Development of an Emulsion Paint from Polyvinyl Acetate/Soybeans Oil Copolymer Binder

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Abstract:- **In this research work, formulation of emulsion paint from pure polyvinyl acetate (PVA) and polyvinyl acetate/soybeans oil (SBO) copolymer (PVA/SBO) resins (binder) was successfully carried out from 0 to 35 % concentrations. However, properties such as viscosity increases from (0.92 to 2.7 m^2/s), density also decreases from (1.28 to 1.06 g/cm^3), pH, flexibility, tackiness, stability and drying time, adhesion, resistance to blistering and chemical resistance of the formulated and commercial paint was carried out which shows encouraging (good) results. The results obtained when compared with the values of the commercial paint are within the acceptable level in the coating industry. The results have demonstrated the development of emulsion paint from PVA/SBO resin, this emulsion paint when fully harnessed will reduce the over dependence on the synthetic oil based paints and hence a reduction in volatile organic compounds (VOC) emission into our environment which will in turn provide a healthier environment.**

Keywords: **Paint binder, polyvinyl acetate/soybean oil copolymer, emulsion paint.**

I. INTRODUCTION

The term "paint" and "surface coating" are often used interchangeably [1]. Surface coating is the more general description of any material that may be applied as a thin continuous layer to a surface [2]. Paint was traditionally used to clear films which are more properly called lacquers or varnishes, [2]. Paint can be defined as a mixture of pigments, binders and solvent that form a continuous film that can be decorative or protective [2]. Vanish is a coating material which when applied to a substrate forms a solid transparent film having protective, decorative or specific technical properties [3].

This copolymer binder (polymer) should be able to use water as its solvent while at the same time deliver the enamel characteristics of the traditional oil paint. This is the main trust of this particular research. The significance of the research is to add value to present emulsion paint by introducing hydrophobic nature of Soybeans oil in to the emulsion paint, which increases resistivity to water, flexibility and reduces Volatile Organic Components VOCs emission, thereby reducing the effect of ozone layer depletion, global warming caused by the emission of Volatile Organic Components (VOCs) from surface coating. Also it will reduce cost, increase quality and develop local technology in the coating industry while increasing environmental health of the society.

II. MATERIALS

Polyvinyl acetate/soybeans oil copolymer binder PVA/SBO (formulated), additives such as rutile, china clay, dispersant, Nicofoam, Paris white, kaolin, and Bermocoll were purchased from Jos Market Plateau State, Nigeria. Analytical grade of sodium dihydrogen phosphate, sulphuric acid, Butanol and distilled water were used. Equipment such as Magnetic stirrer, Bunsen burner, water bath, weighing machine, viscosity cup, stop watch, measuring cylinder, thermometer and syringe, were provided by Department of Chemistry Abubakar Tafawa Balewa University Bauchi, Bauchi state, all materials were used as received.

III. METHODS

Paint Formulation

The method described by [4] was adopted for paint formulation. A volume of 250 ml of water was introduced in to a litre mixing tank, followed by the addition of 20 ml of a deformer, at this time; a stirrer was introduced in to tank. 10 g of Rutile (TiO_2) and 10 g of off white kaolin was then added, followed by addition of 30 g of $CaCO_3$. 5 g of sodium hexametaphosphate was added, followed by 30 ml of formulated PVA/SBO binder, 20 ml of formalin, 4 g of cellulose ether mixed with 20 ml of water was then added. 10 ml of ammonia was finally added. All these ingredients were added one after the other at ten minutes interval each with constant stirring to a desired consistency. The mixture was made up to 500 ml with distilled water.

Evaluation of Paint Samples

Viscosity Measurement

The viscosity of paint sample was evaluated using flow cups viscometer expressed in meter square per seconds m^2/s at room temperature (30^0C), in which the viscosity was calculated from flow time. Triplicate readings were taken for each sample and the average value calculated [4].

pH Determination

The pH of paint samples was determined by using JENWAY 3510 digital pH meter. The pH electrode were

standardized with buffer solution of 7 and rinsed with distilled water. The electrode was then dipped into the paint samples and the pH was recorded [5].

Opacity

Opacity of the paint samples were determined by using the standard Mohest Chart. The paint sample were applied on Mohest Chart (i.e. hiding power chart) and allowed to dry for 24 hrs. The opacity was then evaluated by comparing the dried sample film with the hiding power chart [4].

