The Effect of the Mixture Variation and Holding Time to the Porous Ceramics based from Clay and Active Charcoal as a Filter of Water Vapour

Susilawati[1,2], Anwar Dharma Sembiring[1], Fransiskus Waruwu[1], and Siti Khanifah[1]
[1]*Department of Physics, Faculty of Mathematics and Natural Science, Universitas Sumatera Utara, Medan, 20155, Indonesia*
[2]*Pusat Unggulan Inovasi Green Chitosan dan Material Maju, Universitas Sumatera Utara, Medan, 20155, Indonesia*

Keywords: Clay, Active Charcoal, Porous Ceramic, and Water Vapour Filter.

Abstract: Have made a porous ceramic which was formed by clay and active charcoal with casting technique. The clay which was used comes from the village Iraonogeba regency of Moroó in West of Nias. The active charcoal which is used is active Aquasorb® 1000. The clay and active charcoal sifted with the sieve mesh 200. Then the clay wa activated chemically using the solution H_2SO_4 6% and physically can be activated at a temperature of 300^0C. Ceramic was formed by the technique of slip casting with comparison of variation of clay: charcoal active 100% : 0 percent ; 90% : 10% ; 80% : 20% ; 70% : 30% and 60% : 40%. The ceramics was sintering with sintering temperature 1000^0C with variation of *holding time* 2 hours ; 3 hours and 4 hours. Ceramics characterized to get the value of mechanical properties (pressure and hardness); the size of the diameter of the pores, womb elements (SEM-EDX) and the value of the water vapour adsorption. The results of this characterization shows that the optimum variations there are on the mixtures of clay and active charcoal 80% : 20% with a holding time of 2 hours with pressure = 9.8 MPa and hardness = 184,73 MPa ; the size of the diameter of the pores on average = 8,606 µm and womb elements (EDX) namely elements O = 58,11% ; Si = 24,04% ; Al = 12,33% ; Na = 3,06% ; K = 2.51% ; Ca = 2.22 % ; Fe = 2.01% ; Mg = 1.60 percent and C = 1.54%. water vapour adsorption test shows the value of the maximum hydrogen concentration passed = 61,87% on minutes- 77 with maximum output voltage = 3.09 Volts on minutes 98.

1 INTRODUCTION

Has been widely known that the pottery is one of the first artificial material made by human beings as a result of burning the clay in the fire to produce artificial stone (Buys and Oakley, 2014) clay that burned in the fire was then known as ceramics. Ceramics have some attractive properties compared to metals and poymers, is make them useful for specific applications. Their physical properties have been utilized for many applications. In other applications their mechanical properties acres Washington (Munz and Fett, 2013). Now ceramic products has been expanded and has a wide range of variation one of the porous ceramic. Porous Ceramic is a component of the glomerular filtration which is very useful in various applications and is designed to eliminate concentrate grade which has the size of the micrometer to nanometer from various fluid. Whereas total and the distribution of the size of the pores is the most important aspect of the porous media and effected on most of the characteristics of the porous media such as elasticity and mechanical properties, the movement and the flow of the fluid (Kuila and Prasad, 2013). Whereas the total important to improve permeability and high surface area provided for the adsorption of the vapour of gas (Prenzel et al, 2014). The way of filtering can be consist of the surface filtration and the inside filtration (*cake filtration*)) (Hammel et al, 2014).

Adsorption as surface filtration occurs when a solid surface left open to gas or fluid, which is defined as material enrichment or a rise in the density of the liquid in the region around the interface (Rouquerol et al, 2013). Ceramic Adsorption to gas occurs on the pores of the ceramic surface until the condition where

Susilawati, ., Sembiring, A., Waruwu, F. and Khanifah, S.
The Effect of the Mixture Variation and Holding Time to the Porous Ceramics based from Clay and Active Charcoal as a Filter of Water Vapour.
DOI: 10.5220/0010098410621069
In *Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches (ICOSTEERR 2018) - Research in Industry 4.0*, pages 1062-1069
ISBN: 978-989-758-449-7

the pores is fully charged by the gas or in other words is on the state of the saturated.

