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Bacteria and surfactants for bio-cemented foams

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Microbially-induced carbonate precipitation (MICP) may be used to improve soil strength. The method relies on the total or partial saturation of the porous medium with a calcifying bacterial suspension. The project presented here focuses on filling the porosity of granular packings using bacterial liquid foam in order to achieve low liquid saturation. In addition to saving liquid, the foam would allow the bacteria to be strategically located, *i.e.* at contacts between grains, which is expected to improve the process.

However, this approach raises the issue of the compatibility of the bacteria with the surfactants used to stabilize the foam. The challenge is to maintain the ability of bacteria to induce carbonate (CaCO3) precipitation in their environment while evolving in a high content of surfactants. Most surfactants are used as cleaners. Although they commonly have antimicrobial properties, some of them are well tolerated by bacteria.

In this study, we focused on two families of surfactants: saponin and alkyl polyglucosides, i.e. CXM or CXG, with X = number of carbons, M = maltoside, and G = glucopyranoside. These surfactants were tested with two bacterial strains, namely *Sporosarcina pasteurii* (*SP*) and a strain similar to *Bacillus haynesii* (*BH*).

The choice of formulation was based on the study of several parameters: bacterial activity and growth, pH variation, and CaCO3 precipitation.
When monitoring the bacterial activity and growth of the two strains, samples with C8G or C10G showed much lower activities than those for the control sample (without surfactants). These surfactants inhibited bacterial growth and activity. On the other hand, for samples with C8M, C10M or saponin, bacterial activity and growth were substantially above those associate with the control sample. They increased the bacterial activity because the bacteria degraded these molecules, as revealed by high performance liquid chromatography. Therefore, it appeared that the response of bacteria to APG surfactants was highly dependent on the molecular structure of the APG: bacterial activity was optimal when the carbon chain was the shortest and the hydrophilic head was the largest. However, the experiments with C8M and the *BH* strain showed variations in pH towards an acidification of the medium, which was not suitable for the precipitation of CaCO3. The study of bio-carbonation in the presence of C8M (only with *SP*), C10M, and saponin surfactants showed a sufficient rate of calcification to consider consolidation of a granular packings. Combining all the results, the most convenient surfactants for the precipitation of CaCO3 were found to be C10M, C8M, and saponin.

Besides, the study of the liquid permeability of the foams confined into the porosity of the granular packings showed that APGs allowed for an easier delivery of the nutriments though the medium, as compared to saponin. Therefore, we provided all the information needed to approach granular column calcification tests.

Participation

In-Person

References

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