AIP Conference Proceedings

RESEARCH ARTICLE | JANUARY 19 2024

The effect of sintering temperature of silica water filter produced by slip casting method

Syahmie Sufi Abdul Shukor; Sufizar Ahmad; Shahrul Nizam Rosli; Hamimah Abd. Rahman; Shahruddin Mahzan; Mohd. Azham Azmi; Azzura Ismail; Firdaus Muslem

Check for updates

AIP Conf. Proc. 2925, 020051 (2024)
https://doi.org/10.1063/5.0183215

View Online
Export Citation
CrossMark

01 February 2024 02:04:25

AIP Publishing

The Effect of Sintering Temperature of Silica Water Filter Produced by Slip Casting Method

Syahmie Sufi Abdul Shukor[1, a)], Sufizar Ahmad[2, b)], Shahrul Nizam Rosli[2, c)], Hamimah Abd. Rahman[2, d)], Shahruddin Mahzan[2, e)], Mohd. Azham Azmi[2, f)], Azzura Ismail[2, g)] and Firdaus Muslem[2, h)]

[1]*Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400, Parit Raja, Johor, MALAYSIA*
[2]*Functional Composite Structure, Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, MALAYSIA*

[a)]syahmiesufi@gmail.com
[b)]Corresponding author: sufizar@uthm.edu.my
[c)]cd190106@siswa.uthm.edu.my
[d)]hamimah@uthm.edu.my
[e)]sharudin@uthm.edu.my
[f)]azham@uthm.edu.my
[g)]azzura@uthm.edu.my
[h)]pdaus495@gmail.com

01 February 2024 02:04:25

Abstract. The types of silica that can be obtained from the rice husk waste product included crystalline and amorphous silica. Since the process to obtain the amorphous silica is much more energy-saving than crystalline silica, this study is fully utilizing the amorphous silica to produce the silica water filter. Meanwhile, for the preliminary studies will be conducted by using synthetic silica. In light of that, this study aims to produce amorphous silica from rice husk waste product that can be obtained from the area of Pasir Puteh and Pasir Tumboh, Kelantan. Other than that, this study also aims to fabricate the silica water filter by using the Slip Casting method, and next, investigate the physical and mechanical properties of the developed silica water filter. In this study, the method that will be used to fabricate the silica water filter Slip Casting method. For the preliminary studies of this research, the synthetic silica will be used to test the work rate of the mould for the method mentioned. After the fabrication process, the silica water filter will undergo several testing processes. The testing processes consists of Scanning Electron Microscope (SEM), shrinkage analysis, porosity analysis, density analysis and water absorption analysis. Under this research, amorphous silica with very low residual carbon content (approximately 1.0wt% residual carbon) was successfully being produced. The optimum freeboard height to prevent sand contamination and to achieve complete carbon burnout in the silica rice husk was found to be at least 5000mm. The obtained results indicate that the Slip Casting method can be used to produce the silica water filter. The water that have been flown through the silica water filter have been observed from time-to-time. This shows that the silica water filter has successfully absorbed the unwanted contaminants and change the colour of the water from muddy colour to a clear colored water. In conclusion, the different silica composition and temperature used greatly influence the rate of porosity, density and water absorption of water filtration. For the suggestion of this study, hopefully this research study can have the continuity to have a deeper and more precise case study so that this research study can produce a more effective and efficient silica water filter to help those in needs.

Advanced Materials Characterization Techniques 2022
AIP Conf. Proc. 2925, 020051-1–020051-7; https://doi.org/10.1063/5.0183215
Published by AIP Publishing. 978-0-7354-4804-9/$30.00

INTRODUCTION

The abundant of rice husk today is the reason why many researchers want to study the benefits and appropriate ways to increase the use of rice husk as well as reduce the waste produced by paddy agriculture. Many advantages that can be produced by rice husk which is into fuel and fertilizer. Rice husk is not popular with farmers because it is so cheap to sell. Therefore, the waste produced by paddy crops is a contributor to abundant and causes this waste not to be used.