Mechanical characteristics such as a pressure and hardness is one of the nature of the material that is very important. Various studies have previously using the mixture of clay with carbon (active carbon/ active charcoal) (Phonpuak, 2012; Sarkar, 2012; Shen et al., 2014; Wang, 2013; Yates, 2012). (Susilawati et. al., 2017) has studied the use of natural zeolite with cocoa skin filler as a water vapor filter in the electrolysis process

In this experiment a porous ceramic as water vapour filter characterised the nature of the mechanism made from clay and active charcoal that have pores of that very much spread in all parts of the ceramics, which eventually produce ceramic that is weak with the mechanical nature of the weak. This is the main problem of this experiment. Porous ceramic needed not only have the nature of a good physic but must also have a good mechanical nature. Mechanical nature which is tested in this experiment is a pressure and hardness. The pressure of ceramics tested using Maekawa Testing Machine Tokyo Japan Type MR-20-CT while hardness of ceramics tested using Hardness Tester Matsuzawa Seiki Co,LTD No, 71C4. After strong mechanics characterised, ceramics porous structure will further be observed morphology surface.

The size of the pores and elements analysis using SEM EDX Zeiss types. For applications, ceramics will be tested for filtering the water vapor using the filter KIT is equipped with a hydrogen sensors TGS821.

2 EXPERIMENTAL METHOD

Porous Ceramic is made from clay and active charcoal. Clay which is used comes from the village Iraonogeba, Regency of Moroó in West of Nias and the active charcoal which is used is active Aquasorb® 1000 charcoal. The clay and active charcoal sifted with the sieve mesh 200. The clay activated chemically using the solution H_2SO_4 6% and continued with the activation of physics at a temperature of 300^0C. Ceramic is formed with the technique of *slip casting* with comparison of variation of clay mixtures : active charcoal 100% : 0% ; 90% : 10% ; 80% : 20% ; 70% : 30% and 60% : 40%. Ceramics were sintering with sintering temperature 1000^0C with variation of *holding time* 2 hours ; 3 hours and 4 hours. Ceramics characterised to get the value of mechanical properties (pressure and hardness); the size of the diameter of the pores, unsure elements (SEM-EDX) and the value of the water vapor adsorption.

3 RESULTS AND DISCUSSION

3.1 Mechanical Test

The results of the mechanical test of porous ceramic is shown in the Figure 1 and Figure 2.

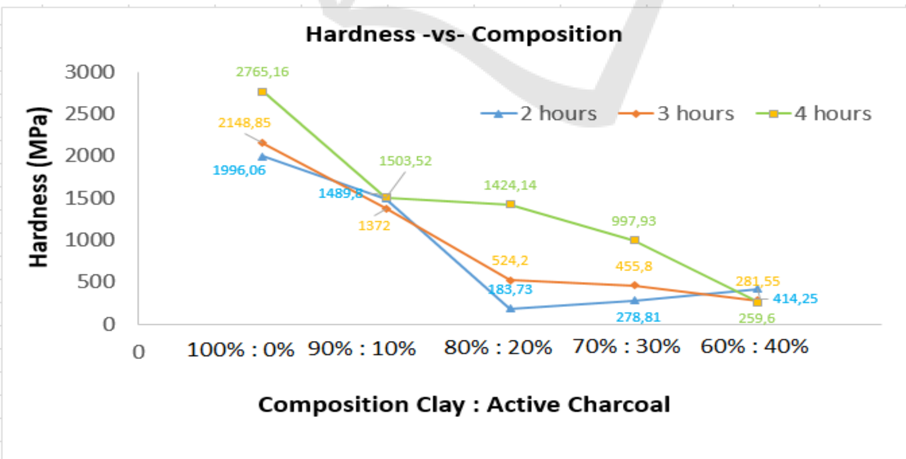


Figure 1 : Chart of Hardness VS Composition.

