Electrochemical nutrient recovery improvement and scaling prevention

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Motivation

Agricultural productivity depends on the use of nitrogen (N), phosphorus (P) and potassium (K) fertilisers. However, the conventional production of these fertilisers is energy and resource-intensive and these fertilisers end up in waste streams [1]. The production of fertiliser from (source-separated) wastewater, particularly through electrochemical systems (ES), offers significant benefits. ES can use renewable electricity and minimise the use of chemicals. Therefore, ES facilitate the recycling of nutrients to agriculture while minimising resource depletion and preventing environmental damage [2, 3].

Technological challenge

The concept is proven, however inorganic scaling on the membrane still limits the application of ES on a larger scale (Figure 1, Graphical abstract) [4]. This project aims to mitigate unwanted inorganic scaling within the ES by investigating integrated chemical-free solutions. Improvements in cell design and operation are required to enhance circularity. Therefore, the use of fresh acids such as sulfuric acid or nitric acid in ES to separate ammonia from the concentrate stream will be limited in this project (Graphical abstract). In addition, the possibilities of ES for producing innovative sodium (Na^+) and chloride (Cl^-)-free pure fertilisers for agricultural use, such as NH_4NO_3 and K-rich streams, will be investigated.

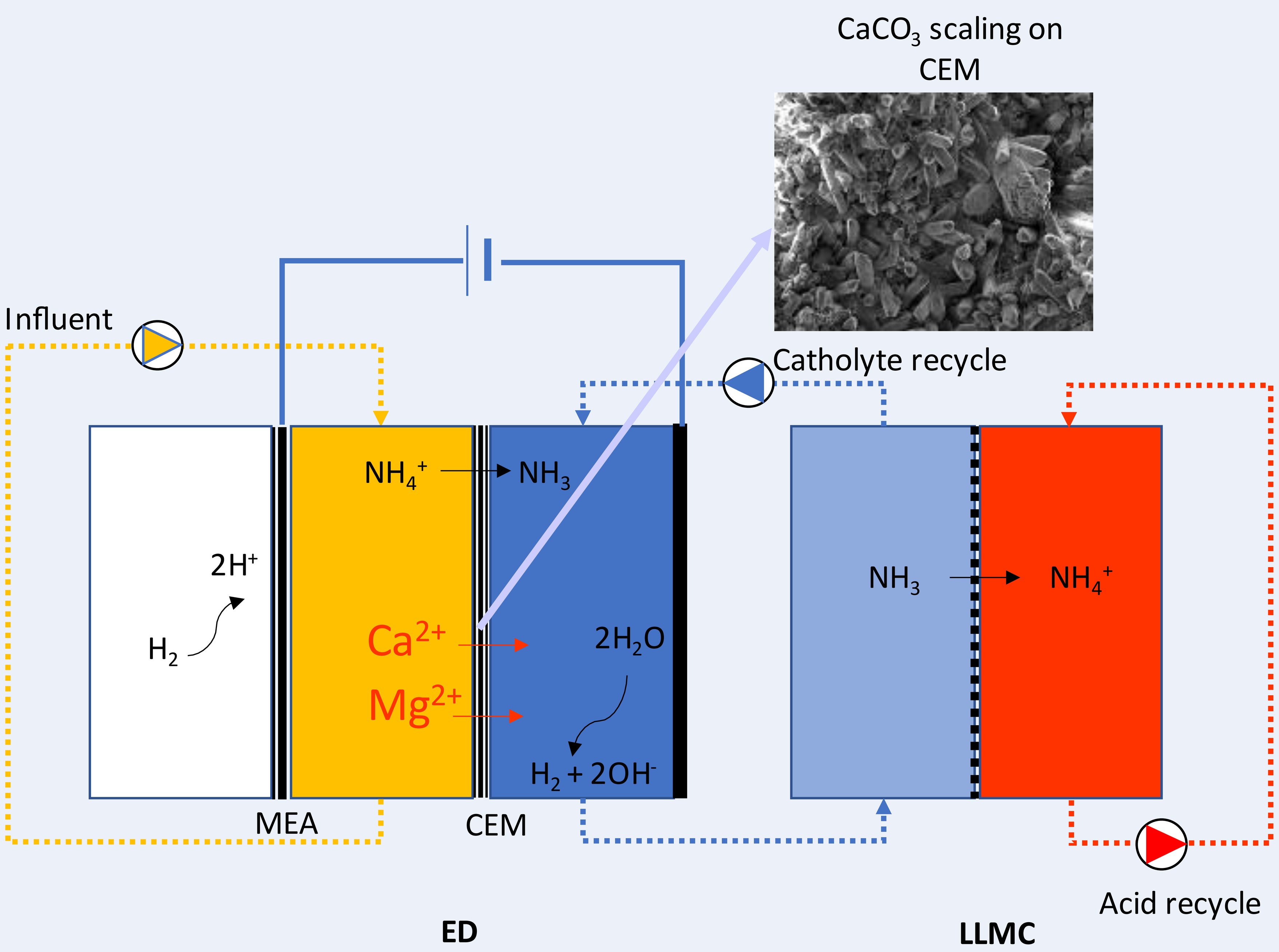
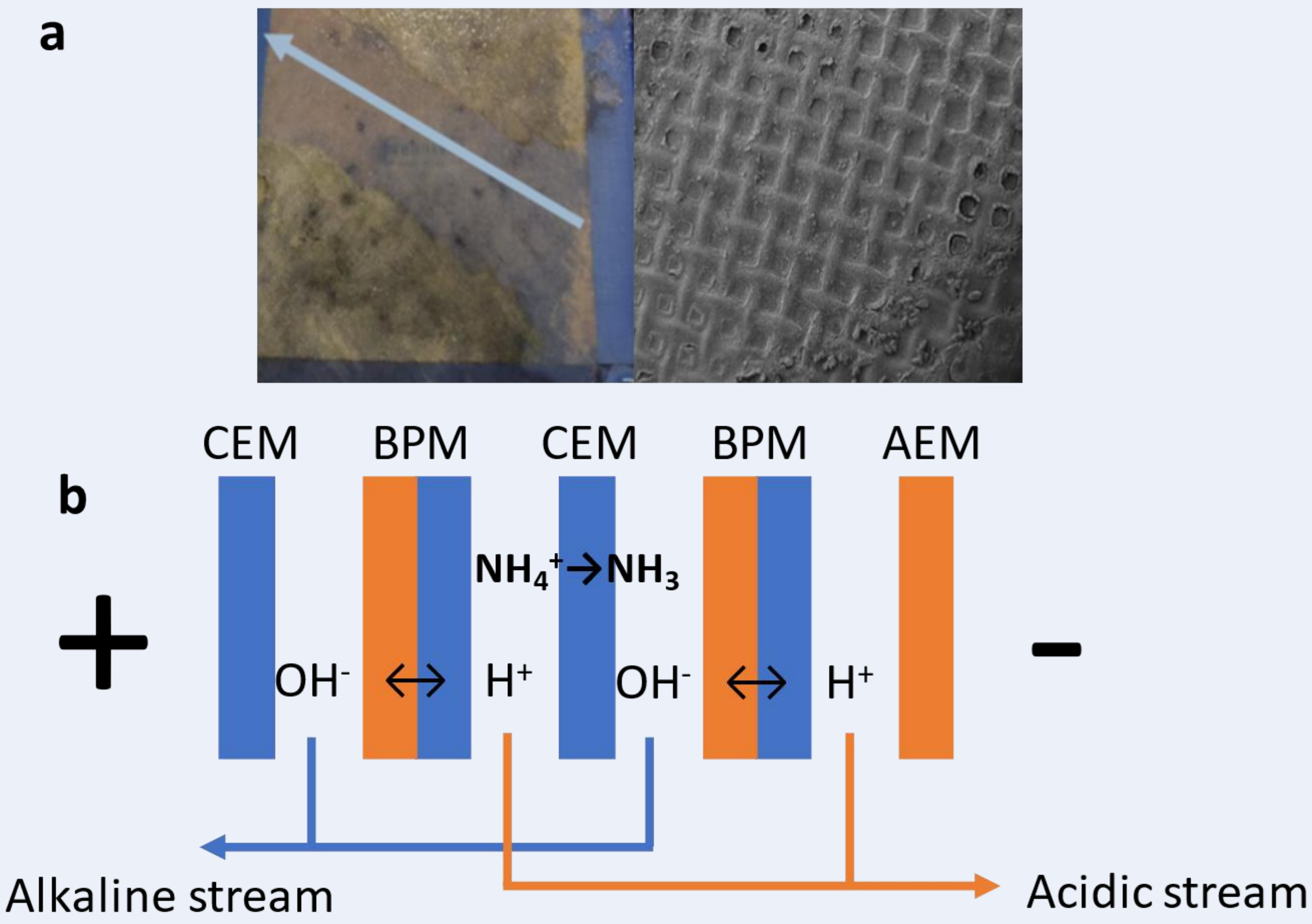


Figure 1. Inorganic scaling of CEM in ES ammonia recovery. MEA: membrane electrode assembly, CEM: cation exchange membrane, ED: electrodialysis, LLMC: liquid-liquid membrane contactor. Adapted from [4].



Graphical abstract. a. Inorganic scaling in CEM and spacers of ES. The arrow shows the direction of the flow. Adapted from [3] **b.** ES with possible production of acidic and alkaline streams. The possible use of these streams still needs investigation. AEM: anion exchange membrane, BPM: bipolar membrane. Adapted from [5].

Research goals

In order to further improve electrochemical nutrient recovery to allow its integration into (source-separated) wastewater treatment, and at the same time, enhance its application in agriculture, the following research goals are proposed:

1. Apply chemical-free solutions to prevent inorganic scaling in ES.
2. Develop a model to predict scaling formation and optimise inorganic scaling prevention inside ES.
3. Reduce the chemicals (acid/base) required during ES ammonium recovery.
4. Design ES to effectively produce ammonium and potassium fertilisers (free of Na^+ and Cl^-).

References

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