Adhesion Property of PU Resin to UHMWPE Fiber with Surface Treatments

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1. INTRODUCTION

Recently, focused on the high strength fiber, the importance of ultra high molecular weight poly ethylenes(UHMWPE) fiber is risen up because of its excellent properties. As the newest protective material, UHMWPE fiber has characteristics of high strength, high specific modulus and low density. Inspite of these advantages, the UHMWPE fiber has poor adhesion property with matrix resins because of non-activity of fiber surface, as well as poor dyeability due to its high crystallinity.

Various treatments to improve its surface properties have been studied. One of them, the low temperature plasma treatment is relatively good and effective method to treat the fiber surface, since it is efficient and environmentally friendly. Several studies are conducted to investigate the effect of cold plasma treatments on many kinds of reinforcing fibers of composites. However, general cold plasma treatment is conducted under vacuum atmosphere and thus processing cost is very expensive. For those reasons, the UV irradiation treatment is one of the alternatives which has a relatively low cost process. However, treatment effect of the UV irradiation is weaker than plasma treatment, and it takes too long processing time. Thus, the UV irradiation has restrictions in applications.

In this study, to overcome the disadvantages of UV treatment, we tried to use a combined process of UV irradiation and acid treatment of the UHMWPE fibers. Adhesion properties of PU resin to the UHMWPE fiber with the UV irradiation and acid surface treatments were characterized, using various instrumental analysis. As the results, the interfacial shear strength of the UHMWPE/PU composite is analyzed.

2. EXPERIMENTALS

Materials

UHMWPE fibers (Dyneema SK76) were provided by DSM Co. as a roving of 1,580 deniers. Matrix resin, waterborne polyurethane, was provided by TML Co. Ltd., Korea. UHMWPE fibers were cleaned and dried before use. Before experiment, fiber cleaning by normal hexane in an ultrasonic bath and washing in the distilled water were conducted.

Acid treatment

Acid solution is prepared with 85% formic acid and distilled water. Its mixing ratio was varied with the content of distilled water of 10wt% to 50wt% in the solution. UHMWPE fibers were immersed in the prepared acid solutions.

UV irradiation treatment

The UV irradiation equipment having an UV lamp from Vilber loumat company which can irradiate wave length of 254nme was used in this study. The UV irradiation energy of the cleaned UHMWPE fiber was varied in the range of 3-18kJ/cm2. To change the UV irradiation energy, the treating time was varied and the distance between the sample and the lamp was fixed at 3 cm. The UV irradiation energy was calculated by the following equation (1). Where, W is output(W=J/s) of UV, s is irradiation time and R is the distance between the sample and the lamp, respectively.

$$J/cm^2 = W \times s / 4\pi R^2 \quad (1)$$

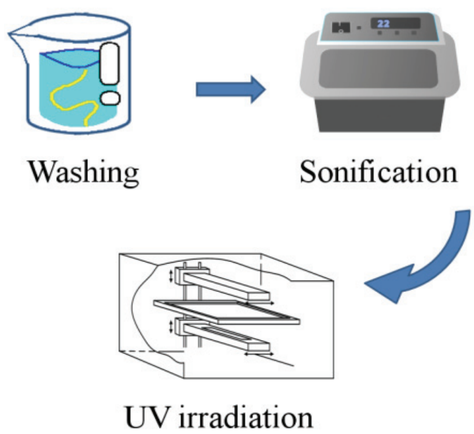

Fig. 1. Schematic diagram of UV irradiation.

Experimental procedure of the UV irradiation was schematically shown in the Fig.1

Characterization

When the UV and acid treatment were finished, the fiber samples were subjected to the surface characterization or adhesion study in order to minimize the exposure of treated fibers to atmosphere. The morphological changes of UHMWPE fibers by surface treatment were investigated by Scanning electron microscope(SEM) and atomic force microscope(AFM). To examine the interfacial shear strength of the UV and acid treated fibers with polyurethane matrix, the micro-droplet debonding tests were conducted on an Instron model 4467 tensile tester at a cross-head speed of 1mm/min.

3. RESULTS AND DISCUSSION

The morphologies of acid and UV treated UHMEPE fibers have more cracks than that of the untreated fibers, the treated fibers had lots of micropits and showed the roughened surface morphology. Surface roughening effects of UV treatments may increase the interfacial adhesion between fiber and resin by enhancing the mechanical interlocking as mentioned above.

Through this study, we knew that the surface morphology and chemical structure were changed by acid and UV treatment of high strength polyethylene fiber. We compared our treatment with the pure chemical treatment about detail study of the surface of UHWMPE fiber and the interfacial shear strength with poly urethane resins. Finally, we studied on the optimum condition of UV treatment of the UHMWPE fibers and their properties by further analysis.

4. CONCLUSIONS

In order to improve the interfacial adhesion between UHMWPE fiber and PU resin, we conducted a combined process of the UV irradiation and acid treatment. As the results, following conclusions were obtained.

1. When the UHMWPE fiber treated with formic acid, its surface showed almost no changes in the sample. However, treated with UV irradiation, it showed some changes on the surface.
2. After combined process of formic acid treatment and UV irradiation, the surface of sample showed considerable modification, compared with other treatment.

The combined process of two treatments was more effective than the acid treatment or the UV treatment respectively. When acid treated and UV irradiated, the UHMWPE fiber has many micropits which can enhane the interfacial adhesion between UHMWPE fiber and PU resin. When this combined process is applied with other technologies, we can obtain the advantages of short treating time, cost saving and the enlargement of application fields.

5. REFERENCES

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