Research Article
Volume 10:6, 2020
DOI: 10.37421/jtese.2020.10.422

Journal of
Textile Science & Engineering

ISSN: 2165-8064 Open Access

Study on the Application and Colour Fastness Properties of Aqueous Dye Extract from Whitfieldia Lateritia Leaves

Okonkwo SN*, Onuegbu GC, Obasi HC, Nnorom OO and Ojiaku PC

Department of Polymer and Textile Engineering, Federal University of Technology Owerri, Nigeria

Abstract

The application and colour fastness properties of aqueous dye extract from Whitfieldia lateritia leaves were studied. The UV-Vis and FT-IR spectra of the dye extracts showed the presence of polyphenols such as flavonoids and tannins. The extract was used to dye cotton fabrics using different mordants viz- alum/tannic acid, ferrous sulphate and potassium dichromate. Pre-mordanting, simultaneous mordanting and post-mordanting methods were also used to dye the cotton fabrics in the presence of sodium chloride as an electrolyte. The cotton fabrics showed a total or slight change in colours with different mordants and mordanting methods. The dyed fabrics were evaluated for Colour fastness to Washing, perspiration and light. The general assessment of the colour fastness tests showed that the aqueous extract of Whitfieldia lat-eritia dye applied under the influence of mordants irrespective of the method of application used showed good ratings.

Keywords: Whitfieldia lateritia • Natural dye • Cotton fabric • Mordants • Colour fastness

Introduction

The application of dyes gotten from natural sources for the dyeing of textile goods has become a possible choice of interest. The selection of local species as a natural dye can make its use practicable, thereby enhancing local biodiversity. Before the development of synthetic dyes, natural dyes were used to colour textile goods. The discovery of synthetic dyes solved the problem of poor colour fastness, lack of variety of colour shades and inadequate technical knowhow on the extraction and application techniques experienced with the use of natural dyes [1]. Synthetic dyes are inexpensive, available in a variety of colours and have excellent fastness properties. However, they are reported to have allergic, toxic and even carcinogenic properties, which are harmful to humans and the environment [2]. Environmental interest and consciousness have, therefore, favoured the development of sustainable products and processes that are less injurious to man and his environment at large [3]. Natural dyes are found to be less toxic than synthetic dyes and generate waste effluents that can be treated via biodegradation. Thus, researchers are focusing their interest to this family of colourants as seemingly alternatives to certain synthetic dyes, especially those that pose a threat to human health and the environment [4,5]. Understanding the potential of vegetable-based materials for natural dye extraction is significant in enabling their application and value from local species.

Natural dyes have some shortcomings in terms of stability and affinity for substrates. Therefore, they require dye procedures or fixatives, such as mordants. Most of these mordants are metal salts, which could form coordination complexes with the natural dye molecule [6]. Also, biomordants, often tannin-rich compounds, which are responsible for the formation of hydrogen bonds, can be used in place of metallic mordants. The use of these mordants improves the stability of the colour produced by natural dyes on substrates [7].

Natural dyes and ways of improving their affinity on textiles have been studied. For instance, the extraction, dyeing and colourfastness properties of dye extracted from the bark of *Croton urucurana* Baill have been investigated [8]. The extract was found to be a potential natural dye source for textile dyeing as good color fastness ratings of the dyed fabrics were obtained [8].

A study on the potential of anthocyanins from blueberries as a natural dye for cotton: a combined experimental and theoretical study, have been undertaken. The study explored the capabilities of anthocyanins as a natural dye on cellulose-based materials. The aim is to investigate the potential of different types of biomordants, which might be equally or more effective compared to metal mordants amongst others. It was reported that the use of metallic mordants was successful for stannous chloride with pre-mordanting only. It further revealed that biomordants showed no sufficient intermolecular interactions to replace this metal salt but endured the wash and light tests [9].

Extraction, characterisation and application of natural dyes from selected plants in Uganda for dyeing of the cotton fabric have been studied. The study used simultaneous mordanting method with 10% (o.w.f) of four selected mordants to dye cotton fabric. The mordanting process resulted in different ratings of colour depth, chroma (C) and hues (H) with noticeable changes in lightness rating (L), and mordant dependent. Light and wash fastness ratings were good, between 3 and 4, suitable for textile application [10].

