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Studies of Some Wool/Acrylic Woven Fabrics

Part II: Polyurethane and Polyacrylate Treated Plain and 2/2 Twill Lightweight Fabrics from Wool Blended with Regular Acrylic

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ABSTRACT

Plain weave and 2/2 twill lightweight fabrics (200 g/m²) made from all-wool, all-acrylic and a range of intimate blends of these two fibre types were treated with a polyurethane polymer from a solvent system and a mixture of the bisulphite adduct of a polyurethane and a polyacrylate polymer from an aqueous system.

Both polymer treatments reduced the relaxation and felting shrinkage of the wool-rich blends to levels similar to those of the acrylic-rich blends. The untreated and treated acrylic-rich blends did not differ much with respect to relaxation and felting shrinkage. The improvement in the appearance after washing due to the treatments was disappointingly small.

At the level of polymer application (2 per cent o.m.f.) used, the effect of the treatment on the crease recovery angle and wrinkle height was small.

Both treatments effected a similar increase in the fabric stiffness. The fabric breaking strength, the tear strength and the bursting strength were almost unaffected by the treatments. The resistance to flat abrasion of the 2/2 twill fabrics was much improved by the treatments, with the polymer mixture applied from the aqueous system being superior. The resistance to flat abrasion of the plain weave fabrics was not greatly affected by the treatments. The results obtained on the wool/acrylic blends are also compared with results previously obtained on wool/polyester blends.

INTRODUCTION

Felting shrinkage of wool and wool-rich blend fabrics have been found to be efficiently controlled by the application of a polyurethane polymer with free isocyanate groups (®Synthappret LKF)[1-3]. In addition, such a treatment resulted in good appearance after washing [2,4] and improved dry crease (or wrinkle) resistance[5-7]. Small levels of Synthappret LKF add-on were sufficient to control felting[1-4] but larger amounts were required to impart significant improvements in the wrinkle recovery[5-7]. However, at high Synthappret LKF add-on levels the handle (stiffness) of the fabric was impaired[2-5] although De Boos[5] has shown how this problem can be (partially) overcome so that higher polyurethane add-on (and thus better wrinkle recovery) was practically feasible. The application of

Synthappret LKF to woven worsted fabrics has been shown to improve resistance to mild abrasion[8] (i.e. reduce the rate at which the fabrics became worn and shiny).

Scanning electron microscope examination[9] has revealed that, when fabrics were treated with Synthappret LKF, individual fibres may be encapsulated in a polymer sheath which may or may not be complete. The presence of polymer bonds between individual fibres (i.e. interfibre bonds or "spotwelding") has also been demonstrated[9]. These effects, singly or collectively, imparted to the fabrics their antifelting properties. The improvement in wrinkle recovery obtained by Synthappret LKF treatment has been partly ascribed to such interfibre bonds[6] and their relationship has been the subject of other papers[10-12].

Polyacrylate polymers have been used to improve the abrasion resistance of cross-linked cellulosic fabrics and also contribute to the improvement in wrinkle recovery. When applied to wool the softer polyacrylates caused no significant changes in the wrinkling properties of wool[7].

A recent article[13] described the application of an ionic water-soluble bisulphite adduct of a polyisocyanate (Synthappret LKF) to wool fabrics. The adduct provided shrinkage control to a wide range of fabrics and easy-care all-wool fabrics could be obtained by flat-setting after resin treatment. Fabrics with delayed cure properties could also be obtained.

Silver and Creed[14] applied the water soluble adduct of Synthappret LKF (BAS) alone, and with the polyacrylate® Primal TR485 to all-wool single jersey structures. They concluded that the application of resin, from either aqueous or solvent systems, improved most fabric properties (e.g. pilling and abrasion resistance) although fabric stiffness (drape coefficient) appeared to increase.

The development of water soluble polyurethane shrink resist polymers prompted this investigation, the aim of this study being to evaluate and compare the performance of a solvent soluble polyurethane treatment with that of a polyurethane adduct and soft polyacrylate mixture when these were applied to blends of wool and regular acrylic. The performance of the untreated fabrics has been the subject of a previous report[16].

EXPERIMENTAL

Plain and 2/2 twill lightweight fabrics (approximately 200 g/m^2) which were prepared for an earlier study[16] were used in this investigation. Regular acrylic (3,3 dtex) was intimately blended with a 64's merino wool to produce six blend levels ranging from all-acrylic to all-wool. The acrylic content of the fabrics was increased in steps of 20 *per cent* (absolute). Other details of the fabrics and processing conditions were given in an earlier publication[16]. Because of the amount of work involved in a study of this nature, and the minor differences in fabric properties observed for the two acrylic fibre linear densities[16], it was decided to include only the blends with the 3,3 dtex acrylic in this investigation.

