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Effect of Alternative Scouring Agents on Dyeing Properties of Cotton/Polyester Blend Fabric

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Abstract: *This research comprises of six alternative agents ($(NH_4)_2C_2O_4$, liquid NH_3, CH_3COOH, NH_4OH, $(COOH)_2$, CH_3CH_2OH) at various concentrations of 1-5% used as scouring agents with NaOH as control on cotton/polyester blend fabric. The samples were bleached, mercerized and dyed. The suitability and reliability of the agents were evaluated for dyeing properties of the treated fabric. Water imbibing properties of the treated fabric, was investigated. The experimental results showed that the percentage exhaustion of indigo dye on the treated fabric were wonderful with values far above average (86.8-62.6%) except for 1% $(NH_4)_2C_2O_4$ that recorded slightly below average (49.7%). 2% liquid NH_3 ranked the highest. The wash fastness is another interesting results where only 1-5% liquid NH_3, 2% and 4% $(NH_4)_2C_2O_4$ that gave a grey scale rating for wash fastness of 4 (very good). The other alternative agents strongly competed at various concentrations with the control which revealed a rating of 5 (excellent wash fastness). 4% $(NH_4)_2C_2O_4$ scoured fabrics recorded the highest water of imbibitions (2.9 g). This implies that the alternative agents are suitable and reliable as impurity-removing (scouring) agents. The alternative agents improved the dyeing and water imbibing properties of the treated fabric far better than the control. Therefore could be employed in the textile industry.*

Keywords: *alternative scouring agents, percentage exhaustion, reliable, suitable, wash fastness, water of imbibitions.*

I. INTRODUCTION

It is necessary to carry out some preparatory treatments before the application of other finishing processes to the newly constructed fabric. Any remaining impurities must be removed and additives used to facilitate the manufacturing process must also be removed [1]. Some of the most frequent pretreatment processes include; scouring, bleaching and mercerization [1].

. It has been established by many researchers such as [2, 3, and 4] that during scouring fatty acids are converted to soap which helps to emulsify other wax-like substances. Caustic soda (NaOH) hydrolyses protein and the molecules are broken along peptide links with the formation of alkali soluble amino acids. Similarly, pectin and lignin are hydrolyzed, gradually destroyed or decomposed to soluble salts.

After scouring, the fabric gives better wetting and penetration properties. This makes the subsequent bleaching and mercerization processes easy resulting in better dye intake and improved mechanical properties. Caustic soda has been used at 2% to achieve this process [5].

After all these chemical treatments, fabrics are usually dyed. Life is good they say, when everything desired are falling in line. Imagine the reason why "Immaculate" white materials are not worn, if not on occasions. This is because colour is good and is desired by all and sundry. The desire for a given fabric lies on its colour (appearance), texture (quality) and so on. Therefore dye is among the treatment that furnishes fabric to make it desirous and loving by all. Colour retention after dyeing is an important parameter in textiles. Colour is often the primary consideration when purchasing clothing and household textiles. When the colour fades or streaks, items are discarded before they are worn out. There are numerous dyes in use, but this work is interested in using indigo. It is classified as historical dye, and has retained its importance up to the present day. From practical indigo dyed cloths such as aizome to modern fashionable jeans, indigo has always had a wide field of application. Moreover, the chronic and acute toxicity of indigo is very low [6]. Indigo which is vat dye, has an affinity for cotton, wool and silk fabrics in its leuco form, but it has a low affinity for synthetic fabrics such as polyester [6]. This author investigated the possibility of dyeing synthetic fabric (polyester) with indigo using the cotton dyeing method but it was not possible. However, the author recently demonstrated the possibility of dyeing polyester fabrics with indigo by controlling the ratio of sodium hydrosulphite and NaOH concentration in the dye bath solution at a mild temperature. The author also applied the method for cotton fabric with great

success. However, there is no information on the application of this method on cotton/polyester blends. This present work developed the interest to apply the method on cotton/polyester blend.

However, scouring with strong alkaline (NaOH) is considered by [7] as pollution process, since it required a large quantity of waste and generates alkaline effluent. Furthermore, the resulting waste solution has high chemical oxygen demand (COD), biological oxygen demand (BOD) and salt content as investigated by [3]. Such waste water when in contact with a water body, may change the pH of an aquatic ecosystem, causing damage to aquatic life [8]. The natural pH of aquatic ecosystems can vary significantly among aquatic ecosystems, optimum conditions for aquatic organisms as reported by [8]ranged from 6 up to 9. Therefore, this demands for more friendly alternative scouring agents. This scouring process in presence of oxygen and at higher concentration and or temperature may result in serious shrinkage, swelling and oxycellulose formation which damages the fibre/fabric and affect the mechanical properties [2 and 3] There is no much work on other alkalis or alternative agents suggested. However, the use of ammonium oxalate by [9] has proved to produce better mechanical properties on bast fibre than the traditional sodium hydroxide. Further findings by [10] proved the use of alternative agents for scouring with improved mechanical properties suitable, reliable, cheaper and more environmentally friendly pH of the scouring effluents of scouring than the commercial NaOH. These findings contributed a part to the birth of this present work.

