Science Front Publishers *Journal for Foundations and Applications of Physics*, vol. 6, No. 1 (2019)
(sciencefront.org) ISSN 2394-3688

An Improved Method for Production of Silica (SiO_2) from Palm Oil Fuel Ash (POFA) using Acidic Wash Treatment (HCl)

Sani Garba Durumin Iya[1*], Mohamed Zaky Noh[2], Siti Noraiza Ab Razak[3], Norazreen sharip[4], Nur Ashikin Ismail[5] and Nur Azureen Alwi Kutty[5]

[1,2,5]Materials Physics Laboratory, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia, Pagoh Educational Hub, 84600 Pagoh, Johor, Malaysia
[1]Power Equipment and Electrical Machinery Development Institute (PEEMADI), Okene, Nigeria
[3,4]Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Educational Hub, 84600 Pagoh, Johor, Malaysia

**Corresponding author E-mail*: d_iya4real@yahoo.com

(Received 15 February 2019, Accepted 13 April 2019, Published 24 April 2019)

Abstract

Palm oil is derived from tropical palm tree that is easily cultivated in tropical countries like Malaysia, Thailand and Brazil. Palm oil fuel ash (POFA) is a by-product from palm oil industry that is produced in large quantity (approximately 4 million tons annually in Malaysia). This paper presents an improved method for production of silica from POFA. Untreated POFA was dried in an oven at 110 ºC for 24hours, it was then grinded in a ball mill for 12 hours at 250 rev/min to reduce the particle size, the powder is dispersed in 1 molar of HCl acid and stirred constantly for 30 min using electric shaker. X-ray fluorescence analysis shows that, POFA treated with acid shows the existence of thirteen chemical elements and the chemical composition of SiO_2 increases after the acidic wash from 15.90 wt% to 43.70 wt%. The percentage difference for SiO_2 is shown to be 175%. Based on the result of this study, it can be concluded that acid wash treatment is suitable for production of silica from POFA.

Keywords: Silica, Palm Oil Fuel Ash (POFA), XRD, XRF, SEM

1. Introduction

Palm oil fuel ash (POFA) is a byproduct from palm oil industry as a result of burning palm oil shell, fiber and empty fruit bunch to heat boiler and generate electricity [1]. POFA management and disposal have been a great challenge faced by palm oil milling industries in the world. POFA has been thrown and dumped in the landfill and it take long time to biodegrade, thus leading to environmental pollution [2]. Over the past decades, palm oil industries witness a tremendous increase, thus the waste by-products also increase. In Malaysia and other tropical countries, palm oil industries have significantly contributed to the socio-economic growth, it is estimated that, Malaysia cultivated 2.65 million hectares of palm oil trees, annually processing about 8 million tons of oil [3].

Brinker and Scherer reported that, industries have been using silica for different purposes ranging from detergent, refining of vegetable oil, for packaging, in pharmaceutical products and in ceramic industries [4]. Process of silica based material production (example tetra chloride, silicon carbide and nitride) have been reviewed by Sun and Gong [5]. They proposed a new technique for silica production from Rice husk ash, insisting the need for the simple and low energy consuming method for silica production is inevitable. Silica production from other sources such as inorganic like mineral and sand requires high temperature is not affordable and lead to high cost of production, discovering a low temperature method is paramount as it is economic wise and save environmental and air pollution [6]. Therefore, introducing a low energy consuming method for silica production from palm oil fuel ash is logical.

The successful incorporation of POFA in concrete as cement partial replacement has sparked several research in the construction and building industries. In the tropical region, palm oil fuel ash is among the prevalent waste products, due to the amorphous nature and higher quantity of silica content in POFA, it can be used in several clay-related materials like ceramic and porcelain [7]. Researchers like Jamo et al attempted to use POFA in the porcelain production as replacement of quartz, they reported that, incorporation of POFA at 15 wt.% enhance both physical and mechanical properties of porcelain [8].

