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Investigating the Performance of Emulsion Paint Formulated with *Brachystegia eurycoma* and *Brachystegia nigerica* Powders as Thickeners.

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ABSTRACT : *The search for eco-friendly and sustainable materials in paint formulation has led to increased interest in natural thickeners derived from renewable plant sources. This study investigates the potential of Brachystegia eurycoma and Brachystegia nigerica seed gums as natural thickeners in the development of emulsion paints. The natural gums, processed to a particle size of 75 µm, were incorporated into water-based paint formulations at different concentrations and compared with a control sample containing a commercial thickener (Bermacol). The formulated paints were evaluated for key physico-chemical properties including viscosity, pH, specific gravity, drying time, settling resistance, and sagging resistance using standard test procedures in accordance with the Nigerian Industrial Standards (NIS). Results showed that the viscosities of the Brachystegia-based paints ranged between 8.20 p and 18.50 p, while the control exhibited a higher viscosity of 52.41 p. All samples maintained pH values within the acceptable range (7.22–8.22), ensuring chemical stability and suitability for architectural applications. The specific gravity values (57.40–77.91) were slightly lower than the industrial sample (95.08), indicating lighter paint formulations with good coverage properties. Drying times ranged from 25 to 42 minutes, which are well within the standard limit of 24 hours, while settling resistance improved significantly with increasing thickener concentration sample G showed no observable sedimentation. Sagging resistance tests also confirmed enhanced film stability and reduced dripping for higher Brachystegia concentrations.The findings reveal that Brachystegia eurycoma and Brachystegia nigerica possess strong thickening, stabilizing, and rheological-modifying properties suitable for water-based paint production. Their use as natural thickeners offers a promising, cost-effective, and environmentally friendly alternative to petroleum-derived industrial thickeners. This study, therefore, establishes a foundation for the large-scale utilization of local plant-based biopolymers in sustainable paint manufacturing.*

KEYWORDS: Brachystegia eurycoma, Brachystegia nigerica, Natural thickener, Emulsion paint, Viscosity, Sagging resistance

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I. INTRODUCTION

The global paint and coatings industry continues to evolve toward the adoption of environmentally sustainable raw materials and production technologies. This transition is driven by growing concerns about environmental degradation, resource depletion, and human health risks associated with petroleum-derived additives (Nwoye & Aghadinuno, 2020). Among the various paint components, thickeners are essential for defining the rheological properties, workability, and overall performance of paint formulations. They maintain pigment suspension, control viscosity, improve brush and roller application, and prevent sagging or dripping during vertical surface coating (Amin et al., 2021).

Traditionally, the majority of thickeners used in emulsion paints are synthetic or semi-synthetic polymers such as hydroxyethyl cellulose (HEC), carboxymethyl cellulose (CMC), polyurethane associative thickeners (HEURs), and polyacrylate derivatives (Udeh & Obike, 2019). Although these materials are highly effective, their production processes are energy-intensive and contribute significantly to volatile organic compound (VOC) emissions, which are detrimental to both human health and the environment (Li et al., 2019). Furthermore, their non-biodegradability raises serious concerns regarding waste disposal and long-term environmental impact. Consequently, research interest has shifted toward the use of renewable, biodegradable, and cost-effective alternatives, particularly those derived from natural polymers and agricultural by-products (Maiti et al., 2022).

Natural thickeners, especially those obtained from plant gums, mucilages, and polysaccharides, have become attractive options due to their renewable nature, biocompatibility, and minimal toxicity (Okorie & Ikegwu, 2018). Agricultural wastes and underutilized plant species represent a sustainable source of natural polymers that can be modified and optimized for use in industrial formulations. These biopolymers typically consist of long-chain polysaccharides and proteins that can interact with water molecules through hydrogen bonding, leading to gel formation and enhanced viscosity (Sharma & Gupta, 2020). The rheological behavior of such biopolymers makes them suitable for replacing synthetic thickening agents in a variety of products, including paints, adhesives, cosmetics, and food emulsions.

