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DYNAMICS OF ENRICHED PARAMAGNETIC REE SALT SOLUTION CLUSTERS UNDER THE INFLUENCE OF THE COUPLED GRAVITY AND MAGNETIC FIELD

Abstract

Rare earth elements (REE) are essential in a broad spectrum of conventional and high-technologies. The beneficiation of the REE, both from primary and secondary raw material resources is economically and environmentally costly, among others due to the similar chemical properties. Recent studies on rare earth ions enrichment harvested by means of permanent magnets offers a new possibility to increase the REE separation and recycling efficiency in the hydrometallurgical stages via magnetic separation step [1]. The physical mechanism was explained recently [2] and consists in an intriguing interplay between gravitational and magnetic field gradient forces which is triggered by the evaporation of the solvent (water). In experiments with a controlled evaporation of water molecules from rare earth salt solution, the formation of a REE concentration boundary layer was observed by interferometry. Without a magnetic field, this configuration becomes hydrodynamically unstable after a while, because heavier solution overlies less dense one. As a result, plumes of buoyant solution, enriched in REE, are emitted from this boundary layer. However, upon applying a magnetic field gradient, a suppression of this instability takes place. Based on further analysis we have shown that the magnetic field gradient force levitates the local REE enrichment, thereby providing access to its separation. Since the transport of the enriched solution cluster is governed by the interplay between gravitational and magnetic field gradient force, parabolic flights with their varying level of gravitational acceleration provide further insights into the dynamics, which is also discussed in this contribution. [1] Yang, Xuegeng, Kristina Tschulik, Margitta Uhlemann, Stefan Odenbach, and Kerstin Eckert. "Enrichment of paramagnetic ions from homogeneous solutions in inhomogeneous magnetic fields." The journal of physical chemistry letters 3, no. 23 (2012): 3559-3564. [2] Lei, Zhe, Barbara Fritzsche, and Kerstin Eckert. "Evaporation-Assisted Magnetic Separation of Rare-Earth Ions in Aqueous Solutions." The Journal of Physical Chemistry C 121, no. 44 (2017): 24576-24587.