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The Influence of Electrode for the Electrochemical Dyeing of Cotton Fabric

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Abstract. Using nickel electrode as dyeing electrode, sodium carbonate as fixing alkali and anodic region as dyeing region, cotton fabric was electrochemically dyed by reactive blue X-BR under external DC power supply. By comparing the dyeing rate, fixation rate, polarization curve and evenness of the two dyeing methods, it can be concluded that the electrochemical dyeing effect of nickel electrode on reactive dye cotton fabric is far better than that of traditional reactive dye dyeing method.

Keywords. Nickel electrode, electrochemical dyeing, reactive dyes

1. Introduction

Cotton and its blended fabric are the mainstream of the textile products in the market at present, this kind of the dyeing of textiles depends heavily on the chromatography is complete, bright color, high color fastness of reactive dyes, and its demand is huge. In the production and processing, in order to improve the dyeing rate and utilization rate of reactive dyes, a large number of electrolyte salts such as NaCl and Na_2SO_4 are needed to promote dyeing rate. This not only greatly increases the cost of dyeing, but more important that dyeing wastewater containing high concentration of electrolyte, their will cause great harm to the environmental water and lead to soil salinization. Therefore, a low salt or even salt-free dyeing of reactive dyes has attracted much attention in recent years. Reactive dye dyeing is famous for its bright color, complete chromatogram, simple application, low cost and high fastness [1-6].

Electrochemical not only closely related to the product of four chemical, at the same time also to infiltrate environmental science, energy science, biology and other areas, such as metal industry has a mixture of these results and electrochemical technology successfully applied in printing and dyeing industry, mainly used in dyeing, bleaching, matrix of industrial waste water degradation decoloring in areas such as [7]: Chemical technology, as a new dyeing technology that is applied in textile dyeing, it has many advantages: multi-function, automation, cleanliness, simple operation and flexibility, etc. Electrochemical technology is mainly used in the dyeing process of sulfurized dyes,

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VAT dyes, acid dyes and other dyes, but there is few research in reactive dyeing, human being need to devote more energy to explore [8-15]

Conventional or traditional dyeing usually needs to improve the dyeing bath temperature with the help of high energy outside world, or increase the dosage of additives to achieve the desired dyeing effect, energy consumption and severe material waste is serious, the subsequent printing and dyeing wastewater treatment is difficult. Therefore, bionics dyeing, foam, electrochemical dyeing and supercritical fluid and a series of new dyeing technology is gradually developed, among them, the use of electrolyte ions directional movement and electrode reaction, replace the heat with electric power in whole or in part and can be lower than that of conventional dyeing temperature on electrochemical dyeing, with higher percentage and dye uptake ratio and rate. As well as less environmental pollution and cost input advantages become very competitive dyeing process [16-20]

In this paper, the electrochemical dyeing of pure cotton fabric under the nickel electrode of reactive blue X-BR was compared with the traditional dyeing method of reactive blue X-BR, and the influence of nickel electrode on the electrochemical dyeing of cotton fabric was explored by comparing its dyeing rate, color fixing rate, polarization curve, uniformity and other properties.

2. Experiment

(1) Fabric: plain cotton cloth that has been reduced, boiled or bleached (0.5 g, 6.2 x 6.2 cm)

(2) Reagents: Na_2SO_4 (AR, Sinopharm Chemical Reagent Co. LTD); Na_2CO_3(AR, Sinopharm Chemical Reagent Co. LTD); Reactive blue X - BR (industrial); $La_2(SO_4)_3$; $Ce_2(SO_4)_3$; $LaCl_3$; $CeCl_3$; Nickel electrode (10 * 10 * 0.1 mm).

Dyes is as shown in figure 1.

(3) The instrument:

Experiment device is as shown in figure 2 and table 1:

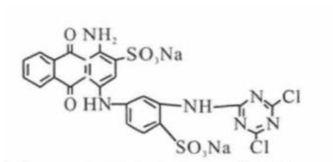

Figure 1. Reactive blue X - BR structural formula.

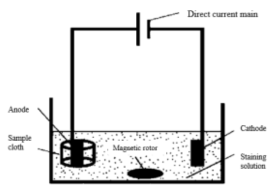

Figure 2. Electrochemical dyeing apparatus.

Table 1. Experimental equipment.

Equipment name	Model	Manufactures
Electric heating constant temperature blowing drying oven	DHG-9070A	Shanghai Thorpe Instrument Co., LTD.
Constant temperature oscillating water bath	L-12A, L-24A	Rabbit Precision Machinery Co., LTD. Xiamen

Electronic balance	FA1204	Ningbo Huafeng Instrument factory of Zhengzhou
CS electrochemical Workstation	CS310	Wuhan Branch, Instrument Co.
Heat collection constant temperature heating magnetic stirrer	DF-101S	Henan Yuhua Instrument Co., LTD

(4) The experimental methods:
Dyeing prescription is as shown in table 2:

Table 2. Dyeing prescription.

Dey/% (owf)	2
NaCl/ ($g \cdot L^{-1}$)	0
Na_2CO_3/($g \cdot L^{-1}$)	10
Bath ratio	1:50

The electrochemical dyeing process is as shown in figure 3:

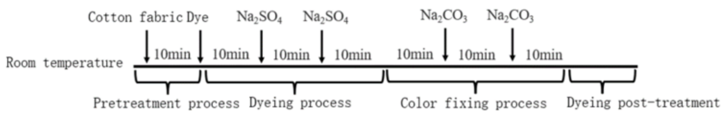

Figure 3. Dyeing process flow diagram.

