Composite Molding (LCM) processes are becoming a popular alternative to the autoclave technology to meet the increased demand for advanced composites with complex shapes, shorter production times and lower costs [1]. One of the most used thermosetting matrices in LCM processes is epoxy resin due to its favorable properties such as high tensile strength and modulus, excellent chemical resistance and high thermal stability. These properties, which make epoxy resins widely applied as matrices for high-performance composites [2] and nanocomposite materials [3],[4], [5], [6] and as adhesives and coatings [7], [8], are reached if the crosslinking process, also named curing, is properly carried out. During curing, epoxy resin changes irreversibly from viscous liquid with low molecular molecular weight into a rubbery and then a solid glass state[9]. During the processing of epoxy based composites, if proper temperature and time are not used, the variation of the degree of cure leads to defect in the composite. If a composite laminate is undercured due to insufficient time in the mold, the matrix has lower properties than those which would develop in a fully cured state. As a consequence, the interlaminar shear strength and the creep resistance of the composite will be reduced and fine interlaminar cracks or delamination can occur. Conversely, if the laminate is overcured, it may result in brittle matrix susceptible to crazing under stress[10].

Moreover, in Liquid Composite Molding processes, the flow behavior of the resin through the fibrous reinforcement during mold filling is an essential factor that influences the final quality of the products. The viscosity, which is a