

# Formulation of Water Based Paints using Polyvinyl Alcohol as Binder, Characterization and their Application on Cement Surface

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## ABSTRACT

Water-based paints were formulated using polyvinyl alcohol as binder and applied on cement surface. The polyvinyl alcohol (PVA) was dissolved in cold water and the mixture stirred continuously at 80°C for 5 hours until a homogenous solution was obtained. The solution obtained was highly viscous with a light amber colour. The paints were formulated using the PVA solution and subsequently, applied onto a flat cemented surface using a small hand brush. The viscosity and density of the paints were found to be ranged between 37-39 centipoises and 1.02-1.09g/cm<sup>3</sup>, respectively. Series of test such as drying times, weathering and adhesion were successfully carried out. The formulated paints also recorded a very good light property of 7. The overall performances of the paints were found to be very good.

**Keywords:** Polyvinyl alcohol, pigments, light fastness, viscosity

## INTRODUCTION

With the application of science in the production of paint, product of high quality is now possible this time, not only to give appearance but more importantly for surface protection (Surajudeen *et al.*, 2015). Paints are classified according to their application and functions i.e. varnishes, lacquers, fillers etc. Emulsion paint which is water

based paint is principally used for external and internal surface coatings, mostly in building (for appearance and as a surface protector). Apart from their protective action, varnishes, and lacquers increases the protective action of manufactured goods (Lambourne, 1988).

Polyvinyl Alcohol (PVA, sometimes referred to as PVOH) is a water

soluble polymer used widely in adhesives, paints, sealants, coatings, textiles, plastics etc. It is a non-toxic, colourless and odourless biodegradable polymer which is not known to occur as a natural product. It has excellent film forming, emulsifying and adhesive properties. It is also resistant to oil, grease, acid, alkali, and organic solvent with long storage stability.

In 2015, Baba and his team formulated some oil paints using pyridone pigments and Soya alkyd and polyvinyl alcohol as binder and applied on leather. In 2016, Baba and his team also formulated emulsion paints using azo pyridone pigments and polyvinyl alcohol as binder, also characterised and applied on wood substrate. The overall performances of the paints were found to be very good. In this paper, inorganic pigments were incorporated in the formulation of water based paints, applied on cemented surface and also characterised.

## **MATERIALS AND METHODS**

### **Materials/Equipment**

Beakers, Stirring rod, Thermometer, Test tubes, Heating mantle, Measuring cylinder, Ceramic pestle and mortar, Flat cemented surface,

Density bottle, Viscometer, Calorimeter, pH meter, Spatula, Stop watch

### **Chemicals/Reagents**

Water, Polyvinyl alcohol Ammonia, Titanium dioxide, Calcium carbonate, Pigments, Kaolin, Texanol (Propanoic acid), Talc (Hydrated magnesium silicate), Silicone oil, Neem oil

## **EXPERIMENTAL PROCEDURE**

### **Preparation Polyvinyl Alcohol Solution**

19.36g of PVA powder was slowly added to 80mls of cold water to avoid formation of lumps. When the powder was fully dispersed in the water, the mixture was heated to the temperature at which the polymer becomes solubilised at 180°C. The mixture was continually stirred at this temperature until the PVA was fully solubilised (www.silverson.com).

### **Formulation of Emulsion Paint**

Calcium carbonate and titanium dioxide was ground in a ceramic mortar and pestle until it became fine powder, then the required quantity of water was added to form a paste. Kaolin powder was then added to the paste and mulled

for 5 minutes. The PVA solution was then added to the paste and mulled for another 15 minutes. Silicone oil, talc powder, and ammonia were then added to the paste sequentially, and thoroughly mixed. The cobalt II oxide-aluminium oxide was mixed in 10mls of distilled water before adding to the paste, then thoroughly mulled until

homogenous mixture was obtained. The texanol was then added in small quantity gradually until the desired thickness was achieved. The same procedure was carried out using the iron III oxide hydroxide pigment. The recipe used for the paint formulation is shown in Table 1

**Table 1: Recipe for the Formulated Paints**

Raw Material	Quantity (g)
Polyvinyl Alcohol	9.68
Ammonia	0.20
Titanium dioxide	10
Kaolin	6.76
Talc	6.76
Texanol	1.17
Calcium carbonate	6.76
Silicone oil	0.25
Neem oil	0.29
Water	10
Cobalt II oxide-aluminium oxide pigment	0.5
<b>Total</b>	<b>52.37</b>

**Pigment Mass Concentration**

$$\text{Pigment mass concentration (PMC)} = \frac{\text{Mass of pigment}}{\text{Total mass of recipe}} \times 100$$

$$\frac{0.5}{52.37} \times 100 = 0.95\% \approx 1\%$$

## CHARACTERIZATION OF PAINTS

### Viscosity

Is a measure of the resistance of the paint to deform under shear stress. The viscosities of the formulated paints were measured using the Brookfield synchro-electric viscometer using spindle number 4 with a speed of 100r.p.m. The results are shown in Table 3

### Density

The densities of the paints were determined using ASTM D1475-14 standards test method for density of liquid coatings. The mass of the density bottle was first determined, and then the mass of the density bottle filled with the paint solution. The results are shown in Table 3

### Solubility

The solubility test of the paints formulated were carried out in order to check their solubility in various solvents like water, ethanol, methanol, kerosene, n-hexane, sulphuric acid. The results are shown in Table 2

### Application of Paint to Substrate

The paints were applied on a flat cement surface made in the department.

