Chemical Modification of Polyester/ Cotton Blends. III. Grafting with 2-Methyl-5-vinylpyridine

Partial carboxymethylation of the cotton component in polyester/cotton blended fabric (72:28) has yielded better stabilization, improved moisture regain, and higher chemical reactivity to easy care finishing agents.[1,2] Acetylation, on the other hand, allows dyeing of both components of the blend with disperse dyes.[3]

This communication presents the changes in properties of this blend brought about by polymerization of 2-methyl-5-vinylpyridine (MVP) in the blend using benzoyl peroxide (BP) as initiator. The mechanism of polymerization is believed to be grafting by vinyl addition to the polyester macroradicals formed under the influence of benzoyl peroxide.[4] The cotton component of the blend is not amenable for this graft polymerization since polymerization of MVP using BP in the presence of 100% cotton fabric did not cause any increase in weight of the fabric. Thus, under the conditions studied, grafting occurred exclusively on the polyester component.

Polymerization of MVP in the presence of polyester/cotton fabric was initiated by using BP. Details of the procedure and conditions used have been described elsewhere.[4]

Dyeing was performed using three different dyestuffs, viZ., an acid dye (Kiton Fast Red BL, C.I. Acid Red 37), a reactive dye (Cibacron Scarlet 4GP, C.I. Reactive Red 16), both dyes kindly supplied by Ciba-Geigy, and a direct dye (Sirius Light Scarlet G-LL, C.I. Direct Red 212), kindly supplied by Bayer. Dyeing was carried out according to the exhaustion method and by following the instructions given for each dye by the manufacturer.

Tensile strength, crease recovery, and moisture regain were determined according to standard methods.[5] The electrical resistivity was measured on an electrometer (Type Van-11, East Germany).

Table I shows that there are substantial changes in the properties of the blend. The tensile strength of the blend increases by 22.7% for 9.9% graft (increase in weight). Increasing the graft yield up to 21.7% does not produce further significant increase in tensile strength since the increase amounts only to 24.6%. This suggests (a) that grafting brings about relaxation of the fibers of the blend components perhaps via removal of strain, (b) that the grafted polymer masks most of the weak points of the yarns of the fabric thereby strengthening the fabric, and (c) that grafting does not significantly disturb the molecular orientation of the polyester fibers in the blend.

The elongation of the blend enhances considerably after grafting (Table I). For example, for 9.9% graft, the elongation increases from 21.6% to 29.6%. Further increase in elongation could be achieved by increasing the graft yield to 15.7% and 21.7%. At these two graft yields, the elongation amounts to 37.4% and 39%, respectively. Since there is an increase in tensile strength as pointed out above, the increase in elongation could be accounted for if one assumes that loosening of the structure of the blend occurs without significant disturbance in fine physical structure of the blend and/or the

TABLE I
Changes in Properties of Polyester/Cotton Blended Fabric After Grafting with MVP Using Benzoyl Peroxide as Initiator[a]

Graft, %	Tensile strength, kg	Elongation at break, %	Crease recovery angle (warp + weft), deg	Moisture regain, %
Untreated blend	37.9	21.6	239	1.3
9.9[b]	46.5	29.6	213	2.6
17.3[c]	46.8	37.4	194	4.9
21.4[d]	47.1	39.0	192	3.2

[a] Benzoyl peroxide concentration, 2.48×10^{-3} mole/l.; temperature, 85°C; time, 1 hr; material:liquor ratio, 1:100.
[b] MVP concentration, 0.65 mole/l.
[c] MVP concentration, 0.79 mole/l.
[d] MVP concentration, 0.81 mole/l.

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grafted polymer deposited inside and nearby the surface of the blended fibers acts as a lubricant. That is, the elasticity of the blend increases because of internal deposition of the vinyl polymer which is most probably in the amorphous form since no stress was applied during the graft polymerization. Consequently, the degree of tightness with which the single chains are packed is lessened.

The crease recovery angle of the blended fabric decreases significantly after grafting; the decrease is greater at higher graft yields (Table I). For example, the ungrafted blend acquires a crease recovery of 239°. This contrasts with 213°, 194°, and 192° for blend samples having 9.9%, 15.7%, and 21.7% graft, respectively. The decrease in crease recovery would indicate that extensibility of the polyester fibers in the blend increases by grafting. This is presumably due to a decrease in the number of crosslinkages (mainly strong hydrogen bonds) which impart to the material resistance to deformation. The number of crosslinkages may probably be decreased by the presence of the grafted polymer within the fiber chain molecules.

A significant enhancement in moisture regain could be achieved by grafting the polyester/cotton blend with MVP using BP as initiator (Table I). The moisture regain increases from 1.3% for the ungrafted blend to 2.6% and 4.9% for grafted blend samples having 9.9% and 17.3% graft, respectively. For a 21.4% graft, on the other hand, the moisture regain is 3.2%.