The specific objectives are to determine the optimum alternative scouring agents with:

- Better dyeing properties such as degree of percentage exhaustion and wash-fastness.
- Improved water of imbibition.
- Thus, this research aim at improving on the quality of Nigerian made fabrics which is in line with the vision of repositioning of Nigeria, that is "vision 20:20:20"

II. Experimental

2.1 Sample Collection and Preparation

The sample cotton/polyester blend fabrics were obtained from Funtua Textile Company Ltd. in Katsina, State Nigeria. While indigo dye was bought from Kano, Nigeria in a chemical shop at the main market. The samples were cut into pieces with dimension 10cm length by 10cm width and kept in the laboratory before treating chemically.

2.2 Methods

The cotton / polyester blend fabrics were scoured, bleached and mercerized according to standard methods as described below.

2.2.1 Scouring Process:

- Scoured by the standard method described by [2] and [5].
- Using 1%, 2%, 3%, 4% and 5% NaOH w/v (as control) fabrics were separately immersed and boiled for 1 hour for each solution.
- The process was repeated using the alternative agents –NH_4OH, $(HN_4)_2C_2O_4$, $(COOH)_2$, CH_3COOH, liquid NH_3 and CH_3CH_2OH each at the various concentrations of 1 to 5% separately.

2.2.2 Bleaching Process:

- Scoured samples were bleached using 4g/l $NaClO_2$ solution according to the procedure described by [2].

2.2.3 Mercerization Process:

- The bleached samples were mercerized with 22% NaOH below 5^0C for 45 minutes in accordance to standard methods of [2] and [5].

2.3 Evaluation of the effect of alternative scouring agents

2.3.1 Determination of Degree of Percentage Exhaustion:

- Dyeing was carried out as described by [6, 11 and 12]. A stock solution of 1g indigo dye was prepared with 2g $Na_2S_2O_4$ and 0.25g NaOH as dye assistants in 250ml volumetric flask
- Dyeing was carried out at 120^0c for 30 minutes at 1% dyeing

$$\text{Volume of dye stock} = \frac{W\,X\,P}{C}$$

W = Weight of fabric sample
P = Percentage dyeing required = 1% dyeing
C = Percentage concentration of stock solution

$$= \frac{1}{250} x\,100 = 0.4$$

- 40:1 liquor to material ratio was carried out
- The amount of dye absorbed was measured and recorded with an ultra violet spectrophotometer (Prolabo 320RD) at wavelength 605nm [6]
- Degree of percentage exhaustion was calculated using

$$\% \text{ Exhaustion} = \frac{A_O - A_t}{A_O}$$

A_O = Initial absorbance
A_t = Absorbance at time t.

2.3.2 Determination of Wash fastness:

- Dyeing was carried out in accordance with the method of [6, 11 and 12]
- 3% dyeing was carried out at liquor to material ratio of 40:1 at 120^0C and for 30 minutes with indigo.
- Wash fastness test was carried out on the dyed fabric according to International Organization for Standardization (ISO3) described by [13].
- Composite of 2cm by 5cm dimension of the dyed and undyed fabric sample was washed by agitation in 2g/l soap and 2g/l sodium carbonate solution at a liquor ratio of 40:1.
- The washing was carried out in a beaker placed in a water bath at 50^0C for 30minutes.
- Washfastness assessment involved comparing the degree of contrast between the originally dyed sample and the specimen tested (washed).
- ISO3 wash fastness grey scale was used for rating of the specimen under test which is a number of this grey scale contrast.

2.3.3 Determination of Water of Imbibition

The water of imbibition of the mercerized cotton/polyester fabrics were determined using the method stated by [14]. The fabrics were weighed and soaked in 250ml distilled water in a beaker for 5 minutes. It was removed and mopped with filter paper gently to remove excess water and it was then weighed again immediately. It was followed by progressive drying at 80^oC in an oven for 5, 10, 15, 20, 25 and 30 minutes. At each of these intervals, the weights of the sample were recorded using analytical balance. The temperature of the laboratory was recorded as 24 ± 2^oC during the experiment. The procedure was repeated three times for each sample and the average was calculated.

III. Result And Discussion

3.1 Effects of alternative Scouring agents, Bleaching and Mercerizing Processes on the Physical Properties of the Cotton/Polyester Blend Fabric.

The following changes were observed during and after the scouring, bleaching and mercerization Processes of the cotton/polyester blend fabric with alternative agents.

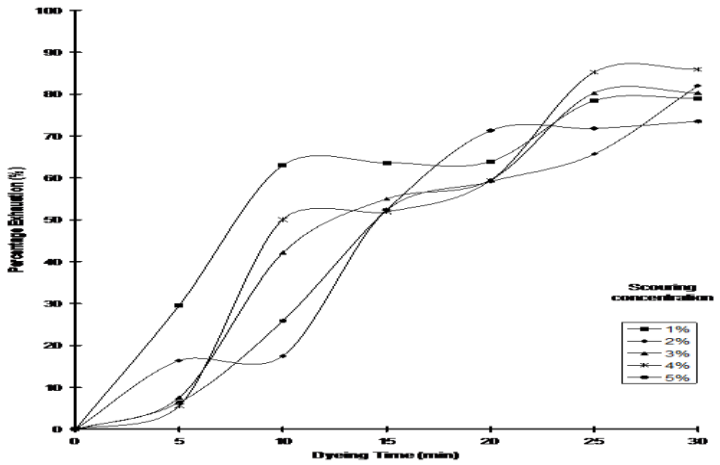


Figure 1: Effect of NaOH Scouring agent on Percentage Exhaustion of Indigo dyed cotton/polyester blend fabric

