

## The Reaction Behavior of Sodium Aluminosilicate During Precipitation Process

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### Abstract

In this paper, the precipitation behavior of sodium aluminosilicate was analyzed in green liquor with high SiO<sub>2</sub> content. The effect of sodium aluminosilicate precipitation was expounded on product quality. At the same time, through laboratory research, the change of sodium aluminosilicate in seed was determined after the reduction of green liquor silica content, the solution of excessive silica content was proposed in products after the precipitation of sodium aluminosilicate.

**Keywords:** Precipitation process, green liquor, sodium aluminosilicate, product quality

### 1. Introduction

In the production of alumina from overseas mines, due to the low reactive silica content in bauxites, in the process of dissolution, the ability of SiO<sub>2</sub> of solution was weak to convert to sodium aluminosilicate, which led to increased SiO<sub>2</sub> levels in green liquor, in the process of precipitation, when the silica was supersaturated in green liquor, it would be precipitated in the form of sodium aluminosilicate, causing the silica content of the product to exceed the standard seriously [1].

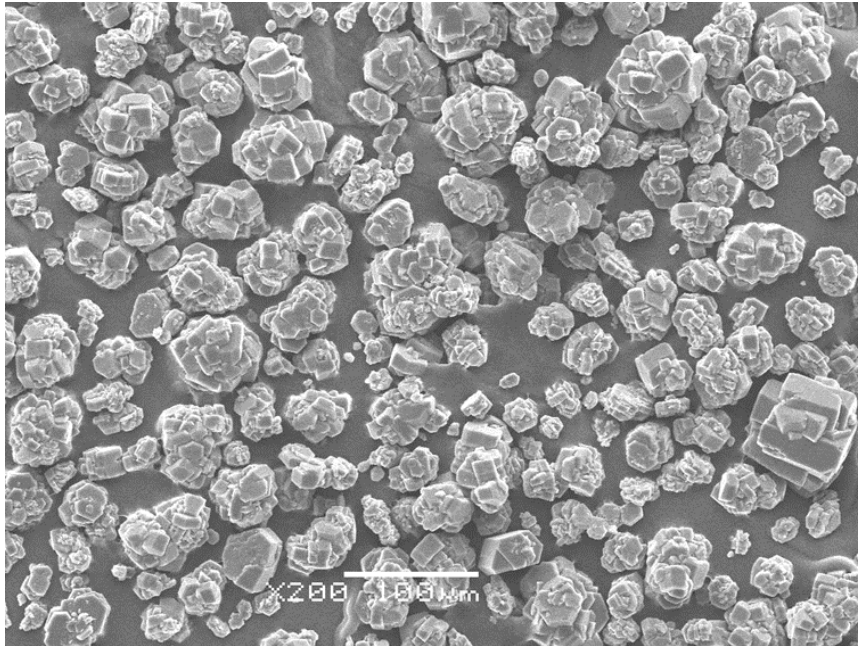
It had been pointed out that the precipitation behavior of SiO<sub>2</sub> was mainly divided into three stages in the precipitation process. In the early stage, sodium aluminosilicate was formed, in the middle stage, sodium aluminosilicate was transformed into crystal, and in the late stage, it was silica in the seed adsorption solution, that was, it decreased in the early stage rapidly, unchanged in the middle stage basically, and decreased in the late stage slowly [2],[3]. In general, the SiO<sub>2</sub> content was higher in green liquor, the precipitation process temperature was higher, the precipitation amount of SiO<sub>2</sub> would be higher in the precipitation process. In addition, due to the obvious seed adhesion at the early stage of precipitation process, when the seed particle size was fine, the effect of adhesion was great, the SiO<sub>2</sub> in the solution would precipitate in large quantities at this time, so the refinement of seed particle size would increase the SiO<sub>2</sub> content in the product [4].

