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FORMULATION OF EMULSION PAINT USING *Cissus pulpunea* (GUILL and Perr) STEM BARK EXTRACT AS BINDER AND A THICKENER

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Abstract
The use of locally sourced materials will help to produce an environmental friendly and more cheap and affordable emulsion paint products. The high cost of emulsion paints in our society is attributed to high cost of the imported raw materials, hence there is need for locally sourced raw materials to substitute the imported ones. In this research, emulsion paint was successfully formulated using *Cissus pulpunea* stem bark extract as an alternative binder and thickener to the conventional widely used Polyvinyl acetate and natrosol compounds. Fresh stems of the plant sample were obtained from Buda forest in Giwa L.G, Kaduna state, Nigeria. 1kg of the sliced stems bark was percolated in 2litres of water for 24 hours were a sticky and highly viscous gummy like liquid was obtained. The extract was characterized using FTIR spectroscopic analysis technique and was later used to formulate emulsion paint as substitute binder and thickener. The FTIR analysis result indicates the presence of C-H ,CO, OH, COOH, functional groups with strong peaks around 1200cm^{-1}, 1650 cm^{-1} , 3500cm^{-1} respectively . Two paint samples were prepared, i.e. A sample using the conventional raw materials containing PVAc as binder and natrosol thickener which served as control (sample A), while sample B contain *Cissus pulpunea* stem bark extract as binder and thickener. The formulated paint (sample B), showed a promising Adhesion to the substrates and viscosity of 10.1.00 poises at 27.2°C and a density of 1.445 kg/L. Other characteristic parameters of the paint samples studied were: *p*H, fastness to light, opacity, drying time and wet abrasion resistance. The results observed from the various analysis carried out show that both samples A and B pass or nearly met the NIS standard of applicability and performance requirements for emulsion paint, Hence, *Cissus pulpunea* stem bark extract can effectively serve as an alternative binder and thickener in emulsion paint production.

INTRODUCTION

Paints can be described as a liquid substance, where the viscosity, drying time, and flow characteristics are determined by their formulation. These include: binder or vehicle, pigment, solvent or thinner, and a drier, which can be applied in relatively thin coats and transforms into a continuous, thin opaque layer on surfaces (Nwakaudu *et al.,* 2012). The primary chemical components of a typical paint consist of solvent/vehicle, binder, pigment, extender, thinner, plasticizer, dispersant, and surfactant. In contrast, the secondary ingredients encompass biocide, anti-foam, rust inhibitor, pH adjuster, wetting agent, fragrance, anti-skinning agent, and anti-floating agent (Nwakaudu *et al.,* 2012). Different kinds of paint have varied compositions based on the formulation of their ingredients and the type of binder used. The binder is a critical component that significantly affects the paint's ability to cover surfaces effectively (Baharuddin *et al.,* 2025). Paints serve both decorative purposes and are essential for safeguarding important assets against natural elements. Several researches were performed with the aim of finding suitable components from the local sources that can serve as alternative to the imported components for the production of emulsion paint. A dye was obtained from the leaves of *Lawsonia inermis* (henna) through a water extraction process, and this color extract was utilized as a replacement for synthetic

the creation of emulsion paint. The resulting paint, made with the natural dye, was analyzed and found to exhibit characteristics similar to those of emulsion paint made with traditional pigments. However, the paint made from the aqueous extract completely faded after being exposed to a 5000 watt tungsten lamp for 48 hours. Despite this, the paint demonstrated promising durability and resistance to rubbing (Abba *et al*., 2020). A binder extender composite resin was formulated from recycled plastic wastes and used in production of emulsion paint. Were the recycled polyethylene (rPE) was prepared by suspending microparticles of low-density polyethylene (LDPE) waste in LDPE pyrolysis oil. The rPE was then blended with waste polystyrene pyrolysis oil (PPO) to form a drying plastic-based composite resin. The resin was used as binder- extender component in emulsion paint formulation. The promising performance of the formulated paint indicates the pontetial of the composite resin for use in emulsion paint production. (Osemeahon, *et al*., 2025).

