Sodium Dodecyle Sulphate Injection as a Secondary Oil Recovery Method

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Abstract
Sodium Dodecyle Sulphate ($CH_3(CH_2)_{11}SO_4$-Na^+) solution was used as a secondary oil recovery by using a lab Model shown in figure-1. The effect of (solution concentration, temperature and salinity) on interfacial tension figure-2 and figure-3 and figure-4 respectively. The best values of these three variables, were taken (those values that give the lowest interfacial tension). Porosity, saturation, permeability were determined in the lab depending on Darcy law. Primary oil recovery was displaced by water until no more oil is obtained then sodium dodecyle sulphate solution was injected. The total oil recovery was 94.8% or 85.7% of the residual oil (secondary oil recovery) figure-5. This method was applied on Iraqi oil field and it gave results close to those obtained in lab model.

Keywords : Porosity , Permeability , Saturation , Oil recovery

ضخ محلول كبريتات دودسيل الصوديوم كطريقة ثانوية لإنتاج النفط

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الخلاصة
لقد تم استعمال محلول كبريتات دودسيل الصوديوم كطريقة ثانوية لإنتاج النفط وذلك باستخدام موديل مختبري (تفاصيله موجودة في متن البحث) شكل (1). كما تم دراسة تأثير كل من (تركيز المحلول ودرجة الحرارة والملوحة) على الشد البيني الأشكال (2، 3، 4) على التوالي وأخذت أفضل هذه القيم لهذه المتغيرات الثلاثة (أفضل القيم هي التي تعطي أقل شد بيني). لقد تم حساب كل من المسامية والتشبع والنفاذية بطريقة عملية في المختبر وذلك بالاعتماد على قانون دارسي. تمت عملية الإزاحة الأولية للنفط عن طريق الدفع بالماء إلى أن توقفت عملية إنتاج النفط، وبعدها تمت عملية ضخ محلول كبريتات دودسيل الصوديوم فأعطى نسبة استخلاص كلية عالية 94.8% أو 85.7% من النفط المتبقي. لقد جربت هذه الطريقة على حقل نفطي عراقي فأعطت نتائج مقاربة لنتائج الموديل المختبري وبطريقة اقتصادية.

Introduction

There are different methods used to produce oil by secondary and tertiary methods, such as water injection, carbon dioxide injection, alcohol injection, natural gas injection, surfactant injection, polymer injection, thermal oil recovery (steam injection, hot water injection). The oil recovery by water injection is low 40% at maximum conditions. Thermal recovery is not efficient because of the loss of heat through out the project from injection point to the reservoir itself. CO_2 injection and natural gas injection leads to interfingering and bad displacement of oil. Alcohol injection is costly. At the last ten years [1] the chemical flooding takes place as an economic, efficient method for secondary

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oil recovery. It depends simply on lowering the capillary pressure because the surfactant solutions characterized by low surface or interfacial tension according to the equation :

$$P_c = \frac{2\rho\cos\theta}{r} \text{........}(2)$$

where :
P_c = Capillary pressure.
ρ = interfacial tension
θ = angle of contact
r = droplet radius
The use of surfactant solution helps oil production by two mechanisms [2, 3, 4] these are :

1- By lowering capillary pressure.

