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Sustainable locally sourced materials for small-scale paint production

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Abstract. Volatile organic compounds (VOCs) and other unsafe chemicals are used in producing chemical paints which releaseharmful gases within the interior spaces where they have been used, whereas, these hazardous elements or components can be removed and replaced with safer and local materials. The aim of this study is to produce a paint product using sustainable locally sourced materials in a small-scale production. Using an experimental approach, a milk-based and clay-based paint were prepared in the laboratory, while physical and chemical tests were carried out such as adhesion test, application test, opacity, drying test, viscosity test and pH test. Clay, Edible starch, Local pigment (Lamp black and local talc), Dry milk and Lime were used as constituent materials in the preparation of the paint products with water as the solvent. Some of the physical and chemical tests carried fell within reasonable PMAN standards for chemical paints. The study recommendsthat more environmental friendly and sustainable materials should be used to replace hazardous materials used in chemical paints for safe environment.

Keywords:*Hazardous, Local materials, Paint products, Small-scale, Sustainable materials*

1. Introduction

Paint products are commonplace commodities that are used for aesthetic purposes and protection purposes [1]. Paint has been in production since prehistoric times.It is one of the earliest on record for the early man producing some form of synthetic substance for personal use. The early production of paint made use of sustainable materials of clays and chalks with animal fats as at 35, 000 years ago which they used to make drawings in caves. The paint technology was further improved by the Egyptians by 2500BC. They were able to produce clear blue coloured pigments by mixing azurite, gum, wax and egg white. These were all sustainable materials that have no significant adverse effect on man. By the first millennium BC, the Greeks improved the paint technology by ensuring the paints were thick and easy to apply and the ability to obtain different colours from their mixture. For instance, to obtain a purple pigment, yellow earth was heated until the colour turned red and it was then placed in vinegar [2]. These were crude methods but it ensured the use of locally sourced and environmental friendly components.

With the improvement in science and high industrialization came the chemical paints, due to its ability to give more characteristics needed in paint products. However, lives can be endangered if materials used in the production of chemical paints are not used minimally or correctly, it will have an awful smell if the materials are over used which in the long run can cause suffocation making it

hazardous to human health. [3]reported that workers or occupants that have long-term exposure to fumes from chemical paints are susceptible to health challenges such as headaches, allergies and asthmatic reactions. Other forms of irritation can also affect the skin, eyes and lungs while there can behigher strain other vital organs. With the high record cases of cancer, [3] reported that there is between twenty to forty percent increase in the risk of some types of cancer, particularly lung cancer, with the added possibility of neurological damage [4]. In the wake of high air pollution, the study point that some of these hazardous elements or components can be removed and replaced with safer and sustainable local materials [5, 6, 7, 8]. Some of the chemical compounds are sometimes released into water bodies such as rivers, ponds, streams which go into the water table thereby polluting water bodies for fishes and drinking water for communities. Sustainable locally sourced materials would have a lesser effect or damage on people and the environment. Therefore, the study produced a paint product using sustainable locally sourced materials in a small-scale production.

2. Review of Related Literature

In the study by [9], emulsion paints were produced by partially replacing the synthetic binders with a locally sourced sustainable material; gum Arabic (Acacia Senegal). Their study showed that the emulsion paints produced resulted in high quality paint products. [9] noted that at 100%replacement of the synthetic binder (PVA), the paint failed to meet the required standard. The study by [10] showed that pigment extender was replaced using Kaolin (China Clay) and compared with emulsion paints produced with Calcium Carbonate ($CaCO_3$). Their study showed that the two paints had similar performance with the Kaolin-based paint performing better in some properties such as opacity, the brushing effects and settling resistance. [11] used starch extracts from potatoes and cassava as pigments in producing emulsion paints and found that at values higher than 40%, the produced paints performed better in the physico-chemical properties.

3. Materials and Methods

The study utilized an experimental research design using various sustainable locally sourced materials to produce in paint product in a laboratory setting. The physical and chemical quality control tests were done on the paint product and compared with the standard for chemical paints. The physical tests done include adhesion test, application test, opacity and drying test. The chemical tests done include viscosity test and pH test of the sustainable paint product. The equipment used in measuring the chemical test is shown in Figure 1. Clay, Edible starch, Local pigment (Lamp black and local talc), Dry milk and Lime were obtained from chemical village in Ojota, Lagos state.The solvent used was water which was obtained from the tap within the laboratory.Two variant of sustainable paint products were produced in the colours of white and black. Laboratory equipment used in the preparation of paint products include; a 4-litre bucket, a wooden rod, an aluminium scooper and a universal measuring scale.

