GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 10, NO. 2, MARCH 2004: 279 - 285
 ISSN 1118- 0579

EFFECTS OF ADOPOL EVS-9279X ON THE EMULSION AND FILM PROPERTIES OF EMULSION PAINT

J. O. E. OTAIGBE and C. C. ONYEMENONU Snr.

(Received 15 August 2003; Revision accepted 17 September 2003)

ABSTRACT

The effects of Adopol EVS-9279X on the emulsion and film properties of emulsion paint were investigated using 5% - 10% w/w sample formulations. Results indicate that Adopol EVS-9279X did not alter the apparent viscosities of the emulsion paint samples. It was found to have lowered the specific gravity from 1.53 to 1.47 minimum at 6% w/w formulation and surface tension from 1.013 x 10^{-1} Nm^{-1} to 0.656 x 10^{-1} Nm^{-1} minimum at 5% w/w formulation, solid content from 53.4% to 47.5% minimum at 10% w/w formulation. It increased pH from 7.01 to a maximum of 8.85 at 5% w/w formulation and water resistance by reducing water absorption from 25.2% to 23.5% minimum at 5% w/w formulation.The drying time was reduced from 33.5 minutes to 20.0 minutes minimum at 7% w/w formulation and flexibility improved within 5% - 10% w/w sample formulations studied.
Key words: Emulsion, Adopol EVS-9279X and Polymer.

INTRODUCTION

Emulsion paint is very widely used to protect and decorate. One of the popular household emulsion paints is the type based on the poly (vinyl acetate) lattices shown in Fig. 1, which is prepared by emulsion polymerization of vinyl acetate ($CH_3COOCH{=}CH_2$) (Turner, 1967). Emulsion polymerization starts with a solution of water-soluble monomers and initiator, or with the solublization of insoluble monomers and initiator using surfactants.

The emulsion is bound to remain unstable except a surfactant is used. This addictive which must be compatible with the solvent reduces the interfacial tension between the droplets and the water and if ionic, gives the droplets an electrostatic charge. Stability in emulsion paint is improved by the use of protective colloids, which are polymeric materials with highly polar and non-polar features in their molecular structures. If the protective colloids are not truly compatible with the film former, gloss will be reduced and the film weakened.

Frequently used colloids in water paints like casein, glue and water soluble cellulose derivatives are often affected by microorganisms, so fungicides and bactericides may be included to prevent deterioration.

Adopol EVS-9279X is an emulsion viscosity stabilizer that is not susceptible to microbial attack. It is produced by Gamor Chemical and Allied Limited, PortHarcourt, Nigeria for use as a protective colloid to improve the stabilization of emulsion paints, agro-industrial suspension, cosmetics, etc, with sodium salt of methyl ethyl cellulose and sodium benzoate as active components. It has been reported to have ability of locking up unwanted metal ions with other additives or trace metals in compounds, and that, this in turn makes it possible to improve shelf life, colour clarity and stability (Airuchia, 1992).

Ebosie studied the characterization and application of differential film formation in Adopol Standard Defoamer, Adopol EVS-9279X and Poly (vinyl acetate) (Ebosie, 1996).

However, since the development, production and marketing of this emulsion viscosity stabilizer in Nigeria, its effects on the emulsion and film properties of emulsion paint, such as viscosity, surface tension, specific gravity, flexibility, pH, water resistance, drying time and solid content have not been reported. Consequently, this paper presents a report of the investigation of the effects of Adopol EVS-9279X on the emulsion and film properties of emulsion paint in order to establish its suitability for application to emulsion paints.

EXPERIMENTAL

MATERIALS

The Adopol EVS-9279X, milky white viscous liquid, specific gravity 1.04 – 1.05 at 30°C, solid content ≈ 2.2% was obtained from Gamor Chemical and Allied Limited, Port Harcourt. The control emulsion paint was obtained from Saclux Paint Industry Limited, Aba. These materials were used as received.

J. O. E. OTAIGBE, Dept. of Pure and Industrial Chemistry, University of Port Harcourt, Port Harcourt, Nigeria.
C. C ONYEMENONU Snr., Dept. of Pure and Industrial Chemistry, University of Port Harcourt, Port Harcourt, Nigeria.