Reducing the SiO<sub>2</sub> content of solution was the most effective method to inhibit the precipitation of sodium aluminosilicate in the precipitation process. Through preliminary studies, Zhengzhou Non-ferrous Metals Research Institute Ltd of CHALCO proposed that the concentration of caustic soda could be reduced in circulating mother liquor effectively by increasing the pre-desilication temperature, increasing the solid content of pre-desilication feed, prolonging the dissolution time, and thus inhibiting the precipitation of sodium aluminosilicate in the precipitation process [5].

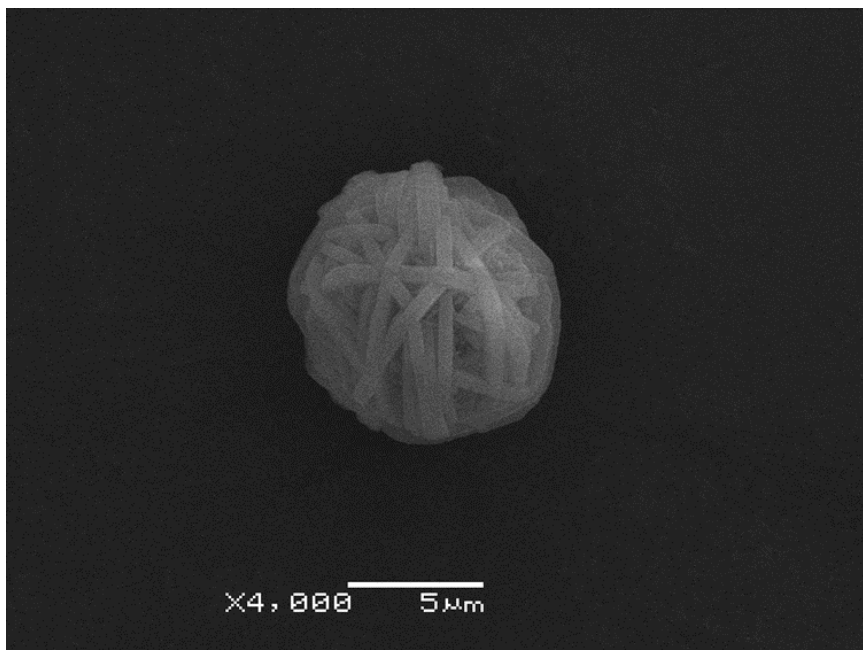
In this paper, when the content of silica increased in green liquor, the precipitation behavior of sodium aluminosilicate crystals was studied during the precipitation process. At the same time, the seed containing a large amount of sodium aluminosilicate were taken to carry out precipitation process tests. The change of sodium aluminosilicate in seed was determined after the reduction of green liquor silica content, the solution of excessive silica content was proposed in products after the precipitation of sodium aluminosilicate.

## 2. Percipitation Behavior of Sodium Aluminosilicate in Precipitation Process

When the silica was supersaturated in green liquor, desilication would occur in the precipitation process, and sodium aluminosilicate impurities would be generated in the seed, resulting in the increase of silica content in the seed. In order to study the precipitation behavior of sodium aluminosilicate in the precipitation process, the alumina hydroxide seed with sodium aluminosilicate precipitated in the production site was taken for three consecutive cycles to observe the precipitation of sodium aluminosilicate in the seed. The change of sodium aluminosilicate was observed by scanning electron microscope at the interval of one month. The results were shown in Figures 1 through 9.



