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Comparative Analysis of Ethanol and Magnesium Oxide Nanoparticles for Enhanced Oil Recovery

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Abstract

In recent years, enhanced oil recovery (EOR) has gained global attention as a promising technique for recovering trapped oil in reservoirs after primary recovery. This study describes EOR experiment, conducted in the laboratory using ethanol and magnesium oxide to ascertain the extent to which it can increase production of oil in depleted reservoirs. Ten litres of crude oil were added to 5g, 10g, 15g, 20g and 25g of ethanol and magnesium oxide nanoparticles respectively. A perfect mixture of same concentration was gotten using Ethanol impregnated with Magnesium oxide nanoparticle (MgO). The crude sample was poured into a typical reservoir model prototype to a volume of 10 litres. The valves and adjustable clips were properly tightened and fastened to maintain pressure and also to prevent blowout. EOR using gas flooding (nitrogen gas) was released into the reservoir prototype with inlet pressure of 1bar and the outlet pressure at 18psi for a period of 10seconds.The result shows that ethanol impregnated with magnesium oxide at 5ml and 5g yielded the highest oil recovery at 9.7 litres followed by ethanol impregnated with magnesium oxide at 10ml and 10g, and at 20ml and 20g which recorded oil recovery at 9.3liters and 9.3liters respectively. The least oil recovery was 7 litres at 15mil of ethanol. The findings from these experiments suggest that nanoparticles serve effectively as EOR agents, and that ethanol can improve their performance.

Key words: Enhanced Oil Recovery (EOR), Oil productivity, Magnesium Oxide, nanoparticles, Ethanol

1.0 Introduction

Global energy consumption is predicted to rise by 30% between 2010 and 2040 (Karatayev et al., 2019). Additionally, it is predicted that oil consumption will reach 111.1 million barrels per day by 2040 (Zhang et al., (2020). Improving oil recovery from the diminishing oil reservoirs has become increasingly crucial due to the depletion of oil supplies and the rise in energy demand brought on by population expansion and rapid industrial development (Joshi et al., 2015). Primary, secondary, and tertiary phases are the three primary stages of the oil recovery process. The primary and secondary stages are known as the traditional methods of oil extraction in the petroleum industry. Secondary oil recovery is used to force more crude oil out of the reservoir using pressure maintenance methods like gas injection and waterflooding once primary oil recovery is no longer practical (Haq et al., (2020b) (Haq et al., 2020a). Conversely, the tertiary phase is commonly known as enhanced oil recovery (EOR) (Pogaku et al., 2018). Continuous extraction of oil leads to a reduction in the pressure gradient within the reservoir, resulting in a decline in oil production rates, consistent with Darcy's law (Höök et al., 2014). EOR involves a variety of operations such as chemical flooding (Brantson et al., 2020) (Jin et al., 2020), gas injection (Song et al. 2020) (Yu et al., 2020), microbial recovery (Nikolova and Gutierrez, 2020) (Niu et al., 2020) and thermal recovery (Doranehgard and Siavashi, 2018) (Mokheimer et al., 2018). The various enhanced oil recovery (EOR) operations are designed to enhance overall oil displacement efficiency, which is influenced by both microscopic and macroscopic displacement efficiencies (Kumar and Mandal, 2017b) (Riahinezhad et al., 2017). One or more of the following factors are influenced to bring about such an improvement: viscosity of oil (Zhu et al., 2018), rock wettability (El-hoshoudy et al., 2017), interfacial tension (IFT) (AfzaliTabar et al., 2020) and capillary forces (You et al., 2018) in addition to changing the displacing and displaced fluids' mobility ratio to more advantageous values (Haruna et al., 2020). EOR helps to increase recovery rates, prolong the useful life of fields, and maximize recoverable oil reserves.

The study of controlling matter at the nuclear, atomic, and super molecular nanoscales—roughly 1–100 nm—is known as nanotechnology. Unique optical, magnetic, electrical, and chemical characteristics are found at the nanoscale (**Hamad et al., 2020).** Compared to large-scale materials of the same mass, nanomaterials have a greater surface area. Their volume concentrations are high.