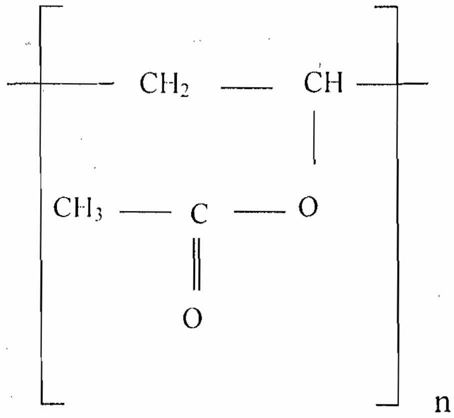

Fig. 1. Poly (vinyl acetate)

SAMPLE PREPARATION

200 g of the emulsion paint were measured into different plastic plates. Varying quantities of Adopol EVS-9279X (ranging from 10 – 20 g) were measured and added to each of the 200 g emulsion paint already measured as shown in Table 1.

The mixtures were homogenized by stirring with a glass rod to obtain 5% - 10% w/w sample formulations. The plates were covered and the samples were allowed to stand for 24 hours to allow for proper interaction of Adopol EVS-9279X with the emulsion paint before the measurements of the emulsion and film properties were carried out.

Table 1: Sample Formulation for Measurements

Sample	Quantity of Emulsion Paint (g)	Quantity of Adopol EVS-9279X (g)	% w/w formulation
A	200	0	0
B	200	10	5
C	200	12	6
D	200	14	7
E	200	16	8
F	200	18	9
G	200	20	10

MEASUREMENT OF EMULSION PROPERTIES

The emulsion properties investigated include: viscosity, surface tension, specific gravity, solid content and pH.

Viscosity

The apparent viscosities of 100 g sample dissolved in 350 ml distilled water of each of the samples were measured using Fann V-G viscometer. The apparent viscosities were calculated using the following equation:

$$Apparent\ Viscosity\ (cp) = \frac{Reading\ at\ 600\ rpm}{2} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Surface Tension

Surface tension of the samples was measured by the traveling microscope method as reported by Raymond (Raymond, 1977). Glass capillary tubes of 0.2 cm diameter and 250 ml beakers were first cleaned with detergent solution, nitric acid, thoroughly rinsed with distilled water and then allowed to dry. A known volume of each prepared sample was put into the beaker, the glass capillary tube was next immersed into the sample in the beaker and clamped in a vertical position. The rise of the sample in the capillary tubes was then measured with Graffin travelling microscope.

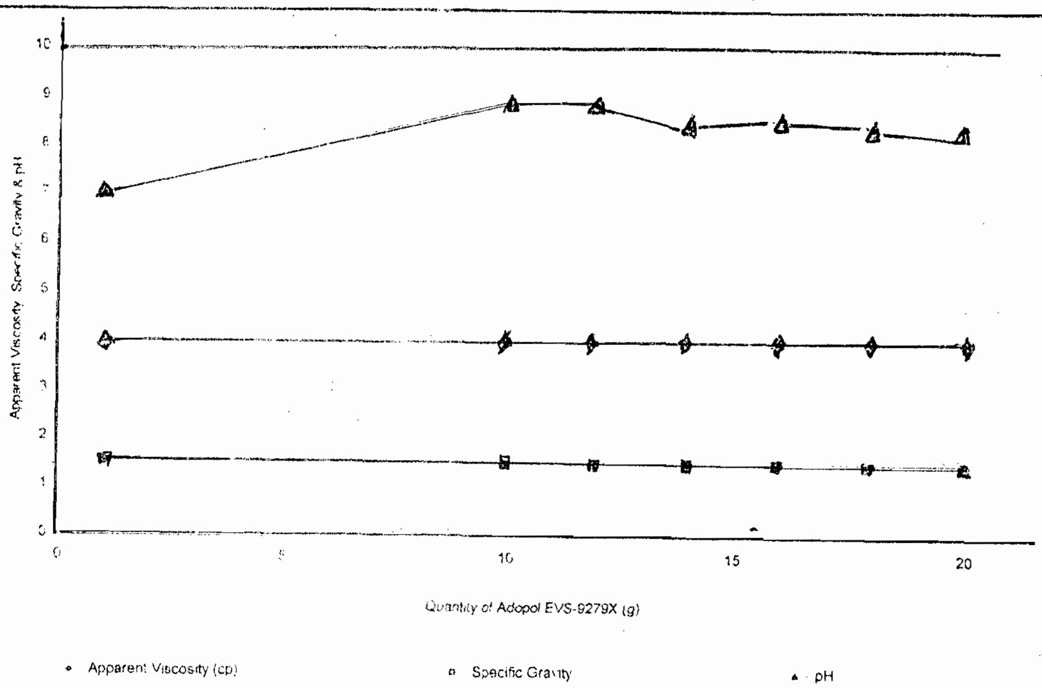

Fig.2: Variation of Apparent Viscosity, Specific Gravity and pH of Emulsion Paint with Quantity of Adopol EVS-9279X.

