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ALTERNATIVES TO NATROSOL AS THICKENER IN THE PRODUCTION OF EMULSION PAINT

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ABSTRACT

Alternative thickeners to an industrial thickener (natrosol) in the production of emulsion paints were investigated. Four starch grades; native starch, native starch modified with sodium acetate, native starch modified with sodium acetate plus fumaric acid and native starch modified with sodium acetate mixed with adipic acid were tested as possible alternatives to natrosol. The physio-chemical properties such as viscosity, density, pH, drying time and durability of the paints produced with these starches as thickeners were compared with paint produced with the industrial thickener (natrosol). There were improvements in these properties in paints produced from the modified starches compared with paint produced from the native starch. The paint produced with native starch modified with sodium acetate and furmaric acid had properties closest to the paint produced with the industrial thickener. The viscosity, density, pH and drying time of the paint produced with sodium acetate and furmaric acid are 61cp, 1.53g/cm^3, 8.43 and 26mins compare to 60cp, 1,54g/cm^3, 8.5 and 25mins for paint produced with the industrial thickener. All paints produced with alternative thickeners deteriorated in properties with time (when observed after three weeks of storage).

Keywords: emulsion paints, natrosol, modified starch, physiochemical properties.

INTRODUCTION

Paint is any liquid, liquefiable, or of mastic composition which, after application to a substrate in a thin layer, is converted to a solid film. It is most commonly used to color, protect or provide texture to objects (Berendsen, 1989). Paint was first used as a protective coating by the Egyptians and Hebrews, who applied pitches and balsams to the exposed wood of their ships. Early artists also relied on easily available natural substances to make paint, such as natural earth pigments, charcoal, berry juice, lard, blood and milkweed sap with the twentieth century seeing the most changes in paint composition and manufactures (Baov, 1981). Today, synthetic pigments and stabilizers are used to mass produce uniform batches of paint, new synthetic vehicles developed from polymers such as polyurethane and styrene-butadiene emerged during the 1940s and today, sand mills and high-speed dispersion mixers are used to grind easily dispersible pigments (Cock, 1985).

Paints can be classified based on composition, end-use, method of cure and appearance (Morgan, 1990). The types of paints commonly used are: latex or emulsion paints, oil-based or gloss paints, lacquers, cement water paints, enamels, fire-retardant paints, heat-resistant paints, and metallic paints.

Paints are composed of (Flick, 1989) resin - the film forming portion of the paint, includes polyvinyl acetate (PVA), alkyd resin etc; solvent - used to thin or disperse the resin, improve its rheorlogy, enables easier applications and formation of the paint film (Dumitiu and Jitaru, 2011), examples: kerosene and water; Pigments - primary; such as titanium dioxide (TiO_2) which impacts on the hiding capabilities of the paint film and ensures ultra-violet protection (Woodbridge, 1991); secondary, also known as extenders - serve as filters and help control viscosity and shine. Examples includes: calcium carbonate ($CaCo_3$), kaolin and talcum; Colorants - the tinting liquids which gives paint its final desired color; Additives (Burrel;, 2003) - substances added in small quantities to give the paint certain required qualities such as ability to dry normally, storing power, modify surface tension, improve flow properties, improve the finished appearance, increase wet edge, improve pigment stability, impart antifreeze properties, control foaming, control skinning, etc. Other types of additives (Turner, 1988; Bently and Turner, 1997) include catalysts, thickeners such as hydroxyethyl and cellulose (Natrosol); stabilizers, emulsifiers, texturizers, adhesion promoters, ultra-violet (UV) stabilizers, flatteners (de-glossing agents), biocides to fight bacterial growth (The Nerdly Painter, 2011), preservative and driers.

Natrosol is used as a thickener in paint production. It is imported as it is not readily available locally, hence accounts for its high cost value. This research seeks local alternatives to natrosol as a thickener in paint production. Cellulose present in Natrosol gives it the ability to be used as a thickener in the production of paint. Hence materials containing cellulose are potential alternatives to natrosol in paint production.