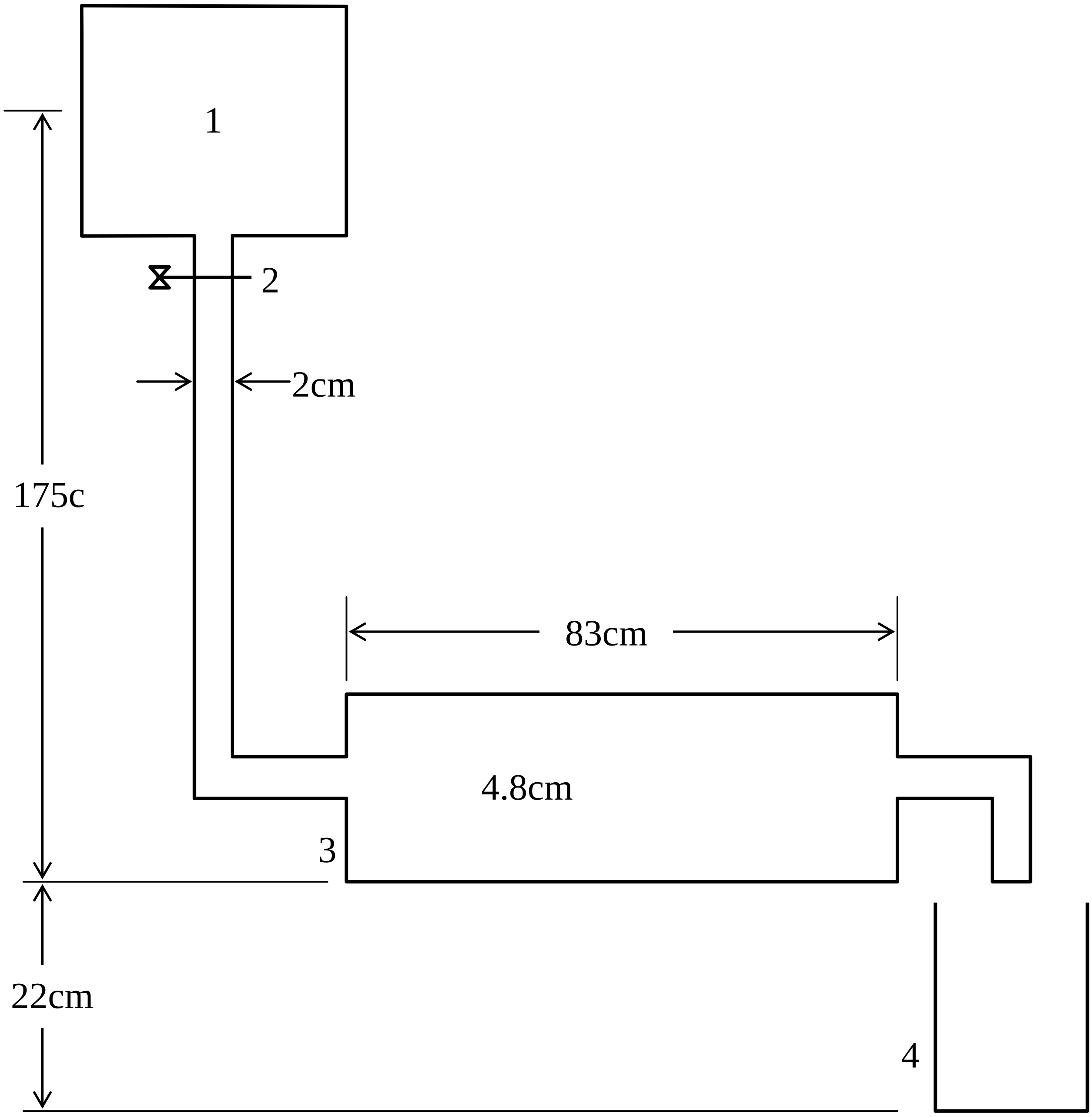
- Surfactant solutions adsorb on rock surfaces and leaving oil free to be produced easily.

In this work basic parameters were investigated, these are the relations between interfacial tension and (solution concentration, temperature and salinity) (figures-2, 3, 4), (figures-5, 6, 7). The optimum value of these variables are used in the lab model (optimum values are those which give the lowest interfacial tension). A total oil recovery obtained was 94.8% or 85.7% of the residual oil recovery. Economic considerations were carried out followed by field application on an Iraqi oil field and it gave the same results approximately. This means that this method very accurate economic recommended method in other Iraqi oil fields.

Experimental Work

Glass tube was used of length 83cm and diameter of 4.8cm filled with sand and tightly fixed with resin, it connected to oil reservoir via glass tube of 2cm diameter. The elevation of oil reservoir was 175cm above the main tube, the oil reservoir was supplied with a valve to start or stop flow and displacement operations while the other end of the main tube is curved down below which there is graduated cylinder to collect produced fluids as shown in figure-1. Porosity of the model was determined by weighting the empty and saturated glass tube, the different weight is the weight of water that entered the pores, divided by the water density give the water volume which is the pore volume.

Dividing the volume by bulk volume of the tube give the effective porosity, permeability was determined by applying Darcy law.



1 : Oil reservoir
2 : Valve
3 : Main tube
4 : Graduated cylinder

Figure 1- Model used in displacement (not to scale)

Results and Discussion

First the model was saturated with water, the water was displaced by oil this displacements give the oil and water saturations.

Interfacial tension was measures by (O-Ring) tensiometer calibrated at the beginning of each set of experiments [8, 9] . The effect of concentration was carried out and the results shown in figure-2, table-1. The lowest value of the interfacial tension corresponding to the optimum concentration is (10^{-3})M. The effect of temperature on interfacial tension was carried out and the results shown in figure-3. The optimum temperature was (38^{o}C) table-2. The effect of salinity on the interfacial tension was carried out and the optimum salinity was (994)p.p.m as shown in figure-4 table-3. The results of displacement operations of fluids are shown in table-4 and figure-5. The following properties was used in the models

K = 625 m.d So = 78% μ_o = 2.1 c.p

ϕ = 38% Sw = 22% ρ = 1.9 atmosphere

Where :

K = permeability Sw = Water saturation

ϕ = 38% μ_o = oil viscosity

So = oil saturation P = pressure

Where c = 10^{-3} M C = solution concentration

T = 38°C T = Temperature

δ = 994 p.p.m s = solution salinity

The results of displacement are shown in figure-5 and a total oil recovery obtained was 94.8% or 85.7% of the residual oil.

