2011 International Conference on Environment Science and Engineering
IPCBEE vol.8 (2011) © (2011) IACSIT Press, Singapore

CHEMICAL AND PHYSICAL PROPERTIES OF FIRED-CLAY BRICK AT DIFFERENT TYPE OF RICE HUSK ASH

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***Abstract*—The aim of this study is to evaluate the chemical and physical properties of clay and RHA as fired-clay brick materials. Four materials with different type rice husk ash, i.e. controlled burning rice husk ash (CBRHA), uncontrolled burning rice husk ash (UCBRHA), ground rice husk (GRH) and clay were used for the study. The X-ray Diffraction (XRD), X-Ray Fluorescence, Thermogravimetric Analysis, and Water adsorption were determined. The results revealed that the silica content for UCBRHA was found to be the highest compared to CBRHA and GRH. In general, the value of clay has the highest LOI (8.75%), followed by GRH, CBRHA and UCBRHA with percentages of 3.53%, 2.02% and 0.97% respectively. However, the TGA/DTA analysis shows the changes in the clay when heated. The clay started losing water when heated up to 250oC. The big changes can be seen between 500oC to 570oC where the dehydroxylation of clay minerals occurred. Finally, the results also showed that the water adsorption of clay more moisture than GRH, CBRHA and UCBRHA.**

Keywords-Clay, rice husk ash, physical properties, water adsorption, thermal analysis

I. INTRODUCTION

Clay brick is the first man made artificial building material and one of the oldest building materials known. Its widespread use is mainly due to the availability of clay in most countries. Its durability and aesthetic appeal also contribute to its extensive application in both load bearing and non-load bearing structures. The properties of clay units depend on the mineralogical compositions of the clays used to manufacture the unit, the manufacturing process and the firing temperature [1].

The recycling of industry-generated wastes as alternative raw materials is not a new process and has been done successfully in a lot of countries. A series of researches have been done to fully utilize waste produce from rice husk. Previous researcher, Rahman [2], produced bricks using uncontrolled burning rice husk ash and reported that the ash has potential to increase the compressive strength of bricks. After Rahman [2], De Gutierrez and Delvasto [3] from Colombia has produced fired-clay brick using ground toasted rice husk (RH) and controlled burning rice husk ash (RHA). The findings concluded that the brick containing controlled burning rice husk ash RHA gave better results than the brick incorporated with ground toasted rice husk (RH). Recently, Danupon et al. [4] investigated the potential use of uncontrolled burning rice husk ash (RHA) to produce lightweight fired-clay brick. From the results obtained, they found that lightweight brick could be produced by increasing the RHA replacement. Though, the compressive strength of the brick was reduced. To date, there is no systematic scientific information published regarding the use of three type of rice husk in its various forms. Therefore, the main aim in this study is to investigate the chemical and physical properties of fired-clay bricks at different type of RHA.

II. MATERIALS

There are four basic materials involved in the study: clay, controlled burning rice husk ash (CBRHA), uncontrolled burning rice husk ash (UCBRHA) and ground rice husk (GRH), In this investigation, the clay was wet and in large chunk. Then, exposed to ambient sun dried at temperature 35°C for 7 days. On the other hand, the rice husk ash was generated after burning rice husk at 700°C for 6 hours in a muffle furnace model Carbolite CWF 1400. Fully burnt RHA was white with grey while partially burnt RHA was grey with black particles. The produced RHA was stored in a closed container and kept in a dry place.

The second replacement material is a waste rice husk ash (uncontrolled burning). The husk was partially burnt by self-burning from a steam boiler. The ash was grey with black particles all over it and it was dumped in an open area. The black particles are the partially burnt rice husk. This UCBRHA was collected directly from the steam boiler discharge pipeline. It was packed in a 50kg sack, stored in a closed container and kept in a dry place. The third replacement material is GRH. Rice husks from the rice mill company were milled using a fabricated ring mill machine and steel ring. The husks were ground to the required particle size. The produced GRH was stored in a closed container and kept in a dry place.

III. METHODS

A. X-Ray Fluorescence Method

This test was carried out to determine the chemical composition of clay, GRH, CBRHA and UCBRHA. The apparatus used in this study was RIGAKU RIX3000. However, Loss on ignition (LOI) value for the sample was determined separately.

