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Use of sericulture by-product i.e. *Sericin* in ecofriendly treatment of cotton fabric

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Abstract

Sericulture in India provides employment to rural youth and women engaged in its various activities. During raw silk processing, a compound known as sericin is released into the environment which causes water pollution if not recovered from discharged water. A study was carried out to utilize the waste product i.e. sericin for the treatment of cotton fabric and see its effect on the properties of fabric. Treatment was given using cross linking agent and catalyst, fabric was later dyed with natural dye manjistha. The treated fabric was tested for crease recovery, wettability, air permeability and UV protection properties. The results revealed that application of silk protein enhances properties of cotton fabric.

Keywords: eco-friendly treatment, functional properties, physical properties, sericin, sericulture

Introduction

Silk protein constitutes two types of proteins i.e. fibroin and sericin. Fibroin forms the main filamentous structure whereas sericin bounds the twin filaments in its sticky layers. During degumming of silk, sericin is largely discharged into the water streams around the sericulture industry which degrades the water sources. Recently sericin has attracted special attention among researchers because of its diverse physiological properties, such as antioxidant, ultraviolet (UV) protection, moisture absorption and antibacterial properties. Sericin is a macromolecular globular protein found in silkworms that performs the function of gluing the silk fibers together. It contains many hydrophilic amino acids, which give it high hydrophilicity and sensitivity to chemical modification. Sericin can be cross linked, copolymerized, and blended with other macromolecular materials to produce materials with improved properties. (Zhang, 2002)

At present, sericin is mostly discarded in silk-processing wastewater. If sericin can be used as a finishing agent for textiles, it will represent a natural value-added finishing agent developed from waste. In addition to that, the recovery of sericin reduces the pollution load in wastewater. Sericin is a biopolymer of molecular weight ranges between 10–300 kDa. About 50000 ton of sericin is cosmetics and food. (Sarovat et. al., 2003, Zhang 2002). Cotton is the most important natural fiber and is preferably used by consumers. Sericin has been found to improve moisture regain and water retention, and reduce electrical resistivity of cotton fibers by using dimethyloldihydroxyethylene urea (DMDHEU) as crosslinking agents (Kongdee *et al*., 2005). Advantage of the specific property of sericin can also be taken by finishing cotton with it to improve wear property of fabric.

Today, there is a growing interest in utilizing waste products for application in textile industry as an ecofriendly approach. If sericin can be utilized in treatment of textiles from the degumming waste liquor, it will represent a significant source of profit for silk cultivators, not to mention the beneficial effect of waste reduction for pollution prevention. It was therefore thought to be of interest to investigate the roles and effects of sericin fraction of silk containing amino acid, when used on cotton for the improvement of its properties.

Materials and Method

Plain-weave cotton fabric having specifications of fabric count (threads/inch) 99 in warp way, 55 in weft way, fabric weight 121.78 $gsq.m^{-1}$ and thickness 0.32 mm was procured from local market. **S**ilk sericin powder was procured from Maharashtra and other chemicals of laboratory reagent grade were used in the study.

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The cotton fabric was desized and scoured which was used for further treatment. Sericin treatment was given on scoured cotton fabric using optimized variables i.e. 0.50% sericin, 4 % crosslinking agent (citric acid), 1% catalyst (sodium hypophosphite) on the basis of weight of fabric at 50°C of treatment temperature for 45 minutes. Sericin treated fabric was dried at 70°C for 4 minutes and cured at 160°C for 2 minutes. Sericin treated fabric was dyed using manjistha using its standardized procedure (Teli et al., 2004).The wrinkle recovery was determined on the Shirley crease recovery tester using BS3086:1972 test method. Samples were cut both in warp and weft directions from the fabrics with a template measuring 0.5×2.5 cm and tested after conditioning. Prolific Air Permeability Tester was used to find the air permeability of the fabrics using BS3321: 1960 test method at 10 mm water column. A sample size of 2x2 inches was taken and placed on the opening of the test cylinder under the clamping place. AATCC Test Method 79 for testing the absorbency of textiles was used to test the propensity of the fabrics to take up water. Ultraviolet Protection Factor (UPF) of untreated and treated dyed fabrics was determined using SDL UV penetration and protection measurement system (Compsec M 350 UV- Visible Spectrometer), according to test method UVR TRANSMISSION AATCC-183:2004. The data were tabulated and appropriate statistical tools and tests were applied to draw meaningful inferences.

Results and Discussion

Table 1 narrates the crease recovery of the untreated and sericin treated dyed samples. In general the warp-way recovery was found to be higher than weft-way and the cloth crease recovery was the resultant of warp and weft recovery angle. The warp recovery was slightly higher for treated dyed fabric (104.2 ±0.58 degree) compared to untreated sample dyed with manjistha (93.8 ±0.58 degree). There was 9.7 % increase in the crease recovery angle of treated dyed fabric i.e. 92.9 degree to 102.5 degree for untreated dyed fabric and treated dyed fabric respectively. Increased crease recovery might be due to the use of cross linking agents, which can covalently crosslink with the adjacent cellulose chains within cotton fibers.