2. Methodology

Palm oil fuel ash (POFA) is mostly a moist powder, therefore it is dried in an oven at a temperature of 110 °C for 24 hours to remove the moisture, the powder is grid using ball milling machine for 12 hours at speed of 250 rev/sec for particle size $\leq$ 50 μm. POFA powder is then washed with HCL acid and stirred using electric shaker for 30 minute and filtered. The powder is sieved and dried again to remove the acid residue. To analyse the effect of acid treatment on chemical composition, morphology and phase composition, X-ray fluorescence analysis (XRF), Scanning electron microscopy (SEM) and X-ray diffraction analysis (XRD) were used.

3. Results and Discussion

X-ray fluorescence analysis is used to identify the chemical composition of POFA and also to quantity of the compounds present. X-ray Bruker S4 Pioneer model operating at 50 mA and 60 kVp is used and the result is presented in Table 1. The chemical composition of treated POFA shows that SiO_2 has the highest composition as 43 wt.% while for untreated it is 15 wt.%, then follows by K_2O,

P_2O_5, Al_2O_3, Cl, CaO and Fe_2O_3 respectively. Evidently, treatment plays a vital role in increasing the chemical composition of silica (SiO_2) and normalizing other chemical compositions. The result of this research is in agreement with other research by [9], where they reports that, silica is the main composition of treated POFA.

Table. 1 Chemical Composition of Untreated and Acid treated POFA

Chemical element present	Untreated POFA (wt.%)	HCl acid treated (wt.%)	Percentage difference (%)
K_2O	35.00	9.21	-74
SiO_2	15.90	43.70	175
C	0.10	0.10	0
CaO	6.00	4.10	-32
Cl	5.33	5.59	4.88
MgO	3.91	3.13	-20
P_2O_5	3.12	8.02	156
SO_3	3.10	0.69	-78
Al_2O_3	2.08	5.52	165
Fe_2O_3	1.36	3.29	142
Na_2O	0.67	0.17	-75
TiO_2	0.26	0.18	-31
MnO	0.16	0.14	-13

Similarly, to calculate the percentage difference equation 1 below is adopted and the result is also shown in table 1 above.

$$\text{Percentage difference} = \frac{Acid\ wash - Untreated}{Untreated} \text{ x } 100 \tag{1}$$

Therefore, percentage difference of each chemical compound is shown in table 1, it is clear that silica has the highest percentage difference of 175 % which indicates that, after acid treatment silica increased by 175 %, so also Al_2O_3, Fe_2O_3 and CaO respectively.

X-Ray Diffraction Analysis (XRD)

The structure of untreated and acid treated POFA is characterized by X-ray diffraction analysis. The analysis is conducted using XRD Bruker D8 Advanced operated at room temperature with Cu-Kα radiation (1.54Â) with 2θ ranging from15º $\leq 2\theta \leq$ 90º to ascertain the structure of POFA powder. For better interpretation and analysis, the result from XRD data is then analyzed using X'Pert High Score application and presented in figure 1.

XRD result for acid treated POFA clearly indicates scattered peaks of amorphous structure, there is distribution of large peaks along the 2θ axis. For acid treated POFA, the major peaks detected are silica (SiO_2) also known as quartz that appear as crystalline phase as result of sharp peak detected along 2θ axis, whereas potassium chloride and sylvine are the minor peaks respectively. Similarly, for the untreated POFA, there is evidence of high intensity diffuse halo peak of amorphous structure with potassium chloride as major phase while quartz as minor phase.

