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Production of Green Emulsion Paint from *Borassus Aethiopum* Starch / *Terminalia Catappa* Seed Oil Copolymer Blend Composite as Binder.

Gloria UM Mashat, D.E.A, Boryo, I.Y Chindo and Sunday, Uzuma Sylvester.
Chemistry Department, Abubakar Tafawa Balewa University, Bauchi, Bauchi State. Nigeria.

ABSTRACT

Alternative binder order than the industrial binder (polyvinyl acetate) was formulated using a blend of starch from Borassus aethiopum and oil from Terminalia catappa seed (BS / TCSO) and used in the production of emulsion water paint were investigated at various concentration of oil in the blend (BS/TCSO) copolymer composite. The physicochemical properties such as pH, density, refractive index, viscosity dry time, Tackiness, adhesion, opacity, stability, flexibility and resistance to blistering were analyzed and compared with paint produced using industrial binder (polyvinyl acetate). There was improvement in most of the paint formulated with the new copolymer composite. The pH, density, refractive index, viscosity of paint produced with the new composite at 20 % oil inclusion in the binder were found to be 8.89, 1.05312g/cm3, 1.641, 23200mPa/s and 15, 81 as compared to 7.93, 1.01600g/cm3, 1.672, 23070mPa/s and 20, 107 for paint produced with the industrial binder (polyvinyl acetate). The paint show improvement in properties as stipulated by PMAN and SON standards. all the paint produced with the alternative copolymer composite (starch/oil) show improvement in properties when observed after six (6) months of storage.

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KEYWORDS
BS = *Borassus aethiopum* starch.
TCSO = *Terminalia catappa* seed oil

Corresponding Author Gloria UM Mashat. ✉ gloriamashat@gmail.com ✉ *Chemistry Department, Abubakar Tafawa Balewa University, Bauchi, Bauchi State. Nigeria.*

INTRODUCTION

Paint was first used in Egypt for protective coating of the wood used for their ships. The early artist used natural and available materials within their environment such as lard, charcoal, natural earth pigments, to make paint (Gunorobon and Misel, 2014). Painting is a unique human activity which contribute to beautification of our world. As paint is playing an important role, it has some draw backs which scientist still never gave up in finding solutions to build safe and healthy environments. The binder in paint, is a major component responsible for adhesive and cohesive of film (Akinterinwa *et al*., 2015).

Surface coating is the more general description of any material that may be applied as a continuous thin layer to a surface. Paint was traditionally used to clear films which are more properly called lacquers or varnishes. Paint can be defined as a mixture of pigments, binders and solvent that form a continuous film that can be decorative or protective. Vanish is a coating material which when applied to a substrate forms a solid transparent film having protective, decorative or specific technical properties (Boryo and Ezeribe, 2011). Emulsion paint are widely used in surface coating in our country due to its ease of application and industrial application. Nigeria depend on the importation of finished product due to its low Industrial development which lead to importation of raw materials for paint production leading to high cost of paint in the market (Nwakaudu and Oghome., 2012).

This new copolymer blend composite from *Borassus aethiopum* starch / *Terminalia catappa* seed oil is soluble in water, with some properties of glossiness of oil paint. The significance of this research is to add value to the present-day emulsion paint by the introduction of the new binder (starch/oil) and the hydrophobic nature of the oil which will give the paint a glossy appearance and increase its resistivity to water, flexibility and dryness. Also, will reduce the cost of raw material importation, help government to promulgate policies that will enhance better environmental protection. It will also increase quality and help in development of local technology in the coating industry.

MATERIALS

Starch/oil copolymer blend was formulated in the laboratory. Polyvinyl acetate, nitrosol, kaolin, calcium carbonate, genepol, titanium dioxide, deformer where purchased from building material market in jos, plateau state. while analytical grades sodium hexametaphosphate, formalin, ethylene glycol, and ammonia where purchased from a chemical store in jos, plateau state. Equipment's such as water bath, hot plate, viscometer, pH meter, refractometer, measuring cylinder, beakers, weighing balance, magnetic stirrer, thermometer, and syringe where provided by the postgraduate laboratory of the department of applied science University of Jos, Plateau state Nigeria.

METHODS

Formulation of Green Emulsion Paint

Emulsion paint was formulated by method described by Osemeahon *et al.* (2013b) and Lawal *et al.* (2019) where 250 ml of distilled water was introduced into the reaction pot, followed by the addition of 20 ml deformer and stirred. 10 g of titanium oxide, 10 g kaolin was added, followed by addition of 30 g $Caco_3$, 5 g of sodium hexametaphosphate and followed by the addition of 30 ml formulated starch/oil binder. 20 ml of formalin, 4 g ethylene glycol was mixed with water; 10 ml of ammonia was then be added. These ingredients were added at 5-mins interval with constant stirring.

