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FORMULATION OF GLOSSY EMULSION PAINT

ABSTRACT

Glossy-emulsion paint was prepared using the formulations: pigment dispersion (20g), PVAc (40g), Glycol (5g), Toluence (3g) and Defoamer (5g). It was found that not only is gloss achieved using these formulations but also for maximum effects, the paint should be produced at low CPVC, high degree of pigment dispersion and enough quantity of alkyd resin incorporated. A simple designed and fabricated devices used in this measurement are called Luminometer, a type of Loxmeter that was used to monitor surface glossiness. This proved to be reliable and handy.

Keywords: Glossy-emulsion, Toluence, Defoamer, PVAc, CPVC, Glycol and Paint.

INTRODUCTION

The surface of many object corrode in the air and are damaged by the effect of weather and wear if not protected and taken care of. For example, iron rusts and wood deteriorates in the atmosphere (1). As many materials become available, the need to modify the surface continues to grow (2). Many surfaces widely believed to be satisfactory without coating are actually attacked by weather, chemicals, atmospheric pollution or other factors and must be protected before certain uses. The wide variety of surfaces which must be protected and decorated has given rise to an infinite number of coating agents such as paints and vanishes not only to protect such surfaces but also to decorate them (4). It obliterates the surface on application and provides colour to it.

In the present investigation, the pigment system was rutile titanium dioxide and calcium carbonate at a weight ration of 3:1 respectively. Polyvinyl acetate and alkyd resin were used as binders. In number of cases, the gloss of paint has decorative properly.

This research investigates ways in which gloss emulsion paints can be enhanced. The present investigation was limited to testing the effects of degree of dispersion of pigment, degree of dryness of film and optical properties of binder on the gloss of formed glossy-emulsion paint.

Emulsion paints are not glossy enough for certain applications. The low degree of gloss emulsion paints precludes its use in a number of applications. Therefore this project investigates ways in which the gloss of emulsion paints can be enhanced.

Factors that could affect the gloss of emulsion paints includes:

a) The degree of dispersion of pigment(s) used.
b) The optical properties of binders, that is, light reflecting, refracting and scattering properties.
c) The degree of dryness of film
d) The pigment: extender ratio.

The present investigation has revealed valuable technical information about emulsion paint based on titanium dioxide/calcium carbonate and poly vinylacetate.

i. The CPVC at a titanium dioxide: calcium carbonate ratio of 3:1 is 0.062 (6.2%)
ii. At PVC values below the CPVC of 0.062 (6.2%), the gloss increases as the PVC is lowered.
iii. The degree of dispersion varies with time of dispersion and influences the gloss of the paint. For time of dispersion varying from 30 minutes to 120 minutes, the gloss increases from 9µ A to 11.6 µA.
iv. Drying of film under a particular condition continues for 3 days with accompanying increase in gloss ranging from 3µA to 9µA.
v. Incorporation of alkyd resin into polyvinyl acetate increases the gloss if both are used as binder.

Paint manufacturing involves bringing pigment particles and binders into close contacts to achieve thorough dispersion of the particles throughout the binder. Dispersion is the most important operation in paint factories, the economics of plant operations are keyed to it. The design of dispersion mills depend on the type of paint manufactured and on the formulation and colours of the equipment must handle.

Paints are made up of three basic components as follows:

PIGMENT: The purpose of the pigment, from a decorative stand point is to obliterate the surface over which the product is applied and

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RESEARCH ARTICLE

provide colour to it. From a protective standpoint for exterior use, the pigment serves the function of protecting the vehicle from degradation by ultraviolet radation (2). Most clear films of drying oil, resin or oleoresinous compositions are not likely to withstand sunlight exposure for more than twelve months. Pigment films, however, will protect for a considerable number of years. Certain pigments are used for their unique chemical functions such as rust inhibition on Meta structures and control of fouling on ship bottoms. Pigments are also classified according to the type or colour. Early classifications distinguished between mineral or natural pigments which came from the earth and were either ground directly or refined to a certain extent; and chemical pigments which required a conversion of one sort or another. Therefore the main functions of pigments are:

a) To impart colour and hiding
b) To provide opacity or covering power to the paint
c) To improve hardness and durability
d) To aid the film-former or vehicle (non vehicle) in protecting the surface.

