SURFACE MODIFICATION OF CARBON FIBER BY PHOTOSENSITIZER

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INTRODUCTION

Surface treatment of reinforcing fibers, which improves the affinity between the fibers and the matrix, is a very important process contributing to the final properties of composites. There are many kinds of surface modification methods available for carbon fiber(CF), such as air or ozone oxidation, chemical oxidation, electrolytic oxidation, plasma treatment, etc. However, these methods either need many hours for treatment, are too complicated, or particular devices such as vacuum or high temperature vessel are needed to modify the CF. We have been studying the surface treatment of CF and the way to simplify the process. As the result, we developed photo-oxygenation as a simple method that can be executed both under atmospheric and dry conditions. And it was found through previous studies that the treatment is effective and useful for CF[1-5]. Surface treatment of CF is essentially an oxidation process. If there were an oxidation process of CF that could be done more effectively by air or oxygen under normal conditions, it would make the simplest treatment of CF that is more energy-saving and useful for manufacturing.

In this paper, application of the photosensitizer to the surface treatment of CF has been studied. In this process the activation of oxygen takes place by energy transfer of photosensitizer. The purpose is to develop a new, simpler, and a greater energy-saving process than the conventional ones.

EXPERIMENTAL

Surface modification by the photosensitizer method is shown in Figure 1. CF surface is modified by immersing it into the photosensitizer solution and then air-drying in the labolatory. Energy source is the light of fluorescent lamp or the sunlight coming into the room. CF samples were non-surface-treated and unsized PAN-based CF (Toho Rayon, 6K). CF samples were cut into about 6cm long and immersed in photosensitizer solution. The immersed CF were air-dried in the labolatory and rinsed with water.

The wettability and the surface properties of treated CF were measured and analyzed for evaluating the modifying effect.

Methylene blue (Wako, Alkaline Laeffer) which was a well known indicator for titration analysis was employed as one of photosensitizer. Other photosensitizer such as 2,4,6-Triphenyl-pyrylium Tetrafluoroborate (TPP), Eosin Bluish (EB) and Erythrosin B (ER) were also employed to compare.

Using the treated and untreated CF, CF/Phenolic resin composite (CFRP) and CF/Cement composite (CFRC) were prepared. Their mechanical properties were measured. PAN-based cloth for CFRP and PAN-based paper for CFRC were employed as CF.

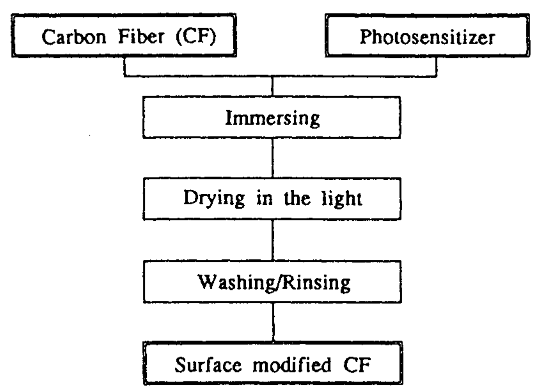

Figure 1 Surface modifying process by the photosensitizer method.

RESULTS AND DISCUSSION

Wettability of treated CF by several photosensitizer is shown in Figure 2. Wettability of treated CF for water was improved by a mere photosensitizer painting. Every treated CF surface changed from hydrophobic of nontreated CF into hydrophilic, but the degree differed with the kind of photosensitizer. Wettability of the treated CF by MB was the highest. Every photosensitizer had a good effect on wettability although the concentration was extremely low (about 0.001mol/l). The effect was not degraded by washing or rinsing.

XPS analysis of CF surface showed that O/C ratio was increased from 0.05 to 0.14. It seems to indicate that oxygen-containing functional groups were introduced by the treatment.

Mechanical properties of prepared CFRP are shown in Table 1. CFRP with treated CF-cloth by MB was equal to CFRP with untreated one in bulk density, but strengthened to about twice in flexural strength. It was confirmed that a remarkable effect appeared by extreme dilute solution.

Mechanical properties of prepared CFRC are shown in Table 2. Flexural strength of CFRC with treated CF-paper by MB or EB was 30-60% higher than untreated one.

CONCLUSIONS

A new surface modification of CF by photosensitizer has been investigated. This method consists of only three steps, immersing in the photosensitizer solution, drying in the light and rinsing by water. The photosensitizer method is simpler and more energy-efficient than conventional methods.

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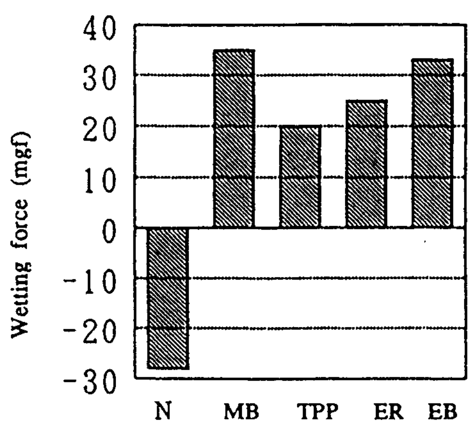

Figure 2 Influence of photosensitizer treating on wetting force.
N:non-treated, MB:treated by MB, TPP:by TPP, ER:by ER, EB:by EB at 0.001mol/l respectively.

Table 1 Mechanical properties of CFRP.

Surface treatment	Bulk density (g/cm^3)	Flexural strength (MPa)	Flexural modulus (MPa)
Untreated	1.31	100	20
MB-treated	1.30	180	19

Table 2 Mechanical properties of CFRC.

Surface treatment	Bulk density (g/cm^3)	Flexural strength (MPa)	Flexural modulus (MPa)
Untreated	1.5	32	3.8
MB-treated	1.4	52	5.8
EB-treated	1.5	41	3.3