Electrochemical recovery of phosphorous by calcium phosphate precipitation

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Motivation

Phosphorous (P) is an essential and non-renewable element for all living organisms [1], unfortunately, phosphorous reserves are diminishing due to the growth of world population in the last decades. It was estimated that present phosphate ores can be used up in 100-400 years [2]. Analysis also reveal that even for the present phosphate rock reserves, the mining cost is likely to increase greatly, as the ore grade is declining. In the same time, loads of phosphorous is discharged to wastewater treatment plants (WWTP) during our daily life activities. When this residual P rich wastewater enters into surface water even at a very low concentration, this can cause a serious environmental problem, namely eutrophication. But if we could recover P from wastewater before it is discharged into water bodies, this can provide an excellent solution for both problems. In our project, we will develop an electrochemical based P recovery method, which produce calcium phosphate as recycled product. Calcium phosphate can be directly used by fertilizer industry.

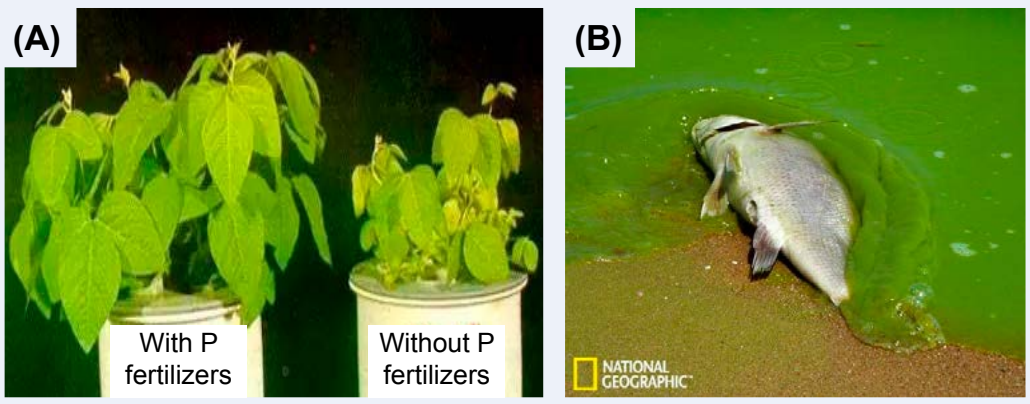

Figure 1. (A) Using P fertilizers accelerate plant growth, (B) Example of fish die because of eutrophication

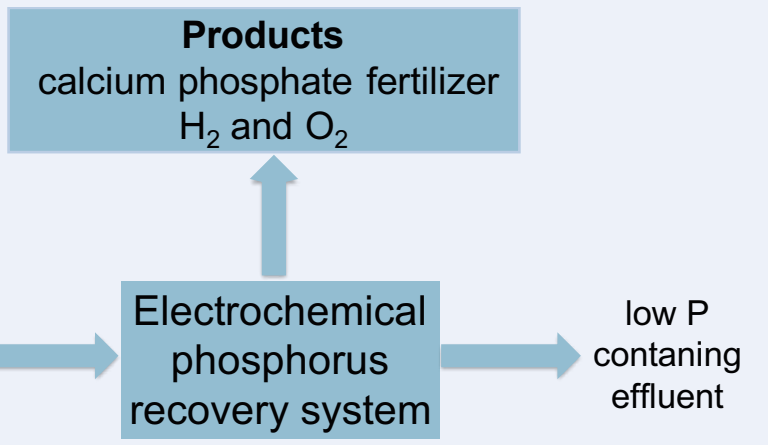

Figure 2. General overview of the electrochemical P recovery system.

