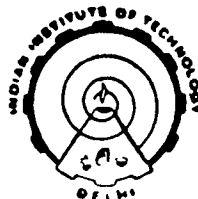


PROPERTY STRUCTURE CORRELATIONS IN SOME WOOL FIBRES

by
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CERTIFICATE

This is to certify that the thesis entitled "PROPERTY STRUCTURE CORRELATIONS IN SOME WOOL FIBRES", submitted by Mr. D. Ramarao to the Indian Institute of Technology, Delhi, for the award of degree of DOCTOR OF PHILOSOPHY is a record of the bonafide research work carried out by him. Mr. D. Rama rao has worked under my guidance for the submission of this thesis, which to my knowledge has reached the requisite standard.

The thesis or any part thereof, has not been submitted to any other University or Institution for the award of any degree or Diploma.



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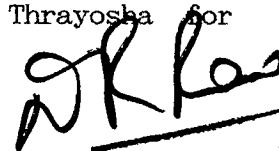
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(D.RAMA RAO)

ABSTRACT

The studies presented in this thesis attempt to seek correlations between mechanical properties and structure in three wool types, viz. Lincoln, Merino and Chokla in the native state. Limited amount of work was also done on these fibres after they had been set by stretch and heat treatment.

Fibre structure was characterised with the help of electron and optical microscopy, X-ray diffraction, thermo-analytical methods and nuclear magnetic resonance. Studies on load-elongation, creep and stress-relaxation behaviours were made under axial loading over a range of time, strain, stress, temperature and humidity. Similar studies were made on their torsional behaviour.

The electron micrographs of stained cross-sections showed that Merino fibre had a bilateral structure with the cortex having nearly 1:2 proportion of para and ortho cells whereas in the other two fibres, the cortical cells were predominantly para. Lincoln wool had the highest crystallite content and orientation, birefringence and thermal stability with Merino having the lowest and Chokla being intermediate. On the other hand, the mobility of water protons and glass transition temperature were the highest in Merino and lowest in Lincoln with Chokla again being intermediate. The torsional rigidity of Merino wool was the highest in the dry state and showed maximum reduction on going to the wet state. In tensile properties like Young's modulus, stress relaxation modulus and creep resistance, Lincoln fibres ranked the highest and Merino the lowest with Chokla being intermediate.

An analysis of these results led to an understanding of the

structural dependence of mechanical properties. In wool the tensile properties, viz. load-elongation, creep and stress relaxation behaviour, are known to be dominated by the characteristics of the α -helices in the ordered, oriented state, which form part of the fibrillar structure, with the fibril-matrix bonds also playing an important role. In the Lincoln and Chokla wools, the α -helix content is higher and they are present in a more ordered and oriented state than in Merino, thus leading to higher modulus and lower creep in the former fibres. On the other hand, the glass transition temperature (T_g) and torsional modulus are known to reflect matrix properties. The high T_g and torsional modulus of Merino fibres in the dry state, compared to Lincoln wool which had the smallest and Chokla wool which was intermediate, can be attributed to the presence of a much larger amount of bulky side groups in Merino wool compared to the other wools. In the dry state, under intense intermolecular bonding, the bulky groups contribute to rigidity. Moreover, Merino wool has a bilateral structure, with the bulky groups being concentrated in the ortho cortical cells. In the wet state, Merino fibres showed the highest T_g but low torsional modulus whereas Lincoln had the lowest T_g and high torsional modulus. Merino wool also showed high mobility of water protons and greater degree of viscoelasticity in the wet state compared to the other wools. It has been suggested that since the bulky side groups require more energy to achieve a mobile state, the wet T_g of Merino would be expected to be higher. However, once they are mobile, these bulky groups can generate more free volume and the mobility of water protons in Merino is therefore high and for the same reason its torsional modulus reduces in the wet state. In addition to the above, the fibril content and

orientation would also make a contribution to the torsional properties.

The present studies have led to a better appreciation of the glass transition phenomenon in wool fibres. T_g has a less spectacular effect on the tensile mechanical properties of wool compared to that in other fibres because first the transition apparently involves motion of side groups and little large scale segmental motion in the matrix phase and second, the ordered and oriented helices continue to contribute substantially to the mechanical properties of the fibre even at large extensions and in the wet state. Torsional modulus is affected relatively more as the material transforms from the glassy to the rubber-like state.