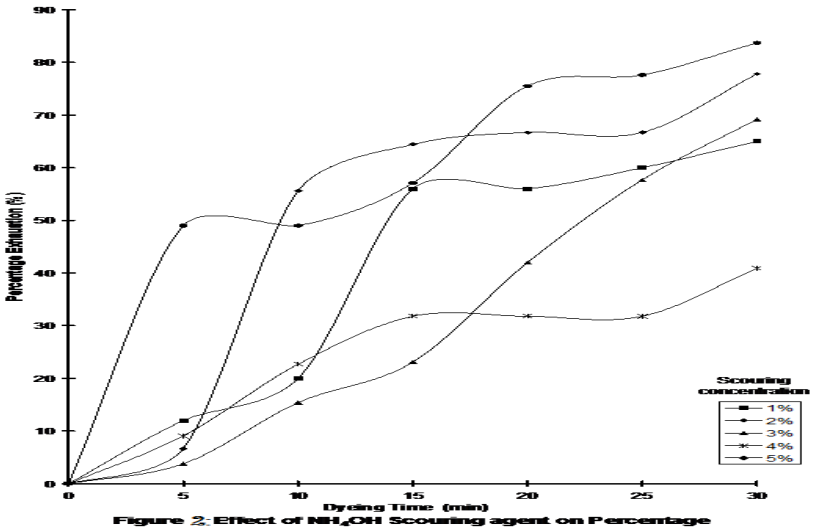


Figure 2: Effect of NH_4OH Scouring agent on Percentage Exhaustion of Indigo dyed cotton/polyester blend fabric

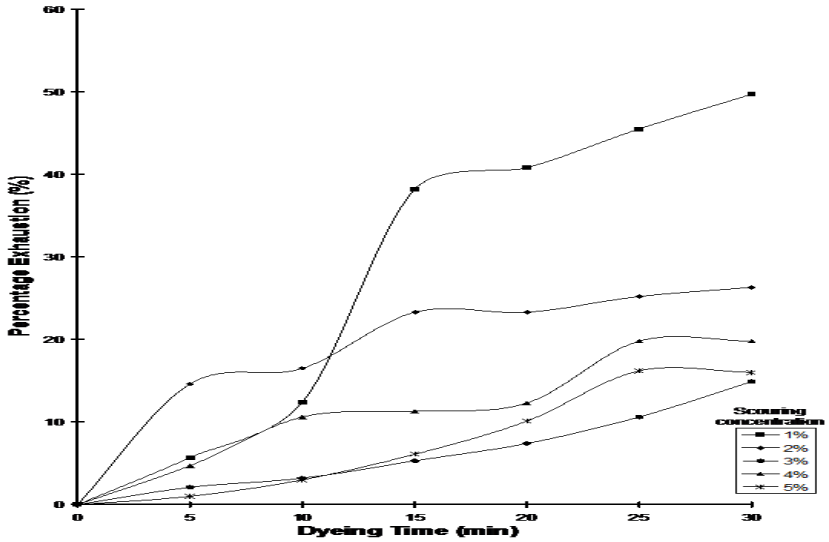


Figure 3: Effect of $(NH_4)_2C_2O_4$ Scouring agent on Percentage Exhaustion of Indigo dyed cotton/polyester blend fabric

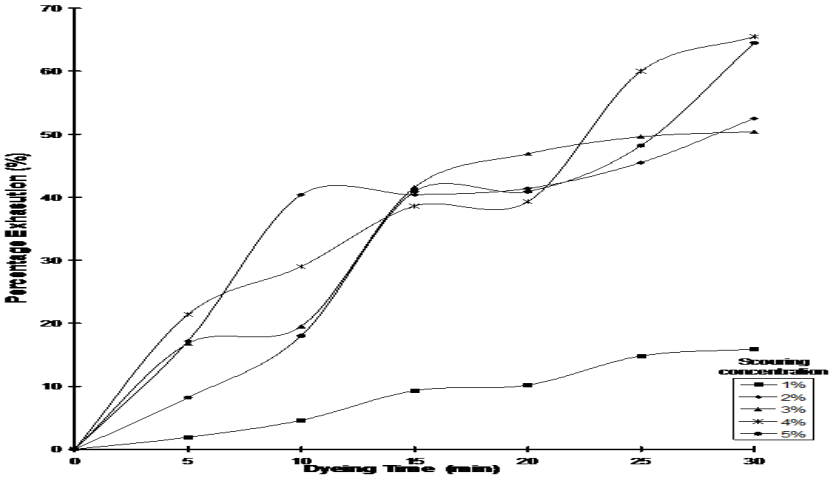


Figure 4: Effect of $(COOH)_2$ Scouring agent on Percentage Exhaustion of Indigo dyed cotton/polyester blend fabric

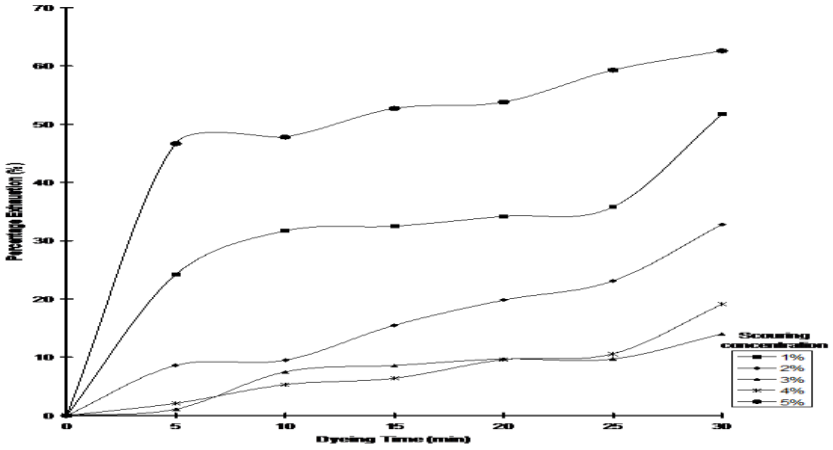


Figure 5: Effect of CH_3COOH Scouring agent on Percentage Exhaustion of Indigo dyed cotton/polyester blend fabric