The surface tension of each of the samples was calculated using the following equation:

$$\tau = \frac{1}{2} r\rho g h \quad (2)$$

where g = acceleration due to gravity (m/s^2), ρ = density of the sample (kg/m^3), r = radius of the capillary tube (cm) and h = rise of the sample in the capillary tube (cm).

Specific Gravity

Standard specific gravity bottle method was used (Airuehia, 1992).A 50 ml specific gravity bottle was thoroughly cleaned with detergent solution and nitric acid to make it free from dirt and grease. It was then rinsed with distilled water and allowed to dry. The dry bottle was weighed and a known volume of distilled water was introduced into the bottle and re-weighed. The bottle was emptied of distilled water, allowed to dry and a known volume of the sample introduced into the bottle and weighed using a Mettler analytical balance.

The specific gravity of the samples was calculated using the following equation:

$$S.G. = \frac{W_3 - W_1}{W_2 - W_1} \quad (3)$$

where

W_1 = mass of empty specific gravity bottle (g),
W_2 = mass of bottle filled with water (g),
W_3 = mass of bottle filled with sample (g),

Solid Content

The ASTM D-1489 method was used (ASTM, 1960). A porcelain crucible was weighed and the mass of the crucible recorded. Some quantity of each sample was slowly introduced into the crucible with the mass of the crucible increased by 1.0 g (i.e. a measurement of 1.0 g of the sample). The crucible with the sample was heated on a hot plate until the content became solid and re-weighed. This process was repeated until a constant mass was obtained.

The percent solid content for each sample was calculated using the following equation:

$$Solid\ Content\ (\%) = \frac{M_{CD} - M_C}{M_{CS} - M_C} x \frac{100}{1} \quad (4)$$

where M_C = mass of crucible (g), M_{CS} = mass of crucible and sample (g) and M_{CD} = mass of crucible and dry sample (g).

pH

1.0 g of each of the samples was measured and diluted with 100 ml distilled water contained in conical flasks. Mettler Delta 340 pH meter, calibrated using a buffer solution was used in measuring the pH of the diluted samples.

MEASUREMENT OF FILM PROPERTIES

Film properties of the emulsion paint investigated include: flexibility, water resistance and drying time.

Flexibility

The flexibility of the samples was determined using the method reported by Raju and Yaseen (Raju and Yaseen, 1983). Neatly prepared glossy paper strips measuring 4 cm x 10 cm were cut to size. A conical bent test apparatus with different metal pipe diameters of 1″, ¾″, ¼″ and 1/6″ mandrels respectively were secured in positions. The samples were uniformly applied and allowed to dry for 72 hours. The paper strips containing the samples were clamped in position and formed round the mandrels of 1″, ¾″, ¼″ and 1/6″ diameters respectively. The test paper was examined after each test to determine the minimum diameter at which failure by stretching and cracking occurred.

Water Resistance

2 cm x 4 cm glass sheets were cleaned with detergent solution, nitric acid and rinsed with distilled water. They were allowed to dry and then weighed. About 2/3 of the sheets were coated with thin films of the samples and allowed to dry in air for at least 72 hours. The sample sheets were weighed again before dipping them into 100 ml beakers, containing distilled water, enough to cover the coated portion of the glass sheets. The set up was allowed to stand for one hour before being brought out, cleaned of the dripping water on the surface and then re-weighed.

The percent increase in weight of the samples due to water absorption, which is inversely proportional to the samples' water resistance was calculated using the following equation:

$$Water\ Absorption(\%) = \frac{Z-Y}{Z-X} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

where X = mass of glass sheet (g), Y = mass of glass sheet + dry sample (g) and Z = mass of glass sheet + dry sample + water absorbed (g).

