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Preparation and Performance Evaluation of an Active Anti-bleeding Solution for Laundering Multicoloured Textile Apparels

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Abstract

The bleeding of deeply colored textile apparel has been a major challenge, leading to fading and crocking of the textile apparel. This research investigates the combination of some dye auxiliaries as a potential anti-bleeding solution for laundering purposes. These are: sodium chloride (NaCl), sodium trioxocarbonate (iv) (Na_2CO_3) and Ascorbic Acid ($C_6H_8O_6$), Vinegar (CH_3COOH) and Calcuim Chloride ($CaCl_2$). Their bleeding regulatory activity were singly determined and their combined effect were analyzed on three bleeding textile samples (Ankara) having different patterns of shades. The UV-visible spectrophotometer was used to determine their respective absorbance at a predetermined wavelength. The values of their corresponding absorbance show that NaCl, Na_2CO_3 and $C_6H_8O_6$ exhibit more excellent resisting power on bleeding textile samples when combined in appropriate ratio of 1.25: 1: 1.65 (w/w) than when singly used. These combined chemicals were prepared and used as the anti-bleeding solution and its performance on a large scale multi-coloured laundered textile evaluated. The best dilution ratio was found to be (10:30 v/v) water to anti-bleeding solution per 2.8 g fabric for laundering and (5:35 v/v) for subsequent rinsing operations. The mean fastness ratings value to light, washing, rubbing, ironing and perspiration for the laundered three textile samples A, B, C were very good. It has over 60% for all the wet and dry agencies tested. 80-90% dyes in each of the textile samples were retained after laundering. This claim was further justified by the colour values of treated textile samples as compared with the untreated ones using a colour comparator. The physicochemical properties of the prepared solution evaluated for the period of eight weeks have a pH of 4.41-5.49, relative density value 1.02-1.08, temperature 29.30-28.07°C and chloride content 964.21-737.32 mg/L. It has an appreciable value of free CO_2 (1054.73mg/L), a conductivity value of 380.50 μm/cm, a constant turbid value of 2.00, and acidity (1368.93 mg/L) and alkalinity (2424.05 mg/L).

Keyword

Bleeding, Anti-Bleeding, Fastness, Absorbance, Fabric

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1. Introduction

Dyed textile apparel is flexible material made up of a network of natural or synthetic fibres, formed by weaving, knitting or other textile fabrication techniques [1, 2]. Natural fibres network to produce this textile materials are processed from animal bodies, plant materials and minerals. The common fibres sourced from animal body include silk from silk worm and wool from sheep of various species. Plants fibres however, are commonly cotton and linen while asbestos is a mineral fibre from rock formations. Other fibres like the rayon, acetates, triacetates, cupramonium has its primary sources from

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natural fibres and can be referred to as regenerated fibres or cellulosic-based (viscous rayon), while the purely synthetic ones are nylon, polyester, acrylics, olefin, spandex etc [3]. The bleeding of textile apparel is described as the running of colour from wet dyed textile material onto another material next to it or into water during laundering operation or by mechanical actions such as friction and abrasion [4]. The bleeding of fabrics can be further defined as an appreciable loss of colour as a result of colour transfer from damp fabric to another substrate or wet fabric into the aqueous medium. This process result in the loss of appreciable amount of dyes which result in fading as the uncontrolled bleeding process continues during processes such as washing, rubbing, ironing and perspiration [5]. Bleeding has become common among deeply coloured textile apparel. Research reveals that, there are some basic reasons responsible for this bleeding action of textile apparel namely: inappropriate dyeing technique, inappropriate dyeing condition of the dye bath (e.g Temperature, additives, time etc), low quality of dye leading to poor bonding ability of the dye to the substrate, lack of penetration of the dyeing agents and lack of proper post-dyeing and finishing processes [6]. Deeply coloured textile apparel exhibiting diverse kind of patterns as in vogue in the locally made Ankaras, Kampala and Batik in Nigeria and elsewhere in Africa and in the world. These textile apparels are known for their appreciable value and use in the Nigerian culture and fashion and in other places. However, majority of these built up shades are often challenged with bleeding during washing and fading on its exposure to sunlight rays over a period of time. This research is channeled toward the evaluation of some dyeing auxiliaries as a way of forestalling the bleeding process of the textile apparels so as to have value for the money use in the purchase of these textile samples and to enhance the durability of the purchased coloured textile apparel.

2. Materials and Method

2.1. Materials

Two yards (1.83 m) each of three (3) indigenous cellulosic printed fabrics (Ankaras), which are prone to bleeding and comprises of varying colour patterns (Figure 1), were purchased from Oja-Oba, Akure, Nigeria. Four commercial dyes namely: Orange 11, Vat Green 9, Vat Red and Vat violet 1, from Osogbo, Nigeria. While the chemical used were HCl, DMSO, vinegar, ascorbic acid, trioxocarbonate (iv), sodium chloride and calcium chloride which were of analytical grade and obtained in chemistry department, federal University of Technology, Akure, Nigeria.

Figure 1. Textile samples.

2.2. Methods

2.2.1. Burning and Chemical Test on the Textile Samples

Each textile sample A, B and C was cut into 10 x 4 cm (2.8 g ± 0.5) and subjected to burning test as described by Zafeiropoulos [6]. Each was also treated with 70% sulphuric acid and 5% NaOH and observation were noted on the action of the textile samples to these agencies.

2.2.2. Determination of λmax for Colour Match of Stripped Dyes with Commercial dyes

The three textile samples were cut into dimension of 4 cm x 10 cm (2.8 g±0.2) and added into three different labeled beakers (250 cm^3). 50 ml of distilled water at 27°C was added each to the beakers and stirred at regular interval for 5 min. The coloured solution was concentrated over a water bath at 30°C for 24 hrs. Thin layer chromatographic technique (TLC) was carried out on each leached out dyes from the textile samples. Thereafter, TLC method of colour separation was used to access the colour composition of the leached dyes from the textile samples [7]. 0.0024M concentration of each of the four commercial dyes (Orange 11, Vat Green 9, Vat Red and Vat Violent 1) were separately prepared and their mixtures in equal ratios. The wave scan of the prepared dyes were run using the UV-Visible spectrophotometer (UV: 752N) to determine the λmax for each leached dye, the commercials and their corresponding mixed dyes. The λmax of the selected dyes were used to monitor the bleeding activity of the three textile samples.

2.2.3. Washing of the Textile Samples with Anti-bleeding Agents (Singly and Combined)

The samples (A, B and C) cut into equal dimensions (4 cm x 10 cm) were placed separately into 8 different beakers containing varying concentration NaCl as describe in Table 1. 50 ml of distilled water at 27°C was added to each of the beaker consisting of the sample and allowed to stand with constant stirring for 5 min. The Absorbance of each of the solution was taken at a predetermined wavelength of 560 nm, 480 nm and 540 nm for sample A, B and C respectively. The same procedure was repeated for Ascorbic Acid and Vinegar as shown in Table 1. The textile samples were also washed as described above with combinations of the anti-bleeding agents in varying proportion stated in Table 2.

2.2.4. Determination of the Best Performance Anti-bleeding Additives

The most effective anti-bleeding additives determined from the initial washing with singly and combined formed of additives based on their low absorbance values namely: NaCl, Na_2CO_3 and Ascorbic acid were prepared separately with varying concentration of 0.5g per 50 cm^3 of distilled water to 4.0 g/50 cm^3 separately at 27°C. The solution was then added together into another empty beaker. 50 ml of the mixed prepared solution from the beaker was measured out and each of the textile samples was added and stirred at constant interval for 5 min. The absorbance of effluent was quantified using UV-spectrophotometer (UV: 752N) at the usual predetermined wavelengths for the textile samples A, B and C respectively.

