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Dye Uptake Assessment of Cotton and Baft Fabrics Washed with Some Selected Nigerian Detergents

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Abstract

Prior to dyeing process, there are certain vital pre-treatment processes that must be given to fabrics. One of which is the scouring of fabrics with detergents. These detergents are known as amphiphathic substances. However, it needful to determine the effectiveness of these detergents used in scouring fabrics by measuring the dye-uptake of the textile material scoured with these detergents during dyeing process. This was done by the use of seven (7) selected Nigerian domestic detergents of known chemical constituents. The cotton and the baft textile sample swabs of 50 cm X 50 cm dimension (7.1g + 0.2) was pre-washed with Nittol, Virony, Ariel, Omo, Zip, Waw and Sunlight detergents of known concentration and goods to liquor ratio of 1:50. These textile swabs were rinsed for 5 times and oven dried at 50°C. Then the pre-mordanting treatment was done to enhance optimum dye absorption of the textile substrates through the use of 1% commercial alum. Each washed textile sample swabs was stepped into the mordanting liquor at 27°C. The wave scan and the calibration curve of the dye stuff used (Plant pigment: *Pigment Vegetal*) was determine using the UV-Visible spectrophotometer. Each dye bath of known concentration (0.29/100ml) was prepared for dyeing the textile swabs and the percentage dye uptake was determined alongside the control textile (textile swabs not washed without detergent), for a dyeing duration of 1-20 min. The baft textile samples generally have higher dye uptake value than the pure cotton. However, out of seven detergents, only Virony (48.91%) and Omo (52.14%) have the highest dye uptake at 360 and 180 seconds respectively.

Keyword

Cotton, Baft, Detergent, Dye Uptake, Washing Dyeing etc

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1. Introduction

Over the years, cellulosic fabrics especially cotton as gain predominant interest of world's textile traders, dyers and colourist [1-2]. This interest is based on various advantageous properties of the fibre that make up the fabric. These include hydrophilicity, air permeability, biodegradability, and a lack of static electricity [3]. Similarly, Baft fabrics (coarse cotton fabrics) also belong to this cellulosic category, whose morphological appearance has lesser orientation when compared to the pure cotton which is crystalline (well oriented) in nature [4]. Cotton is a cellulosic material which exists as a linear polymer consisting of b-D glucopyranose units covalently linked by 1,4-glycosidic bonds [5-6]. Each glucose unit consists of a hydroxyl group which is the main sites of dye fixation as well as chemical modification. The dye often used for this category of fibres is known as the reactive dye [7].

Furthermore, cotton fabrics are primarily dyed with reactive dyes because of the brilliancy, varieties of hue, and high wash-fastness of reactive dyes, which are anionic in nature [8-12]. However, prior to the dyeing operation, scouring (washing) with detergents is essential to remove the extraneous materials and saponify the plant fats which forestalls dye uptake of the fabrics

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and result in poor dye-fibre interaction [13]. This consequently leads to bleeding of the fabrics when rinsed in water [14]. These Detergents are amphipathic molecules containing both hydrophobic carbon (tail) and polar groups (head) at both ends [15]. Being amphipathic in nature, they exhibit unique properties such as forming hydrogen bond with water molecules and to solubilize hydrophobic compounds in water [15]. Consequently, fatty constituents are solubilized and water soluble impurities are removed. Domestic and commercial laundry detergent systems vary widely in composition. However their fundamental composition includes alkyl benzene sulphonate (the active ingredient), tripolyphosphate, sodium silicate, sodium carbonate, sodium perborate, sodium sulphate, carboxymethyl cellulose, foaming agent, optical brightening agent etc. While others contain oxygen generating bleaching compounds such as sodium perborate or sodium per-carbonate [16]. This washing operation is known as the pre-treatment operation and is vital prior to dyeing [13]. During dyeing, one of the most important parameters measured is the dye uptake. This parameter is defined as the direct dip dyeing where all substrate in contact with the dye solution absorbs the dye from the dye bath, leading to the gradual decrease of dye concentration in the solution. Also, for the single dye, the dye uptake is defined as the ratio of dye quantity brought away by the material to the initial total dye quantity in the solution with the constant volume. The expression is that dye uptake = (concentration before dyeing – concentration after dyeing)/concentration before dyeing [3]. In dyeing, cellulosic fibers comes in contact with water and slightly negative charges are built-up at the surface of the substrate due to the ionization of the hydroxyl groups [8-9; 12]. Therefore, a large amount of electrolytes, such as Glauber's salt or sodium chloride, is required to neutralize the repulsive forces between negative charges of the dye and negative charges produced on the fiber surface [11, 17]. The introduction of electrolyte further enhances the optimal dye uptake and forestalls bleeding of dyed fabrics [14]. This research is aimed at investigating some selected Nigerian domestic detergents used to pre-wash the baft and the pure cotton fabrics prior to their dyeing operation. And to quantitatively assess the effects of these detergents vis-à-vis the dye uptake of the cotton and baft fabric respectively.

