Alternatives to Urea in Wool Printing Part 1 Sponge Printing Film Reducing Urea in Wool Printing with Reactive Dyes

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Abstract: ***In order to resolve the problem of water pollution owing to using a large amount of urea in wool printing with reactive dyes, a new paste for printing wool fabrics with reactive dyes was applied which resulted in reducing urea in the printing paste, providing maximum fixation of reactive dyes on wool fabrics. A sponge alginate film was formed on the surface of the wool fabrics. The film contained reactive dye, brewer's yeast enzyme, ethylene glycol and formic acid. During steaming process the sponge film in its new physical properties absorbs a big quantity of water and gives an ideal status to transfer the dye and all the other chemicals into wool fabrics. The K/S of printed samples was increased by about 27.84% for red dye and 21.71% for blue dye which were applied, compared with those printed by the traditional printing paste that containing 200g/kg urea.***

1. Introduction

Urea is an essential auxiliary in reactive dye printing pastes for wool fabrics because during the steaming process, particularly during the use of superheated steam, it is mainly used to swell the fibers so that the dye can rapidly penetrate the fibers. Urea acts as a solvent for the dye as it performs as a moisture-absorbing agent to increase the moisture regain during the steaming process. Thus, urea accelerates the migration of dye from the thickener film into the fibers.[1,2]

As the most common chemical in reactive dye printing is urea, which leads to a high pollution load. A number of attempts have been made to limit or eliminate the use of urea in the printing paste to reduce effluent load.TEG {Triethylene glycol.-'3, 6-dioxaoctane-1.-'B-diol} was used to replace the urea in silk printing with reactive dyes. The effects of TEG on the performance of monochromic and combination printed fabrics were studied through testing K/S values {color depth} of printed fabrics. And the results indicated that the best replacement ratio of TEG to urea was 75% which gave the maximum value of K/S where TEG, as an N-free compound, has the abilities of good solubility and moisture absorbency.[3]

The main objective of the present work is to decrease the amount of urea in the traditional printing paste for wool fabrics in order to reduce the environmental pollution.

2. Experimental

2.1 Materials

100% 2/2 twill wool fabric of 210g/m^2 produced by Ghazl el Mahala Company, Egypt was used throughout this study. Reactive dyes Bezaktiv Red Go and Bezaktiv Blue Go as well as sodium alginate (Sera Print M-AHV 4) were selected in the present work which were kindly supplied by Dystar, Germany. Brewer's yeast enzyme used throughout this work was supplied from the Egyptian Starch, Yeast & Detergents Company. Sera-Wash M-RK and Sera-Fast CDR, manufactured by Dystar, Germany. All other chemicals used during this study were laboratory commercial grades.

2.2 Technical Procedures

2.2.1 Chlorination of wool fabrics

Wool fabrics were firstly washed with Non-ionic detergent (Sera-Wash M-RK)at room temperature for 10 minutes then rinsed with cold water. Then, the wool was treated with 3ml/L sodium hypochlorite and 6ml/Lglacial acetic acidin a diluted bath for 15 minutes at room temperature. After that, the fabrics were treated with 3g/l sodium bisulfite for 15 minutes at room temperature then rinsing well with cold water.

2.2.2 Printing of wool fabrics

Chlorinated wool fabrics were printed with reactive dyes using flat silk screen (37 meshes/ inch) method. The printing paste was prepared by dissolving the thickener (sodium alginate 4%) in water, then the previously dissolved yeast enzyme was added and left for an hour in a warm place or warm bath at 45◦C for fermentation, then dissolved dye and all other chemicals were added to the paste after fermentation time while stirring continuously.

The chlorinated wool samples were printed using the following recipe:

Sodium alginate (4%)	640	g
Reactive dye	50	g/kg
Urea	w	g/kg
Formic acid	30	g/kg
Brewer's yeast	x	g/kg
Ethylene glycol (99%)	y	g/kg
Water	z	g/kg
		1000 g

After printing, the wool fabrics were dried using the dryer at temperature 100ºC for 1 minute.