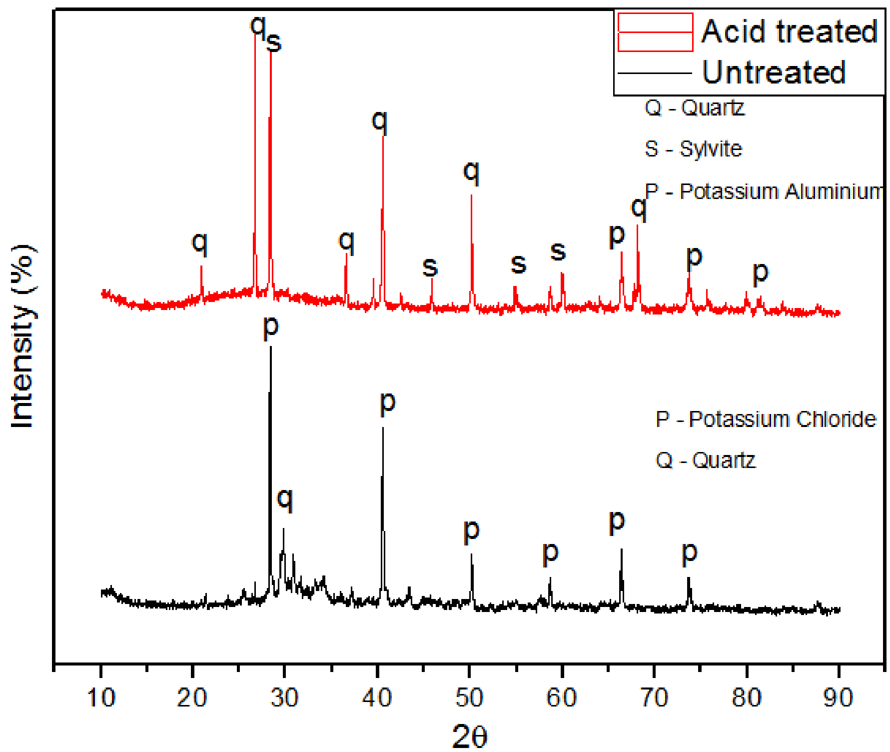

Figure 1. X-ray diffraction (XRD) pattern for Acid treated and Untreated POFA

Scanning Electron Microscopy (SEM)

Scanning Electron Microscopy (SEM) was used to check the morphology structure of untreated and acid treated POFA and the result is presented in figure 2 below.

Figure 2 (a) represent the untreated POFA which is spongy and porous, the texture has irregular and angular shapes that are amorphous in nature. It is pronounced that figure 2 (b) has a medium particle size that appear to be crushed than figure 2 (a). Similarly, for the acid treated sample, the structure is amorphous with irregular shapes, after acid treatment the powder agglomerates and forms a cluster of solid structure. As it is very difficult for the acid to pass through after the treatment due to the agglomeration, the sample has to undergo another grinding process before the characterization.

