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Upgrading and valorizing vivianite recovered from sewage sludge

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Motivation

Phosphorus (P) plays a crucial role in both animals and plants; however, phosphorus rock is a finite resource and unevenly distributed globally. This creates a strong incentive to recover P from secondary sources such as sewage sludge. Over the past ten years, our research group has been at the forefront of recovering phosphorus from sludge in the form of vivianite ($Fe_3(PO_4)_2 \cdot 8H_2O$), a blue iron phosphate mineral that forms in anerobic environments such as digested sludge. Due to its paramagnetic properties, vivianite can be selectively extracted using magnetic separation [1]. This process, known as Vivimag™, has been patented, and the first demonstration-scale installation is currently being built with our industrial partners. For this technology to enter the market, value chains for the recovered vivianite must be developed. This project aims to develop valorization routes for vivianite, either by directly reusing it or by separately upgrading the Fe and P streams.

Technological challenge

Vivianite magnetically recovered from sludge contains impurities, mainly organic matter and other divalent cations present in the vivianite crystal structure itself[2]. Whether such impurities are favorable or unfavorable remains unknown and will depend on the chosen application. Hence, these impurities may influence the way we can valorize vivianite, which is the biggest challenge.
Two main valorization routes exist: (i) direct use of vivianite, such as $LiFePO_4$ batteries[3], and (ii) separation of Fe and P, enabling circular reuse of Fe as a coagulant and recovery of P for fertilizer or chemical use. The role of impurities in these two routes may differ and cannot be generalized. For example, organic matter may serve as a useful carbon source in $LiFePO_4$/C synthesis, whereas it could negatively affect leaching efficiency during Fe-P separation.

Fig 1. Magnetic separator in the pilot plant

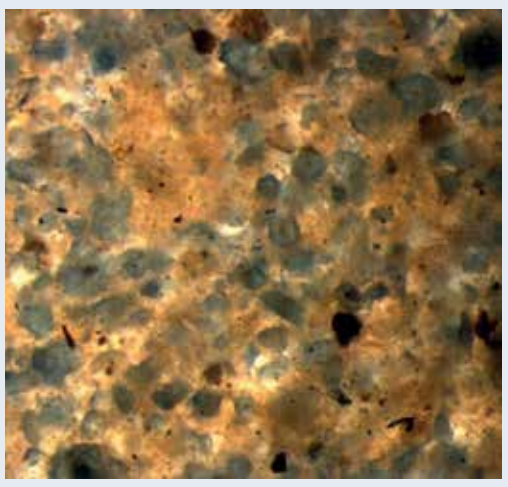

Fig 2. Aspect of vivianite concentrate after separation

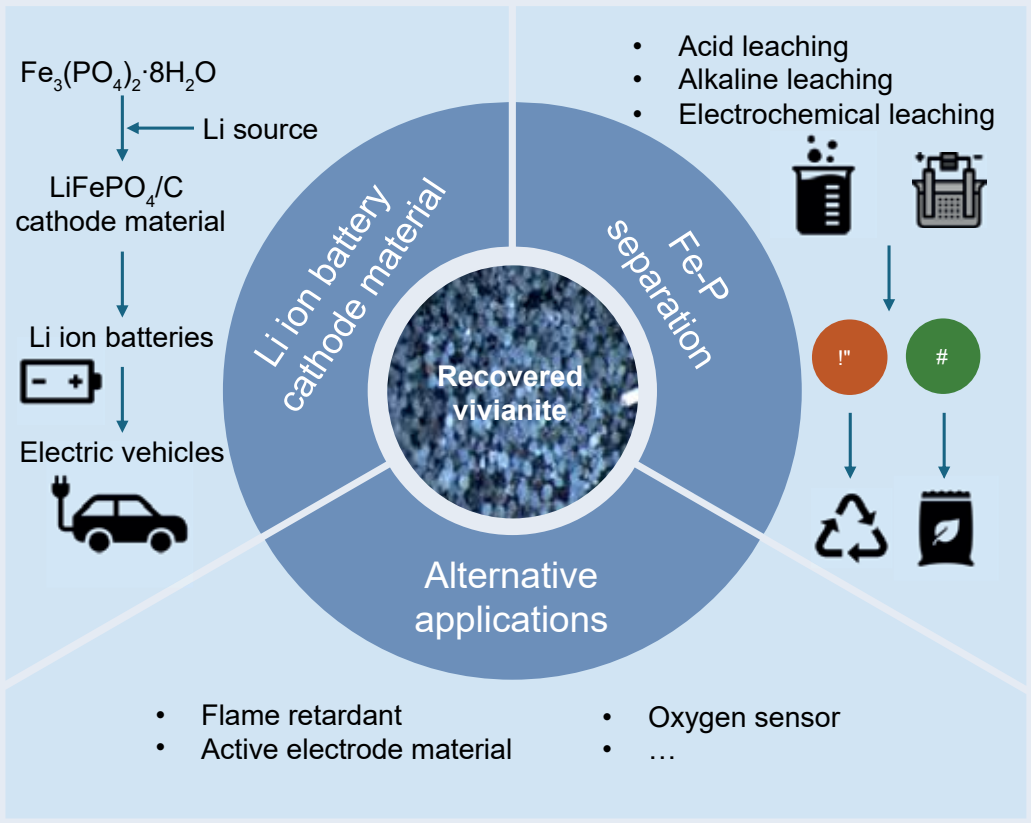

Fig 3. Schematic overview of application-oriented valorization routes.

Research goals

The overall objective of this project is to develop valorization routes for recovered vivianite. Several options exist to reuse vivianite:

- Direct use: investigate the direct reuse of recovered vivianite as a precursor of LiFePO4/C cathode materials,
- Fe-P separation: develop separation routes that split vivianite into two streams, enabling reuse of Fe (e.g. coagulant) and P (e.g. fertilizer or p-products)
- Alternative applications: explore other novel applications based on its properties, for example as flame retardants, oxygen sensor, or active electrode materials.

References

[1] Prot, T. et al. Separation and Purification Technology (2019) .564-579
[2] Zhao, Y. et al. Water Research (2024) 122361.
[3] Chen, T. et al. Scientific Reports(2025) 31420.