마이크로파 가열에 의한 PET/PP 섬유다발의 용융거동에 금속입자의 영향

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Influence of Metal Particles on the Melt Behavior of PET/PP Fiber Bundles by Microwave Heating

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1. Introduction

Microwaves belong to the portion of the electromagnetic spectrum with frequencies between 300MHz and 300GHz.[1] In microwave processing, the energy is delivered directly to materials through molecular interaction with the electromagnetic field. This result in rapid heating throughout the material thickness with the reduced thermal gradients. If microwave is applied to fibrous materials, it can be reduced processing time. Also, application of microwave system has the results of remarkably enhancing productivity and improving operation environment owing to no air pollution. In previous study, we obtaine that the fiber permittivity must be high in order to generate much high-quantity.[2] But most fibers have low permittivity. Thus, inorganic particles(IP) with having high permittivity as bonding media were used to bond fibrous assemblies in this study. We have observed the heating capability and bonding properties of fibrous assemblies using IP and have investigated their morphological structure as well as debonding force with different conditions such as treatment time and kind of IP.

2. Experimental

2.1. Sample preparation

Raw material used to PET/PP fibers. Table 1 shows the dielectric properties and particle size of the used IP. Figure 1 shows the schematic diagram of sample preparation. The samples put between two heat-resistant glass plates with 0.75gf/mm^2 and then treated with different conditions in the specially designed microwave equipment(2450MHz). The IP were dispersed by H_2O and it used heating media.

Table 1. Dielectric properties and size of the used IP.

IP	Size(nm)	Dielectric constant	Loss tangent
TiO_2	32	96	0.0002～0.005
ZrO_2	27	12	0.0004～0.003
Al_2O_3	17	4.5～8.4	0.0002～0.010

2.2 Properties measurement

The morphological structure of bonding region was observed by using a scanning electron microscope(SEM S-5320, Hitachi. Co., Japan) and debonding force of prepared samples was measured by tensile tester(Instron 4467). The grip distance was 30mm. Crosshead speed was 5mm/min, and the used load cell was 5kgf.

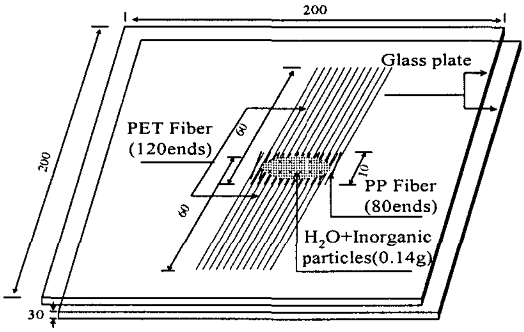


Figure 1. Schematic diagram to sample preparation.(unit: mm)

3. Results and discussion

3.1 Bonding time with IP

The bonding time with IP is increased in regular sequence Al_2O_3 < ZrO_2 < TiO_2 due to their different dielectric constant. In the previous study by Haque[3], the heating value of Al_2O_3 is the largest among the used IP and TiO_2 is smallest IP.[4]

3.2 Debonding force

Figure 2 shows the debonding force of PET/PP fibers with different treatment time and IP. As treatment time was increased, debonding force was increased, and the samples added ZrO_2 is the highest bonding force among the used IP. Because the dispersion of ZrO_2 particles was easier than other IP. Therefore melting area of PP fibers was increased. Consequently as treatment time was increased, debonding force was generally increased without choice of IP.

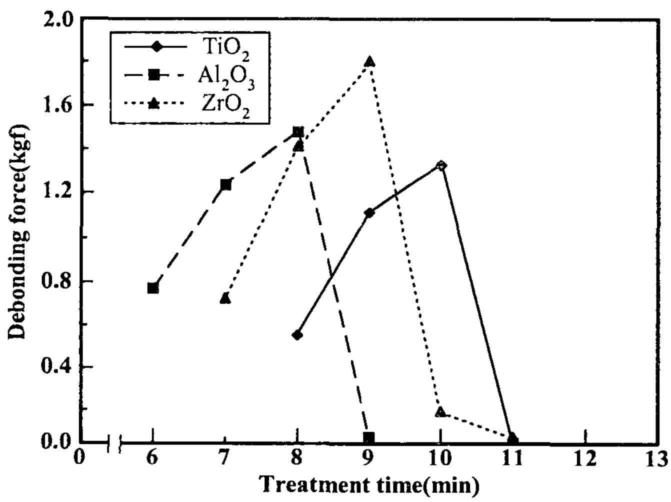


Figure 2. Effect of treatment time on debonding force of PP/PET fibers.

3.3 Change of fiber diameter

Table 2 shows the change of the diameter of PET fibers with treatment time. When treatment time was increased, diameter of PET fibers was increased. Because the shrinkage of PET fiber was appeared by heat generation of IP.

