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The Effect of Gypsum Plaster on The Dry Rate of Emulsion

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Abstract
This study was carried out to access the effect of gypsum plaster on the dry rate of emulsion paint. Gypsum plaster sourced from paint manufactures was added in presence of other raw materials to archive a better formulation. The pH the present product (8.4) falls within standard value of paints .The viscosity of the archived was 10 poise compared to that of standard products (8 poise). The dry time however recorded was 70 minutes compared to that of standard product which is usually 90 -110 minutes. These results underscore the need to further explore the use of gypsum plaster in the manufacture of paints considering its positive effects on the properties of paint especially in the reduction of the dry rate. These results underscore the need to further explore the use of gypsum plaster in the manufacture of paints considering its positive effects on the properties of paint especially in the reduction of the dry rate.
Keywords: dry rate.

1. Introduction

Paint is any liquid, liquefiable, or mastic composition which, after application to a substrate in a thin layer, is converted to a solid film. It is most commonly used to protect, color or provide texture to objects.*(Stephanie Pappa et al.2011).*

In 2011, South African archeologists reported finding a 100,000 year old human-made ochre-based mixture which could have been used like paint.*(http://www.shearerpainting.com/blog/resources/history-of-paint/ Retrieved October 14, 2011)* Cave paintings drawn with red or yellow ochre, hematite, manganese oxide, and charcoal may have been made by early Homo sapiens as long as 40,000 years ago.
Ancient colored walls at Dendera, Egypt, which were exposed for years to the elements, still possess their brilliant color, as vivid as when they were painted about 2,000 years ago. The Egyptians mixed their colors with a gummy substance, and applied them separate from each other without any blending or mixture. They appear to have used six colors: white, black, blue, red, yellow, and green. They first covered the area entirely with white then traced the design in black, leaving out the lights of the ground color. They used minimum for red, and generally of a dark tinge.

Paint was made with the yolk of eggs and therefore, the substance would harden and adhere to the surface it is applied to. Pigment was made from plants, sand, and different soils. Most paints used either oil or water as a base.(Stephanie Pappa *et al.* 2011)

A still extant example of 17th-century house oil painting is Ham House in Surrey, England, where a primer was used along with several undercoats and an elaborate decorative overcoat; the pigment and oil mixture would have been pounded into a paste with a mortar and pestle. The process was done by hand by the painter and exposed them to lead poisoning due to the white-lead powder.*(Berendsen, A. M. et al. 1989).* In 1718, Marshall Smith invented a "Machine or Engine for the Grinding of Colours" in England. Although it is not known precisely how it operated, it was a device that increased the efficiency of pigment grinding dramatically. Soon, a company called Emerton and Manby was advertising exceptionally low priced paints that had been ground with labour saving technology:*(Water-based Alchemy". Retrieved August 11, 2012).*
One Pound of Colour ground in a Horse-Mill will paint twelve Yards of Work, whereas Colour ground any other Way, will not do half that Quantity.

By the proper onset of the Industrial Revolution, paint was being ground in steam powered mills and an alternative to lead based pigments was found in a white derivative of zinc oxide. Interior house painting increasingly became the norm as the 19th century progressed, both for decorative reasons and because the paint was effective in preventing the walls rotting from damp. Linseed oil was also increasingly used as an inexpensive binder.*(Berendsen, A. M et al. 1989).*

The binder, commonly called the vehicle, is the film-forming component of paint. It is the only component that must be present. Components listed below are included optionally, depending on the desired properties of the

cured film.

The binder imparts adhesion and strongly influences such properties as gloss, durability, flexibility, and toughness. *(Water-based Alchemy". Retrieved August 11, 2012),(Berendsen, A. et al. (1989). Marine painting manual. London: Graham & Trotman. ISBN 1-85333-286-0 p. 114.)*
Paints that dry by solvent evaporation and contain the solid binder dissolved in a solvent are known as lacquers. A solid film forms when the solvent evaporates, and because the film can re-dissolve in solvent, lacquers are unsuitable for applications where chemical resistance is important. Classic nitrocellulose lacquers fall into this category, as do non-grain raising stains composed of dyes dissolved in solvent and more modern acrylic-based coatings such as 5-ball Krylon aerosol. Performance varies by formulation, but lacquers generally tend to have better UV resistance and lower corrosion resistance than comparable systems that cure by polymerization or *(coalescence.frpdesigns.com, Formulations, Fundamentals, Manipulation, Calculation and Data Management"] p. 61.)*

