

## **The Effect of Nanoparticles on Enhancing Heavy Oil Recovery Using Microwave Assisted Gravity Drainage (MWAGD) Process**

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### **Abstract**

There are many heavy oil reservoirs around the world, which are, representing about 70% of the total oil resources in the whole world. The primary heavy oil recovery is low, so enhanced oil recovery (EOR) methods are needed. In most of the cases for recovering heavy oil, reducing the oil viscosity is the main mechanism, so thermal EOR methods are used. Conventional thermal EOR methods face many challenges in recovering heavy oil like high heat loss, low efficiency in thin reservoirs, and environmental problems. To overcome these challenges, unconventional thermal EOR methods such as electromagnetic heating methods are used. These methods have some limitations like low depth of penetration and high-energy consumption. Nanotechnology can be used to overcome the challenges of heavy oil production process by the unconventional thermal EOR methods.

In this study, nanoparticles were used to enhance the heavy oil recovery under Microwave Assisted Gravity Drainage (MWAGD) Process. Two types of metal oxides nanoparticles were used in this study that are Gamma Alumina ( $\gamma\text{-Al}_2\text{O}_3$ ) and Titanium (IV) Oxide ( $\text{TiO}_2$ ) at 4 different concentrations. Besides studying the nanoparticles effect on the recovery, the effect of water saturation on the oil recovery, the influence of nanoparticles (type and concentration) on the emulsion viscosity and the distilled water thermal conductivity were also investigated. The tests were done by using heavy oil sample of 19.35 API and glass beads as a porous media with an average porosity of 22.2%. The results showed that, as the water saturation increases, the oil recovery from MWAGD process rises with an optimum recovery at a water saturation of 30%. Also, each type of nanoparticles ( $\gamma\text{-Al}_2\text{O}_3$  and  $\text{TiO}_2$ ) has its own trend in affecting either the emulsion viscosity or water thermal conductivity.  $\text{TiO}_2$  nanoparticle has the greatest effect on the oil recovery at a low concentration of 0.05 wt.% during MWAGD process.

Our tests showed that, this method can be used to improve the performance of unconventional thermal methods for EOR.