

Effect of Surface Treatment for Continuous Fibers on impregnation and Mechanical Properties of Thermoplastic Composites

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Introduction

Continuous fiber reinforced thermoplastic composites have been attractive material system due to the recycle ability and secondary processing in recent years. The fabrication of continuous fiber reinforced thermoplastic composite involves two problems. The first one is that thermoplastics as matrices generally have high melt viscosity so that it is difficult to impregnate resin into reinforcing fiber bundle. To overcome this problem, intermediate materials with CF and thermoplastic fiber have been developed. Since thermoplastic resin is located close to reinforcement fiber bundle, impregnation performance of thermoplastics is excellent.

In this study, thermoplastic resin impregnated continuous carbon fiber as developed with polycarbonate resin powder as an intermediate material for continuous fiber reinforced thermoplastic composite. Resin powder can be close to fiber, impregnation properties should be expected. Two kinds of intermediate materials were fabricated by changing content of resin powder, and impregnation properties and mechanical properties of PIY composites were investigated.

Surface treatment for carbon fiber by PC and molding method

Carbon fibers (T700-6000-SC, TORAY) were used as the reinforcing fiber. PC resin powder with low molecular weight (H-4000, Mitsubishi Gas Chemical Company Inc.) was used as the matrix resin. The powder was dissolved in methylene chloride with concentration of 5.0wt% and 3.3 wt%. Pre-impregnated tape was prepared by dipping continuous fiber into the solution with sizing machine. The resin content on fiber bundle was 4.6 wt% and 2.7wt%.

In order to investigate the impregnation state of molding, unidirectional composite was fabricated. Carbon fibers treated by PC solution of 5wt% concentration was used in this molding. Fiber bundles were wound 36 times unidirectional-aligned on metal flame. 3 types of composite were fabricated; Type 1 was fabricated by sandwiching dry carbon fiber with PC film (FE200B, 50 micro-meter of thickness), Type 2 was fabricated only with pre-impregnated tape, Type 3 was fabricated by sandwiching pre-impregnated tape with PC film. 2 layers of films were inserted at both surface and 3 layers of films were inserted between fiber bundles. For this molding, compression molding method by using concave metal mold was employed. Molding pressure was 7MPa, molding time was 10min, and molding temperature was 290 degree Celsius. Finally, unidirectional plate (20mm in width, 200mm in length) was molded and cross-sectional observation was carried out.

Cross-sectional observations and estimations

Molded specimens were embedded into epoxy resin and polished in order to obtain cross-sectional photos. Figure 1 shows the typical cross-sectional photographs. From these photos,

un-impregnation ratio of each specimen was calculated. Un-impregnation ratio was defined as the area of un-impregnation area divided by the cross section of the molding. Table 1 shows un-impregnation ratio of each composite. Even the resin film was required as appropriate content of matrix, the impregnation state was greatly improved by using pre-impregnated tape.

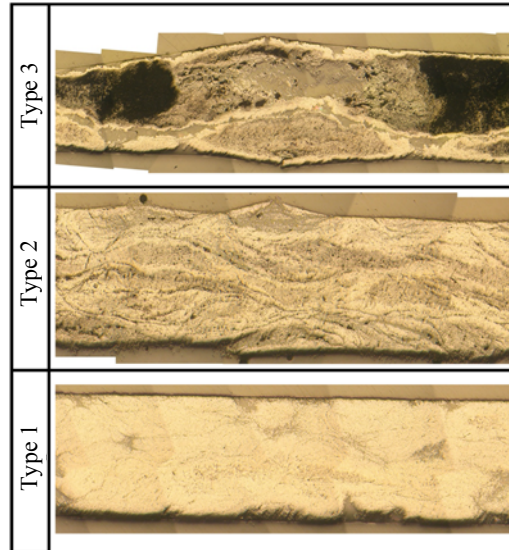


Figure 1: Cross-sectional observation of CF/PC

Table 1: Un-impregnation ratio of CF/PC

Sample Type	1	2	3
Un-impregnation ratio (%)	40.1	27.5	2.1

Tensile test

Tensile test for unidirectional composites was performed by using Type 3 specimens with different PC concentration of 3.3 and 5.0%. The specimen size was 200mm in length, 20mm in width and 2.0mm in thickness. Span length was 100mm and the test speed was 1mm/min. Table 2 shows tensile modulus and strength for each specimens obtained from tensile test. Modulus for each specimens were almost same, while strength of 5.0% specimen was 6% larger than 3.0% specimens. It suggests that concentration of PC solution effected on either impregnation properties or mechanical properties of specimens.

Table2: Results of three point tensile test.

Concentration of treatment (wt%)	3.3	5.0
Modulus (GPa)	164.13	152.74
Strength (MPa)	1367.2	1455.1

3.5 Conclusion

In this study, in order to improve the both impregnation and interfacial properties, surface treatment by using the resin with low molecular weight and same materials with matrix resin was proposed. In the case of film stacking molding, PC treatment could greatly help impregnation of resin into inside of fiber bundles. In addition, it was clarified that PC concentration was important factor to improve mechanical properties of composite.