Fixation:

The printed dried samples were subjected to fixation by steaming at 100ºC for 30 minutes. The steamer manufactured by "Harish Textile Engineers LTD"

Umbergaon, Gujarat, India, Machine No: L.S.255, Year: Oct.1996, Type: H.L: 300/250 was used in this step.

Washing off:

The wool samples were rinsed with running cold water, then they were washed with 6ml/l non-ionic detergent, Sera-Wash M-RK at 60°C for 10 minutes. Finally, the samples were rinsed with cold water and dried at room temperature.(4)

2.3 Measurements

Determination of the color strength (K/S):

Color strength (K/S) of the printswas carried out in the Laboratory of National Research Center (NRC - Cairo, Egypt) (using a Hunter Lab Spectro - Photometer apparatus, model UltraScan PRO made by USA).

Viscosity:

Viscosity measurements of the printing paste were done at National Research Center[NRC - Cairo, Egypt] using Brookfield model DV-111 programmable rheometer, USA at 25°C and at different rate of shear.

Microscope:

The microscope shoots were taken by Video Camera SDL at National Institute of Standards [NIS-Egypt].

3. Results and Discussion

3.1 Effect of yeast enzyme concentration on chlorinated wool

The chlorinated wool fabrics were printed with different concentrations of yeast enzyme which were: 0, 10, 15, 20, 25 and 30 g/kg in the presence of 200g/kg urea.

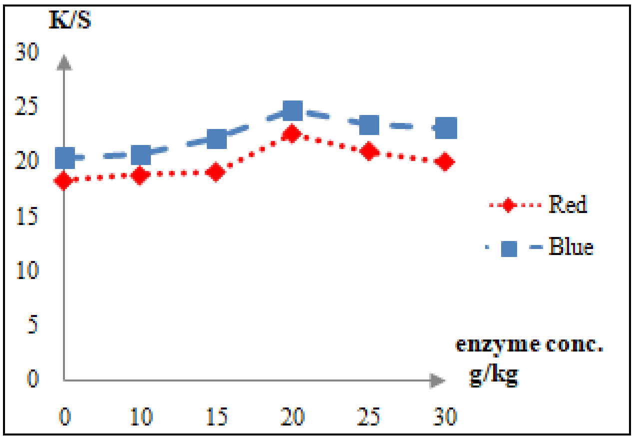


Figure 1: Effect of yeast enzyme conc. on K/S

Figure (1) shows that adding yeast enzyme to sodium alginate thickener and let it for an hour for fermentation gives K/S values higher than the normal recipe which is without yeast enzyme especially by using 20g/kg yeast enzyme, the K/S was increased by about (25.56%) for the red dye color and (21.51%) for the blue dye color. The results of K/S values give an indication that the addition of yeast enzyme to the printing paste has an effect on K/S and gives the best result at 20g/kg enzyme where the K/S of the red dye color is (K/S=22.64) and the K/S of the blue dye color is (K/S=24.79). By increasing the concentration of enzyme more than 20g/kg the K/S values of the two colors are decreased.

3.2 Effect of fermentation time

After adding 20g/kgyeast enzyme to the alginate and before adding the remaining chemicals for printing,different fermentation time: 0, 1, 2, 3 and 4 hours were used to determine the optimum time for fermentation of yeast enzyme.

