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Combination of Silica (SiO_2) Addition from Rice Husk As a Heat-Resistant Coating Material at Wall Paint

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ABSTRACT

The synthesis of silica gel from rice husk ash has been carried out using the sol-gel method, which is mixed into paint as an additive for heat resistance. This research aims to determine the combination of adding SiO2 additive to wall paint as a heat-resistant coating material. The characterization methods used are FTIR, XRD, and SEM. The initial stage of this research involves the synthesis of silica gel from rice husk ash, which is then mixed into 10 mL of paint with varying silica additions of 0.1; 0.2; 0.3; 0.4; and 0.5 grams. After that, it is tested for heat absorption. Based on the FTIR results on silica, silanol (Si-OH) and siloxane (Si-O-Si) groups were observed, and the XRD results indicated that the silica structure produced was amorphous.

Keywords: Rice husk ash, silica gel, heat-resistant, paint, FTIR, XRD.

1. INTRODUCTION

The largest source of heat comes from the sun. Solar radiation emits ultraviolet rays, visible light, and infrared rays that can produce a very significant heating effect. Solar radiation that hits a building can be absorbed, reflected, and transmitted, affecting the interior and exterior surface temperatures.[1] The material that can protect building structures from heat is thermal paint. Paint is defined as a liquid used to coat the surface of a material with the aim of beautifying, strengthening, or protecting that material. After being applied to the surface and drying, the paint will form a thin layer that adheres strongly to the surface.[2] The paint film layer consists of water, binder, additives, and pigments.[3]

Silica is defined as a silicon dioxide (SiO_2) compound, which in its use can take various forms, for example, amorphous in its various forms. Silica is often used as a desiccant, adsorbent, filter medium, and catalyst component. Silica is the main raw material in the glass industry, ceramics, the refractory industry, and an important raw material for the production of silicate solutions, silicon, and alloys.[4] The silica content produced from rice husk ash (a mixture of amorphous and crystalline) is more than 90%, with the remainder

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being oxides of several metals. The high silica content makes rice husk ash a significant potential source of silica in the production of silica-based materials, which generally use quartz sand.[5] silica aerogel as the best thermal insulation material in the world. Silica has the characteristics of high surface area, high porosity and lightness, low thermal conductivity, sound insulation, lightness, and water resistance. Aerogel silica can be used as a thermal, waterproof, and sound insulation material.[6]

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

The materials used in this research rice husk. The chemicals used are NaOH (Sodium Hydroxide) (4M Merck), Aquadest, HCl (Hydrochloric Acid) (37% Merck), Wall Paint, analytical balance, grinding tools (mortar and pestle), 200 mesh sieve, furnace, Buchner funnel and branched Erlenmeyer flask, porcelain dish, hot plate stirrer, vacuum pump (Tasco-150SB-220), FTIR and XRD.

2.2. Research Procedure

2.2.1. Preparation of Rice Husk Ash

Rice husks are cleaned of impurities by washing and then drying them under the sun. After drying, the rice husk is burned in a furnace at a temperature of 700°C for 4 hours. The obtained ash was finely ground and sieved using a 200 mesh sieve.

2.2.2. Production of Sodium Silicate

The ash sample used is the sample that passes through a 200 mesh sieve. 20-gram ash sample was taken and soaked in 150 mL of 12M HCl for 2 hours while being stirred, then left to stand for 24 hours before being filtered. Then the filtered ash was washed until neutral and dried in an oven at 1200°C for 6 hours. Rice husk ash was cooled using a desiccator and its dry weight was measured. Then it was melted with 156 mL of 4M NaOH (stoichiometry) and boiled while stirring until it thickened. After almost dry, the solution was placed in a furnace at 500°C for 30 minutes. After cooling, 200 mL of distilled water was added and left overnight. Then filtered with Whatman 42 filter paper.[7]

2.2.3. Synthesis and Characterization Silica Gel

The filtrate from the previous stage, which is sodium silicate, is added drop by drop with 3M HCl solution while stirring. After a white gel is formed, the process of Aging (gel network maturation) is continued for 24 hours to obtain a dense and homogeneous gel. The formed gel is washed until neutral and dried in an oven at 120°C for 6 hours. The dried silica gel is weighed until constant to obtain the yield weight, then ground using a mortar and pestle. After being ground, the silica gel is sieved using a 200 mesh sieve. The obtained silica gel was characterized using X-Ray Diffractometer (XRD) and Fourier Transform Infrared (FTIR) to determine the functional groups and to understand the structure of the silica gel.[8]