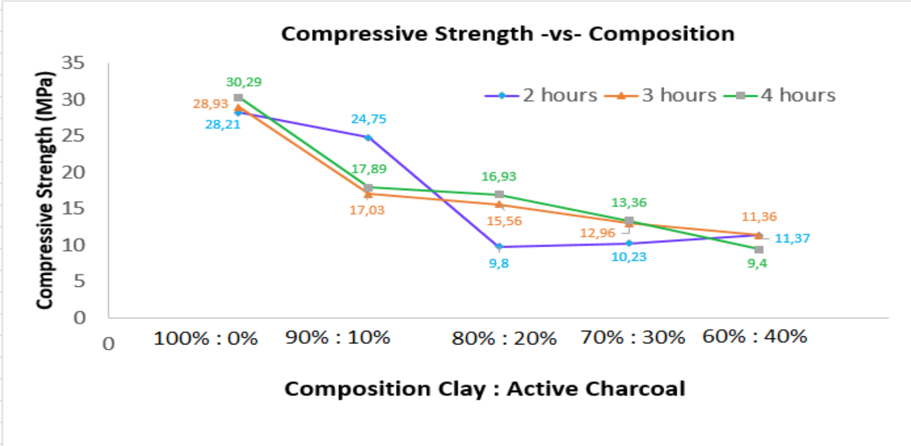
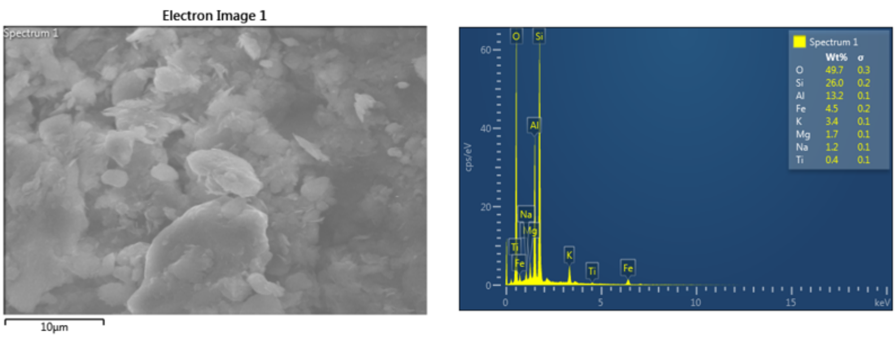


Figure 2 : Chart of Compresive Strength VS Composition.

From the results of compressive strength and hardness test can be taken from the following conclusion that ceramics which is form by clay and active charcoal have strong value of compressive strength and hardness that maximum at mixed variations 90% : 10 % with holding time 4 hours (due to the variation of a mixture of 100% : 0% do not have a mixture of active charcoal in it) while the lowest value is on the variation of a mixture of 80%:20% with holding time 2 hours. But the desired porous ceramic is ceramic that have many pores to be able to accommodate the water vapor when doing the filtration rate or in other words due to the porous ceramic required have pores then by itself the value of mechanical nature compressive strength and hardness) will be low (Yuan, et al, 2016).

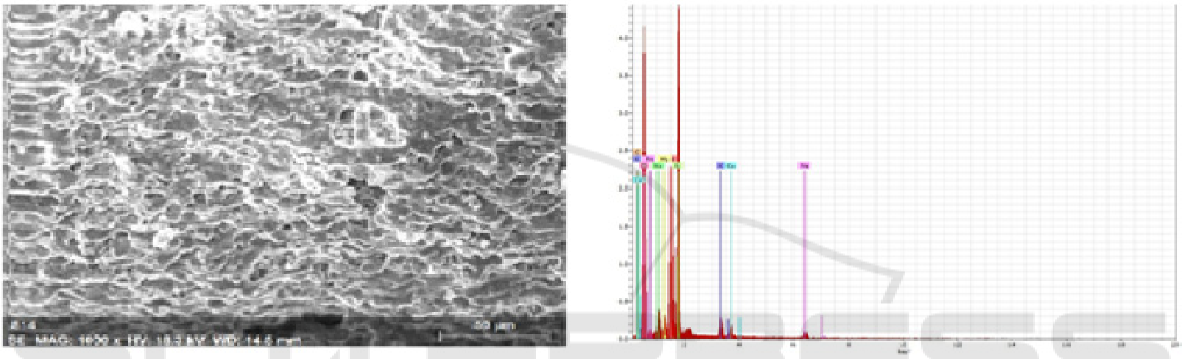
Therefore, then the optimum ceramic on this trial is on ceramics mixed variations 80% : 20% with a mixture of holding time 2 hours with pressure value = 9.8 MPa (Figure 1) and value of violence = 184,73 MPa (Figure 2) while for comparison taken ceramics with the value of the mechanical properties that high on the variation of a mixture of 90% : 10% with a holding time of 4 hours with strong value press = 17.89 MPa and the value of hardness = 1503,52 MPa or 1,50352 GPa. In the Figure can also be seen that the addition of active charcoal is on a mixture of ceramic coating will reduce the value of mechanical properties (either hardness or compressive strength) where the value of the best mechanical properties of ceramics found in a mixture of 100% : 0% without adding active charcoal and the value of the lowest mechanical nature there is on a mixture of 60% : 40%. Based on previous research reference (Yuan, et al, 2016) can be seen that the ceramic that is produced has a worth compressive strength between 13,72±2.2 - 43.5±3.3 MPa and also on the research (Yalcin and Sevinc, 2000) hardness of ceramics has a value between 0.79±0.02 - 8.25±0.09 GPa. So when compared to the ceramic coating on this research is worthy said as a porous ceramic.

