American Journal of Polymer Science & Engineering
http://www.ivyunion.org/index.php/ajpse/

Research Article

Application of New Synthetic Fifth Generation Thickeners for Printing Cotton Fabric with Reactive Dyes

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Abstract

In this study, fifth generation thickener EM620R (polyacrylate emulsion) was developed for reactive printing due to traditional thickener sodium alginate and synthetic thickener caused less saturation of color and increased fabric stiffness. Printing was evaluated for the depth of the shade as well as other properties. The properties was obtained not only depending on the thickener and reactive dye but also depends on the concentration of $NaHCO_3$, Urea in Printing paste, condition of fixation and storing time. After comparison with synthetic thickener and sodium alginate on the basis of K/S value in different situation, AATCC method fastness test; an extra ordinary result came out which was shown as like EM620R (polyacrylate emulsion) > EM620 (polyacrylate emulsion) > Sodium Alginate. Although EM620R (polyacrylate emulsion) development solved the problem and increased the properties which create unthinkable impact on the world market for cost effectiveness.

Keywords: Reactive printing; cotton fabric; synthetic thickener; EM620R; sodium alginate
Received: October 16, 2016; **Accepted**: November 24, 2016; P**ublished**: December 28, 2016
Competing Interests: The authors have declared that no competing interests exist.

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1. Introduction

Textile printing is a method of coloration the textile fabric. It can be obtained by using dyes or pigment in printing paste. This paste is viscous which provided by thickener. Off Course successful prints depend on color, levelness, sharpness, good handling, and sufficient use of dye (color yielding) [1]. These all depend on the type of thickener are used and the printing paste rheology.

Now-a-days several researches had done to alternate widely used reactive printing thickener like sodium alginate because of their higher cost, limited application and non-uniformity of the latter [2]. In this investigation to minimize several drawback of printing paste, application of fifth generation thickener (EM620R) was implemented on cotton fabric to compare with other classical synthetic thickener likes (EM620) and natural thickener sodium alginate.

In this research, analysis of EM620R (polyacrylate emulsion) upon cotton fabric was evaluated in term of K/S. In addition to printing paste storing time, steaming condition on cotton woven fabric after application of fifth generation thickener was described. To evaluate the fabric performance against rubbing, washing, perspiration was done on the application of fifth generation thickener.

2. Materials and Methods

2.1 Materials

Mild scoured, bleached and mercerized plain weave 100% cotton fabric (140 GSM) was used. EM620R (polyacrylate emulsion), EM620 (polyacrylate emulsion) was supplied from EM Chemical, Foshan, China. Sodium Alginate with high viscosity (Cecalginate HV/KL600) was brought from Ceca Kolloid (Chemie of Paris, France). Remazol Brilliant Red F3B (Sulphatoethylsulphone type FH from Dystar) and Remazol Brilliant Blue BB from Dystar), Nonionic detergent (Hostapal CV-ET,FH), and a mild oxidizing agent (ludigol, BASF) were technical grade. Urea & Sodium Bicarbonate were laboratory grade.

2.2 Method

Printing Paste preparation

Paste was prepared according to the following recipes:

Reactive Dye	30g
Stock Thickener	40g
Urea	100g
Sodium bicarbonate	30g
Ludigol®	10g
Water	790 g

Total= 1000g

2.3 Printing Procedure

Printing was done by flat screen magnetic pressure printing machine (HUI BAO, china). After completing the printing then it dried at 100℃ for 5 min and fixed by steaming at 120℃ for 15 min by steaming machine (HUI BAO, china). Printed Samples were rinsed for 15 min with cold water then wash with hot water at 60℃ for 15 min. After that non-ionic detergent (2 gL^{-1}), Soda ash (2 gL^{-1}), sodium hydroxide (2 gL^{-1}) for 15 min at 100℃. This soap sample ringed with cold water and hot water. Finally the wet sample dried.