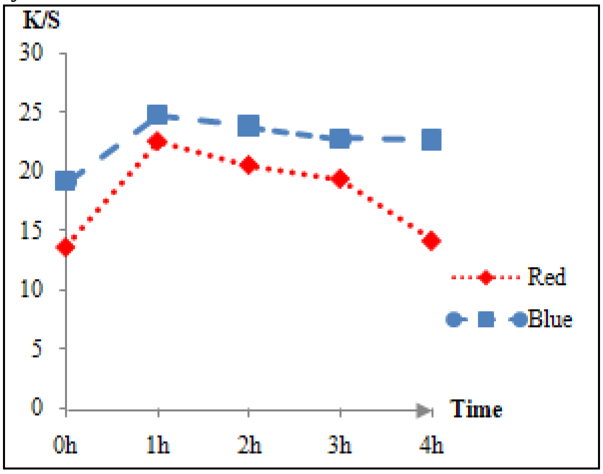


Figure 2: Effect of fermentation time on K/S

It is clear from figure (2)that the K/S value increases to reach its maximum at an hour fermentation time for the two colors, while more increase in fermentation hours up to 4 hours causes a gradual decrease in K/S values for the two colors. By comparing the K/S of the samples printed with zero fermentation time with the samples printed after fermented for an hour, it was found that the K/S increased by about (65.73%) for the red dye color and (28.64%) for the blue dye color.

3.3 Effect of enzyme concentration without urea:

The chlorinated wool fabrics were printed with different concentrations of yeast enzyme which were: 0, 10, 15, 20, 25 and 30 g/kg without urea.

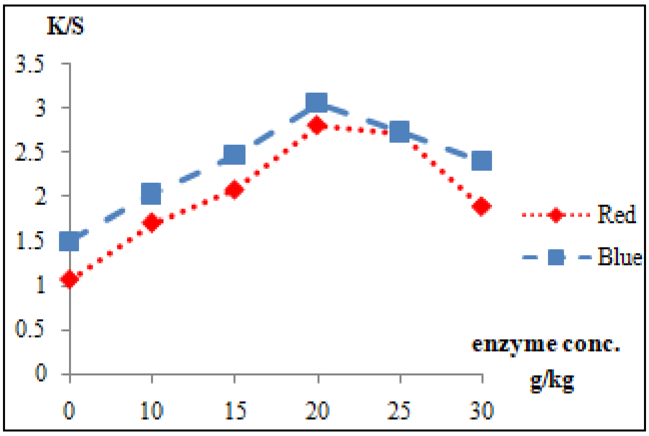


Figure 3: Effect of yeast enzyme conc. without urea on K/S

It is clear from figure (3) that the K/S value increases by increasing the yeast enzyme concentration without adding urea till it reaches its maximum at 20g/kg yeast enzyme which are (K/S =2.81) for red dye color and (K/S =3.06) for blue dye color and this is a high value of K/S to reach without urea. The K/S is increased by about (61.92%) for the red dye color and (50.65%) for the blue one. This means that the yeast enzyme has a good effect on increasing the solubility of the dye in the printing paste which was observed on the printed samples and resulting in increasing the K/S of the printed samples.

3.4 Effect of fermentation time without urea:

After adding the yeast enzyme to the alginate, different fermentation time: 0, 1, 2, 3 and 4 hours were used to determine the optimum time for fermentation of yeast enzyme.

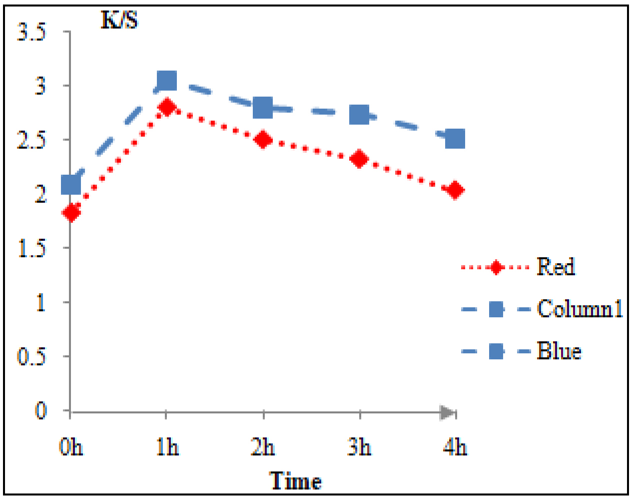


Figure 4: Effect of fermentation time on K/S

It is clear from figure (4) that the K/S value increases to reach its maximum at an hour fermentation time for the two colors where the K/S of the red color is (K/S=2.81) and the K/S of the blue color is (K/S=3.06), while more increase in fermentation hours causes a gradual decrease in K/S values for the two colors.

