**A novel perfect-cross-flow capillary model for purely counter-current imbibition**

Spontaneous imbibition is a ubiquitous phenomenon in many practical situations. In this work, a novel perfect-cross-flow capillary model for counter-current imbibition is studied. It is assumed that fluid can flow without pressure loss between any capillaries that contain the same phase at a given location (Ruth, et al. 2002). In the model, the capillaries were saturated with oil at initial and water was imbibed into the tubes by capillary pressure from one end of the tube with any end sealed. The advancing rate of meniscus in different tubes, the imbibition rate and the pressure different capillaries were analyzed. The models with three tubes and fifty tubes were studied. In addition, the effect of water-oil viscosity ratios, interfacial tension, wettability as well as pore size distribution of capillaries on the spontaneous imbibition was analyzed. The calculated results show that water is always advancing faster in smaller tubes and oil is expelled from the largest tubes. The pore size distribution has great effect on the total rate of spontaneous imbibition and heterogeneity of the advancing distance in different tubes. Additionally, the viscosity ratios have a bearing on the heterogeneity of the advancing distance as well. This work can make a contribution to better understanding the mechanism of purely counter-current imbibition in porous medium with different heterogeneity.