The paint type known as Emulsion in the UK and Latex in the USA is a water-borne dispersion of sub-micrometer polymer particles. These terms in their respective countries cover all paints that use synthetic polymers such as acrylic, vinyl acrylic (PVA), styrene acrylic, etc. as binders*.(Water-based Alchemy". Retrieved August 11, 2012).* The term "latex" in the context of paint in the USA simply means an aqueous dispersion; latex rubber from the rubber tree is not an ingredient. These dispersions are prepared by emulsion polymerization. Such paints cure by a process called coalescence where first the water, and then the trace, or coalescing, solvent, evaporate and draw together and soften the binder particles and fuse them together into irreversibly bound networked structures, so that the paint will not redissolve in the solvent/water that originally carried it. The residual surfactants in paint as well as hydrolytic effects with some polymers cause the paint to remain susceptible to softening and, over time, degradation by water. The general term of latex paint is usually used in the USA, while the term emulsion paint is used for the same products in the UK and the term latex paint is not used at all. Paints that cure by oxidative crosslinking are generally single package coatings. When applied, the exposure to oxygen in the air starts a process that crosslinks and polymerizes the binder component. Classic alkyd enamels would fall into this category. Oxidative cure coatings are catalyzed by metal complex driers such as cobalt naphthenate*(.Water-based Alchemy". Retrieved August 11, 2012),(Berendsen, A. M., et al. 1989). Marine painting manual. London: et al.1999).*

Recent environmental requirements restrict the use of volatile organic compounds (VOCs), and alternative means of curing have been developed, particularly for industrial purposes. In UV curing paints, the solvent is evaporated first, and hardening is then initiated by ultraviolet light. In powder coatings there is little or no solvent, and flow and cure are produced by heating of the substrate after electrostatic application of the dry powder.*(Abarr, James 1999).*The main purposes of the diluents are to dissolve the polymer and adjust the viscosity of the paint. It is volatile and does not become part of the paint film. It also controls flow and application properties, and in some cases can affect the stability of the paint while in liquid state..(Dramatic color change featured". New Materials International)

Pigments are granular solids incorporated in the paint to contribute color. Fillers are granular solids incorporate to impart toughness, texture, give the paint special properties, or to reduce the cost of the paint.(Horvath, Lee. "Coatings Go Beyond Appearance to Provide Quality Control". Foundry Technology. Foundry Management & Technology) Pigments can be classified as either natural or synthetic. Natural pigments include various clays, calcium carbonate, mica, silicas, and talcs. Synthetics would include engineered molecules, calcined clays, blanc fixe, precipitated calcium carbonate, and synthetic pyrogenic silicas.

Hiding pigments, in making paint opaque, also protect the substrate from the harmful effects of ultraviolet light. Hiding pigments include titanium dioxide, phthalo blue, red iron oxide, and many others*(Calcium sulphate for the baking industry" (pdf). Retrieved 2013 Mar 1).*

Fillers are a special type of pigment that serve to thicken the film, support its structure and increase the volume of the paint. Fillers are usually cheap and inert materials, such as diatomaceous earth, talc, lime, barytes, clay, etc.*(Selecting the Right Paint Roller." Selecting the Right Paint Roller. Aubuchan Hardware,2006.Web retrived from http://paint-an)*

Besides the three main categories of ingredients, paint can have a wide variety of miscellaneous additives, which are usually added in small amounts, yet provide a significant effect on the product. Some examples include additives to modify surface tension, improve flow properties, improve the finished appearance, increase wet edge, improve pigment stability, impart antifreeze properties, control foaming, control skinning, etc.[12]
Additives normally do not significantly alter the percentages of individual components in a formulation.*(Calcium sulphate for the baking industry" (pdf). Retrieved 2013 Mar 1)(Selecting the Right Paint Roller." Selecting the Right Paint Roller. Aubuchan Hardware,2006.Web retrived from http://paint-an)[12]*
Paint can be applied as a solid, a gaseous suspension (aerosol) or a liquid. Techniques vary depending on the practical or artistic results desired.*(Stephanie Pappa (2011). "Oldest Human Paint-Making Studio Discovered in Cave". Live Science. Retrieved October 14, 2011)*

In the liquid application, paint can be applied by direct application using brushes, paint rollers, blades, other instruments, or body parts such as fingers and thumbs. .(Dramatic color change featured". New Materials International)

