

SAWTRI TECHNICAL REPORT



No. 491

Foam Finishing

**Part 1: Preliminary Trials on the Application
of Shrinkresist Resins to Wool**

by

G.H.J. van der Walt and N.J.J. van Rensburg

**SOUTH AFRICAN
WOOL AND TEXTILE RESEARCH
INSTITUTE OF THE CSIR**

**P.O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA**

ISBN 0 7988 1970 7

FOAM FINISHING

PART I: PRELIMINARY TRIALS ON THE APPLICATION OF SHRINKRESIST RESINS TO WOOL

by G. H. J. VAN DER WALT and N. J. J. VAN RENSBURG

ABSTRACT

The literature on low add-on techniques and foam finishing is reviewed briefly. Furthermore, some preliminary trials on the shrinkresist treatment of wool fabrics applying Synthappret BAP and Hercosett 125 on a laboratory FFT (Foam Finishing Technology) machine are described.

INTRODUCTION

Textile wet processing is highly energy-intensive and the need to conserve energy will become increasingly important in future planning by textile mills, especially if the rise in the cost of energy over the past decade is considered. Philpott¹ has recently pointed out that the cost of energy has risen by more than 500% since 1973 and in all likelihood it will continue to rise.

A breakdown of the energy consumption of textile mills shows that *wet processing* (preparation, dyeing, finishing) generally requires the largest amount of energy². It is generally accepted that wet processing can use from 40% to 80% of the total energy required to produce a textile product from the raw fibre. Jones² analysed the energy requirements for the dyeing and finishing of a number of fabrics and found that water-heating operations used about 35% to 65% of the total amount of energy consumed and fabric drying and heating 25% to 60%. Obviously, attempts towards energy conservation should be concentrated on these two processes²⁻³.

It is accepted generally that energy conservation in textile finishing centres around the amount of water which has to be removed from the fabric by heating and evaporation. In recent years the efficiencies of drying equipment have been improved steadily. There are definite limits, however, to the improvements of the efficiencies of conventional drying systems⁴, and there are indications that these limits have already been reached in certain cases.

Another route whereby the drying energy requirements could be reduced, is to reduce the amount of water which has to be evaporated or removed from the fabric. In practice this means that the level of add-on or wet pick-up must be reduced. In the conventional padding process the wet pick-up is controlled by the efficiency of the expression method, i.e. the fabric is wetted out thoroughly in the liquor and the excess liquor is then squeezed out by the rollers. The lowest wet pick-up level attainable in such a manner varies

between 60% and 100%, depending on the fibre type. The level of liquor expression in a padder depends on factors such as the nip pressure, rubber hardness and modulus and roller diameter, and the indications are that it would not be possible to further reduce the wet pick-up levels attainable with conventional padders⁵⁻⁷.

In an attempt to reduce the wet pick-up further, some alternatives to rubber covered pad rollers have been developed. Some typical examples are the Prestech or Roberto fibre-type rollers⁵. It is claimed that low wet pick-up values are attained due to the sorption action of the fibre filled roller on the exit side of the nip. These special fibre-filled rollers also have limitations in terms of the lowest wet pick-up value attainable and consequently some other techniques for extracting the excess liquor from the fabrics have been developed. Typical examples are the vacuum slot extractors and the vacuum roll extractors, which utilise a suction action to remove excess liquor from the fabric^{5,6}. Alternatively, compressed air could be used to remove excess liquor, as in the case of the Pletec pneumatic ejector^{5,6}.

Apart from these techniques there are some other indirect padding techniques based on some type of transfer mechanism, such as the loop transfer process or the use of a lick-roller or kiss-roller (Triatex MA)⁵⁻⁸. Mention has also been made of the possible use of spraying techniques. In general, it is claimed that the wet pick-up can be reduced considerably by these techniques.

Goldstein and Smith⁹ reported that the lower limits of wet pick-up possible with various expression methods are as follows:

Method	Lowest wet pick-up (%)	
	Cotton	Synthetics
Padder		
Hard Rubber Rollers	45 – 50	—
Fibre Filled Rollers	40 – 45	30 – 40
Vacuum Extractors		
Slot	48 – 55	10 – 25
Roller	50 – 80	10 – 25
Air Jet Ejectors	35 – 45	10 – 20
Transfer Padding	35 – 40	40 – 50

These lower wet pick-up values are related to the water of imbibition values of the different fibres⁹. For example, the water of imbibition of cotton is approximately 30%, while that of most synthetic fibres varies between 3% and 20%. Most authors⁵⁻⁹ are in agreement that, in order to obtain wet pick-up values lower than the water of imbibition values for the various fibres, methods other than padding or expression of liquid should be sought.