2.2.5. Formulation of the Anti-Bleeding Solution

66 g of ascorbic acid was weighed into 1 L standard flask and 500 ml of distilled water was added and swirl until a clear solution was obtained, then make up to the mark level. The procedure was repeated for 25g of NaCl/500 ml and 20 g Na_2CO_3/500 ml at 27°C±0.5 respectively. The three solutions were gently transferred (due to effervescence of CO_2) into 2 L standard flask. The solution prepared was then corked and stored for further analysis

2.2.6. Determination of the Best Liquor Ratio for the Anti-bleeding Solution Usage

The textile samples (A, B and C) were placed into fifteen (15) different (250 ml) beakers in which 5 beakers hold the same textile samples (2.8 g $\pm$ 0.5). The anti-bleeding solutions and distilled water at 27°C±0.5, were measured in the ratio 10:30 cm^3, 20:20 cm^3, 30:10 cm^3, 40:0 cm^3 and 0:40 cm^3 respectively into each of the beakers containing the sample one at a time. The samples were washed and their absorbance measured as previously described.

2.2.7. Determination of Fastness Properties of the Fabrics

The following fastness properties were performed on the textile samples, such as: washing fastness (Using soap and detergent); Light Fastness (Xenon arc light and sunlight); ironing (dry heat), rubbing fastness and perspiration. These assessments were carried out in compliance with the International Standard Organization (ISO) procedures as described by the Society of Dyers and Colourist [8-13].

Table 1. Singly Screened Anti-bleeding Additives.

Beakers (250 ml)	NaCl (g)	(g)	g)	Vinegar (ml)	Ascorbic Acid (g)
1	0.5	0.5	0.5	1.0	0.5
2	1.0	1.0	1.0	2.0	1.0
3	1.5	1.5	1.5	3.0	1.5
4	2.0	2.0	2.0	4.0	2.0
5	2.5	2.5	2.5	5.0	2.5
6	3.0	3.0	3.0	6.0	3.0
7	3.5	3.5	3.5	7.0	3.5
8	4.0	4.0	4.0	8.0	4.0

Table 2. Anti-Bleeding additives combined together.

Beakers (250 ml) + 100 ml H_2O	NaCl (g) + Vinegar (ml)	(g) + Vinegar (ml)	(g) + Vinegar (ml)	NaCl (g) +Ascorbic acid (g)	NaCl (g) + Na_2CO_3 (g)	Na_2CO_3 (g) + Ascorbic acid (g)
1	0.5 +1.0	0.5 +1.0	0.5 +1.0	0.5 +0.5	0.5 +0.5	0.5 +0.5
2	1.0+ 2.0	1.0+ 2.0	1.0+ 2.0	1.0+ 1.0	1.0+ 1.0	1.0+ 1.0
3	1.5 + 3.0	1.5 + 3.0	1.5 + 3.0	1.5 + 1.5	1.5 + 1.5	1.5 + 1.5
4	2.0 + 4.0	2.0 + 4.0	2.0 + 4.0	2.5 + 2.5	2.5 + 2.5	2.5 + 2.5
5	2.5+ 5.0	2.5+ 5.0	2.5+ 5.0	2.5+ 2.5	2.5+ 2.5	2.5+ 2.5
6	3.0 + 6.0	3.0 + 6.0	3.0 + 6.0	3.0 + 3.0	3.0 + 3.0	3.0 + 3.0
7	3.5 + 7.0	3.5 + 7.0	3.5 + 7.0	3.5 + 3.5	3.5 + 3.5	3.5 + 3.5
8	4.0 + 8.0	4.0 + 8.0	4.0 + 8.0	4.0 + 4.0	4.0 + 4.0	4.0 + 4.0

(i). Fastness to Washing with Detergent and Bar Soap

Swabs from the textile samples were used for this study. Swabs labeled (A2, B2 and C2) with a dimension 4 cm x 10 cm (2.8 g ± 0.2) were washed in 0.5 g detergent (Good Mama) per 50 ml of the solution made up of 30:10 water: anti-bleeding ratio and rinsed with water for 5 min. The same procedure was repeated for swabs labeled (A3, B3 and C3). However, this batch was rinsed with 50 ml solution of 35:5 ml of water: anti-bleeding ratio. The control textile swabs (A1, B1 and C1), was washed only in 0.5 g of detergent per 50 ml distilled water for 5min. The procedure was also carried out for another batch of textile samples washed with soap (Lux) at the same temperature and concentrations. The textile samples were thereafter dried at a temperature of about 50°C for 2 hrs. The observable colour change was assessed using grey scale and the mean value of result obtained was taken as fastness rating for the test [8-10].

(ii). Fastness to Artificial Light (Xenon arc) and Day Light (Sun)

The textile samples washed previously with the formulated anti-bleeding solution, were used for this test. The (8) blue wool light Fastness testing standards of 50 mm X 10 mm and creases free were mounted lengthwise on the specimen holders of light fastness tester model 225. Both were exposed simultaneously for 4h (2h interval per day) at 63°C ± 2°C for 2 days to the artificial light generated within the instrument. A 65% relative humidity was generated within the instrument by saturated solution of (73 g per 100 ml). Another three sets of the samples that have been previously washed were mounted on white cardboards along with blue wool and exposed to daylight (sunlight) by hanging on a line in an open air for 2hrs, between the hours of 11.00am-1.00pm for 4 days. The average temperature of the daylight during exposure of the fabrics ranges between 40-45°C ± 5.0°C. The Fabrics were then assessed for colour fastness by comparing the colour of specimen with that of the reference standard (blue wool). The mean value of each result obtained taken as the fastness rating for the test [8, 12, 13].

(iii). Rubbing Fastness Test

Each swab from the treated and untreated textile samples, 20 cm x 4 cm was placed on the flat bed of the rubbing device. The finger of the crock meter (Hegenstlier E7 Model) was placed on the sample and rubbed back and forth for 10 complete cycles [14]. The grey scale was used to assess the change of shade of the coloured samples.

(iv). Hot Ironing Fastness Test

Swabs of the textile samples (4 cm x 10 cm) were treated as previously described were positioned on a dry white cotton cloth. The pressing iron at a temperature of 75°C ± 5°C was placed on top of the textile samples for 15 secs. Then each set samples was assessed immediately and after exposure to air for change of colour with grey scale. The mean value of the results obtained in all the three treatments was taken as the fastness rating for the test [14].

(v). Perspiration Fastness

Each of textile samples with a dimension 10 cm x 4 cm was rubbed 10 times in 10 secs with dry white cloth fixed on the crock meter apparatus (Heginstler E7), after pre-sprinkled with 5% aqueous ammonia for alkali perspiration and 5% hydrochloric acid for acid perspiration [14]. This procedure was repeated for textile samples (A1, B1, C1), that has been pre-washed with formulated anti-bleeding solution.

2.2.8. Applicability: Laundering of Half-yard Textile with the Solution

Half yard (0.46 m) of textile sample, A, was washed in a washing machine (Heir thermocool) for 5 min at regular interval for five times and the effluent was analyzed with colour match of commercial dye A, that has similar λmax. The colour changes of the treated and untreated effluents from the samples were analyzed using a colour comparator (Lovinbound Tinctometer EC-2000).

