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Manufacturing of Local Plaster of Paris (P.O.P) from Salt Residue Mined in Sege in the Dangme East District of the Greater Accra Region of Ghana

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Abstract: The study sought to find out whether salt residue (Gypsum) that goes waste and poses a threat to the environment could be used to produce Plaster of Paris (P.O.P). Ghana is endowed with natural resources including salt mining of which Sege Salt Mining is of no exception. There is abundant by-product (salt residue). However, it appears the salt residue could be utilized to manufacture Plaster of Paris (P.O.P) locally to feed institutions, agencies and industries that use POP as the main raw material; thereby minimizing the importation of foreign POP. The experimental research method was employed. Sample of the salt residue was obtained from Sege in the Dangme East District of the Greater Accra Region. The salt residue was heated between 120-150°C and crushed into powdered form using corn mill; turning it into POP. The results of the study revealed that the locally produced POP could serve the same purpose as the foreign one. It was recommended, among others, that the by-product could be used to manufacture local POP in order not to pollute the environment with the salt residue.

Keywords: By-product, gypsum, mining, plaster of Paris, residue, salt

INTRODUCTION

Plaster of Paris (P.O.P) is a white powdery mixture of gypsum. It has been named such because the first deposit of gypsum was found in Paris. This powder when mixed with water solidifies, but without losing its volume. During manufacturing process, the gypsum is heated and as such, it does not necessarily require any high heat treatment like ceramics and clays (Worrall, 1996). Because of its property to harden with just water, it is used in a number of areas, but most notably for molding decorative objects.

According to Cornelis and Hurlbut (1985), plaster results from the calcinations of gypsum ($CaSO_4 \bullet 2H_2O$), which partially dehydrates to produce a hemi-hydrate ($CaSO_4 \bullet ½H_2O$). Although plaster of Paris is widely used today; its origin dated 9,000 years old and were found in Anatolia and Syria. It is also known fact those 5000 years ago, the Egyptians burnt gypsum in open-air fire, then crushed it into powder and finally mixed with water to make jointing material for the blocks of monuments, used model of plaster taken directly from the human body.

Plaster of Paris came about in 17000's as Paris was already the "capital of plaster" ("Plaster of Paris) since all the walls of wooden houses were covered with plaster, as a protection against fire. The king of France had enforced this rule after the big London fire literally destroyed this city in 1666. Large gypsum deposits near Paris have long been mined to manufacture "Plaster of Paris".

Gypsum is a sedimentary rock, which settled through the evaporation of sea water, trapped in lagoons. According to the nature of its impurities, gypsum can show various colors, ranging from white to brown, yellow, gray and pink.

In order to produce high-quality Plaster of Paris, great effort needed to be put in clearing and classifying gypsum in order to prepare it for plaster. The chemical reaction is:

$$(CaSO_4 \bullet 2H_2O) + \text{Heat} = (CaSO_4 \bullet ½H_2O) + 1.5H_2O$$

Deer *et al*. (1992) describe plaster of Paris is a calcium sulfate hemi-hydrate: ($CaSO_4 \bullet ½H_2O$) derived from gypsum. It is obtained by firing this mineral at relatively low temperature and then reducing it to powder.

It was estimated that the world production of capacity for gypsum wallboard in 2000 was at least 60 billion ft^2 (about 5.6 billion^2) at more than 250 plants worldwide. About one-half of this capacity was in the United States and Asia and Western Europe each accounted for about one-fifth. Plans to construct or expand dozens of wallboard plants were underway during the year in many countries throughout the world, including Brazil, Germany, India, China, United Kingdom, Chile and Poland (Ambolt, 1999; Dickson, 1998; Mullick, 1999).

According to United States Geological Survey Mineral yearbook 2000, gypsum output is categorized as either calcined or uncalcined. About 42.7% of the calcined gypsum used to manufacture wallboard was consumed in the production of regular half-inch wallboard, fire-resistant wallboard, mobile-home board and lath and veneer base. During 2000, most of the uncalcined gypsum consumed in the United States was used in Portland cement production and the remainder was used primarily in agriculture. Gypsum which is added to cement to retard its setting time, accounted for about 2 to 5% of cement output (Dutton, 1997). Finely ground gypsum rock was used in agriculture and other industries to neutralize sodic soils, to improve soil permeability, to add nutrients, to stabilize slopes and to provide catalytic support for maximum fertilizer benefits. Small amounts of high-purity gypsum were also used in a wide range of industrial operations, including the production of glass, paper, foods and pharmaceuticals.

Plaster of Paris can be classified as gypsum plaster, lime plaster and cement plaster depending on its composition and uses. Artists use plaster of Paris to make metal castings, molds and sculptures. They create the desired shapes, using the plaster moldings. The artist first prepares the molds and then the plaster of Paris poured into it. After drying, the artist gets the desired shapes. When plaster of Paris is exposed to fire, it produces water vapor which slows down the spreading of fire. It is also an excellent insulator to heat and so, used to protect various objects from fire. In the field of medicine, the plaster of Paris is widely used to create soft bondages to treat bone fractures. The fractured bone is wrapped with bondage along with plaster of Paris. The casting holds the damage until it fully recovers. Architecture wise, the plaster of Paris is used specifically for decorative purposes.