All the low add-on techniques mentioned above are aimed basically at refining the conventional padding process and they all involve the use of

conventional aqueous solutions. A novel approach which differs completely from the techniques mentioned above is the use of foams for the application of chemicals to fabrics¹⁰⁻¹⁸. The essential feature of foam finishing is the use of air as primary diluent for the aqueous reagent solution. Normally foams are produced by incorporating suitable foaming agents into a concentrated aqueous formulation and mechanically mixing the solution with air. Foams normally incorporate from 50% to 90% air (by volume), which indicates that the wet pick-up can be reduced significantly through the use of foams. Normally foams are applied to fabrics at wet pick-up values ranging from 10% to 35% (compared with the ranges of 60% to 100% for conventional padding), depending on fibre type and fabric construction¹⁹. Conventional means are used to dry and cure the applied finishing agents.

Before discussing the application of foams to textiles, it is important that some attention be paid to foams and their properties²⁰⁻²⁶. Pure liquids do not foam and apart from air (or any other gas) a third component, namely a surfactant is required to produce the foam. From a thermodynamic point of view the foam phase is not stable and all foams tend to break down eventually. Basically this is due to the fact that foam has a much larger surface area and therefore a higher surface energy than the starting materials, namely air and liquid. There are several factors which affect the stability of foams, such as surface tension, viscosity, surface area, temperature, pH and concentration of surfactant. Apart from the fact that a low surface tension is required, one of the most important factors which affect the stability of a foam is drainage. This takes place when liquid surrounding the entrapped air (bubbles) drains away due to gravity or the Laplace effect, causing the intervening walls to become thinner and allowing the bubbles to coalesce. Fortunately these effects to some extent are counteracted by the Marangoni effect. When the liquid around the bubble flows from the upper to the lower portion of the bubble, the concentration of surfactant at the top of the bubble decreases, while it increases at the bottom. The resultant difference in surface tension causes the interfacial layer surrounding the bubble to move upward, retarding the rise of the bubble.

Basically there are two types of foam, namely unstable and metastable foams¹⁴. Unstable foams break down immediately after foaming (agitation) has stopped, due to the flow (draining) of liquid between the foam lamellae or cell walls. In metastable foams, on the other hand, the drainage of liquid is slowed down at a certain stage, prior to the breakdown of the foam, depending on the stability of the liquid film. The rate of drainage is affected by density, viscosity and film thickness. In a foam that has not drained, the liquid film is relatively thick and the bubbles are spherical²⁷. In well drained foams the films are much thinner and the bubbles assume a polyhedral shape. Foams which are used for the finishing of textiles are of the *metastable type*¹⁴. The specific properties of the foam which is used are normally determined by the specific

foam application technique employed, and the foam may vary from a relatively low degree of metastability (half drainage time, $t_{50\%} = 1$ to 5 minutes) to a high degree of metastability ($t_{50\%} = 1$ to 5 hours)²⁵.

Although the properties of the foam itself are very important, various other factors should also be considered when the foam is applied to the textile material²⁶. For example, the wetting properties of the foam are very important, and depend on the wetting tension and the rate of wetting of the material. Furthermore, the rate of breakdown or collapse of the foam on the fabric, and the transport of the liquid along the fibres and yarns also play an important role.

In general the wet pick-up in foam application is controlled by the stability of the foam, the blow ratio and the actual amount of foam applied to the fabric¹⁹. Blow (or expansion) ratio is defined as the ratio of the mass of liquid used to prepare the foam to the mass of an equal volume of the foam²⁷. Dawson²⁵ recommended blow ratios of 10:1 to 5:1, i.e. foams with densities of 0,1 – 0,2 g/cm³ for the treatment of textiles by doctor roller and slot machines. Bryant²⁸, however, recommended foam densities of 0,005 – 0,30 g/cm³ for the FFT machine.

