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Short Communication

Surface and wettability property analysis of CCF300 carbon fibers with different sizing or without sizing

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ABSTRACT

To analyze the role of sizing on carbon fibers and the mechanism of adhesion in CF/polymer matrix composites, scanning electronic microscopy (SEM), atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS), and dynamic contact angle analysis (DCAA) were selected to characterize the different properties between two types of sizings on carbon fiber CCF300. The results of surface roughness obtained from SEM and AFM images showed that the sizings smooth the surface of CCF300. In addition, the percentage of surface polar functional groups on sized CCF300 decreased slightly after sizing. In another hand, the total surface energy and the polar component of surface energy of the sized CCF300 decreased slightly compared to the unsized CCF300, and the J4 sizing has the more influence.

1. Introduction

Carbon fibers are widely used as reinforcements in composites, especially in advanced composites [1–4]. Mechanical properties of composites primarily depend on the fiber and matrix properties. However, the fiber/matrix interfaces also play an important role in controlling some of the mechanical properties of composites, such as interlaminar shear strength and impact strength. A strong interface can transfer the load efficiently from the matrix to the fiber, resulting in stronger composites. A universal method to increase the fiber/matrix adhesion is surface treatment included oxidation in plasmas, oxidation in air, electrochemical oxidation, and oxidation in nitric acid or phosphoric [5–10]. Surface treatment increasing in the surface polarity or active sites for van der Waals linking and hydrogen bonding can improve the interfacial adhesion between the fiber and surrounding polymer matrix [8–12]. After surface treatment, the fibers are generally sized or coated with a polymer layer [13–15]. The function of sizing is still controversial. Some scholars consider that the purpose of sizing is to insert a polymer between the carbon fiber and the polymer matrix and to use the properties of sizing to control the level of fiber/matrix adhesion [16–18]. Others consider that sizing material usually does not promote adhesion but is present to prevent fiber damage during fiber handling in filament winding, prepregging and weaving operations [19,20]. Otherwise, sizing has also been reported to improve the wetting of fiber by the matrix resin so as to protect its reactivity [21].

This research aims at analyzing whether the sizing agent would increase the surface roughness, numbers of surface reactive groups and wettability of the carbon fiber, therefore enhancing the interface properties of composite, while reducing the friction and preventing fiber damage during subsequent textile processing. The surface morphology and surface roughness of unsized and sized carbon fibers were obtained by scanning electronic microscopy (SEM) and atomic force microscopy (AFM). The surface composition and surface functional groups of fibers were examined by X-ray photoelectron spectroscopy (XPS). Wettability studies were carried out by the dynamic contact angle analysis (DCAA).

2. Materials and experimental

Polyacrylonitrile based carbon fibers CCF300 produced by Wei-Hai TuoZhan fiber Co. Ltd. in China was used without and with J4 and A436 emulsion-type sizings. Whether sizing or not, all the carbon fibers in this research were had been subject to electrochemical oxidation surface treatment before leaving the factory. The main ingredients of sizings are modified epoxy resin. The J4 sizing was obtained commercially from Toho in Japan and the A436 sizing was supplied by Fudan University.

The unsized and sized CCF300 were analyzed using a Thermo VG ESCALAB250 X-ray photoelectron spectrometer (XPS). The spectra were collected using a Mg Kα X-ray source (1253.6 eV) with a power of 300 W. The XPS data were fitted according to Gaussian–Lorentzian function.

The SEM images of CCF300 with or without sizing were characterized by a LEO 1530 field emission scanning electronic microscopy.

Atomic force microscopy (AFM) measurements were performed with a solver P47 pro instrument manufactured by NT-MDT Co. in

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