Research Progress in Mechanical and Manufacturing Engineering Vol. 3 No. 1 (2022) 915-920
© Universiti Tun Hussein Onn Malaysia Publisher's Office

RPMME

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

Characterization of Silica from Pasir Puteh, Kelantan Rice Husk for Water Filter Application

Amirul Eizlan Hadi Abd Aziz[1], Sufizar Ahmad[2]*

[1]Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[2]Functional Composite Structure, Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rpmme.2022.03.01.097
Received 01 Dec 2021; Accepted 01 April 2022; Available online 30 July 2022

Abstract: Water is a basic need for every human being but in order to get clean and safe water, water needs to be treated and filtered so that the water is safe for humans to drink and use. Therefore, the initiative to help this problem is to produce a ceramic type water filter from rice husk. Rice husk is an agro waste that is very much produced in this world. By applying rice husk, the problem of large piles of rice husks can be reduced. In this study, water filter samples were produced from burned rice husk (BRH). The filter composition is 95% BRH and 5% Polyethylene Glycol (PEG). Water filter samples were produced using powder compaction method. Then, the filter go through the sintering process at a temperature of 900 °C, 1000°C and 1100°C. Density and porosity tests as well as water absorption tests were performed to see the physical properties of the water filter samples. The analysis performed is microstructural analysis and element composition analysis. Sample C showed the highest bulk density with value of 1.3153 g/cm^3 and the lowest apparent porosity percentage with value of 39.89%. The percentage of water absorption in sample C was the lowest at 30.35%. Therefore, the best water filter sample is sample C based on the test results. In conclusion, the sintering temperature affects the physical properties of the water filter samples produced from the BRH.

Keywords: Rice Husk, Silica, Water Filter, Density, Porosity, Water Absorption

1. Introduction

Rice husk is a waste material in the process of rice grains into rice. There are almost 0.48 million tons of rice husk produced annually in Malaysia [1]. The yield of rice husk causes pollution to the environment because it is usually burned [2]. This indirectly contributes to air pollution [3]. Nevertheless, rice husk burned to ash can provide a silica content value of 94% - 96% [4].

1.1 Silica from rice husk

**Corresponding author: sufizar@uthm.edu.my*

According to other sources the main component in rice husk ash burned at moderate temperatures produces 80% - 97% amorphous silica composition [5]. Amorphous silica can also be produced by burning rice husk at temperatures below 800℃. Meanwhile, burning rice husk at temperatures above 800℃ produces crystalline silica [6]. The silica content produced from rice husk ash can also be commercialized in the use of water filters. This is because silica has a source of activated carbon and it is tested as an adsorbent [7].

1.2 Water filter rice husk

Water pollution is increasing in Malaysia and water pollution is seen through river water, groundwater and sea water. Therefore, by producing silica from rice husk for water filter application it can help purify the water. Water filters made of ceramic on the market show that ceramic filters have the potential to filter unnecessary substances in water [7]. The use of silica in ceramic filters can also provide a high level of absorption of unwanted substances in the water. In addition, it also provides strength and hardness to ceramic filters by performing the process of burning rice husk at high temperatures [8].

2. Materials and Methods

The materials, methods and equations or otherwise known as methodology, describes all the necessary information that is required to fabricate the water filter sample. It is also to obtain the results from the test and analysis that is done in this study.

2.1 Materials

Raw material used in this study is burnt rice husk (BRH) with binding agent Polyethylene Glycol (PEG). Composition for water filter sample are 95% BRH and 5% PEG with weight of 0.5g. Sample shape is round cylinder. Specifications and properties of materials, equipment, and other resources used in the current study should be described in this section.

2.2 Methods

BRH is milled to micron size and sieved to 160 micron size. Then, BRH is mixed with PEG and go through powder compaction process (dry pressing). After that, green body of water filter is produced. Sample then go through sintering process with temperature of 900°C (sample A), 1000°C (sample B) and 1100°C (sample C). Later, sample is tested for density and porosity test as well as water absorption test according to ASTM C20 standard. Final result is obtained by getting the average value for all test. Sample after sintered is also analysed with microstructure analysis and element composition analysis.

2.3 Equations

Equations and formulae used according to ASTM C20 standard to get the bulk density (*B)*, apparent porosity (*P*) and water asbsorption (*A*). The formula is as follows:

$$Exterior\ volume, V = W - S \qquad \text{Eq. 1}$$

$$Apparent\ porosity, = \frac{W - D}{V} \times 100 \qquad \text{Eq. 2}$$

$$Bulk\ density, B = W - S \qquad \text{Eq. 3}$$

$$Water\ absorption, A = \frac{W - D}{D} \times 100 \qquad \text{Eq. 3}$$

3. Results and Discussion

The results will consist the colour change of water filter samples after sintering process, average value of all test (bulk density, apparent porosity and water absorption). It also shows the result of microstructure analysis and element composition analysis..

