

**SAWTRI
TECHNICAL REPORT**



NO 434

**Chemical Modification and
Processing of *Phormium tenax*
Fibres**

**Part II: The Influence of Chemical and
Mechanical Softening on Fibre Tenacity
and Yield**

by

E. Weideman and L.T. van der Walt

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

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

ISBN 0 7988 1380 6

CHEMICAL MODIFICATION AND PROCESSING OF PHORMIUM TENAX FIBRES

PART II: THE INFLUENCE OF CHEMICAL AND MECHANICAL SOFTENING ON FIBRE TENACITY AND YIELD

by E. WEIDEMAN and L. T. VAN DER WALT

ABSTRACT

The relative importance of various parameters such as temperature, concentration and treatment time in the chemical softening and bleaching of phormium fibre, has been investigated on a pilot scale. The percentage yield and bundle tenacity were selected to evaluate the effect of variations in these parameters. A high yield was obtained when the sodium hydroxide concentration was low. A low bundle tenacity was found when a high sodium hypochlorite temperature and a low pH of the solution was used. It was shown that it was possible to use sodium hydroxide only as a softening agent by treating the fibres under pressure. A softer fibre was obtained when a high caustic soda concentration was used. The bundle tenacity, fibre linear density, yield and the cellulose and lignin content of the treated fibres were determined. Relatively soft fibres were obtained when a mechanical softening process followed the chemical softening treatment.

INTRODUCTION

The softening of phormium fibre by treatment with sodium hydroxide and sodium hypochlorite has been reported¹. Only preliminary results were given as the relative importance of various parameters such as temperature, concentration and treatment time had not yet been investigated. Results of these experiments in which these parameters have been studied are reported in this paper.

For some end-uses, softened, *unbleached* phormium fibre may also be suitable. The possibility of obtaining a soft, unbleached fibre by treating phormium fibre under pressure with sodium hydroxide was therefore investigated and the results of the studies are also reported here.

It has been reported that when a fabric, manufactured from chemically treated phormium fibres was washed, it became softer¹. It was observed that the chemically treated fibres became softer when handled mechanically, e.g. by drawing the fibre over a hard surface, especially when the fibres were in a moist state. The carding operation should, therefore, to a certain extent also soften the fibres. It was also noted that an industrial carding machine produc-

ed a softer sliver than a small carding machine². This softer sliver could have been the result of a *higher regain* of the fibres during the processing on the industrial card, or a better mechanical action of this card. *Jute* fibre can be softened by spraying the fibres with batching oil, followed by the passing of the fibres through a standard jute-softening machine with 64 pairs of fluted rollers^{3, 4}. It seemed, therefore, also worthwhile to investigate the effect of a mechanical treatment on the softness of chemically treated phormium fibres.

EXPERIMENTAL

Materials

Carded phormium fibre containing 7,2% loose particles (including dust and short fibres) and 10,2% gum as determined by Godawa's method⁵ was used throughout.

Chemicals

Technical grade sodium hypochlorite solution and caustic soda were used. All the other chemicals used were of laboratory grade. All percentages of chemicals are given on mass of fibre (omf) except where indicated as mass per volume (m/v).

Apparatus

A *pilot plant apparatus* consisting of four bowls was constructed at SAWTRI. Each bowl has a working volume of 100 litres. The fibres (4 kg) were packed into a cage consisting of 4 horizontal compartments. The cage was automatically moved up and down in the solution in the bowl over a distance of 75 mm and at a speed of 12 strokes per minute. The bowls were heated electrically and the temperature of the solution was adjusted prior to the treatment.

A *laboratory rotary digester* (WEAP) which is normally used for producing paper pulp was used for the treatments involving sodium hydroxide under pressure. Twenty litres of NaOH solution was used in the digester (capacity 25 l), which was rotated at three revolutions per minute. The digester was heated electrically at a rate of 2,3°C per minute. In this case the fibres were first loaded into the digester and then heated to the required temperature.