There are various possible ways in which foams can be applied to textiles, depending on the type of foam^{14,18,25}. In the case of relatively stable foams, the foam is applied first to the substrate, followed by "crushing" it into the fabric. This can be achieved in the nip of a horizontal padder, at a knife-over roll, through the use of a floating knife, or by passing the material over a suction slot. Less stable foams are applied from a slot-applicator in which case the foam breaks down when it comes into contact with the fibre. One such process is the FFT (Foam Finishing Technology) process^{12,17,29,30}. Initial development work started in the early 1970's by Union Carbide and Gaston County in the United States of America, and commercial development began in 1977.

In the FFT process the foam is applied under a small positive pressure to the fabric where it collapses upon contact with the fibres. The foam breaks down to liquid and distributes through the substrate almost instantaneously (within 0,01 seconds). Fast breaking foams of the FFT type require special handling to assure uniform results. The bubbles in these foams coalesce and increase in size during their transport from the foamer to the applicator slot. Furthermore, the rates of collapse and substrate wetting by the foam depend on the foam bubble size and age. It is clear, therefore, that the design of the foam applicator should be such as to provide a uniform distribution of foam across the width of the fabric, and that this is maintained along the length of the fabric as it continuously passes through the machine. Semi-stable foams are applied to fabrics in the FFT process under a small positive pressure and the foam add-on or wet pick-up is controlled by two factors, namely the liquor

pumping rate to the foamer (and thus to the applicator), and the fabric speed^{12,17,29,30}.

The finishing of textiles through foam application is growing rapidly and a large number of publications appear annually on this topic. Furthermore, the number of manufacturers offering foam finishing machines increased from two at ITMA 1979 to about ten at ATME 1980^{31,32}. This technology is successfully applied in various fields, such as sizing³³, dyeing^{24,25} and finishing¹⁴⁻¹⁶ to all the different types of fibres. The economic advantages of foam finishing are to be found in the saving of energy (commercially the foam process has yielded energy savings as high as 70% to 80%, during drying) and in the fact that the processing speed can be doubled as a result of the low wet pick-up values^{12,19,34,35}. Further advantages are claimed to be improvements in some physical properties of the fabrics, such as abrasion resistance, as a result of the reduction in liquor migration during drying^{6,8,12,32}. It was also claimed that chemicals could be saved using the foam finishing technique through more effective application and improved distribution of chemicals on the fabric^{3,32,36}.

In view of the growing importance of foam finishing SAWTRI recently acquired a Gaston County FFT laboratory machine. To date relatively little information is available about the application of shrinkresist resins to wool using the foam finishing technique and this publication describes the results obtained on wool fabrics treated with different shrinkresist resins at different concentrations and at various wet pick-up values. For purposes of comparison some fabrics were treated with the shrinkresist polymers on a conventional padding machine.

EXPERIMENTAL

Fabric

A plain weave all-wool fabric with a mass of 150 g/m² was used in this investigation. This fabric has a high shrinkage propensity and is similar to the standard IWS fabric used for shrinkresist studies. Prior to treatment the fabric was drycleaned in perchloroethylene.

Treatments

Batch Chlorination

This treatment was carried out on a laboratory winch. The wool fabric was wetted out at room temperature in a liquor containing 2,0 g/l NaCl and 0,5 g/l[®]Alcopol 650. The liquor ratio was 50:1. The fabrics were treated with 1,5% active chlorine (on the mass of the fabric) using[®]Basolan DC at a pH of 4,5. After 35 minutes the temperature was increased to 35°C, where it was

maintained until the exhaustion of the active chlorine was complete. The fabrics were then dechlorinated with 3% NaHSO₃ (omf) at 35°C for 25 minutes³⁷.

Polymer Application

Wool fabrics were treated with different concentrations of shrinkresist polymers at various wet pick-up values (nominally 20%, 30% and 40%) on a Gaston County Foam Finishing (FFT) laboratory machine. Prior to the treatments, the shrinkresist polymers were screened in the laboratory in the presence of various surfactants to examine their compatability and to establish whether they would produce foams having the required properties, in terms of foam density and half-life. Once surfactants giving the required foam properties were found, treatments were then carried out on the FFT machine using the shrinkresist polymers and their appropriate catalysts, together with the specific surfactant. For example, in the case of ®Synthappret BAP, ®Impranil DLN was used as a softening agent and sodium bicarbonate as catalyst, while ®Tergitol TMN-6 (15 g/l) and ®Soilax Klenzade Liquid K (5 g/l) were used as foaming agents. The treated fabrics were then dried at 100°C for 3 minutes, followed by curing at 140°C for 3 minutes.

