

The study on the effects of different soda slag treatments on chlorine ion content

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Abstract. Soda slag, produced as the solid waste from the ammonia-soda process, was treated by heating, adding additives and other methods. It was found that the chlorine ion content changed with the treatment of heating or adding additives. Heating treatment showed little effect on the decrease of chlorine ion content. The addition of additives, especially coal ash, had an effect on reducing the chlorine ion content in soda slag. Moreover, with the addition of coal ash, the chlorine ion content decreased gradually. The chlorine ion content reached 0.078 g/g (7.8%) at the amount of coal ash 10%.

1 Introduction

Large amounts of soda slag are produced as the solid waste from the ammonia-soda process. Deposition of piles of soda slag has a negative impact on the environment and occupies lots of lands. Thus comprehensive advantage should be taken from the view of economy and environment. Up to now, researchers have done a lot of research and found applications of soda slag in concrete, cement and other construction materials [1-5]. However, with much chlorine ions contained in soda slag, its application is quite limited. Therefore, it is important to reduce the dissociative chlorine ions in soda slag. In this paper, treatments of heating and adding additives are employed for the sake of the decrease of chlorine ions content.

2 Experimental

2.1 Materials

Major raw materials used in the experiment are soda slag, coal ash, sodium silicate and so on.

The soda slag is obtained from a soda-ash factory using ammonia-soda process in Tangshan. The chemical composition of soda slag is given in Tab.1.

Tab.1 Chemical composition of the soda slag

Composition	Content(%)	Composition	Content (%)
CaSO ₄	45.6	Al ₂ O ₃	3.0
CaCO ₃	3.9	Fe ₂ O ₃	0.7
CaCl ₂	10.5	SiO ₂	7.8
CaO	10.3	Mg(OH) ₂	9.0
NaCl	2.7	H ₂ O	5.3

Coal ash is obtained from a power plant in Tangshan. Tab.2 shows the chemical composition of coal ash.

Tab.2 Chemical composition of the coal ash

Composition	Content (%)	Composition	Content(%)
SiO ₂	50.9	SO ₃	0.8
Al ₂ O ₃	28.1	Na ₂ O	1.8
Fe ₂ O ₃	6.2	K ₂ O	0.6
CaO	3.7	Igloss	6.8
MgO	1.2		

2.2 Instruments

Instruments used in the experiment are listed in Tab. 3.

Tab. 3 Experiment instruments

Instrument	Specification and Model	Manufacturer
Electrothermal blowing drying oven	101-1	Tianjin Experimental Instrument Plant
Ball mill	ND-4L	Nanjing Nanda Tianzun Electronics Co., Ltd.
Chamber electric furnace	SX2-4-10	Tianjin Zhonghuan Experimental Furnace Co., Ltd.
Rapid chlorine ion content analyzer	CL-U II	Beijing Beiao Century Science and Technology Development Co., Ltd.

2.3 Methods

The desired amounts of dried soda slag (or dried soda slag after treatment) were dissolved in distilled water and vigorously stirred for some time. The rapid chlorine ion content analyzer was used to determine the chlorine ion content in the sample.

Methods for the treatment of soda slag were described as follows: heat treatment by directly heating the sample; treatments with different kinds of additives in various amounts.

3 Results and discussion

3.1 Effect of stirring time on the chlorine ion content

10 g soda slag was dissolved in 200 mL distilled water. The resulting suspension or solution was stirred using a magnetic stirring apparatus for some time. Chlorine ion content in the sample was determined with the rapid chlorine ion content analyzer.

A series of samples treated with different prepared to study the effect of stirring time on the chlorine ion content. The stirring time was 1 h, 2 h, 4 h, 8 h and up to 24 h, separately. The results were illustrated in Tab.4.

Tab. 4 Effect of stirring time on the chlorine ion content

Stirring time (h)	Chlorine ion content in the sample (g/g)
1	0.183
2	0.192
4	0.210
8	0.214
12	0.215
16	0.215
20	0.218
24	0.220

As shown in Tab. 4, the chlorine ion content in the samples increased with the extension of stirring time. However, the growth of the chlorine ion content slowed down gradually and changed little after 8 h. It could be concluded that stirring had an effect on the release of chlorine ion in soda slag, and the process of releasing could be almost complete in 8 h. Therefore, the preferable stirring time for the measurement of chlorine ion content was 8 h.