B. X-ray Diffraction (XRD)

In this investigation, the raw materials were analyzed by XRD instrument named BRUKER AXS D8 ADVANCE. Small amount of sample was place on the sample holder then directly taken to characterize. XRD patterns were scanned in steps of 0.0034° in a range of diffraction angle from 5° to 70° of 2θ, using Copper (Cu) as X-ray source with wavelength (λ) of 1.5406 nm.

C. Thermal Analysis

The simultaneous of Thermogravimetric Analysis (TGA) and Differential Thermal Analysis (DTA) was used in this study. Thermogravimetric analysis and Differential Thermal Analysis were applied in order to observe the reactions taking place during the thermal treatment of the samples. The analysis was carried out using NETZECH Model STA 409 PC LUXX. At the specified testing, a total of 20 - 25 mg of the samples were taken in a platinum pan and heated in nitrogen atmosphere at a temperature range between 20 to 1100°C with controlled heating rate 10°C/min.

D. Water adsorption

In this test, the samples were placed inside a porcelain crucible and then dried in an oven at a temperature of 105°C for 24 hours to obtain the dry weight. The samples were weighed using an electronic analytical balance model A&D HM300 that can be readable up to 0.001g. The adsorption of material (total water adsorption) is defined as the increase in the weight of a material due to moisture in air, and can be calculated using equation 1.

$$W\,\% = \frac{(W_b - W_a)}{(W_a - W_c)} \times 100 \quad (1)$$

Where: *W* is moisture content of specimen (%), *Wa* is weight of specimen after oven dried for 24 hours (g), *Wb* is weight of specimen after 24 hours in desiccators (g), and *Wc* is weight of crucible (g).

IV. RESULTS AND DISCUSSION

A. Chemical composition

Table 1 presents the tabulation of the chemical composition for clay and rice husk ash. Indicates that UCBRHA has the highest amount of silica (93%), followed by CBRHA (88%), clay (67%), and GRH (11%). The silica in clay is present in a different form as a free form (SiO_2) and in the form of compounds when mixed with other elements such as aluminium oxide (Al_2O_3) to form kaolinite ($Al_2(Si_2O_5)(OH)_4$) in the feldspar group. The element that contributes to the red colour of clay is iron oxide (Fe_2O_3). The colour is not dominant due to the presence of other materials inside raw clay such as organic matters that make raw clay grey, black, or dark brown depending on the amount present. However, the colour changes after the firing process when carbonaceous material and iron compounds start to oxidize [5].

TABLE I. CHEMICAL COMPOSITIONS OF CLAY AND RICE HUSK ASH

Component (%)	Clay	CBRHA	UCBRHA	GRH
SiO_2	67.000	88.000	93.000	11.000
Al_2O_3	26.000	0.130	0.260	0.230
Fe_2O_3	2.900	0.099	0.100	0.340
Na_2O	0.069	-	0.052	-
MgO	1.200	1.800	0.490	0.580
P_2O_5	0.036	3.300	0.670	2.000
SO_3	0.470	1.000	0.025	0.830
Cl	Trace	0.250	0.011	0.240
K_2O	2.100	4.700	1.100	1.900
CaO	0.110	0.720	0.380	0.400
Cr_2O_3	0.012	-	-	-
MnO	0.010	-	0.029	0.130
NiO	Trace	Trace	Trace	Trace
CuO	Trace	Trace	Trace	Trace

ZnO	Trace	-	Trace	0.028
Br	-	Trace	Trace	-
C	-	Trace	3.000	82.000

B. Phase identification

The controlled burning rice husk ash (CBRHA) was amorphous silica as illustrated in Figure 1. The difference between the amorphous and crystalline phase is that the amorphous has a broad peak and a wide angle of 2θ, while the crystalline phase has a pattern and a sharp peak. The crystalline peak can be seen in Figure 2, where the peak has a pattern and is not broad.

