Seminar Series on Materials Chemistry

SS2022

Thursday May 19th, 2022

13h30, HS4

Minisymposium: Solid-phase extraction for critical materials

Solid-phase extraction for critical materials recovery: Bridging basic science and industrial application

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Critical materials (CMs) are a group of elements that have been determined to be important for the modern economy, but which may face current or potential supply limitations. Some examples of metals that have received the CM designation include the rare earth elements, indium, gallium, and lithium. The last decade has seen a major push for the development of new and improved technologies for the recovery and purification of CMs from various traditional and non-traditional resources in an effort to diversify supply. Solid-phase extraction (SPE) is one broad category of these experimental extraction technologies. SPE involves the application of a solid material to preferentially retain in the solid phase one or more specific components of an aqueous solution, leaving the other components behind in the aqueous phase. A wide range of different sorbents have been used for SPE, and many offer significant potential advantages, including low cost, low environmental impact, and high customizability. Polymer-encapsulated microbes are one example of a cutting-edge material that provides a flexible, scalable, environmentally friendly sorbent for CM recovery. These microbe beads show great promise for the recovery of rare earth elements from non-traditional resources, especially low-grade resources, such as mine wastes and geothermal fluids. To demonstrate the practical viability of this system, and other innovative CM recovery techniques, future SPE studies would benefit from devoting additional focus to the scalability, economic feasibility, and environmental impact of their material.

Mesoporous Sorbents for Rare Earth Element Sequestration

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The rare earth elements (REEs) are used in the production of advanced technologies, such as wind turbines, electric cars, GPS navigation systems, smartphones, fiber optics, computers, and light emitting diodes. The need for REEs has grown significantly in recent decades, and it is expected that, in the near future, demand for these elements will raise even further as consumers continue to expect hi-tech *green* products.[1,2] In order to substantially improve the purification/extraction process and provide a greener alternative to traditional liquid-liquid extraction methods, we propose functional porous hybrid materials as potential solid-phase sorbents for the efficient separation of REEs.[3] Our mesoporous silica sorbents, obtained by controlled grafting of chelating ligands on the silica surface (e.g., KIT-6), are highly reusable and show greater selectivity for REEs than commercially available resins under the tested extraction conditions.[34] These materials particularly demonstrate low uptake of non-lanthanide trivalent ions or actinides. In addition, these materials exhibit very fast uptake of the targeted elements, increasing their marketable potential. To better understand the solid-phase extraction process of hybrid (organo)silica sorbents and to design more efficient extraction materials in the future, we performed board spectroscopic characterization of our materials. The results from these analyzes revealed that, depending on the extracted metal, structure of the ligand, and its attachment to the silica surface, various functional groups (e.g., C=O, N-H or silanols) can act as the preferential adsorption centers and favorably capture different metal ions, which in turn might be associated with the different selectivity of the synthesized sorbents.

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[1] A. Brewer, J. Florek, F. Kleitz, *Green Chem.*, **2022**, *24*, 2752.

[2] J. Florek, S. Giret, E. Juère, D. Larivière, F. Kleitz, *Dalton Trans.*, **2016**, *45*, 14832.

[3] J. Florek, D. Larivière, H. Kählig, S.L. Fiorilli, B. Onida, F.-G. Fontaine, F. Kleitz, *ACS Appl. Mater. Interfaces* **2020**, *12*, 57003.

[4] Y. Hu, L.C. Misal Castro, E. Drouin, J. Florek, H. Kählig, D. Larivière, F. Kleitz, F.-G. Fontaine, *ACS Appl. Mater. Interfaces* **2019**, *11*, 26, 23681.