2.4 Determination of reactive printing K/S

Depth of the color was one of the properties of evaluating the printing. It expressed by K/S value which was measured by the height absorption used an automated filter spectrophotometer and calculated by KubelKa MunK equation that was shown in equation 1 [3].

$$K/S = \frac{(1-R)2}{2R} \quad 1$$

Where K indicated the absorption coefficient and S demonstrated the scattering coefficient.

2.5 Assessment of fastness properties on reactive printed cotton fabric

Others fastness property like rubbing, washing and perspiration test was done by AATCC method.

3. Results and discussion

3.1 Concentration of sodium Bi Carbonate

The effect on K/S value of printed sample depth for changing the concentration of sodium bicarbonates by using new development of fifth generation synthetic thickener was showed in Figure 1.

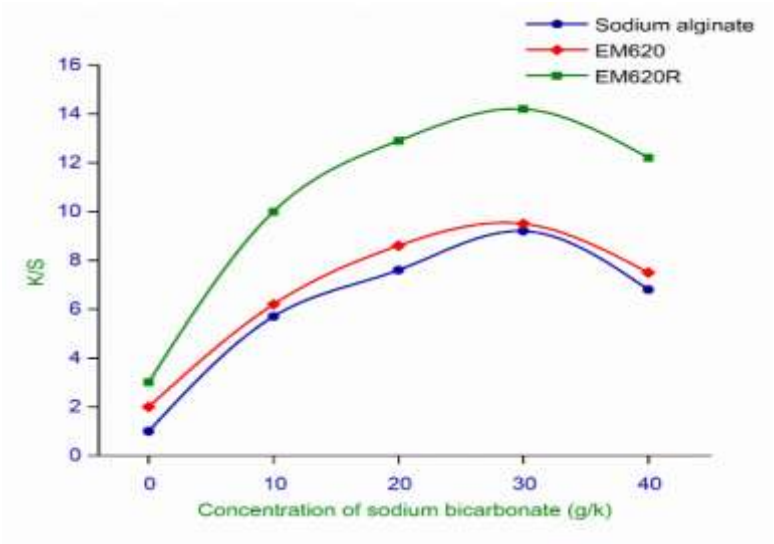

Figure 1 Effect of the concentration of sodium bicarbonate on the depth of the print (K/S) for EM620R, EM620, and Alginate thickener.

According to Figure 1 it was obvious that with respect to increase concentration of sodium bi carbonate affected the K/S values significantly. Moreover for a certain increased of concentration of sodium alginate K/S value increased up to 30 gk^{-1}. But after that K/S values fall down because increased swell ability and extend of neutralization of their free carboxylic group [4] as well as increase viscosity gave significant changed of K/S values which was seen in equation 2. Fixed the dye via ether link with hydroxyl group of cellulose [2] was presented in equation 3. These ether link helped to remove thickener from the printed fabric which results soft handle [5]. For the consequence, greater effect on the depth of the shade of printed substrate was obtained. However, when the concentration was increasing furthermore K/S value was decreased most probably for dye hydrolysis during steaming [2] in equation 4 .Minimizing the paste viscosity resulting excessive penetration of dye into fabric [4]. Partial hydrolysis Cell-O-Dye chemical bond under steaming condition not compatibility with other ingredient of printing paste also caused for less K/S value in equation 5. From Figure 1 it was seen that different thickener executed their performance according to their chemical composition, chemical nature, molecular number, weight, affinity with other component, compatibility and position of acidic group as well as rheological properties of the paste [2].

$$\sim\sim COOH + NaHCO_3 \longrightarrow \sim\sim COONa + H_2O + CO_2 \qquad 2$$

$$Cell\text{-}OH + D\text{-}X \xrightarrow{OH^-} Cell\text{-}O\text{-}D + H\text{-}X \qquad 3$$

$$\text{Dye-X} + H_2O \xrightarrow{OH^-} \text{Dye-OH} + HX \qquad 4$$

$$\text{Cell-O-Dye} + H_2O \xrightarrow[\blacktriangle]{OH^-} \text{Cell-OH} + \text{D-OH} \qquad 5$$

3.2 Urea Concentration

The change of concentration of urea the depth of the color also changed that was visible in

Figure 2. It was apparent that up to 100 gk^{-1} concentration K/S value of different thickener significantly increased because of irrespective of thickener as well as cellulose substrate. This improvement in depth of shade was consequence of the increased swell ability of cellulose structure, increased the disaggregation and solubility of the dye molecule, diffusion ability of the dye molecule from paste into the cellulose fiber. Attracting moisture and retarding the evaporation of water during dyeing. Increasing the propagation of water condensation in the print during steaming step [5, 6].