The rice husk is the outer layer of a rice seed or grain. To protect the seed during the growing season, it is made by hard elements like as silica. Silica is a basic raw material widely used in the semiconductors, ceramics, polymers, and materials industries [1]. The relative amount of silica was increased after burning out the rice husk at different times and temperatures. A 95% silica powder could be produced after heat-treating at 700°C for 6 hours [2]. Silica in rice husk ash contain of amorphous and crystalline. According [3], amorphous and crystalline silica of rice husk ash can be produced when burned at 550ºC to 800ºC and 900ºC to 1300ºC, respectively. It is very important to find pathways to fully utilize the rice husk ash. This generates rice husk ash, which contains a huge quantity (85-95%) of amorphous silica [4]. Then, it is a low-cost and renewable resource, rice husk is a promising adsorbent material for eliminating various pollutants. So that, the type of water filter is chosen is amorphous silica because of the low consumption of energy to produce and good absorbent bad particle of water.

Greentech is short for green technology and refers to environmentally friendly technologies. It can also refer to the manufacture of clean energy. So that, the use of rice husk in the fundamental of fabricating water filter is one of the green technologies because the effect of manufacturing of product reduces the impact on the environment and the uses of the water filter that have been crushed can be reused as fertilizer for paddy agriculture.

Ceramic water filtration is the process of filtering water from pollutants or bacteria using a porous ceramic medium [5]. From generations to generations, water filters have evolved out of a desire to improve bad tastes, then to effectively remove that may cause diseases, and finally to eliminate items that affect appearance. Water filter serves its function through its pore size, which is small enough to trap anything bigger than a water molecule and bacteria [6]. The purpose of this study is to investigate the fabrication a silica filter using the slip casting method as well as to investigate the physical and mechanical characteristics of silica before and after producing the silica water filter.

Rice is an oat grain that is consumed by a large portion of the world's population, particularly in Asia. Rice husk, on the other hand, is the outer layer of rice that forms throughout the rice production process. It is widely produced and readily available around the world, and it is classified as agro-waste. Abundant of paddy husk is dumped in open areas. This is very harmful to the soil and pollutes the environment [7]. Various measures have been taken throughout the year to incorporate rice husk into various materials with the goal of producing a new class of compounds with enhanced qualities, ensuring that it remains in high demand. Rice husk is an excellent insulator that makes it difficult to digest and hard for parasites to breed. It also has an infinite number of floristic fibers, proteins, and some useful assemblies like carboxyl and amidogens [8]. Various business applications will lead to inspections of rice husk usage in rice-producing countries. Rice husk is a low-cost raw material that is tough to come by. Several regulations have been passed prohibiting the use of rice husk in construction materials, pillows, and fertilizers.

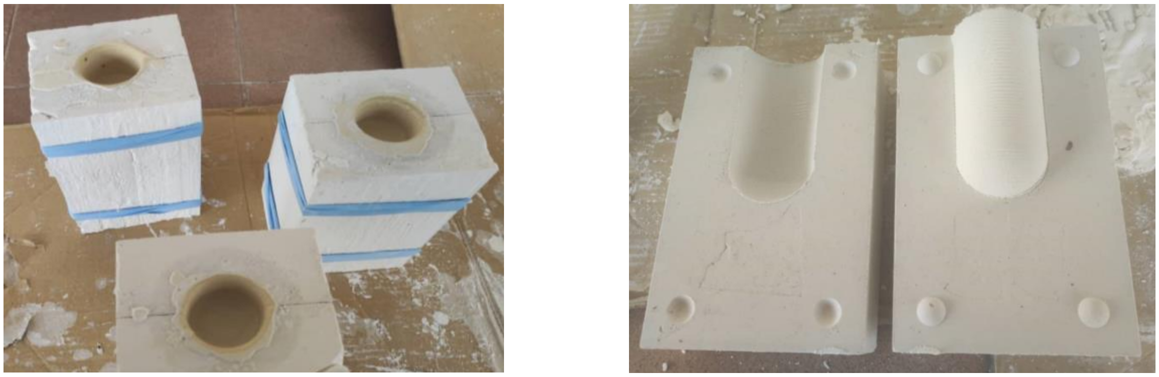
METHODOLOGY

The production of silica-based water filters in this particular research used raw materials such raw silica and other components. This subsection will go into more detail about some of the basic materials that were used in this project. One of the main components used in the manufacture of this water filter is silica. This silica can be found as crystalline form, and it contains roughly 96.99% silica by weight. Based on the composition of the silica, which is 50wt.%, 60 wt.% and 70 wt.% silica, respectively, the silica was divided into a few different samples.

