

# Application of Treated Palm Oil Fuel Ash (POFA) in Paint Production

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## Abstract

The paint manufacturing industry plays a pivotal role across various sectors, including construction, automotive, and home decoration. This project aims to address challenges in paint production by developing an optimal thermal insulation paint utilizing Palm Oil Fuel Ash (POFA) powder. The POFA powder undergoes an initial three-day grinding process to achieve finer particle sizes before undergoing sieving using a 50-micrometer sieve shaker. To enhance the pozzolan characteristics of POFA, the powder undergoes two treatments: heat and acid treatment. These treatments aim to eliminate carbon content, consequently improving the thermal insulation properties of POFA. The resulting powder is then blended with other chemicals using a Kakuhunter mixer for 1 minute, incorporating POFA, Calcium Carbonate (CaCO<sub>3</sub>), and additional chemicals in the paint mixture. Significantly, the viscosity of the paint mixture is explored as the composition of Tylose increases, yielding values of 0.013 cp, 0.017 cp, 0.02 cp, 0.023 cp, and 0.025 cp. This investigation provides insights into how the paint's rheological properties vary with Tylose composition. The main focus lies in examining the final temperature differences among paint mixtures filled with varying proportions of POFA, specifically 25%, 50%, 75%, and 100%. The results elucidate variations in final temperature after a 15-minute exposure to heat, contributing valuable insights into the thermal behavior of the formulated paint mixtures. This research endeavors to contribute to the development of energy-efficient and sustainable paint formulations with enhanced thermal insulation properties, crucial for diverse applications in the construction and automotive sectors.

## 1. Introduction

The paint manufacturing industry plays a significant role in various sectors, such as construction, automotive, and home decoration. However, the environmental impact associated with traditional paint components, including fillers and pigments, has raised concerns about sustainability and waste management [1], [2]. To address these issues, there is a growing need to explore alternative materials that are both environmentally safe and economically viable for use in paint formulation.

One of the challenges faced in the paint manufacturing process is the inefficient technique for separating tiny particles in Palm Oil Fuel Ash (POFA) powder. POFA has shown promise as an insulation additive in paint production, but the difficulty in achieving an efficient separation of tiny particles poses a hindrance to its effective utilization. This inefficiency can lead to variations in the quality and performance of the paint, affecting its overall effectiveness as an insulation material.

Another problem arises when attempting to achieve the desired viscosity in paint formulations while varying the proportions of thickening agents and thermal insulation ingredients, such as POFA. Maintaining the right viscosity is crucial for ensuring proper application and coverage of the paint on various surfaces [3]. The complex interaction between different components makes it challenging to consistently achieve the desired viscosity, leading to inconsistencies in the paint's performance and application.

Furthermore, the incorporation of thermal insulation ingredients, including POFA, may inadvertently result in greater heat transmission [4]. This unexpected outcome can compromise the effectiveness of the paint as an insulation material, defeating the purpose of using such additives. Understanding and mitigating this issue is crucial for ensuring that the final paint formulation effectively provides the desired thermal insulation properties without compromising its overall performance.

In response to these challenges, the research aims to enhance the utilization of POFA as insulation additives in paint production. The construction of a graph to measure the final temperature of the paint, comparing formulations containing POFA with conventional paint, serves as a crucial step in evaluating the thermal insulation properties. By addressing these problem statements, the research endeavors to contribute to the development of environmentally friendly and economically viable paint formulations with improved insulation capabilities.

## 2. Methodology

### 2.1 Preparation of POFA powder

The desired amount of POFA was initially added to a milling jar, which was then filled with various sizes of ball mills for dry milling. M.O.M Mashri discovered that by utilizing different ball mill sizes, this milling technique produces smaller POFA particles [5]. This discovery underscores the importance of milling in achieving the optimal POFA size. For each kilogram of POFA, three kilograms of ball mills of various sizes were milled in the jar over three days to produce the ideal POFA size listed in the table. After three days, the procedure resulted in finer POFA particles.

