

Production of Trowel Paints using Polyvinyl Acetate Synthesized from Vinyl Acetate Monomer as a Binder

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Abstract

Polyvinyl acetate (PVAc) was synthesized from vinyl acetate monomer under atmospheric pressure and temperature of 72°C for three hours. Results obtained on the physico chemical analysis carried out on PVAc indicate that the specific gravity was 1.18, pH 4.2, density 1.25g/cm³, viscosity 0.40 centipoises, and refractive index 1.40. Comparison of these results with the literature values shows that physico chemical properties of the synthesized PVAc were in conformity. The PVAc was then used as a binder in the production of Trowel paint. The results of the physico chemical analysis of the Trowel paint showed that the pH was 7.92, the specific gravity 2.3 and the hard drying time was 22 hours, which were also within range of the standard. The adhesion and opacity were excellent in line with the literature standard. The excellent covering power of this paint makes it to be used directly on non plastered wall, thereby saving the cost of plastering.

Keywords

Polymer; Molecule; Physico chemical parameters; Catalyzed reaction; Acetylene; Acetic acid

Introduction

The polymerization of vinyl acetate monomer gave rise to copolymer and homopolymer. PVAc homo polymers were the first polyvinyl acetate emulsion developed [1, 2]. These polymers are hard and brittle with high molecular weight, high tensile strength and rapid speed of setting. Today these polymers are still the 'work horse' of the industry due to their excellent adhesion to a wide variety of polar substrates [2, 3]. In recent time, PVAc resin have been used as a binder in the paint manufacturing industries owing to the PVAc film possessing good aging characteristics due to resistance to ultra violet rays and oxidation. PVAc as a binder in the paint industry is the dry portion of the paint that binds the pigment particles together and to the painted surface. It gives the film many properties such as hardness, toughness and speed of drying [2, 3]. It also covers cracks and strongly assists in smoothening out imperfect walls. Trowel paint is good for interior and exterior wall of buildings [2, 3].

The aim of this article is to synthesize polyvinyl acetate (polymer) and using it as a binder in the production of trowel paint. Polyvinyl acetate is safe to use because it has no flammable solvent. Polyvinyl acetate is not an ideal molding plastic, so the development of many economic and attractive alternatives rapidly ensued based on ability of vinyl acetate to copolymerize with many other monomers. Hence, copolymers with vinyl chloride, acrylic, monomers, styrene, ethylene and other gave a great range of molding, coating, sheeting, adhesives and insulating materials [4-6]. The liquid polyvinyl acetate emulsion is white, but it becomes clear when it is dries. Although water is used to thin the emulsion, the dried film is water resistant. Heavy impasto layers of paint will not crack unless they are grossly over pigmented. In contrast to ordinary egg and gum emulsion, the dried films are extremely hard and resistant to scratching. The PVAc medium can be stored well in glass or polyethylene container [4-6]. Oxidative addition of acetic acid to ethylene in the presence of palladium catalyst is the most widely used method for the manufacture of vinyl acetate. Addition of acetic acid to ethylene is the oldest manufacturing process of vinyl acetate. The excellent yield of vinyl acetates are produced by the reaction of vinyl chloride and sodium acetate in solution at a temperature of between (50-70°C) in the presence of palladium chloride as catalyst [4-6].

Polyvinyl acetates are generally polymerized by solution, suspension, bulk or

emulsion polymerization techniques. Commercially emulsion polymerization techniques are the predominant method [7, 8]. Semi batch emulsion polymerization process is used in the synthesis of polyvinyl acetate which involves the addition of ingredients, usually surfactants, monomers and initiator in increment. Trowel paint is made of specially pigmented natural aggregate of marble dust and resin or binder (PVAc) of high grade which reinforce its toughness and protects its high aesthetic properties while enhancing its durability [7, 8].

