Preparation and Characterization of Enamel Paint

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Abstract

Enamel paints, white and black, were prepared. Pigments, fillers, additives and binder were used in the preparation of paints. Inorganic pigments (titanium dioxide, ultramarine blue, blanc-fixe and whitening (PCC)) were used for white enamel paint. Organic pigments (carbon black, blanc-fixe and whitening (PCC)) were used for black enamel paint. The physicochemical properties of paints were determined by modern instrumental techniques. Wet paint properties and dry film properties were studied. The viscosities of white and black enamel paint were found to be 79.2 and 61.8 KU respectively. The fineness of these two paints were 10 µm. The drying time for white paint was found to be 2: 21 hours and 5:15 hours for black paint. The specific gravities of white and black enamel paint were found to be 1.02 and 0.92 respectively. The gloss of white and black enamel paint were found to be 78.6 and 60.8 respectively. The hiding power of white and black enamel paint were found to be 89.3% and 100%. The film thickness of white and black enamel paint were found to be 17.6 and 16.46 µm. The hardness of these two enamel paints were found to be 3B. The weathering tests of two enamel paints were studied. After $2^1/_2$ months, the remaining gloss of prepared white paint and black paint are 65 and 40 respectively.

Keywords: Enamel paint, pigment, viscosity, fineness, drying time, specific gravity, hiding power, film thickness

Introduction

Enamel paint is a term that is used to refer to a paint with a hard, glossy and opaque finish. In actuality, the term "enamel paint" does not necessarily have a generally accepted or standardized definition, but historically, enamel paint has been used to refer to any type of enamel paint that is oil based and with a considerably glossy finish. However, due to the rising popularity of latex and water based paints, the term enamel paint has since evolved to refer to a hard surface paint with a high gloss finish. In addition, the term is used to refer to enamel paint brands that are high in quality.

Enamel paints are characterized by their hard, washable and glossy finish and are available with heat resistant properties. They are available in several types, including oil based or alkyd based, which have the features of slower drying times in addition to being harder than that of water based enamel paints. Oil based paints are recognized by their distinguishable solvent odor properties and are easily cleaned using paint thinner or mineral spirits. Additionally, quite a few manufacturers now add varnish to oil based paints. Water based paints, which are also referred to as latex or acrylic paints, are much easier to work with. They have the benefits of ease and simplicity of use, quicker drying times, easily cleaned using water alone and have a much weaker odor. Enamel paints are also available in urethane or polyurethane which are both offered in a water or solvent base.

Properties of Paints

Hiding Power

Hiding power is the ability to hide the surface of an object. When applied too thin, a coating lacks sufficient hiding power. The hiding power of paint measures its ability to obscure a background of contrasting color.

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Gloss

Gloss refers to the level of shine in paint. The Master Painters Institute, which sets standards for the paint industry, assigns gloss factors between 0, which is no gloss, to 100, which is an almost mirror-like shine.

Specific Gravity

Specific gravity is the ratio of the weight of a volume of the substance to the weight of an equal volume of the reference substance. The reference substance is nearly always water at its densest (4˚C) for liquids; for gases it is air at room temperature (21˚C). The temperature and pressure must be specified for both the sample and the reference. Pressure is nearly always 1atm.

Tinting Strength

Tinting strength is a relative concept which indicates its capacity to tint an opaque material that contains another pigment in its formulation. It is the measure of the effectiveness with which a unit quantity of a pigment alters the colour of a material. To modify the colour of the other pigment or to produce pastel shades, coloured pigments are added to whites. The weight of coloured pigments required by a given weight of a white to produce a given depth of the tint is an indication of the tinting strength.

Viscosity

Viscosity measures the paint's thickness and determines whether the paint can be applied with a brush, a roller, a sprayer, or other methods of application. In most cases, interior paints for the home come in a nearly uniform level of viscosity that makes them perfect for brushes or rollers.

Pigments

These not only give the paint its colour and finish, but also serve to protect the surface underneath from corrosion and weathering as well as helping to hold the paint together. Both inorganic and organic substances are used, with the inorganic ones being in general cheaper but with less clear colours. Special pigments can be used to give metallic finishes (for example for car bodies), to be hard wearing (for road markings) etc.

The Constituents of Paint

Additives

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, import antifreeze properties, control foaming, control skinning, etc.

