Improving Displacement Efficiency of An Iraqi crude Oil by Surfactant

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ABSTRACT

Surfactants have been considered for enhanced oil recovery by reduced oil-water interfacial tension. This research experimentally determines the influence of surfactant concentration and formation water Salinity on oil recovery. The commercial anionic Alkyl-benzene sulphonate surfactant were used with different salinity of formation water (134.7,168.5 and187.5 g/l) respectively and with three different surfactant concentrations (10,30 and 50g/l) . Several sand pack flood experiments were conducted using medium crude oil. Experimental results showed that emulsification become better with increasing surfactant concentration and higher oil recovery. The ultimate oil recoveries at 1.1 pore volume(P.V.) are 72,76.2 and 85.1% of original oil in place(OOIP), at surfactant aqueous concentration of 10,30 And 50g/l respectively. The effect of salinity on surfactant performance is studied and the results showed that increasing of salinity reduced oil recoveries (76.2 ,60and 46%OOIP at salinity of134.7,168.5 and187.5g/l respectively).

تحسين كفاءة الازاحة لنفوط الخام العراقية بإستخدام مركبات الشد السطحي

المستخلص

تعتبر مركبات الشد السطحي احدى وسائل الانتاج المدعم للنفوط بسبب قابليتها على تقليل الشد السطحي للنفط ـ الماء هذا البحث يحدد مختبرياً تأثير تركيز محلول الشد السطحي وملوحة مياه الطبقة المكمنية على انتاجية النفط
تم استخدام الكيل – بنزين سلفونات كأحد مركبات الشد السطحي.وتم تحضير (3) محاليل ملحية لكي تكون الماء الطبقي وبتراكيزg/l 134.7,168.5 and 187.5 مع 3 تراكيز مختلفة لمحلول الشد السطحي(10,30,50g/l) واستخدم نفط خام متوسط الكثافة
بينت النتائج انه بازدياد تركيز محلول الشد السطحي يزداد الانتاج 72 ,76.2 ,85.1كنسبة مئوية من الـ OOIP وعند تراكيزg/l10 ,30 ,50 على التوالي .في حين زيادة ملوحة الماء الطبقي (187.5,168.5,134.7g/l) يقلل من الانتاج وكماواضح (76.2 , 60 , 46% OOIP) وعلى التوالي .

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INTRODUCTION

Because of local heterogeneities in the petrophysical properties of the porous medium, the viscous fingering phenomenon may happen when a fluid of lower viscosity displaces one of higher viscosity in a porous media, in which the displacement front between the fluids becomes unstable. Viscous fingering phenomenon is responsible for early breakthrough of the displacing fluid, which leads to unsufficient displacement of the displaced fluid.

Enhanced oil recovery (EOR)is designed to treat the relatively low recovery efficiencies relating to petroleum production processes. All these processes (other than water flooding) in which energy and chemicals are supplied to the reservoir to supplement the natural energy present in the reservoir, where the injected fluids interact with the reservoir rock/ oil / brine system to create favorable conditions for maximum oil recovery [1,2,3].Many investigators[4,5,6] found that the most favorable conditions for maximize oil recovery are oil swelling, lowering of interfacial tension, rock wettability modification and others.

In other hand,EOR means that something other than plain water or brine is being injected in to the reservoir to increase oil recovery [7]. Surfactant flooding one of the most methods used to enhance oil recovery. Surfactants are considered as good enhanced oil recovery agents since 1970s [8], because It can significantly lower the interfacial tensions and alter wetting properties.