3. Results and Discussion

(1) The electrochemical dyeing process

By comparing between electrochemical staining and ordinary dyeing process, we can see that the dyeing effect of electrochemical staining with nickel electrode is compared with that of ordinary dyeing process is as shown in figure 4:

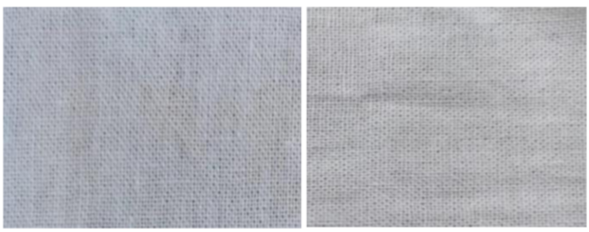

Figure 4. The electrochemical dyeing (left) and traditional dyeing cloth sample (right).

It can be found that the electrochemical dyeing effect by using nickel electrode is obviously higher than that by ordinary dyeing process.

(2) Determination of the dyeing rate

The original dyeing solution was diluted in A volumetric flask with A certain concentration, and the absorbance A_0 (controlled at 0.4~0.7) and the absorbance A of the residual solution after staining were measured at the maximum absorption wavelength (λMax), dyeing rate according to the type (1) calculation.

$$\text{Dyeing rate} = [1 - A/(A_0 \times n)] \times 100\%$$

Type:
A0 - Concentrate absorbance;
A - Dyeing residual liquid absorbance;
n - Dyeing residual liquid to concentrate dilution multiple.
Traditional dyeing process and electrochemical dyeing process as shown in table 3.

Table 3. Ways for dyeing absorbance contrast.

Absorbance	Traditional dyeing	Electrochemical dyeing
Standard dye solution	0.356	
Standard soap boiling liquid	0.030	
Dyeing the residual liquid	0.319	0.296
Liquid soap residue	0.237	0.260

By calculating available reactive blue traditional X-BR dye dyeing rate of 55.19%; dyeing rate in the electrochemical dyeing of 58.43%.

(3) The rate of solid color measurement

Two parts of the same soap solution were prepared separately, and one part was used for dyeing fabric soap. The other is standard soap boiling liquid. The dyed fabric was washed and boiled with soap (saponin 2g/L, soda ash 1g/L, bath ratio 1:50, temperature 95C, time l0min).

Diluting the standard soap boiling liquid to 500mL and suck 500mL in a 100m volumetric flask. Diluting to scale with distilled water. In addition, dilute the soap boiling liquid of the dyeing product to 500mL with distilled water, then siphon 20.00ml into a 100mL volumetric flask and dilute it to scale with distilled water. The absorbance of standard diluent and its boiled diluent was determined by spectrophotometer at maximum absorption wavelength then press type calculation fixation rate:

$$\text{Solid color rate} = E - \frac{C}{B \times n} \times 100\%$$

Type:
E: Dyeing rate;
B: Absorbance of the standard soap boiling liquid;
C: Soap boiling residual liquid absorbance;
n: Standard soap boiling liquid and soap residual liquid test concentration diluted multiples than.

By calculating available reactive blue traditional X-ray BR dye fixation rate is 44.10% electrochemical dyeing fixation rate is 46.25%.

(4) The polarization curve

Polarization curve experiment is an important basic data measurement experiment in "University Chemistry Experiment". Through the measurement of polarization curve, we can master the knowledge of polarization, passivation and over passivation of metal electrode and know the corrosion rate of metal [7].

Polarization curve experiment is an important basic data measurement experiment in the field of physical chemistry. Through the measurement of polarization curve, the knowledge about the polarization of metal electrode, the dissolution, passivation and overpassivation of anode, and the electrodeposition of cathode can be mastered. It can understand the corrosion speed of metal, such as studying the corrosion of grounding network metal and galvanized steel of transmission network, testing the corrosion mechanism and effect of corrosion inhibitor, etc. It can also be used in electroplating, electrolysis and electrical analysis. Through experiments, students can deepen their understanding of electrochemical theory, master basic operation, master basic methods, cultivate rigorous and realistic working style and practical ability. There are many electrochemical methods, but the measurement of polarization curve is the basic method to study the electrode process. Electrochemical parameters such as passivation potential range, passivation potential and passivation current can be obtained by polarization curve [8].

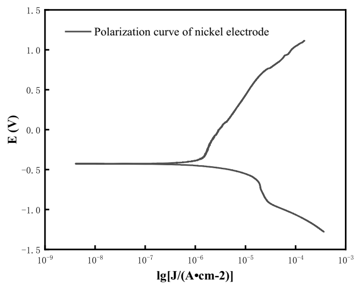

Figure 5. Polarization chart.

As shown in the figure 5, nickel electrode corrosion current is small. The anodic and cathodic curves of nickel electrode are smooth. The high polarization potential and low polarization current of nickel electrode indicate that the nickel electrode has the lowest corrosion rate and better corrosion resistance in the system.

The nickel electrode shows a good corrosion resistance in electrochemical dye solution. But due to the negative reactions such as self-corrosion of the electrode, the transfer of electrons on the electrode surface and the service life of the electrode will be affected, resulting in the decrease of dyeing rate and even uneven dyeing. The excellent electrochemical performance of nickel electrode in dyeing solution will enhance the electrochemical dyeing performance of cotton.

4. Conclusion

The electrochemical staining effect of nickel electrode on reactive blue X-BR is much better than that of traditional dyeing process. From the measured absorbance, it can be seen that the dyeing rate and fixing rate of the electrochemical dyeing of cotton fabric with reactive dyes by nickel electrode are better than the traditional dyeing process. The polarization curve analysis of the nickel electrode shows that the corrosion current of the nickel electrode is very small, the anodic and cathodic curves of the nickel electrode are relatively smooth, and the polarization potential of the nickel electrode is high and the polarization current is low, that indicating the nickel electrode has the lowest corrosion rate and better corrosion resistance under the system.

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