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Recycling of PET/PE Core/Sheath Fiber Wastes as Low Materials of Composites

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In recent years, the textile industry has taken a growing interest in developing system for recycling waste fibers which result from the process of manufacturing products with the goals of protecting the environment and saving energy. In this paper, PET fiber reinforced PE thermoplastic composite was molded by using the waste of non-woven fabrics of PET/PE core/sheath fiber. Two kinds of molding method such as injection and compression molding methods were tried to mold the composites. In the injection molding, the waste fabrics were fed into the injection molding machine directly and PE part of fiber was melted as the matrix material. In the compression molding, the non-woven fabrics and web of fabrics were used as the raw materials. The bending strength and modulus of molded specimens were discussed based on SEM observation results of fracture surface. The bending strength and modulus of the composites were much larger than those for the matrix material for both molding method. Especially, the higher values were obtained for the compression molding. The results suggest that the molding methods described herein shows promise for contributing toward the material recycling of core/sheath type fiber waste.

Key words : Recycling, Core/sheath fiber, Direct injection molding, Compression molding

1. INTRODUCTION

PET/PE core/sheath fiber is extensively used for the thermal-bond non-woven fabrics. However, the large quantities of cut waste are generated in the manufacturing of products and most of these wastes are currently destroyed by fire or buried underground. In this paper, to develop the material recycle technique for these fiber wastes, the molding of composite materials was tried by using the waste of PET/PE fabrics as a raw material of molding.

It is very important to obtain the good dispersion of reinforcement and the good impregnation of matrix resin between neighboring reinforcements. To achieve these problems, many researchers have been presented many ideas until now. One of the techniques is the pre-coating method of matrix around the reinforcement before molding of composites[1,2]. It should be noted here that the core/sheath type fibers are exactly pre-coating materials. Therefore, it is highly expected that the core/sheath fibers will be an excellent raw material of composites.

2. EXPERIMENTAL

2.1 Raw material

The cut waste of non-woven fabrics of PET/PE core/sheath fiber used in this experiment is shown in Fig.1. The composition rate of PET and PE is 50:50 throughout the experiments. The material used are usually used for the food packing, the daily miscellaneous goods, the medical supplies etc.. The waste material used here is a selvage of continuous non-woven fabrics with width of 160mm and density of 14.4g/m^2.

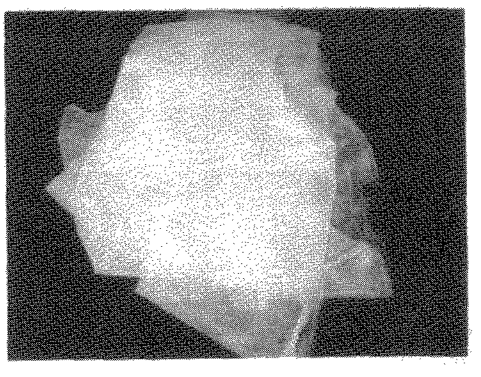

Fig.1 PET/PE Core/sheath Non-woven fabrics

As shown in Fig.2, the melting points of PET and PE are 265 deg. and 130 deg.. The exist of the temperature difference of melting point suggests that the PET and the PE parts will be reinforcement and matrix, respectively, by regulating the molding temperature. The bending and izod impact tests were carried out for the molded composites and the mechanical properties of composite were investigated.

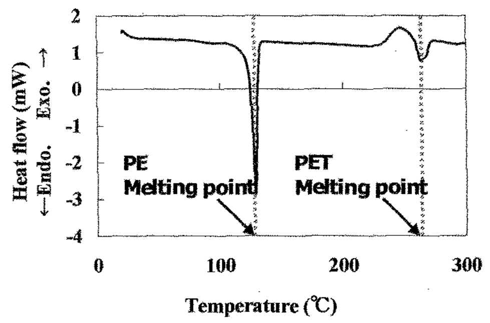

Fig.2 DSC curve

As shown in Fig.2, the melting points of PET and PE are 265 deg. and 130 deg.. The exist of the temperature difference of melting point suggests that the PET and the PE parts will be reinforcement and matrix, respectively, by regulating the molding temperature. The bending and izod impact tests were carried out for the molded composites and the mechanical properties of composite were investigated.