3.5 Effect of urea concentration

The chlorinated wool fabrics were printed with different concentrations of urea which were: 0, 25, 50, 75, 100, 125, 150, 175and 200 g/kg with adding 20g/kg yeast enzyme.

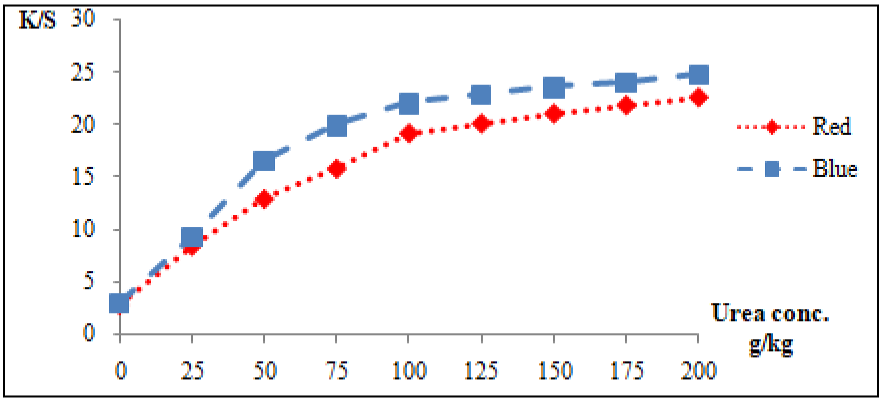


Figure 5: Effect of urea conc. on K/S

It is observed from figure (5) that the increase in color strength (K/S) of the printed samples is directly proportional with the increase of urea concentration. The K/S values at 100g/kg urea were higher than those printed with the traditional printing paste which contains 200g/kg urea by about (6.54%) for the red dye color and (8.03%) for the blue dye color.

3.6 Effect of ethylene glycol concentration without urea

The chlorinated wool fabrics were printed with different concentrations of ethylene glycol which were: 0, 25, 50, 75, 100, 125, 150, 175and 200g/kg with adding 20g/kg yeast enzyme without urea.