Table -1. PropertIes of treated and untreated dyed fabrics

Properties		**Untreated dyed fabric**			**Treated dyed Fabric**			**Percent change**
		Mean ±S.E.	**C.V.**	**Mean**	**Mean ±S.E.**	**C.V.**	**Mean**	
Crease recovery degree	Warp	93.8 ±0.58	1.38	92.90	104.2±0.58	1.24	102.50	+9.70
	Weft	92 ±0.70	1.71		100.8±0.66	1.46		
Wettability (Sec)	-	5.65± 0.05	1.56	-	2.88±0.02	1.34	-	+49.02
Air permeability (cc/sec/cm^2)	-	24.62±.05	-	-	22.07±0.07	-	-	-10.35

The new cross linking bonds formed in the treatment process are stronger than the former hydrogen bonds. The results are supported by the findings of Xing et al. (2011) that the wrinkle recovery angle increased from 163 to 195° and wet wrinkle recovery angle increased from 135 to 195 degree. Treated sample showed a dramatic improvement in wrinkle recovery angle (warp and weft), especially in the wet state. There were hydroxyl groups on the surface of cellulose, hence easy to form hydrogen bond. When samples were wrinkled, cellulose molecules chains slipped, which was the reason that the wrinkle recovery angle of cellulose fabric was low. Hydroxyl groups of the fabric treated with polycarboxylic acid cross-linked with the carboxyl of citric acid and form reticulation structure. Therefore the number of hydroxyl groups to form hydrogen bond decreased which restricted the relative slippage among the cellulose molecules. Consequently, the wrinkle recovery angles increased.The wetting property of sericin pretreated dyed fabric increased 49.02 % as compared to untreated dyed fabric (Table 1). It may due to the reason stated by Kongdee et al. (2005) that sericin has been found to improve moisture regain, water retention and reduce electrical resistivity of cotton fibers. The results of the study are in line with the findings of Kurioka et al. (2011) upon treatment with sericin (1.2%) solution containing citric acid (9%) as a cross-linking agent, the hydrophilic and thermal properties of cotton fabrics improved. The treated fabrics absorbed more water than the non-treated fabrics and the water diffusion time decreased. The air permeability of treated sample decreased after the application of the sericin in comparison to the untreated dyed sample from 24.62 to $22.07 cc/sec/cm^2$ with 11.55 % decrease (Table 1). The reason of decreasing air permeability might be higher fabric thickness and more number of fibers per unit area resisting air flow which led to lower air permeability. Another possible reason is that cotton fibers are hydrophilic, hence absorbed a greater amount of sericin. The absorbed content within fibers could block the air spaces between fibers or yarns, resulting in decrease in air permeability. The results are in agreement to the findings of Ali et.al. (2011), they reported significant decrease in the air permeability of the chitosan treated fabric samples as compared to untreated ones. Sericin treated, manjistha dyed and sericin treated manjistha dyed fabrics were tested for UV protection property. The data in the Table 2 shows that Ultraviolet Protection Factor (UPF) of scoured cotton is good which increased with sericin treatment from 14.25 to 22.39 which is also falling in good UV protection class. It was observed that UPF value of fabric increased upto very good UV protection class on dyeing with manjistha. The increase in UPF value after dyeing is credited to the ability of dyes to selectively absorb visible light. Most dyes absorb light in the region between 400 and 700 nm and the absorption band extends to UV radiation spectrum i.e. 280 nm-400 nm for all dyes. Fabrics, especially when dyed, can absorb significant amount of UV radiation and have protective effect. UV protection capability turned from good to excellent when sericin treated fabric was dyed with manjistha, which can be attributed to the inherent UV resistant property of sericin and darker shade of treated dyed fabric. Pailthorpe (1998) observed that generally for the same fabric construction and dyestuff, the darker the shade, the greater is the fabric UPF. Gulrajani et al. (2008) and Xu et al. (2011) found improvement in the anti-ultraviolet property of sericin-treated fabrics.

Table -2. Ultraviolet Protection property of treated and untreated dyed fabrics

Fabric	**UV Protection Property**		
	UPF	**UPF rating**	**UV Protection class**
Scoured cotton	14.25	15	Good
Sericin treated cotton	22.39	25	Good
Untreated dyed fabric	32.6	30	Very good
Treated dyed fabric	48.4	50	Excellent
15-24: Good protection, 25-39: Very good protection and 40-50, 50+: Excellent protection			

Conclusion

With its unique properties, sericin can be used in the modification of fabrics. The treated cotton fabric exhibited increase in crease recovery and wettability with decrease in air permeability. The results of the research has important role in environment protection, sericin application, adding value to the textiles and it will have a large spreading foreground of industrialization and can bring high economic and social benefits.

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