# The Effect of Mole Ratio of Acrylamide (AM) Monomer and Methylene-bis-acrylamide (MBAM) Crosslinker Toward the Hardmess of Gelcasting Porous Ceramics

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ABSTRACT. The Effect of Mole Ratio of Acrylamide (AM) Monomer and Methylene-bis-Acrylamide (MBAM) Crosslinker Toward the Hardness of Gelcasting Porous Ceramics. The study aimed to determine the effect of mole ratio of acrylamide (AM) monomer and crosslinker methylene-bis-acrylamide (MBAM) croslinker toward the hardness of gelcasting porous ceramics. The raw material used was natural clay of South Sulawesi. The ceramic synthesis process using colloidal gelcasting method with in situ polymerization in the slurry as basic principles. Ceramic powder was added gradually into the premix solution containing a mixture of AM and MBAM with mole ratio of 6: 1; 12: 1; 18: 1; 24: 1, then homogenized and mixed with APS initiator and TEMED catalyst. The ceramic dough then put into a mold, dried in air and then sintered. The ceramic hardness was measured using Brinell Hardness tester. The results showed the ceramic hardness was increased at a ratio of 6: 1 to 18: 1 and decreased at a ratio of 24: 1. The hardest ceramic body occured at a ratio of 18 : 1, that was equal to 104 HB.

*Keywords: ceramics, pores, gelcasting, morphology*

## BACKGROUND

Utilization of porous material either as adsorbent or as catalyst carrier is currently experiencing rapid growth. One of porous material that is widely used is ceramic. According to Jinlong et al. (2011), the optimization of porous ceramics reliability is currently being developed. Porous ceramics are used in the field of industry as carrier catalysts (Kiyoshi et al., 2009), in the health sector as a proponent of artificial bone (Delecrin et al., 2000), and in the food sector as media immobilization of bacteria in the manufacture of yeast (Janiszyn et al. 2007). The products were in Indonesia in the form of finished products obtained from abroad. Thus, in order to increase the utilization of domestic products in line with technological developments, it is necessary for the development of ceramic porous oriented in utilization of natural materials available in Indonesia.

One example of a natural material that potentially used as raw material in the manufacture of ceramics is alumina silica contained in bauxite. Moreover, silica alumina is also contained in natural clay. Traditional techniques have been developed in the manufacture of porous ceramic, such as dry-pressing (Harefa 2009), extrusion (Mongkolkachit et al., 2010), and slip casting (Ramlan (2009), Tjitro et al. (2008), Tambunan ( 2008)). However, the methods have several problems, for example requires large pressure, need porous molds, and the methods are fairly complex (Guangyao et al., 2000). One alternative method in manufacturing of porous ceramic is gelcasting method which is a new method in the field of colloidal with several advantages ; the technique is fairly easy to use with a fairly low cost, resulting in high porosity, fewer used of organic additives, and the mold used can be varied.

However, it is difficult to produce a homogeneous pore size using the gelcasting method (Jinlong et al., 2011). The gelcasting method using a monomer, crosslinker, initiator and catalyst with the principle of in situ polymerization in a ceramic slurry. In this research, the manufacture of the porous material with gelcasting method using silica alumina base material derived from natural clay of South Sulawesi. This study examines the effect of mole ratio of AM monomer and MBAM crosslinker toward the hardness of gelcasting porous ceramics.

## RESEARCH METHOD

The materials used are natural clay of South Sulawesi, acrylamide (AM), methylene-bis-acrylamide (MBAM), ammonium persulphate (APS), and TEMED. The tools used in this study are a set of glassware, sieve (40 mesh and 80 mesh), Mettler AE 166 analytical scales, Barnstead Thermolyne furnace, pycnometer, and Scanning Electron Microscopy (SEM).

### A. Sample preparation

Natural clay is homogenized, and then the sample finely pulverized in a mortar and sieved with 40-80 mesh-sized sieve. The sample used is the sieved powder.