The polymers used in this experiment were Synthappret LKF (a solvent

TABLE I
EFFECT OF TREATMENTS ON CERTAIN FABRIC PROPERTIES

Blend * % Wool/ % Acrylic	Resin Treatment	Sett (Threads per cm) W	Sett (Threads per cm) F	Fabric mass per unit area (g/m2)	Thickness (in mm) measured at 0,5 kPa	Fabric Density (g/cm³)	Air Permeability measured at 98 Pa pressure (ml/s/cm2)	Cantilever Bending Length (cm) W	Cantilever Bending Length (cm) F	Cantilever Bending Length (cm) Mean	Cantilever Flexural Rigidity (mN.mm) W	Cantilever Flexural Rigidity (mN.mm) F	Cantilever Flexural Rigidity (mN.mm) Mean	Drape Coefficient (%)	Bursting Strength (kN/m2)	Elmendorf Tear Strength (N) W	Elmendorf Tear Strength (N) F	Elmendorf Tear Strength (N) Mean	Fabric Breaking Strength (N) W	Fabric Breaking Strength (N) F	Fabric Breaking Strength (N) Mean	Fabric Breaking Tenacity (cN/tex) W	Fabric Breaking Tenacity (cN/tex) F	Fabric Breaking Tenacity (cN/tex) Mean	Extension at Break (%) W	Extension at Break (%) F	Extension at Break (%) Mean
	Plain																										
100/0	Untreated	24,3	18,9	191	0,399	0,479	10,6	1,76	1,51	1,64	10,4	6,6	8,5	53.7	813	22,0	13,2	17,6	355	248	302	7,1	6,4	6,7	37,6	31,1	34,4
	Solvent			196	0,454	0,432	11,0	2,61	2,14	2,38	34,1	18,8	26,4	68,5	869	22,5	13,3	17,9	368	269	319	7,4	6,9	7,2	32,3	32,2	32,3
	Aqueous			196	0,430	0,456	11,3	2,35	1,76	2,05	24,9	10,5	18,2	68,0	887	21,5	12,5	17,0	398	261	330	8,1	6,5	7,3	35,4	33,3	34,4
80/20	Untreated	23,9	19,4	192	0,401	0,479	7,8	1,74	1,61	1,68	10,1	8,0	9,1	56,1	911	17,5	15,0	16,3	450	326	388	9,1	8,1	8,6	27,8	24,2	26,0
	Solvent			193	0,446	0,433	10,3	2,77	2,53	2,65	40,2	30,6	35,4	80,2	984	16,2	13,2	14,7	432	370	401	10,7	9,2	10,0	27,0	34,4	30,7
	Aqueous			199	0,413	0,482	7,9	2,64	1,91	2,28	35,8	13,6	24,7	73,0	984	17,3	12,2	14,7	485	346	416	9,9	8,5	9,2	25,3	35,6	30,5
60/40	Untreated	23,5	19,6	193	0,380	0,508	6,6	1,74	1,71	1,73	10,2	9,7	10,0	55,6	1107	19,0	15,6	17,3	541	449	495	11,0	11,0	11,0	31,0	30,0	30,5
	Solvent			195	0,451	0,432	7,5	2,65	2,31	2,48	35,5	23,5	29,5	77,7	1168	17,0	17,3	17,1	525	453	489	10,7	11,1	10,9	26,3	31,6	29,0
	Aqueous			196	0,413	0,475	7,5	2,60	1,97	2,28	33,7	14,7	24,2	74,5	1165	20,4	14,5	17,4	600	427	514	12,2	10,4	11,3	26,2	35,1	30,7
60/40	Untreated	23,5	19,6	189	0,408	0,463	6,4	1,75	1,69	1,72	10,1	9,1	9,6	56,3	1107	19,7	17,1	18,4	514	466	490	10,5	11,3	10,9	30,9	28,4	29,7
	Solvent			191	0,441	0,433	9,3	2,92	2,48	2,70	46,6	28,5	37,5	76,4	1149	17,2	14,9	15,9	527	457	492	10,7	11,1	10,9	27,9	30,9	29,4
	Aqueous			196	0,429	0,457	7,1	2,57	1,97	2,27	32,6	14,7	23,6	68,4	1152	19,6	15,6	17,6	541	411	476	11,0	10,0	10,5	24,4	31,6	27,7
40/60	Untreated	23,1	17,7	186	0,404	0,460	7,6	1,84	1,76	1,80	11,6	10,1	10,9	55,4	1284	24,9	20,1	22,5	668	494	581	13,5	13,0	13,2	28,1	27,1	27,8
	Solvent			193	0,459	0,420	7,9	2,95	2,36	2,66	48,5	24,8	36,6	78,2	1315	22,2	17,1	19,6	564	522	543	11,9	12,6	12,3	28,6	31,7	30,2
	Aqueous			193	0,421	0,458	9,6	2,78	2,06	2,42	40,6	16,5	28,5	77,5	1320	24,7	18,3	21,5	694	491	593	14,6	11,9	13,3	26,8	30,8	28,8
40/60	Untreated	22,1	19,2	190	0,489	0,389	10,1	1,87	2.05	1,96	12,4	16,4	14,4	60,0	1176	22,9	20,5	21,8	582	515	549	12,3	12,5	12,4	32,9	23,6	28,3
	Solvent			197	0,531	0,371	12,1	2,77	3,06	2,92	41,0	55,3	48,1	75,8	1189	20,7	18,5	19,6	578	541	560	11,6	14,2	12,9	35,2	26,3	30,7
	Aqueous			193	0,492	0,392	10,4	2,65	2,31	2,48	35,1	23,3	29,2	81,2	1310	22,2	18,8	20,5	599	523	561	12,1	13,7	12,9	32,4	27,9	30,2
20/80	Untreated	22,2	19,4	192	0,486	0,395	11,1	1,80	1,98	1,89	11,2	14,9	13,1	58,0	1294	22,0	18,2	20,1	656	564	610	13,8	13,6	13,7	32,3	24,8	28,6
	Solvent			195	0,534	0,365	12,1	2,99	3,15	3,07	51,0	59,7	55,3	83,3	1340	22,3	18,6	20,4	654	593	624	13,8	14,3	14,1	37,1	25,2	31,2