Table 1- The effect of solution concentration on interfacial tension

C (Molar)	γ (dyne/cm)
10^{-5}	2.5
10^{-4}	1.8
10^{-3}	0.85
10^{-2}	2.0
10^{-1}	2.9
10	3.4

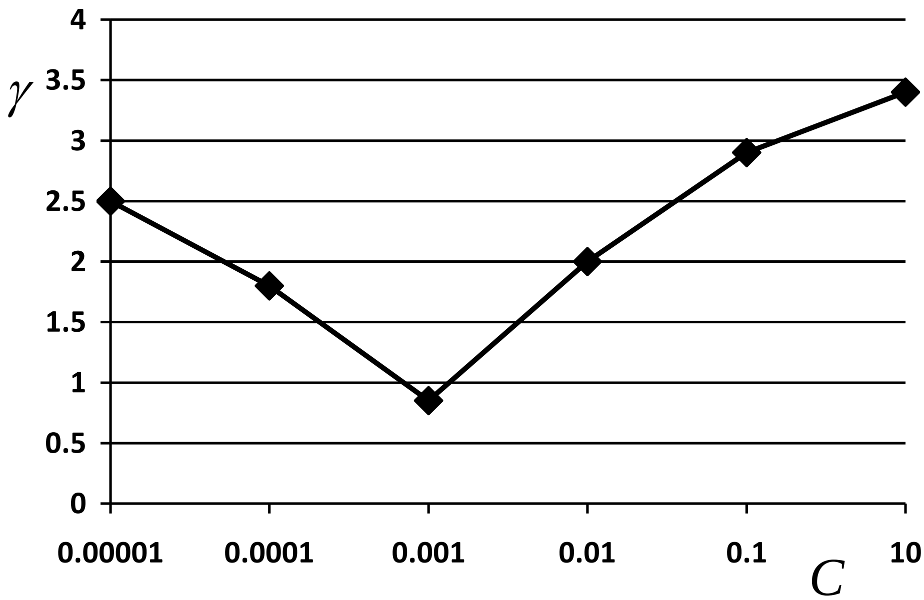


Figure 2-The effect of solution concentration on interfacial tension

Table 2- The effect of temperature concentration on interfacial tension

T, °C	γ (dyne/cm)
10	2.8
20	1.4
30	1.2
40	1.1
50	1.3
60	1.38

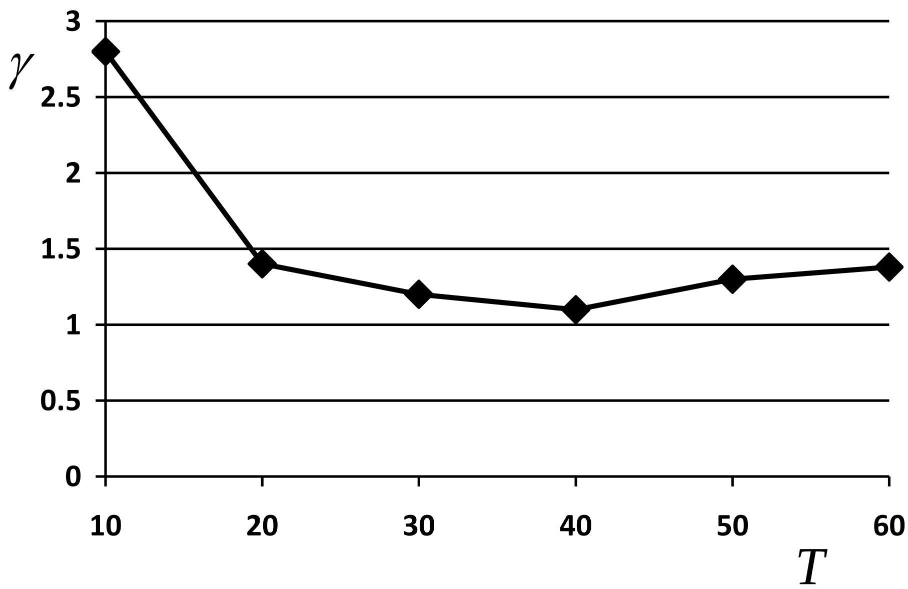


Figure 3- The effect on temperature on interfacial tension

Table 3- The effect of salinity on interfacial tension

S p.p.m (X 10^3)	γ (dyne/cm)
0.5	0.4
1.0	0.6
1.5	0.8
2.0	1.2
2.5	1.9
3.0	2.5
3.5	3.2
4.0	3.8
4.5	4.5
5.0	4.9
5.5	5.3

