New developments in red mud flocculation and control of solid/liquid separation

John Kildea
Director, RD&E, Nalco, An Ecolab Company
Corresponding author: jkildea@nalco.com

Abstract

While the Bayer process is designed to produce alumina, most operating refineries process and handle much more red mud than alumina. Thus the control and separation of red mud from liquor may be considered as the main activity of a Bayer process refinery. Efficient management and control of red mud is a critical issue in optimizing refinery operations. In addition, the focus on mud is likely to continue with good quality bauxite reserves reducing, meaning that refineries now have to process steadily poorer quality bauxite and hence will have to handle more and more red mud. Recently there have been a number of developments across a range of chemical additives that have resulted in improved capability to efficiently manage and process red mud. Key among these has been a range of improvements in flocculant design and chemistry, resulting in improved thickener and washer operations. However, products have also been developed to improve filtration processes (both for liquor polishing and red mud disposal) as well as scale control in filters, pipes and washers. Some of the opportunities that these reagents provide to improve separation, washing, handling and management of red mud are reviewed and discussed.

Keywords: Bayer process; red mud; flocculation; filtration; scale.

1. Introduction

The focus of discussion around most alumina refineries typically centres on how much alumina the plant produces. While production of alumina is the main purpose of operating the plant, in most cases, it is not the main activity of the plant. Solid waste material or red mud that a typical Bayer plant produces and handles far exceeds the tonnes of alumina it makes. As a result, in a perverse way, alumina refineries can be considered as red mud handling facilities that produce alumina, with the main activity of the plant being the handling, separation and transport of the mud.

Estimates of global alumina production (approximately 108 million tonnes in 2014 [1]) can be used to calculate the likely global production of red mud. Based on simple assumptions of an average available alumina of 36 % and 90 % recovery, the amount of red mud processed and treated globally is estimated to be in excess of 150 million tonnes each year, or almost one and a half times the amount of alumina produced.

As a consequence, a range of chemical and engineering solutions have been developed to enhance and improve the separation, handling, treatment and processing of red mud. The purpose of this paper is to review current practice and identify new developments that may assist operators in more efficiently dealing with the increasing amounts of red mud in their plants.

Within this paper the term red mud is used in a general sense to describe all the insoluble components of bauxite that remain as solids after digestion in a Bayer plant. In this context it covers a number of species including fine clays, iron particulates and sand, as well as precipitated alumina trihydrate. It is acknowledged that some species within this broad definition will behave differently (e.g. larger sand particles will generally settle quickly, while clay particles will not) however, for simplicity and convenience, the single term (red mud) is generally used here to describe the whole. In this context, “mud handling” can be used as a term to describe all the aspects involved in processing red mud within the circuit. This includes separation from the liquor as well as washing, transport and disposal of the solids.

Perhaps the most important step in mud handling is the separation of the solid mud from the valuable liquor. In general this is achieved by using a variety of means including thickener or settler vessels, filters, washers and residue lakes or drying ponds. While the operation and design of the overall mud handling system can significantly vary from plant to plant, the use of primary settlers for initial solid-liquid separation followed by washer vessels to recover liquor values from the settler underflow stream is very common practice across the industry. Within this process the use of flocculants to enhance settling and optimize the solid-liquid separation process in these vessels is practically universal.

2. Separation and washing

2.1 Primary settling

The primary settlers are operated to separate the bulk of the liquor from the solids. They deliver a stream of nominally clean liquor in the overflow, as well as a concentrated slurry of solids in the underflow. The efficiency of this process is effectively measured by the amount of solids reporting with the overflow liquor (which should be minimal), together with the amount of liquor in the solids stream. While it is important to minimize the liquor reporting to the underflow by maximizing the concentration of solids, the flow properties of the underflow stream must be maintained in order to sustain continuous operation. As a result, a substantial amount of liquor is required in the underflow. However, in the primary settlers, minimizing the solids in the overflow is a major operational focus.

Within any settling vessel, the dispersed red mud solids settle poorly so flocculants are used. Within the primary settlers the purpose of any flocculant is to capture and settle the mud at the required settling rate and minimize the amount of suspended solids reporting to the overflow. Historically starches were used as flocculants but the settling rates achieved using this type of chemistry was found to be generally less than desirable for modern plant operations. As a result, synthetic high molecular weight polymers are now predominantly used across the industry.

Synthetic polymers can be made from a variety of feedstocks and, in some cases the nature of the polymer can be “tailored” in the manufacturing process to deliver products with different performance characteristics.

The most commonly used synthetic polymers in the Bayer process are polyacrylate based products or polyacrylate-polyacrylamide co-polymers. The primary building block of these synthetic polymers is sodium or ammonium acrylate monomer. The acrylate monomer is either polymerized as a homopolymer or as copolymer with acrylamide (Figures 1 and 2 respectively).

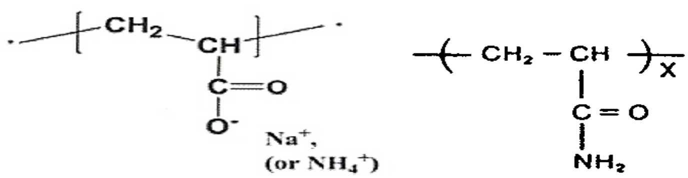

Figure 1. Structure of acrylate (left) and acrylamide homopolymers.

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