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ANALYSIS FABRICATION OF POROUS CERAMICS FROM CLAY AND COPPER POWDER USING PALM OIL POWDER AS A PORE-FORMING AGENT FOR FILTERS IN MOTOR VEHICLE GAS

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ABSTRACT

A study was conducted on the utilization of oil palm wood waste in the production of porous ceramics, which were then used as a motor vehicle exhaust gas filter. The porosity, hardness, and morphology of the resulting ceramics were all measured. Using the gas analysis approach, ceramics with a higher porosity value were also examined for their exhaust gas filtration power. The study's findings show that the particle size of oil palm sawdust has a significant impact on porosity, hardness, and ceramic morphology. The porosity of the ceramic decreases as the particle size decreases, but the hardness increases. Porous ceramics have porosity levels of 60, 57, and 56 percent. Porous ceramics have hardness values of 221, 62, 302, 83, and 363, 46 MPa. And Filtration of exhaust CO gas 1.88%, CO2 1.1%, and HC 1123 ppm.

Keywords: Porosity, Ceramics, Clays, Filtration, Exhaust.

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INTRODUCTION

Ceramic materials consist of complex phases which are compounds of metal and non-metal elements that are bonded ionically or covalently. Ceramics generally have a structured crystalline and few free-electron.[1] The chemical composition of ceramics varies greatly from simple compounds to mixtures of several complex phases. Almost all ceramics are porous ceramics that have pores that can be permeated by fluid so that they can function as a filter for exhaust gases originating from motorized vehicles.[2,3] The research that has been done on the manufacture of porous ceramics by utilizing agricultural waste or industrial waste as a pore-forming agent is graphite[4,5], rice husk ash[6], industrial fly ash waste (wastewater ash).[7] Wood powder in the manufacture of porous ceramics for use in exhaust gas filters.[8,9] Porous ceramics based on zeolite, clay soil, coconut shell charcoal[10], and polyvinyl alcohol (PVA)[11,12] wood in the manufacture of porous ceramics for gasoline motorbike exhaust gas filters. Cellulose (39.77), pentose (21.53), lignin (18.10), water (12.05), ash (2.20), and SiO2 are the primary components found in oil palm stems, which are a plantation waste (0.71 percent).[13] Based on the composition of the content contained in palm oil are mostly organic compounds, which at high-temperature heating will change become gas, the palm oil stalk is a potential pore-forming agent in the formation of ceramics porous. The use of palm oil stem waste powder as a pore-forming agent in the fabrication of porous ceramics was investigated in this work, and to the best of our knowledge, it has never been employed in the development of porous ceramics before. Organic compounds, which can function as pore-forming agents at a sintering temperature of 1000°C, will be oxidized to gas, especially carbon dioxide (CO_2). The amount and the pore size can be adjusted by making various sizes of palm oil stem powder (20, 60, and 100 mesh). The

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porous ceramics that are produced will be used as a filter for gas emissions from motorized vehicles through a mechanism catalyst and absorption.

EXPERIMENTAL

Palm Wood was purchased by PT Perkebunan Nusantara III, Clay has purchased from Wonosari Village, Tanjung Morawa, Aquadest was purchased from Bratachem, and Copper (Cu) Powder. Ammonium hydroxide (NH4OH wt 28%), Hydrogen chloride (HCl wt 37%) were purchased from Sigma Aldrich Co. All chemical reagents are used without purification.

Clay Preparation

The clay is sourced from Wonosari Village in the Tanjung Morawa Subdistrict; the clay pieces are moistened with sufficient water, mixed, and allowed to stand for three nights before being processed five times with a crusher. After the clay has been prepared, it is activated with 37 percent hydrochloric acid (HCl) by the coprecipitation method (deposition).

Palm Oil Wood Powder (POWP) Preparation

The portion of the oil palm wood employed reaches a maximum height of 6 meters. The palm wood is also cut into pieces, the outside skin is peeled away, and the interior is dried and powdered with a size of 20 mesh, 60 mesh, or 100 mesh before being soaked in water for 24 hours. Then it was dried until the moisture content was less than 5%.

Porous ceramics Preparation

The traditional method of printing and pressing porous ceramics involves mixing clay, palm oil stem powder, and copper powder in an 80:15:5% ratio until homogeneous with variations in the size of oil palm wood 20 mesh, 60 mesh, and 100 mesh, which are coded as PC20, PC60, and PC100 sequentially. The mixture is then poured into the frame and compacted with water. Following that, the sintered mixture was maintained at 1000°C for two hours.

