

Emulsion Paint Formulation from Black Seed Powder/Soya Bean Oil Copolymer Binder

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Abstract

The study focused on creating a water-based paint using a locally accessible pigment (black seed powder) and soya bean oil. Soya bean oil's hydrophobicity is incorporated into the paint matrix. The physical and mechanical qualities of the developed emulsion paint were tested. Results were positive for tackiness, stability, blistering, flexibility, and chemical resistance. Physical parameters measured included pH (8.35), density (1.09 g/cm³), viscosity (4.2 m²/s), opacity (4.8 m²/l), drying time (touch to dry and hard to touch) of 28 and 60 min, and specific gravity (1.95 g/cm³). All were found suitable for the coating industry. This paint is water-based. Using it adds value to emulsion paint and helps reduce volatile chemicals. This reduces ozone layer depletion and benefits the environment.

Keywords: Black seed powder/soya bean oil copolymer binder, emulsion paint, coating industry, volatile chemicals, ozone layer

INTRODUCTION

Paint can be described as a colloidal mix of chemicals. When spread in a thin layer on a surface, it forms a solid film [1, 2]. In the past, paint referred to chemicals with pigment suspended in a liquid carrier such as oil or water. Paint is any liquid, liquefiable, or mastic mix applied in a thin layer that solidifies into a film [1–3].

Emulsion paint, which is made up of pigments dispersed in a liquid medium and used as a decorative or protective covering, has been manufactured since prehistoric times, although it was formerly prohibitively expensive and so was mostly employed for artwork [1, 3]. Binders are liquid polymeric or resinous materials used in coating to hold pigments and additives together, providing and enabling the coating, and determining the film's properties, such as flexibility, durability, and chemical resistance. The binder gives qualities like gloss, durability, flexibility, and toughness [4, 5].

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This study focused on emulsion paint formulations that used Black Seed Powder/Soya Bean Oil as a resin (binding). When utilized directly in the formulation of emulsion paint, the resin appears to have a decent drying time. The hard drying time for emulsion paint was 28 and 60 minutes, which is consistent with the standard [6] drying paint time. The analysis (density, opacity, drying time, viscosity, stability, pH, tackiness, resistance to blistering, specific gravity, and chemical resistance) revealed that the emulsion paint met standards and could be used for both decorative and protective purposes, resulting in a healthier environment.

Materials

Soya bean oil/black seed powder, Sodium Chloride, Ammonia, Nastrozol, Calcium Carbonates, Kaolin, Calgon, Titan, Texanol, and formalin were purchased from Muda-Lawal Market in Bauchi, Bauchi State, Nigeria. The Department of Chemistry, Faculty of Science, Abubakar Tafawa Balewa University in Bauchi, Nigeria, donated equipment such as a pH meter, weighing machine, viscometer cup, stopwatch, thermometer, and magnetic stirrer.

Sample Collection and Pretreatment

The black seeds were obtained from an Islamic Chemist shop at Masaka Market, Karu, Nasarawa State, Nigeria. The seeds were carefully picked, pounded to a powdery consistency with a mortar and pestle, then sieved. The soya bean oil was utilized exactly as purchased, as were all other raw materials.

Methods

For formulation, we used the approach reported in [5]. 5 g of black seed powder was mixed with 10 mL of soya bean oil to create a homogenous mixture and left to stand for 30 minutes. 250 mL of water was added to a mixing tank, along with a stirrer, 50 g of titanium dioxide, 10 g of calcium carbonate, 10 mL of formalin, and 5 mL of ammonia. To get the correct consistency, each of these ingredients was added one after the other at intervals of ten (10) minutes while being continuously stirred. The mixture was filled up to 500 mL with distilled water.

Determining the Physical Properties of the Paint Formulated

Drying Time

The dry time of the paint sample was calculated using the [6] technique. A bar applicator was used to apply 25 mL of the paint sample to a glass panel and allow it to dry; hard to touch was taken when the paint film no longer adhered to the finger, and drying to hard was taken when the film resisted finger prints.