2.2.9. Physicochemical Parameters of the Anti-Bleeding Solution

The following tests were carried out on the prepared anti-bleeding solutions for eight (8) weeks, to monitor the solutions storage (or Shelf life): Alkalinity, Acidity, pH, chloride, BOD, conductivity, temperature, turbidity, DO and relative density according to standard method [16],[17]. Also, the colour variation of the anti-bleeding was accessed during the period of storage using a colour comparator (Lovibund Tinctometer EC-2000).

(i). Determination of Electrical Conductivity

The conductivity of the sample was analyzed using conductivity meter which was a conductivity measuring bridge type MC3 instrument. The sample was mixed and an aliquot was taken and poured into the meter sample holder, the reading knob was dipped into it and the reading was taken and recorded [16, 17, 18].

(ii). Determination of Turbidity

Turbidity of the anti-bleeding solution was analyzed using nephelometery method [14, 17],[18] with potable LABTECH digital turbidity metre (DR/890) data logging colorimeter. Distilled water was used to zero the instrument after calibration with standard turbidity suspension supplied with the instrument after setting to read turbidity. The sample was agitated and 20 cm^3 of it was poured into the turbidity meter tube and place in the machine thereafter, the reading was taken [15].

(iii). Determination of pH

The pH meter (Jenway 3015) was primarily standardized using a prepared buffer of pH 4 and pH 9. The electrode was carefully suspended in the sample and allowed to stand until a steady reading was observed before taking the reading [16, 18].

(iv). Temperature

Temperature was measured using portable calibrated mercury thermometer [19, 20].

(v). Dissolved Oxygen

250 cm^3 of the Anti-Bleeding solution was placed into a clean dry beaker and a DO meter was dipped in it. The reading was taken after obtaining a stable and constant value.

(vi). Biochemical Oxygen Demand (BOD)

The BOD5 value of the sample was calculated by taking the difference in the readings of day 0 (DO0) and day 5 (DO5) of the sample poured in an amber bottle and kept in dark room for five days. The resulting difference deduced from the values becomes the BOD5 of the sample [20]

$$\text{Calculation: } BOD_5 = DO_0 - DO_5$$

Where,

DO0= Dissolved oxygen of the first day

DO5= Dissolved oxygen of the fifth day

(vii). Determination of the Total Alkalinity of the solution

0.1488M of HCl was titrated against 25cm^3 of the solution (anti-bleeding) after the addition of two drops of methyl orange indicator to the pipetted solution. The titration continues until a colour change is observed. This immediately follows by the addition of 2 drops of phenolphthalein indicator to the same solution to determine its phenolphthalein alkalinity [16, 17]. The equation used for calculation:

$$Total\ Alkalinity = \frac{(V_m - V_p)x\ Mx\ 100{,}000}{Volume\ of\ the\ Sample\ used\ (ml)}$$

Where,

M is the concentration of the acid used

Vm is the titer value for the methyl orange alkalinity (cm^3)

Vp is the titer value for phenolphthalein alkalinity (cm^3) and 100,000 is the multiplier.

(viii). Determination of the Acidity of the Solution

The acidity of the solution was determined by titrating 0.02M NaOH with 25cm^3 of anti-bleeding solution using 2 drops of phenolphthalein indicator. The acid value was calculated using the formular [16, 17]:

$$Acidity\ Determination = \frac{Tv\ x\ M\ x\ 100{,}000}{Volume\ of\ the\ Sample\ Used\ (ml)}$$

Where,

M is the concentration of the NaOH used

TV is the titer value (cm^3), while 100,000 is the multiplier.

(ix) Determination of Chloride Content of the Solution

0.2M AgNO3 was titrated against 25 cm^3 of the solution after the addition of chromate indicator. The chloride content was calculated as described by in the formula [16, 17]:

$$Chloride\ Content = \frac{Tv\ x\ M\ x\ 70{,}900}{Volume\ of\ the\ sample\ (ml)}$$

Where,

M is the concentration of AgNO3 used

TV is the titer value (cm^3), while 70,900 is the multiplier

3. Results

Table 3. Wavelength maxima (λmax) of commercial dyes used for colour matching of the bleeded textile samples.

		λmax (nm)	**Textile Sample match**	**λmax (nm)**
A	Vat Orange 11	560	Textile Sample A	540 nm
B	Vat Violent 1	480	-	
C	Vat Green 9	490	-	
D	Vat Red	560	-	
*E= (A+B+C+D)	-	480	Textile Sample B	500 nm
*F = (A +D)	-	540	Textile sample C	520 nm
*G = (B+C)	-	460	-	
*H = (B +D)	-	500	-	

*Commercial dyes mixed in equal ratio.

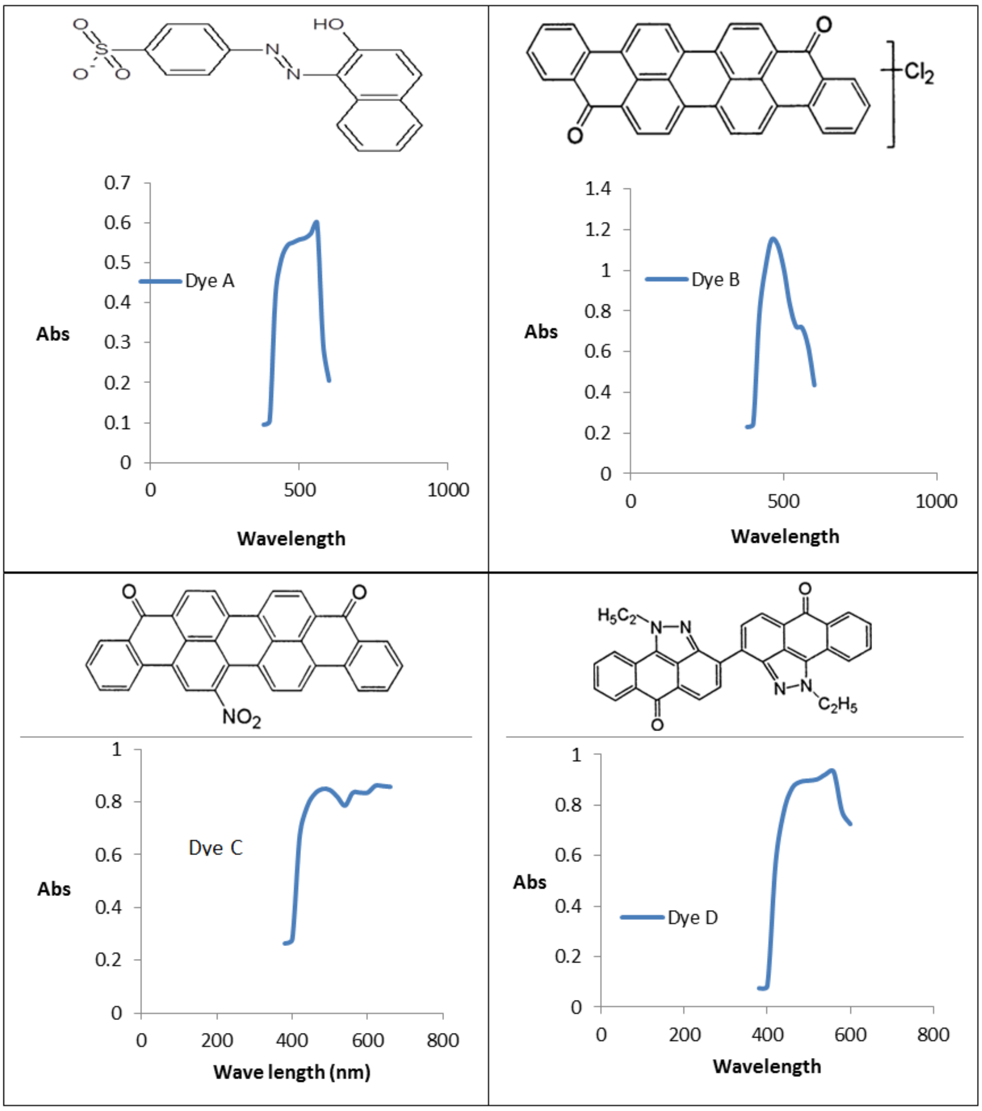
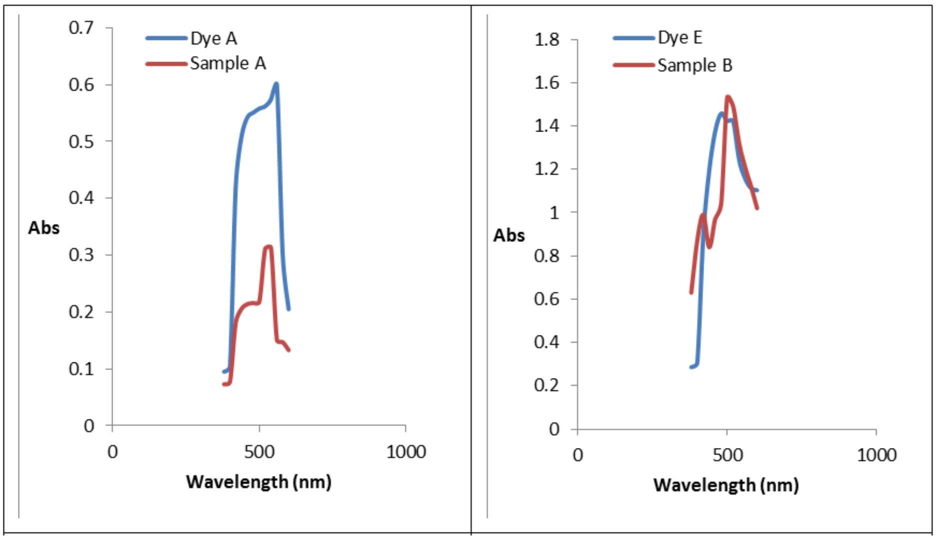


