STRUCTURAL ANALYSIS AND SURFACE MORPHOLOGY OF A TREATED PALM OIL FUEL ASH

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ABSTRACT

Palm oil fuel ash (POFA) has been known to possess a pozzolanic property. The abundance of POFA as an agricultural waste makes it a promising candidate for it to be used as a supplementary cementations material in palm oil producing countries. This paper presents structural analysis and surface morphology of a treated Palm oil fuel ash (POFA). The untreated POFA was grounded for 1.5hours in a ball mill to reduce the particle size and to improve reactivity. It was then heated at a temperature of 600°C 1.5hours in an electric furnace. X-ray fluorescence (XRF), X-ray diffraction (XRD) and scanning electron microscopy (SEM) were used to observe the surface and internal structure of the POFA. The results among other things revealed that the POFA consist of mainly silica (SiO_2), with crystalline structure, microscopic examination showed that the POFA has a porous cellular structure and consists of irregular-shaped particles. This study implies that POFA is good candidate for various applications by ceramic industries.

Key words: POFA; Morphology; SEM; XRD; XRF.

1. INTRODUCTION

Palm oil fuel ash (POFA) is a by-product from biomass thermal power plants where by oil palm residues are burned to generate electricity. Malaysia is one of the largest producer of palm oil with around 41% of the total world supply in the year of 2009– 2010 (Awal *et al.,* 1997; Sata *et al.,* 2004; Chindaprasirt *et al.,* 2007; Chandara *et al.,* 2010; Tangchirapat *et al.,* 2010; Sata *et al.,*2010; Altwair *et al.,* 2011). In Thailand for example, it had been estimated that 2.1 million tons of biomass was used as fuel in 2004, producing about 100,000 tons (5%) of biomass ash (Sata *et al.,* 2004; Tangchirapat *et al.,* 2010). Since palm oil is one of the major raw materials used to produce bio-diesel, it is likely that the production of POFA will increase every year. Very little of the POFA produced is actually used. While some of it serves as low-value material for backfill or fertilizers, most of the POFA is posed as waste in landfills, causing environmental and other problems such as health related problems

(Chindaprasirt *et al.,* 2008; Frías *et al.,* 2008; Ismail *et al.,* 2010; Abdul Awal *et al.,* 2011; Sata *et al.,* 2010; Kroehong *et al.,*2011).

POFA is greyish in colour, becoming dark with increasing proportions of unburnt carbon (Altwair *et al.,* 2011; Bartell *et al.,* 2010; Li, 2011; Steenland *et al.,* 2010). Its chemical composition indicates presence of high mount of silica, which is considered to possess high potentials of serving as cement and porcelain replacement. The large amount of silica freely obtained from this source provides cheap alternative of silica for many industrial uses (Awal *et al.,* 1997; Mannan *et al.,* 2004; Rukzon *et al.,* 2009; Jaturapitakkul *et al.,* 2011).

This paper reports the results of an investigation into the structural analysis of a POFA heated at a temperature of 600°C using X-ray fluorescence (XRF), Scanning electron micrographs (SEM) and X-ray diffraction (XRD). The aim was to study the structure and surface morphology of POFA collected from United Oil Palm Industries Sdn. Bhd. located in Nibong Tebal, Penang, Malaysia and compares it with that obtained from Thailand.

2. EXPERIMENTAL INVESTIGATIONS

The following tests were conducted to characterize the POFA.

2.1 X-ray Fluorescence (XRF)

The removal of excess carbon and other unburned organic materials contained in POFA is important to avoid their potential negative effect on finished product. Thus, the POFA was dried in an oven at 100°C for 24 hours and then sieved using a set of sievers (50 μm) to remove the particles coarser than 50 μm. The untreated POFA (Fig.1a) was then ground in a ball mill to reduce the particle size to improve reactivity. The milling time was approximately 1.5hours at 200 rev/min. The untreated POFA was heated at a temperature of 600°C for 1.5 hours in an electric furnace. After the heat treatment, the colour of treated POFA turned from light brown to greyish red (Fig.1b) when the unburned residue was removed, 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.

