RGC Ref. No.:
UGC/FDS25/E15/17
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

Submission Deadlines:
1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
2. *Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1. Project Title

Colour Fading Effect on Cotton by Plasma-induced Ozone treatment

2. Investigator(s) and Academic Department(s) / Unit(s) Involved

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	Dr. LIU Yaohui /Assistant Professor	Faculty of Science and Technology, Technological and Higher Education Institute of HK
Co-Investigator(s)	Prof. KAN Chi Wai / Professor	Institute of Textiles and Clothing/The Hong Kong Polytechnic University
Others		

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	1 Jan 2018	N/A	N/A
Project Completion Date	31 Dec 2020	30 Jun 2021	9 Nov 2020 (by THEi)

Duration *(in month)*	36	42	9 Nov 2020 (by THEi)
Deadline for Submission of Completion Report	31 Dec 2021	30 Jun 2022	9 Nov 2020 (by THEi)

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. To carry omparable study on the results of colour fading by plasma and conventional colour fading processes.
2. To op mize parameters for colour fading process based on the investigation of relationship between plasma treatment parameters and material parameters of cotton.
3. To inv tigate the effects of plasma-induced colour fading cotton dyes.
4. To develo guideline reference of plasma treatment for colour fading process garment industries.

5.2 Revised objectives

Date of approval from the RGC: N/A

Reasons for the change:

1.

2.

3. ....

5.3 Realisation of the objectives
(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

1. To carry comparable study on the results of colour fading by plasma and conventional colour fading processes.

The objective has been completed by reviewing the conventional colour fading processes and comparing to the study in the current project. The Table 1 compares the advantage of plasma treatment over conventional wet chemical processes.

Table 1 Comparison of plasma treatment over conventional wet chemical processes

Methods	Advantages	Disadvantages
Chemical process e.g., hydrogen peroxide or sodium hypochlorite	Fast operating processes Simplest Application	Most Expensive Wastewater Water Pollution Disposal problem as concentration of sludge Excessive chemicals usage High electrical energy Toxic Chemicals usage (e.g., Acid) Time consuming Inability to create standard designs Not possible on all textile surfaces Loss of quality
Plasma Treatment	Low cost Most rapidly for surface modification No solid waste No air pollution No water pollution Dry operation Wide range of textile surface can be done Even modification result	Modification of the parameters before starting operation Less skilled operating skills

2. To optimize parameters for colour fading process based on the investigation of relationship between plasma treatment parameters and material parameters of cotton.

The objective was achieved by an orthogonal array testing strategy (OATS). Three process parameters in the plasma-induced ozone colour-fading treatment, i.e., (1) oxygen gas concentration (%); (2) water content in fabric (%); and (3) treatment time (minutes), were used for finding the optimum conditions. The colour properties and relative unlevelness index (RUI) were used to assess the performance of various combinations of the plasma treatment

parameters. The order of importance of these parameters is oxygen gas concentration > water content in fabric > treatment time. On the whole, the optimum conditions for colour fading of sulphur-dyed knitted cotton fabric by plasma-induced ozone colour-fading treatment are identified. By calculating the results obtained from the nine trials, the optimum conditions for the plasma-induced ozone colour-fading process for decolourising the dyed sulphur-dyed knitted cotton fabric are: (1) oxygen gas concentration = 70%; (2) water content in fabric = 35%; and (3) treatment time = 30 min.

3. To investigate the effects of plasma-induced colour fading cotton dyes.

The objective was achieved by applying the optimal plasma-induced colour fading conditions on the sulphur-dyed cotton texture. Sulfur dyed cotton textures with various colour depths (0.5%, 1.5%, 2.5%) were set up to be treated different plasma parameters. The colour fading result is assessed by the colour reflectance in percentage (R%) utilizing spectrophotometer under CIE standard illuminant D65. The valid colour fading based on high percentage of reflectance was demonstrated from plasma treatment under higher ozone air concentration (50% and 70% ozone in air) and longer time length of plasma treatment (20 mins and 30 mins). The level of water content contained in the cotton fabrics is appeared to have noteworthy relationship with the degree of decolourization.

