Functional Nanoparticle-Augmented Surfactant Fluid for Enhanced Oil Recovery in Williston Basin

Quarterly Status Report
(for the period of February 1 through May 1, 2019)

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Summary of Current Progress

During the past quarter, our primary goals were to develop one type of nanofluid which can reduce water/oil interfacial tension (IFT) and change wettability of Middle Bakken rocks.

We mainly focused on the following tasks:

1) Commercial silica nanoparticle size distribution test
2) Measurement of IFT between Bakken oil and nanofluid
3) Measurement of Bakken oil-nanofluid contact angles of Middle Bakken rock surfaces

Below are the results of this quarter.

1. Size distribution of commercial silica nanoparticle

1.1 Introduction

The commercial nanofluid used in the study is a colloidal silica obtained from NYACOL company. After it was dispersed in distilled water homogeneously, its size distribution was tested using dynamic light scattering (DLS) technique.

1.2 Summary and discussion

Figure 1 shows the size distribution of the commercial silica nanoparticles in distilled water. The hydrodynamic diameter of the silica particle was mostly between 3~10nm. The silica nanoparticles can be used in oil recovery of Bakken Formation because their sizes are small enough to transport through the nanopores of the formation.

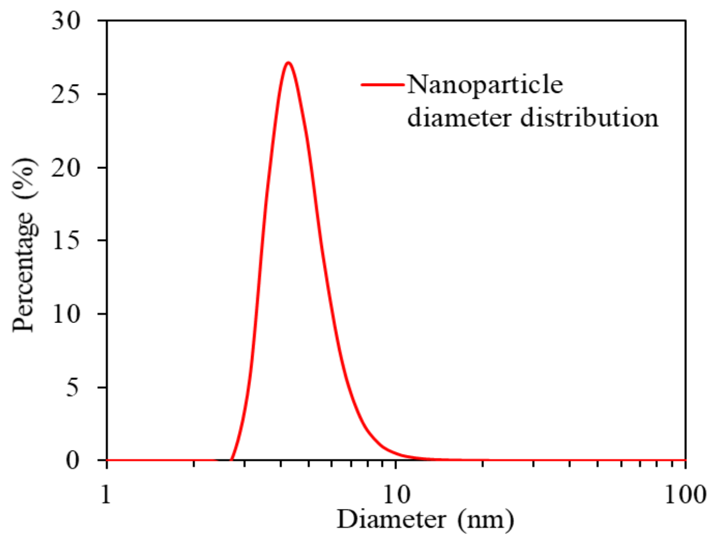


Figure1. Size distribution of commercial silica nanoparticles

2. Measurement of IFT between Bakken oil and nanofluid

2.1 Introduction

This nanofluid is mainly comprised of surfactant and silica nanoparticles, with an expectation of utilizing the synergy between silica nanoparticles and surfactants to enhance the oil recovery[1]. The nanoparticle used is above mentioned. The surfactant is an anionic surfactant obtained from Sasol.

2.2 Summary and discussion

Figure 2 shows the interfacial tention between Bakken oil and nanofluid. It is observed that the silica nanoparticles can significantly reduce the IFT. The IFT decreased dramatically with the addition of nanoparticles to the concentration of 0.1 wt%. Above this concentration (0.1 wt%), the IFT changed slightly and platuaued. The experimental results also indicate that the IFT of nanofluid with 0.4 wt% surfactant is higher than that of nanofluid with 0.1 wt% surfactant. This may be due to aggregation of nanoparticles cuased by the higher surfactant concentration. The aggregation of nanoparticles will decrease its capability in reducing the IFT.

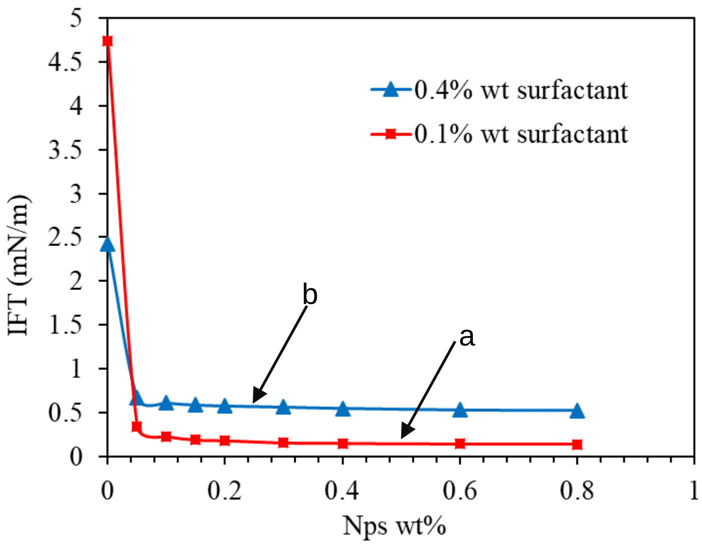


Figure2. Interfacial tension between oil and nanofluids. Curve (a): Nanofluid with 0.1 wt% surfactant. Curve (b): Nanofluid with 0.4 wt% surfactant.

