

Fundamentals of rare earth flotation surface chemistry: Electrokinetic phenomena

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Introduction

Froth flotation relies on the exploitation of variations in interfacial chemical properties of particles in solution. This is typically achieved via the adsorption of selective surfactants (collectors, activators, depressants, etc.) onto the desired mineral surface to render them hydrophobic or hydrophilic. The adsorption of surfactants at the mineral surface is largely controlled by the electrical nature of that mineral surface.

Abstract

In flotation, the electrical nature of the mineral surface is described by an electrokinetic potential known as the zeta potential. The aim of this research is to illustrate the potential determining ions (PDIs) of the rare-earth mineral bastnaesite ((Ce,La)FCO₃) and its associated gangue minerals, calcite (CaCO₃) and barite (BaSO₄).

Initially, pure mineral samples were hand sorted and ground to -32 μm using a mortar and pestle. Sample characterization was performed using inductively coupled plasma mass spectrometry (ICP-MS) in conjunction with X-ray diffraction (XRD) to ensure sample purity. Prior to electrokinetic measurement, 0.1 g/L samples were conditioned for 24 hours on a shaking table. Measurements were performed using a Microtrac Stabino instrument (streaming potential). Each measurement was performed three times for experimental reliability purposes.

Generally, an ion is said to be potentially determining if its adsorption causes a shift in the isoelectric point (IEP) of that mineral. To illustrate whether or not an ion was potentially determining, zeta potential measurements of the minerals in the absence of any metallic salts were measured. After this, samples were added to solutions containing 10⁻³ and 10⁻⁴ M of metallic salts postulated to contain PDIs for the respective minerals (Table 1).

Electrokinetic measurements for barite show that, as the sulfate concentration (SO₄²⁻) is increased, the IEP shifts toward the alkaline direction and, as the Ba²⁺ concentration is increased, the IEP shifts in the acidic direction. This is illustrated in Fig. 1.

Results for calcite show that the IEP shifts in the alkaline direction as the carbonate concentration is increased and, as the Ca²⁺ concentration is increased, the IEP shifts in the acidic direction.

Finally, PDI electrokinetic measurements for bastnaesite show that the IEP shifts in the alkaline direction as the carbonate (Na₂CO₃) concentration is increased. Conversely, as the amount of cerium is increased, the IEP shifts in the acidic direction.

All results obtained were compared with the respective speciation diagrams of each of the mineral/water systems. This provided insight into which species were present in the

system to act as potential determining ions. By understanding how PDIs affect the mineral's zeta potential, it may be possible to manipulate the system, using new reagent schemes, to ultimately increase the grade/recovery of rare earth flotation concentrates.

Table 1 — Metallic salts used in PDI determination.

Mineral	Salts tested
Barite	Ba(NO ₃) ₂
BaSO ₄	Na ₂ SO ₄
Calcite	Na ₂ CO ₃
CaCO ₃	Ca(NO ₃) ₂
Bastnaesite (Ce,La)FCO ₃	Na ₂ CO ₃ Ce(NO ₃) ₃

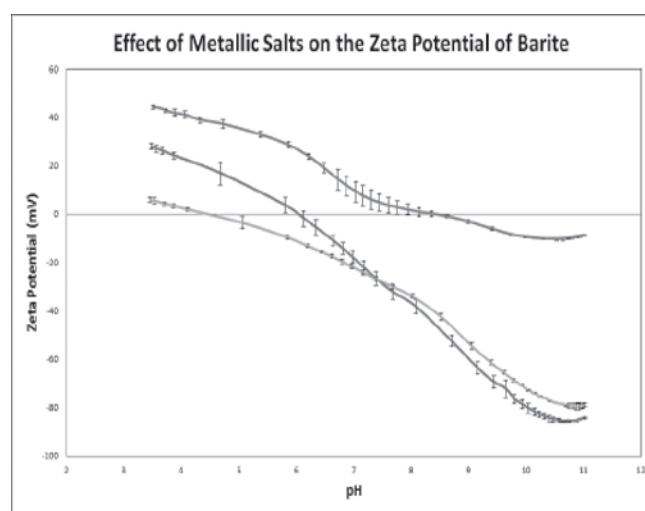


Figure 1 — Effect of metallic salts on the zeta potential of barite.