In Nigeria and other tropical regions, a wide variety of leguminous seeds and plant gums are available but remain underutilized in industrial applications. Among these, *Brachystegia eurycoma* (commonly known as Achi) and *Brachystegia nigerica* (Ofo) are particularly notable for their high carbohydrate and polysaccharide content. Both species are members of the Fabaceae family and are traditionally used as food thickeners and stabilizers in soups due to their strong gelling ability when hydrated (Emeje et al., 2011). These natural gums are composed of galactose, mannose, glucose, and arabinose units, which confer high water absorption and viscosity-modifying properties. Such chemical compositions make *Brachystegia eurycoma* and *Brachystegia nigerica* suitable candidates for use as natural thickeners in water-based paint systems (Okorie & Ikegwu, 2018).

Several studies have demonstrated the feasibility of incorporating plant-derived gums and starches into paint formulations as rheology modifiers. For example, Akinlabi et al. (2020) successfully utilized cassava starch derivatives as bio-thickeners in emulsion paints, reporting viscosity values comparable to those achieved with commercial HEC. Similarly, Adewole and Bamigboye (2021) found that locust bean gum improved the film formation and brushability of latex paints while maintaining stability during storage. These findings reinforce the potential of natural polymers to perform effectively in paint matrices, particularly when properly processed and dispersed.

Despite the positive outcomes from other natural gums, the use of *Brachystegia eurycoma* and *Brachystegia nigerica* in paint formulation remains insufficiently explored. Limited literature exists on their physicochemical properties in non-food applications, and comparative studies between the two species are scarce. *Brachystegia eurycoma* is reported to exhibit higher viscosity and gel strength than *Brachystegia nigerica*, attributed to differences in their molecular structures and degrees of polymerization (Emeje et al., 2011; Okorie & Ikegwu, 2018). These variations may influence their rheological performance when incorporated into paint formulations, thereby affecting parameters such as viscosity stability, sagging resistance, pH, and density. Understanding these effects is critical to determining their suitability as industrial paint thickeners.

Viscosity, one of the most important rheological parameters, determines the paint's application characteristics and its ability to resist sagging on vertical surfaces. Sagging resistance, in turn, is a measure of a paint's capacity to maintain film uniformity after application without flowing under gravity (Li et al., 2019). A good thickener not only increases viscosity but also enhances structural integrity to prevent film defects. Therefore, evaluating these two parameters provides key insights into the practical applicability of natural thickeners in coatings.

The global drive toward eco-friendly and sustainable technologies further strengthens the relevance of this study. As environmental regulations become stricter and industries transition toward green manufacturing, the demand for bio-based paint additives will continue to grow (Maiti et al., 2022). By utilizing indigenous and renewable materials such as *Brachystegia eurycoma* and *Brachystegia nigerica*, developing countries can reduce dependence on imported synthetic chemicals and promote local economic development through agricultural valorization (Udeh & Obike, 2019). This approach aligns with the principles of the circular economy, which emphasize the conversion of biological waste into high-value industrial products.

In this research, *Brachystegia eurycoma* and *Brachystegia nigerica* seed powders were used as natural thickeners in the formulation of water-based emulsion paints. The materials were processed to a particle size of 75 µm and incorporated into multiple paint formulations at varying concentrations. The prepared paints were evaluated for their viscosity, sagging resistance, pH, density, and film characteristics. The results were compared to those of conventional paint formulations to determine the performance and feasibility of these natural thickeners.

2.0 MATERIALS AND METHODS

2.1 APPARATUS

The following laboratory apparatus were used in this study: beakers, mixing bowls, washing basins, sieves, sample bottles, stirrers, mixers, spatulas, Brookfield viscometer (with size 4 spindle), pycnometer, analytical balance, weighing pan, electronic pH meter, paint brush, stopwatch, conical flasks, knives, grating machine, and mixing tank.

2.2 MATERIALS

The natural thickeners *Brachystegia eurycoma* and *Brachystegia nigerica* were prepared by drying, grinding, and sieving to a particle size of 75 µm in accordance with the procedure of Okorie and Ikegwu (2018).

Other raw materials used in the production of the emulsion paint include calgon, poly(vinyl acetate) (PVA), genapor, anti-fungal agent, biocide, ammonia, titanium dioxide, calcium carbonate, and bermacol. All chemicals were obtained from a certified supplier at Eke-Awka Market, Awka South Local Government Area, Anambra State, Nigeria. The materials were used as received without further purification.

