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COLD PAD BATCH DYEING OF LINEN FABRIC WITH SOME REACTIVE DYES

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Abstract

Unmodified linen fabrics were cationized by reaction with two different commercial cationizing agents, CHTAC (3-chloro-2-hydroxypropyltrimethyl ammonium chloride) and PAQAC (polyaminochlorohydrin quaternary ammonium salt with epoxide functionality). The uncationized and cationized linen fabrics were dyed with four different reactive dyes with the cold pad batch dyeing method. The fastness properties of the dyed, cationized linen fabrics were evaluated.

Keywords: Linen fabric – cationizing agents – cold pad batch – fiber reactive dyes - cationization

Introduction

Linen is the yarn or fabric produced from the flax plant. Flax was one of the most widely used textile plant fibers, particularly in the Mediterranean, Eastern and North Europe. It was eventually replaced by cotton in the late 1600's (Ebakomp, 2002). Flax products are used either alone or in conjunction with synthetic fibers in various types of apparel. These metals exhibit excellent physical and chemical properties in terms of water absorbency, dyeability and stability (Preston, 1986., Shore, 1990).

Flax fibers have been reevaluated in recent years by the fashion industry and are increasingly appreciated by consumers due to the aforementioned features that confer freshness, comfort and elegance to linen apparel. Furthermore, demand for linen is growing in Western nations for the production of sheets, towels and other household textile items.

One approach to overcome the lack of affinity of linen for dyes is to modify the fabric to increase dye-fiber interactions. Lewis and Lei reviewed numerous chemicals that can provide cationic charges to cellulosic fibers (Wang et al., 2002). Since reactive dyes carry anionic charges, cationically charged cellulose would be expected to have a high affinity for these dyes. Other workers have demonstrated the feasibility of pretreating cellulosic fabrics with cationic materials prior to dyeing (Kamel et al .,2008) .

The process described in this paper is based on the use of a cationic reactant to modify the dyeing characteristics of linen fibers.

Modifying linen fibers with cationic charges prior to dyeing is an attractive route to improving dye-fiber affinity. Since fiber reactive dyes contain anionic groups for water solubility, the electrostatic interaction between a positively charged fiber and the anionic dye molecules can substantially increase the affinity of the dyes for the fiber. Numerous studies have reported a variety of chemicals that can impart a cationic charge to the cellulosic fibers (Evans et al.,1984.,Saima et al.,2007).

Fiber reactive dyes are molecules that combine chromophores with reactive groups that will form covalent bonds with the fiber via reaction with the fiber’s hydroxyl groups. Alkaline pH (11) is required for this reaction to proceed.

Experimental part

Fabric

Bleached linen fabric 212 gm/m^2 (supplied from SDL Textile Innovators USA) was washed with a solution containing 2g/L nonionic (Apollo scour SDRS supplied from Apollo Chemical USA) detergent at 90 ºC for 30 minutes. The fabric was then thoroughly rinsed with water at room temperature(25 ºC)

Materials

Cationizing agents

CHTAC

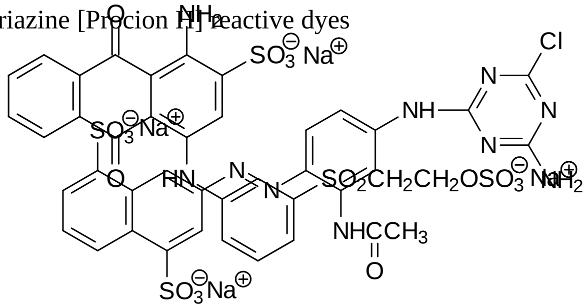
A commercially available solution of 3-chloro-2-hydroxypropyltrimethyl ammonium chloride (65% solution in water) was supplied by Dow Chemical Company USA as CR-2000.

