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Fabrication of Mesoporous Composite from Waste Glass and Its Use as a Water Filter

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Abstract. Mesoporous composites from waste glass have been synthesized by simple heating process. The ability in the control of pore size was controlled by adjusting the time of melting point. In this study, the time of melting process was used a pore-forming agent in composite from waste glass. The composites from waste glass have been synthesized at 750^{o}C with controllable of time 1h, 1.5h, 2h, 2.5h, 3h and 3.5h. The results showed that the composites from waste glass have decreased permeability from $2.09x10^{-13}$ m^2 - $1.04x10^{-14}$ m^2. With this result, the prepared mesoporous composites from waste glass may be used efficiently in various applications, such as water filter.

Keywords: Waste-glass, mesoporous, water, filter.
PACS: 82.70.Dd, Gg, Kj

INTRODUCTION

Glass is one of the modern ceramic products that have a very wide scope of usage [1,2]. The heavy use of glass in various kinds of human needs demands production of this material in very large numbers. Glass has distinctive characteristics compared to other ceramics classes, such as amorphous-structured, non-corrosive and non-volatile because the melting point of the constituent materials is high [3].

That enormous production impacts on the environment such as the production of used glass. Used glasses that are not used anymore are waste that will not decompose naturally by organic decomposer. It calls for alternative ways of handling the creative and innovative ways to make glass waste can be safely returned to nature or recycle them into useful products.

Recycling potential of waste glass has been studied where the waste glass has a lower melting point than its constituent materials, such as SiO_2, Al_2O_3, etc. Waste glass has a melting point temperatures on the order of 700^{o}C [4]. Further utilization of waste glass has been carried out by Mahardika et al. (2012) where the waste glass as a strong composite material ~ 36 MPa and has a fraction of pores (holes) 5 % -10 % [5]. Porous glass has been developed in a variety of important applications such as insulation materials, catalysts, separator membranes, filters and some optoelectronic devices [6,7].

The presence of pores in the composite material of glass waste and its low melting point encourage the use of waste glass as a material with a new functional as water filter. Melting point of a solid is the temperature at which it changes state from a solid to liquid. At the melting point, the pore has a very small size or because its form tended without pore fluid. The arrangement of waste glass melting temperature can be a strategic move to manipulate the formation of pores with different sizes for water filter performance optimization. This study focused on the fabrication of mesoporous composite from waste glass.

EXPERIMENT

Waste glass obtained from environmental washed to separate impurities such as particles of dust. At the next stage, waste glass is milled by ball milling device and resulting glass powders. This powder is the base material of composite manufacturing. Glass powder is combined with polymer poly (vinyl) acetate (PVAc) as adhesive. PVAc polymer is chosen for a very low melting temperature, which is on the order of ~200^{o}C. Glass powder and adhesive PVAc glass blend printed with the press device with a pressure of 5 tons. The next process is the heating of composite waste glass that has been printed. At this stage, the heating temperature used at T = 750^{o}C. Engineering of porous glass composite waste created by varying the heating time t = 1 h, 1.5 h, 2 h, 2.5 h and 3 h.

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Mechanical properties test of a pressure test done to obtain the distribution of compressive strength composite materials that have been produced. Compressive strength obtained from the following equation:

$$\sigma = \frac{F}{A} \quad (1)$$

where F is the maximum force required to composite destroyed and A is the effective area of the subject of pressure. In addition, porosity test was also conducted to obtain information on the absorption of water and composite materials are also used to analyze the composite compressive strength. Porosity test done simply by measuring the dry (m_k) and wet (m_b) mass of the composite material. The estimated value of porosity can be expressed from the following equation:

$$\phi(\%) = \frac{(m_b - m_k)/\rho_f}{V_{total}} x100\% \quad (2)$$

Potential porous composite of waste glass as a filter with the estimated water permeability measurements. Permeabilas measured by Darcy's law:

$$k = \frac{Q\mu\Delta L}{A\rho g\Delta h} \quad (3)$$

where k is the permeability of the filter, Q is the water discharge flowing through the filter, μ is viscosity of the fluid (water), A is the surface area of the filter, ρ is the density of water, Δh is water level in the filter column and g is the acceleration of gravity.