	Aqueous			193	0,489	0,395	11,3	2,53	2,51	2,52	30,6	29,9	30,2	81,6	1422	24,1	19,7	21,9	728	592	660	15,3	14,3	14,8	34,0	25,5	29,8
0/100	Untreated	22,2	19,0	181	0,462	0,392	15,9	1,76	1,92	1,84	9,7	12,8	11,3	53,6	1441	24,6	21,5	23,0	813	684	749	17,3	17,0	17,2	33,3	22,3	27,8
	Solvent			193	0,523	0,369	16,2	3,19	3,28	3,24	61,9	66,7	64,3	86,3	1474	24,6	23,5	24,0	764	644	704	16,3	16,0	16,2	35,3	25,3	30,3
	Aqueous			189	0,486	0,389	18,8	3,06	2,94	3,00	53,0	47,0	50,0	86,3	1655	28,3	22,4	25,3	835	626	731	17,8	15,6	16,7	32,1	24,8	28,5
	2/2 Twill																										
100/0	Untreated	24,7	19,0	195	0,552	0,353	22,3	1,84	1,50	1,67	12,1	6,6	9,4	46,9	823	35,3	31,6	33,4	341	244	293	6,7	6,2	6,5	28,4	26,3	25,5
	Solvent			205	0,646	0,317	26,2	2,08	1,72	1,90	18,0	10,2	14,1	59,1	881	33,9	28,7	31,3	352	259	306	6,9	6,6	6,8	22,9	30,6	26,8
	Aqueous			194	0,581	0,334	30,8	2,40	1,70	2,05	26,2	9,3	17,7	63,4	886	33,4	27,6	30,5	356	252	304	7,0	6,5	6,8	26,7	32,5	29,6
80/20	Untreated	26,0	20,2	193	0,512	0,377	16,1	1,80	1,51	1,66	11,3	6,6	9,0	45,9	911	33,9	37,8	35,9	406	295	351	7,5	7,0	7,3	20,9	27,4	24,2
	Solvent			203	0,617	0,329	21,2	2,63	2,06	2,35	36,2	17,7	26,9	66,9	990	29,3	29,3	29,3	421	348	385	7,9	8,4	8,2	22,1	34,0	28,1
	Aqueous			202	0,589	0,343	24,6	2,58	1,77	2,18	34,0	10,9	22,4	67,3	935	29,5	27,4	28,4	434	328	381	8,0	7,8	7,9	20,9	31,9	26,4
60/40	Untreated	24,3	19,6	188	0,449	0,419	14,6	1,81	1,57	1,69	11,1	7,3	9,2	47,1	1117	34,5	31,7	33,1	526	415	471	10,4	10,1	10,2	23,7	25,6	24,7
	Solvent			200	0,586	0,341	19,4	2,63	2,14	2,39	35,6	19,2	27,4	63,0	1188	32,5	32,4	32,4	511	424	468	10,1	10,4	10,3	24,1	31,7	27,9
	Aqueous			202	0,563	0,359	17,9	2,63	1,82	2,23	36,0	11,9	23,9	67,8	1134	32,4	29,4	30,9	525	407	466	8,0	9,9	9,0	21,5	31,1	26,3
60/40	Untreated	24,4	19,8	190	0,499	0,381	12,8	1,77	1,80	1,79	10,5	11,1	10,8	46,1	1127	37,3	34,4	35,9	525	399	462	10,3	9,6	10,0	23,8	27,0	25,4
	Solvent			203	0,597	0,340	18,2	2,38	1,96	2,17	26,8	14,9	20,8	65,3	1185	33,8	32,0	32,9	494	428	461	9,7	10,3	10,0	23,0	31,7	27,4
	Aqueous			203	0,573	0,354	22,9	2,82	1,92	2,37	44,6	14,0	29,3	73,8	1103	32,6	27,5	30,0	546	395	471	10,7	9,5	10,1	21,0	30,9	26,0
40/60	Untreated	23,4	18,9	191	0,482	0,396	13,2	1,79	1,49	1,64	11,0	6,3	8,7	46,6	1323	38,3	33,6	36,0	621	480	551	12,3	11,8	12,1	23,9	25,4	24,2
	Solvent			199	0,560	0,355	17,9	2,56	2,18	2,37	32,7	20,2	26,4	69,4	1371	37,6	35,8	36,7	620	516	568	12,3	12,7	12,5	24,6	31,8	28,2
	Aqueous			200	0,529	0,378	18,3	2,78	1,89	2,33	42,1	13,2	27,5	72,1	1322	39,6	36,0	37,8	662	484	573	13,2	11,9	12,6	22,2	30,1	26,2
40/60	Untreated	23,9	19,7	190	0,568	0,335	24,5	1,76	1,64	1,70	10,4	8,4	9,4	47,9	1382	39,5	33,3	36,5	614	500	557	12,0	11,8	11,9	25,3	24,3	24,8
	Solvent			205	0,653	0,314	27,4	2,17	1,99	2,08	25,0	15,8	20,4	57,1	1404	38,8	34,9	36,8	574	529	552	11,2	12,5	11,9	27,5	28,7	28,1
	Aqueous			202	0,612	0,330	25,4	2,53	2,11	2,32	32,0	18,6	25,3	73,0	1374	39,8	36,8	38,3	610	497	554	11,9	11,7	11,8	24,9	27,6	26,3
20/80	Untreated	22,7	20,5	191	0,538	0,355	23,3	1,66	1,67	1,67	8,7	8,9	8,8	46,5	1548	34,5	31,0	32,7	694	596	645	14,3	13,6	13,9	26,4	25,6	26,0
	Solvent			199	0,612	0,325	22,2	2,29	2,24	2,27	23,4	21,9	22,6	64,2	1567	39,2	35,6	37,4	653	631	642	13,4	14,4	13,9	29,3	29,1	29,2
	Aqueous			198	0,587	0,337	29,5	2,58	2,24	2,41	33,3	21,8	27,5	72,7	1587	40,9	41,0	40,9	643	626	635	13,2	14,3	13,8	25,6	27,3	26,5
0/100	Untreated	22,6	20,0	185	0,560	0,330	31,4	1,78	1,62	1,70	10,4	7,7	9,1	45,5	1647	41,7	36,4	39,1	803	695	749	16,8	16,4	16,6	28,5	26,0	27,3
	Solvent			191	0,582	0,328	34,7	2,67	2,63	2,65	35,6	34,0	34,8	68,7	1686	43,3	36,7	40,0	758	756	757	15,9	17,9	16,9	29,9	28,8	29,4
	Aqueous			190	0,548	0,347	24,0	2,96	2,52	2,74	48,2	29,7	38,9	87,1	1670	51,6	45,4	48,5	806	722	764	16,9	17,1	17,0	25,4	28,9	27,2

