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Low Salinity Surfactant Nanofluids For Enhanced CO2 Storage Application At High Pressure And Temperature

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Summary

CO2 storage and its containment security are key concern of a large-scale CCS project. One of the most important parameters affecting the CO2 storage potential is CO2/brine interfacial tension. In this work, we use low salinity surfactant nanofluids to demonstrate its potential application for CO2 storage at high pressure and temperature conditions by significantly lowering CO2/brine interfacial tension. The present work gives novel insight on the use of nanoparticles in CO2 storage application. We use Sodium dodecylbenzenesulfonate (SDBS) surfactant and ZrO2 nanoparticles for our formulation. Determination of interfacial tension were carried out using pendent drop method at 20 MPa and 70 °C and drop shape analysis were carried out using pendant drop plugin of Image J software.

Introduction

Large scale CCS projects are gaining worldwide attention due to growing concern of climate change. For a CCS project to be successful, CO_2 storage capacity and its containment security are of key importance (Iglauer, 2017). However, these parameters are greatly dependent on CO_2/Brine interfacial tension (IFT) which is also the prime focus of the present work as there is a serious gap in the fundamental understanding of this area (Al-Anssari et al., 2018).

In CCS context, researchers are presently investigating the potential use of nanoparticles (NP) for enhancing CO_2 storage capacities. Earlier, various studies have been carried out on the effect of pressure, temperature and salinity on IFT between CO_2 and brine. Some work shows that increase in salinity causes IFT of CO_2/brine systems to increase whereas IFT decreases with increase in pressures (Bachu and Bennion, 2009; Chalbaud et al., 2009; Sarmadivaleh et al., 2015). Literature data on IFT for CO_2 and high brine salinity systems at high pressure and temperature shows that, IFT lies roughly in the range of 30 – 50 mN/m (Bachu and Bennion, 2009). However, despite of encouraging results initially with the use of nanoparticles in IFT reduction to 22 mN/m approximately (Al-Anssari et al., 2018), the data available on CO_2/nanofluids systems is very scarce. Moreover, nanoparticles are known to form aggregates if not dispersed effectively. Surfactant can be used as a dispersing agent for dispersing nanoparticles in an aqueous medium uniformly. Besides, nanofluids in combination with surfactant proves to be good wettability modifiers of rock surface (Al-Anssari et al., 2018, 2017, Nwidee et al., 2018, 2017a, 2017b). Thus, in this work we demonstrate that how a low salinity surfactant (Jha et al., 2017) nanofluids can greatly reduce IFT at high pressure and high temperature conditions.

Method and Theory

Structural and residual trapping of CO_2 are highly dependent on the capillary pressure (P_c) which itself is dependent on IFT and three phase (CO_2, brine, rock) contact angle. However, CO_2 wettability study through contact angle measurements are beyond the scope of the present work.

In this work we use NaCl (3214 mg/L ~ 0.055 M), ZrO_2 NP (100-2000 mg/L, hydrophilic, average size ≤ 100 nm) and Sodium dodecylbenzenesulfonate (SDBS, 500 mg/L) as an anionic surfactant to prepare aqueous solutions in ultrapure water by ultrasonication. We use pendant drop method for measuring IFT between CO_2 and low salinity surfactant nanofluids of varying nanoparticles concentrations at 20 MPa and 70 ˚C using an HPHT IFT cell with mounted video camera. Image analysis of captured image of a pendant drop for IFT calculations was carried out by drop profile fitting using pendant drop plugin of Image J software.

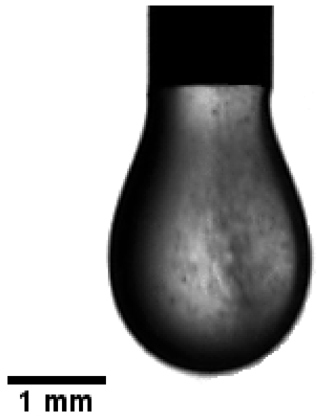

Figure 1 *Drop image at 20 MPa (2900.14 psia) and 70 ˚C.*

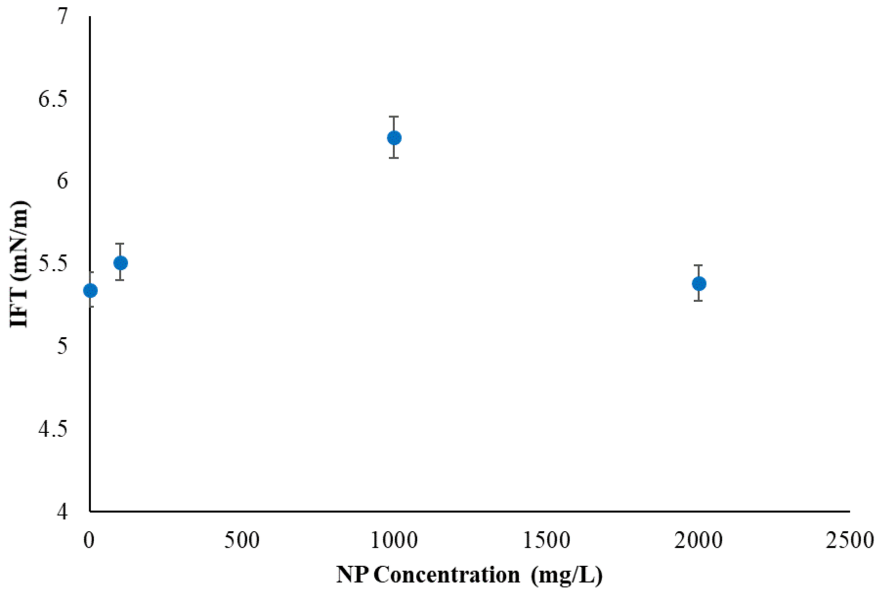

Figure 2 *Experimental value of IFT between Low Salinity Surfactant Nanofluids and CO_2* at *20 MPa and 70 °C.*

Conclusions

The present work gives a novel insight and it is concluded that IFT between CO_2 can brine can be greatly reduced to the range of 5.35 – 6.27 mN/m to enhance CO_2 storage capacity with the use of low salinity surfactant nanofluids. However, we observe that use of surfactants without the ZrO_2 NP can also be effective in reducing the IFT at low salinity conditions i.e. 5.35 mN/m. But the use of NP has an additional advantage of wettability modification of rock surface as suggested by other studies. Further studies will be carried out to see wettability effect of low salinity surfactant nanofluids on rock surface. An ample combination of surfactant and NP in low dosages at low salinity condition can not only reduce IFT but can also modify wettability of rock surface and thus could have major implications towards the success of large CCS projects following low salinity water injection projects.

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