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EFFECT OF CRYSTAL GROWTH MODIFIER ON THE STRUCTURE OF SODIUM ALUMINATE LIQUORS ANALYZED BY RAMAN SPECTROSCOPY

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Abstract

It has been proved that crystal growth modifier (CGM) can improve particle size distribution (PSD) and the alumina production. However, few researches were reported on whether CGM has an effect on the structure of sodium aluminate liquors. In order to provide fundamental guidance to the application of CGM to seed precipitation, the effect of CGM on the structure of synthesized sodium aluminate liquors was studied. It is shown that there is no new characteristic peak and obvious shift in the Raman spectrum of the liquors after adding a certain amount of CGM. By constructing a comparison function and using calculation function of the software of Raman spectrometer, it is found that CGM might have micro effect on the structure of sodium aluminate liquors via changing the concentration of principal ion $Al(OH)_4^-$ in the liquors.

Introduction

In order to intensify the seeded precipitation in sodium aluminate liquors and improve the quality of alumina products, all kinds of intensifying methods are widely investigated. In which CGM has been proved to be able to improve PSD and the alumina production (1-2). It has been widely applied in the alumina refinery of the world. In order to provide guidance to the application of CGM and develop better CGM, some fundamental researches have to be done to find out whether CGM has an effect on the structure of sodium aluminate liquors.

Some researchers studied the effect of the organics on the structure of sodium aluminate liquors. It is found that the organics with adjacent hydroxyl groups have strong inhibition effects on the seeded precipitation process in sodium aluminate liquors. It is thought that the active hydroxyl groups of the organics might be ionized in the Bayer liquors and form molecular compounds with growth units of gibbsite. The difficulty in forming those molecular compounds on the growth units determines the inhabitation ability of the organics (3). Haiyan Yu et al. (4) investigated the effect of long fatty acid organic - PS floating collector on the infrared spectrum of sodium aluminate liquors. Her results showed that the Al-O-Al bond increases while the $Al(OH)_4^-$ bond is constant with the increasing of the amount of collector PS. The peak of Al-O-Al vibration and Al-OH antisymmetric vibration is strengthened much more in the solution of α_k=1.56 and ρ_{Na2O}=160 g/L than in the solution of α_k=3.0 and ρ_{Na2O}=220 g/L. But there is no report on the effect of CGM additives on the structure of sodium aluminate liquors.

Experimental

Experimental regents

CGM Nalco 7837-1;
Synthesized sodium aluminate liquors #1: C_{Na2O} (caustic alkali) = 224 g/L, α_k (molecular ratio of Na_2O to Al_2O_3) =2.92;
Synthesized sodium aluminate solutions #2: C_{Na2O} = 222 g/L, α_k =3.35;

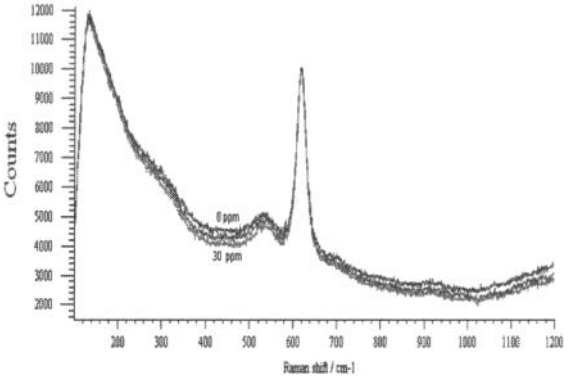
Experimental method

1.0 liter synthesized sodium aluminate liquors are put into a polytetrafluoroethylene beaker, and certain dosage CGM of Nalco 7837-1 is added at a stirring rate of 300 rpm/min^{-1}. After stirring for 30 minutes, some solutions are taken out as sample for Raman spectrum analysis. The blank sample is prepared at the same time.

