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Studies of Some Wool/Polyester Woven Fabrics

Part V: Untreated and Easycare Finished $^2/_2$ Twill Fabrics from Wool Blended with Normal and Special Low Pilling Polyester, Respectively

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STUDIES OF SOME WOOL/POLYESTER WOVEN FABRICS PART V: UNTREATED AND EASYCARE FINISHED $^2/_2$ TWILL FABRICS FROM WOOL BLENDED WITH NORMAL AND SPECIAL LOW PILLING POLYESTER, RESPECTIVELY

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ABSTRACT

A polyurethane and a polyurethane/polyacrylate polymer mixture were applied from a solvent and an aqueous system, respectively, to $^2/_2$ twill lightweight fabrics *(200 g/m²) made from pure wool, pure polyester (two types) and a range of intimate blends of these two fibre types.*

The low pilling polyester type produced fabrics with inferior tensile properties when compared with normal polyester although in other respects there were no significant differences between the fabrics containing the two different polyester types.

The main advantage of the polymer treatments was to reduce the felting shrinkage *and to improve the appearance after washing although, for the severe wash test used, 2* per cent *(o.m.f) of polymer appeared to be insufficient to ensure a satisfactory DP-performance for the* $^2/_2$ *twill all-wool and wool/polyester (80/20) fabrics. The solvent treatment held a slight advantage in terms of the appearance after washing, but it caused a greater deterioration in fabric strength and a larger increase in fabric stiffness than the aqueous treatment.*

If anything, both treatments caused a deterioration in the fabric wrinkle recovery properties.

INTRODUCTION

The effect of polyester level, type of polyester and certain finishing procedures as well as certain easy-care finishes on the properties of *plain weave* fabrics manufactured from wool/polyester intimate blends was examined recently[1, 2].

The advantages of applying polyurethane and polyacrylates to *all-wool* and *wool-rich* blends have been discussed[3] and the effect of a polyurethane and a polyurethane/polyacrylate mixture on the properties of wool/acrylic fabrics in plain and $^2/_2$ twill has been determined. Whereas the relaxation and felting shrinkage was much improved by these treatments the appearance after washing was only marginally improved. Application of the polymer (2 *per cent* o.m.f) had a small effect on the crease recovery angle and the wrinkle height. Both treatments increased the fabric stiffness and the resistance to flat abrasion but did not, however, affect the fabric breaking strength, tear strength and bursting strength.

Hoschke[4] studied the mechanical properties of *plain* weave fabrics produced from wool (untreated and Hercosett treated tops) blended with polyester. The fabric tensile strength improved with increasing polyester content with the fabrics containing the Hercosett treated wool stronger than those containing the untreated wool, although the former had poorer wrinkle recovery properties. Increasing the polyester content improved the fabric wrinkle recovery properties but caused a deterioration in their resistance to pilling.

The present investigation on $^2/_2$ twill wool/polyester blends was initiated to supplement previous studies[1,2] on wool/polyester blend *plain* weaves. It was a further aim of this study to evaluate and compare the performance of a solvent-soluble polyurethane treatment with that of an aqueous mixture of a polyurethane (water soluble) and a soft polyacrylate when these were applied to all-wool and wool/polyester blend twill fabrics.

EXPERIMENTAL

Two undyed polyester types (a special low pilling ®Trevira type 330 and a normal Trevira type 220) were each in turn intimately blended with a 64's quality merino wool to give six blend levels ranging from all-wool to all-polyester. The polyester content of the fabrics was increased in steps of 20 *per cent* (absolute). These blends were processed into $^2/_2$ *twill fabrics* of approximately 200 g/m² in the same manner as the *plain weaves* of an earlier study[1]. After finishing by the usual routine the fabrics were decatised.

The polymers used in this investigation and the methods of application were the same as those used in an earlier study[3].

The mechanical and wrinkling properties of the fabrics were measured in the same manner as before[1,5].

RESULTS AND DISCUSSION

The results of the physical tests are presented in Tables I and II as well as the various graphs (Figs 1 to 4).

Fabric Mass Per Unit Area

The fabric mass per unit area of the solvent treated $^2/_2$ twill fabrics increased on average by 3,8 *per cent* and that of the aqueous treatment by 2,5 *per cent* (see Table I). These increases are larger than the expected 2 *per cent* due to the polymer add-on. The increase in fabric mass per unit area in excess of 2 *per cent* may be attributed to relaxation shrinkage.

Fabric Thickness

Both treatments caused a slight increase in fabric thickness (see Table I). Fabrics of slightly greater thickness were obtained by the solvent treatment (using a dip-tumble method) than by the aqueous treatment (using a pad-method). The higher the wool content of the blend the greater the increase in the fabric thickness. Similar changes to these were previously observed in the case of $^2/_2$ twill wool/acrylic fabrics treated similarly[3].