**Figure 1. Macromorphology of first-period seed.**



**Figure 2. Morphology of sodium aluminosilicate in the first period seed.**

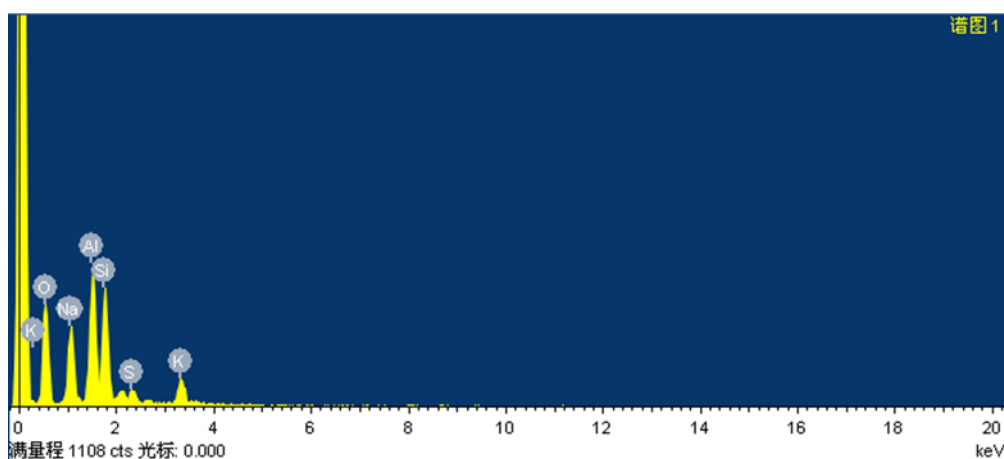


Figure 3. Results of energy spectrum analysis of sodium aluminosilicate in the first period seed.

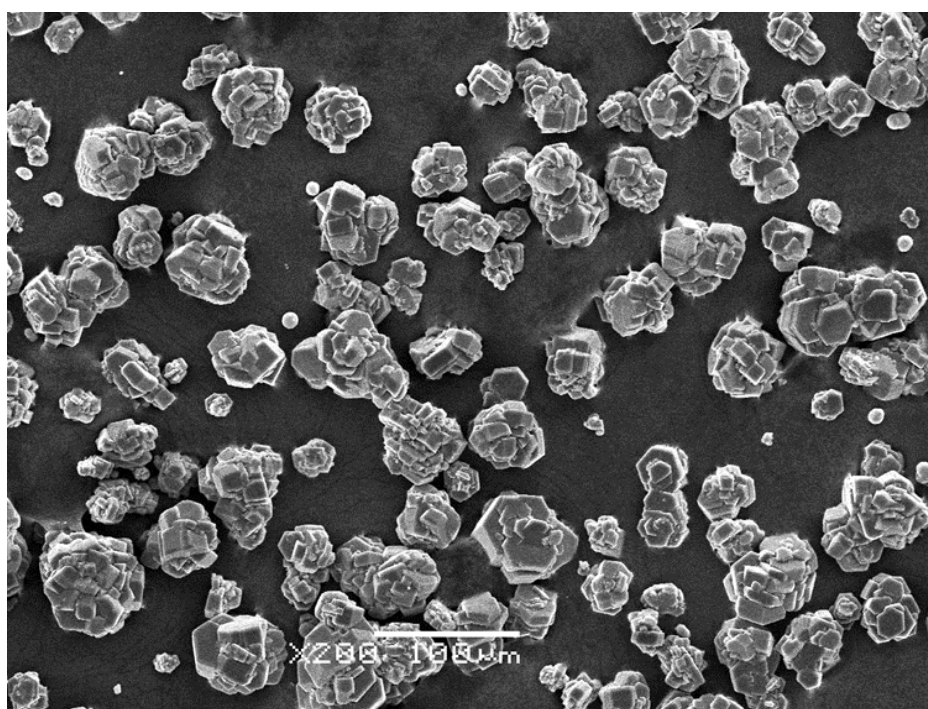


Figure 4. Macromorphology of the second period seed.

