

ANALYZING THE SUITABLE ELECTROLYTE FOR REACTIVE DYEING PROCESS IN COTTON GOODS

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ABSTRACT

In this study, we report a comparison of different electrolytes Glauber salt, Common salt & Vacuum salt for the dyeing of Cotton fibers in a closed dyeing process. The dyeing properties of these systems are compared with their ability to control the different concentration of the electrolyte. In comparison with different salt it has no great effects on cotton dyed fabric as well as on the strength of shade. By the addition of Glauber Salt in dye bath as an electrolyte reduces TDS levels to an approximately 15-20%, this reduction load on ETP reduces the cost. The hardness of water by using Glauber salt is least increased which decreased the necessary of an order to get similar depth shade the concentration of Glauber salt required is less than common salt. However, no significant difference in the levelness of the dyed samples among the three electrolytes was observed and no significant difference in color fastness of the reactive dyed fabrics.

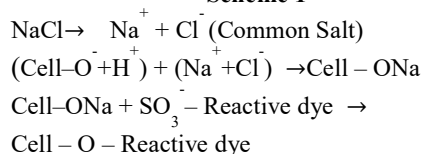
Keywords: Common Salt, Glauber salt, vacuum salt, Reactive dyeing, Dye pick up, color strength

1. INTRODUCTION

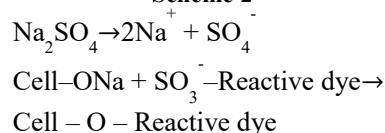
The textile substrate and dye molecule not necessarily should have of homogeneous characteristics to combine with each other. In such case, we require some catalyst to facilitate dyeing action on fabric, (Dawson and Roberts, 2011). Broadly speaking, salt is necessary in three ways, firstly to drive dye into textile during the dyeing process in textile, secondly, use of salt leads to maximum exhaustion of dye molecules during dyeing process in textiles and finally it is used as an electrolyte for migration, adsorption and fixation of the dyestuff to the cellulose material, (Broadbent, 2001 and Koh *et al.*, 2004). In reactive dyeing, the dyeing process can be broadly divided into two phases, namely exhaustion and fixation. The process is lengthy, because much time is spent on the controlled heating of dye bath and portion wise addition of salt and alkali in order to avoid unlevel dyeing and maximizing the exhaustion and fixation. A colorless crystalline solid NaCl inorganic compound of sodium and chlorine a salt in which ionic bonds hold the two components in the familiar white crystals soluble in water has a key role in textile dyeing process in maintaining electrolyte balance in textile dyeing process. Glauber salt is the common name for sodium sulfate dehydrates $\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$; it occurs as white or colorless monoclinic crystals are also used in dyeing purpose, (Brodale and Giauque, 1958). Vacuum salt is manufactured by recrystallization of purified brine solution. In vacuum crystallization process, raw salt is dissolved in water to make a saturated solution and clarify the impurities from the bottom. Vacuum is generated by using a suitable vacuum pump, (Arbor Ann, 1990). Reactive dyes for cotton have negatively charged active groups and they are anionic (Bide and Wang, 1995).

When cotton fiber immersed into water, its surface due to hydroxyl ions become also anionic, hence the dye particles and the cellulosic fiber tend to repel each other. The addition of salt creates an electrical positive double layer which hides negative electrostatic charge of cotton surface. This allows the dye approach the fiber. If electrolyte is not spreaded out uniformly on cotton surface, dye distribution will not even also and patchy dyeing is unavoidable. After the addition of salt and dye sufficient period of time should pass, for the even distribution of salt and the dye. This leveling period is between 30 and 45 minutes, depending upon circulation speed, (Asplanol, 1992).

Scheme 1



Scheme 2



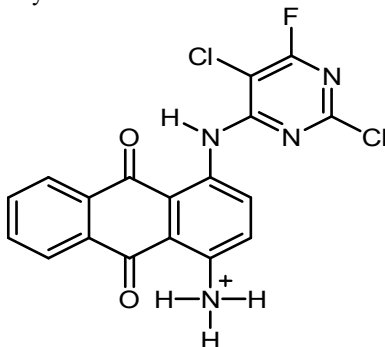
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In this study we investigate the cotton fabric dyeing by using Glauber salt and its comparison with common salt and Vacuum salt. Moreover pollution load caused by addition of all salts are comparatively analyzed.

2. EXPERIMENTAL

2.1 Materials

Scoured single Jersey fabric (100% cotton combed yarn, 26^s, 180GSM) was used for dyeing. Sandoclean PCLF (Detergent) (Clariant) and Centafoam SC (Anti-foaming agent), Sirrix 2UD (sequestering agent), Drimazin E2R (leveling agent) from Clariant were used respectively. The dye used in this study was Drimarene bifunctional Blue ERF (1.5%) Reactive dyes (Figure 1), Drimarene Red 3BFX (0.2%), Drimarene Yellow 4GL (0.3%). Reagent grade sodium carbonate (Na₂CO₃), Electrolyte (Common salt, Glauber salt, Vacuum salt), Caustic soda, Acetic Acid used in this study were obtained from Clariant Chemical Company.



