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Preparation and Characterization of Ceramic Membrane Composition Variations in Pome Waste Treatment

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Abstract

Palm Oil Mill Effluent (POME) is waste generated by the palm oil industry consisting of solid, liquid and gaseous wastes. POME is decomposed in sewage ponds and allowed to decompose naturally. The residual waste generated by this industry is non-toxic but has high polluting power. To overcome this, it is necessary to treat waste by making ceramic membranes. The composition materials needed are clay, zeolite, sodium carbonate and boric acid. The manufacturing method is through the printing and combustion stages at a temperature of 900°C. The results showed that there was an effect of compositional variations on the quality of the final product, namely TSS rejection % 93.355 with a flux value of 0.2474 (L/m^{2}min). From the parameter values obtained, it proves that the ceramic membrane is able to process POME with satisfactory effective results. The quality standard of palm oil liquid waste is in accordance with South Sumatera governor regulation number 8 of 2012 concerning quality standard of liquid waste for industrial, hotel, hospital, domestic and coal mining activities.

Keywords: *POME, Wastewater treatment, Preparation, Characterization, Ceramic membrane*

1. Introduction

Palm Oil Mill Effluent (POME) is a wastewater generated from palm oil processing which needs pretreatment before release into waterways due to its exceedingly contaminating properties [1]. Its colloidal suspension containing 95-96% water, 0.6-0.7% oil and 4-5% fat and total solids. Liquid waste from palm oil produced can endanger human health because it can be a carrier of a disease (as a vehicle), detrimental to the economy because it can cause damage to objects/buildings as well as crops and livestock, can damage or kill life in the water like fish and other domesticated animals, and can damage the beauty (aesthetics), because of the stench and unsightly scenery, especially in the downstream area of the river which is a recreational area [2].

The resulting liquid waste must follow the standards that have been set and cannot be disposed of/applied directly because it will have an impact on environmental pollution. The function of waste treatment (effluent treatment) is to neutralize the waste parameters that are still contained in the wastewater before being applied (land application). One of the liquid waste treatment technologies that is developing rapidly today is using membranes, because membranes have advantages over conventional methods, including a simple process in operation, can take place at room temperature, are non-destructive, so they do not produce changes in the substances to be separated, does not require much energy, and the membrane can be reused [3].

The research about the feasibility and suitability of the membrane technology in POME treatment is carried out with the adsorption treatment (pre-treatment) of treating palm oil mill effluent (POME). Ultrafiltration membrane separation was applied for further treatment and found that a pressure 2 bar with 600 rpm speed and pH 8 obtained lower dissolved solid (123.70 mg/L) and turbidity (4.50 NTU) concentration [4]. The effect of the coagulant Polyaluminium Chloride (PAC) variations and the membrane's operating pressure on the POME treatment process using the nanofiltration membrane (NF) with the coagulation-flocculation process as pretreatment found the highest percentage at a pressure of 10 bar, which is equal to 94.71, 94.86, 97.92 and 95% respectively for BOD, COD, TSS and oil/fat with a flux value of 7.16 L/m^2.hours [5].

In the present study, the researchers want to carry out developments in the processing of palm oil industrial wastewater using ceramic membranes based on clay, zeolite, sodium carbonate and boric acid. Researchers chose the composition because these materials are easy to obtain and the price is quite cheap. Starting from the description above, the problem in this study is to determine the best composition so that a ceramic membrane that meets the standards is obtained.

2. Research Method

The materials used in the form of clay, zeolite, sodium carbonate, and boric acid were purchased at the water treatment store. POME was taken from PT Sawit Mas Sejahtera located in South Sumatera. Before being processed, the waste is carried out an early stage by using a module containing activated carbon and a cartridge filter. The waste that has been pretreated is analyzed for pH and TSS. The waste treatment is carried out by passing through a ceramic membrane using a cross flow device with a pressure of 1.7 bar and a contact time (10, 20 and 30) minutes. The filtered waste was analyzed for pH and TSS.

