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Improvement in physical properties of khadi cotton fabric through pretreatment with swelling agent ethylenediamine

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Abstract
Cotton is a basic necessity of every one's life and it plays a very vital role in the Indian economy. It is generally termed as a major cash crop of India. It sustains the Indian cotton textile industry, which constitutes the single largest segment of organized industries in the country. It provides gainful employment to millions of people from cotton background engaged in harvesting, plucking, and marketing, ginning and pressing of cotton. But, Khadi cotton has some shortcomings, like higher maintenance costs for washing and ironing. It is also less preferred due to rough texture and low drapability. Swelling agents, primarily strong electrolytic solvents have been employed to pretreat cellulose. Due to loosening of crystalline region of cellulose by swelling agents, the absorbency of the fabric towards water and dyes is increased. Therefore, in the present study attempts has been made to optimize conditions for the use of Ethylenediamine and evaluate the changes in physical properties like weight loss, moisture absorption, tensile strength loss, bending length, crease recovery angle, thickness and water absorption. In case of Ethylenediamine, 80% w/v, 60 minutes and 70 °C were selected as optimum concentration, treatment time and temperature, respectively. Swelling agents are important tools in the textile industry for cellulosic fibres. They provide an economical way to treat cotton fabrics. Thus, it was concluded from the present study that the positive effects obtained with Ethylenediamine swelling agent i.e., moisture absorption, bending length and crease recovery angle were maximized by using the optimized process variables.

Keywords: Khadi cotton, ethylenediamine, swelling agents and physical properties

1. Introduction
Handloom sectors have a crucial role to play in supporting and strengthening the rural economy of our country. This sector is the second highest employer in the country after agriculture. In addition to the aristocracy as well as elegance of the products, it is doubtless to say that the aesthetic appeals of handloom fabrics have developed a lot due to innovative designs and ornamentations, which attract the customers all around the world. Handloom product users sometimes experienced that these costly fabrics have faded within a few days either after domestic laundering or exposure to sunlight. Thus spoiling of designs and colour makes the customer restrict from using handloom products.
Handloom sector is known for its heritage and the tradition of excellent craftsmanship. But, Khadi cotton has some shortcomings, like higher maintenance costs for washing and ironing. It is also less preferred due to rough texture and low drapability. The annual reports of khadi and handloom sector presents a sorrowful picture of piling up of stocks in godowns (Sarvani and Balakrishnaiah, 2007) [2]. Swelling agents, primarily strong electrolytic solvents have been employed to pretreat cellulose. Two types of swelling agents are known one is intercrystalline and the other intracrystalline. Intracrystalline swelling agents are effective in loosening the crystalline region of cellulose. The action of swelling agents inherits the outer skin on cotton fibers and causes it to split and form collars; the inner cellulose layers swell rapidly the collars (Fan *et al.*, 1987) [1]. Due to loosening of crystalline region of cellulose by swelling agents, the absorbency of the fabric towards water and dyes is increased. Therefore, in the present study an attempt has been made to optimize conditions for the use of Ethylenediamine and evaluate the changes in physical properties like weight loss, moisture absorption, tensile strength loss, bending length, crease recovery angle, thickness and water absorption.

2. Materials and Methods

2.2 Fabric

Pure white khadi cotton fabric was procured from "Gandhi Ashram" of local market in Pantnagar (Uttarakhand).

3. Test Methods

3.1 Weight loss

Weight of the fabric samples before and after the treatment was calculated and percentage weight loss was calculated using the following formula:

$$\text{Weight loss (\%)} = \frac{(W1 - W2) \times 100}{W1}$$

Where, W1 = Weight of the fabric before enzyme treatment
W2 = Weight of the fabric after enzyme treatment

3.2 Moisture absorption

The moisture content of cotton fabric was determined using IS: 199-1973 test method. The percentage of moisture content in the test specimen was calculated by the following formula:

$$\text{Moisture, percent by mass} = \frac{(a - b) \times 100}{a}$$

Where,
a = original mass, in g, of the test specimen; and
b = oven dry mass in g, of the test specimen

3.3 Strength loss

Raveled strip test method was used. The tensile strength was measured on the KMI electronic tensile strength tester. Strength loss (%) was calculated from the formula:

$$\text{Strength loss (\%)} = \frac{S_1 - S_2}{S_1} \times 100$$

Where,
S_1 = breaking strength before treatment
S_2 = breaking strength after treatment

3.4 Bending length

The bending length of the cotton fabric was determined on Eureka Cloth stiffness tester using IS: 6490-1971 test method. Samples of size 25 x 200 mm were cut from both warp way and weft way direction with the help of a template from different position of the sample under test.

3.5 Crease recovery angle

The crease recovery angle of the cotton fabric was determined by IS: 4681-1968 test method. Warp way and weft way test specimens of 15 x 40 mm size were tested.

4. Results and Discussion

4.1 Ethylenediamine

The mean, standard deviation and F-value for each of the physical tests performed at different concentration, treatment time and temperature of ethylenediamine on khadi cotton fabric are given in table 1, 2 and 3.

