



Effect of Organic Alternative Scouring Agents on Structure of Cellulose/Polyester Blend Fabric

*¹BARAMBU, AU; ¹BORYO, DEA; ¹ADAMU, HM; ¹LAWAL, NM; ²MUSTAPHA, AB

¹Department of Chemistry, Abubakar Tafawa Balewa University Bauchi, Bauchi State, Nigeria

²Department of Chemistry, Gombe State University, Gombe State, Nigeria

*Corresponding Author Email: aubnabiu@gmail.com

ABSTRACT: This study investigated the effect of organic alternative scouring agents on structure of cotton/polyester blend fabric. A structural modification for a cellulose/polyester blend has been carried out using (COOH)₂, CH₃COOH and CH₃CH₂OH alternative scouring agents and NaOH was used as control. The scoured fabrics were then subjected to structural analysis using X-ray diffraction in order to expose the possible modifications on the pretreated fabrics. The samples showed possibilities of being highly competitive with the conventional agent. These inferences were drawn from the difference in the crystallinity index of scoured samples (10.10-60.03%), the crystallite size of scoured samples (6-9 nm) in the crystalline region (6-11 nm), in the amorphous region, inter-planar spacing of the scoured samples (0.340-0.350 nm) of the crystalline region and (0.360-0.390 nm) of the amorphous region of sample and number of crystalline planes of the scoured sample is (3-10) of the cellulose/polyester blend fabric samples via X-ray diffraction studies.

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Cellulose/polyester blend fabric is the combination of natural and synthetic fabrics so that the excellent quality and properties are emphasis and a poor quality and properties are minimize. Polyester and cellulose are probably the most famous and popular fabric blend. The blends of cellulose/polyester have developed into one of the most important textile fabric group. This is due to the unique properties of the fabric which has the potential to be similar in comfort performance to cellulose, but, owing to the presence of the polyester, be of a more stable price (possibly cheaper) than cellulose and possess excellent easy-care properties (Boryo, 2011; Gupta *et al.*, 1997).

Due to a high demand of higher quality of textile fabric therefore, there is a need to improve in the qualities of textile materials in order to meet up with the demand for textile products by the teeming world population (Boryo *et al.*, 2013; Hockenberger *et al.*, 2005; Macda *et al.*, 2004; Ajayi *et al.*, 1997). The idea of chemical modification of cellulose is to introduce functional groups in the cellulose backbone (Yunjie *et al.*, 2008). Structure modification of cellulose is usually achieved by substituting the protons in the hydroxyl groups of cellulose to a varying extent using various substituents. It was reported that a cellulose mono-ester with modified structural property was obtained from the x-ray diffraction obtained from reaction

between OH of cellulose and COOH of the fatty acid in the oil via esterification (Omizegba *et al.*, 2017).

This work investigated structural modification changes on cellulose/polyester blend fabrics by the organic alternative scouring agents and subjected to structural analysis using X-ray diffraction in order to elucidate the possible modifications on the structures of the pretreated fabrics.

MATERIALS AND METHODS

Sample collection and preparation: The sample 35%/65% of cellulose/polyester blend fabric was purchased from Central Market Bauchi, Bauchi State, Nigeria. The sample was cut into pieces of dimension 10 cm length by 10 cm width and kept in the laboratory prior to chemical treatment.

Scouring process (alternative scouring agents): Five separate beakers each containing equal volumes of 1 %, 2 %, 3 %, 4 % and 5 % NaOH solution were boiled for 5 minutes and equal numbers of 10 cm by 10 cm pieces of fabrics were immersed into each of the beaker. The samples were then allowed to boil for one hour using glass rod to completely immerse the fabrics into the solution. The fabrics were rinsed with cold over flowing tap water. 1 % acetic acid was used to

*Corresponding Author Email: aubnabiu@gmail.com

neutralize the fabric followed by washing in 2 % detergent solution. The fabric was rinsed with distilled water and dried in the laboratory at room temperature. The same procedure was repeated for ethanol, acetic acid and oxalic acid for the cellulose/polyester samples. 1% sodium hydroxide solution or 1% acetic acid was used to neutralize the different scouring agents (Boryo *et al.*, 2013).

Bleaching process (alternative scouring agents): All the scoured samples were bleached using 4g/l sodium chlorite (NaClO_2) solution according to the procedure described by Sadov *et al.*, (1973) and employed by (Boryo *et al.*, 2014; Boryo *et al.*, 2017). The pH of the sample was monitored using concentrated nitric acid (HNO_3) at a pH of 3 during preparation. The sodium chlorite solution was boiled on a hot plate for 5 minutes in a beaker, and the scoured fabric was immersed in the solution and allowed to boil for 3 hours at a temperature of 75°C after which it was washed in a hot water, and neutralized with 5% acetic acid, then washed with 2% detergent solution and finally rinsed with cold water and dried in the laboratory at room temperature for 45 minutes.

