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Liquid Ammonia Mercerisation of Cotton: Part VI Liquid Ammonia Treatment of 50/50 Cotton/Polyester Fabrics

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LIQUID AMMONIA MERCERISATION OF COTTON: PART VI: LIQUID AMMONIA TREATMENT OF 50/50 COTTON/ POLYESTER FABRICS

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ABSTRACT

The effect of liquid ammonia on certain properties of 50/50 cotton/polyester blended fabrics was investigated. It was found that, in general, a liquid ammonia treatment had a beneficial effect on some of the properties, such as shrinkage during washing, bursting strength, tear strength, resistance to flex abrasion and crease recovery angle. No deterioration of the other properties investigated was observed. A treatment with liquid ammonia, followed by a resin treatment produced fabrics with a significantly higher resistance to flex abrasion than treatment with resin only, with no deterioration in bursting strength and little effect on the crease recovery angle.

INTRODUCTION

Currently the treatment of cotton fabrics with liquid ammonia appears to become more popular owing to the beneficial properties that can be imparted to such fabrics in many respects. Research carried out at SAWTRI has confirmed these beneficial effects.[1-3]. A large percentage of the cotton-containing end-commodities, however, comprise fabrics composed of cotton/polyester blends. These blends are not only very popular but compete with the conventional, all-cotton fabrics and have already, to a large extent, replaced them in the highly industrialised countries.[4]

Blending of cotton with polyester results in an improved durable press performance and increased resistance to abrasion of the fabrics, but may have an adverse effect on the resistance to pilling, handle and moisture absorption of the fabric[5]. When the blend contains less than a certain percentage of polyester it might not conform to durable press standards and a treatment with durable press resins has to be applied. A resin treatment may increase the durable press rating of the fabric, but will have an adverse effect on fabric strength, mainly due to a strength loss of the cotton fibres. It has been shown that mercerisation of all-cotton fabrics with liquid ammonia reduces this strength loss significantly, and a similar beneficial effect can therefore be expected in the case of cotton/polyester blends. Calamari et al[6] stated that a liquid ammonia treatment of a cotton/polyester sheeting type fabric resulted in an increase in the lustre, tensile properties, wrinkle resistance and the flex life of samples subsequently treated for improved crease resistance. It was also found that an ammonia treatment appeared to be more effective than the conventional sodium hydroxide treatment as a pretreatment for cross-linking. Furthermore it was found that, under the conditions employed, no measurable damage was imparted to the polyester fibres by the liquid ammonia.

Liquid ammonia mercerisation can also be used to improve the smooth drying appearance of rope bleached cotton and cotton/polyester blends.[6] Although the rope mark problem appears to be more serious in the case of all-cotton fabrics than with cotton/polyester blends, there is a definite need to improve the smooth drying appearance of both types of fabric. It has been stated that these desirable effects can be accomplished much more quickly with liquid ammonia than with conventional sodium hydroxide mercerisation.[6] Ammonia ruptures the hydrogen bonds responsible for the longitudinal creases or rope marks and thus allows the fabric to relax and attain a flat configuration.

The purpose of this study was to determine the effect of a liquid ammonia treatment, using the SAWTRI liquid ammonia merceriser, on the dimensional stability and physical properties before and after a subsequent resin treatment of two blended cotton/polyester fabrics and an all-cotton fabric.

EXPERIMENTAL

A plain weave scoured and bleached all-cotton fabric with mass/unit area of 185 g/m^2 and two plain weave scoured, bleached and heat-set 50/50 cotton/polyester fabrics with mass/unit area of 103 g/m^2 and 171 g/m^2 respectively, were used in this investigation. The scouring, bleaching and heat-setting treatments were carried out at a local textile mill. The fabrics were treated with liquid ammonia on the SAWTRI liquid ammonia merceriser as described previously.[7] Four and eight *per cent* stretch respectively, was applied in the warp direction of the fabrics, the contact time in liquid ammonia was 15 seconds and the ammonia was removed from the fabrics by infra-red heat or hot water (± 75°C). Samples of the fabrics treated with liquid ammonia as well as untreated fabrics were subsequently treated with 2,5 5,0 and 7,5 *per cent* of a DMDHEU type resin (®Fixapret CP conc.). $Zn(NO_3)_2.6H_2O$ (10 *per cent* on mass of resin) was used as catalyst and 0,2 *per cent* (on mass of solution) ®Tergitol Speedwet, a non-ionic wetting agent, as wetting agent. The fabrics were dried at room temperature and cured for three minutes at 160° C. The effect of the liquid ammonia treatment on the shrinkage and dimensional stability of the fabrics during liquid ammonia treatment and after washing in a Cubex apparatus, as well as the various physical properties, were determined in the usual manner.[1,2]