Chemical treatment of the fibres

A liquor to goods ratio of 22:1 was used when the fibres were treated in the *pilot plant apparatus*. The temperature of the sodium hydroxide solution was maintained at 90°C to 95°C. The temperature, concentration and pH of the hypochlorite solution and the concentration of the sodium hydroxide were varied. Details are given in Table I. The first bowl contained the sodium hydroxide solution and in some cases a mercerising auxiliary, [®]Dyphenol 731-NF, was added. The second bowl contained tap water for rinsing, the third bowl sodium hypochlorite solution and the fourth bowl tap water for final

rinsing. Upon removal from reaction bowls one and three the fibres were allowed to drain for 10 minutes, followed by rinsing for 10 minutes.

Some experiments were carried out at room temperature or 50°C and using two concentrations of sodium hydroxide. A liquor-to-goods ratio of 12:1 was used.

In the case of the *laboratory digester* a liquor-to-goods ratio of 8:1 was employed. The available sodium hydroxide, on the mass of fibre was either 20% or 120%. The fibres were rinsed in water before being dried in a forced draught oven at 60°C.

Mechanical softening of the fibres

Some of the chemically treated fibres were passed through a backwash unit comprising two bowls and two pairs of squeeze rollers. The bowls were filled with water at room temperature. The squeezing process was repeated five times. After the fibres were dried, it was very difficult to separate them and it was found that in order to facilitate subsequent mechanical processing they had to be opened before drying, and this was done by hand. In one experiment the chemically treated fibres were blended with polypropylene fibres and carded prior to the softening in the backwash.

Mechanical processing

The dried treated fibres were opened by hand and lubricated with ©Bevaloid 4027 fibre lubricant (2%) and water (2%). The lubricated fibres were fed by hand to a Turner Atherton card and delivered in loose form. The carded fibres were again lubricated as before and then hand-blended with 10 dtex polypropylene fibres of staple length 300 mm in the proportion 70:30 phormium/polypropylene. The blended fibres were carded and the card slivers were gilled three times on a Schlumberger GNP gill box.

Tests

The test procedures and analytical methods were as described earlier¹.

RESULTS AND DISCUSSION

Pilot plant studies

An experiment was designed to investigate the relative importance of the concentration of chemicals, temperature, pH and the effect of a mercerising assistant on the tenacity and yield of softened and bleached phormium fibre. The design of the experiment and the results are given in Table I.

The yield of the processed phormium fibres varied from 62% to 80%. The sodium hydroxide concentration had a significant effect on the yield. A statistical analysis showed that the yield increased when the NaOH concentration decreased. The yield was found to be 66,5% when 88% NaOH was used and 78,0% when 8,8% NaOH was used. The other parameters such as concen-

tration, temperature and pH of the sodium hypochlorite solution and mercerising assistant, [®]Dypenol 731-NF did not have any significant effect on the yield.

The bundle tenacity of the dry, processed fibres was also found to be dependent on the reaction conditions. The results were analysed (by analysis of variance) to show which of the main factor and first order interactions were significant at the 95% level. In this analysis the mean values of the significant interactions were examined and it was found that high temperatures and low pH values of the sodium hypochlorite solutions were to be avoided in order to obtain high bundle tenacities. The analysis of the *main effects* further suggested that a low concentration of sodium hypochlorite and the presence of the mercerising auxiliary in the sodium hydroxide solution gave high tenacity values.

The consumption of chlorine by the phormium fibres during the pilot plant treatments is given in Tables II and III. These values also include the amount of chlorine which was lost in the air during the acidification of the sodium hypochlorite solution. Therefore, the amount of chlorine taken up by the fibres may be somewhat lower than the values given in Tables II and III.

It can be seen in Table II that more chlorine was taken up by the fibres when the temperature of the sodium hypochlorite solution was raised from 25°C to 65°C. Furthermore, the rate of exhaustion was higher in the case of the solution with the low pH value (Table III). Treatment at the low pH value, however, yielded very unevenly coloured fibres, which was an indication that the reaction was too fast and the liquor circulation too slow for producing an even treatment.

The colour of the treated fibres varied from light brown to brown for experiments 1 to 8 (Table I). The fibres obtained in experiments 9 to 16 were considerably lighter in colour. In general the colour of the fibres seemed to depend on the pH of the hypochlorite solution and it appeared that the higher pH of the solution, was responsible for the whiter colour.

