Effect of Particle Size from Oil Palm Wood Powder as Pore Forming Agent on Porosity and Hardness of Porous Ceramics based on Clay and Polyvinyl Alcohol

Marpongahtun*, Darwin Yunus Nasution and T. Hidayat
Chemistry Departement University of Sumatera Utara, Medan, North Sumatera , Indonesia

Keywords: Porous Ceramic, Polyvinyl Alcohol, Clay, Pore Forming Agent.

Abstract: Preparation of porous ceramics based on polyvinyl alcohol and clay has been carried out by using oil palm wood powder as a pore forming agent. Porous ceramics are made with a composition: 80% clay, 15% PVA and 5% oil palm wood powder. The size of the particles of palm oil wood powder is varied, namely 100, 150 and 200 mesh. The sintering process is carried out at a temperature of 1000 °C with a holding time of 2 hours. The chemical composition of clay is determined by EDX analysis. The porous ceramics produced were tested for porosity and hardness. The result shows that the particle size of oil palm wood powder is very influential on the hardness and porosity of the ceramic. The larger the mesh size of the particles of oil palm (the smaller the particle size) the higher the hardness of the ceramic, but the porosity is getting smaller.

1 INTRODUCTION

Polymer Porous ceramics are ceramics that have many pores so that the fluid can be absorbed into it. Porous ceramics, besides being able to absorb liquids and gases, are also relatively more resistant to high temperatures, corrosion and contamination of foreign matter, so that they can be used in various fields of application such as motorized vehicle exhaust gas filters. The quality of a porous ceramic product is largely determined by the pore size and the sintering temperature. Pore formation can be done by mixing ceramic raw materials with pore-forming agents based on organic materials such as cellulose. At the time of sintering at high temperatures the organic material will be oxidized to carbon dioxide gas which escapes out of the ceramic so that a small cavity is formed on the ceramic. Agricultural wastes or industrial waste used as pore forming agents are graphite (ALI *et al.*, 2017), rice husk ash (P.Sebayang, 2009), industrial fly ash waste (Dong *et al.*, 2010), paper waste (Dasgupta and Das, 2002), potato starch (Sengphet *et al.*, 2013) and Kenaf Powder (de Oliveira *et al.*, 2015).

The oil palm stem waste originating from the rejuvenation of oil palm plantations is mostly found in North Sumatra. The main components contained in oil palm stems are cellulose (39.77%), pentose (21.53%), lignin (18.10%), water (12.05%) ash (2.20%), SiO2 (0.71%). Based on the composition of the palm oil stem, which is mostly an organic compound, where high temperatures will be converted into gases, the oil palm stem can be a potential source of pore-forming agents.

In this study, palm oil stem waste powder was used as a pore-forming agent in the manufacture of porous ceramics which as far as is known has never been done. It is estimated that oil palm stem powder will be a good pore forming agent because it contains a lot of organic compounds such as cellulose, starch and lignin which at the sintering temperature will be oxidized to gases, especially carbon dioxide gas. This carbon dioxide gas will come out of the ceramic material and will leave pores on the ceramic produced. The number and size of ceramic pores can be adjusted by varying the particle size of the oil palm stem powder (100, 150 and 200 mesh). Next will be the characterization and testing of resistance and porosity. It is hoped that high quality porous ceramics will be obtained.

Marpongahtun, ., Yunus Nasution, D. and Hidayat, T.
Effect of Particle Size from Oil Palm Wood Powder as Pore Forming Agent on Porosity and Hardness of Porous Ceramics based on Clay and Polyvinyl Alcohol.
DOI: 10.5220/0008925902930296
In *Proceedings of the 1st International Conference on Chemical Science and Technology Innovation (ICOCSTI 2019)*, pages 293-296
ISBN: 978-989-758-415-2

2 MATERIALS AND METHODS

2.1 Materials

Clay is obtained from Wonosari Village, TanjungMorawa Sub-District, DeliSerdang District. Oil palm stem powder originated from Southeast Aceh District, Poliviniyl Alcohol produced by Sigma Aldrich.