Dry to Touch and Dry to Hard Test

The dry time of the paint samples was evaluated according to [3] method. Sample of paint were applied on a glass panel with the aid of bar applicator and allowed to dry. Dry to touch were then taken when the paint film was no longer sticking to the finger while dry to hard were taken when the film resisted finger touch [4].

Flexibility Test

Flexibility test was performed according to [5] method. Paint samples were applied on a freshly degreased aluminum foil with the aid of paint applicator. The film was then allowed to air dry under room temperature (30^oC) for 7 days. The panel with the film was bent through 180^o with a smooth action (taking 1 – 2 seconds). Cracking or loss of adhesion was examined. Any crack or loss of adhesion indicates inflexibility or brittleness. Triplicate samples were made and average evaluation taken [4].

Adhesion Test

To evaluate the adhesion property of the paints, the method described by [5] was adopted. A coat of paint film was applied with film applicator on a degreased metal panel and allowed to dry for 48 hours. Two sets of lines, one crossing perpendicularly over the other were drawn on the paint film. An adhesive tape was pressed firmly with the thumb covering all the interactions of the perpendicular line. The adhesive tape was held at its loose ends and forcibly removed from the panel. Removal of more than 50 % of the square lines of the paint film indicates poor adhesion. Triplicate determinations were made at 30^oC for each sample and average value recorded [4].

Density

The above properties were determined according to [3]. The density of the different resins was determined using density bottle, by taking the weight of a known volume of resin inside a density bottle using Metler At400 weighing balance. Thus the density was obtained by taking the known mass over the volume of the sample. Triplicate readings were taken for each sample and the average value calculated [4].

Stability Test

The paint samples were fully sealed in a container and allowed to stay at room temperature (30^0C) for 9 months. At the end of this incubation period, the sample were re-examined for any change in viscosity or coagulation of the emulsion paint. Absence of coagulation or any change in viscosity is regarded as a pass. Triplicate samples were used for each determination and the average value was recorded [4].

Tackiness

Tackiness was done qualitatively on the dried film by hand feeling to find out if the paint film is sticky or not. Stickiness of a dried paint film is an indication that the film is tacky. Triplicate samples were used for each determination and the average quality assessment recorded [4].

Resistance to blistering

Undiluted paint sample was applied to a glass panel with an applicator to give a wet film thickness of about 120 m. This was allowed to dry for 24 hrs. At the end of this period, 4 ml of distilled water in the form of circular drop was placed on the film. The presence of blistering, wrinkling, swelling or cracking within a period of 30 minutes indicates poor water resistance. Triplicate samples were used for each determination and the average quality assessment recorded [4].

Chemical resistance

To evaluate the chemical resistance of the paint films, three flexible aluminum panels (150 mm x 0.3 mm) were used as the test panels. A coat of paint with paint applicator was applied to the panel. One litre glass beaker was filled with 0.1M NaOH solution to depth of 150 mm and the test piece immersed for 48 hrs to the depth of approximately 120 mm. The test piece was removed and washed with running water and stood to dry for 2 hrs. The above procedure was repeated by using 0.1M HCI and 0.1M NaCl respectively. The presence of any surface defects such as cracking, blistering, peeling or change in color indicates poor chemical resistance [4].

IV. RESULTS AND DISCUSSIONS

Physical Properties of Paints Formulated from PVA, PVA/SBO Binder And Commercial Paint.

Viscosity

The results of the viscosity for PVA and PVA/SBO formulated paints are presented in Table 1. This shows a steady increase of viscosity values from 0.92 to 4.4 m^2/s as concentrations of SBO increase from 0 % to 15 %, which means there are strong intermolecular forces and more bonds from the initial stage. This explained the specific interactions between PVA resin and SBO. However, decrease of viscosity values was observed from 2.8 to 2.2 m^2/s at 20 % to 25 % concentration. These results from weak intermolecular forces

and fewer bonds. Also resulting from polymer degradation. Hence an increase to 4.9 m^2/s at 30-35 %.

pH

The results of the pH for PVA and PVA/SBO formulated paints are presented in Table 1. This shows a slight increase in pH values from 8.2 to 8.4 at 0 - 35 % SBO concentrations, which means that Paint formulation, took place in alkaline conditions. The result is within the accepted level required in the coating industry [5].

