

Effect of Chemical Environment on Colour Fastness Property of Wool Dyed With *Phyllanthus muellerianus* Natural Dye

Ogbuanu, Cyril. C*, Amujiogu, Steve. N

Department of Industrial Chemistry, Enugu State University of Science and Technology (ESUT), P.M.B 01660, Enugu Nigeria

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*Corresponding author

Ogbuanu, Cyril. C

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Abstract: In the present investigation the chemical effect on colour fastness of *Phyllanthus muellerianus* dyed wool was studied. Samples were assessed in terms of the colour fading to spotting with dilute hydrochloric acid, with 56% acetic acid, steeping for two minutes at room temperature in 28% ammonium hydroxide without rinsing, exposed to concentrated ammonia fume for 24 hours and spotting with 10% sodium carbonate and calcium hydroxide respectively. Contact with dilute hydrochloric acid brings about significant changes in the color and fastness properties of natural dyed wool yarn. The colours however, remain stable after exposure or contact with alkalis and 56% acetic acid. It can be concluded that *Phyllanthus muellerianus* dyed wool fabric have good colour fastness to perspiration and except with mineral acids.

Keywords: *Phyllanthus muellerianus*, dyed wool, colour fading

INTRODUCTION

Wool is a natural protein, multicellular, staple fibre with density of 1.31g/cm³, which tends to make wool a medium weight fibre [1]. Generally, wool is composed of a special protein called Keratin, made up of amino acids and acidic carboxyl groups. This is what is responsible for its flexibility, elasticity, resilience, and good wrinkle recovery properties.

It's also what allows it to absorb both moisture and dyes so well. It differs from others on account of its high-sulphur content [2]. Wool fibers have a unique surface structure of overlapping scales called cuticle cells. The cuticle cells provide a tough exterior, protecting the fiber from damage. The cells have a waxy coating, making wool water repellent, but still allowing absorption of water vapour. The water-repellent surface makes wool garments naturally shower-proof and also reduces staining because spills don't soak in easily.

This spring-like structure is surrounded by a matrix, which contains high sulphur proteins that readily attract and absorb water molecules. Wool can absorb up to 30% of its weight in water without feeling wet. It also absorbs and retains dyestuffs very well, helps remove sweat and absorbs odours [3].

Alkali reacts with acidic natural dyes of plant origin and form a permanent salt (foods to make a permanent salt) (i.e. a permanent stain). Natural fibers swells in water, so a water-based stain will go deeper into a natural fiber unless a special hydrophobic (water

repellent) finish has been recently applied. The natural dyes that give color to food can be very similar - even identical - to those colors found in shirts, blouses, or oriental carpets [4]. Some dyes and finishes are set on as stain with auxiliaries such as salts, acids and with warm temperatures, and with time allows for wool to be dyed [5].

The use of acetic acid in dyeing is to produce an acid pH for acid dyes. Acid dyes are proper to colour protein fibers such as wool, as well as nylon that require a mildly acidic pH to form a permanent bond to the fiber. Acetic acid is one of the least expensive and most convenient and safe to work with [6].

Sweat or perspiration is almost made up of water with tiny amount of other chemicals (like ammonia, urea, salts of sodium, potassium, zinc, magnesium and calcium) and sugars [7] and are known to effect colour fastness of dyed fabrics. This study therefore is amid to investigate the effect of some likely chemicals of perspiration in colour fastness of dyed wool.

MATERIALS AND METHODS

Collection and processing of plant sample

Phyllanthus muellerianus leaves were collected from Agbani near Faculty of Applied Natural Sciences of Enugu State University of Science and Technology. They were dried in a subdued sunlight and ground into powder form with the aid of Kika Grinding Mill (Model MP300-20 A11 basic). The powder form was used to extract the corresponding dyes.