RESULTS AND DISCUSSION

The effect of different degrees of stretch applied to, and different methods

TABLE I

AREA SHRINKAGE OF COTTON AND COTTON/ POLYESTER FABRICS DURING LIQUID AMMONIA AND SUBSEQUENT WASHING TREATMENTS

Fabric	Stretch (%)	NH_3 Removed by	Area Shrinkage (%) after			
			NH_3	Relaxa-tion	60' Wash	120' Wash
50/50 Cotton/ Polyester (103 g/m²)	Control			6,5	5,3	5,0
	4	Heat	2,6	4,8	3,9	6,0
	4	Hot water	2,0	4,2	3,4	4,4
	8	Heat	3,4	6,7	6,2	7,2
	8	Hot water	2,9	5,8	4,6	5,0
50/50 Cotton/ Polyester (171 g/m²)	Control			5,0	5,7	5,9
	4	Heat	1,3	3,1	3,9	3,9
	4	Hot water	0,8	2,7	3,1	3,3
	8	Heat	1,2	4,3	4,1	4,8
	8	Hot water	1,0	5,5	2,8	2,8
100% Cotton (185 g/m²)	Control			10,0	12,8	12,4
	4	Heat	-2,2	5,0	6,0	7,0
	4	Hot water	0,9	5,5	4,8	6,2
	8	Heat	-3,6	6,5	6,7	7,2
	8	Hot water	-1,5	2,9	5,3	5,3

of removal of ammonia from the fabrics, on the shrinkage of the fabrics during the liquid ammonia treatment and after subsequent washing treatments is given in Table I. It is clear that very little shrinkage occurred during the liquid ammonia treatment, especially in the case of the heavier blended fabric. In the case of the all-cotton fabric in general, an increase in fabric area was encountered. The amount of stretch applied (4 or 8 *per cent*) differed very slightly in their effect on the area shrinkage of the fabrics. Removal of the ammonia by hot water resulted in a slightly lower degree of fabric shrinkage than removal by heat. Furthermore, it can be seen that the liquid ammonia treatment reduced the degree of shrinkage of the all-cotton fabric and heavier blended fabric during subsequent washing tests. In the case of the lightweight cotton/polyester fabric, however, the liquid ammonia did not improve the dimensional stability of the fabric. The liquid ammonia treatment had a greater effect on the all-cotton fabric than on the blended fabrics as would be expected. Removal of the ammonia by hot water consistently gave better results than removal by heat.

The results of some physical properties of the untreated and the liquid ammonia treated fabrics are given in Table II. The results were analysed statistically (Analysis of Variance) in order to determine the effect of the various treatments on the different fabrics. It was found that for all three fabrics, the degree of stretch and the removal of ammonia by heat or hot water had no influence on the breaking strength of the fabrics. The same applies for the breaking extension of the fabrics. The ammonia treatment did, however, result in a lower extension in the case of the all-cotton fabric. The bursting strength of the all-cotton fabric was lower after heat removal of the ammonia than after hot water removal. On the other hand the analysis showed that, in the case of the lightweight blend, heat removal of the ammonia resulted in a higher bursting strength than water removal. No difference was observed in the case of the heavier blend. Furthermore, the higher degree of stretch gave better bursting strength values on all three fabrics. In general an ammonia treatment produced fabrics with a higher bursting strength than the untreated fabrics, especially in the case of the all-cotton fabric and the heavier blended fabric. The tear strength of the treated fabrics was found to be significantly higher than that of the control fabrics. Heat removal of the ammonia produced better tear strength results than hot water removal. The flex abrasion resistance of the fabrics showed the same tendencies as those observed for the tear strength. The statistical analysis furthermore showed that the different processing parameters used during the ammonia treatment did not significantly affect the resistance of the fabrics to flat abrasion. An increase in resistance to flat abrasion, however, was found for the lightweight blended fabric after an ammonia treatment. Heat removal of the ammonia resulted in a more flexible fabric than hot water removal in the case of the all-cotton fabric, but in *stiffer fabrics* in the case of the two blended fabrics. Furthermore, the fabrics treated at the lower degree of stretch were found to be stiffer than those treated at the higher stretch value, especially in the case of the all-cotton fabric. An ammonia treatment generally resulted in higher crease recovery angles in the case of the all-cotton fabric and heavier blended fabric whereas no improvement was found for the lightweight blend. Heat removal of