3.1 Colour of water filter samples after sintering

Figure 1 shows the colour change of water filter samples after sintering. Sample X represents sample that not go through sintering process.

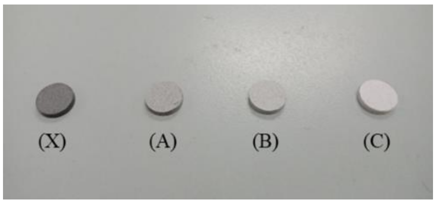

Figure 1: Colour change of samples

It can be observed that after the completion of the sintering process at 900°C, the color of sample A has changed from dark gray to light gray. At 1000°C, the color of sample B has changed from dark gray to light gray as well but is brighter than sample A. Next, the color of sample C at 1100°C has changed from dark gray to white. It can be assessed that the higher the sintering temperature, the brighter the color for each sample of rice husk.

3.2 Average value of all test result (bulk density, apparent porosity and water absorption)

All test is conducted for three times for each sintering temperature. Then, the average value is taken. Table 1 shows the average value of all test.

Table 1: Average value of all test

Sample	Bulk density, B (g/cm^3)	Apparent porosity, P (%)	Water absorption, A (%)
A	1.3087	42.36	32.39
B	1.3096	41.33	31.57
C	1.3153	39.89	30.35

From Table 1, sample A has the lowest bulk density value of 1.3087 g/cm^3 and sample C has the highest bulk density value of 1.3153 g/cm^3. The highest percentage of apparent porosity was in sample A which was 42.36% and the lowest percentage of apparent porosity was in sample C which was 39.89%. The highest percentage of water absorption is in sample A which is 32.39% and the lowest percentage of water absorption is in sample C which is 30.35%. Result from table shows that when sintering temperature increase, the bulk density is increase, apparent porosity and water absorption is decrease.

3.3 Graph of bulk density, apparent porosity and water absorption against temperature

Figure 2, 3 and 4 below shows the graph of bulk density, apparent porosity and water absorption against sintering temperature. This graph is to clearly show the trend of sample when go through different sintering temperature.

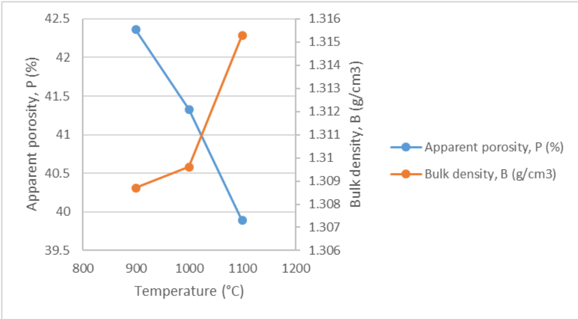

Figure 2: Apparent porosity and bulk density against temperature

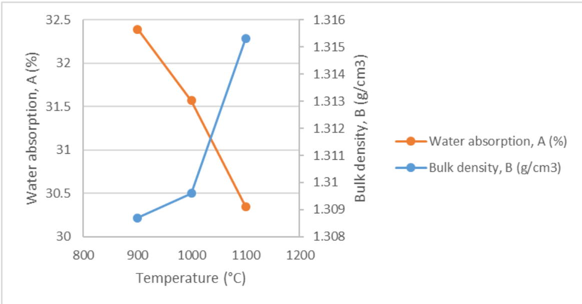

Figure 3: Water absorption and bulk density against temperature

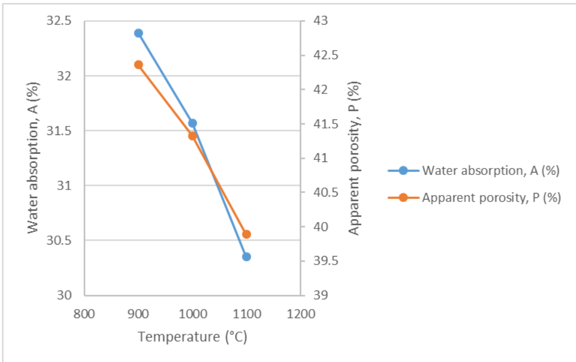

Figure 4: Water absorption and apparent porosity against temperature

3.4 Microstructure analysis

Figure 5 shows the micrograph of sample A, B and C with 1500× magnification. It shows that the sintering temperature affects the microstructure of samples. The higher the sintering temperature, the smaller the pore size and the particles become larger due to the fusion between the particles and the higher the densification.