4. To develop guideline reference of plasma treatment for colour fading process garment industries.

The objective was achieved by finding the relationships among the color depths, ozone air concentrations, water contents and treatment time. Ozone in air concentration is found to be the key factor for controlling the colour fading effect. By knowing the effects of the controlling factors, the garment industries could control the color fading outcomes by adjusting the parameters.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
1. To carry comparable study on the results of colour fading by plasma and conventional colour fading processes.	√	100%
2. To optimize parameters for colour fading process based on the investigation of relationship between plasma treatment parameters and material parameters of cotton.	√	100%
3. To investigate the effects of plasma-induced colour fading cotton dyes.	√	100%

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
4. To develop guideline reference of plasma treatment for colour fading process garment industries.	√	100%

6. Research Outcome

6.1 Major findings and research outcome
(Maximum 1 page; please make reference to Part C where necessary)

A plasma-induced ozone colour-fading treatment was used for treating a blue sulphur-dyed knitted cotton fabric. Since the process parameters of plasma-induced ozone colour-fading treatment are inter-related with one other, the final colour-fading results are affected. An orthogonal array testing strategy (OATS) method was used for determining the optimum conditions of the plasmainduced ozone colour-fading treatment in this study.

Three process parameters used in the plasmainduced ozone colour-fading treatment, i.e., oxygen gas concentration (%), water content in fabric (%), and treatment time (minutes), were used in the optimization process. Experimental results reveal the optimum conditions for fading the colour by plasma-induced ozone colour-fading treatment are: (1) oxygen gas concentration = 70%; (2) water content in fabric = 35%; and (3) treatment time = 30 min. The distribution is shown in Figure 1.

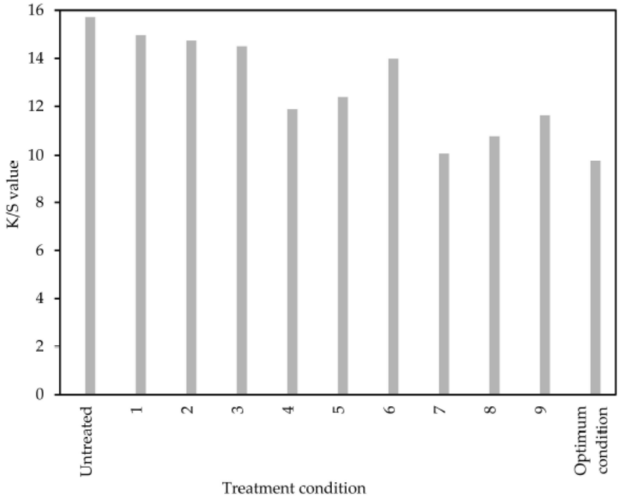

Figure 1. Effect of treatment time of plasma-induced ozone colour-fading effect on the sulphur-dyed knitted cotton fabric (Zhong *et al.*, 2018).

The colour fading result is assessed by the colour reflectance in percentage (R%) utilizing spectrophotometer under CIE standard illuminant D65. Typical color reflection curves are shown in Figure 2. It is found that the plasma-induced ozone colour-fading treatment can effectively remove the colour from the dyed fabric and the colour-fading effect is uniform and even. In addition, the relationships among the color depths of the fabrics, ozone air concentrations, water contents and treatment time are also revealed.

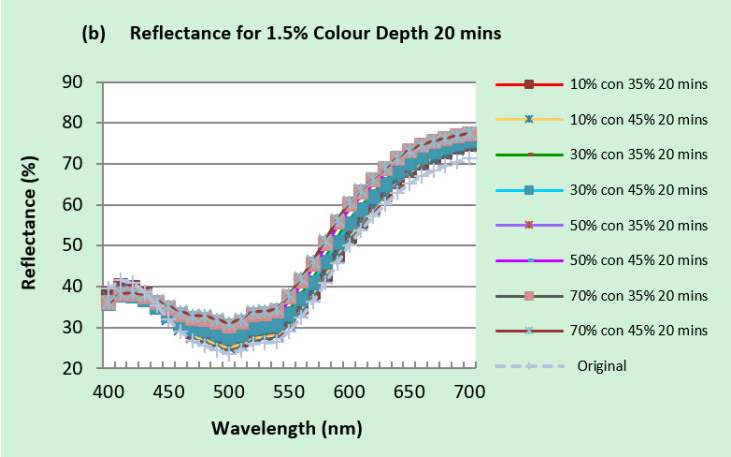

Figure 2 Typical reflectance curves of untreated sulfur dyed cotton samples and plasma treated dyed cotton samples in 1.5 % colour depth under various air concentrations with treatment time of 20 mins (LIU *et al.,* 2020)

The results show that the order of importance of these parameters is: ozone gas concentration > water content in fabric > treatment time. The relationships form valuable references for garment industries to control the color fading effects by the adjusting the operational parameters.