Characterization

Clay

The chemical composition of Clay raw materials is determined by Energy Dispersive X-ray (EDX) and morphology by Scanning Electron Microscopy (SEM).

Ceramic

Porosity

Ceramic porosity was determined by the gravimetric method. Ceramics with known mass sizes are immersed in a container filled with water for 48 hours. The percentage of porosity is calculated by the formula:

$$Porosity\ (\%) = \frac{\text{Weight gain of ceramic (g)}}{\text{Weight of ceramic before immersion (g)}}\, x\ 100\ \%$$

Hardness

Ceramic hardness is determined by means of a digital equivalent hardness tester.

Filtration Power

The filtration power of the porous ceramic is determined by installing the ceramic at the end of the exhaust. The concentration of gas coming out of the canal is measured with a Gas Analyzer

Morphology

Ceramic morphology was evaluated by scanning electron microscopy

RESULTS AND DISCUSSION

Analysis of Clay

The results of the analysis of clay raw materials used with SEM are shown in Fig.-1, and EDX data shows in Fig.-2. SEM images that show the material aggregate and cultivation. Table-1 shows the parameter of EDX data that atom O with a composition of 59.91%, Si with a composition of 16.89%, and Al with a composition of 11.71%.

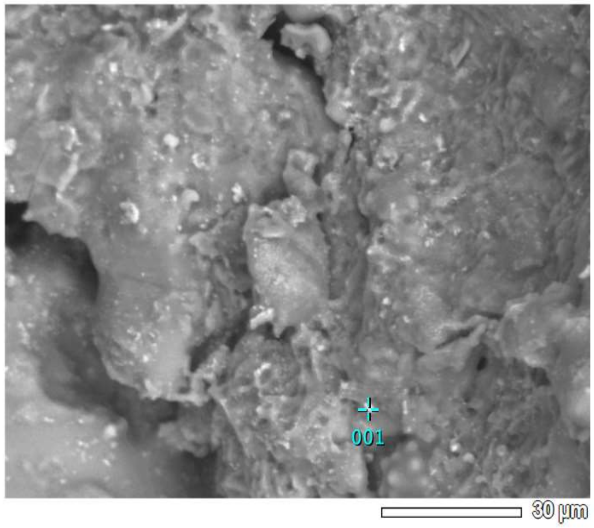


Fig.-1: SEM Image of Clay

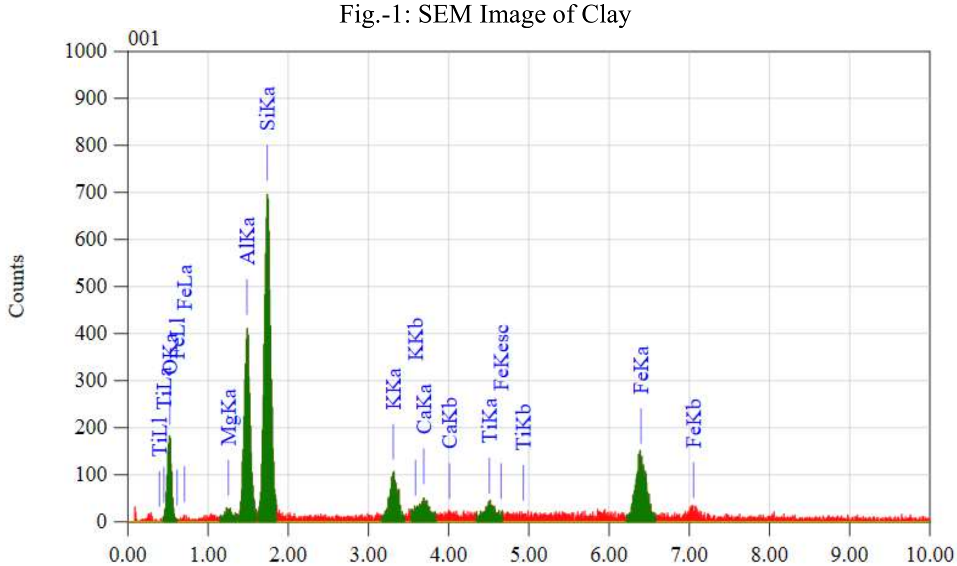


Fig.-2: EDX of Clay Content as Raw Materials

Table-1: Analysis of Clay by EDX

No	Chemical elements	Composition
1	O	59.91
2	Si	16.89
3	Al	11.71
4	Fe	1.94
5	C	8.47
6	K	0.45
7	Ti	0.2
8	Mg	0.32

