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Surface Modification of Polyester Fabrics Using Sugarcane Bagasse

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Abstract: ***Polymer and textiles materials have a huge number of advantages and attractiveness based on their end use application. However, despite these advantageous, polymers have limitations,the chemical composition of polymeric materials especially surface properties like hydrophilicity, roughness, crystallinity, conductivity, lubricity, and cross-linking are required for successful application of polymers in such wide fields such as technical uses and apparel uses. In this work, it studied the effect of surface treated polyester fabric by applying sugarcane bagasse powder (SCBP) or Micro cellulose particle. theinfluence of some major parameters which govern the efficiency of the processsuch as solution pH, bagasse concentration, curing temperature, and curing timeon the treatment process were investigated. the effect of this treatment on fabric moisture wettability of polyester varying the percentage of coating and amount of concentration was studied. The results found were a proof to show sugarcane bagasse can be used for surface modification of polyester fabric to enhance the moisture management. the tensile strength decreased by an average of 10.4% in the warp direction and 12.6% in the weft direction from the untreated polyester fabric.The results of this investigation clearly suggest that bagasse, alow-cost agricultural waste abundant, can be used in the surface modification of polyester fabric.***

Keywords: Bagasse, Surface Modification, Polyester, Water Absorbency, Wicking Performance

1. Introduction

Textiles polymer have a huge number of advantages and attractiveness as a material. However, despite these advantageous, polymers have limitations. In general, there are different surface properties which related to the chemical composition and others properties like hydrophilicity, conductivity, surface roughness, crystallinity, and lubricity are required for successful application of polymers in the wide fields composites, membrane filtration,adhesion, coatings, friction and wear, microelectronic devices, thin-film technology and biomaterials. In fact, polymeric materials that are chemically stable,mechanically strong, and easy to process and manufacture. those polymers having active surfaces usually do not possess excellent mechanical properties which are critical for their successful end use applications. Surface modification of the polymeric fibers is difficult without Affecting the bulk properties has been a classical research topic for many years and is still wide studies as new applications of polymeric materials emerge, especially in the fields of biotechnology, bioengineering, and most recently in nanotechnology. Modification is used to designate a deliberate change in composition or structure leading to an improvement in different type of fiber properties. The challenge is, however, that there does not exist an ideal modification that eliminates all the negative properties and preserves all the positive properties of the fibres. This is why there are a great number of different single-purpose modifications. (Militky, 1991) In spite of the great number of existing modification methods no consistent classification is available as yet. Some authors divide the methods into two groups depending on whether they involve changes in fiber composition (chemical modification) or changes in fiber structure (physical modification). in the plastic industry,surface modification of polymers has become an important research area because polymers are inert materials and usually have a low surface energy, they often do not possess the surface properties needed to meet the demands of various applications. Surface treatment is takes place in advances weather chemical or physical properties of polymer surfaces without affecting bulk properties. Technologies such as surface modifications, which convert inexpensive materials into valuable finished goods, will become even more important in the future as material cost becomes a significant factor in determining the success of an industry (A. Bendak).

2. Materials and Methods

2.1. Bagasse Collection andDevelopment

The low-cost adsorbent used in this study is non-modified sugarcane bagasse collected from Sugar industries or from edible sugar cane. The sugarcane bagasse was washed and boiled several times to remove dirt, color and adherence of chemicals. The remaining solid material was dried near to 100°C for some hours in a convection oven dryer. The dried sugarcane bagasse was crushed into fine particles and kept in desiccators for further experiments.

2.2 Experimental Procedures

Fabric samples of 75 mm X 75 mm, fabric type- Twill 2x1 with GSM of 82 gram with number of warp threads per centimeter- 28 TPC and Number of picks per centimeter- 14 PPC polyester were used and pre-treated using sodium carbonate (3%), detergent and emulsifier (0.5%) at boil for one hour with material-to -liquor ration 1:20 to get rid of the added impurities and washed with distilled water and dried in dryer before applying the alkali treatment. After pre-treating the fabrics alkali treatment preceded to alter the surface of the polyester fabric to introduce active functional groups like carboxylic (COOH) groups and hydroxyl (OH) groups. After alkali treatment, the fabric was rinsed, neutralized with acetic acid followed by soaping with hot water to get rid-off any residues of alkali and then dried at room temperature. The fabric then padded with sugarcane bagasse in the presence of poly acrylic binder and dried and cured at different temperatures and time for optimization of the bagasse and the acrylic binder. Finally, both the treated and untreated fabrics were tested to meet the required performance.