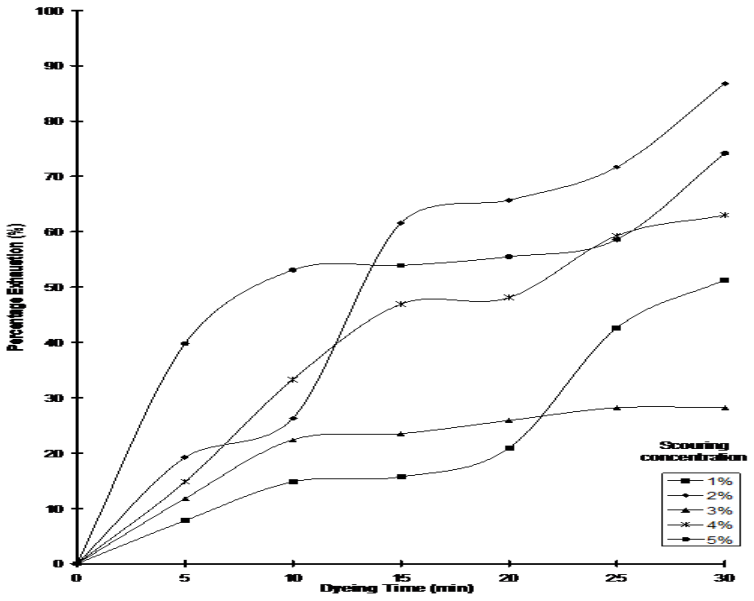


Figure 6: Effect of Liquid NH_3 Scouring agent on Percentage Exhaustion of Indigo dyed cotton/polyester blend fabric

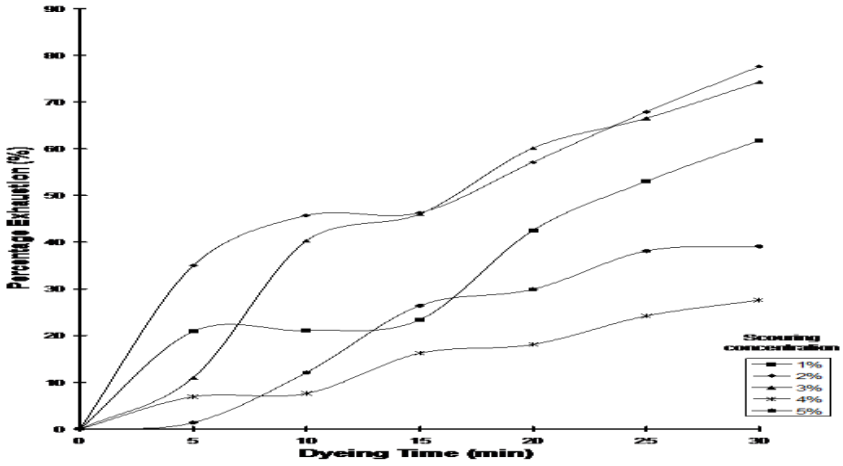


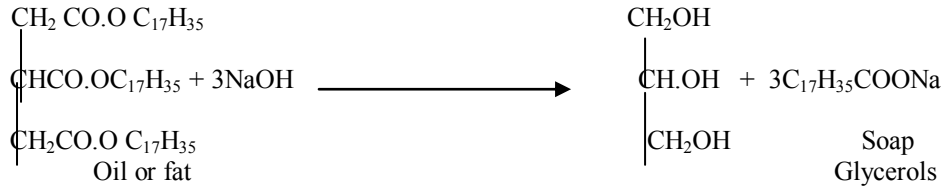
Figure 7: Effect of CH_3CH_2OH Scouring agent on Percentage Exhaustion of Indigo dyed cotton/polyester blend fabric

Table 1: Optimum percentage exhaustion of the effect of Scouring Agents on indigo dyeing process of mercerized cotton/polyester blend fabric

Scouring Agent	Concentration of scouring Agent (%)	Percentage exhaustion (%)
Liquid NH_3	2	86.8
NaOH	4	85.9
NH_4OH	5	83.7
CH_3CH_2OH	2	77.6
$(COOH)_2$	4	65.5
CH_3COOH	5	62.6
$(NH_4)_2C_2O_4$	1	49.7

3.1.1 Scoured Samples

During scouring, the scouring liquor or solution kept changing from colourless solution till after scouring to a slightly yellowish solution for all the alternative agents used and NaOH (control). This implies that purification has taken place. It is believed and is a known fact that during scouring with 2% NaOH, the oil and fat at boiling will be hydrolyzed to glycerol and alkali salt of the fatty acid (soap):



Scheme 1: Hydrolysis of fat or oil by Sodium hydroxide

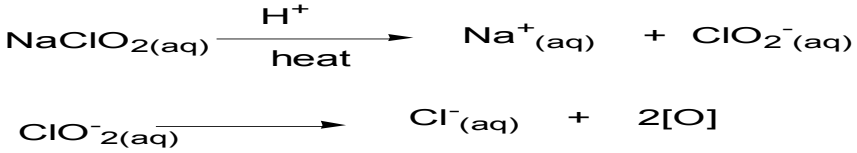
The soaps formed at boiling; promote the emulsification of wax-like substance and unsaponifiable fats [2]. The alkali hydrolyzes proteins, and their molecules are broken along peptide links with the formation of alkali-soluble amino acids [2, 3 and 4]. Pectin and lignin substances are also hydrolyzed, their molecules are gradually destroyed and converted to soluble salts. Mechanically adhered dirt are loosened and held in suspension.

