Heat resistance and mechanical properties of polyphenylene sulfone/glass fiber blends

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Abstract: Blends of Polyphenylene sulfone (PPSU) and Glass fiber(GF) with different weight ratios were prepared by melt extrusion using twin-screw extruder and three-screw extruder which had different shear and melt processing. In this work, the heat resistance of blends were evaluated by heat deflection temperature.In addition, the mechanical property tests were also carried out and the values of tensile modulus and flexural modulus of PPSU/GF blends enhanced to nearly three times higher than these of pure PPSU.
Keywords: Polyphenylene sulfone, Glass fiber, Blends,Heat deflection temperature

1. INTRODUCTION

Polyphenylene sulfone(PPSU) [1] is a kind of plastics which has wide application in electronics, automotive, medical equipment, packaging materials on account of its excellent properties, such as mechanical properties, thermal properties, flame resistance, creep resistance, chemical resistance, high transparency and so on. Glass fiber(GF)[2] reinforced plastics is an important means to increase the mechanical properties of materials. Glass fiber has many advantages, such as superior strength, corrosion resistance, dielectric properties and it is easy to shape.In this research, we illustrate the mechanical properties of different weight ratios in detail.Moreover, we prove that the addition of glass fiber has enhanced the tensile properties and flexural properties of pure PPSU.It improves the heat deflection temperature of blends,which makes the material has great heat resistance. Meanwhile, we find the blends prepared by twin-screw extruder have higher heat deflection temperature and impact strength than that of three-screw extruder, but have worse tensile properties.

2. EXPERIMENTAL

2.1 Materials

PPSU powder was produced by ourself. GF was purchased from Nittobo(china) Co., LTD.

2.2 Blends Preparation

Blends of PPSU powder and GF were first pre-mixed in a high-speed mixer with a speed of 18 r/min for 15 min. The mixed powder was dried in a vacuum oven at 110℃ for 5 h before extrusion.The content of GF was added to be 5%,10%,15%,20% ,25% and 30% of blendsin weight ratio.The polymer powder was blended by using a Haake twin-screw extruder at a screw speed of 200 rpm at335℃ and a three-screw extruder at a screw speed of 150 rpm at 345℃.The pellets were obtained by a granulator.

2.3Characterization Methods

Heat deflection temperature Testing:The heat resistance test was carried out on a Ceast 500 ALOXIDE high temperature thermal deflection temperature/Vicat Apparatus with a heating rate of 120℃/h.

Mechanical Testing: *T*ensile and three-point flexural tests were performed on a Shimadzu AG-1universal testing machine without a strain gauge type extensometer at room temperature. Therates for tensile and flexural tests were 5 and 2 mm min^{-1},respectively. Impact strength was tested by a JJANM-11 impact testing machine with simply supported beam.

3. RESULTS AND DISCUSSION

3.1 Heat deflection temperature

Theheat resistance of pure polymers and different blend compositions investigated by HDT are listed in Table 1and corresponding line chartsare shown in Figure 1.It is clearthat heat deflection temperature values increased with the increase of glass fiber content in the overall trend.The heat resistance of the blends using twin-screw extruder was better than that of three screw extruder.

Table 1.Heat deflection temperature of PPSU/GF Blends

Samples	Heat deflection temperature（℃）	
	twin-screw	three-screw
PPSU	**197.6**	**197.8**
PPSU+5%GF	**209.0**	**199.4**
PPSU+10%GF	**210.0**	**208.6**
PPSU+15%GF	**213.3**	**210.3**
PPSU+20%GF	**214.9**	**211.8**
PPSU+25%GF	**215.2**	**211.5**
PPSU+30%GF	**216.0**	**210.5**

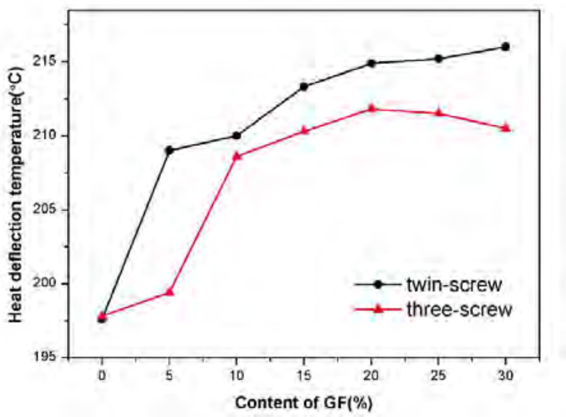

Figure 1. The curves of heat deflection temperature of blends with different contents of GF.

