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RETARDING ACTION OF VARIOUS CHEMICALS ON SETTING AND HARDENING CHARACTERISTICS OF GYPSUM PLASTER AT DIFFERENT pH

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ABSTRACT

Gypsum plaster sets quickly due to its natural process of crystallization. For commercial applications, the retardation of plaster to a desired level is required. The effect of various chemicals as retarders on the setting time, compressive strength and microstructure of the gypsum plaster was investigated at pH 4 to 12 adjusted by the addition of $Ca(OH)_2$ or HCl to gypsum plaster. It was found that retardation factor has no direct relation with the compressive strength of gypsum plaster but pH is certainly related to the strength factor. Maximum compressive strength of the plaster was obtained at pH 7.0. The morphology of the hardened gypsum plaster was found to change according to variation in the pH of the aqueous phase as well as the nature of retarder added.

Introduction

Gypsum is one of the oldest and most versatile building materials known. Gypsum is used in the manufacture of variety of plasters mainly hemihydrate, anhydrite, light weight premixed compositions etc. for use in building, surgical, ceramic, dental and construction sectors. Industrially, the hemihydrate plasters (and forms) are generally used on a large scale for the interior decoration of buildings. Since, gypsum plaster sets quickly on addition of water due to its natural process of crystallization, the retardation of the plasters is necessary to meet the commercial requirements. Various chemicals such as tartaric acid, hydrolysates of horns and hoofs, citric acid, phosphates etc. are employed as the retarders of the gypsum plasters (1). The setting time and compressive strength of gypsum plaster is also influenced by the change in pH of the media. To secure optimum level of retardation for the effective utilization of gypsum plasters, the influence of various chemicals such as hydroxy carboxylic acids, phosphate, sugar on the setting time, compressive strength and microstructure of the β-hemihydrate plaster was studied at different pH values. The results obtained are described and discussed in the paper.

Experimental

Materials. The chemicals used as retarders were kafrata (hydrolysates of horns & hoofs), tartaric acid [L(+)] Potassium sodium tartarate, potassium citrate, borax, citric acid, monocalcium phosphate monohydrate and sugar.

The retarders (0.1%) in powder form were mixed with the ground gypsum plaster produced by heating gypsum ($CaSO_4.2H_2O$ 98%) at 150°C. The setting time of the gypsum plaster was studied at pH 4 to 12. The pH of the solution in contact with the gypsum plaster in acidic range (pH 4 to 5.84) as well as in alkaline range (pH 7.76 to 12.0) was adjusted by adding concentrated HCl (0.26 N to 0.002 N) or powdered $Ca(OH)_2$ (0.5 to 1.5 by wt.% of gypsum plaster) to the gypsum plaster at normal consistency (60%) respectively. The gypsum plaster-water slurry was prepared by mixing water to the plaster containing HCl and $Ca(OH)_2$ separately. The slurry was stirred thoroughly till it was free from lumps. The pH value of the gypsum plaster slurry was measured using a Digital pH Meter Model CL 46 (Toshniwal, India). The initial setting time of the gypsum plaster was determined as per IS:8272-1976(3) and the retardation factor was calculated from it. The retardation factor is defined as the ratio of the initial time of the retarded plaster (in minutes) to the initial setting time of the nonretarded plaster (in minutes). 5 cm × 5 cm × 5 cm cubes of the gypsum plaster containing 0.1% of different retarders were cast at normal consistency, dried and tested for compressive strength as per IS:2542 (Part I)-1978 (4). Scanning electron microscopy of the hardened gypsum plaster was carried out on SEM model 508 (Philips, Holland).

Results and Discussion

Effect of Retarders on Properties of Gypsum Plaster

Setting time. The retardation factor calculated from the setting time of gypsum plaster at different pH values is plotted in Fig.1. The effect of individual retarders is described below.

