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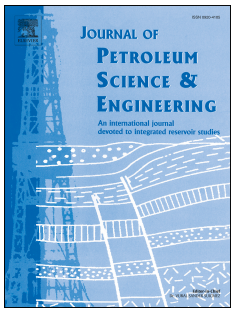

Nanotechnology for oilfield applications: Challenges and impact

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Nanotechnology for Oilfield Applications: Challenges and Impact

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Abstract

Nanotechnology is the design and application of engineered or naturally occurring nanoparticles with at least one dimension of the order of 1 to 100 nm to accomplish specific purposes. Nanoparticles possess three unique properties. First, their small size enables nanoparticles to be transported into formation pores not accessible to larger particles. Second, at nanoscale, material properties are sized dependent because of the large surface area to volume ratio. Therefore nanoparticles can be engineered to contain specific optical, magnetic, interfacial, electrical or chemical properties to perform specific functions. Combined together, these unique properties allow nanoparticles to be used for many purposes in the oilfield. The objective of this paper is to conduct a critical review of the recent literature to determine the status of research and development and field application of nanotechnology to the oilfield.

Most of the proposed applications of nanotechnology in the oilfield can be classified into the following six areas: (1) sensing or imaging, (2) enhanced oil recovery, (3) gas mobility control, (4) drilling and completion, (5) produced fluid treatment, and (6) tight reservoir application. Our review shows that much of the current research is focused on the performance of nanoparticles in the reservoir. Some work is done of the propagation of nanoparticles and very little work is done on the delivery and recovery of nanoparticles. Lack of well-defined health, safety and environmental protocols for safe delivery and recovery of nanoparticles can be a showstopper and more focused research is needed in this area. Our work also shows that affordability of nanoparticles is another showstopper due to the large quantity needed for oilfield applications and the current lack of vendors. As a remedy, we propose focused research and development on the use of naturally-occurring and industrial waste nanoparticles for oilfield applications. Of the six applications areas, we rank imaging, drilling through unstable zones and tight reservoir applications as having the biggest potential impact. Using nanoparticles to detect hydrocarbon saturation in a reservoir can significantly impact how we plan field development, such as well placement. Similarly, using nano-enhanced drilling fluid to stabilize and drill through unstable zones can increase rate of penetration, reduce drilling cost and minimize environmental impact. Furthermore, using specially-designed nanoparticles to image and prop up induced and naturally occurring fractures in tight reservoirs can lead to sweet spot identification and more prolific wells.

Introduction

Nanotechnology is the manipulation, control and integration of atoms and molecules to form materials, structures, components, devices, and systems at the nanoscale (Hornyak et al. 2009). One nanometer is 1 billionth of a meter (Fig. 1). A water molecule is about one-tenth of a nanometer. A glucose molecule is about 1 nm. So a nanometer approaches the size of molecules.