# OPTIMIZING OIL RECOVER IN THR RESERVOIR BY NANOPARTICLES TECHNOLOGY ALUMINUM OXIDE ($Al_2O_3$) USED A SPONTANEOUS IMBIBITION TEST FOR SANDSTONE CORE

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## ABSTRACT

enhanced oil recovery (EOR). EOR consider as the last period for production operations. Where the EOR classify into many types such as thermal injection, gas injection, microbial EOR, and chemical flooding.

Chemical flooding is classified into many types such as polymer, surfactant, alkaline, and nanoparticles EOR such as Iron Oxide ($Fe_2O_3$), Aluminum Oxide ($Al_2O_3$), and Magnesium Oxide (MgO), etc. In this study Nanoparticles, EOR Aluminum oxide ($Al_2O_3$) were used to enhance the oil recovery.

The main objective of this paper is to use the Nanoparticles EOR ($Al_2O_3$) and know it is the effect on increasing the extraction of oil from cores. The big motivation for using $Al_2O_3$ is that it is easy to extract it from raw clay. Where the raw clay is available in Libya and using it will be more economic than using another method of chemical EOR.

Nanoparticles EOR Aluminum oxide ($Al_2O_3$) used a spontaneous imbibition test for sandstone core samples after saturation of crude oil. A spontaneous imbibition test consisting of two scenarios of nanoparticle solution ($Al_2O_3$) with change temperature and compared with one scenario of distilled water. The spontaneous imbibition test was performed in this study at room temperature to oven temperature (30C$^o$, 40C$^o$, 50C$^o$, 60C$^o$, 70C$^o$).

The results show that the process of improving the oil increases with the increase of the concentration of nanoparticles ($Al_2O_3$) and increases the temperature. The higher oil recovery was 76.04% at Nanoparticles ($Al_2O_3$) concentration 1 %. Finally, oil swelling and adsorption ( Nanoparticles with oil drops) have been noticed during the extraction of oil, thus the gravity force will be higher than the capillary force.

**Keywords:** Distilled Water; Aluminum Oxide; Reservoir Sandstone; Recovery Factor; Temperature; oil swelling; Spontaneous imbibition test.

## Introduction

The recovery of oil using natural production mechanisms is called "initial recovery". The initial recovery was the only method available during the early years of the oil industry and it is still the only method used in many oil fields. The basic reservoir energy comes from five mechanisms. (a) Solution gas- drive reservoir (b) gas-cap drive reservoir (c) water drive reservoir (d) combination drive reservoir (e) Gravity drainage reservoir. Some scientists believe that artificial lift methods are considered under primary recovery, and the artificial lifting methods are used when the pressure of the reservoir is reduced: ruptured spray pump, gas lift (continuous and intermittent), submerged electric pump, and hydraulic pump (Green & Willhite, 1998).

The second phase of hydrocarbon production is in which an external liquid such as water or gas is injected into the reservoir through the injection wells in the rocks that have fluid contact with the production wells. The purpose of the secondary recovery is to maintain reservoir pressure and displace the hydrocarbons towards the good hole. The most common secondary recovery techniques are gas injection and water immersion. Typically, the gas is injected into the gas cap and the water is injected into the production area to sweep the oil from the reservoir. The sequential use of primary recovery and secondary recovery in the oil tank produces about 15% to 40% of the original oil in place (Green & Willhite, 1998).

Tertiary Recovery (or EOR) offers any tank operation that is used to change rock/oil/saline reactions (fluid / liquid reaction; fluid/rock interaction) in the reservoir to increase oil recovery. This reaction may reduce surface tension, swelling of the oil, and reduce oil viscosity. Also adjust the wettability modification (Green & Willhite, 1998). These liquids may be mixtures of gases that can be mixed with oil such as carbon dioxide, nitrogen, steam, air, oxygen, polymer solutions, gels, polymer surface compositions, alkaline-efficient polymer compositions, or microorganisms (Chaumet, 1991). The following flow sheet shows the types of various EOR methods that are currently employed in the oil industry