Table-1 shows the results of clay analysis using EDX, the results show that the highest composition is obtained from oxygen, which is 59.91%

The clay activation process is carried out by adding HCl 37% using the coprecipitation or decomposition method. The purpose of this activation is so that the clay becomes more active and opens the pores of the clay so that the absorption of clay becomes maximum. In this study, we used acid to exchange cations in the clay for H+ ions and to release Al, Fe, Mg, and other impurities from the structural lattice, thus converting the clay surface into a pore region and active site.

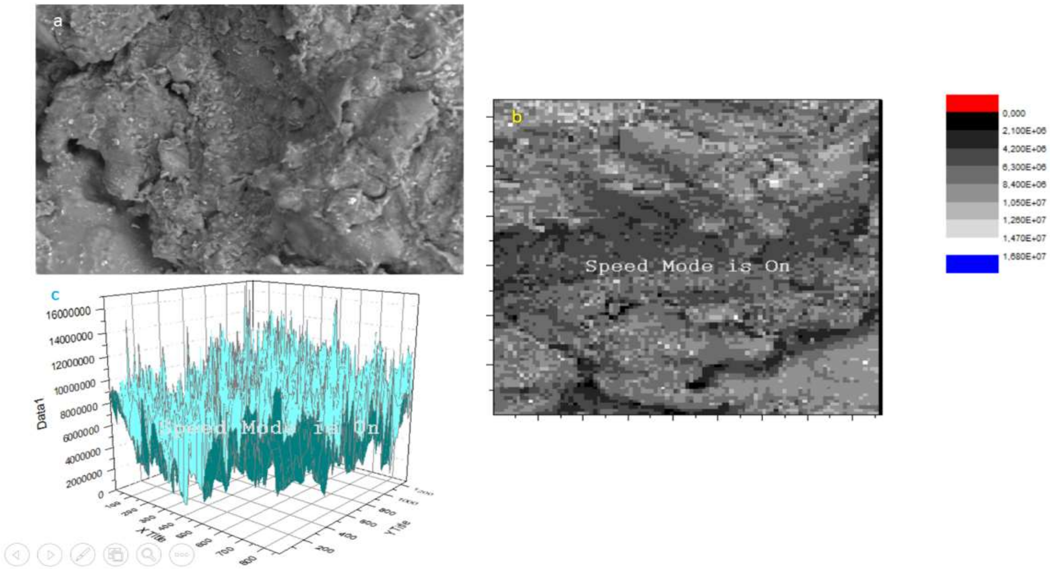


Fig.-3: SEM Clay Photograph Analysis using Origin Program, (a) The Morphology of Clay with Magnification 500x, (b) Grayscale of Clay, (c) 3D Images of Porous Materials

Porous Ceramics

Porous ceramics are produced from a mixture of Clay, POWP, and Cu Powder with a composition of 80:15:5% respectively. Variations in POWP sizes added by 20, 60, and 100 mesh each assigned a code PC20, PC60, and PC100 respectively

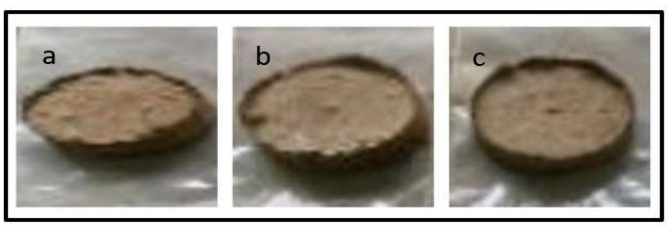


Fig.-4: Photo Images of PC20 (a), PC 60 (b), PC 100 (c)

Hardness Analysis

Hardness analysis is done with a digital equip hardness tester. Then calculate the Vickers hardness with the formula above which is taken from the average hardness of the 3x tests. The results of the hardness value for each porous ceramic can be seen in Table-4

Table-4: Ceramic Hardness Value

No.	Composition			Mesh	HV (Mpa)
	Clay	POWP	Cu		
1	80	15	5	20	221,621
2	80	15	5	60	302,883
3	80	15	5	100	363,460

Table-4 shows the hardness value in the size variation of porous ceramic palm wood powder with clay as a base material, palm oil wood powder, and copper powder (Cu) by sintering at 1000°C with a holding time of 2 hours has increased. Increase in value.