Thus it is expected and assumed that NH_4OH, $(NH_4)_2C_2O_4$, liquid NH_3 will decompose the impurities in a similar manner. So also will CH_3COOH, CH_3CH_2OH and $(COOH)_2$ being organic components and the impurities are mostly organic components "like dissolves like".

At the end of the scouring process, the fabric samples were cleaner, texture improved and there were little decrease in the dimension of both length and width of the treated fabrics. This agrees with the reports of [2, 3 and 4] as the effect of scouring on fabrics and it is expected to improve the dyeing properties.

3.1.2 Bleached Samples

When the scoured samples were immersed in the bleaching solution of $NaClO_2$, it was observed that the cloudy colour changed to slightly faint yellowish colour for all the fabric samples scoured with the various agents. This indicates that pigments and any remaining impurities were removed. This was confirmed by the appearance of the fabric samples. The fabrics became whiter and brighter than the unbleached after bleaching and drying.



Scheme 2: Formation of the atomic oxygen for bleaching with sodium chlorite

3.1.3 Mercerized Samples

The bleached fabrics were mercerized with 22% NaOH. All the samples swells and gradually untwist and became smooth, soft, lustrous and glossy. This is reported by [2 and 15]. to be as a result of chemical, physico-chemical and structural modifications on the fabric by the concentrated alkali. These changes are believed to result into improved properties.

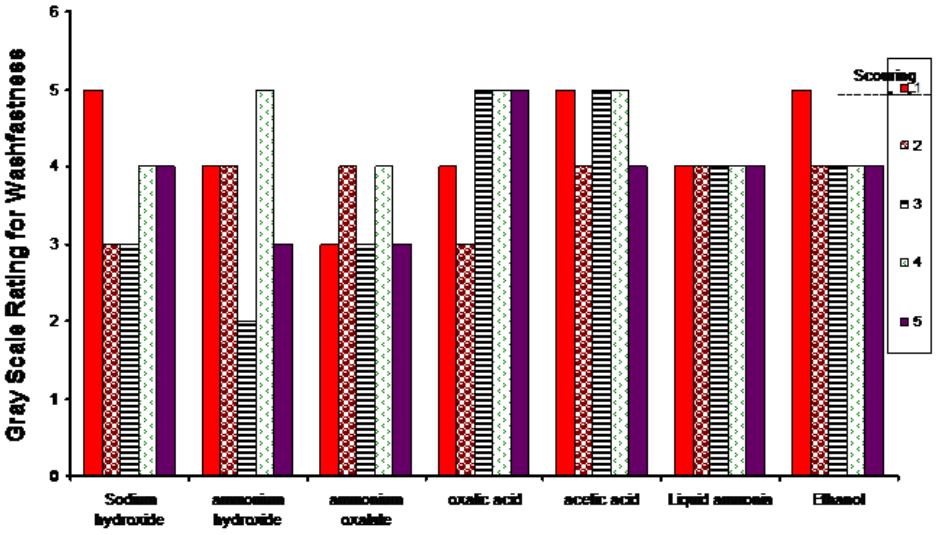


Figure 8: Effect of NaOH (control) and alternative scouring agents on Washfastness of Indigo dyed cotton/polyester blend fabric

Table 2: Optimum Wash-fastness of the effect of Scouring Agents on Indigo Dyed Mercerized Cotton/Polyester Blend Fabric

Scouring Agent	Concentration of scouring Agent (%)	Grey scale rating for washfsatness	Remark
CH_3COOH	1,3 and 4	5	Excellent
$(COOH)_2$	3,4 and 5	5	Excellent
CH_3CH_2OH	1	5	Excellent
NH_4OH	4	5	Excellent
NaOH	1	5	Excellent
LIQUID NH_3	1 - 5	4	Very good
$(NH_4)_2C_2O_4$	2 and 4	4	Very good

3.2 Effects of NaOH (control) and Alternative Scouring Agents on Dyeing Properties of Mercerized Cotton/Polyester Blend Fabric.

The alternative scouring agents and the control affected the degree of percentage exhaustion of indigo dye and wash-fastness of the indigo dyed cotton/polyester blend fabric in the following trend.

3.2.1 Effect of Scouring Agents on Degree of percentage Exhaustion of Indigo Dyed Cotton/Polyester Blend Fabric

With reference to Figures 1-7, the degree of exhaustion increased as the time of dyeing increased. However, there is no regular trend with respect to the various scouring concentrations of the agents. The interesting observation is that dye up take has been affected after the scouring process by the scouring agents at percentage far above average except for 1% $(NH_4)_2C_2O_4$ scoured fabric sample with 49.7% degree of exhaustion. This signifies that the impurities that impede dye adsorption were removed [2] providing pores (amorphous) for dye adsorption. 2% liquid NH_3 scoured fabric recorded the highest degree of exhaustion (86.8%) followed by 4% NaOH Control (85.92%). 5% NH_4OH (83.7%) closely competed with the control, while 2% CH_3CH_2OH (77.6%) competed with the control (Table 1). 4% $(COOH)_2$ and 5% CH_3COOH optimally recorded 65.5% and 62.6% degree of exhaustion respectively. This somehow shows that the alkaline agents recorded higher degree of exhaustion (83.7%-86.8%). This may mean that the alkaline agents saponifies and hydrolyses the impurities far better than the other agents. There by having more amorphous regions for dye adsorption.