Effects of mordanting methods of dye from *Veronia amygdalina* on cotton fabrics colouration have been studied. From the study, cotton fabrics when dyed in the absence of mordants showed a good wash fastness of (4), an excellent dry fastness of (4-5), wet rubbing fastness of (4) and good light fastness of (5). On the application of mordants, various colours were produced with different mordants, and the shades also varied with mordanting techniques though there was no significant improvement on the rubbing and wash fastness. Light fastness was improved from (5) to (6) when mordants were applied especially iron water, ferrous sulphate and potassium dichromate. Still, there was no significant increase in light fastness when alum was used as mordant. Furthermore, they observed that the application of mordants and the method of mordanting enhanced the colour characteristic of the dye on cotton fabrics. They reported that post mordanting technique gave the best colour fastness and strength on the fabrics for most of the mordants used [11].

***Address for Correspondence:** Okonkwo SN, Department of Polymer and Textile Engineering, Federal University of Technology Owerri, Nigeria, Tel: 07063866455; E-mail: samdamian10@gmail.com*

Received 24 August 2020; **Accepted** 05 October 2020; **Published** 12 October 2020

The dyeability and fastness qualities of dye from a henna plant on linen and cotton fibres in the presence of some selected mordants have been investigated [12]. The results of the experiment showed that cotton had a high rate of dye intake than linen. The report further suggested that the colours obtained depended mostly on the solvent used. However, hot water extraction appeared to be more efficacious [12].

An investigation has also been carried out on the extraction of natural dye from green chili (*Capsicum annum*) plant [13]. The dye was extracted using the solvent extraction method while the dyeing was done with two different mordants; copper sulphate and ferrous sulphate. The study reported that the principal colouring agent in green chili is oleoresin. The mordants produced different yellow shades of the chili dye. They gave good light fastness, good rub fastness and moderate wash fastness when the dye was applied on a 100% scoured cotton material [13].

Similarly, the effect of potassium aluminum sulphate (PAS) on dye concentration, hue, and fastness to wash and light for selected regional dyewoods (black walnut, Osage orange, and eastern red cedar) on woolen yarn has been investigated [14]. The use of a PAS mordant influenced the dye concentration, hue, and colour fastness to light and laundering of woolen yarn dyed with sawmill waste with implications for the triple bottom line. Regardless of the type of mordant used, Osage orange changed from a golden yellow to a tan/brown on exposure to light. PAS mordant caused an enhanced colour fastness to light when used for black walnut and eastern red cedar. In contrast, a significant difference for laundering but not for light, was observed for Osage orange [14].

A similar study compared aluminium mordants on the colour fastness of the natural dye on cotton fabric. The result of the study carried out clarifies that the type of aluminium mordant used had much influence on the colour fastness to washing whereas the type of dye used had much impact on colour fastness to light [15].

In another research work, ramie fabrics were dyed with four different natural dyes using rare earth as a mordant. The effect of pre-mordanting, simultaneous mordanting and post mordanting methods were studied. The result indicated that the highest dye uptake by the fabrics was obtained with the post mordanting method. It was also observed that the colour fastness to washing, light and rubbing of the ramie fabrics dyed with the natural dyes were improved by the use of rare earth as mordant. The study also was able to prove that rare earth can be an environmentally friendly mordant in natural dyeing [16].

Natural dye extracted from tea leaves have been used to dye cotton fabric. Use of ferrous sulphate following a pre-mordanting method increased the depth of shade of cotton much more than that obtained for the presence of (Copper sulphate, Tannic acid and Alum) in the dye bath [17].

The extraction of dye from Dapap tree (Erythrina) particularly *Erythrina fusca* L. and its application on cotton and silk in the presence of fixer solutions ($FeSO_4$ and $CaCO_3$) have been studied. From their experiment, they reported that the dye is a red colour dye and that $FeSO_4$ was a better fixer solution (mordant) than $CaCO_3$ [18].

In Nigeria, *Whitfieldia lateritia* is among the most understudied plants as a source of natural dye. *Whitfieldia lateritia* is an evergreen flowering plant belonging to the family of acanthaceae, having well-developed leaves alternately arranged along the stem. It has been found in large quantities in Sierra Leone and Nigeria, both in Africa [19,20].