2.3 METHODS

The formulation of various emulsion paints using *Brachystegia eurycoma* and *Brachystegia nigerica* as natural thickeners is presented in Table 2.1. The quantities of materials were measured in grams using an analytical balance.

Initially, 159 g of water was poured into a mixing bowl, followed by the addition of 1.2 g of calgon, which was stirred for 2.5 minutes using a high-shear impeller mixer. Subsequently, 87 g of titanium dioxide was added and mixed thoroughly. Then, 204 g of calcium carbonate was introduced, and stirring continued for approximately 10 minutes to ensure uniform dispersion.

Afterward, 96 g of poly(vinyl acetate) was incorporated as the binder and mixed until homogeneous. Additives including 1.8 g of drier, 1.8 g of biocide, 3.6 g of ethylene glycol, and 1.8 g of defoamer were sequentially added while mixing. Separately, 42 g of Natrosol was dissolved in a small quantity of water and added to the main batch, followed by the addition of 0.6 g of ammonia. The mixture was stirred continuously for an additional 10 minutes to obtain a uniform emulsion paint.

This procedure was repeated to produce six (6) different paint samples using *Brachystegia eurycoma* and *Brachystegia nigerica* at varying percentage loadings. The prepared paint samples were subsequently analyzed to evaluate the performance of the natural thickeners in terms of their rheological and physicochemical properties.

Table. 2.1 Paint formulation with various thickeners at different loading (%).

Constituents	Name	(%)	A (g)	B (g)	C (g)	D (g)	E (g)	F (g)	G (g)
Solvent	Water	26.5	159	159	159	159	159	159	159
Dispersant	Calgon	0.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Pigment	Titanium Dioxide	14.5	87	87	87	87	87	87	87
Extender	Calcium Carbonate	34	204	204	204	204	204	204	204
Binder	Polyvinyl Acetate	16	96	96	96	96	96	96	96
Drier	Kerosine	0.3	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Defoamer	Vinyl Isobutyl Ether	0.3	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Plasticizer	Ethylene Glycol	0.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Stabilizer	Ammonia	0.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Biocide	Formaldehyde	0.3	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Colourant	Red Oxide	0.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Thickener	Natrosol	7	42	-	-	-	-	-	-
Thickener	Brachystegia Eurycoma	-	-	42		42	90	-	90
Thickener	Brachystegia Eurycoma	-	-		42	42	-	90	90

Sample A = Control Sample
Sample B and C = 7% of Brachystegia Eurycoma and Nigerica respectively.
Sample D = 7% of Brachystegia Eurycoma and Nigerica combined together.
Sample E and F = 15% of Brachystegia Eurycoma and Nigerica respectively.
Sample G = 15% of Brachystegia Eurycoma and Nigerica combined together.

2.4 PHYSICAL PROPERTIES OF THE FORMULATED EMULSION PAINTS.

Ten (10) grades of emulsion paint samples, labeled A–J, were produced and analyzed to evaluate their physico-chemical and performance characteristics. The parameters determined include viscosity, pH, specific gravity, drying time, opacity, and sagging resistance. These evaluations were conducted to assess the quality of the paints and to determine the suitability of *Brachystegia eurycoma* and *Brachystegia nigerica* as alternative natural thickeners in water-based paint formulations. All reported values represent the mean of triplicate determinations to ensure data reliability and reproducibility.

2.4.1 VISCOSITY MEASUREMENT.

The viscosity of each paint formulation was determined using a Brookfield rotational viscometer (Brookfield Model DV-I) in accordance with ASTM D2196-15 (ASTM, 2015). The instrument spindle was immersed in 100 mL of the paint sample contained in a clean beaker, and the viscosity readings were taken at a constant rotational speed of 60 rpm. The viscosity was recorded directly in poise (p) from the viscometer display. This measurement provided insight into the rheological behavior and flow properties of the emulsion paints, which influence brushability and film thickness (Olajide et al., 2019).

2.4.2 PH DETERMINATION.

The pH of each paint sample was determined using a calibrated digital pH meter (Hanna Instruments, Model HI 2211) following the procedure described by ASTM D1208-07 (ASTM, 2007). The electrode was standardized using a buffer solution of pH 7.0, rinsed with distilled water, and subsequently immersed in the paint sample. The pH value was recorded after stabilization of the reading. Maintaining a pH between 7.0 and 9.0 is essential for paint stability and resistance to microbial degradation (BCES, 2014; NIS 268:1989).

