COMPARISON STUDY OF SILICA AND IRON OXIDE NANOPARTICLES AS ENHANCED OIL RECOVERY AGENTS

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ABSTRACT

Fossil fuel has been the primary energy supply compared to other alternative energy sources. Due to economic constraints, locating new reserves becomes harder. Approximately 35 % of the original oil in place can be retrieved from the reservoir by primary and secondary methods, while the rest remained trapped, in the last decade nanoparticles have been considered as an alternative recovery method to boost the oil recovery process and to extract trapped oil. The purpose of this study is to compare the effect of silica (SiO_2) and iron oxide (Fe_3O_4) nanoparticles for their recovery mechanism, the parameters involved in this study include, interfacial tension measurement using tensiometer, wettability alteration using contact angle method, and flooding using glass bead pack model. Silica (SiO_2) and iron oxide Fe_3O_4 with the concentration of (0.02-0.1) wt.% was prepared using deionized water, Sodium chloride (NaCl) as brine with the concentration of (0.7wt% - 2.2wt) has been used. The interfacial tension result showed for silica SiO_2 and iron oxide (Fe_3O_4) 43% and 33% reduction of IFT with an optimum concentration of 0.05 wt.% and 0.1 wt.% respectively. For the contact angle measurement, both silica SiO_2 and iron oxide (Fe_3O_4) nanoparticles alter the oil-wet system to the water-wet system by reducing contact angle 19% and 18% respectively. Finally, the additional oil recovery for SiO_2 and (Fe_3O_4) was 10.7% and 9.8% respectively. This study concludes silica SiO_2 nanofluids are more effective on that brine concentration for an enhanced oil recovery application.

ABSTRAK

Fosil bahan api telah menjadi bekalan tenaga utama membandingkan d untuk alternat lain iv e tenaga sumber. D ue kekangan ekonomi, locat ing rizab baru menjadi lebih sukar . A pproximately 35 % daripada asal minyak di tempat boleh diambil dari takungan dengan kaedah rendah dan menengah, manakala selebihnya kekal terperangkap, dalam nanopartikel dekad lalu telah dianggap sebagai kaedah pemulihan alternatif untuk meningkatkan proses pemulihan minyak dan ekstrak minyak terperangkap. Maksudnya ini kajian adalah untuk membandingkan kesan nanopartikel silika (SiO_2) dan oksida besi (Fe_3O_4) untuk mekanisme pemulihannya, parameter yang terlibat dalam kajian ini termasuk, pengukuran ketegangan antara muka menggunakan tensiometer, perubahan kebasahan menggunakan kaedah sudut kontak, dan banjir menggunakan model pek manik kaca. Silika (SiO_2) dan besi oksida Fe_3O_4 dengan kepekatan (0,02-0,1)% berat dibuat dengan menggunakan air deionisasi, Natrium klorida (NaCl) sebagai air garam dengan kepekatan (0,7wt% - 2,2wt) mempunyai telah digunakan. Hasil ketegangan antara muka menunjukkan untuk silika SiO_2 dan besi oksida (Fe_3O_4) Pengurangan IFT sebanyak 43% dan 33% dengan kepekatan optimum masing-masing 0,05% berat dan 0,1% berat. Untuk pengukuran sudut kontak, kedua-dua nanopartikel silika SiO_2 dan besi oksida (Fe_3O_4) mengubah sistem basah-minyak ke sistem basah-air dengan mengurangkan sudut kontak masing-masing 19% dan 18%. Akhirnya, pemulihan minyak tambahan untuk SiO_2 dan (Fe_3O_4) masing-masing adalah 10.7% dan 9.8%. Kajian ini menyimpulkan bahawa nanofluid silika SiO_2 lebih berkesan pada kepekatan air garam untuk aplikasi pemulihan minyak yang dipertingkatkan.

