Modeling of Kinetic Interface Sensitive Tracers for Two Phase Immiscible Flow in Porous Media with COMSOL Multiphysics® Software

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Abstract

The understanding of the tracer migration in two-phase porous media systems and its reaction over the fluid-fluid interfaces is a challenging task important for a number of engineering applications, e.g. oil recovery, carbon capture and storage in geological reservoirs, remediation groundwater contaminations, etc.

This article describes the implementation in the COMSOL Multiphysics® framework of the mathematical model of two phase immiscible flow and a tracer transport in porous media, first introduced in (Tatomir et al., 2013).

The pressure-saturation formulation is chosen among two-phase flow formulations because it has the most advantages (Helmig, 1997). For closing the system of equations a relationship based on Brooks-Corey approach among capillary pressure, saturation and interfacial area formulation is used. The strongly coupled, parabolic system of partial differential equations is build using the coefficient form PDE interface. The hydrolysis of tracer at the fluid-fluid interfaces follows a pseudo-zero order kinetic reaction and is implemented with the solute transport interface. A verification is done by comparing the solution with one obtained using the Buckley - Leverett equation.

Two numerical simulations for two different spatial-scales are shown as examples. The model is first tested with respect to the sensitivity of different flow and transport parameters: permeability, porosity, and constitutional relationships. A second test investigates the breakthrough curves responses to the geometrical heterogeneity, kinetic rates and injection-shut off cycles.

Reference

Helmig, R., 1997. Multiphase Flow and Transport Processes in the Subsurface: A Contribution to the Modeling of Hydrosystems, 1st ed. Springer.
Tatomir, A., Maier, F., Schaffer, M., Licha, T., Sauter, M., 2013. Modelling of Kinetic Interface Sensitive Tracers for Two-Phase Systems, in: Hou, M.Z., Xie, H., Were, P. (Eds.), Clean Energy Systems in the Subsurface: Production, Storage and Conversion, Springer Series in Geomechanics and Geoengineering. Springer Berlin Heidelberg, pp. 65–74.