Opacity Test

A board was prepped with room-temperature paint. The brush was dipped into the paint sample before being dipped into the 25 mL beaker to prevent it from slipping off the board, and the area of the surface covered was recorded [7].

$$\text{Opacity} = (\text{area of painted surface}) / (\text{volume of paint applied}) \text{ in } (\text{m}^3/\text{L})$$

Density

A sample of the formulated paint was transferred into a 25 mL bottle and filled to the top. The empty bottle was weighed, as well as the bottle and the paint within [7].

$$\text{Density} = (\text{weight of empty bottle} + \text{sample}) - (\text{weight of empty bottle}) / (\text{volume of sample}) (\text{g}/\text{cm}^3).$$

Specific Gravity

This is the ratio of a material's density to the density (mass per volume) of a reference substance (water) at a given temperature. The weight of an empty density container with a cork was taken as W_0 . The bottle was filled with water and weighed as W_1 . The bottle was then emptied and dried before being filled with the formulated paint and weighed as W_2 [7].

$$\text{Specific gravity} = (w_2 - w_0) / (w_1 - w_0).$$

Weights: w_2 = paint + density bottle, w_1 = water + density bottle, and w_0 = empty density bottle.

Viscosity Test

The paint sample was poured into a beaker, and the viscosity was measured using a flow cup viscometer at room temperature, expressed in meter square per second m^2/s , with the viscosity estimated from flow time [2]. Each sample received three readings, with the average value determined.

pH Determination

The pH of the paint samples was tested using a pHS-3C digital pH meter. The pH electrode was calibrated with a buffer solution containing 7 and washed with distilled water [2]. The electrode was then dipped into the paint samples, and the pH was measured.

The Tackiness Test

This was done qualitatively on the dry film using the palm feeling to determine whether or not the paint film was sticky. The stickiness of a dried paint coating indicates that the paint is tacky. For every determination, three samples were used, and the average quality was noted [8].

Adhesion Test

The adhesion of paint was tested by applying a coat of paint film with a film applicator to a degreased metal panel and allowing it to dry for 48 hours. A crosshatch tester was used to draw two sets of lines, one perpendicular to the other, on the paint film. An adhesive tape was forcefully pressed with the thumb to cover all perpendicular line intersections. The adhesive tape was forcibly removed from the panel using its loose ends. The removal of more than 50 % of the paint film's square lines indicates poor adherence. To assess quality, triplicate measurements at room temperature were done for each sample [5].

Flexibility Test

Using a paint applicator, a paint sample was applied to newly degreased and chromated metal. The film was left to air dry at room temperature for seven days. The panel was removed and checked for cracks or loss of adhesive. A crack or loss of adhesion implies rigidity or brittleness. To check quality, triplicate measurements were obtained at room temperature for each sample [9].

Resistance to Blistering

An applicator was used to apply an undiluted paint sample to a glass panel, resulting in a wet film thickness of roughly 120 mm. This was left to dry for 24 hours. At the end of this time, 4 mL of distilled water in the shape of a circular drop was dropped on the film. Blisters, wrinkles, swelling, or cracking within 30 minutes indicate inadequate water resistance. Each determination involved triplicate samples, with the average quality assessment recorded [2].

Chemical Resistance

To assess the chemical resilience of the paint films, three flexible aluminum panels (150 mm x 0.3 mm) were employed as test panels. Using a paint applicator, the surface was painted. A glass beaker was filled with 0.1 M NaOH solution to a depth of 150 mm, and the test piece was immersed for 48 hours to a depth of about 120 mm. The test piece was removed, cleaned with running water, and allowed to dry for two hours. The preceding processes were performed with 0.1 M HCl and 0.1 M NaCl, respectively. Surface flaws such as cracking, blistering, peeling, or shading indicate a lack of chemical resistance [2, 10].

Stability Test

The samples were properly sealed in a container and stored at room temperature for three months. Following the incubation period, the samples were reexamined to check for any changes in the emulsion paint's viscosity or coagulation. The absence of coagulation or any change in viscosity is considered a pass [2, 10]. Each measurement was carried out using three samples, and the average values were noted.

Tests for Dryness to Touch and Hardness

The dry time of the paint samples was assessed using the [2, 10] technique. A bar applicator was used to apply paint samples to a glass panel, which were then left to dry. Dry-to-touch measurements were obtained when the paint film no longer adhered to the finger, and dry-to-hard measurements were taken when the film resisted finger contact.

Results

Tables 1 and 2 show the findings from the mechanical and physical characteristics of the paint made with black seed powder and soybean oil, respectively.

Discussion of Results

pH

pH is a logarithmic scale that measures the acidity or basicity of aqueous solutions. The results are shown in Table 1. The pH of 8.35 indicates that the reaction occurred in a basic state and is within the range that [11] recommends for emulsion paint.

