Wettability Alteration of Microfluidic Rock-on-a-Chip Devices to replicate Reservoir Conditions

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Abstract

Glass-Silicon-Glass (GSG) micromodels are useful in research of multiphase displacement processes, because they provide visual access to displacement mechanisms and phase behaviour as well as reproducible results due to a fixed porous structure. They enable a faster screening of different chemicals and therefore reduce the number of core flood experiments. The micromodels can be designed to match a desired rock type with given grain geometry, porosity and permeability. In order to simulate in-situ reservoir conditions, p and T can be controlled during an experiment and the wettability altered in advance by chemical modification.

To alter the initial water-wet inner glass and silicon surfaces to oil- or mixed-wet, self-assembled monolayers (SAMs) provide a suitable approach. Due to a covalent linkage to the surface, they give thermally, chemically and mechanically stable layers. The chemisorption can be initiated thermally or photochemically, thus offering a patterned modification. The tail group of the applied adsorbate defines the properties of the resulting layer.

In the joint industry project DGMK 746/3, fluorinated silanes have been utilised for a durable and almost permanent wettability alteration to oil-wet. Modified micromodels can be operated in multiple microfluidic experiments at high temperatures and in highly corrosive environments. The molecules bind strongly to silicon and glass surfaces due to silicon-oxygen bonds with intramolecular cross-linkage and the fluorinated tail group defines its chemical resistance.

In this article, we will show the changes in contact angles of oil and water for the applied reagents and the results from microfluidic experiments with unmodified and modified GSG micromodels.