2. Materials and Methods

2.1. Materials

Seven (7) distinct brands of Nigerian made detergents with identified names and chemical composition in Table 1, were selected and purchased from Nao supermarket at Akure North Local Government of Ondo State, Nigeria. Two yards (1.83 m) of the textile samples (pure cotton and baft cotton), were equally purchased in the same location. While the natural dye stuff (Plant pigment: *Pigment Vegetal*) was obtained from Lagos, Nigeria. The washing equipment used was light weight washing machine (2.0 kg Haier thermo-cool: Top loading mini washing machine) and UV-Visible spectrophotometer (UV: 752N) were obtained from the Textile and Polymer Laboratory at the Federal University of Technology, Akure. The analytical weighing balance, glass wares were also gotten from the same location.

Table 1. Showing the detergents brand and their compositions (Ingredients).

Samples	Detergent	Ingredients
A	NITTOL	LABS, Sodium Tripolyphosphate, Sodium Carbonate, Sodium Sulphate, Sodium perborate, Sodium Silicate, Perfume.
B	VIRONY	Surfactants, Builders, Oxygen based bleaching agent, Polycarboxylates, Enzymes, Optical brightener, Perfume.
C	ARIEL	Builders, Surfactants, Oxygen based bleaching agent, Polycarboxylates, Enzymes, Optical brightener, Perfume.
D	OMO	Surfactants, Sodium Sulphate, Sodium Carbonate, Sodium Silicate, Alumina Silicate, Clay, Enzymes, Perfume, Polycarbonates, Optical brightener, Polycarboxylates.
E	ZIP	LABS, Sodium Carbonate, Sodium Silicate, Sodium Sulphate, Cellulose gum, Optical brightening agent, Perfume and Photo-bleach.
F	WAW	Builder system, Sodium Sulphate, Surfactant, Optical brightener, Perfume.
G	SUNLIGHT	Surfactant, Sodium Carbonate, Sodium Silicate, Sodium Sulphate, perfume, Sodium carboxymethyl cellulose, Optical brightener.

2.2. Methods

2.2.1. Preparation of Cotton Materials (Pure Cotton and Baft) Prior to Washing.

Seven (7) swabs of cotton textile sample were cut into a dimension of 50 cm X 50 cm (7.1g + 0.2). (Adetuyi *et al.*, 2020). This dimension was replicated for baft textile sample. These textile swabs were labelled in relation to the selected washing detergents. 355 ml of distilled water added into 1000 ml of measuring cylinder. And the weight of the goods to liquor ratio (1:50) was determined. 5 g of each detergent was added into each measuring cylinder containing the distilled water [18].

2.2.2. Laundry Process

Each of the detergent solution in the measuring cylinder was transferred into the domestic washing machine (2.0 kg Haier thermo-cool: Top loading mini washing machine). Each labelled cotton and baft textile samples in relation to their respective washing detergent, was added into the machine containing the solution and washed for 15 minutes at a temperature of 27°C +0.2. Thereafter, it was rinsed in distilled water (5 times) and oven dried at 40°C [19]. This procedure was repeated for swabs of cotton and baft fabrics washed and rinsed without detergents

2.2.3. Preparation of Fabrics for Dyeing

The pre-treatment method was carried out by modifying Kumaresan *et al*. [20] method. 1g of the each textile samples was measured out of the samples washed with detergents and those rinsed and dried only with distilled water. To pre-treat these textile samples with 1% commercial alum, 1.76 g of the commercial alum was weighed into 250 ml measuring cylinder. Then 20 ml of hot distilled water (65°C) was added to the alum and swirl. It was then make-up to 100 ml mark. Each textile swabs was then added into the prepared mordanting solution for the pre-treatment and then dried at a room temperature (27°C).