In the case of ®Hercosett 125, ®Tergitol TMN-6 (20 g/l) was used as foaming agent. The Hercosett was applied at various wet pick-up values to the wool fabrics which had been treated with 1,5% active chlorine. The treated fabrics were then dried and cured at 90°C for 15 minutes. Some fabrics were treated with aqueous solutions of the different shrinkresist polymers by the conventional padding process using a Benz laboratory padder.

Tests

After curing, the treated fabrics were washed in a Cubex washing machine according to the IWS test method TM 185. To evaluate the levelness of resin application, some of the treated fabrics were stained with a suitable dye³⁸.

RESULTS AND DISCUSSION

Initially some fabrics were treated at a wet pick-up value of approximately 35% by the Foam Finishing Technology (FFT) process and at a wet pick-up of 80% by the conventional padding process, using Synthappret BAP as shrinkresist polymer. The felting shrinkage results are given in Table I and, in general, show little difference between the two methods of application. Treatment at the two lower levels of resin concentration appears to be ineffective for both application processes. At concentrations of 3,0% and 4,0% resin, however, both sets of fabrics showed very little shrinkage. The results obtained with the FFT process are considered to be quite satisfactory, especially if the energy savings in terms of the lower wet pick-up values associated with foam applications are taken into consideration.

TABLE I
THE FELTING SHRINKAGE OF ALL-WOOL FABRICS TREATED
WITH SYNTHAPPRET BAP BY THE FFT PROCESS AND THE
CONVENTIONAL PADDING PROCESS

Application Process	Wet Pick-up (%)	Resin Add-on (%)	Area Shrinkage (%)
FFT	35	1,5	64,3
		2,0	67,9
		3,0	1,4
		4,0	0,5
PAD	80	1,5	64,3
		2,0	61,7
		3,0	1,0
		4,0	1,4
Untreated Control			79,8

Table II showed the percentage area shrinkage of wool fabrics treated with different concentrations of Synthappret BAP at different wet pick-up values by the FFT process. Two levels of resin add-on were employed, namely 2% and 3%. In the case of the fabrics treated with 3,0% resin the percentage shrinkage was very low in all cases and different wet pick-up values did not appear to have an effect on the felting shrinkage results. In the case of the 2% resin treatment, however, the fabrics showed high shrinkage values. This applied to all the different wet pick-up values studied, and was probably due to the fact that 2% resin was too low a level to obtain complete shrink resistance.

TABLE II
THE FELTING SHRINKAGE OF AN ALL-WOOL FABRIC TREATED
WITH SYNTHAPPRET BAP AT DIFFERENT RESIN
CONCENTRATIONS AND VARIOUS WET PICK-UP VALUES
BY THE FFT PROCESS

Resin Add-on (%)	Wet Pick-up (%)	Area Shrinkage* (%)
2	40	26,7
	30	30,7
	20	30,8
3	40	1,0
	30	1,8
	20	3,5
Untreated Control		79,8

*average values of at least 3 treatments.