2.2.4. Addition of Additives to Paint

The paint is made according to the formulation by weighing all the ingredients and mixing them in a container, then stirring at a predetermined speed. The mixing was carried out by adding SiO_2 in amounts of

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0.1; 0.2; 0.3; 0.4; and 0.5 grams into the paint, with each composition having a paint volume of 10 ml, and dispersed for 15 minutes. After that, it was stirred at a speed of 200 rpm.[9]

2.2.5. Thermal Stability Test of Wall Paint Mixture with SiO_2

The heat absorption test was conducted with the following steps: first, dissolve SiO2 compounds of 0.1; 0.2; 0.3; 0.4; and 0.5 grams, each dissolved into 10ml of white paint, then measure the initial temperature of each coating material. Next, heat each coating material by radiation for 5 minutes. Then measure the final temperature of each coating material. Finally, calculate the specific heat for each coating material.

3. RESULTS AND DISCUSSION

3.1. Fourier Transform Infrared (FTIR) Characterization

Silica produced from rice husk ash using the sol-gel method was characterized by FTIR. The purpose of analyzing by characterizing using FTIR is to determine the functional groups in silica. Generally, the x-axis on the graph represents the wave number, while the y-axis represents the percentage transmittance. Silanol groups (Si–OH) and siloxane (Si–O–Si) are typically the functional groups present in silica gel. The resulting FTIR spectrum can be seen in the image.

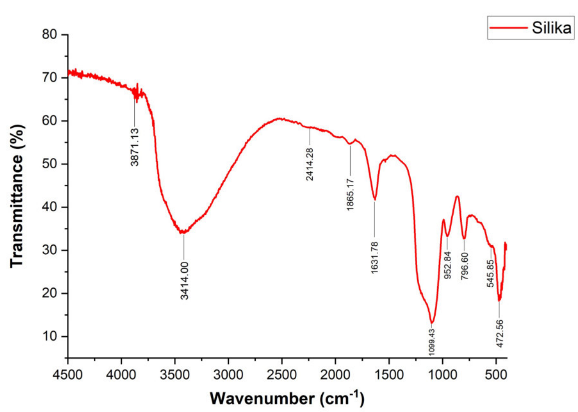

Figure 1. FTIR Silica Characterization Spectrum Results

Based on Figure 1 of the FTIR spectrum, the silica gel from rice husk ash shows characteristic absorption bands in the silica material at 3871.13 cm-1 and 3414.00 cm-1, indicating the presence of stretching vibrations of –OH from Si–OH. In the absorption region at a wavenumber of 1099.43 cm-1, there is an asymmetric stretching vibration of Si–O from the siloxane functional group Si–O–Si. The band absorption at a wavenumber of 2414.28 cm-1 indicates the presence of Si–O bending vibrations, and the stretching vibration of –H is shown at a band absorption with a wavenumber of 1865.17 cm-1. Meanwhile, the absorption band with a wavenumber of 1631.78 cm-1 indicates the bending vibration of –OH from Si–OH and H2O. In the absorption region at a wavenumber of 1099.43 cm-1, there is an asymmetric stretching vibration of Si–O from the siloxane functional group Si–O–Si.The absorption band at the wavenumber 952.84 indicates the presence of Si–O stretching vibration from Si–OH, while the absorption band at the

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wavenumber 796.60 cm-1 indicates the presence of symmetric Si–O stretching vibration from the siloxane functional group Si–O–Si. The bending vibration of Si–O–Si is indicated by the absorption bands at 545.85 cm-1 and 472.56 cm-1.

3.2. X-Ray Diffractometer (XRD) Characterization

Analysis of crystallinity structure is conducted using X-ray diffraction (XRD). The amorphous form is characterized by broad or flat peaks.