2.2 Injection molding

If the core/sheath fabrics are palletized before injection molding, the heat addition process results in degradation of materials. Moreover, the size of pallets limits the length of the reinforcement. Therefore, the pellet-type may be unsuitable for the injection molding of composites. For these reasons, in the present system, the waste of fabrics were fed into the injection machine directly[3] as shown in Fig.3. In addition to the composite materials, the specimen of PE was molded by using the virgin pellet of PE to discuss the reinforcing effect of PET fiber on the mechanical behavior of composites. The conditions of injection molding are shown in Tables I and II. It should be noted here that the injection molding of composite can not be operated in the temperature range T_{mold} < 200 deg. because of the rack of material flow in the burrel.

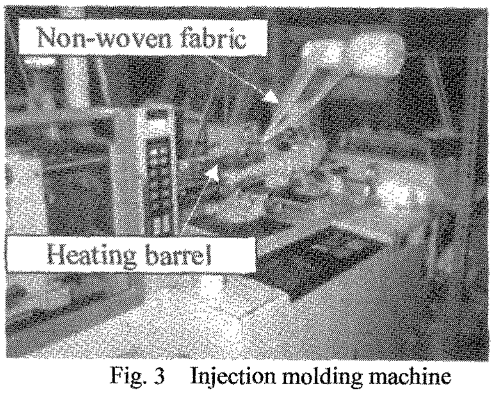

Fig. 3 Injection molding machine

Table I Injection molding temperature (℃)

No.	Die	Nozzle	Barrel
1	60	200	200 - 195 - 190 - 185
2	60	220	220 - 215 - 210 - 205
3	60	240	240 - 235 - 230 - 225
4	60	260	260 - 250 - 245 - 240
5	60	280	280 - 260 - 250 - 240

Table II Injection molding condition

Back pressure	(MPa)	3.75
Injection rate	(mm/s)	46
Injection pressure	(MPa)	212.6
Holding pressure	(MPa)	37.5
Mold clamping force	(kN)	294

2.3 Compression molding

The compression molding was carried out by using the hot press machine as shown in Fig.4.

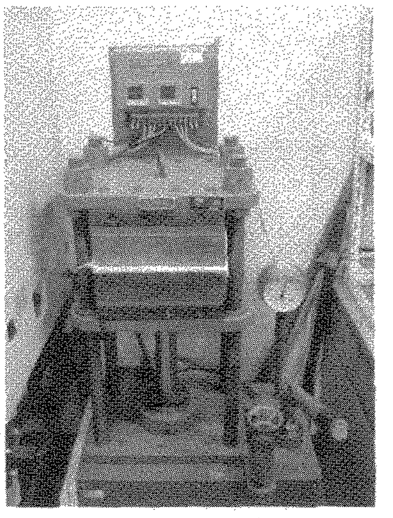

Fig.4 Compression molding machine

Two types of pre-treated fabrics were used for the compression molding. Namely, in case I, the non-woven fabrics were laminated to obtain a fixed thickness of composite and to keep a long fiber length. In case II, the web of fabrics was made by using carding machine shown in Fig.5 in order to obtain a uni-directional fiber orientation. The temperatures of compression molding are shown in Table III.