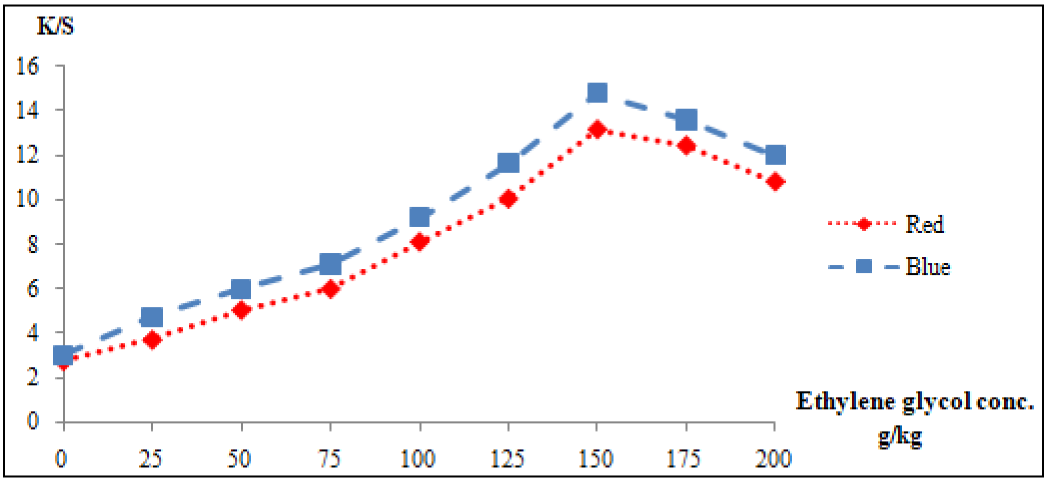


Figure 6: Effect of ethylene glycol conc. without urea on K/S

It is observed from figure (6) that the increase in color strength (K/S) of the printed samples is directly proportional to the increase of ethylene glycol concentration until K/S reaches its maximum value at 150g/kg ethylene glycol for both red and blue dye colors where (K/S=13.2, 14.8) respectively.

3.7 Effect of urea concentration with 150g/kg ethylene glycol

The chlorinated wool fabrics were printed with different concentrations of urea which were: 0, 25, 50, 75 and 100g/kgin the presence of 150g/kg ethylene glycol and 20g/kg yeast enzyme.

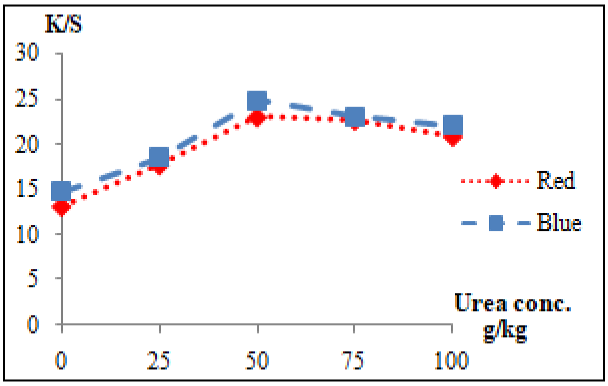
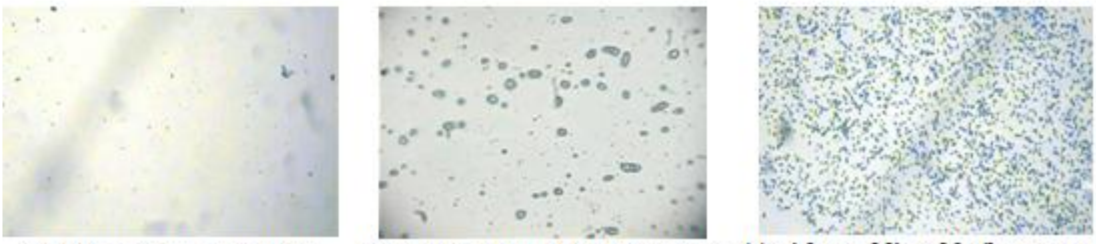


Figure 7: Effect of urea conc. + 150g/kg ethylene glycol on K/S

It is clear from figure (7) that the K/S values of the printed wool samples increase gradually by increasing urea concentration till it reaches its maximum value at 50g/kg to be (K/S=23.05) for red dye color and (K/S=24.83) for blue dye color then decreased by more increasing of urea concentration. This may be due to the increasing of the water content by increasing the urea concentration which causing more dye hydrolysis. Also, it can be noticed that the K/S value of red and blue dyes was increased by about 27.84% and 21.71% respectively than the K/S of the prints with the traditional printing paste.

3.8 Microscope shoots for sodium alginate

Microscope shoots for sodium alginate after fermentation for an hour with adding different concentrations of yeast enzyme are represented in Fig (8). All the shoots was magnified 1000 times the original size.



