Study on the interfacial properties of carbon fiber/epoxy composites under the hygrothermal condition

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Abstract: Carbon fiber (CF) reinforced plastic (CFRP) has been widely used in aerospace industry for their excellent mechanical properties, such as high specific strength and modulus, corrosion resistance, and designability [1]. Especially, T800 grade CF, as represent of high strength and medium modulus CF, has been the reinforcement of mainstream composites.T800 grade CFRP has greatly improved the performance of the equipment and promoted the upgrading of advanced composites.

Thermoset epoxy (EP) resin plays an important role in aerospace structural applications which are often exposed to humid and thermal environment [2]. Composites mechanical properties will obviously debase in the complex environment. Some work focused on moisture absorption of CFRP, showing a two-stage diffusion model: the initial fast diffusion which can be predicted by Fick's law and continuously approaching moisture absorption saturation. Some other research proved that different surface states on carbon fibers can influence the saturated moisture content, as well as the interfacial shear strength [4]. Exactly , the interfacial properties between CF and resin can be influenced by moisture absorption [5–7] because resin is extremely easy to absorb water which leads to volume expansion, while carbon fiber is almost non-absorbent, so that the resin's swelling generates stress and can cause interface debonding [8,9].

This paper characterized the monofilament diameters, surface topography and roughness (Table 1) of different carbon fibers named CF800 by the electron scanning microscope (SEM), atomic force microscope (AFM). The CF800/EP composites hygrothermal properties were researched according to the standard ASTM D5229 and showed some consistency in hygroscopic behavior, and some difference in hygroscopic moisture content (Table 2 and Fig.1). In the meanwhile, the interfacial shear strength (IFSS) was tested under dry state and wet state (Table 3) by the microbond test. The result indicated that the IFSS had a reverse correlation with the saturated moisture content, which meaned that the carbon fiber`s surface states caused some hydrolysis reaction and different physical absorption.

Table 1 Properties of different carbon fibers

Carbon fiber	Diameter(μm)	Roughness(nm)
CF800-1	5.23	22.4
CF800-2	5.25	21.4
CF800-3	5.17	23.1

Table 2 Moisture absorption parameters of different CF800/EP composites

Materials	The straight slopes （$10^{-6}h^{-0.5}$）	diffusion coefficient D（$10^{-6}mm^2h^{-0.5}$）	saturated moisture content（%）	Coefficient of association R2
CF800-1/EP	5.03	0.23	1.09	0.9984
CF800-2/EP	5.44	0.26	1.11	0.9985
CF800-3/EP	5.33	0.22	1.17	0.9983

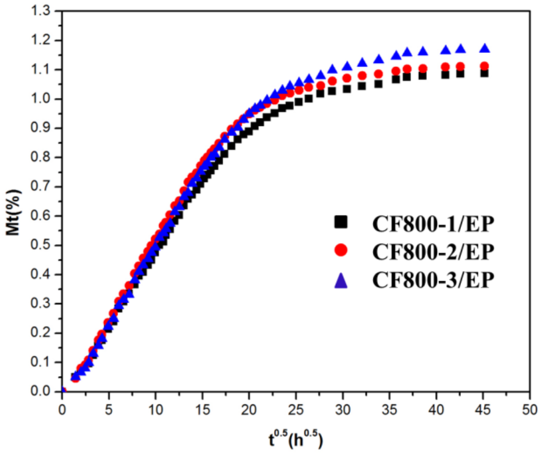

Fig.1. Moisture absorption curve of different CF800/EP composites

Table 3 IFSS under different moisture absorption

Materials	Dry(25℃)		Wet(25℃)		Retention rate(%)
	IFSS(MPa)	CV(%)	IFSS(MPa)	CV(%)	
CF800-1/EP	81.83	8.63	57.40	7.36	70.15
CF800-2/EP	68.11	13.82	52.25	7.01	76.71
CF800-3/EP	68.87	8.43	56.97	12.34	82.87

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