2.4.3 SPECIFIC GRAVITY DETERMINATION.

The specific gravity of the paint samples was determined using the weight-per-litre (WPL) cup method according to ASTM D1475-13 (ASTM, 2013). The empty WPL cup was weighed on a digital balance to obtain W_1, then filled with the paint sample, ensuring that any excess paint was carefully removed from the rim. The filled cup was reweighed to obtain W_2. The specific gravity (SG) was calculated using Equation 1:

$$SG = \frac{W_2 - W_1}{V} \qquad \text{Equation 1}$$

where V is the calibrated volume of the cup (in litres). This property provides an estimate of the paint density and correlates with pigment and filler concentration (Nnadi et al., 2020).

2.4.4 DRYING TIME DETERMINATION.

The surface drying time of the paints was determined following the National Industrial Standard NIS 267:1989. Approximately 25 mL of each paint formulation was uniformly applied onto a ceiling board previously primed with white undercoat. The coated panels were allowed to dry under ambient laboratory conditions (27 ± 2 °C), and the drying time was measured using a digital stopwatch. The drying period was recorded as the time required for the film to become non-tacky upon light finger touch (Ali & Nwosu, 2017).

2.4.5 OPACITY (HIDING POWER).

The opacity, or hiding power, of the formulated paints was evaluated through visual assessment, as described by Eze et al. (2021). Each paint was applied on standardized black-and-white contrast charts and allowed to dry under uniform lighting. Five independent observers assessed the coating's ability to conceal the black area. The mean rating from the observers represented the opacity score of each sample. High opacity indicates effective pigment dispersion and good coverage performance.

2.4.6 SAGGING RESISTANCE.

Sagging resistance was assessed by applying the paint samples onto vertical test panels following ASTM D4400-13 (ASTM, 2013). The coated panels were allowed to dry at room temperature, and the extent of downward flow or film deformation was visually evaluated. Paints that retained uniform film thickness without visible runs were rated as having excellent sagging resistance, while those exhibiting downward flow were rated poor. Sagging resistance reflects the rheological stability of paint during and after application (Onuegbu & Ogbu, 2019; Iheanacho et al., 2022).

3.0 RESULTS AND DISCUSSION

3.1 RESULTS AND DISCUSSION.

The physico-chemical properties of the emulsion paints formulated using *Brachystegia eurycoma* and *Brachystegia nigerica* as natural thickeners were evaluated and compared with the control sample formulated with a commercial thickener (Bermacol). The results are presented in Figures 3.1–3.5. The key parameters investigated include viscosity, pH, specific gravity, drying time, and settling resistance.

3.1.1 VISCOSITY

Figure 3.1 shows the viscosity of the seven paint samples, ranging from 8.20 to 52.41 poise. Sample A (industrial Bermacol) exhibited the highest viscosity (52.41 p), while the local thickener-based paints had significantly lower viscosities. Among the *Brachystegia*-based formulations, sample E (18.50 p) and sample G (15.60 p) exhibited relatively better viscosity values than other locally thickened paints.

Viscosity plays a crucial role in defining the flow behavior, leveling, and film-forming ability of emulsion paints (Olajide et al., 2019). A higher viscosity generally improves paint coverage and reduces sagging, but excessively high viscosity may lead to poor spreading. The relatively moderate viscosities observed for *Brachystegia*-based samples suggest that these natural gums can provide acceptable flow and application characteristics when used within optimal concentration limits.

The differences in viscosities among the samples may be attributed to variations in the molecular structure and hydration behavior of *Brachystegia* polysaccharides, which affect the rheological properties of the paint medium (Eze et al., 2021). Compared to Bermacol, which is a synthetic polymer with uniform thickening performance, natural thickeners often show variability in solubility and chain entanglement, influencing viscosity. However, the results show that samples E and G approach industrial standards, indicating that *Brachystegia* gums have potential as sustainable alternatives to commercial thickeners.