TABLE OF CONTENT

LIST OF TABLES

TABLE NO. **TITLE** **PAGE**

LIST OF FIGURES

FIGURE NO. **TITLE** **PAGE**

LIST OF ABBREVIATIONS

EOR:	Enhanced Oil Recovery
HLB:	Hydrophilic- Lipophilic Balance
IFT:	Interfacial Tension
IONPs:	iron oxide nanoparticles

Chapter 1

Introduction

1.1 Background of Study

Over the past three centuries, fossil fuel was the primary energy supply compared to other alternative energy supplies. On the other hand, due to economic constraints locating new reserves becomes harder. Approximately around 35% of total oil can be recovered from the reservoir by means of the primary and secondary method while the remaining oil will remain trapped in the reservoir (Sukesh and Deka 2017)The remaining oil is essential after water floods and cannot be overlooked at this time of high energy demand. As a result, major oil companies are preferred in utilizing enhanced oil recovery (EOR) methods to achieve energy demands (Manrique and Alvarado 2010).

Several Enhanced oil recovery (EOR) methods have been developed to extract the trapped oil in the reservoir. These EOR and classified into thermal and non-thermal EOR. Thermal EOR is limited to shallow depth reservoir application, hence non-thermal EOR, which includes gas injection, microbial and chemical flooding, receives tremendous attention for oil recovery. Chemical EOR has been considered one of the most promising in EOR applications due to its high efficiency for extracting residual oil compared to other non-thermal EOR methods. Chemical processes are usually constrained by chemicals' exorbitant price, losses of chemicals, and possible formation damages (Chang et al., 2006). As such, more efficient, less expensive, and environmentally safe EOR methods are in great need.

1.2 Problem statement

Nanoparticles provide new routes to resolve unsolved challenges. NPS exhibits several superior properties as EOR agents compared to conventional methods such as chemical method, where pore plugging traped of injection chemicals in the porous media are among the most critical challenges to chemical processes, which causes permeability(k) reduction of the formation and increasing the cost of chemical processes (Luka, Ahmadi et al. 2015)The commonly used NPs are SiO_2, TiO2 and Al_2O_3 are in the range of 100nm to 1 nm. which is smaller than the pore through and pore size. therefore, nanoparticles smoothly flowed and transported across the porous media, eliminating any permeability (k) reduction and loss of the chemicals, Nps can increase the sweep efficiency resulting in higher macroscopic efficiency, which leads to higher recovery. Silica is considered one of the most used promising nanoparticle recovery for improving the EOR mechanism.

The purpose of this study is to compare the effect of silica (SiO_2) and iron oxide (Fe_3O_4) nanoparticles for their recovery mechanism, the parameters involved in this study include, interfacial tension measurement using tensiometer, wettability alteration using contact angle method, and flooding using glass bead pack model.

1.3 Objectives

The objectives of this research are as follow:

i. To investigate Silica and iron oxide nanoparticles' effects to reduce interfacial tension at different concentrations and salinity.
ii. To investigate the Silica and iron oxide nanoparticle to alter wettability at different concentration salinity.
iii. To compare the recovery performance of both silica oxide nanoparticles and iron oxide nanoparticles through flooding tests.

1.4 Scope of the Study

the scope of this study has been categorized as flowing:

i. Measurement of IFT reduction in DI water, at 24^0C, with concentration (0.020wt%, 0.05 wt%, 0.1wt%, for both silica and iron oxide NP to identify optimum concentration.
ii. Measurement of IFT reduction of both Silica and iron oxide nanoparticles with variable NaCl concentration of 0.7wt%,1.2wt%,1.7 wt% 2.2wt% to determine the influence of salinity on IFT reduction.
iii. Measurement of the contact angle in DI water, at 24^0C, with concentration 0.02wt%, 0.05 wt%, 0.1wt%, for both silica and Iron oxide NPs.
iv. Measurement of the contact angle in a 3-phase system using different concentrations of Silica and iron oxide with variable NaCl concentration of 0.7wt%,1.2wt%,1.7wt% 2.2wt% to determine the effect of salinity on contact angle.
v. Conducting flooding test using artificial heterogeneous glass beads pack flooding model at optimum silica oxide and iron oxide nanoparticles concentration at 24^0C.

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