Density

It is a physical characteristic of matter that expresses a mass-to-volume ratio [5]. The density observed for the paint formulation is 1.09 g/cm^3 , which is tabulated in Table 1. This is slightly denser than [6]'s recommended number (1.07 g/cm^3), but still within the defined range. Paint density is determined by the quantity of pigments used.

Dry Time

Table 1 displays the drying time data. The environment, particularly temperature and humidity, affects how long paint takes to dry. The laboratory-temperature emulsion paint was found to have a drying surface time of 28 and 60 minutes, which is consistent with the emulsion paint drying time of no more than 24 hours [11]. The results revealed that the emulsion paint formulation complies with the standard [12].

Opacity

The opacity of paint, which is produced by the difference in refractive index between the formulation constituents, is what allows the paint sampled in Table 1 to conceal the substrate underneath by blocking light transmission. The recorded value was $4.8 \text{ m}^2/\text{L}$ [11] $5.8 \text{ m}^2/\text{L}$. A given surface area can be covered with a small amount of high-quality paint, while a significant volume of low-quality paint is needed. This paint was evaluated for good opacity and was able to cover well with no more than two coats in compliance with the requirement.

Specific Gravity

The specific gravity of the emulsion paint formulated in Table 1 is 1.95. This conforms to [12], indicating that the paint is well granulated.

Viscosity

Table 1 showed that the paint's viscosity was $4.2 \text{ m}^2/\text{s}$. The higher the pigment volume concentration (black seed powder/soya bean oil), the more viscous the paint becomes. The low viscosity paint demonstrated good leveling and high opacity. The shine of the paint was also improved. When applied on a cardboard substrate, the paints were found to have minimal spattering. The low viscosity of the paint allows for a high inclination of movement and simple application. This means there are stronger intermolecular forces and more bonds. Understanding a binder's viscosity is critical, particularly in the coating industry, because it influences flow rate and thermal properties. [13] explains the film's adherence and dry rate. The result falls within the allowed range in the coating business.

Chemical Resistant Test

Table 2 displays the chemical resistance test results for the paint formulation, which show good reactions/resistance to sodium hydroxide, sodium chloride, and hydrochloric acid, indicating that the paint formulation can tolerate high contact with chemicals in both basic and acidic environments.

Resistance to Blistering

Table 2 also displays the results of blistering (water resistance) of the paint formulation. It was discovered that paints passed the blistering test, resulting in a paint with hydrophobic properties that helped to increase water resistance, as stated in [8].

Tackiness

Tackiness is the trait of being both cohesive and sticky. As stated in [7], a liquid's resistance to shear forces and thus flow. The tackiness property, as shown in Table 2, yields positive findings; the stickiness of the paint sample could be attributed to improved network topologies caused by alteration.

Flexibility

The flexibility of the paint samples shown in Table 2 also shows passing results. This could be due to the integration of soybean oil into the paint matrix.

Adhesion

Table 2 indicates that paint formulations have good adhesion properties. According to [12], gloss paint should not remove more than half of the dried film. Thus, the adhesion quality of the formulated paint was good, as none of them removed up to 50 % of the recommended amount.

Table 1. Physical properties of Soya bean oil/black seed powder formulated paint.

S. N.	Physical parameters	Emulsion paint	SON/NIS
1.	pH	8.35	7.0 – 8 – 5
2.	Density (g/cm ³)	1.09	1.07
3.	Viscosity (m ² /s)	4.2 m ² /s	6 – 15
4.	Opacity	4.8 m ² /L	Good
5.	Drying time T. D	28	20
	H. D	60	120
6.	Specific gravity	1.95	1.3 – 1.5
7.	Stability (3 months)	P	P

P=Pass, TD=Touch to Dry, DH=Dry to Hard

Table 2. Mechanical properties of Soya bean oil/black seed powder formulated paint.

S. N.	Physical parameters	Emulsion paint	NIS/SON
1.	Blistering	P	P
2.	Tackiness	P	P
3.	Flexibility	P	P
4.	Chemical Resistance	P	P

P=Pass Result

CONCLUSION

Emulsion paint formulated using Black seed powder/Soya bean oil was successfully used directly as a resin (binder). The drying time of the resin appears quite good when used directly for the formulation of emulsion paint. The hard drying time, 28 and 60 minutes for emulsion paint, is in conformity with the standard [6]. From the analysis carried out (density, opacity, drying time, viscosity, stability, pH, tackiness, resistance to blistering, specific gravity, and chemical resistance), it could be established that the emulsion paint conformed to standard and could be used for both decorative and protective purposes, which in turn provides a healthier environment.

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