To establish the weight of silica that has been set before adding the silica to the beaker, the beaker is first weighed before the slip casting process begins. To create the required silica composition, silica is added to the beaker in accordance with a predetermined weight after it has been weighed. The water is then added to a beaker of silica at the predetermined weight and ratio. The beaker is weighed before the bentonite filler is added in accordance with the specified weight and ratio, which is the same process used with silica. The water and silica mixture in the beaker are swirled until well combined to form a slurry. A POP mould is filled with this slurry.

01 February 2024 02:04:25

Figure 1 (a) below shows the slip casting process for producing the silica water filter. The slurry will be held for a certain period of time to gain the green body of the silica water filter. Figure 1 (b) shows the green body that have been produced by using the slip casting process.



(a) (b)

FIGURE 1. Slip casting process for fabricating the silica water filter

To further enhance the sample structure, bentonite was also added to the slurry combination. Through the pores of the POP mould, the water content in the slurry is absorbed and eliminated. This is because, in accordance with the plan of the cylindrical plaster mould, the POP mould will develop a layer of silica water filter on its surface. The extra slurry is fully removed from the mould to create the right shape for the water filter once the silica layer of the filter reaches the desired thickness. After being entirely removed from the plaster mould, the sample silica water filter is subjected to the sintering process using the sintering method at a temperature of 1000 °C.

01 February 2024 02:04:25

Archimedes' Theory (Density and Porosity Analysis)

In this study, in order to enhance the determination of density and porosity which is to analyze the physical properties, the Archimedes' theory was applied by using the water displacement (Archimedes) Method.

For the water immersion, a borosilicate glass beaker full of distilled water was utilized. A beaker containing distilled water and fine wire was placed hanging on the scales and has been set to zero (0) value. The dry weight of the sample (W_d) was recorded after the scales showed a stable value. Submerged weight of the sample (W_s) was recorded after the scales showed a stable value. Finally, the sample was removed from the beaker and the wet weight of sample (W_w) was measured. The percentage of density and porosity has been easily defined and recorded by calculating the difference in weight before and after the immersion. The bulk density and the percentage of porosity were defined as shown below.

$$\text{Bulk Density} = \frac{W_d}{W_w - W_s} \times \rho_{(\text{water})} \quad (1)$$

$$\text{Percentage of Porosity} = \frac{W_w - W_d}{W_w - W_s} \times 100\% \quad (2)$$

Where;

W_d = Dry Weight (g)

W_s = Soaked Weight (g)

W_w = Wet Weight (g)

ρ = Density of Water (g/cm^3)

RESULTS AND DISCUSSIONS

This section describes the water filter analysis data and relates it for the purpose of improving the quality of silica water filter products. All results or data need to be observed more carefully to ensure that the water filter data produced is an authentic and reliable source for further study in the future. This is because the results and analysis data that have errors may cause problems in improving the level of quality and productivity to be studied later.

The Presence of Silica in Water Filtration Analysis

According to the percentage of silica composition, the Dispersive Energy X-Ray (EDX) analysis indicates the overall presence of silica in this water filter sample. This is shown by the weight and percentage of atoms in the sample.

Table 1 below shows that oxygen (O) has a high weight percentage of 52.05% compared to the weight percentage of silica (Si), which is 47.95%. This shows that the oxygen content dominates the structure of this silica water filter sample for a composition of 50wt.%.

TABLE 1. 50wt.% of silica element in the sample

Element	Weight Percentage (%)	Atomic Percentage (%)
Oxygen (O)	52.05	65.58
Silica (Si)	47.95	34.42

Table 2 below shows the results of EDX analysis for samples with a 60wt.% silica composition. The highest total weight percentage is also in favor of oxygen (O) particles, which are produced at a rate of 51.30% compared to silica, which has a weight percentage of 48.70%. This is because oxygen and silica gain a higher percentage compared to the other elements in this water filter sample.

TABLE 2. 60wt.% of silica element in the sample

Element	Weight Percentage (%)	Atomic Percentage (%)
Oxygen (O)	51.30	64.90
Silica (Si)	48.70	35.10

Based on Table 3, the results of EDX analysis for samples with 70wt.% silica composition showed that the total weight percentage was more to oxygen (O) particles, which was 54.26% compared to silica, which had a weight percentage of 45.74%. In fact, the percentage of elemental particles is also dominated by the element oxygen, which is 67.56%.