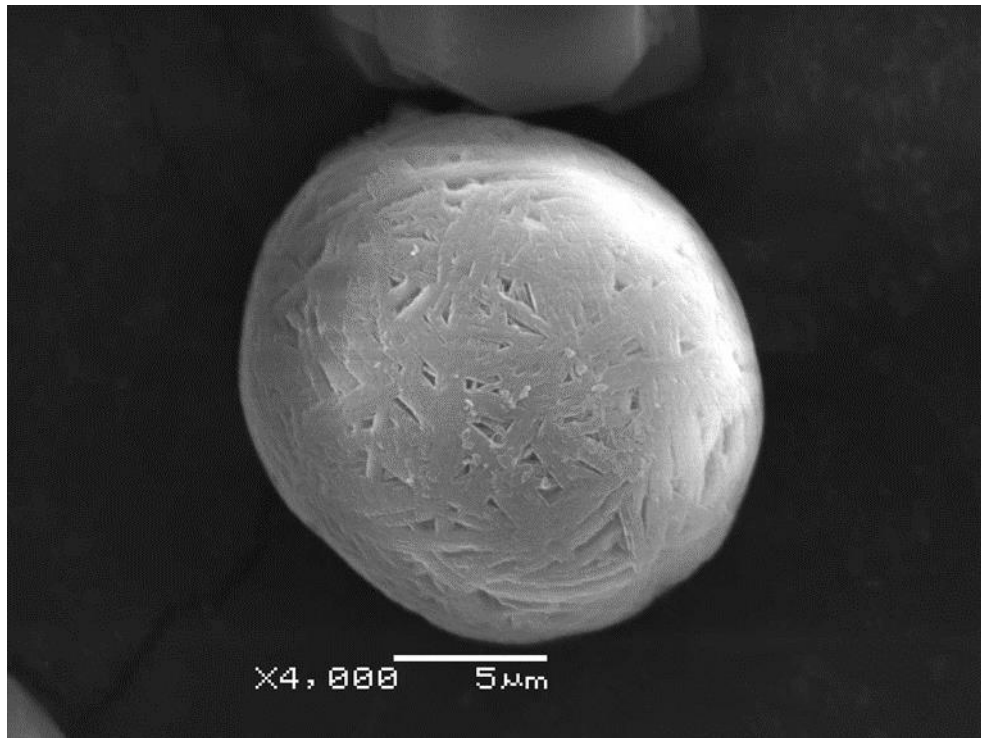


Figure 5. Morphology of sodium aluminosilicate in second period seed.