Once the grinding process was completed, the powdered POFA underwent sieving. To match the desired size of the POFA for use (less than 50  $\mu\text{m}$ ), a 50  $\mu\text{m}$ -length sieve was employed. If any powder could not pass through the sieve, the powder was ground again before proceeding with the screening step until the final powder was obtained.

### 2.2 Treatment of POFA

The Palm Oil Fuel Ash powder (POFA) was subjected to the Protherm furnace machine for a duration of 1.5 hours at 800°C, employing a heating rate of 6 hours and 20 minutes and a cooling rate of 2 hours and 30 minutes. The entirety of this procedural step consumed approximately 10 hours and 20 minutes.

By computing the initial and final values of temperature over time throughout the specified duration, as described by equations (1) and (2), the rates for the heating and cooling processes were determined.

$$\text{Heating rate} = \frac{T_f - T_i}{t} \quad (1)$$

$$\text{Cooling rate} = \frac{T_f - T_i}{T} \quad (2)$$

In the acidic treatment, hydrochloric acid (HCl) was utilised as a precursor. The POFA powder was dried, crushed, and sieved at the start of the process to attain the appropriate particle size and purity. In a beaker, the POFA powder was soaked in 0.2M HCl for 1 hour while being agitated with a magnetic stirrer. The goal is to react with pollutants such as silica and alkaline elements to produce soluble salts that may be rinsed away to dissolve and eradicate them. This yields a purified POFA. To guarantee effective purification and modification of the POFA, the acidic process parameters, including the concentration and duration of the HCl treatment, were carefully regulated. The colour of POFA powder has been brightened as compared to the hue following heat treatment.

## 2.3 Preparation of Paint mixture

This experiment required a few chemicals, and the treated POFA sample was critical to the success of the paint manufacture. Table 1 shows the composition of POFA powder and Tylose as the thickening agent that had been used to produce the paint mixture. A mixing step was employed to increase chemical and physical property uniformity [6]. Calcium Carbonate ( $\text{CaCO}_3$ ), Tylose, Sodium Polycarboxylate, Foamaster, Preventol D7, BioAm, Acrylic, Ruanta, and Palm Oil Fuel Ash (POFA) were used in this experiment to create a paint.

**Table 1** Composition of Palm Oil Fuel Ash (POFA) and Tylose

Composition of Palm Oil Fuel Ash (POFA) (%)	Composition of Tylose (%)
25.0	100.0
50.0	75.0
75.0	50.0
100.0	25.0

The initial stage was to measure all of the chemicals that would be used, including the Palm Oil Fuel Ash (POFA) powder and water as the solvent, and then follow the amount of POFA that would be utilised. To examine the final temperature of the paint, the amount of POFA used in this experiment will range from 0% (no POFA usage), 25%, 50%, 75%, and 100%. The measurement was calculated using the following formulas:

$$m_f = \frac{m_o}{100} \times C_p \quad (3)$$

## 2.4 Temperature test on paint

A controlled environment was created by preparing a tiny chamber or room in which temperatures were accurately changed and monitored. The paint was applied on two surfaces and placed in a control chamber for this project. On each surface, one layer of conventional and thermal insulation paint was applied. As a sunshine simulation, a 25-watt bulb was immediately illuminated on top of the samples. The process started at 25°C for 15 minutes. This procedure was carried out three times for each POFA composition present in the paint mixture. As the thermocouple was placed at both samples, the temperature measurements were presented using a digital thermometer.



**Fig. 1** Thermocouple thermometer device

## 2.5 Viscosity of paint testing

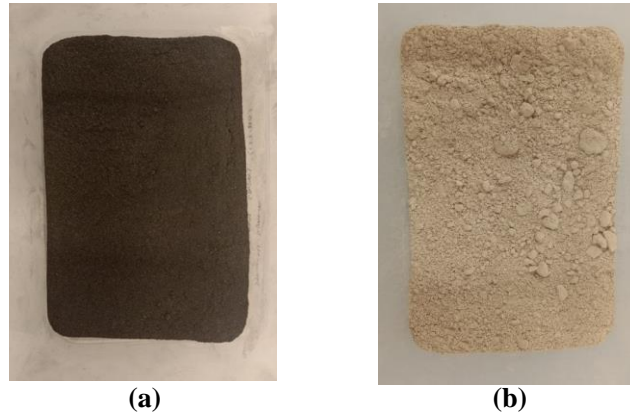
Avoiding contamination and ensure valid data, clean the viscometer and sample container thoroughly between tests. The paint sample was carefully put to the viscometer's sample cup or container to avoid the introduction of air bubbles. The viscometer's spindle or rotor was chosen based on the expected range of paint viscosity. After running the viscometer, let the rotor or spindle spin at a steady pace.