* The fabrics are arranged according to the sequence shown in Table II of reference 16.

TABLE II
FABRIC ABRASION, PILLING, SHRINKAGE AND WRINKLING PROPERTIES

Blend * %Wool/% Acrylic	Resin Treatment	Stol Flex Abrasion (cycles to rupture) W	F	Mean	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 W	F	W + F	At 27°C/75% RH De-aged W	F	W + F	FRL Wrinkling (SD of FRL curve in mm at 27°C/75% RH) De-aged W	F	Mean
Plain																	
100/0	Untreated	1745	2351	2048	3,0	8,4	22,3	1,0	158	160	318	141	139	280	1,13	1,01	1,07
	Solvent	1471	917	1194	3,2	2,8	3,7	1,0	167	163	330	151	144	295	0,78	0,80	0,79
	Aqueous	1418	870	1144	3,5	2,5	3,2	1,0	157	155	312	141	135	276	0,56	0,65	0,61
80/20	Untreated	738	861	800	3,4	5,9	8,1	1,0	148	153	301	138	139	277	0,93	0,77	0,85
	Solvent	1040	830	935	2,4	3,2	4,8	2,0	150	153	303	131	134	265	1,25	0,99	1,12
	Aqueous	882	740	811	2,8	2,6	3,9	1,3	154	144	298	138	137	275	1,11	0,92	1,02
60/40	Untreated	526	514	520	3,4	4,3	4,4	2,0	146	148	294	139	138	277	0,98	0,94	0,96
	Solvent	846	753	800	2,5	2,9	4,7	3,0	158	164	322	137	146	283	1,16	0,99	1,08
	Aqueous	947	777	862	2,4	2,7	3,0	2,0	144	135	289	136	125	261	1,17	0,65	0,91
60/40	Untreated	550	602	576	3,0	4,5	4,1	2,0	142	146	288	137	134	271	1,07	0,83	0,95
	Solvent	817	796	807	2,7	2,7	4,3	1,7	151	153	304	125	128	253	1,12	1,28	1,20
	Aqueous	816	773	794	2,5	3,2	3,5	2,3	149	146	295	131	138	269	0,66	0,98	0,82
40/60	Untreated	495	673	584	3,1	3,4	2,2	3,1	134	139	273	133	126	259	0,99	0,62	0,81
	Solvent	785	640	712	2,6	2,5	3,8	2,3	154	161	315	148	139	287	1,09	1,07	1,08
	Aqueous	933	795	864	2,6	2,4	2,0	2,6	135	146	281	133	133	266	0,98	1,36	1,17
40/60	Untreated	476	607	542	2,9	3,1	3,0	2,3	142	137	279	137	123	260	0,77	0,78	0,78
	Solvent	697	680	689	2,6	2,5	3,5	2,3	151	147	298	126	127	253	1,21	0,88	1,05
	Aqueous	795	796	796	2,2	2,6	3,2	2,6	144	152	296	143	135	278	1,10	0,80	0,95
20/80	Untreated	417	538	478	3,2	1,9	1,3	2,7	138	131	269	122	109	231	0,91	0,77	0,84
	Solvent	704	755	729	2,9	1,8	3,0	3,1	145	148	293	131	128	259	0,93	1,14	1,04
	Aqueous	735	683	709	2,8	2,2	2,7	3,1	139	144	283	134	134	268	1,33	0,96	1,15
0/100	Untreated	372	429	401	3,3	1,3	1,5	3,0	122	111	233	114	99	213	0,91	0,82	0,87
	Solvent	779	581	680	3,4	2,0	2,6	2,0	157	151	308	147	149	296	1,07	1,21	1,14
	Aqueous	865	730	798	4,2	1,4	2,2	3,5	131	140	273	126	127	253	0,89	0,99	0,94
2/2 Twill																	
100/0	Untreated	2136	1644	1890	14,2	8,1	67,7	1,0	158	159	317	138	145	283	0,75	0,80	0,78
	Solvent	1171	863	1017	11,0	1,6	30,9	1,0	165	168	333	141	154	295	0,79	0,57	0,68
	Aqueous	1157	682	919	4,9	1,9	2,1	3,5	171	146	317	137	161	298	0,73	0,55	0,64
80/20	Untreated	1118	718	918	12,9	6,3	54,6	1,0	157	160	317	140	140	280	0,96	0,59	0,78
	Solvent	772	697	735	5,4	1,5	1,8	3,0	162	165	327	151	147	298	0,81	0,80	0,81
	Aqueous	860	708	784	3,5	2,0	2,4	3,1	161	150	311	140	152	292	0,90	0,78	0,84
60/40	Untreated	622	521	572	6,5	4,8	25,1	1,0	152	157	309	140	138	278	0,97	0,75	0,86
	Solvent	1208	691	950	3,7	2,1	2,1	3,5	169	164	333	139	139	278	0,63	0,99	0,81
	Aqueous	771	833	802	2,5	1,6	2,2	3,0	147	164	311	140	134	274	0,93	0,65	0,79
60/40	Untreated	876	530	703	6,5	4,5	27,0	1,0	147	150	297	135	136	271	1,06	0,66	0,86
	Solvent	904	608	756	3,6	1,8	2,1	2,6	170	162	332	143	143	286	0,69	0,75	0,72
	Aqueous	968	658	813	2,8	1,9	2,4	3,0	151	160	311	149	141	290	0,73	0,87	0,80
40/60	Untreated	594	386	480	6,7	2,7	6,7	2,0	144	150	294	138	136	274	0,84	0,84	0,84
	Solvent	944	649	797	3,0	1,7	2,6	2,3	158	160	318	142	142	284	0,83	1,01	0,92
	Aqueous	711	625	668	3,1	1,4	2,2	2,3	145	158	303	129	140	269	0,62	0,87	0,75
40/60	Untreated	614	444	529	6,8	2,2	6,9	2,0	146	152	298	134	137	271	0,73	0,66	0,70
	Solvent	796	745	770	2,7	1,4	1,9	2,7	143	149	292	128	132	260	1,01	0,85	0,93
	Aqueous	949	760	855	2,7	2,2	3,2	2,7	157	159	316	150	146	296	0,85	0,85	0,77
20/80	Untreated	459	407	433	5,2	1,7	3,0	2,7	141	141	282	130	135	265	0,67	0,72	0,70
	Solvent	968	727	848	3,1	2,0	2,1	4,0	154	135	289	131	126	257	1,03	1,28	1,16
	Aqueous	1069	734	902	2,1	2,2	3,2	2,7	152	154	306	146	144	290	1,00	1,08	1,04
0/100	Untreated	419	417	418	2,9	1,3	2,3	3,3	137	144	281	125	129	254	0,68	0,92	0,80
	Solvent	779	581	680	2,1	2,0	2,4	3,0	160	166	326	126	131	267	0,77	1,00	0,89
	Aqueous	728	652	690	2,2	1,6	2,6	2,0	150	142	292	136	142	278	0,72	1,37	1,05

* The fabrics are arranged according to the sequence shown in Table II of reference 16.

soluble polyurethane containing free isocyanate groups) and an aqueous mixture of polymers i.e. the water-soluble bisulphite adduct of Synthappret LKF (Synthappret 4694) and Primal TR485, a soft polyacrylate. The Synthappret LKF was applied (2 *per cent* on mass of fabric) in a Permac Böwe LFM 12 machine by the dip-tumble method. The dried fabrics were cured in an autoclave for 2 minutes at 110°C. The 2 *per cent* (o.m.f.) Synthappret 4694/Primal TR485 aqueous mixture (1:1 ratio) was padded onto the fabrics which were then dried and cured at 135°C for 3 minutes and finally decatised (5 minutes steam, 3 minutes cooling).

The mechanical and wrinkling properties of the fabrics were measured in the same manner as before[16,17].

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 6).

The effect of the acrylic content on the fabric properties was generally the same for the treated fabrics as those reported previously[16] for the untreated fabrics and will not be discussed here.

Fabric Mass per Unit Area

The mass per unit area of the treated fabrics was slightly higher than that of the untreated fabrics. The 2/2 twill showed a slightly larger increase in mass per unit area than the plain weave. The increase in fabric mass per unit area was due partly to the resin add-on and partly to relaxation shrinkage which occurred during the treatment.

Fabric Thickness

The fabric thickness increased slightly upon treatment for both weaves. The 2/2 twill fabrics showed a greater increase in thickness than the plain weave fabrics. Both methods used to apply the polymer will assist relaxation and therefore the development of fabric "bulk". This is considered to be mainly responsible for the observed changes.

Air Permeability

The air permeability of both weaves increased slightly after treatment. The increase for the 2/2 twill was larger than that for the plain weave.

