The effect of weighting salts on the rate of dye absorption and wash fastness of silk yarns

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Abstract

There is chemical relationship between the protein fibers, wool and silk. Therefore silk can be dyed by the same methods as used for wool. Mordant dyes are used to increase dye absorption and wash fastness of wool and silk. In this paper weighing is used instead of mordanting process. A comparison was made by using mordant dyes to see the difference between degummed silk yarns and weighted silk yarns, dyed by the same dyestuff. Salt such as Zn(NO3)2, ZnCl2, Pb(NO3)2, Pb(CH3COO)2 were used for weighting silk and then dyed with 3 mordant dyes: C. I. Mordant orang6, C. I. Acid blue 158, C. I. Mordant brown 33. The results demonstrate that the wash fastness and dye absorption of the samples were improved, which it depends on dye structure. It is advantageous to replace some of the lost weight of silk (during degumming process) and achieve a desirable change in dye uptake and wash fastness.

Keywords: Silk weighting, Silk dyeing, Mordant dyes

1. Introduction

Silk fiber is a protein fiber that is produced from silk worms. Depending on the type of silk worm it is necessary to differentiate between mulberry silk, also called “real silk” and tussah silk, also called “wild silk”. Mulberry silk is produced by the moth (Bombyx mori), whose cocoon spinning silkworms feed mainly on mulberry leaves, and is cultivated as the chief source of commercial silk. Natural silk is highly appreciated for its mechanical properties and its outstanding characteristics, such as luster, handling, draping, etc.

Silk fiber is composed of different alpha amino acids orienting to form a long chain polymer by condensation and polymerization. It consists of 97% protein and the rest are wax, carbohydrate, pigments, and inorganic compounds. The proteins in silk fiber are 75% fibroin and 25% sericin by weight, approximately [1]. The sericin makes silk fiber to be strong and lackluster, therefore, it must be degummed before dyeing [2].

During the degumming of silk, there is a loss in weight amounting to about 25%, but the use of certain natural coloring matters, like logwood or cutch, or of iron compounds such as Prussian Blue, gave an increase in weight which was incidental to the actual dyeing.

Owing to the expensive nature of silk, it is only reasonable to suppose that a demand was made for all dyed materials to show a similar increase in weight and so replace some of the scouring losses. In past, the chief application of weighting was seen in the dyeing of blacks, by the combination of the absorbed tannin with iron salts; the use of colorless tannin extracts enabled a certain amount of weight to be added with other shades.

The introduction of the coal-tar colors marked a departure from weighting as incidental to dyeing and led to the investigation of methods for weighting silk as a finishing process. The use of tin salts is now so well established that even the older method for blacks, with iron salts, tannin, and logwood, is often replaced by treatment with a tin salt in conjunction with cutch as a mordant for logwood.

It has been known for a long time that in the weighting of silk besides tin salts compounds of metal salts such as U, Bi, Pb, Ba, Ni, Ca, Mg, Zn, etc. are known [3].

When silk is subjected to tin weighting, it becomes thicker and heavier in feel and it also acquires a higher draping quality, without losing its other excellent characteristics. For this reason, much work on tin weighting with stannic chloride has been done with silk and other materials [4,5].

Tin weighting involves a number of stages that require careful monitoring to ensure minimum undesirable side effect. The uptake of metal involves a complex series of chemical and physical reactions that are not fully understood. Two views have been put forward regarding the possible mechanisms, namely simple adsorption or chemical combination.

Today the following classes of dyes are chiefly used for dyeing silk: Acid dyes, Metal complex dyes and Reactive dyes. Mordant dyes are used to increase dye absorption and wash fastness of wool and silk.

Mordants are chemical additives that sometimes help a fiber accept a dye that it might otherwise reject. (The word mordant comes from the Latin ”morders” which means “to bite”) some of the more common mordants are Alum plus cream of tartar, potassium dichromate, Iron (II) sulfate, Tin (II) chloride, Copper (II) sulfate and etc.

This research work aims to study the difference between degummed silk yarns and weighted silk yarns, dyed by the same mordant dyes.

2. Experimental

2.1. Materials

2.1.1. Silk yarn

The silk yarn used is degummed (Bombyx mori) silk produced by Kashan silk Co.

2.1.2. Weighting salts

The salts, which easily diffuse in solution into the fibres, hydrolyze during washing; form oxide or chloride compounds insoluble in water are used for the silk weighting. In this research Zn(NO3)2, ZnCl2, Pb(NO3)2 and Pb(CH3COO)2 was used as metal salts.

2.1.3. Mordants and dyestuffs

Samples were dyed by mordant dyestuffs C. I. Mordant orang6, C. I. Acid blue 158, and C. I. Mordant brown 33. Potassium dichromate, Copper (II) sulfate and metal salts that mentioned above (see 2.1.2) were used as mordants.

2.2. Instrumentation

Dyeing was carried out into polymatt dyeing machine equipped with programmable control of time and temperature of dyeing and speed of circulation. The dye absorption (k/s) was detected by Texflash spectrophotometer (Data Color).