### B. Preparation of gelcasting porous ceramic dough

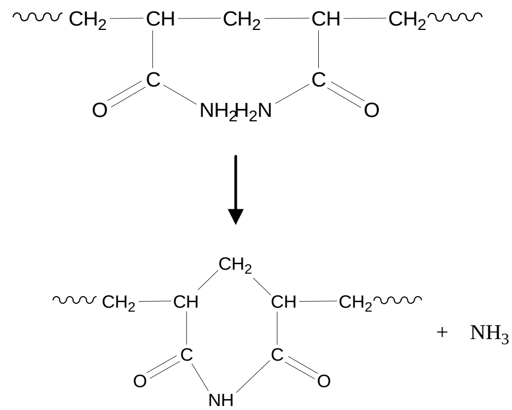
2.8 g of clay is added into the mixture of AM monomers and MBAM crosslinker (40% : 2%). The mole ratio of AM monomer and MBAM crosslinker is varied at 6: 1, 12: 1, 18: 1 and 24: 1. The resulting suspension is homogenized for approximately 20 minutes in a mortar, then 40 mL of 10% APS and 20 uL TEMED 99 % are added. The dough is put in a cylindrical mold with a diameter of 1.9 cm and a height of 1.6 cm and let until the dough can be removed from the mold. The mold is then opened, and the resulting ceramic sample is dried for 2 days in the air. The crude gelcasted ceramics further sintered at a temperature of 100 ° C to 1100 ° C with a heating rate of 50 $^{o}$C / 15 minutes, where detention at a temperature of 100, 200, 500 and 1100 ° C for 60 minutes.

### C. Hardness test of gelcasting porous ceramic

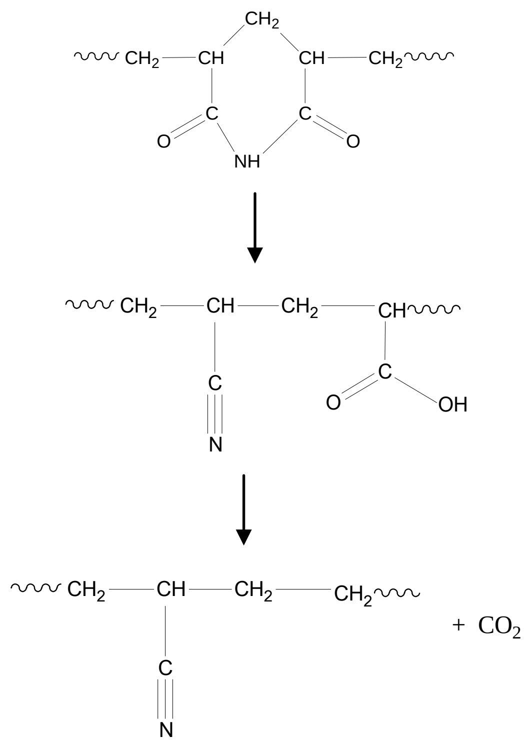
Hardness test (Brinell Hardness/HB) of ceramic samples is made using the hardness tester. Ceramics is smoothed using Ipolising and sandpaper. Ceramics is placed on the stand then pressed by steel ball with a diameter of 10 mm and a load of 5 kg in order to determine the magnitude of hardness.

## RESULT AND DISCUSSION

The resulting pores in the ceramic body occurs in the sintering process. The pores resulted from the loss of the polymer system and then leave empty space in the ceramic body. The loss of these polymers is believed to occur due to the polymer degradation that releases $NH_3$ and $CO_2$ gases at a certain temperature that is predicted occurs at a temperature of 500 ° C which is marked by the emergence of ammonia odors. $NH_3$ release is believed to occur due to the imidization reaction between the amide groups on the monomer and the release of $CO_2$ due to the termination of the polymer side chains with the formation of the imide. The reactions of $NH_3$ gas release in the sintering process is shown in the following equation:




The reaction of $CO_2$ gas release is shown in the following equation:




With the formation of pores through the polymer degradation in ceramic bodies characterized by the releasing of $NH_3$ and $CO_2$ gases then assumed that the number of moles of polymer in the ceramic body will affect the density of ceramics. The parameters that were examined which is the ratio of monomer and crosslinker. The hardness of porous ceramic body are shown in Table 1.

Table 1. The effect of mole ratio of AM : MBAM toward the hardness of ceramic

| AM : MBAM | Hardness (HB) |
|---|---|
| 6 : 1 | 96 |
| 12 : 1 | 97 |
| 18 : 1 | 104 |
| 24 : 1 | 103 |

Table 1 showed that the ceramics hardness increase at the ratio of 6 : 1 to 18 : 1 and decrease at the ratio of 24:1. The increasing of hardness at the ratio of 6 : 1 to 18 : 1 is associated with the greater the ratio AM : MBAM, the less amount of organic compounds are released from the ceramic body so that the alleged number of pores formed becomes less and the hardness of sintering ceramic body increases. In ratio of 24 : 1 ceramic hardness decreases, it is predicted due to the number of closed pore greater than the ratio number of closed pore at the ratio of 18 : 1. Therefore, it is believed that the gas from degradation process are still trapped in the ceramic body and the ceramics becomes more brittle.

## CONCLUSION

Results of the study show the ceramic hardness increase at the mole ratio of AM : MBAM (6: 1 to 18 : 1) and decrease at a ratio of 24 : 1, hardest ceramic body occurs at a ratio of 18 : 1 that is equal to 104 HB.

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