Air Permeability

The air permeability of the untreated fabrics increased slightly as the polyester content increased up to about 80 *per cent* polyester content. The all-polyester fabrics had an air permeability of approximately 50 m ℓ/s/cm² at a pressure of 98 Pa which was about double that obtained for the other blend levels (See Table I).

The air permeability increased slightly after both treatments and the solvent treated fabrics tended to have slightly higher air permeabilities than the aqueous treated fabrics.

Tensile Properties

The fabric breaking tenacity (average of warp and weft) and the bursting strength showed similar trends. Only the results of the former has, therefore, been plotted against polyester content (Fig 1). The fabric tenacity increased almost linearly with polyester content, except for a slight levelling off in the case of the all-polyester fabrics. The fabric tenacity of the $^2/_2$ twill weaves was (at the same blend level) of about the same order as was previously observed[1] for plain weaves. As before[1] the normal polyester performed better than the low-pilling polyester. At high wool content the fabrics were almost unaffected by the polymer treatments but as the polyester content increased so the treatments caused a gradually increasing deterioration in the tensile properties relative to the untreated fabrics which was more pronounced for the solvent treatment than for the aqueous treatment.

Fabrics containing the normal polyester had higher breaking extensions than fabrics containing the low-pilling polyester (see Table II). There was also a tendency for the extension at break to increase with polyester content while the treatments had very little effect.

Stoll Flex Abrasion

The flex abrasion increased almost linearly with polyester content (see Table II). The normal polyester performed better than the low-pilling polyester.