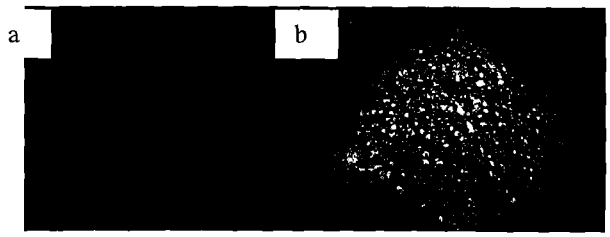

Fig.1: (a) Treated POFA (b) Untreated POFA

2.2 Scanning Electron Microscopy (SEM)

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 the SEM chamber for analysis. The SEM is machine

was operated at operated at 10kV. The magnification of X100 is used to capture photo of the sample.

2.3 X-Ray Diffraction (XRD)

The POFA 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 40kV/20A, at $3° \geq 2\Theta \leq 90°$. The X-Ray Diffractometer (Model Bruker D8 Advance) is available for use at the Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia.

3. RESULT AND DISCUSSION

3.1 Scanning Electron Microscopy

Fig. 2 shows the SEM of treated POFA particles; the particles were irregular in shape and having porous texture. In addition, there was no agglomeration of POFA particles after the heat treatment as can be seen in from Fig. 2. The main component of the treated POFA is SiO_2 (Table 1), which indicates that the chemical compositions of the treated POFA from Malaysia gives 66.91 wt% of SiO_2 compared to the one obtained from Thailand as reported by Kroehong (2011) which gives 55.7 wt% of SiO_2. Followed by Al_2O_3, which is the second component the POFA from Malaysia gives 6.44 wt% of Al_2O_3 compared to the POFA from Thailand which gives only 0.9 wt%.

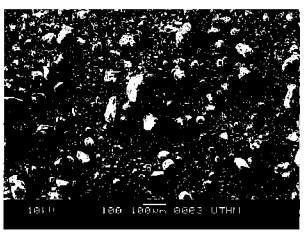

Fig. 2: SEM of the POFA

Table1: Chemical analysis of POFA (wt %)

Chemical Composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	P_2O_2	MgO	SO_3	Na_2O	LOI
POFA (Malaysia)	66.91	6.44	5.72	5.56	5.20	3.72	3.13	0.33	0.19	2.30
POFA [16]	55.7	0.9	2.0	12.5	11.9	-	5.1	2.9	1.0	4.7

3.2 X-Ray Diffraction (XRD) Analysis

X- Ray Diffractometer is a mechanical device for obtaining X-ray intensities as a function of the angle between the incident and the diffracted beams. Fig.3 shows the result of phase diagram (called a diffractogram) indicates the crystalline phases determined are the quartz Q = Quartz, C = Cristoballite and G = Grossular (Ca_3Al_2 (SiO_4)2(OH) $_4$). As it can be seen from the Fig. 3, the peaks increased after treatment. Hence, the treated POFA is expected to give more compressive strength because of the silica content.

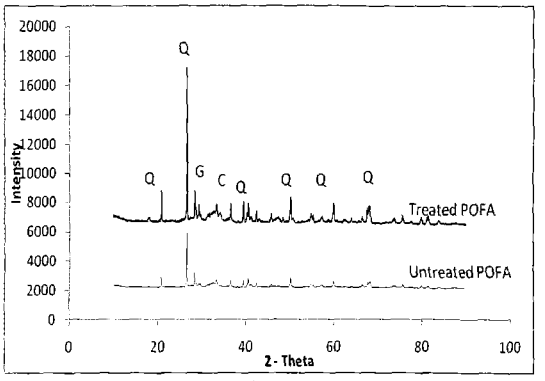

Fig. 3: X-ray diffraction (XRD) spectra for the POFA

4. CONCLUSION

POFA is a valuable natural resource not only as a good source of silica, but also as a source of lignocellulosic material which can be potentially used to produce a range of valuable products. However, product development will require greater understanding of the POFA. The information provided here could form both a useful background on the compositional and morphological characteristics of the POFA surface as well as its internal tissues. Therefore the extension of knowledge on structural analysis and surface morphology of this POFA is very important for the determination of which type POFA to be used by the industries.

ACKNOWLEDGEMENT

The authors would like to acknowledge the financial support of Universiti Tun Hussein Onn Malaysia. We would also like to thank the following Mr. Mohd Azrul Nizam bin Mustari, Mr. Fazlannuddin Hanur bin Harith, Mr. Shahrul Mahadi bin Samsudin, Mr. Mohd Tarmizi bin Nasir, Mr. Anuar bin Ismail, and Mr. Ahmad Nasrull bin Mohamed for their assistance as laboratory technicians.

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