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Application of Mixtures of Resin Finishing to Achieve Some Physical Properties on Interlining Cotton Fabrics: I-Effect of Stiffening and Cross-linking Agents*

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ABSTRACT

To produce interlining fabric, various kinds of chemicals such as cross-linking, softening, stiffening and water repellent agents have been employed. In this work, a mixture of dimethylol dihydroxy ethylene urea (DMDHEU), polyvinyl acetate (PVAc) and some other resins were examined in special finishing of cotton for producing interlining cotton fabrics properties. Majority of cross-linking agents used today is DMDHEU based with low formaldehyde level. In order to elucidate the role of DMDHEU and PVAc in this specific finishing, some physical properties of fabric such as bending length, crease recovery angle, wettability time and thickness were studied with varying their concentrations. Both bending length, thickness and wettability time of cotton fabrics increased on increasing PVAc and DMDHEU concentrations. But, crease recovery angle decreased on increasing PVAc concentration and on the contrary increasing DMDHEU concentration improved the crease recovery angle.

Key Words:

polyvinyl acetate; DMDHEU; resin finishing; interlining fabric; cotton fabric.

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INTRODUCTION

In general, it may be said that a fabric intended for the manufacture of garments needs to possess certain specifications. For example, some interlining fabrics have superior properties such as stiffness, crease resistance, wash fastness and suitable soft handle. Therefore, a composition of resins and chemicals such as stiffening, cross-linking, softening, and water repellent agent are applied for producing interlining cotton fabrics [1].

The use of synthetic polymers in the textile industry dates back to about 1912[2]. During world war I, polyvinyl chloroacetate was first used to impregnate fabrics used as covers for aircrafts structures to minimize air resistance. This seems to be the first commercial use of vinyl polymers [3]. After the war it took quite a few years before PVAc was used regularly as sizing and stiffening agents in the textile industry. At present time probably the most widely stiffener used in textile industry is PVAc due to suitable and durable adhesion. [2-13].

Generally *N*-methylol compounds are used in the cross-linking of cellulosic fabrics [12]. Amino resin finishing commenced in the early 1920s when Tootal Broadhurst Lee took patents out on the manufacture of urea-formaldehyde resins for the production of crease resistant fabrics. Catalysts are required for efficient reaction of the various methylol compounds with cellulose to obtain the desired fabric properties. The free formaldehyde liberated during processing and from resin-finished fabrics in storage was an important problem in clothing hygiene [9-14]. The resin finishing industry has researched extensively a non-formaldehyde resin finishing treatment to provide high safety for practical use. The most common low-formaldehyde cross-linking agent is DMDHEU. It is a bi-functional compound that reacts with cellulose by forming ether linkage under the influence of the acid catalyst.

It was necessary to cure the finished fabric at the high temperature (140-160°C) for about 5 min. Some times, softener such as silicones along with DMDHEU were employed to improve the handle of finished fabric [13-26].

In this research DMDHEU, PVAc, amino silicone, gum (polysaccharide) and acrylate were used as cross-linking agent, stiffener, softener, thickener and binder, respectively. The present work aims to examining the technical feasibility of incorporation of PVAc and DMDHEU in the admixture of special finishing formulation and to clarify their role on the physical properties of finished fabrics (e.g., bending length, wettability time, thickness and crease recovery angle).

EXPERIMENTAL

Fabric

The cotton fabric (112 g/m^2) with 25 picks × 21 ends/cm was desized, scoured and bleached in Najaf-Abad Factory.

Chemicals

DMDHEU was Fixapret CPN from the BASF Company. PVAc was obtained from Sepahan Resin product H-100w. Amino silicone (NI 857) provided from Hansa Finish Company. Polysaccharide gum was Indalca H 7753 from Cesalpina Co. Acrylate binder, Imperon MTB was obtained from Hoechst Co. Catalyst used in this experiment was based on magnesium chloride from Merck Co. Non-ionic detergent was alkyl aryl polyglycol ether from Kimidarou Co.

Chemical Treatments

Fabric samples (50×15 cm) were impregnated with the finishing solution on a laboratory padding mangle (Werner Mathis AG) to about 175% wet pickup, dried at 100°C for 5 min and cured at 150°C for 5 min. The concentration of the aqueous solutions is listed in Table 1.

