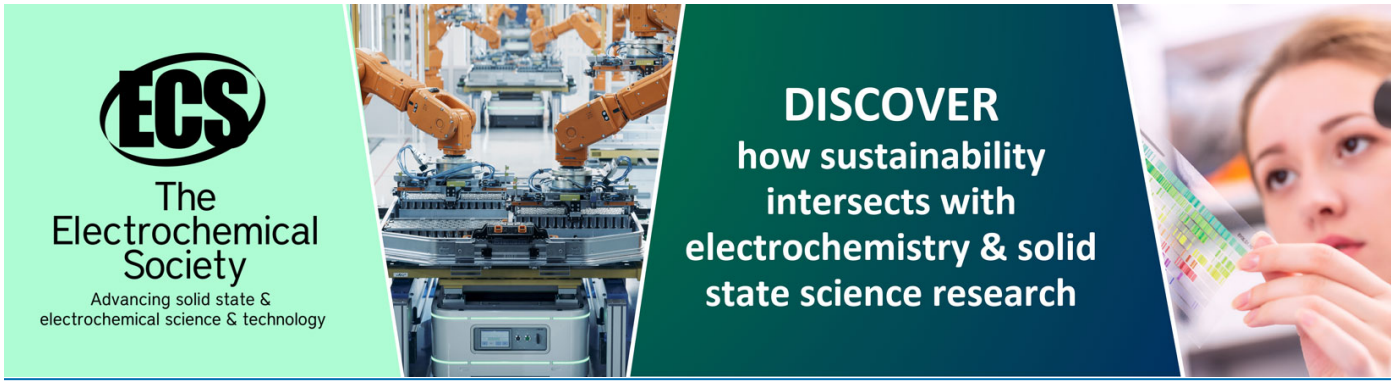
Development of Environment-Friendly Plastering Gypsum



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Development of Environment-Friendly Plastering Gypsum

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Abstract. A new type of plastering gypsum which has good operability was prepared from calcined desulphurization gypsum, ground steel slag and appropriate additives. The proper material ratio is: calcined desulphurization gypsum 95%, ground steel slag 4.5%, and water-retaining additive 0.5%. The product meets the requirements of GB/T 28627-2012. The effects of energy saving and emission reduction of this product were analysed. Compared with the common cement-based or lime-based materials, it has the advantages of better volume stability, lower application cost and less carbon emission.

1. Introduction

Plastering gypsum has a lot of advantages as fire prevention, sound insulation, light insulation and humidity conditioning, etc [1]. It belongs to a sort of non-toxic and pollution-free green construction materials. However, the application of semi-hydrated gypsum is restricted because of the short setting time and poor water resistance [2]. Some retarders are used to adjust the setting time currently [3-5].

The commonly used setting retarders include organic acids and their soluble salts, alkaline phosphates and proteins, etc. Peng J-H [6] thought that the crystal obviously coarsening, and the strength of harden body was decreased evidently after adding citric acid. Ding Y [7] found that both sodium hexametaphosphate and sodium citrate could have retarding function on gypsum, but the influence on mechanical strength was relatively large. Zhang M-M [8] discovered that protein retarders from waste mycelium had the merit of low intensity, but the preparation was complex comparatively. Singh M [9] studied the effects of several kinds of setting retarders on the setting time and hardening characteristics of gypsum under various pH, and discovered that the system' pH had significant influence on compressive strength and microstructure of gypsum paste. These explain that great majority setting retarders not only can change the setting time of gypsum, but also reduce the mechanical strength drastically at the same time. Besides, the cost of retarders used in gypsum is high. Consequently, it is imperative to seek a cheap material instead of conventional retarders.

2. Experimental

2.1. Material

β-semi-hydrated gypsum was provided by Xibaipo Power Plant, which is composed of di-hydrate gypsum 9.83%, semi-hydrated gypsum 86.93% and anhydride 3.24% ; ground steel slag and standard quartz sand were from Pingshan Bai Hua ao Building Materials Limited Co. , the specific surface area of steel slag is 450 m^2/kg. Table 1 and Table 2 give the composition of the main raw materials and the physical and mechanical properties of β-semi-hydrated gypsum respectively.

Table 1. Composition of some raw materials.