There was very little difference between the sixteen samples in terms of softness after they had been carded.

The use of sodium hydroxide under pressure

It was observed that the fibres were not evenly treated, probably due to the fact that the rotary speed of the digester was only three revolutions per minute. A system where the liquor is circulated and the fibres are stationary would probably produce a more even treatment. This was shown, for example, by treating the fibres in a Longclose package dyeing apparatus².

The effect of the temperature of the sodium hydroxide solution and the time of treatment in the digester on the *yield* of the fibre can be seen in Table IV. The yield was normally between 55% and 66% when 20% NaOH was available. The yield was reduced drastically when a higher concentration of NaOH (120%) was used under the same conditions, e.g. the yield was 67,9% when the fibres were treated at 135°C for 30 minutes with 20% NaOH, but was only 47,9% for the same temperature and time with 120% NaOH. A

pronounced mass loss has also been reported⁶ for *jute* fibres boiled in strong sodium hydroxide solutions. In the case of the phormium fibre it seems that 135°C was the maximum feasible temperature which could be used when a high concentration of sodium hydroxide was employed. At higher temperatures a semi-pulp was obtained. This product was unsuitable for the production of a textile yarn.

In spite of the fact that six times more sodium hydroxide was available when the fibres were treated with 120% NaOH instead of 20% NaOH the percentage sodium hydroxide *consumed* by the fibres was not that much higher in the former case. In general, the amount of sodium hydroxide *exhausted* onto the fibres increased with an increase in temperature.

It was found that a higher concentration of sodium hydroxide produced *softer* fibres than a low concentration, e.g. treating the fibres for 30 minutes at 135°C with 120% NaOH produced softer fibres than when 20% NaOH was used. To achieve approximately the same softness with a lower sodium hydroxide concentration, the treatment had to be carried out at a temperature of 150°C for 2 hours.

It can be seen from Table IV that the concentration and reaction time of the sodium hydroxide was critical at the higher temperatures. After a 30 minutes treatment at 150°C a semi-pulp was obtained when 120% sodium hydroxide was employed. Under the same conditions, 20% sodium hydroxide produced fibres which could still be used for producing a textile yarn. Short reaction times at high temperatures, e.g. 10 minutes at 160°C, produced a fibre which could be processed into a yarn, but with longer reaction times (60 minutes) a semi-pulp was obtained. When the reaction temperature was increased a higher percentage cellulose was obtained, while the percentage lignin decreased. However, even the softest fibre which was obtained still contained a considerable amount of lignin.

The fibre linear density was found to be between 36% and 64% of the original value. The fineness of the fibres and the bundle tenacities did not correlate with a specific treatment, i.e. the most drastic treatments did not always give a lower linear density than a less drastic treatment. In general, however, the bundle tenacity of treated fibres was lower than that of the untreated fibres.

Prior to the carding operation the fibres had to be opened by hand. Once dried, however, it was difficult to separate the mass of fibres. This was not caused by the rotation of the digester because it was found that even with the digester stationary, the dried fibres were still sticking to one another. The fibres are easier to separate when moist. However, due to the poor wet strength of the fibres, the amount of moisture present on the fibres should not be too high when they are opened.

The use of sodium hydroxide at atmospheric pressure

The effect of various treatments at atmospheric pressure on the softness of the fibres was investigated. When phormium fibres were treated with a *boiling* 8% sodium hydroxide solution for 30 minutes, the fibres were not as soft as those treated at higher pressures but they were, however, soft enough for certain applications. The yield was about 80%.

When phormium fibres were treated with 20% sodium hydroxide at *room temperature*, it was found that after seven days only 7% sodium hydroxide was consumed by the fibres. The bleaching of these fibres with sodium hypochlorite solution did not produce fibres as soft as those obtained with boiling sodium hydroxide and a sodium hypochlorite treatment.

The effect of a high concentration of sodium hydroxide on the phormium fibres was investigated by treating the fibres with 240% [20% (m/v)] NaOH in the cold. About 20% was consumed by the phormium fibres after seven days. These fibres were very soft.

