

Faculty of women
For Art, Science and Education
Home Economics Department

Thesis Submitted in requirement of Ph.D. (Home Economics- Textile and Clothing) Entitled

"Using different techniques to produce a soil release stain removal fabrics and their evaluation via six sigma process framework" By

Shimaa Hassen Abd El Rahman Mosa

Assistant lecturer in Home Economics department Faculty of Women – Ain Shams University

Supervised by

Prof. Dr. Wafaa A. El-Sayed

Prof. of Textile Chemistry and dyeing Faculty of Women, Ain Shams University.

Prof. Dr. Maha M. T. Eladwi

Prof. of Fashion Design Faculty of Women Ain Shams University

Prof. Dr. Adel Mohamed El Hadidy

Prof. of Textile Engineering, Faculty of Engineering, Mansoura University.

Dr. Neveen Hussein Ibrahim

Ph.D. (Home Economics, Textile and Clothing), Faculty of Women Ain Shams University

2017

Acknowledgement

Thanks to God before and after

Foremost, I would like to express my sincere gratitude to my advisor **Prof. Dr., Wafaa A.El-sayed,** for the continuous support of my Ph.D study and research, for her patience, motivation, enthusiasm, and immense knowledge. Her guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Ph.D study.

Also I am grateful to prof. Dr., Adel Mohamed El -Hadidy Professor of Textile engineering for his sincere guidance and constructive suggestions throughout all the phases of this work.

I would like to thank my advisor **Prof.Dr.Maha M. T.Eladwi**. She has taught me, both consciously and unconsciously, I appreciate all her contributions of time, ideas, and effort to accomplish my Ph.D.

I also appreciate a great deal to **Dr.**, **Neveen Hussein** for her great assistant throughout this work.

My appreciation also goes to my other colleagues in the Home Economics department for their sincere help and support especially **Dr. Rania Shaker** and **Dr. Naglaa Abd El Azem**

This thesis is dedicated to **my family** for their support that I would not be who I am today without their love and support.

Contents

List of figures	Pages XIV
List of tables	XX
List of abbreviations	XXII
	XXIV
Summary 1. Leave de california de l'Acceptance de l'A	
1. Introduction and literature review	1
1.1. Cotton and polyester fibers	2
1.1.1 Cotton fiber	3
1.1.1.1 Physical structure of cotton fiber	4
1.1.1.2 Chemical composition of cotton fiber	5
1.1.1.3 Fiber properties of cotton fiber	5
1.1.1.3.1 Physical properties	5
1.1.1.3.2 Mechanical properties	5
1.1.1.3.3 Chemical properties	6
1.1.3.4 Thermal properties	6
1.1.1.3.5. Environmental properties	6
1.1.2. Polyester fibers	6
1.1.2.1 Physical structure of polyester	7
1.1.2.2. Fiber properties of polyester	8
1.1.2.2.1. Physical properties	8
1.1.2.2.2. Mechanical properties	8
1.1.2.2.3 Chemical properties	9
1.1.2.2.4. Effect of sunlight	9
1.1.2.2.5 Biological properties	9
1.2 Textile Finishing	10
1.2.1. Chemical finishing or wet finishing	10

1.2.2 Mechanical finishing	11
1.2.3 Thermal finishing process	11
1.3 Soil release finish	12
1.3.1 Soil categories	13
1.3.2 Fabric soiling mechanism	14
1.3.3 Stain-repellent finishes	14
1.3.4 Stain/soil release finishes	15
1.3.5 Mechanisms of soil release	15
1.3.6 Soil release chemistry	17
1.3.6.1 Carboxy-based finishes	17
1.3.6.2 Hydroxyl-based finishes	17
1.3.6.3 Ethoxy-based finishes	17
1.3.6.4 Fluorine-based finishes	18
1.3.6 .5 Non-polymer soil-release treatments	18
1.3.7 Principles for Removing Stains	18
1.3.8 Factors affecting soil release finish	18
1.3.9 Properties and advantages achieved by soil	19
release	
1.3.10 Evaluation of soil release	19
1.4 Softener as a soil release agent	20
1.4.1 Cationic softeners	20
1.4.2 Anionic softeners	20
1.4.3 Sulfonates	20
1.4.4 Silicone softeners	20
1.5. Plasma Treatments (as a dry process)	22
1.5.1 Plasma definition	22
1.5.2 Plasma process classification	23
1.5.2.1 Cleaning plasma	23
1.5.2.2 Activation plasma	24
1.5.2.3 Plasma induced grafting	25