2.2.4. Dye Standardization

To determine the maximum absorbance (λmax) of the dye stuff to be used, the stock solution was prepared by dissolving 0.2 g of the dye stuff (Plant pigment: *Pigment Vegetal*) in 100 ml of ethanol at 60°C [20]. An aliquot of the stock was taken and the wave scan was determined using UV spectrophotometer (UV: 752N) from 380-600 nm.

2.2.5. Determination of the Percentage Dye Uptake

The dye bath was prepared by add 50 ml of the prepared dye solution into 250 ml conical flask. Then each labelled and pre-treated textile swabs previously discussed (2.2.3) was introduced into the dye bath, swirled and stirred with a glass rod at regular interval for dyeing to take place. This process was carried out within 1- 20 min at room temperature (27°C + 0.2) [19; 11]. The each dyed textile swabs was dried and the absorbance of the dye stock after the process was determine using the UV spectrophotometer (UV: 752N) at a known wavelength determine in 2.2.4. The percentage exhaustion was then determined mathematically, using the formula:

$$\text{Percentage dye uptake (E)} = \frac{\mathrm{D}i - \mathrm{D}pdl}{\mathrm{D}i} \times 100$$

Where

E is the percentage dye uptake,

D*i* is the initial concentration of the dye bath,

D*pdl* concentration in post dye liquor.

3. Results and Discussion

3.1. Maximum Wavelength and Calibration Curve of the Dye Stuff

The Figure 1 shows the wave scan of the natural dye stuff (Plant pigment: *Pigment Vegetal*) having it maximum absorption (λmax) at 510 nm. Figure 2 shows the calibration curve plot having increasing absorbance as the concentration increases. This behaviour obeys the Beer-Lambert law relating increase in the absorbance of colourants to increase in their concentration [8]. Furthermore, the λmax value is in close proximity with the study on the natural *Rubia* dye carried out by Ashis *et al.* [21]. It is also in tandem with the range of values for spectra and complementary colours [22]. However, it is higher when the value is compared to the natural dye colorant from pomegranate rind (λmax = 460 nm) [23].

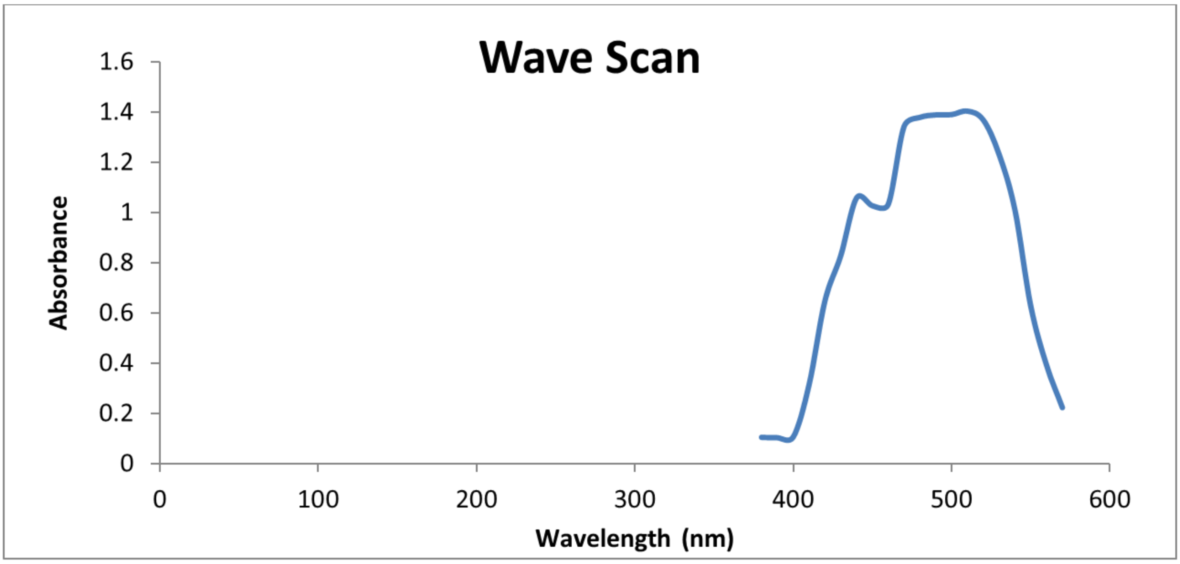

Figure 1. Wave scan of the natural dye stuff (Plant pigment: *Pigment Vegetal*).