The idea of injecting surfactant solution to improve imbibitions recovery was proposed for fractured reservoirs and carbonaceous oil field[9]. A surfactant system should have the ability to lower the oil- water interfacial tension as this is very important in the mobilization of residual oil. Somasundaran.P. and Zhang, L.[10] studied the mechanism of surfactant adsorption on minerals for wettability control in improved oil recovery using surfactant/polymer solutions. They found that wettability of reservoir minerals plays an important role in enhanced oil recovery. It has been shown that mineral wettability is affected by many factors including adsorption of surfactant/polymer conformation, mineralogical compoisition and solution conditions such as PH and salinity. Wan Rosli and EuySoo[11] reported a study on simulation of surfactant based enhanced oil recovery. The study was to determine the effects of wettability and wettability alteration on dodecyllbenzenesulfonate surfactant flooding in carbonate reservoir. They showed that significant differences in an injectivity and oil recovery are caused by changes in the mobility of the injected fluid.Bae[12] reported a flooding project in chevron's Glenn pool Field in Oklahoma. They produced one-third of the residual oil saturation from shallow, low permeability sandstone. Adams et.al[13] reported a surfactant flooding project in a carbonate reservoir, they presented a flooding pilot test for two wells. They found that key reservoir properties affecting the surfactant flooding were heterogeneity and high salinity. Sara Bulow[14] studied how the phase behavior of surfactant systems is influenced by temperature and pressure with the application to EOR in mind, her project is mainly experimental project concerning the understanding of fluid-fluid interaction. In this work, the investigation has been made to select and characterize the surfactant solution in terms of its concentration and viscosity and how they affect surfactant ability to improve displacement efficiency, also the effect of formation water salinity is studied.

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Mechanisms of surfactant flooding

The main mechanism of surfactant flooding is the mobilization of residual oil trapped by capillary forces in the porous medi. The more factor affect the residual oil saturation and interfacial tension is capillary number.Capillary number is defined as the dimensionless ratio between the viscous and the capillary forces[15,10].This ratio given by

$$N_{ca}=\frac{\textbf{viscous forces}}{\textbf{capillary forces}}$$

Where

N_{ca}: capillary number.

Experimental Part

Apparatus and material

Sand pack

Sand pack flood tests is a steel tube of 1.5 inch ID, 11.5 inch length and withstand a pressure up to150 psig **.**The two ends of the sandpack were fitted with the two metal screen to ensure linear flow within the system. Two pressure gauges placed near Its ends to control system. Sand pack flood tests were employed by preparing a sand which washed and dried, the mesh size of the sand is 80- 120 mesh, the sand is packing closely in the steel tube. The sand pack has an average porosity of 36% (pore volume 114.36 cc) and average permeability 3.91 md.

Crude oil

A sample of petroleum obtained from one of Iraqi oil fields has the properties:

Viscosity (μ) =60 C.P.at T= 35^{o}C

Density (ρ) = 0. 943 gm/cc at T= 35^{o}C

API gravity = 20.3 at 60 ^{o}F

Surfactant solution

AIkyl – benzene sulphonate is a type of surfactant used in this research, which prepared by the reaction of sulfonic acid ($RC_6H_4SO_3H$)withNaOH as shown:

$$RC_6H_4SO_3H + NaOH \xrightarrow{PH\simeq 7} RC_6H_4SO_3^- Na^+ + H_2O$$

For surfactant flooding, three different surfactant concentrations were prepared; these are 10, 30, and 50g/l.

Brine

The following salts used to prepare three samples of synthetic brines as formation water to study the effect of increasing salinity on oil recovery by surfactant. Table 1 shows the ionic compositions of synthetic formation water.

Table (1) Formationwater composition

Ionic	Sample A ppm	Sample B ppm	sample C ppm
CL^-	55900	66830	73100
Na^+	50100	65250	70500
Ca^{2+}	28300	35900	43200
So_4^{2-}	150	205	320

HCO_3^-	300	375	430
T.D.S	134.7 g/l	168.5 g/l	187.5 g/l

Test procedure:

Sand pack flood tests employed by packed the tube with clean and dry sand under thorough vibration.Water of known salinity is prepared and used to saturating the sand pack. The saturation is carried out under gravity effect at low rate to prevent channels creation and under vacuum condition and continued for a time after the first drop of water appeared. This is to make sure that the sand pack is homogeneously saturated .Then sand pack was flooded with crude oil at irreducible water saturation. To begin a run, the surfactant solution is admitted in to the sand pack at the required concentration. A run is terminated when oil production has fallen to a low level. Five runs are carried out under different conditions(concentration and salinity,Table(2).Fig(1)show schematic diagram of experimental apparatus.