4.2 Concentration

The khadi cotton fabric samples were treated with different concentrations of ethylenediamine (40, 50, 60, 70 and 80% w/v). It is evident from the table 1 that the weight loss and moisture content increased from 0.46 to 1.13% and 0.39 to 1.59% respectively on increasing concentration of Ethylenediamine from 40 to 80% w/v. In case of bending length reduction in both warp and weft direction was observed by increase in concentration. The bending length in warp direction was 1.32 cm at concentration 40% w/v, while it was reduced to 1.05 cm at concentration 80% w/v. In case of weft direction, the bending length was 1.24 cm at concentration 40% w/v and reduced to 0.99 cm at concentration 80% w/v. Minimum percentage strength loss in both warp (0.32-0.72%) and weft (0.44-0.80%) direction was observed with an increase in concentration. A significant increase in crease recovery angle in both warp (73-107°) and weft (78-115°) direction was found on increasing the concentration. Table 1 depicts that the decrease in thickness occurred from 0.51 to 0.42 mm by increasing concentration from 40 to 80% w/v. The maximum percentage of water absorption (35.37%) was observed when the concentration was increased to 80% w/v.

The F-values, computed from the one-way analysis of variance at 1% level of significance as shown in table 1 was found to be statistically significant. Comparison of means indicated that significant difference in all the physical parameters occurred at all the concentration levels, except in case of moisture content where insignificant difference was found up to 60% w/v concentration, but beyond 60%w/v showed significant increase in moisture content. Thus, considering the above physical parameters studied 80% w/v concentration was selected as optimum for ethylenediamine.

Table 1: Mean value, standard deviation and F- value of physical tests at different concentration of Ethylenediamine swelling agent on khadi cotton fabric

Physical parameters	Concentrations										F value
	40% (w/v)		50% (w/v)		60% (w/v)		70% (w/v)		80% (w/v) *		
	M	SD	M	SD	M	SD	M	SD	M	SD	
Weight loss (%)	0.46	0.29	0.66	0.23	0.86	0.18	1.06	0.14	1.13	0.29	6.70**
Moisture content (%)	0.39	0.23	0.72	0.24	0.92	0.47	1.26	0.23	1.59	0.23	24.22**
Bending length warp (cm)	1.32	0.05	1.21	0.08	1.16	0.04	1.11	0.08	1.05	0.07	43.95**
Bending length weft (cm)	1.24	0.04	1.18	0.05	1.12	0.05	1.07	0.05	0.99	0.08	51.93**
Strength loss warp (%)	0.32	0.01	0.37	0.008	0.46	0.008	0.55	0.008	0.72	0.004	1641.82**
Strength loss weft (%)	0.44	0.008	0.49	0.004	0.64	0.007	0.71	0.01	0.80	0.004	1971.34**
Crease recovery angle warp (°)	73	2.79	79	2.56	84	2.12	93	1.96	107	1.03	169.12**
Crease recovery angle weft (°)	78	2.28	83	2.19	92	2.07	97	1.83	115	1.30	174.65**
Thickness (mm)	0.51	0.01	0.48	0.007	0.47	0.004	0.45	0.005	0.42	0.006	200.84**
Water absorption (%)	15.37	2.90	22.04	1.62	25.13	1.52	29.03	1.50	35.37	1.40	72.56**

* Selected concentration, ** 1% level of significance

4.3 Treatment time

The khadi cotton fabric was given treatment with optimized concentration for different durations i.e. 20, 30, 40, 50 and 60 minutes. The data in the table 2 clearly indicates that at 20 minutes, slight weight loss (0.26%) and moisture content (0.39%) was found, but on increasing treatment time at 60 minutes, 1.59% weight loss and 2.26% moisture content was observed. In case of bending length decrease in both warp (1.36-0.95 cm) and weft (1.29-0.92 cm) direction was recorded with an increase in treatment time. A slight percentage strength loss in both warp (0.39-0.97%) and weft (0.43-1.04%) direction was obtained by increasing treatment time ranging from 20-60 minutes. The significant increase in crease recovery angle in both warp and weft direction was obtained. At 20 minutes of treatment time, 68° and 78° crease recovery angle was found in warp and weft direction, respectively whereas the crease recovery angle was increased to 124° and 130° in both warp and weft direction, respectively at 60 minutes of treatment time. It was seen from the table 2 that the thickness decreased from 0.51 to 0.38 mm with an increase in treatment time. The significant increase in water absorption from 16.77 to 42.86% was recorded by increasing treatment time from 20-60 minutes.

The F-value [Table 2], as computed from the one-way analysis of variance at 1% level of significance was found to be statistically significant. It was also found by comparison of means that significant differences in the mean values of the physical parameters occurred at five different treatment times. On the basis of above physical parameters studied in relation to different levels of treatment time, 60 minutes of treatment time was considered as optimum for Ethylenediamine.