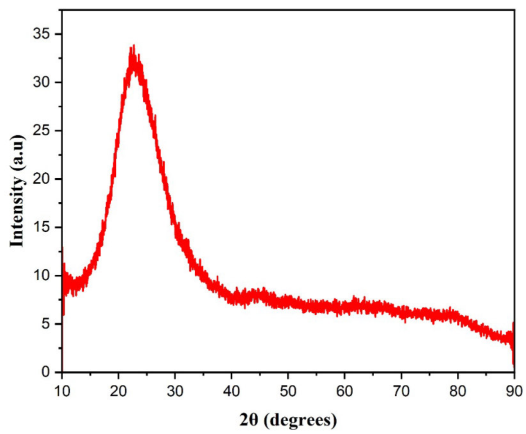

Figure 2. XRD Characterization Results of Silica Gel

Based on Figure 4.7, the results of the XRD characterization test of silica gel from rice husk ash can be seen, showing that the silica gel synthesized from rice husk ash with a NaOH concentration of 4M exhibits various broad peaks in the diffraction angle range of 2θ = 21-23°. According to Kalapathy et al. (2000), silica with broad peaks around 2θ = 20 – 22º indicates that the resulting structure is amorphous (low degree of crystallinity).

3.3. Heat Absorption Test

Thermal conductivity is the ability of a material or substance to conduct heat. To determine the thermal conductivity of wall paint, a heat absorption test is conducted.

Table 1. Results of the Paint/Silica Heat Absorption Test

Q(J)	m (kg)	Initial T (K)	Final T (K)	ΔT (K)	c (kj/kg.K)
1203,2	0,1 x 10^{-3}	303	307	4	3008,0000
1203,2	0,2 x 10^{-3}	303	306,6	3,6	1671,1111
1203,2	0,3 x 10^{-3}	303	306,4	3,4	1179.6078
1203,2	0,4 x 10^{-3}	303	306,1	3,1	970.3225
1203,2	0,5 x 10^{-3}	303	306	3	802.1333

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The radiation result of 1203.2 J on each sample for five minutes produced varying temperature changes in each sample. The largest temperature increase occurred in sample one, which was 4°K with a SiO_2 mass of 0.1 grams, the smallest mass variation. Then the temperature increase becomes smaller with the increase in the mass of the SiO_2 compound. The smallest temperature increase of 1°K occurred in sample five with a SiO_2 compound mass of 0.5 grams. This shows that the mass of SiO2 is inversely proportional to the sample temperature. The larger the mass of SiO_2 mixed into the sample, the slower the temperature increase in the sample. This is because the SiO_2 compound has the characteristic of not being able to store heat. The ability of the sample to store heat is indicated by the specific heat capacity of the sample. The table shows that as the mass of SiO_2 increases, the heat capacity of the material decreases. To show the relationship between the mass of SiO_2 and the heat capacity of the sample mathematically, a regression data analysis of the sample's linear graph data is required.

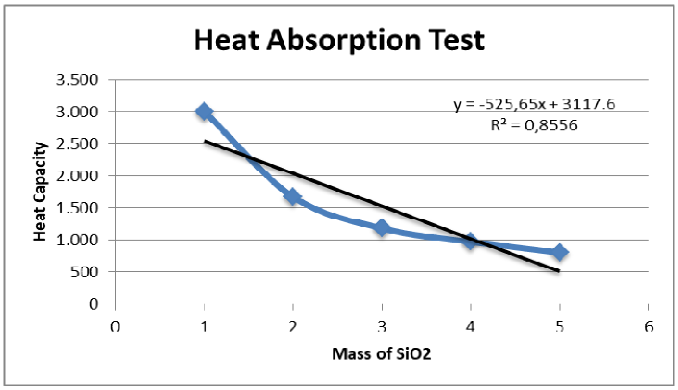

Figure 3. Graph of Heat Absorption Test Results

Using linear regression analysis, the graph equation obtained is = -525.65x + 3117.6, r = 0.90801, R^2 = 0.8556. Because the calculated r is greater than the table r, there is a significant correlation between the mass of SiO_2 and the heat capacity of the sample. The coefficient of determination R^2 = 0.8556 explains that 85.56% of the sample's heat capacity is determined by the mass of SiO_2 and the remaining 14.44% is determined by other factors.

4. CONCLUSION

The XRD characterization results of the silica gel produced from rice husk ash show that the structure is amorphous, characterized by broad or flat peaks. The FTIR characterization results of the silica gel from rice husk ash show the presence of siloxane groups (Si-O-Si) and silanol groups (Si-OH). In the thermal stability test results, the higher the silica concentration, the lower the heat capacity produced.

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