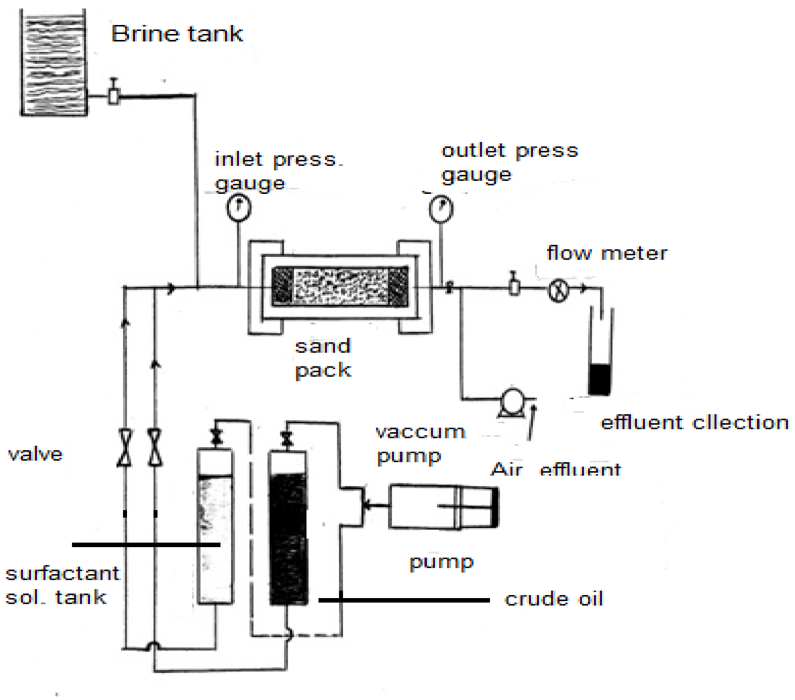

Figure (1):schematic diagram of experimental apparatus

Table(2):Run Tests Conditions

Run No.	**surfactant solution Concentration,g/l**	**Water salinity,g/l**
1	10	134.79

2	30	134.79
3	50	134.79
4	30	168.5
5	30	187.5

Result and Discussion

In runs 1, 2 and 3 surfactant solution is used as an injection fluid at concentrations 10,30 and 50g/lrespectively withformation water salinity 134.7 g/l. The results obtained from these runs are plotted in Fig (2), as oil recovery versus the cumulative fluid produced.

The curves of runs 1,2,and 3 in Fig(2) show the oil recovery percent as a function of the cumulative P.V. produced. Two distinct parts can be seen in these curves, before break through (1st. Part) and after break through (2nd part) the break through point is fairly well- defined. The first part is characterized by a steeper slope, where a relatively high oil recovery is achieved with the produced P.V., however in the second part both oil and water are produced and this leads to a more gentle slope. A comparison between the production results at various concentrations (runs 1,2 and 3) shows that the behavior of the plots at earlier time is characterized by a constant rate of production but the lower concentration leads to lower recovery.

The ultimate oil recoveries at 1.1 P.V. produced are 72, 76.2 and 85.1% of OOIP at surfactant aqueous concentration of 10,30 and 50 g/l respectively .This is due to good emulsification or solubility cation concentration be obtained at high concentration , which leads to reduce the viscosity of crude oil and enhance the wettability of formation by alternated the wet ability from oil- wet to water- wet conditions . The increasing of surfactant concentration lead to reduction in the oil – water interfacial tension and assist imbibitions effect. Similar findings have been reported by many investigators[10,15]. Oil recovery was increased through the mechanisms of oil entrapment and carrying by emulsification which might make the concentration of surfactant solution increase . This phenomenon could be confirmed by the color of surfactant solution after being adsorbed. The color of surfactant solution after being adsorbed was brown. Runs 4 and 5 shows the effect of salinity increasing on efficiency of removal by surfactant at constant surfactant concentration.

