Development of In-situ CO_2 EOR Formulations in Liquid Rich Tight Reservoirs

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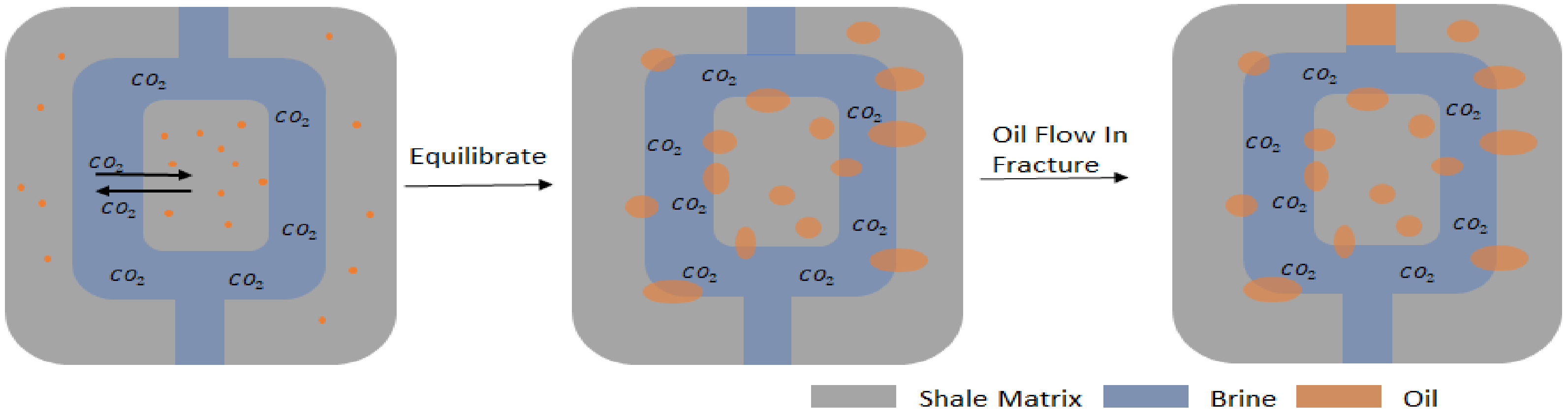
Fundamental Mechanisms:

I. CO2 – generating Additives Decomposition:

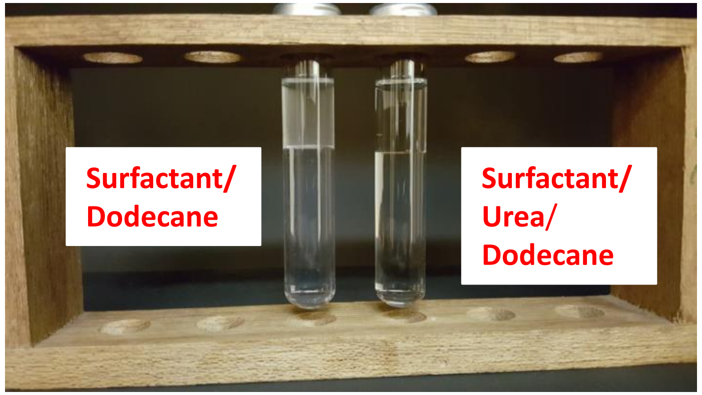
$$Urea \rightarrow NH_3\,\text{(aq.)} + CO_2\,\text{(aq.)}$$

II. CO2 Transport/Diffusion and Oil Swelling

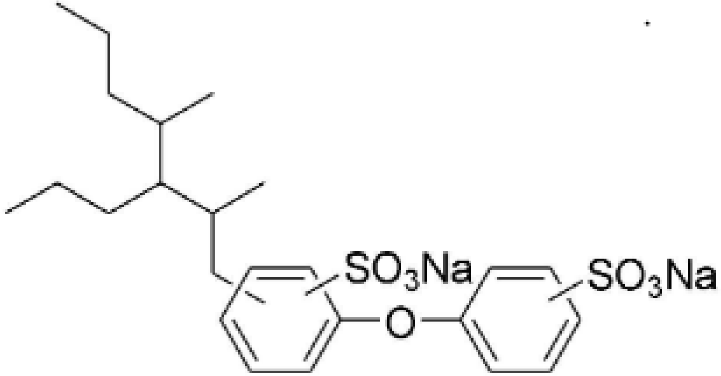


III. NH_3 Wettability reversal

- Surfactants can reduce the oil-water interfacial tension and wettability of shale
- Increase water imbibition and oil recovery
- Reduce water blockage at the matrix-fracture interface
- Could there be synergy between surfactants and in-situ CO_2 generation system?

