AA18 - Improving Whiteness of Alumina Trihydrate through Reduction in Colored Organics in Bayer Liquor

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Abstract

Conventionally Bayer process is used to produce alumina trihydrate (ATH) from bauxite ore involving caustic digestion at elevated temperature and pressure. During dissolution, a good portion of organics degrade resulting in the formation of different organic compounds, viz: oxalate, organics precipitable by evaporation and other organics.

Organics in Bayer process liquor are generally present in the following proportions: 25% as humics, 9% as hxalate, 21% as huilding block organics (aromatics) and 45% as aliphatics (acetate, formate, etc.).

Humics are the major color causing organics which impart a dull color to the alumina trihydrate. This is especially important for chemical grade manufacturers wherein alumina trihydrate is sold as product for cable applications, solid surface and other applications.

Bauxite source has a major impact on the dissolution of humic substances. For instance, the bauxites processed from the Western and Eastern Ghat regions of India have relatively low conversion of organic in liquor as compared to imported sources of bauxite which have almost double the organic conversion. Also considering the non-availability of high-grade bauxites in India, there is a growing need for using imported sources of bauxite for achieving the desired plant efficiencies and consumption factors. However, this tends to have a negative impact on the liquor quality, especially w.r.t organic carbon content as well as humic substances having a major impact on the alumina trihydrate quality.

Although there are different processes available for the reduction of the color causing impurities from the Bayer liquor, the present studies depict the cost-effective process for improving the color properties of alumina trihydrate.

This paper presents a detailed study, conducted with the use of humic removal aids and its effect on the color properties of the products.

KeyWords: Bauxite, Bayer process, brightness, color, humate, hydrate, organics.

1. Introduction

Most of the organic impurities present in the Bayer circuit come from bauxite during digestion. A certain fraction comes from additives such as synthetic flocculants, dewatering aids, antifoaming agents and crystal growth modifiers. These compounds are often added to the system to improve process performance. Most of the organics end up in the process as sodium oxalate or carbonate, which are the major degradation products. Some of the organics leave the system by adsorbing onto the bauxite residue or the alumina trihydrate as it precipitates. A certain portion remains which degrades slowly and accumulates within the circuit until an equilibrium concentration is reached.

These organics have a detrimental effect on the Bayer process in general. Some of the organic species have known to directly interfere with the nucleation, agglomeration and crystal growth rate of alumina trihydrate during precipitation. This reduces the precipitation yields substantially. Certain organics are also responsible for changing the morphology of the solid and increasing soda incorporation, thereby lowering the quality of the end product. In terms of cost, the loss of caustic due to formation of sodium organic compounds such as sodium oxalate or carbonate is significant.

The impact of organics is particularly significant in older plants wherein the organic carbon content is saturated over years and this affects the overall process control in the refinery. Even though metallurgical grade alumina manufacturers can still run with higher organic carbon content in liquor without major impact on product quality, the chemical grade alumina manufacturers face issues w.r.t higher soda content, fineness and lower brightness / whiteness, which are the major customer requirements for high end speciality applications.

Hence there is a need to lower the organic carbon content in the liquor to improve the plant efficiency as well as the product quality. Even though there are several methods for reducing the organic carbon content such as use of liquor burning, sintering of bauxite etc., these are highly cost intensive and hence use of additives has emerged as a viable solution. Various additives such as humate removal aids are being developed for reducing the humate content in liquor which has an adverse impact on the product whiteness and brightness.

This paper discusses about the application of humate removal aids for reducing the organic carbon content in liquor thereby improving the whiteness of hydrate.

2. Conceptual Approach

The major organic compounds present in Bayer liquor are classified into three categories, which are based on their molecular weight distributions. The first fraction is referred to as “humic matter” and includes all of the high molecular weight material having molecular weights in excess of 500. The second fraction is referred to as “building block organics “. The last fraction represents the low molecular weight degradation products.

Essentially approximately 50 % of the total organic carbon in Bayer liquor is present as low molecular weight organic acids. The other 50 % is evenly distributed between the humic matter (25 %) and the “building block” organics (25 %). Humic matter has a major impact on the liquor quality and thereby on the end product quality especially w.r.t whiteness / brightness. Hence a development work was initiated for understanding the impact of additives such as humate removal aids on the humate reduction in liquor and resulting impact on product quality.