Table 1: Different parameters combinations used for polyester surface modification.

Sample number	Bagasse Conc. (%)	Curing Temp. (^{O}C)	Time (min)	Binder (g/l)
1	20	120	2	5
2	30	140	4	10
3	50	160	6	15

2.3 Alkali Treatment of Polyester fabric

PET is chemically inert, has no functional groups and no affinity for the sugarcane lignocellulose bagasse, it is rich in hydroxyl (OH) functional groups. As a result, it is treated with 4% sodium hydroxide solution for 45 minutes with material to liquor ratio of 1:20 at a temperature of 60°C. An average weight loss of 7.55% has been recorded from this experiment(Fig. 1)

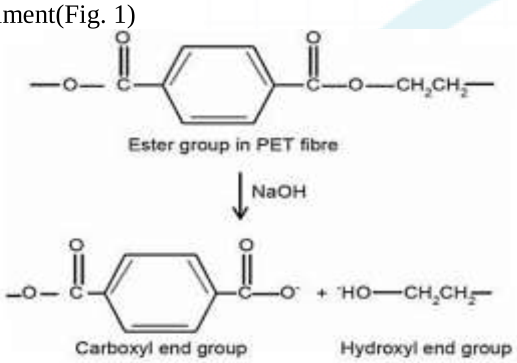

Figure 1: Alkali Hydrolysis of PET

2.4 Application of sugarcane Bagasse

The sugarcane bagasse finely grinded with a size of 110 micrometer powder form and applied into the alkali treated polyester fabric using laboratory padding machine in the presence of the poly-acrylic binder. The finished ratio was taken from the literature (Magdi el messiry) with 20%, 30% and 50% followed by optimization of the bagasse with the poly-acrylic binder of concentrations 5g/l, 10g/l and 15g/l. curing temperature and curing time has also been optimized. For optimization a four factor three level Taguchi design of experiment has been used. A total of nine experiments were carried out as per the design experiment software based on the above table parameters (Table 2).

Table 2: Four Factorial Three Level Taguchi Design of Experiment

Number of Trials	Bagasse Conc. (%)	Curing Temp.(^{O}C)	Curing Time (Min.)	Poly acrylic binder (g/l)	Sample code
1	20	120	2	5	S_1
2	20	140	4	10	S_2
3	20	160	6	15	S_3
4	30	120	4	15	S_4
5	30	140	6	5	S_5
6	30	160	2	10	S_6
7	50	120	6	10	S_7
8	50	140	2	15	S_8
9	50	160	4	5	S_9

3. Results and Discussion

Parameters which have a direct relation with surface modification of polyester fabric with alkali solution and sugarcane bagasse has been measured. Absorbency, tensile strength, tear strength, fabric air permeability, moisture regain, wicking test and FTIR test of all the samples are measured using a standard test method.

3.1 Effect of Sugarcane Bagasse on Fabric Water Absorbency

Polyester fabric water absorbency is determined by its polymer structure and morphological structure. When the surface of the fabric is altered its absorbency will increase but with decreasing strength because the polymer chains are broken because of the sodium hydroxide treatment. The following indicates (Table 3) the absorbency behavior of different polyester fabric samples with different concentration of caustic soda. A pre-treated polyester fabric sample has been used as a control and named control C_1. A standard test method AATCC/ASTM Test method Ts-018 has been used to carry out the test. The test technique is planned to measure the water absorbency of the polyester fabric by measuring the time and it takes a drop of water placed on the fabric surface to be completely absorbed into the fabric.

