International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 13 (2017) pp. 3914-3918
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Hydrogen Purification Using Natural Pahae Zeolit and Cocoa Rind Based Filter

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Abstract

The water vapor filter was fabricated from combination of natural pahae zeolit, clay, and cocoa rind by a chemical reaction and followed by heating process at various temperatures of 700^0C, 800^0C, and 900^oC, respectively. The filter was used to purify hydrogen gas which was produced from an electrolysis process by adsorbing water vapor. The result showed that the optimal heating temperature was at 700^oC where the filter could adsorb water vapor until 100%. Comparing to another compositions, the addition of clay and rind cocoa showed the significant increase in water vapor adsorbtion, the filters based on natural pahae zeolit 44.57%, natural pahae zeolit + clay and natural pahae zeolit + cocoa rind evidenced 51.81% and 47.31%, respectively. Therefore, the water vapor filter based on the combination of natural pahae zeolit + clay + cocoa rind was the most suitable composition to purify hydrogen gas.

Keywords: Hydrogen Purification, Water Vapour Filter, Natural Pahae Zeolit, Rind Cocoa, Clay.

INTRODUCTION

Nowadays, the world is in the crisis of energy. The crisis is caused by human who using fuel and gas in a large amount. Before facing the worst version of the energy crisis, we have to find the alternative energy source which can be renewable. Hydrogen is one of the alternative energy which gets a special attention from many countries. Especially from the upper class country. The demand for cleaner energy has incited greater interest in hydrogen energy as it offers a superior alternative to conventional fossil fuel combustion, thanks to its high energy density [9], higher energy conversion efficiency and its environmental friendly nature [6]. Current H_2 production methods include, steam-methane reforming, coal gasification, water-electrolysis etc. [7]. The hydrogen which is produced by electrolysis is more benefical because it is cheaper, faster and there is no chemical added. But, beside hydrogen and oxygen, there is water molecule which is come from the deviding process as the impact of the water temperature increasment. One of the effort in order to maximize the production of pure hydrogen is by using a potential adsorbent as the water vapor filter.

Comparing to another adsorbent such as active carbon and silica gel, zeolit is more interesting to be used as a filter because it has a high efectivity of adsorption [11]. Zeolite is alumino-silicate compound with tetrahedral bound linked by oxygen. Atom Al is negatif that can be neralized by cation. The exchangable cation affects the adsorption ability of zeolite. Beside that, the ability is also influenced by Si/Al ratio, surface area, and size od zeolite pore [13]. The porous structure of zeolite with many channels and cavities makes zeolite becomes one of potential sorbent materials with highly surface area [17].

The previous research [10] showed that the filter based on the natural pahae zeolit could be done a good adsorption to the water vapor. To optimize the performance of the filter adsorption, the natural pahae zeolit was mixed with the cocoa rind and clay. Both are chosen because there are a large amount of cocoa rinds and clay stock. In Indonesia, the cocoa rind is useless. But if we want to optimize the value added of the cocoa rind, it can be used to produce pectin. The component structure of pectin contains many active cluster so the pectin can be used as the source of bioadsorbent [19]. In the other hand, clay is the important part in the ground which trap naturally the polution that flows by water on the surface or in the ground by the the process of adsorbing or the ion exchanging. The factors that make clay as an adsorbent are the large specific surface, stabel by the chemical or mechanical, various surface structure, and the high capability of ion exchange [2].

RESEARCH METODOLOGY

Zeolites are the best adsorber for the adsorption process [14]. The zeolite utilization as adsorber due to the porous structure, molecular sieve and absorbing ability for small molecules such as water which can enter the zeolite [4]. Modifications of the natural zeolite are needs to be done to improve their performance before used as an adsorbent. The zeolites showed better performance in crystallinity and acidity after treated with HCl [16].