Mercerization process (alternative scouring agents): In this research work mercerization process was carried out using concentrated solutions of 22% NaOH at a temperature 5°C for 45 minutes.

Preparation of samples: Fabric samples were conditioned in an oven at 80°C for 48 hours to remove moisture present at the surface and absorbed within the fabric samples. The samples were then blended using a manual blender.

XRD analysis of samples: Powder XRD data were collected using an X-ray diffractometer (Bruker AXS D-8 Advance, Germany), equipped with Cu radiation source (wavelength $\lambda = 1.54056 \text{ \AA}$) operating at 40 kV and 40 mA and a Vantec detector.

The crystallinity index was estimated in this study using the equation adopted by El-Ebissy *et al.*, (2016) as shown below in Equation 1.

$$\text{CI (\%)} = \frac{I_{c+a}}{I_a} \times 100\% \quad 1$$

Where; I_{c+a} is the intensity of the crystalline and amorphous peak, I_a is the intensity of the amorphous peak.

The crystallite size was determined using scherrer's formula which is as shown below;

$$\text{Crystal size (D) (nm)} = \frac{0.89\lambda}{\beta \cos \theta} \quad 2$$

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The inter-planar spacing was determined using Bragg's formula (El-Ebissy *et al.*, 2016). Equation (3);

$$n\lambda = 2d \sin \theta, \text{ where } n = 1 \quad 3$$

Interplanar spacing (d-spacing) (nm) = $n\lambda/2\sin \theta$

Where; λ is the X-ray wavelength (0.154 nm), β is the angular width at half maximum intensity determine with the aid of Gaussian fit of the peaks on the diffractograms of the samples and θ is the Bragg angle.

RESULT AND DISCUSSION

Effect of organic alternative scouring agents on percentage crystallinity index of cellulose/polyester blend fabric: Oxalic acid (COOH_2) scoured cellulose/polyester fabric (Figure 1a) showed decrease in crystallinity index (10.10 - 33.70%) when 4 and 5 wt.% concentration were employed. This could be an indication that the crystalline region was hydrolyzed or morphologically transformed during scouring. For such interaction to occur, the amorphous region would also be affected. Cellulose/polyester fabric blend fabric scoured with CH_3COOH showed increase in crystallinity index (47.36 - 60.03%) (Figure 1b) with increase in concentration of CH_3COOH employed; this might not be unconnected to partial hydrolysis of the amorphous region of the fabric due to high temperature of scouring. Increase in crystallinity index could bring about desired improvement in mechanical strength in a cellulose/polyester blend fabric. The possibility of morphological modification of the cellulose/polyester blend fabric on scouring with CH_3COOH could also have resulted in increase in crystallinity index. Cellulose/polyester blend fabric scoured with $\text{CH}_3\text{CH}_2\text{OH}$ (11.12 - 52.91%) (Figure 1c) showed higher crystallinity index at 2 wt.% but lower crystallinity index at 1 wt.% compared to the untreated sample. This suggested that cellulose/polyester blend fabric sample used in this study was sensitive to small change in concentration of $\text{CH}_3\text{CH}_2\text{OH}$ on scouring.

Effect of organic alternative scouring agents on d-spacing: The inter-planar spacing of both amorphous and crystalline regions (0.345 - 0.350 nm) of (COOH_2)₂ were relatively constant. However, structural modification and certain degree of influence were observed in the X-ray diffraction pattern of the cellulose/polyester blend scoured with (COOH_2)₂, the findings showed that cellulose/polyester blend fabric scoured with (COOH_2)₂ might possess good dyeing. The variation in the inter-planar spacing (0.340 – 0.345 nm) (Figure.2c) in both crystalline region and amorphous regions was relatively low compared to

when NaOH was used (Sadov *et al.*, 1973). This could also be attributed to partial hydrolysis of the amorphous region of the cellulose/polyester blend fabric on scouring with CH_3COOH . This could account for high linear density observed with use of CH_3COOH as alternative scouring agent Boryo *et al.* (2013). The inter-planar spacing of $\text{CH}_3\text{CH}_2\text{OH}$ for amorphous region varied like the crystallinity index.

However, the inter-planar spacing of the crystalline region (0.343 nm) remains approximately constant. Also the degree of interaction of $\text{CH}_3\text{CH}_2\text{OH}$ as scouring agent was higher for amorphous region compared to crystalline region based on the variation of the inter-planar spacing.