Figure 2. Dye A (Orange 11) λmax 560 nm; Dye B (Vat violet) λmax 480 nm; Dye C (Vat Green 9) λmax 490 nm; Dye D (Vat Red) λmax 560 nm.



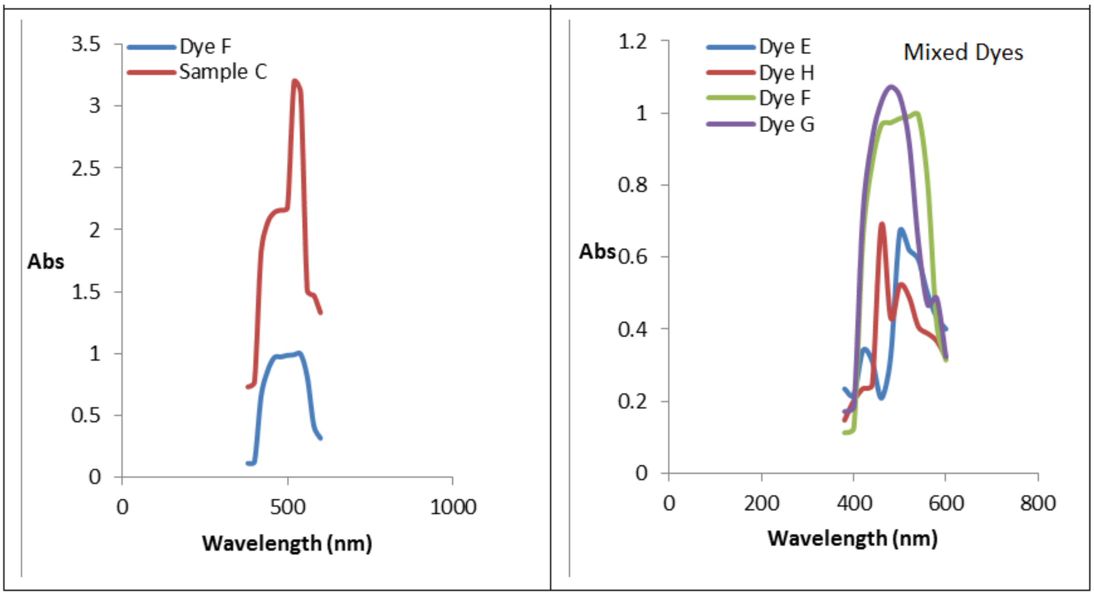


Figure 3. Comparative wave scan of the commercial dyes and their corresponding matches with the leached dyes from textile samples A, B, C.