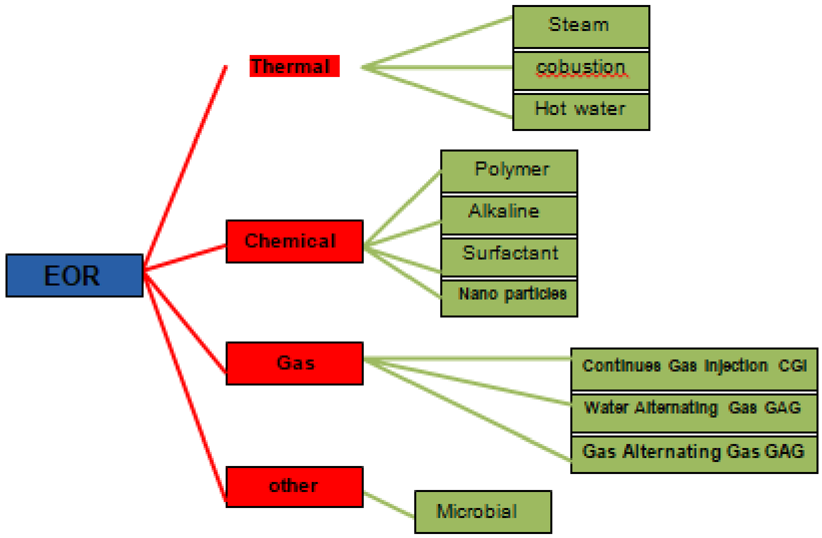


**Figure 1** Flow Sheet for EOR Methods.

of (Aluminum, Zinc, Magnesium, Iron, Zirconium, Nickel, Tin, and Silicon). It is therefore imperative to find out the effect of these nanoparticle oxides on oil recovery since this is the primary objective of the oil industry (Ogolo, Olafuyi, & Onyekonwu, 2012).

The application of nanotechnology in the oil and gas industry is just emerging. Recent research projects have shown that nanotechnology has the potential to solve or manage several problems in the petroleum industry. One of the speculated areas of application is enhanced oil recovery (EOR). The ability of nanoparticles to alter certain factors in the formation and in oil properties can be taken advantage of to enhance recovery. This involves introducing these nanoparticles into formations and studying their effect on oil recovery (Ogolo et al., 2012).

## MATERIALS

Aluminum nanoparticle particles (Al2O3) were used in this study. Sandstone samples were used after routine testing and distilled water. Light sweet crude oil was used (density: 0.8245, API: 40, viscosity: 5.6136 and Boris 3.5915 @ 25 ° C and @ 37.5 ° C, Sp.Gr @ 60/60Fo :0.8249). Aluminum strips were used to prepare the Al2O3 nanoparticle solution in the laboratory.

## METHOD

Core Sample Preparation. First, clean the basic sample. Second, dry the basic samples and weigh them. Third, saturate the cores with distilled water and weigh the cores. Fourth, bulk size measurement. Fifth, pore size measurement. Sixth, measure porosity. Seventh, dry the core sample and weigh the cores. Eighth, saturated cores with oil by using a vacuum pump and weight as shown in figure 3. Ninth, OOIP measurement. Tenth, porosity oil measurement

**Figure 3.** Saturated Samples. **Figure 2.** **Vacuum Chamber During Run Vacuum Pump with Oil**

### Preparation of the Aluminum Hydroxide Al(OH)3 Nano Particles.

Aluminum hydroxide Al (OH)3 was prepared by using strips of very pure aluminum foil (99.9%) purity as shown in figure 4, the strips surfaces were firstly cleaned up by brushing it and washing it several times by bi-distilled water to get rid of the oxidized aluminum surface. Secondly, the strips were degreased with acetone and thoroughly rinsed with bi-distilled water. next, they were amalgamated by immersion for 10 sec.in Hg2Cl2 ( BDH Chemicals Ltd. Poole, England). The aluminum strips were then placed in a backer (5L) containing bi-distilled water and adjusted to PH = 9.