Density

The results of the density for PVA and PVA/SBO formulated paints are presented in Table 1. The density of the formulated paint gradually drops from 1.28 to 1.06 g/cm^3 at 0 % to 35 % SBO inclusion. This means that decrease in density of the paint samples may be as a result of increase in volume of the paint samples. This implies that increase or addition of the SBO affected the volume of the paint than the corresponding mass, thereby insignificantly increasing the mass as the concentration of the SBO increase. According to SON the minimum approved standard is 1.01 g/cm^3[5].

Adhesion, Tackiness, Flexibility, Opacity and Drying times of Paint Formulations

From Table 1, paint formulations from PVA and PVA/SBO shows 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 1 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 1 also indicates pass results; the hiding power of paint sample displayed in Table 1 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 1; the drying time of paint samples is a little above standard value [5]. This type of behavior should be expected since oil films are generally slow in drying. The oil segment in PVA/SBO binder therefore account for the present result witnessed in the paint. An additive in the form of drier may be required for this binder in order to improve the drying time.

Table 1 also shows the result of blistering (water resistance) of the different paint formulations. It is observed that paints pass resistance to blistering test. The above results indicate that SBO segments has been cross-linked into the PVA/SBO copolymers thus making the resulting paint to display hydrophobic property which helped to increase the water resistance of the resulting paint formulation [6].

Chemical Resistance

From the Table 1, it was established that the paint formulated at various SBO concentrations has chemical resistance. The stability of paint samples formulated when immersed for 48 hrs in 0.1 M NaOH and 0.1 M HCl solutions means the paints has alkali resistance and fairly acidic resistance. Which means the formulated paint can be applied in basic and acidic environment.

Table 1:Physical Properties of Paints Formulated From Pure PVA and PVA/SBO Binder

S/N	Parameters	Pure PVA	PVA/SBO (35:65)	SON
1.	Viscosity (m^2/s)	0.92	2.7	6-15
2.	pH	8.2	8.4	7.0-8.5
3.	Density (g/cm^3)	1.28	1.06	Min 1.01
4.	Tackiness	P	P	P
5.	Flexibility	P	P	P
6.	Drying time T.D (min) H.D	17 35	26 67	20 120
7.	Opacity	G	G	P
8.	Stability (after 12 month)	P	P	P
9.	Adhesion	G	G	P
10.	Chemical resistance	P	P	P
11.	Resistance to blistering	P	P	P

*P = Pass, G = Good, T.D = Touch to dry and H.D = Hard to dry.

V. CONCLUSION

Formulated emulsion paint from pure PVA and PVA/SBO copolymer binder and commercially available paint showed a remarkable property. The values of density, viscosity, drying time, refractive index, stability, flexibility, adhesion, pH, and tackiness, resistance to blistering and chemical resistance obtained from this experiment are within the acceptable levels required in the coating industry. This emulsion paint formulated when fully harnessed will add value to the present emulsion paint by reducing the moisture uptake, flexibility and reduce the over dependence on oil based paints and hence a reduction in VOC emission into our environment that destroyed the atmospheric ozone layer, which will in turn provide a healthier environment.

REFERENCES

[1]. Akinterinwa A, Osemeahon S.A, I.I Nkafamiya, and P.M Dass, (2015). Formulation of Emulsion Paint from Copolymer composite of Dimethylol Urea/polystyrene, *International Journal of chemical and processing Engineering Research***7** (7): 20-26. www.iiste.org2015.

[2]. Boryo D.E.A and Ezeribe A.I (2011). **The principles and production processes of some chemical industries** New Era production, Bauchi Nigeria 1st ed. Pp 67-88.

[3]. Osemeahon, S.A., and Barminas J.T., (2007). Study of Composite from reactive Blending of Methylol Urea Resin with Natural Rubber. *African Journal of Biotechnology*.**6**(6):810-817.

[4]. Osemeahon, S.A., A.J. Hotton, and F.G Fadawa. (2013). Development of Mosquito repellant Emulsion Paint f I: Effect from Neem Seed Oil. *The international Journal of Green and Herbal Chemistry*.**2**(3):641-650.

[5]. SON, (1990). **Standard for paint and Varnish Part 6**: Test Method for Paints for Decoration Purpose. Pg. 1-24.

[6]. Surajudeen Abdulsalam, Zebulu Dauma Maiwada. (2015). Production of Emulsion House Paint using Polyvinyl Acetate and Gum Arabic as Binder. *International Journal of Material Science and Applications*.**4**, No. 5, pp. 350-353.