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Performance of Porous Composite from Waste Glass on Salt Purification Process

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Abstract

Porous composite from waste glass has been synthesized by hydrothermal method. Synthesize process was focus on varies of PEG concentration 1-10 %. Herein, the porous composite has been tested as filter on brackish water in order to increase quality of salt. The initial test of filtration result was carried out by conductivity of the filtrate, while FTIR, AAS, and SEM EDX were used to analyze quality of salt. Conductivity of the filtrate decrease which was confirmed by AAS that Na concentration in the salt decreased as well when it was filtered by the composite with higher PEG concentration. SEM EDX of the salt showed morphology of salt crystal with decreasing of impurities such as Mg, C, O and S after filtration process. FTIR analysis indicated decreasing peaks at IR region which corresponds to the reduce impurities concentration. The ability of porous composite from waste glass in order to remove the impurities shows that it can be used in salt purification process.

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Keywords: porous composite, waste glass, filter, salt;

1. Introduction

Salt (NaCl) has played the important role of human life since the ancient era. The history recorded that it was used for cooking wheat and barley since 5000 BC. In the modern era, the growing of population and industry bring out the vastly demand of salt. Now, salt is being widely used in the household needs, textile industry, oil industry, pharmacy, etc [1]. The widely demand of salt is carrying out salt production as potential industry to increase wealthy society.

Indonesia is an archipelago with coastline of 95,181 km and long sunlight period has very great potential of sea water for salt production. As other developing countries, salt manufacturing methods in Indonesia are using traditional methods that result low quality salt for industrial demands. The methods are commonly use salt evaporation pond which base naturally from soil that the result of salt is contaminated by impurities. Therefore, increasing of salt quality is very important to elevate the economic level in Indonesia.

In industry, salt which has high NaCl concentration is vitally required which known as industrial salt. In order to obtain industrial salt, natural salt must be purified to remove impurities such as colloid particle, Ca^{2+}, Mg^{2+} and SO_4^{2-} [2]. Generally, in solar salt purification processes are including precipitation and filtration [3]. Porous materials are widely used in the filtration process. One of interesting material for filtration is porous glass composite.

Porous composite from waste glass is promising material as filter medium in salt purification process due to it has good mechanical properties, water permeability and chemical inertness [4]. Moreover, recycle waste glass as new functional filter medium material can be an alternating solution to manage municipal waste problems, because this waste unable to decompose naturally and lead to the environment problems [5].

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Melting point of waste glass is lower than the glass raw material and also clay composite, that it will give cost profit in fabrication composite process [6-8].

Mechanism of fabricating porous glass composite is simple. Generally, a glassy phase shows metastable or immiscible phenomena. Raw material and complementally component for control chemical composition are mixed and then heat at arbitrary temperature to generate a phase separation texture and form the pores [9]. However, pore forming agents are incorporate into the composite in order to control porosity. The pore forming agents are generally classified into synthetic organic matters, natural organic matters, metallic and inorganic matters and liquid. The shape, size and the amount of the agent can also effect on pore of the composite as well as pore size, shape, and surface area of the composited [10]. Therefore, it will influence water permeability and filter performance of the composite to remove impurities in salt purification process.

2. Methods

2.1. Porous composite synthesis

Initial step, waste glasses which transparent such as glass, bottle, window glass were collected from the environment and were cleansed to remove impurities. The waste were broken into small flakes subsequently milled by ball milling to prepare raw material of the porous composite. The raw material was added by PEG as pore forming agent, then both materials were pressed at 5 metric tons. Porosity of porous composite was controlled by PEG that was varied with concentration 1-10 % in the composite. The composite was sintered at 700 °C along 2.5 h to form porous composite.

2.2. Filter performance test of porous composite

Filter performance test of porous composite in salt purification has been conducted by used the porous composite as filter medium in filter device. Salt source was obtained from brackish water. Brackish water with volume 10 L was filtered in the device with pressure 1 bar. After filtration process, filtrate solution was evaporated at 100 °C to obtain salt.