Fibres treated with 240% [20% (m/v)] NaOH at 50°C absorbed about 20% after one hour. A yield of almost 70% was obtained. The fibres were not softer than those treated at a lower concentration of sodium hydroxide at the boil.

Mechanical Softening

All chemically treated phormium fibres became considerably softer after the mechanical treatment in the backwash machine, i.e. passing the fibres through the squeeze rollers after wetting in water. It was found e.g. that fibres which received a less drastic chemical treatment (8% NaOH for 30 minutes at the boil) followed by the mechanical softening were softer than fibres which received a more drastic chemical treatment (20% NaOH at 135°C for 30 minutes) without mechanical softening. Phormium fibres which had not received a chemical treatment, however, could not be softened in this manner.

The fibre linear density of the sodium hydroxide — sodium hypochlorite treated phormium fibres was 17,0 tex after carding, and it was further reduced to 10,4 tex after mechanical softening in the backwash and a carding operation.

The mechanical softening was more successful when fibres were treated in the backwash before carding than when card sliver was treated.

SUMMARY AND CONCLUSIONS

The effect of various reaction conditions on some of the properties of chemically softened phormium fibres and the effect of mechanical softening of chemically treated fibres was investigated.

At atmospheric pressure, the sodium hydroxide concentration should be low to ensure maximum fibre yield. The yield showed a significant decrease

when the fibres were treated under pressure with sodium hydroxide at higher temperatures. These fibres were, however, softer than those treated at atmospheric pressure.

Treatments at high pressures produced fibres which still contained a considerable amount of lignin (more than 7%). It would seem that the removal of too much lignin results in the breakdown of phormium into semi-pulp, too short for producing a suitable textile yarn.

It was found that during treatments under atmospheric pressure, a high temperature and a low pH of the sodium hypochlorite solution should be avoided as these are detrimental to the bundle tenacity. A low concentration of the sodium hypochlorite solution and the presence of a mercerising assistant in the sodium hydroxide solution gave fibres with high tenacity values.

Highly concentrated sodium hydroxide solutions at room temperature can also be used to produce soft fibres but a much longer reaction time was required. Reaction times can be reduced by increasing the temperature of the solution. The consumption of sodium hydroxide was found to be high and a considerable amount was lost during the rinsing step. It would seem that the room temperature treatments have practically no advantages over the one using a low concentration of sodium hydroxide at the boil.

Although the chemical treatment of the fibres produced a fairly soft fibre, the biggest improvement in the handle of the fibres was found after the chemically softened fibres had been subjected to a mechanical treatment by passing the wet fibres through a pair of rollers.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the National Timber Research Institute, CSIR, Pretoria, for the experiments in the digester and the following departments at SAWTRI: Testing Services for physical and mechanical properties, the Worsted Processing department for the carding and gilling and the Statistics department.

Permission by the Department of Industries to publish this report is gratefully acknowledged.

THE USE OF PROPRIETARY NAMES

® Denotes registered trade marks. Bevaloid 4027 is the trade mark of Messrs Bevaloid and Dypenol 731-NF of Messrs Dexter Chemical Corporation. The fact that products with proprietary names have been used in this report does not in any way imply that SAWTRI recommends them or that there are not substitutes which may be of equal value or even better.

REFERENCES

1. Weideman, E. and Grabherr, Hilke, Chemical Modification and Processing of *Phormium tenax* Fibres, Part I: A Preliminary Report, *SAWTRI Techn. Rep.* No. 365 (August, 1977).
2. Unpublished results.
3. Bandyopadhyay, S. B., Ray, P. K. and Chakravarty, A. C., The Effect of the Application of Batching Oil on the Fine Structure and Mechanical Properties of Jute, *J. Text. Inst.*, **67**, 235 (1976).
4. Ghosh, S. K., Sinha, M. K. and Chakravarty, A. C., The Tensile Properties of Jute and Mesta Fibre After Piling, *Text. Manuf.*, **77**, 44 (1977).
5. Godawa, T. O., The Washing of Decorticated and Dried *Phormium tenax* Fibres, Part I: A Preliminary Note, *SAWTRI Bulletin*, **9**, (2), 41 (1975).
6. Anon, Chemical Reactivity of Jute, *Jute Chronicle*, **4**, 93 (1969).

pronounced mass loss has also been reported⁶ for *jute* fibres boiled in strong sodium hydroxide solutions. In the case of the phormium fibre it seems that 135°C was the maximum feasible temperature which could be used when a high concentration of sodium hydroxide was employed. At higher temperatures a semi-pulp was obtained. This product was unsuitable for the production of a textile yarn.