Component	SiO2 (%)	Fe2O3 (%)	Al2O3 (%)	CaO (%)	MgO (%)	MnO (%)	SO3 (%)	Other
β-semi-hydrated gypsum	7.45	0.42	1.13	38.16	0.19	—	48.41	4.24
Steel slag	13.96	27.18	5.28	33.19	8.18	5.82	0.33	6.06

Table 2. Physical and mechanical properties of semi-hydrated gypsum.

Standard consistency water demand (%)	Setting time		Dry intensity	
	Initial time (min)	Final time (min)	Flexural strength (MPa)	Compressive strength (MPa)
0.62	5	8	5	13

2.2. Method

Determined the setting time and mechanical strength of β-semi-hydrated gypsum according to GB/T 28627-2012. A certain proportion of ground steel slag was put into gypsum pastes to determine the desired setting time. The gypsum slurry containing ground steel slag and additive was poured into molds of 40 ×40 ×40mm and de-mold after 2 h. The samples were then cured at 55℃ for 3 days. Put the samples into oven and dried at (40±2℃) to constant weight, tested its flexural and compressive strength.

3. Results and Discussion

3.1. Effects of Grinding Steel Slag on Setting Time of Gypsum

Grinding steel slag was used to adjust the setting time of β-semi-hydrated gypsum. The results are shown in Figure 1 and Figure 2.

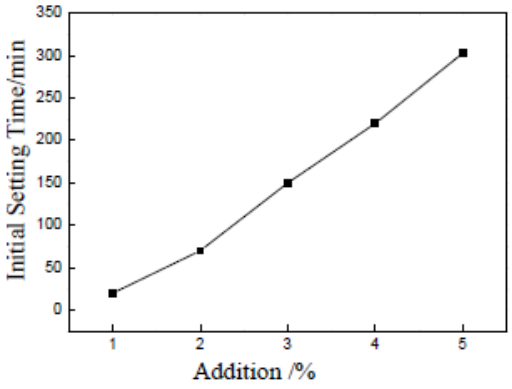

Figure 1. Effects of steel slag on initial setting time.

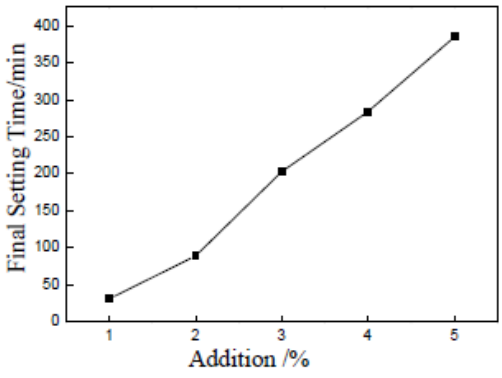

Figure 2. Effects of steel slag on final setting time.

As can be seen from Figure 1 and Figure 2, with the increase in the addition of ground steel slag, the setting time of β-semi-hydrated gypsum was prolonged. When the addition of steel slag was 3%, the initial setting time was 150 minutes and the final setting time arrived to 205 minutes. This explains that ground steel slag has a certain retarding effect on gypsum.

3.2. Effects of Retarders on Mechanical Strength of Gypsum

Flexural strength and compressive strength were investigated against the addition of ground steel slag in β-semi-hydrated gypsum. The results are shown in Figure 3 and Figure 4.

From Figure 3 and Figure 4, we discovered that with the increase in steel slag addition, the mechanical strength of gypsum also reduced. When the addition of steel slag was 3%, the flexural strength was 3.5MPa and the compressive strength was 6.8MPa. But the loss of mechanical strength is mild and the cost is much lower compared to frequently-used citrates and phosphates.