3. Development of Humate Removal Aid

The process for development of humate removal aid involved the following steps

- **Literature Survey:** Study on origin of humates, its classification, effect on hydrate color & methods of reduction were evaluated in detail.

- **Data Analysis:** The organic carbon profile in liquor across the refinery was analysed to understand the extent of organic carbon input from the liquor. Also, the data on hydrate whiteness/ brightness was analysed.

Various bauxite sources were analysed for Total Organic Carbon (TOCA) and cyclic organic load tests were conducted to determine the extent of organic carbon conversion into liquor and also the oxalate conversion. This data helped in understanding the overall impact of organic carbon on the Bayer liquor.

- **Humate removal Aid:** Humate removal aid samples were sourced from various speciality chemicals manufacturers for evaluation.

- **Humate Removal Aid Testing:** The test plan involved the following major steps of analyzing the absorbance of liquor at 690 nm wavelength at spectrophotometer, before and after addition of the humate removal aid chemical. Also, the whiteness of product hydrate before and after chemical addition.

- **Dosage Optimization:** Various tests were conducted with the humate removal aid samples and the dosage was optimized, based on the reduction in organic carbon content in liquor and the improvement in brightness of hydrate.

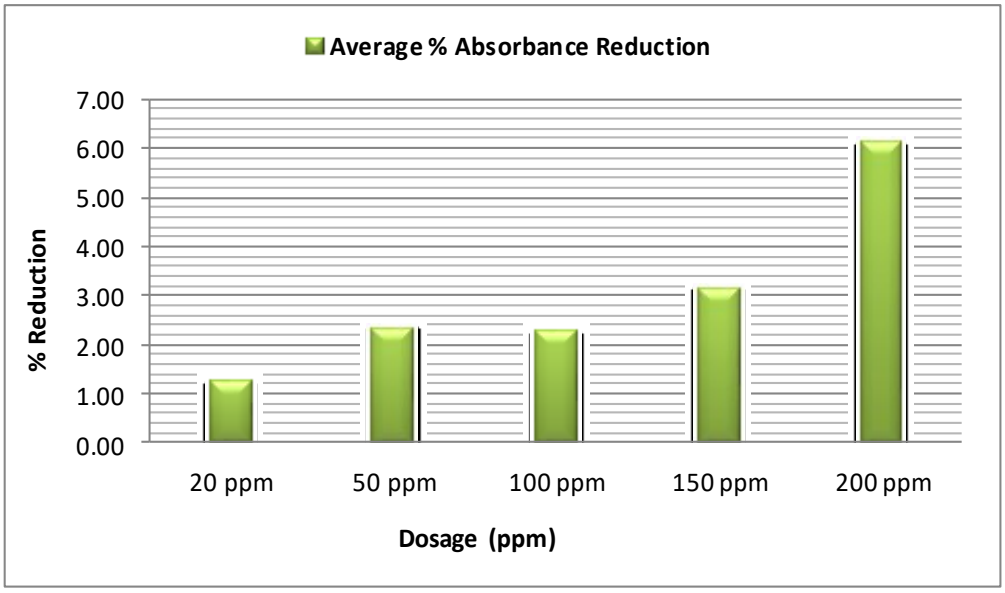

Figure 1. Dosage optimization based on absorbance reduction.

From the above figure it is observed that, the maximum absorbance reduction is obtained at 150-200 ppm dosage.

- **Precipitation Tests**

The process followed for precipitation tests for studying the impact of humate removal aid on hydrate whiteness / brightness is given below.