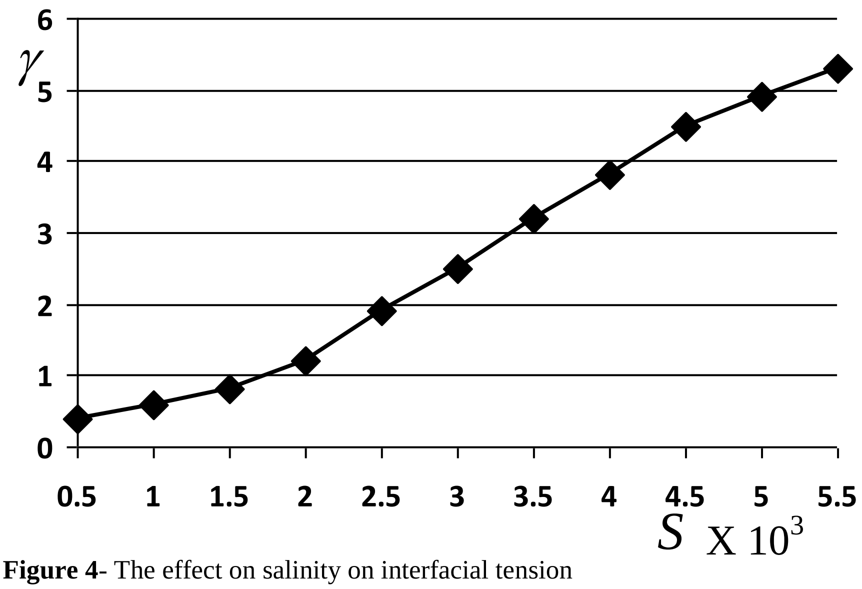


Figure 4- The effect on salinity on interfacial tension

Table 4- The results of displacement operations

Pore volume injected X 10^{-1}	Oil recovery %
1	20
2	23
3	25
4	36
5	48
6	64
7	80
8	92
9	93
10	94.8

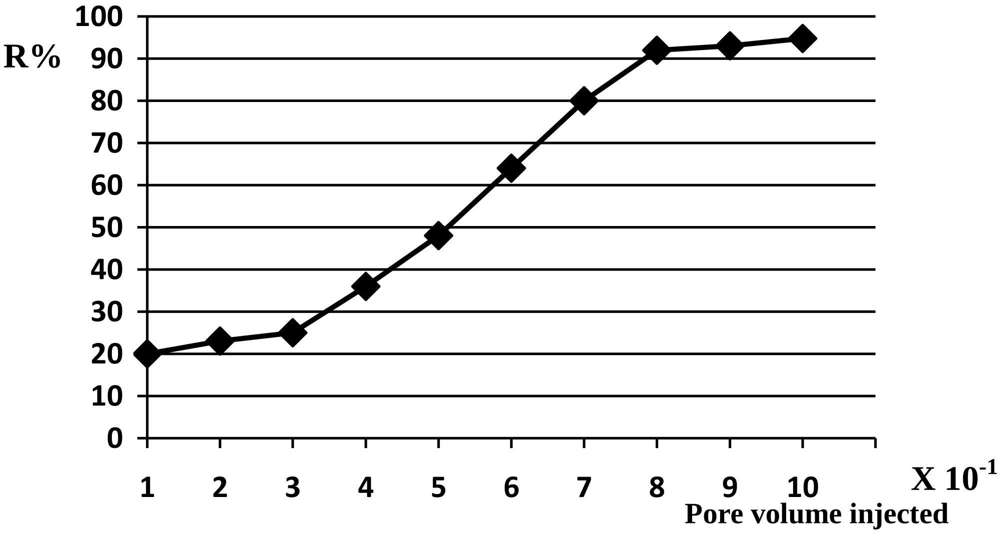


Figure 5- Total oil recovery (R%) VS total volume injected

Field application

The results of this work were applied on an (Iraqi X field) and it gave the same results approximately. A container of the mentioned surfactant was purchased by (125) dollar and diluted to the optimum mentioned concentration and it was enough to produce (50) barrels of oil assuming that the price of 1 barrel (50) dollar, that means (2500) dollar. Now the ratio of project cost to the price of the recovered oil is $\frac{125}{2500} 0.05$ or 5%. Therefore it is recommended to use this method at commercial scale.

Conclusion

1. Surfactant solutions characterized by low interfacial tension and this aids oil production.
2. Anionic type of surfactants are used in this work and it gave the best oil recovery.
3. Surfactant solutions suitable for oil production because they adsorb on rock surface leaving free to be produced.
4. Surfactant solutions are cheep and hence they can be used as an economic for secondary oil recovery.
5. High recovery are obtained in this method.

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