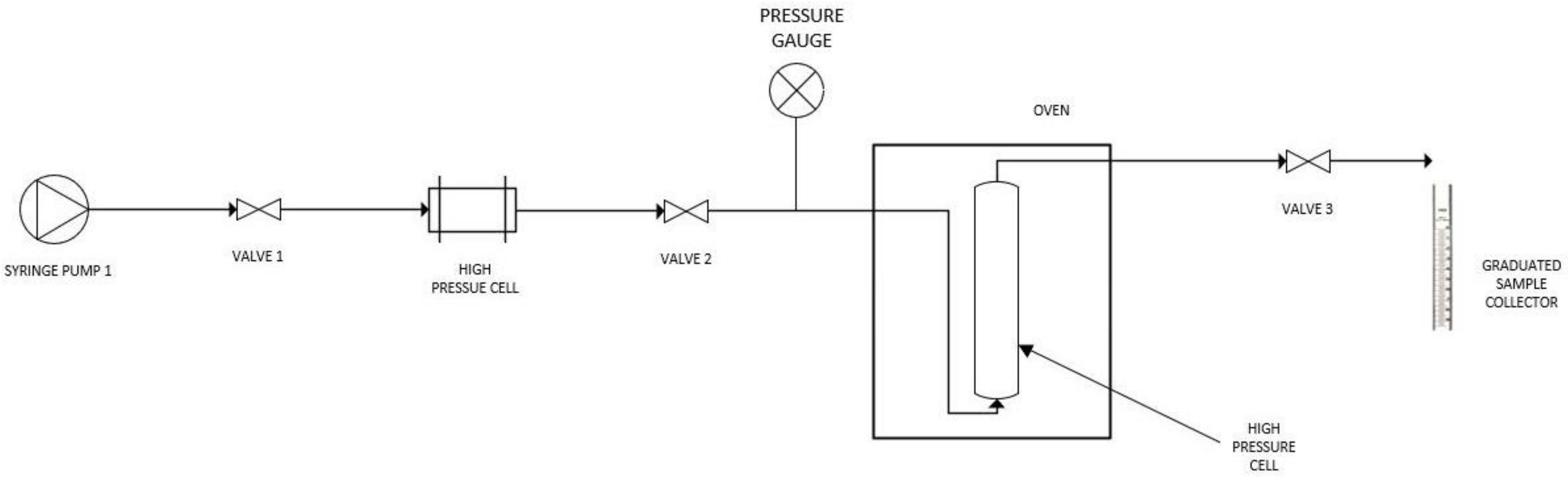


- C12 (Branched) Sodium Diphenyl Oxide Disulfonate
- Compatible with a broad range of acids and alkalis
- CMC (0.1m NaCl @ 25°C), g/100g = 0.007
- Stable at high temperatures