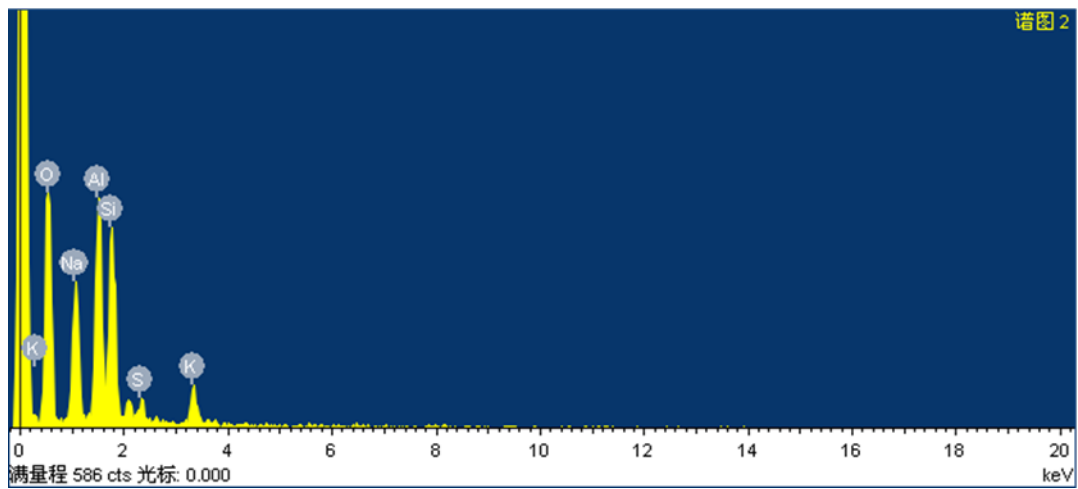
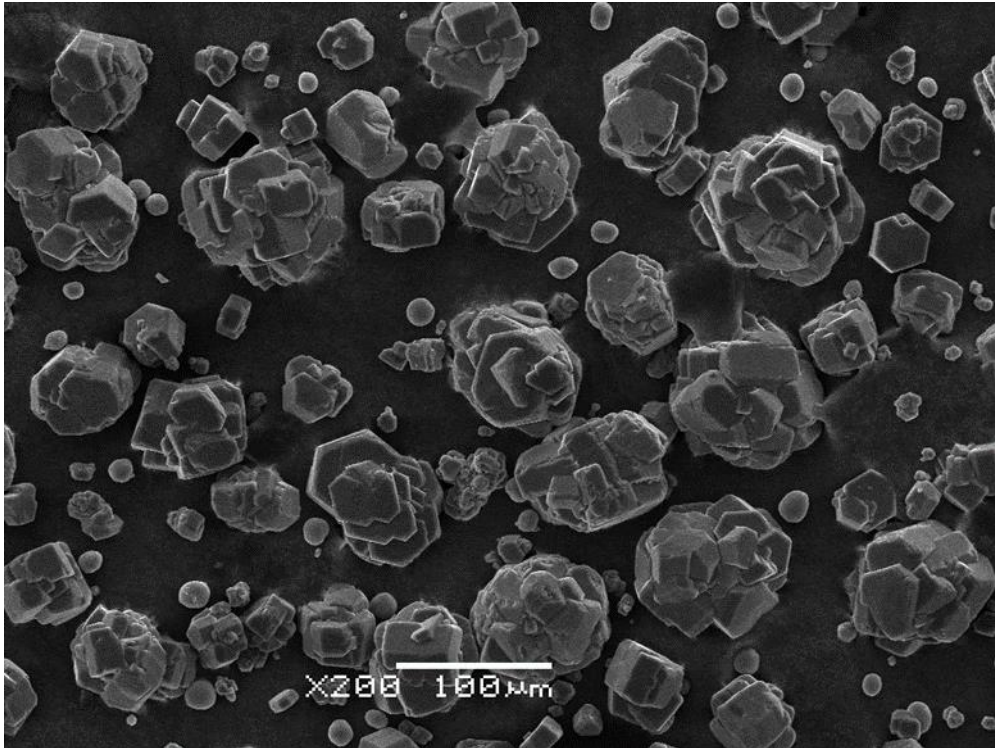
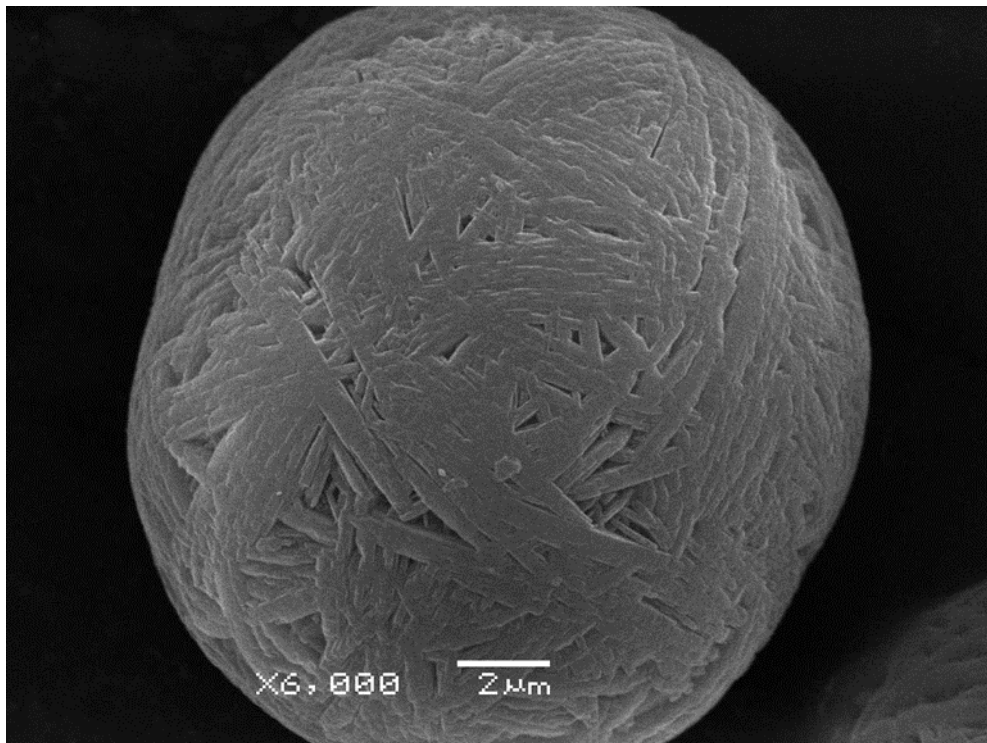