Table 3: Absorbency test (drop test)

Samples	Time (Min: Sec. Micro sec) at different Drop places					Average
	1	2	3	4	5	
C_1	00:46.48	00:52.08	01:04.31	00:35.84	01:10.19	00:53.78
S_1	00:24.98	00:28.18	00:25.35	00:26.08	00:25.34	00:25.99
S_2	00:20.99	00:16.81	00:19.03	00:21.66	00:19.93	00:19.68
S_3	00:14.12	00:38.16	00:30.33	00:14.96	00:35.41	00:26.60
S_4	00:22.56	00:28.26	00:20.78	00:24.66	00:22.29	00:23.71
S_5	00:26.85	00:24.32	00:26.54	00:28.14	00:22.15	00:25.60
S_6	00:22.12	00:20.97	00:23.45	00:18.26	00:22.31	00:21.42
S_7	00:15.23	00:12.37	00:12.69	00:14.81	00:14.22	00:13.86
S_8	00:21.74	00:23.85	00:23.96	00:24.12	00:23.84	00:23.50
S_9	00:17.54	00:17.95	00:15.61	00:11.24	00:12.68	00:15.00

Modification of fiber surface composition in textiles can change the entire surface wetting behavior. The surface hydrophilicity of untreated, alkali treated and alkali& sugarcane bagasse treated samples was evaluated by measuring water drop absorption time.Alkali & sugarcane bagasse treated polyester fabric samples showed remarkable increase of hydrophilicity. The graph (Fig 2) indicates the effect of sugarcane bagasse concentration in the absorbency of the polyester fabric. When the concentration of the bagasse increases the time taken by the polyester fabric to absorb water will be reduced.

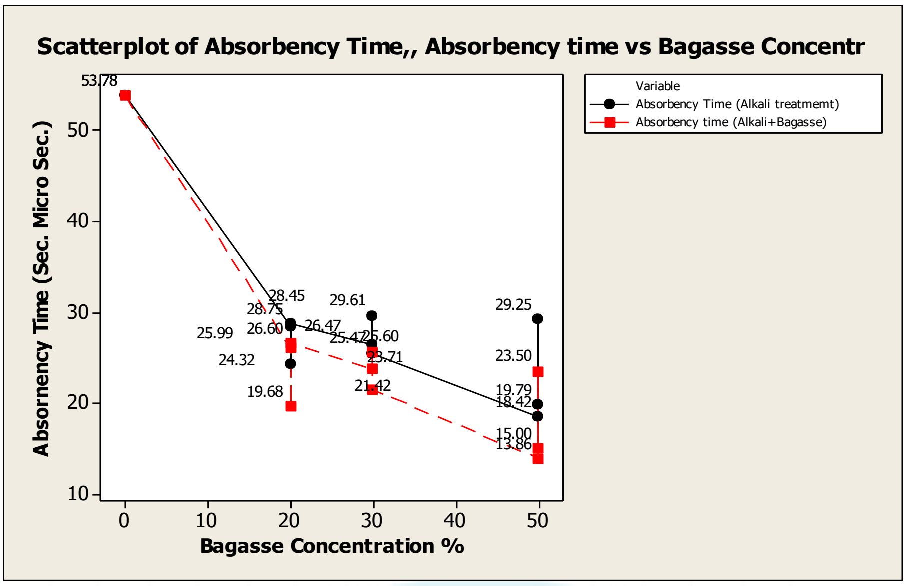

Figure 2: Effect of Sugarcane bagasse on absorbency

Table 4: Drop Test Comparison for differently treated polyester fabric

Samples	Bagasse Conc. %	Absorbency Time Alkali + Bagasse (Min, Sec., Micro Sec)	Absorbency Time, Alkali treatment only (Min, Sec., Micro Sec)	% Increase in Absorbency
C_1	-	00:53.78	00:53.78	0
S_1	20	00:25.99	00:28.45	8.64
S_2	20	00:19.68	00:24.32	19.07
S_3	20	00:26.60	00:28.75	7.48
S_4	30	00:23.71	00:26.47	10.42
S_5	30	00:25.60	00:29.61	13.54
S_6	30	00:21.42	00:25.47	15.9
S_7	50	00:13.86	00:18.42	24.75
S_8	50	00:23.50	00:29.25	19.67
S_9	50	00:15.00	00:19.79	24.20