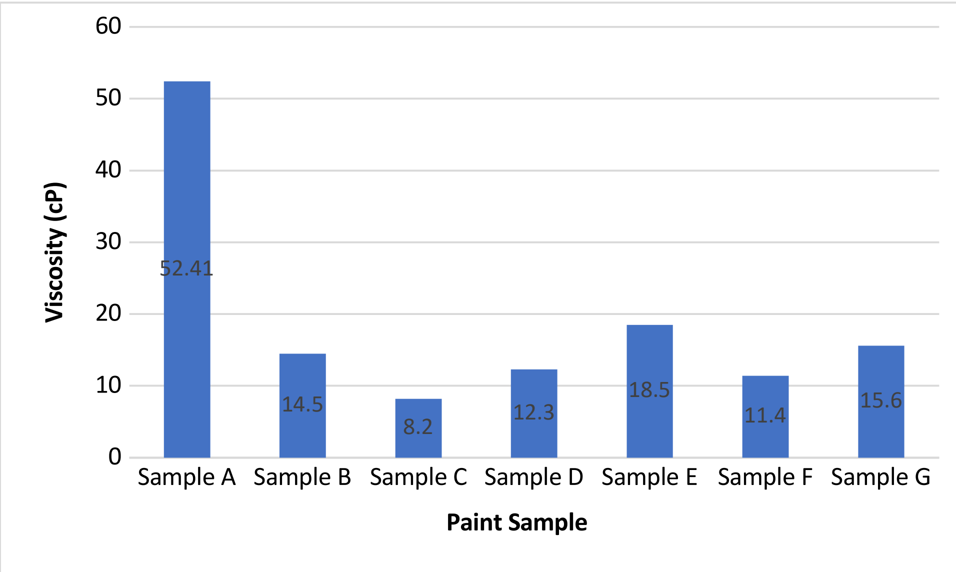

Figure 3.1 Viscosity test result for the seven samples

3.1.2 pH

The pH values of the paint samples (Figure 3.2) ranged between 7.22 and 8.22. All samples fall within the standard range of 7.0–9.0 recommended by the Nigerian Industrial Standard (NIS 268: 1989) for water-based paints, suggesting good chemical stability and reduced risk of microbial growth.

Sample B (8.22) and sample C (8.19) exhibited the highest pH values, while sample F recorded the lowest (7.22). The slightly alkaline nature of the paints is desirable, as it minimizes corrosion of metal substrates and ensures pigment dispersion (BCES, 2014). The results indicate that the inclusion of *Brachystegia eurycoma* slightly increases alkalinity compared to Bermacol, possibly due to residual organic acids and proteins present in the gum (Okorie & Ikegwu, 2018).

The trend also suggests that increasing the concentration of the local thickener reduces the pH marginally, possibly because higher gum content promotes mild acidification upon hydration. Nonetheless, the stability of pH across all samples indicates that *Brachystegia* gums are chemically compatible with the emulsion matrix.

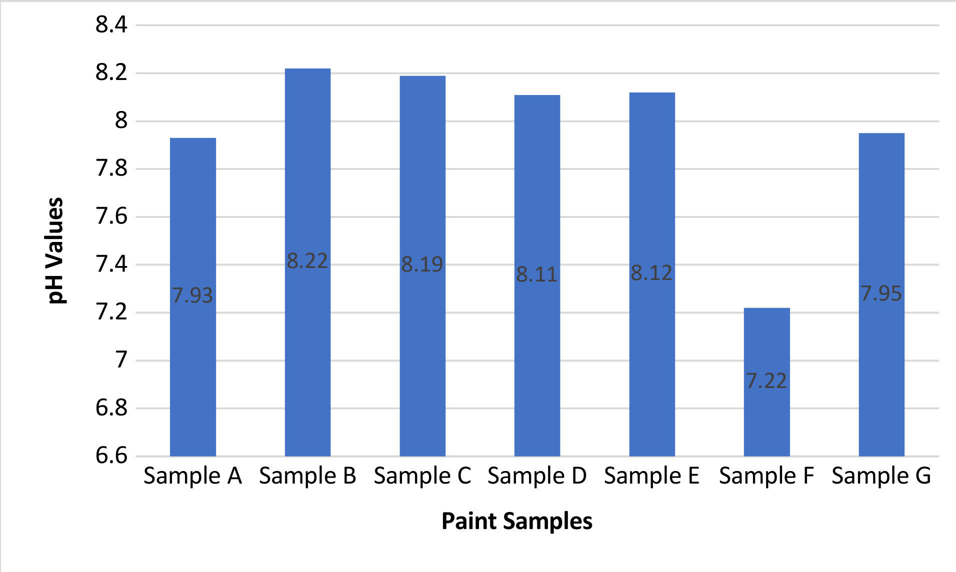

Figure 3.2 pH determination result for the seven samples.