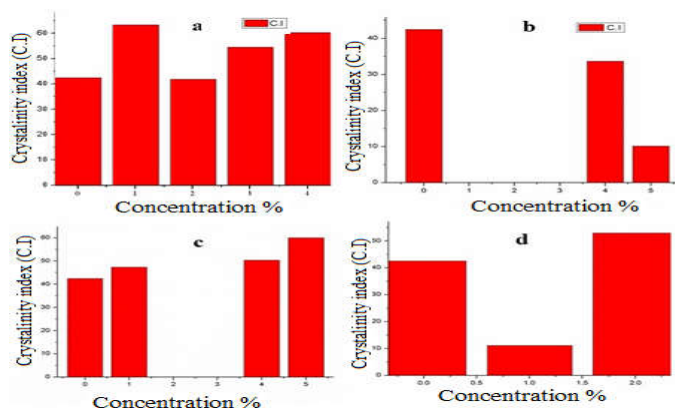


Fig 1: Percentage crystallinity index for (a) NaOH, (b) $(\text{COOH})_2$, (c) CH_3COOH , and (d) $\text{CH}_3\text{CH}_2\text{OH}$ scouring of cellulose/polyester blend fabric

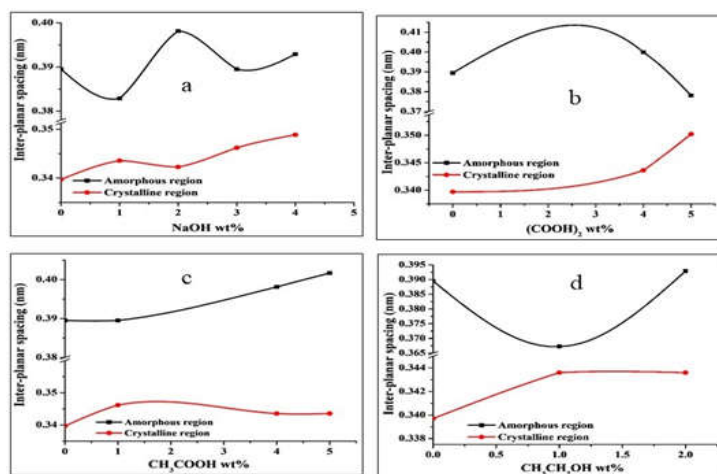


Fig 2: The inter-planer spacing (d-spacing) for (a) NaOH, (b) $(\text{COOH})_2$, (c) CH_3COOH , and (d) $\text{CH}_3\text{CH}_2\text{OH}$ scouring of cellulose/polyester blend fabric

Effect of organic alternative scouring agents on crystallite size: The degree of influence of the oxalic acid used in scouring on both regions could be observed in almost equivalent crystallite size of both regions. While the crystallite size of the amorphous region decreased with increase in concentration of CH_3COOH used in the scouring process, the crystallite size of the crystalline region (8.0 - 11.0 nm) increased. This could also be attributed to partial hydrolysis of the amorphous region of the cellulose/polyester blend fabric on scouring with CH_3COOH . The elongation of

the crystallite size of the crystalline region could account for high linear density observed with use of CH_3COOH as alternative scouring agent (Boryo *et al.*, 2013). Crystallite sizes of $\text{CH}_3\text{CH}_2\text{OH}$, for both regions varied widely with the amorphous region experiencing a decrease while the crystalline region (6.0 - 9.0 nm) experienced increase. At 2 wt.% the crystallite sizes of both regions were almost equivalent. The crystallite size of both the crystalline and amorphous region increase with increase in concentration of $(\text{COOH})_2$ used in the scouring

process. This could be attributed to partial hydrolysis of the crystalline and amorphous region of cellulose/polyester blend fabric.

Effect of organic alternative scouring agents on number of crystalline planes: The number of crystalline planes varies (4.0 - 6.0) an indication of structural modification on the cellulose/polyester blend fabric scoured with (COOH)₂. Although structural modification and certain degree of influence were observed in the X-ray diffraction pattern of the cellulose/polyester blend fabric scoured with (COOH)₂, the findings showed that cellulose/polyester blend fabric scoured with (COOH)₂ might possess good dyeing properties (Boryo, *et al.*, 2017). The possibility of morphological modification of the cellulose/polyester blend fabric on scouring with CH₃COOH could also have resulted in increase in crystallinity index as shown by the variation in number of crystalline planes (Figure 4d). The variation in the inter-planar spacing (Figure 11c) in both crystalline region and amorphous regions was relatively low compared to when NaOH was used.. The number of crystalline planes (4.0 – 9.0) also increased with increased wt.% of CH₃CH₂OH. This observation suggested that the crystallinity index was more influenced by morphological transition than hydrolysis of the amorphous region.

