Study on the Dyeing Properties of Astrazon Red FBL on Carboxymethylation Cotton

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Abstract. The salt-free dyeing of cotton fabric were studied, at the same time, the influence of dye dosage, pH value, temperature, liquor ratio and dyeing time on dyeing behavior were discussed in this paper. The results showed that the suitable dyeing conditions of carboxymethylly modified cotton fiber with Astrazon red FBL were as follows: the dosage of Astrazon red FBL was 2% o.w.f, the dyeing pH value was 6-7, the temperature was 70°C, the ratio was 1:20, and the dyeing time was 70 min. Under the conditions of the dyeing process, the dyeing K/S value of the modified cotton fiber can up to 26 or so.

Introduction

The fabrics made of natural fiber, especially cotton fabrics, are popular with people because of their softness, hygroscopic breathability, antistatic properties, comfortable wearing, and economic benefits, etc. Cotton fibers are usually dyed with reactive dyes, and a lot of neutral electrolytes were needed to add into the dyeing process. From an ecological point of view, the discharge of high salinity wastewater has changed the natural water quality and destroyed the ecological environment. The high permeability of salt will lead to soil salinization around the rivers and lakes and reduce the yield of the crops [1]. Secondly, it is wasting salt resources and increasing production cost. Usually, cotton fiber is modified by cationic agent to improve the adsorption capacity of reactive dyes and other anionic dyes [2,3]. However, few researches concerned on anionic modification of cotton fibers and dyed them with cationic dyes. In this experiment, the carboxymethylly modified cotton fibers were dyed with Astrazon dyes to study the dyeing properties of the anionic modification of cotton fibers. This helps us to understand the dyeing properties of anionic modified cotton fibers.

Experimental

Materials

Fabric: The scoured and bleached cotton fabrics (117 ± 5 g/m²) were used.

Dye: Astrazon red FBL, purchased from DyStar (shangahi) Chemical Corporation Ltd.

Chemicals: sodium hydroxide, ethanol, glacial acetic acid, all above chemicals are analytical pure, purchased from China National Medicines Corporation Ltd; sodium chloroacetate, purchased from Shanghai Macklin Biochemical Co., Ltd.

Preparation of Carboxymethyl Cotton Fabric

Two reaction steps were used for the production of carboxymethyl cotton fabric, namely alkalization and etherification.
Alkalization: Cotton fabric was dipped into sodium hydroxide water solution (15% wt.) at 20℃ for 10 min, the textile was then baked at 60℃ for 10 min.

Etherification: Experiments were carried out using ethanol/water at 6/4 volume ratio as solvent. The obtained alkali cellulose fabric was dipped into sodium chloroacetate solution (150g/L) at 20℃ for 10 min, removed the textile and placed in the sealed bag for 1h at 70℃. After that, the textile was washed three times in water for 10 min, neutralized by acetic acid (2% wt.), washed three times in water for 10 min, and finally dried in oven.

**Dyeing of the Modified Cotton Fabric**
The process of the modified cotton fabric dyeing is shown in Figure 1.

![Diagram of the process of the modified cotton fabric dyeing](image)

**Color Measurement**
(1) The K/S values of the fabric were measured by X-rite Colorspec, and each sample was measured 8 times with an average value.
(2) The photos of sample were taken with the iPhone 6s plus.

**Results and Discussion**

**Effect of Dye Dosage on Carboxymethyl Cotton Fabric Dyeing Properties**
The effect of dye dosage on dyeing properties of carboxymethyl cotton fabric is shown in Fig. 2.
Figure 2. Effect of dye dosage on dyeing properties of carboxymethyl cotton fabric.

As can be seen from Figure 2, the K/S value of the fabric increased with the increasing amount of dye. At first, the amount of dye on the fiber increased fast, the K/S value of fabric increased rapidly. With the further increase in the amount of dye, the K/S value increases slowly. It might be due to the limited number of Astrazon dyestuffs on the carboxymethyl cotton fabric. When the dosage of dye is too large, the monolayer adsorption would occur on the dye molecules and the adsorption is saturated at a fixed position, resulting in the K/S value increasing slowly. The figure shows that the amount of dye at 2% is more appropriate. If the amount of dye is too small, it is difficult that the dye adsorbed on the fabric became saturate, and the color of the fabric is shallower. If the amount of dye is too high, a large amount of dye will be wasted, the dyeing cost is increased, and it will make the environment become polluted.

**Effect of pH Value on Carboxymethyl Cotton Fabric Dyeing Properties**

The effect of dyeing pH value on dyeing properties of carboxymethyl modified cotton fabric is shown in Table 1.