TABLE I

EFFECT OF TREATMENTS ON CERTAIN FABRIC PROPERTIES

Blend % Wool/% Polyester	Resin treatment	Sett (threads per cm)		Fabric Mass per Unit Area (g/m²)	Thickness measured at 0,5 kPa (in mm)	Fabric Density (g/cm³)	Air Permeability measured at 98 Pa (ml/s/cm²/98 Pa)	Cantilever Bending Length (cm)			Cantilever Flexural Rigidity (mN. mm)			Drape Coefficient (%)	Bursting Strength (kN/m²)	Fabric Breaking Strength (N)			Fabric Breaking Tenacity (cN/tex)			Extension at Break (%)		
		W	F					W	F	Mean	W	F	Mean			W	F	Mean	W	F	Mean	W	F	Mean
100/0	Untreated	22,2	22,7	198	0,526	0,376	17,9	1,57	1,58	1,57	7,5	7,6	7,6	46,3	832	289	274	282	6,1	5,8	6,0	23,5	17,9	20,7
	Solvent			204	0,618	0,330	25,3	2,03	2,14	2,09	16,6	19,6	18,1	61,6	850	296	280	288	6,3	5,9	6,1	25,8	26,4	26,1
	Aqueous			204	0,586	0,348	22,6	2,04	1,85	1,95	16,9	12,6	14,7	62,9	857	319	279	299	6,7	5,9	6,3	23,0	24,8	23,9
TREVIRA TYPE 220																								
80/20	Untreated	22,6	22,1	199	0,498	0,400	18,3	1,63	1,62	1,63	8,4	8,3	8,4	47,0	1275	504	474	489	10,6	10,0	10,3	30,3	26,5	28,4
	Solvent			205	0,570	0,360	23,9	2,21	2,41	2,31	21,7	28,1	24,9	67,9	1311	501	518	510	10,6	10,9	10,7	33,2	28,6	30,9
	Aqueous			205	0,550	0,373	22,7	2,13	1,99	2,06	19,4	15,8	17,6	67,0	1304	551	503	527	11,6	10,6	11,1	32,4	30,2	31,3
60/40	Untreated	22,8	22,2	197	0,470	0,419	18,6	1,64	1,70	1,67	8,5	9,5	9,0	49,8	1770	706	721	714	14,9	15,2	15,0	27,3	32,4	30,0
	Solvent			206	0,581	0,355	24,1	2,42	2,72	2,57	28,6	40,6	34,6	71,0	1798	720	736	728	15,3	15,6	15,4	35,6	30,8	33,2
	Aqueous			200	0,515	0,388	23,5	2,40	2,24	2,32	27,0	22,0	24,5	67,6	1736	773	707	740	16,3	14,9	15,6	32,0	30,8	31,4
40/60	Untreated	22,6	22,6	208	0,472	0,441	17,2	1,71	1,75	1,73	10,2	10,9	10,6	49,1	2306	1062	1056	1059	22,4	23,3	22,9	38,4	32,0	35,2
	Solvent			218	0,584	0,373	22,3	2,60	2,81	2,71	37,5	47,4	42,4	72,8	2120	1031	1028	1030	21,8	21,7	21,7	38,6	32,8	35,7
	Aqueous			209	0,485	0,431	19,3	2,66	2,31	2,48	38,5	25,2	31,8	74,0	2265	1152	901	1027	24,4	19,0	21,7	35,7	32,7	34,2
20/80	Untreated	22,7	22,2	203	0,449	0,452	23,2	1,72	1,80	1,76	10,1	11,6	10,9	52,0	2659	1266	1294	1280	26,7	27,3	27,0	36,3	34,5	35,4
	Solvent			212	0,523	0,405	28.6	3,33	3,13	3,23	74,7	63,7	70,2	78,7	2426	1163	1220	1192	24,6	25,8	25,2	36,1	27,8	32,0
	Aqueous			211	0,474	0,422	23,9	2,36	2,28	2,32	27,1	24,5	25,8	73,4	2695	1210	1231	1221	25,6	26,0	25,8	34,8	30,4	32,6
0/100	Untreated	22,7	22,3	188	0,453	0,415	49,7	1,75	1,82	1,79	9,9	11,1	10,5	48,9	2831	1358	1389	1374	28,7	29,4	29,0	37,1	28,6	32,9
	Solvent			195	0,520	0,375	64,1	3,53	3,97	3,75	84,0	119,5	101,7	86,7	2534	1196	1168	1182	25,3	24,7	25,0	32,9	26,0	29,5
	Aqueous			193	0,475	0,406	57,9	2,55	2,54	2,54	31,3	30,9	31,1	77,4	2739	1323	1294	1309	28,0	27,4	27,7	36,6	32,3	34,5
TREVIRA TYPE 330																								
80/20	Untreated	22,2	23,0	195	0,490	0,398	18,1	1,69	1,69	1,69	9,3	8,8	9,1	47,7	1192	454	429	442	9,6	9,1	9,4	25,1	23,7	24,4
	Solvent			200	0,609	0,328	24,8	2,20	2,25	2,23	20,8	22,3	21,5	65,6	1192	484	462	473	10,2	9,8	10,0	30,3	26,1	28,2
	Aqueous			199	0,536	0,371	23,2	2,40	2,00	2,20	26,9	15,6	21,2	67,3	1197	501	436	469	10,6	9,2	9,9	25,6	25,8	25,7
60/40	Untreated	22,2	23,0	202	0,499	0,405	19,3	1,74	1,70	1,72	10,4	9,7	10,1	49,0	1631	703	686	695	14,8	14,5	14,6	30,0	25,0	27,5
	Solvent			210	0,587	0,358	22,0	2,42	2,71	2,57	29,1	40,9	35,0	72,2	1582	660	688	674	13,9	14,5	14,1	31,2	26,3	28,8
	Aqueous			206	0,532	0,387	21,7	2,42	2,14	2,28	28,6	19,7	24,1	72,2	1644	751	660	706	15,9	13,9	14,9	29,4	28,7	29,1
40/60	Untreated	22,8	22,1	203	0,490	0,414	19,8	1,69	1,74	1,72	9,6	10,5	10,1	50,1	2042	903	932	918	19,1	19,7	19,4	32,3	26,5	29,4
	Solvent			213	0,554	0,384	23,3	2,69	2,92	2,81	40,6	51,9	46,2	75,5	1940	869	883	876	18,4	18,7	18,6	31,3	24,8	28,1
	Aqueous			210	0,535	0,393	25,0	2,39	2,13	2,26	28,0	19,9	23,9	68,8	2020	941	902	922	19,9	19,1	19,5	28,2	28,2	28,2
20/80	Untreated	22,4	22,3	202	0,458	0,441	24,9	1,80	1,77	1,79	11,5	11,0	11,3	50,6	2324	1115	1125	1120	23,5	23,8	23,6	33,3	27,1	30,2
	Solvent			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Aqueous			209	0,496	0,421	26,5	2,36	2,57	2,46	26,9	34,7	30,8	64,9	2337	981	1155	1068	20,7	24,4	22,6	32,2	28,4	30,3
0/100	Untreated	22,6	22,6	193	0,490	0,394	48,1	1,73	1,84	1,79	9,8	11,8	10,8	51,7	2447	1088	1136	1112	23,0	24,0	23,5	28,9	22,4	25,7
	Solvent			198	0,534	0,371	54,7	1,88	2,22	2,05	12,9	21,2	17,0	52,5	2257	992	897	945	20,9	19,0	20,0	28,1	24,4	26,3
	Aqueous			196	0,492	0,398	54,4	2,87	2,86	2,86	45,4	44,9	45,1	82,3	2254	1032	1161	1097	21,8	24,5	23,2	27,3	26,6	27,0