PAQAC

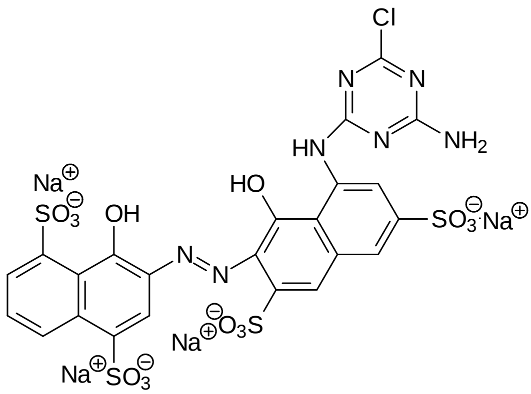
A polyaminochlorohydrin quaternary ammonium salt with epoxide functionally was supplied by (Huntsman, Switzerland) as an aqueous solution of approximately 40% solid content as Albafix.

Dyes used

Monochlorotriazine [Procion H] reactive dyes

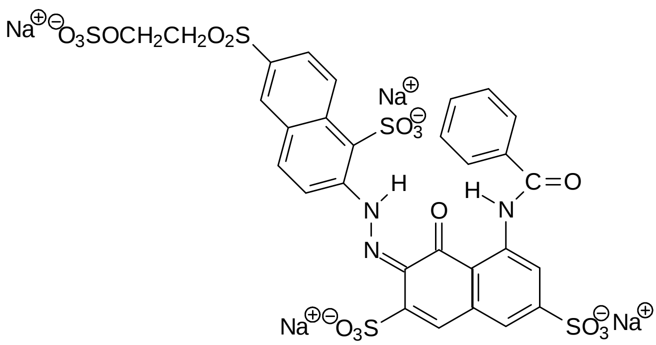


CI Reactive Yellow 3 λmax = 410 nm in water



CI Reactive Blue 13 λmax = 590 nm in water

Vinyl sulfone (Remazol) reactive dyes



CI Reactive Red 180λmax = 520 nm in water

-CI Reactive Blue 19 λmax = 610 nm in water

All dyes were of pure grade and supplied by Dystar, Germany. Other chemicals were commercial grade.

Methods

Cationization process

Solutions consisting of different concentrations (100-250) gm/L, and different concentrations of sodium hydroxide (60-210) gm/L.) of CHTAC were pad applied to the linen fabric [an HVF Laboratory padder from Werner Mathis was used]. The 2, 3 – epoxy propyltrimethyl ammonium chloride reactant is formed in situ in the pad bath. To minimize hydrolysis of the epoxy reactant, the sodium hydroxide was added to the bath just prior to application. The padder was adjusted to give pickup of constant value 90%. The padded fabric was wrapped in plastic to prevent chemical migration due to evaporation of water and to exclude carbon dioxide from the padded fabric. The wrapped fabric was stored at room temperature for different time intervals (8-24) hrs, then rinsed several times with water and finally with diluted (1g/L) acetic acid solution followed by air drying. The final fabric pH was 7.4 (AATCC ,1999) .

The same method for cationization was used with the PAQAC cationizing agent.

Dyeing procedures

Linen was cold pad batch dyed with the selected reactive dyes. Using 2.5% owf shades of the dyes, the cationized and uncationized linen fabrics were padded with the dyeing solutions at pH 11, by adding the dyeing solution portionwise with the padded fabric with a constant wet pickup of 90%. The padded fabric was wrapped in plastic to prevent chemical migration due to evaporation of water and stored at room temperature for 24 hours. Minimal rinsing was needed since the dye-fiber interactions are strong enough to allow a single warm rinse following the dyeing. Soaping with 3g/L nonionic detergent at 70ºC for 30 minutes was done followed by rinsing with water and air drying.

To confirm the effect of different cationization factors with the two cationizing compounds CHTAC and PAQAC the k/s values of the dyed fabrics at the maximum absorbance wave length λmax for each dye were measured using Data Color Spectra Flash SF600 plus spectrophotometer with SLi-form/NG software from Shelyn.

The fastness properties of the cationized dyed linen fabrics were determined (AATCC ,1999).

The gray scale was used to evaluate the staining and color change of the dyed fabric samples.

