Microscopic and Mesoscopic Polymer Adsorption in Enhanced Oil Recovery (EOR)

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PROBLEM STATEMENT

The polymer EOR utilizes high molecular weight polymers to improve the viscosity of the displacing aqueous phase. This polymer-brine solution has a better sweep efficiency than the normal brine solution. But the polymers get adsorbed on the rock surface. Polymer adsorption on the pore surface has a negative impact and therefore needs to be minimized. Here we are investigating polymer adsorption fundamentally through QCM and SMFS.

RESULTS

• Effect of substrates

Upon passing the polymer solution, the sensor undergoes frequency shift ($\Delta f$) and Dissipation shift ($\Delta \eta$) due to adsorption, density and viscosity effects. The amount of polymer adsorbed can be extracted by using appropriate model. Polymer studied: Flopaam 3630 (20 MDa) and Polyacrylamide (PAM) (2 MDa).

• Effect of ions on adsorption

Some factors affecting adhesion:
- Charge on the polymer
- Surface charge (charge on the clays)
- Ions present in the brine
- pH of the solution

QCM-D

Effect of substrates

Adsorption of 0.2% polymer in 10 mM CaCl$_2$

More adsorption of Flopaam and PAM on alumina substrate

Effect of ions on adsorption

Adsorption of 0.2% Flopaam in salt solution on alumina substrate

Distilled Ca$^{2+}$ ions increase the adsorbed amount of Flopaam on Alumina

AFM BASED SINGLE MOLECULE FORCE SPECTROSCOPY (SMFS)

The polymer is grafted on to the cantilever and its interaction with the substrate is observed. The deflection of the cantilever and the piezo contractions (converted to force and separation respectively) give us information about desorption force and desorption length.$^{[3]}$

RESULTS

• Study on Homopolymers: Polyacrylamide (PAM) and Polyacrylic acid (PAA)

• Study on Copolymers: Flopaam 3130 (Molecular weight = 2 MDa)

CONCLUSIONS

- QCM-D and SMFS by AFM can be used to study the polymer adsorption at mesoscopic and microscopic level.
- QCM-D preliminary experiments suggest the effect of substrate and ions on polymer adsorption
- SMFS of homopolymers implies Polyacrylic acid is highly influenced by presence of ions.
- SMFS of copolymer requires a lower molecular weight system

Acknowledgement: The work of Mohan, A. forms part of the research programme of DPI, Project 807.

The project is sponsored by SNF and Shell Global Solutions International BV. DPI, P.O. Box 902, 5600 AX Eindhoven, the Netherlands

The EOR polymers (Flopaam 3630 and 3130) used in the experiments are provided by SNF.