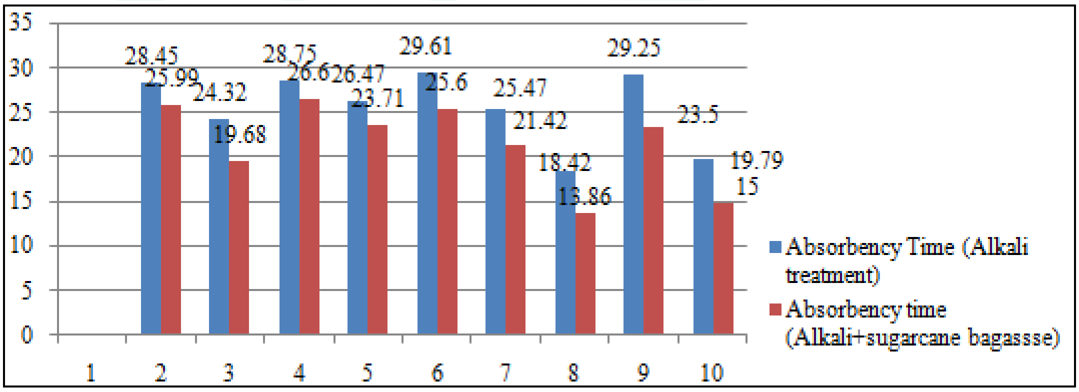

Figure 3: Absorbency Time for Alkali treated, alkali & Bagasse treated polyester Fabric

3.2 Effect of hydrolysis on weight loss of polyester fabric

Almost all the studies on alkaline hydrolysis of polyester indicate weight loss. However, the extent of weight loss varies depending on the hydrolytic conditions. In the present study the alkaline hydrolysis of polyester was carried out using 4% NaOH at a temperature of 60°C for one hour. It was observed that the alkaline treatment of PET fabrics leads to a loss in weight of the fabrics.

Table 5: Effect of alkali hydrolysis on weight loss

Sample code	Weight before alkali treatment (gram)	Weight after alkali treatment (gram)	%weight loss
S_1	3.36	3.12	7.14
S_2	3.44	3.26	5.23
S_3	4.92	4.56	7.27
S_4	2.65	2.37	10.5
S_5	2.20	1.98	10
S_6	2.18	2.01	7.79
S_7	2.26	2.11	6.63
S_8	2.22	2.06	7.21
S_9	3.40	3.19	6.18

3.3 Effect of Alkali treatment on Fabric Physical Property

3.3.1 Tensile strength

Tensile strength ISO 13934/1 specifies a procedure to determine the maximum force and elongation at maximum force of test specimens. the weight loss due to alkaline hydrolysis of polyester is bound to result in strength loss (table 6, 7). Even though there is a debate among the researchers, the acceptable limit of tensile strength loss is from 5-10% (Melkie Getnet).

Table 6: Tensile Strength (Warp direction)

Sample type	Percentage Weight Loss %	Force (N)	Elongation %	Time (Sec)
C_1	0	355	26.49	11.2
S_1	7.14	322	23.23	14.4
S_2	5.23	299	21.03	13.0
S_3	7.27	303	26.61	16.0
S_4	10.5	325	23.19	14.0
S_5	10	323	23.12	14.0
S_6	7.79	301	23.47	13.0
S_7	6.63	325	23.51	14.0
S_8	7.21	314	22.05	14.3
S_9	6.18	312	23.14	16.0

Table 7: Tensile strength (Weft direction)

Sample type	Percentage Weight Loss %	Force (N)	Elongation %	Time (Sec)
C_1	0	139	18.44	10.6
S_1	7.14	123	14.03	8.8
S_2	5.23	120	14.31	9.2
S_3	7.27	110	18.33	11.2
S_4	10.5	101	19.27	11.7
S_5	10	133	18.51	11.3
S_6	7.79	121	18.89	10.6
S_7	6.63	105	18.41	11.2
S_8	7.21	131	18.24	11.3
S_9	6.18	138	17.65	9.2

3.3.2 Tear Strength

In this methodtear strengthmeasurement coversall the force which helpsto propagate a single-rip tear starting from a cut in the polyester fabric and using a falling pendulum type apparatus. Both warp and weft directions of all the samples were tested (Table 8).