Study on the proximate and mineral compositions of *Whitfieldia lateritia* leaves have been reported [21]. Analysis of the plant extract has shown that the it contains flavonoids, alkaloids, saponins, cardiac glycosides and tannins in the leaves of *Whitfieldia lateritia* [20,22]. In a recent study, dyeing of cotton fabric with sodium hydroxide extract of *Whitfieldia lateritia* dye has been reported to be most efficient at 70°C for the range of temperatures studied, at a dyeing time of 60 min. Also, different mordants and mordant application techniques have been used to improve the affinity between the dye and cotton fibre thereby resulting in an increase in its colour fastness properties as well as a change in colour of the dyed fabric [23].

This work attempts to study the application and colour fastness properties of cotton fabrics dyed with aqueous dye extract from *Whitfieldia lateritia* in the presence of mordants.

Materials and Method

Materials

Whitfieldia lateritia plant leaves were obtained from Ihiagwa, Owerri, Nigeria. It was authenticated by Mrs. M. N Osuagwu of the Department of Plant Science and Biotechnology, Michael Okpala University of Agriculture Umudike, Nigeria. A desized and bleached plain weave cotton fabric (60 ± 1 warp and 48 ± 1 weft per inch) and white polyester fabric (55 ± 1warp and 55 ± 1weft per inch) were obtained from Woolen, and Synthetic Textile Manufacturing Ltd, Ikeja, Lagos Nigeria. Other materials used include perspirometer, blue wool scale, grey scale, distilled wate. Sodium hydroxide, sodium chloride, potassium aluminium sulphate, tannic acid, disodium hydrogen orthophosphate dehydrate, histidine monohydrochloride monohydrate, sodium dihydrogen orthophosphate dehydrate were analytical grade products of Loba Chemie PVT Limited.

Sample preparation

The leaves of *Whitfieldia lateritia* plant were washed and kept under room temperature (27± 2°C) for 14 days to dry until crisp. The dried leaves were then pulverized using a mill to reduce particle size and passed through a micro-sieve of 53µm mesh size and stored in polyethylene bags for further use. Different quantities of *Whitfieldia lateritia* powder were obtained using an electronic weighing balance to be used for extraction.

Dye extraction using distilled water as solvent

The extraction was done at material to liquor ratio (MLR) of 1:25 at a temperature of 70°C for 60 min using a thermostatic water bath. The methodology employed in Okonkwo et al. [23] was used. The aqueous dye solution was prepared by adding 1gm of *Whitfieldia lateritia* leaves powder in a beaker containing 25 ml of water and heating the solution at 70°C for 60 min. The dye solution was filtered to obtain a clear solution which was further used to dye cotton fabric. Figure 1 shows the images of the *Whitfieldia lateritia* leaves and aqueous extract used in this study.

UV-Vis spectroscopy and FT-IR spectroscopy of the dye extract

Cary 300 UV-Visible spectrophotometer was employed to determine the wavelength of maximum absorption (λ_{max}) of *Whitfieldia lateritia* dye extract. A blank was prepared for the extracting solvent. An automatic pipette was used to put the blank and the dye extract in their respective cuvettes. The sample was then scanned between the region 300-800 nm wavelength and the value for maximum absorbance, and its corresponding wavelength was determined [20]. FT-IR of the extract was conducted using the Cary 630 FT-IR spectrophotometer, with 16 scans within the spectral range of 4000-650 cm^{-1} at a resolution of 8 cm^{-1}.

Figure 1. Images of the *Whitfieldia lateritia* (a) leaves and (b) aqueous extract.

Mordants and mordanting methods

Potassium dichromate, ferrous sulphate and a mixture of alum and tannic acid (50/50) were the mordants used for the fabric dyeing. The Pre-mordanting, simultaneous mordanting and post-mordanting methods were employed. The weight of mordant and sodium chloride salt (NaCl) used was 30% (0.3 g) each, on the weight (1 g) of the fabric. The methodology used in this present study for mordanting of fabrics was as reported in Okonkwo et al. [23].

Pre-mordanting

This involves the immersion of the fabrics in an aqueous solution containing the mordants at a temperature of 70°C for 40 min using a material to liquor ratio (MLR) of 1:40. After pre-mordanting, the dyeing of the mordanted fabrics was done for 60 min, in the presence of NaCl salt. The dye bath was stirred at 5 min interval during dyeing. After dyeing for 60 min, the fabrics were removed and rinsed in cold distilled water before drying under shade.