Material and Method

The reactor was placed on the magnetic stirrer and charged with all the surfactants and part of the initiator (a drop) and the stirrer was switched on. The reactor mixture was heated directly in the water-bath to the reaction temperature of 70°C. The temperature was verified with thermometer. After 30 minutes of continuous stirring, typically 8% of total amount of vinyl acetate was subsequently added to the reactor to produce a substance called in-situ seed latex. In the reactor, polymerization started by the initiator generating free radicals by thermal decomposition of aqueous phase. The free radicals reacted with the monomers present in the water phase to form oligomer chain. The oligomer can be absorbed into micelles or can continue to grow and absorb surfactant molecule. In either case it leads to the formation of polymer particles. The process continued until no micelles were left. Monomers and initiator were then added at 30 minutes interval to sustain the polymerization process. Finally all monomers were added to the reactor, the polymerization continued until the conversion of residual monomer into the polymer particles, gradually the polymerization rate decreases to zero when no residual monomer was left. The polymerization process lasted for three hours. In other to improve on the characteristics of the polyvinyl acetate, plasticizer (di butyl phthalate) of 1cm³ was added to the PVAc. The beaker was placed on the magnetic stirrer; solvent (water) 15g and polyvinyl acetate 5g were added and stirred for 10 minutes. The tinting pigment was added drop wise and stirred for 20 minutes for proper dispersion. Weighed 200g of the fine-white marble-dust was then charged and stirred for 30minutes to get pigmented. The mixture was poured on a drying tray and then hard-dried on the heating mantle for 1 hour at 120°C. Black and red pigmented marble-dust were produced, the pigmented marble-dust were left to cool at normal room temperature 25°C. The beaker was

washed and mounted on the magnetic stirrer, 50g of PVAc, 10g of distilled water and the formulated 200g of the pigmented marble-dust were charged into it. The mixture was allowed to stir for 30 minutes. Three drops of biocide and 2g of hydroxyl methyl cellulose (Natrosol) were added and the resulting mixture was stirred for 30 minutes.

Determination of the Physico Chemical Properties of Polyvinyl Acetate

Viscosity Measurement

The standard method of viscosity determination was employed using the viscometer bath capillary inserted into the viscometer bath. A reasonable quantity of the sample was poured into the U-tube viscometer with capillary and then corked. The U-tube was suspended into the viscometer bath containing water and the temperature of the bath was 33°C. The cork was removed and the time taken for the content to run up starting from the top mark to the middle mark was noted using a stop watch. From this result the viscosity of the sample was calculated.

Specific Gravity Test

The empty specific gravity (SG) bottle was weighed and its weight recorded. The same SG bottle was filled with the trowel paint and weighed and its weight was recorded. The difference in the weight between the SG bottle filled with the paint and the empty SG bottle gives the density.

pH Measurement

The pH of the trowel paint was measured by the pH meter electrode. 40cm³ of the sample was collected into a beaker of 50cm³ and the pH value was determined by inserting the electrode into it. The value was now read from the instrument and recorded.

Opacity Test

This test was carried out by using the trowel blade to apply the paint on the wall (substrate) to test its covering power; a good covering power can easily be seen by the use of naked eye.

Adhesion Test

This was done after the paint has dried on the substrate. The level of adherence of the

film to the wall is tested by using the bear hand to rub the substrate; if it does not stain the hand, the paint can then be said to adhere well.

Drying Time Test

Although there are three types of drying: the soft dry, hard dry and surface coat dry. The drying of the trowel paint occurs by the evaporation of the solvent in the paint which is accompanied by the hardening of the resin binding the pigmented marble-dust together and to the coated surface.

Application Time

This was done by applying the paint on plastered and non plastered wall using the trowel blade. Thorough examination was conducted on its binding, coverage ability, cracking and chalking.

Results and Discussion

Table 1 shows the physico chemical properties of the polyvinyl acetate produced. It can be seen from the Table that the viscosity of the synthesized polyvinyl acetate was 0.4 centipoises; this value is close to the standard value of 0.43 centipoises. The specific gravity determined at 20°C was 1.18 and close to the one obtained from the literature of 1.19. The value of the refractive index determined by refractometer was 1.40 as against the 1.50 of the standard specification. The pH value of the polyvinyl acetate was 4.2 which is acidic and in the range of the expected standard values of 3-5. The molecular weight was 87.0g/mol which are very close to the standard value of 86.09g/mol.

