FINE ALUMINUM HYDROXIDE PRECIPITATION FROM SODIUM ALUMINATE LEACH LIQUOR

Sıla Meva Elitaş [1]
Batuhan Dikici [1]
Ali Ergüzeloğlu[1]
Bayram Güneş[1]
Hatice Kübra Akben[1]
[1]**Yeditepe University**
Department of Materials Science and Nanotechnology Engineering, Istanbul, 34755 Turkey

Keywords: Alumina trihydrate (ATH); Seeded Precipitation; Bayer liquor; Particle Size

ABSTRACT

Fine alumina trihydrate (ATH) is the primary filler of environmentally acceptable flame retardants, artificial agate, and other products, in addition to being the raw material for alumina-based ceramics and catalyst carriers. This study aims to investigate the fine aluminum trihydrate precipitation process from sodium aluminate Bayer leach liquor by adding industrial aluminum hydroxide as a seed with varying concentrations. Optimum precipitation temperature and time was determined for finer particle size. The morphology and particle size distribution of seeds and precipitated products were examined using scanning electron microscopy (SEM) images and particle size distribution (PSD) analysis.

INTRODUCTION

The most common form of aluminum in nature is bauxite ore, which is a complex mixture of silica, iron oxides, aluminum hydroxides, and other impurities. The well-known Bayer process is the industrially preferred method to produce alumina (Al_2O_3) from bauxite ore [1]. The precipitation stage, in which alumina hydrate crystals (gibbsite, $Al(OH)_3$) crystallize from a supersaturated sodium aluminate solution, is a particularly crucial stage of this process. Three essential phenomena are involved in this precipitation step: agglomeration (aggregation of smaller crystals into larger particles), nucleation (formation of new crystal nuclei), and crystal growth (increase in crystal size) [2]. Several studies have focused on methods to improve gibbsite precipitation's overall productivity and efficiency. Process optimization techniques include modifying operating parameters like temperature, stirring speed, and supersaturation levels are included in these approaches [3]. To increase yield and precipitation efficiency, researchers have also looked into changing the amounts of two important reactants, dissolved alumina and caustic soda (NaOH) [4, 5]. Adding seed crystals to the supersaturated solution is a well-researched and successful method. Both mechanical activation (such as milling or grinding to increase surface area and defect density) and thermal activation (heat treatments that change crystal structure and stability) are particularly common methods for these seeds, which can be chemically inert or activated [6, 7]. The nucleation and development of crystals are accelerated by mechanically activating seeds because it increases their specific surface area, produces more reactive defects, and enhances their catalytic effect on the precipitation kinetics. Due to enhanced wettability and reduced interfacial tension, even small additions of activated seeds (3.1–4.6 g/L) significantly increased precipitation ratios by roughly 3.23–3.92%, according to Xiao-bin et al. [8], who reported notable improvements in precipitation ratios (54.51–56.38%) by introducing mixtures of activated seeds and conventional industrial seeds.

The aim of this study is to thoroughly examine how gibbsite precipitation from sodium aluminate solutions is affected by two distinct active seeds as well as a conventional industrial seed. Using advanced characterization techniques like particle size distribution (PSD) analysis, scanning electron microscopy (SEM) imaging for morphological insights, Brunauer-Emmett-Teller (BET) surface area measurements, and Fourier transform infrared spectroscopy (FTIR) for in-depth chemical and bonding analyses, in-depth analyses are carried out to elucidate the underlying precipitation mechanisms. By using these approaches, the current study aims to increase the efficiency and dependability of the Bayer process by improving fundamental knowledge, offering fresh insights on precipitation mechanisms, and suggesting practical business plans.

Materials and Method

The solution reactor is a 250 cc glass beaker. The experiments were carried out by covering the beaker with aluminum foil. The thermometer was also placed on the lid. IKA C-MAG HS 7 magnetic stirrer with heating system was used. The experiments were carried out by stirring at 210 rpm. In Table 1, B indicates the ATH used to prepare the Bayer liquor and S1 indicates the ATH used as seed.