Results and discussion

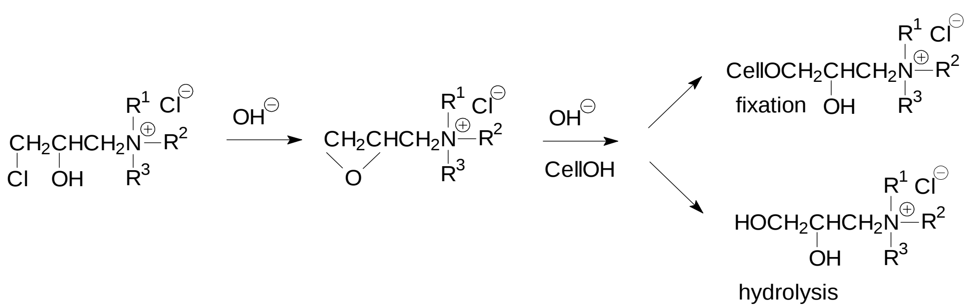
Cationization

Several studies[(Hauser et al., 2002 .,Hauser et al., 2001.,Hauser et al., 2000.,Purista,.,2007 ,El shishawy et al., 2004) were reported to determine the optimum reaction conditions for preparation of the cationic cellulosic fiber using 3-chloro 2-hydroxypropyltrimethyl ammonium chloride (CHTAC).

The cold pad batch method for cationization with CHTAC is a pH dependent reaction process requiring the addition of alkali (sodium hydroxide solution) (Hashm et al., 2005).

PAQAC is a polyaminochlorohydrin quaternary ammonium polymer with epoxide functionally that can also react with cellulose via ether formation in the presence of alkali .

Therefore the reactivity of these reagents in aqueous alkaline medium during the pretreatment process is similar to that of reactive dyes during the dyeing process of cellulosic fibers, especially regarding the hydrolytic effect of water that competes with either formation. Thus the cationization reactions can be represented by the following scheme.



where for CHTAC R[1], R[2], R[3] = CH_3
and for PAQAC R[1], R[2]=alkyl and R[3] = polyamine

Factors affecting the cationization process

Batching time effect:

The fabrics were padded in solution containing 60g/l sodium hydroxide ,100g/l cationizing agent CHTAC and/or PAQAC and wetting agent 2g/l.After padding the fabrics were wrapped in plastic for different time intervals of 8, 12, 16, 20 and 24 hours. The samples were rinsed and neutralized with 1g/L acetic acid solution.

Cationized linen fabric with CHTAC and/or PAQAC and the uncationized linen fabric were dyed using the four dyes 2.5% shade with the cold pad batch dyeing method. After batching the dyed fabrics were rinsed and soaped with a solution containing 3g/L nonionic detergent at 70ºC for 30 minutes and rinsed and air dried.

The dyed uncationized linen fabric had no color after soaping with the four different dyes, so the K/S values for the linen cationized with CHTAC were compared to the linen cationized with PAQAC.

Figure 1 represents the relation between batch time in cationization with CHTAC and the value of K/S of the dyed cationized linen fabric dyed with the four reactive dyes used. This figure shows that better K/S values were obtained when the batching time was 12 hours in the case of CHTAC.

Figure 2 shows that better K/S values were also obtained at batching time of 12 hours for the cationization with PAQAC.