Test Methods

The bending length of fabric was measured in warp direction according to B.S.3356: 1961. This quantity is a measure of the resistance of the fabric to bending by external forces and also it is directly related to the quality of stiffness.

Crease recovery angle of the fabrics was determined under dry and wet condition by B.S. 3086: 1972. The magnitude of the crease recovery angle is an indication of the ability of fabric to recover from accidental creasing and folding deformations.

The British Standard method B.S. 3086: 1972 was used to determine the wettability for expressing the water repellency of finished fabrics. Thickness of finished fabric was measured by using laboratory thickness tester Hans Baer AG according to B.S.2544:1954. This quantity can describe the thickness increasing of fabric after resin finishing.

Table 1. The concentration of finishing resins (g/L).

PVAc	DMDHEU	Amino silicone	Indalca	Binder	$MgCl_2$ (Catalyst)
0-300	200	20	20	100	8
300	0-200	20	20	100	8

Each sample was laundered one time at 60°C for 30 min with non-ionic detergent (0.05 %solution) as described in B.S.4923:1973. Laundry was carried out to evaluate the durability and wash fastness of achieved physical properties of fabric in the laundry. These physical properties of finished fabric were measured several times.

RESULTS AND DISCUSSION

In this research, some physical properties of finished fabric were studied under the variety of PVAc and DMDHEU concentrations along with other chemicals.

Effect of PVAc Concentration

The changes of bending length versus PVAc concentration is plotted in Figure 1. It was clearly observed that the bending length of finished fabric increased markedly on increasing PVAc concentration. Increase of bending length may be attributed to adhesion and stiffening behaviour of PVAc. Additionally, comparing the data of bending length before and after laundry, it was indicated that PVAc as a stiffener has good wash fastness.

In Figure 2, wettability time is plotted as a function of PVAc concentration. Wettability time can indicate the amount of water repellency of finished fabrics. The time of wettability will be increased on increasing the

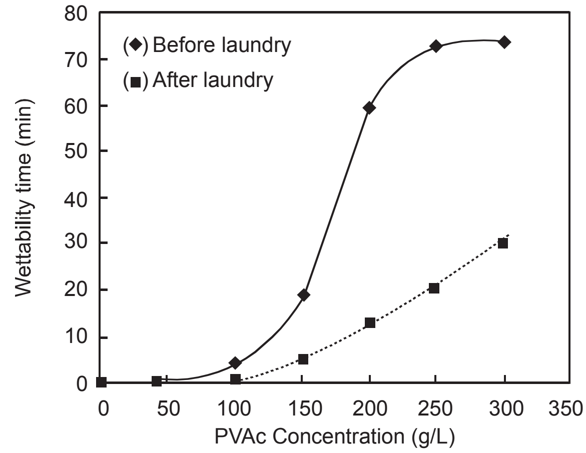


Figure 2. Effect of PVAc concentration on wettability time of fabric in admixture resins, DMDHEU (200 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

PVAc concentration. The increase of wettability time may be attributed to the thick coverage of PVAc on cellulosic substrate, because it was obsereved that the thickness of finished fabric was increased with increasing PVAc concentratin in Figure 3. This coating of PVAc can increase the time of wettability.

Figure 4 shows the changes of crease recovery angle of finished fabric against PVAc concentration. It was presented that crease recovery angle was promi-

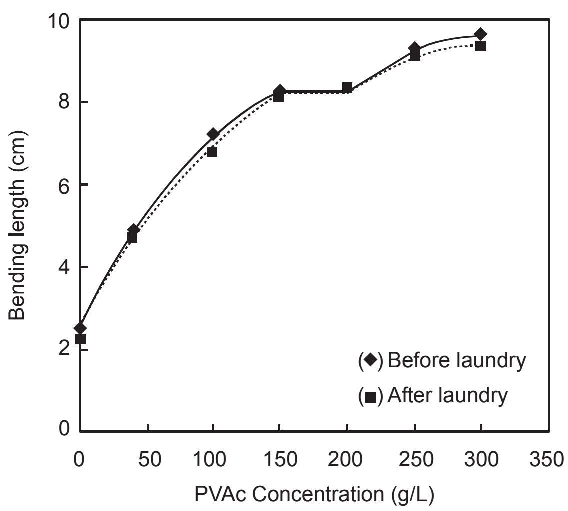


Figure 1. Effect of PVAc concentration on bending length of fabric in admixture resins, DMDHEU (200 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

