Polypropylene Fiber Surface Modification via Nitrogen Plasma Pretreatment & Grafting and Subsequent Dyeing

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Abstract: Polypropylene (PP) fiber has outstanding physical and chemical advantages, but it is very difficult to be dyed so PP fiber's applications are greatly restricted. We have here studied the methods to ameliorate the dyeing property by nitrogen (N_2) plasma pretreatment and acrylic acid grafting. Its surface chemical composition was changed after plasma treatments and was characterized by Scanning Electronic Mirror-SEM, Fourier Transformed Infrared Spectra-FTIR accordingly. The results show that the fiber's surface after treatment could been dyed by basic blue 54 dyestuffs.

Key words: polypropylene fibre; plasma pretreatment; acrylic acid grafting; dyeing; dyeing ratio
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Polypropylene (PP) fibre is an important synthetic fibre appeared in the 60's of 20th century. But PP fibre can't be painted easily comparing with other fibres. So its application and development were greatly restricted[1].

Many attempts have been made to let PP fibre be easily dyed for more than 30 years. Our works hope to ameliorate the dyeing property through the surface modification by using plasma treatment.

1 Experiment methods and process

Experiment process according to the folowing orders:

Blank sample: Cleaning PP fibre → Testing → Dyeing → Testing

Sample one: Cleaning PP fibre → Treatment by Plasma N_2 → Testing → Dyeing → Testing

Sample two: Cleaning PP fibre → Treatment by Plasma N_2 → Testing → Grafting acrylic acid by plasma solicitation → Testing → Dyeing → Testing

1.1 Pretreatment of PP by plasma N_2

Put the cleaned PP in the plasma device, and discharge the Nitrogen gas with ratio frequency (RF) of 13.56 MHz.

1.2 Plasma grafting treatment with acrylic acid

Took the PP sample pretreated by plasma N_2 (5 min, 20 Pa N_2 and RF 30W) as the grafting sample, then introducing the vapor of acrylic acid into the device.

1.3 Dyeing

Adding the dyeing-aid solvent into the dye bath in which there were the dyestuffs of Basic Blue 54. 2%. The bath-water ratio is 1∶40.

2 Characterizations and discussions

2.1 Fourier transformed infrared spectra-FTIR figures

Comparing the FTIR figure 1 of three different samples: (a) (b) (c), we can see in (b) there is a strong transmittance peak at 3300 cm^{-1}, this peak shows that the amine group —NH_2 was introduced into the fibre. The figure (c) shows the transmittance peak at 1680 cm^{-1}. That shows the carboxyl groups C=O greatly increased and the acrylic acid were induced successfully[2,3].

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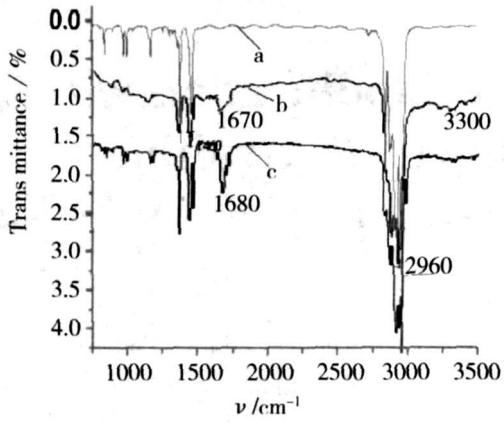

Fig. 1 PP fibre without treatment (a), PP fibre treated by Plasma N_2 (b), and PP fibre pretreated by Plasma N_2 then grafting with acrylic acid (c)

2.2 Scanning electronic microscope-SEM results

Figure 2 is SEM images from Blank sample, Sample one, Sample two, respectively. We can see from the SEM images that the surface topography of PP changed by plasma treatment. PP surface was smooth before treatment. But after treatment, PP surface changed as concave and protruding.

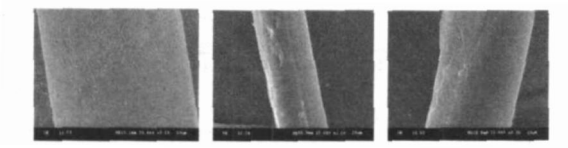

Fig. 2 SEM image for PP fibre without treatment (Left); SEM image for PP fibre treated by Plasma N_2 (Middle); and SEM image for PP fibre pretreated by plasma N_2 then grafting with acrylic acid (Right)

2.3 The dyeing effect of samples

The dyeing effects are shown in Fig. 3. We can see that PP fibre with grafting with acrylic acid can be dyed in Basic Blue 54 dyestuff, but PP fibre without treatment can't be dyed with any dyestuff.

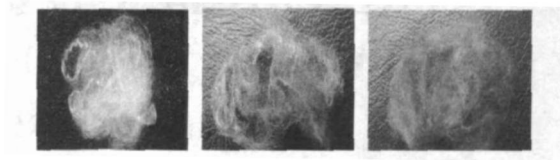

Fig. 3 Dyeing effect of PP fibre without treatment (Left); Dyeing effect of PP fibre with treatment by Plasma N_2 (Middle); Dyeing effect of PP fibre with grafting with acrylic acid (Right)

3 Conclusions

The dyeing property of PP fibre can be improved through the treatment by Plasma N_2 and by grafting with acrylic acid. The FTIR characterization indicats that the active groups of carbonyl group, amine group or amide group, etc were introduced onto PP fibre surface through above treaments. The SEM observations revealed that samples' surface was roughened or small agglomeration appeared. Therefore, the dyeing ratio of PP fibre relatively improved through the pretreatment of Plasma N_2 and further acrylic acid grafting, causing that PP fibre can be dyed with bright color.

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N_2等离子体接枝处理丙纶改性及染色的初步研究

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摘 要: 丙纶纤维具有显著的物理化学优点, 但丙纶纤维染色困难制约了其应用与发展。本研究用氮气等离子体对丙纶纤维进行表面处理, 然后用丙烯酸接枝丙纶纤维。用傅立叶变换红外光谱和扫描电镜分析改性前后样品。结果表明: 等离子体表面处理接枝后的丙纶纤维能染上鲜艳的阳离子艳兰。

关键词: 丙纶纤维; 氮等离子处理; 丙烯酸接枝; 染色; 上染率

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