Table-2 shows the different test properties carried out on the trowel paint produced. The analysis showed that the pH value was 7.92 which are between the standard values of 7.50-8.50 which is alkaline. The result of the specific gravity was the same with that of the standard. The coat thickness on the wall was 1.5mm thick which is the same with the standard and given a good coverage power [3]. The adhesion was good implying the good binding ability of the resin (binder) to the pigmented marble-dust and to the substrate (wall). The drying time for soft, hard and surface coating drying was 1 hour 30 minutes, 3 hours 20 minute and 22 hours respectively, which are within the standard drying time. From the

applications on the plastered and non plastered walls (substrate); the binder reinforce its toughness and protects its aesthetic properties. They both have a good coverage power, they also cover cracks and strongly assist in smoothening out imperfect walls, there was no cracking and chalking due to high grade of the binder and hard-dried pigmentation of the marble-dust. Tables 3 and 4 shows pigmentation ratio and production ratio of the Trowel paint produced.

Table 1. Physico chemical properties of the produced polyvinyl acetate (PVAc)

Properties	Standard values for PVAc	Results for PVAc
Viscosity	0.43 centipoises	0.40 centipoises
Density	1.30g/cm ³	1.25g/cm ³
Refractive index	1.50	1.40
pH	3-5	4.2
Molecular weight	86.09g/mol	87.0g/mol
Specific gravity	1.19	1.18
Specific volume	0.769cm ³ /g	0.833cm ³ /g

Table 2. Values for the test properties of the produced Trowel paint

Properties	Standard values	Results obtained
Opacity	Excellent covering power	Good covering power
pH	7.50-8.50	7.92
Specific gravity	2.20-2.50	2.35
Adhesion	Good adhesion	Good adhesion
Soft drying	1-2 hours	1 hour 30 minutes
Hard drying	24 hours	22 hours
Surface coating drying	3-4 hours	3 hours 20 minutes

Table 3. Pigmentation ratio of the produced Trowel paint

Components	% composition
Distilled water	6-818
Polyvinyl acetate	2.227
Pigment (colourant)	0.012
Marble- dust	90.10

Table 4. Production ratio of the produced Trowel paint

Components	% composition
Distilled water	3.816
Polyvinyl acetate	19.10
Marble- dust	76.33
Thickener	0.763
Biocide	0.002

Conclusions

Based on the present studies it can be inferred that the physico chemical properties of the synthesized polyvinyl acetate produced conform to the standards. So, if all ideal conditions are met, high grade polyvinyl acetate can be produced at a Laboratory scale, which can be scaled up to industrial scale.

The trowel paint produced is also of high standard based on the result of the specific gravity, adhesion test, opacity, pH test, drying time test which were all within the range of the standards.

References

1. Bentley J., Turner G.P.A., *Introduction to Paint Chemistry and Principles of Paint Technology*, London, Chapman and Hall, 4th Edition, 1998, p. 91-187.
2. Rodriguez F., Cohen C., Ober C.K., Archer L. A., *Principles of Polymer Systems*, New York, USA, Taylor and Francis, 5th Edition, 2003, p. 584-590.
3. Flory P. J., *Principles of Polymer Chemistry*, Sage House, 512 East State Street, Ithaca, New York, USA, Cornell University Press, 1995, p. 333-336.
4. Candau F., Ottewil R. H., *An Introduction to Polymer Colloids*, the Netherlands, Kluwer Academic Publications, Dordrecht, 1990, p. 1-29.
5. Fitch R.M.L., *Polymer Colloids: a comprehensive introduction*, USA, Academic Press Inc., 1997, p. 1-4.
6. Godwin J., *Colloids and Interfaces with Surfactants and Polymers An Introduction*, The Atrium Southern Gate, Chichester, West Sussex, England, John Wiley and Sons Ltd, 2004, p. 27-46 & p. 177-185.
7. McCrum N.G., Buckley C.P., Bucknall, C.B., *Principles of Polymer Engineering*, U.K., Oxford University Press, Oxford, 1998, p. 19-30.

8. Szwarc M., Bywater S., Beylen V., Smets G., Worsfold D. J., *Advanced Polymer Science*, Germany, Spingerverlag, Berlin, 1988, 49, p. 87.