1.5.2.4 Plasma induced Polymerization	25
1.5.3 Plasma Textile applications	26
1.5.4 Different types of power supply to generate	26
the plasma	
1.5.4.1 Low pressure plasmas (vacuum	27
plasma)	
1.5.4.2 Atmospheric pressure plasmas	27
1.5.4.2.1 Corona treatment	28
1.5.4.2.2 Dielectric barrier discharge (Silent	28
discharge) DBD	
1.5.4.3. Glow discharge (APGD)	29
1.5.5 Gases commonly used for plasma	29
treatments are	
1.5.6 Effect of plasma on fibres and polymers	29
1.5.6.1 Plasma treatment of cellulose based fibre	30
1.5.6.2 Plasma treatment of Synthetic fibre	34
1.6 Dyeing	36
1.6.1 Chromophore and Auxochromes:	37
1.6.1.1 Chromophores	37
1.6.1.2 Auxochromes	37
1.6.2 in this work some dyes are selected to	39
apply them on the finished fabric as Vinyl	
sulphone reactive dye and disperse dyes.	
1.6.2.1 Reactive dyes	39
1.6.2.1.1 Vinyl sulphone dyes	40
1.6.2.2 Disperse dyes	41
1.7 Six sigma process	43
1.7.1 The steps of Six Sigma	44
1.7.1.1 DMAIC (Define, Measure, Analyze,	44
Improve and Control)	

1.7.1.2 DFSS (Design for Six Sigma	45
1.7.1.3 Lean (Discover and eliminate	45
unnecessary steps in a process)	
1.7.2 Building the Six Sigma Infrastructure	45
1.7.3 How to Calculate Six Sigma Qualities	46
1.7.4 Key Concepts of Six Sigma	47
1.8 Antimicrobial finishing	49
1.8.1. Microbe	49
1.8.2. Requirements of antimicrobial finishing	49
1.8.3. Types of antimicrobials	50
1.8.3.1. Leaching type (conventional	50
antimicrobial)	
1.8.3.2. Non - Leaching type	50
1.8.4 Mechanisms of antimicrobial action	51
1.8.4.1 The controlled release mechanism	51
1.8.4.2 The barrier or blocking mechanisms	51
1.8.4.3 The regeneration mechanism	51
1.8.5. The Antimicrobial Agents	51
1.8.5.1. Metallic Salts	52
1.8.5.2. Quaternary ammonium Salts	52
1.8.5.3. Magnesium Peroxide Based agents	52
1.8.5.4 Poly-hexamethylene biguandine	52
(PHMBG)	
1.8.5.5. Organic N – Halamines Compound	52
1.8.5.6. Chitosan	53
1.9. Upcycling Used Garments to Recreate	54
Sustainable Fashion Designs	
1.9.1 Elements of design	57
1.9.1.1 Color	57
(a) Hue	58

(b) Value	58
(c) Intensity	58
1.9.1.2 Shape	58
1.9.1.3 Line	59
(a) Line types	59
(b) Line directions	59
(c) Line applications	60
1.9.1.4 Texture	61
1.9.2 Principles of design	61
1.9.2.1. Balance	61
1.9.2.2. Proportion	62
1.9.2.3. Emphasis	62
1.9.2.4. Rhythm	62
1.9.2.5. Harmony	63
2.Aim of the work	64
2-1 The plan of the work	64
3. Experimental work	66
3.1. Materials	66
3.1.1. Fabric and accessories	66
3.1.2. Chemicals	66
3.1.3 Plasma device	67
3.1.4. Microorganisms	67
3.1.4 .1. Microorganisms used in the	67
bacterial test	
3.1.4.2. Media used	67
3.1.5. Dyes	68
3.2. Methods	69
3.2.1 Pretreatment of the fabric	69
3.2.2. Wet processing treatment	69