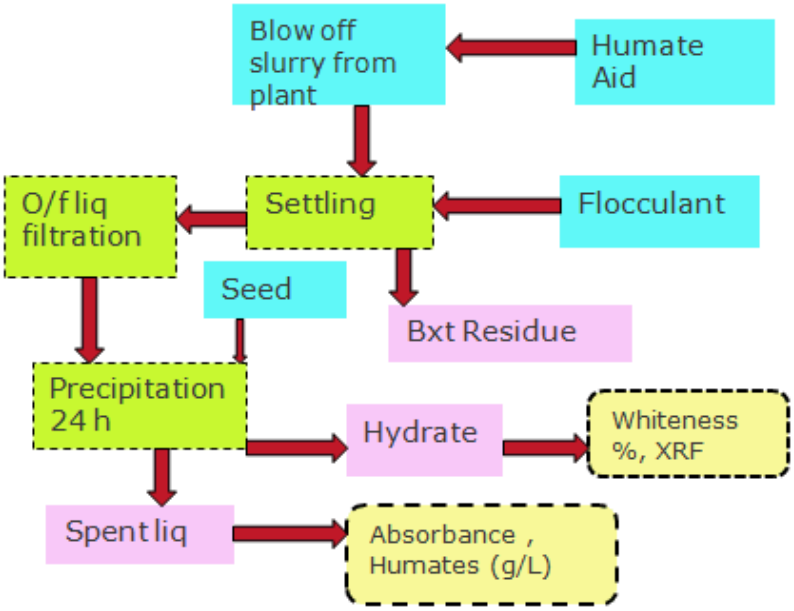

Figure 2. Flow diagram for precipitation laboratory trials.

The humate removal aid chemical was added in blow -off slurry and liquor after residue separation, was used for hydrate precipitation. Hydrate was analysed for Whiteness and the spent liquor was analysed for % Absorbance and humates (g/L). Results are presented in Table below.

Table 1. Results of laboratory tests.

Humate Aid	Decrease in Humate content	Increase in Whiteness
	%	
HA-1	12.5	10.1
HA-2	10.4	9.9

From the above table, it is observed that there is ~ 10-12% reduction in humate concentration with both the chemicals. This is also in line with the reduction in absorbance, as theory shows that reduction in absorbance corresponds to reduction in humates. ~ 10% improvement could also be seen in hydrate whiteness as a resultant impact of the reduction in humates, over 3-4 cycles.

Overall, it was observed that ~10-12% of humate concentration can be reduced in laboratory with both the humate removal aid chemicals, with HA-1 giving slightly higher reduction.

- **Plant Scale Evaluation:**

Based on the encouraging results obtained in the laboratory for evaluation of Humate removal aid chemicals, a plant scale evaluation of HA-1 was planned. The trial was conducted for a period of 50 days with different dosage ranges viz. 5 ppm, 10 ppm, 20 ppm and 25 ppm. During the trial period, analysis of Pregnant Liquor and Spent liquor absorbance was done along with fortnightly analysis of TOCA in liquors along with hydrate whiteness / brightness. The results of the trial are presented below.

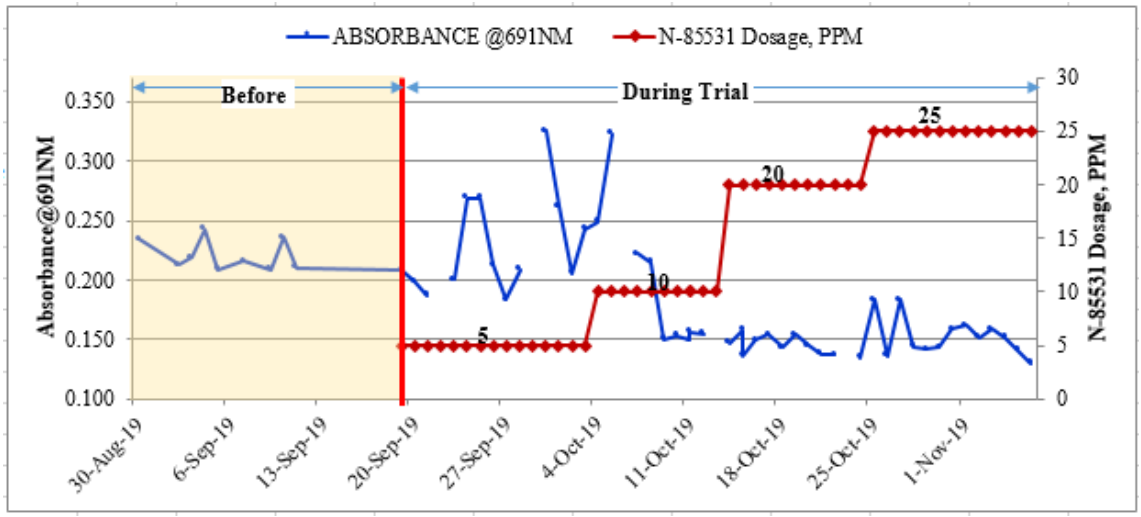

Figure 3. Data on absorbance reduction during plant trial.

From above graph it is observed that there is a substantial impact on the absorbance reading at 25 PPM chemical HA-1 dosage, where absorbance reading has come down to 0.130 units against pretrial value of 0.221.

