

REUSE OF PLASTER WASTE FROM JEWELRY INDUSTRY BY MIXING WITH NEW PLASTER

N. Srisittipokakun^{a, b, *}, A. Angnanon^{a, b} and J. Kaewkhao^{a, b}

^aPhysics Program, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, Nakhon Pathom, 73000, Thailand

^bCenter of Excellence in Glass Technology and Materials Science (CEGM), Nakhon Pathom Rajabhat University, Nakhon Pathom, 73000, Thailand

Received 24 July 2015; Revised 10 October 2015; Accepted 2 December 2015;
Available online: 15 January 2016

ABSTRACT

In this research, all plaster waste samples were dried at room temperature and were ground to fine powder. The structural identification of these samples have been investigated using X-ray Diffractometer. The hemihydrate phase was presented only in the new plaster, whereas the dihydrate phase was occurred in only the new plaster mix with water sample. Otherwise, increase in heating temperature the hemihydrate phase decreased and did not occur in temperature higher than 350 °C. This may be due to that the structure of dihydrate transforms to hemihydrates phase in temperature of 100 °C - 200 °C. Therefore, the plaster waste sample was selected to mix with new plaster with different ratio to produce the plaster mold and then investigated their setting times. The appreciate ratio between the amount of P1 to P4 was 60:40 because this sample can be reused the plaster waste for 40%.

KEYWORDS: *Plaster, X-ray diffraction, Anhydrite, jewelry industry, viscosity*

*

Corresponding authors; e-mail: nattapon2004@gmail.com Tel.: +6634-261065 Fax: -

INTRODUCTION

Jewelry casting is a process of making jewelry pieces that involves the pouring of liquid metal alloy into a mold. It is usually referred to as lost-wax casting because the casting mold is created using a wax model that is melted away to leave a hollow chamber in the mold. This technique has been used for thousands of years, and is still widely used today by both master craftsmen and home crafters to make precise reproductions of original jewelry pieces. Plaster mold casting, also called rubber plaster molding (RPM), is a method of producing aluminum or zinc castings by pouring liquid metal into plaster (gypsum) molds. Plaster mold casting is a manufacturing process having a similar technique to sand casting. In industry parts such as valves, tooling, gears, lock and Jewelry components may be manufactured by plaster mold casting. At a local jewelry industry in Nakhon Pathom, Thailand, approximately 1 tonnes of plaster waste was produced every month. After the plaster mold casting process, the molds are disposed of in landfills and often dumped directly into the environment. It is very important for sustainable

development of various jewelry industries and protection of the environment because the plaster waste materials from industries would increase every year. Normally, plaster is produced from the calcination of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) which partially dihydrates to produce a hemihydrate or plaster ($\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$), anhydrite (CaSO_4) [1].

Plaster occurs when gypsum is heated to the right temperature. However, if gypsum is heated to higher temperature, its structure changes to anhydrite. Anhydrite will not be occurred the hydration reaction [2]. There is abundance of plaster waste disposed from jewelry industry as an environmental problem. Then has been studying properties reuse of plaster waste from jewelry industry, depreciate waste and cost.

MATERIALS AND METHODS

The main use of plaster in jewelry industry is to produce mold for jewelry casting by lost-wax technique. Firstly, the plaster was mixed with water at water/plaster ratio of 38 ml /100 g. When the mold was set, it was heated in a furnace at 550 °C for 4 hr. After that, liquid

metal was poured into the plaster mold. Finally, remove the excess plaster from jewelry piece. Plaster waste from cleaning process was stored in storage tanks for a month before dispose. The process of making jewelry pieces is shown in Fig. 1. The plaster samples were collected from different processes, which are new plaster (P1), new plaster mixed with water (P2), new plaster mixed with water and heated at 550 °C (P3), waste plaster from final process (P4) and the waste plaster stored in storage tank for a month (P5).

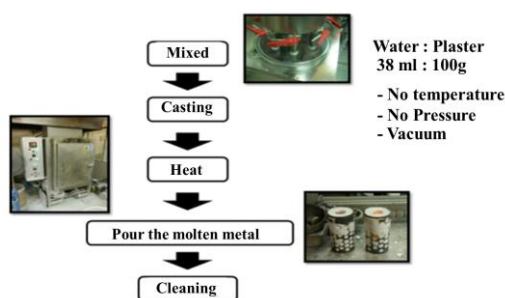


Fig. 1. The process uses plaster of the jewelry industry.