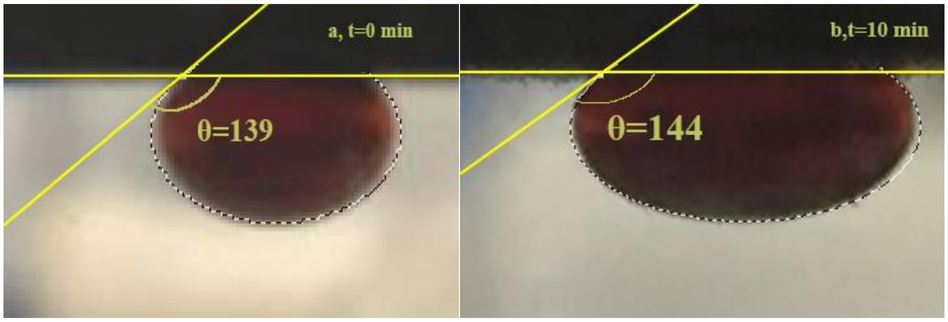
3. Measurement of contact angle

3.1 Introduction

In order to evaluate the effect of nanofluids on Bakken oil-nanofluid contact angles of Middle Bakken rock surfaces, the dynamic contact angles as a function of both time and nanoparticle concentrations were both measured.

3.2 Summary and discussions

The Middle Bakken core sample is from Well 22180. The dynamic contact angle of oil with rock slide was measured. Figure 3 and Figure 4 show the Bakken oil-nanofluid dynamic contact angles of Middle Bakken rock sample at different time.



(a) (b)

Figure 3. Bakken oil-nanofluid contact angle of Middle Bakken rock surface with nanofluid. (a) t=0 min, (b) t =10 min.

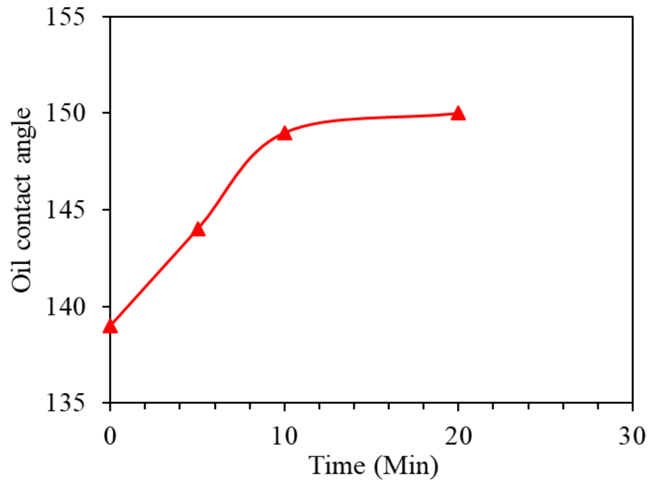


Figure 4. Bakken oil-nanofluid contact angle of Middle Bakken rock surface with nanofluid as a function of time

As can be seen from Figures 3 and 4, the contact agnle increases with the time. Because the contact angle is larger than 120º, the rock can be regarded as water wet. The nanofluid change the rock much water wet. This will be beneficial for EOR.

In the following experimental study of nanoparticle concetrations on IFT, surfactant concentration was maintained at a constant value of 0.1 wt%. The contact angles were tested with increasing nanoparticle concentrations. As shown in Figure 5, contact angle increases significantly as nanoparticles concentrations increase from 0 to 0.1 wt%. Then contact angle changes sightly with further increase of nanoparticle concentration.The reason for contact angle increase is possiblly that the nanoparticles were adsorbed at rock surface and changed the wettability[2].

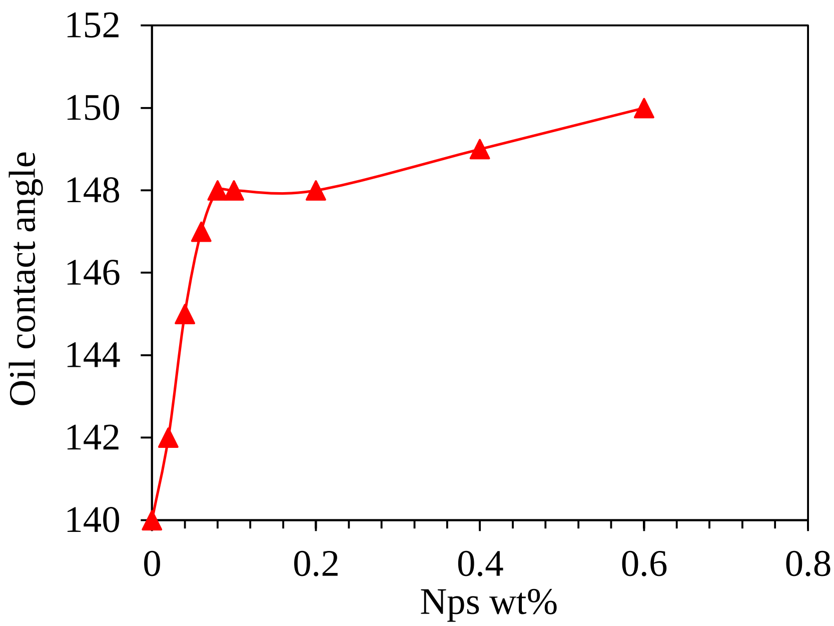


Figure 5. Contact angle as a function of nanoparticle concentration

Future Work

1. Nanofluid imbibition tests in different Middle Bakken rocks.
2. Optimum concentration of surfactant and nanoparticles for EOR.
3. Synthesis of silicon quantum dots.
4. Characterization of nanofluid.

References

[1] Zhao, M.; Lv, W.; Li, Y & Wu, Y. Study on the synergy between silica nanoparticles and surfactants for enhanced oil recovery during spontaneous imbibition. **2019** *J. Mol Liq,* 285,1-8.

[2] Zhang, T.; Murphy, M. J.; Yu, Hai & Bryant, S. L. Investigation of nanoparticle adsorption during transport in porous media. **2015**, *SPE J*, 20(4), 667-677.