Also the Fig1,2 shows higher values of K/S for the linen fabric treated with CHTAC compared to the linen treated with PAQAC as a result of the strong bonding and
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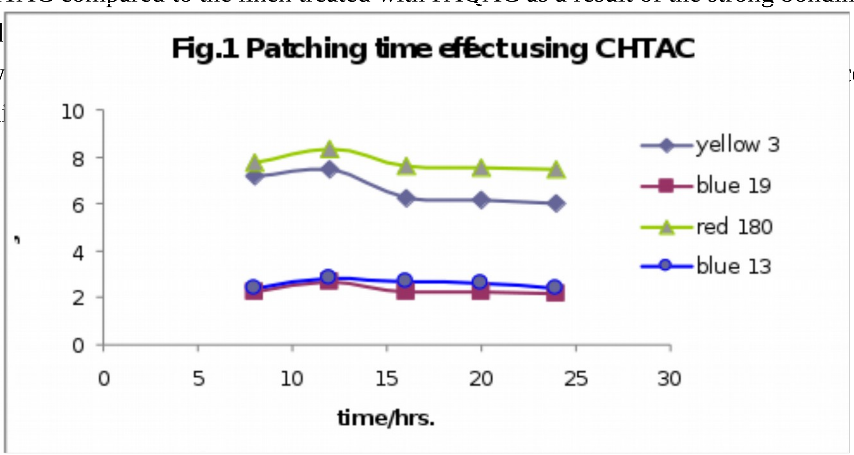
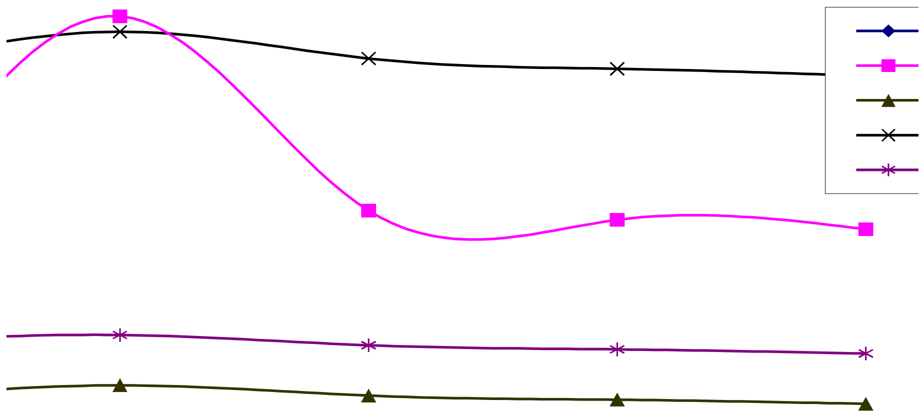


Fig.1 Patching time effect using CHTAC



Sodium hydroxide concentration effect:

At constant concentration of the cationizing agents, 100g/L, and a batching time of 12 hours, different concentrations (60, 90, 120, 150, 180 and 210 g/L) of sodium hydroxide were used. After dyeing with constant conditions, the relation between the sodium hydroxide concentration and the K/S values for the cationized dyed fabric with CHTAC and PAQAC are represented in Figures 3 and 4.

