AA07 - Effect of CGM on the Particle Size of Aluminum Hydroxide During the Seed Addition to a Sodium Aluminate Solution

Yang Guili[1], Qi Lijuan[2], Zheng Chunhui[3] and Shao Shuai[4]
1. Professor
2. Engineer
3. Engineer
4. Engineer
Zhengzhou Non-ferrous Metals Research Institute Co. Ltd of CHALCO, Zhengzhou, China

Abstract

The addition of CGM to sodium aluminate solution affects seed secondary nucleation and is one of the main factors contributing to fine aluminum hydroxide particles agglomeration. The experimental results showed that adding the right amount of CGM to a sodium aluminate solution can inhibit to some extent seed secondary nucleation, reduce seed secondary nucleation rate, promote the fine aluminum hydroxide particles agglomeration and optimize the grain size of aluminum hydroxide. In this experiment, the appropriate amount of CGM was 15 – 20 ppm and excessive addition did not play a positive role in secondary nucleation and particle agglomeration of seed. According to the seed addition process of an industrial sodium aluminate solution, the appropriate amount of CGM should be determined by experiments under different process conditions, so as to obtain the best aluminum hydroxide particle size composition and sodium oxalate removal rate.

Keywords: CGM, sodium aluminate solution, crystal seed decomposition, secondary nucleation, agglomeration.

1. Introduction

It is well known that the decomposition process of sodium aluminate solution includes the decomposition process of aluminate ion and the crystallization process of aluminum hydroxide. The crystallization process of aluminum hydroxide includes the following steps: Nucleation (primary and secondary), agglomeration, growth and breakage or attrition. The agglomeration and crystal growth of seed will make the aluminum hydroxide crystal coarser, while the secondary nucleation and crystal breakage will lead to fine aluminum hydroxide crystals. Inhibiting the formation of secondary crystal nucleus and promoting the adhesion and crystal growth of aluminum hydroxide are beneficial to the production of sandy alumina. Because the additive has interface adsorption, orientational, micelle formation, and the resulting decline properties such as surface tension, adding additives to sodium aluminate solution can control the particle size, strengthening the particles in order to obtain uniform particle size and shape for the coarse sand alumina [2]. But because in the process of decomposition of sodium aluminate solution, the decomposition temperature, time, influent concentration and addition amounts of seed produce a great impact on the crystal of aluminum hydroxide precipitation. The decomposition process of a sodium aluminate solution by adding CGM is more complicated. CGM addition requires research on the impact of secondary nucleation and crystals agglomeration for the production of aluminum hydroxide and its particle size control.

Because of the complexity of sodium aluminate solution, a lot of factors associated with the production of alumina such as bauxite chemical composition, liquor caustic and alumina concentration and the adiition of CGM has an impact on aluminum hydroxide granulometry.

In this paper, the effects of additives on the secondary nucleation of seed were studied using two indexes secondary nucleation frequencies f1.92 and f3.55 (the number of 1.92 µm and 3.55 µm particles), and the effects of additives on the polymerization of alumina hydroxide were studied on the three indexes of -45µm, -60µm and D50.

2. Test Materials and Instruments

2.1 Test Materials

Sodium hydroxide: analytical pure chemical reagent.

Crystal seed alumina hydroxide: The aluminum hydroxide filter cake from precipitation process was washed with hot deionized water several times to remove the sodium aluminate and sodium oxalate and other impurities attached to the surface of the crystal. After blending, the sample was sealed and stored for use. The particle size of the washed seed was determined to be -45 µm (12 % by weight) and D50 of 63.30 µm.

Additive CGM: derived from an additive used in an aluminum oxide plant and manufactured by Norandel.

Sodium aluminate solution: pure sodium hydroxide dissolved in a certain volume of deionized water mixture. Industrial aluminum hydroxide was dissolved in the heated sodium hydroxide solution and then filtered. The obtained sodium aluminate solution was analyzed for caustic and alumina.

2.2 Test Instruments and Equipment

Electronic balance, electric sensitive area particle size meter, temperature control water bath decomposition tank, vacuum pump, etc.