Ghana is endowed with natural resources including salt mining of which Sege Salt Mining is of no exception. It offers employment to the indigenous people. However, it appears the leftovers of the salt mining in Sege could be utilized to produce plaster of Paris.

This study therefore seeks to find out whether salt residue (gypsum) can be used to produce Plaster of Paris (POP). The proposed local production of plaster of Paris will feed institutions, agencies and industries especially artworks such as ceramics and sculpture that use Plaster of Paris (POP) as the main raw material for mould and casting processes. This will help to minimize the importation of foreign Plaster of Paris (POP) into the country. It will also provide employment and income for the indigenous people and also reducing the high rate of unemployment in Ghana.

MATERIALS AND METHODS

The researchers employed the experimental research method for this study. An experiment usually involves two groups of subjects; an experimental group and a control or a comparison group (Fraenkel and

Fig. 1: Oven for heating the salt residue

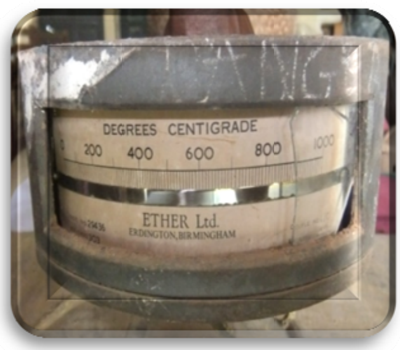

Fig. 2: Pyrometer for measuring mature temperature

Fig. 3: Gas cylinder used as a source of fuel for the oven

Wallen, 2000). In this study, the salt residue (gypsum) used to product the local Plaster of Paris (POP) served as the experimental group while the foreign plaster of Paris was the comparison group.

Equipment and materials used:

- Equipment (Fig. 1-4)
- Materials (Fig. 4-5)

Preparation of the salt residue: Sample of the salt residue was mined from a salt pond in Sege at the Son go Salt Factory near Ada. The mined salt residue was washed in a basin to remove raw salt, stone, sand,

(a)

(b)

Fig. 4: (a) Corn mill for grinding the salt residue, (b) salt residue mined from Sege

Fig. 5: Drying of the salt residue in the sun

twigs, shells and other unwanted materials. The salt residue was dried in the hot sun for 2 days. The purpose of drying was to evaporate any excess water present.

Heating of the salt residue (Gypsum): After drying, the residue was put into sheet pans and placed in the gas oven for heating. The reason for heating the salt residue was to further eliminate any moisture content within the mineral and also changing the glass clear sandy crystals to opaque white. A pyrometer was used to determine the material temperature. In the course of heating the salt residue, some few sheet pans were taken out from the oven to serve as the under heated

Fig. 6: Heating of the salt residue

Fig. 7: Removing the heated salt residue from the oven

Fig. 8: Pouring of gypsum into the plastic bag

sample of the residue at the temperature of 90°C. The rest were occasionally brought out from the oven, poured into a basin, stirred with a wooden bat and placed back into the oven to ensure uniform heating. To ascertain that it had been well heated, sample of the residue was rubbed with the fingers and it should become fragile, easily broken and crushed into powder in-between the fingers. The required heating temperature was between 120-150°C determined by the pyrometer. The oven was allowed to cool down after heating before it was opened. The heated salt residue became gypsum. It was poured into sack for grinding.

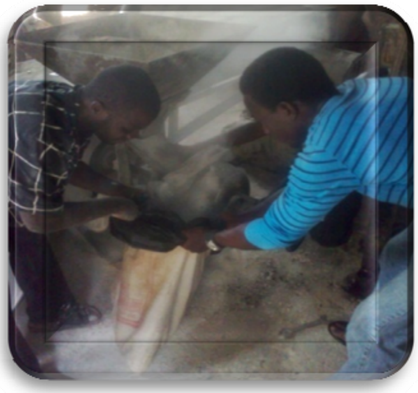

Fig. 9: Grinding of the gypsum in the corn mill

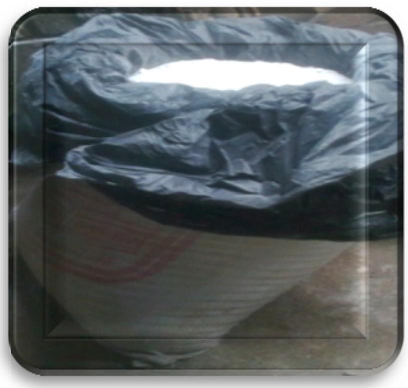

Fig. 10: Sample of the plaster of Paris

Both the under heated and well heated gypsum were corn milled separately into a uniform smooth grained white powder, turning it to Plaster of Paris (POP) and stored in plastic bag used as lining of the sack. It was then kept away from moisture (Fig. 6-10).