RESULTS AND DISCUSSION

Compressive strength of porous glass waste composite with variations of PVAC adhesive polymer is shown in Figure 1. Compressive strength of the composites increased along with percentage of mass of PVAc adhesive. Increasing the amount of adhesive causes the grains of glass powder bound due to the strong adhesion force of PVAc adhesive. The adhesion force describes adhesion, so that with increasing percentage of mass adhesive, then contacts of glass powder grains with adhesive is increasing as well.

Optimum compressive strength composite is observed in the percentage of weight composition 20 wt% PVAc adhesive, i.e. 13,8 $N.m^{-2}$. Compressive strength is relatively constant with the addition of PVAC adhesive mass percent over than 20 wt%. Estimated optimum composition of composite compressive strength properties due to the subsequent composite application is used as a water filter. Composites will gain hydrostatic pressure on the filtration process that takes a composite that has optimum compressive strength.

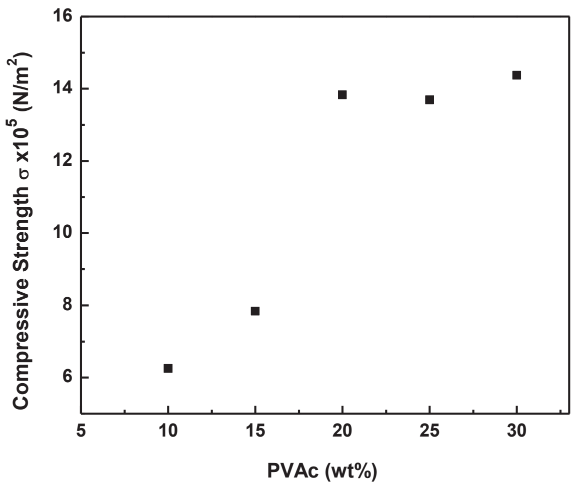
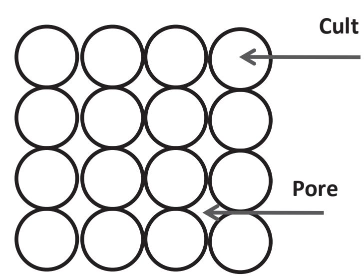


FIGURE 1. Compressive Strength of waste glass composite with PVAc adhesive variations.

Fabrication of pore sizes in the waste glass composite with optimum composition is done by varying the process parameters of the heating time. This step is based on that process of melting (melting) of the edges so that the glass powder has melted will be bound and fused with each other so that the rest of the space that is not covered by glass powder is said to be porous. Illustrations engineered pore formation mechanism for waste glass composite is shown in the following figure:

(a).



(b).

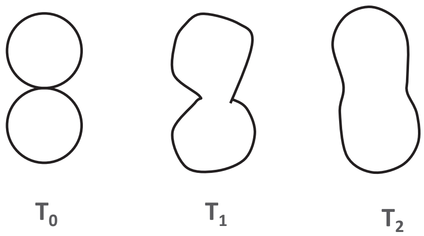


FIGURE 2. (a). Composite of glass, (b) Process of grain melting with temperature variations.

Fabrication of pore composites with optimum composition is done by heating process at a temperature T = 750°C with heating intervals of 1 h, 1.5 h, 2 h, 2.5 h and 3 h. In Figure 3 it is observed that the compressive strength of the composite decreases with increasing heating time. These results indicate that with increasing heating time, the grains of the glass powder melts to form the glass back and tend to cause compressive strength decreased..

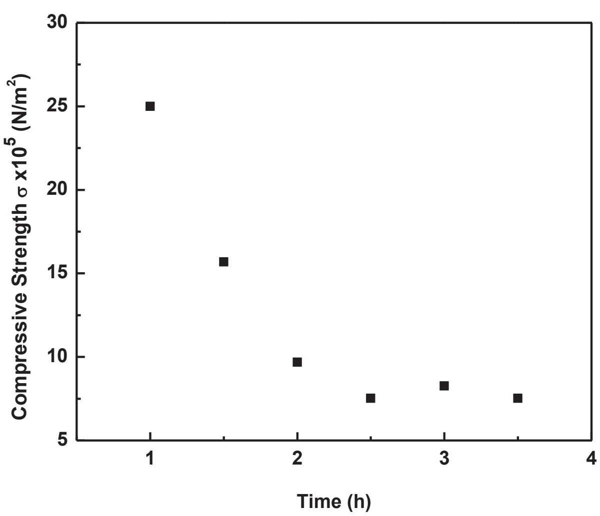


FIGURE 3. Compressive Strength of glass waste composite with heating time variations.