The Kafrata retarder (Curve 1) is very effective in pH range of 4-12. The retardation factor increased with the increase in pH values of the gypsum plaster. Highest retardation factor was

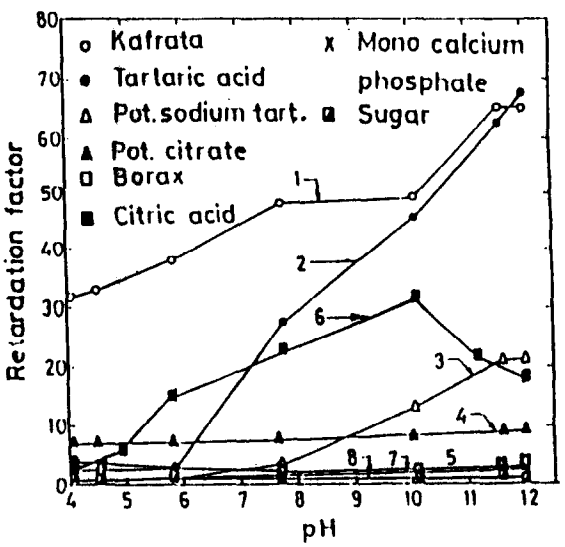

FIG. 1.
Relationship between pH & retardation factor of gypsum plaster.

attained at pH 10-12. The retarding action of Kafrata on the gypsum plaster is due to effect of functional groups of aliphatic alpha amino acids present in protein hydrolysates (5). The retardation factor for the tartaric acid retarder (curve 2) is enhanced with the increase in pH values from 4 to 12. It can be seen from pH 10 upwards, the retarding factor increased steeply. Hence, tartaric acid is especially suitable for the highly alkaline range. In case of potassium sodium tartarate (Curve 3), the retardation factor is lower than tartaric acid at both high and low pH values showing less effectiveness than the tartaric acid. However, the retardation factor increased sharply in the pH range 8 to 12. In the potassium citrate (curve 4), the retardation factor was lower at pH range 4 to 12 than the retarders described above. The curves 5, 7 and 8 for the retarders borax, monocalcium phosphate and sugar showed that the retardation factors decreased considerably between pH 4 to 12 compared to curves 1, 2, 3, 4 and 6. Whereas in case of citric acid (curve 6), the retardation factor increased with the increase in pH. Optimum value was attained at pH 10.0. Beyond pH 10.0, the retardation factor dropped. The retarding action of citric acid on the gypsum plaster is attributed to the formation of hydrogen citrate ions or the tri-and tetra-valent citrate ions.

Compressive strength. The effect of retarders on the compressive strength of set and hardened gypsum plaster at different pH is shown in Table 1.

It can be seen that the pH has direct relation with the compressive strength of gypsum plaster but the retardation factor does not influence the strength of plaster. Data show that at pH 7.0, maximum attainment of strength generally was achieved which clearly manifests that neutral environment is necessary for the proper development of strength in the plasters.

Microstructure of hardened gypsum plaster. The addition of retarders to the gypsum plaster affect the morphology and technological properties of the hardened gypsum. Alternation in the habit of the crystals was observed on the addition of different retarders. With tartaric acid, agglomerated subhedral to anhedral prismatic cystals of short length with rounded bodies were developed causing drop in the compressive strength of plaster (Table 1) at different pH values. However, at pH 7.0 maximum strength developed which diminished with the increasing pH values. On addition of potassium citrate, citric acid and monocalcium phosphate, euhedral to subhedral prismatic and needle shaped crystals of variable quantities and sizes are formed.

TABLE 1

Effect of Retarders on Compressive Strength of Gypsum Plaster

Retarders (0.1% Conc.)	Compressive Strength (MPa)		
pH	4.00	7.0	12.0
As such	12.0	14.0	13.6
Kafrata	4.0	12.0	7.0
Tartaric acid	6.5	8.6	5.8
Potassium sodium tartarate	11.5	12.0	4.5
Potassium citrate	8.5	12.0	6.5
Citric acid	6.5	5.5	2.0
Borax	7.5	14.0	11.0
Monocalcium phosphate	10.0	11.6	11.0
Sugar	8.5	13.5	13.6

Conclusions

1. The retardation factor was much higher for the retarders Kafrata and tartaric acid at pH 4 to 12. The retarding action increases sharply at pH 10 and upwards indicating their suitability at highly alkaline range.
2. The retardation factor decreased for the retarders potassium sodium tartrate, potassium citrate, borax, monocalcium phosphate and suger at pH 4 to 12 indicating shortening of strength of the plasters.
3. No direct relation was established between retardation factor and the compressive strength of the hardened gypsum plaster.
4. Maximum compressive strength of the plaster was attained at pH 7.0.

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