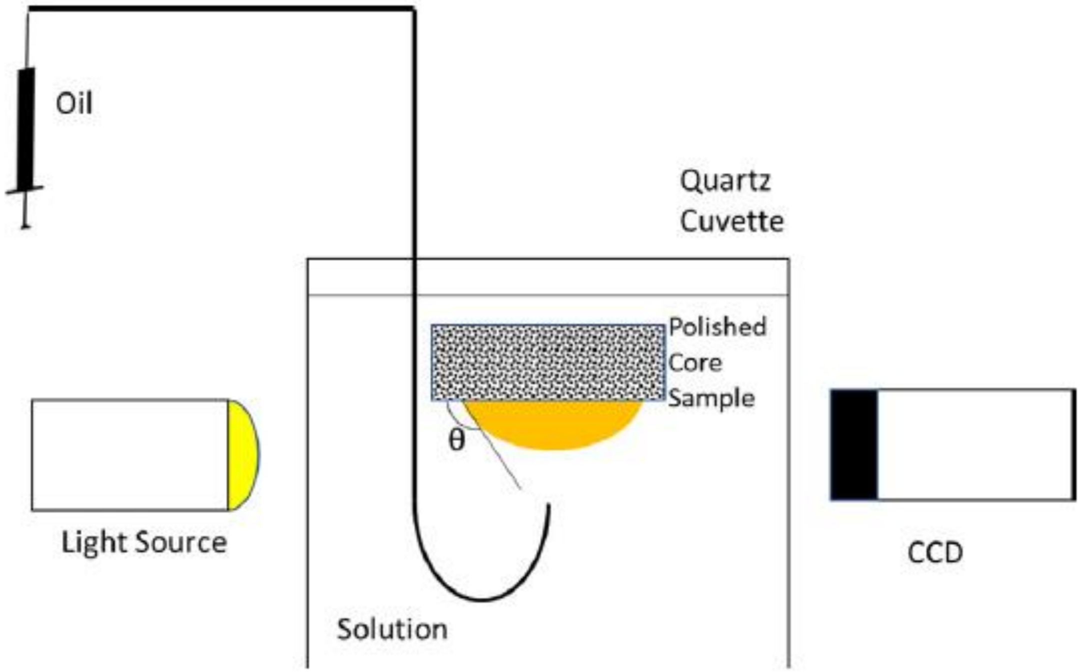


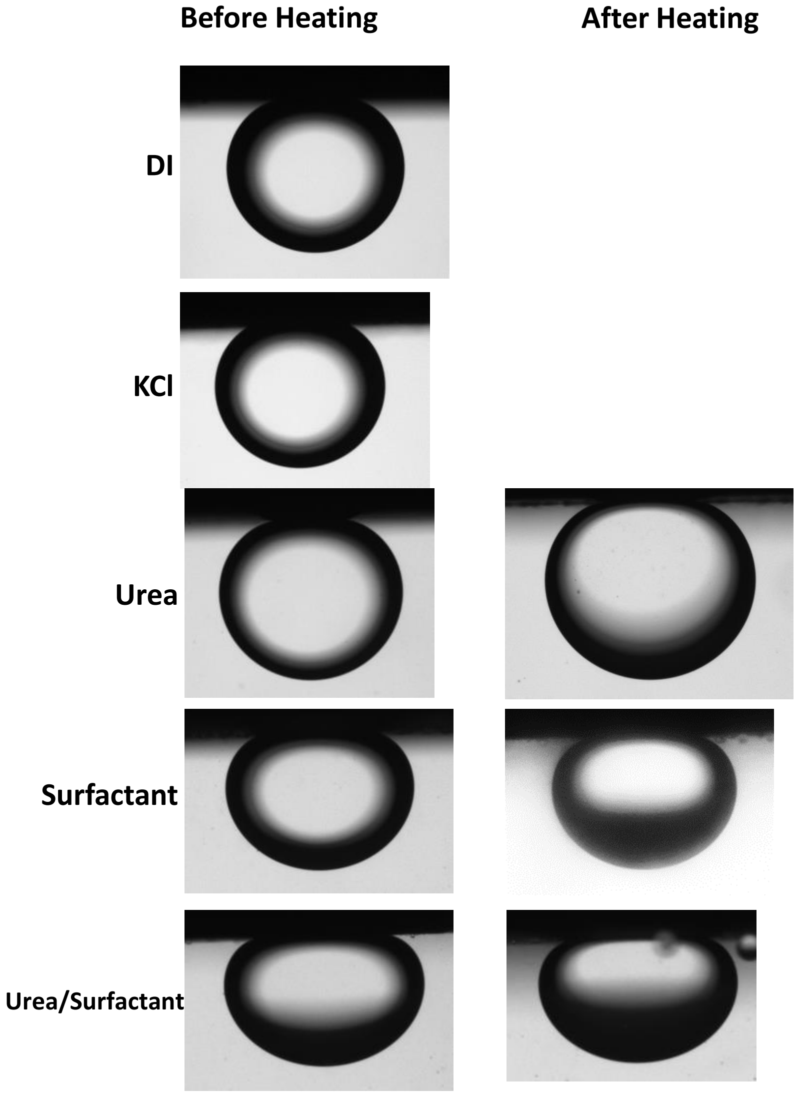
Experimental Procedure

- Measure and weigh Woodford cores. The cores used were 1” x 2” cores
- Dry the cores at 110^{o}C until weight is constant
- Measure the porosity of the core samples
- Saturate cores with dodecane in a vacuum vessel for 24 hours
- Saturate cores with dodecane at 5000 psi for 24 hours
- Weight the cores to determine amount of dodecane imbibed
- Soak the cores in a core holder in the EOR fluid at 250^{o}F and 1500 psi



