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Chemical and Mineralogical Properties of Rice Husk Ash (RHA)

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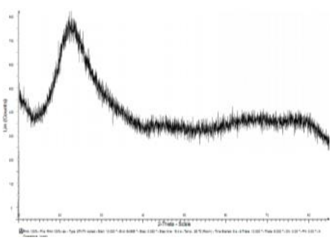
Graphical abstract



Abstract

Rice husk ash (RHA) as a silica source was studied, resulting from burning at a temperature of 700ºC in an electric furnace. RHA consists of inorganic, incombustible matter in the rice husk that has been fused into an amorphous structure. Microscopic techniques, such as X-ray fluorescence (XRF), X-ray diffraction (XRD) and scanning electron microscopy (SEM) were used to observe the surface and internal structure of the RHA. The results among other things revealed that RHA consist of mainly SiO2, with amorphous structure, Microscopic examination showed that has a porous cellular structure and consists of irregular-shaped particles.

Keywords: RHA; XRF; XRD; SEM; Differential Thermal Analysis (DTA)

Abstrak

Abu sekam beras sebagai satu sumber silica telah disiasat dan menunjukkan pembakaran pada suhu 700ºC dalam relau elektrik. Abu sekam beras mengandungi bahan inorganik, tidak mudah terbakar di dalam abu sekam yang telah diserap ke dalam struktur amorfus. Teknik mikroskopi, seperti pendaflour sinar-X (XRF), pembelauan sinar-X (XRD) dan mikroskop imbasan electron (SEM) telah digunakan untuk memerhati permukaan dan sktruktur dalaman untuk abu sekam beras. Keputusan menunjukkan abu sekam beras mengandungi SiO_2 kebanyakannya dengan struktur amorfus. Pemeriksaan mikroskop menunjukkan terdapat struktur sellular poros dan mengandungi partikel yang tidak teratur bentuknya.

Kata kunci: RHA; XRF; XRD; SEM; analisis suhu perbezaan

1.0 INTRODUCTION

Among the different existing residues and by-products, the possibility of using rice husk (RH) has attracted more attention of the researchers than any other crop residues. First due to the over abundance of this residue, 100 million tonnes of husk are obtained from an annual world production of 500 million tonnes of rice, a huge quantity of residue that can only be consumed by the cement, and ceramic industries that use a wide range of by-product [1-10]. Secondly, RH is not appropriate as feed for animals due to its few nutritional properties and its irregular abrasive surface is resistant to natural degradation, which poses serious accumulation problems. When it is incinerated, it produces a great quantity of ash. On average, each one tonne of RH on complete combustion produce 200 kg of RHA. No other crop residue generates such quantity of ash when it is burnt [11]. Thirdly, the use of RHA as a supplementary material is of interest to many developing countries.

The potential global rice husk ash production is estimated at 21 million tonnes per year [2] which in Malaysia alone, a total amount of 78 thousand tonnes is produced annually [3]. Within recent decades, the emission of rice husk ash into the ecosystem has attracted huge criticisms and complaints, mainly associated with its persistent, carcinogenic and bio-accumulative effects, resulting in silicosis syndrome, fatigue, shortness of breath, loss of appetite (respiratory failure) and even death [12-17]. With the price of the ash disposal cost (either in landfills or ash ponds) hitting as high as \$5/ton in developing countries and \$50/ton in developed countries, the urgency of transforming the residue into a more valuable end product has been promulgated [5].

The large amount of silica freely obtained from this source provides an abundant and cheap alternative of silica for many industrial uses [18-20]. The reactivity of the silica depends on the preparation and temperature [6].

The structural analysis of RHA burned at a temperature of 700ºC was carried out using X-ray fluorescence (XRF), Scanning electron micrographs (SEM), X-ray diffraction (XRD), and Differential Thermal analysis (DTA). The aim was to study the structure and surface morphology of the extracted silica of the RHA from Muar Johor and compare it with that obtained from India.

2.0 EXPERIMENTAL

The following tests were conducted to characterize the rice husk ash which has been collected from Muar.

2.1 X-ray Fluorescence (XRF)

The RH (Rice husk ash) was thoroughly washed with distilled water in order to remove adhering soil and dust. After that it was dried in an oven at 100°C for 24 hours. Then the deried husk was subjected to the chemical treatment; 2 M HCL, 5% solid at 25°C before calcinations to increase silica content. After the leaching process, the treated husks were washed with distill water and then dried again. The treated husk was then subjected to calcinations at 700°C for six (6) hours, after which it was subjected to the XRF analysis. The machine used for the analysis was XRF Bruker S4 Pioneer which was operated at 60 KVP and 50 Ma.

2.2 Scanning Electron Microscopy

JOEL-JSM-6380 Instrument was used to study the morphology of the POFA which is available at Mechanical Laboratory, Universiti Tun Hussein Onn Malaysia. Small amount of POFA powder was poured on the carbon tape which is attached to the holder. Then the excess powder was blown with air gun to ensure that small pieces of the powder remain on the tape. After that it was put into in the SEM chamber for analysis. The SEM is machine was operated at operated at 10 kV. The magnification of X100 is used to capture a photo of the sample.

