Studies on Low Pressure Air Plasma Treatment to Vanya Silk

Subrata Das*

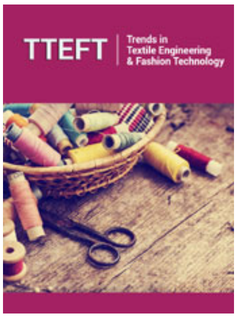
Professor, Fashion Technology Department, Bannari Amman Institute of Technology, India

Abstract

Tasar, muga and eri silk yarns were treated with low pressure air plasma. Though tenacity and elongation property of tasar, muga and eri silk did not change significantly with plasma treatment, but improvement of wicking property was noticed. Surface morphology of non-mulberry silk was changed after plasma treatment. In the case of tasar, eri and muga, sharp serrations on fibre surface were minimized after plasma treatment.

Keywords: Plasma; Non-mulberry; Tenacity; Elongation; Wicking; SEM

ISSN: 2578-0271



***Corresponding author:** Subrata Das, Professor, Fashion Technology Department, Bannari Amman Institute of Technology, Sathyamangalam, Erode Distt, Tamil Nadu 838401, India

Submission: April 15, 2024

Published: June 12, 2024

Volume 10 - Issue 1

How to cite this article: Subrata Das*. Studies on Low Pressure Air Plasma Treatment to Vanya Silk. Trends Textile Eng FashionTechnol.10(1).TTEFT.000728.2024. DOI: 10.31031/TTEFT.2024.10.000728

Introduction

Wild silks are often referred to in India as 'Vanya' silks: The term 'Vanya' is of Sanskrit origin, meaning untamed, wild, or forest based. Muga, Tasar, and Eri silkworms are not fully tamed and the world calls the silks they produce 'wild silks'. India produces four kinds of silk: mulberry, tasar, muga and eri. In raw silk production, India stands second. In fact, China is the largest producer of silk [1]. In the fashion arena, customers prefer diversity along with conventional varieties in textile products [2]. Dr Irving Langmuir, an American Chemist and Physicist had first applied 'Plasma' to ionised gas in 1929 [3]. Surfaces of textiles can be modified by atmospheric pressure cold plasma. Chemical modification of the surface of textiles is done by using different gases in eco-friendly plasma treatment process [4]. Plasma technology does not damage or alter the bulk properties of the materials and keep environmental pollution in control, similar to that of dry finishing [5]. Plasma treatment in the Textile Industry was investigated by Zille Andrea et al. [6].

The use of non-polymerising gases in atmospheric pressure plasma treatment of textiles has been discussed by Kale Kiran H [7]. Desizing of cotton textiles by plasma treatment has been discussed by Lam CF et al. [8]. Plasma treatment can be applied in the pad-dry-cure process for making Rechargeable antimicrobial cotton fabric can be produced by treatment with plasma in the pad-dry-cure process. Such fabric inhibits *S. Aureus* as reported by Zhou CE et al. [9]. Plasma treatment for pigment application to textiles was also investigated by Man WS et al. [10]. Polyester, nylon 6, nylon 66, aramid and wool fabrics were treated with plasma [11-13] for the improvement in dye uptake. Zhang [14] used graft polymerized acrylamide by plasma induced method and analysed the surface of silk fabrics [14]. Fibroin film was prepared and treated with CF_4 plasma by Nishikawa et al. [15]. Silk fabrics were treated with SF_6 plasma by Selli et al. [16] wherein F replaced H. Successful fluorination happened in such treatment Surface area of 0_2 plasma treated silk fabrics was evaluated by Nakano et al. [17] by using a modified BET apparatus. In a study conducted by Iriyama Yu et al. [18], silk fabrics were exposed to 0_2, N_2, and H plasmas for obtaining higher colour depth in dyeing and good color fastness to rubbing.

The objective of this study is to explore the effect of using low pressure air plasma treatment to vanya silks viz. tasar, eri and muga silk with respect to changes in tenacity, elongation wicking, and surface morphology.

Materials and Methods

Degummed silk yarns of tasar (*Antheraea mylitta* D.), muga (*Antheraea assama* WW.) and eri (*Philosamia ricini* B.) collected from Central Silk Board, Bangalore, India were used for the study.