TABLE II

EFFECT OF TREATMENTS ON FABRIC ABRASION, PILLING, SHRINKAGE AND WRINKLING PROPERTIES

Blend % Wool/ % Polyester	Resin Treatment	Stoll Flex Abrasion (Cycles to Rupture)			Flat Abrasion (% Mass Loss at 10 000 cycles)	Relaxation Shrinkage (% Area Shrinkage) IWS TM 9	Felting Shrinkage (% Area Shrinkage) IWS TM 185	DP Rating	MONSANTO CREASE RECOVERY ANGLE (IN DEGREES) at 20° C/65% RH		De-aged	At 27° C/75% RH		De-aged	FRL Wrinkle Height (in mm) De-aged at 27° C/75% RH		
		W	F	Mean					W	F	W + F	W	F	W + F	W	F	Mean
100/0	Untreated	1073	844	959	21,0	7,3	70,1	1,0	160	157	317	150	147	297	0,74	1,35	1,05
	Solvent	785	1072	929	12,2	3,2	6,7	2,5	159	160	319	148	141	289	0,67	1,25	0,96
	Aqueous	762	823	792	6,2	1,9	3,4	2,1	159	161	320	150	146	296	0,73	0,90	0,82
TREVIRA TYPE 220																	
80/20	Untreated	2135	2264	2200	13,1	4,0	55,3	1,0	156	162	318	151	149	300	0,70	0,72	0,71
	Solvent	2525	1832	2179	7,1	2,0	3,4	3,5	166	163	329	154	156	310	0,77	0,85	0,81
	Aqueous	1960	1967	1965	5,8	1,7	2,7	2,9	168	163	331	145	151	296	0,89	0,77	0,83
60/40	Untreated	6068	5925	5997	8,6	2,2	17,4	1,0	164	167	331	155	158	313	0,46	0,72	0,59
	Solvent	4276	5003	4640	4,8	1,9	2,6	3,5	166	166	332	158	157	315	0,53	0,61	0,57
	Aqueous	4559	3799	4179	3,2	1,9	2,7	3,4	164	166	330	158	154	312	0,64	0,82	0,73
40/60	Untreated	15121	10327	12724	4,4	1,4	4,8	3,6	166	165	331	161	160	321	0,60	0,47	0,54
	Solvent	8356	5550	6953	2,9	1,3	1,8	3,5	166	167	333	158	157	315	0,63	0,56	0,60
	Aqueous	5327	5699	5513	2,5	1,9	2,9	2,9	166	165	331	153	155	308	0,73	0,63	0,68
20/80	Untreated	11742	12115	11929	1,8	1,6	2,5	4,7	168	163	331	160	158	318	0,41	0,38	0,40
	Solvent	6835	6817	6826	1,7	1,4	2,1	3,5	164	168	332	154	152	306	0,80	0,72	0,76
	Aqueous	6867	7132	7000	2,0	1,4	2,4	3,5	164	162	326	147	151	298	0,70	0,70	0,70
0/100	Untreated	14348	14848	14598	0,7	1,0	2.1	4,3	165	164	329	163	162	325	0,24	0,33	0,29
	Solvent	5131	7948	6540	0,7	1,6	1,8	3,8	163	165	328	154	150	304	1,16	0,84	1,00
	Aqueous	7235	7469	7352	0,9	1,3	2,1	3,6	167	165	332	157	148	305	0,46	0,82	0,64
TREVIRA TYPE 330																	
80/20	Untreated	2441	2015	2228	10,6	4,8	56,3	1,0	165	161	326	164	166	330	0,79	0,77	0,78
	Solvent	3874	2009	2942	7,6	2,0	3,3	3,6	165	170	335	146	155	301	0,76	0,82	0,79
	Aqueous	2644	1194	1919	4,8	2,2	3,7	2,8	162	162	324	143	146	289	0,76	0,53	0,65
60/40	Untreated	4843	4928	4886	5,4	2,3	17,9	1,0	165	166	331	160	158	318	0,45	0,72	0,59
	Solvent	2256	2407	2332	5,5	1,1	2,4	4,0	167	166	333	152	158	310	0,74	0,59	0,66
	Aqueous	3293	2792	3043	4,3	1,5	2,7	4,1	167	165	332	150	149	299	0,70	0,61	0,66
40/60	Untreated	8951	5896	7424	4,7	1,5	4,4	3,6	161	166	327	162	163	325	0,31	0,51	0,41
	Solvent	2426	3781	3104	3,4	1,5	2,1	3,7	164	165	329	154	158	312	0,58	0,47	0,53
	Aqueous	3333	3300	3317	2,3	1,2	2,0	3,5	163	167	330	152	151	303	0,58	0,51	0,55
20/80	Untreated	9233	8796	9015	3,8	1,1	2,6	4,0	162	163	325	155	153	308	0,30	0,38	0,34
	Solvent	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Aqueous	4130	3977	4054	1,9	0,8	1,5	3,5	169	168	337	150	156	306	0,79	0,61	0,70
0/100	Untreated	6101	9172	7637	1,6	0,8	1,8	4,6	172	165	337	164	160	324	0,31	0,32	0,32
	Solvent	4656	4887	4772	2,3	1,1	2,0	4,7	170	167	337	156	149	305	0,34	0,39	0,37
	Aqueous	4088	3466	3777	1,8	1,0	1,7	3,4	167	168	335	158	159	317	0,56	0,58	0,57