The material are natural pahae zeolit from Tarutung Tapanuli Utara, cocoa rind from Desa Jaharun Deli Serdang and the clay from Desa Wonosari Lubuk Pakam Deli Serdang. Based on the previous rsearch, the size of natural pahae zeolit, cocoa rind and the clay was 200 mesh [10]. Separately, Pahae zeolit and clay were activated by soaking them into a chemical process in H_2SO_4 6% for two hour using magnetic stirrer and hot plate. After the preparation, natural pahae zeolit, cocoa rind and clay were mixed with the variation 100%:0%:0%, 95%:5%:0%, 95%:0%:5%, 90%:5%:5%. Then, put the result into the mold and pressed with a hidrolic under 3 tons pressure for 10 minutes. The sample which had been molded was activated with the temperatures 700^0C, 800^0C, and 900^0C. The sample which had been activated had to be tested mechanically to know it's adsorption ability and to know it's ability in adsorbing the water vapor. The test of water vapor adsorbing was by putting the filter on the chamber which had been connected with a hydrogen sensor (Figure 1).

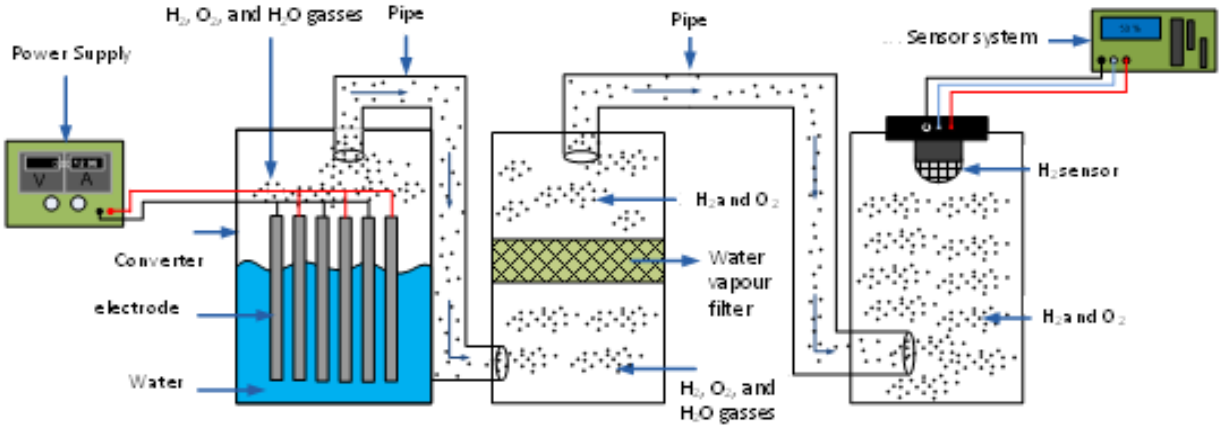


Figure 1: Scheme of Water Vapor Filter Adsorption Test

ANALYSIS AND DISCUSSION

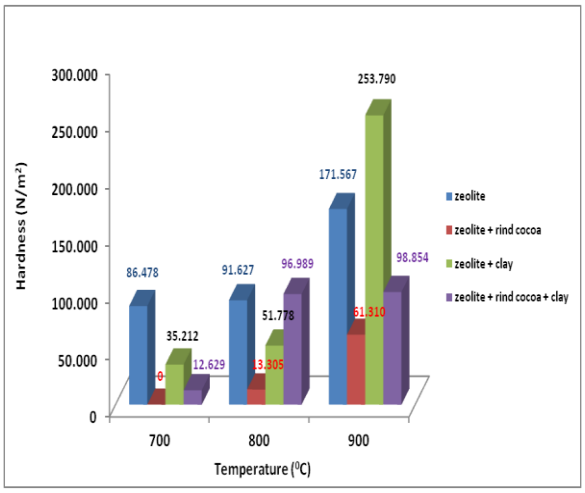
Hardness Test

Mechanical test was done to know how hard the water vapor filter. The result can be seen on Figure 2. Figure 2 shows that the hardness was based on the materials compotition and the activation temperature which were used in making the filter. The hardest filter is shown on the filter of zeolit + clay on the temperature of 900^0C and the soft texture is shown on the filter of zeolit + cocoa rind on the temperature of 700^0C. Therefore, the addition of clay on zeolit increased the hardness of the filter because clay had a high chemical and mechanical stability [12]. Beside that, clay is soil which size is microscopic and submicroscopic, so while it was mixed with zeolit, clay could fill the zeolit's pores. This made the mixtures of zeolit + clay more solid. Clay will be so hard when it is dry and plastically by the mix of some water. When it is mixed by a lot of water it will be sticky (cohesive) and so soft, so in the temperature of 900^0C the filter shows the highest level of hardness.

