

## AA16 – Study on Influencing Factors of Precipitation Ratio

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### Abstract

Seeded precipitation of sodium aluminate solution was a key procedure in the Bayer process to produce alumina. This process exposed vital impacts not only on the quality and yield, but also on the technical and economic indexes of the alumina. The precipitation ratio of sodium aluminate solution was one of the main economic and technical indices of alumina production process. To improve the precipitation ratio, the relationship between green liquor  $\alpha_k$ , green liquor  $\text{Na}_2\text{O}_K$ , green liquor  $\text{Na}_2\text{O}_C$ , precipitation temperature, precipitation solids content, precipitation time and precipitation ratio were studied in this paper. The optimum precipitation ratio was obtained by determining the appropriate precipitation system.

**Keywords:** Green liquor, Precipitation, Precipitation ratio, Influencing factors.

### 1. Introduction

The relationship between the seed decomposition ratio of the Bayer process and the cycle efficiency, total capacity and alumina production cost, this relationship was one of the most important economic and technical indicators of alumina production process to improve the precipitation ratio [1].

The process of precipitation by the Bayer method refers to the process of adding seed in supersaturated sodium aluminate solution, cooling down and continuously stirring to decompose and precipitate aluminum hydroxide. Due to the relatively large interfacial tension between sodium aluminate solution and aluminum hydroxide crystal, the precipitation process provides a low surface energy, resulting in the difficulty of spontaneous nucleation of aluminum hydroxide. Therefore, it was necessary to add a certain mass of seeds to overcome the interfacial tension between sodium aluminate solution and aluminum hydroxide crystals, so that aluminum hydroxide crystals could be precipitated [2].

To increase the rate of precipitation and crystallization for the aluminum hydroxide, the sodium aluminate solution required a large supersaturation, such as lower precipitation temperature, lower green liquor  $\text{Na}_2\text{O}_K$  ( $\text{Na}_2\text{O}$  caustic) and molar ratio of  $\text{Na}_2\text{O}_K$  to  $\text{Al}_2\text{O}_3$  ( $\alpha_k$ ). At the same time, it was necessary to add a certain amount of highly active seeds in sodium aluminate solution, such as a high precipitation solids content. In addition, the longer precipitation time and the lower impurity content of solution were also conducive to improving the precipitation ratio [3].

Because the precipitation process of sodium aluminate solution was more complicated and there were many process parameters associated with the precipitation ratio, it was necessary to study the precipitation system of specific alumina production enterprises to determine the best process parameters and improve the precipitation ratio [4].

## 2. Test Materials and Test Methods

### 2.1 Test Materials

The green liquor and seeds were taken from the alumina production site. During the condition test, the composition of the solution was adjusted with analytical pure sodium carbonate and sodium hydroxide reagents. The chemical component in green liquor from an alumina refinery was shown in Table 1.

**Table 1. Chemical component in green liquor, g/L.**

Composition	Na <sub>2</sub> O <sub>T</sub> (total)	Al <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O <sub>K</sub>	α <sub>k</sub>	Na <sub>2</sub> O <sub>C</sub> /Na <sub>2</sub> O <sub>T</sub>
Content	199.5	180.3	160.0	1.46	0.20

The chemical component of impurities for seed was shown in Table 2.

**Table 2. Component of aluminum hydroxide seed, %.**

Composition	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O
Content	0.015	0.013	0.24

### 2.2 Test Methods

After preheating at the initial precipitation temperature, a certain amount of alumina hydroxide seed was added and ran under the established precipitation temperature system. After a certain period, samples were collected and analyzed for the composition of the solution. The correlations between the change of its composition and adjustments made were investigated. After a certain period, the precipitation slurry was separated from liquid and solid. The components of Na<sub>2</sub>O<sub>T</sub>, Al<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O<sub>K</sub> were analyzed, and the precipitation ratio was calculated. Table 3 showed the variation range of influence that needed to be investigated in this precipitation test [5].