Table 8: Tear Strength (warp and weft directions)

Sample Type	Tear strength (Newton)	
	Warp Direction	Weft Direction
C_1	>63	>63
S_1	58.63	54.82
S_2	60.47	55.85
S_3	60.14	57.47
S_4	58.48	56.57
S_5	61.35	58.58
S_6	60.21	56.54
S_7	61.47	58.64
S_8	61.44	57.29
S_9	60.54	56.45

3.3.3 Effect of Sugarcane Bagasse on fabric wicking performance

Wicking of fabrics was measured in accordance with ISO 9073 after three washes. Based on ISO 9073 standard, the water transport height is determined by a vertical strip wicking test.

3.3.4 FT-IR analysis

In Fourier-transform infrared spectroscopy, the radiation is passed through polyester sample and Some of the radiation is absorbed by the sample and some of it is passed through (transmitted). The resulting radiationdenotes the molecular absorption and transmission of light and it creates molecular fingerprint of the sample.

Like a fingerprint no two unique molecular structures produce the same infrared spectrum. The FTIR spectra of untreated, NaOH treated and NaOH+Sugarcane bagasse treated fabrics are shown. The high peaks from around 1700cm-1 indicate the original signals, such as characteristics spectra of stretching vibration band of C=O at around 1730 cm-1 and C-O-C stretching vibration band at around 1097 to 1300 cm-1. All these peaks confirm the existence of ester linkages. During the treatment of Sodium hydroxide, treated polyestershows that reduction of strong peak to weak peak at around 1097-1700 cm-1 which shows the elimination of short chains in the ester linkage and also shows an additional peak at around 2359 cm-1.