Simultaneous mordanting

In the simultaneous mordanting method, the fabrics were immersed in the dye bath containing a solution of the mordant, dye and NaCl salt. Dyeing took place at 70°C for 60 min using an MLR of 1:40. The dye bath was stirred at 5 min interval of the process. After dyeing for 60 min, the fabrics were removed and rinsed in cold distilled water before drying under shade.

Post-mordanting

In the post method, the fabrics were immersed in a dye bath containing the dye extract only. Dyeing was carried out at 70°C for 60 min at an MLR of 1:40 in the presence of NaCl salt. Intermittent stirring was maintained at every 5 min. After dyeing, the fabrics were then mordanted in a bath containing the mordant. Mordanting was carried out for 40 min at an MLR of 1:40 at 70°C. The fabrics were removed after mordanting and rinsed in cold distilled water before drying under shade.

Colour fastness assessment

Colour fastness of dyed fabrics was evaluated for washing, perspiration and light fastness properties, according to the test procedures used by Okonkwo et al. [23].

Results and Discussion

UV-Vis spectroscopy analysis

The UV-Vis Spectroscopy analysis of the aqueous dye extract of *Whitfieldia lateritia* is shown in Figure 2. The figure shows that the maximum absorption lies within the UV region, specifically at a wavelength of 308 nm and this falls within the spectral range of flavonoids. This result is in line with the findings of Okonkwo et al. [20] and Charu et al. [24]. Phenols and phenolic acids have been reported to show absorption bands between 250 and 290 nm. In comparison, flavones and flavonols exhibit two absorption bands of approximately the same intensity at about 250 and 350 nm [6]. The maximum absorption of the present extract may be associated with the presence of flavonoids.

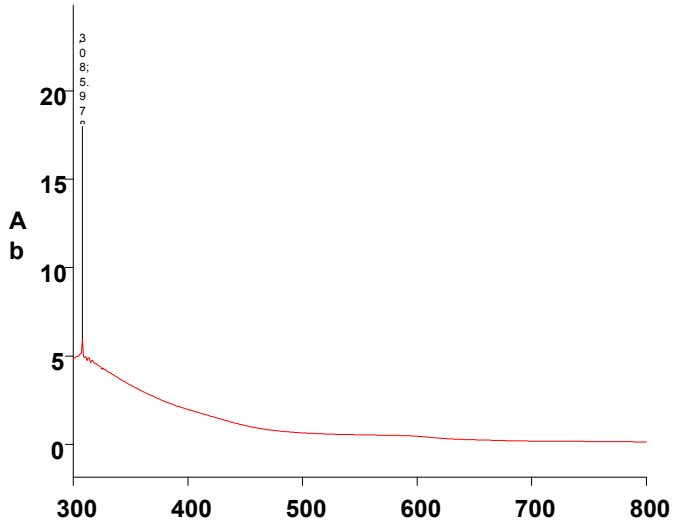

Figure 2. Absorption spectrum of aqueous dye extract of *Whitfieldia lateritia* leaves.

FT-IR was used to identify the functional groups of the components in the dye extract. Figure 3 shows that the absorbance spectrum is pure since it has less than five absorption bands. This occurrence suggests that the extract components may be a low molecular weight compound [25]. The absorption band of O-H stretching vibrations around 3257.7cm^{-1} was observed. This suggests the presence of polyphenols, such as flavonoids and tannins [6]. The broad absorbance seen is due to the intramolecular hydrogen bonding between the OH group and adjacent oxygen atom [26]. This observation is in agreement with the result reported in Okonkwo et al. [20]. The peak at 2120.9 cm^{-1} is an indication of the presence of C≡C stretch that is an alkyne. This is most likely because the intensity of the peak is weak, which is also why it may be symmetrically substituted. Furthermore, an absorption band around 1636.3 cm^{-1} belonging to the C=C bond stretching vibrations was observed and is typical of a conjugated alkene.

