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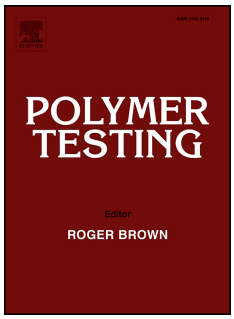

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Shrinkage behavior of Araldite epoxy resin using Archimedes' principle

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Abstract

Knowledge about the volumetric behavior of epoxy resins (chemical shrinkage) during curing is a basic requirement for constitutive modeling of curing processes in Continuum Mechanics. This paper covers shrinkage measurements while a special hot anhydrid-curing epoxy resin cures. The measuring method is based on Archimedes' principle also for elevated temperatures up to $140\,^{\circ}\mathrm{C}$, where a precision scale is drawn on. Moreover, a magnetic suspension between the scale and the sample ensures a constant immersion depth of the sample to avoid negative side effects. Apart from shrinkage measurements, the thermal expansion of the uncured epoxy resin over a comprehensive temperature range is measured using a chemically stable epoxy mixture. Based on an exact description of the deformation, we introduce a model for the thermo-chemical deformations, where it is possible to separate thermal from chemical deformations. This is done under nearly pressure-free conditions to avoid any mechanical deformations regarding the curing kinetics. Using this information, we draw on the most common curing model of Kamal and Sourour to the resulting evolution of the degree of cure, so that DSC measurements can be circumvented. Both methods are compared.

Keywords: shrinkage, epoxy resin, Archimedes' principle, Araldite

1. Introduction

Epoxy resins are widely applied as matrix material for fiber-reinforced composite materials. During the production of such composites, the resins cure accompanied by exothermic chemical reactions. Additionally, the reactions are connected to chemical shrinkage. Combined with thermal deformations, large residual stresses might result in a final component part. Thus, it is necessary to investigate the chemical shrinkage and thermal deformation of epoxy resins.

Unfortunately, there are no established and standardized methods to determine deformations due to the chemical reaction of epoxies. Hence, several measurement devices and setups are proposed in the literature. For example, it is possible to use a hydrometer in the liquid curing state, see [1], or a pycnometer, see [2]. To investigate the shrinkage during the entire curing process, other methods have to be found. [1] applied a discontinuous method. Samples of neat

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