Set-up for 72 hours experiment



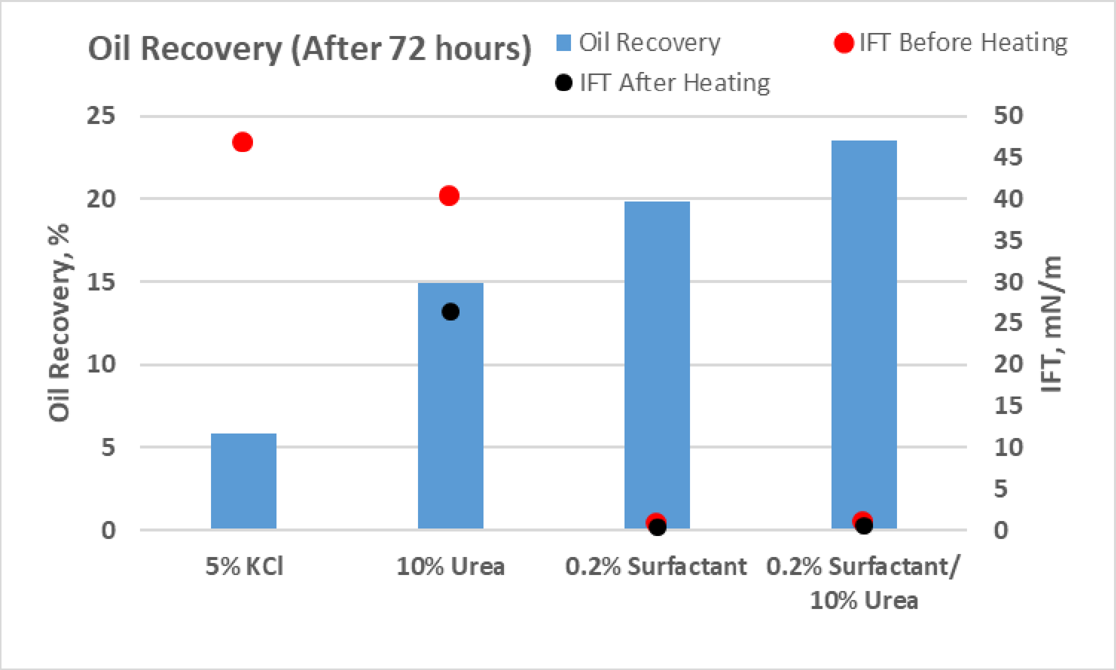


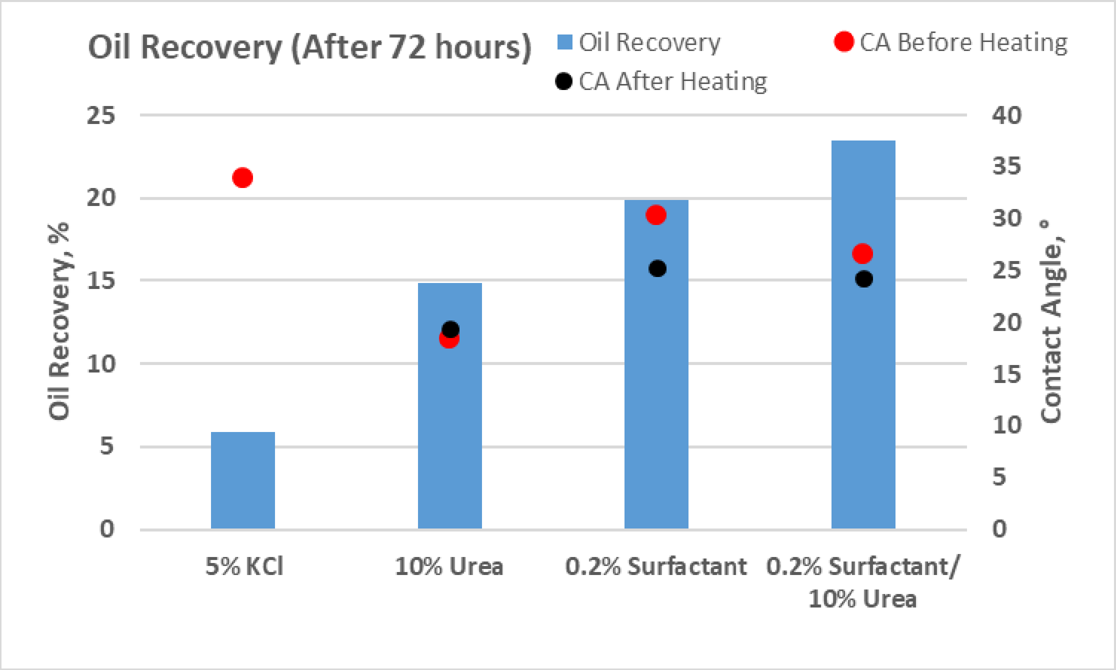
	IFT, mN/m	
Fluid	Before heating	After heating
5% KCl	46.7	
10% Urea	40.3	26.3
0.2% Surfactant	0.9	0.4
Urea/Surfactant	1.0	0.6