In the other hand, the addition of cocoa rind on zeolit decreased the hardness level of the filter. This is because the cocoa rind contains a lot of hard fiber [20] and when the mixture of zeolit + clay was burned on the temperature of 700^0C, there were more pores on the filter.

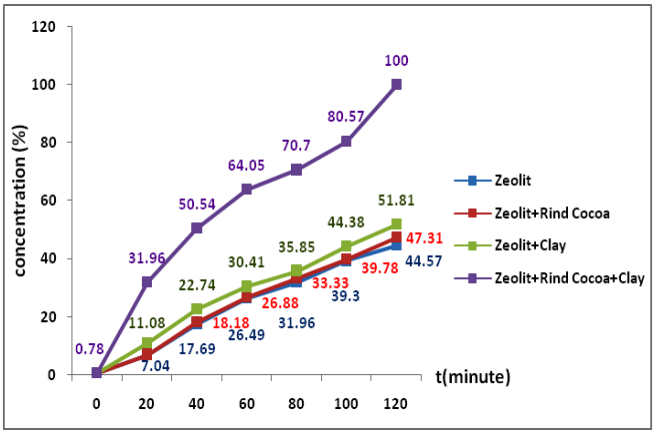
The result of the hardness test on zeolit filter shows a bad level of hardness. It is because there were physical activation and modification on the filter [18]. The hardness level of the filter would be fine when the zeolit filter was given the high temperature. And the addition of another material which contained different unsure decreased the hardness level of zeolit + cocoa rind. In such composition, zeolit contained a lot of silica and aluminium. In the other hand, cocoa rind doesn't contain such unsure. But, by adding another material which contains the same unsure will make the hardness level better like the zeolit + clay filter which both contain silica and aluminium.

The zeolit + cocoa rind + clay filter had a better hardness level comparing to the zeolit + cocoa rind filter. This is because there was material modification where zeolit+cocoa rind as the matrix and the filler had a different unsure mixed with clay which had the same unsure with zeolit.



Adsorption Test

An Adsorption test is a test where a certain molecule is caught from fluid on the solid surface (adsorbent). The result of water vapor adsorption is identified from the hydrogen sensor where the sensor is very sensitive of the water vapor (if there is water vapor which passes the sensor, the sensor will not be able to read the increasement amount of the hydrogen). Figure 3 is the result of the hydrogen sensor's reading on water vapor filter on the temperature of 700^{0}C, 800^{0}C, and 900^{0}C



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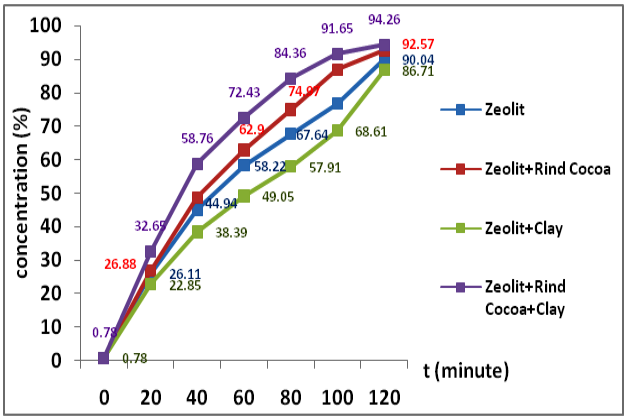

