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Optimising electrochemical phosphate recovery

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Motivation

Phosphorous (P) is a crucial and unreplaceable nutrient for human life. Nowadays, it is mainly extracted from phosphate rocks. Unfortunately, this source is a finite and non-renewable resource. Moreover, there are no substantial P reservoirs in the European Union (EU). For these reasons, the EU declared this element a critical raw material in 2014. In addition, P is also a major polluter, and its abundance in wastewater is relatively high[1,2]. A solution that would solve both aspects is the circular use of phosphorus. However, newer and cheaper solutions are needed for P removal and recovery from industrial wastewater. Electrochemically induced calcium phosphate precipitation is a suitable way to achieve that. This technology is particularly appealing for wastewater where P is close to saturation and the salinity is high (i.e., cheese wastewater) (Figure 1).[3]

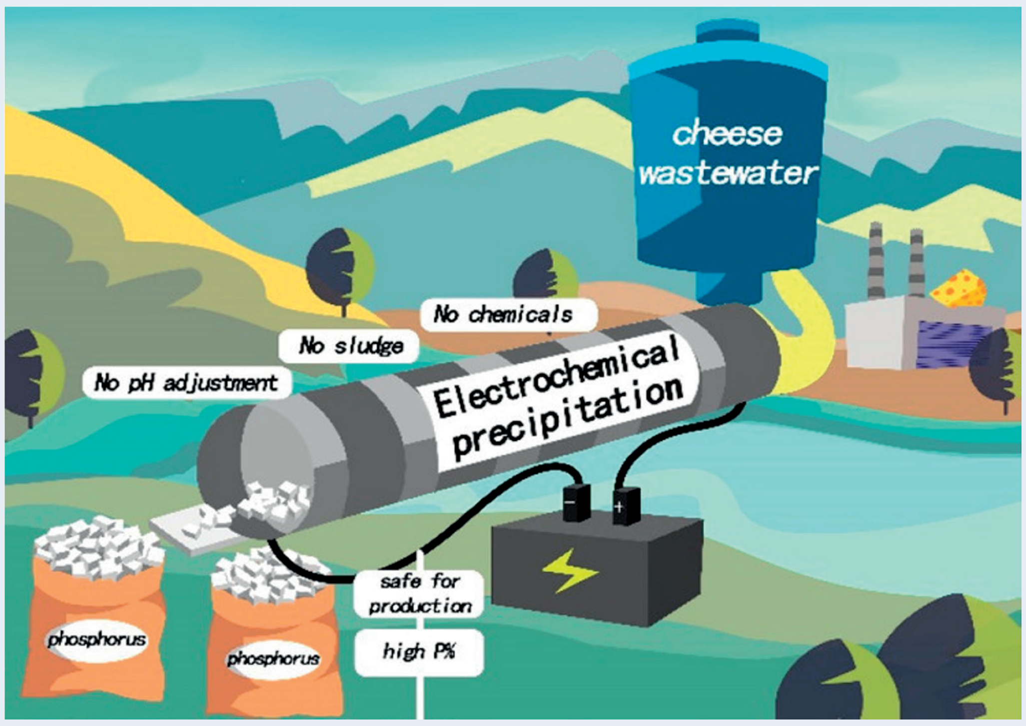

Figure 1. Phosphorous recovery from cheese wastewater. Adapted from Lei et al [4].

Technological challenge

This novel technology can induce calcium phosphate precipitation thanks to the higher local pH created at the cathode by the hydrogen evolution reaction without dosing any chemicals (Figure 2, up) [3]. The feasibility of electrochemical phosphate recovery has already been proven on a laboratory scale using real cheese wastewater and non-precious metal cathodes (Figure 2, down). However, the following issues need to be addressed to scale up the technology:

1. Avoid chlorine evolution
2. Reduce the energy consumption of the cell
3. Reduce the cost of the cell
4. Find a suitable way to collect the product in continuum.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101034321.

