“Urease Immobilization for Advancing Enzyme-Induced Calcium Carbonate Precipitation Applications”

Zachary Frieling
M.S. Candidate, Thesis Defense
Chemical & Biological Engineering Department
Montana State University, Bozeman

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ABSTRACT

Microbially induced calcium carbonate precipitation (MICP) is a widely studied field of research exploiting bacterial activity to form a calcium carbonate precipitate that has been used to modify porous media. MICP is an enzymatically driven process and uses the enzyme urease to change solution chemistry to favor calcium carbonate precipitation. An enzyme slurry can be used in lieu of microbial growth and can be applied in a similar fashion and is commonly referred to as enzymatically induced calcium carbonate precipitation (EICP). For some applications temperature can stunt microbial growth and EICP may be the preferred method. However, as the temperature increases further the urease enzyme is thermally inactivated inhibiting calcium carbonate precipitation. Thermal inactivation limits the potential use of EICP in higher temperature environments. To combat thermal inactivation, immobilization of the urease enzyme through entrapment in silica gel and adsorption on an internally porous ceramic proppant was evaluated, and the first order inactivation coefficient (k_d) was determined for temperatures between 60°C and 90°C. It was found that immobilization of the urease enzyme drastically reduced the apparent k_d when compared to the free, non-immobilized form. Column experiments were performed using the urease immobilized on the ceramic proppant at room temperature (~23°C) and at 60°C. It was found that the immobilized urease retained high activity for the duration of the experiments even when subjected to the elevated temperature condition. The immobilized form of the urease enzyme was indeed protected from thermal degradation. It also seemed that the immobilized form of the urease enzyme was shielded from inactivation from active calcium carbonate precipitation, as observed in previous EICP and MICP experiments, in which ureolytic activity decreased rapidly as calcium carbonate precipitated. As a result, the immobilized form of the urease enzyme showed promise for advancing EICP applications.