Optimum Conditions for Alternative Scouring Agents: In Table 1 all the optimum condition of the scoured agent for percentage crystallinity index are higher than that of the control (2% NaOH) with the exception of (5% COOH)₂, the decrease in crystallinity index could be as a result of low molecular way of (COOH)₂ compare to order alternative agent. Even though the d-spacing did not show much improvement compared to the control (0.340 or slightly higher, and 0.340 respectively) for the scouring agents as shown in Table 2. Table 3 and 4 all the optimum condition are higher than that of control with these all the alternative agent can computes with the control owing to it less hazardous effect and cheaper than NaOH.

Table 1: Optimum Conditions for Alternative Scouring Agents on Percentage Crystallinity Index

Scouring agent	Percentage crystallinity index(%CI)
2% NaOH	41.89
5% (COOH) ₂	33.70
2%CH ₃ CH ₂ OH	52.91
5%CH ₃ COOH	60.03

Table 2: Optimum Conditions for Alternative Scouring Agents on d-spacing

Scouring agent	d-spacing (nm)
2% NaOH	0.340
5% (COOH) ₂	0.345
2% CH ₃ CH ₂ OH	0.343
5%CH ₃ COOH	0.340

Table 4: Optimum Conditions for Alternative Scouring Agents on Crystalline Plane

Scouring agent	Percentage crystalline plane
2% NaOH	10.0
5% (COOH) ₂	6.0
2% CH ₃ CH ₂ OH	9.0
4%CH ₃ COOH	7.0

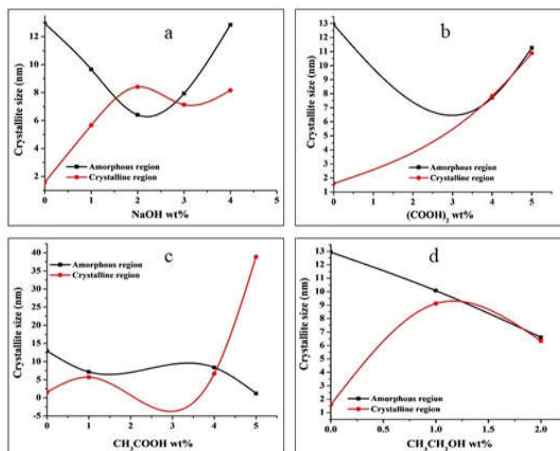


Fig 3: The Crystallite size for (a) NaOH, (b) (COOH)₂, (c) CH₃COOH, and (d) CH₃CH₂OH Scouring of Cellulose/Polyester Blend Fabric

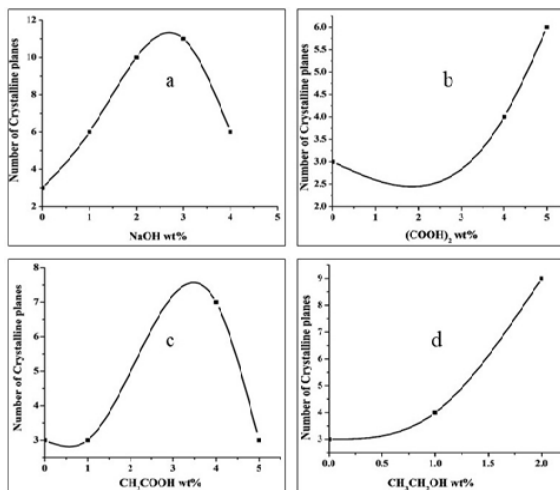


Fig 4: The Number of Crystalline Plane for (a) NaOH, (b) (COOH)₂, (c) CH₃COOH, and (d) CH₃CH₂OH scouring of cellulose/polyester blend fabric.

Table 2: Optimum Conditions for Alternative Scouring Agents on Crystallite Size

Scouring agent	Crystallite size (nm)
2% NaOH	8.0
5% (COOH) ₂	11.0
2% CH ₃ CH ₂ OH	9.0
5%CH ₃ COOH	40.0

Conclusion: The scouring of cellulose/polyester blend fabric using alternative agents was conducted view to find out the effect on the structures of the fabric were evaluated using X-ray diffraction. The scoured agent for percentage crystallinity index are higher than that of the control (2% NaOH) with the exception of (5% COOH)₂, the decrease in crystallinity index could be as a result of low molecular weight of (COOH)₂ compare to other alternative agent. It was confirmed that the modifications on the fabric were both physical and chemical changes.

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