The use of cassava starch, a locally available raw material as an alternative to natrosol in paint production was investigated. Native starches irrespective of their source have been reported to be unsuitable for many industrial applications because of their inability to withstand processing conditions such as extreme temperature (has low thermal resistance), diverse pH, loss of viscosity and high shear rate (low shear resistance) (Okezie, 1982; Singh *et al*. 2007). To improve on the desirable functional properties and overcome its limitations, native starches are often modified (Miyazaki *et al*., 2006) - alteration of its physical and chemical characteristics to improve structural properties.

The production of improved/modified grades of native starch using modification by cross linking has been performed by Akpa and Dagde, (2012). The produced modified native starches had improved properties in viscosity, solubility and gelatinization temperatures. The modified starches produced by Akpa and Dagde (2012) were tested in this work as possible alternatives to natrosol as thickeners in emulsion paint production. The best three of the five modified starch grades produced by Akpa and Dagde were tested in this work as possible alternatives to the industrial thickener (natrosol) in emulsion paint production.

MATERIALS AND METHODS

Apparatus

Beakers, Conical flasks, weighing pan, Sample bottles, Stirrer, Mixer, Spatula, Brookfield viscometer, Size 4 spindle, Pycnometer, Analytical balance, Electronic pH meter, paint brush, stop watch, washing basins, knives, grating machine, sieve, settling basins, Mixing bowls, Batch tray dryer and Mixing Tank.

Raw materials

The emulsion paint was produced using the following raw materials: pigments - titanium oxide and calcium carbonate; solvents - water and kerosene; resins - polyvinyl acetate (PVA) and additives such as defoamer, thickner - natrosol, native starch and three modified starch grades as produced by Akpa and Dagde, (2012). The raw materials (pigments, solvents, resins and defoamer) were obtained from a chemical shop at the mile 3 market in Port-Harcourt, Rivers State, Nigeria. The industrial thickener natrosol was supplied by a paint company in Port-Harcourt, Rivers State, Nigeria, while the native starch and modified varieties were produced by Akpa and Dagde, (2012) and obtained from the Department of Chemical/Petrochemical Engineering, Rivers State University of Science and Technology Port-Harcourt.

Methods

A laboratory scale production of emulsion paint was performed. The proportion and weights of the different raw materials were obtained from a paint manufacturing company in Port-Harcourt and used in the paint production. Five grades of paint were produced following the procedure outlined in Figure-1 using five different thickeners; the industrial thickener - natrosol, native starch and three modified starches (native starch modified with sodium acetate, sodium acetate plus fumaric acid and sodium acetate mixed with adipic acid). The paint produced were labeled grade A, B, C, D and E, respectively as stated in Table-1.

Table-1. Thickener used for the different starch grades.

Paint grade	Thickener
A	Natrosol
B	Native Starch
C	Modified starch with Sodium Acetate
D	Modified starch with Sodium Acetate and Fumaric acid
E	Modified starch with Sodium Acetate and Adipic acid

The paint production was performed at the Unit Operations Laboratory of the Department of Chemical/Petrochemical Engineering, Rivers State University of Science and Technology, Port-Harcourt, Rivers State, Nigeria.

Experimental procedure

The experimental procedure used in the paint production is as outlined in Figure-1.

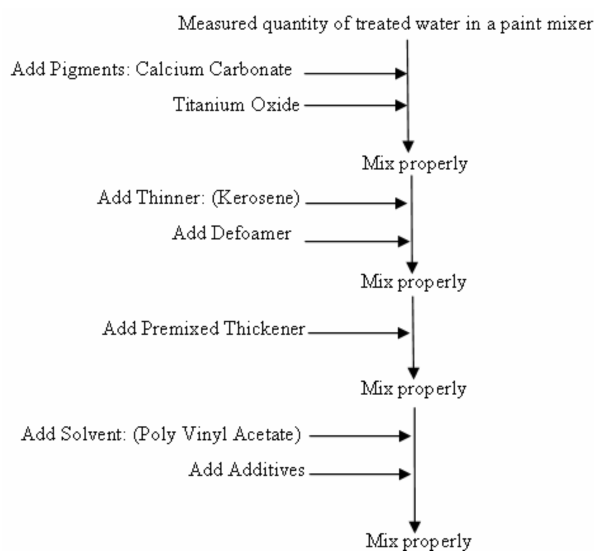

Figure-1. Flow chart for the laboratory production of paint.