CONTENTS

	Page No.
CHAPTER I INTRODUCTION	1
1.1 Historical Background	1
1.2 Some Distinctive Features	3
1.3 Histological Characteristics	5
1.3.1 The cortex	5
1.3.2 Medulla	8
1.3.3 The cuticle	8
1.3.4 The scale structure	9
1.4 Morphological Characteristics of Cortical Cells	10
1.4.1 Cortical assymetry	10
1.4.2 Fibril fraction	10
1.5 Fine Structure	11
1.6 Chemical Composition	12
1.6.1 Amino acid composition	12
1.6.2 Keratin derivatives	12
1.7 Mechanical And Other Properties	14
1.7.1 Effect of biological origin on mechanical properties	14
1.7.2 Modulus or stiffness	17
1.7.2.1 Keratin-water system	17
1.7.2.2 Anisotropy	18
1.7.3 Visco-elastic effects	19
1.7.4 Structure-property relationships	19
CHAPTER II SELECTION AND CONDITIONING OF WOOL FIBRES AND CHARACTERISATION OF THEIR MORPHOLOGY	21
2.1 Sample Selection	21
2.1.1 Selection of wool types	21
2.1.2 Origin of wool samples	22
2.1.3 Cleaning	22
2.1.4 Fineness distribution	22
2.1.5 Selection of test specimen	23
2.1.5.1 Single fibre selection	24
2.2 Sample Conditioning	25
2.2.1 Introduction	25
2.2.2 Mechanically reversible zone	25
2.2.3 Mechanical conditionig	26
2.2.4 Environmental coditioning	27
2.2.4.1 Humidity	27
2.2.4.2 Temperature	28

2.3	Moisture Regain	28
2.4	Morphological Characteristics	29
2.4.1	Scanning Electron Microscopy	29
2.4.1.1	Scale structure	29
2.4.1.2	Cross-sectional profiles	31
2.4.2	Transmission Electron Microscopy	31
2.4.2.1	Section preparation	31
2.4.2.2	Gross morphology	33
2.4.2.3	Nature of cell wall boundary	36
2.4.2.4	Size and Shape of cortical cells	36
2.4.2.5	Microfibrils	36
CHAPTER III	X-RAY DIFFRACTION STUDIES	37
3.1	Introduction	37
3.1.1	Origin of Wide Angle X-ray Scattering	37
3.1.2	Phase transformation	38
3.2	Experimental	39
3.2.1	Sample preparation	39
3.2.1.1	Types of samples	39
3.2.1.2	Powder preparation	39
3.2.1.3	Stretching of samples	39
3.2.1.4	Set samples	40
3.2.2	X-Ray diffraction studies	41
3.3	Results And Discussion	42
3.3.1	α - β transformation on stretching of wool fibres	42
3.3.1.1	Flat plate X-ray patterns of the three wool	42
3.3.1.2	Effect of thermal treatment	42
3.3.1.3	Radial scans	45
3.3.1.4	Determination of relative phase fractions	47
3.3.1.5	Comparison with existing data	49
3.3.2	Determination of crystallinity	52
3.3.2.1	Introduction	52
3.3.2.2	Methods used	53
3.3.2.3	The crystallinity data	56
3.3.2.4	Comparison with published data	57
3.3.3	Crystallite orientation	57
3.3.4	Dimensions of crystallites	60
CHAPTER IV	BIREFRINGENCE	62
4.1	Introduction	62
4.2	Experimental	65
4.2.1	Sample selection	65
4.2.2	Measurement of birefringence	65
4.2.3	Birefringence at different moisture regains	66
4.2.4	Birefringence of the fibre in alcohols	67
4.2.5	Birefringence of stretched fibres	67
4.2.6	Birefringence of set fibres	67

4.3	Results And Discussion	68
4.3.1	Birefringence at different moisture regains	68
4.3.1.1	Measured birefringence values	68
4.3.1.2	A model to explain the birefringence data	68
4.3.1.3	The contribution of form birefringence	71
4.3.1.4	Optical anisotropy in the three wools	73
4.3.2	Birefringence of the fibres in alcohols	74
4.3.2.1	Introduction	74
4.3.2.2	The birefringence data	75
4.3.3	Birefringence of stretched fibres	76
4.3.4	Birefringence of set fibres	78
4.3.4.1	Introduction	78
4.3.4.2	Fibres set without any stretch	79
4.3.4.3	Fibres set in yield region	80
4.3.4.4	Fibres set in post-yield region	82
4.3.4.5	Birefringence as a function of set strain	82
4.3.4.6	The effect of humidity on the birefringence of stretch-set fibres	85
CHAPTER V	THERMAL CHARACTERISTICS	86
5.1	Introduction	86
5.1.1	Transitions upto 200°C	86
5.1.2	Transitions in the 200-300°C range	88
5.1.3	Transitions above 300°C	89
5.2	Experimental	89
5.2.1	Samples	89
5.2.2	TGA studies	90
5.2.3	DSC studies	90
5.2.4	DTA studies	91
5.2.5	TMA studies	91
5.3	Results And Discussion	92
5.3.1	TGA studies	92
5.3.1.1	Control samples	92
5.3.1.2	Modified fibres	95
5.3.2	DSC studies	96
5.3.3	DTA studies	100
5.3.3.1	Control samples	100
5.3.3.2	Modified fibres	102
5.3.4	TMA studies	105
5.3.4.1	Introduction	105
5.3.4.2	Control fibres	107
5.3.4.3	Modified fibres	110
CHAPTER VI	NUCLEAR MAGNETIC RESONANCE	112
6.1	Introduction	112
6.2	Background Theory	114
6.2.1	Basic concepts	114
6.2.2	Line width	115