3.2 SEM-EDX



Element	Line Type	Wt%	Wt% Sigma	Atomic %	Standard Label
O	K series	49.75	0.26	64.54	SiO2
Na	K series	1.16	0.07	1.05	Albite
Mg	K series	1.66	0.07	1.42	MgO
Al	K series	13.15	0.13	10.12	Al2O3
Si	K series	26.03	0.19	19.24	SiO2
K	K series	3.42	0.09	1.81	KBr
Ti	K series	0.37	0.07	0.16	Ti
Fe	K series	4.46	0.18	1.66	Fe
Total:		100.00		100.00	

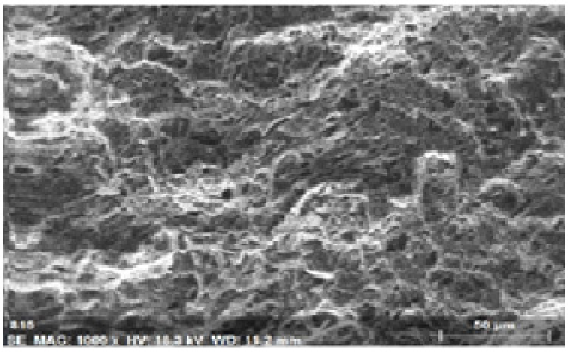
(a)

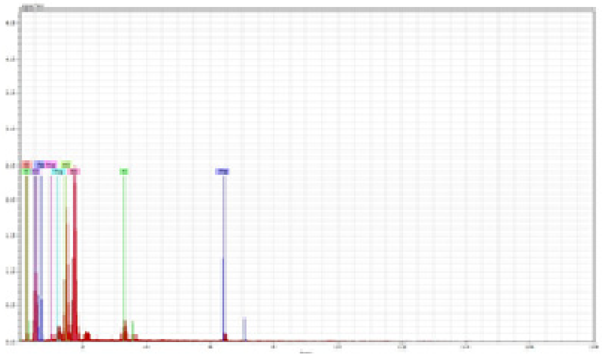


Spectrum: SAMPEL B

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
O	8	K-series	29.20	37.60	47.82	4.70	0.458	0.820	1.000	1.000
Si	14	K-series	19.71	25.37	18.38	0.89	0.139	1.819	1.000	1.003
Al	13	K-series	14.06	18.10	13.65	0.72	0.125	1.431	1.000	1.013
C	6	K-series	6.56	8.44	14.30	2.24	0.137	0.616	1.000	1.000
K	19	K-series	3.23	4.16	2.16	0.15	0.019	2.172	1.000	1.013
Fe	26	K-series	2.72	3.50	1.28	0.15	0.016	2.001	1.000	1.063
Mg	12	K-series	1.51	1.95	1.63	0.14	0.015	1.311	1.000	1.015
Na	11	K-series	0.68	0.88	0.78	0.10	0.008	1.119	1.000	1.008
		Total:	77.67	100.00	100.00					

(b)





Spectrum: SAMPEL A

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
O	8	K-series	58.11	54.10	66.92	8.19	0.955	0.567	1.000	1.000
Si	14	K-series	24.04	22.38	15.77	1.08	0.151	1.478	1.000	1.003
Al	13	K-series	12.33	11.48	8.42	0.65	0.098	1.163	1.000	1.012
Na	11	K-series	3.06	2.85	2.45	0.27	0.031	0.908	1.000	1.006
K	19	K-series	2.51	2.34	1.18	0.14	0.013	1.767	1.000	1.017
Ca	20	K-series	2.22	2.06	1.02	0.14	0.012	1.682	1.000	1.013
Fe	26	K-series	2.01	1.87	0.66	0.15	0.011	1.632	1.000	1.071
Mg	12	K-series	1.60	1.49	1.21	0.15	0.014	1.065	1.000	1.011
C	6	K-series	1.54	1.43	2.36	0.97	0.038	0.381	1.000	1.000
		Total:	107.42	100.00	100.00					

