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Editorial

Special Issue on "Nanotech for Oil and Gas"

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1. Introduction

Nanotechnology has important applications in many industries, including oil and gas. Research on nanotechnology applications in the oil and gas industry has been growing rapidly in the past decade. Nanotechnology has the potential to revolutionize the petroleum industry both upstream and downstream, and creates enormous opportunities for more efficient and effective oil and gas production. Essentially, the industry has been part of nanotechnology since the beginning because oil reserves are really emulsions of oil, gas and water in the nano- and micro-scale.

The development in nanoscience and nanotechnology has enabled the design, synthesis and application of nanoparticles, nanosensors and nanorobots, etc. in a rational way. They could become an integral part of the oil and gas recovery process, potentially improving every stage including exploration, drilling, production, enhanced oil recovery (EOR), transport, as well as refinery processes [1].

2. Nanotechnology and Nanomaterials Applications in the Oil and Gas Industry

The aim of this Special Issue is to report the latest research outcomes on nanotechnology and nanomaterials applications in the oil and gas industry. We aimed to collect research on the fundamental aspects and applications of nanotechnology in hydrocarbon detection, drilling and hydraulic fracturing fluids, enhanced oil recovery, oil well cementing, corrosion inhibition, formation fines control, geology, etc. In total 10 papers were accepted by this Special Issue.

The first paper by Agista et al. [2] provides a state-of-the-art review on the application of nanoparticles and nanotechnology in the petroleum industry. It briefly summarized nanotechnology application in exploration and reservoir characterization, drilling and completion, production and stimulation, and refinery. Thereafter, this paper focused on the application of nanoparticles in EOR. The different types of nanomaterials that have been studied in EOR were discussed with respect to their properties, performance, advantages, and disadvantages. The parameters that will affect the performance of nanoparticles in EOR, and guidelines for promising recovery factors were emphasized. The mechanisms of the effect of nanoparticles on the EOR processes were underlined, such as wettability alteration, interfacial tension reduction, disjoining pressure, and viscosity control.

Three papers focus on nanomaterials in drilling operations. The paper by Qiu et al. [3] applied amphiphilic (poly(styrene-methyl methacrylate-acrylamide)/nano-SiO_2) composite materials as a novel shale stabilizer for water-based muds, which possessed the advantages of both plugging capacity and hydration inhibition during the drilling operations. The nanocomposite only created slight variations on the rheological parameters of the water-based muds and showed a significant filtration control performance. The paper by Husin et al. [4], on the other hand, applied graphene nanoplatelets and silver nanoparticles (NPs) to a water-based mud. They demonstrated that the graphene nanoplatelet and the silver NPs increased the plastic viscosity by up to 89.2% and 64.2%, respectively, while both the yield point and the fluid loss values were reduced. The paper by C. Yu et al. [5] reported polystyrene-organo-montmorillonite (PS-OMMT) nanocomposite particles modified with an anionic surfactant, and its tribological properties as an additive to polyalphaolefin (PAO). They showed that the presence of OMMT can effectively reduce the average molecular weight and particle size of PS. Compared with pure PS, the PS-OMMT nanocomposites possessed higher stability during thermal decomposition and higher glass transition temperatures. The PAO systems incorporating the nanocomposite particles exhibited higher friction reduction and antiwear properties compared with pure PAO, and could improve drilling fluid lubrication.

One paper explores NPs for EOR applications. The paper by Abhishek et al. [6] studied the potential of different silica nanofluids as surface modifying agents for Berea sandstone. Surface modification of sandstone by silica NPs has net attractive potential with fines, leading to reduction of fines migration and improvement of water injectivity. They suggested that NPs could be utilized to overcome the problem of formation damage induced during low salinity flooding in sandstones.

The paper by Zhang et al. [7] reported a very interesting study on the application of red mud (RM) and $NH_4H_2PO_4$ composite nanoparticle powder in the suppression of gas explosion. The $NH_4H_2PO_4$/RM composite powders possessed considerable suppression properties on methane explosions. When the loading of $NH_4H_2PO_4$ reached 30% the maximum pressure and the maximum pressure rise rate of methane (9.5% premixed methane-air) explosions were decreased by 35.1% and 95.8%, respectively, and the time to reach the pressure peak was extended from 0.07 s to 0.50 s.

Three papers focus on the experimental study of pore structure characteristics, permeability and gas diffusivity. The paper by Fang et al. [8] applied mercury intrusion porosimetry (MIP) to study the pore size, pore volume and pore structures for different ranks of coal. The effective diffusion coefficients and permeability of differently ranked coals were theoretically deduced from MIP data. They showed that CH_4 diffusivity exhibits an increasing trend with the increase of permeability and porosity. The paper by Jiu et al. [9] quantitatively analyzed the pore size distribution and pore throat coordination number of tight sandstone by scanning electron microscopy (SEM) in combination with high-pressure MIP experiments. They reported that the permeability of tight sandstone increases with the average pore throat radius, sorting coefficient, median pore throat radius, and average pore throat coordination number, but decreases with the increase of the pore throat ratio. The porosity is positively correlated with the average pore radius and pore throat coordination number, but negatively correlated with the pore throat radius. The paper by Ji et al. [10] applied a combination of sophisticated characterization techniques, i.e., low-field nuclear magnetic resonance (NMR), SEM, MIP, and pulse-decay-permeability measurement to study the pore structure and permeability of different ranks of coal. The permeability was found to be related to the NMR porosity and movable fluid porosity. These studies provide fundamental basis for investigating the gas/oil reserves in tight sandstone and other unconventional reservoirs, and could have important implications for gas sequestration or gas production from enhanced coalbed methane recovery.

Lastly, the paper by Hou et al. [11] is a numerical study. They proposed a fully coupled model for describing gas flow in multiscale shale reservoirs by combining the effects of pore size distribution, stress-sensitivity, and adsorption/desorption. The proposed model was validated using traditional models as well as field data on gas production from Marcellus Shale. The model showed promising applications for analyzing various gas flow regimes in multiscale pores/fractures, and accurately evaluating in situ apparent permeability and the gas flow capacities of shale reservoirs.

3. Field Scale Application of Nanotechnology in the Oil and Gas Industry

The Special Issue has not been able to touch upon all aforementioned areas of application in the oil and gas industry. Therefore, more fundamental research in different areas need to be addressed. In addition, most of the work reported in this Special Issue was experimental work and limited to laboratory scale. Exploration work in bridging the gaps between research, development and implementation is required. To leap forward nanotechnology application in the oil and gas industry, field-scale tests are to be performed, even though the petroleum industry is known to be conservative. Fortunately, we are already witnessing this, e.g., Auroris Energy is conducting field test of nanomaterials application for EOR in Indonesia.

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