Page No.
Ι
III
VIII
Х

## THESIS INDEX

## CONTENTS

Sr. No.	CONTENTS	Page No.
CHAPTER 1	INTRODUCTION	
1.1	Background	1
1.2	Need for development	4
1.3	Research outline	6
CHAPTER 2	LITERATURE REVIEW	
2.1	Technical textiles-overview	7
2.2	Functional characteristics of fibres for technical textiles	11
2.2.1	Mechanical characteristics	11
2.2.2	Chemical characteristics	12
2.2.3	Physical characteristics	13
2.2.4	Biological characteristics	15
2.3	Eco-friendly fibres for technical textiles	17
2.4	Advanced technical textiles	21
2.4.1	Fibres for advanced technical textiles	21

2.4.2	Nano fibres for technical textiles	28
2.4.3	High performance fibres for technical textiles	31
2.5	Smart and interactive textiles	32
2.5.1	Inherently conductive polymers	35
2.5.2	Shape memory materials	35
2.5.3	Optical fibres	36
2.5.4	Applications of smart textiles	37
2.5.5	Non-woven fabrics for infection control	39
2.6	Synthetic fibres and pollution	41
2.6.1	Health risks of synthetic fibres	42
2.6.2	Environmental risks of synthetic fibres	42
2.6.3	Long term adverse effects of synthetic products	43
2.6.4	Environmental impact of medical waste	44
2.7	Coating of textiles	46
2.7.1	Materials for coating	46
2.7.2	Various types of coating	47
2.8	Antimicrobial materials and its application	52
2.8.1	Mechanism of antimicrobial finishes	52
2.8.2	Antimicrobial finishes	53
2.8.3	Antimicrobial activities on cotton fabrics	54
2.8.4	Antimicrobial activity of Azadirachta Indica (Neem)	57
2.9	Textile adhesives	58

2.9.1	Adhesion theory	59
2.9.2	Adhesive types	61
2.10	Medical textiles	61
2.10.1	Fibres used in medical textiles	62
2.10.2	Criteria and properties of medical textiles	63
2.10.3	Medical device directive	69
2.10.4	Market potential and growth	69
2.11	Medical garments	70
2.11.1	Various medical garments	71
2.11.2	Medical gowns	75
2.11.3	Design considerations of surgical gowns	76
2.11.4	Textiles for construction of surgical gowns	80
2.11.5	Performance standards for surgical gowns	83
2.11.6	Selection of surgical gown	85
2.12	Environmental impact of medical waste	89
2.13	Growth control of microorganisms	92
2.13.1	Microbial control	92
2.13.2	Finishes for surgical gown effectiveness	98
2.14	Testing of surgical gown materials	101
2.15	Developments in fabrics for healthcare	105
2.15.1	Bamboo charcoal blended union fabrics	105
2.15.2	Textile finishing with partial application of micro particles	106

2.15.3	Barrier effect by permanent thin layer of micro particles	107
CHAPTER 3	MATERIALS AND MEHODS	
3.1	Introduction	109
3.2	Materials	109
3.2.1	Fabrics	109
3.2.2	Nano cellulose	110
3.2.3	Cross-linking agent	110
3.2.4	Neem seed oil as antibacterial agent	111
3.3	Methods	111
3.3.1	Preparation of nano cellulose	111
3.3.2	Coating of nano cellulose on fabric surface	112
3.3.3	Preparation of fabric specimen of coated fabric	113
3.3.4	Evaluation of various characteristics	115
3.3.5	Evaluation of antibacterial characteristics of fabric	118
CHAPTER 4	<b>RESULTS AND DISCUSSION</b>	
4.1	Fabric mass density	124
4.2	Tensile strength	129
4.2.1	Machine direction	129
4.2.2	Cross machine direction	134
4.3	Air permeability	137
4.4	Water repellence	141
4.5	Fabric stiffness	144

4.5.1	Bending modulus in machine direction	144
4.5.2	Bending modulus in cross machine direction	148
4.6	Anti-bacterial property	152
CHAPTER 5	CONCLUSIONS AND FURTHER SCOPE OF RESEARCH	
5.1	Conclusions	159
5.2	Further scope	161
	REFERENCES	162
	BIBLIOGRAPHY	166

