

# Study on the sedimentation capability of bauxite flotation concentrate

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**Abstract:** The sedimentation behaviors of bauxite flotation concentrates were investigated at different pH values and flocculant dosages. The effects of three types of flocculants (cationic, anionic and non-ionic polyacrylamide flocculants) as well as the molecular weight of anionic flocculants on the sedimentation of concentrate were studied. It is shown from the experimental results that at the pH 7.0, best sedimentation capability is reached when anionic polyacrylamide flocculant (molecular weight 14 million) is added and the optimal dosage is 30 g/t.

**Key words:** bauxite; concentrate; flocculant; polyacrylamide (PAM)

## 1 Introduction

The flotation-Bayer technology, which was developed specifically for high aluminum and silicon contents diaspora in China, has been applied successfully. Bauxite from Henan Province or other places in China has been processed by Central South University and Zhengzhou Research Institute in laboratory and commercial scale. The concentrate with aluminum to silicon ratio above 11 and alumina recovery of 90 % was recovered from the feed ore with aluminum to silicon ratio around 5.7. Prolonging the exploitation of aluminum for another 60 years, the implication of flotation-Bayer technology made a great contribution to the aluminum industry. A problem, however, is remaining unsolved. In order to realize the perfect liberation of valuable and gangue mineral, the ore must be ground to 85 % passing 200 mesh, which would inevitably bring some problems, namely, the large presence of fines in the concentrate, with the inherent low precipitation rate, produce process water with a high amount of fines, which is unsuitable for the flotation system and because of the low pulp density, the capacity of the filter separator can not be fully utilized and the life-span of filtering medium is compromised, thus the cost is increased considerably. There have been a lot of researches in this field<sup>[1-5]</sup>, which have been a consortium of literatures on the effects of inorganic salt, organic flocculant in the precipitation of the fines, while the effects of organic polymeric flocculant in the process

were rarely studied.

In this paper, the low-grade bauxite flotation concentrate was taken as the subject to study the influences of factors, such as organic polymeric flocculant type, molecular weight on the precipitation of the fines by measuring the height difference before and after the addition of flocculant, thus providing important data for the choice of effective flocculant.

## 2 Material methods

### 2.1 Materials

The flotation concentrate was taken from Jiaxian, Henan Province. The particle size distribution of the sample was determined by a CILAS1180 high resolution size analyzer based on the principle of laser ensemble light scattering. The particle distribution is shown in Table 1.

The chemical composition of the sample was shown in Table 2 while the phase analysis results were shown in Table 3.

**Table 1 Particle size distribution of the bauxite flotation concentrate**

Particle size/mm	+0.15	-0.15 ~ +0.074	-0.074 ~ +0.037	-0.037 ~ +0.02	-0.02
Distribution/%	5.2	18.56	24.36	25.63	26.25

**Table 2 Chemical composition of the concentrate**

Composition	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	MgO
% (Wt)	65.92	6.56	6.22	2.85	0.60	0.097	0.36	0.27

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**Table 3 Phase analysis of minerals in the concentrate**

Phase	Diaspore	Illite	Kaolinite	Hematite	Magnetite	Rutile	Anatase
% (Wt)	73.6	4.8	8.2	3.2	0.6	0.7	2.1

## 2.2 Methods

Sedimentation experiments were performed in a plugged measuring cylinder. Flotation concentrate was regulated to a given pH in a beaker, before being transferred to the flocculant solution of 0.1 %, where the solution was churned up for 3 minutes; the solution was then transferred to the measuring cylinder where it would be added up to 250 mL with water. After fixed interval, the height of the solid-liquid interface was put down. All the water in the experiments was distilled water. The pH value of the solution was measured by the pH meter PHS-3C.

## 2.3 Test apparatus

The equipment and apparatus used in the experiments are as follows: a JB50-D electro-agitator PHS-3C pH meter; a stop watch; beaker; a plugged measuring cylinder (250 mL).

