



Continuous changes in electrical conductivity of sodium aluminate solution in seeded precipitation



Gui-hua LIU, Zheng LI, Tian-gui QI, Qiu-sheng ZHOU, Zhi-hong PENG, Xiao-bin LI

School of Metallurgy and Environment, Central South University, Changsha 410083, China

Received 18 January 2015; accepted 29 July 2015

Abstract: The mechanism of seeded precipitation of sodium aluminate solution was studied by measuring the seeded-precipitation rate and electrical conductivity online, as well as calculating the activity and fraction of ion pair. The results show that the electrical conductivity of sodium aluminate slurry linearly decreases with increasing aluminum hydroxide addition. Moreover, both the electrical conductivity of slurry and the difference in electrical conductivity between sodium aluminate solution and slurry remarkably decline in the first 60 min before gradually increasing in the preliminary 10 h and finally reaching almost the same level after 10 h. In low Na_2O concentration solution the activities of NaOH and $\text{NaAl}(\text{OH})_4$ in seeded precipitation are high, which can enlarge the difference in conductivity between slurry and solution. Additionally, more ion pairs exist in solution in preliminary seeded precipitation, and the adsorption of $\text{Na}^+\text{Al}(\text{OH})_4^-$ on seed surface is likely to break the equilibrium of ion pair formation and to decrease the difference in conductivity in preliminary seeded precipitation.

Key words: sodium aluminate solution; seeded precipitation; electrical conductivity; activity coefficient; ion pair

1 Introduction

Seeded precipitation for preparing aluminum hydroxide (AH) is used in alumina refineries, including AH precipitated from pregnant sodium aluminate solution ($\text{Al}(\text{OH})_4^- \rightleftharpoons \text{Al}(\text{OH})_3 + \text{OH}^-$) and coarse AH crystallized by nucleation [1], agglomeration, and growth [2]. The mechanism of seeded precipitation was extensively studied by solubility of AH [3–5], electrical conductivity [6], surface tension [7], viscosity [8], activity [9] in the solution and the structure of aluminate ion. Based on kinetic studies [10], various methods, such as varying the concentration of caustic soda or alumina [11], adding active seed [12] and crystallization additives [13], irradiating with ultrasonic sound [14], and setting up an additional electric field or magnetic field [15] have been used to increase precipitation rate. However, the seeded-precipitation ratio in theory is greater than that in practice in the precipitation time range of 30–55 h. Low seeded-precipitation rate, long precipitation time, and low output of equipment are the disadvantages in alumina refineries for preparing sandy alumina. The main reason lies in the uncertainty of the

mechanism in seeded precipitation with high seed content.

The structure of aluminate ion is the key to understand the mechanism of seeded precipitation. Numerous researchers have studied the structure of aluminate ion in synthetic solution or solution from alumina refinery by filtration or centrifugation [16]. By measuring electrical conductivity, surface tension, viscosity or obtaining ultraviolet spectrum, infrared spectrum, Raman spectrum, or nuclear magnetic resonance (NMR) [17–19], the following conclusions about the aluminate ion structure can be drawn. Firstly, aluminate ion structure varies with the concentration, preparation method and hold time of solution [20–22]. Secondly, tetrahedral $\text{Al}(\text{OH})_4^-$ is the dominant form in sodium aluminate solution, though dimer ion $[\text{Al}_2\text{O}(\text{OH})_6]^{2-}$ and other aluminate ion may exist in concentrated solution [6]. Thirdly, polymer aluminate anion, acting as growth units in precipitation, is aggregated from $\text{Al}(\text{OH})_4^-$ in seeded precipitation [23]. Fourthly, Na^+ , OH^- or H_2O also affect the forms of the aluminate ion because of the formation of ion hydration or ion pair [24,25]. All results suggest that various conversions among aluminate ions extremely affect the

seeded precipitation. However, we often neglect the significant difference in aluminate ion structure in solution and slurry with high content of seed, and pay little attention on the influence of seed on the aluminate structure. Moreover, the changes in structure and mechanism of the preliminary period in seeded precipitation are rarely studied.

In this work, we investigated the influence of AH seed and solution composition on the electrical conductivity of sodium aluminate solution by detecting electrical conductivity online, discussed the variation of electrical conductivity based on the calculation of mean activity coefficient and ion pair, and further explored the mechanism of seeded precipitation. All results will benefit the development of new technology for seeded precipitation.