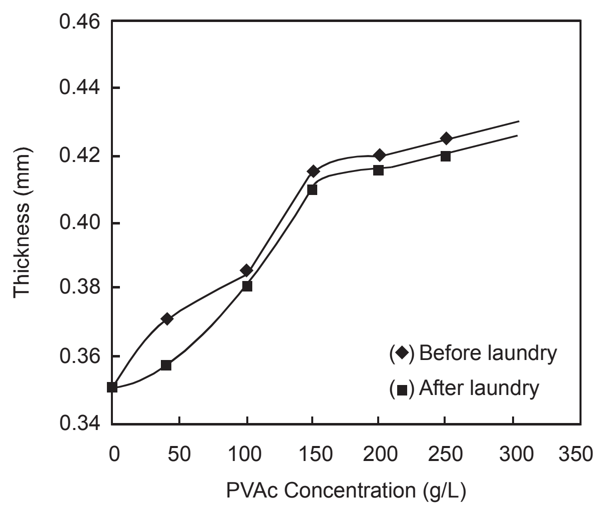


Figure 3. Effect of PVAc concentration on thickness of fabric in admixture resins, DMDHEU (200 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

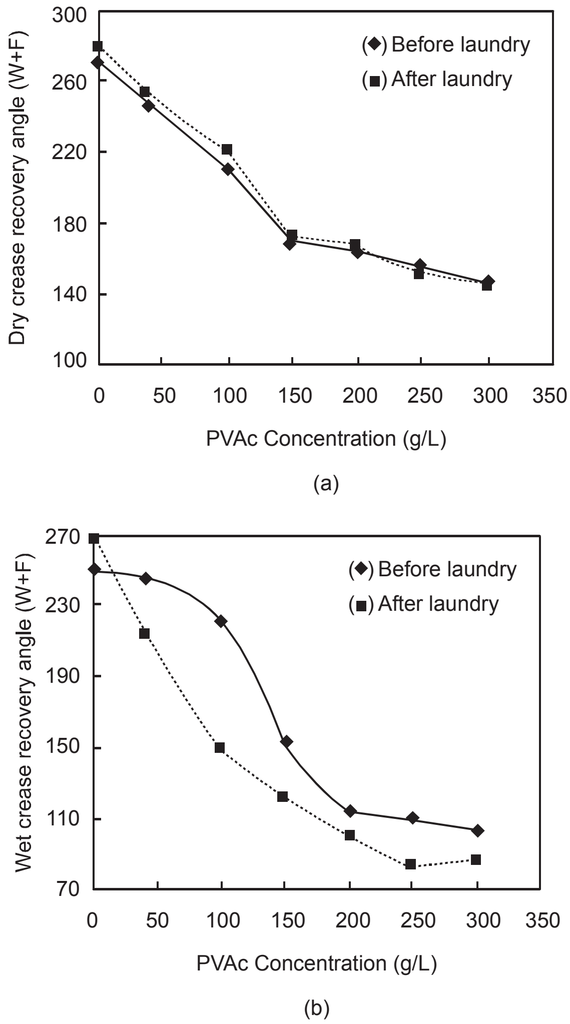


Figure 4. Effect of PVAc concentration on (a) dry and (b) wet crease recovery angle of fabric in admixture resins, DMDHEU (200 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

nently reduced with increasing PVAc concentration, due to stiffening and weightening behaviour of PVAc.

Effect of DMDHEU Concentration

The influence of DMDHEU concentration on the bending length of finished fabric was depicted in Figure 5. It was obviously indicated that the bending length was magnified with increasing DMDHEU concentration, due to cross-linking of cellulose. Under stress, the hydrogen bonds between adjacent cellulose chains can break allowing the chains to slip past each other. But after cross-linking of cellulose by DMDHEU, some hydrogen bonds were converted to covalent bonds,