Filtration Power Analysis

On the formed ceramic, do a capability filtration examination to determine the high levels of exhaust gas that can be generated by vehicle exhaust gases before and after filtering. The particle size of the 20mesh sample was chosen in this study, which had a high porosity value of 60%. Exhaust gas emission analysis using a Gas Analyzer, this tool can show the levels of pollutants, namely CO, CO_2, HC, and NOx that come out of the exhaust hood of a motorized vehicle. The measurement results can be immediately known Through the print-out directly coming out of the tool, the measurement results include levels of CO 1.88 (%), HC1123 (ppm), and CO_2 1.1 (%). Based on the test results from the BK3 Medan (North Sumatera - Indonesia) the data obtained from the calculation of the percentage of radical gas absorption can be seen in Table-5 the absorption percentage of CO, CO2, and HC gases.

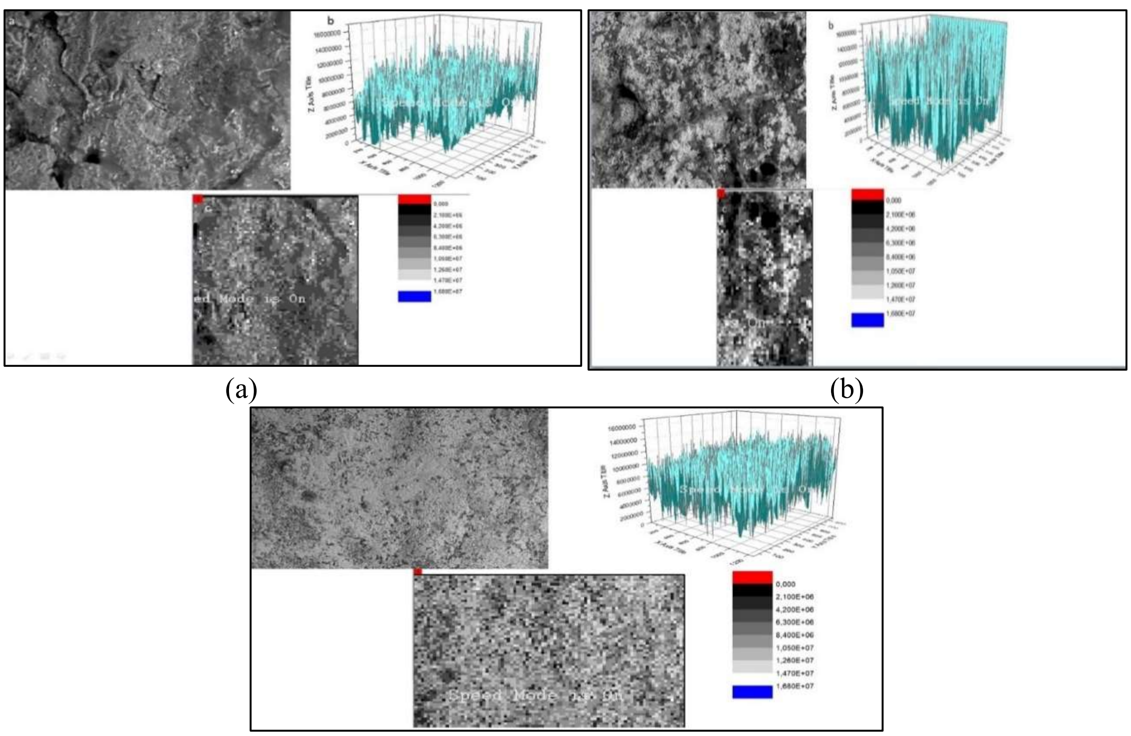
Table-5: Percentage of CO, CO_2, and HC Gas Absorption

No	CO		CO_2		HC	
	Before	After	Before	After	Before	After
1	4.29	1.88	2	1.1	142.5	112.3

From the three gases, it can be seen that HC gas is the largest percentage of gas absorption, followed by CO and the least is CO_2. Where CO absorbed 1.88%, CO_2 absorbed 1.1% and HC absorbed 1123 ppm. The amount of CO_2 absorbed is most likely because CO gas is more abundant in the air than other gases. CO gas is produced not only from the exhaust fumes of passing automobiles on the street, but also from the burnt products produced by the community, industry, and others where CO 56%, HC 21%, and CO2 45% filtering levels are achieved.

