Carbonic Anhydrase-Catalyzed CO_2 Sequestration in Seawater

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Motivation

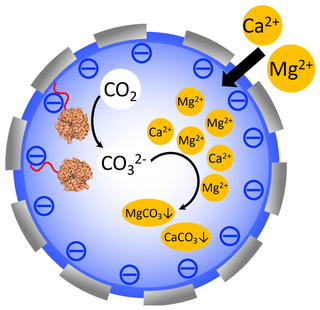
- Investigate the feasibility of carbonic anhydrases for overcoming the slow CO_2 and water combination in seawater
- Explore the potential of seawater in sequestering CO_2

Project Description

- Screen and identify carbonic anhydrase isomers that retain high activity under high-salinity conditions
- Determine the optimal conditions for carbonic anhydrase-mediated carbonate precipitation in seawater
- Improve carbonic anhydrase efficacy in seawater by modifying the enzyme microenvironment

Context

- The slow combination of CO_2 and water prevents sequestering CO_2 in seawater far from cost-viable
- Current processes require alkalifying seawater[1]
- We will minimize the environmental impact and reduce the cost of seawater CO_2 sequestration using carbonic anhydrase to overcome the slow kinetics of CO_2 hydration



A schematic illustration of a bionanoreactor for enhanced CO_2 sequestration. Carbonic anhydrases that convert CO_2 to carbonates[2] are encapsulated in a negatively-charged protein compartment, which concentrates mineral cations.[3]

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Develop a carbonic anhydrase-based **enzymatic** approach for sustainable **CO_2 sequestration** in **seawater**.

Project Deliverables

- A carbonic anhydrase isomer that efficiently converts CO_2 to carbonates in seawater
- An optimal condition of carbonic anhydrase-mediated CO_2 sequestration in seawater
- A bionanoreactor that encapsulates carbonic anhydrase for enhanced CO_2 sequestration
- Two journal articles and several conference presentations
- Preliminary data for standard NSF grant applications

Potential Impact

- Lead to a new potential gigaton-scale CO_2 sequestration strategy that will make significant contributions to reaching net-zero CO_2 emissions and alleviating global warming
- Provoke the expansion of current carbon anhydrase applications to more environmental matrices such as soil and surface water bodies, which will provide a suite of solutions for sequestering CO_2

References and/or Acknowledgements

1. La Plante, E. C.; Simonetti, D. A.; Wang, J. B.; Al-Turki, A.; Chen, X.; Jassby, D.; Sant, G. N. Saline Water-Based Mineralization Pathway for Gigatonne-Scale CO_2 Management. *ACS Sustainable Chem. Eng.* **2021,** *9*, 1073-1089.
2. Effendi, S. S. W.; Ng, I. S. The Prospective and Potential of Carbonic Anhydrase for Carbon Dioxide Sequestration: A Critical Review. *Process Biochem.* **2019,** *87*, 55-65.
3. Azuma, Y.; Bader, D. L. V.; Hilvert, D. Substrate Sorting by a Supercharged Nanoreactor. *J. Am. Chem. Soc.* **2018**, *140* (3), 860–863.