Extraction of Plant dyes

The powdered leaves material (1.5 kg) was percolated in acetone and water (50/50 v/v) at the ratio of 1:3 for 48 hours and filtered. The filtrate was made free of acetone by distillation and the aqueous filtrate was partitioned successively with n-hexane, chloroform, ethyl acetate and n-butanol. The fractions were concentrated using rotary evaporator. The concentrate was dried at 65°C in a Pickstone Thermostatic Oven series 30/300 (Model BD/AL) to a constant weight [8].

Column chromatographic separation of dyes

A column prepared with chloroform and silica gel was impregnated with a solution of ethyl acetate fraction in (1g in 7.5 mL) methanol. This was eluted with gradient of n-hexane increasing the polarity with ethyl acetate. Eight fraction were collected and TLC analysis conducted [9].

Washing of wool

All the test fabrics (wool) were cut into 30 x 12 cm and washed for 15-20 minutes with 1 g/L of non-ionic detergent (ESUT liquid detergent) and 0.5 g/L concentrated ammonia at 40-50 °C. The material was then washed thoroughly with plenty of tap water and soaked in distilled water for 30 min and air dried at room temperature [10, 11].

Dyeing

Dyeing were carried out at acidic pH by adding the required amount of acetic acid (CH₃COOH). Wool (Cashmere) samples were dyed using a dye bath containing 3 % dye, 8 % sodium sulphate and 4 % acetic acid at liquor ratio of 1:50. All the test fabrics were dipped in 250 mL of dyeing solution (dye bath) at room temperature. The temperature was gradually raised to boiling and the dyeing continued at the boiling temperature for 1hr. Water was then removed by squeezing the material [12, 13, 10, 11].

Post mordanting of fabrics

The process of mordanting was started at 60 °C and slowly increased to boil with gentle stirring and continued for 1 h with different mordants (copper sulfate, potassium dichromate, alum and tin chloride) at varied concentrations (2.5, 5, 7.5, 10, 12.5 and 15 %) and optimized dyeing conditions using 1% acetic acid. Then was left to cool down to room temperature and

rinsed in running tap water until the colour became clear. After the fabric was squeezed and kept to dry [14, 10, 11].

Colourfastness to acid and alkalis

This test is intended to determine the resistance of color of dyed textile to the action of acidic and alkaline perspiration. This test were aimed to evaluate the resistance of the specimens to simulated action of acid fumes, sizes, alkaline sizes, alkaline cleaning agents and alkaline street dirt. These methods of test are applicable to textiles made from all fibers in form of yarns or fabrics, whether dyed, printed or otherwise coloured according to AATCC Test Method 6-1972.

These specimens were cut to 3 x 6 cm, tested accordingly and the effect on the colour of the dyed specimen evaluated and defined by reference to the Gray Scale for Colour Change.

Acid test: Hydrochloric acid tests

The dyed specimens were spotted with hydrochloric acid solution (100 mL of 35 % acid made up to one liter) at room temperature. The specimens were allowed to dry at room temperature without rinsing.

Acetic acid tests

The dyed specimens were spotted with acetic acid (56 %) and allowed to dry at room temperature without rinsing.

Alkalis test: Ammonium hydroxide test

The dyed specimens were steeped for two minutes at room temperature in concentrated ammonium hydroxide (28 % NH₃) and dried at room temperature without rinsing.

Sodium carbonate tests

The dyed specimens were steeped in 10 % sodium carbonate solution for two minutes at room temperature and dried at room temperature without rinsing.

Exposure to ammonium hydroxide fume test

The dyed specimens were hanged in a bell jar (4 L) and placed on a glass plate over a 3 inch evaporating dish containing 10 mL of concentrated ammonium hydroxide (28 % NH₃) for 24- hours.

Calcium hydroxide test

The dyed specimens were spotted with a freshly prepared calcium hydroxide paste, allowed to dry at room temperature and then brushed to remove the dry powder. Effect of chemical contact and environment.

RESULTS AND DISCUSSIONS

The result of fading of dye from $K_2Cr_2O_7$ and $CuSO_4$ mordanted wool fabric on contact with chemical and chemical environment was represented below.