Low pressure air plasma treatment

A glow discharge generator (Show Co. Ltd., Japan) was used for the treatment of silk yarns at M/s Bangalore Plasma Tech Pvt. Ltd., Bengalooru, India. The glow discharge apparatus was a radio-frequency etching system operation at 13.56MHZ and using an aluminum square chamber with an internal size of 200mm x 200mm. The silk yarns selected for the study were dried in an oven at 40 °C for 12 hours to minimize the water content in fibers before plasma treatment for 10 min. Airflow was adjusted at the rate of 20cc/minute at room temperature and silk yarns were treated with a low pressure of 0.5 mil bar. The tensile properties, wicking properties, dye uptake properties and surface morphology of degummed silk yarns were investigated after plasma treatment.

Tenacity and elongation

Tenacity and elongation tests were carried out on Instron Tensile Strength Tester (Model No. 5500R6021) by following the ASTM D 2256 test method. Tenacity is expressed as breaking load in grams per denier of yarn. Elongation is the amount the stretch when pulled to the breaking point and expressed in percentage.

Wicking

Wicking properties of plasma treated and untreated degummed silk yarns were studied by following AATCC 197 test method. Plasma treated and untreated silk degummed yarns were tied to glass rods. Depending on the denier of the yarn dead weight was hanged to maintain uniform tension to the silk yarn and markings at 6 centimeter from the glass rod were executed. Coloured solution was prepared by dissolving acid dye in cold water. Then samples were prepared and are dipped till the markings. Duration of 20 minutes was allowed to wick the tinted liquid vertically through the samples. Wicking height was noted down for all the samples.

Surface characterization (SEM)

Samples were viewed under scanning electron microscope (LEICA S 40 Cambridge, U.K.) at required magnifications. Morphological studies of the surface of the samples were investigated.

Result and Discussion

Tenacity, elongation and wicking height of plasma treated yarn varieties viz. tasar, muga and eri are shown in Table 1 in comparison with the control i.e., original degummed silk yarn.

Table 1: Properties of yarn under plasma treatment.

Sl. No.	Yarn	Tenacity (g/den)		Elongation (%)		Wicking Height (cm)	
		Controlled	Plasma Treated	Controlled	Plasma Treated	Controlled	Plasma Treated
1	Tasar (*Antheraea mylitta D.*)	2.4	2.3	31.9	30.4	0.1	0.4
2	Muga (*Antheraea assama Ww*)	3.9	4	41.7	42.1	0.1	0.5
3	Eri (*Philosamia ricini B.*)	1.6	1.5	28.5	24.3	1	1.5

The tenacity of tasar is 2.4g/den and 2.3g/den in original and plasma treatment, respectively. The muga silk has tenacity value under controlled and plasma treatments are 3.9g/den and 4.0g/den. Eri yarn has recorded 1.6g/den and 1.5g/den tenacity values in controlled and plasma treatment. The pair of controlled values and plasma treatment experimental values for elongation with respect to tasar, muga and eri yarns are recorded as 31.9% and 30.4%, 41.7% and 42.1%, and 28.5% and 24.3%, respectively. The plasma treatment against controlled conditions for the yarns of tasar, muga and eri with respect to wicking height is measured as 0.1cm and 0.4cm (tasar), 0.1cm and 0.5cm (muga) and 1.0cm and 1.5cm (eri), respectively.

ANOVA for tenacity and elongation

ANOVA for tenacity and elongation for tasar silk, muga silk and eri silk yarn is given in Table 2.

Table 2: ANOVA for tenacity and elongation (%) of tasar, muga and eri silk yarn.

Parameters		Sum of Squares	df	Mean Square	F	Sig.
TASAR (*Antheraea mylitta* D.)						
TENACITY	Between Groups	0.001	1	0.001	0.012	0.916
	Within Groups	0.551	8	0.069		
ELONGATION	Between Groups	5.161	1	5.161	0.252	0.63
	Within Groups	164.155	8	20.519		
Muga (*Antheraea assama* Ww.)						
TENACITY	Between Groups	0.005	1	0.005	0.025	0.878
	Within Groups	1.583	8	0.198		
ELONGATION	Between Groups	0.359	1	0.359	0.018	0.895
	Within Groups	155.547	8	19.443		

Eri (*Samia (Philosamia) ricini* B.)						
TENACITY	Between Groups	0.016	1	0.016	1.467	0.26
	Within Groups	0.085	8	0.011		
ELONGATION	Between Groups	44.029	1	44.029	0.062	0.062
	Within Groups	74.981	8	9.373		

It has been observed from the statistical analysis that the significance value (Sig.) for tenacity varies from 0.260 to 0.916 and elongation varies from 0.062 to 0.895 across all the three varieties of yarn taken for the study. The significance value (sig.) is more than 0.05. Therefore, there is no statistically significant difference in the mean value of tenacity and elongation in all the three varieties of silk yarns.