TABLE 3. 70wt.% of silica element in the sample

Element	Weight Percentage (%)	Atomic Percentage (%)
Oxygen (O)	54.26	67.56
Silica (Si)	45.74	32.44

Density and Porosity Analysis

The porosity analysis findings are shown in the bar chart above, which is based on Figure 2. Sample for 60wt.% silica composition has the maximum total porosity of 0.474 percent, while sample for 50wt.% silica composition has the lowest total porosity of 0.394 percent. The type of fillers used influence the findings of the porosity analysis. There can be less bentonite utilized during the sintering process than there was before to the sintering process, resulting in the water filter sample having a porous silica surface. For its high porosity percentage, sample for the 60wt.% silica composition had the lowest density rate of all the water filter samples tested. It is also more prone to

01 February 2024 02:04:25

cracking and breaking. As a result, this porosity analysis can be used to determine the amount of impurity that can be filtered out of water by looking at the percentage of porosity in the water filter.

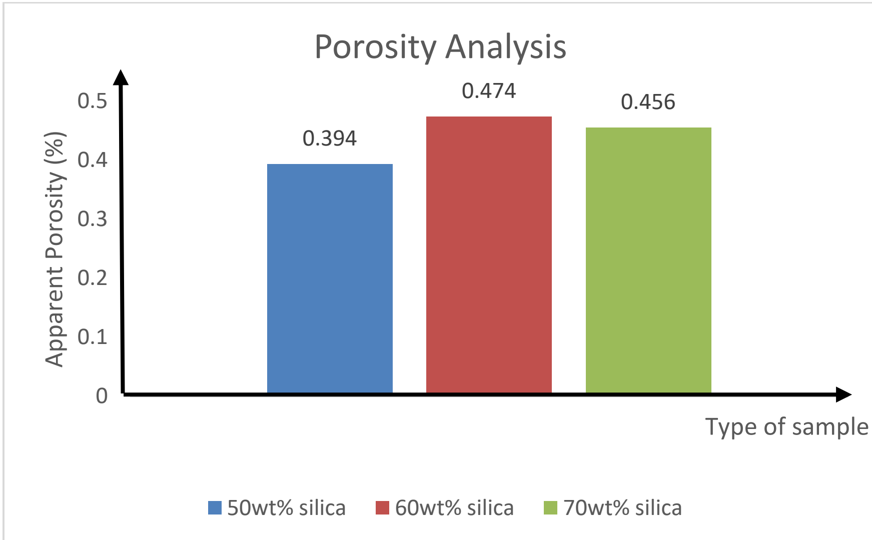


FIGURE 2. Results of porosity percentage rates for samples composed of 50wt.%, 60wt.% and 70wt.% silica.

Based on Figure 3 below, the results show that the highest total density value is sample for the composition of 50wt.% silica, which is 1.510 g/cm^3. The lowest density value is sample for the composition of 60wt.% silica, which contributes about 1.366 g/cm^3. Meanwhile, for 70wt.% of silica contributes 1.385 g/cm^3 of density. This indicates that a high-density value will cause the pore percentage to be low. This situation occurs because the particles that fill the space of the sample surface are reduced, and then the surface pores take place to replace the particles that fill the space in the sample surface.

