

Effect of Lithium on the Seed Precipitation Process

Dongzhan Han¹, Yaguang Li², Gengbiao Xie³ and Feiyu Zhang⁴

1. Professor Level Senior Engineer

2, 3. Engineers

4. Assistant Engineer

Zhengzhou Non-ferrous Metals Research Institute of Chalco (ZRI), Zhengzhou, China

Corresponding author: yg_li124@chinalco.com.cn

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Abstract

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The bauxite deposits in the Henan and Shanxi regions of China are rich in lithium content. During the digestion process, lithium enters the sodium aluminate solution, where lithium ions, as impurity ions, negatively affects the precipitation process. This study investigates the behaviour of lithium ions during seed precipitation, thus clarifying the precipitation patterns of lithium during the process. The results acquired indicate that during the initial stage of precipitation, lithium ions rapidly precipitate from the sodium aluminate solution. With a precipitation time of 1 hour, the precipitation rate of lithium exceeds 90 %, and at 2 hours, it exceeds 99 %. Lithium ions significantly influence the microstructure of aluminium hydroxide, with fine particles either existing independently or adhering to the surface of larger aluminium hydroxide crystals, leading to product particle refinement. The presence of lithium in the aluminium hydroxide product affects both its purity and strength; moreover, higher lithium content results in an increased attrition index of alumina and reduced product strength.

Keywords: Lithium ions, Seed precipitation, Precipitation rate.

1. Introduction

The seed precipitation of sodium aluminate solution is one of the key processes in alumina production with Bayer process, significantly affecting the process output, quality of alumina products, and overall technical indicators. It is generally recognized [1] that when the Li₂O content in alumina products is controlled below 0.05 %, no negative impact will be exerted on the technical-economic indicators or stable operation of aluminium smelters. By reverse calculation, the corresponding lithium ion concentration in the pregnant liquor is approximately 0.02 g/L. However, in some Chinese alumina refineries using high-lithium bauxite, the Li⁺ concentration in the pregnant liquor even reaches 0.15 g/L, which not only causes production issues but also creates opportunities for lithium extraction from the system. Domestic and international researchers have conducted studies on the influence of lithium ions on the precipitation process. Prestudge [2] observed that during the precipitation of aluminium hydroxide by adding sodium hydroxide to aluminium chloride, Li⁺ ions could modify the structure of pseudo-boehmite. Xiaobin Li [3] suggested that in the seed precipitation process of diasporite-type bauxite for alumina production, Li⁺ ions in the solution had no impact on the precipitation rate or particle size distribution (PSD). Wenqiang Huang [4] investigated the impact of lithium ions on the seed precipitation process and concluded that lithium ions could enhance the precipitation rate of sodium aluminate solution while increasing the lithium content in the products. Since lithium-containing aluminium hydroxide preferentially nucleates during precipitation, the nucleated particles are very fine, leading to a significant increase in the total quantity of particles in the sodium aluminate solution. However, the influence of lithium ions on the seed precipitation process of sodium aluminate solution has not been systematically investigated.

This study investigates the influence of lithium ions on the seed precipitation process in sodium aluminate solution under the existing precipitation system for producing diasporite-type bauxite with the Bayer process. It examines the distribution patterns of lithium ions during precipitation and reveals the reaction behaviour of lithium ions as well as the migration and transformation mechanisms. The study aims to provide a theoretical foundation for the efficient separation, enrichment, and extraction of lithium from sodium aluminate solutions.

2. Change in Lithium Ion Concentration During Precipitation Process

Under the precipitation conditions of an initial temperature of 69 °C, a final temperature of 54 °C, seed dosage of 500 g/L, and a precipitation time of 2 hours, the influence of different lithium ion concentrations (0.05 g/L and 0.5 g/L) on the lithium precipitation rate during seed precipitation was investigated using green liquor, as shown in Figure 1, for the following conditions: an initial precipitation temperature of 69 °C, a final precipitation temperature of 54 °C, a seed dosage of 500 g/L, and a precipitation duration of 2 hours.

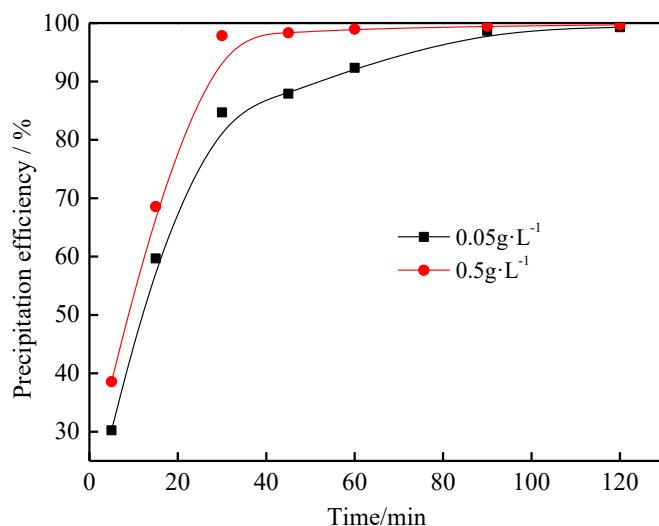


Figure 1. Impact of precipitation time on lithium precipitation rate from sodium aluminate solution.