## 2.4 Reagents

The concentrate is alkaline, so the regulator is hydrochloric acid, which is of analytical purity. Cationic, anionic and non-ionic polyacrylamides (PAM) are of chemical purity. The characters of the PAM are shown in Table 4.

**Table 4 Characters of the PAM**

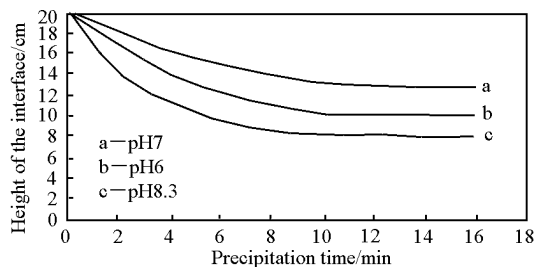
Type of PAM	Function	Molecular weight (million)
Non-ionic	$-\text{NH}_2$	11
Cationic	$-\text{NH}_3^+$ , $-\text{NH}_2^+$ , $-\text{NR}_4^+$	12
Anionic	$-\text{COO}^-$ , $-\text{CONH}_2^-$	5, 12, 14

## 3 Results and discussions

### 3.1 Effect of the pH value on concentrate precipitation

In the bauxite flotation process, as the regulator, the sodium carbonate is added into the cells, so the pH value of slurry is about 9.5, thus the flotation concentrate is alkaline. There are lots of fines in it and the surface charge of these particles is electronegative, the repulsive force among the particles render the concentrate hard to conglomerate and settle down. Fig. 1 shows the effect of pH values on sedimentation property.

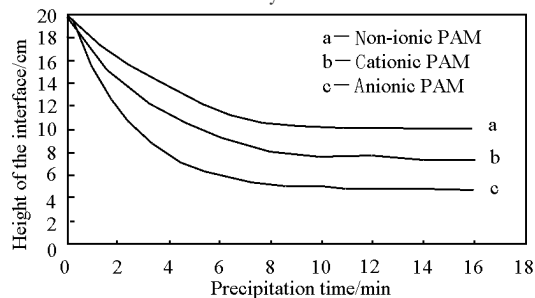
It is seen from Fig. 1 that when the pH value is 8.3, the concentrate is hard to settle down because of the strong repulsive forces among the particles. At pH 6, the interactions among particles get weaker and the particles then unite with water as loose load of suspen-

**Fig. 1 Effect of pH values on the precipitation of bauxite concentrate**

solid, whose density is smaller than the water. The collision and friction among the particles slow it down during its precipitation. The precipitation of concentrate is fairly good when the pH is set at 7.0. It can also be seen from the Fig. 1 that it is impossible to achieve rapid precipitation of concentrate only by adjusting pH value and more work needs to be done to study the effects of flocculants at the proper pH value.

### 3.2 Effect of PAM types

The effects of PAM types, namely, cationic, anionic and non-ionic PAM with molecular weight among 11 ~ 12 million on the precipitation of bauxite flotation concentrate were studied. From Fig. 2, where the pH value is set at 7.0 and the same flocculants dosage is administered to the flotation to study the effects of different PAMs on the concentrate sedimentation capability, it can be seen that the influence sequence of the three types of flocculants is as follows: anionic PAM > cationic PAM > non-ionic PAM, so anionic PAM is chosen to continue the study.

**Fig. 2 Effect of three PAM on sedimentation**

### 3.3 Effect of anionic PAM with different molecular weights

The influence of anionic PAM with different molecular weights which are 5 million, 12 million and 14 million respectively were studied. with the same dosage, the precipitation performance of anionic PAM with higher molecular weight (14 million) is better than those of anionic PAM with lower molecular weight (12 million, 5 million), which is easily interpreted from Fig. 3.

