

## **Influence of Polymeric Materials in Laundry Detergent for Improving of Wash Fastness and Staining of Cotton Dyed with Bi-functional Reactive Dyes**

<sup>1</sup>M.E. Yazdanshenas, <sup>2</sup>P. Valipoor, <sup>3</sup>M. Montazer, <sup>4</sup>M. Tajbakhsh, <sup>5</sup>M. Khalilzadeh and <sup>6</sup>A.G. Ebadi

<sup>1</sup>Textile Department, Islamic Azad University, Yazd Branch, Yazd, 155, Iran

<sup>2</sup>Chemical Engineering Department, Islamic Azad University, Jouybar branch, Jouybar, Iran

<sup>3</sup>Textile Department, Amirkabir University of Technology, Textile, Tehran, 5875/4413, Iran

<sup>4</sup>Chemistry Department, Mazandaran University, Babolsar, Iran

<sup>5</sup>Chemistry Department, Islamic Azad University, Ghaemshahr Branch, Ghaemshahr 163, Iran

<sup>6</sup>Department of Biological Sciences Islamic Azad University, Jouybar Branch, Jouybar, Iran

**Abstract:** The wash fastness of fabric dyed with bi-functional reactive dyes is better than mono-functional reactive dyes. However, this cannot satisfy the wash fastness needs for clothing. The oxidizing agent contain in laundry detergent affect on dye-fiber bonds leads to color bleeding and consequently may stain the other clothing materials. Nowadays, new products introduced by the powder procedure to prevent from hydrolyze dye, dye-fiber bonds breakages and the staining adjacent fabrics. In this research, copoly vinyl imidazol-vinyl pyrrolidone and 1-Ethyl-3-methyl-imidazolium dicyanamide were used as an additive for producing better washing fastness and reduce staining. The results showed that these additives reduce the dye bleeding and staining but the dye-fiber bond breakage can not be prevented completely by these chemical agents.

**Key words:** Polymer • wash fastness • colour care • laundry detergent

### **INTRODUCTION**

The linkages between dyes and fibers can be formed through the different physical and chemical bonding. Vander Walls forces, ionic linkages, hydrogen bonding and hydrophobic interactions are formed these bonding [1, 2]. The wash fastness properties of cotton fabrics dyed with reactive dyes are usually good. This is related to the types and the numbers of the functional groups and bridging groups in the dye [3-5]. The covalent bonds between dye and fiber can be hydrolyzed during laundering process. The hydrolyzed dyes can be extracted from the dyed fabric and then comes to the washing solution as the hydrolyzed dyes are soluble in water they might deposit on the adjusted fabrics [5-9].

Different fixing agents have already produced for the cotton fabrics dyed with direct dyes to increase the dye durability during laundering. Also, some of the researchers found that the cationic polymers might inhibit the existence of dye from the dyed fabrics [10].

Cationic polymers can then oriented on the fabric surface and produce a complex between dye and polymer. These complexes have a lower solubility in water comparing with direct dyes. Therefore, dye bleeding during laundering decreases with using of cationic polymers in washing powder. Polyvinylpyrrolidone, Polyvinylimidazole and their mixture PVP/PVI are capable to produce a complex with dye in the washing liquor [11, 12]. These polymers are highly polar and they could protonated during laundering meaning that they can be temporarily charged which is dependant on the pH of the laundering solution. However, some of the polymers in the washing powder which could produce a complex with dyes are dispersed in the laundering solution and have a lower tendency for the fabrics. This leads to a lower staining.

In this research work the influence of addition of two types of polymers into the laundering liquor solution on the wash fastness properties of the cotton fabrics dyed with different bi-functional reactive dyes at various temperatures were evaluated.

## MATERIAL AND METHODS

**Materials:** Plain woven cotton fabric (bleached) and Cellulosic cellophane from Yuyao Paper Mill, were used for this work. Bi-functional reactive dyes Levafix Navy Blue E-BNA with fluoro chloro prymidine/vinyl sulphone (CI Reactive Blue 225) and Remazol Red RB with monochlorotriazine/vinyl sulphone (CI Reactive Red 198) from Dystar, ECE standard detergent (SDL), sodium perborate tetra hydrate (SDL), tetra acetyl ethylene diamine (SDL), 1-vinyl 2-pyrrolidone copolymer (polymer 1), 1-ethyl-3-methyl imidazol dicyanamide (polymer 2) were used.