The characteristics of the membrane aim to determine the feasibility of the membrane before use. The characteristics of this membrane include determination of membrane pore size, membrane thickness measurement and determine the membrane diameter. The resulting chitosan – PVC ceramic membrane was photographed using Scanning Electron Microscopy (SEM).

The process of making Ceramic Membranes by mixing materials and then printing them with gypsum molds. The material is removed from the mold and placed on a banana leaf sheet. The next treatment was dried at room temperature for 7 days. Then burned at a temperature of 900^oC for 12 hours.

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Table 1. Ceramic Membrane Composition

Material	Ceramic Membrane 1 (%)	Ceramic Membrane 2 (%)	Ceramic Membrane 3 (%)	Ceramic Membrane 4 (%)	Ceramic Membrane 5 (%)
Clay	67,5	70	75	75	77,5
Zeolite	25	22,75	20,5	18,25	16
Sodium Carbonate	5,5	5,25	5	4,75	4,5
Boric Acid	2	2	2	2	2

The ceramic membrane design is shown in figure 1.

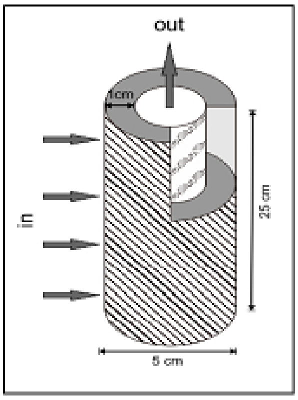

Figure. 1. Design of Ceramic Membrane

3. Findings

The variation of the composition used is expected to help researchers get the best type of membrane with a certain composition. Determination of variations in the composition of clay, zeolite, sodium carbonate, and boric acid based on previous studies [6]. The percentage of clay used in each membrane has the most weight presentation, namely membrane 1 67.5% wt, membrane 2 70 % wt, membrane 3 75 % wt, membrane 4 75 % wt, and membrane 5 77.5 %wt. This is because clay has plastic properties that function as a binder in the formation process so that the formed object will not crack, break or change shape. The use of zeolite on each membrane ranged from 16% - 25%, on membrane 1 25% wt, membrane 2 22.75 %wt, membrane 3 20.5% wt, membrane 4 18.25 %wt, and membrane 5 16 %wt. Zeolite on the membrane will open the membrane pores formed by clay bonds so that it can form pores on the membrane. The materials used are additional materials, namely sodium carbonate and boric acid. Sodium carbonate and boric acid are categorized as new materials used in ceramic membranes.

The percentage by weight of sodium carbonate in the range of 4.5% - 5.5 that is, the use of sodium carbonate serves to improve the distribution of the material so that homogeneity is obtained. And the next additive is boric acid, with the use of as much as 2% on each membrane. The use of boric acid aims to strengthen the bonds in the membrane. The manufacture of ceramic membranes is carried out by the method of making ceramic crafts in general, namely starting from material selection, refining, printing, and drying.

Table 2. The Characteristic of Ceramic Membrane

Dimension	**1**	**2**	**3**	**4**	**5**
ID (cm)	3.5	3.5	3.5	3.5	3.5
OD (cm)	5	5	5	5	5
Surface area(cm^2)	274.75	274.75	274.75	274.75	274.75
Thickness(cm)	1	1	1	1	1
Pore(µm)	0.5-1	0.5-1	0.5-1	0.5-1	0.5
Membrane type	Microfiltration	Microfiltration	Microfiltration	Microfiltration	Microfiltration
Filter type	Cross flow	Cross flow	Cross flow	Cross flow	Cross flow
Pressure (bar)	0.6	0.6	0.6	0.6	0.6
Temperature (ºC)	30	30	30	30	30

The characteristics of ceramic membranes can be seen from the SEM (Scanning Electronic Microscopy) test. It can be used to determine the pore size contained in ceramic membranes. SEM testing was carried out on membrane 5 which was considered the best compared to other membranes. Membrane 5 has the best COD, TSS, and pH parameter values. It was found that membrane 5 has a pore size of 5.9 m. Sandeep and Pradip also using the same material composition, namely clay, zeolite, sodium carbonate, and boric acid and using variations temperature [7]. At the best temperature of 800ºC after SEM analysis, the pore size was 5.3 m. Another study was also used natural zeolite as a membrane material without using a clay mixture, which was about 6 m [8]. The pore size corresponds to the type of microfiltration membrane that has a pore of 0.1-10 m [9].