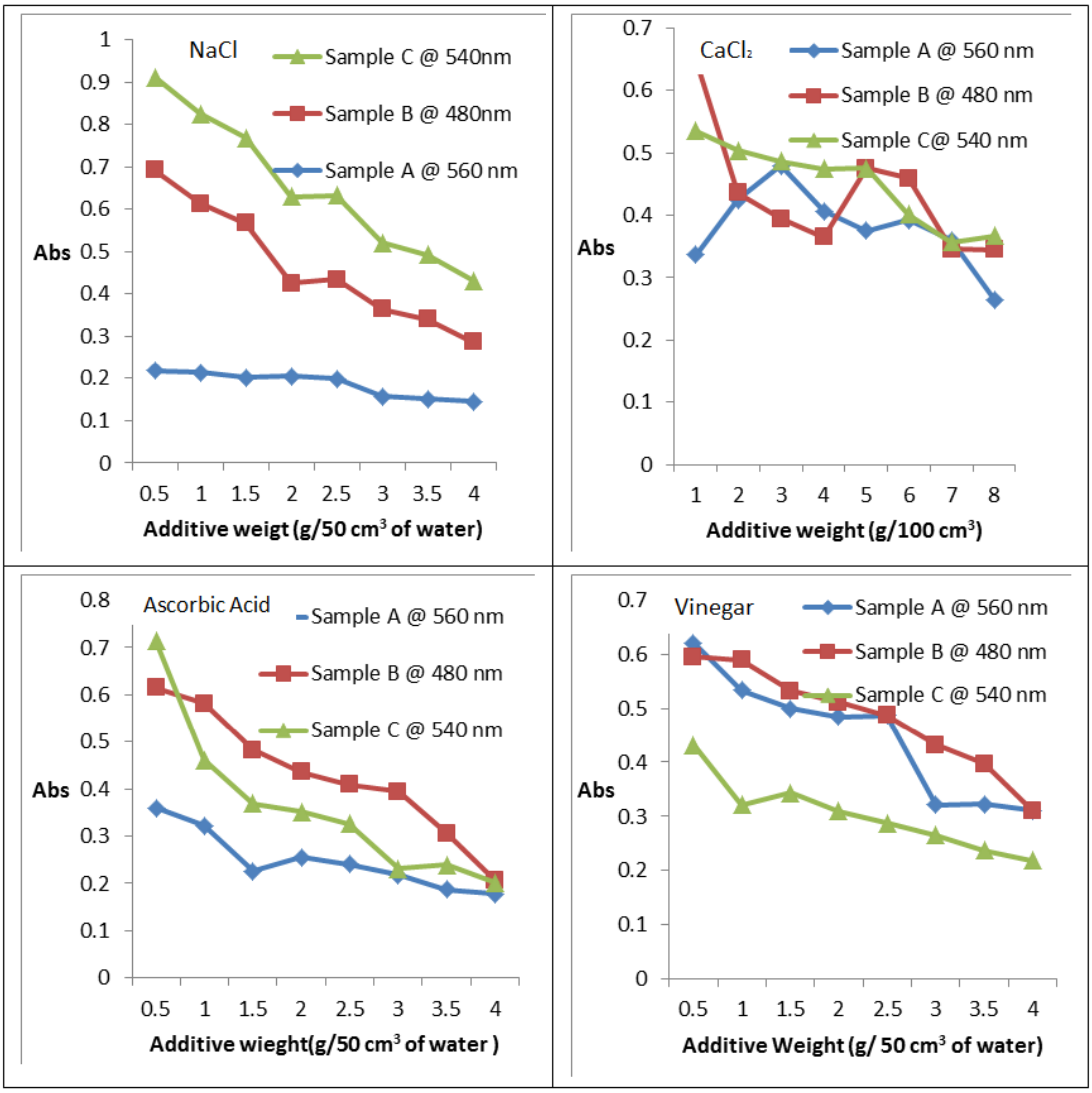


Figure 4. Performance of the single anti-bleeding additives in the laundered textile samples A, B, C.

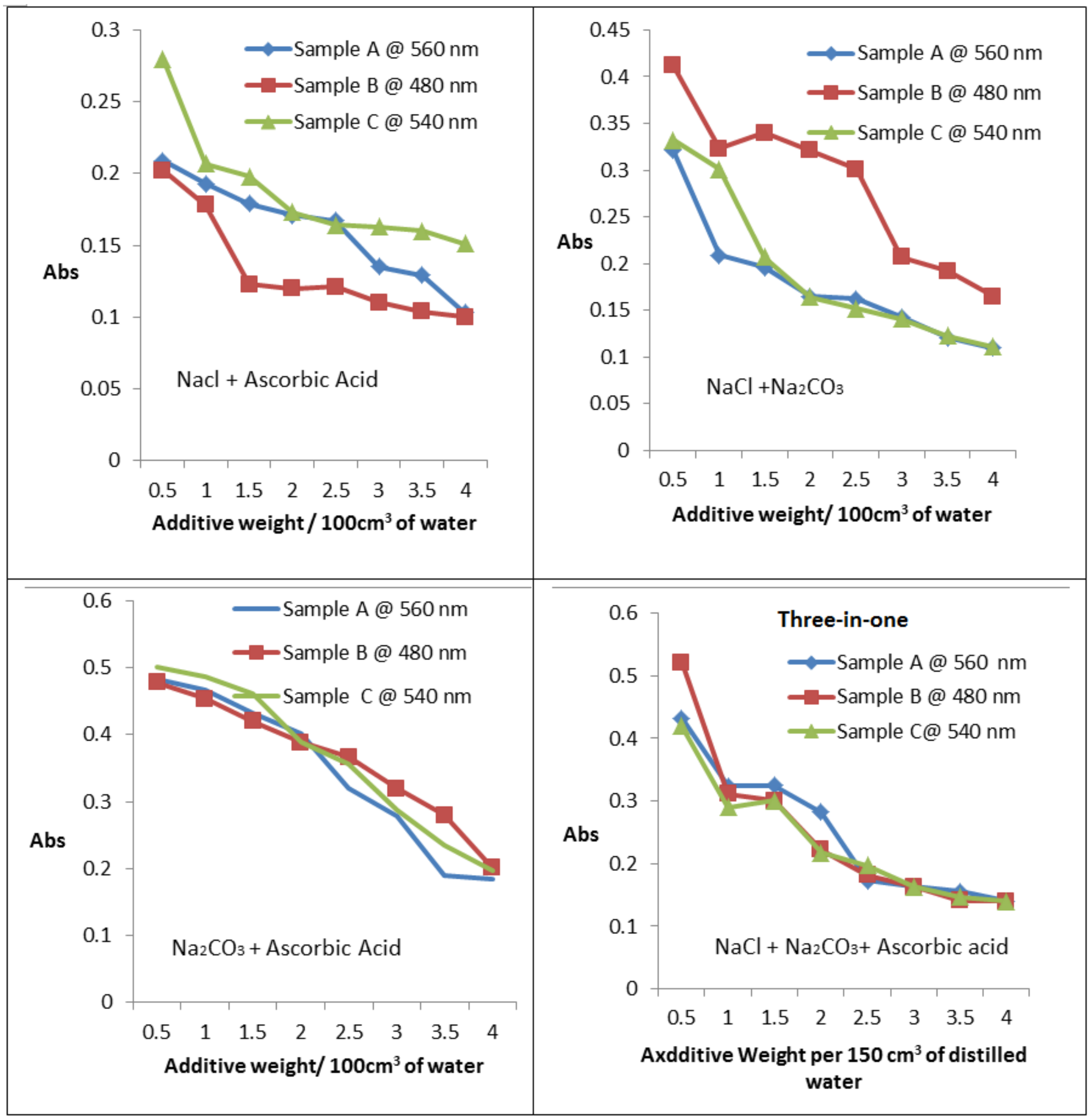
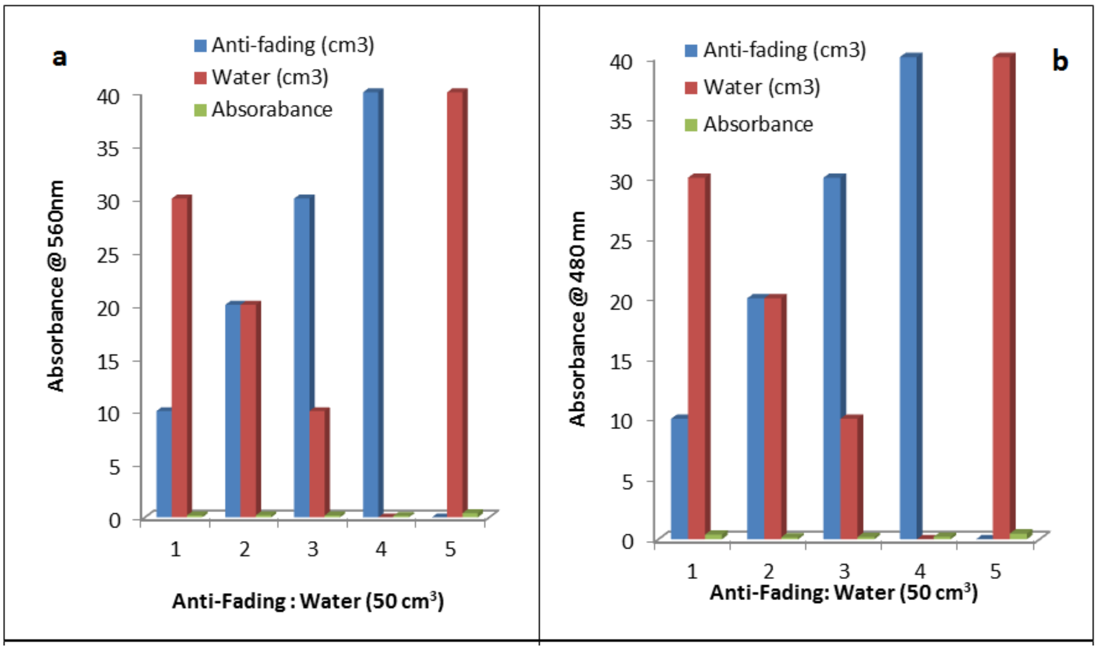


Figure 5. Performance of the combined anti-bleeding additive on the laundered Textile samples A, B, C.



