Experimental Investigation of the Influence of Nanoparticles Adsorption on Wettability Alteration for Berea Sandstone

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Abstract

Nanoparticles, as part of nanotechnology, have already drawn attention for their promising potential of increasing oil recovery. In the last few years, some publications have addressed this topic, but the basic enhanced oil recovery (EOR) mechanisms have not been released very clearly. Wettability alteration was proposed as an important EOR mechanism for nanoparticles fluids. In order to better understand nanoparticles adsorption behavior inside core and its effect on wettability alteration, a series of wettability index measurement experiments for oil wet, neutral wet and water wet Berea sandstone were conducted. The wettability index of core plugs without nanoparticles treatment and core plugs with nanoparticles treatment was measured by using Amott method. Both hydrophilic silica nano-structure particles (NSP) and hydrophilic silica colloidal nanoparticles (CNP) were utilized in above experiments. The results of wettability alteration experiments indicated that hydrophilic nanoparticles have ability of changing wettability of Berea sandstone to be more water wet, and basically the higher concentration the more water wet will be. And different type of nanoparticles has different effect on the wettability alteration process. At the same concentration CNP can make oil wet core more water wet than NSP for oil wet core. While in neutral wet condition, lower concentration NSP can alter wettability to be more water wet than CNP, but at higher concentration core treated by CNP has higher wettability index than NSP. The initial wettability of core plug also can affect adsorption of nanoparticles inside core. Nanoparticles adsorption inside neutral wet and water wet core is stronger and more than their adsorption in oil wet core. Based on observation of wettability alteration experiments, the mechanism of nanoparticles adsorption alteration wettability was proposed.

Introduction

Advantage of nanoparticles as novel EOR agent

1. Silica (SiO2), the main component of sandstone
2. Green material, environmental friendly
3. Small size, 1-100 nm
4. Easy to be surface functionalized
5. Cheap

Adsorption of nanoparticles in porous media

After hydrophilic or hydrophobic nanoparticle suspension is injected into porous media, five phenomena will occur: adsorption, desorption, blocking, transportation and aggregation of nanoparticles. Since the nanoparticles is Brownian particle, so five forces (the attractive potential force of van der Waals, repulsion force of electric double layers, Born repulsion, acid-base interaction, and hydrodynamics) will dominate the adsorption and desorption of nanoparticles on porous wall. Blocking will take place if the diameter of the nanoparticle is larger than the size of pore throat, or when some nanoparticles aggregate at the pore throat.

Material and experimental methods

Nanoparticles: hydrophilic silica Nano-Structure Particles (NSP) and hydrophilic silica Colloidal NanoParticles (CNP) were employed in this experimental study.

Nanofluids: various concentrations nanofluids (0.05 wt. %, 0.2 wt. % and 0.5 wt. %) were prepared by sonicator. 3 wt. % brine was used as dispersion fluid for nanofluid. The density and viscosity of nanofluid is similar with brine.

Oils: The oil used in WI measurement is decane, and the density is 0.73 g/ml.

Cores: In wettability index measurement 49 core plugs with wettability of oil wet, neutral wet and water wet were utilized. Average porosity and permeability are 19.5% and 334 mD respectively.

Experimental results and discussion

Conclusions

1. Hydrophilic nanoparticles have ability alter wettability of core to more water wet.
2. Different types of nanoparticles have different effect on wettability alteration.
3. Different core’s wettability also influence nanoparticles adsorption inside core and wettability alteration.

Reference


Figure 1. Left: ESEM image for adsorption of nanoparticle on porous wall (particle size about 100nm) Taked from SPE 123161. Right: Microscope image for adsorption of nanoparticles in glass micromodel.

Figure 2. TEM images of nanoparticles (left: NSP; right: CNP)

Figure 3. Nanofluid for NSP (left) and CNP (right)

Figure 4. Berea sandstone core plugs (left: oil wet; middle: neutral wet; right: water wet)

Figure 5. Amott test (left: spontaneous imbibition; right: spontaneous drainage)