Composite compressive strength measurement results are supported by the results of porosity measurements where porosity decreases with increasing heating time, as shown in Figure 4. **P**ores decreases due to the heating process due to the grains of glass that has been melted grains form a single unit and forming glass back. Porosity diverse observational data shows that the pore engineering has been successfully carried out by varying the heating time. This result became one of the important contributions that obtained from the study for the recycling of waste glass.

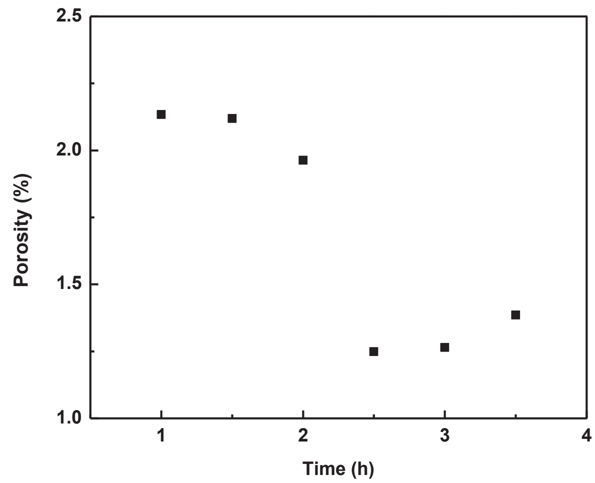


FIGURE 4. Porosity of glass waste composite with heating time variations.

Initial composite test as a water filter is made by measuring its ability to pass fluids (permeability). This is based on that filter permeability and processes are required to have good filtration. Permeability is measured with the principles of Darcy's law. Measurement results obtained permeability values decreased with increasing heating time. Permeability composite value distribution in Figure 5 corresponds to the porosity in Figure 4.

Permeabiltas and porosity value achieve the same optimum conditions ie the heating time t = 2.5 hours. However, under these conditions, the water discharge is very low at 8 ml per 25 minutes so it is not effectively used as a filter. Effective filtration process observed in the composite with heating time t = 2 hours. Water as a test sample having a good filtration process in which water enters the composite pore water until saturated state could then filtered. Different conditions of heating at 1 hour and 1.5 hours, the water does not undergo filtration process.

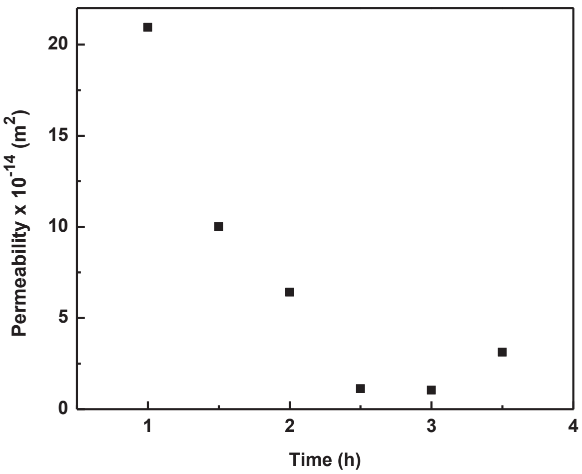


FIGURE 5. Permeability of glass waste composite with heating time variations.

CONCLUSION

Composites of waste glass with various pores can be obtained by varying the parameters process, i.e. the heating time. Porous composite of waste glass which has good performance of the filtration process in the parameter of fabrication pressure process P = 3 tons, the heating time t = 2 h and the heating temperature T = 750°C. Porous composite of glass waste that has characteristics of high compressive strength on the order of ~10^5 Nm^{-2}, on the order of 10^{-14} m^2 permeability and porosity on the order of 5% is considered suitable as a water filter.

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