Figure 1. Viscometer and pH meter used to test the paint product.

4. Results and Discussion

In this section a step by step recipe for the production of a sustainable paint product is discussed. Using a manual process the constituents of the sustainable paint product was mixed in 4-litre paint bucket. The first sustainable paint product that was produced was termed "Milk-based paint" which gave an off-white colouration after production. The second sustainable paint product was termed "Clay-based paint" which gave a black colouration after production. Figure 2and Figure 3 showed the weight in kilogram (Kg) of the constituent materials used in the production of the Milk-based paint product and Clay-based paint respectively. In the manufacturing of the sustainable paint product, the quantity of water (solvent) added at the beginning is half the quantity of the desired outcome. Stirring of the mix should be done in a clockwise direction so as to avoid mould formation in the paint product and give it a smooth finish. A step by step procedure for the manufacturing of a Milk-based paint product showed that 3Kg of water (solvent) is first added into a 4-litre paint bucket. Add lime (as an additive) of about 0.5Kg and stir with a wooden stick, then clay (as a binder) of about 0.7Kg is added and mixed in a clockwise direction, then milk (as an additive) of 0.3Kg is added to the mix. Milk is added only in the production of the Milk-based paint, then add the pigment which is talc of 0.2Kg, then starch (as an additive) of 0.6Kg is added. For a black coloured milk-based paint product, a black pigment of lampblack can be used.

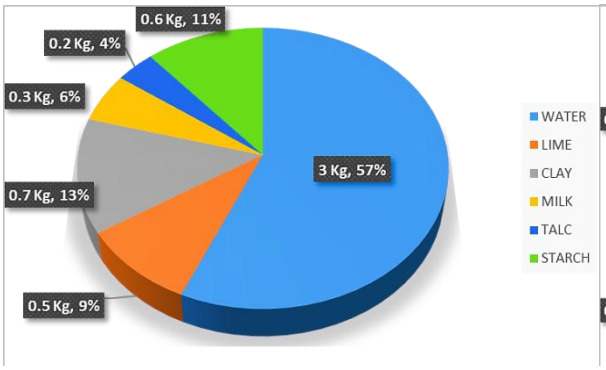

Figure 2. Constituents of Milk-based paint

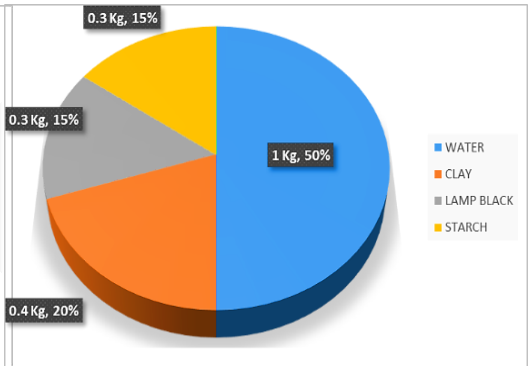

Figure 3. Constituents of Clay-based paint

In the production of the clay-based paint product, the step by step procedure showed that 1Kg of water is first added into a 4-litre bucket as the solvent. Add starch as the additive of 0.3Kg and stir very well with a wooden stick, then clay as the binder of 0.4Kg is added to the mix and the clockwise motion of mixing continues, then 0.3Kg of the lampblack (pigment) is added. To obtain a white colour of the Clay-based paint, the lampblack is replaced with talc (pigment). Figure 4showed the final product of the milk-based paint and clay-based paint in the 4-litre paint bucket.

Figure 4. Final product of the milk-based paint and clay-based paint.

4.1 Physical Tests

The physical tests carried out include adhesion test, application test, opacity test and drying time test on the sustainable paint product. Table 1 showed the physical properties of the sustainable paint product produced. The adhesion test was carried out upon a concrete material surface. This was carried out by painting a concrete surface and using the hand to rub its surface to notice any form of stain as shown in Figure 5. If any form of stain is recorded then it is noted that the adhesion test has failed. The application test was carried out by checking the coverage ability of the paint and any form of cracking observed. The drying test measured the time for which the paint evaporates from the surface of the coated surface. The opacity test showed the covering power of the paint and the extent to which the concrete surface is not visible to the naked eye. The physical properties were compared with the Paints Manufacturers Association of Nigeria (PMAN) standard for chemical paints.