3.2.2 E*ffect of Scouring Agents on Wash-fastness of Indigo dyed Cotton/ Polyester Blend Fabric*

Colour retention after dyeing is important parameters in textiles [13]. Colour is often the primary consideration when purchasing clothing and household textiles. When the colour fades or streaks, items are discarded before they are worn out.

The scouring process has shown an excellent improvement in the dye adsorption and retention. With reference to Figure 8 and Table 2, it is observed that the organic alternative agents (1%, 3% and 4% CH_3COOH, 3% 4% and 5% $(COOH)_2$ and 1% CH_3CH_2OH) including 4% NH_4OH strongly competed with the control (NaOH) with a grey scale rating of 5, indicating excellent wash-fastness. In the actual sense, this implies that despite their lower degree of exhaustion (that is the organic alternative agents), the dye adsorbed were properly fixed in the provided amorphous region of the cotton/polyester fabric. This also means that the organic alternative agents are better scouring agents, removing the impurities and creating permanent pores (amorphous region). This permanent space allowed for better intermolecular hydrogen bond and Vander Wa'als force between the dye and the fabrics. Thus the dye molecules were bonded, therefore improving resistance to washing. This indicates that, there is no loss in intensity of colour suggesting insignificant change in hue. This is as a result of insignificant breakdown of colourant itself inside the fabric.

Optimum wash-fastness for 1-5% liquid NH_3 and 2-4% $(NH_4)_2C_2O_4$ recorded a grey scale rating of 4 respectively which is referred to as a very good rating. This implies that there is a slight loss in depth and change in hue of the colour. It also has a slight change in contrast. Liquid NH_3 recorded the highest percentage exhaustion, but part of the adsorbed dye suffered little breakdown of colourant during washing. This may imply that artificial amorphous regions might have been created and the adsorbed dye molecules were not fixed to the fabric. Therefore the unfixed dye remains on the surface of the fabric, giving it a falsified deeper shade. On washing the unfixed dye is detached from the surface of the fabric and only those that are properly fixed remain on the fabric after washing.

2% and 4% $(NH_4)_2C_2O_4$ also gave an optimum grey scale rating for wash-fastness of 4 that is, very good. This agrees with the observed percentage exhaustion which is below average. This implies that the dye adsorbed were not all retained because of improper fixing in the available pores.

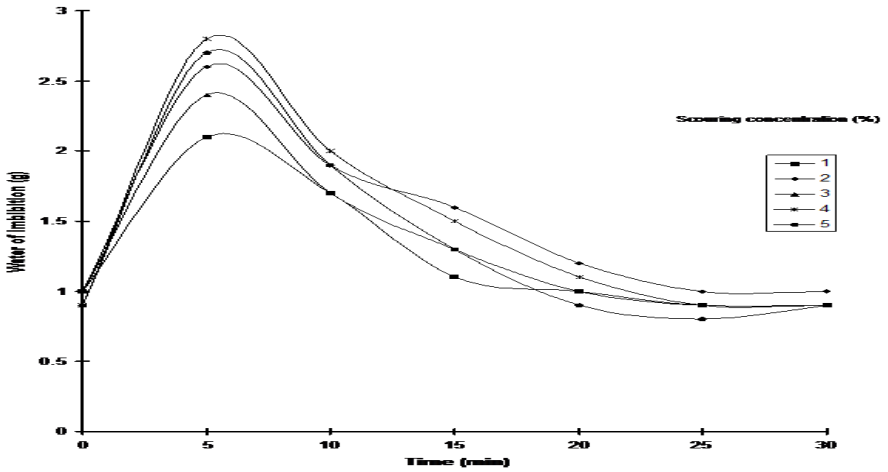


Figure 9: Effect of NaOH Scouring agent on water of imbibition of mercerized cotton/polyester blend fabric

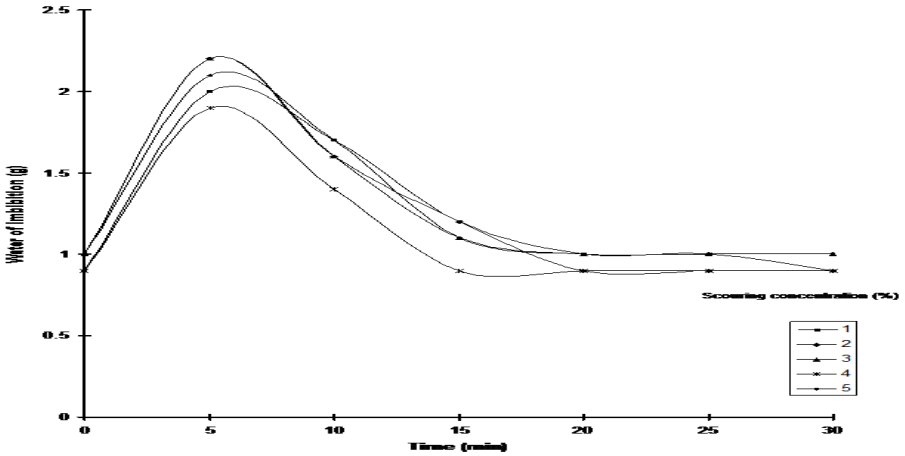


Figure 10: Effect of NH_4OH Scouring agent on water of imbibition of mercerized cotton/polyester blend fabric

