Ceramic Membrane Preparation From Waste : Effect of Binders

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***Abstract* - Porcelain based ceramic supports from sanitary waste were prepared by using different amounts of binders, Polyvinyl Alcohol (PVA) and Polyethylene Glycol (PEG 1500).Converting the sanitary waste into ceramic as a construction material can reduce the utilization cost of the waste but also as an alternative method that has low cost to produce ceramic.The purpose of the research were to identify the ceramic support that has been prepared from the waste and to know the effect of binder on the ceramic support itself. The aimed is to prepare the ceramic membrane support using waste with the help of PVA and PEG as a binders by using compression method. The ceramic properties were analyzed by Fourier Transform Infrared Spectroscopy (FTIR).Result shows that 10wt% PEG is optimum in terms of organic materials as it identify the molecular components and structures exist in the membrane.**

***Keywords* - Binders, Ceramic Membrane, FTIR**

INTRODUCTION

Ceramic has become one of the ancient industries in the world. Now, it has become one of the demand in the world. There are a lot of production of ceramic from expensive materials to low expensive material. Industry's now has been searching the new materials that has low cost to produce ceramic. One of the materials are by using the waste to produce the ceramic. The waste such as sanitary waste, glass waste, fly ash has been introduced to the world in production of ceramic by adding other additives such as binders to make the ceramic more strong and not easily crack (S. H. Amin, 2016). In order to make a good ceramic, the most important things is to look the membrane itself about the materials used, methods to fabricated the ceramic membrane and the equipment used to characterize the membrane.

Ceramic wastes in Spain abound and they are generated by not only the industry, but also by the construction sector. According to Ministries of Forment in Espanio,2010 approximately 950 kg per person/year derived from the construction field in 2007 in Spain, although this amount lowered in subsequent years due to the economic crisis (520 kg per person and per year in 2009)

Generally, membranes can be classified into two general groups known as organic and inorganic. Organic can be acknowledge as polymeric while inorganic membranes can be acknowledge as ceramic membranes (M.Khalili,2014). Porous ceramics are widely used as filters, catalyst carriers, separation membranes, and bio-ceramics. Ceramic membranes are generally composed of three layers. The inner layer is the porous supported layer which provides a high mechanical strength for the fabricated membrane. The second one is the intermediate layer which is coated over the supported layer and characterized by a lower pore size. Because of the difference in pore size between the support layer and the top layer, the intermediate layer acts as a bridge between these two layers. The last one is the top layer at which the separation takes place (Li, 2007; Peng, 2008; Synthetic Membrane, 2013).

There have been many studies focused on the preparation of porous ceramics. Generally, porous ceramics have good properties such as high mechanical strength, abrasion resistance, and chemical and thermal

stability (Isobe et al., 2006). The main raw materials of commercial porous ceramics are alumina, zirconia, titania, silica, and mullite (Dong et al., 2006). Alumina is the most widely used of the oxide ceramics because of its hardness, good corrosion resistance, high thermal resistance, and ease of processing (Sathiyakumar and Gnanam, 2003). However, the membrane may crack during the process. So, binders are introduced to provide strength and avoid cracking in the membrane layer.(M. R. Othman ,2000). By using the PVA and other additives as a binder, symmetric macro-porous ceramic can be produced. Different binders and additives will result in different characteristics of the membrane such as size distribution and pore size. There are a few parameter that affect the porosity of membrane support pore size which are type of binder, powder and binder miling time, molding pressure and also the sintering temperature (M. Khalili, 2014).

Actually using ceramic membrane instead of conventional steps in water treatment (coagulation, sedimentation, and filtration) has proved to be more advantageous and effective [Gaulinger, 2007; Peng, 2008].. There are various methods for fabricating ceramic membranes from their raw materials. These methods include slip casting, tape casting, pressing, extrusion, sol-gel process, dip coating, chemical vapor deposition, and anodic oxidation. The selection of any preparation method depends on the application and the desired membrane structure (Li, 2007). The decomposition of the binder and its effect on the density and strength of the membrane can be relate to each other (Shibani Das, 2011). So, this research is aimed to prepare the ceramic membrane support using sanitary waste with the help of PVA and PEG as a binders. The method used in this research was prepared by the extrusion method using sanitary waste dough containing binders (PVA and PEG).The phase composition, microstructure were investigated.

