Advancing ureolysis driven mineral sealing strategies for environmental engineering applications

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Calcium carbonate precipitation induced through urea hydrolysis (ureolysis) has been widely investigated for use in engineering applications such as concrete remediation, wellbore integrity and CO_2 sequestration [1]. While much of the literature focuses on microbially-induced $CaCO_3$ (MICP) precipitation, the urease enzyme responsible for urea hydrolysis is synthesized by many organisms in addition to bacteria, including plants, algae and fungi [2]. The present study therefore aims to expand upon successful biomineralization sealing technologies through investigation of further urease enzyme sources for utilization under a wider range of environmental conditions. Expanding the range of temperatures, pressures and chemical conditions under which ureolysis driven mineral precipitation is applicable will allow for broader use in environmental engineering applications such as enhanced oil recovery, deeper wellbore integrity and coal combustion remediation.

While enzyme purification methods are abundant in the literature for sources of urease from plants such as jack bean, soy and pigeonpea, jack bean meal has been utilized as a lower cost, crude source of urease in initial permeability and kinetic studies. These experiments have been undertaken to determine high temperature abiotic $CaCO_3$ precipitation at temperatures in which traditional mesophiles utilized in MICP are unsuitable. Permeability has been shown to be reduced by one order of magnitude in sandstone cores subjected to jack bean, calcium and urea pulses at 60°C, while kinetic batch studies between 20°C - 80°C demonstrate that urea hydrolysis follows a first order rate with k constants between 0.07 – 0.60 mol l^{-1} h^{-1}. The fastest rates occur at 60°C with enzyme inactivation beginning to occur when jack bean has been exposed to 80°C for extended periods of time. At temperatures > 90°C thermally induced urea hydrolysis has the potential to be utilized for $CaCO_3$ precipitation while investigation into ureolytic thermophillic fungi for use at high temperatures is also being investigated.

[1] Phillips *et al*. (2013) *Biofouling* **29**, 715-733. [2] Krajewska (2009) *J. Mol. Catal. B: Enzym.* **59,** 9-21.