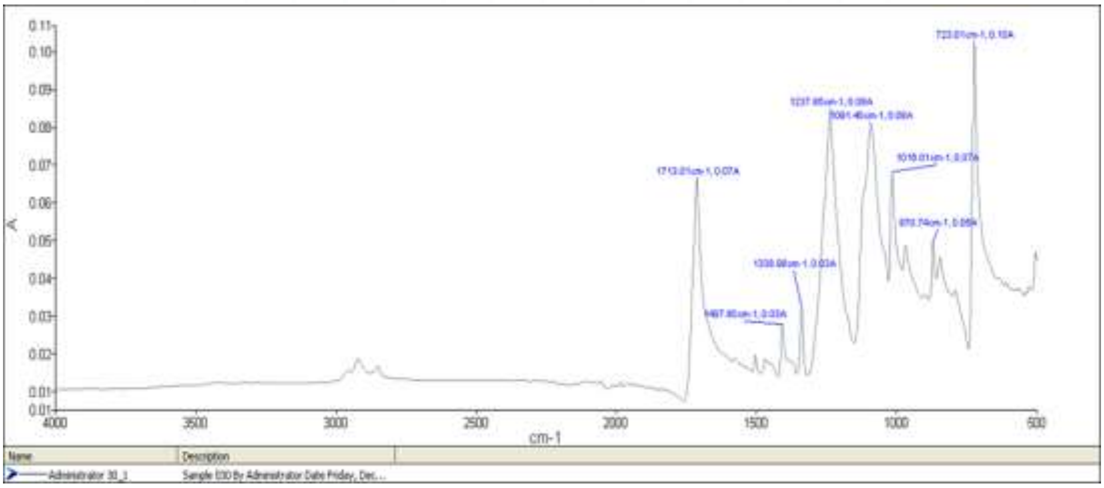

Figure 4: FTIR result of untreated polyester fabric

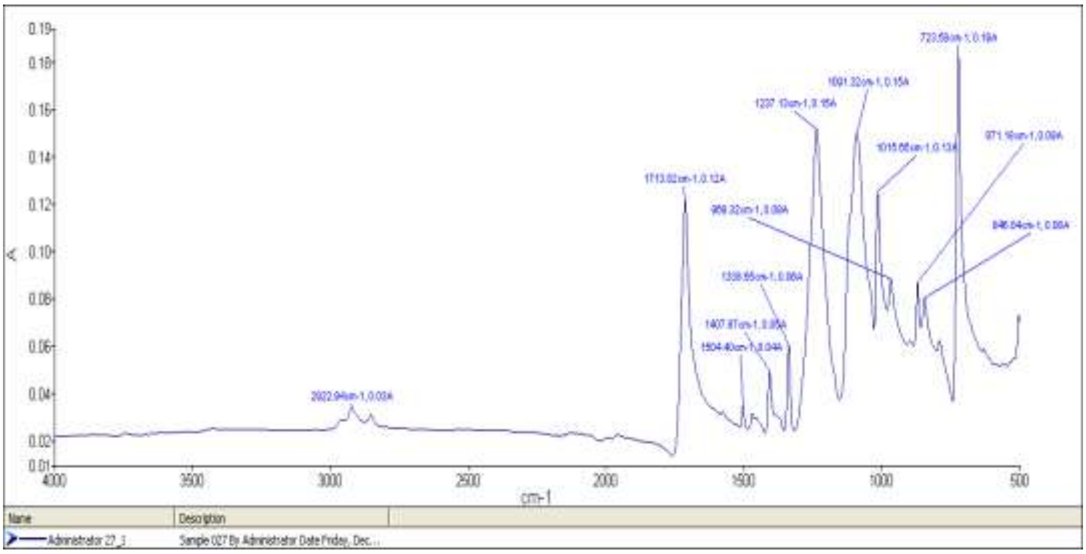

Figure 5: FTIR result of alkali treated polyester fabric

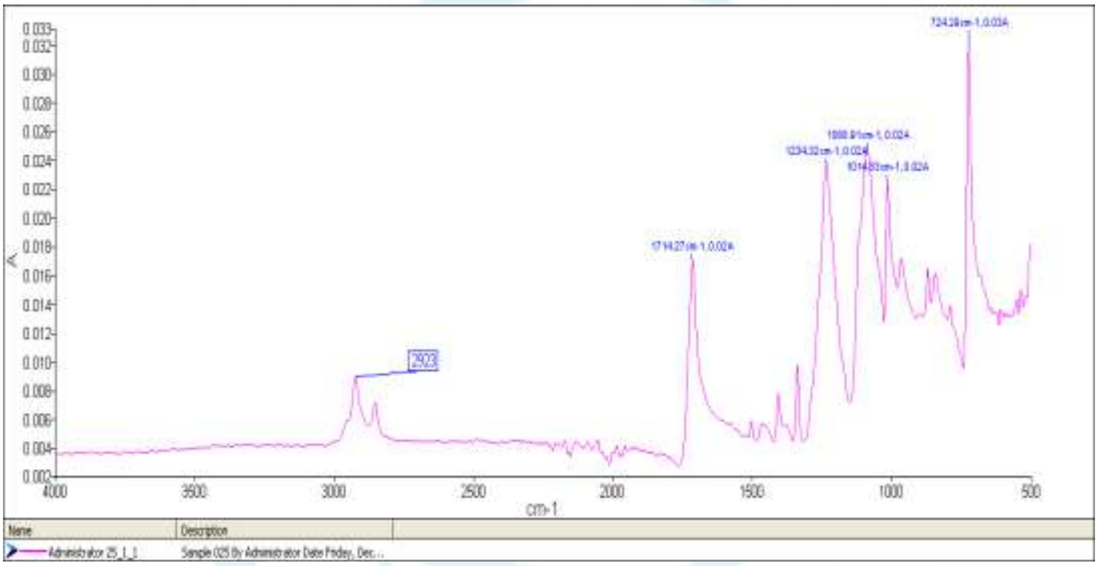

Figure 6: FTIR result of alkali + sugarcane bagasse treated polyester fabric

4. Conclusion

The results obtained within the frame of this work prove the concept for functional sugarcane bagasse micro-cellulose finishing as a surface modifying system with the aim to upgrade the moisture management of Polyester fabrics. The present study revealed that the surface modification of polyester fabric using sugarcane bagasse is successful as it improves its water absorbency.

5. Disclosure

KalidGashaw and Amare Worku Currently working as Lecturer in Textile Chemistry at Dire Dawa Institute of Technology (DDIT), Dire Dawa University, Dire Dawa, Ethiopia.

6. Conflicts of Interest

The authors declare that they have no conflicts of interest.

7. Acknowledgements

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