Composites Part B: Engineering

Cure kinetics, morphology development, and rheology of a high-performance carbon-fiber-reinforced epoxy composite

Keletso Mphahlele [a,b], Suprakas Sinha Ray [a,c,*], Andrei Kolesnikov [b]

[a] DST-CSIR National Centre for Nanostructured Materials, Council for Scientific and Industrial Research, Pretoria, 0001, South Africa
[b] Department of Chemical, Metallurgical and Material Engineering, Tshwane University of Technology, Pretoria, 0001, South Africa
[c] Department of Chemical Sciences, University of Johannesburg, Doornfontein, 2028, Johannesburg, South Africa

https://www.sciencedirect.com/science/article/pii/S1359836818310680

Abstract

Carbon-fiber-reinforced polymer (CFRP) is a thermosetting high-performance epoxy composite used in the manufacturing of advanced aircraft components. The curing kinetics and rheological characteristics can have a great effect on the macroscopic performance properties of the composite materials. Thus, understanding the curing reactions of CFRP is important to the development and optimization of composite manufacturing processes. This paper presents a comprehensive evaluation of the cure characteristics of a commercially available epoxy prepeg (pre-impregnated carbon fiber) using differential scanning calorimetry (DSC), rheology, and Fourier-transform infrared (FTIR) spectroscopy. The Ozawa and Kissinger methods are used to measure the activation energies of curing reactions. The DSC results show that the degree of curing is strongly affected by time, whereas rheological characteristics of the composite show that the gel temperature values and obtained gel point increase with the heating rate. On the other hand, the morphological study using IR microscopy reveals the phase homogeneity and resin infiltration in a three-dimensional crosslinked network of the cured epoxy prepreg when a lower heating rate is used. A lower heating rate (or slow curing process) allows the optimum intermixing of epoxy, thus promotes maximum epoxy infiltration inside the fiber reinforcement, which can improve the mechanical performance of the composite by reducing the deformation and residual stress during the curing process.