3. Test and Analysis Methods

3.1 Test

Aluminum hydroxide crystal seed was added to a certain amount of synthetic sodium alumina solution, and the decomposition test was carried out in a water bath decomposition tank to simulate the production conditions at the site. After the end of the decomposition test, the slurry was filtered, and the mass concentration of caustic soda and alumina determined in the filtrate. The filter cake of aluminum hydroxide was thoroughly washed with hot deionized water many times, and and a blended sample was analyzed forparticle size.

3.2 Analysis Method

The caustic alkali concentration in sodium aluminate solution was determined using a standard solution of hydrochloric acid and the alumina concentration was determined by EDTA complexometric titration. The particle size of aluminum hydroxide was measured with the use of a Coulter Counter.

4. Experimental Results and Discussion

The effect of CGM on particle size was shown by the frequency of secondary nucleation of seed and the precipitation of fine particles of alumina hydroxide. Nucleation frequency is defined as the number of the finest particles in the seed separation process, and the main measuring instrument is the electrosensitive regional particle size meter, namely the coulter counter. In order to produce sand-like alumina with uniform granularity, the number of secondary nucleation resulting in the formation of a large number of fine $Al(OH)_3$ must be reduced, namely, the nucleation frequency must be controlled, and conditions must be created to promote the agglomeration of fine $Al(OH)_3$.

The decomposition test was carried out under the simulated production conditions of an alumina plant. The original solution was decomposed N_k160-165 g/L, α_k ±1.45, and the crystal seed solid contained 750 g/L. The initial temperature of decomposition was 63°C. The effect of adding CGM on the particle size of the decomposed product was investigated by changing the amount of CGM.

4.1 Effect of CGM on the Frequency of Secondary Nucleation of Seed

Under the above experimental conditions, the influence of the addition of CGM on the secondary nucleation frequency f1.92 and f3.55 of the seed during the decomposition of sodium aluminate solution was studied. The test results after four cycles are shown in Figures 1 and 2.

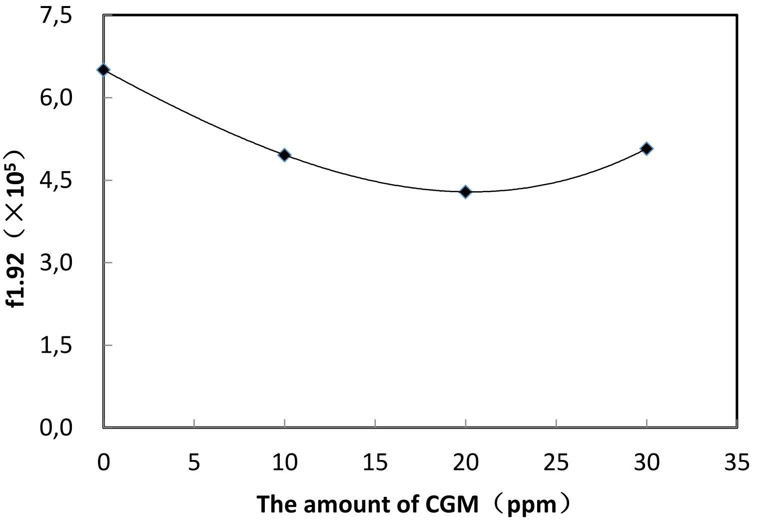

Figure 1. Effect of CGM on secondary nucleation frequency f1.92.

Figure 1 shows that the influence of CGM added to the synthetic sodium aluminate solution on f1.92 decreased first and then increased under experimental conditions. When the CGM concentration was lower than 20ppm, the secondary nucleation frequency f1.92 decreased with the increase of CGM concentration. However, when the addition of CGM was greater than 20ppm, f1.92 increased significantly with the increase of CGM, and the number of fine particles increased significantly. This indicates that the inhibition of secondary nucleation of crystals in the decomposition of sodium aluminate solution does not decrease with more CGM. The optimal addition is related to the characteristics of the additive itself. Due to the critical micelle characteristics of CGM, when the additive amount is large and exceeds the optimal concentration, an over adsorption of CGM phenomenon will occur on the crystal, which affects the crystallization of aluminate ions and increases the frequency of secondary nucleation, leading to product fineness [3]. Therefore, to control the frequency of secondary nucleation of crystals, the addition of to different sodium aluminate solutions should be tested in order to determine the optimal amount.