Rollers generally have a handle that allows for different lengths of poles to be attached, allowing painting at different heights. Generally, roller application requires two coats for even color. A roller with a thicker nap is used to apply paint on uneven surfaces. Edges are often finished with an angled brush. *(Horvath, Lee. "Coatings Go Beyond Appearance to Provide Quality Control". Foundry Technology. Foundry Management & Technology)*
To dispose off paint it can be dried and disposed of in the domestic waste stream, provided that it contains no prohibited substances. Disposal of liquid paint usually requires special handling and should be treated as hazardous waste, and disposed of according to local regulations.[12*](Oster, J. D. & Frenkel, H. (1980). "The chemistry of the reclamation of sodic soils with gypsum and lime". Soil Science S)*
The main reasons of paint failure after application on surface are the applicator and improper treatment of surface.

This usually occurs when the dilution of the paint is not done as per manufacturers recommendation. There can be a case of over dilution and under dilution, as well as dilution with the incorrect diluent.
Foreign contaminants added without the manufacturers consent which results in various film defects.
Peeling/Blistering are most commonly due to improper surface treatment before application and inherent moisture/dampness being present in the substrate.*(Alleyne, Richard (2008-10-27). "World's largest crystal discovered in Mexican cave". London: The Telegraph. Retrieved 2009-06)*

Chalking is the progressive powdering of the paint film on the painted surface. The primary reason for the problem is polymer degradation of the paint matrix due to exposure of UV radiation in sunshine and condensation from dew. The degree of chalking varies as epoxies react quickly while acrylics and polyurethanes can remain unchanged for long periods.(Paint Finish and Sheen Information; Info on Satin, Eggshell, Matte, and Other Paint Finishes." Professional Painting Contract)

Cracking of paint film is due to the unequal expansion or contraction of paint coats. It usually happens when the coats of the paint are not allowed to cure/dry completely before the next coat is applied. The degree of cracking can be assessed according to International Standard ISO 4628 Part 4 or ASTM Method D661 (Standard Test Method for Evaluating Degree of Cracking of Exterior Paints*).(Bayliss, D.A.; Deacon, D.H. (2002). Steelwork corrosion control (2nd ed. ed.). London: Spon. pp. 13.6.6 Chalking. ISBN 978-0-)*

Blistering is due to improper surface exposure of paint to strong sunshine. The degree of blistering can be assessed according to ISO 4628 Part 2 or ASTM Method D714 (Standard Test Method for Evaluating Degree of Blistering of Paints). (Alleyne, Richard (2008-10-27). "World's largest crystal discovered in Mexican cave". London: The Telegraph. Retrieved 2009-06) (Paint Finish and Sheen Information; Info on Satin, Eggshell, Matte, and Other Paint Finishes." Professional Painting Contract) *(Bayliss, D.A.; Deacon, D.H. (2002). Steelwork corrosion control (2nd ed. ed.). London: Spon. pp. 13.6.6 Chalking. ISBN 978-0-)*

Gypsum is a very soft sulphate mineral composed of calcium sulphate dihydrate, with the chemical formula $CaSO4 \cdot 2H2O$.*(A. Spurgeon, Watching Paint Dry: Organic Solvent Syndrome in late-Twentieth-Century Britain. Med Hist. 2006 April 1; 50(2): 1)* It can be used as a fertilizer, is the main constituent in many forms of plaster and is widely mined. A very fine-grained white or lightly tinted variety of gypsum, called alabaster, has been

used for sculpture by many cultures including Ancient Egypt, Mesopotamia and the Nottingham alabasters of medieval England. It is the definition of a hardness of 2 on the Mohs scale of mineral hardness. It forms as an evaporate mineral and as a hydration product of anhydrite.

