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Dual benefits of immobilised carbonic anhydrase: enhancing water quality and reducing carbon footprint in desalination processes

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ABSTRACT

The low mineral content in water produced by desalination processes can pose health concerns for those in water-scarce regions where it is the primary means of supplying drinkable water. Vital minerals such as calcium and magnesium are important to reintroduce to these water supplies via remineralisation processes. The conventional approach for the remineralisation of water is to contact demineralised water with natural Mg- and Ca-containing rocks. However, this process is slow and not well suited to industrial scale. Newer innovative methods apply CO_2 to generate carbonic acid in water in order to speed up the dissolution of these minerals. This not only serves to remineralise the water but also acts as a CO_2 sink. Carbonic anhydrase (CA), an enzyme that catalyses the reversible conversion of carbon dioxide and water into bicarbonate and protons, presents a promising addition to accelerate the dissolution of carbonate salts by speeding up the conversion of CO_2 into carbonic acid. This study aims to immobilise CA on solid supports to enhance its stability, reusability, and dissolution efficiency. Investigation into immobilisation on a textile support using chitosan proved successful, achieving 91% activity recovery and a CA loading of 0.661 mg CA/g textile. This method for CA immobilisation was then slightly scaled up and used in a continuous remineralisation setup. The results showed an improvement in magnesium dissolution from magnesite rock of more than 300% compared with the control setup without active enzyme. This technology developed here could improve the cost-effectiveness of CO_2-based remineralisation solutions for producing high-quality mineral water from desalinated water, addressing global water sustainability challenges.

Keywords: Desalination; Post-treatment; Magnesium; Carbon footprint; CO_2 capture; Remineralisation

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