Table 2: Mean value, standard deviation and F- value of physical tests at different treatment time of Ethylenediamine swelling agent on khadi cotton fabric

Physical parameters	Treatment time										F Value
	20 min		30 min		40 min		50 min		60 min*		
	M	SD	M	SD	M	SD	M	SD	M	SD	
Weight loss (%)	0.26	0.14	0.66	0.23	1.13	0.50	1.39	0.14	1.59	0.14	19.65**
Moisture content (%)	0.39	0	0.79	0.24	1.52	0.23	1.86	0.24	2.26	0.23	100.72**
Bending length warp (cm)	1.36	0.04	1.26	0.08	1.04	0.08	0.99	0.08	0.95	0.07	115.55**
Bending length weft (cm)	1.29	0.04	1.18	0.05	0.98	0.05	0.96	0.04	0.92	0.05	198.29**
Strength loss warp (%)	0.39	0.007	0.46	0.008	0.73	0.004	0.83	0.004	0.97	0.004	8116.38**
Strength loss weft (%)	0.43	0.007	0.55	0.008	0.82	0.005	0.94	0.005	1.04	0.004	8014.82**
Crease recovery angle warp (°)	68	2.94	87	2.83	107	1.94	115	1.34	124	1.14	209.97**
Crease recovery angle weft (°)	78	2.73	96	2.12	118	1.92	122	1.62	130	0.54	616.65**
Thickness (mm)	0.51	0.006	0.47	0.006	0.43	0.01	0.39	0.006	0.38	0.005	519.81**
Water absorption (%)	16.77	2.94	23.50	1.64	35.71	1.67	38.13	1.36	42.86	0.53	180.49**

* Selected treatment time, ** 1% level of significance

4.4 Temperature

Ethylenediamine treatment was given on cotton fabric with optimized concentration and treatment time at temperatures viz., 30, 40, 50, 60 and 70 °C. It is clear from the table 3 that the weight loss and moisture content was increased from 0.59 to 2.06% and 1.19 to 3.46%, respectively on raising temperature from 30 to 70 °C. Similarly in case of bending length, reduction in both warp (1.37-0.91 cm) and weft (1.28-0.87 cm) direction was observed by increasing temperature. A slight percentage strength loss in both warp (0.73-1.17%) and weft (0.87-1.26%) direction have been reported. The significant increase in crease recovery angle in both warp (79-130°) and weft (87-137°) direction was recorded with an increase in temperature. It was observed from the table 3 that the thickness reduced from 0.50-0.35 mm on increasing temperature. The water absorption was 20.90, 32.62, 44.57, 48.90 and 55.18% at 30, 40, 50, 60 and 70 °C of temperature, respectively.

The F-value, obtained from the one-way analysis of variance as depicted in table 3 was found to be statistically significant at 1% level of significance. It was also concluded from the comparison of means that there was significant difference in the mean values of the physical parameters due to five different temperatures, except in case of weight loss where insignificant difference up to 40 °C was found. However, increase in temperature beyond 40 °C showed significant weight loss. Considering the above studied physical parameters the optimum temperature was selected as 70 °C.

Table 3: Mean value, standard deviation and F- value of physical tests at different temperature of Ethylenediamine swelling agent on khadi cotton fabric

Physical parameters	Temperature										F value
	30 °C		40 °C		50 °C		60 °C		70 °C*		
	M	SD	M	SD	M	SD	M	SD	M	SD	
Weight loss (%)	0.59	0.36	0.86	0.18	1.66	0.23	1.86	0.18	2.06	0.14	36.74**
Moisture content (%)	1.19	0.23	1.52	0	2.19	0.23	2.86	0.24	3.46	0	78.57**
Bending length warp (cm)	1.37	0.05	1.18	0.05	0.96	0.04	0.92	0.05	0.88	0.04	312.09**
Bending length weft (cm)	1.28	0.05	1.13	0.05	0.93	0.05	0.89	0.04	0.87	0.05	225.41**
Strength loss warp (%)	0.73	0.008	0.84	0.008	0.98	0.005	1.07	0.008	1.17	0.004	2706.37**
Strength loss weft (%)	0.87	0.01	0.94	0.007	1.06	0.005	1.13	0.005	1.26	0.004	1881.28**
Crease recovery angle warp (°)	79	1.09	93	0.89	124	0.54	127	0.54	130	0.54	4581.63**
Crease recovery angle weft (°)	87	2.23	116	2.19	130	0.54	1.33	0.44	137	0.44	995.47**
Thickness (mm)	0.50	0.004	0.46	0.009	0.38	0.008	0.37	0.004	0.35	0.004	923.94**
Water absorption (%)	20.90	2.03	32.62	1.96	44.57	1.83	48.90	1.47	55.18	1.44	266.71**

* Selected temperature, ** 1% level of significance

5. Conclusion

The pretreatment with swelling agents with optimized conditions enhances the physical properties as well as colour strength and colour fastness properties. Thus, some of the shortcomings of khadi cotton like rough texture, less dye ability and poor colour fastness can be minimized by chemical processing by using swelling agents in optimum conditions and it can be recommended for handloom sectors as these sectors supports and strengthen the rural economy of our country.

6. References

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