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Electrowetting Effect using Dielectric Nanoparticles for Enhanced Oil Recovery

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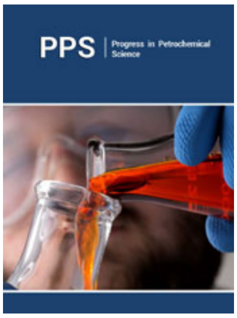

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Abstract

Rock wettability change is one of the important parameters that determine Enhanced Oil Recovery (EOR) in which various Nanoparticles (NPs) have influenced in that regard. Hence, proving an alternative approach to improve wettability is essential, it was recently proposed that modifying wetted reservoir rock by applying an Electro Magnetic (EM) field (Electrowetting) can facilitate oil displacement because the injected NPs could be activated profoundly under EM field and lead to bring an optimistic change. Dielectric NPs were recently used for electrowetting analysis due to their essential thermal conductivity and a reasonable outcome was subsequently reported. This is attributed to the free charges of the dielectric NPs that were found to be attracted by the electric field near the contact line, and the polarized dipoles of the NPs that appear to be on the oil/NFs interface because of which the electrowetting will subsequently improve. Hence, electrowetting could serve as a substantial approach that can facilitate oil displacement in the reservoir which in turn improves EOR.

Keywords: Electrowetting; Dielectric NPs; Enhanced oil recovery

Abbreviations: NPs: Nanoparticles; EM: Electro Magnetic; EOR: Enhanced Oil Recovery

Introduction

Hydrocarbon is one of the important and major contributing factors for gaining energy globally [1-3]. Unfortunately, oil reservoirs in the world are suffering from the persistent attachment of the crude oil in the reservoir rock pores in which more than 70% of the existing oil in reservoirs across the globe cannot be extracted by using an outdated method of oil extraction which were known to be primary and secondary methods [2]. The primary method causes by the underground pressure or gas expansion in the reservoir that can cause oil to flow which resulted in oil being removed without the requirement of using an external force to detach oil from the reservoir, utilizing this method cannot recover more than 15% of the residual oil in the reservoir. Subsequently, advanced methods of secondary recovery were initiated in which the water used to be flushed in the reservoirs and stimulate oil mobility. Still, additional challenges that restrain oil mobility did exist in the sense that 55 to 70% of the oil cannot be recovered due to the continued viscous fingering as crude oil is heavily viscous and therefore water as less viscous fluids cannot displace plentiful oil and therefore will slide past the oil front, causing adverse fingering and lowering the recovery factor [1]. This has necessitated the innovation of tertiary/Enhanced Oil Recovery (EOR), which is the method in which the oil can be recovered by three methods which include heating oil (thermal), gas miscible flooding, and chemical injection. Significantly, EOR was found to have recovered 30 to 60% of the residual oil.

The small size of NPs against reservoir rock holes allowed them to successfully flow in reservoir rock with limited distraction [2], significantly, different NPs were explored to show some positive change for reservoir characteristics such as wettability alteration and interfacial tension. Therefore, the rock surface wetting stage is an important parameter that determines EOR. Reservoir rock is often found to be oil-wet, which brings some limitations for the successful conveyance of fluids. As a result, changing the oil-wet reservoir rock to a water-wet situation will significantly improve the removal of the trapped oil in the rock holes. The contact angle is the most common method used to measure the wettability of the rock surfaces which relies upon whether the angle is above, below, or equal to 90o (Figure 1a) [2]. Different NPs were studied to influence in changing rock surface wettability from oil-wet to water-wet which included TiO_2 [4,5], Al_2O_3 [4-7], ZrO_2 [6], and Fe_2O_3/Fe_3O_4 [7,8], and SiO_2 [5,7]. However, NPs in reservoir still phases challenges of agglomeration that render them less effective and being trapped in the rock holes due to the high temperature of the reservoir, a new idea of employing energy via the electrician method in the reservoir that liberates the active mobility of the fluids was proposed by Haroun [9]. Therefore, reservoir rock wettability could be improved profoundly under the influence of an EM field known as (electrowetting), because the energy absorption of the NPs from the EM sources could introduce some disturbances within the fluids that facilitate oil displacement.

Discussion

The high response of energy stimulus by dielectric NPs makes them a suitable candidate to be used in the EM field which could stimulate NPs mobility in the reservoir. Recently, Goniometer was connected to the frequency generator in which the energy can be introduced through solenoid coil to the nanofluids which can activate the fluid performance (Figure 1b) [10]. Few experiments have recently shown a considerable outcome concerning electrowetting while employing dielectric NPs of ZnO and Al_2O_3 ZnO [10-12], moreover, Yttrium Iron Garnet (YIG) was also recently reported to have shown a significant influence concerning interfacial tension and wettability under the influence of EM field [13-15].