**Dyeing:** Laboratory dyeing with the reactive dyes were carried out in a Ahiba Texomat laboratory dyeing machine with a liquor to fabric ratio of 40:1. Dyeing of cotton fabrics and cellophane with reactive dyes were performed according to the procedure offered by manufacturer. The dyed fabrics and cellophane samples washed off.

**Fastness:** The dyed fabric samples were tested according to ISO standard methods. The specific test used for testing of the effect of polymer additives during laundering was ISO 105 C08 (2001). Different polymers used at various laundering temperature (40, 50, 60, 70 and 95°C). After laundering, the cotton samples rinsed and dried in air vertically. The cellophane samples rinsed and dried by the specific pressure between two papers. The colour changes of dyed fabrics and the staining on the white cotton fabrics evaluated by CIE Lab system with light source D65. Colour changes on the cellophane dyed samples were evaluated by UV-visible spectrophotometer.

## RESULTS AND DISCUSSION

**Fastness on the fabric:** Reactive dyes with various reactive groups were examined to assess their stability during laundering with different formulation. The results showed that all of the dyes employed, gave a colour differences ( $\Delta E$ ) of less than 1 when the samples washed with solution ISO 105 C08 without polymer additives at 40°C. However, the reactive dye with FCP/VS reactive groups showed a higher colour differences (Fig. 1). The results of staining are shown in Fig. 2. The staining of sample dyed with reactive dye containing FCP/VS was higher than the other dyed samples. An increase in the washing temperature leads to an increase in the colour changes (Fig. 1). However, the staining on the adjacent fabrics decreased above 60°C (Fig. 2).

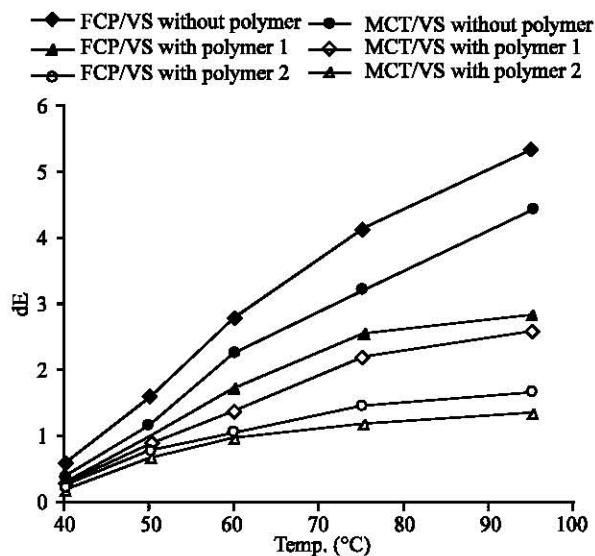


Fig. 1: Effect of temperature and types of the polymer during laundering on the color changes of reactive dyed cotton with two different dyes

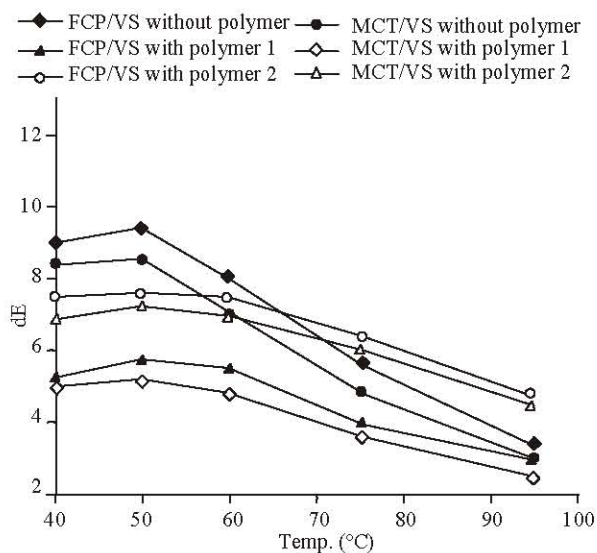


Fig. 2: Effect of temperature and types of the polymer during laundering on the staining of reactive dyed cotton with two different dyes

The changes in the color of the dyed sample and white adjacent fabric are showed schematically in Fig. 3.

Tetraacetyldiamine (TAED) is an activator used in laundering detergent. An increase in the washing temperature leads to increase in the effectiveness of peracetic acid produced by the TAED as shown in reaction 1.