TABLE 1: Recipe for Green Emulsion Paint Formulation using Starch/oil as a Binder

Materials	Quantity
Water	250 ml
Kaolin	10 g
Calcium Carbonate	30 g
Deformer	20 ml
Titanium oxide ($Ti0_2$)	10 g
Sodium hexametaphosphate	5.00 g
Starch/oil binder	30.00 ml
Green colour paste	0.10 g
Formalin	20.00 ml
Ethylene glycol	4.00 g
Ammonia	10.00 m

Physical Properties Assessment of Green Emulsion Paint Formulated using Starch/oil Binder

Determination of pH of green paint formulated

Method described by Osemeahon *et al.* (2013a) was adopted. The pH of the paint sample was determined using a digital pH meter (Jenway 3510). The electrode pH meter was standardized with buffer 7 solution, rinsed with distilled water and was dipped into 50 ml of paint sample in a beaker and triplicate readings were recorded and the average were calculated.

Determination of Density of green Paint Formulated

The method described by Osemeahon *et al.* (2013) was adopted. The density of the different paints produced were determined by measuring a known weight of known volume of paint into a density bottle 20 cm^3 using weighing balance, the density was calculated using mass/volume relationship. Triplicate readings were taken for each sample and an average value were calculated and recorded.

Determination of Refractive index of green Paint Formulated

An abbe refractometer was used to determine the refractive index of the different paint sample formulated. A drop of each sample was dropped on the refractometer and the readings were taken in triplicates and the average was calculated and recorded.

Determination of Viscosity of green Paint Formulated

An NDJ-5S digital rotary viscometer was used in the determination of the viscosities of the different formulated with the varying concentrations of starch/oil blend binder, spindle number two (2) was used at 6rpm for the determination. The viscosity was determined by filling a 100 ml viscosity cup with the paint sample and placed under the viscometer and spindle inserted into it. The viscometer was set on Auto and the readings for each rpm was noted and recorded.

Application property Assessment of Green Emulsion Paint Formulated using Starch/oil Binder

Determination of drying time of green emulsion paint

Dry time test was carried out according to method described by Lawal *et al*. (2019) and Osemeahon and Barminas. (2006) the paint samples were applied on a glass board with an applicator and allow to dry, then followed by touching the film with finger to confirm the dry touch and dry to hardness time. Dry touch time was recorded when the paint was film was no longer sticky to the finger and dry hard time were recorded when the paint film resisted the finger.

Determination of Adhesion of green emulsion paint

Method described by Lawal *et al. (*2013) was adopted. A coat of paint film was applied on a degreased surface of a ceiling board using an applicator and allowed to dry for 48 hours after which two lines crossing each other perpendicularly were drawn on the paint film. An adhesive tape was pressed firmly unto the coated surface, and then forcibly removed. The test of adhesion was based on the removal of more than 50 % of the square lines of the paint which will be regarded as poor adhesion. Three determinations were made at 27 ^{o}C for each paint sample and an average assessment was recorded.

Determination of Stability of green emulsion paint

Stability test was carried out on the paint by sealing the paint in a container at room temperature (27^{o}C) for 6 months. At the end of the incubation period, the paint sample was re-examined for any change in viscosity or coagulation of the emulsion paint. Absence of these two was regarded as pass (Lawal *et al*., 2019).

Determination of Resistance to blistering of green emulsion paint

Method described by Osemeahon *et al.* (2013a) was adopted. Undiluted paint sample was applied on a glass panel using an applicator to give a thickness of about 120um. This was allowed to dry for 24 hours. About 2 – 4 ml of distilled water in the form of circular drops was applied on the film and observed for 30minutes. Absence of blistering, swelling, cracking or wrinkling indicate good water resistance.

Determination of Flexibility of green emulsion paint

Method described by SON (1990) was adopted. Paint sample was applied on a ceiling board and allowed to dry under room temperature for 7days. The panel with film was through 180^{o} with a smooth action and returned to its normal state. Cracks or any loss of adhesion was observed indicate poor flexibility. The absence of cracks and any loss of adhesion was regarded as pass. Three determinations were made for each paint sample and an average assessment recorded.

Determination of Opacity of formulated paint

Method described by Osemeahon *et al.* (2013a) and Lawal *et al*. (2019) was adopted. Paint samples were applied on a Mohest chart and allow to dry for 24 hours. The opacity was evaluated by comparing the dried sample film with the hiding power chart. Three determinations were carried out for each sample and mean value assessed and recorded.

Determination of Tackiness of formulated paint

The method described by Lawal *et al.* (2019) was adopted tackiness test was carried out on the dried paint film by hand filing. Stickiness of the dried paint is an indication that the paint film is tacky. Absence of stickiness of the dry paint was regarded as good. About three determinations were carried out for each sample and the mean value calculated and recorded.

RESULTS AND DISCUSION

Physicochemical properties of green emulsion paint formulated using starch / oil copolymer composite and pure PVA

pH

The result of the pH for BS/TCSO and pure PVA formulated paints are represented in table 2. The trend shows the pH of paints produced using BS / TCSO binder to be in the range of 7.98 – 9.07 while paint produced using pure PVA has pH of 7.93. this means that the paint is acidic and fall within the PMAN stipulated standard values. The pH of this paint can be used to inhibit microbial activities in the paint film (Akinterinwa *et al*., 2015).