VEHICLE: (Non Volatile) – This second main constituent of paint, the non volatile vehicle in most cases is composed of drying oils, resins or a combination of the two as used in latex glossy paint(2). A few types of paint have inorganic vehicles. It is often referred to as the binder or medium and is the material responsible for film formation as the paint dries, that is, becomes covered from a liquid or semi-liquid layer on the substrate to a hard coherent solid film (3). The purpose of the nonvolatile vehicle are:

a. To impart cohesion and adhesion to the paint film
b. To convert from the liquid coating to a solid dry film
c. To act as a moisture barrier thereby providing resistance to water, chemicals and abrasion.
d. To provide gloss to the coatings.
e. To bind the pigment particles together.

VEHICLE (Volatile): This is also known as solvent. It usually consist of hydrocarbon solvents or water, it is used to lower the viscosity of the composition for ease of application. Organic solvents other than hydro-carbons, including ketones and esters are necessary in some types of composition.

MATERIALS, EQUIPMENT AND METHODS

LIST OF MATERIALS

Polyvinyl acetate (PVAc), Rutile titanium dioxide (TiO_2), Alkyd resin, Toluene, Calcium Carbonate ($CaCo_3$), Glycol, Sodium Carboxymethyl Cellulose, Calgon, Genepor and Defoamer.

EQUIPMENT

BALL MILL: This is the machine used in making pigment dispersions which was used in forming emulsion and glossy-emulsion paints. This ball mill grinds by tumbling heavy metal or ceramic ball through the paints in a cylindrical container and sand grinder, which circulate a suspension of sand in paint through a rotor assembly at high speed. A find grind can be achieved with the ball mills operating for eight hours or more on single batches or with sand grinders delivering a nearly continuous output. Ball mills have certain advantages over other paint machines, the finished paint is made in one operation and the mill requires no attention other than filling and discharging.

LUMINOMETER: This machine is used in measuring the gloss of the formed glossy-emulsion paint. The gloss of a paint film is assessed by measuring the total amount of light reflected from the surface, generally at an angle of 45^0 or 60^0, though other angles are occasionally used. The method of using Luminometer is by clamping a coated surface with a stand at an angle of 45^0 from the Luminometer in such a way that the center of the surface is at the same height with the light passage point of the Luminometer. Light was applied through a tube on the surface at constant length (26mm) with all the surfaces to be tested on. (all should be kept and only the coated surfaces should be changed at interval). Then the reading in μA was take

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METHODS

DETERMINATION OF CRITICAL PIGMENT VOLUME CONCENTRATION OF TITANIUM DIOXIDE/POLYVINYL ACETATE SYSTEM

Four batches of emulsion paints were formulated using titanium dioxide and calcium carbonate (in the ration of 3:1), genepur, calgon, sodium carboxymethy) cellulose, polyvinyl acetate (PVAc), glycol and defoamer. These four batches of paint were formed with different quantities of pigment dispersions and PVAc as illustrated in table 1 below.

TABLE 1: DIFFERENT FORMULAE FOR EMULSION PAINT FORMULATION

BASE	**WEIGHT IN GRAMS**			
Pigment dispersions	10	15	20	25
Glycol	5	5	5	5
PVAc	50	45	40	35
Defoamer	5	5	5	5
Net weight	70	70	70	70

From these four batches of emulsion paint, a known mass (4g) of film was spread on a smooth surface. It was allowed to dry in an open air for 72h. The densities of dried films were determined using Vanier caliper and their results shown in table 2.

Table 2: DIMENSIONS AND DENSITIES OF PAINT FILMS

PIGMENTS WEIGHT FOR THE DRIED FILM

(g)	length (cm)	Width (cm)	Thickness (cm)	Volume (cm^3)	Mass (g)	Density (g/cm^3)
10	8.295	7.820	0.180	11.676	2.2	0.188
15	8.415	7.875	0.060	3.979	1.9	0.478
20	8.367	7.920	0.030	1.988	1.7	0.955
25	8.550	7.860	0.067	4.508	2.1	0.467

The pigment volume concentrations (PVC) for the different films were determined. For example, the PVC for 10g of pigment was found as shown below.

