The research of far infrared flame retardant polyester staple fiber

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Abstract: Far infrared flame retardant slices was prepared, fiber with far infrared flame retardant composite function was also prepared by the method of melt spinning. Scanning electron microscopy (SEM) was used to observe the fibrous microscopic structure. In the SEM images, functional ultrafine powder particle size and distribution in the fiber were visible. The results show that the functional ultrafine powder is evenly distributed on the fibrous surface, which is closely combined with fiber, and the far infrared emissivity is F, which is more than (8 to 14 microns) 0.88. Far infrared flame retardant polyester fiber has not only good flame retardant, but also environmental health effect: releasing negative ions and launch far-infrared, which shows wide application prospect. The fiber was processed into far-infrared flame retardant electric blanket, whose functional indicators and flame retardant properties are not reduced.

1. Introduction

Electric blanket is a contact heating appliance. Electric blankets use special insulative cable-type electric heating elements, which were snake-like woven into or seamed into the blanket. The heat is issued when the electric heating elements was powered on. Electric blanket was mainly used to improve the bed temperature to achieve the purpose of keeping warm for sleeping person. In addition, electric blanket can also be used for bedding dehumidification. Electric blanket has many advantages, such as less power consumption, temperature adjustable, easy to use, and so on. Therefore, electric blanket is popular with consumers, especially in cold northern China and southern humid areas.

However, electric blanket also has some disadvantages: drying, radiation and fire safe hidden troubles. The use of textiles is one of the important factors that threaten the fire. It is an important measure to reduce the risk of fire by adopting flame retardant method to deal with textiles. Combining the flame retardant requirements of textile products, the development and production of flame retardant, low smoke and excellent flame retardant products can prevent the threat of textiles fire fundamentally and provide safety and security for people's lives and property [1-3].
In this experiment, flame retardant polyester staple fiber with far-infrared function was prepared. Far infrared flame retardant slices was prepared, fiber with far infrared flame retardant composite function was also prepared by the method of melt spinning. Far infrared emissivity and flame retardance at room temperature were measured.

Electric blanket with far infrared flame retardant fibers has a unique far-infrared function, which can effectively improve the metabolism of human body, promote blood circulation, anti-inflammatory analgesic and eliminate fatigue. Moreover, the natural far infrared emission function of the far infrared flame retardant fibers has a higher infrared absorption and thermal storage capacity, which can not only save energy, but also greatly reduce the side effects of radiation. And its good flame retardant properties can effectively prevent the occurrence of fire accidents, and because of the addition of powder formed irregular fiber surface, making the electric blanket has a good breathable properties, which make the electric blanket can maintain and regulate the body's normal water to avoid throat thirst feeling [4-6].

2. Experiment

2.1. Experimental materials and equipments

The main experimental materials used in the experiment are shown in Table 1.

| Name                        | Factory                                           |
|-----------------------------|---------------------------------------------------|
| Superfine functional powder | Beijing General Research Institute of Mining and Metallurgy |
| Far infrared flame retardant polyester chips | Sichuan East wood Technology Group Co., Ltd |
| Additives                   | Market procurement                                |
| Cationic modified polyester chips | Zhejiang Chemical Fiber Joint Group           |

The main experimental equipments used in the experiment are shown in Table 2.

| Name               | Factory                                      |
|--------------------|----------------------------------------------|
| Vacuum drum dryer  | Jiangyin, Jiangsu Chemical Machinery Co       |
| Spinning machine   | Jiangsu new pure Chemical Fiber Equipment Co., Ltd |

2.2. The preparation of far infrared flame retardant polyester chips

The terephthalic acid(C₈H₆O₄), ethylene glycol((CH₂OH)₂), flame retardants, far-infrared functional powder, catalyst and other additives were added into the esterification kettle according to a certain proportion. The esterification temperature was controlled between 245-258℃. When the water content reaching the predetermined value, and the top temperature of the column lowering than 100℃, is the end point of esterification. After esterification, the esterification liquid was introduced into polycondensation kettle, the condensation temperature was controlled between 275-285℃, vacuum <50Pa. Stop stirring when the motor stirring power meetting the technical requirements, and after cooling, pelleting and drying, the far infrared flame retardant polyester masterbatch was prepared.