Scheme 3: Structure of dye Drimarene Blue, Sandoz (British Patent 1440506)

2.2 Dyeing

A 100 ml dye bath, suitable for a 3.0 g sample of Cotton containing Reactive dye (Scheme 3) (2% on the weight of fabric), leveling agent (0.5g/l) and different concentrated Electrolyte was prepared. Dyeing was performed for 60 min at 60^o C in Supermat (Taiwan) Laboratory dyeing machine. The dyeing method used is shown in Figure 1. After dyeing all the samples were hot rinsed and treated with fixing agent (Sandofix EC, 1.5g/l) followed by washing and finally air-drying.

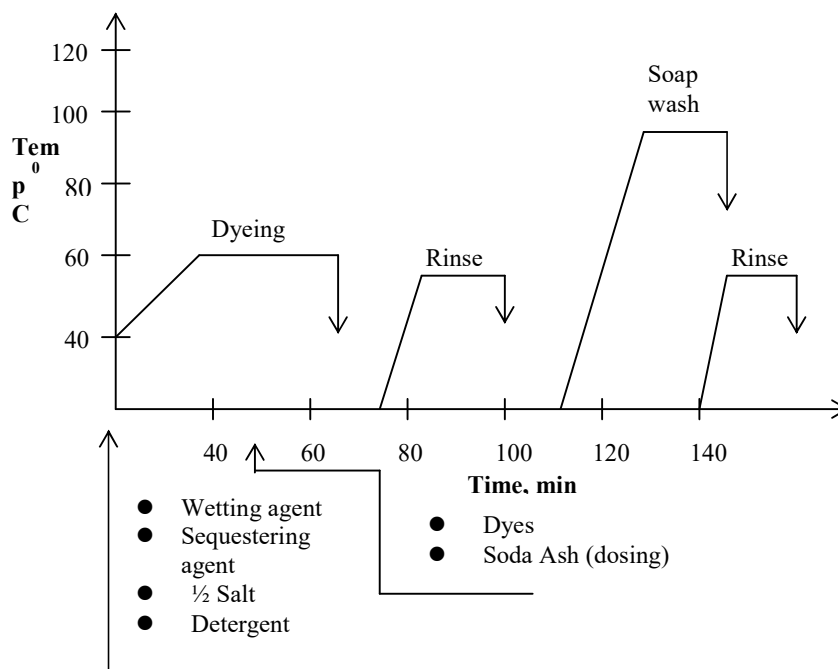


Figure 1: Dyeing profile of cotton fabric with reactive dye

2.3 Dyeing Properties

After dyeing a 5 ml sample of the residual dye bath was removed to measure the absorbance value using a UV-Vis spectrophotometer (HP8452A, Hewlett Packard) and the percentage dye bath exhaustion (%E) was calculated by using Eqn 1:

$$\%E = \frac{A_1 - A_2}{A_1} \times 100 \quad (1)$$

Where A_1 and A_2 are the absorbance of the dye bath before and after dyeing respectively. Dye bath pH and conductivity values were obtained using a pH/conductivity meter from the residual dye at room temperature after dyeing, (Xin, 2006).

The color of the dyed samples was measured using a spectrophotometer (Data Color-650 (USA), standard light D_{65} , 10° standard observers, specular component included) interfaced with personal computer.

2.4 Exhaustion behavior

Each dye pot was removed from the dyeing machine at 10 min intervals and the residual dye bath exhaustion, TDS and Hardness were measured. The K/S values of the dyed samples were measured using a spectrophotometer. The dyeing rates in the presence of different concentration of the salt expressed in the form of dye bath exhaustion and K/S were investigated in a comparative manner, (Koh *et al.*, 2004).

2.5 Color fastness test

Color fastness was determined according to international standards. The specific tests used were: ISO 105-C06 (color fastness to washing), ISO 105-E04 (Color fastness to perspiration), ISO 105-B02 (Color fastness to light) & ISO 105-X12 (color fastness to rubbing). Staining and change in color were assessed instrumentally, in order to determine gray scale ratings according to ISO 105-A05, (Park and Shore, 2006).

