# The use of laurylamine hydrocholoride $CH_3(CH_2)_{11}\ NH_3 - \overline{Cl}$ for secondary oil recovery

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## Abstract:

Laurylamine hydrochloride $CH_3(CH_2)_{11}\ NH_3 - Cl$ has been chosen from cationic surfactants to produce secondary oil using lab. model shown in fig. (1). The relationship between interfacial tension and (temperature, salinity and solution concentration) have been studied as shown in fig. (2, 3, 4) respectively. The optimum values of these three variables are taken (those values that give the lowest interfacial tension). Saturation, permeability and porosity are measured in the lab. The primary oil recovery was displaced by water injection until no more oil can be obtained, then laurylamine chloride is injected as a secondary oil recovery. The total oil recovery is 96.6% or 88.8% of the residual oil has been recovered by this technique as shown in fig. (5). This method was applied in an oil field and it gave approximate values close to that obtained in the lab.

**Key words : surfactants, optimum concentration, optimum salinity, optimum temperature, oil recovery, Lab. Model, injection process.**

## Introduction :

A large number of techniques are available for the production of oil by secondary and tertiary methods, among them (water injection, carbon dioxide injection, alcohol flooding, natural gas injection, thermal oil recovery, and chemical flooding [1].

The oil recovery by water injection is low (40% at max. conditions). Thermal recovery (hot water injection, steam injection) is not efficient [2] due to the loss of heat from the injection well to the reservoir itself. Carbon dioxide and natural gas injection lead to inter fingering and bad displacement of oil. Alcohol injection is costly. At the last (15) years the chemical flooding takes place as an economic efficient method for secondary oil recovery [3]. It depends on lowering interfacial tension and this results in lowering the capillary pressure according to the equation :

$$Pc = \frac{2\sigma \cos\theta}{r} \quad \ldots\ldots\ldots [4]$$

Where;

| | |
|---|---|
| Pc = capillary pressure | dyne/cm$^2$ |
| $\sigma$ = interfacial tension | dyne/cm |
| $\theta$ = contact angle | degree |
| r = radius of droplet | cm |

Also surfactant solutions aid in oil production because surfactant solutions adsorb on rock surface leaving oil free to be produced easily [5, 6]. In this work basic parameters have been investigated, these are the relations between the interfacial tension and (temperature, salinity, and solution concentration) figures (2, 3, 4) respectively. The best values of these variables are used (these values that give the lowest values of interfacial tension) in a lab. model. The total oil recovery obtained has been 96.6% or 88.8% of the residual oil. Field

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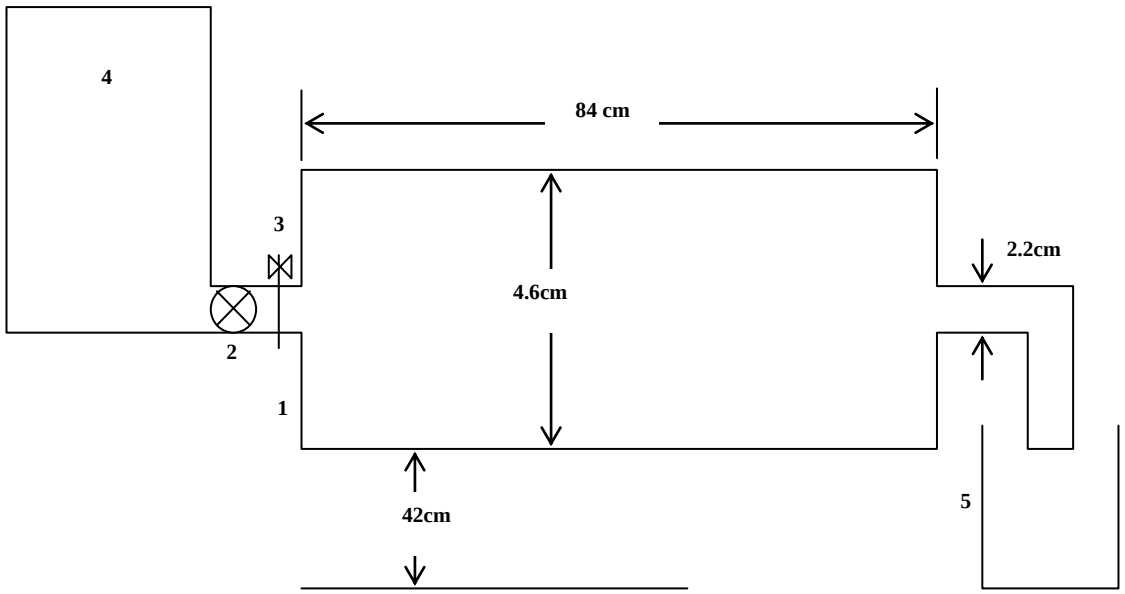
application has been carried out and it gave the same results approximately and it found that it is very economic.