Density

The result for the density of paints formulated with BS / TCSO and pure PVA are represented in table 2. The result shows the density to drop at 5 % oil inclusion of BS/TCSO copolymer o 0.90714. as the oil inclusion increases in the copolymer, the densities increase from 1.04809 – 1.02613 for 10 – 25 % oil inclusion in BS – TCSO but dropped again from 0.89602 – 0.89934 at 30-35

% oil inclusion. The decrease in density may be due to an increase in the volume of oil included in the copolymer blend. This implies that, increase and decrease oil concentration affected the corresponding mass, thereby insignificantly increase the mass of oil concentration (Lawal *et al.,* 2019). The low density observed is attributed to change in morphology of composite as oil concentration increases leading to increase in specific interaction and free volume in composite (Akinterinwa *et al*., 2015). This densities from 1.026 (10 %), 1.04809(15 %) and 1.05(20 %) were within the SON standard for coating industry.

Refractive index

The result for the refractive index of paint formulated with BS / TCSO and pure PVA are represented in table 2. The result show that the refractive index for both the paint formulated all fall between 1.612 – 1.666. This is slightly higher than the PMAN standard for coating industry, the higher refractive index values hence gloss can be attributed to the orientation and state of aggregation established between the composite thereby creating light scattering boundaries and discontinuities in the molecular structure.

Viscosity

The result for the viscosity of paint formulated using BS / TCSO and pure PVA are represented in table 2. The trend shows that paint formulated using pure PVA had a viscosity of 23.070mPa/s whereas for the paint produced with BS / TCSO copolymer blend, there was an initial drop from in 5 – 15 % oil inclusion, but it was later observed to have a gradual and proportionate increase from 20 – 35 % oil inclusion in the copolymer blend. The initial drop is attributed to weak intermolecular forces and fewer bonds resulting from polymer degradation, while the increase from 20 – 35 % results from specific interaction between the BS and TCSO resulting from strong intermolecular forces and bonds also resulting from polymer degradation (Lawal *et al*.,2019). The higher viscosity is attributed to effects of higher molecular weight and crosslinking density (Akinterinwa *et al*., 2015).

Opacity, Adhesion, Tackiness, Flexibility, Resistance to blistering, Stability and Drying time of paint formulated using BS / TCSO copolymer composite and pure PVA

From Table 2, shows that paint formulations using PVA and BS / TCSO has good adhesion property. According to Nigeria Industrial Standard, NIS 268-1989, gloss paint should not exhibit more than 50 % removal of the dry film. Thus, adhesion property of formulated paint was good since none gave a removal of up to 50 % as recommended by NIS. The tackiness property also displayed in Table 2 shows good results; the stickiness of the paint samples may be as a result of enhanced network structures occasioned by modification. The flexibility of the paint samples displayed in Table 2 also indicates pass results; the hiding power of paint sample displayed in Table 2 shows good results, the ability to prevent the transmission of light in order to hide the substrate below is the opacity in paint which is generated by differences in refractive index between the formulation ingredients. The drying properties of paint films are displayed in Table 2; the drying time of paint samples is a little above standard value (Lawal *et al.,* 2019).

This type of behavior should be expected since oil films are generally slow in drying. The oil segment in BS / TCSO copolymer therefore account for the present result witnessed in the paint. An additive in the form of drier is not required for this binder. Table 2 also shows the result of resistance to blistering of the different paint formulations. It is observed that paints pass resistance to blistering test. The above results indicate that TCSO segments has been cross-linked into the BS / TCSO copolymers thus making the resulting paint to display hydrophobic property which helped to increase the resistance to blistering of the resulting paint formulation (Lawal *et al.,* 2019)

Table 2; physicochemical properties of paint formulated using BS / TCSO blend copolymer and pure PVA paint.

s/n	Parameter	BS / TCSO (80:20 %) oil inclusion	Pure PVA	PMAN STANDARD	SON
1	pH	8.89	7.93	7.00 – 8.50	
2	Density(g/cm^3)	1.05312	1.01600	1.45 – 1.70	
3	Refractive index	1.641	1.672	1.01	
4	Viscosity (mPa/s)	23200	23070	Above 45 poise	
5	Opacity	Pass	Pass	Pass	
6	Adhesion	Excellent	Excellent	Pass	
7	Tackiness	Good	Good	Good	
8	Resistance to blistering	Pass	Pass	Pass	
9	Flexibility	Pass	Pass	Pass	
10	Stability	Good	Good	Excellent	
11	Drying time	15 / 81	20 / 107	20 / 120	

CONCLUSION

Emulsion paint formulated using the new BS / TCSO blend copolymer and that from pure PVA, show good paint physicochemical properties. All values for pH, density, refractive index, viscosity, adhesion, drying time, stability, opacity, resistance to blistering, flexibility and tackiness fall within the PMAN stipulated standard values which are required in the coating industry. Therefore, this paint formulated with the new (BS / TCSO) copolymer blend resin if properly harnessed will add value to the present-day emulsion paint, reduced cost of importation and production of paint, provide safer and healthier environment and encouraged the planting of *Borassus aethiopum* as well as *Terminalia catappa* trees.

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