2.3. Methods

2.3.1. Silk-weighting

Five grams of silk yarns were dried at 105ºC, then immersed in metal salts solution and is allowed to absorb the salt to saturation.

The material was then washed thoroughly with cold water, which hydrolyzes the salt to yield gels of metal oxide and acid. The gel of metal oxide is precipitated in the fibers, while the wash water carries the acid away. The gel-fibers were next treated with a hot solution (70ºC) of disodium phosphate (180 g/l). The material was again washed thoroughly with cold water, when 25-30% (o.w.f) loading has been obtained the material finally treated with sodium silicate solution (12ºTW at 70ºC). We named these materials G1. G2 materials were treated only by metal salts, that is, this materials immersed in metal salts solution without treating with disodium phosphate or sodium silicate solution.

2.3.2. Dyeing

All samples, G1, G2, G3 (degummed silk yarns, untreated with weighting salts) and G4 (degummed materials mordanted with potassium dichromate and copper (II) sulfate solution), were dyed with mordant dyes in common process.

Wash fastness of dyed silk was determined by the methods described in BS washing test 1006 CO 2 (ISO 2) [6].

3. Results and discussion

The spectrophotometric specification, k/s, and wash fastness of the silk yarns are shown in table (1). It can be observed that the samples weighted with lead salts (G1) have the highest dye uptake. However, the degummed silk yarn (G3) has a high dye uptake too, but less wash fastness. There is a same condition for G1 and G3 in table (2). Therefore, it reveals that the weighting salt can act as positive factor on dye absorption, and also by forming the large complex molecule consists of mordant dyes molecules, that is obviously less water-soluble when on the fiber, possesses greater wet fastness, like mordants.

Table 1 untreated (G3) and treated silk yarns (G1) with weighting salts, then dyed with: C. I. Mordant orang6

Weighted silk by	K/S	Wash fastness
-	8.6	3
Zn(NO3)2	6.9	5
ZnCl2	5.9	4-5
Pb(CH3COO)2	8.0	4-5
Pb(NO3)2	8.7	4

Table 2 untreated (G3) and treated silk yarns (G1) with weighting salts, then dyed with: C. I. Acid blue 158

Weighted silk by	K/S	Wash fastness
-	3.1	3-4
Zn(NO3)2	3.4	4-5
ZnCl2	3.3	4
Pb(CH3COO)2	3.8	4
Pb(NO3)2	3.7	4

Table 3 untreated (G3) and treated silk yarns (G1) with weighting salts, then dyed with: C. I. Mordant brown 33

Weighted silk by	K/S	Wash fastness
-	6.2	3
Zn(NO3)2	7.3	2
ZnCl2	5.7	1-2
Pb(CH3COO)2	7.0	3
Pb(NO3)2	6.5	2-3

In table (3) G1 and G3 have a same value for dye absorption and wash fastness. It means that the effectiveness of weighting salts on k/s value and wash fastness of samples is very much dependent on the physical and chemical structure of mordant dyes.

Table 4 unweighting silk yarns treated by mordants (G4), then dyed with: C. I. Mordant orang6.

Mordants	K/S	Wash fastness
Potassium dichromate (sour method)	16.8	5
Potassium dichromate (sweet method)	12.0	5
Copper (II) sulfate (sour method)	14.0	4-5
Copper (II) sulfate (sweet method)	13.4	4-5

Table 5 Total weight increases of silk yarns, which treated only by weighting salt (G2) in weighting process

Weighting salts	Weight increase (%)
Zn(NO3)2	2.33
ZnCl2	8.84
Pb(CH3COO)2	16.5
Pb(NO3)2	11.5

Table 6 silk yarns, which treated only by weighting salt (G2) in weighting process.

Mordants	K/S	Wash fastness
Zn(NO3)2	15.0	5
ZnCl2	14.9	5
Pb(CH3COO)2	9.0	4-5
Pb(NO3)2	13.6	4-5

In table (4), the k/s ratio and wash fastness of samples, which treated by mordants then dyed by mordant dyestuffs, were greater in comparison to table (1). But in table (6) the samples that treated only by weighting salts and did not treated by disodium phosphate or sodium silicate solution have the same value for k/s and wash fastness in comparison to table (4).

It means that the phosphate and silicate steps in weighting process decrease the metal oxide presented in the silk yarn. Hence, we were able to achieve the higher value for weighting silk yarns in k/s and wash fastness by optimizing these steps in weighting process.

4. Conclusion

The dye uptake and wash fastness of weighted silk yarns (G1), yarns treated only by weighting metal salts (G2), degummed and metal salts free silk yarns (G3), and mordanted silk yarns (G4) were comprised. It was found that the silk weighting process could act as mordanting process on mordant dyeing of silk yarns. Furthermore, it reveals that the k/s ratio and wash fastness of weighted silk yarns increase by optimizing the phosphate and silicate steps in weighting process.

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