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# Estimation of crude oil/brine/carbonates interactions using macroscopic and microscopic apparatus

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Low salinity water flooding has received a strong interest and been an area of research lately. Previous laboratory core flooding tests have shown that injecting low salinity water can improve oil recovery in carbonate reservoirs through wettability alteration. However, consistent mechanistic clarification of the underlying mechanisms at the pore scale level has not emerged yet. The major focus of this work is to study the complex interactions of crude oil/brine/ carbonates system at a molecular scale and then to provide a fundamental understanding of the physiochemical mechanisms involved in practical wettability alteration due to salinity changes. Adhesion forces by means of the atomic force microscopy (AFM) apparatus, macroscopic contact angle and interfacial tension (IFT) were experimentally investigated. To reduce surface roughness, flat calcite crystal surfaces were used to mimic the carbonates, while ready chemically modified tips (ST-PNP-COOH) were utilized to model polar-oil droplets. Synthetic formation water, seawater and various proportions of diluted seawater were used as selected saline solutions. Adhesion force maps were acquired for the same scanned area upon exposure to different saline solutions, injected in a sequential manner, starting from super saline solution (200000 ppm) ending up with 50 diluted sea water (873 ppm). The results of microscopic measurements reveal that the overall average of adhesion forces between a polar-oil droplet and calcite surface is decreased by about 45%, as the salinity decreased upto two times dilution. A small change (3–5%) in the adhesion values has been observed with the further diluted versions of sweater. The microscopic AFM results are qualitatively consistent with the macroscopic contact angle measurements. Experiments with saline solutions containing different concentrations of SO42- and Mg2+ show that SO42- ion has more effect on the adhesion force values than Mg2+ ion and there is a critical concentration of sulphate, beyond which its effect will be revisable.

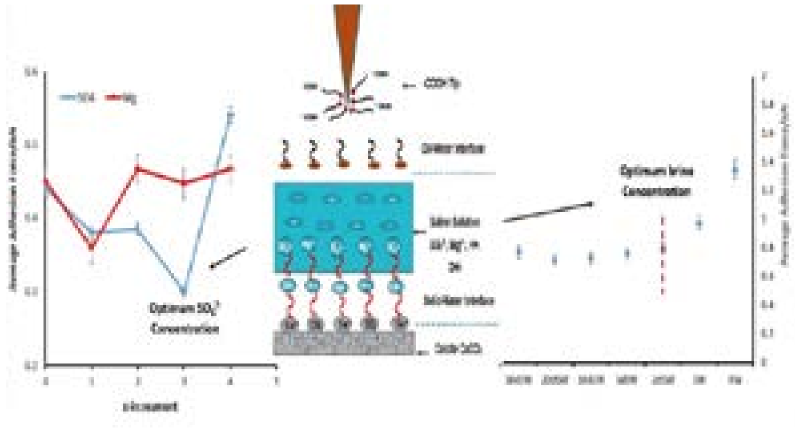

Fig: Effect of brine salinity and ionic strength on adhesion force

## Recent Publications

1. Pedersen N R, Hassenkam H, Ceccato M, Dalby K N, et al. (2016) Low salinity effect at pore scale: probing wettability changes in Middle East limestone. Energy & Fuels 30(5):3768–3775.
2. Nasralla R A, Bataweel M A and Nasr-El-Din H A (2013) Investigation of wettability alteration and oil-recovery improvement by low-salinity water in sandstone rock. Journal of Canadian Petroleum Technology 52(02):144-154.
3. Israelachvili J N (2011) Intermolecular and Surface Forces. Academic Press.
4. Fathi S J, Austad T and Strand S (2010) "Smart water" as a wettability modifier in chalk: the effect of salinity and ionic composition. Energy & Fuels 24(4):2514–2519.

5. Kumar K, Dao E K and Mohantly K K (2008) Atomic force microscopy study of wettability alteration by surfactants. Society of Petroleum Engineers 13(2):137–145.

## Biography

Arije Al Khafaji has a BSc and MSc in Petroleum Engineering from the University of Baghdad with more than nine years' experience working in the Iraqi Ministry Of Oil, Directorate of Reservoirs and Oil Fields Development, mainly as a Reservoir Engineer. She has extensive knowledge in Reservoir Engineering and has performed a full reservoir study using reservoir simulation tools. Also, she is involved in projects of redevelopment studies of mature fields, field development planning and secondary recovery by water flooding. Currently, she is doing her PhD in Petroleum Engineering at the University of Leeds. She is specifically studying the effect of low salinity flooding of enhanced oil recovery.

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