Tensile Properties

The tenacity, tear strength and bursting strength of the treated fabrics were not changed significantly by either treatment. The slight improvements which were sometimes evident could be due to slight changes in the fabric sett (structure) which occurred as a result of possible relaxation during the treatments. No con-

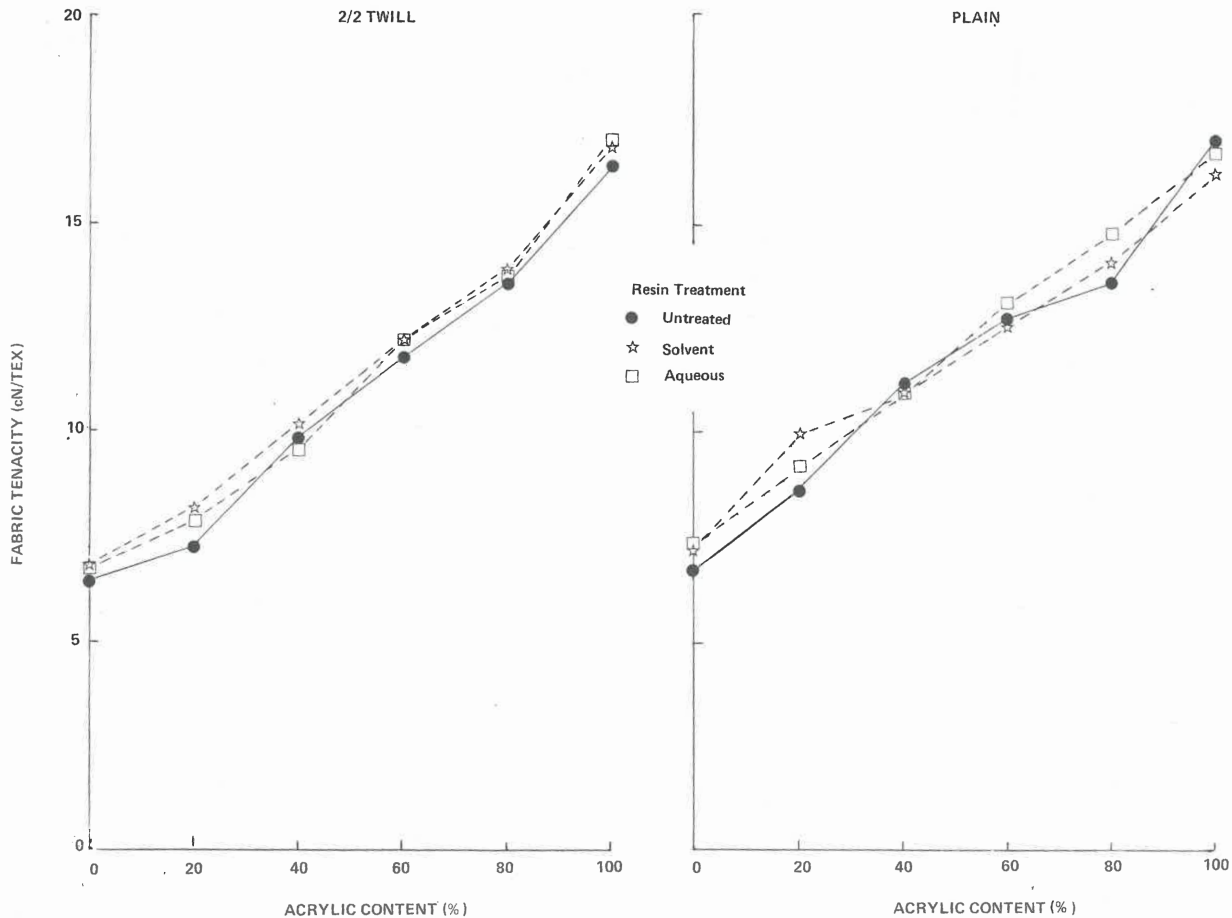

FIGURE 1

The relationship between fabric tenacity (mean of warp and weft) and acrylic content for the two weaves and the various treatments.

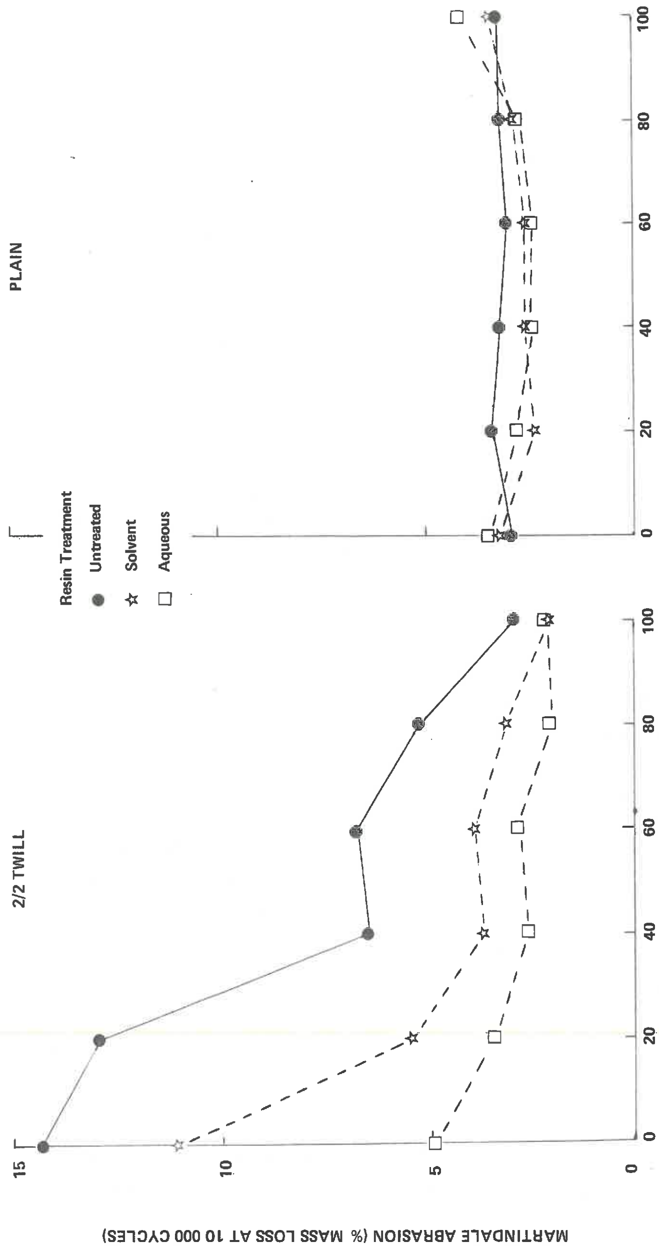

FIGURE 2
The relationship between resistance to flat abrasion and acrylic content for the two weaves and the various treatments.

sistent difference of any significance was observed between the two treatments. The general trends are illustrated by the fabric tenacity results plotted in Fig. 1.

Stoll Flex Abrasion

A deterioration in the flex abrasion properties of the all-wool fabric was observed after the treatment, whereas the flex abrasion of the blend and all-acrylic fabrics improved after the resin treatments. Both treatments gave similar results.

