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Impact of salinity to microbial induced carbonate precipitation—a surface enhanced Raman spectroscopic approach

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Anthropogenically induced salinization is a concern for global freshwater and marine environments. Cyanobacteria are among the many microorganisms impacted by climate change as salinity increases in the environment, posing a threat to their role in global carbon cycling. While cyanobacterial physiology under salinity has been well studied, the impact of salinization on microbial-induced carbonate precipitation remains poorly understood. This study examines the impact of salinity on microbial-induced carbonate precipitation to better predict carbon dioxide (CO_2) sequestration and extrapolate potential shifts in the global carbon cycle in both freshwater lakes and marine environments. Surface-enhanced Raman spectroscopy (SERS) has the potential to enhance signals from microscale precipitates and to overcome background interferences.

We examined the biomineralization of calcium carbonate minerals by cyanobacteria under simulated saline conditions. A freshwater strain of *Synechocystis*, a marine strain of *Synechococcus*, and an isolated picocyanobacterial strain from Lake Geneva were exposed to saline and hypersaline conditions. A SERS protocol was adapted to monitor the precipitation and attachment of $CaCO_3$ to cyanobacterial cells. Further spatial and temporal changes to cell surface properties and water chemistry were monitored using scanning electron microscopy (SEM), ion chromatography, potentiometric titration, and inductively coupled plasma mass spectrometry (ICP-MS). Raman analyses indicated improved resolution of both cyanobacterial surface functional groups and detected $CaCO_3$ precipitates under salinity-induced stress. Raman mapping highlighted $CaCO_3$ precipitates surrounding the cyanobacteria. These findings provide insight into how salinity impacts the kinetics of microbial-induced carbonate precipitation. Changes to freshwater systems will have downstream impacts on long-term carbon sequestration and the expected carbon dioxide removal within these aqueous systems.