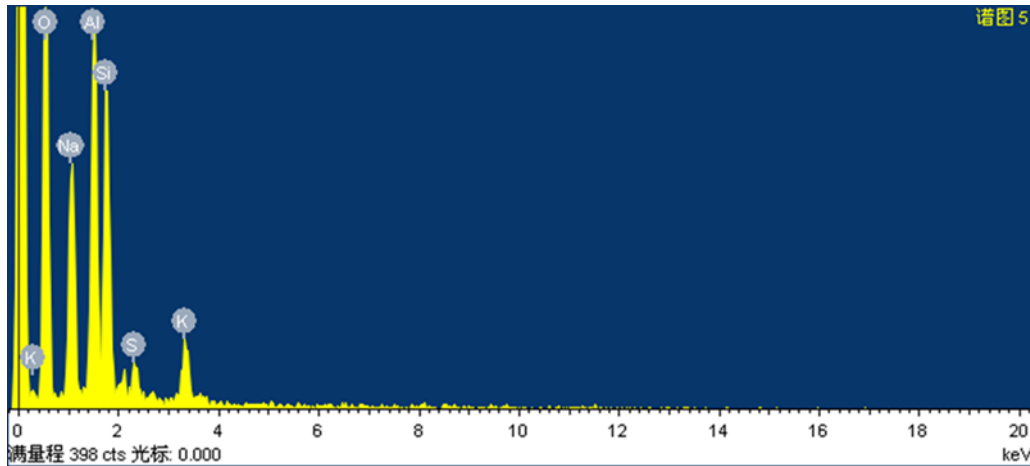
Figure 6. Results of energy spectrum analysis of sodium aluminosilicate in second period seed.



**Figure 7. Macromorphology of the third period seed.**



**Figure 8. Morphology of sodium aluminosilicate in third period seed.**



**Figure 9. Results of energy spectrum analysis of sodium aluminosilicate in third period seed.**

Figure 1 to Figure 3 showed the precipitation of sodium aluminosilicate in the first period seed. As could be seen from the figure, when the  $\text{SiO}_2$  of solution was supersaturated, the sodium aluminosilicate would precipitate on the surface of 5-10 $\mu\text{m}$  aluminum hydroxide particles, and its morphology was cross rod structure. At this time, the  $\text{SiO}_2$  content was 0.05 % in seed, more than two times the standard value.

Figure 4 to Figure 6 showed the precipitation of sodium aluminosilicate in the second period seed. As could be seen from the figure, the sodium aluminosilicate had wrapped the aluminum hydroxide crystal nucleus completely after one month, which was wool ball, and its diameter grew from 5-10  $\mu\text{m}$  to 10-15  $\mu\text{m}$ . At this time, the silicon dioxide content in the seed increased to 0.12 %.

Figure 7 to 9 were the precipitation of sodium aluminosilicate in the third-period seed. It could be seen from the figure that, the volume of sodium aluminosilicate increased again and stabilized to 20  $\mu\text{m}$  after one month. The surface of sodium aluminosilicate had passivated gradually and did not grow. At this time, the content of silicon dioxide reached the maximum value of 0.25 % in seed.

### 3. Inhibition of Sodium Aluminosilicate Precipitation Test

#### 3.1 Test Equipment

The main types of equipment used for this test were:

1. Water baths, developed by the Zhengzhou Research Institute, used to independently heat the system and maintain constant temperature.
2. Analytical balances.
3. Vacuum filter devices.

The main equipment used for sample analysis during the test were:

1. The  $\text{SiO}_2$  content of sodium aluminate solution and seed were analyzed by 723N visible spectrophotometer.
2. Scanning Electron Microscope (JSM6360LV) for seed morphology analysis.
3. Chemical Titration for sodium aluminate solution composition analysis.