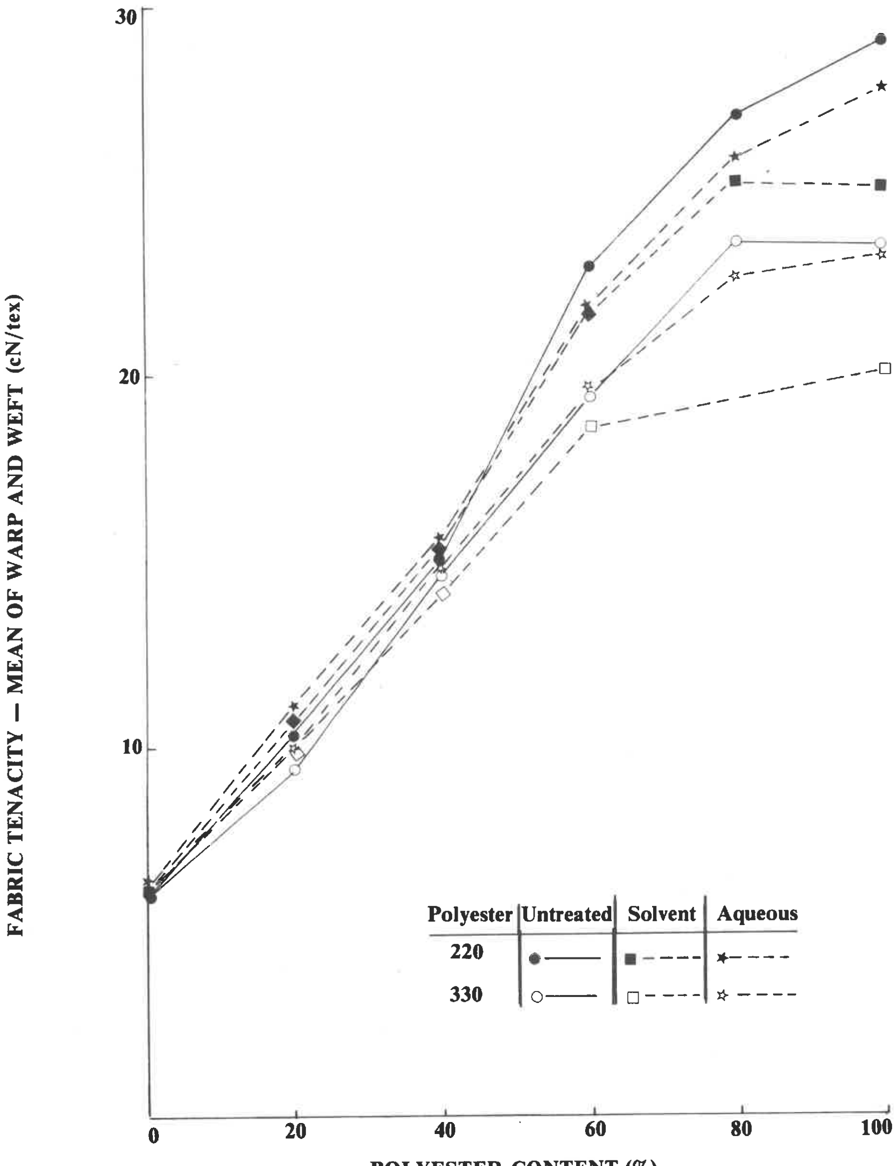

Fig. 1 The relationship between fabric tenacity (mean of warp and weft) and polyester content

A higher resistance to flex abrasion was observed for the $^{2}/_{2}$ twills than for the plain weave fabrics tested previously[1], particularly at the higher levels of polyester content.

Both treatments reduced the resistance to flex abrasion by about the same amount, with the difference between the two polyester types persisting after the treatments.