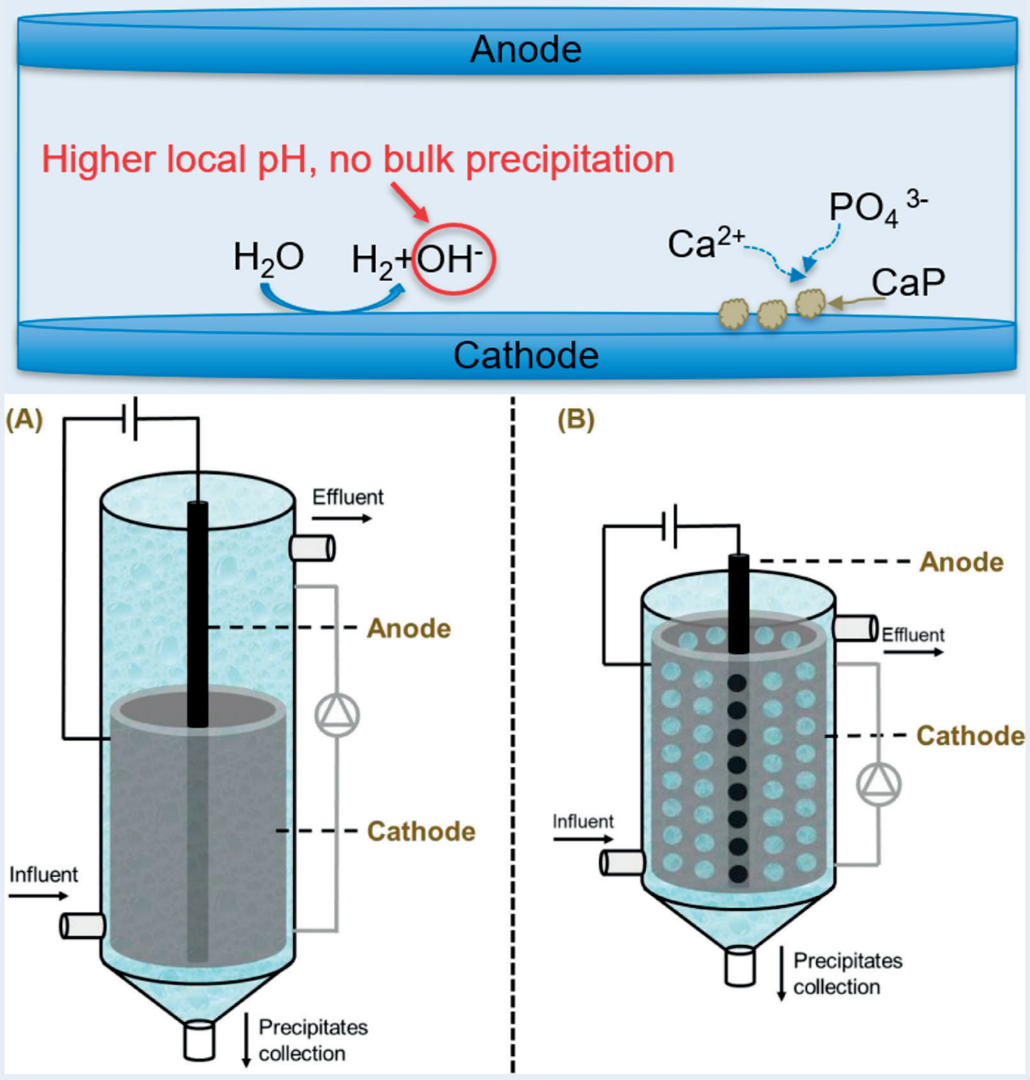

Figure 2. (Up) Schematic of the electrochemical cell for calcium phosphate precipitation. Adapted from Lei et al [3]. (Down) Design of prototype reactors. (A) The column-shaped electrochemical reactor consists of a non-open tubular stainless-steel cathode. (B) The column-shaped electrochemical reactor consists of a tubular stainless-steel cathode (35.4% open area). Adapted from [5].

Research goals

To develop a pilot to treat cheese wastewater with our industrial partners and finally extend its usage to other wastewater streams, the following research questions are proposed:

1. Are there ways to limit/avoid chlorine evolution and toxic product formation?
2. What are the suitable electrode materials that reduce both capital and operation costs?
3. What kind of cell design would allow for an effective and safe operation at the largest scale?
4. Can this technology be expanded to other suitable industrial wastewater cases?

References

[1] European Commission. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions on the 2017 List of Critical Raw Materials for the EU.; 2017.
[2] El Bamiki, Radouan, et al. "Phosphate Rocks: A Review of Sedimentary and Igneous Occurrences in Morocco." Minerals 11.10 (2021): 1137.
[3] Wang, Yicheng, et al. "Electrochemically mediated precipitation of phosphate minerals for phosphorus removal and recovery: Progress and perspective." Water research 209 (2022): 117891.
[4] Lei, Yang, et al. "Electrochemical recovery of phosphorus from acidic cheese wastewater: Feasibility, quality of products, and comparison with chemical precipitation." ACS Es&t Water 1.4 (2021): 1002-1013.
[5] Lei, Yang, et al. "Electrochemical recovery of phosphorus from wastewater using tubular stainless-steel cathode for a scalable long-term operation." Water Research 199 (2021): 117199.