Results and discussion

Construction of a comparison function

The Raman spectrum of sodium aluminate liquors #1 with different CGM dosage was shown in Fig.1. Two characteristic peaks were shown in the Raman spectrum of sodium aluminate liquors #1. One is in the wave number of 620 cm^{-1}, which represents the principle ions of $Al(OH)_4^-$. The other is in the wave number of 535 cm^{-1}, which represents di-polymer ion of $[Al_2O(OH)_6]^{2-}$. There is no new characteristic peak or obvious shift in the Raman spectrum of the liquors with CGM addition of 15ppm or 30 ppm. It illustrated that the addition of CGM has no macro-effect on the structure of sodium aluminate solutions.



The solution used is sodium aluminate liquors #1 with C_{Na2O}=224 g/L and α_k =2.92; The curves from top to bottom are the blank, the liquors with 15 ppm CGM addition, and the liquors with 30 ppm CGM addition

Fig. 1 the Raman spectrum of sodium aluminate liquors #1 with different CGM dosage

To investigate whether CGM has micro effect on the synthesized sodium aluminate liquors, a comparison function is constructed

and the calculation function of the Raman spectrometer software is used to analyze the Raman spectrum. The method to construct a comparison function is described as follows:

$$y=f(x)-cg(x) \quad (1)$$

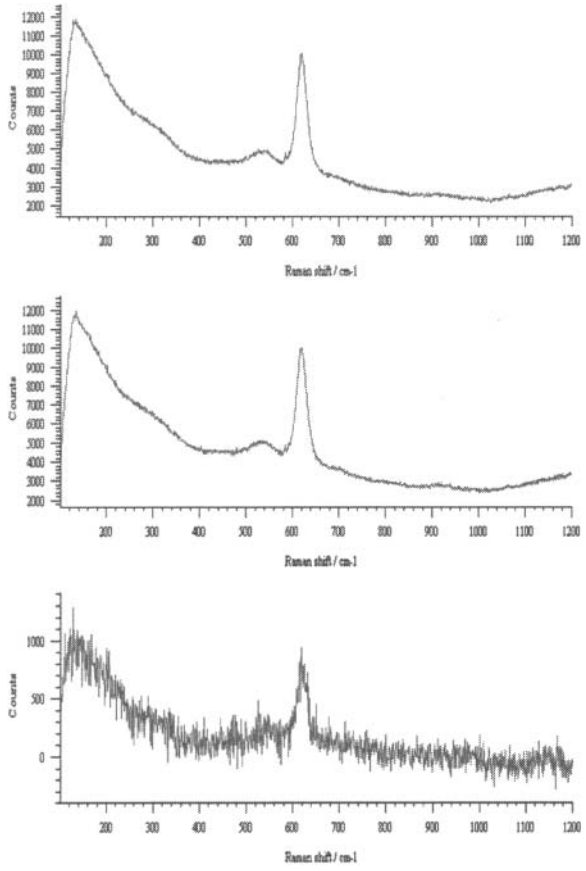
where, f(x) is the Raman spectrum of sodium aluminate liquors with a certain dosage of CGM; g(x) is the Raman spectrum of blank sodium aluminate liquors; C is a comparison efficient of the peak intensity of internal substance sliders at 920 cm^{-1}, which is the ratio of that of f(x) to g(x).

More than three parallel experiments are carried out to check the validity of the Raman spectrum. Once the Raman spectrum is obtained, the comparison function of y is then calculated.

If the comparison function of y was a horizontal line in the area of characteristic peaks of sodium aluminate liquors, CGM had no effect on the structure of sodium aluminate liquors. Otherwise, CGM had some effects on the structure of sodium aluminate liquors.

Effect of CGM on the structure of synthesized sodium aluminate liquors

Effects of CGM with the dosage of 15ppm and 30 ppm on the structure of sodium aluminate liquors #1 are shown in Fig.2 and Fig.3.