Martindale Abrasion

The resistance to flat abrasion of the $^{2}/_{2}$ twill fabrics improved markedly as the polyester content increased (Table II) although no consistent difference due to the polyester type was observed. Both treatments improved the resistance to flat abrasion, which is in agreement with previous results on polyurethane treated fabrics[2, 3]. Better abrasion resistance was obtained by the aqueous treatment.

Fabric Stiffness

A plot of flexural rigidity against polyester content (Fig 2) illustrates the general effects of polyester content and the various treatments on the fabric stiffness properties. As the polyester content increased the stiffness of the untreated fabrics increased slightly. No effect due to the polyester type was detected.

Although both treatments caused similar increases in the drape coefficient, the flexural rigidity (or bending length) was increased less by the aqueous treatment than by the solvent treatment (see Table I).

Relaxation and Felting Shrinkage

The relaxation shrinkage of the untreated fabrics decreased with an increase in polyester content and no difference due to polyester type was observed (see Table II). Both polymer treatments reduced the area relaxation shrinkage of all blends to about 2 *per cent*, or less, which is approximately the level of area relaxation shrinkage of the untreated high polyester content fabrics. The improvements in relaxation shrinkage may be due to either spotwelding (interfibre bonding) or relaxation, or both, resulting from the polymer treatments.

The area felting shrinkage of the *untreated* fabrics decreased sharply as the polyester content increased (Fig 3). Compared to similar plain weave fabrics[2] the $^{2}/_{2}$ twill all-wool and wool-rich fabrics exhibited greater *felting* shrinkage. The felting shrinkage of all the blend levels was reduced by both treatments to a low level (approximately 3 *per cent* area shrinkage) except for the solvent treated *all-wool* fabric which still exhibited an area felting shrinkage of about 7 *per cent*.

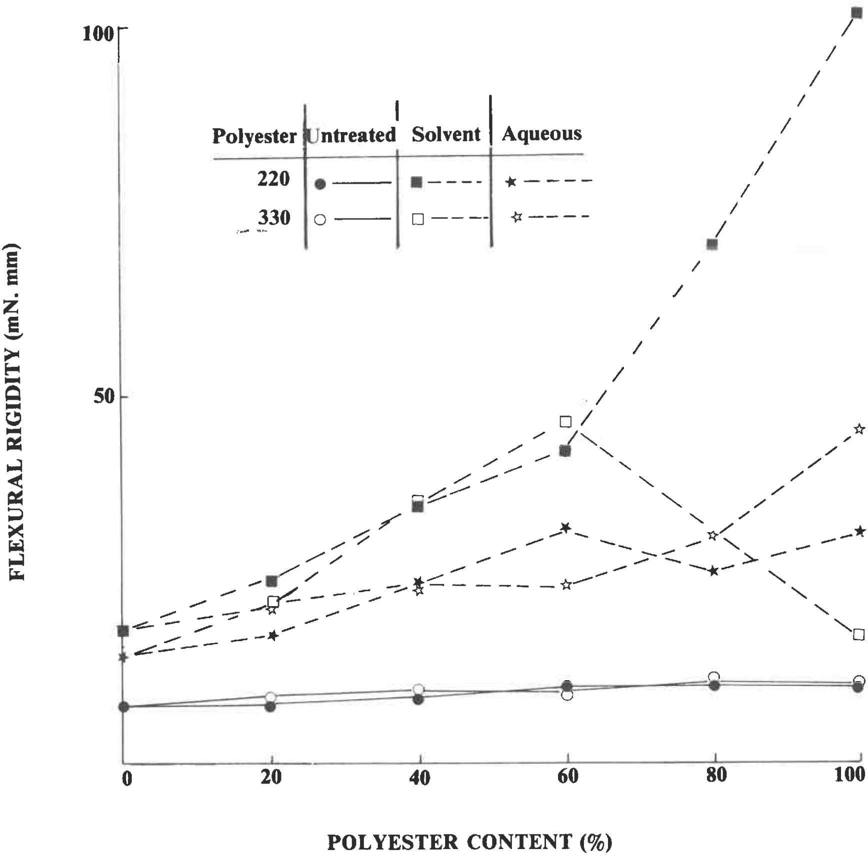

Fig. 2 The relationship between flexural rigidity (mean of warp and weft) and polyester content

Appearance After Washing

The untreated $^2/_2$ twill fabrics containing 60 *per cent* or more wool had DP-ratings of 1 and compared unfavourably with similar plain weave fabrics[2]. Fabrics containing less than 60 *per cent* wool had DP-ratings of about 4 and performed similarly to the plain weave fabrics[2].

The DP-performance of the solvent treated fabrics tended to be slightly better than that of the aqueous treated fabrics. It seems that the *treated* $^2/_2$ twill fabrics tended to have slightly poorer durable press performance than similar plain weave fabrics[2] given slightly different treatments.

