Formation study and influence of tricalcium aluminate (TCA) on the polishing process of green liquor

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Abstract

Tricalcium aluminate hexahydrate (TCA) is a compound used in the Bayer process, in the step of green liquor polishing whose function is to act as a filter aid. It is obtained by reaction of the slaked lime which is added to the Bayer liquor. This liquor could be green, spent or refiltered. The paper aims at consolidating knowledge about the TCA, studying its formation mechanism, using different liquors (as described above) and comparing products to indicate which ones is the best to use in the polishing step. Additional studies such as characterization and morphology of formed products with the aid of electron microscopy (SEM) and X-ray diffraction (XRD) were important to reveal by the microstructure of formed calcium compounds, the influence of caustic concentration on the quality of TCA formed. The paper indicates that the green liquor is more appropriate to be used because it presents a higher concentration of alumina and temperature when compared to the spent liquor.

Keywords: Tricalcium aluminate hexahydrate; Bayer liquor; X-ray diffraction; electron microscopy.

1. Introduction

TCA, whose chemical composition is $Ca_3Al_3(OH)_{12}$, is used in the Bayer Process as a filter aid, in the step of green liquor polishing, before the crystallization process. Its function is to help retain the solid impurities present in this liquor, by increasing the filtration efficiency due to minimization of the filter cake resistance [1]. As this material is considered an aid, particle morphology and size distribution of those have great importance on the efficiency of that compound in the polishing process.

One of the main steps in the process of obtaining alumina is polishing or clarification of the green liquor (solution containing high concentration of dissolved aluminum hydroxide, resulting in alkaline lixiviation of bauxite in the Bayer process), it is at this stage that retains the unwanted solid particles contained liquor (red mud), before crystallisation of the aluminum hydroxide.

The clarification process of liquor is done using vertical filters under pressure with the help of tricalcium aluminate - TCA prepared in a previous step for polishing, a reaction between sodium aluminate contained in spent liquor (solution containing low concentration dissolved aluminum hydroxide) and slaked lime [$Ca(OH)_2$]. The resulting product of reaction is a suspension whose size distribution and shape of the particles should meet the requirements of filtration efficiency and quality of the filtrate [2].

Among the variables that influence the characteristics of tricalcium aluminate it is important to note the temperature, the addition of reagents (source of calcium, concentrations), the presence of impurities, the stirrer speed and reaction time, which are decisive for which quality of TCA formed in the Bayer process [1, 3, 4].

In some refineries, the tricalcium aluminate is prepared with spent liquor whose concentration of dissolved aluminum hydroxide and temperature are smaller than the green and refiltered liquors whose raw materials which are most indicated for obtaining TCA. Therefore, it is necessary to get a better knowledge of the material obtained by reaction of spent liquor with slaked lime. Moreover, it is important to know information about TCA prepared with the green and refiltered liquors and its influence on clarification process by comparing which the two liquors is most recommended in the preparation of tricalcium aluminate, in order to optimize this process.

2. Objectives

The objective of this paper is to study and compare the formation mechanism of the TCA obtained from the spent liquor, green and refiltered, in order to get specific knowledge of these products. Moreover, also aims to study the parameters of influence in the preparation of TCA and characterize the products.

2. Methodology

Tests were performed in order to simulate in the laboratory the preparation of TCA, using the same conditions used in the industry, using for this purpose, slaked lime and spent, green and refiltered liquors, from staging area tricalcium aluminate in order to compare the obtained product, characterized by the particle size distribution analysis, XRD, SEM and EDX.

The formation study of TCA, using different liquors as raw material, occurred in two different steps as below.

3.1. Preparation of TCA using spent, green and re-filtered liquors

The sample preparation was performed in the laboratory, similar to the process conditions, and the lime suspension (slaked lime) and liquors (spent, green and refiltered) were coming from the industrial area of preparation of TCA.

To simulate the process of preparing was used an oven with rotary device to simulate the shaking (single speed), with digital temperature control, according to Figure 1.

Figure 1. Equipment used in the process of preparation of TCA in the laboratory. Source: Hydro Alunorte, 2013.

Considering the useful volume of 125 mL of the bottles used in the tests and conditions for adjustment volumetric of process, the following volumes were established for the tested

5. Conclusions

The study showed that the use of spent liquor to the formation of tricalcium aluminate, is connected the formation of multiple parallel compounds, which interfere directly in the TCA properties. Moreover, it was noted throughout the study that the use of green liquor to the preparation of TCA is most appropriate, because it presents a higher concentration of dissolved aluminate, which favors the formation of tricalcium aluminate disadvantaging calcium reaction with other possible existing elements in Bayer liquor (impurities).

It was also observed that the difference of the structure of TCA formed from the spent, green and refiltered liquor may be related to the precipitation of aluminum hydroxide from sodium aluminate, who suffers direct influence of temperature.

It is evident the influence of impurities such as Na_2CO_3 (carbonates), in the reactions with CaO (calcium oxide) to form structures with different particle size and morphology expected to tricalcium aluminate. The temperature of the liquor at the moment of formation of TCA could directly affect the appearance of unwanted structures, because there is a strong precipitation of compounds that should be dissolved, especially in spent liquor.

6. References

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