IMPORTANCE & APPLICATIONS OF NANOTECHNOLOGY

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Application of Nanotechnology in Enhanced Recovery Oil and Gas

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Published Online: Dec 14, 2020

eBook: Importance & Applications of Nanotechnology

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/

Abstract

In today's world, oil and gas are the most vital fuel needs of human societies. However, given the limited oil and gas resources in the world and the limited human ability to explore, produce and exploit hydrocarbon resources, the need to develop new technologies for scientific and practical development and Enhanced Oil Recovery (EOR) it feels. In the meantime, the new and unique nanotechnology has the capacity and potential to make significant changes in various oil and gas fields. In this chapter, the effects and performance of nanotechnology on Enhanced Recovery operations from oil and gas reservoirs in four main sections: The use of nano fluids, nanoparticles, nano surfactants and nano composite hydrogels and the efficiency of using nanotechnology in each field have been investigated.

Keywords: Enhanced recovery; Nano composite; Nano surfactants; Nano fluids; Nanoparticles.

Introduction

Global energy demand is projected to continue to grow, and although the use of alternative energy sources such as nuclear and renewable energy will increase in the coming years, this increase compared to Fossil fuels are scarce and the main role of renewable energy sources will be complementary and supportive for at least the next two decades [1-3]. Realizing the fact that global energy demand will reach its highest level in the coming years, the need for a scientific and practical transformation in the core of oil and gas engineering to increase productivity is felt more than ever. In the meantime, nanoscience as a science that aims to review the production structure of materials and optimize the process of production and exploitation of them, has the potential to create a great revolution in all current human technologies, including the exploitation of hydrocarbon resources [4-6]. And by using their vast capabilities, technologies that are more efficient and healthier than what we see today, Introduce. In general, nanoscience by improving the structure of matter in atomic dimensions and creating an optimal structure for materials, improves many properties such as useful surface, strength, saving the amount of material used and so on [7-10]. In the oil and gas industry, since the strength, stability and dimensions of the equipment used is very important, significant changes can be achieved using nanotechnology. As mentioned in one of the recently published articles, with the help of nanotechnology, the global oil and gas extraction coefficient is expected to increase by about 10% [11-14]. In order to respond to the growing demand for global oil and gas resources, either new hydrocarbon resources must be discovered and exploited, or using various technologies, oil and gas in place and without use in the reservoir under Exploitation processes should be exploited. However, due to the difficult conditions of exploration and protection of existing hydrocarbon resources, the use of the second method is more logical and principled [15-17]. Today, nanotechnology has made major advances in Enhanced Recovery oil and gas reservoirs. For example, the use of intelligent fluids or nanofluids that change the wettability of reservoir rock and reduce the tensile strength of drag and binders in the direction of sand bonding, or the use of surfactants that increase Enhanced Recovery the yield of the reservoirs are relatively fully controlled [18-20].

Citation: Kianfar E, (2020). Importance & Applications of Nanotechnology, MedDocs Publishers. Vol. 5, Chapter 3, pp. 16-21.

Stages of efficiency and production of hydrocarbon reservoirs

According to Figure 1, the hydrocarbon fluid is stored inside the reservoir and requires the use of different methods for extraction.

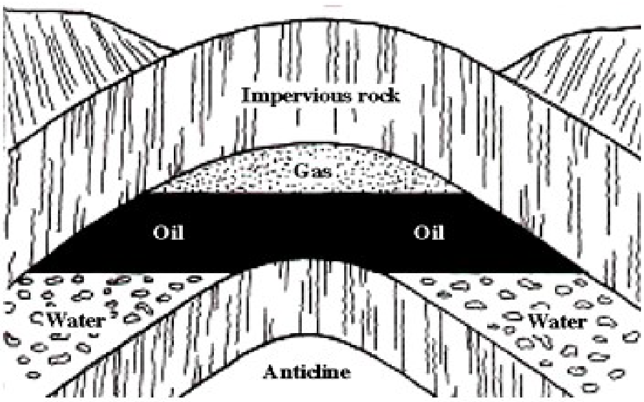

Figure 1: Storage of oil and gas in the reservoir [2].

According to Figure 2, there are different steps and methods for extracting fluid from the reservoir. In the Primary Recovery stage, the fluid is removed from the reservoir by natural pressure or by using an artificial lift [21-24]. Naturally, the natural pressure in the reservoir after a period of decline or from the beginning the need for help to expel fluid at this stage the gas is injected into the cap upper or injection of water into the Underground tablecloth, the Enhanced Recovery of container increase. However, if the reservoir pressure drop is felt due to a long period of operation and the fluid remains stagnant, it is necessary to use methods Enhanced Recovery or EOR. In this case, the commercially successful propagation methods are generally divided into three categories, in each category, different methods can be used [25-28].