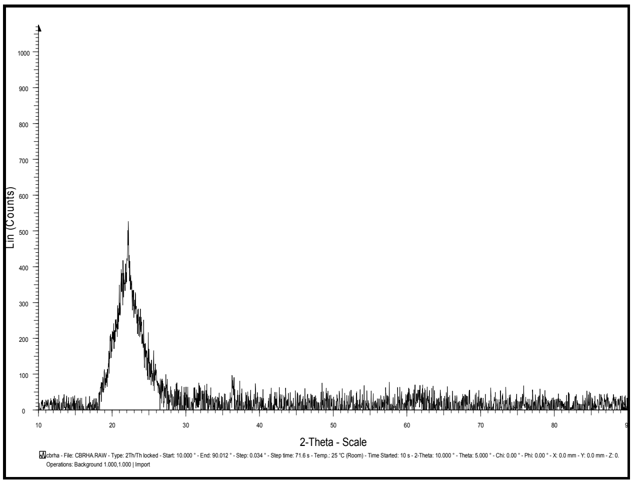

Figure 1. XRD of Controlled Burning Rice Husk Ash (CBRHA)

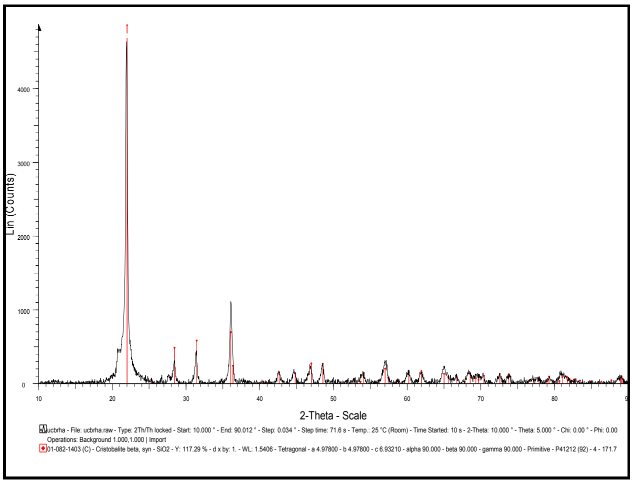

Figure 2. XRD of Uncontrolled Burning Rice Husk Ash (UCBRHA)

C. Thermal Analysis

The effect of heat on the clay was initially studied using TG-DTA analysis as shown in Figure 3. The initial weight of the sample was 69.000 mg, which was reduced to 68.011 mg at the lowest point at 658.8^{o}C. The TG-DTA analysis curve shows the changes in the clay when heated. The clay started losing water when it was heated up to 250^{o}C. The big changes can be seen between 500^{o}C to 570^{o}C where the dehydroxylation of clay minerals occurred. The effect of fluxes components such as K_2O, Na_2O and CaO, could be seen when the clay started to have a reaction that began around 900^{o}C. This also marks the beginning of the sintering process for the clay and also as the starting point to select temperature range to determine optimum firing temperature.

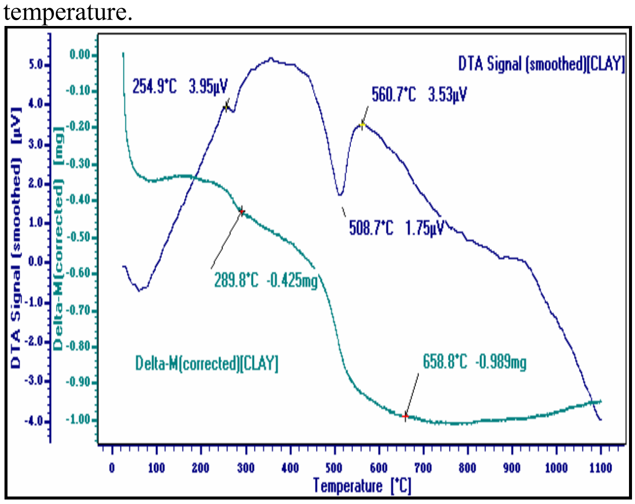

Figure 3. Thermogravimetric analysis of clay

D. Loss on ignition (LOI)

Table 2 summarized the value loss on ignition for the raw material. This value is important to indicate the loss during the firing of the fired-clay brick. Based on the Table, the value of clay has the highest LOI (8.75%), followed by GRH, CBRHA and UCBRHA with percentages of loss of 3.53%, 2.02% and 0.97% respectively. High LOI value is because clay in nature contained more water in it grains and it's evaporate during the LOI test.