For detailed analysis results please refer to the publications mentioned in Part C.

6.2 Potential for further development of the research and the proposed course of action *(Maximum half a page)*

Colour fading or decolourization is an indispensable textile finishing technique that can give a stylish appearance by adding acceptable worn look fabric textures, and providing more options to clients. Low temperature plasma treatment with air contains clear yield during process and with eco-accommodating setting with no toxic pollutant discharge and reduction of handling time has been presented. Ozone plasma treatment has been a compelling strategy for surface modification of textile fabrics by a dry etching process. According to the eco-friendly nature of plasma, a specific benefit of ozone plasma treatment over other traditional textile finishing strategies is the likelihood to control the process parameters including ozone concentration in air, water content and time length for plasma treatment. The plasma colour fading technology can be further investigated on various fabrics and different dyes. In addition, colour fading effects of the knitted cotton fabric with various properties can be further studied. To reveal the advantages of the plasma colour fading technologies, the economic analysis can be further studied by considering the whole production cycle.

7. Layman's Summary

(Describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

In textile applications, the colour-fading process can be classified as a finishing method to provide aesthetic effect of worn and vintage look in the products. There are many different colour-fading processes that can be used for such textile applications. However, much of the conventional colour-fading processes involve the use of large quantities of water and chemicals, which increases the generation of effluents. The plasma-induced ozone color-fading treatment in this study offers an environmentally friendly way for the garment industries to produce desired effects on fabrics. It significantly reduces the generation of the effluent and reduce the cost of wastewater treatment. The project reveals the relationships among the properties of the fabrics, ozone air concentrations, water contents and treatment time. The results suggest optimal operational conditions for colour fading on cotton fabrics. The findings from this project also offer the valuable reference for garment industries to control the desired colour fading effects by adjusting the key parameters. It is believed that the findings would significantly help to increase the productivity of the industry and reduce the generation of wastewater.

Part C: Research Output

8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project

(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				**Author(s)** *(denote the corresponding author with an asterisk*)*	**Title and Journal / Book** *(with the volume, pages and other necessary publishing details specified)*	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
Year of Publication	**Year of Acceptance** *(For paper accepted but not yet published)*	**Under Review**	**Under Preparation** *(optional)*						
2020				Yaohui Liu *, Yanming Wang, Hiu-yan Cheung, Chi Wai Kan and Hong Chua	Colour Rflectance Investigation of Decolouriz ed Sulfur Dyed Cotton Knitted Fabric via Ozone Plasma Treatment (World Journal of Engineerin g and Technology 08(03):429-442 DOI:10.42 36/wjet.202 0.83032)	No	Yes	Yes	Yes

2018				Dan Zhong, Yao-Hui Liu, Ngan-Ting Cheung, Chi-Wai Kan and Hong Chua	A Parameter Study of the Effect of a Plasma-Induced Ozone Colour-Fading Process on Sulphur-Dyed Cotton Fabric (Processes 2018, 6, 81; doi:10.3390/pr6070081)	Yes (31 May 2019)	No	Yes	Yes

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered

(Please attach a copy of each conference abstract)

Month / Year / Place	**Title**	**Conference Name**	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
Aug/2019/ Japan	Color Reflectance Study of Decolorized Reactive Dyed Cotton Knitted Fabric by Ozone Plasma Treatment	International Conference on Engineering, Science, and Industrial Applications	31 May 2019	No	Yes	Yes

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning

(Please elaborate)

The large-scale study of plasma color fading is being sought. The technology is believed to increase the productivity of the garment industries. However, due to the COVID-19 epidemic and closure of the border. The connection with manufactures in Mainland China is significantly affected. It is expected that the technology can be promoted to the manufactures in the coming future to improve the efficiency of colour fading process and reduce the wastewater generation in garment industry.

11. Student(s) Trained

(Please attach a copy of the title page of the thesis)

Name	Degree Registered for	Date of Registration	Date of Thesis Submission / Graduation
[redacted]	[redacted]	[redacted]	[redacted]

12. Other Impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

Nil

13. Statistics on Research Outputs

	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
No. of outputs arising directly from this research project	2 (published)	1	0	0	Type	No.
					Ph.D Thesis	1

14. Public Access Of Completion Report

(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	Reasons
Nil	