Recent research indicates that a number of problems facing the petroleum industry may be controlled or resolved by nanotechnology. Recovery can be improved by using nanoparticles' capacity to change specific aspects of the formation and the characteristics of the oil. This entails putting these nanoparticles into formations and observing how they affect the recovery of oil (Ogolo et al., 2012).

Ethanol serves as an effective dispersing agent, characterized by its solubility in formation water, low volatility, high boiling point, and low toxicity. These properties ensure that it aligns with our commitment to environmental safety. Ethanol has certain physical characteristics because of its hydroxyl group, which causes it to mix with some polar substances like water and some non-polar fluids like light hydrocarbons (Onyekonwu and Ogolo 2010).

2.0 Materials and Methods

2.1 Equipment and Materials Used

- Viscometer
- Air coolant
- Heater Control (Pensky Martens model)
- Test-tubes
- Thermometer
- Heat thermometer
- 50mil and 25mil Pycnometers
- Weighing meter
- Spatula
- Crucible
- Beaker graduated cylinder
- Masking tape
- Stopwatch
- Pressure compressors
- Buckets and drums
- Stir rod
- Funnel
- Adjustable spanners
- Reservoir prototype
- Pure crude sample
- Ethanol used as the primary Chemical to reduce fluid viscosity and recover residual hydrocarbon
- Magnesium oxide used as a nanoparticle for EOR
- Nitrogen gas, this is used to flush the Ethanol and Magnesium to support EOR

Stage 1

The crude oil sample was tested to obtain the following fluid properties: pour point, cloud point, flash point, density, API gravity, viscosity.

The crude sample was poured into a typical reservoir model prototype to a volume of 10liter. The valves and adjustable clips are properly tightened and fastened to maintain pressure and also to prevent blowout. EOR using gas flooding (nitrogen gas) was released into the reservoir prototype with inlet pressure of 1bar and the outlet pressure at 18psi for a period of 10seconds, and the recovered crude sample at secondary recovery was 7.34 litres.

Stage 2

2.2 Flushing First Concentration with Magnesium Oxide, MgO+N_2

Procedure: Using Magnesium oxide **MgO**, as the desired nanoparticles.

5g of magnesium oxide **MgO**, was measured using an electronic scale and poured into 10liters of crude sample and was rigorously stirred and poured into the reservoir prototype through the injection well and shut down (soaked) for a period of 2 hours. This is done to:

i. Build up pressure and maintain pressure
ii. Reduce hydrocarbon molecules making it more viscous.

After shut down (soaked) for a period of **2 hours**, with inlet pressure of 1bar and the outlet pressure at 18psi for a period of 10seconds, the recovery oil was **7.34 litres**. Same procedure for 10g, 15g, 20g and 25g **MgO** gave recovery of 7.5 litres, 7.8 litres, 8 litres and 8.5 litres respectively.

2.3 First Concentration with Ethanol, C_2H_6O +N_2

Procedure: Using **ethanol C_2H_6O**

5mil of **ethanol C_2H_6O**, was measured using a test tube and poured into 10liters of crude sample and was rigorously stirred and poured into the reservoir prototype through the injection well and shut down (soaked) for a period of 2 hours. This is done to:

1. Build up pressure and maintain pressure
2. Reduce hydrocarbon molecules making it more viscous.

After shut down (soaked) for a period of **2 hours**, with inlet pressure of 1bar and the outlet pressure at 18psi for a period of 10seconds, the recovery oil was **7.36 litres**. Same procedure for 10mil, 15mil, 20mil and 25mil of **C_2H_6O** gave recovery of 7.40 litres, 7.0 litres, 7.25 litres and 7.40 litres respectively.

Stage 3

2.4 First Concentration with Ethanol Impregnated with Magnesium Oxide

C_2H_6O +MgO+N_2

Procedure: Using **ethanol C_2H_6O and magnesium oxide +MgO+N_2**

10 litres of crude sample was measured, and 5mil of ethanol was measured and poured into the crude sample, and also 5g of MgO was poured into the crude sample and was rigorously stirred and poured into the reservoir prototype and shut down for a period of 2 hours.