2.2 Methods

2.2.1 Preparation of Palm Oil Stem Powder

The oil palm stems used are oil palm stems resulting from the rejuvenation of oil palm plantations. Furthermore, the outer bark of the oil palm stem skin is peeled and it is cut into smaller sizes. The inside of the palm oil stem is dried and then made into powder with sizes 100, 150 and 200 mesh and then soaked in water for 24 hours. Then dried until the water content is below 5%.

2.2.2 Clay Treatment

Clay is dried using an oven for 30 minutes at 105ºC. The dried clay is smoothed using a ball mill and sieved with a 200 mesh size sieve. Then weigh 10 grams, put it into a glass beaker and add 40 mL of 37% HCl solution. The mixture is stirred using a magnetic stirrer at 70ºC for 40 minutes. After the stirring process is complete, filtering is done using filter paper. Then the residue is put in a glass beaker andadd 40 mL of 15% NH_4OH solution, stirred, filtered and dry for 4 hours at 70ºC. Furthermore, the chemical composition ofthe clay that has been treated (activated) is determined by EDX analysis.

2.2.3 Manufacturing of Porous Ceramic

Manufacturing of porous ceramics is done by mixing and stirring until homogeneous clay, oil palm stem powder and PVA with a percent ratio of clay: oil palm stem powder: PVA is 80: 15: 5. Variations in particle size of oil palm wood are 100, 150 and 200 mesh. Then the dough is pressed with a pressure of 300 M.Pa with a hold time of 10 minutes. Then the specimen was removed from the mold and sintered at 1000 ° C for 2 hours. The porous ceramic material produced is determined by its porosity and morphology (Gregorová *et al.*, 2009) (Putri *et al.*, 2018).

2.3 Characterization

2.3.1 Hardness of Porous Ceramics

Ceramic hardness is determined using Digital Vickers Hardness Tester TH723/724 Closed-loop control system The hardness's calculated using the following formula: Hardness = $1.854(F/D^2)$, with D^2 the area of the indentation (measured in square millimetres) and F = the applied load (measured in kilograms-force)

2.3.1 Porosity of Porous Ceramics

Measurement of ceramic porosity is carried out by weighing the dry weight of the ceramic, then soaking the ceramic in water for 24 hours, after the ceramic has been dried with a cloth and then weighed again. Ceramic porosity is calculated using the formula:

$$P = [\frac{W1 - W)}{W0 - W2}]x100\% \qquad (1)$$

P = porosity of ceramics
W_1 = wet sample weight
W_2 = dry sample weight
W_0 = sample weight in water

3 RESULT AND DISCUSSION

3.1 The Oil Palm Wood Powder

The particle sizes of oil palm stem powder particles are 100, 150 and 200 mesh. The results are shown in Figure 1.

3.2 Clay

Prior to ceramic printing, the clay raw material is first activated with 37% Chloride Acid. Activation aims to increase the size of the pores of the clay so that the absorption of clay fluid increases. Figure 2 shows clay before and after activation.

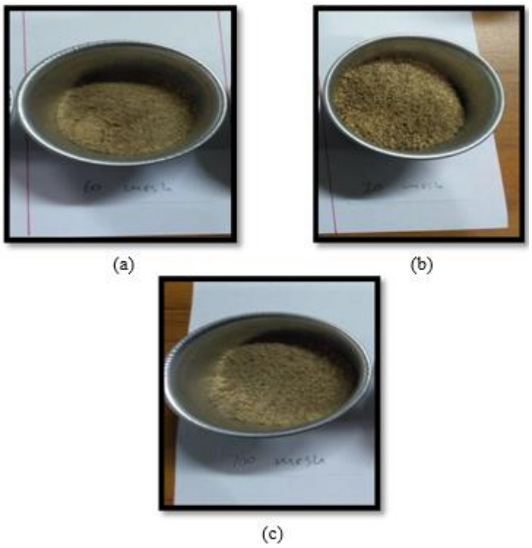

Figure 1: Oil palm stem powder (a) 100, (b) 150, (c) 200 mesh.