Martindale Abrasion

The same trends observed for wool/polyester fabrics[4] were also observed for wool/acrylic 2/2 twill fabrics after the polyurethane treatment, viz. an improvement in their abrasion resistance. This is illustrated in Fig. 2. This result is in agreement with the observed reduction in the development of shine of mildly abraded Synthappret LKF treated fabrics[8].

Small improvements were realised for the plain weave fabrics but, initially, these fabrics had good abrasion resistance. The advantage of using these polymers was more apparent for the 2/2 twill fabrics and also as the wool content increased. The 2/2 twill fabrics treated with the aqueous mixture of polymers had better abrasion resistance than the fabrics treated with the solvent soluble polymer and approached that of the plain weave fabrics.

Fabric Stiffness

Both treatments caused similar increases in the drape coefficient of the fabrics. The 2/2 twill fabrics had slightly lower drape coefficients before and after treatment than the plain weave fabrics which confirms previous observations[4].

In Fig. 3 flexural rigidity has been plotted against acrylic content for the various treatments. The cantilever flexural rigidity (or bending length) was also increased by the polyurethane treatments. Both treatments resulted in approximately the same increases for the 2/2 twill fabrics, but for the plain weave fabrics the aqueous treatment caused a much smaller increase in the fabric stiffness.

The increase in fabric stiffness is a well-known[2-5,18] disadvantage of applying polyurethane polymers.

Relaxation and Felting Shrinkage

Both polymer treatments resulted in a similar reduction in relaxation shrinkage for all blend levels (Fig. 4). The reduction in relaxation shrinkage can probably be ascribed to relaxation during the resin treatment since both processes (i.e. dip-tumble process for the solvent soluble application and "wet-pad" process for the aqueous application) promotes fabric relaxation. Spotwelding (interfibre bonding) may also partially inhibit relaxation. This reduced relaxation shrinkage is an added advantage since it ensures that very little shrinkage will occur after the shrinkproofing had been carried out.

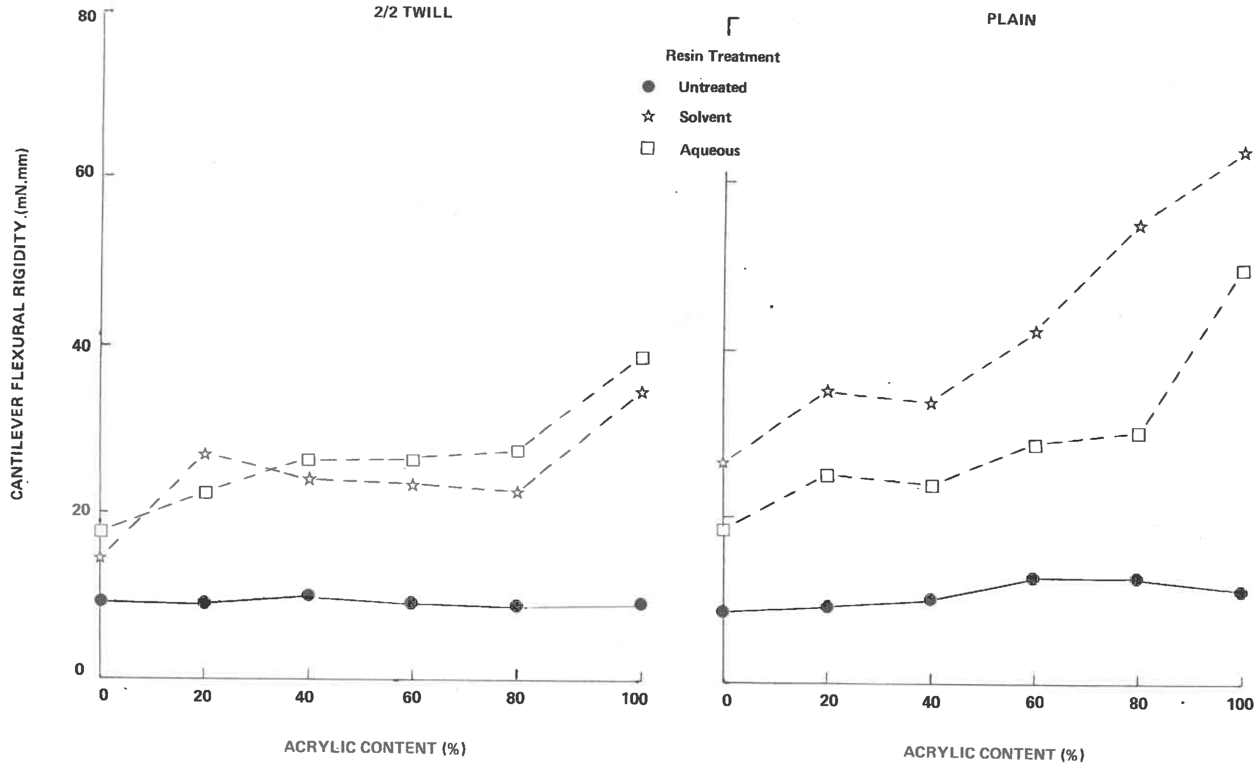

FIGURE 3
The relationship between flexural rigidity (mean of warp and weft) and acrylic content for the two weaves and the various treatments.