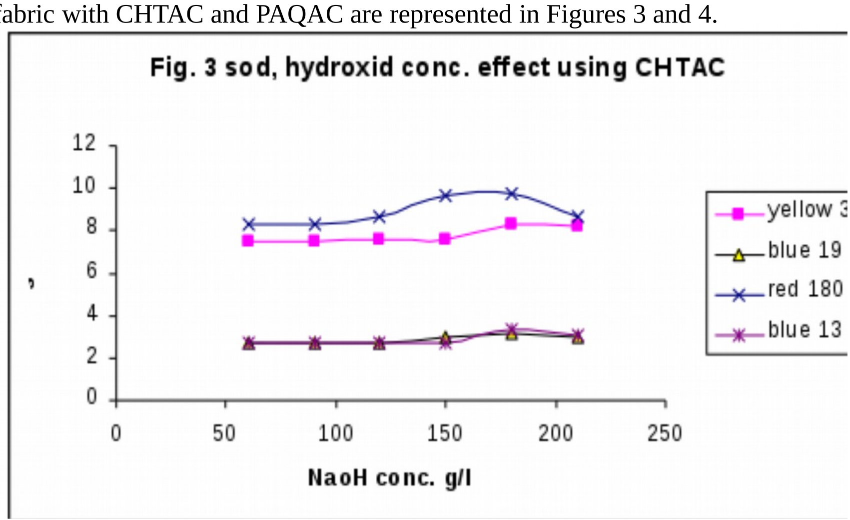


Fig. 3 sod, hydroxid conc. effect using CHTAC

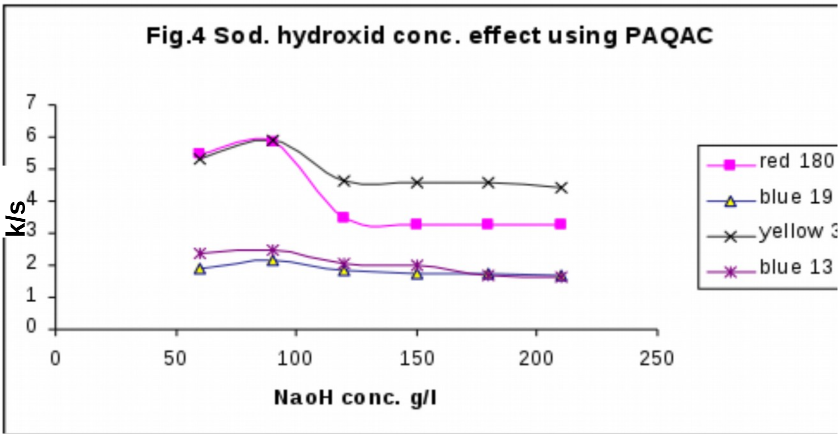
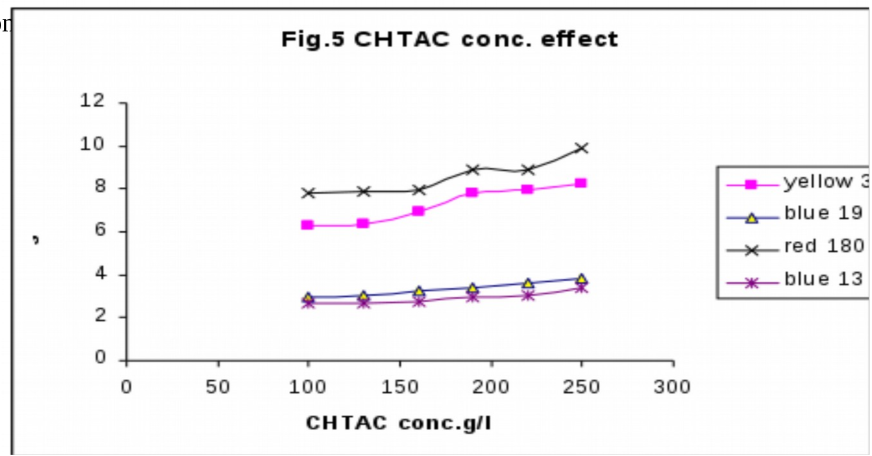


Figure 3 shows that the maximum value of K/S for each dye used was obtained when using 180 g/L sodium hydroxide solution with CHTAC cationizing agent.

Figure 4 shows that the best results were obtained when using 90 g/L sodium hydroxide with PAQAC cationizing agent.

Cationizing agent concentration effects

The cationization reaction was carried out at constant batching time 12 hours and constant concentration of sodium hydroxide 180 g/L in the case of using CHTAC cationizing agent and 90 g/L in the case of using PAQAC cationizing agent for different concentrations of the cationizing agents 100, 130, 160, 190, 220 and 250 g/L. After the dyeing process with the four dyes and after soaping, the results in Figures 5 and 6 show the relation between K/S values and cationizing agent con



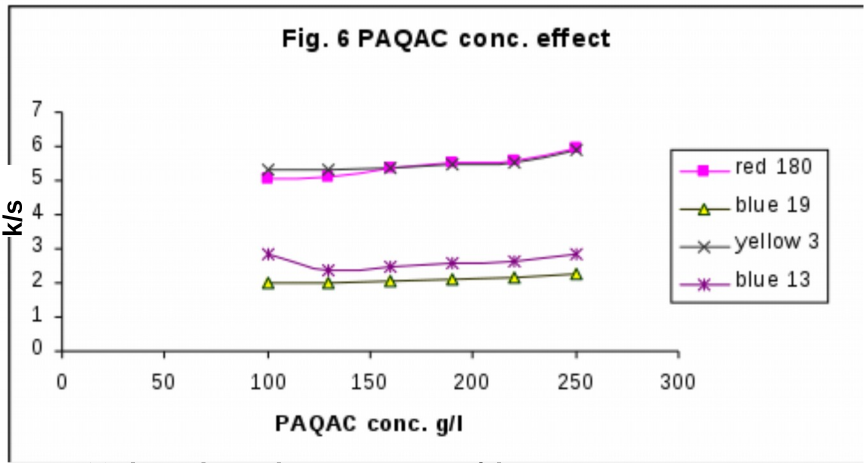


Fig. 6 PAQAC conc. effect

Figure (5) shows that as the concentration of the cationizing agent CHTAC increased from 100-250 g/L, the value of K/S for the dyed fabric increased with the best results at a CHTAC concentration of 250 g/L.

