Assessment of Chemical Additives Impact on Alumina Refinery Processes

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Abstract

Introduction of new chemical additives into the Bayer circuit or the replacement of an existing one is required from time to time to support security of supply, cost reduction, better performance, or to align with new technologies. If the steps taken to select a new product are not carefully considered, introduction of these additives could change the liquor characteristics and result in adverse effects on particle sizing, oxalate control, settling, and/or filtration. To mitigate this, Al Taweelah alumina refinery has developed a comprehensive poisoning test methodology to screen and qualify chemical additives prior to field trials and permanent use. This methodology looks at the refinery as a whole, and not the area of use in isolation. Additives are evaluated in the lab for their impacts on agglomeration, growth, and settler/washer circuit, aiming to identify potential changes in nucleation, agglomeration, oxalate imbalance or settling and filtration. This paper provides a comprehensive evaluation of the results obtained from laboratory tests, offering insights into the importance of a careful evaluation before experimenting new chemicals in the plant. The findings have significant implications for alumina refinery operations.

Keywords: Bayer chemical additives, Poisoning test, Nucleation, Agglomeration, Oxalate control.

1. Introduction

Al Taweelah alumina refinery was commissioned in March 2019 and has now significantly exceeded nameplate capacity with continual improvements in different areas. To support the fast growth, some chemical additives were introduced to the process, and others were required to be replaced with the change in the liquor properties.

In 2022, after starting a field trial of a filtration aid, there was an observed nucleation spike in the precipitation circuit a few days later, that exhibited a different behavior from normal, including a change in the oxalate balance. It is always difficult to establish causality in cases like this, since many other factors can affect nucleation and oxalate stability [1], but a more comprehensive problem solving was performed, and the filtration aid additive was disqualified for use.

Another important event occurred in the Clarification circuit, where the introduction of a bauxite handling aid was followed by a disturbance in the slurry settling, leading to a significant production loss. Laboratory tests were conducted, concluding that the high temperature in digestion did not degrade or inactivate the chemical, allowing it to hinder settling behavior and result in the detrimental effect in the clarifiers.

Even in a well-established refinery, the replacement of an additive or the introduction of a new one can be required from time to time to support supply security, reduce cost, improve performance, or align with new technologies. For this reason, there is a constant drive for lab testing and field trials. The qualification of these products for use is complex since the chemistry is not fully known and the implications of these products in the Bayer process are not always explored by the suppliers. In addition to that, the variety of products for the same application has increased over the years, and new developments are constantly in progress.

In general, any substance added to the Bayer process has potential to be harmful, and sometimes, due to the continuous change of the process, negative effects could be linked to a normal process variability [2]. A poisoned liquor can compromise yield, affect nucleation in precipitation, stabilize or destabilize the oxalate balance, or lead to flow reductions due to settling or filtration issues. Some studies have already explored the effect of dewatering aids in nucleation and sizing control [3], and defoamer and hydrate flocculant in yield [4]. Crystal growth modifiers (CGMs) are made to act on the agglomeration and can also impact oxalate stability [5].

Other important aspects to be considered are the interaction effect of these products, and their accumulation over time [6]. It is unknown whether the chemicals adsorb significantly in the particles or stay in the liquor. Both scenarios pose potential risks. Seed and wash water are recycled back into the precipitation stage, and it is unclear whether all additives are completely degraded during digestion. Refineries have specific particularities, such as low or high digestion temperatures, different precipitation conditions, oxalate free or co-precipitation, among other aspects, and it is always advised to assess its impact on particle sizing, yield, oxalate control, settling, and/or filtration.

The objective of this study is to present the methodology adopted by EGA to screen and qualify chemical additives prior to field trials and permanent use, followed by the results obtained from the experiments.

2. Experiments

The laboratory sequence presented below refers to the methodology adopted to evaluate the impact of the chemicals in precipitation and clarification, and it is divided into poisoning tests and settling/filtration tests.

2.1 Lab Methodology for Poisoning Test

The poisoning test is designed such that it simulates the precipitation conditions in the lab, including agglomeration and growth sections. This is carried out in a temperature-controlled rotating water bath using plant liquors, namely pregnant liquor (PGL), which is the alumina rich stream from the clarifiers, and filtered dilution liquor (FDL) which is sourced from the 1st washer overflow, as well as plant seed (washed and dried fine seed) and plant slurry (coarse seed slurry). The liquor is first dosed with the chemical additive and mixed properly, then the fine seed is added. The slurry is left in the water bath for 5 hours at 80 °C to simulate agglomeration conditions. After the agglomeration simulation is completed, coarse seed slurry is introduced to the mixture. The samples are kept overnight (approximately 16–18 hours) at growth conditions, with the temperature dropping until it reaches 60 °C. A total of 25 bottles is prepared: 10 bottles for the agglomeration test, 15 bottles for the growth test.

The experiment investigates the effects of different additive concentrations on the precipitation circuit. It includes a control group with no additive (blank), a medium dose group (20 ppm), and a high dose group (100 ppm) in v/v basis. The impact of the additive is studied on the yield, the hydrate particle size distribution (PSD) and nucleation, impurities in the liquor, trace impurities in the precipitated hydrate, and oxalate concentration. Analyses are done in duplication for liquor concentration, impurities, PSD, and single test for oxalate and nucleation. The choice of plant

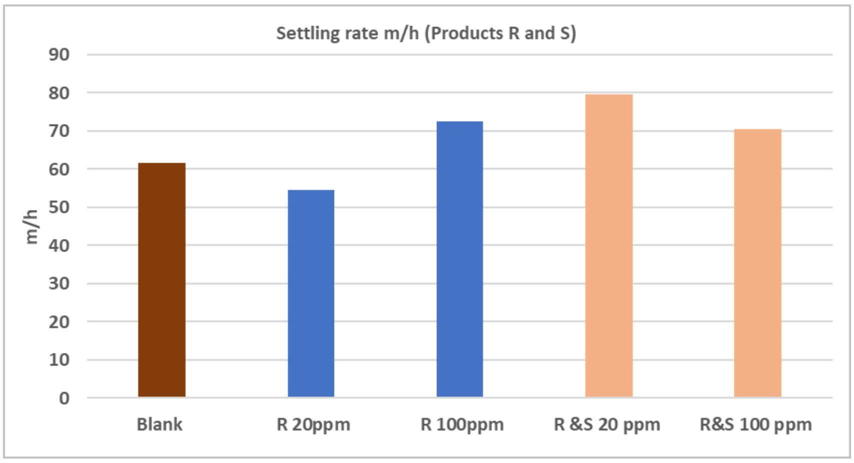

Figure 11. Settling test variability of products R and S against a blank (uncertainty is calculated at ± 5 m/h).

5. Conclusions

Based on the lab work presented in this paper, it was demonstrated that chemical additives can cause collateral effects in downstream areas of the Bayer process, with important variation presented for yield, oxalate stability and nucleation, and they must be used with caution, if not rejected, when negative impacts occur, especially in nucleation. The methodology developed by Al Taweelah alumina effectively qualifies new products before field trials, considering both resource limitations and time constraints. Alumina refineries should be aware of these potential effects and collaborate closely with suppliers to gain a deeper understanding of additives and improve their performance. Understanding the residual concentration of recirculating products in the liquor and their impact on yield, especially regarding partitioning into the hydrate, is an area to be explored. Additionally, investigating the impact of these additives on liquor density (which can affect digestion hydraulics) and their degradation at high temperatures are also valuable pursuits.

6. References

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