Table 3: PVC FOR 10G OF PIGMENT

Component	Weight	Density	Volume
Pigment	10	6.87	1.46
PVAC	50	0.9	55.6
Total			57.06

$$\text{PVC} = \frac{Vp}{Vp + Vb}$$

Where Vp – pigment volume

Vb– volume of the binder

$$\text{PVC} = \frac{1.46}{1.46 + 55.6}$$

$$= \frac{1.46}{57.06} = 0.026$$

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DETERMINATION OF CPVC

CPVC was determined by the plot of density (g) against PVC as shown in table 4 below.

TABLE 4: PLOT OF DENSITY (G) AGAINST PVC

G	0.19	0.48	0.86	0.47
PVC	0.026	0.042	0.062	0.086

From the table, a nice glossy-emulsion paint can be prepared at the CPVC of 0.062 (6.2%). CPVC is the stage where air occupying the interstitial spaces of the pigment has been displaced by binder. Any increase in pigment concentration above CPVC level lead to voids in the paint film with a consequent increase in permeability, and below CPVC leads to the separation of pigment particles from each other. The CPVC increases with increasing amount of dispersing agent indicating that the close packing of pigment particles is intimately associated with degree of dispersion. When the pigment loading o the applied film is below the critical pigment volume concentration, the film may become rucked in patches as a result of efflorescence.

DETERMINATION OF THE EFFECT OF VARIATION IN TIME OF PIGMENT DISPERSION ON THE GLOSS OF A DRIED FILM

Glossy-emulsion paints were prepared at different times of pigment dispersion (30 mins, 60 mins, 90 mins and 120 mins of dispersion) with the formula as shown in table 5 below.

Table 5: FORMULA FOR GLOSSY-EMULSION PAINTS FORMULATION WITH DIFFERENT DEGRESS OF PIGMENT DISPERSION

BASE	WEIGHT IN GRAMS
Pigments dispersion	20
PVAc	40
Glycol	5
Alkyd resin	5
Toluene	3
Dofoamer	5
NET WEIGHT	78

The gloss of this glossy-emulsion paints coated on a smooth surface, prepared at different times of dispersion were tested with a Luminometer. The glossy measurements were taken at some hour intervals to determine the effect of dryness in gloss of paint films.

DETERMINATION OF THE EFFECT OF VARIATION IN THE QUANTITY OF ALKYD RESIN (BINDER) ON THE GLOSS OF A DRIED FILM

Glossy-emulsion paints were formulated with different quantities of binder, with their formulae as shown in table IV

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Udeozo I. P *et al*, The *Experiment, 2013 Vol. 13(1), 822-828*

Table 6: FORMULAE FOR GLOSSY-EMULSION PAINTS FORMULATION WITH DIFFERENT QUANTITIES OFBINDER.

BASE	WEIGHT IN GRAMS			
Pigment dispersions	20	20	20	20
Glycol	5	5	5	5
PVAc	40	40	40	40
Alkyd resin	5	20	35	45
Toluene	3	10	15	20
Defoamer	5	5	5	5
Net weight	78	100	120	135
PVC	0.098	0.070	0.058	0.052

GENERAL FORMULATION PRINCIPLE

FORMULATION OF EMULSION/LATEX PAINT: An emulsion or latex paint can be produced either by blending plasticized polymer latex with a pigment dispersion which is already prepared or by adding dry pigments and extenders to plasticized latex under sufficient agitation to ensure adequate dispersion.

PREPARATION OF PIGMENT DISPERSION: In addition to water, the aqueous phase of pigment pastes usually contains wetting agents, dispersing agents and colloid stabilizers. The latter also function as viscosity modifiers. Although all these functions may be combined in a single substance, it is generally better to use a combination of substance. Indeed, experience over several years has shown that it is preferable for the aqueous phase of the pigment dispersion to contain a balance of anionic and non aniogenic compounds which together form an efficient wetting, dispersing and stabilizing system. It is also convenient to add any additional substances such as fungicides, corrosion inhibitors, antifoaming agents etc. via the pigment dispersion, if these are required in the finished paint.

The following procedure was used for making pigment dispersion; 10% aqueous solution of calgon and sodium carboxymethyl cellulose (which are dispersing agent and colloid stabilizer) respectively were prepared. Also 10% solution of genepur which is a wetting agent was also, prepared. Thoroughly premix 150g of titanium dioxide, 50g of calcium carbonate, 50g of genepur and calgon respectively and then 20g of sodium carboxymethyl cellulose using a stirrer and then grind using a ball mill or colloid mill.