(yellow)	Measured with pendant drop
(blue)	Measured with spinning drop

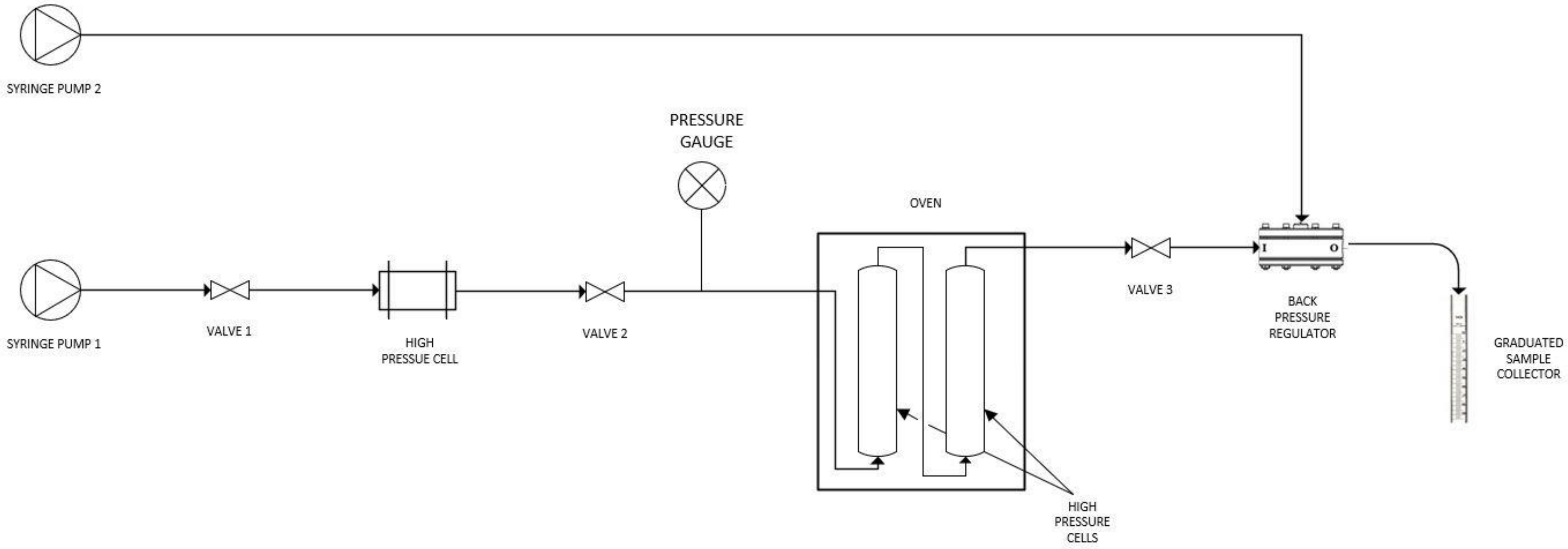
	Contact angle	
Fluid	Before heating	After heating
DI	29.0 ± 2.4	
5% KCl	33.8 ± 2.2	
10% Urea	18.3 ± 1.6	19.3 ± 2.9
0.2% Surfactant	30.3 ± 2.9	25.2 ± 3.3
Urea/Surfactant	26.6 ± 1.5	24.3 ± 3.0