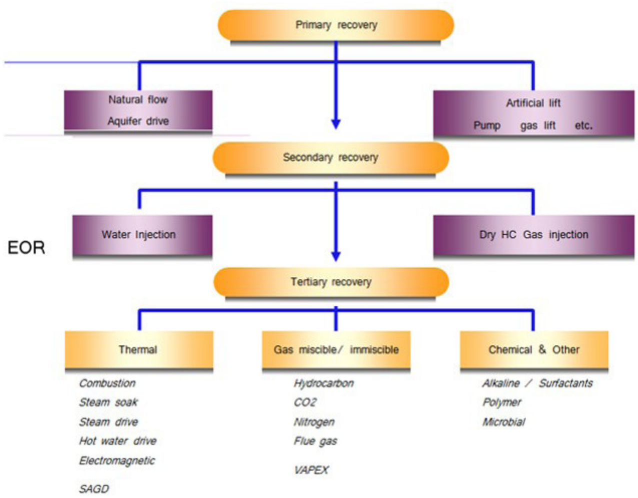

Figure 2: Stages of efficiency and production of hydrocarbon reservoirs or EOR.

General methods of enhanced recovery

Thermal enhanced recovery

This method involves applying heat to the reservoirs by injecting various types of steam, hot water, electromagnetic method, etc. and reduces the viscosity of heavy oil and its exit from the reservoirs [29-30].

Enhanced recovery using gas injection

In this method, by injecting insoluble gases such as natural gas, carbon dioxide and nitrogen that expand in the reservoir and cause fluid to move to the wellhead and also by injecting oil-soluble gases that reduce its viscosity, Because increase the Enhanced Recovery from the well [31].

Enhanced recovery using chemical injections

This method, also known as (CEOR = Chemically Enhanced Oil Recovery), tries to increase the extraction rate from the reservoirs by injecting chemical Enhanced Recovery and compounds. Since nano science has the ability to improve the properties of matter and create new chemical compounds, its significant effects can be seen in CEOR [32].

Enhanced recovery using nanofluids

Today, a new generation of fluids has been considered by researchers in the oil and gas industry, called nanofluids or smart fluids, and is obtained by adding nanoparticles with low volumetric concentrations to fluids to increase and improve their properties. One of the most important properties of nanofluids is that their properties are strongly dependent on the dimensions of nanoparticles in them [4]. Such intelligent fluids can improve the Enhanced Recovery process from reservoirs by altering wettability, reducing tensile strength, and sand strength. For example, Soleimanov et al. [4] were able to show that the use of nanoparticles increases the rheological properties as well as the effect of the surfactant solution in the oil extraction process and in the first place causes a change in the surface tensile strength of the oil-surfactant mixture [33-35].

Enhanced recovery using nanoparticles

Among the important applications of nanoparticles in this field are the use of nanomaterials to facilitate the separation of oil and gas inside the reservoirs and the use of nanodetectors inside the tank rock. These nanoparticles, when they come in contact with rocks containing crude oil, release their cargo and recycle the crude oil. Hong Kong Nanotechnology GP Company is one of the pioneers in the development of silicon carbide, a nano-sized ceramic powder. Using these powders, very hard materials can be produced. This mixture eliminates damage to the reservoirs wall in the well and increases the oil extraction capacity. Also, according to studies, one of the main applications of nanoparticles is to change the wettability of the reservoir rock. Resilience of a fluid-reservoir rock system is defined as the ability of one fluid to spread on the rock surface in the presence of another fluid. Wettability not only determines the initial distribution of fluid but is also a major factor in how fluid flows in the reservoir and plays an important role in oil and gas production. In general, hydrophilic reservoir rock is preferable to oil-friendly. Because in the case of oil-loving reservoir rock, oil tends to stick to it and reduce production. When the well is exploited, due to the damages to the formation, the reservoir rock may become oil-friendly, in which case the wettability of the reservoir rock can be well corrected by using nanoparticles. For this purpose, the effect of nanofluids on the wettability of carbonate rock as one of the main factors in overharvesting has been investigated in studies and ZrO_2, TiO_2, $CaCO_3$ and SiO_2 nanoparticles are used in this regard [36-37]. Ju et al. Also showed that the use of polysilicon nanoparticles could change the reservoir rock from petroleum to hydrophilic. According to transmission electron microscope images, polysilicon nanoparticles were observed on the cavity wall (Figure 3) [33,45].