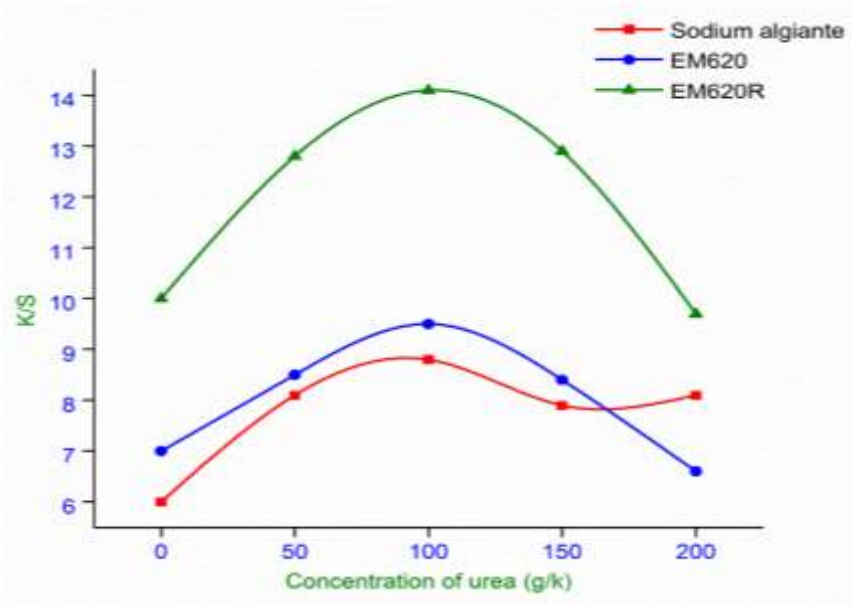

Figure 2 Effect of the concentration of urea on the depth of the print (K/S) for EM620R, EM620 and alginate thickener.

Furthermore increasing the concentration of the urea beyond 100 gk^{-1} showed the revers impact on K/S value irrespective of the used thickener in Figure 2. It's happened for side interaction with used dyes and the interaction with other components that was used in the printing paste. For this consequence the fixation of dyes was disrupted, thereby altering the rheological properties which lead to excessive penetration of dye molecule within the highly swell cellulose substrate [7]. The net effect of this is less fixation of color i.e. low depth of shades.

3.3 Steaming Condition

3.3.1 Steaming *temperature*

In reactive printing, steaming was very necessary and important step for fixation of dye with cellulose substrate. The K/S value of different thickener respectively in different temperature and time was demonstrated in Figure 3 and Figure 4. From Figure 3, it's cleared that up to 110℃ for 15min K/S value was increased very fastly. Increasing of K/S value by increasing temperature was a direct consequence of the increase solubility, the increase swell ability to the cellulose substrate, the simplify the dye realize from the printing paste to cellulose substrate, increasing the amount of dye fixation, thereby giving raise to the deeper depth of shade. On the other hand increase of more steaming temperature at 120℃ decreased of K/S value because of the more amount of dye hydrolysis, easily penetration of the released dye, side interaction with used thickener, shortage in accessible active side like hydroxyl group [1]. The sequence of steaming temperature of different thickener with respect to K/S was represented as EM620R (polyacrylate emulsion) > EM620 (polyacrylate emulsion) > Sodium Alginate.

