POSTER

Influence of surface treatment on the mechanical properties of pitch-based carbon fibers and CFRP

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INTRODUCTION

To develop good mechanical properties of carbon fiber reinforced plastics (CFRP), the interface between fiber and resin needs to have proper adhesion. Carbon fibers are treated by surface oxidation to get the proper adhesion. Electrochemical oxidation is commonly used in the industrial process. Excessive oxidation leads to fiber damage and excessive bonding between fiber and resin, and, as a result, CFRP could fail in a catastrophic manner.

We reported previously that the optimum condition of surface treatment for mesophase pitch-based carbon fibers varied depending on fiber tensile modulus and electrolyte[1,2]. Though there have been many reports dealing with surface oxidation of high modulus carbon fiber, there are few reports dealing with carbon fiber of modulus higher than 600GPa. We have investigated the relationship between degree of the surface treatment using electrochemical oxidation and oxygen content of fiber surface analyzed with X-ray photoelectron spectroscopy (ESCA), and mechanical properties of the fiber of 700GPa.

EXPERIMENTAL

Materials:
Mesophase pitch-based carbon fiber of ESKAINOS NU70 manufactured by Nippon Steel Corporation was used in this study. Tensile modulus is 700GPa. The average diameter of single-filament was 7.2μm and the density was 2.15 g/cm3.

Surface treatments:
The fiber was electrochemically oxidized in sulfuric acid solution, and the degree of surface treatment was changed over five proportional levels. Level 0 designates untreated. The treated fiber without sizing was used for single-filament tensile test and analysis with X-ray photoelectron spectroscopy (ESCA). The treated fiber with sizing was used for resin-impregnated yarns tensile test and also used for preparation of prepreg.

Tensile test of carbon fibers:
Single-filament tensile test was performed according to JIS R 7601. The gauge length was 25mm. Tensile strength of single-filament was determined with the average of 25 single-filament tests. Resin-impregnated yarns tensile test was performed according to JIS R 7601, too.

Preparation of composite:
The unidirectional laminates of 10 prepreg plies were cured with autoclave to the 1.0 mm thickness and the fiber volume fraction of around 60%.

Test of CFRP:
Tensile and compressive tests were performed according to JIS K 7076.

RESULTS AND DISCUSSIONS

Fig.1 shows the relation between treatment levels and values of O/O+C analyzed with ESCA. The oxygen content of surface increases with the treatment from levels 0 to 4. Fig.2 shows the influences of treatment level on the single-filament and resin-impregnated yarn tensile strengths of NU70. As the level of oxidation increases, the tensile strengths decrease. The surface treatment could have damaged the fiber surface because the oxidation alters the form and structure of fiber surface.

Fig.3 shows the relationship between the treatment level and 90° tensile strength of CFRP. The 90° tensile strength increases rapidly, especially at the low treatment level, and increases slightly from level 2 to 3. At level 4, the 90° strength decreases slightly, suggesting that the 90° strength will not increase with increasing treatment level further. It is apparent that up to the level 3, the 90° strength increases with increasing the oxygen content.

Fig.4 shows the relation between the treatment level and the 0° compressive strength of CFRP. The surface treatment has no influence on the 0° compressive strength of CFRP. This is because, in the case of the present ultra high tensile modulus carbon, the compressive failure is governed by coupon shear buckling, but not by fiber matrix debonding.

CONCLUSIONS

The following are concluded:

1. When the level of oxidation is increased, the tensile strength of the fiber decreases, while the oxygen content of surface increases.
2. The 90° tensile strength of CFRP increases during the surface treatment. However, the surface treatment have no influence on the 0° compressive strength of CFRP.

REFERENCES

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2. H.Kimura and K.Kubomura, "Electrochemical treatment of pitch based carbon fibers," International Conference on Carbon, pp.728-730(1992)

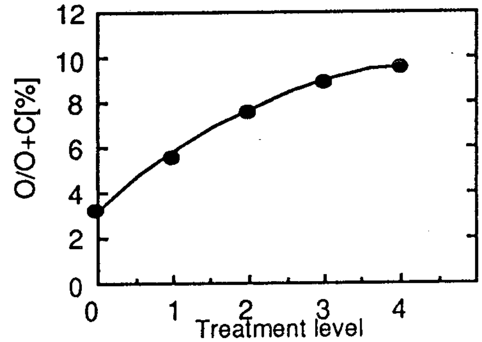

Fig.1 The relation between treatment level and O/O+C analyzed with ESCA.

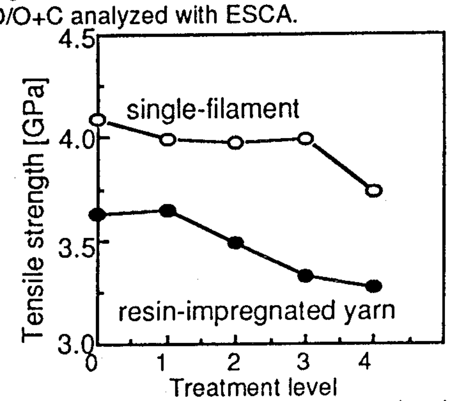

Fig.2 The relation between treatment level and tensile strength.

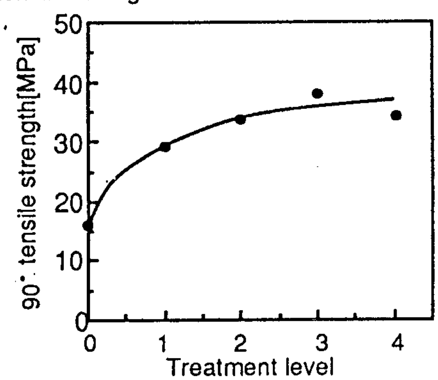

Fig.3 The relation between treatment level and 90° tensile strength of CFRP.

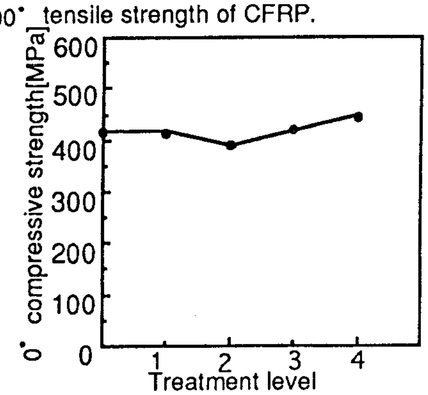

Fig.4 The relation between treatment level and 0° compressive strength of CFRP.