TABLE II
PHYSICAL PROPERTIES OF COTTON AND COTTON/POLYESTER FABRICS AFTER LIQUID AMMONIA TREATMENT

Fabric	Stretch (%)	Ammonia Removed By	PHYSICAL PROPERTIES								
			Breaking Strength (N)	Breaking Extension (%)	Bursting Strength (kN/m²)	Tear Strength (N)	Flex Abrasion (cycles to rupture)	Flat Abrasion % mass loss after		Bending Length (cm)	Monsanto Crease Recovery Angle (W + F)
								5 000 cycles	10 000 cycles		
50/50 Polyester/ Cotton (103 g/m²)	Control		462	10,3	835	17,8	2010	4,4	8,0	1,78	260
	4	Heat	454	11,0	819	24,0	3730	3,5	6,7	1,78	255
	4	Hot water	447	10,1	753	24,3	3372	3,3	6,1	1,74	261
	8	Heat	452	11,5	843	24,4	3200	3,6	6,7	1,78	251
	8	Hot water	459	10,0	786	21,8	2966	3,3	6,0	1,68	262
50/50 Polyester/ Cotton (171 g/m²)	Control		738	8,3	1394	32,8	4050	1,8	3,2	1,99	248
	4	Heat	705	8,0	1476	37,6	6472	1,6	3,1	1,94	260
	4	Hot water	744	7,5	1456	34,1	5433	2,4	2,7	1,80	244
	8	Heat	742	8,2	1499	36,6	5991	1,6	3,3	1,99	261
	8	Hot water	767	7,5	1501	35,8	5288	1,5	2,6	1,82	255
100% Cotton (185 g/m²)	Control		642	12,4	1170	20,7	941	2,6	4,4	2,25	162
	4	Heat	622	10,8	1316	28,8	2105	2,5	4,2	2,43	206
	4	Hot water	641	11,8	1308	20,6	1141	3,1	4,7	2,71	185
	8	Heat	613	10,5	1334	28,6	1964	2,1	4,3	2,18	202
	8	Hot water	654	11,0	1438	25,5	1310	2,3	3,7	2,13	164

ammonia resulted in higher crease recovery angles than hot water removal in the case of the all-cotton fabric and heavier blended fabric, but in lower values in the case of the lightweight blended fabric.

Some physical properties of the liquid ammonia treated fabrics after *resin treatment* are given in Table III. These results were also analysed statistically. The analysis clearly showed that an ammonia pretreatment of the all-cotton fabric resulted in lower bursting strength losses than those encountered with the resin treated control fabrics. This effect was not so marked in the case of the two blended fabrics, but there was, however, a slight improvement in the bursting strength of the ammonia treated fabrics compared with the control fabrics. The analysis furthermore showed that heat removal of the ammonia from the all-cotton and the lightweight blended fabric resulted in higher bursting strength values than the removal by hot water, whereas no differences were observed in the case of the heavier blend. It was found that, when four *per cent* stretch was applied to the all-cotton fabric, heat removal of the ammonia gave higher bursting strength values than hot water removal whereas heat and water removal treatments produced the same results when eight *per cent* stretch was applied. In the case of the other two fabrics the degree of stretch had no influence on the bursting strength.

As far as the resistance to flex abrasion is concerned the analysis showed that a pretreatment with liquid ammonia significantly increased the resistance to abrasion of the resin treated fabrics. The resistance of the fabrics to flex abrasion decreased with increasing levels of add-on of resin. Heat removal of the ammonia resulted in a significantly higher resistance to flex abrasion than water removal. The stretching of the fabrics to different degrees had no effect on the resistance of the fabrics to flex abrasion.

An ammonia pretreatment resulted in higher crease recovery angles of the all-cotton fabric especially at the low levels of resin add-on. The analysis showed that the crease recovery angles of the blended fabrics were not affected by the liquid ammonia treatment. The analysis further showed that neither the degree of stretch applied, nor the heat or hot water removal of ammonia, had any effect on the crease recovery angle of all three different resin treated fabrics.

From the results obtained it is not clear whether the liquid ammonia damaged the polyester fibre in the blend to any extent. Further work on the effect of liquid ammonia on the physical properties of an all-polyester fabric will be carried out to investigate this aspect.