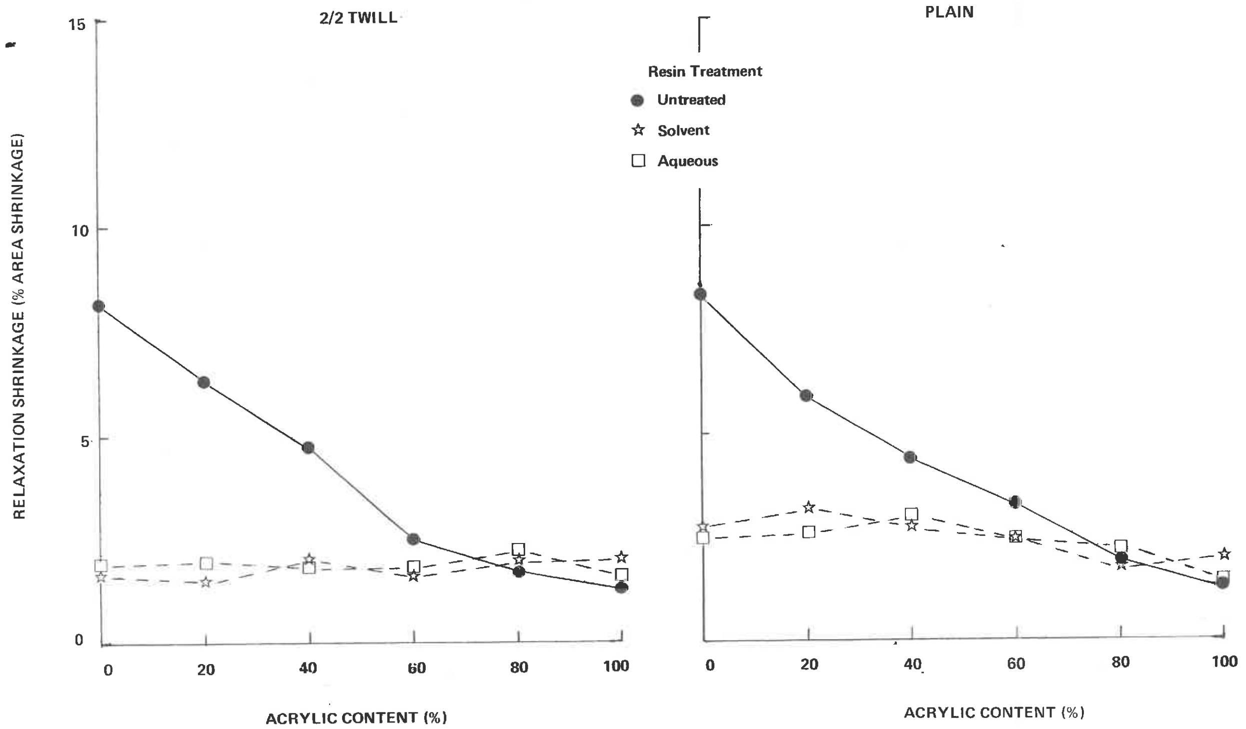

FIGURE 4
The relationship between relaxation shrinkage and acrylic content for the two weaves and the various treatments.

The felting shrinkage of all the blend levels, for both the plain and 2/2 twill weaves, was reduced by both polymer treatments to a low level (approximately 3 *per cent* area shrinkage) similar to that obtained for the all-acrylic and acrylic-rich blends (see Fig. 5). A similar low level of area shrinkage was obtained by other workers when applying polyurethane[1-4] at similar levels of application as that used here.

Appearance after washing (DP rating)

Improvement in DP rating due to the polymer treatments was disappointingly small (see Table II) when compared with the work of others[2,4]. Since acrylic has a low softening point care must be taken during washing, otherwise poor durable press ratings may result. The wash test used in this study for assessing the durable press performance was also very severe compared with that normally used for assessing the durable press performance of cotton type fabrics. The level of add-on therefore appears to have been insufficient for ensuring durable press performance when using a severe wash test such as the three hour Cubex wash employed here. Had a less severe wash test been used, this level of application may have given adequate DP performance. Nevertheless, it appears futile to subject the fabric to different wash tests for shrinkage and durable press performance, respectively.

It may be noted that wool/polyester blend fabrics given similar treatments and washed together with these fabrics gave superior DP ratings.

Monsanto Crease Recovery

The fabrics were tested in the *de-aged* state at both 65%RH/20°C and 75% RH/27°C (see Table II). Some improvements in the crease recovery angle was observed after the respective treatments. Reasons for the improvements effected by polyurethane have been suggested by Shishoo[6]. No difference of any consequence was observed for the two different treatments when creasing at 75%RH/27°C although the solvent treatment appeared to give superior results when tested at 65% RH/20°C. More consistent and larger improvements in the crease recovery angles as a result of the polymer treatments were obtained for the acrylic-rich and all-acrylic fabrics. As would be expected, lower crease recovery angles were obtained when the fabrics were creased at 75%RH/27°C than when they were creased at 65% RH/20°C.

FRL Wrinkling

The FRL wrinkle height was plotted against the acrylic content for the various treatments (Fig. 6). The results are contradictory to those obtained for the crease recovery angle in that, while improvements were noticed for the all-wool and wool-rich fabrics after the treatments, the opposite occurred for the treated acrylic-rich blends. No consistent differences due to the different treatments were observed, although the solvent treatment appeared to be inferior to the aqueous treatment in the case of the plain fabrics.

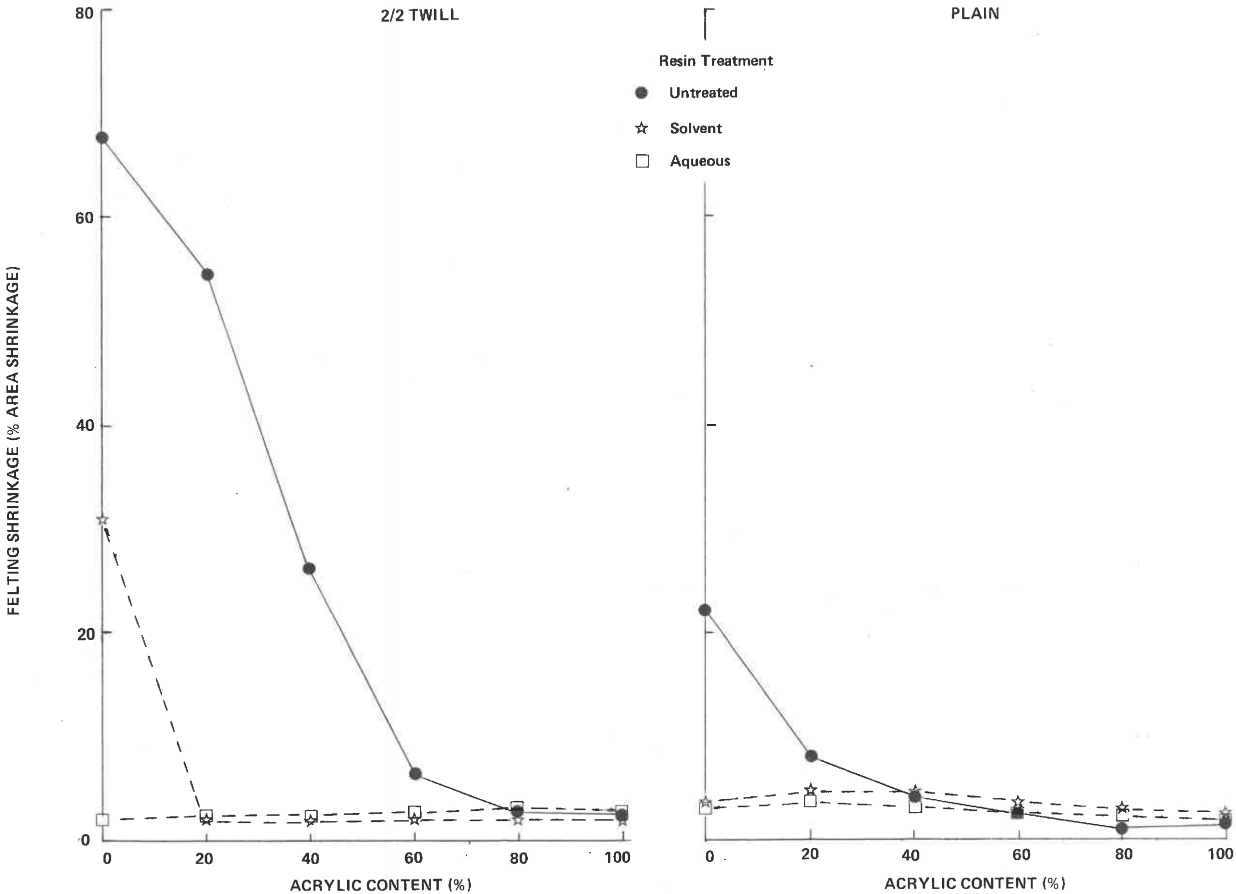

FIGURE 5
The relationship between felting shrinkage and acrylic content for the two weaves and the various treatments.