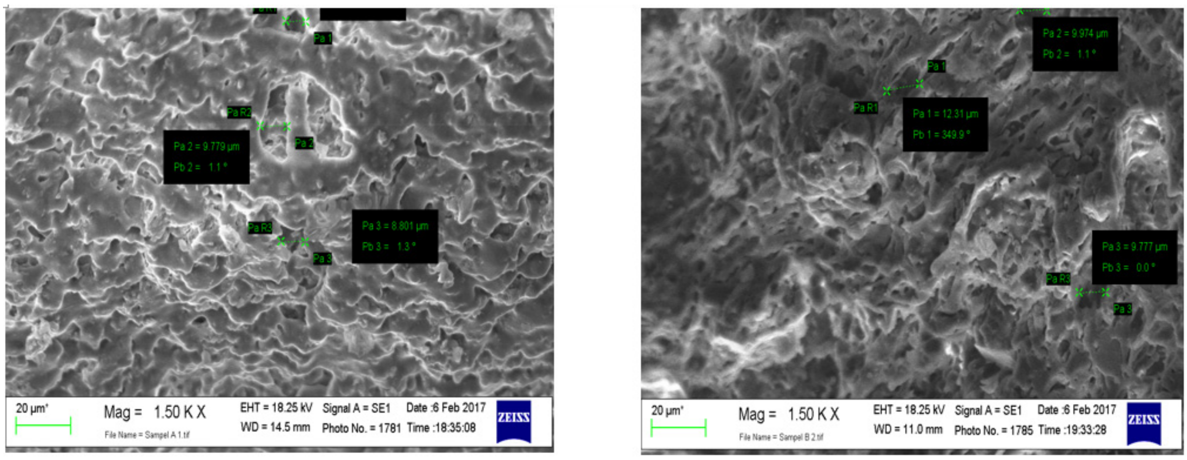
(c)

Figure 3 : SEM - EDX test results (a) clay without charcoal (b) clay: activated charcoal with 80%: 20% mixed variation, with a holding time of 2 hours (c) clay: activated charcoal with 90%: 10% mixed variation, with a holding time of 4 hours.

From the observations of the morphology of the ceramic surface can be used as an example of 80%: 20% mixture with a holding time of 2 hours has larger and more pores compared to 90%: 10% mixture with a 4 hour holding time which has pores which is far less and not evenly distributed.

While the results of the analysis using EDX can be used to mix 80%: 20% with a holding time of 2 hours which is equal to = 58.11% compared to a mixture of 90%: 10% with a 4 hour holding time of = 29, 20% where oxygen indicates that the porosity (eg oxygen from free air trapped in the pores) in the 80%: 20% Mixture with 2 hours holding time is far more than the 90%: 10% mixture with a 4 hour holding time. When compared to the concentration of oxygen in clay soil that has not been activated it can be seen the amount of oxygen in the mixture of 80%: 20% with a holding time of 2 hours compared to before the mixed clay is 90%: 10% with holding time 4 hours before clay is activated.
This reinforces that the 80%: 20% mixture with a 2 hour holding time is a better mixture.

From the reading of EDX elements, it can also be seen that the content of Ti in clay that was previously read by 0.37% was no longer found in 80%: 20% mixture with a holding time of 2 hours and a mixture of 90%: 10% with a holding time of 4 hours. This shows that chemical activation and technology can eliminate impurities but can also increase the surface area and porosity of raw clay (Toor et al, 2015). In addition, SEM-EDX also measured pore diameters at 3 different pores . Pore diameter measurements using SEM EDX are shown in the following figure with



(a) (b)

Figure 4 : Results of SEM observations for pore diameters with 1500 times magnification (a) samples with a mixture of 80%: 20%, 2-hour holding time, and (b) samples with a mixture of 90%: 10% 4-hour holding time.