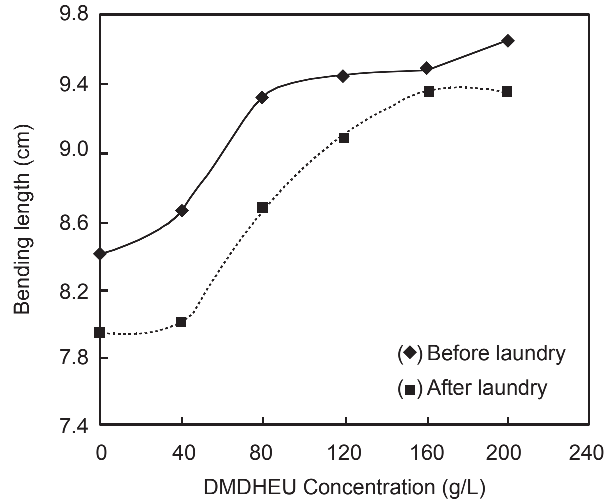


Figure 5. Effect of DMDHEU concentration on bending length of fabric in admixture resins, PVAc (300 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

therefore; stiffness and bending length of finished fabric were increased with increasing DMDHEU concentration. The reaction between DMDHEU and cellulose was indicated as in Scheme I [10, 11, 14, 15, 16].

Figure 6 depicted the changes of wettability versus DMDHEU concentration. On the basis of the last explanation, wettability is related to the free hydroxyl

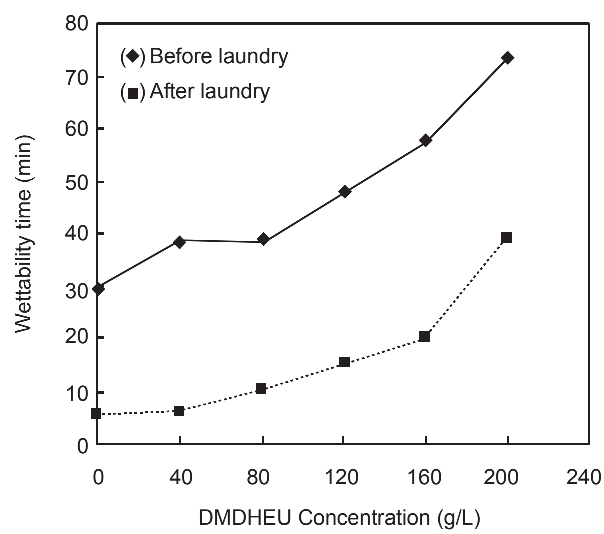
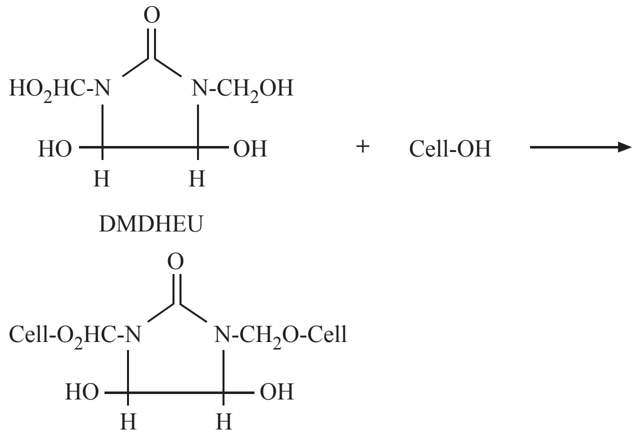


Figure 6. Effect of DMDHEU concentration on wettability time of fabric in admixture resins, PVAc (300 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

groups of cellulose. DMDHEU can react with free hydroxyls of cellulose and create the cross-linked cellulose.



Scheme I

Therefore, DMDHEU can reduce the hydroxyl groups of cellulose by cross-linking of cellulose chains. With reduction of hydroxyl groups, the time of wettability was increased, due to cross-linking of cellulose. The changes of thickness versus DMDHEU concentration were indicated in Figure 7. It was observed that the thickness was increased on increasing DMDHEU concentration, but this enhancement was not remarkable when it compared with the increasing of PVAc concentration.