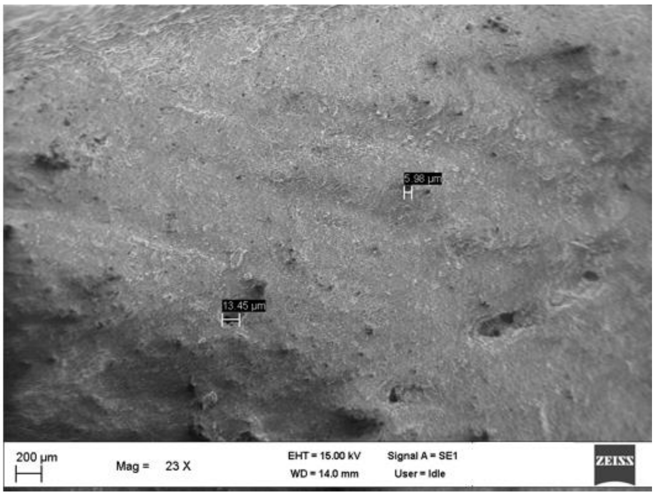

Figure 2. SEM of Membrane 5

Before being filtered with a ceramic membrane, a pretreatment process was carried out first by-passing POME on a module containing activated carbon and obtained results for pH (5.3 and 6) and TSS (504.2 and 316 mg/L) before and after the filter. The pretreatment process is carried out by passing palm oil effluent into the activated carbon module and cartridge filter, this pretreatment process will reduce the concentration of various parameters of TSS, and pH. After the pretreatment process is carried out, the sludge content contained in palm oil liquid waste will be reduced, so that it will facilitate the performance of the ceramic membrane. The activated carbon adsorption has proven to be effective for the removal of several types of inorganic and organic contaminants. The use of activated carbon can reduce the concentration of TSS to 316 mg/L. In the pretreatment, the pH value increased very slightly, namely at the beginning the POME pH of 5.3 to 6.

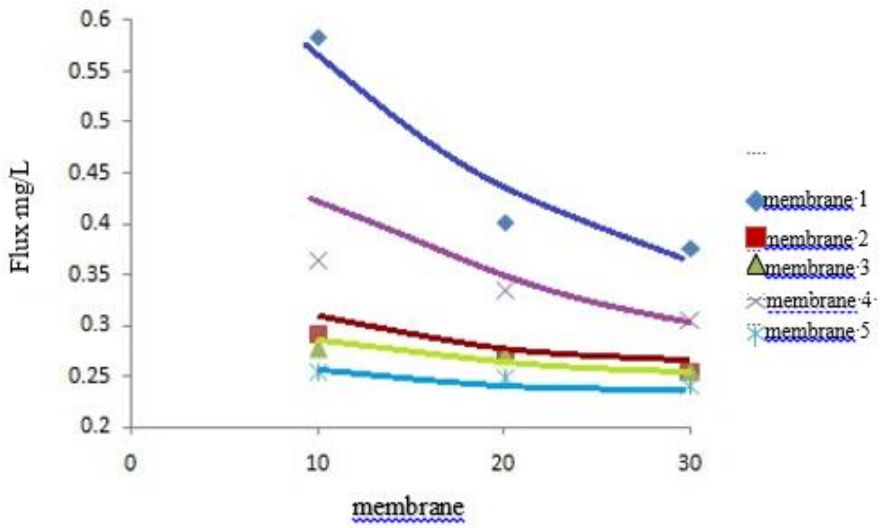

Figure 3. Flux Versus Membrane Chart

Determination of flux is a way to determine the feasibility of the membrane. Determination of flux is done by varying the processing time so that a certain volume of permeate is produced on each membrane made with different compositions. Taking or measuring the volume of permeate coming out of the membrane pores was carried out every 10 to 30 minutes with a pressure of 1.7 bar.