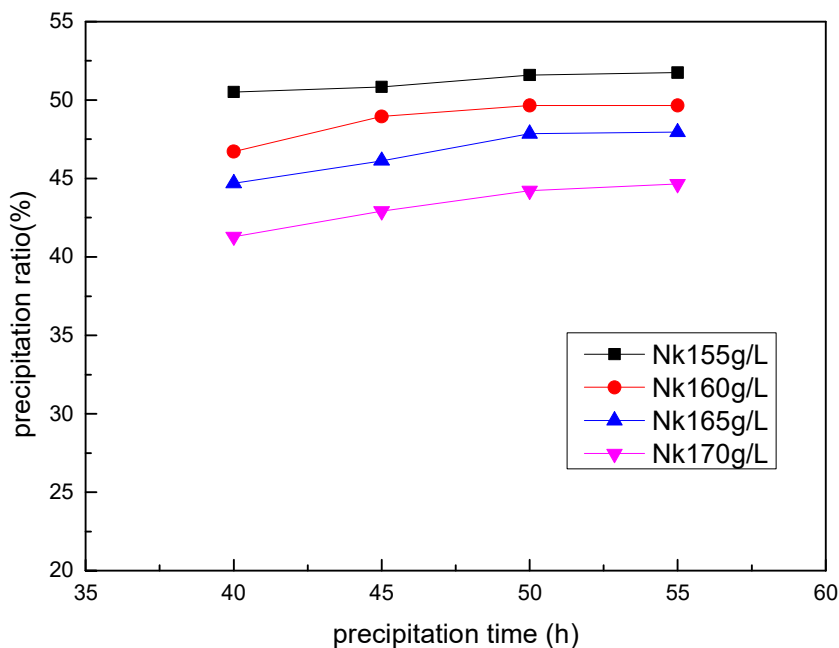
**Table 3. Experimental matrix.**

Serial number	Influence	variation range
1	green liquor Na <sub>2</sub> O <sub>K</sub>	155–170 g/L
2	initial precipitation temperature	58–63 °C
3	precipitation solids content	650–800 g/L
4	green liquor α <sub>k</sub>	1.44–1.55
5	green liquor Na <sub>2</sub> O <sub>C</sub> (carbonate)	23–43 g/L
6	precipitation time	40–55 h

## 3. Test Results and Discussion

### 3.1 Influence of Green Liquor Na<sub>2</sub>O<sub>K</sub> on Precipitation Ratio

Under the conditions of α<sub>k</sub> (1.46), Na<sub>2</sub>O<sub>C</sub>/Na<sub>2</sub>O<sub>T</sub> (0.20), precipitation solids content (750 g/L), precipitation temperature (initial temperature 60 °C to final temperature 48 °C). When the green liquor Na<sub>2</sub>O<sub>K</sub> (hereinafter N<sub>k</sub>) was 155 g/L, 160 g/L, 165 g/L and 170 g/L respectively, the effects of different green liquor Na<sub>2</sub>O<sub>K</sub> on the decomposition ratio were investigated. The test results were shown in Figure 1.



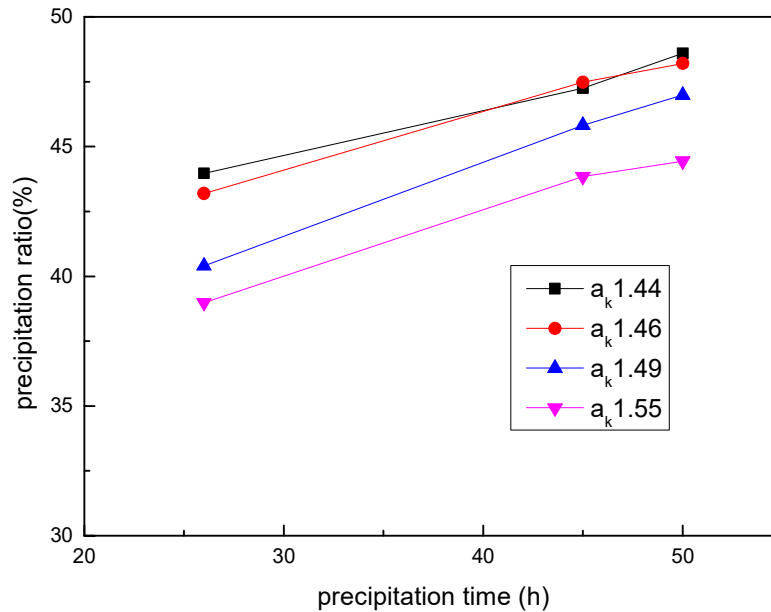
**Figure 1. Influence of green liquor  $\text{Na}_2\text{O}_K$  on precipitation ratio.**