CHEMICAL ANALYSIS

The produced paints were analyzed for viscosity, density, pH and drying time to ascertain the quality of the paints and the suitability of the proposed starch grades as alternative thickeners in paint production. All results presented were the average of duplicate analysis.

Determination of viscosity

The viscosity profiles of the paints were obtained using a viscometer (LvDv I+, Brookfield, USA) following the technique proposed by AOAC, (2000).

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Density

The densities of the paints were determined by taking the weight of a known volume of the different paints in a density bottle (pycnometer) using an analytical balance.

Determination of pH

This was determined using a pH meter (model HI 8424 with pH buffer 7). 25ml of paint sample was mixed in beaker with 25ml of distilled water and stirred properly. The pH meter was inserted into the solution and the reading taken.

Drying time

Paint was applied on a clean dry wall, the paint was monitored and the time taken to obtain a dried film was observed and recorded.

Durability

The paints produced were subjected to a durability test to ascertain how long they can stand before deteriorating. The paints produced from the five different thickeners were allowed to stand for three weeks after which they were all observed and quality test to determine viscosity, density, pH, and drying time was performed.

RESULTS AND DISCUSSIONS

The results of the various analyses to determine the physico-chemical properties of the produced paints are presented in Table-2. The properties of the paints produced from the different starch grades (B, C, D and E) were compared with that of the paint produced using the industrial thickener (A) as reference.

Table-2. Physico-chemical properties of produced paints.

S/N	Paint grade	Thickener	Property			
			Viscosity (Cp)	Density (g/cm3)	pH	Drying time (mins)
1	A	Natrosol	60	1.54	8.5	25
2	B	Native Starch	54	1.50	8.0	20
3	C	Native starch modified with Sodium Acetate	7	1.52	8.10	10
4	D	Native starch modified with Sodium Acetate mixed with furmaric acid	61	1.53	8.43	26
5	E	Native starch modified with Sodium Acetate mixed with adipic acid	86	1.58	8.60	35

Viscosity

Table-2 shows the viscosity of the paints produced with the various thickeners. It was observed that all the paint grades thicken instantly except the grade C paint that thickened after it was left for five minutes. The paint grades D and E from modified native starch had higher viscosity than paint grade B from unmodified native starch. The viscosity of paint grade E was the highest and much higher (paint was very thick) than that of Paint grade A while the viscosity of paint grade D was very close to that of Paint grade A from the industrial thickener.

Paint produced using native starch modified with sodium acetate (a base only) was very light as its viscosity was very low (7cp) as compared with (54cp) produced using native starch. Modification using sodium acetate mixed with an acid produced thicker paints. This is seen in the viscosity of the paints produced using the grades D and E thickeners.

Density

The densities of all the paint grades were very close. The paints from the modified starches had higher (improved) values than the paint from the unmodified native starch. The paint grade D from the modified starch had density value closest to that of paint grade A from the industrial thickener.

pH

The paints from the modified starches had higher pH values than the paint from the unmodified native starch. The paint grade D had pH value closest to that of paint grade A from the industrial while the paint grade E had higher pH value compared to the paint grade A. Modification increased the basicity of the produced paint as the paints produced with the modified starches had pH values of 8.10, 8.43 and 8.60 compared with 8.0 for paint produced with unmodified starch.