After shut down (soaked) for a period of **2 hours**, with inlet pressure of 1bar and the outlet pressure at 18psi for a period of 10seconds, the recovery oil was 9.7 litres. Same procedure for 10mil ethanol and 10g magnesium oxide, 15mil ethanol and 15g magnesium oxide, 20mil ethanol and 20g magnesium oxide, 25mil ethanol and 25g magnesium oxide gave oil recovery of 9.3 litres, 6.65 litres, 9.3 litres, and 9 litres respectively.

3.0 Results and Discussion

Figure 3.1 shows the behaviour and property of the crude oil sample based on its recovery volume with concentration. An increase in concentration leads to increase in volume, and vice versa.

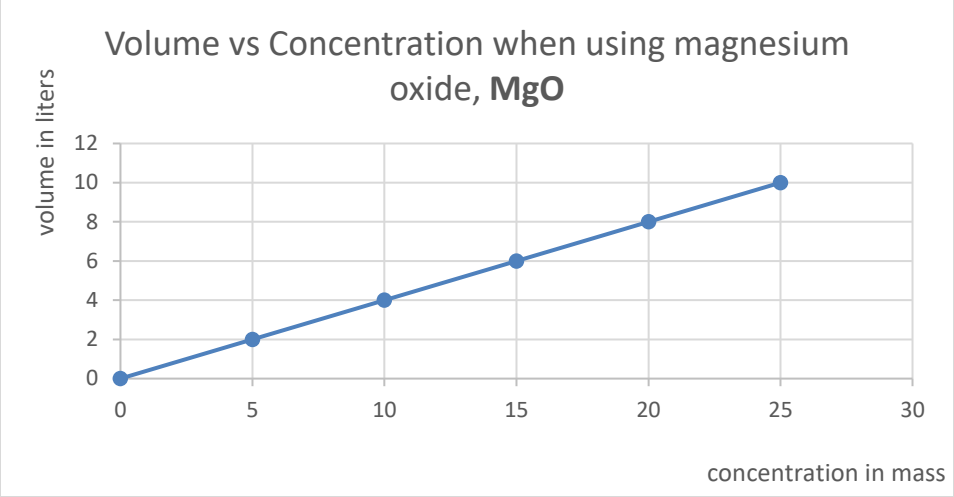


Figure 3.1: effect of MgO nanoparticles in EOR of heavy hydrocarbon plotted in volume against concentration

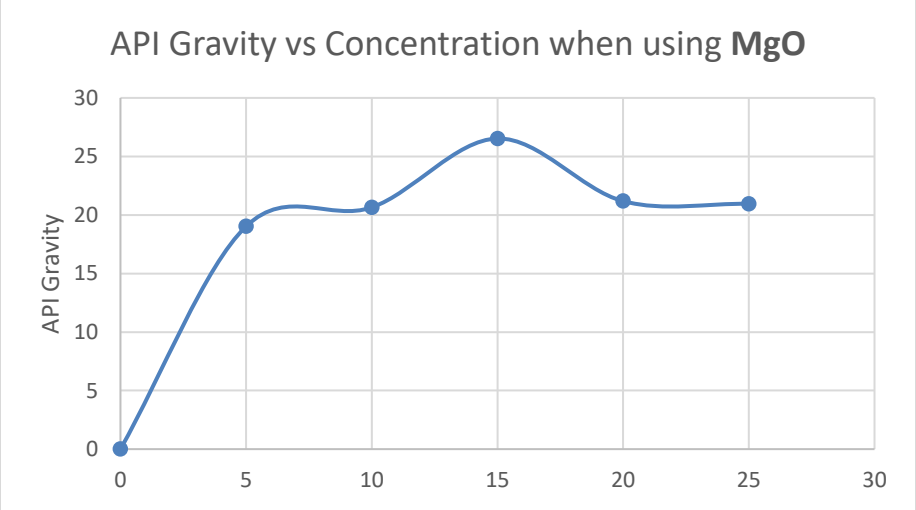


Figure 3.2: effect of nanoparticles in EOR of heavy hydrocarbon plotted in API gravity against concentration

Figure 3.2, shows the reduction in viscosity rapidly after 2hours soaking. These viscosities are as result of the concentration, the higher the concentration, the lower the viscosity and vice versa.