Contact angle, °	
0 - 75	Water Wet
75 - 105	Intermediate Wet
105 - 180	Oil Wet

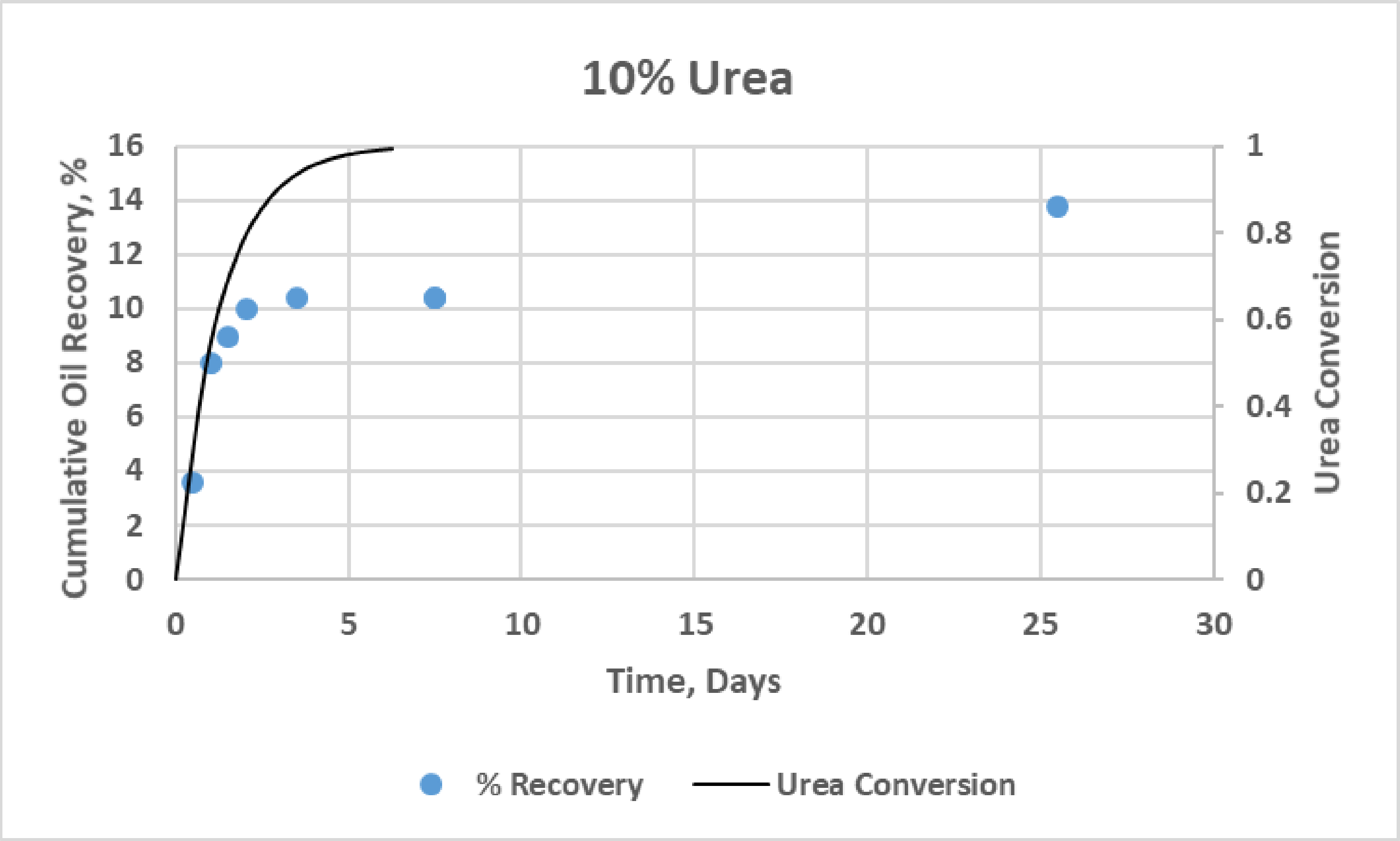


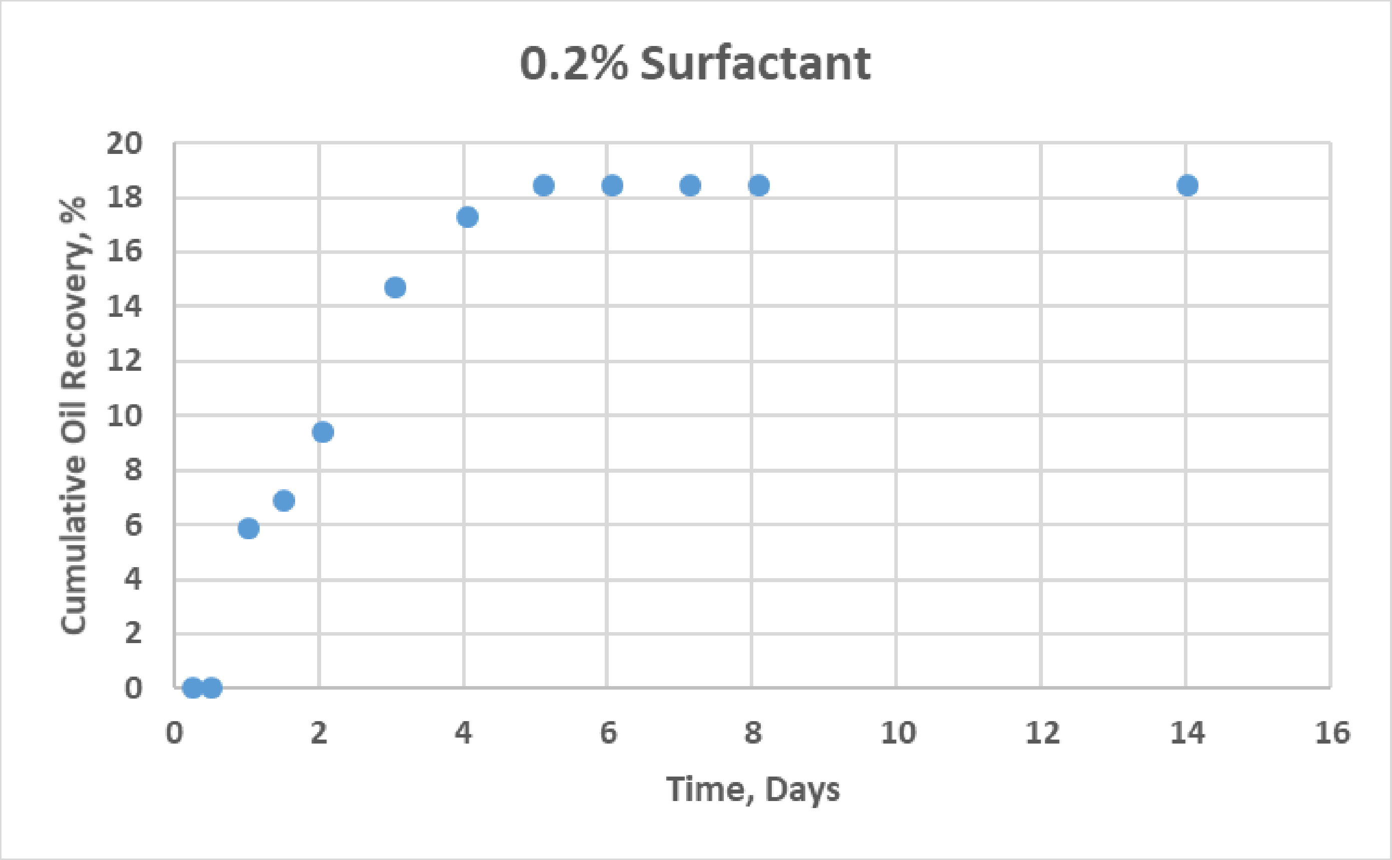


- All cores were from the same block of Woodford shale outcrop
- Porosity range from 5 to 7.5 %



Set-up for Extended Period Experiment


10% Urea
Cumulative Oil Recovery, %
0
2
4
6
8
10
12
14
16
Urea Conversion
0
0.2
0.4
0.6
0.8
1
Time, Days
0
5
10
15
20
25
30
% Recovery
Urea Conversion


0.2% Surfactant
Cumulative Oil Recovery, %
0
2
4
6
8
10
12
14
16
18
20
0
2
4
6
8
10
12
14
16
Time, Days

Conclusions

- The best oil recovery was achieved with the hybrid system that combines urea and surfactant
- Oil recovery is dependent on both IFT reduction and wettability changes
- IFT reduction plays a more dominant role in oil recovery since the shale rock used in this work is originally water-wet