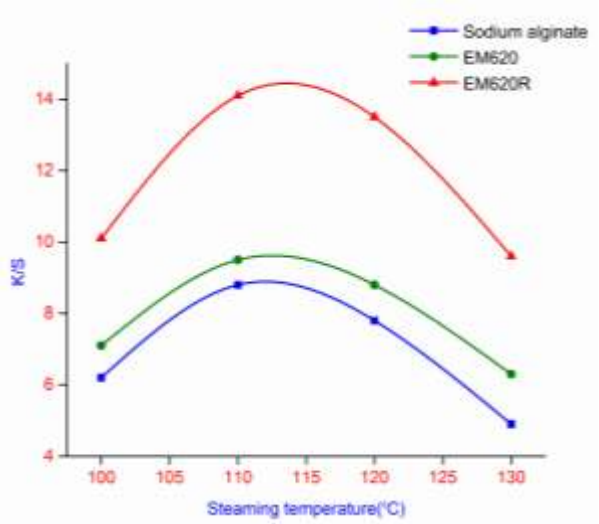

Figure 3 Effect of the steaming temperature on the depth of the print (K/S) for EM620R, EM620 and Alginate thickener.

3.3.2 Steaming time

Figure 4 showed that at 110℃ for 0-35 min for reactive printing depth (K/S value) of

TU	FM	K/S	Rubbing Fastness	Wash Fastness	Perspiration Fastness	Handle	Sharpness

different thickener. From the Figure 4 it's cleared that K/S value of thickener was increased up to 15min. Proper steaming time was necessary for swelling of thickener film, helps to remove the thickener transfer dye from the printing paste to cellulose substrate, open the cellulose structure for dye diffusion and penetration, helps to decompose $NaHCO_3$ for alkaline pH, enabling dye-fiber interaction & fixation by bonding covalent bond [6]. Furthermore increasing of steaming time up to 35 min it showed that the reverse effect of thickener on K/S value due to increase hydrolysis of used reactive dyes, thus decrease the ability to form covalent bond between dye and the hydroxyl group of cellulose substrate and effect on film properties, thus blocking the entrapped reactive dye molecules. From the chemical nature it was clear that EM620R (polyacrylate emulsion) > EM620 (polyacrylate emulsion) > Sodium Alginate.

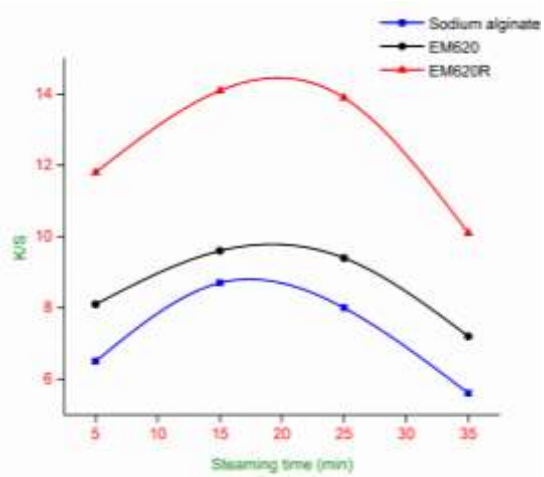

Figure 4 Effect of the steaming time on the depth of the print (K/S) for EM620R, EM620 and Alginate thickener.

3.4 Fixation method

Table 1 Effect of Fixation method on printing performance*

			Wet	Dry	Alt	St		Acidic			Alkaline				
						C	W	Alt.	St		Alt.	St			
									C	W		C	W		
SA	Sm	9.2	3	3-4	3-4	3-4	4	3	3	3	3-4	4	4	Soft	Excellent
	Tm	7.1	2	3	2-3	3	3	2	2-3	2-3	2	2-3	2-3	Harsh	Excellent
EM	Sm	9.5	3-4	4	4	4	5	5	4-5	5	5	4-5	5	Soft	Excellent
	Tm	7.3	3	3-4	3-4	3-4	3-4	4	3-4	4	3-4	3-4	3-4	Harsh	Excellent
EMR	Sm	14.2	4-5	5	5	5	5	5	4-5	5	5	5	5	Soft	Excellent
	Tm	11.9	3-4	4	4	4	4	3-4	4	4	4-5	4	4-5	Harsh	Excellent

*TU means thickener used, FM for Fixation Method (Sm for steaming, Tm for thermo soiling), Alt means Alteration, Staining represented by St, C stands for cotton, Wool indicated by W, $NaHCO_3$: for SA (30 gk^{-1}); for EM (30 gk^{-1}); for EM620R (30 gk^{-1}); Urea (100 gk^{-1}); Remazol Brilliant Blue BB (30 gk^{-1}); thickener (40 gk^{-1}); Ludigol® (10 gk^{-1}).

