



# Enhancement of Heavy Oil Recovery by Nanoparticle/Microwave Application

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Around 70% of the total oil resources in the world are heavy. The primary heavy oil recovery is low due to the high viscosity and low mobility; hence, thermal enhanced oil recovery methods are widely applied to increase the oil production. In a conventional approach, oil is heated by different methods such as hot water or steam flooding and the heated oil is produced from a lower well by the aid of gravity. Different challenges such as high heat loss and low efficiency are faced in these conventional thermal recovery methods especially in deep reservoirs. Hence, novel, unconventional approaches such as electrical heating and electromagnetic heating methods are required to overcome these challenges. Achieving the optimum and cheap oil recovery by these methods is a critical task in petroleum engineering industry. To improve the performance of unconventional methods, nanotechnology can play an important role. Nano materials due to their high surface to volume ratio, more heat absorbance, and more conductivity can be used in a novel approach called nanomaterial/microwave thermal oil recovery to increase the oil production especially from deep, narrow formations.

In this work, several nanofluids prepared from nanoparticles such as  $\gamma$ -Alumina ( $\gamma$ -Al<sub>2</sub>O<sub>3</sub>), Titanium (IV) oxide (TiO<sub>2</sub>), MgO, and Fe<sub>3</sub>O<sub>4</sub> were used to enhance the oil viscosity reduction in the porous media under microwave assisted gravity drainage recovery mechanism. Different parameters such as water heat conductivity, water/oil emulsion viscosity, and oil mobility in the porous media were investigated during the application of the new method.

Our tests showed that adding nanoparticles can increase the absorption of microwave radiation in the oil/water system in the porous media. The magnitude of this increase is related to the type, particle size distribution in base fluid and, concentration of nanoparticles. Aluminum oxide nanoparticle was found to have the greatest effect on thermal properties of water. This nanoparticle made approximately 7°C improvement in the temperature alteration under microwave irradiation compared to the normal method. Also TiO<sub>2</sub> nanoparticle showed the best effect on the oil recovery at a low concentration of 0.05 wt. % during nanoparticle/microwave process. Hence, our experiments showed that besides other applications of nanotechnology in enhance oil recovery, heavy oil recovery can also be affected by nano materials.