Effect of mordant and mordanting methods on cotton fabrics dyed with aqueous dye extract of whitfieldia lateritia

The effect of mordants and mordanting methods on dyed cotton fabrics are presented in Figure 4. It can be seen that the colour shade of the fabric

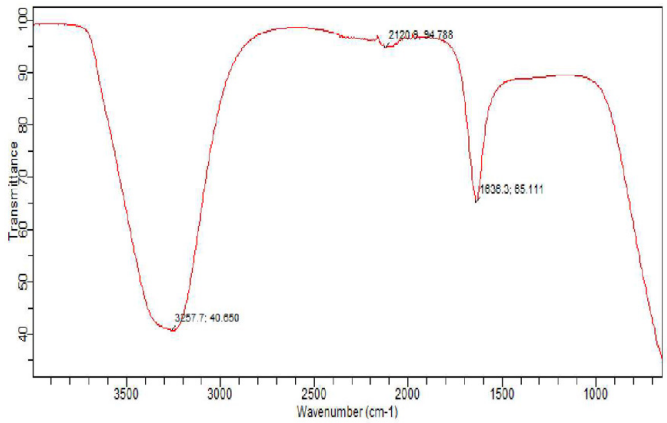

Figure 3. Infrared spectrum of *Whitfieldia lateritia* dye extracted with distilled water.

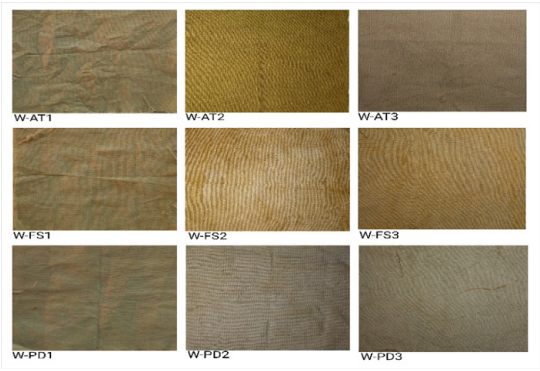

Figure 4. Cotton fabrics dyed with aqueous dye extract of *Whitfieldia lateritia* using different mordants and mordanting methods. Where: W-AT designates dyed cotton fabrics mordanted with a mixture of alum and tannic acid. W-PD designates dyed cotton fabrics mordanted with potassium dichromate. W-FS designates dyed cotton fabrics mordanted with ferrous sulphate. The numbers "1, 2 and 3" represent "pre-, simultaneous and post-" mordanting methods respectively as used in this study.

shifted with a change in the mordant application method for all the mordants used. From the figure, it is further observed that the use of mordant on *Whitfieldia lateritia* dye extracts for dyeing of cotton fabrics causes a shift in colour. The shift could be due to the interaction between the molecules of the mordant, dye extract and the fabric. This observation is consistent with the findings of Okonkwo et al. [20] and Okonkwo et al. [23].

Colour fastness to washing

Table 1 describes the results for the colour fastness properties to washing. Fastness to the colour change of the dyed fabrics after washing gave a good result as none of the samples was below 3; the highest grade being 4/5 for W-AT_2 followed by W-FS_3 (4). The least grade was 3 for W-AT_1, W-PD_1, W-PD_2 and W-PD_3 on the grey scale for colour change. From the result, there was a colour change after washing of the fabrics indicating that some dye molecules which were not firmly attached to the fabric left the fabric during washing. The adjacent cotton fabrics were not noticeably stained as the fastness to staining was 4 except for W-FS_3, which recorded 5.

Table 1. Colour fastness properties to washing of cotton fabrics dyed with aqueous dye extract of *whitfieldia lateritia* using different mordants and mordanting methods.

Sample code	Wash Fastness	
	Colour change	Staining
W-AT_1	3	4
W-AT_2	04-May	4
W-AT_3	03-Apr	4
W-PD_1	3	4
W-PD_2	3	4
W-PD_3	3	4
W-FS_1	03-Apr	4
W-FS_2	03-Apr	4
W-FS_3	4	5

Colour fastness to perspiration

Table 2 displays the results for the colour fastness property to perspiration to cotton fabric dyed with the aqueous dye extract of *Whitfieldia lateritia* using different mordants and mordanting techniques. The grey scale is used to rate the performance of fabrics assessed for colour fastness to perspiration to colour change of the specimen and staining of the adjacent fabric. From the results obtained, the cotton fabrics dyed with this dye extract recorded excellent performance with the pre-mordanted fabric W-FS_1 having the least grade (2). From the result, it shows that fabrics dyed with aqueous extract of *Whitfieldia lateritia* dye will perform moderately well under conditions that promotes perspiration.