3.2.2.1 Treatment with Strucksilon 8450	69
3.2.2.2 Treatment with Durex HS-300N	69
3.2.3 Plasma treatment	70
3.2.4 Soiling technique	71
3.2.5. Dyeing of cotton and polyester fabrics	71
with reactive and disperse dyes	
3.2.5.1 Dyeing of cotton fabric with reactive dye	71
3.2.5.2 Dyeing of polyester fabric with	72
disperses dye	
3.2.6. Tie and dye	73
3.3. Testing and analysis method	73
3.3.1. Soil release testing	73
3.3.2 Antimicrobial testing of the treated	75
fabrics	
3.3.3 Physico- mechanical measurements	76
3.3.3.1. Breathability	76
3.3.3.2. The crease recovery angles (°)	76
3.3.3. The evaluation of wettability	76
3.3.4 Durability test	76
3.3.5 Color strength (K/S)	76
3.3.6 Color fastness properties	77
3.3.6.1. Light fastness	77
3.3.6.2. Wash fastness	77
3.4. Application in the clothes field	78
3.4.1. Sustainable clothes with added value	78
3.4.1.1 Design (1)	79
3.4.1.2 Design (2)	79
3.4.1.3 Design (3)	80
3.4.1.4 Design (4)	80

3.4.1.5 Design (5)	81
3.4.1.6 Design (6)	81
3.4.1.7 Design (7)	82
3.4.1.8 Design (8)	82
3.4.1.9 Design (9)	83
3.4.1.10 Design (10)	83
3.4.2. The following are four fashion	84
design sketches with their pattern for	
different purposes 3.4.2.1 Design number (1) and its pattern	84
3.4.2.2 Design number (2) and its pattern	86
3.4.2.3 Design number (3) and its pattern	88
3.4.2.4 Design number (4) and its pattern	90
4. Result and discussion.	92
4.1 soil release results	92
4.1.1 Soil release wet processing results	92
4.1.1.1 Strucksilon silicone softener studied	92
factors	
4.1.1.1 Effect of Strucksilon on stain	92
removal from cotton fabric	
4.1.1.1.1 Effect of different concentrations	92
of Strucksilon on stain removal from cotton	
fabric 4.1.1.1.2 Effect of different pH of	95
Strucksilon on stain removal from cotton	73
fabric	
4.1.1.1.3 Effect of different Pick up of	97
Strucksilion on stain removal from cotton	
fabric	
4.1.1.1.4 Effect of different Drying	99
temperature of Strucksilion on stain removal	

of cotton fabric	
4.1.1.1.5 Effect of different drying time of	101
Strucksilion on stain removal of cotton	
fabric	
4.1.1.1.6 Effect of different curing	103
temperature of Strucksilion on stain removal	
of cotton fabric	
4.1.1.1.7 Effect of different Curing time of	105
Strucksilion on stain removal of cotton	
fabric	
4.1.1.1.2 Effect of Strucksilion on stain	107
removal of polyester fabric	
4.1.1.2.1 Effect of different concentration	107
of Strucksilion on stain removal of polyester	
fabric	
4.1.1.2.2 Effect of different pH of	110
Strucksilion on stain removal of polyester	
fabric	
4.1.1.2.3 Effect of different Pick up of	112
Strucksilion on stain removal of polyester	
fabric	
4.1.1.2.4 Effect of different Drying	114
temperature of Strucksilion on stain removal	
of polyester fabric	
4.1.1.2.5 Effect of different drying time of	116
Strucksilion on stain removal of polyester	
fabric	
4.1.1.2.6 Effect of different Curing	118
temperature of Strucksilion on stain removal	
of polyester fabric	
4.1.1.2.7 Effect of different curing time of	120
Strucksilion on stain removal of polyester	
fabric	

4.1.1.2 Durex HS 300N macro emulsion	122
nonionic modified Polyethersiloxane studied factors	
4.1.1.2.1 Effect of Durex HS 300N on stain	122
removal of cotton fabric	122
4.1.1.2.1.1 Effect of different concentrations	122
of Durex HS 300N on stain removal of	122
cotton fabric	
4.1.1.2.1.2 Effect of different pH of Durex	125
HS 300N on stain removal of cotton fabric	123
4.1.1.2.1.3 Effect of different pick up of	127
Durex HS 300N on stain removal of cotton	127
fabric	
4.1.1.2.1.4 Effect of different drying	129
temperature of Durex HS 300N on stain	
removal of cotton fabric	
4.1.1.2.1.5 Effect of different drying time of	131
Durex HS 300N on stain removal of cotton	
fabric	
4.1.1.2.1.6 Effect of different curing temp of	133
Durex HS 300N on stain removal of cotton	
fabric	
4.1.1.2.1.7 Effect of different curing time of	135
Durex HS 300N on stain removal of cotton	
fabric	
4.1.1.2.2 Effect of Durex HS 300N on stain	138
removal of polyester fabric	
4.1.1.2.2.1 Effect of different concentrations	138
of Durex HS 300N on stain removal from	
polyester fabric	
4.1.1.2.2.2 Effect of different pH of Durex	140
HS 300N on stain removal from polyester	
fabric	