METHODOLOGY

Materials and Methods

Commercially available the sanitary waste, porcelain waste (Top Gloves Company) and binders (PVA and PEG) solids were used as the starting materials in the research. The sanitary waste were sieved to get the particle size less than 180 micron.

The binders needed to be diluted to produce the desired concentration which were 10wt% , 20wt%, and 30wt% of PVA and PEG concentration each. Firstly, 10 wt% of PVA was dissolved in 90 wt% of distilled water (based on dry weight of binders) by using the magnetic stirrer at 90^{o}C for 2 h until the solid dissolved completely. Then, the procedures were repeated five times to produce 10 wt%, 20 wt% and 30 wt% concentration of PVA and PEG each. After that, the porcelain waste powder were first mixed with the 10 wt% PVA solution and mixed it until it became a dough. After that, the dough were left in room temperature for 30 minutes to let it dry a little before compressed to form a sample with a 10 mm diameter and 118 mm length by using compression machine. It was a dry pressing method under load of 150 kPa with the duration time about 1 minutes to obtain the form. The form were dried at room temperature for 48 h. Six kinds of samples with different concentration of binders were referred as 10 wt% PVA, 20 wt% PVA, 30 wt% PVA, 10 wt% PEG, 20 wt% PEG and 30 wt% PEG. The samples then were characterized according to their compositions and structures.

Characterization

Fourier Transform Infrared Spectroscopy (FTIR) was used to investigate the molecular and composition existed in the ceramic membrane. The FTIR of the PVA and PEG samples were shown in Figure 1. As seen, the FTIR spectra of PVA and PEG samples showed the strong peaks that existed in the ceramic membrane.