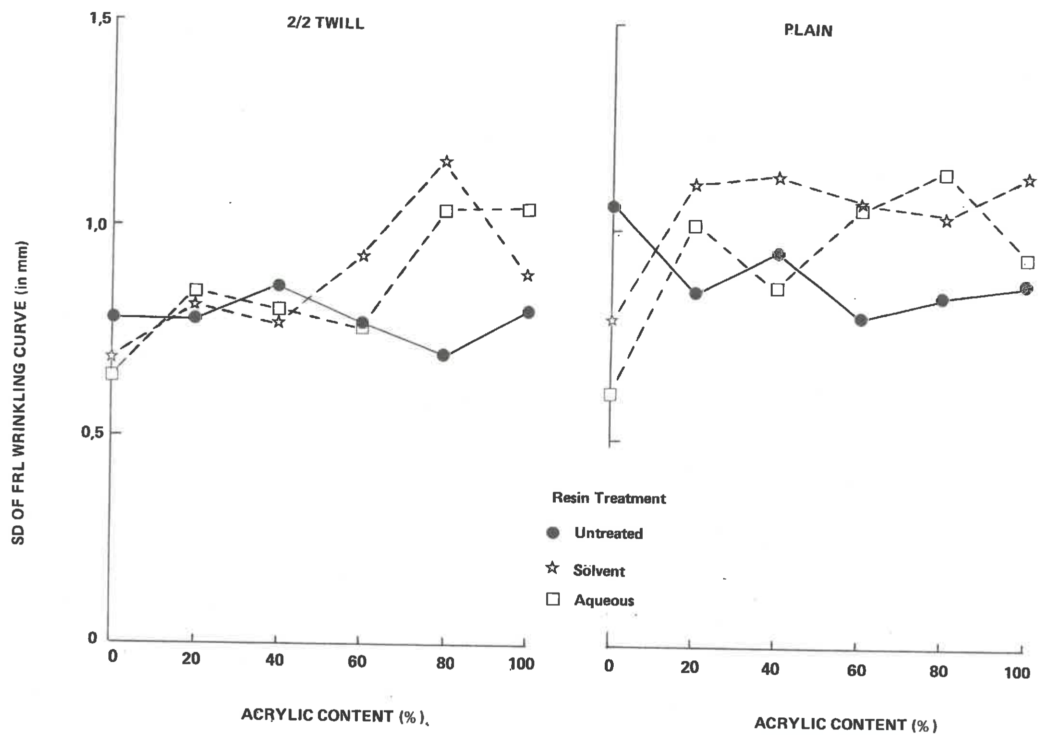

FIGURE 6
The relationship between FRL wrinkling (75% RH/27°C) and acrylic content for the two weaves and the various treatments.

General

Taking an overall view of the work carried out on wool/acrylic and wool/polyester blended fabrics ($\approx$ 200 g/m^2) it appears that the wool/polyester blend fabrics were generally equal or superior to the wool/acrylic fabrics in the measured properties. It also appears that a blend level of approximately 60/40 wool/polyester may be the best combination from the point of view of comfort and durability, although a resin treatment would still be required to reduce felting shrinkage if the fabric is to be given a severe wash. This can be adequately achieved by applying about 2 *per cent* of a polyurethane (from either aqueous or solvent systems) or else by applying about 5 *per cent* of a silicone resin (e.g. DC 109). The latter appears to be preferable in terms of the fabric properties in general.

SUMMARY AND CONCLUSIONS

The mechanical properties of untreated and polymer treated (polyurethane and polyurethane/polyacrylate applied from solvent and aqueous systems, respectively) lightweight (200 g/m^2) plain and 2/2 twill weave fabrics consisting of blends of wool and regular acrylic were compared.

In general, the two polymer treatments resulted in approximately the same changes in the fabric properties when compared with the untreated fabrics, except for the flat abrasion resistance (Martindale) results where the aqueous polymer mixture was superior.

The strength characteristics (tensile strength, tear strength, bursting strength and flex abrasion) were not changed to any significant extent by the treatments. The felting shrinkage, relaxation shrinkage, flat abrasion resistance, Monsanto crease recovery angle, air permeability and durable press ratings showed improvements upon treatment. The improvements in the appearance after washing and the Monsanto crease recovery angle were slight, however. A larger polymer add-on (i.e. greater than 2 *per cent* o.m.f.) would probably have effected greater improvements. Of the measured properties, the fabric stiffness was the only one which deteriorated upon treatment.

For the particular structures used in this investigation, *untreated* plain weave fabrics having 20 *per cent* or more acrylic and 2/2 twill fabrics having 60 *per cent* or more acrylic had an area felting shrinkage of less than 5 *per cent* after the three-hour wash test. Both polymer treatments, when applied at a 2 *per cent* (o.m.f.) level, reduced the felting shrinkage of the all-wool and wool-rich fabrics to less than 5 *per cent* shrinkage in area.

Untreated plain weave fabrics having 60 *per cent* or more and 2/2 twill fabrics having 80 *per cent* or more acrylic had durable press (DP) ratings of approximately 3. These fabrics, therefore, required resin treatment, not to mention fabrics having higher percentages of wool. The appearance after washing (i.e. DP level) was not improved very much by either treatment.

Taking all the technical factors into consideration it seems that wool-rich plain and 2/2 twill fabrics, acceptable in both comfort and mechanical properties (except perhaps appearance after washing), could be obtained by treating the fabrics with two *per cent* (o.m.f.) of a polyurethane (solvent system) or a polyurethane/polyacrylate mixture (aqueous system). Perhaps a slight preference should be given to the aqueous application because it results in better abrasion resistance, and, possibly, slightly less stiff fabrics (when compared with the solvent soluble polymer application).

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THE USE OF PROPRIETARY NAMES

®Synthappret LKF is a registered trade name of Messrs Bayer, and ®Primal is a registered trade name of Messrs Rohm and Haas.

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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