All plaster waste samples were dried at room temperature and were ground to fine powder. The structural identification of these samples have been investigated using X-ray Diffractometer (XRD-6100, Shimadzu) with Cu radiation at a scanning rate of 2°/min in the 2θ range from 10° to 80°. The structures in each sample were identified from the diffractograms by reference to Joint Committee on Powder Diffraction Standard File (JCPDS).

RESULTS AND DISCUSSION

Crystal structure analysis

The powder X-ray diffraction patterns and characteristic peaks of plaster samples are shown in Fig. 2. The XRD patterns showed the characteristic phases of anhydrite, quartz and cristobalite in all samples. Moreover, the hemihydrate phase was presented only in the P1 sample, whereas the dihydrate phase was occurred in only the P2 sample. Otherwise, the P3, P4 and P5 samples did not show the both characteristic phases of hemihydrate and dihydrate. Therefore, the P2 sample was chosen and was separated into seven groups in order to study the thermal effect of heating temperature on crystal structure. The divided P2 samples were heated from 100 °C to 700 °C for 4 hr in furnace and were denoted as

P2-100, P2-200, P2-300, P2-400, P2-500, P2-600 and P2-700 (the labeling number indicate heating temperature), respectively.

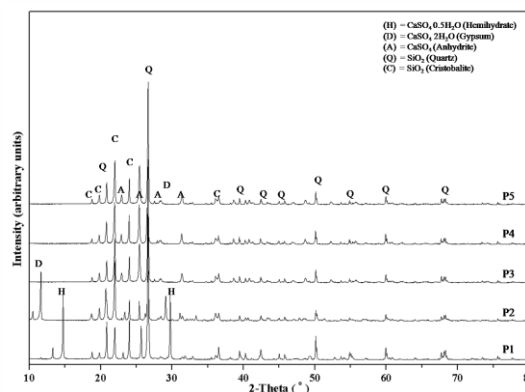


Fig. 2. X-ray diffraction patterns of sample for the jewelry industry.

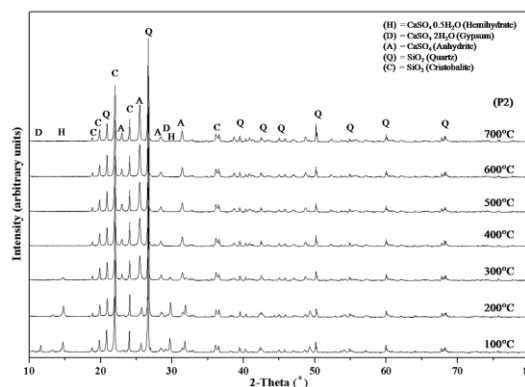


Fig. 3. X-ray diffraction pattern of plaster P2 heated at 100-700°C for 4 h.

The crystal structures of all above samples were investigated and showed in Fig. 3. The phase of dihydrate occurs only in the P2-100 sample. Otherwise, increase in heating temperature the hemihydrate phase decreased and did not occur in the P2-400, P2-500, P2-600 and P2-700 samples. This may be due to that the structure of dihydrate transforms to hemihydrates phase in temperature of 100 °C - 200 °C. Moreover, when the temperature is higher than 400 °C the hemihydrates transform to anhydrite phase. From these results, the heating temperature in the range of 100 °C - 200 °C and 300 °C - 400 °C were chosen to evaluate the transformation of dihydrate, hemihydrates and anhydrite structures. In Fig. 4, at heating temperature higher than 110 °C, the dihydrate phase disappear. Moreover, in Fig. 5 showed that the hemihydrates decreased with increasing heating temperature from 300 °C up to 350 °C

and the spectrum showed only the anhydrite structure when temperature is higher that 350 °C.

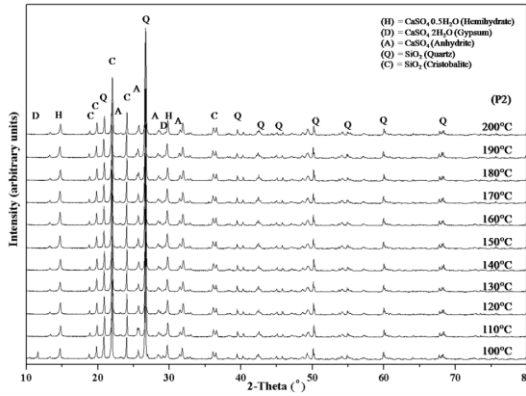


Fig. 4. X-ray diffraction pattern of plaster P2 heated at 100-200°C for 4 h.