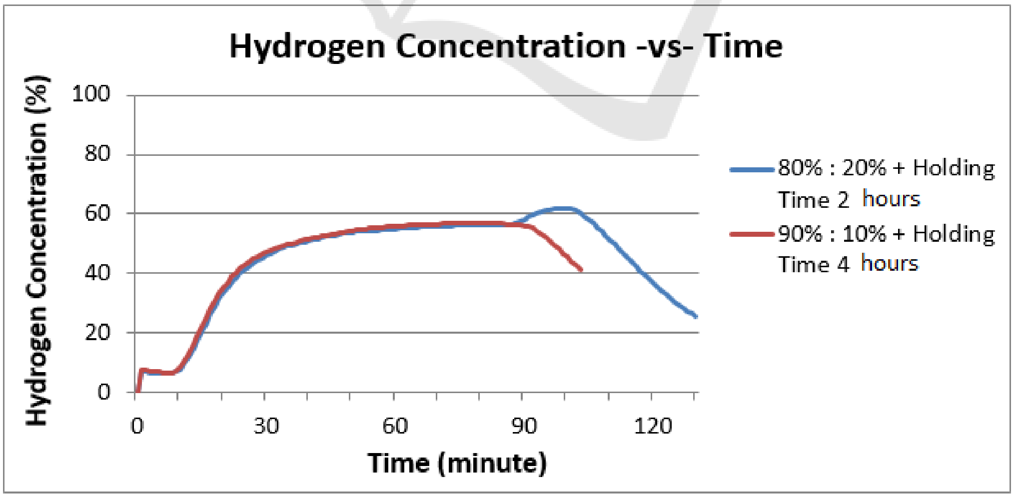
From the results of the diameter size measurement of the pores using SEM can be seen that the plates with a mixture of variations 80% : 20% with holding time 2 hours have the size of the diameter of the pores average = 8,606 µm.

While ceramics with mixed variations 90% : 10% with holding time 4 hours have the size of the diameter of the pores on average = 10.

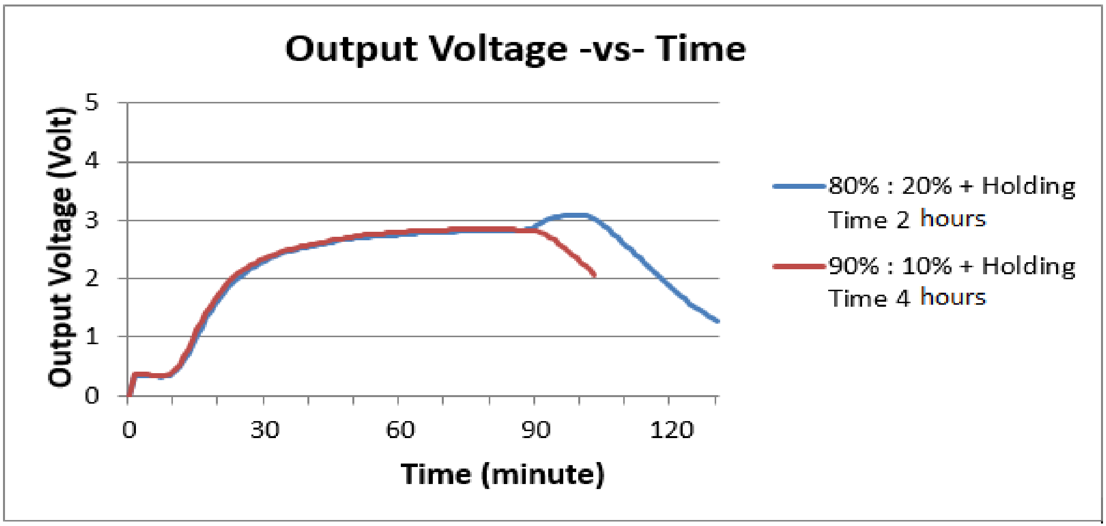
Have no evidence that the depiction of the multitude of pores which is actually on the ceramic coating is complex because of the extent of the spreading of the size and shape of the pores and the complexity of the network of pores .

From the measurement result proved both variation of these ceramics including ceramic coating type of *macroporous ceramic* due to the ceramic has the size of the pores greater than 50 nm (d >50 nm).

3.3 Water Vapour Adsorption Test



(a)



(b)

Figure 5 : Charts of The Water Vapour Adsorption based on (a) Hydrogen Concentration (b) Output Voltage.

