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Pore scale modeling and understanding of Kinetic Interfacial Sensitive tracer reactive transport process in immiscible two-phase flow in porous media

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The recently developed kinetic interface sensitive (KIS) tracer, which is designed to characterize the fluid-fluid interfacial area during dynamic multiphase flow process, has been tested in column scale experiments (Tatomir, 2018), and the uncertainties in resulting data shows necessity for pore scale study to further understanding of KIS tracer reactive transport process. A pore scale model is built with phase field method, which treat interface as diffuse layer with finite thickness. The model treats the governing Cahn-Hilliard equation, coupled with Navier-Stokes and solute transport equations. A time dependent adaptive mesh refinement technique is applied for saving computational resources. The model is first tested by simulation of bubble relaxation and co-current channel parallel two-phase flow. With selection of suitable values of mobility and interface thickness controlling factor, the simulation results show high consistency with analytical and literature results. Then KIS tracer reaction is simulated in the process of displacement of water phase by the oil phase. The simulations are performed on porous media composed of uniform distributed perfectly round spheres of diameter (d=200um) and of randomly distributed spheres of mixed sizes from 150um to 250um at various capillary number and viscosity ratio conditions. The measured concentration of KIS reacted product at outlet is used to back calculate the fluid-fluid interfacial area during the injecting process. In the case of the uniform distributed porous medium, KIS tracer can estimate the geometrically calculated fluid-fluid interface area. In fingering flow pattern, due to produced mass residue in trapped phase, KIS tracer is only targeting the mobile interface which relate to moving front of the intrude phase. The results of this research show that the KIS tracer method is measuring the mobile part of the fluid-fluid interfacial area. This confirms the initial assumptions of the method.