Binder

The binder is the film-forming component of paint. It is the only component that is always present among all the various types of formulations. Many binders are too thick to be applied and must be thinned. The type of thinner, if present, varies with the binder. The binder imports properties such as gloss, durability, flexibility and toughness.

Drier

An oil drying agent, also known as siccative, is a coordination compound that accelerates (catalyzes) the hardening of drying oils, often as they are used in oil-based paint.

Solvent

The main purpose of the solvent 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. Its main function is as the carrier for the non-volatile components. To spread heavier oils (for example, linseed) as in oil-based interior house paint, a thinner oil is required.

Materials and Methods

Preparation of White Enamel Paint

Procedure

The pigments (1.5725 lb), the additives (0.04 lb) and the binder (2.26 lb) were mixed. The resulting mixture was dissolved in 2.6 lb of solvent. Then, it was stirred with Heavy Duty Mixer. The paste was formed. It was ground with Triple Roller Mill and then was added with some binder. Then, it was added 0.125 lb of drier and was stirred with High Speed Mixer. The white enamel paint was formed.

Preparation of Black Enamel Paint

Procedure

The pigments (1.28 lb), the additives (0.04 lb) and the binder (2.6 lb) were mixed. The resulting mixture was dissolved in 3.21 lb of solvent. Then, it was stirred with Heavy Duty Mixer. The paste was formed. It was ground with Triple Roller Mill and then was added with some binder. Then, it was added 0.06 lb of drier and was stirred with High Speed Mixer. The black enamel paint was formed. Table (1) shows the methods for the characterization of prepared white and black enamel paints.

Table (1) Methods for the Characterization of Prepared White and Black Enamel Paints.

Sr No.	Paint Property	Analysis Method
1	Viscosity	ASTM-D-428788
2	Fineness	ASTM-D-1210
3	Drying Time	Drying Recorder
4	Specific Gravity	ASTM-D-1475
5	Gloss	ASTM-D-523
6	Weathering Resistance	ASTM-D-523
7	Hiding Power Test	ASTM-E-97
8	Adhesion	Cut with knife
9	Film Thickness	ASTM-B-499
10	Hardness	ASTM-D-3363

Results and Discussion

Wet Paint Properties of Prepared White Paint and Standard UPG White Paint

Table (2) shows the comparison of wet paint properties of prepared white paint and standard UPG white paint. The viscosities of paint were determined by Ford viscosity cup method. The viscosities of these two paints are nearly the same. The fineness of paint was determined by Hegmann Gauge. The fineness of two paints are the same. The rate of drying

time were tested by the drying time recorder. They are three steps in the drying process of paint. There are touch, hard and through. When the solvent evaporates, enamel paints are considered dry. When the finger no longer detects a soft tacky condition, the film feels firm. The drying time of (touch) prepared white paint and standard UPG white paint are different because the used solvent in the prepared paint are different from the used solvent in the standard UPG white paint. The alkyd resin reacts with oxygen from the atmosphere and polymerises to form a hard coating. The drying time (hard) of prepared white paint is slower than the standard UPG white paint because the added binder in the paints are different. The drying time (through) of the prepared white paint is faster than the standard UPG white paint because the amount of driers in the prepared white paint is greater than those of in the standard UPG white paint. The types of drier in the preparation of these two paints are different. The specific gravities of paint was determined by Pyknometer. The specific gravities of these two paints are nearly the same.

Wet Paint Properties of Prepared Black Paint and Standard UPG Black Paint

Table (3) shows the comparison of wet paint properties of prepared black paint and standard UPG black paint. The viscosities of these two paints were determined by Ford viscosity cup method. The viscosity of prepared black paint is lower than the standard UPG black paint because turpentine was added in the prepared black paint. The fineness and specific gravity of these two paints are the same. The drying time of these two paints were determined by the drying time recorder. The drying time (touch) of prepared black paint is slower than the standard UPG black paint because the solvent in the standard UPG black paint evaporates faster than the solvent in the prepared black paint. The drying time (hard) of the prepared black paint is slower than the standard UPG balck paint because the used binders in these two paints are different. The drying time (through) of the prepared black paint is faster than standard UPG black paint because the amount of used drier in the prepared black paint are greater than those of in the standard UPG black paint. The types of used drier in these two paints are different.