### 3. Results and Discussion

This section will be demonstrated by diagrams and data from testing on thermal insulation paint using Palm Oil Fuel Ash (POFA) or any other ash with similar properties to POFA.

#### 3.1 Preparation of Palm Oil Fuel Ash (POFA) Powder

Fig. 2 clearly displays the differences in the POFA powder before and after treatment (a and b respectively). The untreated powder is darker in color than the treated powder. Furthermore, the treated powder appears finer, but the original POFA powder appears coarse. It is because Carbon oxidation occurs up to temperatures of 360 to 380°C, therefore the amount of carbon in the POFA drops while the amount of oxygen grows. The POFA will remain constant after temperatures hit 850 to 880 °C. In this application, the term "stable" means that the POFA contains enough oxygen to swap with carbon [7].



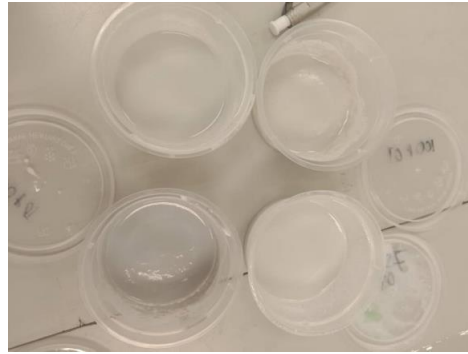
**Fig. 2** Sample of Palm Oil Fuel Ash (POFA) (a) before treatment; (b) after treatment

The mass of the POFA powder is noticeably reduced compared to its initial mass, attributable to a decrease in the amount of carbon (C element) present in the POFA powder from its initial value. Specifically, there is a significant loss of 30% in the mass of the POFA powder after undergoing the heating treatment process [8]. This reduction in mass highlights the impact of the treatment on the carbon content within the POFA powder, underscoring the importance of understanding the changes in composition that occur during the heating process.