Gypsum is moderately water-soluble (~2.0–2.5 g/l at 25°C)frpdesigns.com, Formulations, Fundamentals, Manipulation, Calculation and Data Management"] p. 61. and, in contrast to most other salts, it exhibits a retrograde solubility, becoming less soluble at higher temperatures. When gypsum is heated in air it loses water and converts first to calcium sulfate hemihydrate, (bassanite, often simply called "plaster") and, if heated further, to anhydrous calcium sulfate (anhydrite). As for anhydrite, its solubility in saline solutions and in brines is also strongly dependent on NaCl concentration.*(Gypsum in HandAbook of Mineralogy).*

Gypsum crystals are found to contain anion water and hydrogen bonding.*(Gypsum at Mindat).*Veins of gypsum in the silts/marls of the Tea Green and Grey Marls, Blue Anchor, Somerset, UK.Gypsum is a common mineral, with thick and extensive evaporite beds in association with sedimentary rocks. Deposits are known to occur in strata from as far back as the Archaean eon.*(Compact Oxford English Dictionary: gypsum)(Smith, Joshua (2007): Borderland smuggling: Patriots, loyalists, and illicit trade in the Northeast, 1780-1820. Gainesville,)* Commercial exploitation of the area, strongly opposed by area residents, was permanently prevented in 1933 when president Herbert Hoover declared the gypsum dunes a protected national monument.

Gypsum is also formed as a by-product of sulfide oxidation, amongst others by pyrite oxidation, when the sulfuric acid generated reacts with calcium carbonate. Its presence indicates oxidizing conditions. Under reducing conditions, the sulfates it contains can be reduced back to sulfide by sulfate reducing bacteria. Electric power stations burning coal with flue gas desulfurization produce large quantities of gypsum as a byproduct from the scrubbers. *(Bock, E. (1961):* "On the solubility of anhydrous calcium sulphate and of gypsum in concentrated solutions of sodium chloride *(Mandal, Pradip K et al.2002*)."Anion water in gypsum (CaSO4·2H2O) and hemihydrate (CaSO4·1/2H2O)".(*Cement and ConJuan Manuel García-Ruiz, et al. 2007).* This study is aimed at the use of gypsum plaster in the manufacture of paints considering its positive effects on the properties of paint especially in the reduction of the dry rate, thereby increasing the durability of paint.

2.(Material and Method)

Material:

The following raw materials was sourced from Demcok chemical Limited Port Harcout, River State. These includes; Water, Calcium Carbonate, Titanium dioxide, Gypsum Plaster (in powdered form), Polyvinyl acetate, Deformer, Calgon, Ammonia, Bermacol, formalin, Ethylene glycol. Ammonia, Bermocol,, Formalin, Ethylene glycol.

2.1Formulation Procedure

To produce sample of exactly one liter, 200g of H_2O was measured into the mixer with 50g ethylene glycol, 10g of white spirit, 300g of calcium carbonate and 100g of titanium dioxide, the mixture was stirred gradually for 15 minutes. 6g of properly ground calgon, 20g of Bermoco, and 50g of H_2O were mixed separately and added into the mixer. The mixture was stirred thoroughly for 40 minutes for proper dispersion. Finally, 100g of polyvinyl acetate, 20g of defoamer, 4g of NH_3 and 15g of formalin were added in the slurry and the mixture stirred vigorously for a long time. 20g of H_2O was added into the slurry little by little to adjust the viscosity of the paint. The mixture was stirred thoroughly and as emulsion paint sample was produced. With the same procedure as above, another sample was also formulated as follows:- Using the same raw materials but reduction in quality of calcium carbonate and titanium dioxide by 5g each and adding 100g of gypsum plaster to formulate an gypsum paint.

Table 1: Quantities (by weight) of material used for the formulation of emulsion paint sample one (standard/normal emulsion).

REAGENTS	QUANTITY (g)	WEIGHT FRACTION	WEIGHT(g)
Water	270	0.270	27
Ethylene glycol	50	0.050	5
White spirit	10	0.010	1
Calcium carbonate	300	0.300	30
Titanium dioxide	200	0.200	20
Bermercol	20	0.020	2
Calgon	6	0.006	0.6
Polyvinyl acetate	105	0.105	10.5
Defoamer	20	0.020	2
Ammonia	4	0.004	0.4
Formalin	15	0.015	1.5
TOTAL	**1000g**	**1.000g**	**100%**

Table 2: Summary of the quantities (by weight) of the materials used for the formulation of Gypsum Emulsion paint.

REAGENTS	QUANTITY (g)	WEIGHT FRACTION	WEIGHT (%)
Water	270	0.270	27
Ethylene glycol	50	0.050	5
White spirit	10	0.010	1
Calcium carbonate	250	0.250	25
Plaster of Paris	100	0.100	10
Titanium dioxide	150	0.150	15
Bermercol	20	0.020	2
Calgon	6	0.006	0.6
Polyvinyl acetate	105	0.105	10.5
Defoamer	20	0.020	2
Ammonia	4	0.004	0.4
Formalin	15	0.015	1.5
TOTAL	**1000**	**1.000**	**100%**

3.Assessment of the Properties of the Paint at Rest Condition

The following paint properties were assessed at rest condition (26^0C) studies as follows:-

3.1 pH Test

This test is based on the determination if the product is acidic or alkaline.