Morphology Analysis

The resulting porous ceramics were then subjected to SEM tests to see the pore size morphology and the composition of the ceramics formed. The shape of the porous ceramic particles observed by SEM is shown in Fig.-1 which is the result of SEM observations at a magnification of 500 times from the SEM photo. The combustion process at high temperatures transforms the solid into a gas, affecting the number and size of pores on the porous ceramic surface, resulting in an uneven surface and apparent pore gaps in the sample. This is a result of the sample being heated or sintered. The morphology and porosity of the samples were analyzed using Origin Pro 8.5 software on the results of SEM photos at 500 times magnification, which can be seen in Fig-5.



(a) (b) (c)

Fig-5. Morphology PC20 image with PC20 3-dimensional image (a) Porous Ceramic 20 Mesh (PC20), (b) Porous Ceramics 60 Mesh (PC60), and (c) Porous Ceramics 100 Mesh

SEM magnification 500x image analysis (Fig.-5a), using origin pro 8.5 software produces metrics data consisting of X and Y axes showing the metrics values and produces metrics data that is plotted into a 3-dimensional image (b) consisting of solid (crystalline) parts and the porous part, then from the metrics data, it is obtained Gray Scale Colour (c) the color level indicates the depth of location in a volume. Porosity calculation (Table-2) uses the following equation:

$$\text{Vsolid} = \int_{Ymin}^{Ymax}\int_{Xmin}^{Xmax} f(X,Y)dxdy \tag{1}$$

$$\text{Vtotal} = \int\text{max (Xmax – Xmin) (Ymax – Ymin)} \tag{2}$$

$$\emptyset = \frac{Vpore}{Vtotal} = \frac{(Vtotal - Vsolid)}{Vsolid} \tag{3}$$

Table-2: Porosity Calculation based on Data Metrics SEM magnification 500x image of samples PC20, PC60, PC100

No.	Data Metric	Sample		
		PS20	PS60	PS100
1	H_{max}	1,68x10^{7}	1,68x10^{7}	1,68x10^{7}
2	H_{min}	0	0	0
3	X	1265	1237	1253
4	Y	871	865	863
5	Z	1,68x107	1,68x10^{7}	1,68x10^{7}
6	V_{total}	1,85x10^{13}	1,80x10^{13}	1,82x10^{13}
7	$V_{integral}$	7,45x10^{12}	7,65x10^{12}	7,45x10^{12}
8	V_{solid}	7,45x10^{12}	7,65x10^{12}	7,45x10^{12}
9	$V_{under\ the\ curve}$	0	0	0
10	V_{pore}	1,11x10^{13}	1,03x10^{13}	1,02x10^{13}
11	Porosity (%)	**60**	**57**	**56**

Table-3 shows that the value of porosity in the size of oil palm sawdust in the manufacture of porous ceramics with clay, oil palm wood powder, and copper powder (Cu) sintered at a temperature of 1000˚C with a holding time of 2 hours has decreased, this decrease in porosity proves that the greater the size of oil palm sawdust on porous ceramics causes the porosity value to increase or be directly proportional to it. The porosity value of porous ceramics with various sizes pores of 20 mesh, 60 mesh, and 100 mesh range between 60%, 57%, 56% respectively, according to the literature, porous ceramics that act as filters absorb between 25.89% and 32.16% of water.

Table-3: Ceramic Porosity Value

No.	Composition			Mesh	Porosity (%)
	Clay	POWP	Cu		
1	80	15	5	20	60
2	80	15	5	60	57
3	80	15	5	100	56

CONCLUSION

Clay activated with HCl is a porous material with a porosity of 57%, making clay a matrix capable of maximizing the absorption of porous ceramics. Porous ceramics that are used as motor vehicle exhaust gas filters at a composition value of 80%: 15%: 5% and with a temperature of 1000˚C with 20, 60, and 100 mesh produce porosity values of 60; 57; and 56% and hardness values of 221.621; 302. 883; and 363. 460 MPa. In the morphological analysis using SEM, it can be seen that the distribution of the pores has begun to appear in the sample. From the results of the filtration data analysis on the resulting porous ceramics, it can be seen that CO is absorbed by 1.88%, CO2 is absorbed by 1.1% and HC is absorbed by 1123 ppm.

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