**Sample Preparation:** Three wooden mould measuring 10x4cm in dimension was constructed. The cement acquired from Samaru market was mixed with sand and water to obtain a mortar. The mortar was then poured into the wooden mould and allowed to dry. Finally, the dried mortar was removed from the mould.

**Method of Coating:** The paints were applied on the substrate using the hand brush method.

### Surface Drying Time

This is the time taken for the paint to be dry to touch after application (Evan, 2003). The sample was coated using hand brush, and then the time taken for it to dry was measured using white paper to touch the surface until no stain was observed on the paper. A stop watch was used to record the time. The same procedure was repeated for the remaining paints. The results are shown in Table 3

### Hard Drying Time

As the paint dries, its solid components contact and adhere to each other. The time taken for this to occur is called the hard drying time (Evans 2010). This is the time when the sample is much less vulnerable

to damage by scratch, or water without fear of harm. The results are shown in Table 3.

### **pH Test**

This test checks the alkalinity or acidity of the formulated paints. It was determined using a pH meter. The pH meter was inserted into the paint and the readings were taken as discussed in 3.

### **Weathering and Water Resistance Test**

Is carried out to test the paint under real world conditions like sunlight, rain, extreme temperature, humidity and comparing the amount of fading to a painted surface that was not exposed (Adetoun, 2013). The water resistance test was carried out to check if the paint is stable in the presence of water and to observe if the paint will swell and absorb water or form blisters. The result is discussed in 3.

### **Adhesion Test**

A cross-hatch is made on the dried painted surface. A piece of tape is

applied to the cross-hatch, and then pulled off. A good paint will remain on the surface, and paint with poor adhesion means there is too much or too little thickener/hardener. The result is discussed in 3.7.

### **Optical Density**

This is carried out using a photoelectric calorimeter. The meter was standardized by adjusting it to read 100% light transmittance with 5ml distilled water at a wavelength of 660nm. The results are shown in Table 3.

### **Light Fastness**

2/3 of the painted surface was covered with a black polythene bag and the part to be tested was exposed to light from xenon lamp along with eight blue wools, for 72hours. The fastness was assessed and the fading of the substrate was compared to the standard procedure outlined in ISO 105. As shown in Table 3.

## RESULTS AND DISCUSSIONS

**Table 2: The solubility of formulated paints in various solvents**

Solvents	Solubility
Water	Soluble
Ethanol	Soluble
n-hexane	Insoluble
Methanol	Soluble
Kerosene	Insoluble
Sulphuric acid	Insoluble

**Table 3: Viscosity and density, optical density, light fastness, surface and hard drying times**

Paint Sample	Viscosity (Centipoises)	Density (g/cm <sup>3</sup> )	Surface drying time (Minutes)	Hard drying time (Minutes)	Optical density	Light Fastness
A	37.5	1.0200	30:00	1:30	1.36	7
B	39.5	1.0692	30:26	1:35	1.37	7
C	36.8	0.9954	20:00	1:00	1.49	7

### Viscosity

Table 3 have shown the viscosity of the formulated paints. It was observed that the commercial paint has lower viscosity than the formulated paint which could be as a result of different ratios of recipe and due to different molecular mass and quantity of pigments used in the formulation.

### Density

The densities of the formulated paints were found to be very close and that of the commercial paint was lower than the densities of the

formulated paint which also could be due to differences in composition ratio or molecular mass of pigments used.

### Surface Drying Time

Surface drying time depends very much on the application conditions like temperature and humidity and also on the application method (Rohm, 2003).The surface drying time of the formulated paints found to be very close to the surface drying time of the commercial paint. The slight difference could be due to difference in viscosity values of the

both paints. The results are shown in Table 3.

### **Hard Drying Time**

It is also very dependent on application conditions and method. In coatings manufacture today, hard drying time for latex based paint is within 1-4 hours (Evan, 2003).

The hard drying time of the formulated paints were found to be slightly higher than that of the commercial paint. This could be that drying agent was incorporated in the commercial paint which was not part of the recipe of the formulated paint. The result also shows that it conforms to standard which is between 1-4hours according to the European coatings. The results are shown in Table 3.

### **pH Test**

The pH values of the formulated paints fall within the range of 6.5-6.7 which indicates that the paint is acidic. The pH range is not a favourable condition for bacteria to thrive in it; therefore it is not susceptible to bacteria attack (Surajudeen *et al*, 2015).

### **Weathering and Water Resistance Test**

The painted samples showed very good weathering properties when

exposed to sunlight and rainfall for 48 hours, and when the samples were immersed in a beaker of water, it did not absorb water which can cause swelling and blistering of the paint. This shows that the paint can withstand weathering conditions and can be used as an exterior and interior paint purposes.

### **Adhesion Test**

The adhesion of the formulated paint was found to be excellent. When the tape was removed from the painted surface, the paint remained on the surface which shows that the paint has good adhesion property.

### **Light Fastness**

From Table 4.10, the paints formulated generally have very good light fastness. The formulated paints have bright colours and did not change colour even on exposure to light after 72hours including the control sample. This shows that it conforms to standard procedure outlined in ISO 105.

### **CONCLUSION**

Water based paints using inorganic pigments and polyvinyl alcohol as binder were successfully formulated and characterised for pH, light fastness, viscosity, density, surface

and hard drying time, adhesion, optical density, water resistance and solubility in different solvents was tested and measured. The overall performances of the formulated paints were found to be very good.

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