Characteristics of exterior emulsion paint using natural rubber latex as binder was investigated. Natural rubber latex is enhanced by incorporating acrylic resin through a grafting process. This involves mixing several additives, including benzoyl peroxide, Sodium Lauryl Sulfate (SLS), Ethylenediaminetetraacetic Acid Disodium Salt (EDTA 2 Na), Sodium sulfite, and Polypropylene glycol into the latex at a temperature of 85 °C for 60 minutes. The resulting natural rubber latex binder is then combined with an exterior paint base, followed by characterization using Fourier transform infrared (FT-IR) spectroscopy, scrub tests, abrasion tests, opacity measurements, contact angle assessments, and scanning electron microscopy (SEM). The findings indicated that increasing the acrylic resin content within the natural rubber latex led to improved

performance of the paint. The optimal results were observed with natural rubber latex grafted with acrylic resin in a 50:50 ratio (NRL-AR (50:50)), yielding scrub and abrasion performance of 2400 cycles at a binder concentration of 18%, pigment volume concentration (PVC) of 50%, and a contact angle of 76°. Additionally, SEM images revealed that the modified natural rubber latex binder featuring acrylic resin exhibited no agglomeration, demonstrating a superior distribution of paint components (Baharuddin *et al.,* 2025). Formulation and characterization of fire retardant emulsion paint using locally sourced pigment and extender was carried out, the paint shows improved fire resistance with an ignition time of 37 minutes and burning rate of 0.264 cm/min in contrast to the non fire retardant paint which shows ignition time of of 2 minutes and burning rate of 3.265 cm/ minutes. (Okeke, *et al*., 2026). A study was carried out on Corrosion protection of mild Steel by Eco-friendly paint formulated with *Mangifera Indica* and the he formulated paint was found to have high potential for commercialization and industrialization (Amusa *et al*., 2026).

Cissus pulpunea (Guill and perr). Dafaraa or loda in hausa language

Cissus populnea, also referred to as Guill and Perr, is a tropical species within the Vitaceae family. This plant is a tall, woody climber that can grow up to eight meters in height and has a semicircular form. It is predominantly found in tropical regions of Africa, Asia, Australia, Central and South America, and northern Mexico. The plant has a natural capacity to retain moisture, which helps it stay fresh throughout much of the season. It produces a gel-like substance, and its gum is hydrocolloid, forming mucilage. It is known for a variety of medicinal uses across different cultures. Its extracts are believed to possess antibacterial properties, act as an antitrypanosomal plant, provide gum powder, and are part of a herbal anti-sickling remedy in Nigeria. In Benin, it is valued for its diuretic properties.(Adeleye *et al.,* 2015)

Materials and methods

Two samples of emulsion paints were prepared in the laboratory aa follows:

Sample A: Emulsion paint containing conventional raw materials with PVAc as binder and natrosol thickener.

Sample B: Emulsion paint containing *Cissus pulpunea* stem bark extract as binder and thickener

-Raw materials

All the conventional raw materials were purchased at ODIBEST coating materials Nigeria limited along park road Pz, zaria and all components were industrial grades. The raw materials are as follows:

Distilled water
Calgon
Colur paste
Titanium dioxide (TiO_2)
Calcium carbonate ($CaCO_3$)
Textural class silt loam soil
Deformer
Polyvinyl acetate (PVAc)
Formalin
Natrosol
Ammonium solution

Methods

Sample preparation

Fresh stems of *Cissus pulpunea (*Guill and perr)plant) were obtained from Buda forest in Giwa L.G , Kaduna state, Nigeria. The sample is then washed with water to remove unwanted substances. To extract the mucilage, 1kg of the sliced stems was percolated in 2litres of water for 24 hours. A sticky, highly viscous gummy/gelly like liquid was obtained ant it is filtered using muslin bag (Adeleye *et al*., 2015).

FTIR analysis.

Part of the filtered *Cissus pulpunea* mucilage was dried at room temperature and subjected to FTIR spectroscopic analysis.

Formulation of the conventional emulsion paint (sample A)

Conventional emulsion paint was formulated using the conventional raw materials according to (Abba *et al.,* 2023) where 50g of Calgon was dissolved in 3000ml of distilled water, from which 120g of (TiO_2) was added followed by intense stirring in a small container, 1300g of $CaCO_3$ (conventional extender) was poured to the mixture and stir thoroughly for some minutes. 125g of polyvinyl acetate (binder) was then added followed by addition of 5g of natrosol (thickener) the mixture was shaken and agitated for quite some minutes until a homogeneous mixture was obtained. 20g of biocide, 40g of deformer and 50ml of ammonia was added to the mixture followed by intense stirring until a homogeneous mixture was attained.

Formulation of emulsion paint using Cissus pulpunea stem bark extract as binder and thickener (sample B)

The same procedures were observed as above but in this case, 125g of the extract obtained from the *Cissus pulpunea* stem bark was utilized as binder and thickener in replacement for PVAc and Natrosol.

Characterization and performance properties of the prepared paint samples.

The Characterization and performance analysis of the prepared paint samples were carried out using National Industrial Standard (NIS 276:2018) methods, in which PH, density, viscosity, drying time, Adhesion, light fastness , and wet abrasion resistance were analyzed.