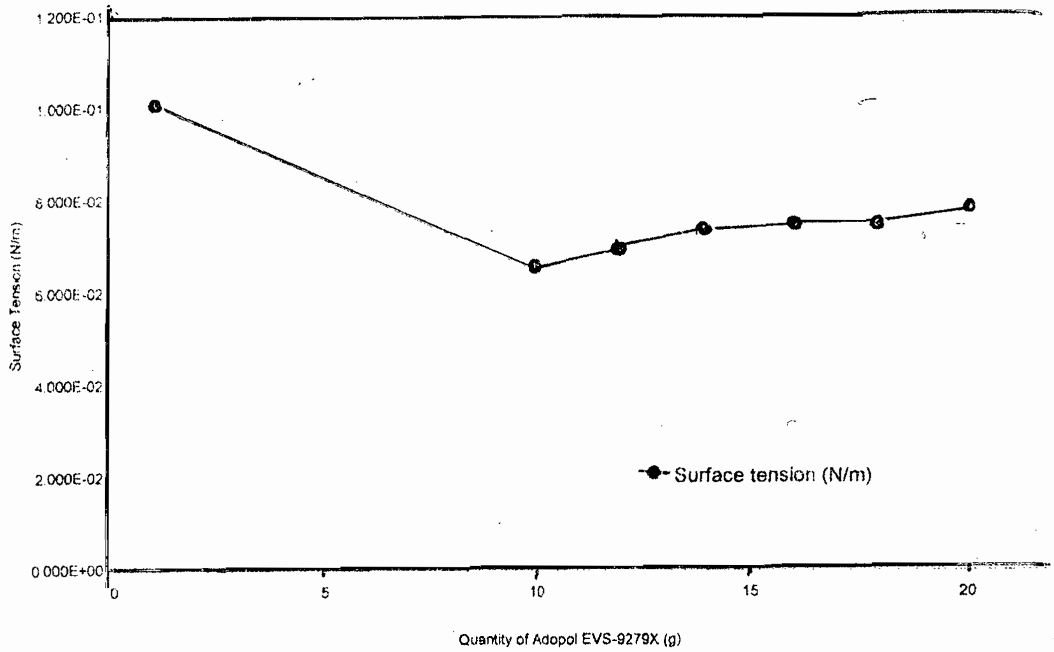

Fig. 3: Variation of Surface Tension of Emulsion Paint with Quantity of Adopol EVS-9279X

Drying Time

ASTM D-1640 standard test method was used in the determination of Dry-to-Touch Time (DTT) of the various samples (ASTM, 1960). Each sample was uniformly applied to 3 cm x 3 cm glossy paper and the time taken for the sample to adhere and rub up when a finger was slightly rubbed across the surface was measured using a stopwatch.

RESULTS AND DISCUSSION

Results of the effects of Adopol EVS-9279X on the emulsion and film properties of emulsion paint are shown in Table 2. Table 3 shows the results of the flexibility measurements.

The investigation shows that Adopol EVS-9279X does not alter the viscosities of 100 g in 350 ml distilled water samples, which were found to remain constant at 4.0 cp within 5 - 10 % w/w formulations studied. This shows that Adopol EVS-9279X alters the shear stress and shear rate of emulsion paint in a proportional manner as the viscosities remained constant thereby exhibiting good characteristics of an emulsion viscosity stabilizer.

Table 2: Results of Emulsion and Film Properties of Emulsion Paint Samples.

Sample	Apparent Viscosity (cp)	Surface Tension (N/m)	Specific gravity	Solid Content (%)	pH	Water Absorption (%)	Drying Time (min)
A	4.0	1.013×10^{-1}	1.53	53.4	7.01	25.2	33.5
B	4.0	0.656×10^{-1}	1.49	50.6	8.85	23.5	25.0
C	4.0	0.701×10^{-1}	1.47	49.5	8.52	24.4	22.0
D	4.0	0.742×10^{-1}	1.48	49.3	8.44	24.5	20.0
E	4.0	0.751×10^{-1}	1.48	48.8	8.61	25.7	20.5
F	4.0	0.750×10^{-1}	1.48	48.0	8.42	25.8	23.4
G	4.0	0.789×10^{-1}	1.49	47.5	8.45	26.9	26.5

Table 3: Results of the Flexibility Measurements

Sample	Size of Mandrels (Inches).				Remark
	1	¾	¼	1/6	
A	1	¾	¼	1/6	Failed
B	1	¾	¼	1/6	Passed
C	1	¾	¼	1/6	Passed
D	1	¾	¼	1/6	Passed
E	1	¾	¼	1/6	Passed
F	1	¾	¼	1/6	Passed
G	1	¾	¼	1/6	Passed

The apparent viscosities were unaltered by Adopol EVS-9279X because of its low solid content ≈ 2.2% and compatibility with water, since it is made of sodium salt of methyl ethyl cellulose and sodium benzoate both of which are soluble in water. High solid content of an additive is necessary to change solution apparent viscosities of emulsion paint, when added in small quantities. Adopol EVS-9279X stabilizes the paint emulsion by electrostatic interactions.