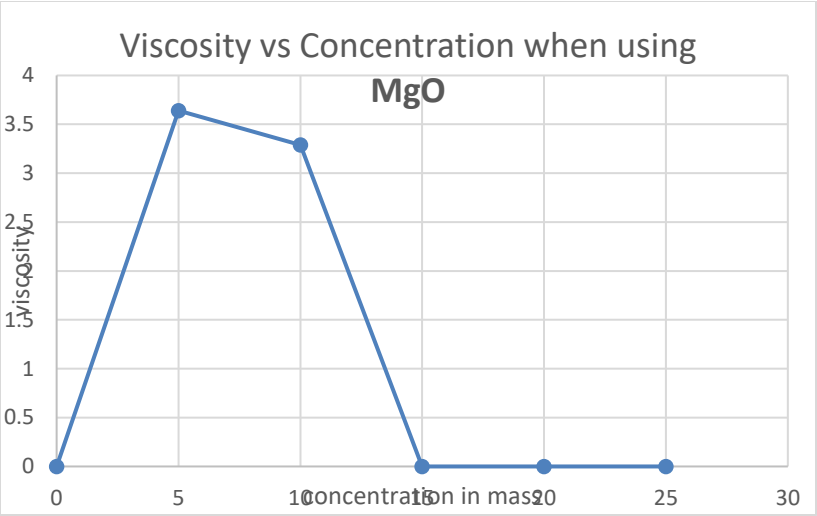


Figure 3.3: effect of nanoparticles in EOR of heavy hydrocarbon plotted in Viscosity against Concentration

Figure 3.4 shows the reduction in its density rapidly after 2hours soaking. These densities are as result of the concentration, at 10g of magnesium oxide, the density of crude reduced and was sustained on reduction down to 25g of magnesium oxide.

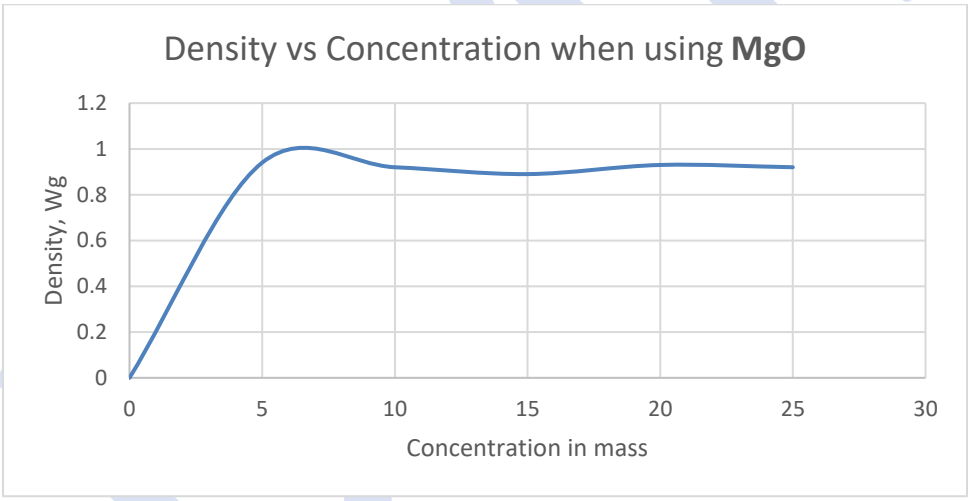


Figure 3.4: effect of nanoparticles in EOR of heavy hydrocarbon plotted in Density against Concentration

Figure 5 shows the reduction in its density. These densities are as result of the concentration, at 10ml of ethanol, the density of crude reduced and was sustained on reduction down to 25ml of ethanol.