Determination of *p*H

The pH meter was switched on and then the electrode was dipped in a beaker containing a buffer solution of pH 7.0 in other to standardize it. The samples were each dissolved in 10 ml of distilled water independently and then the *p*H of each of the samples was taken. The electrode was finally standardized cleaned, kept and switched off (Mamza *et al*., 2015).

Determination of Viscosity

viscometer was switched on, with the spindle fixed and auto-zeroed. Each of the samples was transferred into a container and then the spindle is dipped in it. The viscometer was then switched on and the reading was taken, this was done independently for each of the samples at the temperature of 27.2°C and the spindle

speed was taken to be 0.1 rotation per minute (Mamza *et al*., 2015).

Determination of Opacity

The paint samples were each applied on a surface area until the area was covered; this was done independently for each of the sample. The ratio of the area of painted surface to the volume of paint applied was taken for each of the samples (NIS 276 :2018 part 6).

Determination of Drying Time

The drying time of the formulated samples were determined by applying the paint samples independently to a substrate (interlocks) and drying time was determined by exposure to air and recorded as adopted by (Anderson, 2022).

Determination of wet abrasion resistance

Paint samples were applied to a prepared, clean and dried panel, and cured, automated scrub tester with a bristle brush and abrasive medium of water/detergent was performed for a set number of cycles, evaluating failure by weight loss or visual inspection to assign a durability class (NIS 276: 2018)

Determination of Adhesion (ASTM D3359)

This is carried out using standard method as outlined by NIS where the two paint samples were applied with film applicator on a fully degreased metal panel and allowed to dry for 48 hours. Two sets of lines one crossing perpendicularly over the other were drawn with a cross hatch tester on the paint film. An adhesive tape equivalent to "Tea film 204" is then pressed firmly with the thumb covering all the interactions of the perpendicular lines. The adhesive tape is held at its loose and forcibly removed from the panel and observations were recorded (NIS 276 : 2018).

Determination Fastness to light

Light Fastness test was carried out on the prepared paints on painted sample specimen by the use of a 500 watts fading lamp to determine light stability or fadedness as the paints interact with light. The procedure involved aligning both the eight blue standards and the painted samples, until the last specimen faded (Abba *et al*., 2022; Joshua *et al*., 2023). The rating of the painted samples was performed to evaluate the extent of fading (Joshua *et al*., 2023).

RESULTS

FTIR spectroscopic analysis result of the *Cissus pulpunea* stem bark extract.

The FTIR spectra of *Cissus Pulpunea* Stem Extract revealed broad strong peak between 3268.9 Cm^{-1} - 3852.8 Cm^{-1} OH stretching vibration from which the locally emulsion paint was prepared broad band positioned at 3268.9 Cm^{-1} is related to the presence of hydroxyl group attributed to OH–bending and OH–stretching. Furthermore, the peaks at 1636.30 Cm^{-1} is assigned to the stretching of C=O functional group. At 1341.8 Cm^{-1} C-H bending vibration in alkane was recorded. Furthermore, the FTIR result detected phenolic and carbonyl groups which were shown to correlate with the reulst reported by (Aboje *et al.,* 2022) The presence of these functional groups (OH and C=O) suggest the presence of carboxylic group (–COOH). When comparing with earlier studies, *Cissus* plants typically show strong FTIR peaks for –OH stretching at 3258.3 cm^{-1}, similar band was also obtained in this studies (3268.9 cm^{-1}) for OH medium stretching vibration, C=O stretching (1600 –1700 cm^{-1}), and C–O vibrations (1000 –1200 cm^{-1}). These are related to phenolic compounds, carbohydrates, and organic acids present in the plant extracts (Nwankwo *et al*., 2021). The key functional groups observed in the FTIR spectroscopic analysis of the *Cissus pulpunea* stem bark extract matched with those functional groups responsible for binding activity as such, this suggests the extract has a potential binding abilities. The average results of the physical properties and performance assessment of the formulated paint samples Were shown in the table below:

PARAMETERS	SAMPLE A.	SAMPLE B.
*p*H	10.19	11.05
DENSITY(Kg/L)	1.321	1.447
VISCOSITY (Poises) @ 27°C	9.8	10.1
ADHESION	Adhered well to the wall with no cracking and no dirt retention.	Adhered well to the wall with no cracking and no dirt retention.
FASTNESS TO LIGHT	No colour change.	No colour change.
OPACITY	Covered well at 2 coats	Covered well at 2 coats
DRYING TIME	9 minutes	
(SURFACE DRYING TIME).	19 minutes	13 minutes
(HARD DRYING TIME).		37 minutes
WET ABRASION RESISTANCE	Economy grade at 118 cycles	interior grade at 57 cycles