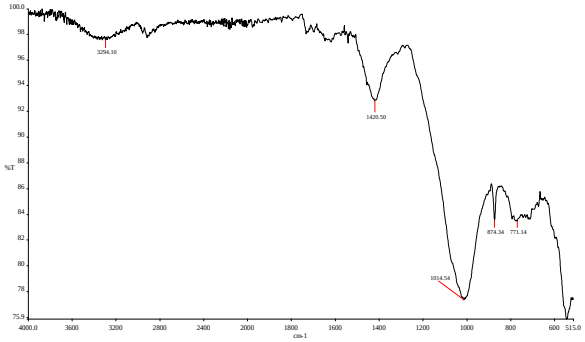

Figure 1 (a) . FTIR spectra of 10 wt% PVA solution

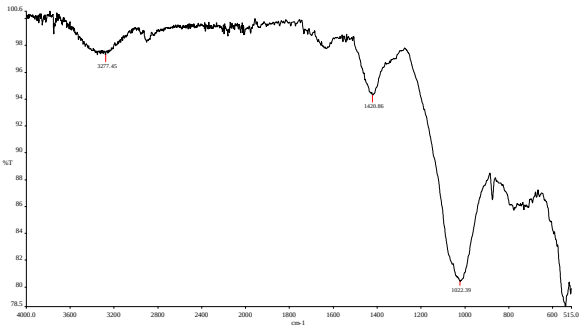

Figure 1 (b) . FTIR spectra of 20 wt% PVA solution

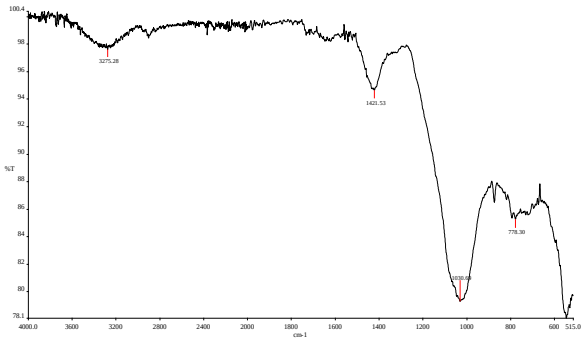

Figure 1 (c) . FTIR spectra of 30 wt% PVA solution

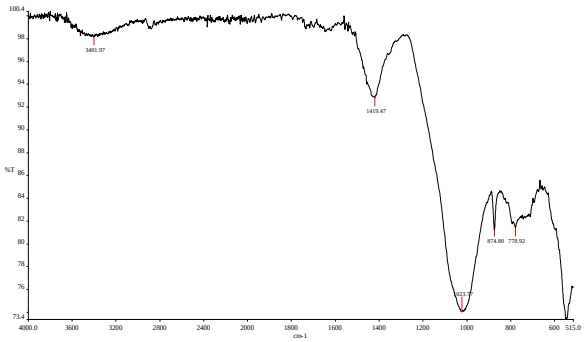

Figure 1 (d) . FTIR spectra of 10 wt% PEG solution

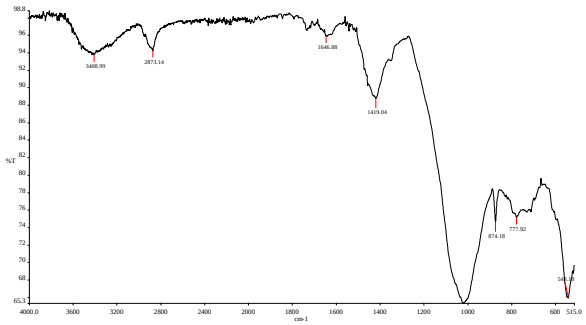

Figure 1 (e) . FTIR spectra of 20 wt% PEG solution

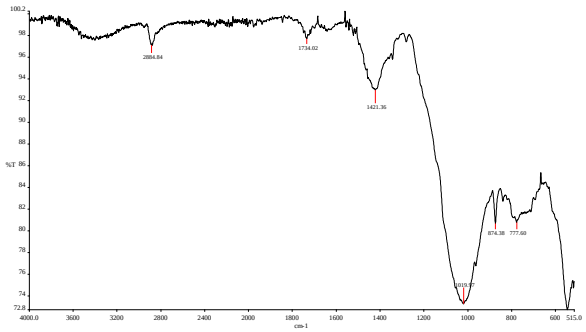

Figure 1 (f) . FTIR spectra of 30 wt% PEG solution

The mixtures of ceramic with given proportions in Table 1 were homogenized with addition of binder (PVA and PEG). The proportion of the samples was limited to maximum amount of 30% (by weight) as the concentration of 30 wt% PVA binder started to difficult to dilute.

Parameter	Concentration (wt%)	Distilled water (mL)
PVA 1	10	90
PEG 1		
PVA 2	20	80
PEG 2		
PVA 3	30	70
PEG 3		

Table 1 : The proportions of the sample

DISCUSSIONS

Figure 1(a, b, c, d, e and f) displays the

corresponding infrared spectra. As seen, the infrared spectra of the samples are rather similar, presenting the analogous absorption bands. For Figure 1 a, it showed the first bands at 3294.10 cm^{-1} respectively related to O – H stretching and bending modes of molecular water. For second peaks, the band at 1420.50 cm^{-1} indicated that it has Vinyl C – H bending in plane while the third peak showed the band at 1014.54 cm^{-1} related to halogen – carbon stretching, C – F (Aliphatic fluoro compounds). The next peaks showed that the aromatic ring (aryl group) existed with C – H (1, 3 –Disubstitution (meta)) at 874.34 cm^{-1}. The fifth peaks showed that at the band 771.14 cm^{-1} aliphatic chloro compounds, C – Cl stretching existed in the sample. For Figure 1 b and 1 c, the results showed a slightly different in value but the similar in terms of patterns of infrared spectra.

Figure 1 d, it showed the first bands at 3401.97 cm^{-1} respectively related to N – H stretching modes of molecular Nitrogen. For second peaks, the band at 1419.47 cm^{-1} indicated that it has Vinyl C – H bending in plane while the third peak showed the band at 1023.77 cm^{-1} related to aliphatic phosphate, P - O – C stretching. The next peaks showed that the aromatic ring (aryl group) existed with C – H (1, 3 –Disubstitution (meta)) at 874.80 cm^{-1}. The fifth peaks showed that at the band 778.92 cm^{-1} aliphatic chloro compounds, C – Cl stretching existed in the sample. For Figure 1 e and 1 f, the results showed a slightly different in value but the similar in terms of patterns of infrared spectra. These value shift to lower wavenumbers when the degree of silicon substitution by aluminium in the second coordination sphere increase, as the consequences of the weaker Al – O bonds.

CONCLUSION

1. Results obtained from the ceramic membrane preparation from waste with 10 wt%, 20 wt% and 30 wt% of binders (PVA and PEG) proved the possibility of producing membrane from ceramic waste, porcelain waste.
2. Results obtained from FTIR showed that 10 wt% PEG is more suitable compared others for ceramic membrane preparation.

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