The effect of printing was evaluated in terms of K/S value, fastness properties, it was the evidence in Table 1. After using the same thickener in case of fixation by steaming and by thermo soling the result came out that fixation by steaming method was better because of higher K/S value. This happened because of dissolution, thickener swell ability, enhances electrostatic repulsion between the anionic dye and its $-COO^-$ groups. Thus, in high temperature dye readily transfer from the thickener film to fabric in steaming process than them soling process. By this way steaming improve dye fixation as well as K/S value of the prints. In case of thermo soling method dehydration of poly acrylic based thickener and form intermolecular condensation product as well as increase (150℃ for 5 min) in this condition. Thus disturbed the whole process of fixation as well as lower K/S value and enhance the roughness also. It was noted from the Table 1 that the fastness properties thermo soling process is lower than the steaming fixation process. It can be conclude that steam fixed prints had higher K/S value; improve fastness properties and softer handle than thermo-fixed process.

3.5 Storing time (performance properties)

Performance of storing time (8 days) was evaluated on the basis of K/S value, fastness properties i.e., washing, rubbing, perspiration as well as the softness and sharpness of the printed sample using dyes with different thickener. The results of storing time shown in the Table 2. From the Table 2 it was seen that after 8 days K/S value of thickener was decreased as well as other properties also decreased due to partial hydrolysis of reactive dye in alkaline condition, variation in thickener structure and rheological properties [2]. Prolonged storing time decreased the wet and dry rubbing fastness both because of extent fixation of dyes and entrapped the unfixed dyes in prints.

It also showed from the Table 2 that the perspiration fastness of alkaline was better than acidic regardless of the used reactive dye and thickener, storing time had a slight negative effect on acid. But in case of handle there had no special effect on storing.

TU	ST (h)	K/S	Rubbing Fastness		Wash Fastness			Perspiration Fastness						Handle	Sharpness
								Acidic			Alkaline				
			Wet	Dry	Alt	St		Alt.	St		Alt.	St			
						C	W		C	W		C	W		
SA	0	9.2	3	3-4	3-4	3-4	4	3	3	3	3-4	4	4	Soft	Excellent
	192	8.1	2-3	3-4	2-3	3	3	2-3	2-3	2-3	2	3	3-4	Soft	Very Good
EM	0	9.5	3-4	4-5	4	4	5	5	4-5	5	5	4-5	5	Soft	Excellent
	192	8.4	3	3-4	3	3-4	3-4	4-5	3-4	4	3-4	3-4	4	Soft	Very Good
EMR	0	14.2	4-5	5	5	5	5	5	4-5	5	5	5	5	Soft	Excellent
	192	13.8	3-4	4-5	4-5	4	4-5	4-5	4	4-5	4-5	4-5	4-5	Soft	Excellent

Table 2 Effect of storing time (8 Days) on thickener used *

*TU means thickener used, ST means storing time, $NaHCO_3$: for SA (30 gk^{-1}); for EM (30 gk^{-1}); for EM620R (30 gk^{-1}); Urea (100 gk^{-1}); Remazol Brilliant Red F3B (30 gk^{-1}); thickener (40 gk^{-1}); Ludigol® (10 gk^{-1}).