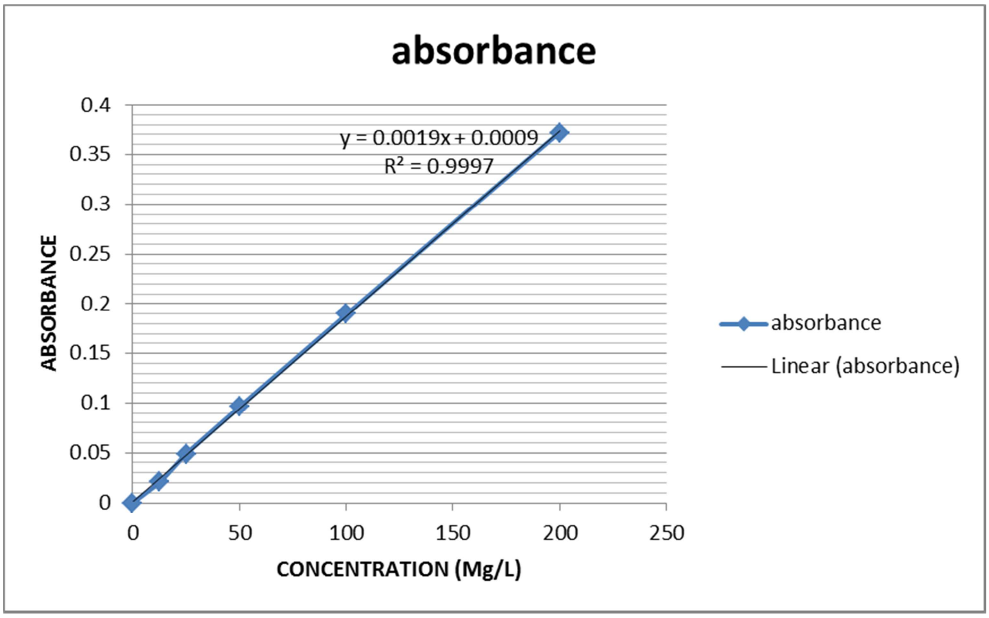

Figure 2. Calibration curve of the natural dye stuff (Plant pigment: *Pigment Vegetal*).