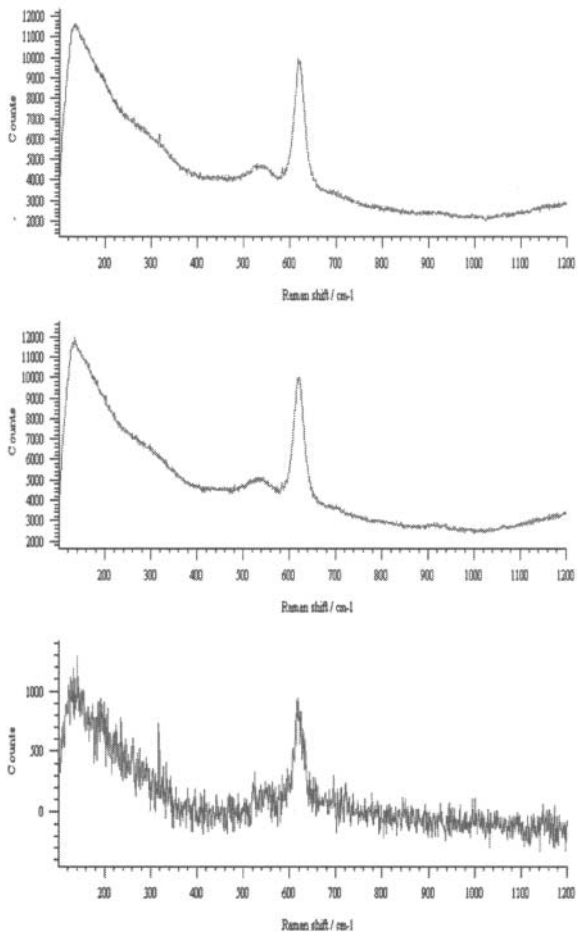


The curves from top to bottom: the liquors with 15 ppm CGM, the blank, the comparison function of y.

Fig. 2 Effect of CGM with the dosage of 15 ppm on the structure of sodium aluminate liquors #1

It can be seen from Fig.2 that the comparison function of y is not a horizontal line in the area of characteristic peaks of sodium aluminate liquors. It appears a peak in the wave number of 620 cm^{-1}, and its intensity is not as strong as the blank. It illustrates that the addition of 15 ppm CGM slightly increases the amount of principal ion of $Al(OH)_4^-$ in synthesized sodium aluminate liquors, thus has a micro effect on the structure of the liquors.

Fig. 3 also shows a micro peak in the wave number of 620 cm^{-1}, similar to Fig.2, which means that CGM with 30ppm dosage also has a micro effect on the structure of sodium aluminate liquors.



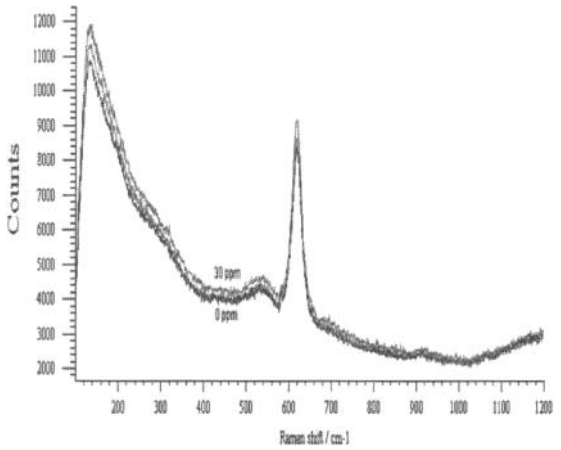
The curves from top to bottom: the liquors with 30 ppm CGM, the blank, the comparison function of y.

Fig. 3 Effect of CGM with the dosage of 30 ppm on the structure of sodium aluminate liquors #1

The effect of the dosage of CGM on the Raman spectrum of sodium aluminate liquors #2 is shown in Fig.4. Similarly, there is no new characteristic peak and obvious shift observed in the

Raman spectrum of the liquors after adding 15ppm or 30 ppm CGM.

Same method and procedure are utilized to study the effect of CGM with the addition of 15 ppm or 30 ppm on the Raman spectrum of sodium aluminate liquors #2, the related comparison function of y is shown in Fig.5 and Fig.6 respectively. It shows that the principal ion of $Al(OH)_4^-$ in sodium aluminate liquors #2 also slightly increases after adding certain amount of CGM for the comparison function of y, which means the addition of CGM also has micro effect on the structure of sodium aluminate liquors #2.