Based on the results of the water vapor adsorption test can be seen that the variation of a mixture of 80% : 20% with holding time 2 hours that the hydrogen concentration which is read by the censorship is 61,87% with output voltage 3.09 Volts on minutes to 98 while on the variation of a mixture of 90% : 10% with holding time 4 hours the test results shows that the concentration of hydrogen which is read by the censorship is 57,08% on minutes to 77 with output voltage of 3.09 Volts on minutes to 98 . From the results of this test, it can be concluded that the application of the water vapour filter turns to ceramics with the basic materials of clay and active charcoal variation by a mixture of 80% : 20% with holding time 2 hours better in filtering the water vapour.

4 CONCLUSIONS

Ceramics with the basic materials of clay and active charcoal can be used as a water vapor filter with the optimum mixture variations 80% : 20% with a holding time of 2 hours is supported by mechanical data test (pressure and hardness), observation SHEM-EDX (morphology surface, the size of the diameter of the pores and the analysis of unsures elements). From the test of the water vapour adsorption also proves that a mixture of 80% : 20% with a holding time of 2 hours is the optimum variations that can be filtering the water vapour.

ACKNOWLEDGEMENTS

The authors are very grateful to Universitas Sumatera Utara for its funding according to TALENTA research contract 2018 with number 2590/UN5.1.R/PPM/2017 on March 16th, 2018.

REFERENCES

Buys, S. and Oakley, V., 2014. *Conservation and restoration of ceramics*. Routledge.

Hammel, E.C., Ighodaro, O.R. and Okoli, O.I., 2014. Processing and properties of advanced porous ceramics: an application based review. *Ceramics International*, *40*(10), pp.15351-15370.

Kuila, U. and Prasad, M., 2013. Specific surface area and pore size distribution in clays and shales. *Geophysical Prospecting*, *61*(2), pp.341-362.

Munz, D., & Fett, T. 2013. *Ceramics: mechanical properties, failure behaviour, materials selection* (Vol. 36). Springer Science & Business Media.

Phonphuak, N. and Thiansem, S., 2012. Using charcoal to increase properties and durability of fired test briquettes. *Construction and Building Materials*, *29*, pp.612-618.

Prenzel, T., Guedes, T.L.M., Schlüter, F., Wilhelm, M. and Rezwan, K., 2014. Tailoring surfaces of hybrid ceramics for gas adsorption–From alkanes to CO 2. *Separation and Purification Technology*, *129*, pp.80-89.

Rouquerol, J., Rouquerol, F., Llewellyn, P., Maurin, G., & Sing, K. S. 2013. *Adsorption by powders and porous* *solids: principles, methodology and applications*. Academic press.

Sarkar, S., Bandyopadhyay, S., Larbot, A. and Cerneaux, S., 2012. New clay–alumina porous capillary supports for filtration application. *Journal of membrane science*, *392*, pp.130-136.

Shen, Y., Zhao, P. and Shao, Q., 2014. Porous silica and carbon derived materials from rice husk pyrolysis char. *Microporous and Mesoporous Materials*, *188*, pp.46-76.

Susilawati, Tulus I. N., Fynnisa Z., and Hamonangan N. 2017. Hydrogen purification using natural pahae zeolit and cocoa rind based filter. *International Journal of Applied Engineering Research* 12 (13), 3914-3918.

Toor, M., Jin, B., Dai, S., & Vimonses, V. 2015. Activating natural bentonite as a cost-effective adsorbent for removal of Congo-red in wastewater. *Journal of Industrial and Engineering Chemistry*, *21*, 653-661.

Wang, A., Gao, X., Giese, R.F. and Chung, D.D.L., 2013. A ceramic–carbon hybrid as a high-temperature structural monolith and reinforcing filler and binder for carbon/carbon composites. *Carbon*, *59*, pp.76-92.

Yalçın, N., & Sevinc, V. 2000. Studies of the surface area and porosity of activated carbons prepared from rice husks. *Carbon*, *38*(14), 1943-1945.

Yates, M., Martín-Luengo, M.A., Argomaniz, L.V. and Velasco, S.N., 2012. Design of activated carbon–clay composites for effluent decontamination. *Microporous and Mesoporous Materials*, *154*, pp.87-92.

Yuan, B, Li, H. X, Wang, G., Yu, J. B., Ma, W. K, filter. Journal of Alloys and Compunds, 684, 613-615

Yuan, B., Li, H. X., Wang, G., Yu, J. B., Ma, W. K., Liu, L. F., ... & Shen, Z. J. 2016. Preparation and properties of porous silicon carbide based ceramic