3. RESULTS AND DISCUSSION

3.1 Dyeing Properties

A Cellulose polymer has primary and secondary hydroxy groups which utilizes as nucleophiles. Under alkali conditions, the cellulose -OH groups are encouraged to deprotonate to give cellulose-O⁻ groups. These can attack electron-poor regions of the reactive hydroxy group and perform either aromatic nucleophilic substitution to aromatics or nucleophilic addition to alkenes. One problem is that instead of reacting with -OH groups on the cellulose, the fiber reactive group may react with the HO⁻ in the alkali solution and become hydrolyzed. The two reactions compete and this unfavorable because the hydrolyzed dye cannot react further.

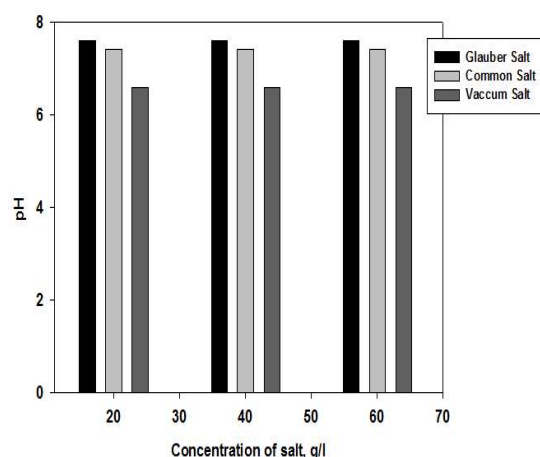


Figure 2: Effect of Various salt concentrations on the dye bath pH

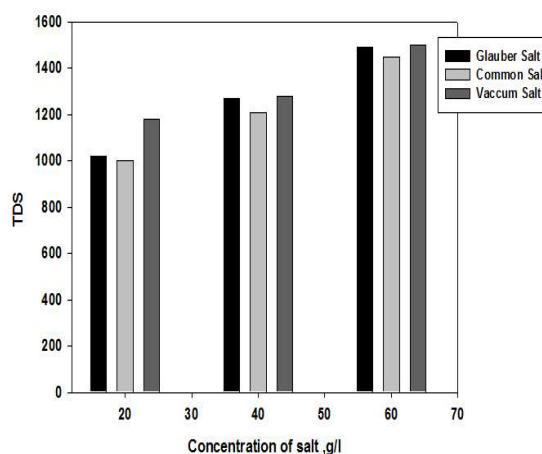


Figure 3: Effect of Various salt concentrations at the dye bath TDS levels

Figure 2 shows the residual dye bath pH with the concentration of different salt. As the concentration of different salt increases the dye bath pH has no changed in the solution. Glauber salt shows the higher pH values and it turns to the alkaline condition which is very essential for reactive dyeing process. However common salt shows the neutral pH values in the dye bath.

In this Figure 3 shows that the Total Dissolved Solid values of the dye bath increase by increasing the concentration of salt. Glauber salt in the dye bath reduces Total Dissolved Solid (TDS) levels to an approximately 15-20%. The concentration of salt increased the Total Dissolved Solid (TDS) levels which caused the environmental hazards and pollution load for ETP in dye house.

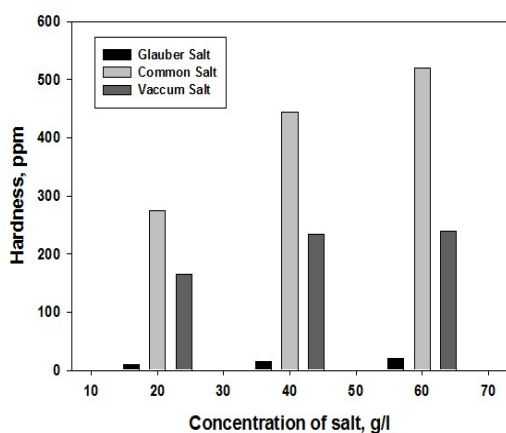


Figure 4: Effect of Various salt concentrations at the dye bath Hardness (ppm).

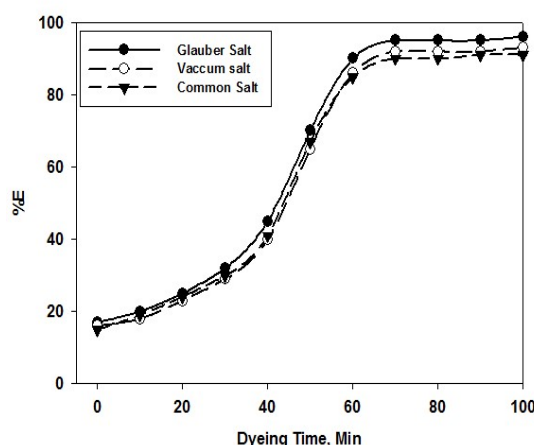


Figure 5: Dyeing rates of Cotton with dye in the presence of different electrolytes in terms of percentage of dye bath exhaustion.