3.2 Tensile modulus and Tensile strength

Table 2 shows the values of tensile properties of PPSU/GF blends.From Figure 2, we could observe thattensile strengthand tensile modulus values increased with the increase of glass fiber content gradually.Even the tensile modulus increased to a value of 3.5 GPa for composite with 30 wt % GF content prepared by three-screw extruder, which was nearly three times of that of pure PPSU.Meanwhile, the tensile strengthof blends using twin-screw extruder was higher than that of three screw extruder.The tensile modulus value was opposite to it.

Table 2.Tensile Properties of PPSU/GF Blends

Samples	**Tensile modulus（Gpa）**		**Tensile strength（Mpa）**	
	twin-screw	three-screw	twin-screw	three-screw
PPSU	**1.1**±0.0	**1.3**±0.0	**69**±0.2	**72**±2.5
PPSU+5%GF	**1.1**±0.0	**1.6**±0.0	**77**±0.9	**74**±0.3
PPSU+10%GF	**1.5**±0.2	**2.0**±0.0	**87**±0.7	**82**±1.3
PPSU+15%GF	**1.7**±0.1	**2.4**±0.1	**96**±0.4	**88**±0.7

PPSU+20%GF	**1.7**±0.2	**2.9**±0.1	**104**±0.3	**94**±1.1
PPSU+25%GF	**1.6**±0.1	**3.2**±0.1	**106**±0.9	**98**±0.2
PPSU+30%GF	**1.8**±0.2	**3.5**±0.1	**110**±1.0	**102**±0.7

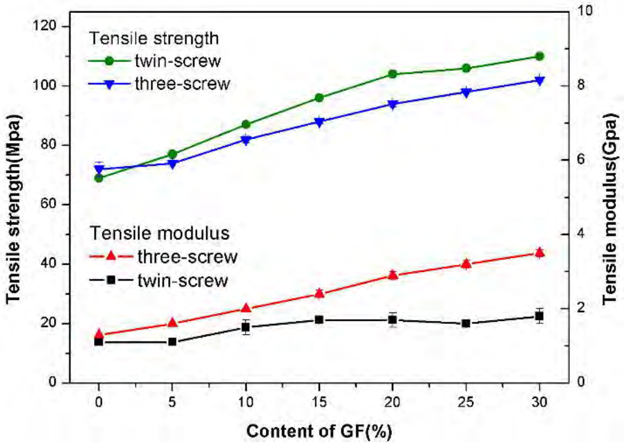

Figure 2. The curves of tensile modulus and strength of the blends with different contents of GF.

3.3Flexural modulus andFlexural strength

Table 3 shows the values of flexural properties of PPSU/GF blends. From Figure 3, it appeared thatflexural strength andflexural modulus values increased with the increasing content of glass fiber in general.Furthermore, the flexural properties of blends prepared by twin-screw extruder were better than these of three-screw extruder.