Drying time

The lighter the paint (low viscosity) the faster it dries (Talbert, 2007). This trend is seen in Table-2 where the drying time of the paints in increasing viscosity is: paint grade C, B, A, D and E. Paints produced with native starch modified with only a base (sodium acetate) paint grade C had lowest drying time of all the paint grades produced. Paints produced with native starch modified with a base (sodium acetate) and an acid (furmaric acid, paint garde D or adipic acid, paint grade E) had higher drying time compared with paint produced with the industrial thickener, paint grade A and paint produced with unmodified native starch, paint grade B. The paint grade D produced from starch modified using sodium acetate with fumaric acid had drying time value closest to the paint produced using the industrial thickener (Natrosol), paint grade A.

Durability

The five paint grades were re-analyzed after three weeks to determine their physico-chemical properties. The results are presented in Table-3.

Table-3. Properties of paints after three weeks.

S/N	Paint grade	Thickener	Property			
			Viscosity (Cp)	Density (g/cm3)	pH	Drying time (mins)
1	A	Natrosol	60	1.54	8.5	25
2	B	Native Starch	5	1.18	6.25	8
3	C	Native starch modified with Sodium Acetate	2	0.76	6.44	5
4	D	Native starch modified with Sodium Acetate mixed with furmaric acid	18	1.32	6.53	15
5	E	Modification with Sodium Acetate mixed with adipic acid	6	1.16	6.17	8

Table-3 shows that the properties of all paint grades (B, C, D and E) produced from the alternative raw thickenerss - the native and the modified starches changed except paint grade A produced with the synthetic thickener (Natrosol). There was complete deterioration in quality of the paints grades B, C, D and E produced from the native and modified starches. The viscosities and drying times reduced drastically, the densities minimally while the pH reduced significantly making the paints more acidic. The deterioration in the produced paint quality (using the physiochemical properties as bases) in increasing order is paint grade D, E, B and C. paint. This deterioration can be attributed to the activities of microbes which are able to feed on the cellulose substance in the paint produced with native and modified starches whereas they cannot feed on the cellulose in natrosol because it is inorganic (synthetic).

CONCLUSIONS

Emulsion paints using four starch grades; native starch, native starch modified with sodium acetate, native starch modified with sodium acetate plus fumaric acid and native starch modified with sodium acetate mixed with adipic acid as thickeners were produced. The physiochemical properties of these paints were compared to those of the paint produced with an industrial thickener (natrosol) to determine if any could serve as possible alternative to natrosol. The paint produced using native starch modified with sodium acetate mixed with an acid (furmaric or adipic acid) (paint grades D and E) had improved properties in viscosity, density, pH and drying time compared with paint produced using un-modified native starch (paint grade B). The paint produced using starch modified with only sodium acetate (paint grade C) did not have improvements in any property compared with paint produced using un-modified native starch (paint grade B). Similar improvements in physiochemical properties were observed in Native starch modified using a mixture of base (sodium acetate) and acid (furmaric or adipic) as reported in an earlier work of Akpa and Dagde, (2012).

The paint produced with native starch modified with sodium acetate and furmaric acid had properties closest to the paint produced with the industrial thickener. The viscosity, density, pH and drying time of the paint produced with sodium acetate and furmaric acid are 61cp, 1.53g/cm^3, 8.43 and 26mins compare to 60cp, 1, 54g/cm^3, 8.5 and 25mins for paint produced with the industrial thickener. Therefore native starch modified with sodium acetate and furmaric acid can serve as a substitute to natrosol in the production of emulsion paints.

However, all the paints produced with alternative thickeners deteriorated in properties with time when observed after three weeks of storage while the properties of the paint produced with the industrial thickener did not change. To be a suitable alternative thickener, the properties of the paint produced with native starch modified with sodium acetate and furmaric acid as thickener must not change in properties within a reasonable period of time. Further work in this regard is proposed aimed at developing appropriate preservatives as additives in the production of emulsion paint using native starch modified with sodium acetate and furmaric acid as thickener.

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