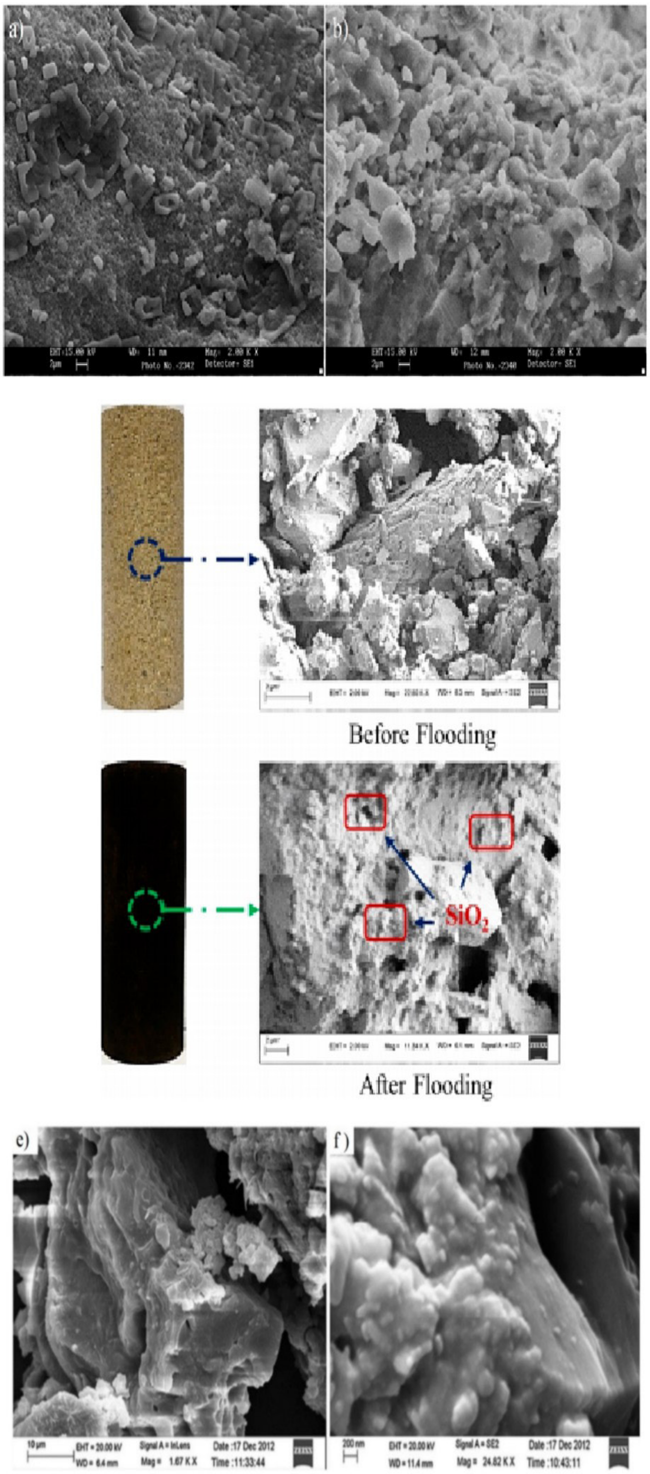

Figure 3: SEM images of sand samples with (**a**) 0.45 wt.% and (**b**) 0.90 wt.% clay NPs after polymer (**c**) Core sample before surfactant–polymer NP flooding, (**d**) deposition of NPs on the core sample after surfactant–polymer NP flooding (**e**,**f**) SEM images of core plug after flooding with NPs [33,45].

Enhanced recovery using nano-surfactants

Surfactants are derived from the word surface active agent in 1950, meaning surface activator, and refers to substances that reduce surface tension. These materials can be divided into bio-surfactants (biosurfactants), nanoscale surfactants (nanosurfactants) and polymeric surfactants based on the structure and production method. In fact, when these materials are dissolved in the solvent, they form structures with nanoscale to micrometer dimensions. These materials often consist of a hydrophilic head and a hydrophobic tail, and depending on the nature of their tail into categories: Nonionic or uncharged, anionic or negatively charged, cationic cationic) or amphoteric charge, which has both positive and negative charge (Figure 4). If the surfactant contains a hydrocarbon chain with less than one carbon atom gate, it is called a solvent in water. This is because the magnetic pole heads kill the whole molecule in water. However, when the length of the hydrocarbon chain is greater than fourteen carbon atoms, these compounds are called water-insoluble surfactants. Because they do not dissolve in water due to their long hydrocarbon chain. When the dimensions of the mentioned materials are in the range of less than 100 nm, they are called nanosorfactants. According to researchers, the activity of substances is related to their size and the level of their active surface. This phenomenon could indicate that the properties of surfactants (which are their surface activities) also increase significantly with decreasing dimensions. Normally, coating a surface with classic surfactants requires about 100 times more material than nanosorfactants! Also, the self-assembly of molecules in nanosorfactants is much better. One of the most important properties of surfactants is the disappearance of emulsions, ie small droplets and bubbles that form from one liquid to another. For example, when flooding operations with surfactants and polymers are used in tanks, water-oil emulsions are formed, which are re-used to separate them with various surfactants [8]. The primary purpose of using surfactants in increasing reservoirs is to reduce surface tension, correct the reservoir rock and reduce the viscosity of the oil. However, many of these materials are adsorbed in the initial intervals of the formation or have an adverse effect on wettability. Therefore, it reduces their effect in lowering capillary pressure. While the goal is to reduce capillary pressure and increase the permeability of the formation in Enhanced Recovery. Evidence shows that nanosurfactants reduce capillary pressure in the refractive zone and improve the flow of reservoir fluid in this area. Because when the dimensions of these materials are in the nanometer range, their ability to penetrate into the cavities and their active surface increases significantly [38-50].