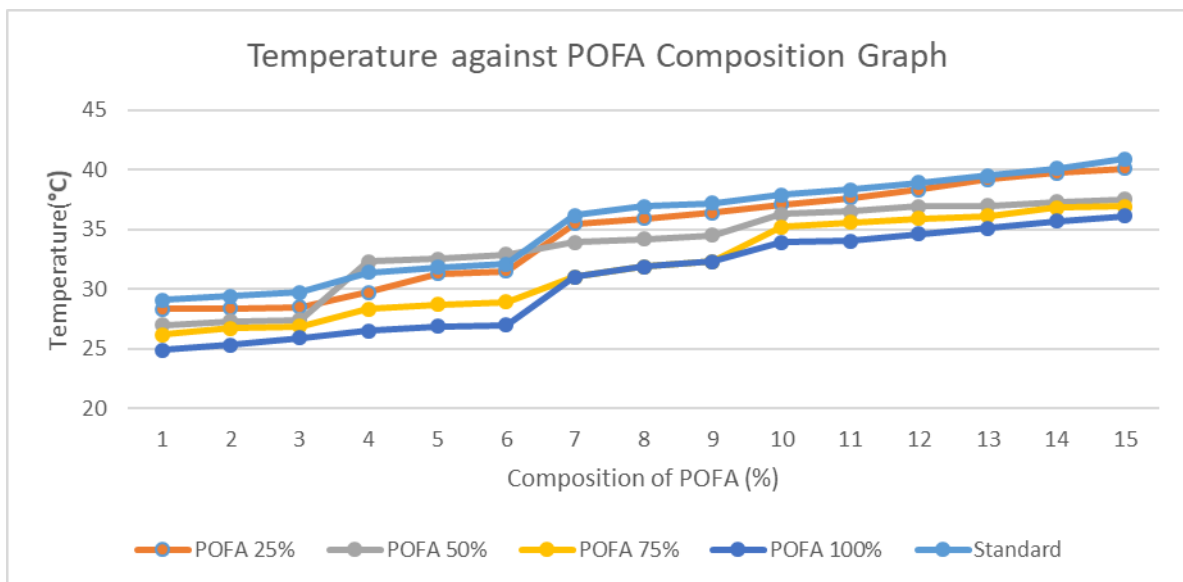
#### 3.2 Temperature of paint

The temperature of the paint containing Palm Oil Fuel Ash (POFA) is lower compared to that of the standard paint. The thermo-physical properties employed for analyzing the thermal behavior of concrete encompass thermal conductivity, thermal diffusivity, thermal resistivity, and specific heat, as outlined in the publication "Investigation on thermal properties of rice husk ash-blended palm kernel shell concrete." Thermal conductivity, defined as the ability of a substance to conduct and store heat [9], [10], is a key parameter in this analysis.

Fig. 4 below presents the results of the conducted experiment. It is noteworthy that the final temperature for the paint mixture with 25% POFA powder was higher than the other readings. Additionally, the concluding temperature for paint mixtures containing 100% POFA demonstrates lower readings than others. This discrepancy is attributed to the high amorphous silica content in POFA, which imparts insulating qualities. Silica-based compounds, due to their poor thermal conductivity, prove excellent as insulation materials [11].



**Fig. 3** Sample of the paint mixtures



**Fig. 4** Graph of temperature against time for different composition of POFA

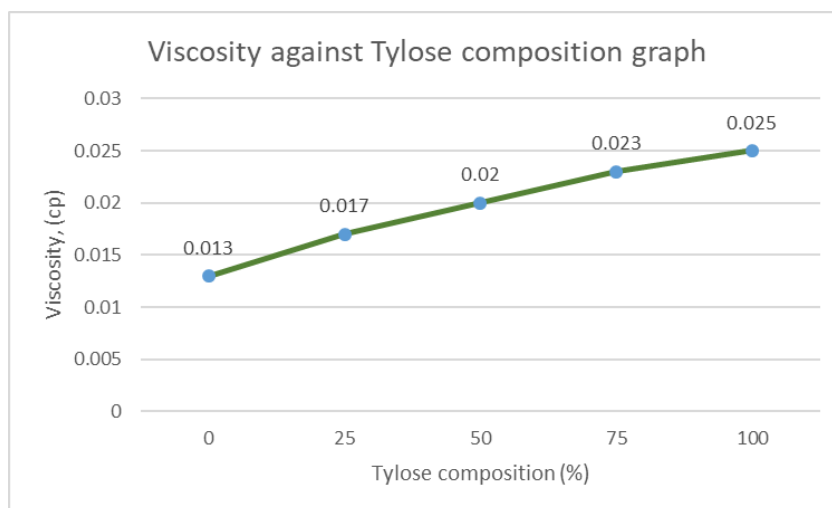
### 3.3 Viscosity of paint

Within paint formulations, the incorporation of thickening agents serves the purpose of managing viscosity and enhancing rheological properties. Fig. 5 illustrates a notable increase in viscosity values corresponding to the escalating presence of the thickening agent, Tylose.

The augmentation of viscosity is imperative in achieving the desired consistency and application characteristics of the paint. As Tylose concentrations rise, the interaction with the paint components leads to heightened resistance to flow, thereby influencing the overall viscosity of the mixture [12]. This controlled increase in viscosity is advantageous for ensuring optimal application and adherence to surfaces.

To contextualize these findings, a comparison with standard viscosity values is paramount. The standard viscosity values act as benchmarks, enabling an evaluation of the formulated paint's adherence to industry norms. A close examination of the obtained viscosity data in relation to these standards provides insights into the efficacy of the paint mixture. Deviations from the established standards may indicate a need for adjustments in the thickening agent concentration to align with industry expectations.