## LIST OF TABLES

Table No.	Title of Table	Page No.
2.1	Indian technical textiles market size (Rs. Crore)	10
2.2	Selective list of applications in advanced technical textiles	22
2.3	Comparison of fibres properties of conventional fibres	25
2.4	Comparison of advantages and limitations of main commodity fibres	25
2.5	Various Properties of non-conventional fibres	26
2.6	Mechanical properties of various high-performance fibres	32
2.7	Various types of raw material of textile adhesives	59
2.8	Implantable materials	65
2.9	Non-implantable materials	66
2.10	Extra corporeal materials	68
2.11	Healthcare and Hygiene materials	68
2.12	Size of diseases causing bacteria	78
2.13	Size of highly infectious disease virus	78
2.14	Fabric permeability required to maintain equilibrium	79
2.15	ANSI/AAMI PB70: Barrier performance levels for various medical	0.4
2.16	procedures Levels of performance at an AQL of 4%	84 84
2.17	Standard tests for various non barrier property	84
2.18	Comparison of reusable and disposable surgical gowns	87
2.19	General system boundaries for surgical gowns	91
2.20	Fibre testing standards	103
2.21	Yarn testing standards	103
2.22	Fabric testing standards	104
3.1	Specifications of various fabrics used for performance study of surgical gown	
3.2	Various parameters of nano cellulose solution for fabric coating	110 113
3.3	Various specifications of cellulose solution for coating and fabric code	114
3.4	Standard spray test rating chart	117
3.5	Various fabric samples used for antibacterial treatment	119
3.6	Various bacterium used for culture test of antibacterial finished fabrics	121
4.1	Increase in fabric mass density with cellulose solution of different concentrations (%)	125

4.2	Increase in fabric mass density at different cross linking agent in cellulose solution (%)	127
4.3	Tensile strength in machine direction with different concentration of cellulose solution (N)	130
4.4	Tensile strength in machine direction at different cross-linking agent in the solution (N)	132
4.5	Tensile strength in cross machine direction with different concentration of cellulose solution (N)	135
4.6	Tensile strength in cross machine direction at different cross-linking agent in the solution (N)	136
4.7	Air permeability of fabrics with different nano cellulose concentration $(cm^3/cm^2/s)$	138
4.8	Air permeability of fabrics with different concentrations of cross-linking agent $(cm^3/cm^2/s)$	139
4.9	Water repellence grade of fabrics with different cellulose concentration	142
4.10	Water repellence grade of fabrics with different cross-linking agent concentrations	143
4.11	Bending modulus in m/c direction at different concentration of cellulose solution $(kg/cm^2)$	145
4.12	Bending modulus in m/c direction at different cross-linking agent concentrations (kg/cm <sup>2</sup> )	147
4.13	Bending modulus in cross m/c direction at different concentration of cellulose solution $(kg/cm^2)$	149
4.14	Bending modulus in cross m/c direction at different cross-linking agent concentrations (kg/cm <sup>2</sup> )	151

## LIST OF FIGURES

Figure No.	Title of Figure	Page No.
2.1	Share of various segments in global technical textiles market (2018)	9
2.2	Share of various sectors of Indian technical textiles market (2017-18)	10
2.3	Relative size of wood chips, wood fibre and cellulose nano fibre	30
2.4	Self-illuminating optical fibres	36
2.5	Various fibres used in medical textiles	62
2.6	Classification of medical textiles	65
2.7	Various nonwoven material compositions for surgical gowns	81
2.8	Critical zones for surgical gowns	83
2.9	Evaluation criteria for selection of surgical gown	87
2.10	Various environmental factors of Reusable and disposable gowns	89
2.11	Environmental impacts of reusable gowns	91
2.12	Physical chemistry of wetting agent	100
3.1	Dishes prepared for anti-bacterial testing	123
4.1	Effect of cross-linking agent concentration with 10gpl nano cellulose concentration on increase in fabric mass density	125
4.2	Effect of cross-linking agent concentration with 20gpl nano cellulose concentration on increase in fabric mass density	125
4.3	Effect of cross-linking agent concentration with 30gpl nano cellulose concentration on increase in fabric mass density	126
4.4	Effect of nano cellulose concentration without cross-inking agent on increase in fabric mass density	127
4.5	Effect of nano cellulose concentration with 5gp cross-linking agent on increase in fabric mass density	128
4.6	Effect of nano cellulose concentration with 10gpl cross-linking agent on increase in fabric mass density	128
4.7	Effect of cross-linking agent concentration with 10gpl nano cellulose concentration on tensile strength in machine direction	130