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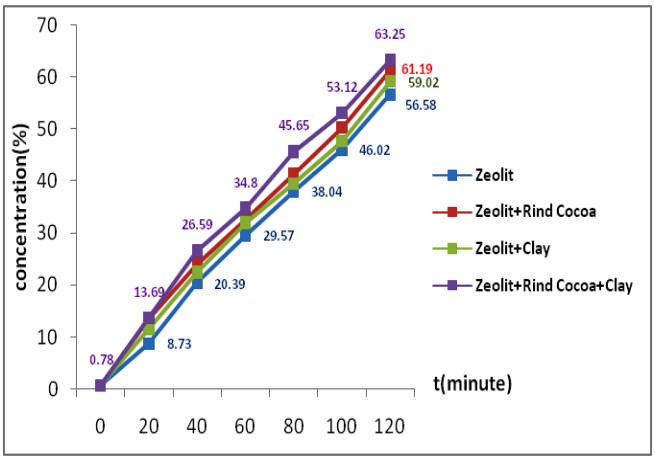

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Figure 3. Concentration of hydrogen gas sensor as a function of time for zeolite filter, zeolite+rind cocoa filter, zeolite+clay filter, zeolite+rind cocoa+clay filter at temperatures of a.700^{0}C; b. 800^{0}C ; c. 900^{o}C

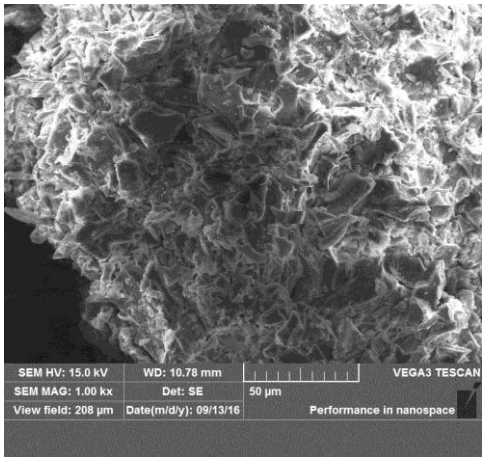
Figure 3 shows that the water vapor adsorption was influenced by the material activation and modification on water vapor filter. The optimal hydrogen gas reading reached 100% was shown on the zeolit+cocoa rind+clay filter on the 700^{0}C temperature. And the zeolit filter on the 700^{0}C temperature only reached 44.57% as the lowest result of the hydrogen gas reading. So, the modification of zeolit + cocoa rind + clay could increase the adsorption ability of the water vapor filter because cocoa rind contained pectin. Pectin is a biosorbent source [19] and clay as the adsorbent which has a high ion exchange ability. This is because clay contains silica and aluminium unsure.

The result of adsorption test from Figure 3 shows that the water vapor filter which was activated on the temperature of 800^{0}C had a better ability in adsorbing water vapor comparing with the temperature of 900^{0}C. Because of those temperatures, the filter based on zeolit + cocoa rind + clay, had a good ability in adsorbing. It means that the filter can adsorb the water vapor and pass the hydrogen gas. Those temperatures made the pores of the water vapor filter widen and had a high ability in adsorbing another materials such as fluid and gas.

SEM Analysis

Water vapor filter Scanning Electron Microscope (SEM) analysis which is based on zeolit + cacao rind + clay at the temperature 700^{0}C, 800^{0}C and 900^{0}C is aimed to know the morphology differences between the three temperature. Figure 4 shows the differents of the SEM water vapor filter's result with the variation temperature at 700^{0}C, 800^{0}C and 900^{0}C. The SEM analysis was done at Main Forensic Laboratory of

Mabes POLRI using SEM type EVO 50 Carl Zeiss.



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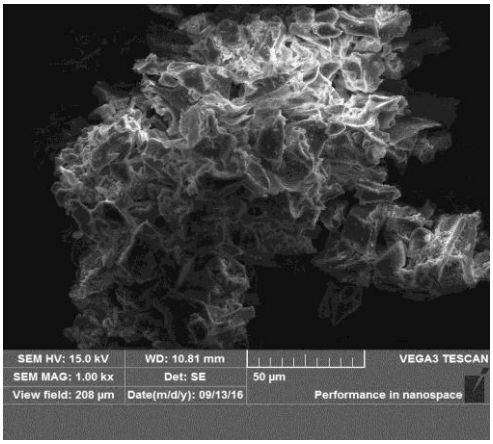