3.2 Effect of heating temperature on the chlorine ion content

The soda slag samples were heated at 500 °C, 700 °C, 900 °C, 1100 °C and 1300 °C for 2 h, respectively. After cooling to ambient temperature, the samples were ground and sieved to more than 200 mesh for later use.

10 g sample was dissolved in 200 mL distilled water and the solution was under vigorous stirring for 8 h. Then the chlorine ion content was measured (as shown in Tab. 5).

Tab.5 Effect of heating temperature on the chlorine ion content

Heating temperature (°C)	Chlorine ion content in the sample (g/g)
25	0.214
500	0.125
700	0.098
900	0.136
1100	0.162
1300	0.227

From Table 5 we found that at the beginning of the increase of heating temperature the chlorine ion content decreased gradually. Some of the chlorine ions volatilized with the increasing temperature, resulting in the decrease in chlorine ion content. While above 900 °C, the chlorine ion content rose instead, which was attributed to the decomposition of carbonates in soda slag. Therefore, single heat treatment was unqualified for reducing the chlorine ion content in soda slag.

3.3 Effect of amount of coal ash on the chlorine ion content

The soda slag and coal ash were dried, ground and sieved to more than 200 mesh. A series of samples were obtained by adding different amounts of coal ash into soda slag.

The addition of coal ash was based on the amount of soda slag. 2 g, 4 g, 6 g and 10 g coal ash were mixed with 100 g soda slag, respectively, to prepare the samples of 2%, 4%, 6% and 10% content, as defined. After fully mixed, certain amounts of samples (each containing 10 g soda slag) were dissolved in 200 mL distilled water and stirred for 8 h. The chlorine ion contents were measured and results were reported in Tab. 6.

Tab.6 Effect of amount of coal ash on the chlorine ion content

Amount of coal ash (%)	Chlorine ion content in the sample (g/g)
2	0.192
4	0.125
6	0.094
8	0.082
10	0.078

Tab.6 showed that the chlorine ion content declined with the addition of coal ash. With base in soda slag, activation of the coal ash took place, to form gel. As a result, the fixation of gel with the chlorine ions led to the decline of the dissociative chlorine ion content.

3.4 Effect of amount of sodium silicate on the chlorine ion content

The soda slag was dried, ground and sieved to more than 200 mesh. Add different amounts of sodium silicate into the soda slag and a series of samples were prepared.

The addition of sodium silicate was based on the amount of soda slag, which was defined the same as in 3.3. The effect of the amount of sodium silicate added on the chlorine ion content was presented in Tab.7.

Tab. 7 Effect of amount of sodium silicate on the chlorine ion content

Amount of sodium silicate(%)	Chlorine ion content in the sample (g/g)
2	0.210
4	0.202
6	0.190
8	0.185
10	0.172

The addition of sodium silicate had an effect of constraint on the chlorine ion in soda slag (shown in Tab.7). Increasing the amount of sodium silicate, the chlorine ion content detected in soda slag decreased slightly.

4 Conclusions

The measurement of the chlorine ion content was related to the stirring time of soda slag. Longer stirring time led to more leached chlorine ion. Considering the efficiency of measurement, preferable stirring time was 8 h.

Heat treatment and additives had effects on the chlorine ion content. Single heat treatment showed limited influence on the decrease of the chlorine ion content. Adding additives, especially the coal ash, led to obvious decrease of the chlorine ion content. With the increasing amount of coal ash, the chlorine ion content decreased gradually. The chlorine ion content was 0.078 g/g (7.8%) when adding 10% coal ash.

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References

- [1] W.EZEK, O.CELESTINE, Some basic geotechnical properties of expansive soil modified using pyroclastic dust, *Engineering Geology*, 107 (2009), 61-65.
- [2] S.L.Sun, Q.H.Zheng, J.Tang, et al, Experimental research on expansive soil improved by soda residue, *Rock and Soil Mechanics*, 6 (2012), 1608-1612.
- [3] J.J.Yang, W.Xie, L.Zhang, Study on Experimental Preparation of Cement Mortar Incorporating Fly Ash-soda Residue, *Bulletin of the Chinese Ceramic Society*, 5 (2010), 1211-1216.
- [4] Y.Y.Li, S.W.Yan, J.Y.Zhang, et al. Engineering properties and microstructural features of the soda residue. *Chinese Journal of Geotechnical Engineering*, 1 (1999), 101.
- [5] R.K.Agarwal, S.V.Paralkar, A.K.Chatterjee, Chloride salts as reaction medium for low temperature clinkrisation-a probe into alinite technology. 8th International Congress Chemical Cement. 1986.