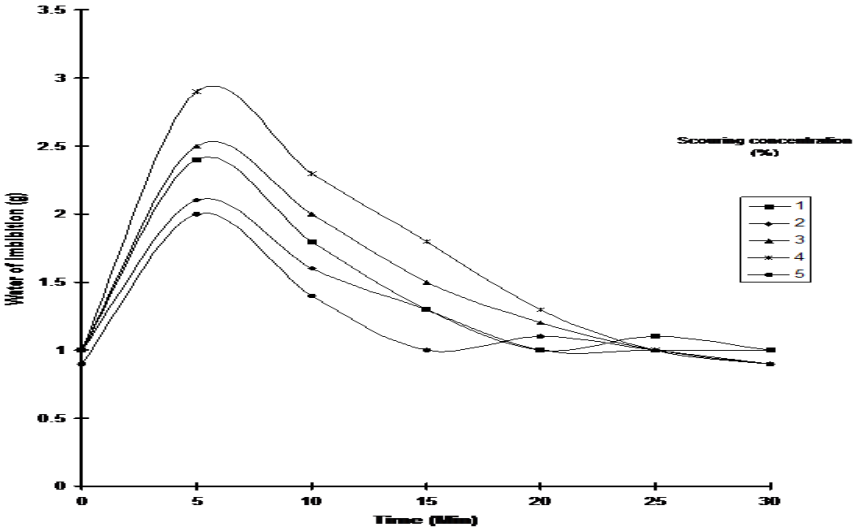


Figure 11: Effect of $(NH_4)_2C_2O_4$ scouring agent on water of inbibition of mercerized cotton/polyester blend fabric

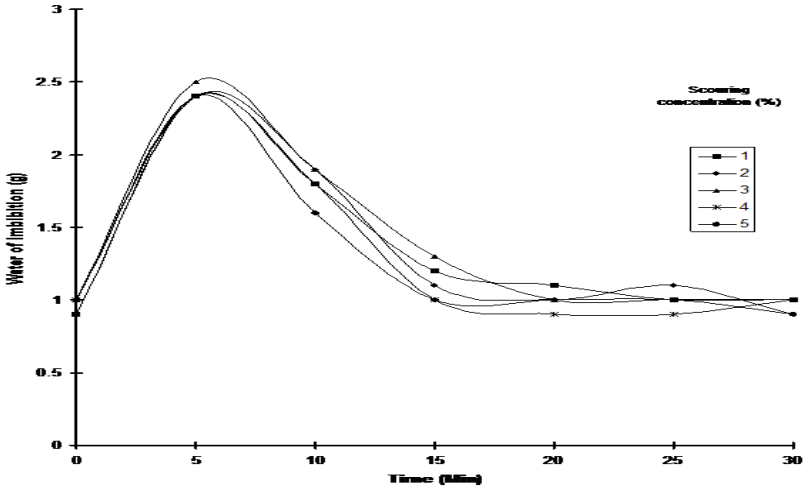


Figure 12: Effect of $(COOH)_2$ Scouring agent on water of inbibition of mercerized cotton/polyester blend fabric

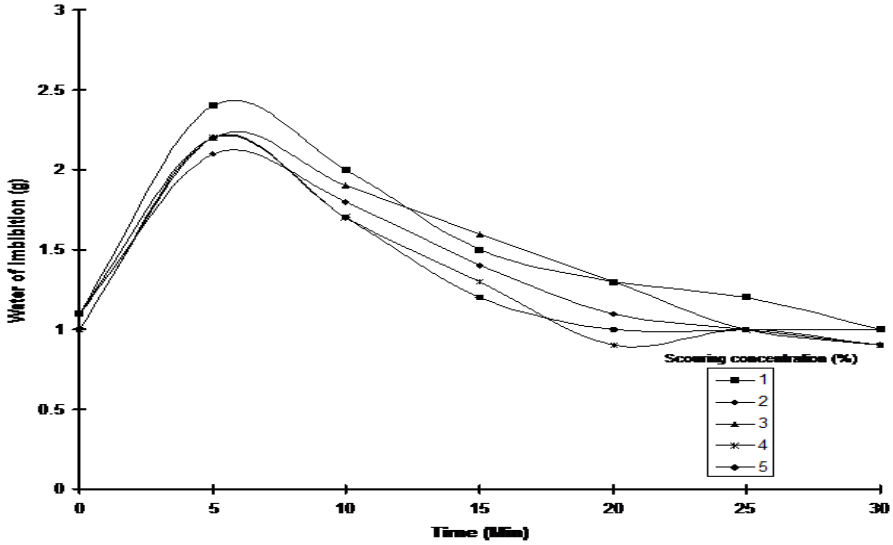


Figure 13: Effect of CH_3COOH Scouring agent on water of imbibition of mercerized cotton/polyester blend fabric

