UV Light Degradation of Poly(phenylene sulfide)/nano-TiO_2 Composites

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Abstract: The properties of PPS/nano-TiO_2 composites for different UV irradiation time were investigated by FTIR, DSC, DMA. The crystallinity and storage modulus of samples increased with the nano-TiO_2 content increasing. Nano-TiO_2 retarded the degradation of PPS chains to form oligomers caused by UV irradiation, but caused more -OH group in the surface of PPS composites. The crystallinity of PPS/6% nano-TiO_2 composite decreased after UV irradiation.

Key words: poly(phenylene sulfide); nano-TiO_2; UV light degradation; FTIR
CLC number: TQ324.8 Document code: A Article ID: 0529-6579(2007)S1-0134-02

Poly(phenylene sulfide)(PPS) is one of the most important engineering polymers based on its good combination of toughness, high-temperature performance, resistance to solvents and other chemicals, flame retardance, moisture absorption and precision moldability[1-2]. The application of PPS fiber fabric filter for high temperature flue gas cleaning has been rapidly expanded in coal-fired power plant, cement plant and incineration plant[3-4]. However, upon continued exposure to UV-rich light, the color of PPS film and fiber darkens to yellow, tan, or brown, the UV-induced changes of color and property of PPS has been found to be a big obstacle for the further application. In this work, changes of structure and crystallinity in the surface of PPS/nano-TiO_2 composites have been studied by FTIR, DSC and DMA.

1 Experiments

1.1 Materials

Injection grade PPS resin[PPS-hbo(cross)] obtained from Sichan Deyang Co., China, molecular weight noted 48000. Rutile nano-titanium dioxide surface modified by stearic acid obtained from Shanghai Kangyu Co., China, the diameter of particles noted below 80 nm.

1.2 Sample Preparation and testing

PPS resin powder was mixed with nano-titanium dioxide by high speed mixer, then blended with twin-screw extruder and cut to pellets. The pellets were injected to the mold to form sample, the thickness of samples was 2 mm.

The infrared reflection spectra were obtained by means of Bruker Tensor 27 Fourier transform Infrared instrument. DSC was done on a TA Q100 instrument. DMA was measured by use of TA Q800 instrument using single cantilever accessory. Ultraviolet irradiation aging measurements were detected by UB-1 Xe lamp-weather instrument, Zhengzhou University of Light Industry.

2 Results and Discussion

Samples exhibited a glass change temperature at 87℃, a cool crystallization temperature about 121℃ and melting temperature at 285℃, respectively. The degrees of crystallization for pure PPS, PPS/0.5% nano-TiO_2 and PPS/6% nano-TiO_2 composites are 18.4%, 19.3% and 23.8%, respectively. nano-TiO_2 acted as nuclear function. As the nano-TiO_2 content increasing, the storage modulus improved.

2.1 Molecular structrue

The comparing reflection FTIR spectra of different UV irradiation time for PPS/6% nano-TiO_2 composites are showed in Fig.1. After UV radiation, the absorbance intensity of bands at 3417 cm^{-1} (ν), 1647 cm^{-1}

①收稿日期: 2007-01-10
基金项目: 国家 863资助项目 (2006AA03Z550); 上海纺织控股集团资助项目
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(e) and 1178 cm^{-1} (c) increased obviously while which at 1225 cm^{-1} (d), 1036 cm^{-1} (b), and 648 cm^{-1} (a) appeared and became stronger gradually. Peaks at 1647 cm^{-1} and 1178 cm^{-1} assumed to combine band and C-H in-plane deformation.

Bands at 3417 cm^{-1}, 1225 cm^{-1} and 1036 cm^{-1} are attributed to Φ-OH, Φ-O-Φ, and Φ-O- (H) stretch vibration, respectively. The band at 648 cm^{-1} is difficult for assignment exactly. Besides changed bands mentioned above, two shoulder peaks at 1157 cm^{-1} and 691 cm^{-1} belonged to oligomers changed apparently. The absorbance intensities of two shoulder peaks in pure PPS enhanced obviously when UV irradiation 200 h, and changed slightly along with the prolonged time, but which in composites increased slowly before 400 h. Results showed that nano-TiO_2 retarded the degradation of PPS caused by UV irradiation. The higher nano-TiO_2 content, the power oligomers produced.

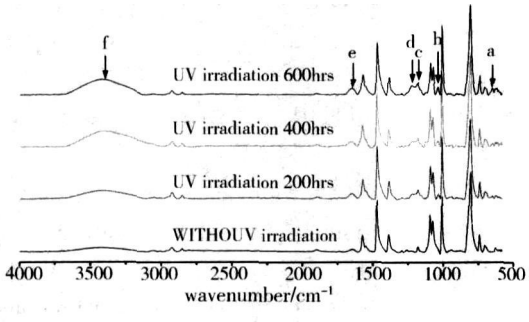

Fig. 1　Reflection FTIR spectra of PPS/6% nano-TiO_2 composites normalized to the band at 1470 cm^{-1}

2.2　Crystallinity

As the UV irradiation time progressively increasing, the crystallization degree of pure PPS increased gradually and changed slightly after 400 h. For PPS/nano-0.5% TiO_2 composite, the crystallization degree increased before 200 h, and decreased after 200 h. But crystallization degree of PPS/nano-6% TiO_2 composite decreased along with the UV aging time, the detailed data are shown in Tab. 1. High crystallinity causes more change for samples by UV irradiation.

Tab. 1　Crystallization degrees (X_c) of samples

Time of UV irradiation/h	Pure PPS	PPS/0.5% nano-TiO_2	PPS/6.0% nano-TiO_2
0	18.4	19.3	23.8
200	19.3	22.3	22.6
400	20.9	20.7	21.5
600	21	19.3	16.4

3　Conclusion

The degrees of crystallization for pure PPS, PPS/0.5% TiO_2 and PPS/6% TiO_2 composites are 18.4%, 19.3% and 23.8%, respectively. nano-TiO_2 acts as nuclear function. Nano-TiO_2 retarded the degradation of PPS caused by UV irradiation. After UV irradiation, the crystallinity of pure PPS increased, but which of PPS/6% nano-TiO_2 composite decreased.

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紫外光辐照对聚苯硫醚/纳米氧化钛复合材料的影响

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摘　要：采用 FTIR、DSC、DMA对不同紫外光辐照时间的聚苯硫醚/纳米氧化钛复合材料的性能进行研究。随着纳米氧化钛含量的增加，材料的结晶度和贮能模量增加。纳米氧化钛的加入抑制了因紫外光引发造成的聚苯硫醚分子链的降解。紫外光辐照后，聚苯硫醚/6%纳米氧化钛复合材料的结晶度明显降低。

关键词：聚苯硫醚；纳米氧化钛；紫外光；降解；红外光谱

中图分类号：TQ324.8