Figure 1 shows that as the precipitation reaction proceeds, the lithium precipitation rate increases rapidly, with higher lithium concentrations in the green liquor leading to greater precipitation rates. At a precipitation time of 60 minutes, the lithium precipitation rate exceeds 90 %, and at a precipitation time of 2 hours, it exceeds 99 %, indicating that nearly all lithium ions in the solution have entered the aluminium hydroxide particles. This demonstrates that lithium ions enter the products during the initial stage of precipitation, and their behaviour in the alumina production process is a one-way process without cyclic accumulation.

Figure 2 shows the impact of lithium ion concentration on the precipitation rate during the initial precipitation stage, with the following conditions: an initial precipitation temperature of 69 °C, a final precipitation temperature of 54 °C and a seed charge of 500 g/L. It can be seen that during the initial precipitation stage, the precipitation rate of sodium aluminate solution increases with the rise of the lithium ion concentration in the solution, and the higher the lithium ion concentration, the more pronounced its effect on the precipitation rate. At a precipitation time of 2 hours, when the lithium ion concentration in green liquor is 0.05 g/L, the precipitation rate is 21.65 %, whereas at a lithium ion concentration of 0.5 g/L in green liquor, the precipitation rate reaches 23.70 %. This demonstrates that increasing the lithium ion concentration in the solution enhances the seed precipitation rate of sodium aluminate solution in the initial precipitation stage.

Table 2. Attrition index of alumina with different lithium contents.

No.	Li ₂ O content in alumina (%)	Attrition index (%)
1	0.0003	23.80
2	0.017	24.20
3	0.110	42.80

Note: No. 1, No. 2 and No. 3 correspond to lithium concentrations of 0, 0.05 and 0.5 g/L in the green liquor, respectively.

8. Conclusion

1. In the initial stage of precipitation, lithium precipitates rapidly from the sodium aluminate solution. At a precipitation time of 1 hour, the precipitation rate of lithium exceeds 90 %, and at 2 hours, it exceeds 99 %. Therefore, nearly all lithium ions in the pregnant liquor enter into aluminium hydroxide during the initial precipitation stage (within 2 hours).
2. In the initial stage of precipitation, lithium ions shorten the induction period for aluminium hydroxide precipitation in sodium aluminate solution, thereby enhancing the precipitation rate. In the middle and later stages, however, the lithium-containing aluminium hydroxide precipitates as flaky aggregates attached to the surface of aluminium hydroxide, which hinders the growth of seeds and consequently reduces the precipitation rate.
3. Lithium ions significantly influence the microstructure of aluminium hydroxide. Lithium ions increase the content of fine solid particles in the solution, with these fine particles existing either independently or attached to the surface of larger aluminium hydroxide crystals. As a result, lithium ions raise the proportion of fine particles (-45 µm) in the product, leading to finer particle sizes. The presence of lithium in the aluminium hydroxide product affects both its purity and strength. Moreover, higher lithium content results in an increased attrition index and reduced strength of alumina.

9. Acknowledgement

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10. References

1. Yunfeng Zhou, et al., Study on lithium balance during electrolysis of lithium-rich alumina. *Light Metals*, 2016, (1): 30–33 (in Chinese).
2. Clive A. Prestidge and Igor Ametov, Cation effects during aggregation and agglomeration of gibbsite particles under synthetic Bayer crystallisation conditions, *Journal of Crystal Growth*, 209(4), 2000, 924–933, [https://doi.org/10.1016/S0022-0248\(99\)00727-7](https://doi.org/10.1016/S0022-0248(99)00727-7).
3. Xiaobin Li, Yuanzhi Long, Study on Production Process of Lithium-containing Alumina, *Mining and Metallurgical Engineering*, 1989, 9(3): 46–50 (in Chinese).
4. Wen-qiang Huang, et al., Effect of lithium ion on seed precipitation from sodium aluminate solution, *Transactions of Nonferrous Metals Society of China*, 2019, 29(6), 1323–1331, [https://doi.org/10.1016/S1003-6326\(19\)65039-9](https://doi.org/10.1016/S1003-6326(19)65039-9).
5. Danqin Wang, Structural evolution of sodium aluminate solution during seed precipitation. Changsha: Central South University, 2012 (in Chinese).
6. E. Robert, et al., Structure and thermodynamics of alkali fluoride-aluminium fluoride-alumina melts, Vapor pressure, solubility, and Raman spectroscopic studies, *The Journal of Physical Chemistry B*, 1997, 101(46): 9447–9457.