2.3 Husk Ash through X-Ray Diffraction (XRD)

The rice husk ash samples were subjected to X-Ray Diffraction (XRD) analysis using an X-Ray Diffractometer to determine their silica structure. Prior to analysis, the ash samples were ground to a powder form by simple pounding using a mortar and pestle due to its brittle nature.

The ground samples were analyzed by Cu Kα radiation with a scanning rate of 0.05° per second 40 kV/20A, speed 0.05°/min and scanning at $3^o \geq 2\Theta \leq 90^o$. The X-Ray Diffractometer (Model Bruker D8 Advance) is available for use at the Faculty of Civil Engineering.

2.3 Differential Thermal Analysis (DTA)

DTA of the RHA was determined by using a Lenseis Thermobalance instrument, in Ceramics and Polymer laboratory UTHM. Information about the thermal properties of RHA especially the point is of great importance to this study. The DTA observation can give the temperature change of the sample to obtain suitable sintering temperature. To do the test, little amount of RHA powder (19.2 mg) was used for the heating and cooling. The speed of the test was 10°C/minutes and the maximum temperature 1000°C

3.0 RESULTS AND DISCUSSION

3.1 Chemical Composition

It is evident from Table 1 that treated RHA from Muar gives higher silica (93 wt%) and alumina (2.11 w%) compared to untreated RHA from the same place, without alumina trace, and treated RHA from India as reported by Prasad [7] which gives silica, alumina 1.21 w%.

Table 1 Chemical analysis of RHA

Composition	Treated RHA (Muar)	Untreated RHA (Muar)	Treated RHA (India) [4]
SiO_2	93.70	90.10	88.44
Al_2O_3	2.11	-	1.21
K_2O	1.18	4.37	1.81
P_2O_5	0.96	2.11	-
CaO	0.81	0.84	1.20
MgO	0.53	0.83	1.82
SO_3	0.45	-	-
CO_2	0.10	0.10	
Fe_2O_3	-	-	0.40
Na_2O	-	-	0.50
Cl	-	0.24	
L.O.I.	0.16	1.41	4.62

3.2 Husk Ash through X-Ray Diffraction (XRD) Analysis

Figure 1 shows the resulting phase diagram (called a diffractogram) indicates that the ash was mainly amorphous form as indicated by a broad peak cantered on 2Θ angle. The phase concentration is indicated by the peak height, with higher peak representing higher concentration. The amorphous structure is indicated by a background hump at peak position of approximately 25° on the diffractogram.

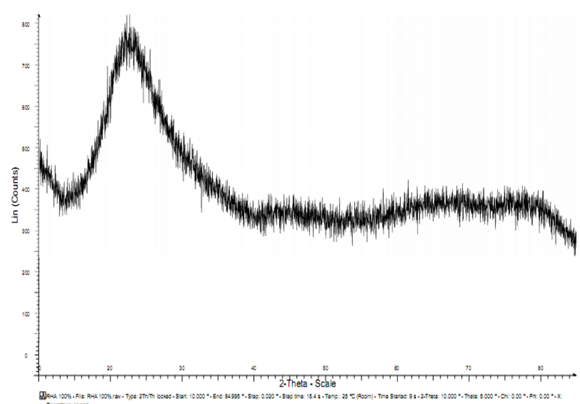


Figure 1 X-ray diffraction (XRD) spectra for the RHA

3.3 Differential Thermal Analysis (DTA)

The result of the DTA process can be seen from Figure 2 which shows the first positive peak at 71.3°C. This is the first exothermal peak (the release of heat) due to the impurities of unburned rice husk structure and also the removal of absorbed water [8]. Then endothermic peak (absorption of heat) obtained at 95.1°C. This possibly could be due to the removal of hydroxyl groups, decomposition of nitrite ion and also removal of carbon moieties. Lastly, the maximum exothermic peak occurs at 144.9°C may be due to the decomposition of the sample structure; presumably is the melting point of the sample.

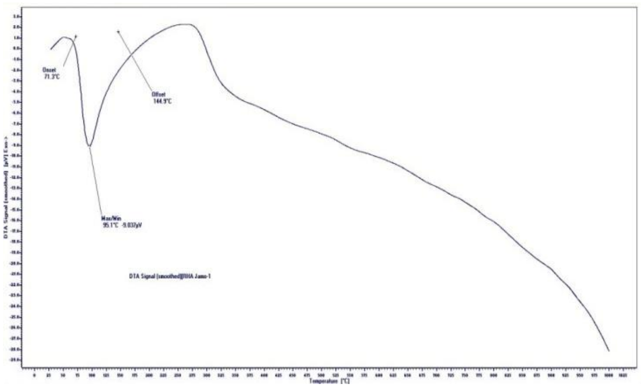


Figure 2 Differential thermal analysis (DTA) of RHA

4.0 CONCLUSION

The RHA examined under this study is completely amorphous, combustion at 700°C produces the most reactive material, in which amorphous SiO_4 tetrahedra are present and no SiOH are detected in large amount. The presence of SiOH groups and crystalline phases in silica reduces the reactivity of silica in whiteware compositions. Recycling of RHA will conserve the natural raw materials and abridge the disposal cost. This will create new revenues and business opportunities while protecting the environment.

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