Based on the data acquired, the following conclusions can be made:

- With the same precipitation time, the precipitation ratio gradually decreased with the increase of green liquor  $\text{Na}_2\text{O}_K$ .
- When green liquor  $\text{Na}_2\text{O}_K$  was higher than 165 g/L, the precipitation ratio would be significantly reduced.
- With the gradual increase of green liquor  $\text{Na}_2\text{O}_K$ , the precipitation ratio was affected by the precipitation time.
- When green liquor  $\text{Na}_2\text{O}_K$  was low, a high precipitation ratio could be achieved in a short time.
- Recommended green liquor  $\text{Na}_2\text{O}_K$  less than 165 g/L.

### 3.2 Influence of Green Liquor $\alpha_k$ on Precipitation Ratio

Under the conditions of  $\text{Na}_2\text{O}_K$  (160 g/L),  $\text{Na}_2\text{O}_C/\text{Na}_2\text{O}_T$  (0.20), precipitation solids content (750 g/L), precipitation temperature (initial temperature 60 °C to final temperature 48 °C). When the green liquor  $\alpha_k$  was 1.40, 1.45, 1.50 and 1.55, the effects of different green liquor  $\alpha_k$  on the decomposition ratio were investigated. The test results were shown in Figure 2.



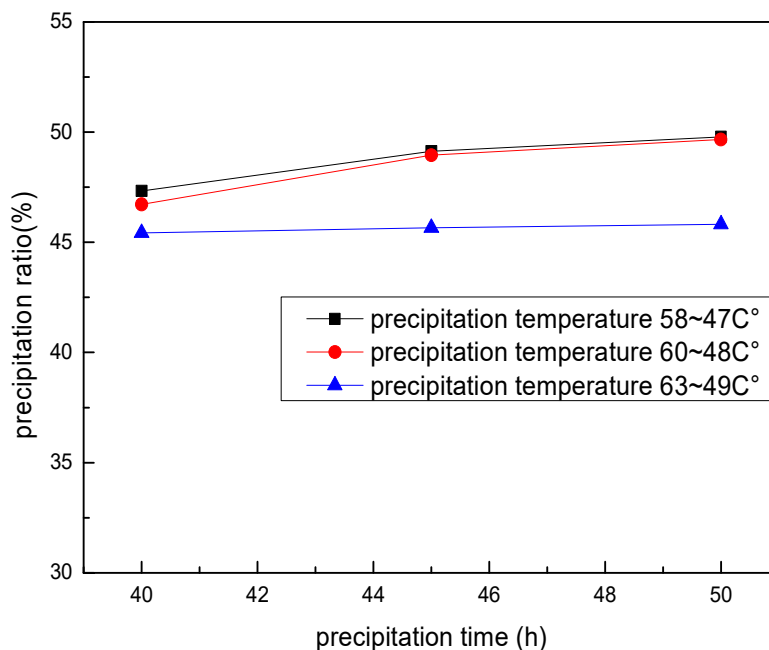
**Figure 2. Influence of green liquor  $\alpha_k$  on precipitation ratio.**

Based on the data acquired, the following conclusions can be made:

- With the same precipitation time, the precipitation ratio decreased with the increase of green liquor  $\alpha_k$ .
- When green liquor  $\alpha_k$  was 1.44–1.46, the precipitation ratio did not change much.
- The precipitation time was less than 45 hours, which has a greater impact on the precipitation ratio.
- It was recommended that the green liquor  $\alpha_k$  was 1.46, and the precipitation time was 45 hours.