In spite of the fact that six times more sodium hydroxide was available when the fibres were treated with 120% NaOH instead of 20% NaOH the percentage sodium hydroxide *consumed* by the fibres was not that much higher in the former case. In general, the amount of sodium hydroxide *exhausted* onto the fibres increased with an increase in temperature.

It was found that a higher concentration of sodium hydroxide produced *softer* fibres than a low concentration, e.g. treating the fibres for 30 minutes at 135°C with 120% NaOH produced softer fibres than when 20% NaOH was used. To achieve approximately the same softness with a lower sodium hydroxide concentration, the treatment had to be carried out at a temperature of 150°C for 2 hours.

It can be seen from Table IV that the concentration and reaction time of the sodium hydroxide was critical at the higher temperatures. After a 30 minutes treatment at 150°C a semi-pulp was obtained when 120% sodium hydroxide was employed. Under the same conditions, 20% sodium hydroxide produced fibres which could still be used for producing a textile yarn. Short reaction times at high temperatures, e.g. 10 minutes at 160°C, produced a fibre which could be processed into a yarn, but with longer reaction times (60 minutes) a semi-pulp was obtained. When the reaction temperature was increased a higher percentage cellulose was obtained, while the percentage lignin decreased. However, even the softest fibre which was obtained still contained a considerable amount of lignin.

The fibre linear density was found to be between 36% and 64% of the original value. The fineness of the fibres and the bundle tenacities did not correlate with a specific treatment, i.e. the most drastic treatments did not always give a lower linear density than a less drastic treatment. In general, however, the bundle tenacity of treated fibres was lower than that of the untreated fibres.

Prior to the carding operation the fibres had to be opened by hand. Once dried, however, it was difficult to separate the mass of fibres. This was not caused by the rotation of the digester because it was found that even with the digester stationary, the dried fibres were still sticking to one another. The fibres are easier to separate when moist. However, due to the poor wet strength of the fibres, the amount of moisture present on the fibres should not be too high when they are opened.

The use of sodium hydroxide at atmospheric pressure

The effect of various treatments at atmospheric pressure on the softness of the fibres was investigated. When phormium fibres were treated with a *boiling* 8% sodium hydroxide solution for 30 minutes, the fibres were not as soft as those treated at higher pressures but they were, however, soft enough for certain applications. The yield was about 80%.

When phormium fibres were treated with 20% sodium hydroxide at *room temperature*, it was found that after seven days only 7% sodium hydroxide was consumed by the fibres. The bleaching of these fibres with sodium hypochlorite solution did not produce fibres as soft as those obtained with boiling sodium hydroxide and a sodium hypochlorite treatment.

The effect of a high concentration of sodium hydroxide on the phormium fibres was investigated by treating the fibres with 240% [20% (m/v)] NaOH in the cold. About 20% was consumed by the phormium fibres after seven days. These fibres were very soft.

Fibres treated with 240% [20% (m/v)] NaOH at 50°C absorbed about 20% after one hour. A yield of almost 70% was obtained. The fibres were not softer than those treated at a lower concentration of sodium hydroxide at the boil.

Mechanical Softening

All chemically treated phormium fibres became considerably softer after the mechanical treatment in the backwash machine, i.e. passing the fibres through the squeeze rollers after wetting in water. It was found e.g. that fibres which received a less drastic chemical treatment (8% NaOH for 30 minutes at the boil) followed by the mechanical softening were softer than fibres which received a more drastic chemical treatment (20% NaOH at 135°C for 30 minutes) without mechanical softening. Phormium fibres which had not received a chemical treatment, however, could not be softened in this manner.