### 3.2 Test Materials and Methods

To add green liquor with different concentrations of SiO<sub>2</sub> into 4 precipitation process tanks which had been heated to a predetermined temperature and add aluminum hydroxide seed with and without sodium aluminosilicate respectively. Start stirring, run under the established precipitation process temperature system, sample and analyze the chemical composition of solution and seed after a certain time, separated the decomposed slurry from solid after a certain precipitation process time, analyzed the composition of solution and seed and made corresponding calculation.

The precipitation process test conditions were as follows: the temperature of the first tank was 65 °C, the temperature of the last tank was 56 °C, the precipitation process time was 45 hours, the CGM content was 20 ppm, and the solid content was 700 g/L.

The green liquor and crystal species added in the 1# to 4# precipitation process tank were shown in Table 1, and the chemical composition of green liquor was shown in Table 2, Chemical composition of seed was shown in Table 3.

**Table 1 Types of green liquor and seed**

	1#	2#	3#	4#
<b>Seed type</b>	Low SiO <sub>2</sub> seed	Low SiO <sub>2</sub> seed	High SiO <sub>2</sub> seed	High SiO <sub>2</sub> seed
<b>Green liquor type</b>	Low SiO <sub>2</sub> green liquor	High SiO <sub>2</sub> green liquor	High SiO <sub>2</sub> green liquor	Low SiO <sub>2</sub> green liquor

**Table 2 Chemical composition of green liquor**

	Na <sub>2</sub> O <sub>K</sub> g/L	SiO <sub>2</sub> g/L
<b>Low SiO<sub>2</sub> green liquor</b>	153	0.732
<b>High SiO<sub>2</sub> green liquor</b>	154	1.141

**Table 3 Chemical composition of seed**

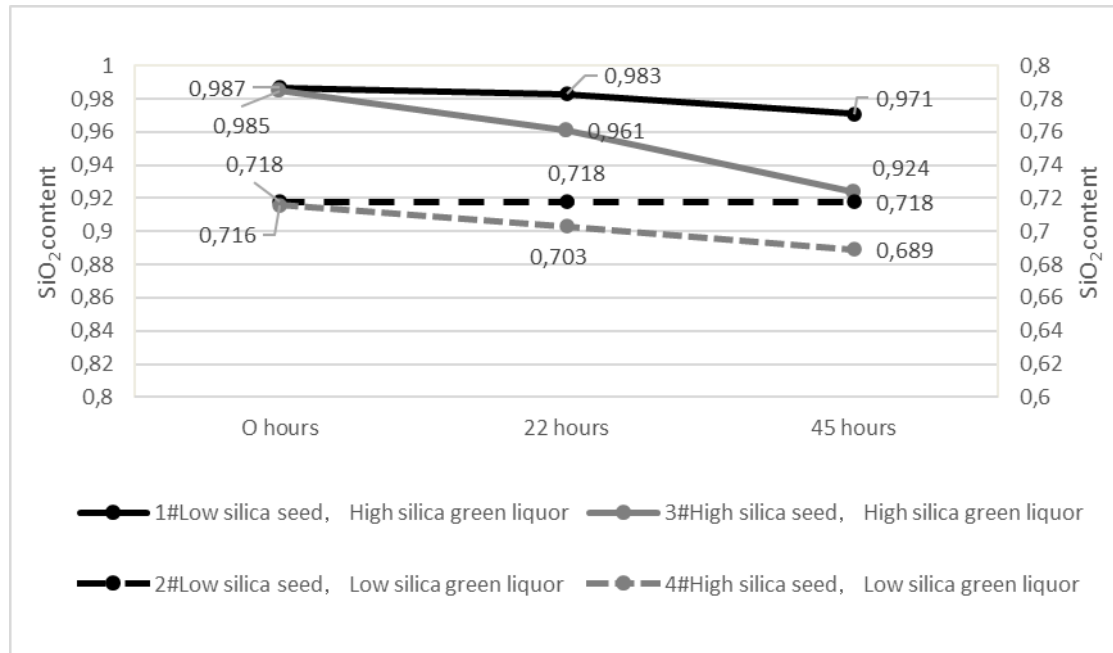
	SiO <sub>2</sub> %
<b>High SiO<sub>2</sub> seed</b>	0.24
<b>Low SiO<sub>2</sub> seed</b>	0.02

### 3.3 Experimental Results and Discussion

After mixing green liquor and seed of different types, precipitation process test was conducted to investigate the change of SiO<sub>2</sub> in solution before and after the test. The test results were shown in Table 4 and Figure 10.