ANOVA analysis of wicking height

Table 3 depicts the output of the ANOVA analysis for tasar yarn and wicking height. This is to understand whether there is a statistically significant difference between group means or not.

Table 3: ANOVA for tasar yarn and wicking height.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.135	1	0.135	27	0.007
Within Groups	0.02	4	0.005		
Total	0.155	5			

As the significance value (sig.) is 0.007 (i.e., p=0.007), which is below 0.05, there is a statistically significant difference in the mean wicking height. If the number found in the Sig. column is less than the critical value of alpha (α=0.05) set by the researchers, then the effect is said to be significant. The p-value (0.007) is less than the significance level (0.05), the null hypothesis is rejected and concluded that not all of population means are equal. Also, this is supported by the F as the F_{table} value (18.5) is less than the $F_{calculated}$ value (27.0). Hence the null hypothesis is rejected and alternative hypothesis is accepted as population mean is not equal for tasar Yarn.

Table 4 shows the output of the ANOVA analysis for muga yarn. This is to understand whether there is a statistically significant difference between group means or not.

Table 4: ANOVA for muga yarn and wicking height.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.202	1	0.202	121	0.001
Within Groups	0.007	4	0.002		
Total	0.209	5			

As the significance value (sig.) is 0.001 (i.e., p=0.001), which is below 0.05 and therefore, there is a statistically significant difference in the mean wicking height. If the number found in the Sig. column is less than the critical value of alpha (α=0.05) set by the researchers, then the effect is said to be significant. The p-value (0.001) is less than to the significance level (0.05), the null hypothesis is rejected and concluded that not all of population means are equal. Also, this is supported by the F as the F_{table} value (84.5) is less than the $F_{calculated}$ value (121.0). Hence the null hypothesis is rejected and alternative hypothesis is accepted as population mean are not equal for muga yarn.

Table 5 shows the output of the ANOVA analysis for eri yarn. This is to understand whether there is a statistically significant difference between group means or not.

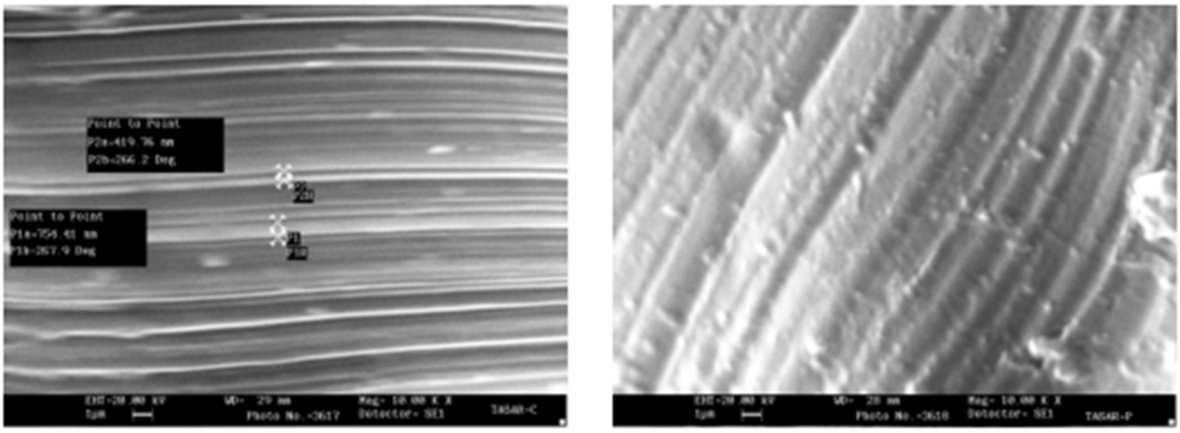
Table 5: ANOVA for eri yarn and wicking height.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.282	1	0.282	84.5	0.001
Within Groups	0.013	4	0.003		
Total	0.295	5			

As the significance value (sig.) is 0.001 (i.e., p=0.001), which is below 0.05 and therefore, there is a statistically significant difference in the mean wicking height. If the number found in the Sig. column is less than the critical value of alpha (α=0.05) set by the researchers, then the effect is said to be significant. The p-value (0.001) is less than to the significance level (0.05), the null hypothesis is rejected and concluded that not all of population means are equal. Also, this is supported by the F as the F_{table} value (18.5) is less than the $F_{calculated}$ value (84.5). Hence the null hypothesis is rejected, and alternative hypothesis is accepted as population mean are not equal for eri yarn.