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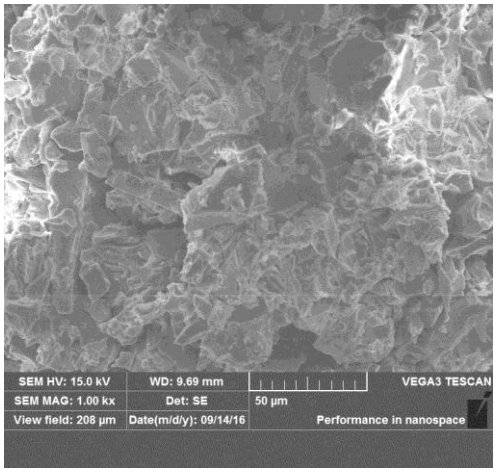

(c)

Figure 4. The Morphology of Water Vapor Filter Based on Zeolit + Cacao Rind + Clay Which is Activated at The Temperature (a) 700^{0}C (b) 800^{0}C (c) 900^{0}C

The morphology of water vapor filter which was activated at the temperature 700^{0}C has more distributed pores compared to the water vapor filters which were activated at the temperature 800^{0}C and 900^{0}C because they didn't have enough distributed pores. The filter which has more distributed pores would adsorb more. This is proved by the adsorption test (Figure 3). It can be conclude that the optimum calcining is at the temperature 700^{o}C. In the other hand, the calcining at the temperature up to 700^{o}C starts to break the zeolit structure then automatically the ability of the adsorption will be less.

Ratio of Si/Al

The unsure analysis was done by using EDX which is shown on Figure 5. The zeolit + cocoa rind + clay filter on the temperature of 700^{0}C reached the amount of 1.6 as the lowest ratio of Si/Al. The low ratio of Si/Al will increase the ability of zeolit to adsorb more water vapor.

The temperature increasement will increase the mobility of molecule that can be adsorbed into the pores of the filter filter [3]. This would decrease the interaction between adsorbent and adsorbat so would effect the adsorption ability. The unsures which were contained in the material effected the ratio of Si/Al on that material. Therefore, the filter ability in adsorbing the water vapor is influenced by the ratio of Si/Al.

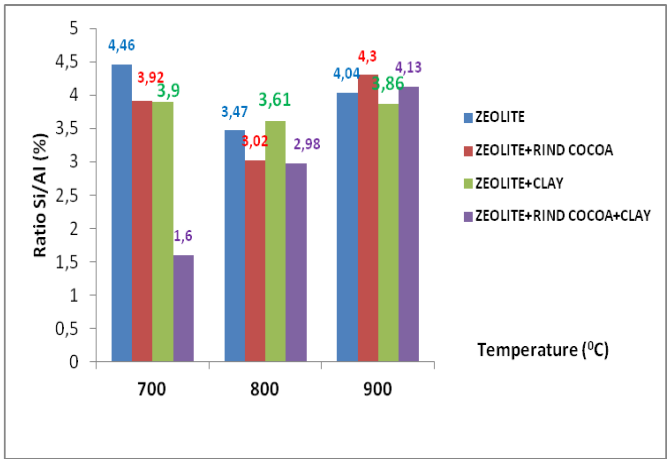

Figure 5: Ratio of Si/Al on Various Temperature and Materials Composition

CONCLUSION

The result of adsorption test shows that the filter ability in passing the hydrogen reached 100% in 2 hour. It was shown in the mixtures of zeolit + cocoa rind + clay which was burned on the temperature of 700^{0}C. The result is also supported by the result of SEM analysis which shows the mixture of zeolit + cacao rind + clay at the temperature 700^{o}C has more distributed pores and the unsure contents test result which shows the mixtures of zeolit + cacao rind + clay at the temperature 700^{o}C has the lowest Si/Al ratio.

ACKNOWLEDGEMENTS

Writer would like to thank to Dirjen Dikti for the funding on 2016 and to everybody who has helped and supported this journal, especially to the head of Laboratorium Terpadu Fisika Universitas of Sumatera Utara, and the Team of Auto Physics Universitas Sumatra Utara (TOP USU).

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