Dry Film Properties of Prepared White Paint and Standard UPG White Paint

Table (4) shows the comparison of dry film properties of prepared white paint and standard UPG white paint. The gloss of paint was determined by glossmeter. The gloss of prepared white paint is lower than the standard UPG white paint because the quantities of pigments and additives in these two paints are different. So, the gloss of two paints are different. The weathering resistance tests of these two paints were determined. After $2^1/_2$ months, the remaining gloss percent of prepared white paint is lower than the standard UPG white paint. Therefore, the standard UPG white paint is more resistant than the prepared white paint from the various weathering conditions. The hiding power of paint was determined by a machine. The hiding power of these two paints are nearly the same. The adhesion of paint was determined by cutting with a knife. The adhesion of two paints are the same. The film thickness of paint was determined by a film thickness tester. The pigments and the binder are left on the surface when the paint dries and the liquid portion evaporates. Thus, a lower solids content can provide a thinner dry paint film. The film thickness of prepared white paint is lower than the standard UPG white paint because the solid contents in prepared white paint were lower than those in the standard UPG paint. The hardness of paints were determined by a pencil hardness gauge. The hardness of these two paints are 3B and 4B respectively.

Dry Film Properties of Prepared Black Paint and Standard UPG Black Paint

Table (5) shows the comparison of dry film properties of prepared black paint and standard UPG black paint. The gloss of paint was determined by a glossmeter. The gloss of prepared black paint is lower than the standard UPG black paint because the quantities of pigments and additives in these two paints are different. So, the gloss of two paints are different. The weathering resistance tests of these two paints were determined. After $2^1/_2$ months, the remaining gloss percent of prepared black paint is lower than the standard UPG black paint. Therefore, the standard UPG black paint is more resistant than the prepared black paint from the various weathering conditions. The hiding power of paint was determined by machine. The hiding power and adhesion of these two paints are the same. The film thickness of paint was determined by a film thickness tester. The pigments and the binder are left on the surface when the paint dries and the liquid portion evaporates. Thus, a lower solids content can provide a thinner dry paint film. The film thickness of prepared black paint is lower than the standard UPG black paint because the solid contents in prepared black paint were lower than those in the standard UPG paint. The hardness of paints were determined by a pencil hardness gauge. The hardness of these two paints are 3B and 4B respectively.

Table (2) Comparison of Wet Paint Properties of Prepared White Paint and Standard UPG White Paint.

Sr. No	Paint Property	Prepared White Paint	Standard UPG White Paint	Analysis Method
1.	Viscosity (KU)	79.2	80.9	ASTM-D 428788
2.	Fineness (μm)	10	10	ASTM-D 1210
3.	Drying Time (hours) (Touch) (Hard) (Through)	 1:48 2:09 2:21	 00:48 1:00 3:42	Drying Recorder
4.	Specific Gravity	1.02	1.03	ASTM-1475

Table (3) Comparison of Wet Paint Properties of Prepared Black Paint and Standard UPG Black Paint.

Sr. No	Paint Property	Prepared Black Paint	Standard UPG Black Paint	Analysis Method
1.	Viscosity (KU)	61.8	87.3	ASTM-D428788
2.	Fineness (μm)	10	10	ASTM-D1210
3.	DryingTime (hours) (Touch) (Hard) (Through)	 3:00 3:42 5:15	 00:36 2:45 5:30	Drying Recorder
4.	Specific Gravity	0.92	0.92	ASTM-1475

Table (4) Comparison of Dry Film Properties of Prepared White Paint and Standard UPG White Paint

Sr. No	Paint Property	Prepared White Paint	Standard UPG White Paint	Analysis Method
1.	Color	White	White	
2.	Gloss (60˚)	78.6	89	ASTM-D 523
3.	Weathering Test (after 2½ months) Gloss	65	75	ASTM-D 523
4.	Remaining Gloss (%)	82.70	84.27	
5.	Hiding Power (%)	89.3	90.0	ASTM-E 97
6.	Adhesion (%)	100	100	Cut with knife
7.	Film Thickness (µm)	17.6	22.6	ASTM-B 499
8.	Hardness	3B	4B	ASTM-D 3363

Table (5) Comparison of Dry Film Properties of Prepared Black Paint and Standard UPG Black Paint.