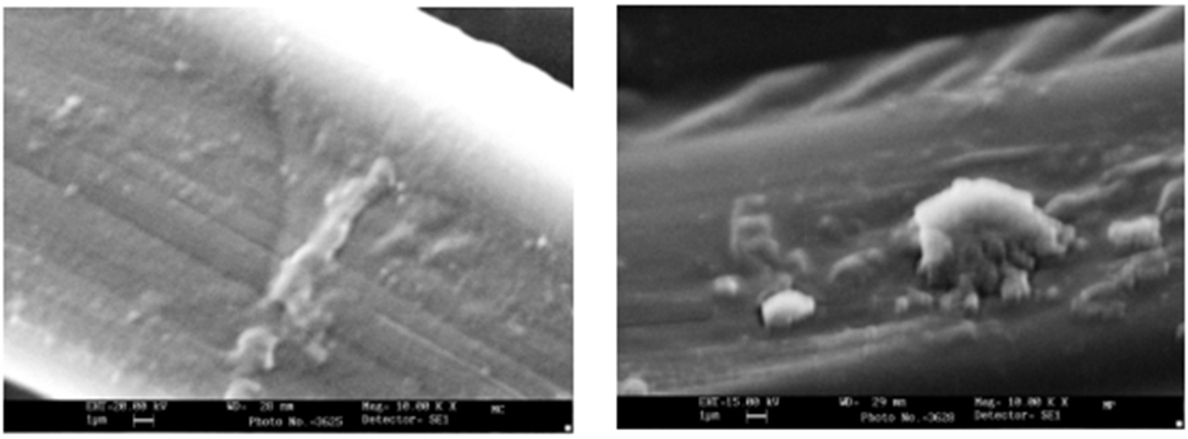
Effect of plasma treatment on surface morphology of different silk yarns

Surface morphology of the untreated and 10 min plasma treated silk substrates of all the three varieties were observed under scanning electron microscope at suitable magnifications. In the case of tasar, muga, and eri yarn, it can be seen from (Figures 1a, 2a and 3a) that untreated samples have sharp serrations morphology. However, in plasma treated samples, sharp serrations on fibre surface are minimized to a large extent as visible in (Figures 1b, 2b and 3b).



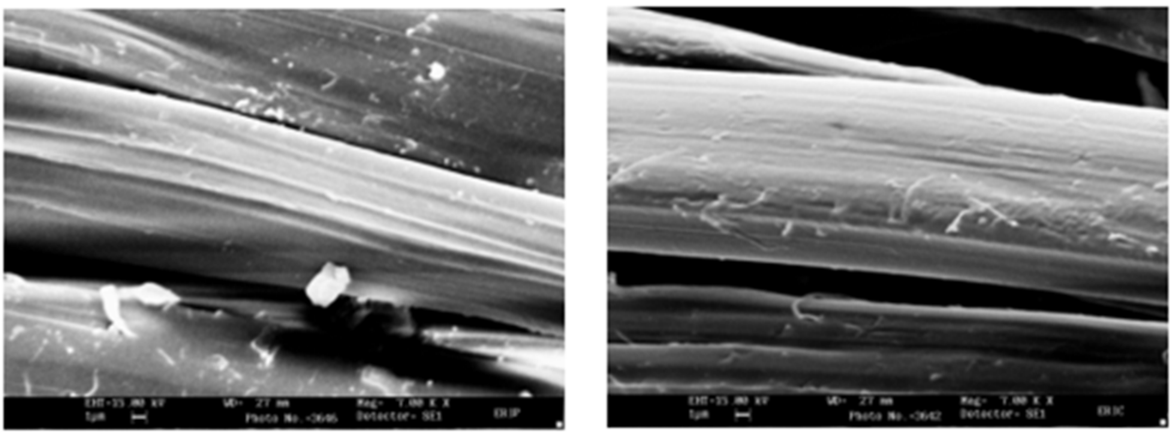
(a) untreated (b) plasma treated

Figure 1: Surface morphology of the tasar yarn at magnification of 10kX: (a) untreated. (b) plasma treated.