4.8	Effect of cross-linking agent concentration with 20gpl nano cellulose concentration on tensile strength in machine direction	130
4.9	Effect of cross-linking agent concentration with 30gpl nano cellulose concentration on tensile strength in machine direction	131
4.10	Effect of nano cellulose concentration without cross- linking agent on tensile strength in machine direction	133
4.11	Effect of nano cellulose concentration with 5gpl cross- linking agent on tensile strength in machine direction	151
4.12	Effect of nano cellulose concentration with 10gpl cross-linking agent on tensile strength in machine direction	133
4.13	Effect of cross-linking agent concentration with 10gpl nano cellulose on tensile strength in cross machine direction	134
4.14	Effect of cross-linking agent concentration with 20gpl nano cellulose on tensile strength in cross machine direction	134
4.15	Effect of cross-linking agent concentration with 30gpl nano cellulose on tensile strength in cross machine direction	135
4.16	Effect of nano cellulose concentration without cross- linking agent on tensile strength in cross machine direction	136
4.17	Effect of nano cellulose concentration with 5gpl cross- linking agent on tensile strength in cross machine direction	136
4.18	Effect of nano cellulose concentration with 10gpl cross- linking agent on tensile strength in cross machine direction	137
4.19	Effect of cross-linking agent concentration with 10gpl nano cellulose concentration on air permeability	137
4.20	Effect of cross-linking agent concentration with 20gpl nano cellulose concentration on air permeability	138
4.21	Effect of cross-linking agent concentration with 30gpl nano cellulose concentration on air permeability	138
4.22	Effect of nano cellulose concentration without cross-linking agent on air permeability	139
4.23	Effect of nano cellulose concentration with 5gpl cross-linking agent on air permeability	141
4.24	Effect of nano cellulose concentration with 10 gpl cross-linking agent on air permeability	141
4.25	Effect of cross-linking agent concentration on water repellence grade with 10gpl nano cellulose concentration	141
4.26	Effect of cross-linking agent concentration with 20gpl nano cellulose concentration on water repellence grade	141
4.27	Effect of Cross-linking agent concentration with 30gpl nano cellulose concentration on water repellence grade	142
4.28	Effect of nano cellulose concentration without cross-linking agent on water repellence grade	143
4.29	Effect of cellulose concentration with 5gpl cross-linking agent on water repellence grade	144

4.30	Effect of cellulose concentration with 10gpl cross-linking agent on water repellence grade	144
4.31	Effect of cross-linking agent concentration with 10gpl cellulose concentration on bending modulus in machine direction	145
4.32	Effect of cross-linking agent concentration with 20gpl cellulose concentration on bending modulus in machine direction	145
4.33	Effect of cross-linking agent concentration with 30gpl cellulose concentration on bending modulus in machine direction	146
4.34	Effect of nano cellulose concentration without cross-linking agent on bending modulus in machine direction	147
4.35	Effect of nano cellulose concentration with 5gpl cross- linking agent on bending modulus in machine direction	148
4.36	Effect of nano cellulose concentration with 10 gpl cross- linking agent on bending modulus in machine direction	148
4.37	Effect of cross-linking agent concentration with 10gpl cellulose concentration on bending modulus in cross machine direction	172
4.38	Effect of cross-linking agent concentration with 20gpl cellulose concentration on bending modulus in cross machine direction	149
4.39	Effect of cross-linking agent concentration with 30gpl cellulose concentration on bending modulus in cross machine direction	150
4.40	Effect of nano cellulose concentration without cross- linking agent on bending modulus in cross machine direction	151
4.41	Effect of nano cellulose concentration with 5gpl cross-linking agent on bending modulus in cross machine direction	151
4.42	Effect of nano cellulose concentration with 10gpl cross- linking agent on bending modulus in cross machine direction	152
4.43	Sample 8A, Bacteria S.A.	153
4.44	Sample 8 A, Bacteria E.C.	154
4.45	Sample 8C, Bacteria S.A.	155
4.46	Sample 8C, Bacteria E.C	156
4.47	Sample 9 A, Bacteria S.A.	156
4.48	Sample 9 A, Bacteria E.C.	157
4.49	Sample 9 C, Bacteria S.A.	157
4.50	Sample 9 C, Bacteria E.C.	158