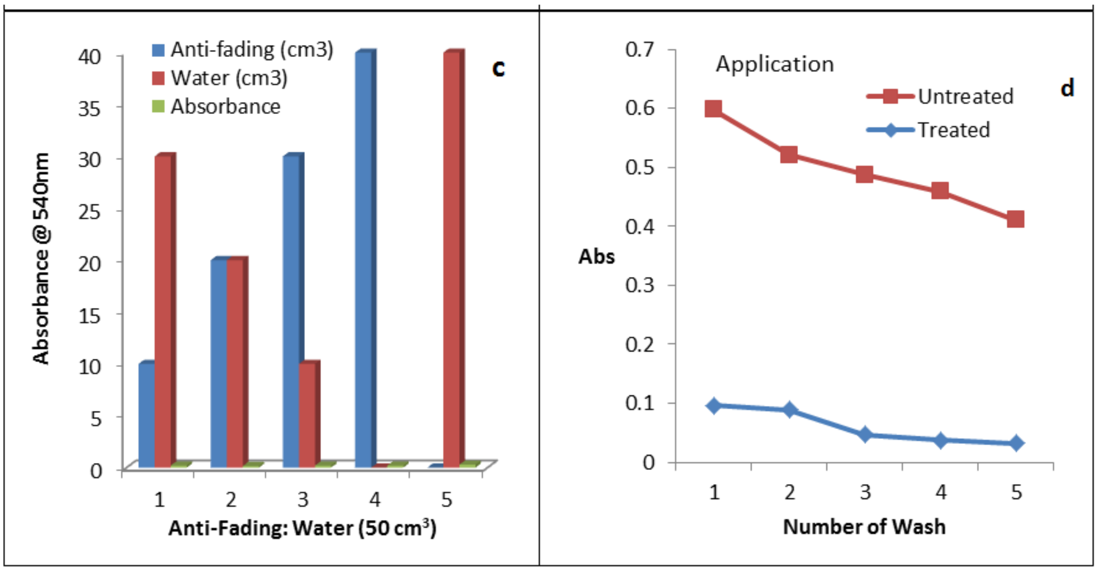


Figure 6. (a-c) performance evaluation of varying ratio of anti-bleeding to water on textile samples A, B, C respectively; (d) performance evaluation of anti-bleeding solution on larger textile sample A.

Table 4. Fastness properties of the textile samples laundered with anti-bleeding solutions.

Samples	Washing BS DT		Ironing BS DT		Rubbing BS DT		SF BS DT		MF BS DT		Acid Perspiration	Alkali Perspiration
A1	3	3	2+	3	2	2	2	2	3	3	3	3
B1	3	2+	3	3	3	3	3	3	2	3	3	3
C1	3	3	3	4	4	4+	4	4	4	4	4	4
Mean Values	3	3	2+	3+	3	3	3	3	3	3+	3	3
A2	4	4	4	4	4	4	4	4	4	4	4	4
B2	4+	4	4	4	4	4	4	4+	4	4	4	4
C2	4+	4	5	5	5	4	5	4	4	5	5	5
Mean Values	4+	4	4+	4+	4+	4	4+	4	4	4+	4+	4+
A3	5	5	4	4	4	4	4	4	5	5	-	-
B3	5	5	4	4	4	4	4	5	5	5	-	-
C3	5	5	5	5	5	5	5	5	5	5	-	-
Mean Values	5	5	4+	4+	4+	4+	4+	4+	5	5	-	-

Key: BS- Bar Soap, DT- Detergent, MF- Machine fastness (Xenon arc Light), SF- Sunlight
A1, B1 and C1: Samples laundered with water and rinsed with water (control Sample)
A2, B2 and C2: Samples laundered with combination of water and anti-bleeding and consequently rinsed in water.
A3, B3 and C3: Samples laundered with combination of water and anti-bleeding and consequently rinsed in combination of water and anti-bleeding.
Grey Scale Rating: 1-poor, 2-Below average, 3-Average, 4-Good, 5-8 Excellent

Table 5. The Physicochemical properties of the anti-bleeding solution.

Parameter	1	2	3	4
Conductivity (µm/cm)	380.50^{a} ± 0.23	884.83^{e} ± 4.09	769.83^{d} ± 7.45	657.00^{c} ± 18.00
pH	4.41^{a} ± 0.01	4.99^{c} ± 0.01	5.04^{d} ± 0.01	4.81^{b} ± 0.01
Temperature (°C)	29.30^{b} ± 0.00	28.03^{a} ± 0.63	29.35^{b} ± 0.03	28.07^{a} ± 0.07
Electric Potential (mv)	133.00 ± 0.00	116.00 ± 0.00	119.00 ± 0.00	119 ± 0.00
Turbidity	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00
Chloride (mg/L)	737.32^{a} ± 0.02	737.36^{a} ± 0.01	737.34^{a} ± 0.01	1037.91^{f} ± 0.07
Free CO$_2$ (mg/L)	1054.73^{g} ± 0.02	1067.64 ± 0.07	1027.91^{f} ± 0.01	1023.92^{e} ± 1.92
Acidity (mg/L)	1368.93^{a} ± 0.02	2896.12^{f} ± 0.02	2910.14^{g} ± 0.09	2967.31^{h} ± 0.01
Total Alkalinity (mg/L)	2424.05^{b} ± 0.05	2184.35^{b} ± 0.03	1904.42^{b} ± 0.21	2262.65^{b} ± 0.33
Relative Density	1.03^{a} ± 0.00	1.04^{a} ± 0.00	1.03^{a} ± 0.01	1.03^{a} ± 0.01

Table 5. Continued.

Parameter	5	6	7	8
Conductivity (µm/cm)	636.00^{b} ± 0.00	960.83^{f} ± 0.44	886.20^{e} ± 0.15	865.60^{e} ± 0.21
pH	5.49^{f} ± 0.03	5.45^{ef} ± 0.00	5.43^{e} ± 0.00	5.40^{e} ± 0.03
Temperature (°C)	28.60^{a} ±0.06	28.43^{a} ± 0.07	28.47^{q} ± 0.12	28.46^{a} ± 0.02
Electric Potential (mv)	117 ± 0.00	121 ± 0.00	125 ± 0.00	123 ± 0.00
Turbidity	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00
Chloride (mg/L)	850.53^{b} ± 0.15	975.49^{e} ± 0.10	890.50^{c} ± 0.00	964.21^{d} ± 0.01

