DEVELOPMENT AND CHARACTERIZATION OF SURFACE-MODIFIED NANOPARTICLES USING FLUORINE-BASED CHEMICALS

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Abstract

Scientists have been using chemical treatment to change the wettability of near-wellbore region for condensate banking removal (1-5). However, this technique performed unsatisfactorily as the chemical treatment only reduces the surface energy without modifying the surface roughness and negatively affects the gas relative permeability (6). Hence, in the present study, an alternative surface-modified nanoparticle using fluorine-based chemicals was developed as a new wettability alteration agent since fluorine exhibits a high degree of water and oil repellency (7). The new wettability alteration agent was evaluated based on FTIR, DLS and TGA characterization. The results show that the surface of nanoparticles has been modified with fluorine-based chemicals coating and this is proven from: FTIR spectra with new peaks observed; DLS characterization with incremental size of surface-modified nanoparticles; and TGA with decomposition rate of coating agents. Implications of the results will path the way for future research direction in using fluorine surface modified nanoparticles as a wettability alteration agent.

Keywords: Nanoparticles, Surface Modified, Fluorine, Fluoroalkanoic Acid

Research Highlights

1. Nanosilica surface is successfully functionalized with fluoroalkanoic acid.
2. FTIR, DLS and TGA characterization confirmed the success of fluorine-surface-modified nanoparticles development.

Research Objectives

The synthesis of fluorinated-silica-nanoparticles using perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA) as a wettability alteration agent were reported for the first time in this paper. The method for synthesizing and characterizing is described in detail. It is believed that these fluorinated nanoparticles can improve the gas productivity by removing the liquid blockage near the wellbore.

Methodology

Fluorinated nanoparticles were prepared by dispersing 0.02 g of SiO₂ nanoparticles in 10 mL of ethanol, followed by adding 10 mL of mixture containing PFOA (0.02 g) and ethanol (10 mL) to the solution at room temperature. Then, the solution was sonicated for 30 minutes with temperature at 70 °C, above the melting point of PFOA and PFNA. This temperature is selected so that the fluorochemicals (PFOA and PFNA) could coat the nanoparticles easily above its

melting point. The experiments above were then repeated using different type of fluorochemicals, i.e. PFNA. Prior to characterization, the nanofluid – which is the coated nanoparticles suspended in ethanol – was then sent to oven at temperature above ethanol boiling point in order to remove any moisture residues with the nanoparticles. The end product of surface-modified nanoparticles after being dried is in a solid form (powder). This powder is then subjected to further characterization such as FTIR, DLS and TGA.

Results

FTIR spectra of the unmodified nanosilica and the surface-modified nanoparticles is shown in Figure 1. Characterization of unmodified nanosilica and fluorinated nanosilica by DLS is shown in Figure 2. Figure 3 showed the TGA analysis of the pure silica nanoparticles and functionalized nanosilica.

Figure 1: FTIR spectra of (a) unmodified nanosilica; (b) PFOA-modified-nanosilica; (c) PFNA-modified-nanosilica.

Figure 2: DLS of the unmodified nanosilica and surface-modified nanosilica.

Figure 3: TGA analyses of the unmodified and surface-modified nanosilica.

Findings

FTIR characterization showed several new peaks formed on the surface-modified nanoparticles compare to the pure nanosilica. This confirmed that a new bond has been formed on the surface of nanoparticles. DLS characterization showed the particles to be approximately 100 – 400 nm

in size and that the uniformity was maintained during the functionalization of the silica nanoparticles. Incremental size between pure nanosilica and surface-modified nanosilica indicated that the surface has been shrouded by the coating agent. TGA characterization, however, showed higher decomposition rate in functionalized nanoparticles compare to unmodified nanosilica. This indicated that the functionalized nanoparticles has thicker coating compare to the unmodified nanosilica.

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