Table 1. Size and specific areas of seeds.

Seed	Size, Dv_{50} (μm)	Sp. surface area (m^2/g)
B	15.0	1.101
S1	10.8	1.135

ATH seeds was received from Alumina d.o.o. Zvornik. 140 g/L B and 150 g/L NaOH were used while preparing the Bayer liquor. After 100 ml of Bayer liquor was prepared and placed in the reactor, the temperature was adjusted. Then the seed was added and the volume was completed to 250 ml. The precipitation reaction was allowed to develop for the desired time. The slurry was filtered with filter paper (NO 1). The filtered powder was washed until the pH was 7. Thus, the remaining soda was reduced. Finally, the precipitated ATH was dried in the oven at 110 ^{0}C for 24 h.

The effects of time and temperature to precipitation were investigated in the experiments as seen in Table 2.

Table 2. Experiment conditions

Exp.	Temperature (^{0}C)	Time (h)
E1	55	24
E2	55	48
E3	55	60
E4	45	48
E5	65	48

Conclusion

The precipitation temperature was changed between 35-65 ^{0}C. The minimum particle size was reached at 55 ^{0}C. An increase in particle size was observed after 55 ^{0}C. The reason for this is that the low temperatures of 40-55 ^{0}C increased supersaturation and made nucleation effective. 24 h, 48 h, 60 h precipitation times were investigated. At the end of 48 h, an efficient precipitation rate was reached.

Acknowledgements
This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

1. REREFENCES

1. Li, H., Zhang, L., Liu, X., & Chen, Y. (2009). Preparation of a nano-sized α-Al_2O_3 powder from a supersaturated sodium aluminate solution. *Ceramics International*, 35(2), 901–904. https://doi.org/10.1016/j.ceramint.2008.02.010
2. Liu, G., Wang, P., Qi, T., Li, X., Tian, L., Zhou, Q., & Peng, Z. (2014). Variation of soda content in fine alumina trihydrate by seeded precipitation. *Transactions of Nonferrous Metals Society of China*, 24(1), 243–249. https://doi.org/10.1016/S1003-6326(14)63053-3
3. Liu, Z., Chen, W., & Li, W. (2011). Effects of caustic sodium concentration and molecular ratio of Na_2O to Al_2O_3 on agglomeration in the precipitation process. *JOM*, 62(11), 32–34. https://doi.org/10.1007/s11837-011-0127-z
4. Lu, B., Zhang, Y., Chen, Y., & Li, H. (2019). Intensifying gibbsite precipitation from sodium aluminate solution by adding a mixed seed. *Journal of Central South University*, 26(2), 312–322. https://doi.org/10.1007/s11771-019-4041-9
5. Shang, G. Z. (1995). The preparation of high active seeds of aluminum hydroxide. *Light Metals*, 8, 12–14.
6. Yeboah, I., Awuah-Offei, K., Kesse, G. O., & Opoku, F. (2014). A comparative study of the super cooling and carbonization processes of the gibbsitic Ghanaian Bauxite. *International Journal of Engineering Science and Innovative Technology*, 3(6), 76–85.
7. Zeng, J., Yin, Z., & Chen, Q. (2007). Intensification of precipitation of gibbsite from seeded caustic sodium aluminate liquor by seed activation and addition of crown ether. *Hydrometallurgy*, 89(1–2), 107–116. https://doi.org/10.1016/j.hydromet.2007.06.005
8. Zhang, B., Liu, G., Tian, Y., & Wang, X. (2008). Effects of temperature and initial molar ratio of Na_2O to Al_2O_3 on agglomeration of fine $Al(OH)_3$ seed in synthetic Bayer solution. *Journal of Central South University of Technology*, 15(6), 786–790. https://doi.org/10.1007/s11771-008-0122-6