The improvement in moisture regain could be associated with loosening of the structure of the polyester component in the blend. In other words, grafting opens up the structure of the polyester, decreases tightness of chain packing, and allows for more water accommodation. The decline in the moisture regain value beyond 17% graft could possibly be attributed to the blocking of the pores in the polyester fibers by the MVP molecules.

Figure 1 shows the electrical resistivity as a function of temperature for the ungrafted blend and for blend samples having 9.9% and 17.3% graft. As can be seen, the grafted samples have much lower electrical resistivity than the ungrafted samples. Furthermore, the electrical resistivity is lower with sample having 17.3% graft than with sample of 9.9% graft.

It is well known that as electrical resistivity of a textile material decreases, its ability to accumulate static charges decreases. Hence, it can be concluded that one of the outstanding contributions of grafting MVP onto polyester/cotton blend is its ability to effectively control static electricity.

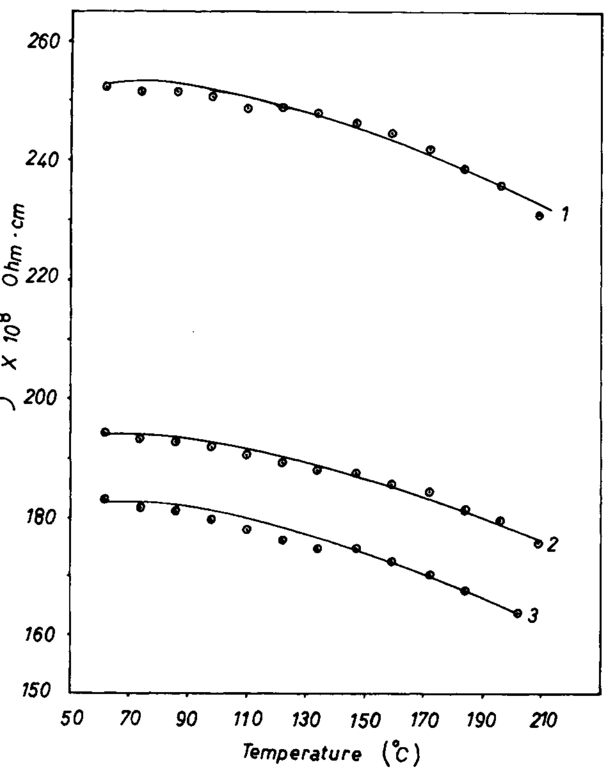

Fig. 1. Electrical resistivity of polyester/cotton blend before and after grafting: (1) untreated blend; (2) 9.9% graft.

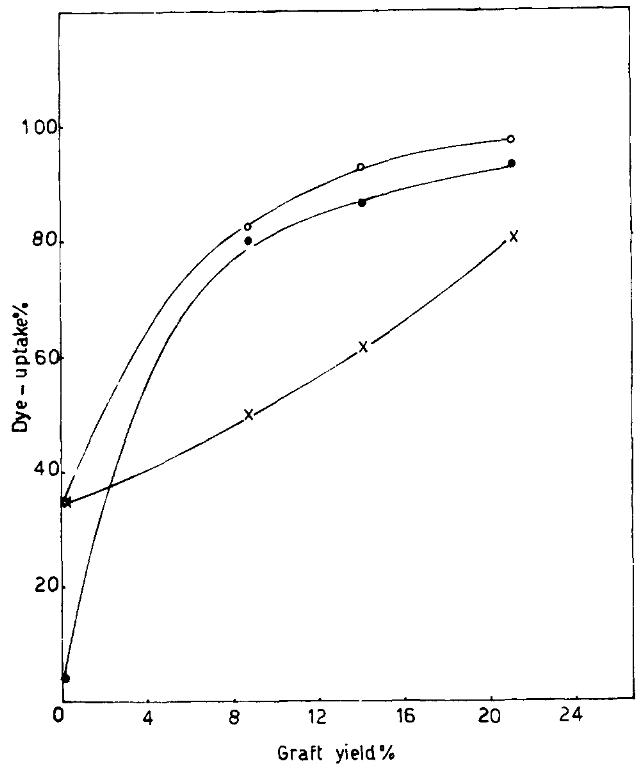

Fig. 2. Dye uptake vs graft yield: (O) Sirius Light Scarlet G-LL; (●) Kiton Fast Red BL; (X) Cibacron Scarlet 4 GB.

Figure 2 shows the dye uptake versus the graft yield when dyeing was performed using the three different dyes in question. It is clear that regardless of the dye used, the dye uptake increases as the graft yield increases. The higher dye uptake in case of the direct dye could be attributed to the formation of salt linkages between the acidic solubilizing groups in the dye and the pyridine moieties in the graft. This and the presence of chlorine atom in the reactive dye, which permits quaternization of pyridine, would account for the higher uptake observed with the reactive dye. The significant enhancement in dye uptake of the acid dye by grafting MVP onto the polyester component of the blend is rather expected and is in accordance with the literature.[6,7]

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