According to Rahman [2] reported that the loss on ignition for clay as 8.35% and RHA as 3.59%. However, CBRHA value is higher than UCBRHA is due to condition during the LOI test. CBRHA was produced in control condition where the temperature was 700^{o}C. When the temperature of 1000^{o}C was applied during the LOI test, it will undergo changes in phase from amorphous to crystalline and some of volatile compound will evaporate. Compared to UCBRHA, it was produce from factory steam boiler where the temperature used was 1000^{o}C. When the temperature of 1000^{o}C was applied to it, this crystalline phase RHA was in stable condition and only carbon will evaporate during the test.

TABLE II. LOSS ON IGNITION FOR CLAY AND REPLACEMENT MATERIALS

Material	Clay	CBRHA	UCBRHA	GRH
LOI (%)	8.75	2.02	0.97	3.53

E. Water adsorption for clay, CBRHA, UCBRHA and GRH

Figure 4 represents a graphical illustration of moisture adsorption for all materials. Indicate that clay adsorbs more moisture than other material, with an adsorption value of 0.9981g, followed by GRH with 0.9337g, CBRHA with 0.2644g and UCBRHA with 0.1475g. The second highest water adsorption is GRH. This is because raw rice husks contain about 50% cellulose, 20-30% lignin and 15-20% silica [6]. Conversely, when the rice husk is heated, the water inside the cellulose and lignin will dry up and cause a loss in mass [7]. These rice husks can absorb water significantly because of its hydrophilic characteristics [8]. Furthermore, these rice husks have been ground which increases its surface area. This could lead to an increase in the amount of water absorbed compared to unground rice husks.

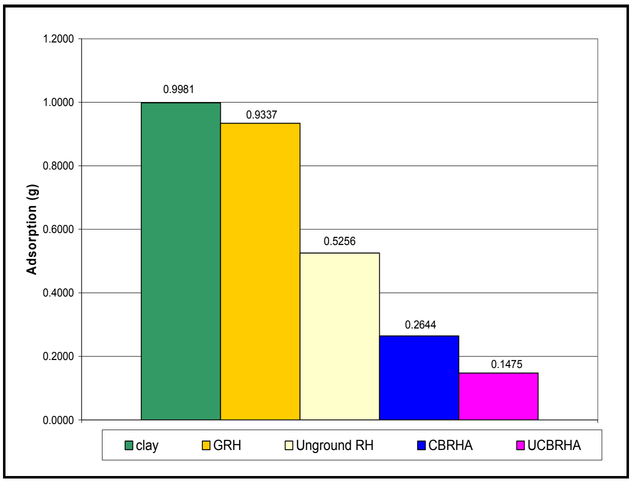

Figure 4. Results of water adsorption for clay, GRH, unground RH, CBRHA and UCBRHA

V. CONCLUSION

An experimental study was conducted to investigate the influence of chemical and physical properties of fired-clay brick at different type rice husk ash. The following conclusions can be drawn:

a. The silica (SiO_2) content for UCBRHA was found to be the highest compared to CBRHA and GRH. However, the setback for this material is that the carbon content detected in UCBRHA could lead to a porous structure.

b. The TG-DTA analysis shows the changes in the clay when heated. The clay started losing water when heated up to 250^{o}C. The big changes can be seen between 500^{o}C to 570^{o}C where the dehydroxylation of clay minerals occurred.

c. Based on the results LOI, the value of clay has the highest LOI (8.75%), followed by GRH, CBRHA and UCBRHA with percentages of 3.53%, 2.02% and 0.97% respectively. High LOI value is because clay in nature contained more water in it grains and it's evaporate during the LOI test.

d. The water adsorption of clay more moisture than other material, with an adsorption value of 0.9981g, followed by GRH with 0.9337g, CBRHA with 0.2644g and UCBRHA with 0.1475g. Generally, The second highest water adsorption is GRH.

ACKNOWLEDGMENT

The support provided by Universiti Sains Malaysia in the form of a research grant for this study is very much appreciated.

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