**Table 4 Change of solution SiO<sub>2</sub> during precipitation process**

Number	SiO <sub>2</sub> content in solution at 0 hours g/L	SiO <sub>2</sub> content in solution at 22 hours g/L	SiO <sub>2</sub> content in solution at 45 hours g/L	SiO <sub>2</sub> content in solution from precipitation process
1#	0.987	0.983	0.971	0.016
2#	0.718	0.718	0.718	0
3#	0.985	0.961	0.924	0.061
4#	0.716	0.703	0.689	0.027



**Figure 10. Precipitation test results of green liquor and seed with different SiO<sub>2</sub> contents.**

As could be seen from the figure, when the SiO<sub>2</sub> content was high in green liquor, if the seed did not contain sodium aluminosilicate, a small amount of SiO<sub>2</sub> would still be precipitated in the precipitation process. However, if the seed contained a large amount of sodium aluminosilicate, sodium aluminosilicate would further induce the precipitation of sodium silicate, resulting in a significant reduction of SiO<sub>2</sub> in the solution. When the SiO<sub>2</sub> content was reduced in green liquor and the seed was used without sodium aluminosilicate, the amount of SiO<sub>2</sub> released during precipitation process was 0, if the seed containing a large amount of sodium aluminosilicate was used for the test, SiO<sub>2</sub> precipitation was inhibited due to the low level of SiO<sub>2</sub> in green liquor effectively. However, compared with the seed without sodium aluminosilicate, a small amount of SiO<sub>2</sub> was still precipitated in the precipitation process due to the strong inductivity of sodium aluminosilicate.

Through this experiment, it could be concluded that the precipitation behavior of sodium aluminosilicate was mainly related to the SiO<sub>2</sub> content in green liquor and the induction of sodium aluminosilicate in seed. When the SiO<sub>2</sub> content of the product increases due to the presence of sodium aluminosilicate in the seed, the precipitation of SiO<sub>2</sub> in the solution could be inhibited by reducing the SiO<sub>2</sub> content of green liquor, to inhibit the growth of sodium aluminosilicate crystals and reduce the growth rate of SiO<sub>2</sub> of the product. At the same time, according to the production situation, the solid content of the precipitation process tank was reduced to accelerate the replacement of seed and the expulsion of sodium aluminosilicate crystal.

#### 4. Conclusion

1. When the SiO<sub>2</sub> of solution was supersaturated, sodium aluminosilicate would precipitate on the surface of 5-10 μm aluminum hydroxide particles, and its morphology was a cross rod-like structure. With the decomposition process, the volume of sodium aluminosilicate would gradually grow to 20 μm after two months. At this time, the surface of sodium aluminosilicate had passivated gradually and did not grow, and the SiO<sub>2</sub> content of seed reached the maximum value of 0.25 %.

2. The precipitation behavior of sodium aluminosilicate was mainly related to the SiO<sub>2</sub> content in green liquor and the induction of sodium aluminosilicate in seed during precipitation process.
3. When the SiO<sub>2</sub> content of the product increased due to the presence of sodium aluminosilicate in the seed, the precipitation of SiO<sub>2</sub> from the solution could be inhibited by reducing the SiO<sub>2</sub> content of green liquor, to inhibit the growth of sodium aluminosilicate crystals and reduce the growth rate of SiO<sub>2</sub> of the product.
4. According to the production situation, the solid content of precipitation process tank was reduced to accelerate the replacement of seed and the expulsion of sodium aluminosilicate crystal.

## 5. References

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