### 3.3 Influence of the Precipitation Temperature on the Precipitation Ratio

Under the conditions of  $\text{Na}_2\text{O}_K$  (160 g/L),  $\alpha_k$  (1.46), precipitation solids content (750 g/L),  $\text{Na}_2\text{O}_C/\text{Na}_2\text{O}_T$  (0.20), when the precipitation initial temperatures and final temperatures were 58 - 47 °C, 60 - 48 °C and 63 - 49 °C, the effects of different precipitation temperatures on the precipitation ratio were investigated. The test results were shown in Figure 3.



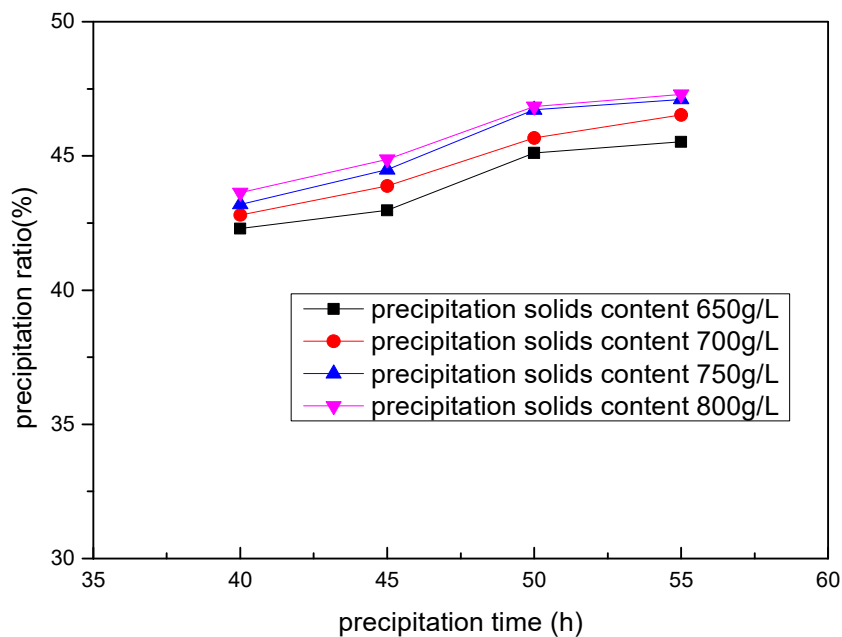
**Figure 3. Influence of the precipitation temperature on the precipitation ratio.**

Based on the data acquired, the following conclusions can be made:

- When the green liquor  $\text{Na}_2\text{O}_K$  was 160 g/L and if the precipitation temperature of the first tank was lower than 60 °C, which could make the green liquor achieve the best supersaturation, and the precipitation ratio was the best at this time, and the precipitation time was greater than 45 hours.
- When green liquor  $\text{Na}_2\text{O}_K$  was 160 g/L and if the precipitation temperature of the first tank was higher than 60 °C, the precipitation ratio would not increase even if the dissolution time was prolonged because of the low green liquor supersaturation.

### 3.4 Influence of Precipitation Solids Content on Precipitation Ratio

Under the conditions of  $\text{Na}_2\text{O}_K$  (167 g/L),  $\alpha_k$  (1.46),  $\text{Na}_2\text{O}_C/\text{Na}_2\text{O}_T$  (0.20), precipitation temperature (initial temperature 60 °C to final temperature 48 °C). When the green liquor precipitation solids content was 650 g/L, 700 g/L, 750 g/L and 800 g/L, the effects of different precipitation solids content on the decomposition ratio were investigated. The test results were shown in Figure 4.



