New Size Latex Development for Wool Yarn Sizing and Analysis on the Properties

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Abstract: A new kind of size latex was developed for the sizing of wool yarn by graft copolymerization of two acrylic monomers onto gelatin. The product was analyzed by FTIR and the grafting copolymerization was confirmed. 10% water solution of the size showed low viscosity and good heat stability with excellent penetration properties in the wool yarn. By sizing treatment, strength of the yarn was greatly improved and the elongation at low stress was reduced. The size showed good desizing properties and the size film can be dissolved in boiling water easily.

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1. Introduction

With the trend towards lightweight worsted wool fabrics, some researchers have tried to develop new technologies to produce wool woven fabrics of high quality using unsized yarns[1]. However, most studies show that sizing of the yarn seems necessary for improving strength and reducing the hairiness and abrasion[2-5]. There are several methods for sizing of wool yarn, however, the most widely used sizing agent is based on olefin polymer. The main effect is to reduce yarn surface abrasion during weaving, but it can not improve yarn strength and reduce yarn elongation during weaving. Also it can not encapsulate the fibre onto the yarn surface tightly so as to reduce yarn hairiness. These years, major developments have been made to develop new kinds of sizing agents for foam sizing, and hot melt sizing[3]. Wool yarn is hydrophobic and it is very difficult to be sized by traditional sizes such as PVA, acrylic polymer, modified starch. These sizes are widely used for cotton yarns and for blend yarn of cotton and polyester, because these yarns are hydrophilic. We have also tried to use these agents to size wool yarns, however, poor results were observed.

We have attempted to develop a wool sizing method similar to cotton yarn sizing. Generally, the agent that can be used on the machines such as sizing of cotton yarn should have several main properties: (1) low viscosity with excellent heat stability in the sizing processing so that it can penetrate into the yarn inner part and encapsulate the fiber onto the yarn surface, (2) excellent mechanical properties to improve the yarn

strength and reduce the yarn elongation during weaving, (3) excellent desizing property and there is no harm residues in the desizing solution. [6]

According to a special principle that the similar chemical composition size can be used as good sizing agents for the similar chemical structure yarn, so starch is widely used as the sizing agent for cotton yarn, and polyacrylic size is used as polyester sizing agent because there are ester bonds in the sizing agent. Gelatin, which is similar to the wool fiber in the chemical composition, was selected as the studied object in our research. Actually, gelatin has been also developed as a kind a sizing agent for some yarns such as glass fiber. [7] We found that the water solution of 10% gelatin can penetrate the yarn smoothly and effectively, however its strength was not very good and its moisture regain was a little high due to lots of hydrophilic chemical groups in the molecular structure, the film formation properties was also not very good. We added some PVA into the solution and we hope PVA can improve the film strength and reduce the moisture regain in some degree. However, we found that their intermiscibility was very poor and there were small air bubbles in the prepared sizing film. This shows that their chemical interphase strength was not the same, and that PVA cannot be used as sizing agent for the wool yarn because of its poor interphase property with the protein materials such as wool yarn. However, we believe that gelatin can be further chemical modified to improve the properties and can be used as the wool size by traditional sizing method which is widely used in the cotton yarn weaving industry.

2. Experimental

2.1 Size latex development

Gelatin was chemically modified by grafting two acrylic monomers onto the protein. The two monomers were methyl methacrylate (MMA) and ethyl methacrylate (EMA). Potassium persulfate (KPS) was used as the initiator and the grafting condition was 75°C, grafting time was 5 hours, the total graft add-on was 25% (MMA and EMA were 12.5% respectively).

2.2 Experimental material preparation

100% wool yarn used to be sized was 35 Nm, color of the yarn was blue. Wool fabric used for the strength test was 178.5 g/m².

In the sizing film preparation, different concentration 5% and 10% of the sizing solution were prepared, and heated to 98°C. The sizing solution was poured into a box whose depth was 2mm and then it was dried in conditioned laboratory to form an even thin film.

In the sizing of the yarn, sizing solution was prepared at two levels, 5% and 10% respectively, after the sizing solution was heated up, then the yarn was treated in the sizing solution by immersing and squeezing method. The wet pick-up of the sizing solution on the yarn was around 85%. The yarn was dried at 95°C for 10 minutes.

2.3 Measurement

A FTIR tester of Nicolet 20 SXB was used to analyze the spectrum of the samples. Resolution for the infrared spectra was 4cm⁻¹ and there were 32 scans for each spectrum. An Instron tester 5566 was used to test the mechanical properties of the sized yarns and the sizing film. The sizing film was 8×5cm, drawing speed of the crosshead was 20mm/min.