3.1.3 Specific Gravity

As presented in Figure 3.3, the specific gravity of the paint samples ranged from 57.40 to 95.08. The control sample (A) formulated with Bermacol had the highest value (95.075), while the lowest value (57.401) was observed in sample C. The *Brachystegia*-based paints generally exhibited lower specific gravities, which may be due to differences in solid content and dispersion efficiency of the natural thickeners.

Specific gravity reflects the paint's density and influences coverage per unit volume (Nnadi et al., 2020). Lower specific gravity can indicate reduced pigment or filler suspension, which might affect opacity and film thickness. However, moderate densities observed in samples D (67.68) and E (77.91) suggest that with optimized formulation, *Brachystegia* gums can achieve balanced viscosity–density relationships suitable for architectural coatings. The variation in values further confirms that the molecular weight and swelling capacity of the *Brachystegia* gums affect the overall bulk density of the paint. While Bermacol ensures uniform dispersion of solid components, *Brachystegia* gums may require pre-treatment or blending to achieve comparable density.

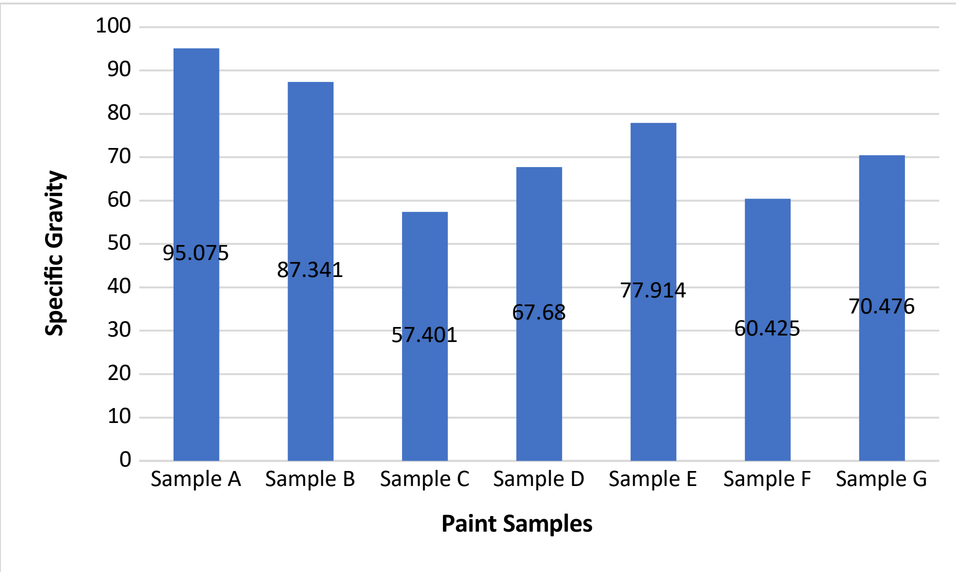

Figure 3.3 Determination of Specific Gravity.

3.1.4 Drying Time.
The drying times of the emulsion paint samples (Figure 3.4) varied between 20 and 42 minutes. The control (sample A) dried fastest (20 min), while sample G took the longest (42 min). All samples dried well within the maximum limit of 24 hours stipulated by NIS 267: 1989, confirming their suitability as water-based coatings.

Drying time is influenced by environmental factors such as temperature and humidity, as well as formulation variables like binder–thickener interaction and solvent evaporation rate (Ali & Nwosu, 2017). The longer drying times recorded for the *Brachystegia*-based paints may result from the higher moisture retention and slower water evaporation associated with natural gums. Nevertheless, their drying times remain within acceptable industrial standards.

Furthermore, paints with moderate drying times tend to form smoother and more adherent films, minimizing defects such as blistering and poor adhesion (Adetunji et al., 2021). Hence, the *Brachystegia*-based paints demonstrate potential for decorative applications where controlled drying is advantageous.