(a): Plane sodium alginate **(b): After adding 10g/kg enzyme** **(c): After adding 20g/kg enzyme**

Figure 8: Microscope shoots for sodium alginate after adding different concentrations of yeast enzyme

The major role of the yeast enzyme as it is known, using in baking as a leavener or leavening agent, where yeast begins feeding on the sugars in the dough, and releases the carbon dioxide gas in the form of air pockets or air bubbles that makes bread rise at a much slower rate and this process is called fermentation process. Thousands of carbon dioxide gas bubbles are produced as the yeast goes to work during the fermentation process.[5]When the dough is baked in an oven, over a fire, or in a steamer, depending on what kind of bread you're baking, the yeast dies and the air pockets set, giving the baked product a soft and spongy texture.[6] The same conversion is happened in the case of fermentation of sodium alginate where sodium alginate is polysaccharide which are polymeric carbohydrate.[7,8]

It is shown from figure (8-a) that pure sodium alginate is in an aggregation case before adding yeast enzyme. After adding yeast enzyme to sodium alginate, it can be noticed that the enzyme began to deal with the aggregated parts of the sodium alginate as it started to dissolve the rest of the aggregated sodium alginate during the fermentation time and at the same time carbon dioxide bubbles were produced as shown in figure (b&c).

By increasing the concentration of the yeast enzyme from 10 to 20g/kg, the carbon dioxide bubbles also increased resulting in more ability of the printing paste to absorb condensed water during steaming.

Increasing water content of the printing paste improves solubilization of dyes and paste components and assures good transferring and penetrating of paste components into wool fabrics.

3.9 Viscosity measurement

Table 1: Viscosity measurement of sodium alginate after adding different concentrations of yeast enzyme

RPM	1	2	4	5	9
Rate of shearing sec^{-1}	0.34	0.68	1.36	1.7	3.06
Viscosity C.P (Pure Sodium alginate + 1cm^3 water)	43450	37677	33000	28450	22890
Viscosity C.P (Sodium alginate + 10g/kg Enzyme - After an hour)	50931	41782	34469	29555	24427
Viscosity C.P (Sodium alginate + 20g/kg Enzyme - After an hour)	57300	44957	35530	31200	25808

The addition of 1cm^3 water to the pure sodium alginate is to adjust the addition of enzyme to the other experiments. Table (1) presented the sodium alginate viscosity alone and with yeast enzyme after fermentation for an hour. The results reveal that there is an increase in the viscosity with addition of yeast enzyme.

By increasing the enzyme concentration from 10 to 20g/kg, the viscosity also increased. This can be due to the increasing of the amount of carbon dioxide bubbles into the paste and consequently increasing the pressure of air bubbles which reflected on increasing the viscosity of sodium alginate paste.

4. Conclusion

It can be concluded that without addition of urea in the printing paste, the results were unsatisfactory. The same K/S results of traditional paste or higher (depending on dye type) can be obtained by replacing half concentration of urea with 20g/kg yeast enzyme. Furthermore a higher color strength up to 27% than the traditional paste could be obtained when we replace 75% of the amount of urea with combination of yeast enzyme and ethylene glycol.

References

[1] B. Glover, "colourage annual", P. (67, 80), 2005.
[2] I. Tarakacioglu, A. T. Ozguney, A. Ozerdem and E. Bilgin, "Textile Research journal", Vol. 74, P. (63:67), 2004.
[3] C. Ding, L. Wang, J. Lin & D. Ni, "Advanced Materials Research", Vol. 175, P.(691;695), 2011.
[4] Miles, L.W.C., "Textile Printing", Dyers Co. Publications Trust, P. (251, 252), 1981.
[5] https://www.exploratorium.edu/cooking/bread/bread_science.html
[6] R. C. Rowe, P. J. Sheskey, M. E. Quinn, "Adipic Acid", Handbook of Pharmaceutical Excipients, 6th ed., 2009.
[7] A. Varki, R. Cummings, J. Esko, H. Freeze, P. Stanley, C. Bertozzi, G. Hart and M . Etzler, "Essentials of glycobiology", 2nd edition, 2008.
[8] A. Varki, R. Cummings, J. Esko, J. Freeze, G. Hart and J. Marth, "Essentials of glycobiology" Cold Spring Harbor Laboratory Press, 1999.