2.3. Characterization

Firstly, conductivity of filtrate solution was measured by simple method. *Atomic Absorption Spectroscopy* (AAS) was used to measure Na concentration of the salt. *Fourier Transform Infrared* (FTIR) spectroscopy was used to analyze impurities content of salt. *Scanning Electron Microscopy with Energy Dispersive X-Ray* (SEM EDX) used to inspect morphology of salt and also concentration atomic and molecule impurities of the salt.

3. Results and Discussion

Porous composite has been successfully fabricated from waste glass by simple heating in temperature 700°C with various PEG compositions. The composites are heated along 2.5 h. PEG with concentration 1% - 10% poses as pore forming agent of the glass composite. Porosity and permeability of the composite can be shown in Fig.1.

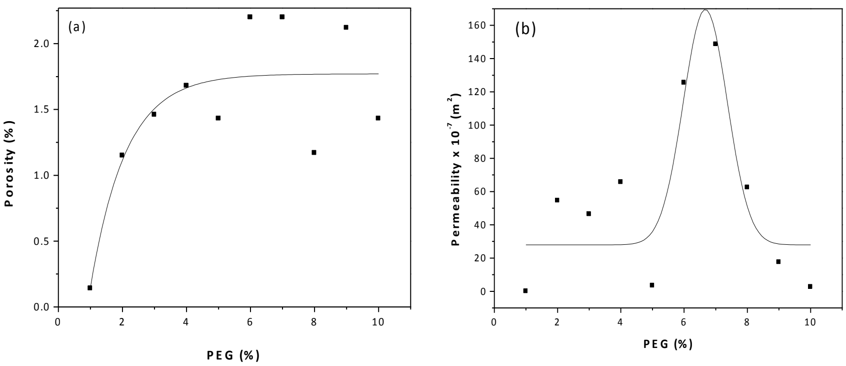


Fig.1. Effect of PEG concentration on (a) porosity, (b) permeability of porous composite from waste glass

Porosity of the composite increased exponentially with higher concentration of PEG, while permeability showed a maximum value when PEG concentration at 7 %. This polymer performed as pore forming agent of the glass composite due to it was vaporized at 250°C, then leave the composite and give empty spaces in the composite. The pores of the waste glass composited are immediately formed when cult powder melt. Higher amount of PEG have given larger volume of empty space that lead to larger porosity of the composite. Mechanism of pore formation of porous composite can be illustrated in Fig.2.

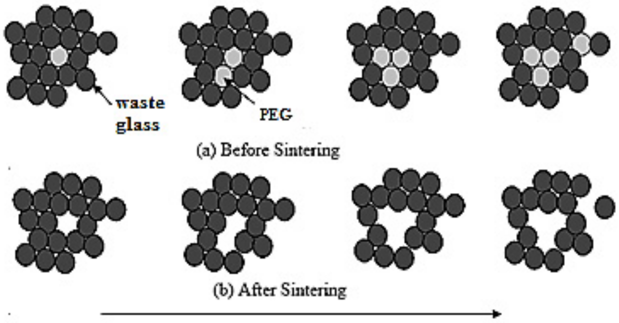
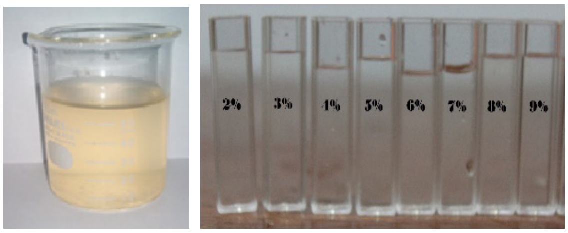


Fig.2. Illustration pore formation of porous composite from waste glass

Performance of porous composite from waste glass as filtration medium on salt purification method was tested by use the composite to filter brackish water from salt pond. The filtration result of the composite can be shown in Fig.3.