4.1.1.2.2.3 Effect of different pick up of	142
Durex HS 300N on stain removal from	
polyester fabric	
4.1.1.2.2.4 Effect of different drying temp.	144
of Durex HS 300N on stain removal from	
polyester fabric	
4.1.1.2.2.5 Effect of different drying time of	146
Durex HS 300N on stain removal from	
polyester fabric	
4.1.1.2.2.6 Effect of different curing temp.	148
of Durex HS 300N on stain removal from	
polyester fabric	
4.1.1.2.2.7 Effect of different curing time of	150
Durex HS 300N on stain removal from	
polyester fabric	
4.1.2 Soil release stain removal of plasma	153
treated fabric	
4.1.2.1 soil release stain removal plasma	153
treated cotton fabric	
4.1.2.2 soil release stain removal plasma	157
treatment of polyester fabric	
4.2 Implementing six sigma framework in the	162
soil release stain removal	
4.2.1 Six sigma methodology (DMAIC)	162
4.2.2 calculating process of sigma level	163
4.3 Effect of Wet and Dry process treatment of	166
cotton and polyester fabric on the bacterial	
growth.	
4.3.1 Effect of wet process treatment of	166
cotton and polyester fabric on the bacterial	
growth:	
4.3.2 Effect of Dry process treatment of	167
cotton and polyester fabric on the bacterial	

growth:	
4.3.2.1 The effect of air plasma treatment of cotton fabric on the reduction growth % of	168
bacteria:	
4.3.2.2 Effect of argon plasma treatment of	168
cotton fabric on the reduction % growth of	100
bacteria:	
4.3.2.3 Effect of plasma treatment of	168
polyester fabric on the reduction % growth	
of bacteria:	
4.4 Physico mechanical properties of treated	170
cotton and polyester fabrics:	
4.4.1 Breathability:	171
4.4.2 Crease recovery:	172
4.4.3 Wettability:	173
4.5 Durability test result:	174
4.6 Effect of wet and dry treatment of cotton and	177
polyester fabric on color strength (K/S):	
4.6.1 Effect of the dyeing of wet and dry	180
treated cotton and polyester fabric on the	
soil release:	100
4.7 Fastness properties:	183
4.7.1 Wash fastness:	184
4.7.2 Light fastness:	184
5. Designs and products	186
5.1. Tie and Dye Technique:	186
5.2 Embroidery stitch:	186
5.2.1 Running stitch (Hand Basting)	186
5.2.2 Cross stitch	187
5.2.3 Satin stitch:	188
5.4 Designs	189
5	

Design (1)	189
Design (2):	190
Design (3)	191
Design (4):	192
Design (5):	193
Design (6):	194
Design (7):	195
Design (8):	196
Design (9):	197
Design (10)	198
Design (11)	199
Design (11) application:	201
Design (12)	202
Design (12) application:	204
Design (13)	205
Design (13) application:	207
Design (14):	208
Design (14) application:	210
5.4 .1 Designs Evaluations - Factors affecting	211
Design	
5.4.1.1 Factors which need to be considered by	211
the designer during the design process	
5.4.1.2 Data Presentation and Interpretation:	211
5.4.2 Test method roadmap:	213
5.4.3 Two basic procedures of subjective	213
evaluation were proposed:	
5.4.4 The following are the Questionnaire sheet	214
of the products:	

5.5 The following are the results of the product	215
evaluation 5.6 The overall acceptability results:	222
Reference	224
Conclusion	242
Appendix	243
الملخص العربي	۲
الهدف من البحث	1

List of figures

	Pages
Figure (1): Classification of natural and man-made	2
fibers.	
Figure (2): Structure of cellulose.	3