The surface tension, specific gravity and solid content were found to be lowered by Adopol EVS-9279X. The lowering of surface tension was found to be more significant at low concentrations. For instance, the surface tension was lowered from 1.013×10^{-1} Nm^{-1} for the control to a minimum of 0.656×10^{-1} Nm^{-1} at 5 % w/w formulation. This shows that Adopol EVS-9279X at low concentration exhibits surfactant characteristics on emulsion paint. This result is particularly desirable since it shows that Adopol EVS-9279X could improve wetability and prevent "cissing" in emulsion paints.

In the case of specific gravity, the maximum reduction was achieved at 6 % w/w sample formulation by lowering the specific gravity from 1.53 to 1.47. However, a reduction in specific gravity was achieved in all the sample formulations studied. The implication of this effect is that more areas will be covered during painting compared with an equivalent quantity of paint with a higher specific gravity.

The solid content was observed to decrease progressively as the quantity of Adopol EVS-9279X added increased. A reduction in solid content obviously reduces the film forming potential. However, the reduction in solid content is not significant at low concentration of 5 % w/w formulation, where a reduction of 2.8 % was observed. At this concentration, the solid content was 50.6 %, which is good, considering the positive effects achievable at this formulation concentration.

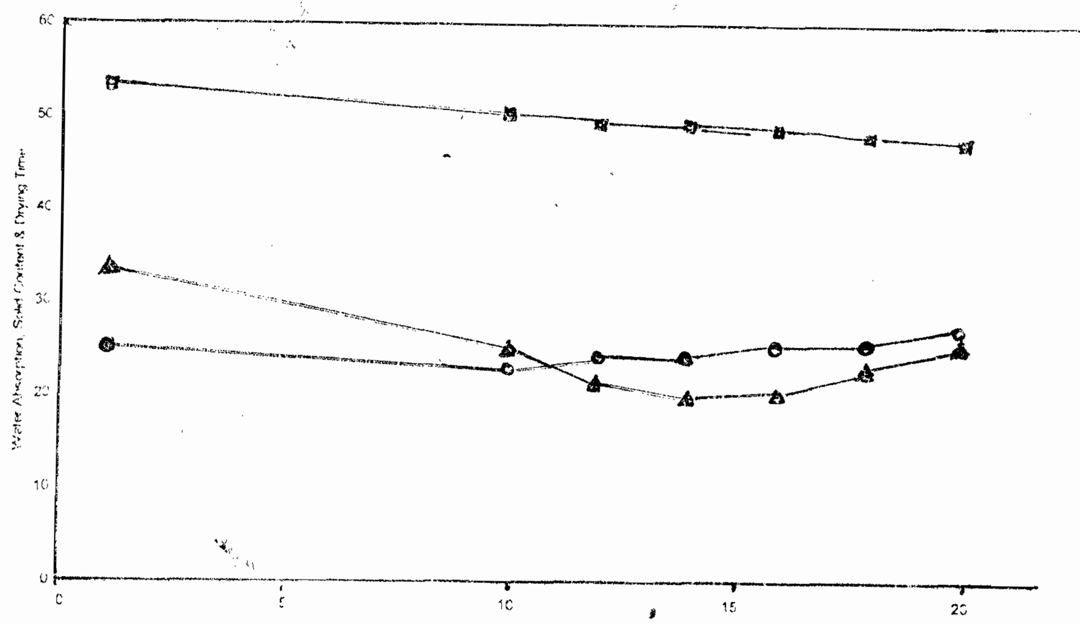

Fig.4 Variation of Water Absorption, Solid Content & Drying Time of Emulsion Paint with Quantity of Adopol EVS-9279X (g)

The pH of emulsion paint was found to increase within the concentration range studied. A maximum increase was achieved at 5 % w/w formulation where pH increased from 7.01 for the control to 8.85 for the sample. This means that Adopol EVS-9279X decreased the activity of hydroxonium ion in emulsion paint. This means that within the concentration range studied, the non-polar portion of sodium methyl ethyl cellulose and sodium benzoate, which are active components of Adopol EVS-9279X reduces the activity of hydroxonium ion in aqueous media leading to an increase in pH values.