Table 3.Flexural Properties of PPSU/GF Blends

Samples	**Flexural modulus（Gpa）**		**Flexural strength（Mpa）**	
	twin-screw	three-screw	twin-screw	three-screw
PPSU	**2.5**±0.0	**2.3**±0.0	**91**±0.4	**76**±0.1
PPSU+5%GF	**3.2**±0.1	**2.9**±0.1	**114**±1.5	**92**±1.3
PPSU+10%GF	**4.2**±0.0	**3.6**±0.0	**134**±0.4	**106**±1.3
PPSU+15%GF	**5.1**±0.2	**4.4**±0.1	**155**±1.7	**126**±1.6
PPSU+20%GF	**6.0**±0.2	**5.0**±0.1	**161**±3.7	**137**±1.2
PPSU+25%GF	**6.6**±0.2	**5.9**±0.2	**154**±3.6	**151**±1.6
PPSU+30%GF	**7.2**±0.1	**6.6**±0.2	**155**±2.1	**155**±3.7

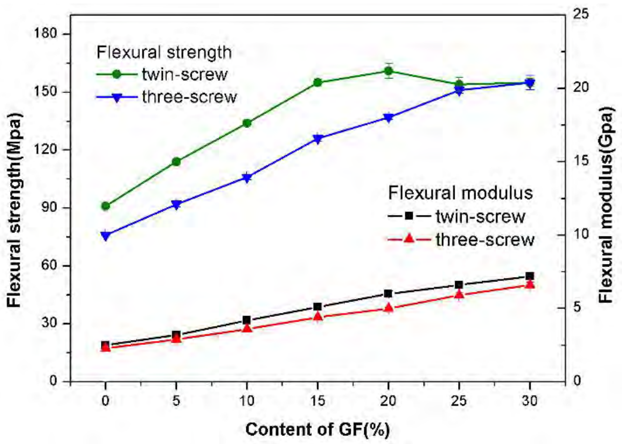

Figure 3. The curves of flexural modulus andstrength of the blends with different contents ofGF.

3.4 Impact strength

Table 4 and Figure 4 present the impact strength of each blending composites.Apparently, the incorporation of glass fiber had a certain effect on the inherent impact performance of pure PPSU whether the blends were prepared by twin-screw extruder or three screw extruder.

Table 4.Impact strength of PPSU/GF Blends

Samples	Impact strength（KJ/错误！未找到引用源。）	
	twin-screw	three-screw
PPSU	**47.7**±1.8	**34.9**±1.7
PPSU+5%GF	**9.1**±1.6	**7.2**±1.5
PPSU+10%GF	**7.7**±1.2	**5.3**±1.1
PPSU+15%GF	**9.0**±1.5	**5.7**±1.0
PPSU+20%GF	**11.5**±0.5	**5.5**±0.9
PPSU+25%GF	**8.9**±1.3	**6.0**±0.6
PPSU+30%GF	**8.8**±0.4	**6.0**±0.6

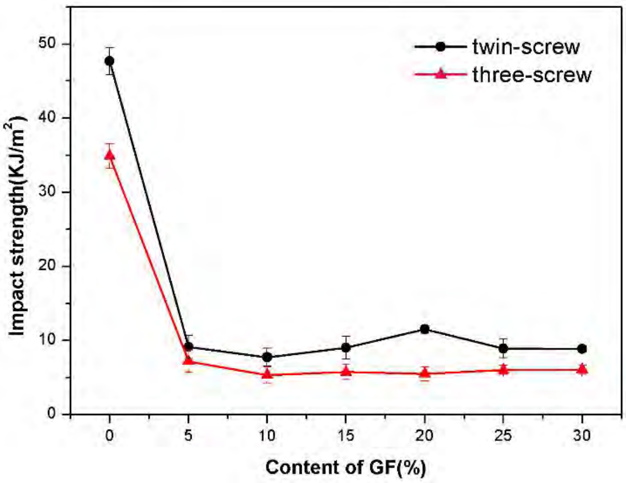

Figure 4. The curve of impact strength of blends with different contents of GF.

4. CONCLUSIONS

The HDT results indicated that the incorporation of glass fiber could improve the heat resistance of PPSU, and the properties of blends prepared bytwin-screw extruder was more prominent.Mechanical properties test results showed that glass fiber can augment the elasticity and rigidity of PPSU, but reduce the toughness. Simultaneously, because of its relatively small shear force, twin-screw extrudercan remain more original characteristics of the materials in the preparation of blends.Therefore,it has better reinforcing effect compared to three-screw extruder on the whole.

References

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