DISCUSSION

*p*H

Sample B shows higher *p*H value of 11.05 than sample A with 10.19 which indicates that the paint sample containing the locally sourced binder is more alkaline in nature. Similar observation was reported by (Bhavsar and Raghavendra, 2023) This could be attributed to the presence of high intense stretching of hydroxyl functional group observed in the FTIR analysis of the *Cissus pulpunea* stem bark extract which is used as a binder and thickener in sample B. *p*H significantly affects emulsion paints by controlling stability, viscosity, microbial growth, and film properties; generally, a slightly alkaline *p*H (8-9.5) is ideal for performance preventing it from becoming too runny or thick, improving texture, adhesion, color, and preventing bacterial spoilage, while deviations (too high or too low) can ruin the paint's consistency and shelf-life.

Viscosity

both the formulated paint samples showed viscosity values close to the NIS standard of minimum of 6 poises. Sample B which contains the locally sourced binder and thickener shows higher viscosity of 10.1 poises compared to sample A with 9.8. Though, partially replaced raw materials paints were more viscose compared to the conventionally prepared compared to that of the sample A (the conventionally made paint) with recorded viscosity 9.8 poises as mentioned earlier, similar result was reported by (Titus *et al .,*2024) where a formulated emulsion paint using waste expanded polystyrene as binder shows a viscosity of 10 poises . With high viscosity nature of sample B, it suggest that stem bark extract provided the thickening property required. Viscosity in emulsion paints critically affects application (flow, leveling, sag/drip), finish (sheen, uniformity), stability (dispersion of colorants), and even droplet impact behavior, with optimal levels ensuring smooth, even coats, while deviations lead to poor coverage, sagging, or splashing, with high viscosity usually meaning thicker paint and lower gloss, and vice versa.

Drying time

Sample B shows slightly higher surface and hard drying times than sample A at 40% humidity, this could be attributed to the higher Viscosity earlier reported in sample B. this result was supported by (Abba, *et al.,* 2020) where it was reported that emulsion paint formulated using locally sourced pigment showed higher drying time than a paint sample formulated using conventional pigment. Both samples A and B showed surface and hard drying times acceptable with the NIS standard which states maximum of 20 and 120 minutes respectively.

Adhesion

Both paint samples passed the adhesion test as they showed no cracking no fading and no dirt retention when tested using the standard cross hatch method. These properties showed by both samples, suggest that the *Cissus pulpunea* stem extract used as binder in sample B is well compatible and can be used as binder in emulsion paint. The same result was reported by (A.A olutayo *et al.,* 2011) as the same extract was used as a binder in the formulation of paracetamol tablet.

Wet abrasion resistance

In emulsion paint, wet abrasion resistance is the ability of the dried paint film to withstand mechanical wear and damage like scrubbing, rubbing, or cleaning when it is wet, without losing significant material, colour, or protective qualities. With respect to this, Sample A containing the conventional raw materials is rated as economy grade by withstanding up to 118 cycles as reported in the table above. Sample B on the hand is rated as interior grade at 57 cycles. Wet abrasion resistance some times help to determine the quality and compatibility of the binder used in emulsion paint, Sample A shows higher binding ability than Sample B. Both samples possessed the required density, opacity and fastness to light properties that are in line with the NIS standard of applicability.

CONCLUSION

FTIR analysis of the *Cissus pulpunea* stem bark extract shows the presence of O-H, C=O, COOH, and C-H functional groups. The presence of these functional groups (OH and C=O) suggest the presence of carboxylic gro sample containing *Cissus pulpunea* stem bark extract as binder and thickener (sample B) shows higher *p*H, density, and higher viscosity of 10.05, 1.447,and 10.1 poises respectively than the corresponding sample A which contain PVAc binder and natrosol thickener. The surface and hard drying times were higher in sample B with 13 and 37 minutes respectively. Both samples show acceptable performances in line with the SON standard interms of opacity, adhesion, and fastness to light. Sample A shows superior wet abrasion resistance and was rated economy grade at 118 cycles, Whereas sample B was rated interior grade at 57 cycles. The physical and performance analysis carried out on both samples shows that *Cissus pulpunea* stem bark extract (mucilage) can be used as a binder and thickener in the formulation of emulsion paint.

Recommendations

More investigations should be carried out to check the curing methods the *Cissus Pupulnea* stem bark extract in order to enhance it's binding and thickening properties for best used in Emulsion paints.

More research should be carried out to find alternative substituents from local materials in place of imported materials in production of emulsion paint.

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