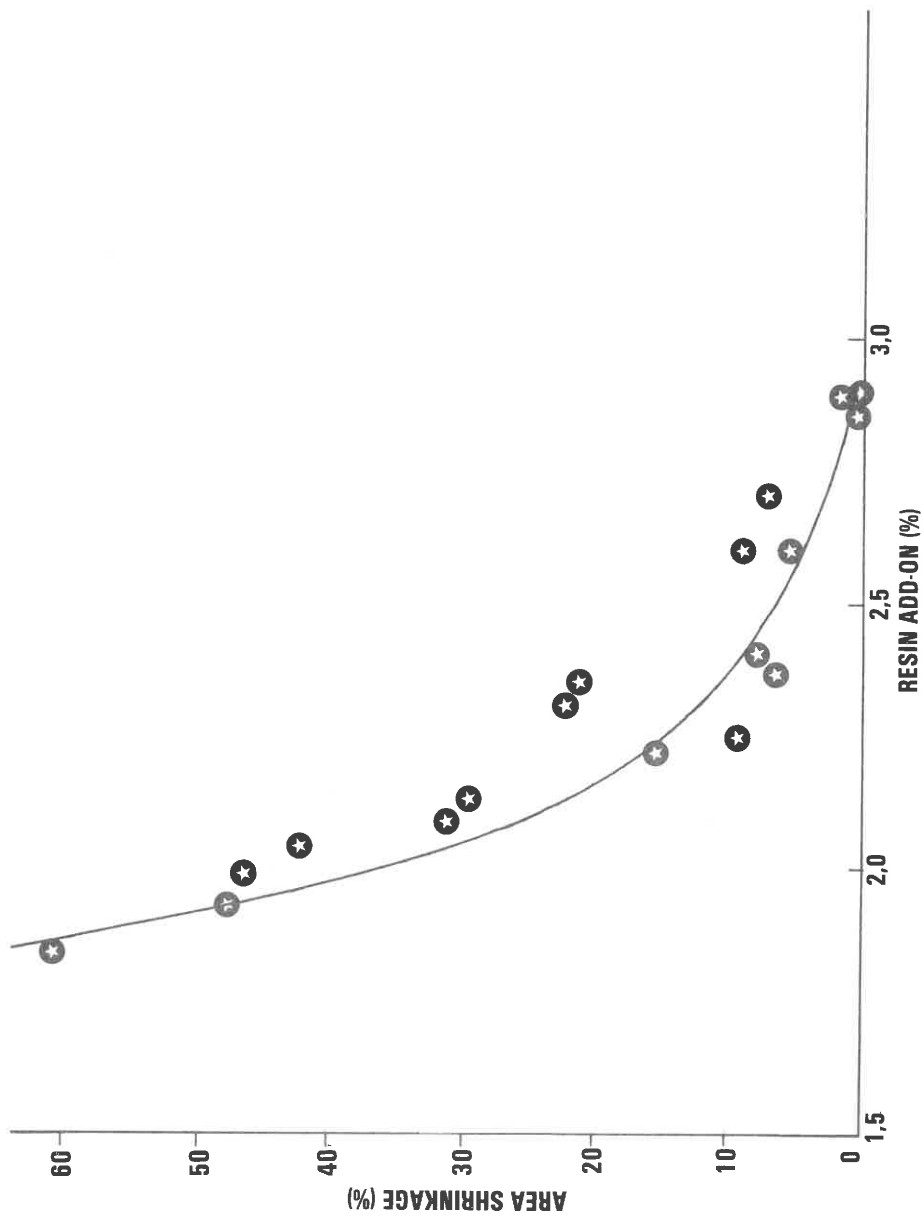


FIGURE 1
The Area Shrinkage of Wool Fabrics treated with Different Concentrations of Synthappret BAP on a Conventional Padder

Figure 1 shows the effect of resin add-on level on the felting shrinkage of this particular fabric when treated on a conventional padder. In this specific case at least 2,4% resin was required to reduce the felting shrinkage of the fabric to less than 10% and this explains the relatively high felting shrinkage values obtained with the 2% resin treatment. The results are in general agreement with those of Smith³⁹, who recently reported that a relatively heavyweight all-wool fabric (294 g/m²) could be successfully shrinkresist treated with about 1,6% to 2,0% Synthappret BAP on an FFT machine.

In some further studies the distribution of resin on some of the fabrics was assessed, using a staining technique. The results are given in Figure 2, which shows a comparison between the face (side facing the applicator slot)