Table-1: Fading to exposure to concentrated ammonia for 24 hours; to steeping in dilute ammonia solution and drying at room temperature for 24 hours; to staining with 10% Na_2CO_3 ; and staining with 10% calcium hydroxide respectively

Mordant concentration (%)	Fading with test solution 1A and condition	
	$CuSO_4$	K_2CrO_7
2.5	5	5
5	5	5
7.5	5	5
10	5	5
12.5	5	5
15	5	5

The result of the fading grade effect of exposure to concentrated ammonia (NH_3), steeping for 30 minutes in dilute ammonia solution, and contact with 10% sodium carbonate (Na_2CO_3) and 10% calcium hydroxide, and also dilute hydrochloric acid and 56% acetic acid was plotted against the mordant concentration. As can be seen from Fig. 1, a straight line graph was obtained. This indicates that the chemicals tested has little or no effect.

The results of the fading experiment to determine the effect of staining with dilute hydrochloric

acid on dyed fabrics mordanted with $K_2Cr_2O_7$ and $CuSO_4$ shows clearly that they faded 25% and 50% respectively. This probably is due increase in free amino groups and in disulfide content with decrease in tyrosine content as estimated by the Shinohara method [15]. This will alter the structure and hence the bonds of the wool fabric and the dye. The results also shows that the amount of dye faded or decomposed at a particular mordant concentration is the same for $K_2Cr_2O_7$ and $CuSO_4$ mordants. This results demonstrated that the effect of the acids is greater than that obtained with the alkalis.

Table-2: Fading to staining with dilute hydrochloric acid

Mordant concentration (%)	Fading to staining with dilute hydrochloric acid	
	$CuSO_4$	K_2CrO_7
2.5	4	2
5	3	2
7.5	3	2
10	3	2
12.5	3	2
15	3	2

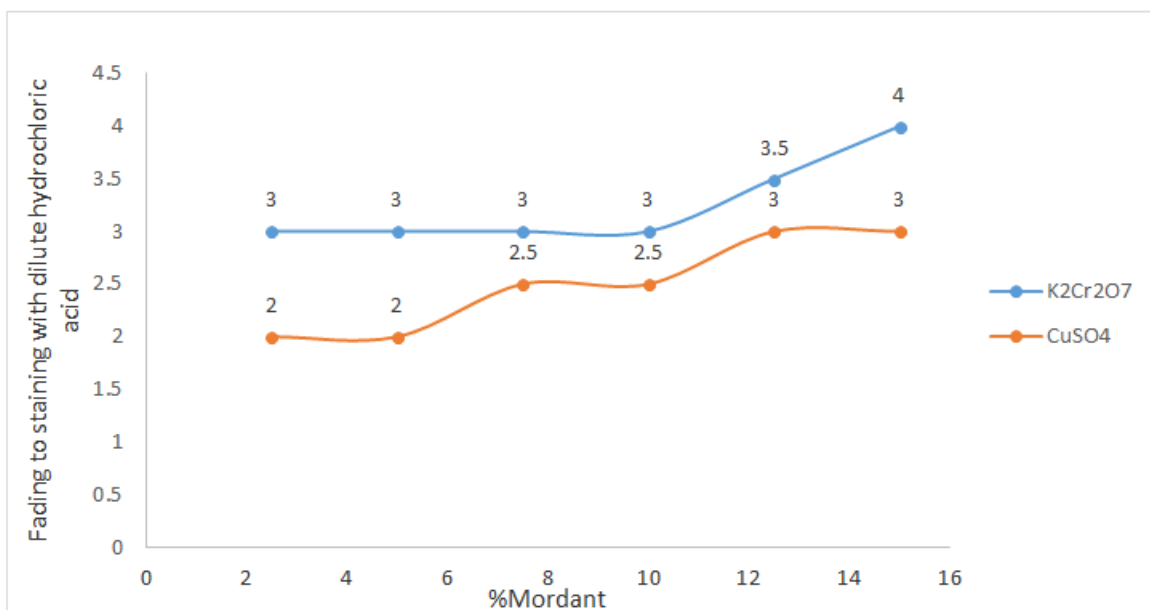


Fig-2: Fading to staining with dilute hydrochloric acid

Table-3: Fading to staining with 56% acetic acid

Mordant concentration (%)	Fading with 56% acetic acid	
	CuSO ₄	K ₂ CrO ₇
2.5	4	3
5	4	3
7.5	4	3
10	4	3
12.5	4	3
15	4	3