Ammonia gas was passed through the suspension with stirring in the N2 gas atmosphere. N2 gas atmosphere was used to prevent the oxidation of aluminum strips. After exposure period needed for complete (15 days) dissolving the strips at room temperature, during which the PH was kept constant by adding ammonium hydroxide solution ($NH_4OH$). The precipitate was filtered and washed several time with hot-be distilled water to remove the excess of ammonia the precipitate after that, dried at 120 Co for 24 hrs. The dried precipitate was $Al(OH)_3$. The precipitate Al $(OH)_3$ was then burned into the Burning Furnace at a temperature ( of 1000 Co to 1200 Co) for 2hr until aluminum hydroxide converted $Al_2O_3$ and becomes white. This method has been applied at Sebha university and also X-ray Diffraction and IR spectroscopy have been done in another research to make sure that the nanoparticles of $Al_2O_3$ can be obtained by following this method (Hafsa Ahmed, 2013).

**Figure 4.** Strips of Very Pure Aluminum

The Spontaneous Imbibition Test. Weight of nanoparticle powder, powder particles divided into two parts to calculate the concentration of quantitative powder nanoparticles, concentration of (1.2g) = 1 %, concentration of (0.6g) =0.45%. The number of nanoparticles was limited, thus two scenarios could be conducted for this study.

$$\text{Amount of } (Al_2O_3) = \frac{(wt\ \%)*(distillate\ water\ with\ liter)}{(100 - wt\%)}$$

Put each of the powder of nanoparticles $Al_2O_3$ in a cup and mix it with distilled water, take the nanoparticle solution with a sample and place it in a graduated tester, raise the temperature at room temperature to oven temperature (30 Co, 40 Co, 50 Co, 60 Co, 70 Co) and take the result of oil recovery on many times until constant result, and calculate oil recovery. as shown in fighter (5).

**Figure (5).** Graduated Tester That By Distillate Water &($Al_2O_3$)

## RESULTS & DISCUSSION

Effect of distillate water, with time, and temperature on oil spontaneous imbibition test for these basic core samples have been used by the water-distilled recovery for core sample. In this study we have used basic core samples of sandstone, the spontaneous imbibition test for these basic core samples has been used by the water-distill without properties change, the basic core samples used are (S- 001), and after the distilled water displaced of the oil is present in the core sample, For the recovery of oil at the beginning of this experiment very low at room temperature ( 25 Co) for 24 hours was (13.55%), then the temperature has been increased to (30 Co) for 24 hours, a slightly increased has been noticed in oil recovery and it was (18.06%), And then increased the temperature to (40 Co) other 24 hours, the oil recovery rate was (30.11%), and continued to increase the temperature to (50 Co) other 24 hours, the recovery rate of oil was (45.16%), then the gradual temperature has been increased to (60 Co) for 24 hours where oil recovery has been increased to (58.69%). Finally, the temperature has increased to (70Co) for 24 hours and the rate of increase was at (70.75%)