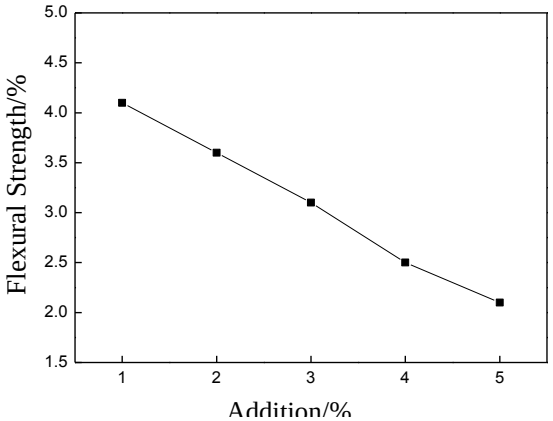

Figure 3. Effects of steel slag on flexural strength

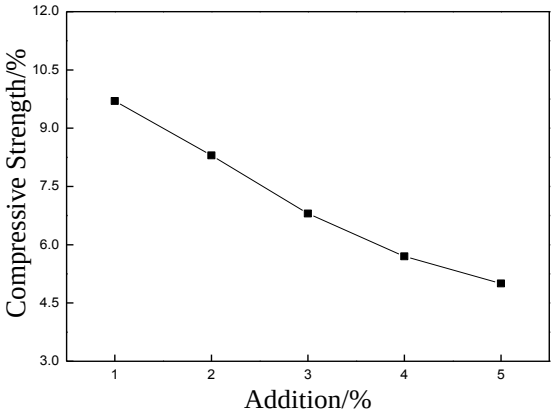

Figure 4. Effects of steel slag on compressive strength

3.3. Preparation of Plastering Gypsum

The optimized material proportion (mass ratio) of plastering gypsum was 95% calcined desulphurization gypsum, was 4.5% ground steel slag, and water-retaining additive was 0.5%. The flexural strength of the product was 2MPa, and the compressive strength was 4MPa. The other performances of this product conform to GB/T 28627-2012. Figure 5 and Figure 6 give the photos of raw materials and product.

Figure 5. Plastering gypsum materials.

Figure 6. Plastering gypsum.

4. Analysis of Energy Saving and Emission Reduction

This product can reduce the carbon dioxide emissions in terms of energy conservation compared to cement- or lime based plastering. The Life Cycle Assessment (LCA) was carried out and the results are shown in Figure 7.

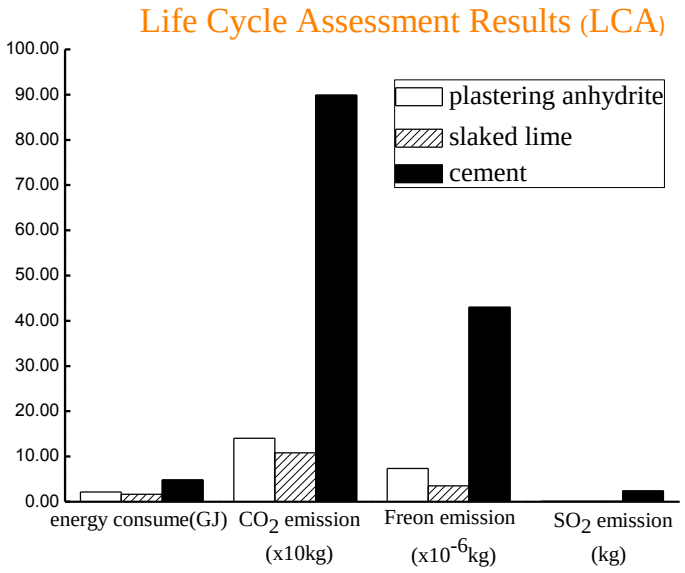

Figure 7. Energy saving comparison chart.

As can be found from Figure 7, plastering gypsum had obvious advantages over cement and lime based product; the energy consumption, carbon dioxide and sulphur dioxide emissions were lower than the later; thus the economic and environmental benefits were higher than the former as well. Besides, gypsum has the advantages of stable performance, less shrinkage and short construction period. Therefore, plastering gypsum is worthy of promotion as wall painting materials.

5. Conclusion

(1) With calcined desulphurization gypsum, ground steel slag as major materials to prepare plastering gypsum conforms to principles of the circular economy laws. This product meets GB/T 28627-2012, and has the characteristics of mild mechanical loss, low cost and high economic benefits.

(2)When the addition of steel slag was 3%, the initial setting time was 150 minutes and the final setting time reached 205 minutes. The addition of ground steel slag may change the hydration kinetics process of gypsum, reduce the formation of dihydrate gypsum and extend the setting time accordingly.

(3) LCA results indicated that compared with cement and lime-based product, plastering gypsum has prominent advantages. Its energy consumption, carbon dioxide and sulphur dioxide emissions are much lower.

6. Acknowledgements

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7. References

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