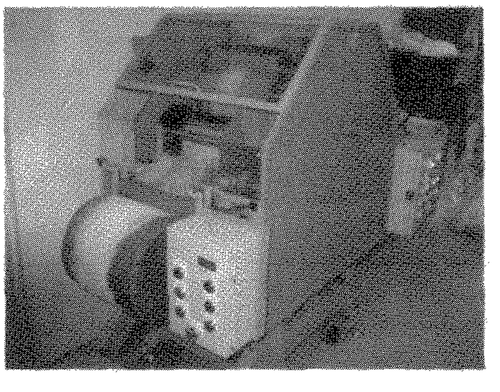

Fig.5 Carding machine

Table III Compression molding temperature

Molding temperature (℃)	180 , 200 , 220 , 240

3. RESULTS

3.1 Bending property

The bending strength was evaluated from the maximum bending stress, and was shown in Fig.6. It should be noted here that the strength of PET/PE composites is higher than that of PE matrix in the range of higher temperature. Especially, the bending strength of PET/PE composite for 200 deg. is almost three times as large as that of PE matrix. It is cleared from this figure that the strengths decrease with increasing the molding temperature.

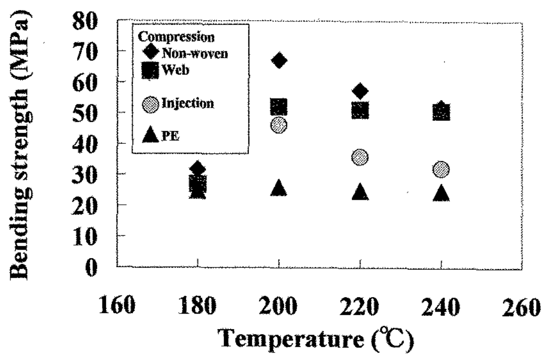

Fig.6 Bending strength

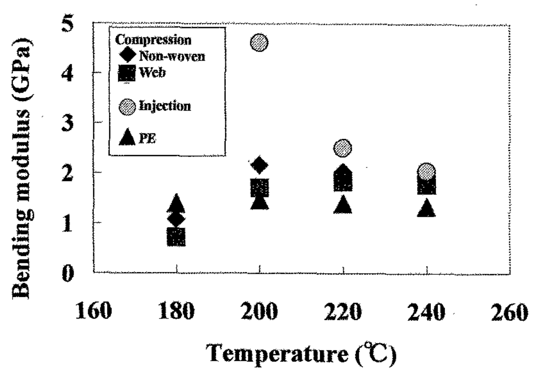

Fig.7 Bending modulus

The bending modulus was evaluated from the initial curves of load-deflection relations and was shown in Fig.7. It is cleared from figure that the modulus decreases with increasing the molding temperature. The modulus for 200 deg. is much higher than that of PE matrix.

3.2 Izod impact property

The izod impact values are shown in Fig.8. The fairly large values can be obtained for the composites molded by compression molding using non-woven fabrics, and the value at 200 deg. is almost fifty times as large as that of PE matrix. The values for the composite using web are also fairly larger than those of PE matrix. The maximum impact values exist at 200 deg. for all composites and the values decrease with increasing molding temperature in the range over 200 deg.. It is concluded here that the long PET fiber acts as a good reinforcement for impact load.

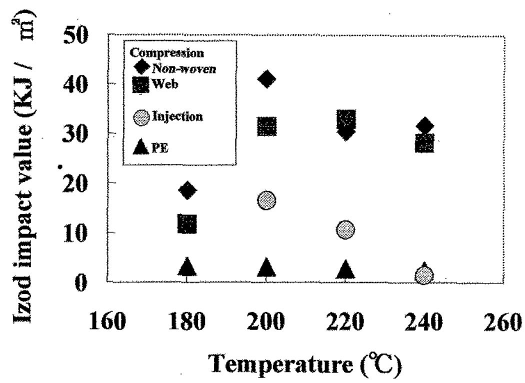

Fig.8 Izod impact value

3.3 SEM observation

The SEM observation results of fracture surface are shown in Figs.9 and 10 for the composites molded by injection and compression method at 200 deg., respectively.