Table 2. Mean diameters of PET fibers with treatment time. (unit: ㎛)

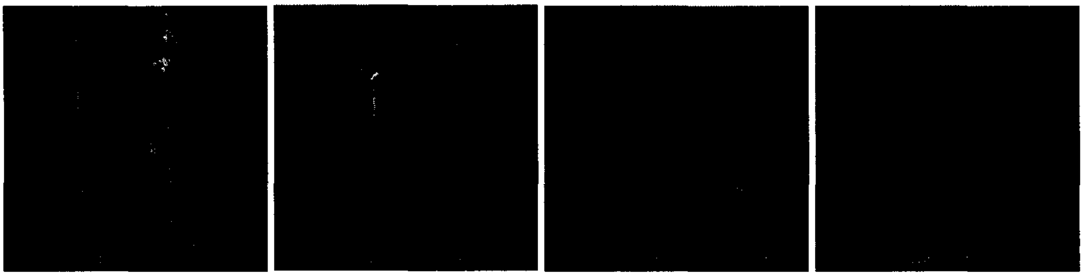
Treatment time(min)	TiO_2	ZrO_2	Al_2O_3
0	22.74		
6	-	-	23.85
7	-	23.75	27.96
8	24.86	24.43	28.24
9	25.97	26.58	-
10	27.24	-	-

3.4 Effect of IP

Figure 3 shows the morphological structure of melting region for the PP fiber with different treatment time. As treatment time was increased, melting region between fiber and TiO_2 was increased. Because fibers were melted directly by heat generation of TiO_2.

Figure 4 shows the morphological structures of bonding regions on the PET/PP fibers with different IP at fixed treatment time(8min). When treatment time was fixed at 8min, PP fibers began to thicken in the PET/PP fibers added TiO_2. And with the ZrO_2, PP fibers started to melt. In the Figure(c), PP fiber was melted completely. These results due to high dielectric constant and heating value of IP.

Figure 5 shows the debonding force of PET/PP fibers with different IP at constant treatment time(8min). The debonding force of samples added Al_2O_3 is the largest value among used IP. Because heating value of Al_2O_3 is larger than other IP.



(a) 8min (b) 9min (c) 10min (d) 11min

Figure 3. Microphotographs of PP/TiO_2 fibers with different treatment time.

4. Conclusions

1. To bonded the fibrous assemblies the optimum treatment time differs from the used IP which depends on the particle size and dielectric constant. In this experiment, optimum treatment times of TiO_2, ZrO_2 and Al_2O_3 are 10, 9 and 8minute, respectively.
2. In case of PET/PP fibers added ZrO_2, maximum debonding force was 1.9kgf and it is highest value among other IP and treatment conditions.

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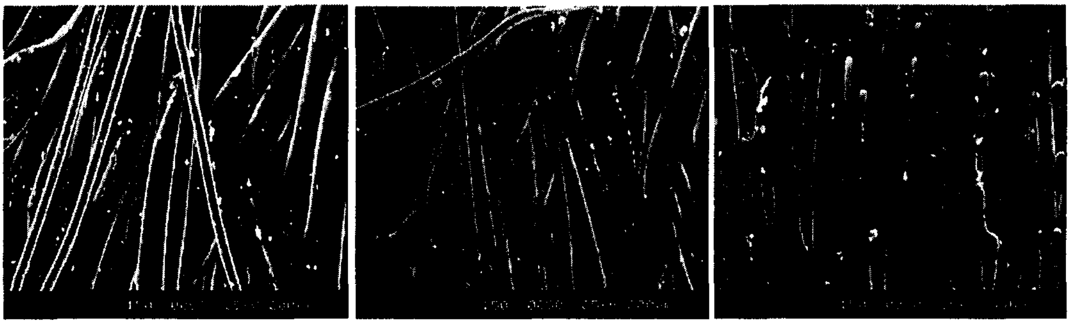
5. References

1. E. T. Thostenson and T. W. Chou, *Microwave processing: fundamentals and application*, composites: part A, V(30), 1055-1071(1990)
2. Chen, E. J. Siochi, T. C. Ward and J. E. Mcgrath, *Basic ideas of microwave processing of polymers*, Polymer Engineering and Science, V.33, 1992-1109(1993)
3. Kazi E. Haque, *Microwave energy for mineral treatment processing- a brief review* Int. J. Miner. Process. 57, 1-24(1999)
4. N. Standish, H. K. Worner and D. Y. Obuchowski, *Particle size effect in microwave heating of granular materials*, Powder technology, 66(3), 225-230(1991)



(a) TiO_2 (b) ZrO_2 (c) Al_2O_3

Figure 4. Microphotographs of PET/PP fibers with different IP. (8min)

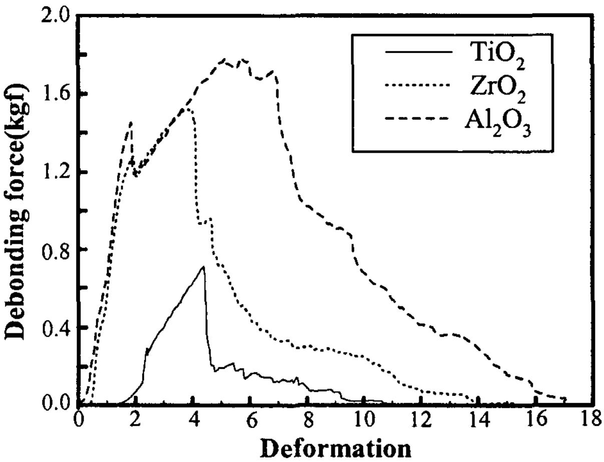


Figure 5. Debonding force/deformation curves of PET/PP fibers with different IP. (8min)