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PRACTICE ABSTRACT

TECHNICAL REPORT ELECTRODIALYSIS

Separation efficiency using electrodialysis to recover mineral concentrate from CAP

SHORT SUMMARY FOR PRACTITIONERS

EN version

Separating Nitrogen, Phosphorus, and Potassium (NPK) nutrients from carboxylic acids (CAP solutions) via Electrodialysis (ED) is proposed as the main research route to producing liquid bio-based fertiliser on the RUSTICA project. Recovering at least 90% plant nutrients (i.e., K^+, NH_4^+, NO_3^-, PO_4^{3-}, and SO_4^{2-}), concentrating the nutrients to 2-5 fold, and separating 80% of the 90% recovered nutrients from the Volatile Fatty Acids (VFAs) in the CAP solution have been the initial targets. The electrodialysis separating the nutrients from various fruits and vegetables such as paprika, leek, mango wastes, etc., named Gross Market Wastes and Allgro produced various liquid nutrient concentrates comprising 8403-22 728 mg/L K^+, 2703-14525 mg/L NH_4^+, 256-5385 mg/L NO_3^-, 727-2809 mg/L SO_4^{2-}, and 592-5744 mg/L PO_4^{3-}. About 90-99% of nutrient was recovered and concentrated to a maximum range of 7-15 fold. A separation efficiency of 47-70% was attained between the VFAs and the nutrients, indicating that 47-70%g/g of the VFAs was removed from the 90-99% recovered nutrients concentrate. However, due to the very low concentrations (200-400 mg/L) of NO_3^- and PO_4^3 in the CAP solution fed to the electrodialysis, their amount compared with K^+ is still limited. Hence, UGent is improving the electrodialysis to boost the nitrate and phosphate concentrations as close as possible to potassium. Overall, the findings suggest that it is feasible to recover and concentrate nutrients from the CAP solution via electrodialysis. However, the quality and quantity of the liquid nutrient concentrate strongly depend on the CAP solution.

SHORT SUMMARY FOR PRACTITIONERS

NATIVE version

Separating Nitrogen, Phosphorus, and Potassium (NPK) nutrients from carboxylic acids (CAP solutions) via Electrodialysis (ED) is proposed as the main research route to producing liquid bio-based fertiliser on the RUSTICA project. Recovering at least 90% plant nutrients (i.e., K^+, NH_4^+, NO_3^-, PO_4^{3-}, and SO_4^{2-}), concentrating the nutrients to 2-5 fold, and separating 80% of the 90% recovered nutrients from the Volatile Fatty Acids (VFAs) in the CAP solution have been the initial targets. The electrodialysis separating the nutrients from various fruits and vegetables such as paprika, leek, mango wastes, etc., named Gross Market Wastes and Allgro produced various liquid nutrient concentrates comprising 8403-22 728 mg/L K^+, 2703-14525 mg/L NH_4^+, 256-5385 mg/L NO_3^-, 727-2809 mg/L SO_4^{2-}, and 592-5744 mg/L PO_4^{3-}. About 90-99% of nutrient was recovered and concentrated to a maximum range of 7-15 fold. A separation efficiency of 47-70% was attained between the VFAs and the nutrients, indicating that 47-70%g/g of the VFAs was removed from the 90-99% recovered nutrients concentrate. However, due to the very low concentrations (200-400 mg/L) of NO_3^- and PO_4^3 in the CAP solution fed to the electrodialysis, their amount compared with K^+ is still limited. Hence, UGent is improving the electrodialysis to boost the nitrate and phosphate concentrations as close as possible to potassium. Overall, the findings suggest that it is feasible to recover and concentrate nutrients from the CAP solution via electrodialysis. However, the quality and quantity of the liquid nutrient concentrate strongly depend on the CAP solution.

Demonstration of circular bio-based fertilisers and implementation of optimized fertiliser strategies and value chains in rural communities

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 101000527

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TECHNICAL REPORT ELECTRODIALYSIS

Separation efficiency using electrodialysis to recover mineral concentrate from CAP

CONTEXT

One-third (1.3 billion tons) of food waste is generated annually worldwide. However, the rapid population growth increases the stress on food demands. Meanwhile, the depletion of inorganic phosphorus and potassium reserves for conventional fertilisers may cause a scarcity of inorganic fertilisers for food production. Therefore, the world is strategically transitioning to bio-based plant nutrients via fermentation using food wastes and other bio-based streams as sustainable feedstock, contributing to the loop of circular bio-economy.

PROBLEM

The very low plant nutrients, especially nitrate, phosphate, ammonium, and sulfate concentrations in the fermented food wastes (CAP solution), the complexity of the CAP solution, and the major presence of non-nutritional substances such as volatile fatty acids (VFAs), sugars, lactic acid, alcohols, and proteins limit the direct application of the fermented food wastes as bio-based fertilisers.

APPROACH

Innovative technologies are required to overcome these problems by increasing nutrient concentrations and largely reducing non-nutritional substances from the recovered nutrients. Electrodialysis is a competitive technology applied to recover and increase nutrient concentrations from fermented food wastes. It utilises an electrical current to transport and concentrate the nutrients from the fermented food wastes to water forming a liquid nutrient concentrate potential for bio-based fertiliser.

OUTCOME

1. The electrodialysis separated the plant nutrients from the CAP solution, producing various bulk liquid nutrient concentrates comprising 8403-22 728 mg/L K^+, 2703-14525 mg/L NH_4^+, 256-5385 mg/L NO_3^-, 727-2809 mg/L SO_4^{2-}, and 592-5744 mg/L PO_4^{3-}.
2. About 90-99% of nutrients were recovered and concentrated to a maximum of 7-15 fold.
3. A separation efficiency of 47-70% was achieved between the VFAs and nutrients, indicating that 47-70%g/g of the VFAs was removed from the 90-99% recovered nutrients concentrate.

PRACTICAL RECOMMENDATIONS

- The quality and quantity of the liquid nutrient concentrate depends on the CAP solution. Thus, ions such as Sodium, Chloride, and Lactic acid strongly compete with the plant nutrients during electrodialysis, hence reducing the quality of the liquid nutrient concentrate. Therefore, any additive containing Sodium and Chloride or generation of more Lactic acid compared to the nutrients must be avoided. Either Calcium or Magnesium concentration of more than 1200mg/L in the CAP solution must be avoided since they induce membrane fouling which increases the energy consumption of the electrodialysis

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