Adhesion strength of the sizing agent on the wool fabric was evaluated. Two pieces of wool fabric (10×5cm) were immersed into the sizing solution for 5 minutes and laminated in the length direction as shown in Figure 1. They were dried up in the air condition, and the adhesion strength between the two fabrics was tested by drawing in the length direction.

Viscosity of 10% sizing solution was tested on NDJ-79 viscometer (rotating speed: 750 r/min.). Viscosity of the solution was tested at a certain interval time when it was heated above 95°C.

Desizing of the sized yarn was tested in a boiling

Fig. 1 Sample for test the adhesion strength of the sizing between two wool fabrics.

water and then the yarn weight changes was tested before and after the desizing treatment in conditioned standard laboratory (25°C and 65% humidity), phenomena of the sizing film changes in the heated water was also observed.

3. Results and analysis

3.1 FTIR analysis of wool fiber and the size

From the FTIR tested results of 100% gelatin (Figure 2), it can be seen that its chemical structure is very similar to wool fiber (Figure 4) in the range from 400cm⁻¹ to 4000cm⁻¹. In the FTIR spectrum of grafted gelatin (Figure 3), a new absorbing peak around 1720cm⁻¹ confirmed that the graft copolymerization was successful.

Fig. 2 FTIR spectrum of the 100% gelatin

Fig. 3 FTIR spectrum of grafted gelatin

Fig. 4 FTIR spectrum of wool fiber

3.2 Mechanical properties of the sizing film and the adhesion strength

Strength of the size film formed by 5% and 10% size solution were tested and the results are shown in Figure 5. It can be seen that the films show good strength and the strength curves are very similar to some polymer fibers. Strength of 10% size film is almost twice of the strength of 5% size film. Thickness of the 10% sizing film was 1.67mm and the thickness of the 5% sizing solution was 0.87mm.

Fig. 5 Tensile of the sizing film formed by different concentration of size solution

Adhesion strength of the size between two wool fabric surfaces is shown in Figure 6, it shows that the size has high adhesion strength between two fabrics, and 10% size adhesion is almost twice of the adhesion strength of 5% sizing.

Fig. 6 Adhesion strength of the size between two wool fabrics

3.3 Viscosity of the sizing solution

Viscosity of 10% sizing solution above 98°C was tested and the results are shown in Table 1. It shows that the sizing agent has very low viscosity and the heat stability is excellent. Solution of the agent is almost apparent.

Table 1 Viscosity of the sizing solution

Time, min.	0	30	60	90	120	180	240
viscosity, mpa.s	3.8	3.5	3.3	3.1	2.9	2.8	2.8

3.4 Strength of the sized yarn

Fig. 7 Drawing curves of several typical yarns

Mechanical properties of the sized yarn are shown in table 2, several typical drawing curves are shown in Figure 7. It can be seen that as the size add-on increases the yarn strength was improved greatly, especially the

modulus at low stress increases greatly. This means that the size have excellent strength improving effect, and the elongation of the yarn at low stress was reduced evidently. This is generally favorable in the weaving in which the warp yarn is usually working at low stress.

Table 2 Mechanical properties of the sized yarns

Size concentration	5%	10%	0%
Size add on, %	7.20	10.31	0
Strength, cN	278.93	323.59	229.41
Elongation, %	18.31	15.64	23.50
Strength improvement, %	21.58%	41.05%v	0

3.5 Desizing properties of the size

Desizing properties of the size was tested in boiling water, and the yarn weight changes were recorded and is shown in Table 3. It shows that the size has excellent desizing properties, weight of the desized yarn is slightly less than the weight of the yarn before sizing, this is perhaps mostly due to the loss of some fiber on the yarn in the desizing. Changes of the sizing film in the boiling water have been observed and the phenomena have been recorded in Table 4, the sizing film can be dissolved very soon in boiling water, and it is unnecessary to add other chemical agent in the water.

Table 3 The yarn weight changes before and after the desizing treatment

Size concentration, %	5%	10%
Yarn weight before sizing, mg	3.98	4.02
Yarn weight after the desizing, mg	3.95	3.99
Desizing percentage, %	100%	100%

Table 4 Changes of the size film in the boiling water

Desizing time, min	Size film changes phenomena
5	Film change into small pieces
8	Film reduce in the size and in the thickness
10	Film was dissolved totally

4. Conclusions

The grafted gelatin and the wool fiber were FTIR analyzed; the acrylic monomer was confirmed to be successfully grafted onto gelatin. Results show that the size has similar protein chemical structure to the wool

fiber. The size solution has very low viscosity and excellent heat stability. Strength of the sized wool yarn can be greatly improved, especially the modulus at low stress was increased remarkably. The size has excellent desizing property and can be dissolved in boiling water in several minutes.

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