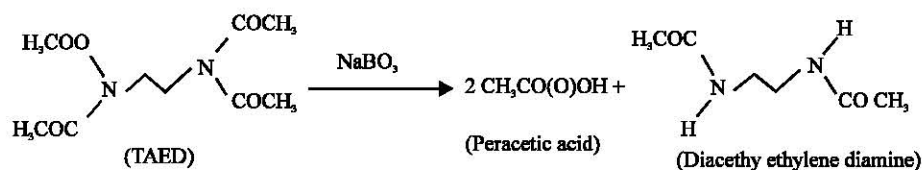
**Reaction 1:**

Table 1: Changes in the rate of dye absorbance value of untreated dye solution to the dye absorbance value of treated dye in the washing solution with and without polymer at different temperature for 140 min

Type functional group	Condition washing	Changes in the rate of dye absorbance value of untreated dye solution to the dye absorbance value of treated dye				
		C°40	C°50	C°60	C°70	C°95
FCP/VS	Without polymer					
	Polymer 1					
	Polymer2	1.0117	1.055	1.121	1.237	1.495
MCT/VS	Without polymer					
	Polymer 1					
	Polymer2	1.012	1.026	1.068	1.098	1.105

This causes breaking of fiber-dye bonds. The reduction of staining at higher temperature could be attributed to the degradation of hydrolyzed dyes which are bleeding from the fabrics to the washing solution. The results of colour changes on the blank washing solution which contains dye, sodium perborate and TAED indicated that an increase in the washing temperature causes a fading in the dye solution (Table 1). This could be due to the degradation of dyes or hydrolyzed dyes by the oxidative bleaching agent.

Above 60°C in alkali conditions, peracetic acid has a higher activity which will conduct a higher breaking of fiber-dye linkages (Table 1). The results showed that lower staining observed when the laundering temperature is above 60°C (Fig. 2). This means that some of the hydrolyzed dyes decomposed by the singlet oxygen produced through depredation of peracetic acid (Table 1). A decrease in the staining on the adjacent fabric above 60°C could be due to the decrease in the affinity of the hydrolyzed dyes to the fabric (Fig. 8). This also could be caused by the influence of presence of the polymers in the laundry solution (Fig. 2). It could be observed that the repeated laundering (5 cycles) leads to obtain a higher colour changes (Fig. 4 and 5).

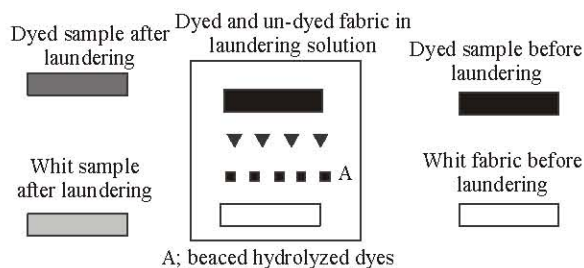


Fig. 3: Schematic of color changes and staining during laundering

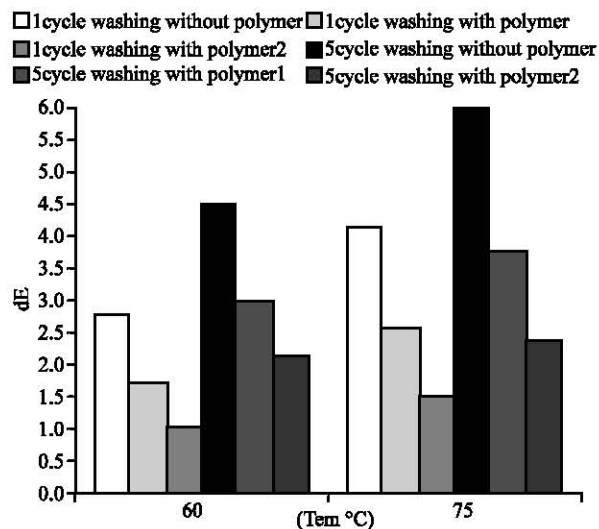


Fig. 4: Effect of temperature and repeated laundering on color changes of fabric dyed with FCP/VS reactive dyes

The existence of polymers 1 and 2 in the laundering solution at 40°C showed no influences on the colour changes. However, an increase in the laundering temperature with the presence of the polymers lowered the colour changes. It can also be observed that the colour changes lowered by the presence of polymer 1 and 2 at above 60°C. The results in Table 1, Fig. 4 and 5 showed that presence of polymer 1 in the repeated laundry at 60 and 75°C has a better performance for preventing of hydrolyzed dyes from bleeding. With using polymer 2 with washing powder in the repeated laundry a lower change in the colour of the fabric could be observed (Fig. 4 and 5).