Table 1. Physical properties of sustainable paint product

Paint name	**Properties**	**Result Obtained**	**PMAN Standard**
Off-White Milk Based Paint	Application test	1.44 square meters per litre, no crack noticed	2.50 – 3.50square meter per litre
	Opacity test	Two coat finish	Two coat finish
	Drying Time (25^0C)	52 mins	25 – 30 minutes
	Adhesion test	Stain noticed	No stain should be recorded
Lamp Black Milk Based Paint	Application test	1 square meters per litre, no crack noticed.	2.50 – 3.50square meter per litre
	Opacity test	Two coat finish	Two coat finish
	Drying Time (25^0C)	30 mins	25 – 30 minutes
	Adhesion test	No stain recorded	No stain should be recorded

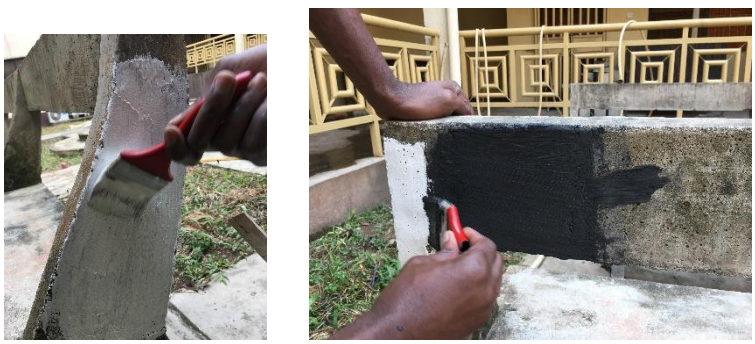

Figure 5. Physical tests on the two brand of paint products

4.2 Chemical Test

Chemical tests were carried out on the sustainable paint product produced. Chemical tests such as viscosity and pH value tests were conducted as shown in Table 2 and Table 3 respectively. Viscosity is the resistance against flow. It is the state of being thick, sticky and semi-fluid in consistency due to internal friction.

Table 2. Viscosity of the sustainable paint product

Sample	Spindle	Torque (%)	Speed (r/m)	Viscosity (cp)
Off-White Milk-Based	03	22.0	2.0	11000
Paint	03	23.8	2.0	11900
	03	21.2	2.0	10600
Black coloured Clay-Based	03	23.7	4.0	5930
Paint	03	24.7	4.0	6180
	03	22.0	4.0	5500

The pH value was also measured. The pH value is a figure expressing the acidity or alkalinity of a solution on a logarithmic scale in which 7 is a neutral value, where lower values are more acidic and greater values than 7 is more alkaline. Comparing the pH values with the PMAN standard of 7.5 – 8.50 showed that the pH values for the off-white Milk-based paint and Black coloured clay-based paint produced is above the required level at 12.40 and 11.50. This can be attributed to the high percentage of the binder - clay material as a constituent materials when making both paint products. Although, paint products should have a balanced pH value which would help the quality of the paint product. Subsequent production should reduce the clay content in the sustainable paint.

Table 3. pH of the sustainable paint product

Sample	pH value	Temperature	Nature
Off-White Milk-Based Paint	12.40	24.5	Alkaline
Black coloured Clay-Based Paint	11.50	24.9	Alkaline

5. Conclusion

The study engaged in a small scale production of a paint product using sustainable locally sourced materials. Using sustainable locally sourced materials such as lime, clay, milk, talc and starch in making an off-white milk-based paint while clay, lamp black and starch was used in making black coloured clay-based paint. The physical and chemical properties of the sustainable paint produced using locally sourced materials was carried out. Some of the properties were within the Paints Manufacturers Association of Nigeria (PMAN) standard for chemical paints. Although, the sustainable paint differs from chemical paints due to the constituent materials. The materials used in the production of the sustainable paint products are environmentally friendly and the final product did not have any hazardous effect. The study recommended that the availability of local materials which are used in the manufacturing of these paint products would encourage the production by small and medium scale entrepreneurs. The study was able to produce a white and black paint sample which can be used in the painting of internal walls as the prolonged durability of the paint product was not tested. The use of sustainable building materials should be encouraged as opposed to materials that are susceptible to releasing harmful materials on the users and the environment.

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