The sodium aluminate liquors #2: N_k 222 g/L and α_k 3.35; The curves from top to bottom: the liquors with 30 ppm CGM, the liquors with 15 ppm CGM, the blank.

Fig. 4 Effect of the dosage of CGM on the Raman spectrum of the sodium aluminate liquors #2

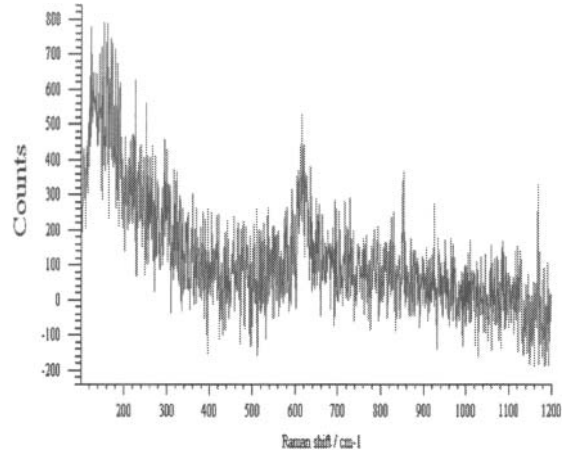


Fig. 5 Effect of 15 ppm CGM on the structure of sodium aluminate liquors #2

According to the reference (5), the seeded precipitation process of sodium aluminate liquors might be as follows:

$$Al(OH)_4^- \rightarrow Al_2O(OH)_6^{2-} ..... \rightarrow Al(OH)_3$$

To certain sodium aluminate liquors, the total aluminate content is constant. Since CGM of Nalco 7837-1 makes the principal ion $Al(OH)_4^-$ increase, it might decrease aluminate polymer ions and inhibit the transferring rate of principal ion of $Al(OH)_4^-$ to the growth units. Thus CGM Nalco 7837-1 might not improve the yield of sodium aluminate liquors, which has also been proved by the industrial application that CGM of 7837-1 could improve the PSD of gibbsite products, but could not improve the yield of the liquors. It might be inferred that, among the organics which decreases the concentration of principal ion $Al(OH)_4^-$ of sodium aluminate liquors, a new kind of CGM improving the yield of the liquors might be developed.

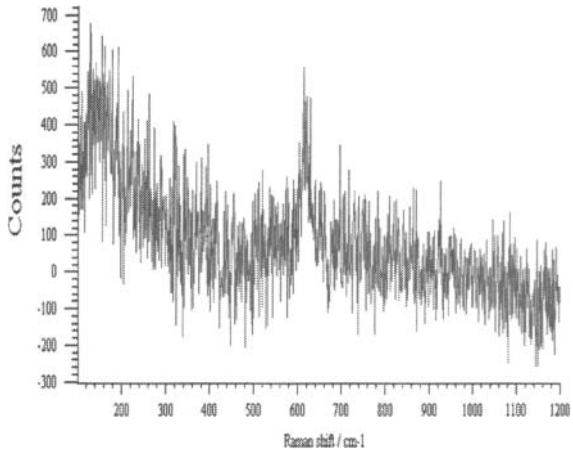


Fig. 6 Effect of 30 ppm CGM on the structure of sodium aluminate liquors #2

Conclusion

1) There is no new characteristic peak and obvious shift in the Raman spectrum of synthesized sodium aluminate liquors after adding a certain amount of CGM Nalco 7837-1.
2) By constructing a comparison function and using calculation function of the software of Raman spectrometer, it is found that CGM of Nalco 7837-1 might have micro effect on the structure of the liquors via changing the concentration of principal ion $Al(OH)_4^-$ in the the liquors.
3) Among the organics which decreases the concentration of principal ion $Al(OH)_4^-$ of sodium aluminate liquors, a new kind of CGM improving the yield of the liquors might be developed.

Acknowledgement

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