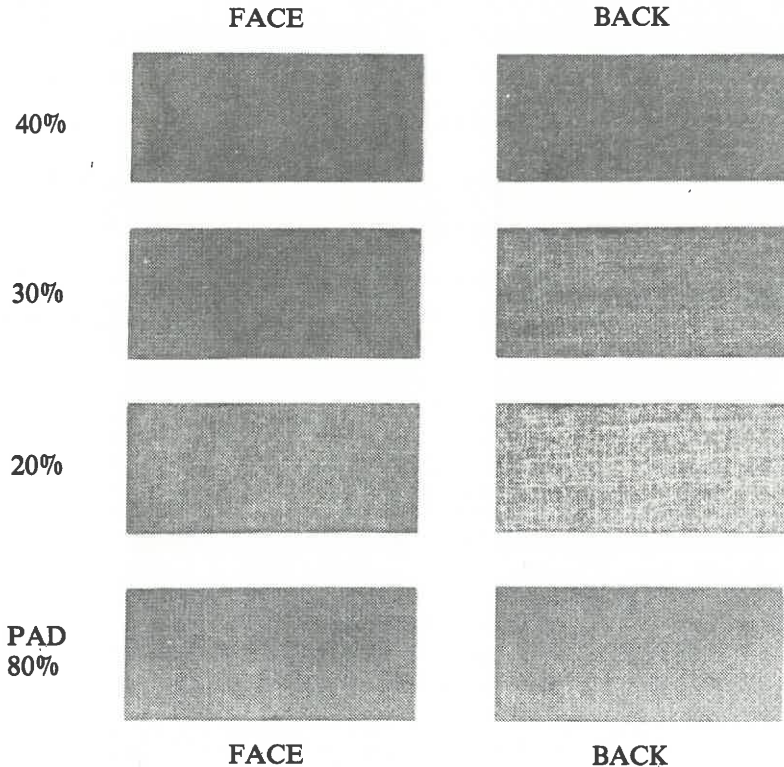


FIGURE 2

The difference in colour between the face and back of all-wool fabrics treated with 3,0% resin at different wet pick-up values by the FFT process and the conventional padding process

and the back of the fabrics treated on the FFT machine with 3% resin at wet pick-up values of 40%, 30% and 20%. The resin was stained blue, whereas the wool remained unstained. The figure indicates that the difference between the amount of resin on the face and back of the fabric increased when the wet pick-up value decreased. In contrast to the foam application there was no difference in resin distribution between the face and back of the fabrics treated with resin at a wet pick-up of 80% by the conventional padding process.

At this stage it is not yet clear how important the difference between the face and back application would be in practice, but a second applicator is to be installed on the machine, which would facilitate the application of foam onto both sides of the fabric, and this would probably eliminate any differences between the face and the back of the fabric.

Finally, some chlorinated wool fabrics were treated with Hercosett on the FFT machine and on a conventional padder. The results obtained are given in Table III.

TABLE III

THE FELTING SHRINKAGE OF ALL-WOOL FABRICS TREATED WITH HERCOSETT BY THE FFT PROCESS AND THE CONVENTIONAL PADDING PROCESS

Process	Wet Pick-up (%)	Resin Add-on (%)	Area Shrinkage* (%)
FFT	30	1	63,1
		2	- 0,5
PAD	80	1	73,4
		2	0
Control (Chlorinated only)			77,2

* Negative value indicates extension of fabric.

In general the results show no difference between fabrics treated by the FFT process and the conventional padding process. Treatment of the chlorinated fabrics with 1,0% resin appeared to be ineffective for both application processes, but when 2,0% resin was used, however, the fabrics showed very little shrinkage.

SUMMARY

The literature on low add-on techniques and foam finishing has been reviewed briefly. Preliminary studies have indicated that shrinkresist resins can be successfully applied to wool fabrics by the FFT process.

Practically no difference could be detected between the felting shrinkage results (IWS TM 185) of woven all-wool fabrics treated with Synthappret BAP resin by the FFT (Foam Finishing Technology) process and those of fabrics treated by the conventional padding process. In the latter case a wet pick-up value of 80% was applied while a wet pick-up of approximately 35% was used in the case of the FFT machine. Similar results were obtained in the case of treatments with Hercosett resin.

In some further studies the distribution of resin on the fabrics was evaluated by the use of a staining technique. It was found that in the case of the FFT process, the difference between the amount of resin on the face and the back of the fabrics appeared to increase when the wet pick-up decreased from 40% to 20%. In contrast to the foam application there was no difference between the face and back of the fabrics treated with resin at a wet pick-up of 80%, by the conventional padding process. Other than these, no differences were noticed in the felting shrinkage results.

ACKNOWLEDGEMENTS

The authors would like to thank Mrs J. White for valuable technical assistance. Permission by the S.A. Wool Board to publish these results is also gratefully acknowledged.

THE USE OF PROPRIETARY NAMES

Products marked ® are registered trade names, and Synthappret BAP and Impranil DLN are the trade names of Messrs Bayer, Alcopol 650 of Messrs Allied Colloids, Basolan DC of Messrs BASF, Tergitol TMN-6 of Messrs Union Carbide, Hercosett 125 of Messrs Hercules and Soilax Klenzade Liquid K of Messrs Klensan. This does not imply that the authors recommend them or that there are not substitutes which may be of equal value or even better.