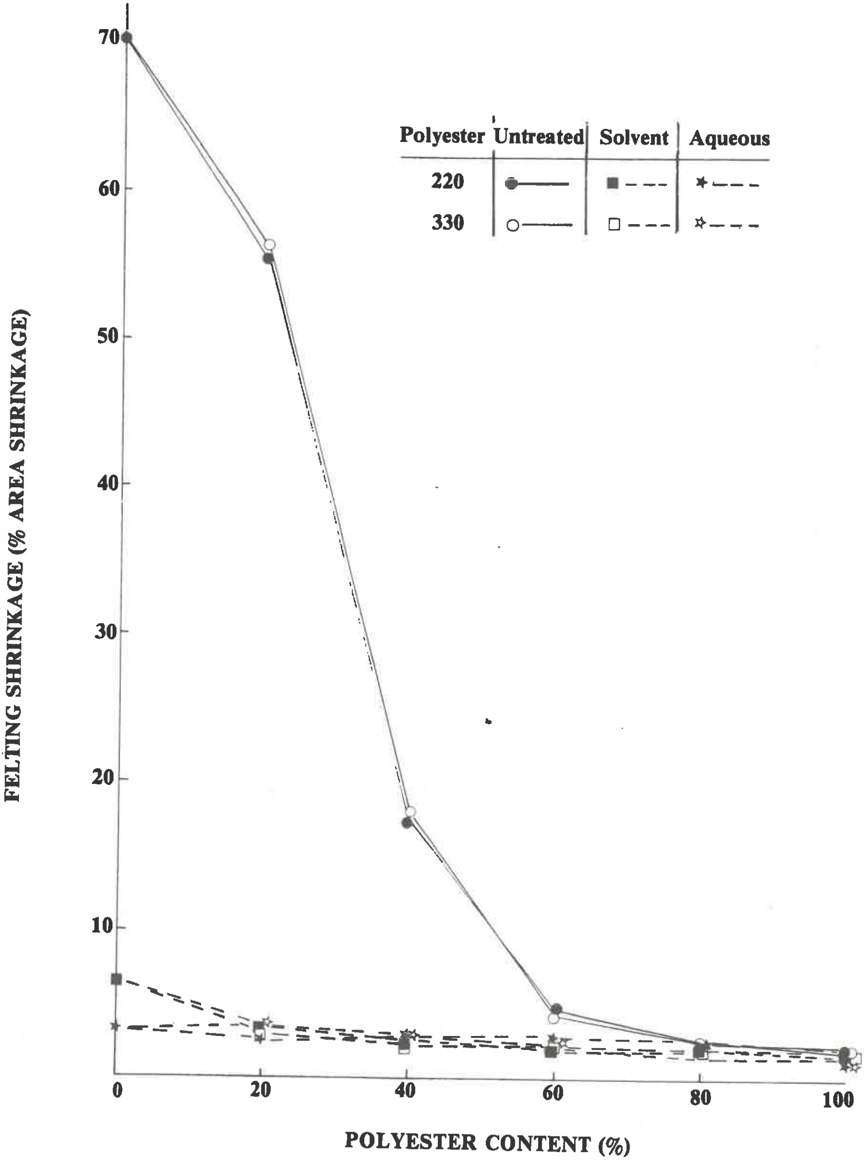

Fig. 3 The relationship between felting shrinkage and polyester content

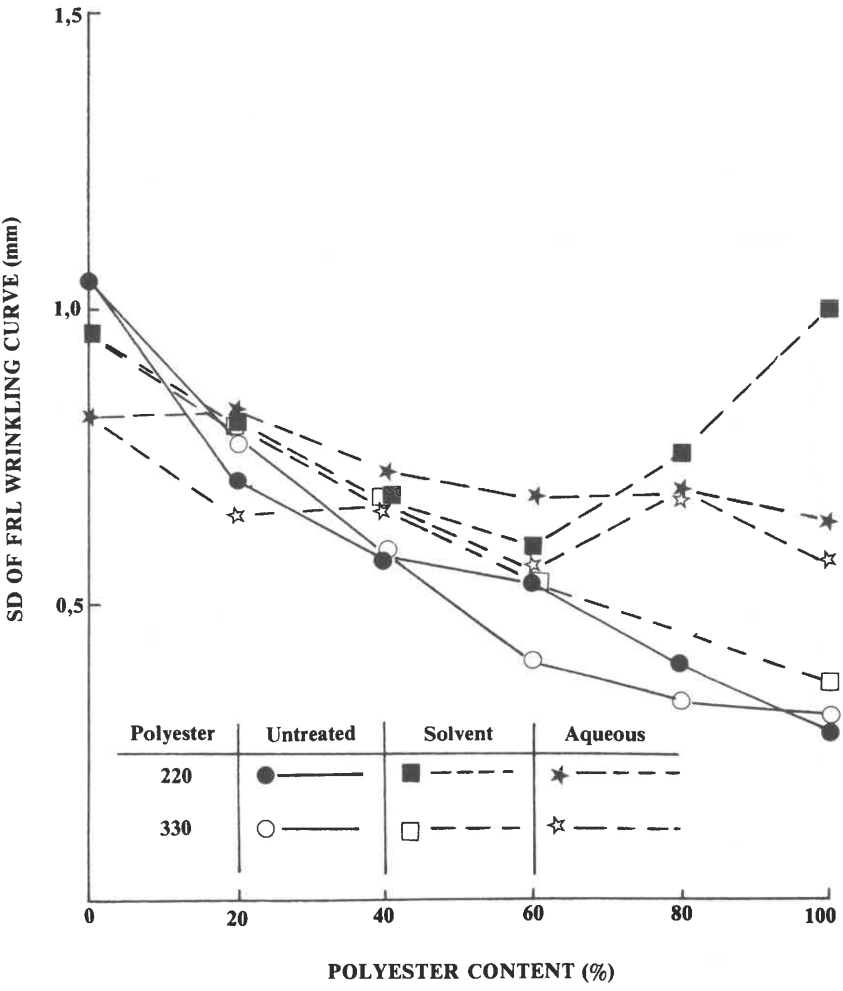

Fig. 4 The relationship between FRL wrinkling (75% RH/27° C) and polyester content

Monsanto Crease Recovery

The fabrics were creased in the de-aged state at both 65% RH/20° C and 75% RH/27° C and allowed to relax at 65% RH/20° C.

A small improvement in the crease recovery angle resulted from an increase in the polyester content with little difference between the polyester types (see Table II). When creasing occurred at 20°C/65 % RH the effect due to the polymers or polymer type was very small. Under high humidity/high temperature creasing conditions the polymer treated fabrics generally performed worse than the untreated fabrics. The polymer mixture applied from an aqueous medium tended to produce fabrics having a poorer performance than those treated in the solvent system.

FRL Wrinkling

An improvement in wrinkling performance of the untreated fabrics occurred with an increase in polyester content with no difference between polyester types (Fig 4). There was also a tendency towards better wrinkle recovery with an increase in polyester content for the polymer treated fabrics. The polymer treatments effected a slight improvement in the wrinkle recovery of the all-wool fabrics, with the aqueous treatment being slightly better. No clear and consistent difference between the different polymer treatments was evident for the blends.

SUMMARY AND CONCLUSIONS

The mechanical properties of untreated and polymer treated (polyurethane and polyurethane/polyacrylate mixture applied from solvent and aqueous systems, respectively) lightweight $^2/_2$ twill fabrics consisting of blends of wool with either a special low pilling polyester (Trevira type 330) or a normal polyester (Trevira type 220) were compared.