6.2.3	The spin-spin and spin-lattice relaxation times	116
6.2.4	Magic angle spinning	118
6.2.5	Fourier transform spectroscopy	119
6.2.6	Spin-echo techniques to measure T_1 and T_2	120
	6.2.6.1 Spin-spin relaxation time	120
	6.2.6.2 Spin-lattice relaxation time	120
6.2.7	Mobility factor	121
6.3	Experimental	121
6.3.1	Sample preparation	121
6.3.2	NMR measurements	122
	6.3.2.1 The spectrometer	122
	6.3.2.2 Spin-spin relaxation time	122
	6.3.2.3 Absorption and derivative curves	122
	6.3.2.4 Spin-lattice relaxation time	123
6.4	Results And Discussion	123
6.4.1	A typical resonance curve from hydrated wool	123
6.4.2	Influence of moisture on NMR signals	125
6.4.3	Relaxation times	128
6.4.4	Mechanism of water sorption in wool	132
6.4.5	Studies on melted fibres	135
6.4.6	Comparison between three wools	137
CHAPTER VII	TENSILE AND TORSIONAL PROPERTIES	138
7.1	Introduction	138
7.1.1	Hookean region	138
7.1.2	Yield region	139
7.1.3	Post-yield region	139
7.2	Mechanical Models	140
7.2.1	Hearle and Chapman's model	140
7.2.2	Feughelmans's model	141
7.2.3	Composite models	141
7.3	Experimental	142
7.3.1	Load-elongation curve	142
7.3.2	Torsional modulus	143
7.3.3	Work done, work recovery and elastic recovery	144
7.4	Results And Discussion	144
7.4.1	Shapes of the stress-strain curves	144
7.4.2	Temperature dependence of tensile properties in water	145
7.4.3	Moisture-dependence of tensile properties	150
7.4.4	Work done, work recovery and elastic recovery	153
7.4.5	Torsional modulus	155
7.4.6	The ratio of Hookean modulus to Yield modulus	157
7.4.7	Wool as a two phase composite	158

CHAPTER VIII	CREEP IN WOOL FIBRES	161
8.1	Introduction	161
8.2	Experimental	162
8.2.1	The creep apparatus	162
8.2.2	Loading mechanism	164
8.2.3	Fibre and load selection	164
8.2.4	The creep test	164
8.2.5	The creep and compliance curves	165
8.2.6	Master curves and distribution spectra	166
8.3	Results And Discussion	166
8.3.1	Effect of loading time	166
8.3.2	Creep in the Hookean region in water at different temperatures	168
8.3.2.1	The creep curves	168
8.3.2.2	The creep compliance master curves	171
8.3.3	Creep in the yield region in water at different temperatures	173
8.3.3.1	The creep curves	173
8.3.3.2	The creep compliance master curves	175
8.3.4	Room temperature creep in water at different loads	176
8.3.4.1	The creep curves and their analysis	176
8.3.4.2	Master creep compliance curves	180
CHAPTER IX	STRESS RELAXATION STUDIES	183
9.1	Introduction	183
9.1.1	Stress relaxation in polymers	183
9.1.2	The mechanism of stress relaxation in wool	184
9.2	Experimental	186
9.2.1	Samples	186
9.2.2	Measurments	186
9.3	Results And Discussion	186
9.3.1	Stress relaxation data at low strain rates	186
9.3.1.1	Hookean region	186
9.3.1.2	Yield region	189
9.3.1.3	Post-yield region	192
9.3.1.4	Activation energy in the post-yield region	194
9.3.2	Stress relaxation data in the Hookean region at high strain rates	195
CHAPTER X	SUMMARY AND CONCLUSIONS	199
	REFERENCES	206