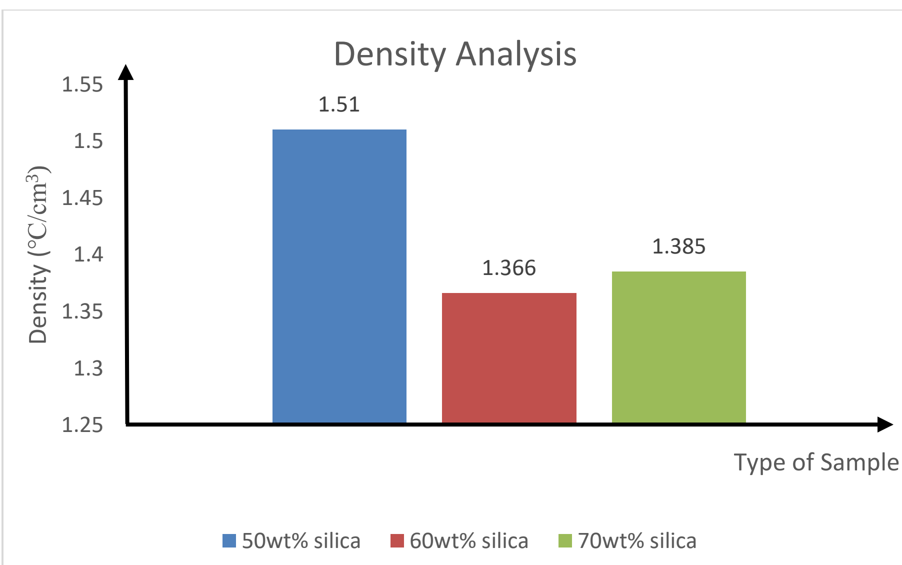


FIGURE 3. Results of density analysis after completion of testing for samples composed of 50wt.%, 60wt.% and 70wt.% silica

01 February 2024 02:04:25

Demonstration Testing of The Silica Water Filter

The silica water filter will be placed in a designated container as shown in Figure 4 (a) below. Three silica water filters will be used simultaneously to get the results that needed to be obtained. As in Figure 4 (a) below, 60wt.% of silica water filter have been used to demonstrate the water filtration system. After the water have been flown through all the silica water filter, the colour of the water changes will be observed from time-to-time in 10 minutes interval. This will show that the silica water filters are able to filter a dirty and muddy water that have been flown through in the system as in Figure 4 (b). The example of the set-up is shown in Figure 4 below.

(a) (b)

FIGURE 4. Demonstration of the water filtration system by 60wt.% of silica water filter

01 February 2024 02:04:25

CONCLUSION

In conclusion, due to the ability to save time, labor, and easily accessible mould materials, the slip casting process is employed as the primary method in the production of silica water filters. The sintering process is the trickiest and most challenging stage in the development of these water filters. This is due to the fact that if the water content is not completely eliminated, the sintering process could result in cracking and brittleness on the water filter. The fabricated water filter will then be put to the test and go through some of the stated analysis procedures. Regarding size and surface smoothness, this water filter is contrasted with the conventional water filter. In comparison to conventional water filters, the fabricated water filter is smaller in size. Even though the water filter's size and surface area are comparatively small, it still has a high capacity to filter water and eliminate contaminants from the water. Despite having a far more porous surface than conventional water filters, this water filter has been successful in removing dirt and other pollutants from the water.

ACKNOWLEDGMENTS

The authors would like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for its support on the accomplishment of this research activity. This research was supported by University Tun Hussein Onn Malaysia (UTHM) through Grant Tier 1 (Vot Q119).

REFERENCES

1. S. A. Ajeel, K. A. Sukkar and N. K. Zedin, *IOP Conference Series: Materials Science and Engineering* **2190** 012013 (2020).
2. S. S. Alias, Z. Harun and S. Abu Mansor, *World Journal of Engineering*, **17(4)**, 553–562 (2020).
3. V. P. Della, I. Kühn and D. Hotza, *Materials Letters*, **57(4)**, 818–821 (2002).
4. I. J. Fernandes, D. Calheiro, F. A. L. Sánchez, A. L. D. Camacho, T. L. A. De Campos Rocha, C. A. M. Moraes and V. C. De Sousa, *Materials Research*, **20**, 519–525 (2017).
5. Z. Harun, M. F. Shohur, M. Z. Yunos, M. R. Jamalludin and A. F. Ismail, *Applied Mechanics and Materials*, **328**, 798–801 (2013).

6. S. K. S. Hossain, L. Mathur and P. K. Roy, *Journal of Asian Ceramic Societies*, **6(4)**, 299–313 (2018).
7. S. K. Hubadillah, M. H. D. Othman, A. F. Ismail, M. A. Rahman, J. Jaafar, Y. Iwamoto, S. Honda, M. I. H. M. Dzahir, and M. Z. M. Yusop, *Ceramics International*, **44(9)**, 10498–10509 (2018).
8. F. M. Mohamed and K. A. Alfalous, *Egyptian Journal of Aquatic Research*, **46(2),** 131–136 (2020).

01 February 2024 02:04:25