Hydrogen Bonding Adsorption Principle in Caustic Solution of Aluminium Hydroxide

Meng Ling-li[1] and Zhang Li[2]
1,2. Process Engineers
Zhengzhou Non-ferrous Metals Research Institute of Chalco (ZRI), Zhengzhou, China
Corresponding author: qintian4666@163.com
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Abstract

In this paper, the concept of hydrogen bonding adsorption was investigated for $Al(OH)_3$-NaOH-H_2O-S (solid) system. Aluminium hydroxide transfer between solid and liquid phase by hydrogen bonding adsorption and desorption, only with hydrogen bond breaking or formation of aluminium hydroxide crystal. When the $Al(OH)_3$-NaOH-H_2O-S (solid) system achieves equilibrium, this is due to hydrogen bonding adsorption. Equilibrium equation of the system was obtained, CE = 90 $S^{-0.1}N^{1.5}\cdot exp(-18522.9/(R\cdot T))$. No chemical reaction occurs when aluminium hydroxide dissolves in caustic solution process or crystallises in a seeded precipitation process. In the liquid phase, alumina is in the form of $Al(OH)_3$, rather than $Al(OH)_4^-$. In this concept, supersaturation does not exist in sodium aluminate solution.

Keywords: Bayer process, Solubility, Hydrogen bonding, Phase equilibrium, Seed precipitation.

1. Introduction

Bayer process was born more than one hundred years, The basic principle of Bayer process is established on the Na_2O-Al_2O_3-H_2O system, according to the generally accepted theory, alumina exists in form of $Al(OH)_4^-$ or two poly-aluminate ions in caustic solution. Alumina concentration in caustic solution depends on the solubility, where seeded precipitation process is a chemical reaction, which eventually stops when alumina solubility is reached. However, according to this theory, the super saturation phenomenon is difficult to explain, even it is thought that spent liquid is supersaturated. Researchers have attributed this to the complex structure of $Al(OH)_4^-$ in caustic solution, still there is no reasonable results supporting this up to now.

Researching on the basic principles of the Bayer process is important to the alumina industry, also it is of great significance to improve the quality of the products. In this paper, the principle of hydrogen bonding adsorption was adopted on Al $(OH)_3$-NaOH-H_2O-S (solid) system.

2. Experiment

A series of experiments were conducted to study various aspects of the crystallisation phenomena, such as the effect of temperature, solid concentration and caustic concentration.

2.1 Experimental Materials

Aluminium hydroxide: grade AH-1 GB/T 4294-2010, specific surface area: 0.104 m^2/g. Caustic: chemical pure.

Table 1. Size distribution of aluminium hydroxide.

Size, µm	10	15	20	30	40	50	60	80	120	150	200
%	0.91	3.53	5.80	8.29	11.16	16.69	24.83	44.57	77.91	91.18	99.22

2.2 Experimental Instrument and Analysis

A 5 L stainless steel container was used, with stirring, automatic temperature control of ± 0.1 °C. Laser particle size was analyzed using a Mastersizer 2000 instrument.

2.3 Experimental Operation

2.3.1 The Relationship Between the End Alumina Concentration and Temperature

Sodium aluminate solution 5 L, caustic concentration Na_2O 100 g/L, alumina concentration Al_2O_3 80 g/L, heated to 60 °C. Dried aluminium hydroxide 3 kg was added to the sodium aluminate solution, stirring. After 50 hours, the slurry was separated, analysis alumina concentration, sampling once every 5 hours. Three of difference of alumina concentration is less than 0.5 g/L, that reach the end, three results mean as the end of alumina concentration. Then cooling to 55, 50 and 45 °C, repeated sampling.

2.3.2 Relationship Between the End Alumina Concentration and the Amount of Solid Aluminium Hydroxide

Sodium aluminate solution 5 L, caustic concentration Na_2O 100 g/L, alumina concentration, Al_2O_3 80g/L, temperature 50 °C. Respectively, adding dried aluminium hydroxide 2, 3, 4 and 5 kg. Sampling was the same as described in 2.3.1.

2.3.3 The Relationship between the End Alumina Concentration and Caustic Concentration

Sodium aluminate solution 5 L, caustic concentration Na2O 120, 110, 100, 90 g/L, alumina concentration Al_2O_3 90 g/L, temperature: 50 °C. 3 kg dried aluminium hydroxide was added to the sodium aluminate solution, stirring. Sampling was the same as described in 2.3.1.

3. Results and Discussion

Alumina concentration at the end under the different conditions are shown in Table 2.

Table 2. Alumina concentration at the end under different conditions.

No.	N, g/L	W, g/L	T, °C	C, g/L
1	100	600	60	74.2
2	100	600	55	67.5
3	100	600	50	60.6
4	100	600	45	54.5
5	100	1000	50	57.3
6	100	800	50	58.6
7	100	400	50	62.2
8	120	600	50	79.1
9	110	600	50	69.3
10	90	600	50	51.2

N: caustic (Na_2O) concentration; W: solid content; T: temperature; C: end alumina (Al_2O_3 concentration,

6. Reference

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