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CFD simulation for miscible and immiscible viscous fingering formation for distinct injective fluids

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P. Saffman and G.I. Taylor investigated the Saffman-Taylor instability, also known as viscous fingering, which is the creation of patterns in a morphologically unstable interface between two fluids in a porous medium, mathematically for the first time in 1958. The most frequent occurrence of this circumstance occurs during enhanced oil recovery and drainage processes via porous or soil mediums. When a more viscous fluid is displaced by a less viscous fluid and injected at a relative speed through a porous medium, the interface becomes unstable and forms protuberances resembling fingers. Using COMSOL Multiphysics, we were able to visualize the formation of miscible and immiscible viscous fingers in a homogeneous porous medium by injecting various fluids, including water, carbonated water, and nano-brines (aluminum oxide, silicon dioxide, and magnesium oxide) during the enhanced oil recovery process. Nanopowders and carbon dioxide are miscible in both water and oil. It tends to reduce viscosity, improving mobility. This allows oil to flow more freely towards the production well. This study was done in a 2D Darcian frame for various injection log-mobility ratios. We captured the spatio-temporal evolution at certain times and discussed the results for each injective fluid. As a result, we can conclude that with nano-brines, we can recover more oil than with other methods and less oil when using water injection, according to the findings of the existing literature. Among nano-brines, aluminum oxide comes first, followed by silicon dioxide and magnesium oxide, respectively.

Keywords: COMSOL Multiphysics, Darcy law, Enhanced oil recovery, Log-mobility ratio, Miscible and immiscible viscous fingering

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