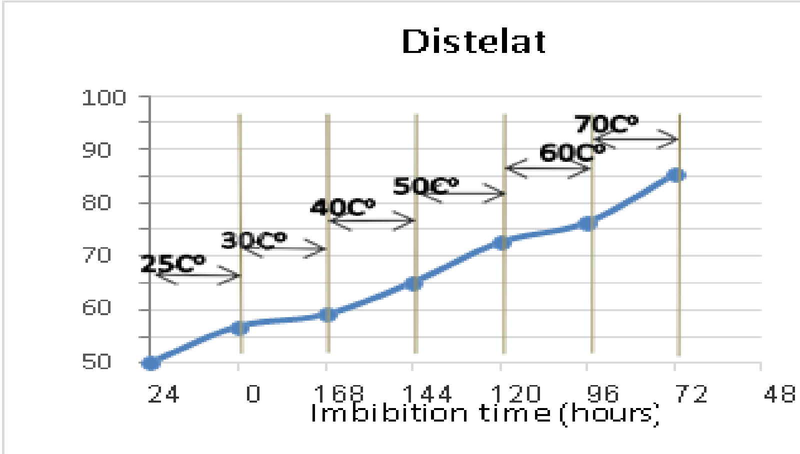


**Figure (6):** Effect of Distelat Water on Cumulative Oil Recovery for Sandstone Core Samples with Time and Temperature

## Effect of Nanoparticles (Al2O3), with Time, and Temperature on Oil Recovery for Core Sample

First Scenario at Constriction 0.45% @ weight nano Al2O3 (0.6 gm). In the first scenario, we used basic sandstone core samples, and the spontaneous imbibtion test for these basic coresamples was used with the nanoparticlas solution (Al2O3) at conctriction 0.45% representing ----0.6 g of the nanoparticlas powder (Al2O3) ,the sample used for this test is (S-004), we observed the penetration of the nano powder into the sample pores and where it reduced of the oil viscosity, the oil recovery at the beginning of the experiment at room temperature (25Co) for 24 hours was very low at (14.26%), then we increased the temperature to (30 Co) for another 24 hours, the temperature has been slightly increased in oil recovery to (23.25%), and the temperature was increased to (40Co) for another 24 hours and the recovery rate of oil was (38.75%), and we continued to increase the temperature to (50Co) for another 24 hours the recovery rate of oil was (52.70%), and then the temperature was increased gradual to(60 Co) for another 24 hours and the oil recovery was (60.45%),where we reached temperature (70Co) for another 24 hours and the rate of increase was very high the cumulative recovery and it was (74.40%) as showing in figher (7)

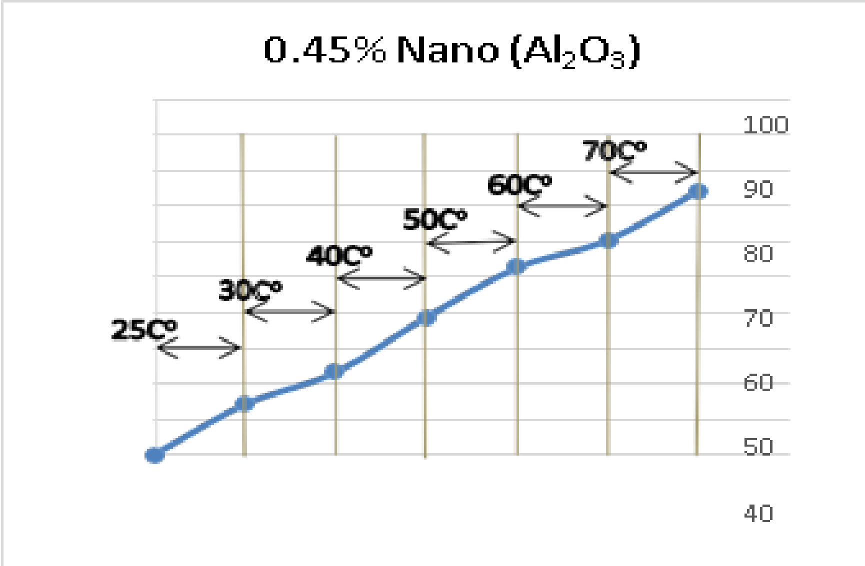


**Figure (7):** Effect Al2O3 Constriction 0.45% of on Cumulative Oil Recovery For Sandstone Core Samples with Time and Temperature

Second scenario at constriction 1% @ weight nano Al2O3 (1.2 gm). In the second scenario, we used basic sandstone core samples the spontaneous imbibtion test for these basic core samples was used with the nanoparticlas solution (Al2O3) and increased the concentration to 1%, which represents 1.2 gm of the nanoparticlas powder (Al2O3), the sample used for this test is (S-009), the penetration of the nano powder into the core sample pores has been observed and where oil sweilling has been noticed, the oil recovery at the beginning of the experiment at room temperature (25Co) for 24 hours was (12.07%), then the temperature was increased to (30 Co) for another 24 hours, oil recovery was at (30.17%), and then the temperature has increased to (40 Co) for another 24 hours and the recovery of oil was (44.66%), and we continued to increase the temperature to (50Co) for another 24 hours the recovery of oil was (54.31%), and then the temperature was gradualy increased to (60 Co) for another 24 hours and the oil recovery was (62.76%), while during the temperature at (70Co) for another 24 hours the oil recovery was (76.04%) as showing in figher (8).