Some samples of the paints were put in different beaker and the pH of the paint samples were determined using litmus paper, which has numbers ranging from 1 to 14.

3.2 Viscosity Test

The viscosity or resistance of the sample to flow was determined using the universal rotthinner which works on the principle of the viscosity drag of a cylinder rotating in the sample which is attached to a fly wheel suspended by a torsion wire. The viscosity of the samples were checked and their results were recorded.

3.3 Water Miscibility Test

Small portion of the sample were put into different test tubes and some drops of water was added into each test tube and shaken thoroughly. The sample were left to settle after two minutes and their property of miscibility with water were observed.

3.4 Drying Test

The samples were applied on a smooth surface and were checked from time to time. i.e at interval to determine how long it takes each sample to dry.

3.5 Opacity Test

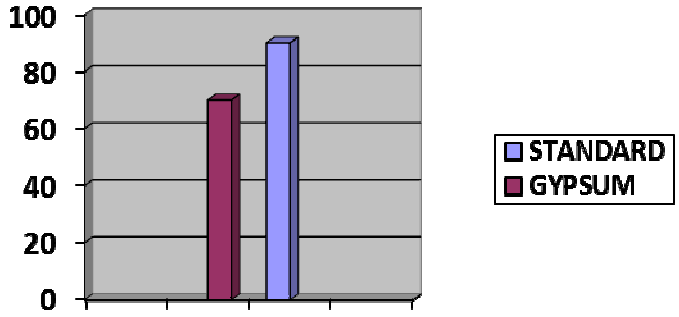
The paints samples were spread on a panel and were allowed to dry at room temperature for 24 hours. The panel was painted again and left for another day before testing.

4. Results and Discussion

The results of the study are presented in figure 1 and Table 1

Figure 1, show a bar chat of the different product against dry rate.
Drying time is the time required of a paint film from the time of application to dry to a hard resistant film. The two samples were spread on a panel and the time required for each sample to dry was taken by monitoring the time interval with the aid of stop watch. It was observed that under ambient conditions, the paint samples dried between 70 minutes and 90 - 110 minutes, which shows that the difference in the drying rate of these sample are not that negligible, because it meets consumers want in a product as regards to drying rate.

FIGURE 1. *(Time against Product)*



Dry rate of both products.

The results of various parameter determined are presented in Table 1.
Opacity is the covering of paint i.e. the surface area the paint is able to cover. A very good and well formulated paint required only a coat for a good coverage. The both paint samples required only a little amount to cover a large surface, i.e. the sample volume of paints, the gypsum paint and the standard produced covering of the same area of surface. This opacities with emulsion paint does not appear to have been adversely affected by the substitution.

Water miscibility of each sample does not appear to be different since they all formed solution with it, i.e. they all formed solution with water. The viscosity of the two samples were recorded as follows:- Sample 1 (standard) 8 poise sample 2 (with gypsum) 10 poise. And this show that the change in viscosity of the sample does not appear to be significant.

Finally, the pH the present product (8.4) falls within standard value of paints .the pH of the different sample compared with that obtained from the standard sample and they were all observed to be basic. All these test were carried out at room temperature (26^0C).

Table 1. Assessment of the Properties of the Paint at Rest Condition.

Emulsion paint samples	Temp.	Opacity	Water Miscibility	Drying time	Viscosity	pH
Sample 1	26^oC	Good	Miscible, thus forms solution with water	Dried under 90 minutes	8poise	8.9
Sample 2 Emulsion P.O.P Paint (screeding piant)	26^oC	Good and matty	Miscible, thus forms solution with water	Dried under 70min	10 poise	8.1

5. Conclusion

From the study carried out, it could be seen that gypsum plaster added with other raw material reagent in the production of emulsion paint without producing significant, or any adverse effect on the properties of the paint, but rather, enhances the dry rate of the paint.
Through this means a lot of money will be saved by customers by increased durability and serviceability of the product, thus making the value of paint a kind dear. These results underscore/suggest the need to further explore

the use of gypsum plaster in the manufacture of paints considering its positive effects on the properties of paint especially in the reduction of the dry rate.

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