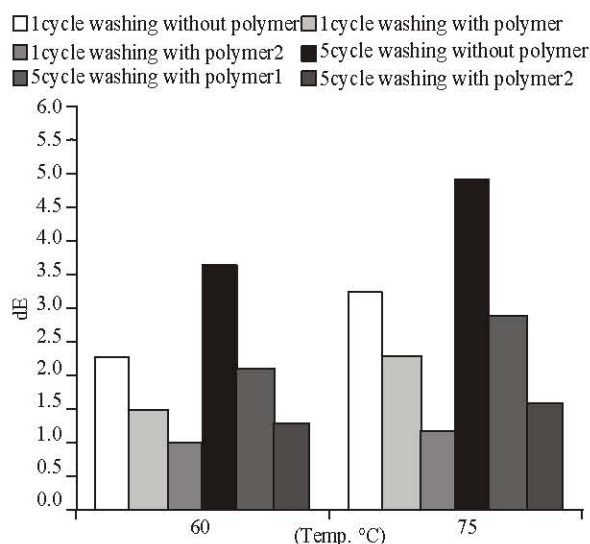


Fig. 5: Effect of temperature and repeated laundering on color changes of fabric dyed with MCT/VS reactive dyes

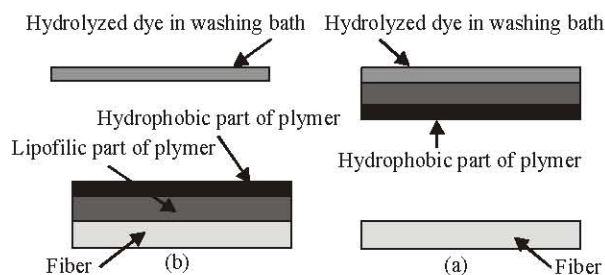


Fig. 6: Polymer 1 performance during laundering Hydrolyzed dye protection B fiber protection

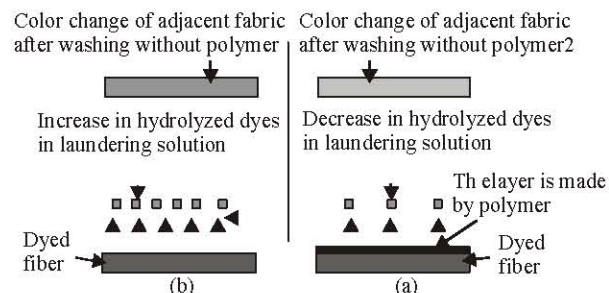


Fig. 7: Polymer 2 performance during laundering, a) Fiber protected by the polymer, b) Without polymer.

The staining on the adjacent fabric with washing liquor containing polymer 1 was less than that of washing liquor containing polymer 2 or without polymer (Fig. 2 and 8). This means that the polymer 2 did not preserve the hydrolyzed dyes from staining. It can be suggested that these polymers are suitable for washing of the fabrics

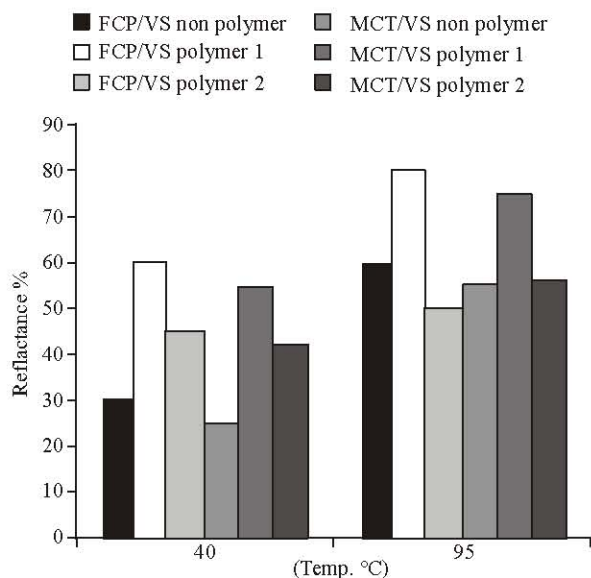


Fig. 8: Effect of Temperature and polymers on the Whiteness of the un-dyed fabric during laundering (containing sodium perborate and TAED) along with reactive dyes of FCP/VS and MCT/VS

dyed with oxidative sensitive reactive dyes. The performance of polymer 1 and 2 are schematically presented in Fig. 6 and 7.