<table>
<thead>
<tr>
<th>pH</th>
<th>K/S</th>
<th>sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td>26.1</td>
<td></td>
</tr>
<tr>
<td>8-9</td>
<td>23.0</td>
<td></td>
</tr>
<tr>
<td>10-11</td>
<td>9.5</td>
<td></td>
</tr>
</tbody>
</table>

From Table 1, it can be seen that the K/S value increases firstly and then decreases with the increase of pH value. The K/S value of the dyed cotton fabric is the highest at pH = 6-7. Because of under the condition of too low pH value, the ionization of the carboxyl groups on cotton fiber is
inhibited. With the increase of pH value, the carboxyl ionization on the modified cotton fabric increases continuously and the negative charge of the fabric increases. Therefore, the K/S value of fabric is increased continuously. However, when the pH value is too high, the Astrazon red FBL dye will form small solid particles, which are more difficult to dissolve in the dye liquor and reduce the K/S value of the fabric. It shows that the Astrazon red FBL dyeing carboxymethyl cotton fibers on the appropriate pH = 6-7.

**Effect of Dyeing Temperature on Carboxymethyl Cotton Fabric Dyeing Properties**

The effect of dyeing temperature on dyeing properties of carboxymethyl modified cotton fabric is shown in Fig. 3.

![Figure 3. Effect of dyeing temperature on dyeing properties of carboxymethyl cotton fabric.](image)

It can be seen from figure 3 that the dyeing temperature hasn't significant effect on the K/S value of carboxymethylated cotton fabrics. Due to the Astrazon red FBL combining with carboxyl groups of the anionic modified cotton fibers are based on ionic bonds. The carboxyl group content of the modified cotton fiber is constant, that is, the content of the dye base is fixed. The dyeing diffusion model of Astrazon dyes on carboxymethyl modified cotton fiber is the pore diffusion model, and it means that increasing the temperature can increase the dye diffusion rate, but the final dye adsorption capacity and K/S value is of little. If the dyeing temperature is too high, it increased the chance of the dye desorption. Taking into account the levelling property of fabric, it is appropriate to select the dyeing temperature of about 70°C.

**Effect of Dyeing Liquor Ratio on Carboxymethyl Cotton Fabric Dyeing Properties**

The effect of dyeing liquor ratio on dyeing properties of carboxymethyl modified cotton fabric is shown in Fig. 4.

![Figure 4. Effect of dyeing liquor ratio on dyeing properties of carboxymethylated cotton fabric.](image)
From Figure 4, we can see that the liquor ratio from 1:20 to 1:100, at first, the K/S value of fabric is decreasing and then it is increasing, but the overall results indicating the liquor ratio has little effect on the dyeing properties. It is mainly due to the Astrazon red FBL combining with carboxyl groups of the anionic modified cotton fibers are based on ionic bonds. The dye rate is extremely fast, and liquor ratio has little effect on it. In Fig. 4, the results of 1:20 liquor ratio is similar to the fabric at 1:80 liquor ratio, and the water consumption at 1:20 liquor ratio is less than that at 1:80, it can reduce the discharge of dyed wastewater, and it can also ensure the levelling property of fabric, so the choice of 1:20 liquor ratio is more appropriate.

**Effect of Dyeing Time on of Carboxymethyl Cotton Fabric Dyeing Properties**

The influence of dyeing time on dyeing properties of carboxymethyl modified cotton fabric is shown in Figure 5.

![Figure 5. Influence of dyeing time on dyeing properties of carboxymethyl cotton fabric.](image)

It can be seen from Fig.5 that dyeing K/S value of the fabric shows an increasing trend at first and then a decreasing trend with the increase of dyeing time. The dyeing of carboxymethyl cotton fabrics with Astrazon red FBL reached the dyeing saturation in about 70 minutes. The cotton fibers are natural fibers, and there were a large number of holes in the fibers. The dyeing was in accordance with the mechanism of pore diffusion model. Under a certain time, Fiber can be well dyed. Then if the dyeing time prolongs, it will increase the desorption rate of the dye, and decrease the K/S value. Therefore, dyeing time is appropriate in about 70 minutes.

**Conclusions**

1. The carboxymethylated cotton fiber was successfully dyed with Astrazon red FBL dye, and the dyeing K/S value of carboxymethylated cotton fiber can reach about 26.
2. When the Astrazon red FBL dyed the carboxymethyl cotton fiber, with the increase of the amount of dye, the color strength (K/S) of fabric dyeing also increased. When the amount of the dye exceeded 2% owf, with the dye dosage increased, the color strength (K/S) hardly increased. And it is better to control the dosage of dye in 2% owf. The effect of dyeing pH value is increased firstly and then decreased, and the optimum pH = 6-7. The dyeing temperature and liquor ratio haven't significant effect on the K/S value of the carboxymethylated cotton fabrics. And the suitable dyeing time is about 70 minutes.

**References**