The investigation into the impact of Tylose concentration on paint viscosity highlights its crucial role in achieving desired rheological properties. The comparison with standard viscosity values further contextualizes the findings, aiding in the assessment of the formulated paint's suitability for industry standards and potential areas for refinement.



**Fig. 5** Graph of viscosity against Tylose composition

#### 4. Conclusion

In this study, it is observed that certain blends exhibit superior performance in terms of retaining cool temperatures. The accurate determination of proportions between Palm Oil Fuel Ash (POFA) and the thickening agent emerges as a crucial factor for optimizing the paint's efficacy in heat blocking. This finding implies the potential for developing more energy-efficient paints tailored for application in various structures. The precise calibration of POFA and thickening agent ratios can significantly contribute to the formulation of paints that offer enhanced thermal insulation properties, thereby contributing to the creation of sustainable and energy-efficient architectural coatings.

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#### Conflict of interest

Authors declare there is no conflict of interests regarding the paper's publication.

#### Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design, data collection, methodology, analysis and interpretation of results:** Muhammad Aizad Husni Hazlan, Mohd Zaky Noh and Rahimi L. Muhamud. All authors reviewed the results and approved the final version of the manuscript.

#### References

- [1] Citra, A. D. P., Purwanto, P., & Soenoko, H. R. (2020). Life cycle assessment and quality of utilization of paint waste as a raw material of paving block. *Journal of Ecological Engineering*, 21(2), 89–94.
- [2] Sunarto, S., Purwanto, P., & Hadi, S. P. (2017). Quantification of greenhouse gas emissions from municipal solid waste recycling and disposal in Malang city Indonesia. *Journal of Ecological Engineering*, 18(3).
- [3] Huminic, G., Huminic, A., Fleacă, C., Dumitrache, F., & Morjan, I. (2021). Experimental study on viscosity of water based Fe–Si hybrid nanofluids. *Journal of Molecular Liquids*, 321, 114938.
- [4] Almahmoud, S., & Jouhara, H. (2019). Experimental and theoretical investigation on a radiative flat heatpipe heat exchanger. *Energy*, 174, 972–984.
- [5] Mashri, M. O. M., Johari, M. A. M., Ahmad, Z. A., & Mijarsh, M. J. A. (2022). Influence of milling process of palm oil fuel ash on the properties of palm oil fuel ash-based alkali activated mortar. *Case Studies in Construction Materials*, 16, e00857.
- [6] Gong, S., Zuo, Z., Xie, G., Lu, H., & Zhang, J. (2019). Numerical simulation of wet particle flows in an intensive mixer. *Powder Technology*, 346, 301–315.
- [7] Carvalho, C. (2015). *Thermal and chemical treatments to rice husk valorization*.
- [8] Rovnaník, P. (2010). Effect of curing temperature on the development of hard structure of metakaolin-based geopolymer. *Construction and building materials*, 24(7), 1176–1183.

- [9] Liu, J., Zhu, J., Tian, M., Gu, X., Schmidt, A., & Yang, R. (2013). Simultaneous measurement of thermal conductivity and heat capacity of bulk and thin film materials using frequency-dependent transient thermoreflectance method. *Review of Scientific Instruments*, 84(3), 034902.
- [10] Raheem, A. A., Oriola, K. O., Kareem, M. A., & Abdul Wahab, R. (2021). Investigation on thermal properties of rice husk ash-blended palm kernel shell concrete. *Environmental Challenges*, 5, 100284.
- [11] Lamy-Mendes, A., Pontinha, A. D. R., Alves, P., Santos, P., & Durães, L. (2021). Progress in silica aerogel- containing materials for buildings' thermal insulation. *Construction and Building Materials*, 286, 122815.
- [12] Yan, X., Zhao, W., Wang, L., & Qian, X. (2021). Effect of Microcapsule Concentration with Different Core-Shell Ratios on Waterborne Topcoat Film Properties for Tilia europaea. *Coatings*. <https://doi.org/10.3390/coatings11091013>