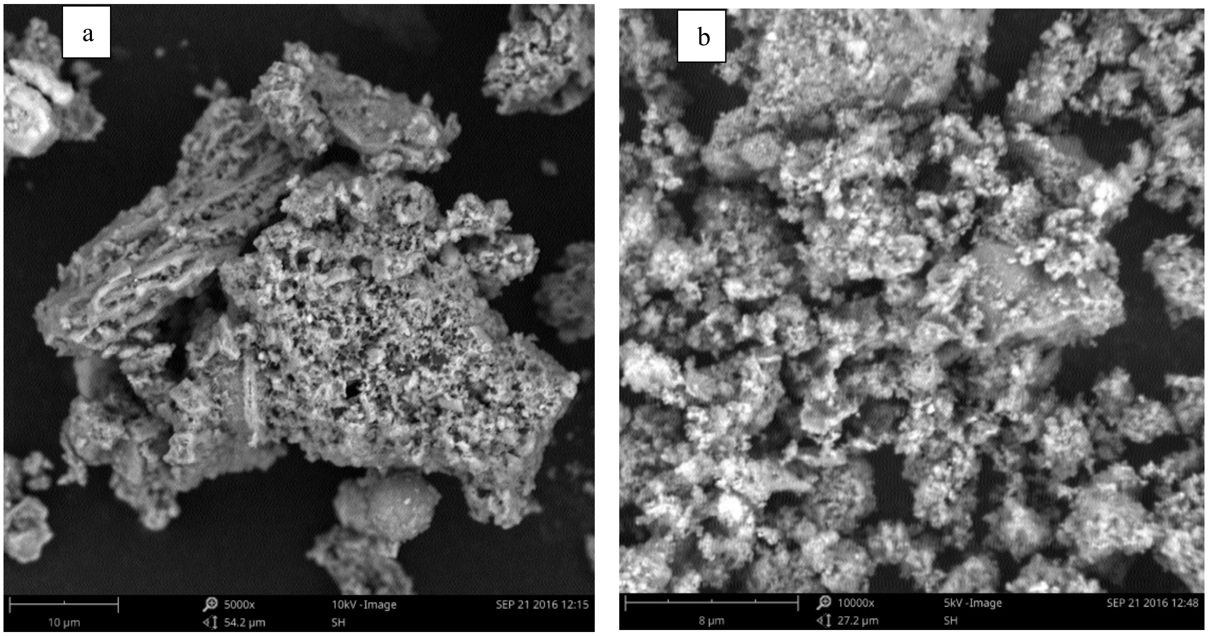

Figure 2. (a) Microstructure of Untreated POFA (b) Microstructure of Acidic Treatment

4. Conclusion

Based on the result of this study, it can be concluded that the acidic wash treatment is suitable for production of silica from palm oil fuel ash. The objective of the study was achieved which is to produce silica from palm oil fuel ash using acidic wash treatment, and to determine the chemical composition of acidic wash treated and untreated POFA. X-ray fluorescence analysis shows an increase of silica content due to acid treatment, this indicates that, acid treatment is good for the enhancement of the silica content in POFA. X-ray diffraction analysis supported the finding of XRF whereby after acid treatment silica became the major composition and many impurities were washed away.

Acknowledgements

The authors would like to acknowledge the support of Mr. Kamarul Affendi bin Hamdan, Mr. Shahrul Mahadi bin Ismail, Mr. Tarmizi bin Nasir, Mr. Anuar bin Ismail, Mr. Ishak bin Ayub and Mohd Yusof bin Mohd Sahil for their technical support as laboratory staff.

REFERENCES

[1] K. Muthusamy, N. W. Kamaruzzaman, M. A. Zubir, M. W. Hussin, A. R. M. Sam, and A. Budiea, “Long Term Investigation on Sulphate Resistance of Concrete Containing Laterite Aggregate,” *ARPN J. Eng. Appl. Sci.*, **11**, no. 4, pp. 2406–2411, (2016)

[2] K. Muthusamy, N. Zamri, and M. Amirulkhairi, "Effect of mixing ingredient on compressive strength of oil palm shell lightweight aggregate concrete containing palm oil fuel ash," *Procedia Eng.*, **125**, pp. 804–810, (2015)

[3] P. Chindaprasirt, S. Rukzon, and V. Sirivivatnanon, "Resistance to chloride penetration of blended Portland cement mortar containing palm oil fuel ash, rice husk ash and fly ash," *Constr. Build. Mater.*, **22**, no. 5, pp. 932–938, (2008)

[4] C. J. Brinker and G. W. Scherer, *Sol-gel science : the physics and chemistry of sol-gel processing*. Academic Press, 1990.

[5] L. Sun and K. Gong, "Silicon-based materials from rice husks and their applications," *Ind. Eng. Chem. Res.*, **40**, no. 25, pp. 5861–5877, (2001)

[6] U. Kalapathy, A. Proctor, and J. Shultz, "An Improved Method for Production of Silica From Rice Hull Ash," *Bioresour. Technol.*, **85**, no. 3, pp. 285–289, (2002)

[7] S. Pourakbar, A. Asadi, B. B. K. Huat, and M. H. Fasihnikoutalab, "Stabilization Of Clayey Soil Using Ultrafine Palm Oil Fuel Ash (POFA) And Cement," *Transp. Geotech.*, **3**, pp. 24–35, (2015)

[8] M. Z. Noh, H. U. Jamo, and Z. A. Ahmad, "Effect of temperature and composition of palm oil fuel ash on compressive strength of porcelain," *Appl. Mech. Mater.*, **660**, pp. 173–177, (2014)

[9] H. U. Jamo and M. N. N. Maharaz, "Influence of Mould Pressure and Substitution of Quartz By Palm Oil Fuel Ash on the Hardness of Porcelain Body," *Sci. World J.*, **9**, no. 4, pp. 23–28, (2014)