Figure 2: a) Clay before activation b) Clay after activation.

Table 1: Ceramic composition.

No	Composition			Particle size (Mesh)
	Clay	OPTP	PVA	
1	80	15	5	100
2	80	15	5	150
3	80	15	5	200

Table 2: Ceramic properties.

No	Porosity (%)	Hardness (MPa)
1	27	221.62
2	22	302.88
3	20	363.46

Table 3: Chemical element composition of clay after activation.

Element	Percentage
Si	23.72
Al	15.80
O	47.94
Fe	5.53
C	5.09
K	0.87
Ti	0.66
Mg	0.59

Elemental Analysis of activated clay were obtained by EDX analysis. Elemental composition were listed in Table 3.

3.3 Porous Ceramic

Porous ceramics are made with a weight percent ratio of clay: PVA: oil palm stem powder 80: 15: 5. Variation is the particle size of oil palm stem powder is 100, 150 and 200 mesh. Then sintered at 1000ºC for 2 hours. The results can be seen in Figure 3.

Figure 3: Porous ceramics with particle sizeoil palm stem powder a) 100 b) 150 c) 200 mesh.

3.4 Porosity of Porous Ceramics

There is a correlation between particle size of palm oil stem powder and porosity and hardness of ceramics. The smaller the particle size of oil palm stem powder, the size of porosity increases while the hardness decreases (Putri et al., 2018) (Zhi-, 2012). This means that if the porosity rises, the cavity in the ceramic material will increase so that the resistance to pressure decreases. On the one hand, with increasing porosity, it is estimated that the absorption capacity will increase.

3.5 Ceramics Morphology

The porous ceramics produced were tested for SEM to evaluate of the morphology of ceramics. The SEM photographs are shown in Figure 4.

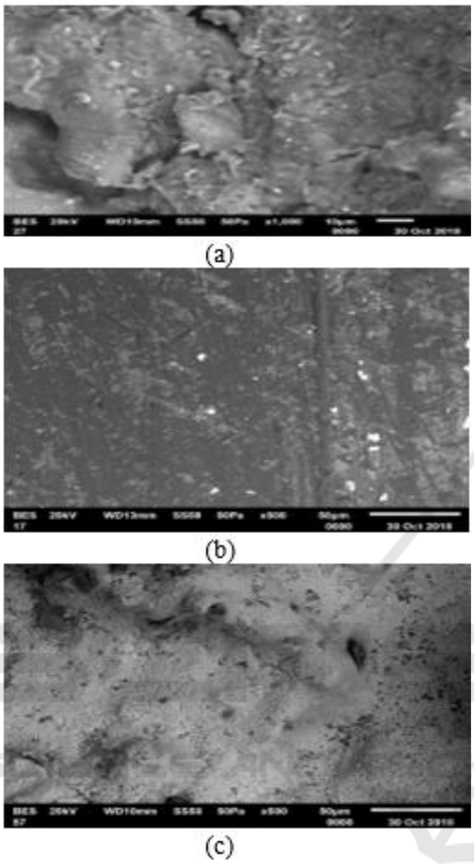

Figure 4: Photograph SEM of Porous Ceramics a) 100 b) 150 and c) 200 mesh.

From the SEM photograph, it can be seen that the larger the particle size the larger the ceramic pore is formed (Korjakins, Upeniece and Bajare, 2006) (Sandra, Budi and Sulsilo, 2014) Photo SEM in figure a shows a larger pore size compared to images b and c. This is in accordance with the smaller particle size of the coconut stem powder.

4 CONCLUSIONS

Porous ceramics can be made from clay and PVA by using palm oil stem powder as a regulating agent and pore forming. The particle size of palm oil powder has a significant effect on the hardness and porosity of the ceramic. The smaller the powder size the stronger the ceramic but the porosity decreases.

ACKNOWLEDGEMENTS

Author would like to thank to Rector of University of Sumatera Urara for the funding from the project of PD-TALENTA 2018.

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