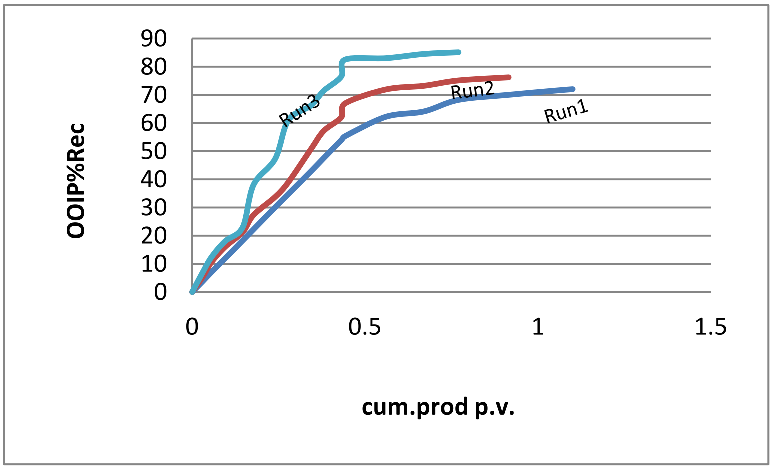

Figure (2): production results comparison

The results of runs 4 and 5 are presented in Fig(3), and compared with results of run2 shows that oil recovery at water salinity 134.7g/l is 76.2% (run2) while the oil recovery are 60% and 45% at water salinities 168.5 and 187.5g/l respectively(runs 4 and 5), similar findings have been reported by many investigators[12,14] .

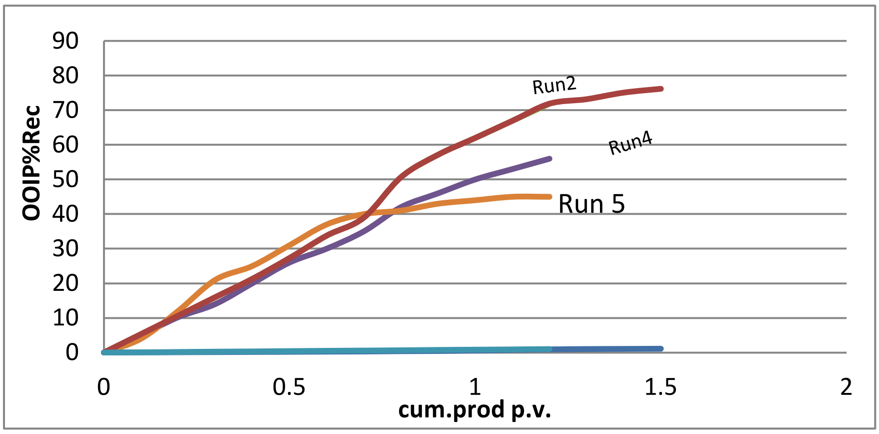

Figure (3): comparison of oil recovery with different salinities

All these results refere to decrease oil recovery with increase water salinity.
The decreasing of oil recovery is because of adsorption mechanism by which surfactant is trapped by the reservoir rock[10] , It is found that adsorption of surfactants at the solid- liquid interface will always take place and most times, instantaneously .A adsorption of surfactants at the solid / liquid interface comes into play by electrostatic interaction between solid (adsorbent) and surfactant (adsor ate)ion exchange, ion pairing and hydrophobic bonding are some of the mechanisms by which surfactants adsorb onto mineral surfaces of the rock[10,13].

CONCLUSIONS

1-Surfactant solution concentration and water salinity are play important roles in oil recovery efficiency by surfactant.
2-Ithas been shown that increase of surfactant solution concentration lead to improve oil recovery efficiency because of emulsification mechanism.
3-It has been shown that increase of water salinity lead to decrease of oil recovery percent because of adsorption mechanism.

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