The fibre linear density of the sodium hydroxide — sodium hypochlorite treated phormium fibres was 17,0 tex after carding, and it was further reduced to 10,4 tex after mechanical softening in the backwash and a carding operation.

The mechanical softening was more successful when fibres were treated in the backwash before carding than when card sliver was treated.

SUMMARY AND CONCLUSIONS

The effect of various reaction conditions on some of the properties of chemically softened phormium fibres and the effect of mechanical softening of chemically treated fibres was investigated.

At atmospheric pressure, the sodium hydroxide concentration should be low to ensure maximum fibre yield. The yield showed a significant decrease

when the fibres were treated under pressure with sodium hydroxide at higher temperatures. These fibres were, however, softer than those treated at atmospheric pressure.

Treatments at high pressures produced fibres which still contained a considerable amount of lignin (more than 7%). It would seem that the removal of too much lignin results in the breakdown of phormium into semi-pulp, too short for producing a suitable textile yarn.

It was found that during treatments under atmospheric pressure, a high temperature and a low pH of the sodium hypochlorite solution should be avoided as these are detrimental to the bundle tenacity. A low concentration of the sodium hypochlorite solution and the presence of a mercerising assistant in the sodium hydroxide solution gave fibres with high tenacity values.

Highly concentrated sodium hydroxide solutions at room temperature can also be used to produce soft fibres but a much longer reaction time was required. Reaction times can be reduced by increasing the temperature of the solution. The consumption of sodium hydroxide was found to be high and a considerable amount was lost during the rinsing step. It would seem that the room temperature treatments have practically no advantages over the one using a low concentration of sodium hydroxide at the boil.

Although the chemical treatment of the fibres produced a fairly soft fibre, the biggest improvement in the handle of the fibres was found after the chemically softened fibres had been subjected to a mechanical treatment by passing the wet fibres through a pair of rollers.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the National Timber Research Institute, CSIR, Pretoria, for the experiments in the digester and the following departments at SAWTRI: Testing Services for physical and mechanical properties, the Worsted Processing department for the carding and gilling and the Statistics department.

Permission by the Department of Industries to publish this report is gratefully acknowledged.

THE USE OF PROPRIETARY NAMES

® Denotes registered trade marks. Bevaloid 4027 is the trade mark of Messrs Bevaloid and Dypenol 731-NF of Messrs Dexter Chemical Corporation. The fact that products with proprietary names have been used in this report does not in any way imply that SAWTRI recommends them or that there are not substitutes which may be of equal value or even better.

REFERENCES

1. Weideman, E. and Grabherr, Hilke, Chemical Modification and Processing of *Phormium tenax* Fibres, Part I: A Preliminary Report, *SAWTRI Techn. Rep.* No. 365 (August, 1977).
2. Unpublished results.
3. Bandyopadhyay, S. B., Ray, P. K. and Chakravarty, A. C., The Effect of the Application of Batching Oil on the Fine Structure and Mechanical Properties of Jute, *J. Text. Inst.*, **67**, 235 (1976).
4. Ghosh, S. K., Sinha, M. K. and Chakravarty, A. C., The Tensile Properties of Jute and Mesta Fibre After Piling, *Text. Manuf.*, **77**, 44 (1977).
5. Godawa, T. O., The Washing of Decorticated and Dried *Phormium tenax* Fibres, Part I: A Preliminary Note, *SAWTRI Bulletin*, **9**, (2), 41 (1975).
6. Anon, Chemical Reactivity of Jute, *Jute Chronicle*, **4**, 93 (1969).

