Enhancement of Interfacial Performance of Fiber/Epoxy Composites by a Two-step Surface Treatment

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1. Introduction

Fiber reinforced plastics (FRP) have been used as boat, aircraft exterior, automobile and interior and exterior of the railway vehicle, because of its high specific strength and specific modulus, corrosion resistance and excellent dimensional stability compared to metal materials [1]. When the FRP is loaded, the fibers mainly bear the stress and the interface takes responsibilities of transferring stress from the matrices to the fibers, so ultimate performance of the composite is greatly determined by the interface. However, the interfacial performance of FRP is poor. In order to improve it, fiber surface modified by plasma irradiation followed by grafting of silane coupling agent was carried out.

2. Materials and Experimental Methods

Plain-woven carbon fibers sheet (CO6343) was supplied by Toray Industries, Inc., Japan. The epoxy resin(XNR 6815) and curing agent(XNH 6815) were obtained from Nagase ChemteX Corporation. The silane coupling agent 3-Glycidyloxypropyltrimethoxysilane (G0210) were purchased from Tokyo Chemical Industry Co., Ltd., Japan.

The carbon fibers were treated in the mixed oxygen gas plasma. The energy was supplied from a 1 kW radio frequency source with excitation frequency of 13.56 MHz. After the degree of vacuum in the chamber reached 1.0×10^{-2} Pa, oxygen gas was allowed to flow into the chamber.

The surface activated fibers were submerged in the silane solution. For the preparation of silane solution, a 1% silane solution was firstly obtained by adding agents to a distilled water. The silane solution was then stirred for 1 h before use. After the immersion treatment, the fiber samples were dried in an oven at 110°C.

Carbon fiber/epoxy composite was molded according to VaRTM method. The matrix was prepared by mixing epoxy resin and curing agent with the weight ratio of 100:27.

3. Results and Discussion

In order to evaluate how the silane coupling treatment affects the adhesion between carbon fiber and resin, a short beam test was performed to calculate the interlaminar shear strength(ILSS), it can be calculated through the following equations:

$$\tau = \frac{3F}{4bh} \tag{1}$$

Fig.1 shows the ILSS of samples treated with epoxy based silane coupling agent G0210. It can be seen from Fig. 1 that the ILSS is increased compared to the untreated case. Also, no significant change in ILSS was observed even if the immersion time was changed to 2 min, 20 min, and 60 min.

Fig.2 shows SEM images of the fractured surface of untreated sample and that treated with G0210. In the Fig.2(b), there is not much pulling out of the fibers. The adhesion between the fiber and the resin is improved.

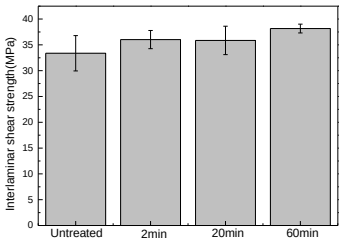

Fig.1 Average value of ILSS of samples treated for different immersion times with G0210

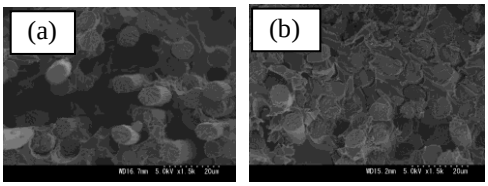

Fig.2 Fractured surface (a) Untreated, (b) G0210

4. Conclusions

The two-step surface treatment was an effective method to improve interfacial property of the carbon fiber/epoxy composite.

References

[1] N. Guermazi, A.B. Tarjem, I. Ksouri, H.F. Ayedi, On the durability of FRP composites for aircraft structures in hygrothermal conditioning, Composites B: Eng. 85 (2016) 294-304.