RESULTS AND DISCUSSION

Testing of the Plaster of Paris (POP): In testing of the Plaster of Paris (POP), two different tests were carried out to examine and observe the characteristics and differences about the study. These were; the locally produced Plaster of Paris (POP) (the experimental group) and the foreign Plaster Of Paris (POP) (the comparison group) as stated by Fraenkel and Wallen (2000).

The experimental group was labeled test “A” and the comparison group as test “B”. In test “A”, sample of the under heated Plaster of Paris (POP) powder (90°C) was gradually mixed with about 60-80 parts of water and stirred till a lightly thick paste suspension was achieved so that the plaster could easily be poured into a seized mould before it sets. The plaster suspension was timed and in just 5 min, it had set very hard and smooth, with a clean white appearance.

Fig.11: Mixing of under heated plaster of Paris

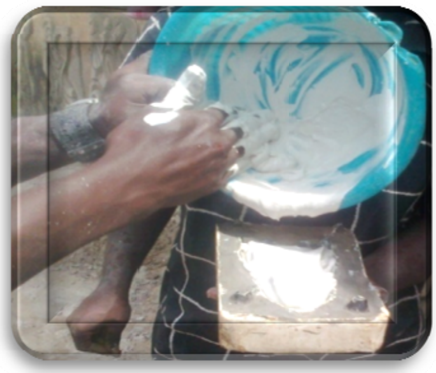

Fig.12: Pouring of under heated plaster of Paris

Fig. 13: Hard set and under heated plaster of Paris

After the plaster had set, the residual water was removed by exposure to the wind in covered outdoor rack. By the time drying was completed all but 0.5% of excess water had been removed. It was also observed that it had loose bonding of particles making it set weaker with chalky particles, heavy in weight and had a low affinity of water. Figure 11, 12 and 13 show the process of casting the under heated plaster of Paris as an experiment.

Sample of the well heated Plaster of Paris (POP) powder (120-150°C) was taken through the same process of mixing with water and pouring into a seized mould to cast solid. It was revealed that the suspension

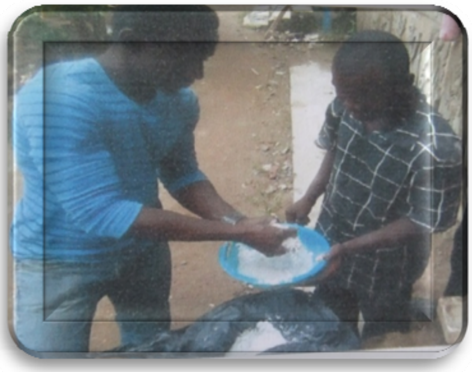

Fig.14: Mixing of well heated plaster of Paris

Fig.15: Pouring of well heated plaster of Paris into seized mold

Fig. 16: Hard set of well heated plaster of Paris

took just 3 min to set, had a porous surface making absorption of water quicker, appeared off-white in color, stronger bonding of particles making it set hard, light in weight and had a high affinity for water. It could therefore be deduced that the appropriate heating temperature for this local Plaster of Paris (POP) should be between 120 and 150°C. These qualities of the local Plaster of Paris (POP) made it useful and appropriate product to be used as raw material for industries and confirmed Deer *et al*. (1992) opinions on the uses of Plaster of Paris (POP). Figure 14, 15, 16 and 17 explain

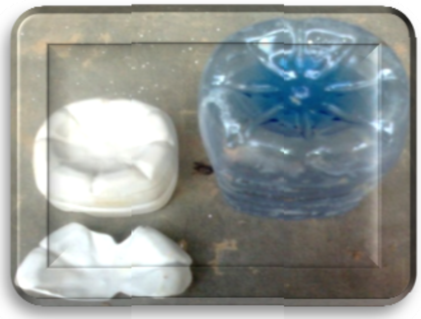

Fig. 17: Cast piece from plastic container

the systematic procedures for casting the well heated plaster of Paris.

In comparing the locally produced plaster of Paris to the foreign one, it came to light that the only difference was the setting time. While it took just about 2 min for the foreign Plaster of Paris (POP) to set, it took the local over 3 min to set. However, there could be the introduction of certain common additives such as potassium sulfate, detergent, starch, ground gypsum and others could be used along with water to change the way in which the plaster sets.

CONCLUSION

In conclusion, the researcher had been able to manufacture locally prepared Plaster of Paris (POP) from salt residue that could augment the foreign one thereby minimizing the importation of foreign Plaster of Paris (POP).

RECOMMENDATIONS

The following recommendations had therefore been made:

- This technology of producing Plaster of Paris (POP) locally could be transferred to the indigenous people in Sege to serve as a source of income and employment in the area.
- Further research could also be carried out in all salt mining areas to ascertain whether every salt residue could be used to product Plaster of Paris (POP).
- There could also be further scientific research to determine other properties of the locally prepared Plaster of Paris (POP) such as durability, strength, ability to set faster and to further develop the Plaster of Paris (POP).
- The government and other private companies could establish local industries in the Sege Township to manufacture Plaster of Paris (POP) to feed industries, hospitals and agencies that use Plaster of Paris (POP) as raw material.

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