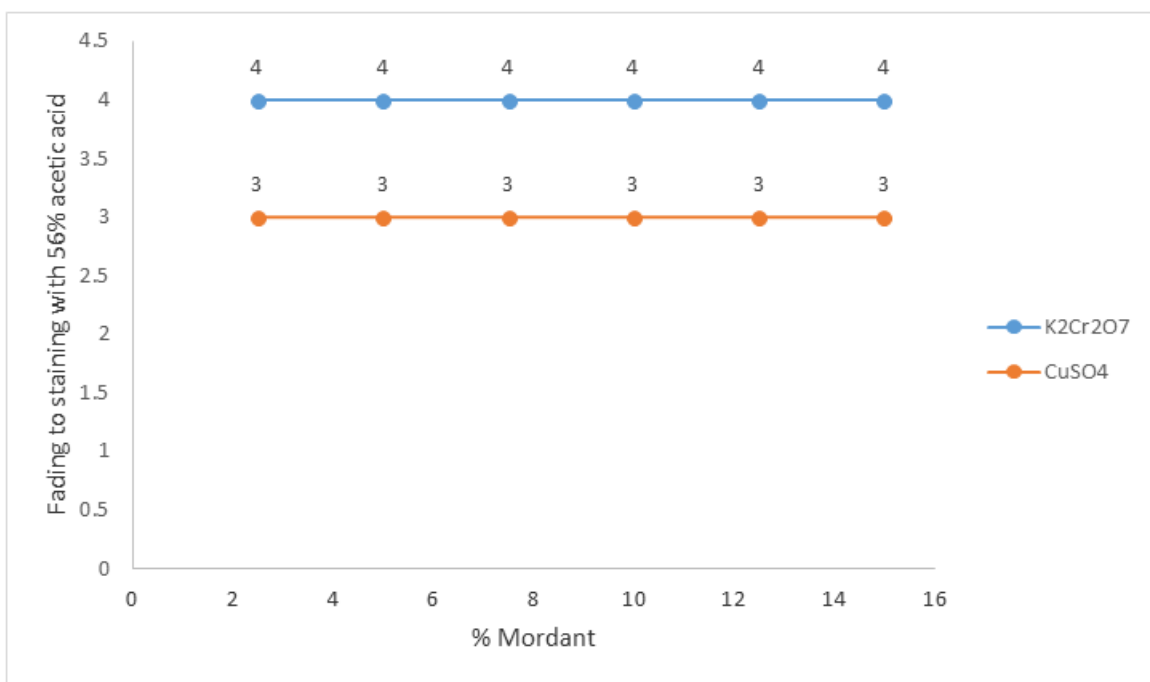


Fig-3: Fading to staining with 56% acetic acid

CONCLUSIONS

Other alkali compounds such as exposure to concentrated ammonia (NH₃) fume for 24 hours; steeping in dilute ammonia solution for 30 minutes; staining with 10% sodium carbonate (Na₂CO₃) and 10% calcium hydroxide did not have any significant fading of the dyed wool fabric. This indicates that alkalis have no effect on the colour fastness of the dyed wool fabric.

The amount of dye faded with staining with dilute hydrochloric acid (HCl) was more in CuSO₄ mordanted wool fabric (50%) than in K₂Cr₂O₇ (25%) the amount of dye faded with staining with 56% acetic acid was 20% for CuSO₄ and 40% for K₂Cr₂O₇. It can be concluded that *Phyllanthus muellerianus* dyed wool fabric have good colour fastness to perspiration and except with mineral acids.

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