Increases in air permeability, fabric stiffness, fabric breaking strength, bursting strength, resistance to flex abrasion and flat abrasion and improvements in dimensional stability, durable press performance and wrinkle and crease recovery properties occurred with increasing polyester content. Compared with previous results obtained on plain weave fabrics, of similar mass per unit area, the $^2/_2$ twills exhibited higher washing shrinkage, air permeability, tear strength and resistance to flex abrasion but lower resistance to flat abrasion. The appearance after washing of the $^2/_2$ twills tended to be slightly worse than that of the plain weaves while their wrinkling recovery properties were generally found to be slightly better than those of the corresponding plain weave fabrics.

Fabrics containing the normal polyester were better than those containing the low pilling polyester as far as fabric breaking tenacity, bursting strength and flex abrasion were concerned. There was little difference between polyester types in resistance to flat abrasion, fabric stiffness properties, dimensional stability, fabric appearance after washing and wrinkle- and crease recovery properties.

After the respective polymer treatments, the dimensional stability and appearance after washing (of the wool-rich fabrics) improved, the air permeability, fabric stiffness and resistance to flat abrasion increased whereas the fabric strength, flex abrasion and resistance to flex abrasion decreased.

When comparing the solvent treatment with the aqueous treatment the former resulted in lower fabric strength, greater fabric stiffness, lower resistance to flat abrasion and slightly better durable press performance. No difference between the two treatments was observed for the air permeability, extension at break, resistance to flex abrasion, drape coefficient and dimensional stability.

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THE USE OF PROPRIETARY NAMES

®Trevira is a registered trade name of Messrs Hoechst.

The fact that products with proprietary names have been used in this investigation does not imply that there are not others equally good or better.

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