2.3. The preparation of far infrared flame retardant polyester staple fiber

Far infrared flame retardant polyester chips were dried in the temperature of 150℃-170℃ for 8~10h, and then well mixed according to a certain proportion of the mixing machine before melt spinning. The spinning process conditions (1.67dtex × 38mm):

(a) The set temperature of screw extruder: I ~ V were 260 ℃, 270 ℃, 278 ℃, 275 ℃, 275 ℃ respectively;
(b) melt pipe: 275°C;
(c) pre-filter: 270°C;
(d) spinning box: 275°C;
(e) Metering pump speed: 35 rpm; Specifications: 12 cc;
(f) pump supply: 487.2 g / min;
(g) spinning speed: 900 m / min;
(h) Amount of oil: 0.7%.

The drafting process is set as follows:
(a) Draft speed: 120 m / min;
(b) draft multiple: 3.8 times;
(c) Drafting temperature: oil and water bath 72 °C; steam 105 °C;
(d) oven heat setting 115 ~ 120 °C;
(e) number of crimp: 8-9 pieces / 25mm;
(f) heat setting temperature: 120 °C.

3. Results and discussion

3.1. The test results of far infrared flame retardant polyester staple fiber

3.1.1. Ash measurement. By measuring the ash, on the one hand, the content of inorganic powder in the fiber and the maintain situation of the active ingredient can be determined; on the other hand, the process of granulation and spinning filtration performance can be determined. There are three groups of parallel experiments according to the national standard GB / T9345-88, the results were in Table 3:

| Number | Initial weight (g) | After burning constant weight (g) | Ash (%) |
|--------|--------------------|-----------------------------------|---------|
| 1      | 10.3465            | 0.3325                            | 3.2136  |
| 2      | 10.7149            | 0.3444                            | 3.2142  |
| 3      | 10.3100            | 0.3304                            | 3.2046  |

The average ash content of the far infrared flame retardant polyester staple fiber is 3.21%. By calculating the content of each substance in the fiber, the results show that the mineral powders were whole into the fiber, and the filter performance is good among the whole process in this study, and the active ingredient was well maintained.

3.1.2. Measurement of flame retardant properties. The flame retardant properties of the far infrared flame retardant polyester staple was measured by the authority, and the test results: limit oxygen index ≥ 30%, flame retardant UL94 V-2, with a very high limit oxygen index, low smoke, difficult to lead retardant, flame retardant effect of permanent, non-toxic, non-corrosive, non-polluting, is environmentally friendly halogen-free flame retardant products.

3.1.3. Far infrared emission function. The far infrared emission rate of the far infrared flame retardant polyester staple was measured by the authority, and the test results: far infrared emission rate is F(8-14μm)> 0.88, and the match rate with human skin’s wavelength is high, so it can be well absorbed by the body.
3.2. Analysis of far infrared flame retardant polyester staple fiber by SEM

![Figure 1. SEM images of far infrared flame retardant polyester staple fiber](image)

Figure 1 shows different magnification scanning electron microscopy photos of far infrared flame retardant PET staple, it can be observed that the distribution of far-infrared powder in the jurisdiction of the shape. From a, b figures, far infrared powders and fiber can be seen closely. The surface of fiber has many folds, which increase the surface area and improve the distribution area of far infrared powder materials and nano-additives.

4. Conclusion

The prepared far infrared flame retardant polyester staple fiber by this project has far infrared emissivity F (8-14 μm) > 0.88, limiting oxygen index ≥30% and flame retardant UL94 V-2. The flame retardant can withstand high-temperature melt spinning and has good compatibility with the host polymer. Therefore, the post-spinning treatment can not be affected and the physical and mechanical properties of the fiber has no big impact. The far infrared flame retardant polyester staple fiber has good flame-retardant performance durability. From the SEM figures, it can be seen that the ultra-fine far infrared particles were more evenly distributed in the fibrous surface and has a close combination with the fiber. The filtration and spinning performance of the far infrared modified polyester masterbatch is good. The far infrared flame retardant polyester staple fiber not only has far infrared effect and flame retardant properties, but also has a higher breaking strength and better functional fibrous performance, which make it has widely promotion and application value. The fiber was processed into far-infrared flame retardant electric blanket by the Chengdu Rainbow (Group) Co., Ltd., whose functional indicators and flame retardant properties are not reduced.

Acknowledgements

The authors are grateful for State Key Laboratory of Metastable Materials Science and Technology of Yanshang University, and the support of Jiangsu zhangjiagang anshun technology development co., LTD, Sichuan east of material science and technology group co., LTD In mianyang, China, and chengdu rainbow (group) co., LTD Chengdu, China.

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