ROLE OF SURFACE ENERGY IN CARBON FIBER \ EPOXY MATRIX COMPOSITES

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Introduction

The role of interfaces in the fibre-reinforced composites is a subject of considerable research activites, because the fibre/ matrix interface has long been recognized as a key factor strongly affecting the composites properties.
It is well known that the the surface oxidation of carbon fibres improves the overall composites properties (1,2). This effect is usually related to one or several of the following parameters. First ,the fibres may contain specific morphology after oxidation, giving rise to a new zone in the vicinity of the fibre surface, differently from the bulk composition. On the other hand,oxygen-containing groups,developed at the surface after oxidation are proposed to be important for better fibre-to -marix adhesion, because they are able to react with the matrix, creating chemical bonds at the interface.
In this work, we discuss the change in wettability after heat treatment and air oxidation of carbon fibres and their effect on interlaminar shear strength (ILSS) for epoxy resin composites.

Experimental

Unidirectional composites of size 150 x 5 x 4 mm were made by reinforcing separate batches of carbon fiber with epoxy as a matrix. A standard match mould die technique was used to prepare several batches of polymer composites. Carbon fiber studied in the experiments was high modulus type manufactured by Toho Rayon Company Ltd. Under the trade name of HMS35 (as received, coded as C).
The fibers were first heat treated at 700°C for 2 sec. in inert atmosphere to remove sizing agent (coded as A). The carbon fibers were thereafter oxidized in air at 430°C for 4 hours to introduce the functional groups and to increase the surface area(coded as B).
To minimize the effects of excessive burn off , the weight loss of carbon fiber was carefully controlled during air oxidation and heat treatment so as not to exceed 1 wt. % loss for all samples.
In order to observe the change in strength of carbon fibers before and after the air oxidation and heat treatment the tensile strength was measured using Instron with the cross head speed set at 5mm/min.
The surface force of treated carbon fiber was measured with dynamic contact angle analyzer (DCA322).

Results and Discussion

The weight loss of the carbon fiber during oxidation and heat treatment is presented in table (1).
Wadsworth and Watt (3) suggested that the weight loss of the fiber during oxidative surface treatment should be kept under 6 wt.%.
In this study the weight loss of the fiber during surface treatment was not to exceed 1wt.%. since the weight loss of the carbon fibers was kept at a minimum, the tensile strength showed little change.
Table 2 shows the surface force variation of the surface treated carbon fibers as determined from the dynamic contact angle analysis measurements. The surface force of the A fiber is 0.13 mg. while that of B fiber is 0.15 mg. This means that the wettability of B fiber is greater then that of A fiber. It implies that oxidation treatment increases the functional groups on the surface of the carbon fiber. The surface force of C fiber is 0.11 mg. This indicates that the wettability of B and A fibers is greater than that of C fiber. The ILSS recognized as one of the critical failure modes in fiber reinforced composite and depends greatly on the matrix properties and fiber matrix interfacial adhesion.
The surface treated high modulus carbon fibre composites showed higher ILSS values than those of untreated fibre composites. Fig(1) shows the ILSS of the composites made of carbon fibre with different treatments.

Conclusion

Comparing the effects of the carbon fibres surface chemistry on the interfacial properties of epoxy composites, it is obvious that there is no simple conclusion to be drawn for the optimum Adhesion state. However, both the oxidative treatment and heat treatment of the fibres are found to influence the ILSS of the UD composites. Further work on this is currently in progress.

Acknowledgments

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References

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3. N. J. Wadshworth and W. watt, US patent No. 3476,703 (1969)

Table 1. Weight loss and strength variation of differently treated carbon fibres

Surface treatment	Weight loss(%)	Specific strength ratio
A	.85	1
B	1.00	0.99

Table 2. Surface forces of differently treated carbon fibres determined from DCA

Surface treatment	surface force(mg.)
A	0.13
B	0.15
C	o.11

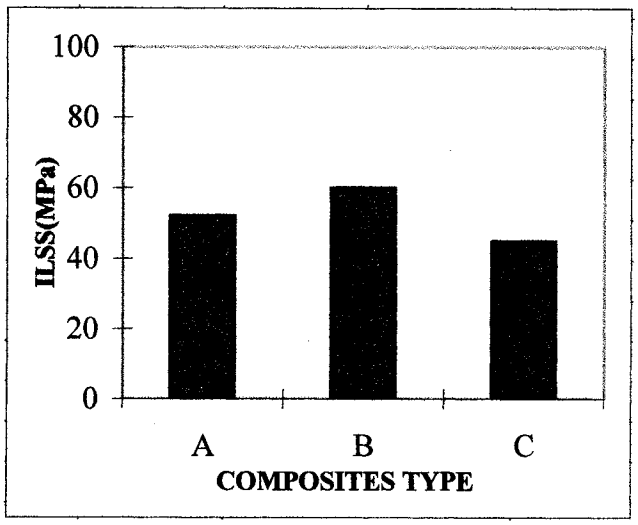

Figure 1. interlaminar shear strength and surface treatment conditions