(a) (b)

Fig.3. (a) Brackish water from salt pond (b) filtration result of porous composite from waste glass

Fig.3 shows ability of the composite to remove impurities in salt purification process, while color of the solutions turns into almost colorless after filtration process. Impurities such as colloid particles have larger size than pore of the porous composite that they are blocked by the composite. Pore size of waste glass composite has been revealed by Sulhadi et al, 2015 in the order 1.6 nm – 2.1 nm [11]. The number of pore forming agent causes pore size and may relate to porosity of the composite. This can be shown in porosity result of the composite in various PEG concentrations. In addition, it may cause filtration result in salt purification process.

Characterization of filtration results were initially conducted by measured conductivity of filtrate solution. The conductivity of filtrate solutions which were filtrated by the composite synthesized with PEG concentration variation could be shown in Fig.4.

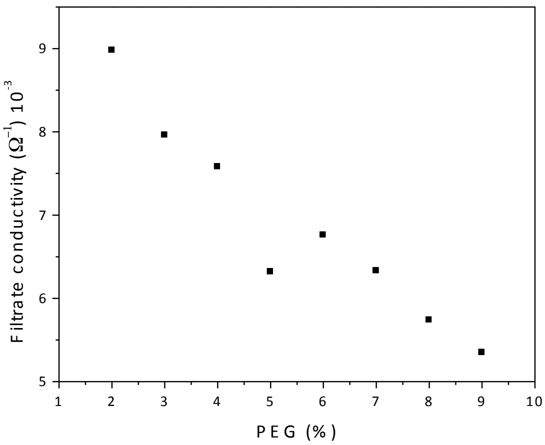


Fig.4. Conductivity of filtrate solution after filtration process using porous composite from waste glass which is synthesized in PEG concentration 2 % - 9 %

Conductivity of filtrate solution tends to decrease when it is filtered by the composite which is synthesized with increasing of PEG concentration. This phenomenon is due to increase of colloidal particles in the filtrate solution. Filter medium play an important role in block mechanism for colloidal particles which size larger the pore size of the composite. Colloidal particles from brackish water in salt pond are may be an isolator because salt pond base is natural soil, while NaCl is an conductor in solution. Therefore, higher amounts of colloidal particle lead to decrease filtrate solution conductivity.

Na concentration of filtrate solution has been characterized by *Atomic Absorption Spectroscopy* (AAS). The result of characterization is shown Table 1. Increasing of Na^+ in the filtrate solution after filtration indicates the ability of composite to increase quality of salt as filter medium in salt purification process. Higher amount of PEG in composite synthesized process tend to decrease Na^+ which correspond to the conductivity of filtrate solution result.

Table 1. Na concentration of brackish water and filtration results of porous composite from waste glass

No	Sample	Na (mg/L)
1	Brackish water	2354.50
2	2 %	2911.50
3	6 %	2465.50

Morphology and atomic structure of salt has been characterized by *Scanning Electron Microscopy with Energy Dispersive X-Ray* (SEM EDX). Morphology of salt can be shown in Fig.5.

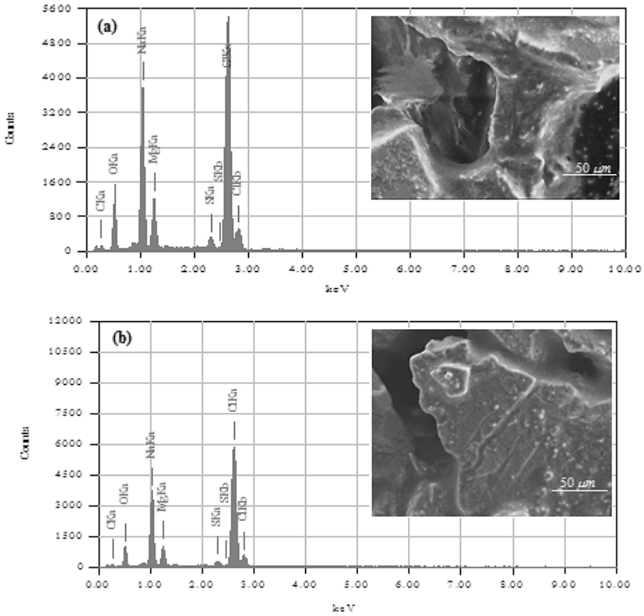


Fig.5. Atomic distribution and morphology of salt (a) before filtration (b) after filtration using porous composite from waste glass