In Figure 3 it can be seen that the longer the filtration process takes place, the lower the flux value for each membrane used with different compositions. This happens because of the accumulation of particles that are stuck in the pores of the membrane (fouling). Thus, covering the waste that will pass through the membrane. The ceramic membrane was washed with distilled water to prevent the accumulation of particles [10]. Membrane washing will help increase flux rise. Fouling handling treatment is carried out by setting pressure with water or washing with an acid solution if the membrane productivity cannot return to its original state with backwashing. The chemical used is hydrochloric acid (HCl) to overcome fouling caused by mineral salts and metals.

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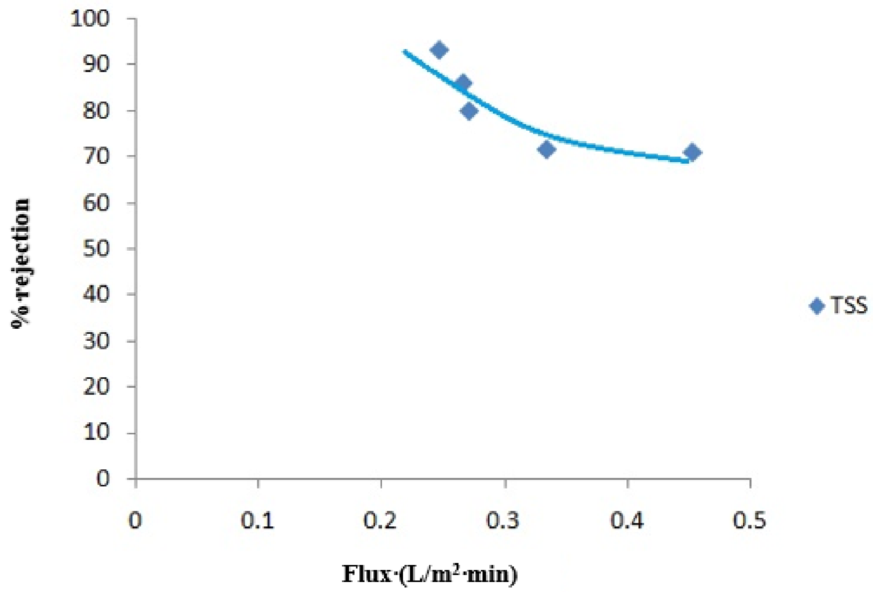

Figure 4. Flux Versus Rejection

In Figure 4 the determination of rejection seen from the TSS parameter of palm oil waste water, it can be seen that the increasing flux due to the pore size of the membrane formed from the composition of the material used in the manufacture of ceramic membranes causes the % rejection to decrease. So that it can be seen in membrane 5 with the composition of the materials used in the manufacture of ceramic membranes are 77.5 (% wt) clay, 16 (% wt) zeolite, 4,5 (% wt) sodium carbonate, and 2 (% wt) boric acid. can form small enough pores so that the average flux value is 0.2474 L/minute m^2. This is supported by SEM analysis, it can be seen that the pore size formed in the composition forms a pore of 5.9 m. % Rejection of the TSS parameter 61.53% has a relatively high rejection % compared to other membranes, this is due to the small pores of the membrane, so the waste particles will be difficult to escape, so that the % rejection or rejection is high.

4. Conclusion

From the research conducted, it can be concluded that ceramic membrane 1 with a composition of 77.5 % wt of clay, 16 % wt of zeolite, 4.5 % wt of sodium carbonate, 2 % wt of boric acid can reduce the concentration TSS 93.35% with operating conditions at a pressure of 1.7 bar and a time range of 10 to 30 minutes. After testing the Scanning Electron Microscope analysis, it showed that the ceramic filter produced was a microfiltration type membrane with a pore size of 5.9 m. With the parameter values obtained, it proves that the ceramic membrane is able to process POME with satisfactory effectiveness results, where this value has shown results that are in accordance with the quality standards of palm oil effluent according to the regulation of the Governor of South Sumatra number 8 of 2012.

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