SUMMARY

Two cotton/polyester blended fabrics and an all-cotton fabric were treated on the SAWTRI liquid ammonia merceriser to establish the effect of liquid ammonia on the physical properties and dimensional stability of the

TABLE III

PHYSICAL PROPERTIES OF COTTON AND COTTON/POLYESTER FABRICS AFTER LIQUID AMMONIA AND RESIN TREATMENTS

Fabric	Stretch (%)	Ammonia Removed by	PHYSICAL PROPERTIES: BURSTING STRENGTH (kN/m²) 0% Resin	2,5% Resin	5,0% Resin	7,5% Resin	FLEX ABRASION (Cycles to rupture) 0% Resin	2,5% Resin	5,0% Resin	7,5% Resin	MONSANTO CREASE RECOVERY ANGLE (W + F) 0% Resin	2,5% Resin	5,0% Resin	7,5% Resin
50/50 Polyester/ Cotton (103 g/m²)	Control		835	628	657	664	2010	2815	1907	1164	260	269	284	285
	4	Heat	819	689	652	662	3730	3301	2068	1763	255	271	292	286
	4	Hot water	753	615	598	650	3372	2257	2293	1662	261	273	296	299
	8	Heat	843	770	760	691	3200	3084	2525	2189	251	260	289	306
	8	Hot water	786	691	696	677	2966	2775	2364	1514	262	262	283	288
50/50 Polyester Cotton (171 g/m²)	Control		1394	1069	1140	1147	4050	4540	3225	2371	248	264	263	285
	4	Heat	1476	1380	1204	1189	6472	5645	4525	3664	260	267	279	291
	4	Hot water	1456	1255	1243	1152	5433	4538	3996	3631	244	276	283	291
	8	Heat	1499	1302	1216	1250	5991	4885	4283	3631	261	261	279	288
	8	Hot water	1501	1160	1162	1273	5288	4351	3997	3526	255	266	263	276
100% Cotton (185 g/m²)	Control		1170	973	760	620	941	913	370	183	162	168	228	271
	4	Heat	1316	1314	1121	823	2105	1455	1604	511	206	187	216	263
	4	Hot water	1308	1184	900	652	1141	982	427	148	185	187	245	271
	8	Heat	1334	1339	1150	863	1964	1580	1388	499	202	201	216	263
	8	Hot water	1438	1231	1062	834	1310	1016	324	170	164	217	231	276

fabrics. It was found that a liquid ammonia treatment reduced the shrinkage of the all-cotton fabric and the heavier blended fabric during washing but in the case of the lightweight blended fabric no effect was observed. Removal of the ammonia from the fabric by hot water gave better results than removal by heat.

It was found that the liquid ammonia treatment did not have a significant effect on the breaking strength, breaking extension and the resistance of the fabrics to flat abrasion. A liquid ammonia treatment, however, resulted in lower extension values in the case of the all-cotton fabric and in an increase in the resistance of the lightweight blend to flat abrasion. The bursting strength of the all-cotton fabric and the heavier blended fabric treated with liquid ammonia was found to be higher than that of the control fabric, especially in the case where the fabrics were stretched to a higher degree. The tear strength and resistance to flex abrasion of the fabrics treated with liquid ammonia also were found to be significantly higher than that of the control fabrics. It was found that the liquid ammonia treatment had the biggest effect on the bending length (stiffness) of the all-cotton fabric compared to the control fabric. The bending lengths of the two blended fabrics was not significantly affected by the liquid ammonia. It was also found that heat removal of the ammonia from the all-cotton fabric resulted in a more flexible fabric than hot water removal, but in stiffer fabrics in the case of the other two fabrics. The lower degree of stretch produced stiffer fabrics than did the higher degree of stretch. The liquid ammonia treatment, in general, resulted in lower crease recovery angles on the lightweight blend and in bigger angles on the other two fabrics. Removal of the ammonia from the fabrics by heat resulted in higher crease recovery angles in the case of the all-cotton fabric and heavier blended fabrics, but in lower values for the lightweight blend when compared with those obtained after removal by hot water.

After resin treatment of the fabrics it was found that a liquid ammonia pretreatment reduced the loss in bursting strength of the all-cotton fabric. For the lightweight and heavier blended fabrics a pretreatment with liquid ammonia had no beneficial effect on the bursting strength although it did result in a slight improvement. When considering the flex abrasion resistance of the fabrics after resin treatment it was found that a liquid ammonia pretreatment resulted in a significant increase in resistance of all three fabrics to flex abrasion, especially when heat was used to remove the ammonia. Finally, it was found that the liquid ammonia pretreatment had no effect on the crease recovery angle of the fabrics after resin treatment except for the low add-on levels of resin on the all-cotton fabric.

A costing analysis to compare the economics of liquid ammonia and the conventional sodium hydroxide mercerisation processes will be given in the next report of this series.

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