TABLE I
EXPERIMENTAL DESIGN AND EFFECT OF VARIABLES ON
YIELD AND TENACITY

Variable* Experiment No.	Level**					Yield (%)	Bundle Tenacity (cN/tex)
	A	B	C	D	E		
1	L	L	L	L	L	80	2,8
2	H	L	L	L	H	72	15,1
3	L	H	L	L	H	77	9,9
4	H	H	L	L	L	67	15,9
5	L	L	H	L	H	77	15,7
6	H	L	H	L	L	65	***
7	L	H	H	L	L	77	***
8	H	H	H	L	H	67	15,6
9	L	L	L	H	H	80	23,7
10	H	L	L	H	L	67	19,7
11	L	H	L	H	L	77	21,6
12	H	H	L	H	H	62	17,3
13	L	L	H	H	L	77	19,1
14	H	L	H	H	H	67	19,7
15	L	H	H	H	H	77	14,5
16	H	H	H	H	L	65	11,1
Control						—	26,9

**level of factor

* Variables	L = low	H = High
A = NaOH concentration (available)	8,8%	88%
B = NaOCl Temperature	25°C	65°C
C = % Active Chlorine (available)	8,8%	22%
D = pH of NaOCl Solution	5	11
E = Mercerising Auxiliary (Dypenol 731-NF)	0	1% (m/v)

*** Fibres were too brittle to be carded.

TABLE II

**THE RATE OF CHLORINE UPTAKE BY PHORMIUM FIBRES FROM
A SODIUM HYPOCHLORITE SOLUTION AT pH 11 AND AT
TWO TEMPERATURES AND CONCENTRATIONS**

REACTION TIME (min)	% Chlorine Exhausted			
	25°C		65°C	
	*8,8% Cl_2	*22% Cl_2	*8,8% Cl_2	*22% Cl_2
10	2,2	3,9	7,1	9,0
20	2,7	4,5	8,8	13,0
30	—	5,7	—	15,3
40	3,1	—	—	—
60	—	6,8	—	—
90	5,0	—	—	—

*Available chlorine

TABLE III

**THE RATE OF CHLORINE UPTAKE BY PHORMIUM FIBRES
FROM A SODIUM HYPOCHLORITE SOLUTION AT pH 5 AND
AT TWO TEMPERATURES AND CONCENTRATIONS**

REACTION TIME (min)	% Chlorine Exhausted			
	25°C		65°C	
	*8,8% Cl_2	*22% Cl_2	*8,8% Cl_2	*22% Cl_2
10	6,6	12,5	8,8	22
20	8,8	14,6	—	—
30	—	15,1	—	—
40	—	15,1	—	—

*Available chlorine

TABLE IV

**THE EFFECT OF TEMPERATURE AND TIME OF TREATMENT IN A LABORATORY
DIGESTOR ON SOME CHEMICAL AND PHYSICAL PROPERTIES OF PHORMIUM FIBRE**

NaOH Available (%)	TREATMENT IN DIGESTOR		NaOH Exhausted (%)	Yield (%)	CHEMICAL CONSTITUTION		PHYSICAL PROPERTIES		
	Temperature (°C)	Time of Treatment (min)			Cellulose (%)	Lignin (%)	Fibre Linear Density (tex)	Bundle Tenacity (cN/tex)	
20	Untreated	—	—	—	60,0	12,1	39,8	28,7	
	125	120	8,4	66,1	78,5	11,3	18,6	26,6	
	125	240	10,9	65,1	80,0	10,3	18,1	21,1	
	135	30	11,0	67,9	79,8	10,4	20,7	23,7	
	135	60	10,7	63,9	79,6	10,0	14,2	21,7	
	135	120	10,9	63,5	84,2	8,3	20,9	26,4	
	150	30	11,0	62,1	82,5	10,4	21,8	22,6	
	150	60	11,3	57,9	84,9	8,8	21,7	23,6	
	150	120	12,8	56,9	87,0	7,0	19,3	18,4	
	160	10	13,3	64,4	86,5	7,3	25,3	20,6	
	160	30	13,8	56,3	86,4	7,6	15,4	21,4	
	*160	60	14,0	55,4	—	—	—	—	
	120	125	30	17,6	51,5	82,6	11,3	20,4	20,5
		135	30	18,0	47,9	87,0	8,8	20,9	21,6
*150		30	17,5	40,7	—	—	—	—	
*165		30	18,5	37,0	—	—	—	—	

*Semi-pulp was obtained — not suitable for manufacturing textile yarn.

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 1380 6