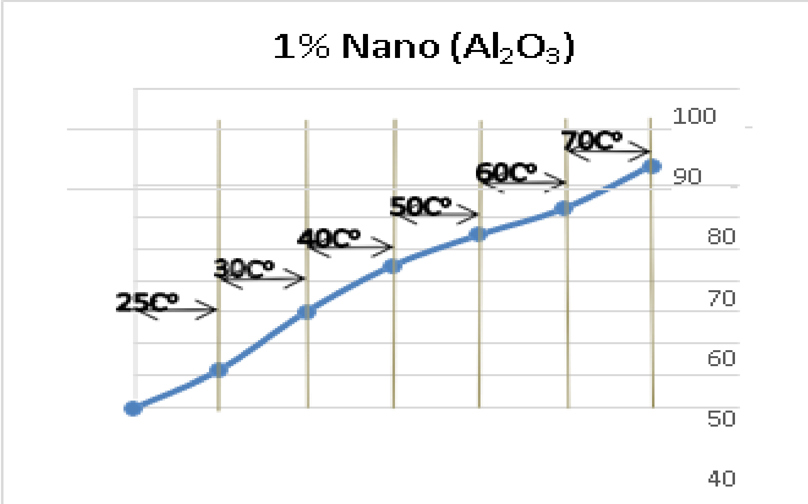


**Figure (8):** Effect Al2O3 at Constriction 1% of on Cumulative Oil Recovery for Sandstone Core Samples with Time and Temperature

The nanoparticles have been proved that can absorb the oil droplets especially at a temperature of 25 Co to 40 Co, consisting of grains (Al2O3) containing oil. Thus, the nanoparticles can make the gravity force higher than the capillary force and that is will help the oil drops to recover.

When the temperature is higher than 40 Co, there is an increase in the size of grains (Al2O3) of the nanoparticles. When the temperature is increased to 60 Co and 70 Co, the nanoparticles have been separated from the oil droplets.

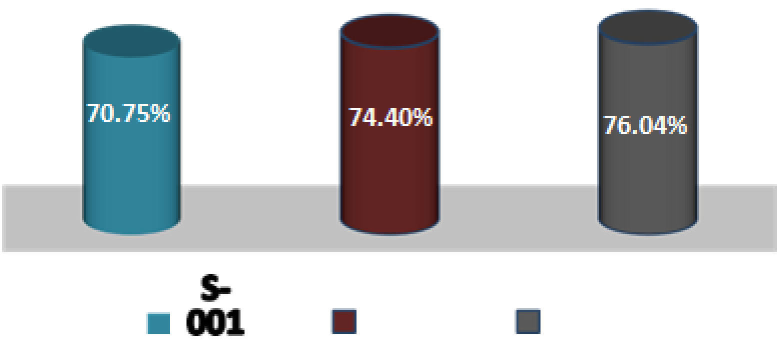


Figure (8) Comparison between oil recoveries for sandstone core Samples

## Conclusions

The conclusions reached after this study are :

✓ Nanoparticles of ($Al_2O_3$) scattered in distilled water have the potential to improve oil extraction is to get the best oil recovery from rock.

✓ Whenever the higher the concentration of ($Al_2O_3$), where the higher the recovery rate.

✓ Nanoparticles of ($Al_2O_3$) scattered in distilled water have a capacity of oil absorption and adsorption and that will help to enhance the oil recovery.

## Recommendations

In this study we recommend that you consider the following :

❖ Should be knowing the information of the properties of nanoparticles and the factors that affect them.

❖ Use another type of reservoir rock such as carbonate rocks and compare them with sandstone rocks.

❖ Use of another type of nanoparticle and test its ability to extract and recover the oil from the rock.

❖ Should be used large quantities of nanoparticles in the spontaneous imbibition test obtain the best results

❖ The use of any other type of crude oil with the different combinations of oil and know its viscosity.

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