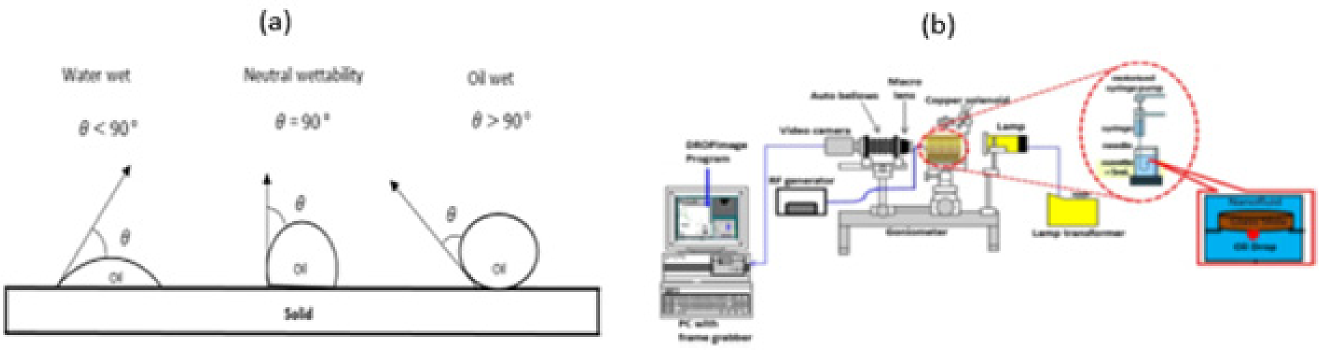

Figure 1: (a) Wettability of rock surface (b) Goniometer with EM connection for electrowetting measurements.

Conclusion

Considering the significant influent of the rock surface wettability change for improving oil productivity by employing different NPs, the idea of utilizing the EM field for reservoir rock wettability analysis (electrowetting) was proposed. Dielectric NPs are regarded as a good candidate for the task considering their electrical conductivity in the presence of EM field, and it was reported to have displayed an essential outcome by changing rock wettability from oil-wet to water-wet.

References

1. Hassan YM, Guan BH, Chuan LK, Zaid HM, Hamza MF, et al. (2021) Effect of annealing temperature on the rheological property of ZnO/SiO_2 nanocomposites for enhanced oil recovery. Materials Today: Proceedings.
2. Hassan YM, Guan BH, Chuan LK, Zaid HM, Hamza MF, et al. (2021) Application of magnetic and dielectric nanofluids for electromagnetic-assistance enhanced oil recovery: A review. Crystals 11(2): 106.
3. Adam AA, Dennis JO, Al-Hadeethi Y, Mkawi EM, Abdulkadir BA, et al. (2020) State of the art and new directions on electrospun lignin/cellulose nanofibers for supercapacitor application: A systematic literature review. Polymers 12(12): 2884.
4. Esfandyari BA, Radzuan J, Samsuri A, Piroozian A, Hokmabadi M (2014) Impact of metal oxide nanoparticles on enhanced oil recovery from limestone media at several temperatures. Energy Fuels 28(10): 6255-6266.
5. Hendraningrat L, Torsæter O (2015) Metal oxide-based nanoparticles: Revealing their potential to enhance oil recovery in different wettability systems. Applied Nanoscience 5(2): 181-199.
6. Moslan M, Sulaiman WRW, Ismail AR, Jaafar MZ (2017) Applications of aluminium oxide and zirconium oxide nanoparticles in altering dolomite rock wettability using different dispersing medium. Italian Association of Chemical Engineering 56: 1339-1344.
7. Joonaki E Ghanaatian S (2014) The application of nanofluids for enhanced oil recovery: Effects on interfacial tension and coreflooding process. Petroleum Science and Technology 32(21): 2599-2607.
8. Rezvani H, Riazi M, Tabaei M, Kazemzadeh Y (2018) Experimental investigation of interfacial properties in the EOR mechanisms by the novel synthesized Fe_3O_4@Chitosan nanocomposites. Colloids and Surfaces 544: 15-27.
9. Haroun MR, Hassan S, Ansari A, Kindy N, Sayed NA, et al. (2012) Smart nano-EOR process for Abu Dhabi carbonate reservoirs. Abu Dhabi International Petroleum Conference and Exhibition, United Arab Emirates.
10. Adil M, Zaid HM, Chuan LK (2020) Electromagnetically-induced change in interfacial tension and contact angle of oil droplet using dielectric nanofluids. Fuel 259: 116274.
11. Adil M, Lee K, Zaid HM, Latiff NRA, Alnarabijiet MS (2018) Experimental study on electromagnetic-assisted ZnO nanofluid flooding for enhanced oil recovery (EOR). PLoS One 13(2).

12. Lee K, Adil M, Zaid HM, Guan BH, Soleimani H, et al. (2019) Wettability, Interfacial Tension (IFT) and viscosity alteration of nanofluids under Electromagnetic (EM) waves for enhanced oil recovery (IFT) applications, in Engineering Design Applications. Springer 92: 305-311.
13. Lau ZY, Lee KC, Soleimani H, Beh HG (2019) Experimental study of electromagnetic-assisted rare-earth doped Yttrium Iron Garnet (YIG) nanofluids on wettability and interfacial tension alteration. Energies 12(20): 3806.
14. Lee KC, Sukri MNM, Guan BH, Zaid HM, Soleimani H (2019) Interfacial tension and viscosity alteration of samarium doped Yttrium Iron Garnet (YIG) nanofluid under the presence of electromagnetic waves. Defect and Diffusion Forum 390: 64-70.
15. Lee KC, Shuhaili FM, Zaid HM, Hoe GB (2018) Neodymium (Nd) doped Yttrium Iron Garnet (YIG) nanofluid activated by electromagnetic waves for Enhanced Oil Recovery (EOR). Journal of Physics: Conference Series 1123(1): 1-6.