Table 2. Results of Humate Removal Aid Plant Trial.

TOC reduction	9.88	%
Whiteness improvement	25.6	
Brightness improvement	9.21	

Thus, from the above table, it is observed that there is a substantial improvement in the Whiteness and Brightness of hydrate in comparison to pretrial period. The plant scale improvement is closely matching with the results of laboratory trial.

The reduction in TOC and the improvement in the hydrate whiteness and brightness was also visible in figure below.

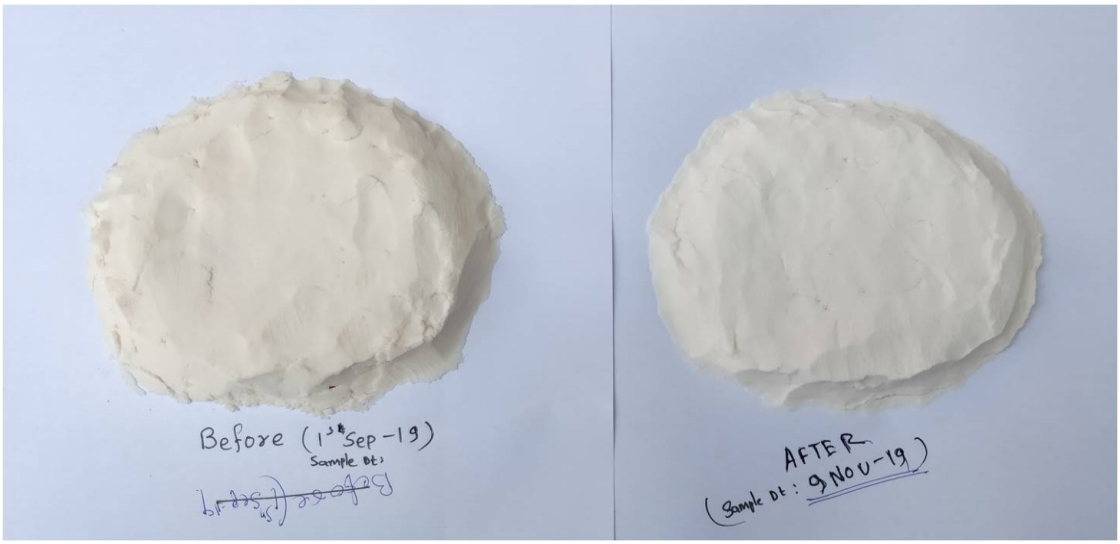

Figure 4. Hydrate whiteness before and after trial.

From Figure 4 it is clearly observed that the hydrate sample is visually whiter than the pretrial hydrate sample.

Thus, from the above laboratory and plant scale evaluation, it can be concluded that the humate removal aids can be successfully applied to Bayer liquor for reducing the Total Organic Carbon content thereby leading to substantial improvement in brightness / whiteness of hydrate.

4. Discussion

This paper presents the application of humate removal aids to Bayer liquor for reducing the Total Organic Carbon content with a view to improve the brightness / whiteness of alumina trihydrate.

The source and distribution of the organics in Bayer liquor is discussed. Normally the major source is bauxite along with a marginal amount from speciality chemicals used in the alumina refinery. Out of the total organics present in the Bayer liquor, the color causing organics or humates account for ~ 25 %. However, the impact of these organics on the Bayer liquor quality as well as that of the end product is significant. This is especially important for chemical grade alumina manufacturers, where hydrate whiteness / brightness is a major requirement from customers.

Even though there are various methods for reducing the organic content in liquor per say, these methods are tedious and not economically viable. However, in the recent years, use of chemicals such as humate removal aids has gained importance owing to its ease of application.

Various trials were conducted with humate removal aid chemicals received from suppliers and the impact on TOC reduction and hydrate whiteness was noted. The lab trials with HA-1 chemical were successful and yielded good results. There was a reduction in humate content in Bayer liquor by ~ 10-12 % with an improvement in hydrate whiteness by ~ 10 %.

The findings from the successful laboratory trials were translated into plant scale evaluation of HA-1, which also yielded similar results. In fact, the hydrate produced from the trial was visually whiter than the pretrial hydrate sample.

Thus, from the above laboratory and plant scale evaluation, it can be concluded that the humate removal aids can be successfully applied to Bayer liquor for reducing the Total Organic Carbon content thereby leading to substantial improvement in brightness / whiteness of hydrate.

5. References

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