(a) untreated (b) plasma treated

Figure 2: Surface morphology of the muga yarn at magnification of 10kX: (a) untreated. (b) plasma treated.



(a) untreated (b) plasma treated

Figure 3: Surface morphology of the eri yarn at magnification of 7kX: (a) untreated. (b) plasma treated.

Conclusion

There is no significant outcome of low-pressure air plasma treatment on strength and elongation property of tasar, muga and eri degummed silk yarn. Wicking property has been improved significantly in tasar, muga and eri yarn after plasma treatment. The surface morphology of tasar, muga and eri silks is modified by plasma treatment. The sharp serrations of tasar, muga and eri have been minimized with the application of plasma treatment.

References

1. Baskar H (2006) Indian sericulture: Exciting path ahead. Indian Silk 44: 21.
2. Papnar N (2005) Blending for yarn amelioration. Textile Trends 48: 41.
3. Kartick S, Manjeet J, Agarwal Ashwini K (2006) Atmospheric pressure glow discharge plasma and its application in textiles. Indian Journal of Fibre and Textile Research 31: 83.
4. Jhala PB (2005) Monograph of plasma textile technology: Design applications, national institute of design. Ahmedabad, India.
5. Satreerat KH, Supasai T, Paosawatyanyong B, Kamlangkla K, Pavarajarn V (2008) Enhancement of hydrophobicity of silk fabrics by SF6 plasma. Applied Surface Science 254(15): 4744-4749.
6. Zille A, Oliveira FR, Souto AP (2014) Plasma treatment in textile industry. Plasma Processes and Polymers 12(2): 98-131.
7. Kale Kiran H, Desai AN (2011) Atmospheric pressure plasma treatment of textiles using non-polymerising gases. Indian Journal of Fibre & Textile Research 36: 289-299.
8. Lam CF, Kan CW, Ng SP, Chan CK (2015) Effect of plasma treatment on cotton desizing. Research Journal of Textile and Apparel 19(1): 46-58.
9. Zhou CE, Kan CW, Yuen CWM, Matinlinna JP, Tsoi JKH, et al. (2015) Plasma treatment applied in the pad-dry-cure process for making rechargeable antimicrobial cotton fabric that inhibits *S. Aureus*. Textile Research Journal 86(20): 2202-2215.
10. Man WS, Kan CW, Ng SP (2015) Plasma treatment for pigment application to textiles-A critical review. Research Journal of Textile and Apparel 19(1): 11-24.
11. Kobayashi S, Wakida T, Niu S, Hazama S, Doi C, et al. (1995) Effect of plasma treatment on surface of protein fabrics. Journal of Society of Dyers and Colourists 111: 72.
12. Oktem T, Ayhan H, Seventekin N, Piskin E (1999) Modification of polyester fabrics by *in situ* plasma or post plasma polymerization by acrylic acid. Journal of Society of Dyers and Colourists 115(9): 274-279.
13. Jahagirdar CI, Srivastava Y (2001) The impact of nitrogen low temperature plasma treatment upon the physical-chemical properties of polyester fabric. Journal of Applied Polymer Science 82: 292.
14. Zhang J (1997) The surface characterization of mulberry silk grafted with acrylamide by plasma copolymerization. Journal of Applied Polymer Science 64(9): 1713-1717.
15. Nishikawa A, Makara H, Shimasaki N (1994) Effect of plasma on the degradation of synthetic polymers. Sen'iGakkaishi 50: 274.
16. Selli E, Riccardi C, Massafra MR, Marcandalli B (2001) Studies on antibacterial dressings obtained by fluorinated post-discharge plasma. Macromol Chem Phys 202: 1672.
17. Nakano S, Isono T, Furutani M, Senzaki T, Suzuki M (1994) Changes in specific surface area of silk by treatment with low temperature oxygen plasma, Sen'iGakkaishi 50: 136-141.
18. Yu I, Mochizuki T, Watanabe M, Utada M (2002) Plasma treatment of silk fabrics for better dyeability. Journal of Photopolymer Science and Technology 15(2): 299-306.