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Modification of wettability and interfacial tension by biosurfactant-producing bacteria for geologic carbon storage

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Injection of carbon dioxide (CO2) into deep geologic formations has been widely proposed as an effective way for the permanent storage of CO2. Modification of the interfacial properties of CO2 in minerals by using surfactant has been proposed aiming on increasing the mobility of CO2 through porous media. Surfactants are proven to effectively alter the interfacial tension and wettability in both CO2/water/mineral system, improving the displacement and sweep efficiencies of CO2 in porous media. In the meantime, biosurfactants have been drawing much attention as an alternative to the chemical surfactants for their biodegradability, ecological suitability and low toxicity. However, the question as to the extent of microbial alterations in fluid wettability and interfacial tension under reservoir pressure and temperature conditions still warrants further investigation. Therefore, this study investigated the role of lipopeptide biosurfactant on wettability and interfacial tension alterations in a CO2/brine/mineral system for different CO2 phases during the growth of thermotolerant and barotolerant bacteria, Bacillus subtilis, and the production of lipopeptide biosurfactant, surfactin. Quartz, mica and carbonate substrates were selected and used as representative minerals. While monitoring the changes in the interfacial tension and wettability with pH, fluid samples were acquired from the brine phase, and the concentrations of glucose, nitrate, ammonium and surfactin in the acquired samples were quantitatively assessed using various assays and spectroscopic methods. As a result of surfactin production by B. subtilis, we observed the reductions in interfacial tension and increases in contact angle at all tested cases. The concentration of surfactin and the rate of wettability alteration differed with the experimental conditions. The modification of CO2 wettability was the greatest for liquid CO2 while the least of modification was observed for gaseous CO2. The obtained results allow in-depth assessment of the feasibility of using biosurfactant-producing bacteria for effective geologic carbon storage practices.

References

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