Parameter	**5**	**6**	**7**	**8**
Free CO_2 (mg/L)	$973.48^{d} \pm 0.14$	$925.68^{c} \pm 0.01$	$882.90^{b} \pm 0.02$	$885.71^{b} \pm 0.01$
Acidity (mg/L)	$2565.60^{e} \pm 0.03$	$2192.\ 22^{d} \pm 0.00$	$2096.\ 53^{b} \pm 0.04$	$2120.33^{c} \pm 0.12$
Total Alkalinity (mg/L)	$2084.30^{b} \pm 0.03$	$2184.41^{b} \pm 0.05$	$2120.1`7^{b} \pm 0.17$	$887.95\ ^{a} \pm 666.67$
Relative Density	$1.08^{a} \pm 0.06$	$1.07\ ^{a} \pm 0.05$	$1.08\ ^{a} \pm 0.05$	$1.02\ ^{a} \pm 0.00$

Values are mean of triplicate determination (n=3) $\pm$ standard error, statistically significant at $p<0.05$ level where $a<b<c$

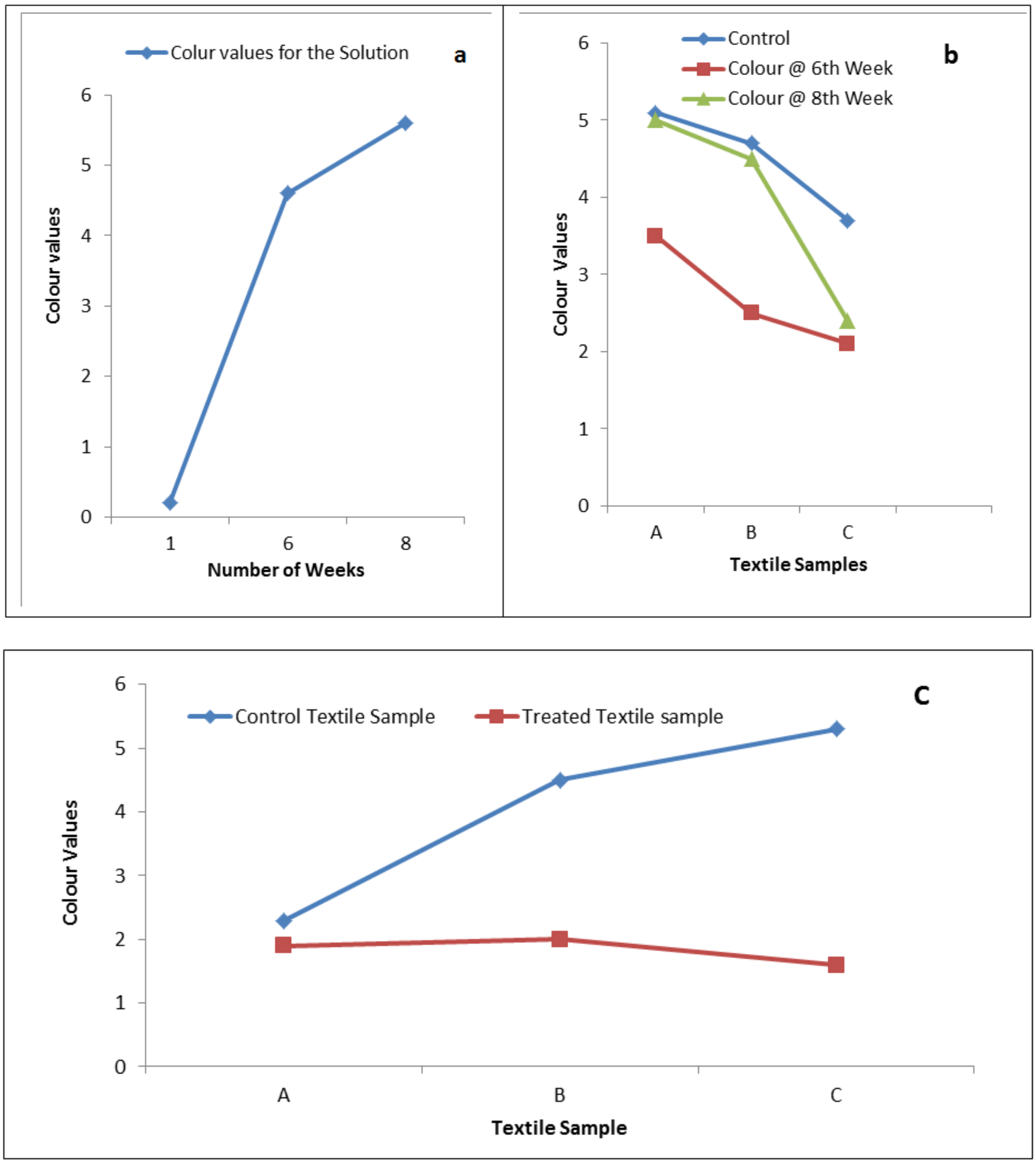


Figure 7. Colour variation of the formulated solution and its performance on the textile samples accessed by colour comparator.

4. Discussion

Burning and chemical test

The fibres that make up the textile samples do not shrink on approaching flame, burns readily without melting, and continues to burn after glowing and its residue after burning was a light gray ash. This characterizes the fibres of the three textile samples as cellulosic fibres when interacting with flame as reported by Guptal *et al* [21]. The fibre was not reactive to 70% sulphuric acid but destroys in 5% NaOH, confirmed the property of cellulosic fibres as confirmed by Oh *et al* [22, 6].

Wavelength maxima (λmax) of the commercial dyes matched with the bleeded textile samples.

Table 3 shows the maxima wavelengths of the commercial dyes and their equally mixed portion of dyes matched with the bleeded textile samples A, B, C. Figures 2 and 3 shows the wave scan of these dyes. Their values are in agreement with the elucidated TLC dye from the bleeded textile samples and spectral colours of the electromagnetic spectrum. Also, there is a tendency that the dyes used in textile samples A, B, C were in tandem with the commercial dyes scanned [23].

Performance of the anti-bleeding additives on the laundered textile samples

The result of the laundered textile samples that were screened singly with the anti-bleeding solution was shown in Figure 4. The solutions of all the single anti-bleeding additives are all electrolyte with ranging degree of dissociations [24, 25]. NaCl proves to be more effective in regulating the bleeding of the textile apparels. Calcium chloride in Figure 4 exhibit a zig- zag trend in the values of their absorbance compared to NaCl that fall abruptly as the additive concentration increases. This effect can be due to NaCl exhibiting more solubility than $CaCl_2$ by driving itself easily into the fibre matrix [24] which can be as a result of the phenomenon called common ion effect or the small atomic size of sodium [26]. However, the anti-bleeding action can be assumed to be the effect of the electrolyte in the solution which has the capacity of enhancing maximum exhaustion of the textile dyes. The same action observed for NaCl was observed for other singly screened additives (Na_2CO_3, ascorbic acid, vinegar) at varying concentration per 50 cm^3 of distilled water. Na_2CO_3 is known for its dye fixing additive used during dyeing operation of most different classes of dyes such as vat dyeing and acid dyeing [26]. Udoka [27] shows that vinegar is an anti-bleeding additive which can be use the in reduction of bleeding and crocking of textile apparel. However when the anti-bleeding additives of all the singly screened additives were considered, NaCl, Ascorbic Acid and Na_2CO_3 proved to be the most effective.