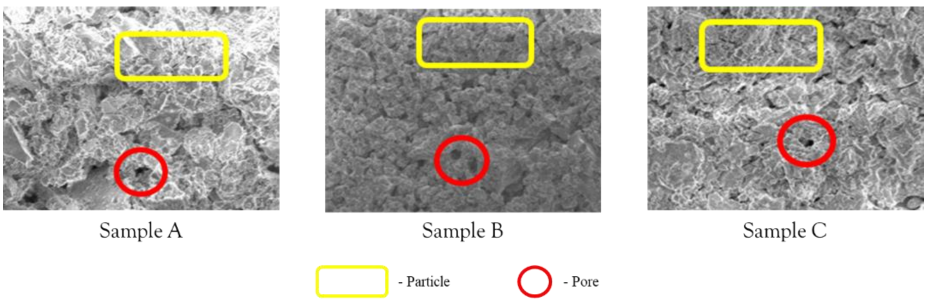

Figure 5: Micrograph of sample A, B and C

3.4 Element composition analysis

Table 2 shows the element composition of each sample. Showed that rice husk samples that through sintering process at 900°C, 1000°C and 1100°C does produced silica. Changes in sintering temperature can affect the weight of the elements in each sample. The higher the sintering temperature, the greater the weight of the oxygen element and the lower the weight of the silicon element. Increase in oxygen is due to oxidization [9].

Table 2: Element composition of each sample

Sample	Element	Weight (%)
A	Oxygen (O)	51.1
	Silicon (Si)	48.89
B	Oxygen (O)	60.29
	Silicon (Si)	39.71
C	Oxygen (O)	66.07
	Silicon (Si)	33.93

4. Conclusion

It can be concluded that sintering temperature affects the physical properties of the water filter samples. As the sintering temperature increases, a color change occurs from dark to light on the water filter sample. Then, increase in sintering temperature also causes the bulk density value of the sample to increase and the percentage of apparent porosity of the sample to decrease. In addition, the water absorption percentage of the sample also decreases as the sintering temperature increases. Through microstructural analysis, it is proves that there is a change in the microstructure of the sample when the sintering temperature increases where the pores get smaller and the particles get larger. As for element composition analysis, it is shown that the water filter sample does contained silica.

Acknowledgement

The authors would like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for the support in conducting the research.

References

[1] Shafie, S. M. (2016). A review on paddy residue based power generation: Energy, environment and economic perspective. *Renewable and Sustainable Energy Reviews*, *59*, 1089-1100.

[2] Ahmed, A. E., & Adam, F. (2007). Indium incorporated silica from rice husk and its catalytic activity. *Microporous and mesoporous materials*, *103*(1-3), 284-295.

[3] Akinyele, J. O., Olateju, O. T., & Oikelome, O. K. (2015). Rice husk as filler in the production of bricks using gboko clay. *Nigerian Journal of Technology*, *34*(4), 672-678.

[4] Putro, A. L., & Prasetyoko, D. (2007). Abu sekam padi sebagai sumber silika pada sintesis zeolit ZSM-5 tanpa menggunakan templat organik. *Akta kimindo, 3*(1), 33-36.

[5] Uddin, M. N., RASHID, M. M., Taweekun, J., Techato, K., Roy, R., & Rahman, M. A. (2018). Investigation on producing silica from rice husk biomass. *International Journal of Renewable Energy Resources*, *8*(1), 7-12.

[6] Rufai, I. A., Uche, O. A. U., & Ogork, E. K. (2012). Biosilica from rice husk ash a new engineering raw material in Nigeria. In *National Engineering Conference Exhibition and Annual General Meeting "Harmony* (Vol. 2012, pp. 1-20).

[7] Zainal, N. S., Mohamad, Z., Mustapa, M. S., & Badarulzaman, N. A. (2020). Characterization of Amorphous Silica and Crystalline Silica From Rice Husk Ash on Water Filtration Application.

[8] Li, Z., Zhang, J., Du, J., Han, B., & Wang, J. (2006). Preparation of silica microrods with nano-sized pores in ionic liquid microemulsions. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *286*(1-3), 117-120.

[9] Li, D. (Ed.). (2008). *Encyclopedia of microfluidics and nanofluidics*. Springer Science & Business Media.