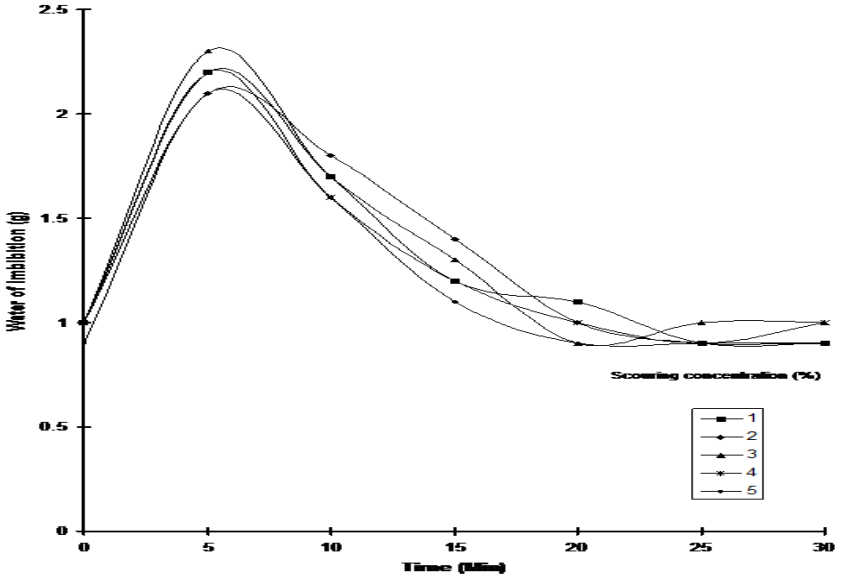


Figure 14: Effect of Liquid NH_3 Scouring agent on water of inbibition of mercerized cotton/polyester blend fabric

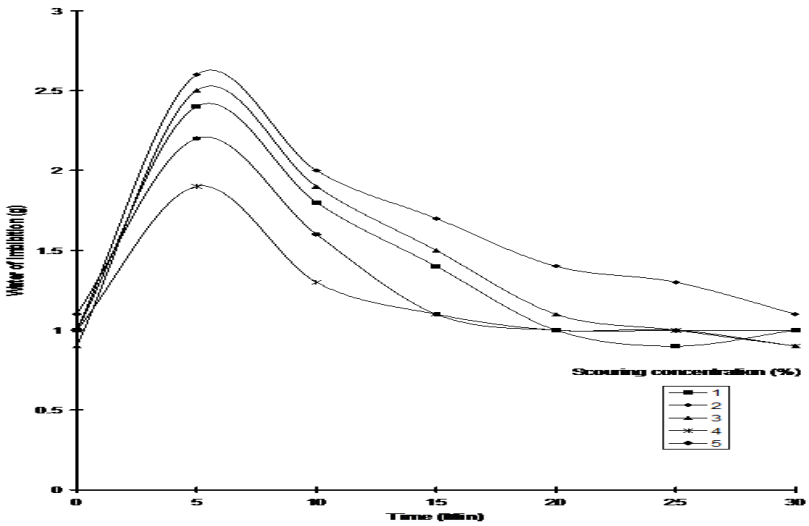


Figure 15: Effect of CH_3CH_2OH Scouring agent on water of inbibition of mercerized cotton/polyester blend fabric

Table 3: Optimum Water of Imbibition of the effect of Scouring Agents on Mercerized Cotton/Polyester Blend Fabric

Scouring Agent	Concentration of scouring Agent (%)	Water of imbibition (g)
$(NH_4)_2C_2O_4$	4	2.9
NaOH	4	2.8
CH_3CH_2OH	2	2.6
$(COOH)_2$	3	2.5
CH_3COOH	1	2.4
Liquid NH_3	1	2.3
NH_4OH	2 and 3	2.2
Untreated	0	1.8

3.2.3 Effect of Alternative Scouring Agents and control (NaOH) on Water of Imbibition of Mercerizing Cotton/Polyester Blend Fabric

According to [16], water of imbibition measures the quantity of water that is absorbed under specified conditions and temperature. From Figures 9-15 there is improvement in water of imbibition for the scoured cotton/polyester blend fabrics. This suggests that the scouring process has effected proper removal of impurities occupying the amorphous region, there by increasing its water adsorption capacity. It was also observed that, there is gradual decrease in the water imbibed by all the fabric samples as the drying time increase. The gradual decrease implies that the scoured fabrics have retention property of the imbibed water even under oven drying condition. This implies a promising dyeing property. Table 3 shows the optimum water of imbibition of the scouring agents for cotton/polyester blend fabric. The values ranged competitively from 2.9 - 2.2g for all the scouring agents. 4% $(NH_4)_2C_2O_4$ recorded the highest followed by 4% NaOH scoured sample fabric. This also agrees with [17] work on Kenaf fibre. The least value (2.2g) was recorded by 2% and 3% NH_4OH scoured fabric.

Moisture affects the manner in which fabric behaves in different humidity conditions. For example at high moisture content, properties such as tensile strength, breaking load, breaking strength, and breaking extension increases [18]. This is due to the presence of hydrogen bonding between water molecules and the molecules of the fabrics (cellulose, etc). It therefore finds it difficult to break away [19]. This means that these scouring agents will favour improvements in mechanical properties of the fabric when wet.

IV. Conclusion:

The effects of alternative scouring agents on the dyeing properties of treated cotton/polyester blend fabric in some cases are much better than those of the industrial and commercial scouring agents (NaOH). Also in some cases these alternative agents compared favorably with the control.. Therefore, these alternative agents could be employed as scouring agents industrially and commercially.

It is recommended that the alternative scouring agents be adapted in the textile industry and commercially.

Acknowledgement:

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