3.6 Effect of Dye type

Table 3 Effect of dye type on Printing Performance*

Used Dyes	U T	K/S	Rubbing Fastness		Wash Fastness			Perspiration Fastness						Handle	Sharpness
								Acidic			Alkaline				
			Wet	Dry	Alt	St		Alt.	St		Alt.	St			
						C	W		C	W		C	W		
Red F3B	NA	9.2	3	3-4	3-4	3-4	4	3	3	3	3-4	4	4	Soft	Excellent
	EM	9.5	3-4	4	4	4	5	5	4-5	5	5	4-5	5	Soft	Excellent
	EMR	14.2	4-5	5	5	5	5	5	4-5	5	5	5	5	Soft	Excellent
Blue BB	NA	8.8	3	3-4	3-4	3-4	3-4	3	3-4	4	4	3-4	4	Soft	Excellent
	EM	9.1	3-4	4	4	4	4	4	4	4	4-5	4-5	4-5	Soft	Excellent
	EMR	13.8	4-5	5	4-5	4-5	4-5	4-5	4	4-5	4-5	4-5	5	Soft	Excellent

*$NaHCO_3$: for SA (30 gk^{-1}); for EM (30 gk^{-1}); for EM620R (30 gk^{-1}); Urea (100 gk^{-1}); Remazol Brilliant Red F3B (30 gk^{-1}); thickener (40 gk^{-1}); Ludigol® (10 gk^{-1}).Blue BB, Remazol Brilliant Blue BB; Red F3B, Remazol Brilliant Red F3B

Two different dyes (Remazol Brilliant Blue BB & Remazol Brilliant Red F3B) were used to see the effect of the fifth generation thickener on printing. After fixation at 120℃ for 15 min by steaming, the results from Table 3 showed that change of K/S value and other properties for different thickener. For the different function on printing the following effectiveness was drawn as like EM620R (polyacrylate emulsion) > EM620 (polyacrylate emulsion) > Sodium Alginate. In every case of printing with these thickener the amount of dyes were same but the K/S value was different. These happened because of the comparatively easier dye relies and transfer from thickener film. The difference of printing properties depend on the dye substantively and reactivity, mode of interaction, molecular size and state of aggregation, location and extend of fixation, affinity towards the used thickeners as well as stability, irrespective of the thickener and condition used. The wet rubbing fastness was lower than dry rubbing fastness because of the unfixed dye trapped in the prints. All printing sample displayed a soft handle.

4. Comparison with Fifth generation thickener with sodium Alginate

From all the table and graph of this study it exhibited that the use of newly developed fifth generation thickener properties is comparatively best to other synthetic and natural thickener like sodium alginate. Table 2 showed that after storing 8 days the K/S value was slightly decreased. These because of hydrolysis of the used reactive dyes in alkaline condition and/or structure change of used thickener for the interaction with other component of the printing paste. As a result the extent of dye fixation and fastness properties decrease marginally. Table 2 also showed that the sample thickened with EM620R gained a higher depth of color; improve fastness properties i.e. rubbing, washing and perspiration compared with those printed with sodium alginate. This represented that these paste had higher ability to transfer dye from the printing paste to fabric with a slight tendency to react with the dye. For this the printing sample was drawn as like EM620R (polyacrylate emulsion) > EM620 (polyacrylate emulsion) > Sodium Alginate. The difference of K/S value and the other fastness properties within the range thickener used are probably due to the difference in the physical and chemical nature, rheological properties, molecular weight, number and location of functional groups (i.e. COOH, OH) as well as compatibility, stability and reactivity with other component in the printing paste.

5. Conclusion

Depending on various concentration of Urea, $NaHCO_3$ got different result of handle, rubbing, washing, perspiration and so on. But the optimum parameter was found at Urea concentration (100 gk^{-1}), $NaHCO_3$ (30 gk^{-1}), steaming temperature 100℃ and time 15 min. Viscosity of the printing paste as well as K/S value and fastness properties of the printing paste governed by the nature of the dye and the printing

thickener. Storing of the printing paste for 8 days result decrease apparent viscosity along with slight decrease of K/S value and the other fastness properties.

Acknowledgement

This research was supported by EM Chemical, Foshan, Guangdong,China. Special gratitude to Prof. Heng Quan (Vice dean, department of school of chemistry and chemical engineering, Wuhan Textile University, China.) to cooperate and stave for doing research work by proper guideline.

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