2 Experimental

2.1 Materials

Sodium aluminate solution was prepared with analytically pure AH and sodium hydroxide (Xilong Chemical Co., Ltd.). AH was added as the seed in precipitation. Seeded precipitation was conducted in an 1.5 L steel-tank which was heated by water bath. The electrical conductivity of solution was measured online by M300 conductivity meter (METTLER TOLEDO, Shanghai, Co., Ltd.).

2.2 Experimental procedures

1 L sodium aluminate solution with $\alpha_k=1.41$ (molar ratio of caustic soda (Na_2O) to alumina (Al_2O_3) in sodium aluminate solution) was added into 1.5 L tank, heated to 55 °C and stirred at 150 r/min. AH was then added according to the seed coefficient $K_f=3.4$ (mass ratio of alumina in seed to alumina in solution). Meanwhile, the online conductivity meter was turned on, and the data were recorded simultaneously. Lastly, the slurry in seeded precipitation was obtained at a given time, and Na_2O and Al_2O_3 concentrations were detected following the separation of solid and solution.

2.3 Methods

Na_2O and Al_2O_3 concentrations in sodium aluminate solution were determined by titration. Afterwards, the seeded-precipitation rate (η) was calculated according to the following equation:

$$\eta = \frac{\alpha_{kt} - \alpha_{k0}}{\alpha_{kt}} \times 100\% \quad (1)$$

where subscripts 0 and t stand for initial time and time t in seeded precipitation, respectively.

The difference in conductivity value ($\Delta\sigma$) in seeded precipitation was obtained by subtracting the electrical

conductivity of the slurry from the electrical conductivity of the solution.

3 Results and discussion

3.1 Electrical conductivity of slurry in seeded precipitation at constant temperature

3.1.1 Influence of AH addition on electrical conductivity of slurry

The strong polarity of AH highly affects the electrical conductivity of sodium aluminate solution, as shown in Fig. 1.

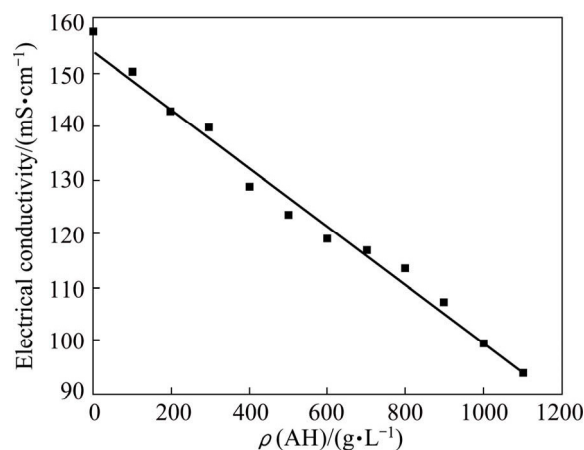


Fig. 1 Influence of AH addition on electrical conductivity of slurry

The test conditions are as follows: $\rho(\text{Na}_2\text{O})=130 \text{ g/L}$; $\alpha_k=1.45$; seeded precipitation temperature 55 °C; stirring speed 150 r/min.

The electrical conductivity (σ) of the slurry linearly decreases with increasing AH concentration in the solution of 130 g/L Na_2O (Fig. 1). The decrease of the electrical conductivity of the slurry can be attributed to the inversely induced-electrical field, resulting from the polar surface of AH. Afterwards, linear equation is obtained:

$$\sigma = -0.054\rho(\text{AH}) + 153.72 \quad (2)$$

where σ is the electrical conductivity, and $\rho(\text{AH})$ is the AH concentration, g/L. The correlation coefficient R^2 is 0.985.

Based on Eq. (2), the influence of AH (seed and AH precipitated from solution) on the electrical conductivity of the slurry can be discussed.

3.1.2 Changes in electrical conductivity in preliminary seeded precipitation

The stability of the sodium aluminate solution is broken after adding seed. However, few researchers have reported changes in electrical conductivity in preliminary seeded precipitation. The electrical conductivity of sodium aluminate solution after adding seed in the first

Download English Version:

<https://daneshyari.com/en/article/1635805>

Download Persian Version:

<https://daneshyari.com/article/1635805>

[Daneshyari.com](https://daneshyari.com)