USE OF DIFFERENT MICROBIAL CULTURES FOR BIOLEACHING OF SCANDIUM FROM BAUXITE RESIDUE

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Abstract

The bauxite residue (BR), is a highly alkaline waste by-product generated from the Bayer process for alumina production. More than 3.5 billion tons of BR have been stockpiled globally in storage areas, with ~120 million tons added annually[1]. The disposal of BR constitutes a universal environmental concern due to its alkalinity and volume. BR contains valuable metals, such as iron, titanium, aluminium and rare earth elements (REEs), in particular, scandium (Sc), which represents up to 95% of the economic value of REEs in Greek BR[1]. Furthermore, technology blooming has resulted in a higher demand for critical raw materials (CRMs). According to the European Commission, the most senior supply risk of CRMs corresponds to REEs. It is, therefore, crucial to develop an efficient and environmentally friendly technology to utilise BR.

Acid leaching with nitric, sulfuric and hydrochloric acid for the extraction of REEs from BR has been extensively studied[1]. Biotechnologies, based on microorganisms and their interaction with different materials, can play an essential role in metalrecovery[2]. Bioleaching is a technology considered as 'a green technology' with operational flexibility and low energy requirements[3]. The scope of this study is the development of a bioleaching procedure for Sc recovery from BR and the optimisation of the process by testing several variables.

The investigation of bioleaching of Sc from BR was performed using different microbial cultures in batch bioassays. All experiments were conducted with BR samples, provided from Mytilineos S.A. in the form of ferroalumina. The initial pH of the BR was 11.3. The chemical composition and mineralogical analysis of BR are reported elsewhere[1]. The cultures used in this study are: (a) an activated sludge inoculum collected from a pilot-scale anaerobic digester[4], (b) a Chemoheterotrophic Bacterium, *Acetobacter tropicalis,* (c) a fungus, *Aspergillus niger*. Batch experiments were performed using the Automated Methane Potential Test System II (AMPTS). Each of the AMPTS' bottles (500 ml total volume; 400 ml working volume and 100 ml

headspace) was equipped with an individual mechanical stirrer and operated as a bench-scale anaerobic bioreactor. All experiments started simultaneously. During start-up, flushing with N_2 took place, and all samples were maintained at 35°C throughout the experiment. BR of 1% and 10% S/L- pulp density was added in bottles. Pre-treatment of BR involved pH adjustment to 7 with 0.1M HCl. All batch tests were conducted in triplicate and control samples were tested. In the experiments with anaerobic sludge inoculum, the substrates for the co-digestion were condensed from the drying and shredding of Household Fermentable Waste from Municipal Wastewater Treatment Plant[4]. Chemical analysis of the leachate solutions after filtration was conducted by 7000 DV Perkin Elmer ICP-OES. The measurements of TSS (Total Suspended Solids) and VSS (Volatile Suspended Solids) for biomass determination were carried out according to Standard Methods[5]. The identification of VFAs (Volatile Fatty Acids) and organic acids was performed with a Shimadzu (GC2010) gas chromatograph and an Agilent Technologies 1260 Infinity II HPLC.

Preliminary experiments with activated sludge inoculum showed that Sc recovery of almost 20% for solid to liquid ratio (S/L) of 1:10 was achieved, while for (S/L) of 1:100, a Sc recovery of only 3% was obtained. Further increase of the pulp density in the leaching solution is expected to result in even higher Sc concentration. The activated sludge inoculum drastically reduced the pH to 3.0 in the bottles containing 10% BR, due to the in-situ production of organic acids during the leaching procedure. Ethanedioic (oxalic), 3carboxy,3hydroxypentanedioic (citric), ethanoic (acetic), propionic, isobutanoic (isobutyric), butanoic (butyric), isopentanoic (isovaleric) and pentanoic (valeric)acids were detected by HPLC (Fig. 1) as well as by GC. However, abiotic leaching with laboratory prepared solutions of acetic, propionic and butyric acids individually was not as effective as bioleaching. It led to lower recovery yields, suggesting the production of other than the identified organic acids contributing to leaching efficiency and/or a synergistic impact of different organic acids probably combined with a different leaching mechanism. Biomass determination results showed that at a solid to liquid ratio (S/L) of 1:10 BR, the biomass production of activated sludge inoculum was higher than that of S/L 1:100 with a relevant short lag phase duration. The stationary phase was reached after 10 days of incubation and the biomass at this point was around 30 g/L.

Optimisation of the bioleaching process is in progress, using different microbial cultures and different pulp densities aiming to minimise the incubation time and maximise Sc recovery. Up to now, the results, compared with those obtained by abiotic organic acids, indicate a probable synergistic effect of the different organic acids produced by microorganisms along with a more targeted leaching mechanism.

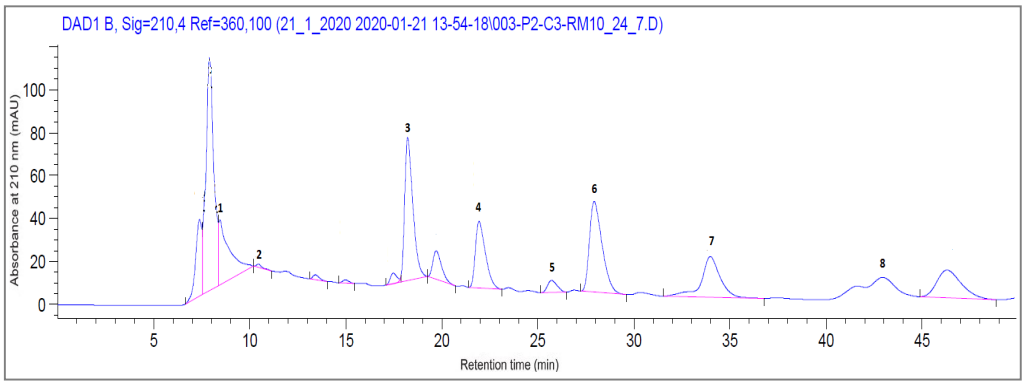

Figure 1: Chromatogram of HPLC with organic acid peaks detected at stationary phase in the experiments with activated sludge inoculum. Peaks: 1 = oxalic acid, 2 = citric acid, 3 = acetic acid, 4 = propionic acid, 5 = isobutyric acid, 6 = Butyric acid, 7 = isovaleric acid, 8= valeric acid.

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