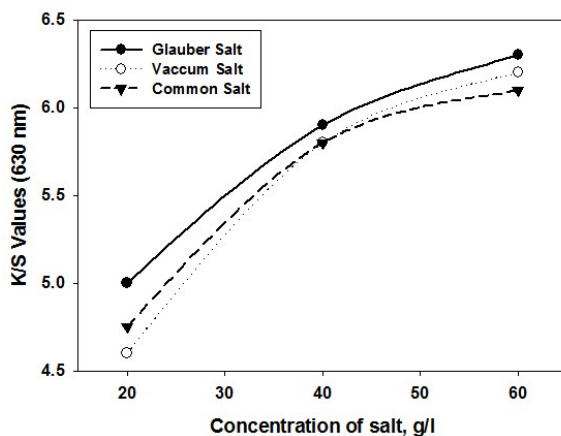


Figure 6: Effect of Various salt concentrations on K/S values of dyed fabrics

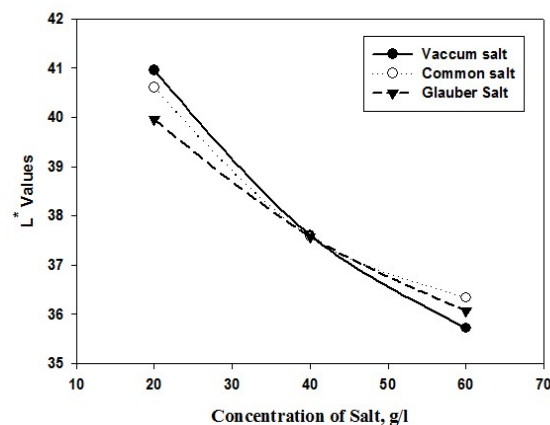


Figure 7: Effect of Various salt concentrations on L* values of dyed fabrics

The Hardness of water also measured from the dye bath which is influenced by the different concentration of the salt. The increased amount hardness may cause the unlevel dyeing. Glauber salt is not influenced by hard water that's why it may produce low hardness in the dye bath. In the case of Common salt it may produce highest hardness in the dye bath

Figure 5 shows the dyeing rates of cotton fabric with reactive dye in the presence of various electrolytes expressed in terms of dye bath exhaustion. It can be seen from this figure that the first 60 min of dyeing the dye baths shows 98%r exhaustion which is influenced by Glauber salt. In case of common salt and Vacuum salt shows 95% exhaustion. Therefore it can be sure that Glauber salt shows higher satisfactory result as electrolyte in the reactive dyeing process.

In this figure 6 it can be seen that the differences in different concentration of Glauber salt shows the significant changes of the K/S values than the other electrolytes. Because Glauber salt (Na_2SO_4) produce (Na^{2+}) ion which is twice more than the Common salt and Vacuum salt (NaCl). So Glauber salt can influence more dye uptake. Figure 7 shows that the L* values also influences by the concentration of salt. When the concentration of salt increases the shade depth becomes darker however 40g/l is the most considerable point for both of electrolytes. In the industrial point of view 40 g/l of the salt is suitable for the depth of shade and also suitable for cost minimization. Figure 8 clearly shows that the difference of color change for the different concentration of salt.

When the salt concentration increases the depth of shade also considerably changed by the influence of electrolyte. It is visually estimated that Glauber salt shows the highest performance for the reactive dyeing with cotton fabric.

Concentration of salt (g/l)	Glauber salt (GS)	Vaccum salt (VS)	Common salt (CS)
20g/l			
40g/l			
60g/l			

Figure 8: Effect of Various salt concentrations on the depth of shade of cotton fabrics

3.2 Color fastness

The rating of color fastness to washing of dyed fabrics shows 4-5. Color fastness to perspiration and light of dyed fabrics were in the range of 4-5 and color fastness to rubbing was all 4 irrespective of the different concentration of the electrolyte. (Where 5= excellent, 4= good, 3=average, 2=poor, 1=extremely poor). These results demonstrate that there is no difference in color fastness of dyed fabrics under various concentration of electrolyte is detectable.

4. CONCLUSION

However we did not observe any considerable difference in the levelness of the dyed samples among the three electrolytes in the laboratory scale dyeing undertaken in this study. But this study clearly shows that the use of different concentrated salt offers distinct advantages in the dyeing of cotton with reactive dyes in a closed dyeing system. In comparison with different salt we have investigated that Glauber salt shows the effective result for the reactive dyeing process. Consequently, these Glauber salts show higher percentage dye bath exhaustion than the Common salt and Vacuum salt in closed dyeing systems. In addition of Glauber salt as an electrolyte in the dye bath reduces Total Dissolved Solid (TDS) levels to an approximately 15-20%. This reduces load on ETP in turn provides cost advantages. Therefore the hardness of water by using Glauber salt is least increased and to get similar depth of shade the necessity of the concentration of Glauber salt is less than common salt.

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