Table 2. Colour fastness properties to light and perspiration of cotton fabrics dyed with aqueous extract of *Whitfieldia lateritia* using different mordants and mordanting methods.

Sample code	Perspiration Fastness	Light Fastness
W-AT_1	4	6
W-AT_2	4	7
W-AT_3	4	6
W-PD_1	3	4
W-PD_2	3	5
W-PD_3	4	6
W-FS_1	2	7
W-FS_2	3	7
W-FS_3	03-Apr	6

Colour fastness to light

The results of the colour fastness properties to light of cotton fabric dyed with the aqueous dye extract of *Whitfieldia lateritia* using different mordants and mordanting methods is shown in Table. The blue wool scale is used to rate the performance of fabrics assessed for colour fastness to light to the extent of fading of the test specimen. In Table 2, it can be seen that the ratings ranged from 4 for W-PD_1; 5 for W-PD_2; 6 for W-AT_1, W-AT_3, W-PD_3 and W-FS_3; and 7 for W-AT_2, W-FS_1 and W-FS_2. These results indicate a slow rate of fading of the dye colours on fabrics when used at areas having a moderate intensity of sunlight. The high ratings obtained can be attributed to the fact that when metallic mordants are used, a complex is formed with transition metals. The complex protects the chromophores from photolytic degradation. The chromophoric group absorbs the photons which by resonating within six-member ring dissipate their energy, thereby protecting the dyes [27]. Hence, the metal mordants used in the present study protect the dye from photolytic degradation, thus, giving excellent light fastness.

Conclusion

This work has explored the capabilities of aqueous dye extract of *Whitfieldia lateritia* in dyeing cotton fabric in the presence of mordants using different mordant application methods. The UV-Vis spectroscopy and FT-IR spectroscopy, both confirmed the presence of polyphenols such as flavonoids and tannins. The extracted dye can be used in combination with mordants such as the ones used in this work to colour cotton fabric. The different methods of the mordant application were seen to cause a change in the colour of the fabric. The general assessment of the colour fastness tests showed that the aqueous dye extract of *Whitfieldia lateritia* irrespective of the mordant and method of mordant application followed has good ratings.

References

1. Siva R. "Status of Natural Dyes and Dye-yielding Plants in India." Review Article. *Current Science.* (2007): 916-925.
2. Saxena S and Raja ASM. "Natural Dyes: Sources, Chemistry, Application and Sustainability Issues." *Roadmap to sustainable textiles and clothing* (2014): 37-80.
3. Haws KL, Winterich KP and Naylor RW. "Seeing the World Through Green-tinted Glasses: Green Consumption Values and Responses to Environmentally Friendly Products." *J Consum Psychol* (2014):336-354.
4. Shahid M, Shahid UI and Mohammad F. "Recent Advancements in Natural Dye Applications: A Review." *J Clean Prod* (2013): 310-311.
5. Brookstein DS. "Factors Associated with Textile Pattern Dermatitis Caused by Contact Allergy to Dyes, Finishes, Foams, and Preservatives." *Dermatol Clin* (2009): 309-322.
6. Shahid Ul-Islam and Mohammad F. "Natural Colorants in the Presence of Anchors so-called Mordants as Promising Coloring and Antimicrobial Agents for Textile Materials." *ACS Sustainable Chem Eng* (2015): 2361-2375.
7. İşmal OE. "Greener natural dyeing pathway using a by-product of Olive Oil; Prina and Biomordants." *Fibers Polym* (2017): 773-785.
8. Silva PMS, Fischitello TS, Queiroz R and Freeman HS, et al. "Natural dye from Croton urucurana Baill. bark: Extraction, Physicochemical Characterization, Textile Dyeing and Color Fastness Properties." *Dyes and Pigments* (2019).
9. Kim P, Elias VB, Veronique VS and Karen DC, et al. "The Potential of Anthocyanins from Blueberries as a Natural Dye for Cotton: A combined experimental and theoretical study." *Dyes and Pigments* (2020).
10. Wanyama PAG, Kiremire BT and Murumu JES. "Extraction, characterisation and application of natural dyes from selected plants in Uganda for dyeing of cotton fabric." *Afr J Plant Sci* (2014):185-195.
11. Loum and Lukyambuzi. "Effects of Mordanting Methods of Dye from *Vernonia amygdalina* on Cotton Fabrics Colouration." *J Lang Techno Entrep Afr* (2013):17-27.