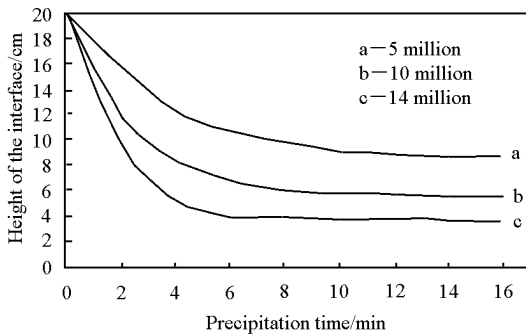


Fig. 3 Effects of molecular weights on bauxite concentrate precipitation

### 3.4 Effect of dosage

Anionic PAM with the molecular weight of 14 million was chosen to study the effect of dosage on sedimentation. From the Fig. 4, It can be seen that with dosage increasing, the time for complete precipitation of concentrate becomes increasingly shorter. Only 4 minutes are needed to settle down the concentrate when the dosage is increased to 30 g/t or 50 g/t. 30 g/t was chosen because of economical consideration.

### 3.5 Mechanism study

From the Table 3, the phase of the flotation concentrate, 73.6 % is diaspore, 8.2 % is kaolinite. The crystal structure of diaspore consists of

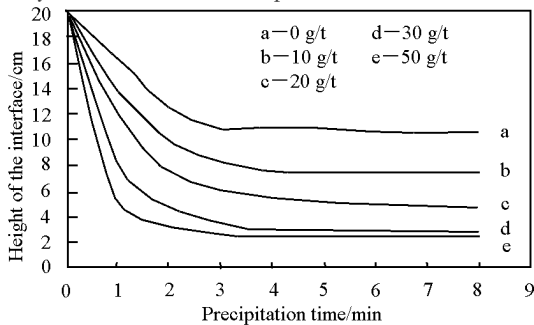


Fig. 4 Effect of dosage on sedimentation of bauxite concentrate

hexagonal close-packed oxygen sheets with aluminum atoms filling two-thirds of the octahedral interstice sites. Each occupied octahedron shares four edges with adjacent aluminum octahedrons, forming double chains in the C axis direction. These units are joined together by sharing the apical oxygen atoms. Diaspore breaks along (010) crystal planes where the binding is the weakest during grinding. Comminution destroys ionic/covalent Al—O bonds, resulting in a surface of unsaturated or ionic nature.

Kaolinite is layer-structured aluminosilicate mineral, which shows a platy habit. The unit layers are held together by a variety of inter-layer forces, including

van der Waals force, hydrogen bonding force and/or ionic binding forces. Two layers of kaolinite are covalently bound together through common oxygen atoms, forming a layer-structured repeating unit. During grinding, the minerals are cleaved mainly in the parallel layer directions by overcoming the inter-layer forces.

Different PAM acts with the minerals by different modes<sup>[6]</sup>. To anionic PAM,  $-\text{COO}^-$  acts with the minerals by chemical adsorption, to cationic PAM,  $-\text{NH}_3^+$ ,  $-\text{NH}_2^+$  or  $-\text{NR}_4^+$  act by electrostatic adsorption, while to non-ionic, PAM action modes is physical adsorption relatively, sedimentation capability is best when anionic PAM is appended.

## 4 Conclusions

The pH value is very important in the precipitation of fine bauxite concentrate. pH value, whether it is too high or too low, is not beneficial to the sedimentations of fines and better results are obtained at pH value around 7.

Of the organic polymeric flocculants used in the experiments, the precipitation performance of anionic flocculant is better than non-ionic and cationic flocculants. Anionic flocculant with larger molecular weight show better precipitation ability on the concentrate. With the consideration of economical aspects, 30 g/t is the optical dosage.

The action mechanism is studied, it is concluded that the interactions of anionic flocculant and bauxite concentrate are mainly chemical adsorption and hydrogen bonding, while the interactions of cationic and non-ionic flocculant and concentrate particle are mainly electrostatic adsorption and chemical adsorption respectively.

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