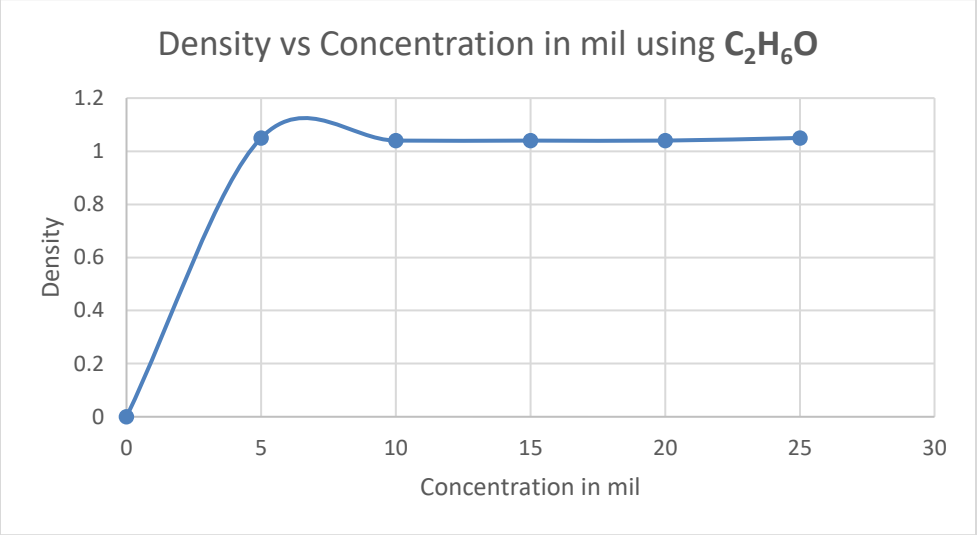


Figure 3.5: effect of ethanol in EOR of heavy hydrocarbon plotted in Density against Concentration in ml.

Figure 3.6 shows the decline in viscosity. These viscosities are as result of the concentration, the higher the concentration, the lower the viscosity and vice versa.

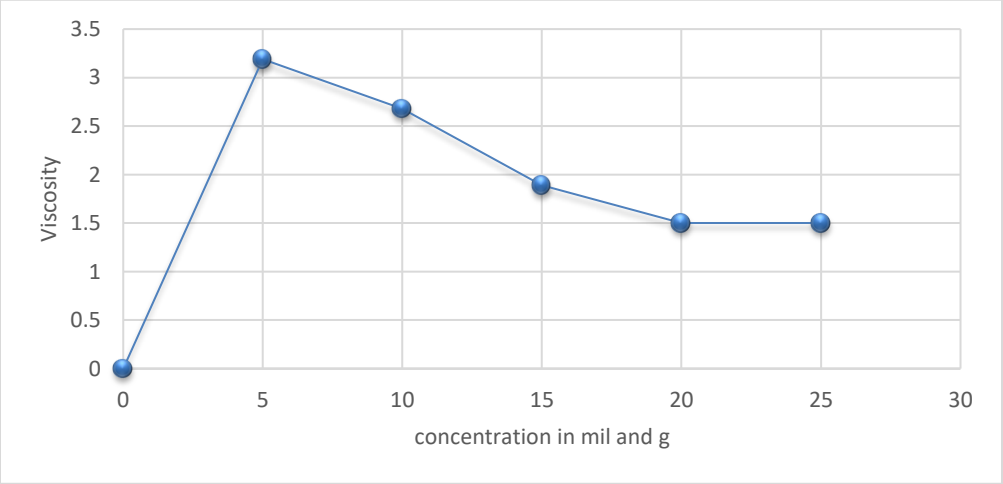


Figure 3.6: effect of ethanol C_4H_6O and magnesium oxide MgO in EOR of heavy hydrocarbon plotted in Viscosity against Concentration in ml. and grams.

4.0 Conclusion

Comparative analysis of ethanol and magnesium oxide nanoparticles for enhanced oil recovery has been investigated. The findings from the analysis carried out revealed that ethanol impregnated with magnesium oxide at 5mil and 5g gave the highest oil recovery at 9.7 litres, followed by ethanol impregnated with magnesium oxide at 10ml and 10g, and at 20ml and 20g which gave oil recovery at 9.3liters and 9.3liters respectively. The least oil recovery was 7 litres at 15ml of ethanol. According to these experimental findings, ethanol can improve the performance of nanoparticles, which are effective enhanced oil recovery agents.

The use of certain nanoparticles in enhanced oil recovery is anticipated to increase recovery rates and enhance hydrocarbon output. The application of nanoparticles, nanofluids, and nanotechnology presents a considerable opportunity to enhance oil recovery efforts. However, more research is needed to examine the effects of ethanol and different properties with nanoparticles, such as the decrease in interfacial tension, the increase in oil viscosity reduction, the decrease in mobility ratio, and changes in permeability.

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