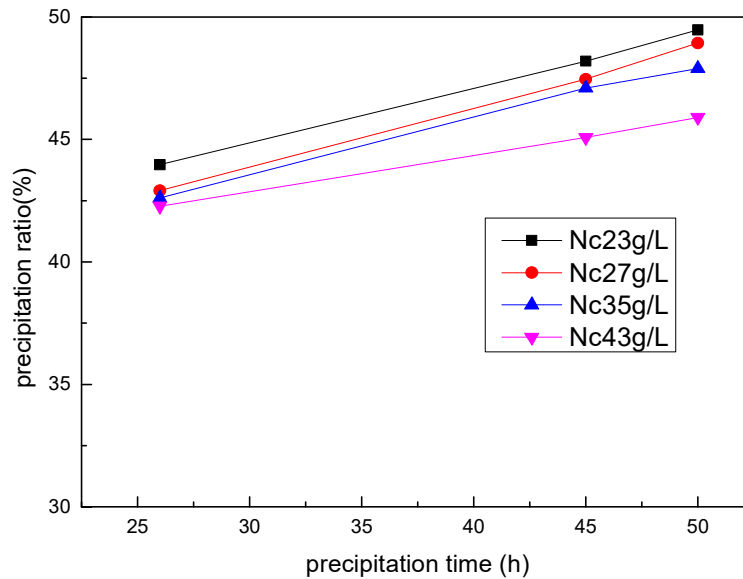
**Figure 4. Influence of precipitation solids content on precipitation ratio.**

Based on the data acquired, the following conclusions can be made:

- With the increase of precipitation solids content, the precipitation ratio tended to increase.
- When the precipitation solids content was 650–750 g/L, the precipitation ratio could be increased by 0.5–1.0 % for each increase of 50 g/L, while the precipitation ratio was only increased by 0.2 % for 750–800 g/L.
- When green liquor  $\text{Na}_2\text{O}_K$  was 167 g/L, the solution supersaturation was low, it was recommended to increase the precipitation solids content to more than 750 g/L, while extending the precipitation time to 50 hours, to achieve the best precipitation ratio.

### 3.5 Influence of Green Liquor $\text{Na}_2\text{O}_C$ on Precipitation Ratio

Under the conditions of  $\text{Na}_2\text{O}_K$  (160 g/L),  $\alpha_k$  (1.45), precipitation solids content (750 g/L), precipitation temperature (initial temperature 60 °C to final temperature 48 °C), When the green liquor  $\text{Na}_2\text{O}_C$  (hereinafter  $\text{Nc}$ ) was 23 g/L, 27 g/L, 35 g/L and 43 g/L the effects of different  $\text{Na}_2\text{O}_C$  on the precipitation ratio were investigated, as shown in Figure 5.



**Figure 5. Influence of green liquor  $\text{Na}_2\text{O}_C$  on precipitation ratio.**

Based on the data acquired, the following conclusions can be made:

- With the increase of  $\text{Na}_2\text{O}_C$  in green liquor, the precipitation ratio decreased significantly.
- For every 3 g/L increase in green liquor  $\text{Na}_2\text{O}_C$ , the precipitation ratio decreased by about 0.5 %.
- When green liquor  $\text{Na}_2\text{O}_C$  was greater than 35 g/L, the precipitation ratio would be reduced in much greater extent.

### 3.6 Influence of Precipitation Time on Precipitation Ratio

Throughout the above tests, it could be concluded that if the supersaturation of green liquor was large and the precipitation solids content was high, the precipitation time was recommended to be about 45 hours, if the supersaturation of aluminum green liquor was low, the precipitation solids content was low, and the  $\text{Na}_2\text{O}_C$  content of green liquor was high, it was recommended to extend the precipitation time to 50 hours to improve the precipitation ratio.

## 4. Conclusions and Suggestions

The basic idea of improving the precipitation ratio was to increase the supersaturation of green liquor as much as possible under the premise of ensuring sufficient precipitation time and precipitation solids content, that was, reasonable controlling of green liquor  $\text{Na}_2\text{O}_K$ ,  $\alpha_k$ , and precipitation first tank temperature, and reducing the content of impurities such as  $\text{Na}_2\text{O}_C$  in green liquor.

Through experimental research, it was proposed that the best process system for improving the precipitation ratio of the enterprise was as follows: precipitation time was 45–50 hours, precipitation starting solid content was 750 g/L, initial precipitation temperature was 60 °C, green liquor  $\text{Na}_2\text{O}_K$  was 160–165 g /L, green liquor  $\alpha_k$  was 1.46, green liquor  $\text{Na}_2\text{O}_C$  was less than 35 g/L.

At the same time, it could be concluded that reducing green liquor  $\text{Na}_2\text{O}_K$  and  $\text{Na}_2\text{O}_C$  was the most effective means to improve the precipitation ratio.

## 5. References

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