pH-responsive behavior of aqueous CTAB/NaSal solutions

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Abstract

In this study, we investigate the pH-responsive behavior of an aqueous solution of cetyltrimethylammonium bromide (CTAB) in the presence of sodium salicylate (NaSal). The fluid can be switched between gel-like and fluid-like within a narrow pH range.

1. Introduction

About 60% of the world's remaining oil reserves are contained in carbonate reservoirs which are often heterogeneous with wide permeability variations. In the matrix acidization of carbonate reservoirs, injected acid preferentially flows into high permeability zones leaving lower permeability zones unstimulated. Thus diversion techniques have to be employed to ensure total zonal coverage of the formation and hence effective stimulation. Certain self-assembly systems such as the CTAB/NaSal system exhibit pH response becoming viscoelastic upon an increase in pH due to a transformation from spherical to wormlike micelles and this can be utilized in ensuring effective stimulation in heterogeneous carbonate reservoirs.

2. Objective

The objective of this study is to fundamentally understand the change in rheological behavior that results with changing pH.

3. Analyses

The bubble recoil test which involves swirling solution containing vials and observing the movement of small bubbles trapped in it was used to determine the pH at which the aqueous CTAB/NaSal solutions lose their viscoelasticity. Fluorescent polystyrene particles dispersed in aqueous solutions of CTAB and NaSal were imaged on an inverted microscope. To extract the rheology of the solution from the time-dependent microscopy images of the polystyrene particles, we implemented a particle tracking algorithm to obtain the time evolution of the mean square displacement (MSD) from which we obtained the storage and loss moduli using the numerical method of Mason and Weitz.

4. Discussion

Dynamic light scattering (DLS) measurements were done on 2.5mM CTAB/2.5mM NaSal (Fig. 1). It can be seen that the relaxation time of the micelles decreases with decrease in pH indicating a transition from wormlike to spherical micelles. The addition of NaCl does not change the transition pH indicating that the pH-responsive behavior is primarily due to the presence of Sal-. The pH at which different concentrations of aqueous CTAB/NaSal solutions lose their viscoelasticity (Fig. 1) was obtained from the simple bubble recoil test.

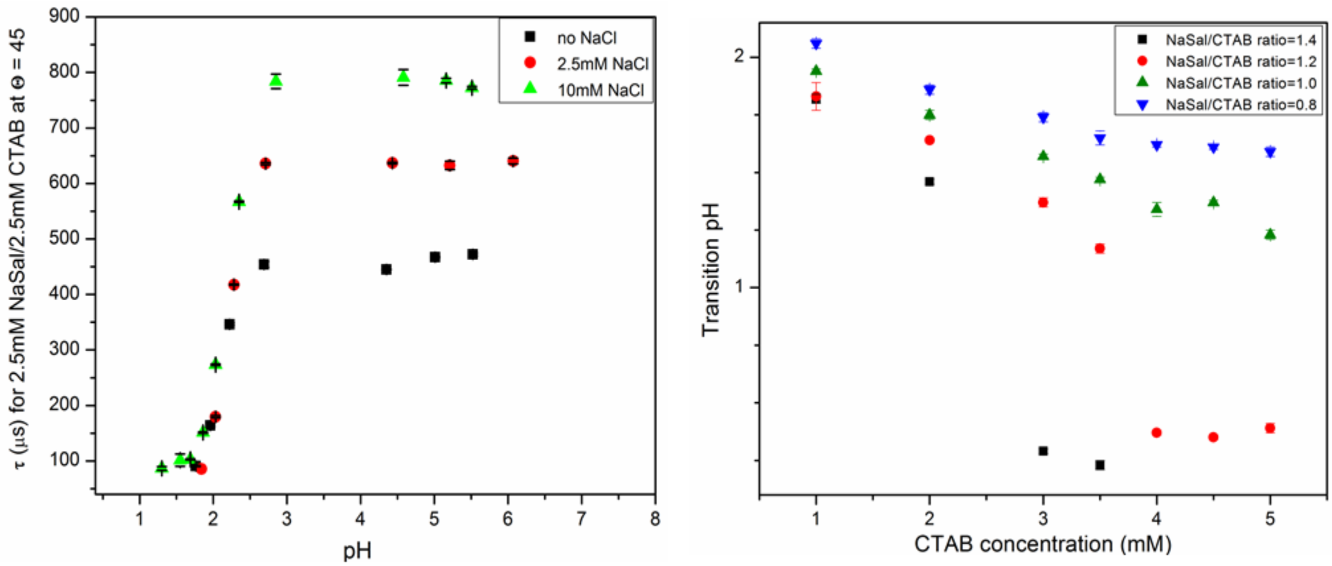

Figure 1. (Left) Relaxation time vs pH for an aqueous solution of 2.5mM CTAB/2.5mM NaCl. (Right) Phase diagram for CTAB-NaSal solutions showing transition pH

5. Conclusion

It was revealed that the transition pH of these solutions and the associated change in rheology and viscosity of the system upon transition was dependent on the NaSal to CTAB ratio (Cs/Cd) and on the concentration of CTAB (Cd)。

6. Acknowledgement

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7. References

Chang, F.; Qu, Q.; Frenier, W. SPE 65033 2001

Aswal, V. K.; Goyal, P. S.; Thiyagarajan P. J. Phys. Chem. B. 1998, 102, 2469-2473

Rodrigues, R. K.; Silva, M. A.; Sabadini, E. Langmuir 2008, 24, 13875-13879

Mason, T. G.; Weitz, D. A. Phys. Rev. Lett. 1995, 74 1250-1253