12. Udeani NA. "Potential of Henna Leaves as Dye and Its Fastness Properties on Fabric." *Int J Chem, Mole, Nuc, Mat and Metallurgical Eng* (2015):1459-1466.

13. Kulkarni SS, Bodake UM and Pathade GR. "Extraction of Natural Dye from Chili (Capsicum Annum) for Textile Colouration." *Univers J Environ Res Technol* (2011): 58-63

14. Doty K, Haar S, Kim J, and Black walnut, et al. "Sawmill Waste as Natural Dyes: Effect of Aluminum Mordant on Colour Parameters." *Fash Text* (2016): 22-25.

15. Haar S, Schrader E and Gatewood BM. "Comparison of Aluminium Mordants on the Colour fastness of Natural Dyes on Cotton." *Cloth Text Res J* (2013): 97-108.

16. Zheng GH, Fu HB, Liu GP. "Application of Rare Earth as Mordant for the Dyeing of Ramie Fabrics with Natural Dyes." *Korean J Chem Eng* (2011): 2148-2155.

17. Eman AB. "Extraction of Natural dye from Tea leaves and its application on Giza 86 Egyptian Cotton Fabric. *Int J Adv Sci Eng* (2017): 455-462.

18. Mahmudi A, Mawardi AK, Putri ES and Alharis, et al. "Extraction of Natural Dyes from Dadap Flower (Erythrina fusca L.) and its Application in Dyeing of Cotton and Silk." (2014).

19. D'Incalci M, Steward WP and Escher AY. "Use of cancer chemo preventive phytochemical as anti-neoplastic agents. *Lancetonocology* (2005): 899-904.

20. Okonkwo SN, Ohanuzue CBC, Onuegbu GC and Obasi HC, et al. "Extraction of natural dyes from *Whitfieldia lateritia* plant and its application on cotton fabric." *J Textile Sci Eng* (2019): 392.

21. Njoku OU, Okorie UC, Obasi NA, and Ogwulumba SI. "Proximate and Mineral Compositions of *Whitfieldia lateritia* Leaves from Ishiagu-Ivo, Ebonyi State, Nigeria." *J Biol Chem Research* (2015*): 77-83.*

22. Aja PM, Okorie UC, Ozougwu VEO and Onya-Mmaghiri EA. "Phytochemical and Gas Chromatography-Mass Spectrometric (GC-MS) Analyses of *Whitfieldia lateritia* Leaf." *Afr J Basic Appl Sci* (2016*): 41-54.*

23. Okonkwo SN, Onuegbu G, Obasi C and Nnorom O. "Effect of Temperature and Mordant on the Dyeing of Cotton Using Sodium Hydroxide Extract of *Whitfieldia lateritia* Dye." *Int J Inno Res Sci Eng Tech* (2019): 7301-7308.

24. Charu S, Sangita S and Gupta VB. "Extraction of a Natural Dye from *Sesbania aculeata* Plant." *J Text Appar Technol Manag* (2012).

25. Coates J. "Interpetation of Infrared Spectra, A practical Approach" in R.A. Meyers, (ed.), *Encyclopedia of analytical Chemistry* Chichester, John Wiley and Sons ltd (2000).

26. Nnorom OO and Onuegbu GC. "Authentication of *Rothmanian whitfieldii* Dye Extract with FTIR Spectroscopy." *J Tex Sci Tech* (2019): 38-47.

27. Mohammad GU. "Extraction of Eco-Friendly Natural Dyes from Mango Leaves and Their Application on Silk Fabric." *Uddin Textiles and Clothing Sustainability* (2015).

How to cite this article: Okonkwo SN, Onuegbu GC, Obasi HC, Nnorom OO and Ojiaku PC. Study on the Application and Colour Fastness Properties of Aqueous Dye Extract from Whitfieldia Lateritia Leaves. *J Textile Sci Eng* 10 (2020) doi: 10.37421/jtese.2020.10.422