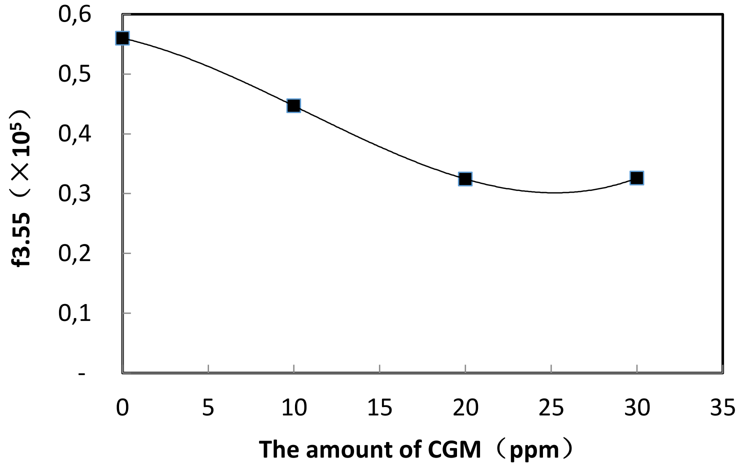

Figure 2. Effect of CGM on secondary nucleation frequency f3.55 of seed.

Figure 2 shows that when the CGM concentration is lower than 25 ppm, the secondary nucleation frequency f3.55 of the seed decreases significantly with the increase of CGM concentration, but when CGM concentration is greater than 25 ppm, f3.55 increases slowly with the increase of CGM concentration, which is similar to the effect of CGM on f1.92. Therefore, in order to control the frequency of secondary nucleation of crystal seed, different sodium aluminate solutions and additives should be tested so as to obtain the best particle size composition.

4.2 Effect of CGM on the Agglomeration of Aluminum Hydroxide Particles

Agglomeration is a process by which fine particles in the crystal seed gather to form a firm agglomerate with solid phase Al $(OH)_3$ crystallized out of sodium aluminate solution. This is an important way to increase the particle size of aluminum hydroxide crystal [4]. Under the above test conditions, the effects of different CGM additions on -45 µm, -60 µm and median diameter of aluminum hydroxide products were studied. The effects of CGM additions on the agglomeration of fine alumina particles during the decomposition of sodium aluminate solution were studied. The test results after four cycles are shown in Figures 3 and 4.

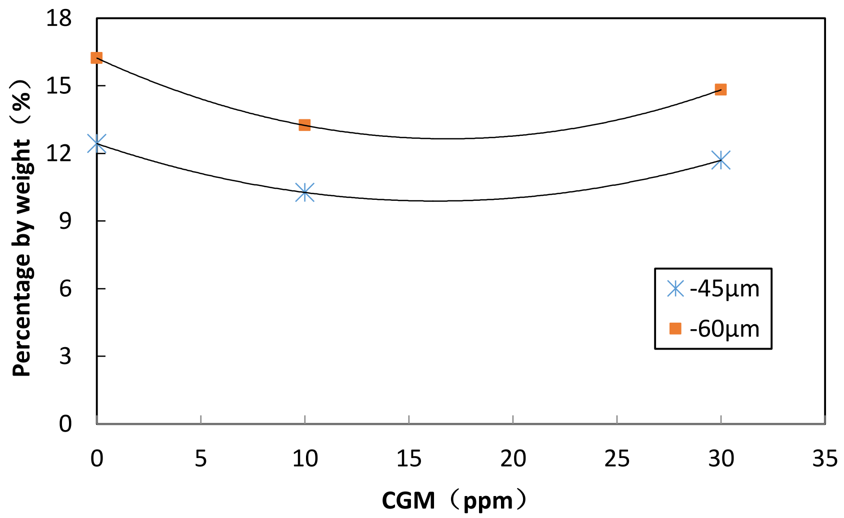

Figure 3. Influence of CGM on the content of -45 µm and -60 µm of aluminum hydroxide particles.

