C04: Efficient Flotation of Engineered Artificial Minerals from Metallurgical Slags by Exploiting Interaction Scanning (FlotEnAMIS)

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Overview

The PP2315 addresses the crystallization of certain mineral phases in metallurgical slags in order to allow the recovery of critical metals like lithium. FlotEnAMIS will focus on the separation of fine particles of these so called engineered artificial mineral phases (EnAMs) by flotation that exploits the differences in wettability of said particles. More in detail it wants to understand the surface properties of EnAMs and use this knowledge to find suitable flotation reagents regimes (collectors, depressants, regulators, modifiers). The EnAM phases will be surface characterized with contact and non-contact atomic force microscopy (AFM) to evaluate topological features and surface potential properties with colloidal probe AFM.

The project will improve our understanding of froth flotation separation and generates pioneering work within the surface characterization of EnAMs while using AFM and furthermore exploring this method as a screening tool for flotation reagents.

Model System

The material focus will be on metallurgical slags typical for Li-ion battery recycling which are included in the Li-Si-Al-Ca-Mg-Mn-O slag system. It was determined that lithium aluminate as the main Li-containing mineral and gehlenite as gangue mineral are the two most abundant EnAM phases in Li-bearing slags (Elwert 2012). Thus, the model system uses these two EnAMs for the development of suitable reagent regimes in flotation. Additionally, actual Li-slags with different ratios of manganese will be designed and produced within the PP2315 and characterized since the Li-Ionbatteries in the new generations contain higher Mn-amounts.

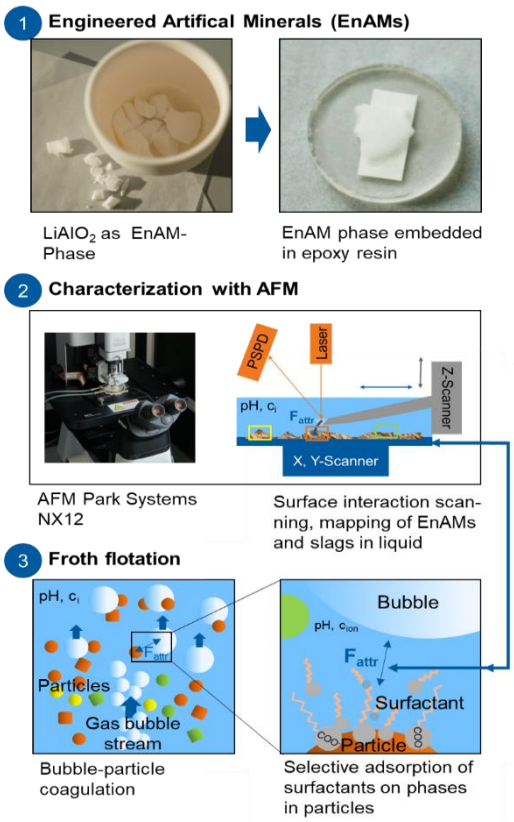

Figure 1: Schematic description of the project approach.

Approach

In the first step, the pure EnAMs $LiAlO_2$ and gehlenite are generated via high temperature synthesis and real engineered small-scale slag samples are produced in the PP2315. The surface characterization is done on solid planar substrates in epoxy resin (Fig. 1_1) (Babel 2018). Since typical flotability test approaches and sessile drop contact angles are unsuitable for a lack of available material, different AFM modii allow flotability

assessments and reagent screening in the second step (Fig 1_2). The pure EnAMs are milled to create specific particle size fractions, which are analysed for their flotation behaviour via microflotation experiments using different reagents. In the third step results from microflotation tests are correlated with the AFM investigations for verification. The most suitable reagents identified will be applied in batch flotation tests with the synthesized EnAMs (Fig 1_3).

AFM investigations

In order to understand the surface properties of the individually synthesized EnAMs and of the EnAM phases within actual slags a normal tip for structure microscopy and a hydrophilic colloidal probe for surface charge mapping are used in AFM investigations (Wu 2021). Once their surface behavior is understood, flotation collectors and depressants are screened including different anionic and cationic surfactants and organic polymeric as well as inorganic regulators. The screening is performed via hydrophobic colloidal probe AFM in liquid for micro- and nanoscopic hydrophobicity mapping. Furthermore, the project wants to exploit quantitative AFM using the oscillating dynamic non-contact mode to further deepen our understanding of hydrophobic interaction forces, which play a significant role in flotation.

References

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