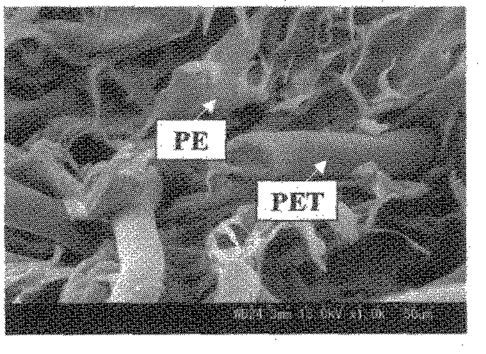

Fig.9 SEM observation picture
(200 deg. by injection molding)

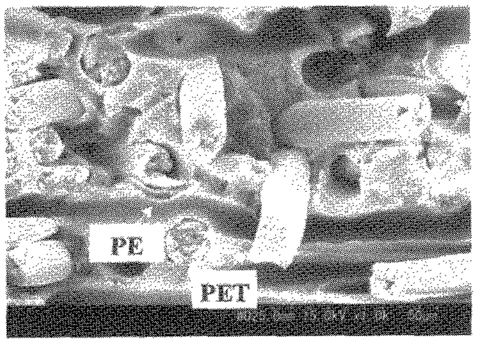

Fig.10 SEM observation picture
(200 deg. by compression molding)

The fairly good dispersion of PET fibers can be achieved in both composites. However, the adhesion between PET fiber and PE matrix can be seen in these figures. The lack of adhesion may be lead the lower bending strength for the composites with short PET fiber molded by injection molding as shown in Fig.6.

3.4 Tensile property of reinforced fiber

As discussed above, the bending strength and impact value decrease with increasing the molding temperature. However, the properties of PE matrix are constant for various molding temperature. As a result, it is expected that the decrease of said properties may be caused by the thermal damage of PET fiber during the molding process.

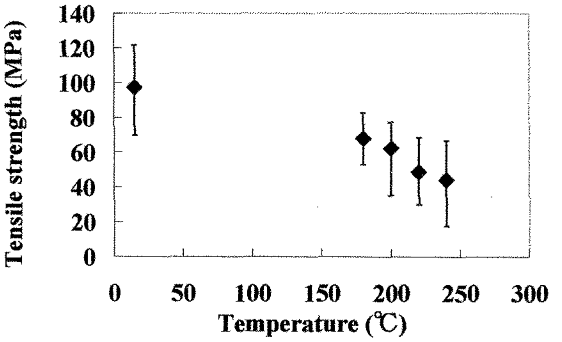

Fig.11 Tensile strength of PET fiber

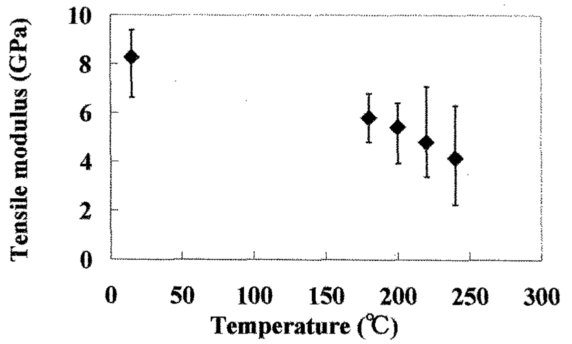

Fig.12 Tensile modulus of PET fiber

Therefore, the tensile properties against the temperature were measured by using the non-extended PET thread molded from the PET pellet with the same molecular weight as PET fiber of non-woven fabrics. The results of tensile properties are shown in Figs.11 and 12 for strength and modulus, respectively. It is cleared from these figures that the deterioration of bending and impact properties should be caused by the thermal damage of PET fiber.

4.Conclusions

Based on the above results, injection and compression molding methods, wherein the waste of PET/PE core/sheath non-woven fabrics are used as a raw material of composites without the separation of each fiber, show promise for contributing to the new recycling system of many core/sheath types fiber wastes. Especially, fairly large impact value can be obtained for the composites molded by compression method using non-woven fabrics, because of the long PET fiber.

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