As can be seen from Figure 3 after four cycles, the particle size composition of -45 µm and -60µm showed the same change rule with the increase of CGM, and both showed a slow decrease trend when CGM increased from 0 to 15-20 ppm. When the amount of CGM was more than 20 ppm, the content of the two grain sizes showed a trend of slow increase. In general, when the amount of CGM was 15-20 ppm, the content of the two grain levels reached the minimum value, and aluminum hydroxide particles had a good adhesion effect.

Some studies have shown that there is a good correspondence between seed f3.55 and -45 µm. The above experimental results have confirmedthe correspondence between the two. It indicates that by observing the change of nucleation frequency f3.55, we can timely predict which stage the seed classification process will enter. When the nucleation frequency increases, the seed classification will enter the size reduction stage, and when the nucleation frequency decreases, the seed classification will enter the coarsening stage [5].

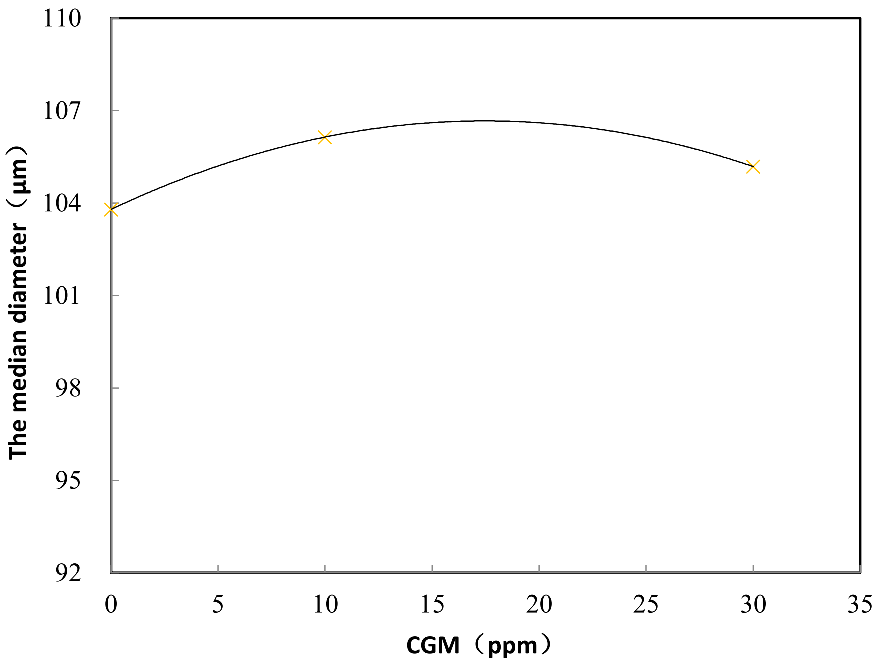

Figure 4. Influence of CGM on the median diameter of aluminum hydroxide particles.

The median diameter is also known as the critical radius of particles, which means that particles larger than or smaller than the particle size account for 50 %. The larger the value is, the larger the particle size is. The effect of the addition of CGM on the median diameter of aluminum hydroxide particles shown in Figure 4 is in good agreement with the effect of CGM on the contents of -45 m and -60 m in the product of aluminum hydroxide particles shown in Figure 3. The critical radius of aluminum hydroxide particles decreases with the increase of the content of these two-grain levels and increases with the decrease of the content of these two grain levels. When the amount of CGM is about 15-20 ppm, the critical radius is the largest and the alumina hydroxide particles are bigger.

5. Conclusions

To some extent, the addition of an appropriate concentration of CGM in a seeded solution of sodium aluminate can inhibit the frequency of secondary nucleation of crystals thus promoting the agglomeration of fine particles of aluminum hydroxide and increasing the critical radius of particles. Under the conditions of this test, the appropriate concentration of CGM in the decomposition of synthetic sodium aluminate solution is 15-20 ppm, under which the aluminum hydroxide with coarse particle size can be obtained. When it is higher than or lower than 15-20 ppm, the seed has a greater chance of secondary nucleation and less particle agglomeration, which is not conducive to obtaining qualified sandy alumina.

According to seeded solutions of sodium aluminate, the suitable amount of CGM should be determined by experiments under different concentration conditions, so as to facilitate the production of sandy alumina.

6. References

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