It is known that pH decreases with increase in temperature and paints are known to deteriorate faster at higher temperatures. Consequently, paints are expected to deteriorate faster at lower pH values as well. Therefore, Adopol EVS-9279X will prevent paints from fast deterioration since it increases the pH of the emulsion paint studied. This stabilization effect is more pronounced at low concentrations, in this case 5 % w/w formulation. This agrees with other conventional polymeric emulsifiers in use, which are known to give stability at very low concentrations (Turner, 1967).

Results of the investigation of apparent viscosity, specific gravity and pH are further illustrated in Fig. 2, while Fig. 3, illustrates results on surface tension.

Film properties such as flexibility, water resistance and drying time were also investigated. Results show that Adopol EVS-9279X reduced the drying time and improved the water resistance especially at low formulation concentrations. The drying time was reduced from 33.5 minutes for the control to 20.0 - 26.5 minutes within the concentration range studied, with the lowest time recorded at 7 % w/w formulation. This indicates that Adopol EVS-9279X lowers the glass transition temperature (Tg) thereby improving the paint capacity of coalescing to form a film at room temperature and thus reducing the drying time. Low drying time is desired in paints because it reduces application time especially when more than one coat need to be applied within a short time.

Water absorption was measured as an index for determining the samples' water resistance. Analysis of the results shows that water absorption was initially lowered from 25.2 % for the control to 23.5 % at 5 % w/w sample formulation, 24.4 % at 6 % w/w sample formulation, which later increased to values higher than that of the control at higher formulation concentration to a maximum of 26.9 % at 10 % w/w sample formulation.

It is reasoned that the particles of Adopol EVS-9279X physically adsorb on the surface of the polymer film and tend to overlap one another, thereby acting like tiles on a roof at low formulation concentration of 5 % - 7 %, which is responsible for the increase in resistance to water absorption. Results of the water absorption measurements, drying time and solid content are presented in graphical form as Fig. 4.

Finally, the results of the flexibility measurements revealed that the emulsion paint, which failed the flexibility test had its flexibility improved in all the concentration range studied. It is believed that the emulsion was made more flexible by its admixture with smaller molecules of Adopol EVS-9279X, which separate the larger polymer/other non-polymer components of the paint and reduce attractive forces between them, acting as a lubricant and thus allowing the polymer molecules to slide past one another.

CONCLUSION

The quantity of Adopol EVS-9279X in the emulsion paint is an important factor in determining the trends of its effects on the emulsion and film properties of the emulsion paint. It does not affect the viscosity of the paint samples within the formulation concentration studied. It however reduced the specific gravity, surface tension, solid content, drying time, water absorption and increased pH of the emulsion paint especially at low w/w sample formulation of about 5 %. The flexibility was improved significantly within the formulation concentration studied.

REFERENCES

Airuehia, G. I., 1992. Formulation, Characterization and Application of Newsprint Inks from Rubber Seed Oil and Cut-back Bitumen Malthene, Fellowship Diploma Thesis, Nigeria Institute of Science Technology, Ibadan.

Airuehia, G. I., 1992. Products Data Manual, Gamor Chemical and Allied Limited, Port Harcourt, 5 – 6.

ASTM 1960. Annual Book of ASTM D-1489 Standards, Part 25.

ASTM 1960. Annual Book of ASTM D-1640 Standards, Part 15, 18, 26 and 41.

Ebosie, A. E., 1996. Differential Film Formation in Adopol Standard Defoamer, Adopol EVS-9279X and Poly (vinyl acetate) – Their Characterization and Applications, M.Sc. Thesis, University of Port Harcourt.

Raju, K. V. S. N. and Yaseen, M., 1983. The Effect of Part Replacement of Titanium Dioxide by Barytes on the Properties of Alkyd Paints, JOCCA, New York, 401 – 423.

Raymond, C., 1977. Physical Chemistry with Application to Biological Systems, Wiley, New York, 22 – 35.

Turner, G. P. A., 1967. Introduction to Paint Chemistry, Chapman and Hall, London, 95 – 106.