1D Simulations for Microbial Enhanced Oil Recovery with Metabolite Partitioning

We have developed a mathematical model describing the process of microbial enhanced oil recovery (MEOR). The one-dimensional isothermal model comprises displacement of oil by water containing bacteria and substrate for their feeding. The bacterial products are both bacteria and metabolites. In the context of MEOR modeling, a novel approach is partitioning of metabolites between the oil and the water phases. The partitioning is determined by a distribution coefficient. The transfer part of the metabolite to oil phase is equivalent to its "disappearance", so that the total effect from of metabolite in the water phase is reduced. The metabolite produced is surfactant reducing oil–water interfacial tension, which results in oil mobilization. The reduction of interfacial tension is implemented through relative permeability curve modifications primarily by lowering residual oil saturation. The characteristics for the water phase saturation profiles and the oil recovery curves are elucidated. However, the effect from the surfactant is not necessarily restricted to influence only interfacial tension, but it can also be an approach for changing, e.g., wettability. The distribution coefficient determines the time lag, until residual oil mobilization is initialized. It has also been found that the final recovery depends on the distance from the inlet before the surfactant effect takes place. The surfactant effect position is sensitive to changes in maximum growth rate, and injection concentrations of bacteria and substrate, thus determining the final recovery.

Different methods for incorporating surfactant-induced reduction of interfacial tension into models are investigated. We have suggested one method, where several parameters can be estimated in order to obtain a better fit with experimental data. For all the methods, the incremental recovery is very similar, only coming from small differences in water phase saturation profiles. Overall, a significant incremental oil recovery can be achieved, when the sensitive parameters in the context of MEOR are carefully dealt with.