Solvay's Solvent Extraction Technology to Remove Organics from Bayer Process

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Abstract

Accumulation of organics in Bayer process liquors has many negative impacts on alumina production, including reduced liquor productivity and precipitation yield, lower quality alumina product and increased energy consumption. Existing organic removal technologies are either too costly or inefficient. A breakthrough organic removal process based on solvent extraction technology, developed by Solvay, has shown great potential to help alumina refineries significantly reduce the total organic carbon (TOC) in their Bayer liquor, and thus improve their production efficiency. This paper presents an overview of the whole organic removal process, footprint, economic and sustainability benefits to alumina refineries, and required equipment setup to run the process.

Keywords: Bayer process, Organic removal, Solvent extraction, Alumina production increase.

1. Introduction

Organic materials are introduced to the Bayer process principally from dissolution and digestion of organic material such as humates in bauxite ore, and addition of organic additives such as flocculants, deformers, scale inhibitors etc. [1]. As the Bayer process is cyclic, any organic matter entering the process stream accumulates with each cycle of the process, with a steady state determined by process input and output streams. The major organic exits are (a) the red mud circuit, (b) with the gibbsite product, and (c) via any organic removal steps in place [2].

Organic accumulation in Bayer liquor has many negative effects on alumina production. Some organic compounds in Bayer liquor, especially the low molecular weight (Mw) organic compounds, can adsorb to the nucleation sites of gibbsite, reducing the crystallization rate, and lowering liquor productivity and precipitation yield [3]. The sodium oxalate in Bayer liquor, if not adequately controlled, can build up to a level of supersaturation before crystallizing in a fine needle-like form. These fine oxalate needles co-crystalize with gibbsite and inhibit its agglomeration, resulting in finer particle size distribution (PSD) of gibbsite particles, decreased filtration rate of gibbsite slurry, increased scale growth rate, excessive foaming in the precipitation stage, and increased occluded soda in alumina after calcination [2-4]. The high molecular weight organics in Bayer liquor, especially humate molecules, bind to gibbsite crystal particles during precipitation, and reduce the brightness of gibbsitesignificantly. Note that the brightness of gibbsite indicates the reflectance of gibbsite across the visible spectrum, and gibbsite with higher brightness has higher reflectance of visible light. Additionally, due to their surfactant-like nature, medium and high molecular weight humic substances are often responsible for liquor foaming [5] and interference with red mud flocculation [6].

Removing organic impurities from the Bayer process can bring several benefits to alumina refineries, such as increased yield and production rate, lower energy consumption and raw material costs, improved product quality (gibbsite brightness, PSD, and occluded soda), and reduced foaming and scaling. Many technologies have been developed and implemented to remove organics from the Bayer process, including liquor burning, seed washing, salting out process, side stream oxalate removal, oxalate cold precipitation process, and humate removal via poly(DADMAC) [1, 7-10]. The comparison of these existing technologies is summarized in Table 1. All of these known technologies require significant costs to operate while having only a modicum of impact on the organics load of the refinery

Table 1. Comparison of existing organic removal technologies for Bayer process.

Name of Technology	Description	Pros	Cons	Organic removal efficiency
Humate removal	Addition of poly(DADMAC) to form complex with humate	Reduce [humate]	Chloride ingress from poly(DADMAC); Only remove humate	low
Oxalate cold precipitation	Use activated carbon to reduce humate content, then precipitate oxalate via cooling	Reduce [oxalate] and [humate]	Low efficiency	low
Side stream oxalate precipitation	Use oxalate seed to induce oxalate crystallization	Reduce [oxalate]	Low capacity; High CAPEX; Only remove oxalate	low
Salting out process	Evaporation of side stream liquor to precipitate organics and carbonate	Remove some organics and carbonate	Energy intensive; High CAPEX and OPEX; High CO_2 emissions	medium
Seed washing	Co-precipitation of oxalate with gibbsite, followed by hot water washing of seed to dissolve oxalate	Reduce [oxalate]	High CAPEX and OPEX; Water ingress; Only remove oxalate	medium
Liquor burning	Evaporation of side stream liquor followed by calcination	Remove 99% TOC in treated stream and recover caustic tied to impurities	High CAPEX/OPEX; High CO_2 emissions: High operation challenges	high

2. Results and Discussion

2.1 Overview of Solvay's Organic Removal Process

Solvay has developed a solvent extraction (SX) based technology to extract organics from Bayer liquor and significantly reduce total organic carbon content (TOC). A schematic flow diagram of this new organic removal process is shown in Figure 1. This technology consists of four units: SX unit, strip liquor recycling unit, regeneration (regn.) liquor recycling unit, and organic destruction

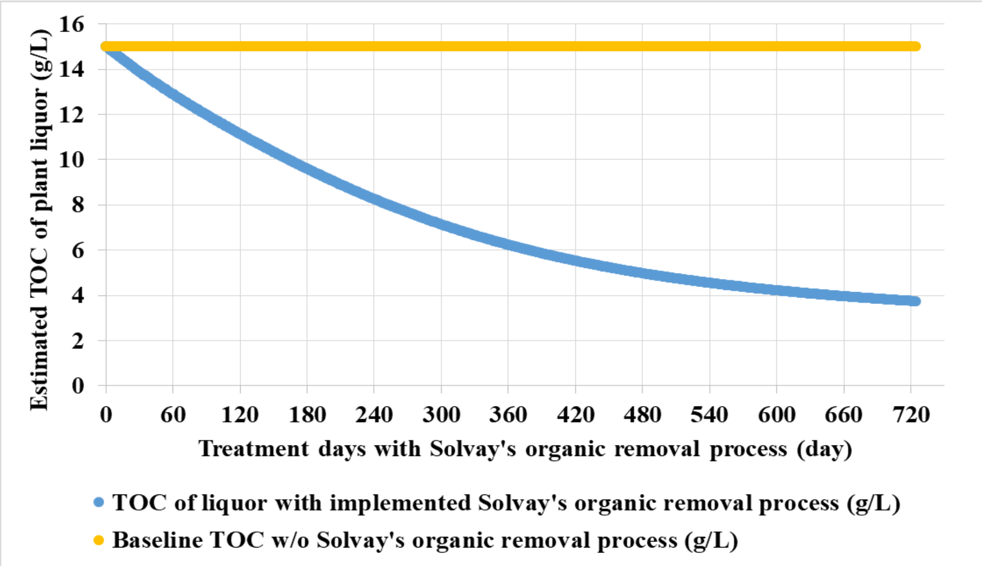

Figure 18. The estimated plant liquor TOC change over time with the implementation of Solvay's organic removal process based on the assumptions in Table 3.

3. Conclusion

In summary, Solvay has developed a breakthrough organic removal process based on solvent extraction composed of four operating units: SX, strip liquor recycling, regeneration liquor recycling and organic destruction. Bench scale and pilot scale tests have been conducted to validate the chemical equilibria, continuous lab-scale operation and engineering specifications, and demonstrate the benefits associated with TOC reduction in plant liquors.

4. References

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