Based on the result, crystalline salt can be seen with roughness surface structure. Investigation atomic structure of salt was performed by energy dispersive X-Ray showed that component salt was including Na, Cl and impurities such as C, S, Mg, and O. The main target component in which pass through the filter medium is NaCl. Based on radius of each atom, NaCl has molecular size 0.361 nm. Sulhadi et al have revealed pore size of the waste glass composited order 1.6 nm – 2.1 nm that NaCl molecules can pass through the filter easily [11]. The presence of C, S, O, and Mg in the salt result is indicates some impurity molecules. Generally, some impurities are presence in salt including $MgSO_4$, $CaCl_2$, Na_2SO_4, $MgCl_2$, KCl, KBr, and insoluble matter [12]. After filtration concentration of C and Mg, S and O are decrease show the composite ability to block some impurities instead of colloid particles.

The chemical compounds of salt are also investigated by *Fourier Transform Infrared* (FTIR) which are shown in Fig.6. According to the result either salt before filtration or after filtration shows band peaks at 3544 cm^{-1}, 2126 cm^{-1}, 1639 cm^{-1}, 1112 cm^{-1} and 545 cm^{-1}. As the other alkali halides, NaCl is transparent in infrared region [13]. In addition, presence number of the peaks shows impurities content of salt. Broader peak with center at 3544 cm^{-1} relates to OH vibrations which indicated hydrate

($NaCl.nH_2O$) formation when salt is evaporated [14]. Peaks detection at 2126 cm^{-1} and 1639 cm^{-1} correspond to C=O stretching in CO_2 while peaks at 1112 cm^{-1} and 542 cm^{-1} correspond to SO_4^{-2} [15-16].

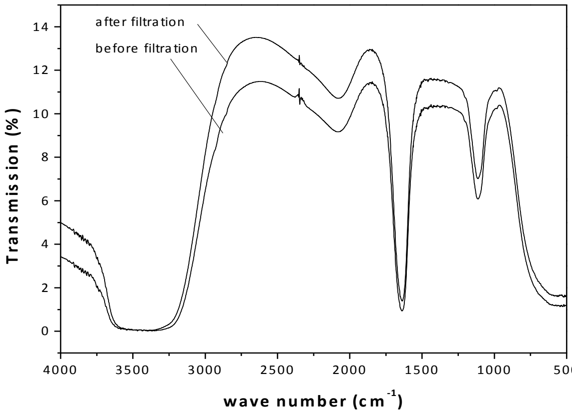


Fig.6. FTIR Spectrum of salt before and after filtration using porous composite from waste glass

The decreasing peaks at 2126 cm^{-1}, 1639 cm^{-1}, 1112 cm^{-1} and 542 cm^{-1} for salt after filtration may show that the impurities such as CO_2, $MgSO_4$, Na_2SO_4 in the salt are decrease. This phenomenon indicates that the composite can reduces impurities in molecular level beside colloidal particle which benefit for salt purification process.

4. Conclusion

This study has shown performance of porous composite from waste glass on salt purification process. The porous composite has been successfully synthesized by hydrothermal process with PEG concentration as pore forming agent. The study has shown that increasing PEG concentration would increase porosity of the composite and it affected on performance of the composite as salt filter medium. The conductivity of the filtrate solution and Na content decreased when porosity of the composite increase. Colorless filtrate solution was obtained after filtration indicated that the composite able to block colloid particle. Decreasing concentration of atomic impurities and spectra band in IR regions through SEM EDX analysis and FTIR analysis have shown that potential of the composite to reduce molecular impurities in salt purification process.

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