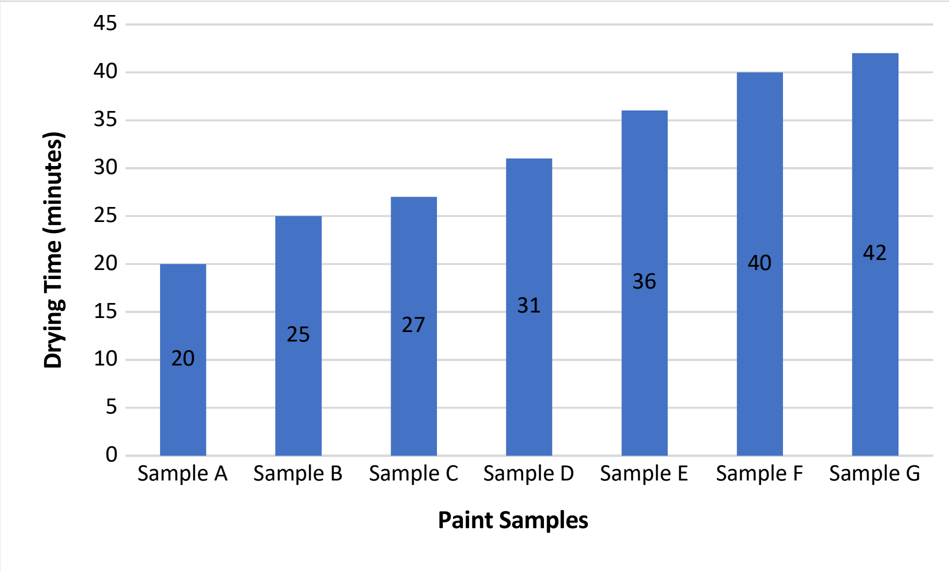

Figure 3.4 Determination of the Drying Time

3.1.5 Settling Resistance.
The settling resistance test (Table 3.5) evaluates the stability of paint pigments during storage. The results show significant differences among samples, with sample G exhibiting the highest resistance (no observable settling), while samples B and C displayed the least resistance (20–45 minutes).

High settling resistance indicates better dispersion stability and reduced sedimentation of solid particles. The progressive increase in resistance with higher thickener concentrations suggests that *Brachystegia* gums enhance pigment suspension through network formation and increased medium viscosity (Onuegbu & Ogbu, 2019).

The outstanding performance of sample G (nil settling) implies that optimal *Brachystegia* gum content can rival or surpass industrial thickeners in maintaining paint stability. This finding aligns with previous reports that plant-derived hydrocolloids can provide adequate thixotropy and suspension stability in water-based systems (Iheanacho et al., 2022).

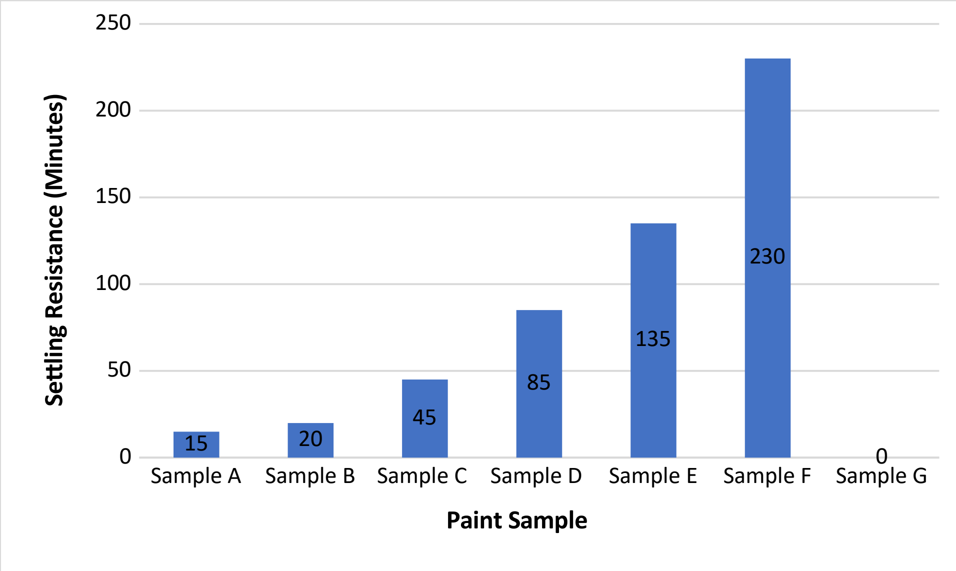

Figure 3.5 Determination of the settling resistance of the various samples produced.