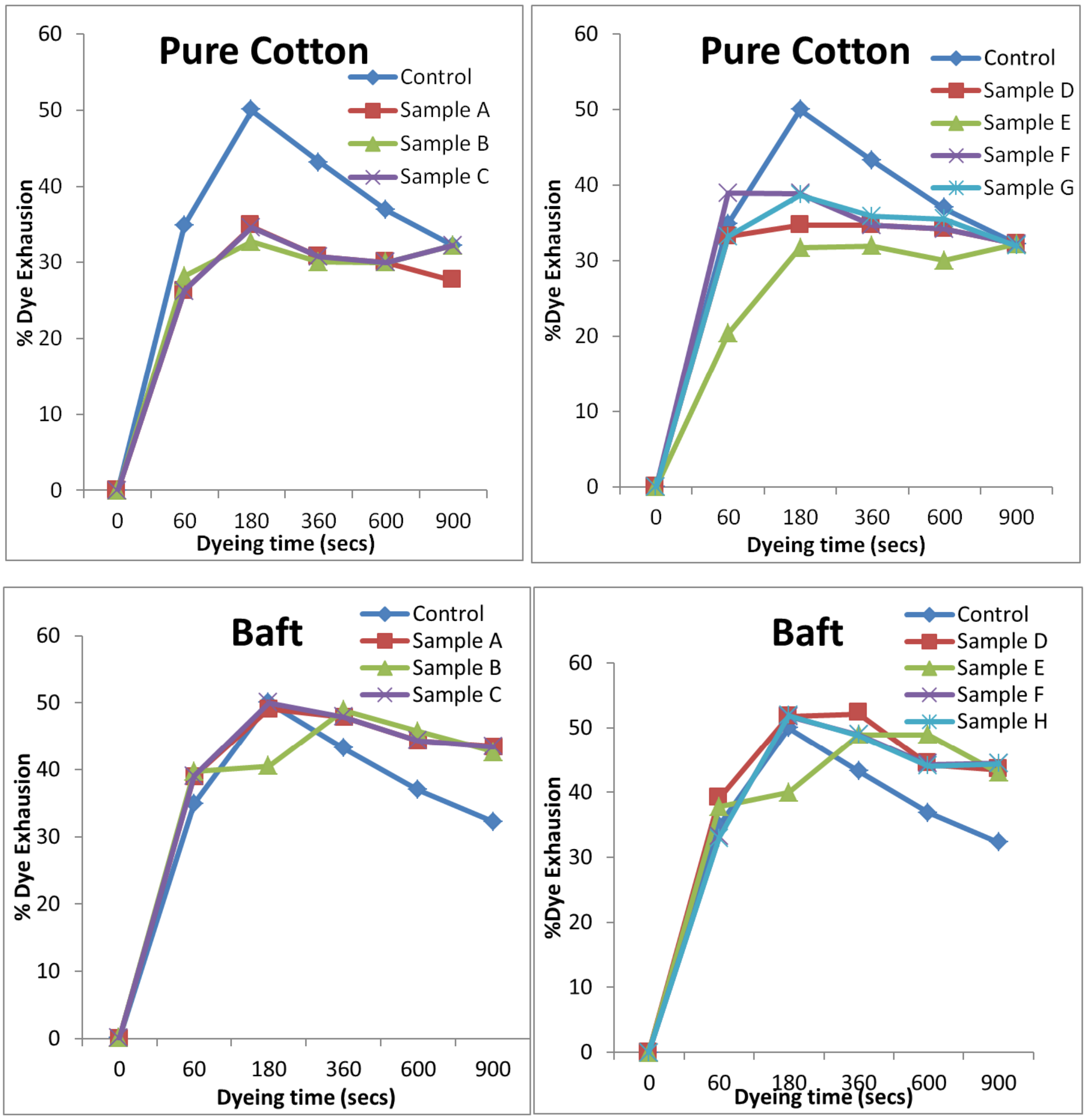

Figure 3. %Dye Uptake of dyed pure cotton and baft textile samples.

3.2. Percentage Dye Exhaustion of Samples Washed with Various Detergents

The Figure 3 shows the percentage dye uptake for pure cotton and baft washed seven selected Nigerian made detergents (Nittol, Virony, Ariel, Omo, Zip, Waw and Sunlight). Considering the control (i.e the textile sample swabs washed without detergents), its value of dye uptake is 49.95% and 55.85% at 180 secs for pure cotton and baft respectively. However, the Nittol washed textile sample swabs has its maximum dye uptake of 34.67%. While the respective value for textile swabs washed with Virony, Ariel, Omo and Sunlight are 32.69%, 34.55%, 34.67% and 38.69% respectively at 180 secs. However, the textile swabs washed with Zip has a value of 31.97% at 360 secs and 39.01% for Waw at 60 secs respectively. These values were for pure cotton textile swabs. The baft textile swabs washed with similar detergents under study has a value of 49.09%, 34.55%, 51.8%, 51.9% at 180 secs for Nittol, Ariel, Waw and sunlight detergent respectively. While Virony and Omo washed textile swabs has highest value of 48.91%, 52.14% respectively.

Mercerization alters the morphological arrangement of cotton fibre which is brought about by alkali compounds present in detergent constituents and enhances cationization of the cotton fibre substrate during dyeing [24]. Hence, facilitate increase in the dye uptake. This suggest the reason for the higher dye uptake recorded for textile swabs washed with Virony and Omo detergents having appreciable cationic surfactants [25]. Generally, from the results the baft has higher percentage dye uptake compared to the pure cotton. This may result for the less ordered orientation (armophous) of the fibre matrix of baft when compared to the crystalline arrangement of pure cotton. This morphological arrangement is said to have an appreciable effective in the maximum exhaustion of the dye into the fibre matrix [26-27]. In addition to this claims, Anthoulias and Burkinsha [28] reveals that the coarse and hydrophilic nature of the Baft textile materials resulting to diffusion, absorption and transportation of the dyes molecules into the fibre matrix. Dyeing process continues until either all of the dye in the dyebath moves into the substrate or until an equilibrium is achieved. At this point, the dye molecules constantly exchange between the aqueous phase and fibre phase and the process of dye adsorption onto the fibre and the process of dye desorption from the fibre are equal [29]. However, the variation in the time for the exhaustion is based on the chemical composition present in each detergent.

4. Conclusion

The effect of the dye uptake on the selected Nigerian washed detergent was assessed and only Virony (48.91%) and Omo (52.14%) have the highest dye uptake at 360 and 180 seconds respectively. However, based on the coarse morphological nature of baft, it has has higher dye uptake than the pure cotton of crystalline arrangement. The dyeing process was also enhancing by pre-treatment with the natural plant pigment used for the dyeing process.

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