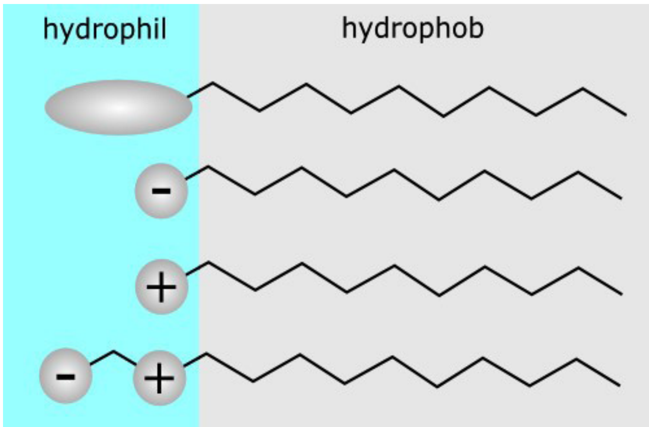

Figure 4: Types of surfactants based on the type of tail [7].

Enhanced recovery using nanocomposite hydrogels

According to studies, if the amount of water production along with oil increases due to the natural rift of the reservoir or increased water injection to increase the Enhanced Recovery and the well reaches the irrigation stage, then the ground facilities will not be able to separate water from oil. Therefore, after identifying the source of the gaps, gels or other methods should be used to manage the reservoir water. In this method, the cracks and the conical surface of the reservoir water are covered with gel, thus preventing the water from rising and rising too high in the reservoirs. In fact, hydrogels are hydrophilic 3D polymers that swell on contact with water but do not dissolve. Nowadays, the types of these materials that are used in the process of Enhanced Recovery can be referred to as polyacrylamide-based nanocomposite gels. Today, in order to increase the strength of the polymer gel network, nanocomposite hydrogels are used, which are abbreviated to NC gels. These gels have a strong tendency to absorb water while also showing high mechanical strength and thermal stability. In fact, polymer nanocomposites are a new generation of materials that contain a polymer matrix and a small percentage (less than 10% by weight) of a nanometer reinforce that are blended together in a convenient way. Nanoparticles due to their very small size and very high contact surface in the amount of loading meters improve the desired properties and issues related to common reinforcements, such as weight gain, surface defects and processing problems are less seen in them. These gelling systems include a water-soluble polymer and one or more of the main crosslinking agents. Also, these polymers can be injected into reservoirs with conventional pumps due to their water-like viscosity. They become stiff and play a role as a path reducer or blocker. In this method, due to the similarity of water viscosity and polymer gels, the cost of injection into the well is much lower than other methods. Also, the penetration depth of this type of gel is much higher than cement due to structural similarity with water; On the other hand, the strength and durability of this type of gels is more than ten times compared to ordinary gels in similar conditions. It should also be noted that these types of gels are not permanent and in case of incorrect injection, their effect can be neutralized with another chemical agent [42-47, 51-66].

Discussion & conclusion

This chapter reviews the applications and role of nanotechnology in increasing the Enhanced Recovery of hydrocarbon reservoirs. At first, the conventional methods of production and extraction as well as the increase of harvest were briefly examined and in each field, the aspects of improvement of each method were described by nanotechnology. This means that the problems in the industry, especially the oil industry, can be solved to a large extent by using nanotechnology - which is a new approach to the arrangement and structure of matter and improves its properties. As mentioned in the text with reference to reliable sources, the results of experiments conducted by researchers show that in the section of overdraft, using nanoparticles, nanofluids, nanosurfactants and nanocomposite hydrogels, the amount of in-situ fluid withdrawal in reservoirs can be greatly improved.

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