In order to study the staining of dyes during the laundering, the white cotton fabric treated with different solution of dyes and sodium perborate and TAED with and without polymers at various temperatures for 30 minutes. The results indicated in Fig. 8 showed that presence of polymer 1 leads to a lower staining on the white fabric and also increase in temperature causes a higher staining on the fabric.

For the purpose of precise study on the color changes during laundering, laundering process carried out on the dyed cellophane and also the behavior of the polymers additive on the dye migration to the wash bath was investigated. The cellophane dyed samples washed with and without polymers at 40, 50, 60, 75 and 90°C for 30 minutes. These samples rinsed and dried between two absorbent papers. The results of spectrophotometer on the cellophane dyed and washed expressed as  $\ln A_0/A$  (Fig. 9) where  $A_0$  and  $A$  are absorbency of dyed cellophane and absorbency of washed cellophane respectively. The results showed that the sample dyed with bi-functional FCP/VS reactive dye has lower color changes comparing with the sample dyed with bi-functional MCT/VS reactive dye during washing without polymers (Fig. 9).

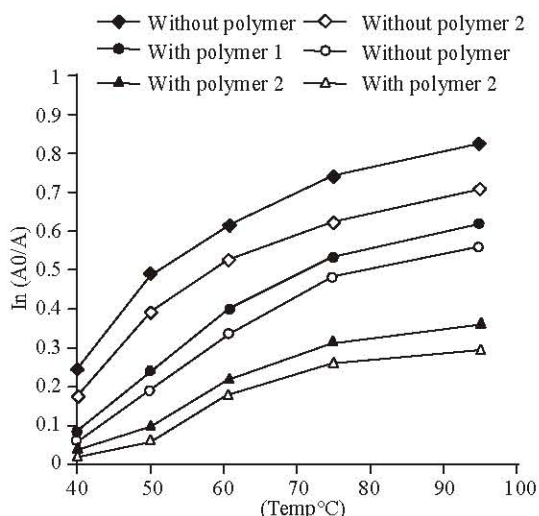


Fig. 9: Effect of Temperature and polymers on the  $A_0/A$  of the cellophane dyed with FCP/VS and MCT/VS reactive dyes during laundering (containing ECE detergent, sodium perborate and TAED)

This color changes could be resulted from breakage of dye-cellophane bonds and or degradation of dye chromogen (Table 1). Higher colour changed observed by the sample dyed with bi-functional FCP/VS reactive dye could be as a result of presence of pyrimidine group in the dye which is sensitive to the oxidative conditions of the laundering. However an increase in the laundering temperature leads to a higher color changes on the samples. As a result of presence of polymer 1 in the laundering solution, lower changes observed on the samples. It can also be observed that the color changed lowered above 60°C. This could be conducted to the action of polymer 1 which is acted as a better preservative for hydrolyzed dyes above 60°C. It can be also mentioned that the samples washed with polymer 2 showed a lower color changes.

### CONCLUSION

Presence of oxidative bleaching agents in home laundering detergents formulation could cause a higher color changes and staining. However, increasing of temperature followed by dye chromogen degradation resulted a lower staining [12].

The results indicated that presence of polymers above 60°C is more effective and lower color changes and staining observed above 60°C on the washed samples. This could be due to the more effectiveness of polymers to protect the dyed samples. However, polymer 1 showed a better protective performance in transferring of

hydrolyzed dyes from the washing-bath to the adjacent fabrics[12].

The results also showed that polymer 2 prevent the hydrolyzed dyes from bleeding and then it can be suggested as a good color care material for dyed fabrics. It seems that this polymer acts similar to the dye fixing agents for direct dyes which oriented on the dyed samples and prevent dye bleeding. The polymer 1 shows a less color care properties but it was a good protective agent for adjacent fabrics or produce a stable complex with hydrolyzed dyes and prevent from deposition of dyes on the adjacent fabrics. The bi-functional reactive dye with MCT/VS reactive groups showed a better wash fastness in comparison with the reactive dyes of FCP/VS.

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