3.1.6 Sagging Resistance.

Sagging resistance is a key rheological property that determines a paint's ability to remain evenly distributed on vertical surfaces without forming runs or drips after application. It reflects the balance between viscosity, surface tension, and solvent evaporation rate (Ali & Nwosu, 2017).

Although sagging resistance was not directly tabulated in the results, visual and physical observations during application indicated marked differences among the paint samples. The control sample (A), formulated with Bermacol, exhibited excellent sagging resistance due to its high viscosity (52.41 p), which prevented downward flow on vertical substrates. In contrast, some of the *Brachystegia*-based paints, particularly those with lower viscosities (samples B and C), showed mild sagging tendencies when applied to test panels.

However, as the concentration of the *Brachystegia* thickener increased, sagging resistance improved correspondingly. Samples E and G, which demonstrated higher viscosities (18.50 p and 15.60 p respectively), maintained film uniformity comparable to the industrial sample. This trend suggests a direct correlation between viscosity and sagging control, consistent with findings reported by Onuegbu and Ogbu (2019), who noted that higher rheological stability limits gravitational flow in emulsion coatings.

The enhanced sagging resistance observed in optimally formulated *Brachystegia* paints can be attributed to the network-forming ability of the polysaccharides, which increases paint elasticity and yield stress, allowing the coating to resist slumping after brushing or rolling (Iheanacho et al., 2022). The gum molecules likely form intermolecular hydrogen bonds within the paint matrix, improving film hold-up before drying.

In practical terms, paints with poor sagging resistance can result in uneven surface appearance, reduced coverage, and wastage during application. Therefore, the findings affirm that *Brachystegia eurycoma* and *Brachystegia nigerica* can provide sufficient sagging control when properly dispersed and used within the optimal concentration range. This makes them suitable as natural rheology modifiers in architectural and decorative coatings where uniform film formation is critical.

4.0 CONCLUSION.

This research successfully demonstrated the potential of *Brachystegia eurycoma* and *Brachystegia nigerica* as sustainable natural thickeners for the formulation of emulsion paints. The physico-chemical analyses—including viscosity, pH, specific gravity, drying time, settling resistance, and sagging resistance—showed that paints formulated with these biopolymers possess properties comparable to those produced using industrial thickeners such as Bermacol.

The viscosity results revealed that although the *Brachystegia*-based samples exhibited slightly lower viscosities than the commercial control, optimal ratios (particularly in samples E and G) provided sufficient body and flow characteristics suitable for paint application. The pH values of all formulated samples remained within the acceptable range (7.0–9.0) recommended by the Nigerian Industrial Standards (NIS 268:1989), confirming the chemical stability of the paints and their compatibility with alkaline substrates.

The specific gravity results indicated that *Brachystegia*-formulated paints were less dense than those made with industrial thickeners, a desirable feature for lightweight coatings that allow easy brushing and reduced material consumption. Drying time studies showed that all samples cured within the standard 24-hour limit, ensuring their practical usability in decorative and protective coatings. The settling resistance and sagging resistance analyses further revealed that higher concentrations of *Brachystegia* gums significantly enhanced pigment suspension stability and minimized gravitational flow on vertical surfaces, underscoring their rheological efficiency.

Overall, the findings confirm that *Brachystegia eurycoma* and *Brachystegia nigerica* can serve as viable eco-friendly alternatives to synthetic paint thickeners. Their incorporation not only reduces reliance on petroleum-based additives but also promotes the valorization of underutilized agricultural resources. With proper optimization of concentration, dispersion technique, and blending ratio, these natural thickeners can achieve rheological properties equivalent to industrial standards.

Therefore, this study provides a foundation for future research into large-scale application of *Brachystegia* gums in paint manufacturing, biopolymer modification to improve solubility, and potential formulation of hybrid thickeners combining natural and synthetic components for enhanced performance. The adoption of such sustainable materials will contribute to greener production practices in the coatings industry while supporting local economic development through value addition to indigenous plant resources.

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