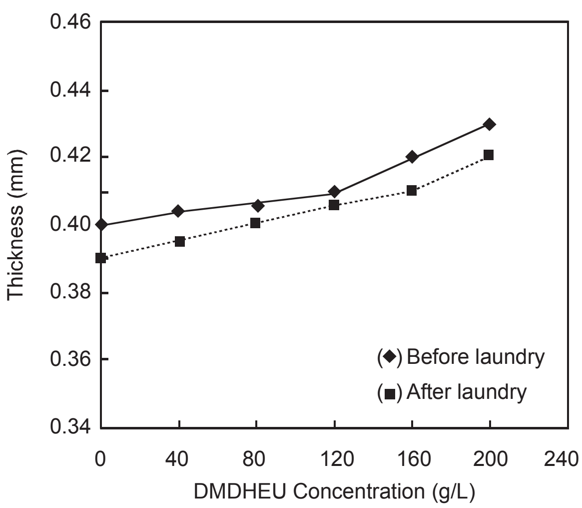


Figure 7. Effect of DMDHEU concentration on thickness of fabric in admixture resins, PVAc (300 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

The effect of DMDHEU concentrations versus crease recovery angle were plotted in Figure 8. It was indicated that the both dry crease recovery angle and wet crease recovery angle were markedly increased with increasing DMDHEU concentration. As it was described earlier DMDHEU were applied as cross-linking agent in this study. DMDHEU can react with free hydroxyls of cellulose chains; therefore, it can convert the weak hydrogen bonds between cellulosic chains to stronger covalent bonds.

Therefore, the crease recovery angle of finished fabric was improved by the formation of covalent cross-links between cellulosic chains.

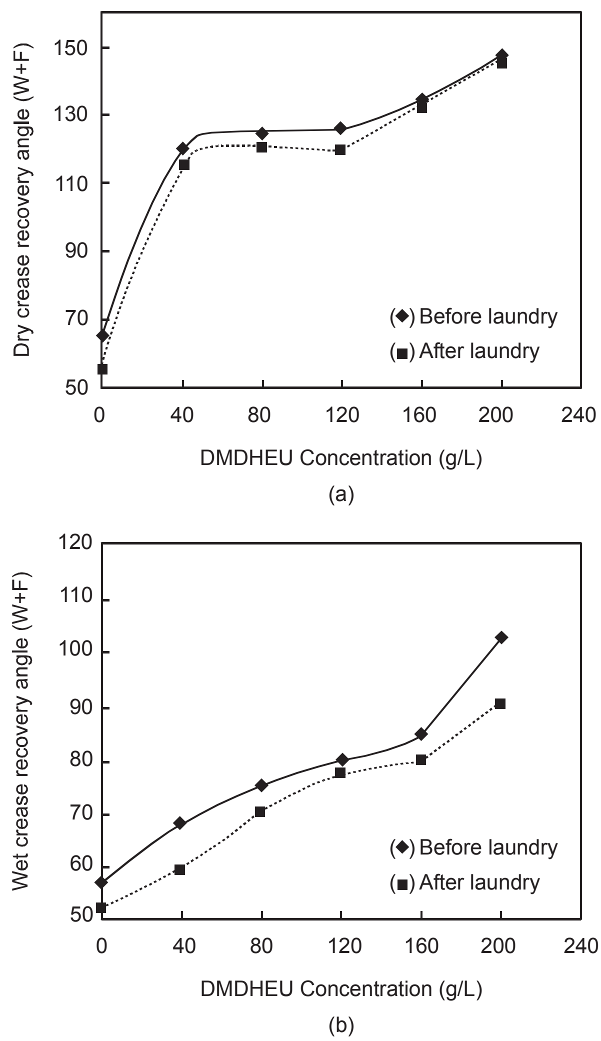


Figure 8. Effect of DMDHEU concentration on (a) dry and (b) wet crease recovery angle of fabric in admixture resins, PVAC (300 g/L), amino silicone (20 g/L), gum (20 g/L), binder (100 g/L) and $MgCl_2$ (8 g/L); dried at 100°C (5 min); cured at 150°C/5 min.

CONCLUSION

Considering the results, it is expected that PVAc as stiffener can increase the bending length, thickness and time of wettability of fabric and also this stiffener has a suitable wash-fastness. But crease recovery angle of finished fabric was reduced with increasing of PVAc concentration; therefore, the cross-linking agent as DMDHEU was employed to overcome this problem. DMDHEU as cross-linking agent can increase the bending length, wettability time and crease recovery angle of finished fabric. Therefore, PVAc and DMDHEU play an important role in the physical properties of finished fabric. Using PVAc along with DMDHEU, amino silicone, binder and gum give the most satisfactory properties for making interlining fabrics.

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