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STUDIES OF REACTION MECHANISM AND PHYSICAL NATURE OF LIGHT-WEIGHT BASIC MAGNESIUM CARBONATE

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The reaction mechanism of light - weight magnesium carbonate has been studied and concluded that it is based upon formation of colloidal magnesium hydroxide and adsorption of HCO_3^- ions on magnesium hydroxide surface under optimum conditions. Precipitation, carried out in the presence of sodium bicarbonate over a concentration range of 1M to 0.01M, is a continuous function of the carbon dioxide remaining in the solution. Temperature between 70˚C and 80˚C, stirring speed of 900 rpm, gradual addition of magnesium sulfate solution and mass ratio of soda ash to sodium bicarbonate (3:2) were found to be the optimum conditions for obtaining light - weight magnesium carbonate.

Key words**:** Reaction mechanism, Light - weight magnesium carbonate, Effect of sodium bicarbonate.

Introduction

There have been extensive studies conducted on the preparation of light-weight magnesium carbonate with the aim to get optimum conditions. A number of researchers studied the preparation of basic magnesium carbonate. The following processes are the examples of the previous studies. Harold (1933) reported that light magnesium carbonate is precipitated by heating the solution containing magnesium bicarbonate in the presence of crystallizing agent such as gelatin, gum arabic, castor oil sulfonin, etc. Samuel (1936) studied the preparation of light magnesium carbonate using soda ash, sodium bicarbonate and magnesium salt solution by introducing steam into the mixture until temperature was 70 - 90˚C; the role of bicarbonate ions did not mention during the reaction. Morifuji *et al* (1991) added hydroxy carboxylic acid salts to magnesium carbonate to produce light-weight magnesium carbonate. Paul (1934) obtained light magnesium carbonate by adding giobesite (dolomite) to the solution of sodium bisulfate at room temperature instead of using epsom salt and soda ash. Bertrand (1932) converted heavy magnesium carbonate into light magnesium carbonate by mixing asbestos fibre to the slurry of heavy carbonate between 150˚F to 250˚F without using sodium bicarbonate; but he could not get the maximum degree of lightness. Okata (1995) and Mita *et al* (1994) also converted heavy magnesium carbonate into light magnesium carbonate by introducing steam directly into the solution to raise temperature to 180˚C and observed smaller changes of absorption and desorption of water.

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However, these studies are insufficient to explain the complete reaction mechanism for light - weight magnesium carbonate. Therefore, the present study was undertaken to evaluate the optimum conditions to get utmost degree of lightness and regulate other influencing factors for producing light - weight magnesium carbonate.

Experimental

Epsom salt, soda ash and sodium bicarbonate of technical grade were used throughout the experiments. De-ionized water with conductivity of $10^7\Omega$/cm was used in the preparation of all solutions. A flask (500 cm^3) with lid having two necks was used as reaction vessel. All experiments were conducted at concentration varying from 1M to 0.5M, at temperature between 70 - 80˚C and at a constant stirring speed of about 900 rpm. The central hole of the lid was used for the introduction of thermometer and second for the addition of the sample. A hot plate with controlled temperature and stirring speed was used throughout the studies. The solutions of magnesium sulfate , sodium carbonate and sodium bicarbonate used were prepared from IM-solution. In each experiment, 10.0g ± 0.05g of epsom salt solution was added in a thin stream to the reaction medium containing magnetically stirred solution of sodium carbonate (7.2g ± 0.05g) and sodium bicarbonate (4.8g ± 0.05g). Carbon dioxide gas was evolved and immediately estimated in the moist freshly precipitated basic carbonate, in order to avoid any loss of carbon dioxide from the precipitate which might arise through air-drying following precipitation. The dissolved carbon dioxide (both free and combined) in each experiments is directly estimated in a convenient volume

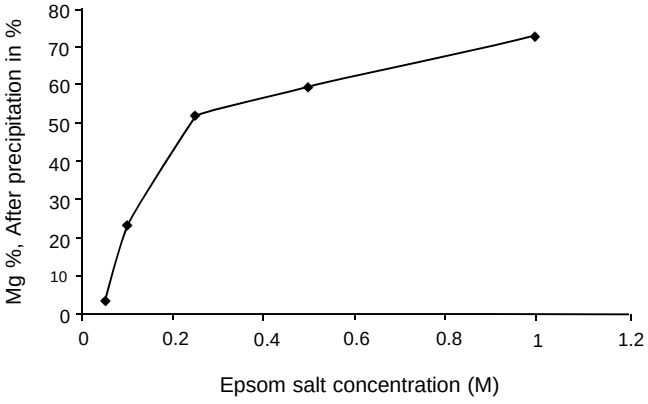

Fig 1. Effect of epsom salt concentration.

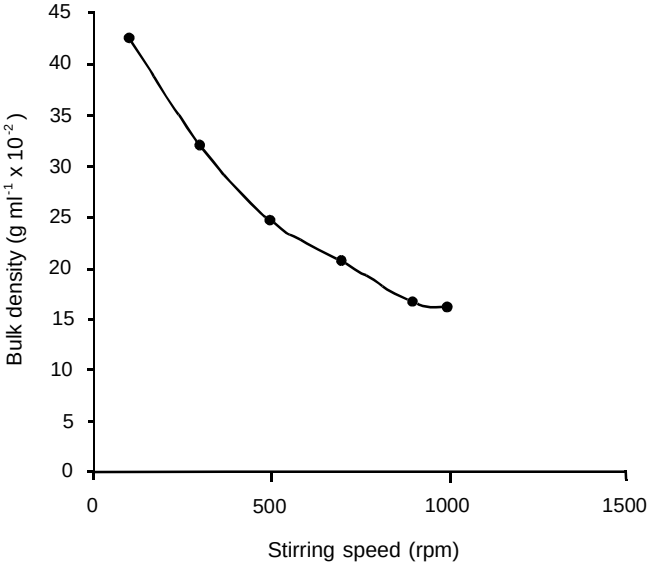

Fig 2. Effect of stirring speed on bulk density.

of solution, 10, 25 or 50 c.c. and bulk density of dried $MgCO_3$ in each experiment was also determined. After estimation of carbon dioxide gas, magnesium in solution was determined, by oxine method using hydroxyquinoline (Arthur 1964).