Sr. No	Paint Property	Prepared Black Paint	Standard UPG Black Paint	Analysis Method
1.	Color	Black	Black	
2.	Gloss (60˚)	60.8	89.9	ASTM-D 523
3.	Weathering Test (after 2½ months) Gloss	40	80	ASTM-D 523
4.	Remaining Gloss (%)	65.79	88.99	
4.	Hiding Power (%)	100	100	ASTM-E 97
5.	Adhesion (%)	100	100	Cut with knife
6.	Film Thickness(µm)	16.46	18.56	ASTM-B 499
7.	Hardness	3B	4B	ASTM-D 3363

Weathering Test

Figure (1) Comparison of weathering test (Prepared Paint and Standard UPG Paint).

Hiding Power Test

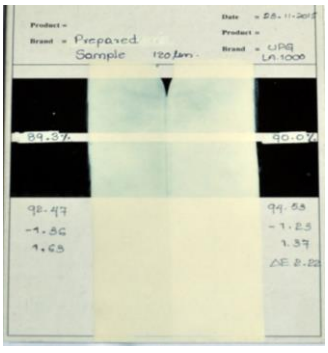

Figure (2) Comparison of hiding power test (Prepared White Paint and Standard UPG White Paint).

Hiding Power Test

Figure (3) Comparison of hiding power test (Prepared Black Paint and Standard UPG Black Paint).

Film Thickness Test

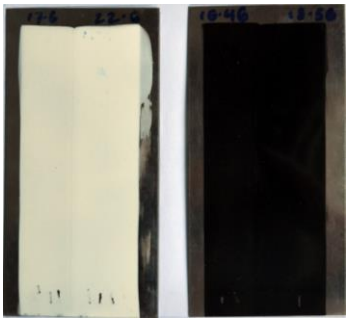

Figure (4) Comparison of film thickness test (Prepared Paint and Standard UPG Paint).

Conclusion

In this research work, enamel white paint and enamel black paint were prepared. The wet paint properties and the dry film properties of the prepared white and black paints were studied. The physicochemical properties of prepared white and black paints were compared with those of standard UPG white and black paints.

The viscosities of the prepared white and black paints were found to be 79.2 KU and 61.8 KU. These viscosities are lower than the viscosities of standard UPG white and black paints. The viscosity of prepared black paint is lower than those of prepared white paint. The viscosity of the paint, which essentially serves as a measure of its thickness, is an important factor to consider. Therefore, The film thickness of prepared black paint is lower than those of prepared white paint. The fineness of both prepared white and black paints were found to be 10μm respectively. These values are the same as the standard UPG paints' values. The drying times of the prepared white paint were found to be 1:48 hr (touch), 2:09 hr (hard) and 2:21 hr (through) respectively. The drying times of the prepared black paint were found to be 3:00 hr (touch), 3:42 hr (hard) and 5:15 hr (through) respectively. The drying times of the prepared white and black paints are faster than those of the standard UPG paints. The specific gravities of the prepared white and black paints were found to be 1.02 and 0.92 respectively.

The gloss of the prepared white and black paints were found to be 78.6 and 60.8 respectively. The gloss of the prepared white and black paints were lower than the standard UPG paints. The gloss of prepared white paint is more glossier than those of prepared black paint. The weathering tests of the prepared white and black paints were also studied. After $2^1/_2$ months later, the gloss of the prepared white and black paints were found to be 65 and 40 respectively. The remaining gloss percent of the prepared white and black paints were found to be 82.70% and 65.79% respectively. Therefore, the prepared white paint is more resistance than the prepared black paint from the various weathering conditions.

The hiding power of the prepared white and black paints were found to be 89.3% and 100% respectively. The hiding power of prepared black paint is better than those of prepared white paint. Both adhesion percent of prepared white and black paints were found to be 100%. The prepared and standard UPG white and black paints have the best adhesion properties. The film thickness of the prepared white and black paints were found to be 17.6 μm and 16.46 μm respectively. The film thickness of prepared white paint is thicker than those of the prepared black paint. The hardness of both prepared white and black paints was found to be 3B pencil. The qualities of prepared white and black paints are not appreciably

different with standard UPG white and black paints. Therefore, the prepared white and black paints are suitable for various purposes of coating and painting.

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