Performance of the combined anti-bleeding additives on the laundered textile samples

Figure 5 shows the result of laundered textile samples A, B and C with the combined anti-bleeding additives. The combined form of NaCl and ascorbic acid shows a more excellent regulation of retarding the bleeding of the dyes from the fabrics. This is evident from 3.0 g/100 ml of each of the additive (Figure 5). When the activity of NaCl is compared in combined form to its single form, anti-bleeding activity takes prominent effect from 1.5 g/100 ml of the additive compared to its effect at 3.0 g/ 50 ml in single form. Furthermore, Cristea and Vilarem [28] observed from the report that ascorbic acid is a good anti-oxidizing agent. It enhances fastness of built up hue on substrates (especially textile material) to light and heat. It is worthy of note that reduction in bleeding of the textile samples takes place with increasing concentration of the additives, exhibiting more excellent activity to regulate the bleeding in combined form. This same action was observed when NaCl was combined with Na2CO3. Na2CO3 is known for creating proper pH for dye bath and also acts as dye fixing agent. Reduction in absorbance values from 0.207 to 0.165 for Sample A, 0.141 to 0.111 for sample B and C was observed. The possible reaction in the dye bath for both sodium chloride and ascorbic acid is shown in equation (1):

$$NaCl+C_6H_8O_6 \rightarrow C_6H_7O_6Na+HCl \quad (1)$$

However, when Na_2CO_3 was combined with ascorbic acid. The effect of the two eco-friendly dye auxiliaries reduces the bleeding of the textile samples as manifested in their absorbance values. Sample A reduces from 0.279 to 0.184, Sample B 0.320-0.201 and 0.288 to 0.184 for sample C respectively. The possible reaction resulting from the dyebath for reaction of the ascorbic acid and Sodium trioxocarbonate (iv) depicted in equation (2).

$$Na_2CO_3+2C_6H_8O_6 \rightarrow 2C_6H_7O_6Na+H_2O+CO_2 \quad (2)$$

The use of Na_2CO_3 enhances the adequate dye-fibre bonding during dyeing and the subsequent retention of the dyes in washing [29]. The performance of additives in single and combined form was then evaluated and most effective anti-bleeding additives selected were (NaCl, Na_2CO_3 and Ascorbic acid) which forestall bleeding more efficiently. At additive concentration of 1 g/50 cm^3, a sharp reduction in the bleeding activity of the textile samples was recorded. The values of their absorbance falls from 0.432 to 0.324 for sample A, 0.521 to 0.325 for sample B, 0.420 to 0.290 from sample C in Figure 5 (three-in-one). This activity can be as a result of the combined activity of the dye fixing agents [6], their electrolytes properties and their active anti-oxidizing actions [26]. Furthermore, Jung *et al* [30] reveals that in dyeing with azo and vat dyes, it is importance to use soft water. This possibility can be archived base on the presence of water softening additive (Na_2CO_3) present in the formulation. Also, it enhances dye uptake by the textile samples from leaching out. The dye molecules used on the textiles samples are probably azo dye (Orange 11) and Vat dyes (Vat green 9, Vat Red and Vat Violet) which requires pH range of 7.5-10.5, to maintain the shades of the samples, which can be enhanced by the presence of Na_2CO_3 present in the formulated solution during washing [28-31].

Applicability: Liquor ratio

Figure 6a-6c shows the varying ratio of the anti-bleeding to water and their corresponding absorbance values for textile samples A, B, C respectively. The most effective formulation was found to be 10:30 and 40:0 of anti-bleeding to water. However, 10:30 was much more considered based on its cost effectiveness. The combination of NaCl, Na_2CO_3 and absorbic acid account for the joint works of forestalling the bleeding dyes from the textile substrate and hence, enhances its fastness to washing and to light (see Table 4). Figure 6d shows a great disparity in their absorbance measurement of treated (washed with anti-bleeding solution) and untreated textile sample. The results of the absorbance, from the first to the fifth washing shows that, the formulation regulate the bleeding even at the first washing. When their absorbance values were compared with the normal washing, it shows 0.097 for treated and 0.501 for the untreated. The value of their absorbance decreases with increasing washing. The anti-bleeding solution actually has a great effect by drastically reducing dye bleeding from the material. 80% of the dyes were retained in the fabrics.

Fastness Properties of the Laundered Textile Apparels

The fastness property of textile apparel accounts for its commercial acceptance. The mean fastness ratings of textile samples under study are shown in Table 4. Their overall mean fastness rating can be considered good, 4.5-5.0 (56-63%) and >3 (60%) based on a scale of 8 and 5 for light and other fastness test respectively [31, 32, 33]. The reasons adduced in the previous discussion sufficed for the retention of the dyes during washing of the textile samples.

Comparing the textile samples swabs with the control textile swabs (A1, B1, C1), the sample swabs laundered with combination of water and anti-bleeding solution and rinsed with water and the formulation (A3, B3, C3) exhibit more excellent fastness with mean fastness rating of 4^+, 4^+ and 5 for samples A, B, C, when compared with the values for other set of textile swabs (A2, B2, C2). When Vat dyes is employed in dyeing of fabrics, on exposure to light its exhibit excellent fastness property [31]. However, the use of an active anti-oxidizing, electrolyte and dye fixing auxiliaries embedded in this anti-bleeding formulation enhances the fastness of the textile dyes to light from natural source (sunlight) and to UV rays coming from Xenon arc light [29, 31, 34].

Physicochemical Properties of the Anti-bleeding Solution

The physicochemical properties of the formulated anti-bleeding solution are shown in Table 5. The results of eight weeks of periodic monitoring show that the formulation has a relative density of 1.03±0.5 which is slightly higher than the density of water, and slightly acidic pH, 4.4-5.40. The solution has a high conductivity and this was in agreement with Al-Kdasi *et al* [35], which reveals that solution consisting of appreciable amount of this salt has a high value of conductivity. The NaCl plays an important role as dyeing electrolyte. The high value of free CO_2 (10547.73 ± 0.2mg/L) from first week of production and decreases gradually to 885.71 ± 0.01 (mg/L) at the eight week. The presence of free CO_2 can be as a result of the Na_2CO_3 reacting with other additives leading to effervescence of gas (CO_2). The formulation also consists of high chloride content and alkalinity value of 2424.05±0.05 (mg/L) from the first week, while the acidity content is high from first week 1368.93±0.02 to 2120±0.12 (mg/L) at the eighth week. The high chloride content is as a result of the NaCl additive present in the formulation. However, the value for the turbidity remains constant (2.00±0.00) for all the eight weeks. These suggest that all through the period of examination there was no formation of colloidal precipitate capable of increasing the turbidity value of the formulation. It was observed that, after six weeks of periodic study of the formulation, an amber colouration was formed; confirming the presence of sodium ascorbate and this increases its colour values as shown in Figure 7a. However, the colour change does not affect the potency as an anti-bleeding solution in laundering fabric. There was appreciable dye retention in all the textile samples (Figure 7b, c). The use of colour comparator in the determination of the intensity of the bleeding textile samples shows the forestalling ability of the anti-bleeding solution (Figure 7). Furthermore, 87% dye was retained in textile sample A, 90.53% and 89.83% dyes in textile samples B and C respectively after washing.

5. Conclusion

This research has revealed the investigation of anti-bleeding activity of the five active dye additives namely: NaCl, Na_2CO_3, ascorbic acid, vinegar and $CaCl_2$. These additives were singly screened and in combined form. The most active additives that forestall bleeding of the three textile samples under investigation were NaCl, Na_2CO_3 and ascorbic acid at ratio of 1.25: 1: 1.65 w/w. The turbidity of the prepared anti-bleeding solution were maintain throughout the 8-weeks of study and its efficacy upto 6-weeks after production. Within this efficacy period, the solution has excellent performance in forestalling bleeding in multicoloured textile apparels when used during washing and subsequent rinsing of the materials up to over 80% dye retentions in the textile samples

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