Results and Discussion

Effect of epsom salt concentration. Some experiments were conducted to study the effect of epsom salt concentration upon conversion rate by varying its concentration from 0.05M to 1M. The reaction medium contained the solutions of soda ash and sodium bicarbonate in the mass ratio 3:2 at temperature of 70°C. By addition of magnesium sulfate solution to reaction medium, carbon dioxide gas evolved and estimated in moist freshly precipitated basic carbonate. The results are shown in Fig 1. The results in the figure show that the conversion rate first increases sharply upto 52% during

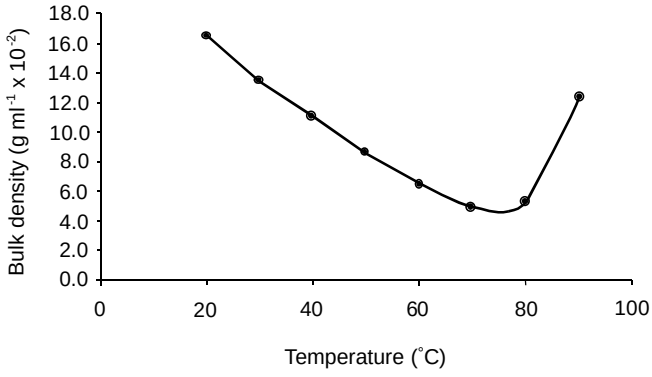

Fig 3. Effect of temperature on bulk density.

concentration change of 0.2M (i.e. 0.25 - 0.05M). Afterwards during further change of 0.2M (i.e. 0.25 - 0.45M) conversion rate was found to be very slow, which may be due to the formation of magnesium ions in the solution which are adsorbed on the surface of epsom salt. This caused the decrease in conversion rate of epsom salt to magnesium carbonate. From the above mentioned findings a logarithmic behaviour of con version rate is observed. Therefore, it may be concluded that conversion rate is enhanced by increasing concentration of epsom salt and degree of conversion rate is adversely effected by the increase in concentration of magnesium carbonate in the resulting mixture. Similar tendency was also reported by Jack (1939).

Effect of stirring speed. In order to examine the effect of stirring speed on degree of lightness, a number of experiments at different stirring speeds i.e. 100 - 1000 rpm were performed using the reaction medium containing 1M solution of epsom salt, soda ash and sodium bicarbonate in the mass ratio 3:2 at temperature of 70°C. The results described in Fig 2 show that bulk density is an inverse function of stirring speed. It is also observed from the results in the figure that bulk density decreases sharply during a change of stirring speed from 100 - 900 rpm, thereby it attains its least value at 900 rpm. Therefore, it may be concluded that the degree of lightness corresponding to slope in figure between stirring speed 900 rpm and 1000 rpm was independent. Hereafter, all experiments were conducted at 900 rpm.

*Effect of temperature.*Effect of temperature on bulk density was examined at temperatures ranging from 20°C to 90°C. The reaction bath contained 1M solutions of epsom salt, soda ash and sodium bicarbonate in the mass ratio 3:2. The values of bulk density obtained from different experiments were plotted against temperature in the Fig 3.

The results in Fig 3 shows that bulk density at temperature of 20°C was maximum, which goes on decreasing gradually, showing linear relation over whole temperature ranging from 20°C -

70˚C. The least bulk density was obtained at temperature of 75˚C. It is observed from the results that least bulk density was obtained due to the formation of colloidal magnesium hydroxide and subsequent adsorption of bicarbonate ions over the surface of magnesium hydroxide. At temperature beyond 75˚C decomposition of bicarbonate takes place resulting in the increase in bulk density again as appears in the figure. It can be concluded that the effect of temperature on bulk density may be interpreted in the ways that it not only helps in the formation of colloidal magnesium hydroxides but also in adsorption of HCO_3^- ions. This adsorption process of HCO_3^- phenomenon was in agreement with observation of earlier workers (Jack 1940).

a) $Mg(OH)_2 \xrightarrow[\text{adsorption}]{HCO_3} Mg\begin{matrix}OH\\HCO_3\end{matrix} + OH^-$

b) $MgCO_3^- + Mg\begin{matrix}OH\\HCO_3\end{matrix} \longrightarrow MgCO_3^- \quad Mg\begin{matrix}OH\\HCO_3\end{matrix}$

Conclusion

The reaction mechanism and physical nature of light weight magnesium carbonate was studied in the presence of sodium bicarbonate. The experimental results indicate that conversion rate is a logarithmic function of epsom salt concentration. From these studies, it is also concluded that temperature between 70˚C - 80˚C, stirring speed of 900 rpm and mass ratio of sodium carbonate to sodium bicarbonate (3:2) are the optimum conditions to get utmost degree of lightness of basic magnesium carbonate i.e. 0.05g/ml. Under optimum conditions employed, the reaction mechanism is based upon the formation of colloidal magnesium hydroxide and subsequent adsorption of HCO_3^- ions on magnesium hydroxide surface. A combination of these effects is supported by evidence.

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