TABLE 7: FORMULATION OF PIGMENT DISPERSION WITH TiO_2 AND $CaCo_3$ IN THE RATIO 3:1

BASE	WEIGHT IN GRAMS DRY	WEIGHT IN GRAMS ACTUAL
$Ti0_2$	150	150
$CaCo_3$	50	50
Genepur (10%)	5	50
Calgon (10%)	5	50
Sodiumcarboxymethyl Cellulose (10%)	2	20

BLENDING OF LATEX AND PIGMENT DISPERSION

This process presented no problem in a correctly formulated paint. If problems of destabilization or of undue thickening are encountered, then it is to the formulation rather than blending procedure that one must look for remedy. The cause of such effects is usually to be found in interaction between the colloids and surface-active substances of the pigment dispersion and those which were initially present in the latex.

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Blending procedures are essentially simple. Either the pigment dispersion is added to the latex with stirring or the plasticised latex is added to the pigment dispersion. A period of stirring after the blending has been completed is very desirable, but any form of violent agitation should be avoided at this stage.

RESULTS

The results of the investigations on degree of pigment dispersion, variation in the quantity of alkyd resin and dryness of paint films are as shown and discussed.

TABLE 8: RESULTS OF THE EFFECT OF VARIATION IN DEGREE OF PIGMENT DISPERSION ON THE GLOSS OF PAINT FILMS.

TIME OF DISPERSION	RESULT
After 30 minutes of dispersion	9
After 60 minutes of dispersion	10
After 90 minutes of dispersion	10
After 120 minutes of dispersion	11.6

Table 9: RESULTS OF THE EFFECT OF DRYNESS IN THE GLOSS OF PAINT FILM During drying (µA)

Times Of Dispersion	After 24 H	After 48 H	After 72 H
For 30 minutes of dispersion	3.0	7.0	9.0
For 60m minutes of dispersion	3.5	6.3	10.0
For 90 minutes of dispersion	3.6	7.6	10.0
For 120 minutes of dispersion	3.7	7.8	11.6

Table 10: RESULTS ON THE EFFECT OF VARIATION IN THE QUANTITY OF ALKYD RESIN ON THE GLOSS OF PAINT FILMS.

Quantities of alkyd resin (g)	Results
5	11.0
20	12.6
35	15.0
45	17.8

TABLE 11:

Components	Weight (g)	density (g/cm^3)	volume (cm^3
Pigment dispersions	45	0.9	50
Glycol	15	4.16	3.6
PVAc	5	2.71	1.85
TOTAL			55.45

$$\text{PVC} = \frac{vp}{vp + vb}$$

$$= \frac{5.45}{50.0 + 5.45} = \frac{5.45}{55.45} = 0.098$$

The PVC values for other paint films were obtained as well.

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TABLE 12

Gloss	11.0	12.6	15.0	17.8
PVC	0.10	0.07	0.06	0.05

DISCUSSION

Table 8 results show that gloss increases as time of dispersion increases. This is as a result of reduction in the particle size of pigment which is accompanied by thorough dispersion of the pigment particles. Table 9 illustrated the results obtained from testing the gloss of films applied (spread) on a smooth surface at some hour interval (24 h, 48 h. and 72 h).

The result shows that the degree of dryness of films had effect on the glossy nature of the films. The more dried a film is, the more glossy that film portrays. From the results in table 12, it was shown that gloss increases steadily from 11.0μA to 17.8 μA. Therefore increase in the quantity of alkyd resin increases the gloss of the paint. This confirmed the fact that optical properties of binder in paint affect the gloss of that paint.

The results generally indicated that below CPVC, more gloss-emulsion paints were produced while less gloss-emulsion paints were obtained above the CPVC.

CONCLUSION

In conclusion, glossy-emulsion paint can be produced at the optimum composition of 6.2% (0.062). Gloss is dictated by factors such as degree of pigment dispersion and the quantity of binders etc. The gloss of such paints on surfaces can be conveniently measured using Luminometer and to achieve maximum glossy effect, paint formulation should be at PVC below CPVC.

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