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Mathematical model of microbiological oil recovery with wetting inversion by bio-surfactants

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Oil displacement by water which contains microorganisms able to produce bio-surfactants is one of the most promising methods of oil recovery. The bio-surfactant significantly reduces the surface tension and weakens the negative role of capillary oil trapping. The second effect caused by surfactants is inversion of wetting, which is even more important for oil recovery, since it allows separating oil from pore walls, making it non-wetting (in carbonate reservoirs). We develop the mathematical model of this process, which takes into account both mentioned effects. The model of wetting alternation is its key point. On the macroscale this effect leads to the modification of the relative permeability curves, which may be modeled by special kinetic relationships. The closure relationships for the characteristic time of wetting inversion has been obtained by modelling this process at the pore-scale. The numerical method of diffuse interface was applied to system water-surfactant-oil separated by a meniscus on a solid surface.
For the kinetics of bacterial population grow and decay, we suggest new nonlinear relationships, which enables to model various physiological stages, including the lag stage.
The results of modeling showed the appearance of regimes of self-organization manifested in the form of auto-oscillatory waves in time and in space.

References

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