Setting time and viscosity analysis

The result from Fig. 2, showed that the hydratio of the P4 sample cannot take place then this sample cannot be reused again. Therefore, the P4 sample was selected to mix with new plaster (the P1 sample) with different ratio to produce the plaster mold and then investigated their setting times. The ratio between amount of P1 and that of P4 are 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90 and 0:100 %wt, respectively. All above mixtures and water were mixed in the water/plaster ratio of 38 ml /100 g to set and recorded their setting time. The Viscosity of mixed plaster samples were measured by using Viscometer, Brookfield model DV-I+ for RV probe No.2 speed 0.5 RPM.

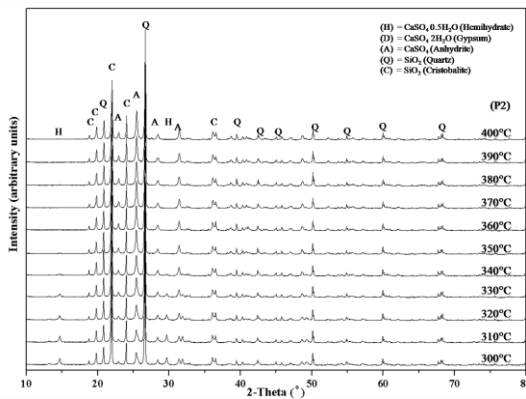


Fig. 5. X-ray diffraction pattern of plaster P2 heated at 300-400°C for 4 h.

Table 1. Setting time is plastered in various ratios.

Ratio (P1 : P4)	Setting Time (min)
100 : 0	30
90 : 10	32
80 : 20	34
70 : 30	36
60 : 40	38
50 : 50	>>1Day
40 : 60	>>1Day
30 : 70	>>1Day
20 : 80	>>1Day
10 : 90	>>1Day
0 : 100	>>1Day

The setting time of the mixed plaster samples were enlisted in Table 1. The result found that with higher amount of P4, the mixed plaster samples set quicker. The result of viscosity also has the similar trend with those of setting time when increasing the amount of P4.

Due to the viscotisy of mixed plaster sample with ratio of 100:0 was 2.36×10^4 mPa.s. Hence, the four mixed plaster samples with the ratio of 90:10, 80:20, 70:30 and 60:40 were selected in order to adjust their viscosity come close to that of the 100:0 sample. In this process, the various amount of water were added to samples and measured their viscosity (As seen in Fig. 6). From this result, with different ratio of P1 to P4 the different water conten are required.

For the all mentioned results, the setting time of mixed plaster samples of 100:0, 90:10, 80:20, 70:30, 60:40 are not much difference. Therefore, the appreciate ratio between the amount of P1 to P4 was 60:40 because this sample can be reused the plaster waster for 40%.

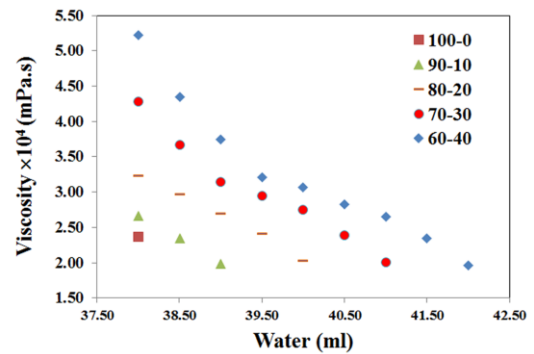


Fig. 6. Relationships are between viscosity and water.

CONCLUSION

In this research, found that the plaster heating temperature higher than 350 °C, the spectrum showed only the anhydrite structure. The appreciate ratio between the amount of P1 to P4 was 60:40 because this sample can be reused the plaster waster for 40%.

ACKNOWLEDGEMENTS

The authors would like to thanks the Research and Development Institute, Nakhon Pathom Rajabhat University (NPRU) and Old Moon Company Ltd. for funding this research and facility supports. We would like to express thank Sakon Nakhon Rajabhat University International Conference 2015 (SNRU-IC 2015) for preparation document, commentation, prove English gammar and submission.

REFERENCES

- [1] G. Baohong M. Xianfa, W. Zhongbiao, Y. Liuchun, S. Zhuoxian: *Chem. Eng. J.* 54, **2009** 719–725.
- [2] N.B. Singh, B. Middendorf: *Prog. Cryst. Growth Charact. Mater.* 53, **2007** 57-77.