REFERENCES

1. Philpott, G. C., *Int. Dyer*, **165** (2), 82 (February, 1981).
2. Jones, D. M., Shirley Institute Publication S11 (8-10 October, 1974).
3. Jerg, G., *Dyers Dyegest*, **9** (2), 3 (March, 1980).
4. Leah, R. D., *Text. Inst. Ind.*, **16** (12), 395 (December, 1978).
5. Goldstein, H. B., *Text. Chem. Color.*, **11** (7), 148 (July, 1979).
6. Goldstein, H. B. and Smith, H. W., *Text. Chem. Color.*, **12** (3), 49 (March, 1980).

7. Juby, J., Book of Papers, *17th Canad. Text. Seminar*, Ontario, Canada, 113 (27-30 May, 1980).
8. Leah, R. D., *Papers of the 62nd Annual Conf. of the Text. Inst.*, Edinburgh, 1-11 (September 19-21, 1978).
9. Goldstein, H. B. and Smith, H. W., Book of Papers, 1979, *AATCC Nat. Techn. Conf.*, Cherry Hill, N. J., 229 (3-5 October, 1979).
10. Anon, *Am. Dyest. Rep.*, **68** (7), 28 (July, 1979).
11. Turner, J. D., *Text. Chem. Color.*, **12** (3), 43 (March, 1980).
12. Clifford, F., *Text. Chem. Color.*, **12** (3), 46 (March, 1980).
13. De Loach, H. O., *Text. Chem. Color.*, **12** (5), 93 (May, 1980).
14. Guth, C. and Gysin, H. P., *Textilveredl.*, **15**, 428 (1980).
15. Avril, M. W., *Text. J. Aust.*, **56** (1), 7 (1980).
16. Avril, M. W., *Text. J. Aust.*, **56** (2), 7 (1980).
17. Turner, G. R., *Text. Chem. Color.*, **13** (2), 28 (Feb., 1981).
18. Lauchenauer, A., *Textilveredl.*, **16**, 177 (1981).
19. Namboodi, C. G. and Duke, M. W., *Text. Res. J.*, **49** (3), 156 (March, 1979).
20. Shedlovsky, L., *Kirk-Othmer Encyclopedia Chem. Technol.*, 2nd Ed., **9**, 884.
21. Ross, S., *Kirk-Othmer Encyclopedia Chem. Technol.*, 3rd Ed., **11**, 127
22. O'Farrel, T. F., *Tappi Annual Meeting*, 15th March, 1976, New York Hilton Hotel, New York.
23. Egan, E. J., *Am. Dyest. Rep.*, **68**, 24 (July, 1979).
24. Mitter, M., *Text. Prax.*, **36**, 429 (1981).
25. Dawson, T. L., *J. Soc. Dyers. Colour*, **97** (6), 262 (June, 1981).
26. Bettens, L., *De Tex-Textilis*, 184 (June, 1981).
27. Anon., *Text. Ind.*, **143**, 56 (1979).
28. Bryant, G. M., Publication Union Carbide Technical Center, South Charleston, USA.
29. Clifford, G. F., *Text. Chem. Col.*, **10** (12), 269 (Dec., 1978).
30. Eikoetter, M. W. H., *De Tex-Textilis*, 201 (June, 1981).
31. Anon, *Chemiefasern*, **30/82**, 955 (December, 1980).
32. Leary, R. H., *Text. Asia*, **11**, 36 (Dec., 1980).
33. Anon, *Am. Text. Rep./Bull. Ed.*, **10** (2), 14 (1981).
34. Levy, D., *Int. Dyer*, **164** (7), 369 (December 12, 1980).
35. Anon, *Am. Dyest. Rep.*, **68** (7), 28 (July, 1979).
36. Eikoetter, M. W. H., *SFR's Nordic Conf.*, Boras, Sweden (11-13 Sept., 1980).
37. Swanepoel, O. A. and Van Rooyen, Annette, *SAWTRI Techn. Rep. No.* 215 (November, 1969).
38. Van der Walt, G. H. J., Unpublished results.
39. Smith, C. P., *Text. Res. J.*, **51** (4), 255 (April, 1981).

Published by
The South African Wool and Textile Research Institute,
P.O. Box 1124, Port Elizabeth, South Africa,
and printed in the Republic of South Africa
by Nasionale Koerante Beperk, P.O. Box 525, Port Elizabeth.

© Copyright reserved

ISBN 0 7988 1970 7