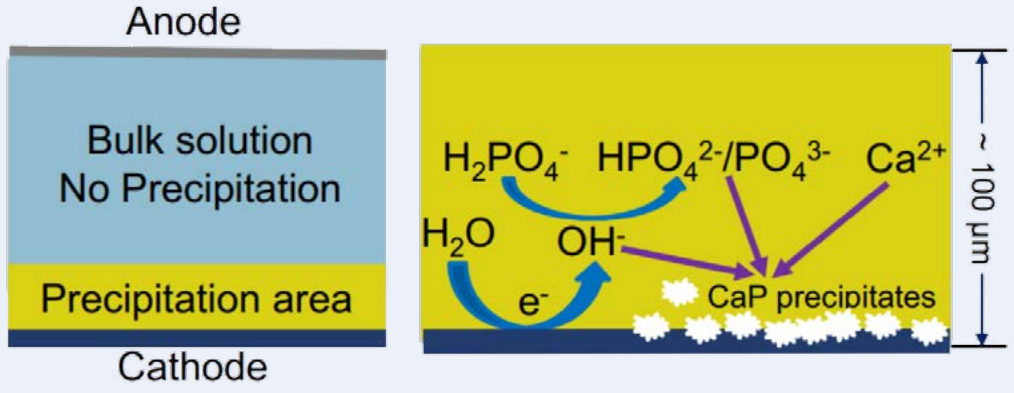

Figure 3. Mechanism of electrochemical induced calcium phosphate precipitation.

Technological challenges

Electrochemical precipitation, as a promising method for removal of phosphate from waste streams, has received increased interest, because of the availability and low (chemicals consumption) costs of the technology, the low temperatures used which would lead to crystalline products, and also, the ability to control the thickness, composition and microstructure of deposition. Here, the challenges are:

- identify the influence of water matrix
- Understand the effects of physical and chemical properties of electrodes on P recovery
- how to collect the formed calcium phosphate particles in this system

Proof of principle

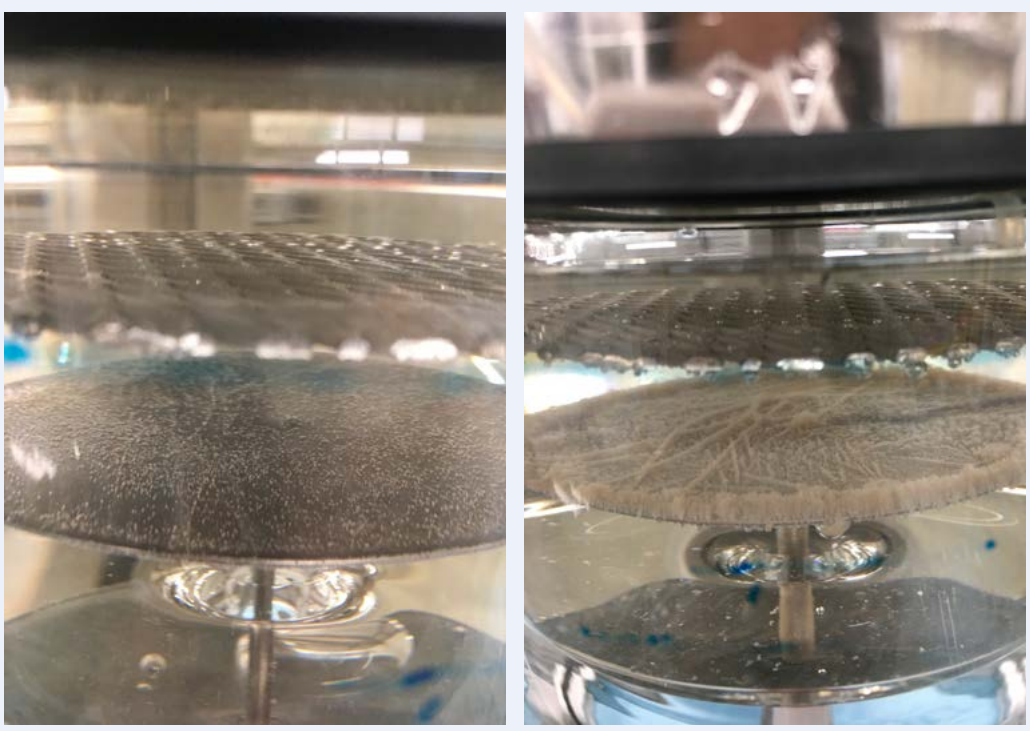

Figure 4. The surface of Ti cathode are totally covered by calcium phosphate precipitates after 24 hours' electrolysis. Conditions: 20 mA; 1.0 Ca^{2+}, 0.6 mM HPO_4^-.

References

[1] Bradford-Hartke, Z., et al., Environmental Benefits and Burdens of Phosphorus Recovery from Municipal Wastewater. Environ Sci Technol, 2015. 49(14): p. 8611-8622.
[2] Desmidt, E., et al., Global Phosphorus Scarcity and Full-Scale P-Recovery Techniques: A Review. Crit Rev Env Sci Tec, 2014. 45(4): p. 336-384.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 665874

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