Figure (6) shows that similar results were found with the PAQAC cationizing agent.

Fastness properties

Table I shows that the fabrics dyed after cationization with CHTAC show comparable wet fastness and color fastness properties when compared with the samples cationized with PAQAC cationizing agent.

dye used	Cationizing agent	washing fastness			perspiration fastness: acidic			perspiration fastness: alkaline			rubbing fastness		light fastness	
		.st*	*st*	Alt.	.st*	*st*	Alt.	.st*	*st*	Alt.	dry	wet	20 hrs.	40 hrs.
Yellow 3	CHTAC	3-4	4	4	3-4	4	4	3	4	3-4	4-5	3-4	4-5	4
	PAQAC	3-4	4	4	3-4	4	4	3	4	3-4	3-4	2	3	2-3
Blue 19	CHTAC	4-5	4	4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3	4	3-4
	PAQAC	4-5	4	4	4	4	3-4	4	4	4	2-3	1-2	2-3	2
Red 180	CHTAC	4-5	4-5	4-5	4	4	4	4	4	4	3	2	4-5	4
	PAQAC	4	4	4	4	4	4	4	4	4	3	1-2	2-3	1-2
Blue 13	CHTAC	4-5	4-5	4-5	4	4	4	4	4	4	4	3-4	4	3-4
	PAQAC	4	4	4	4-5	4	4	4	4	4	3	2	3	2-3

St** = staining on wool
St* = staining on cotton
Alt.= alteration in color

The light fastness ratings indicate that the cationization reaction with CHTAC has taken place through the fiber, not just on the surface. The poor light fastness of the fabric treated with PAQAC cationizing agent suggests that surface dyeing has occurred (Mashaly , 2007).

Cost considerations

The only extra process costs involved are the cationizing agents and extra processing time.

The cost when using CHTAC as a cationizing agent at the optimum conditions will be:

(as of August 2007)
Sodium hydroxide solid at 1$/pound
PAQAC at 4$/pound
CHTAC at 2$/pound

So, the best conditions for CHTAC are 180g/L NaOH and 250 g/L of CHTAC with the total cost for making one Liter cationization solution is 0.40 $+1.10$ = 1.50$

For PAQAC will be 0.20$ + 2.20$ = 2.40$ to prepare one Liter of PAQAC cationizing solution. The one liter of cationizing agent solution will be enough cationize about one Kg of linen fabric.

Conclusions

Uncationized linen fabric does not dye with the selected dyes using cold pad batch dyeing.The K/S values for the linen cationized with CHTAC were compared to the linen cationized with PAQAC. The results shows that better K/S values were obtained when the batching time was 12 hours in the case of CHTAC this holds trough in case of using PAQAC with better k/s values in case of using CHTAC.

Better k/s values were obtained at 180 g/L of Sodium hydroxide in case of using CHTAC and 90g/L in case of PAQAC.

Results shows that better K/S values were also obtained when using CHTAC concentration of 250g/L and this holes trough when using PAQAC .

-Cationic treatment of linen fabric with CHTAC produced deeper shades when dyeing with selected fiber reactive dyes in the cold pad batch method than fabrics cationized with PAQAC.

-The different fastness properties(washing-rubbing- perspiration) for the cationized dyed linen fabric when using the two different cationizing agents (CHTAC and PAQAC) are almost the same.

-The light fastness results for the dyed fabrics treated with CHTAC are better than that when using PAQAC cationizing agent this indicate that the cationization reaction with CHTAC has taken place through the fiber, not just on the surface. The poor light fastness of the fabric treated wit PAQAC cationizing agent suggests that surface dyeing has occurred

-The total cost for preparation of one liter of the cationizing agent of CHTAC at the optimum condition will be 1.5 $ in august 2007 while this cost in case of using PAQAC cationizing agent will be 2.4$ at the same date.

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