## Materials and Methods :

A lab model consists of a glass tube of 84cm length and 4.6 cm diameter filled with sand tightly packed with resin, it has been connected to oil tank through glass tube of 2.2 cm diameter. The oil tank is supplied with a valve to initiate or stop flow. Also it is supplied with pump to facilitate the flow. The other end of the tube is curved down below which is graduated cylinder to receive produced fluids as shown in fig. (1). Permeability has been calculated by using Darcy law. Porosity has been determined by weighing the empty & saturated the sand pack.




1- main tube 2- pump 3- valve 4- oil reservoir 5-graduated cylinder

**Fig. (1) Model used in displacement process (not to scale)**

The difference in weight is the weight of water that entered in pores, dividing the weight by water density gives the volume of the water which is equal the pore volume, then :

$$\%\phi = \frac{VP}{VB} \times 100 \quad \text{…….. [7]}$$

where VP = pore volume

$\phi$ = porosity (effective)

VB = Bulk volume

## Results and Discussion:

First the model has been saturated with water, then the water has been displaced by oil, now the model contains two fluids, water and oil. Interfacial tension has been measured by (O-Ring) tensiometer calibrated at the beginning of each set of experiments [8]. The effect of temperature on interfacial tension has been carried out and their results are shown in fig.(2). The optimum temperature that corresponds to the lowest interfacial tension has been 36$^{o}$C give the optimum recovery because it corresponds to the minimum interfacial tension. [9] The effect of salinity on the interfacial tension has been carried out. The optimum salinity that corresponds to the low interfacial tension has been (986 p.p.m) as shown in fig. (3) this salinity (986 p.p.m) give the optimum recovery because it

corresponds to the minimum interfacial tension. The effect of solution concentration is studied, the optimum concentration corresponding to the lowest interfacial tension is ($10^{-2}$M) [10] this concentration ($10^{-2}$M) give the optimum recovery because it corresponds to the minimum interfacial tension. The following properties are used in the lab model.

K = 580 m.d sw = 18%

$\phi$ = 40% $\mu_o$ = 2.3 c.p

$\delta_o$ = 82% P=1.85 atmosphere

T = 36°C C = $10^{-2}$ M

S = 986 p.p.m

Where

K = Permeability m.d

$\phi$ = Porosity (effective)

$\delta_o$ = Oil saturation

sw = Water saturation

$\mu_o$ = Oil viscosity c.p

P = Pressure atmosphere

C = Solution concentration, molar

S = Salinity of solution p.p.m

T = Temperature °C

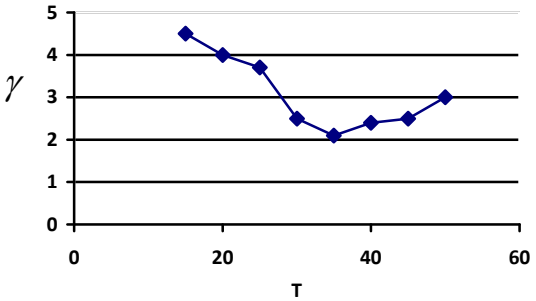



**Fig. (2) The effect of temperature on interfacial tension**

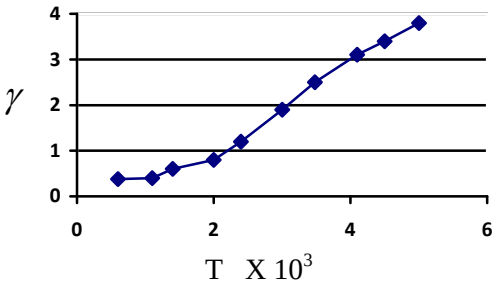



**Fig. (3) The effect of salinity on interfacial tension**

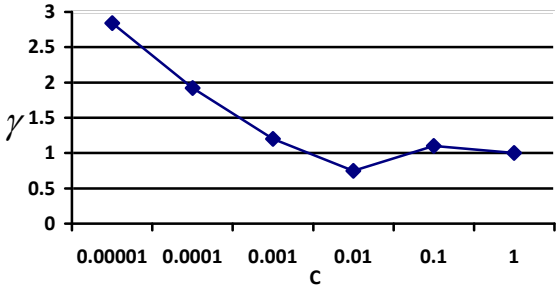



**Fig. (4) The effect of solution concentration on interfacial tension**

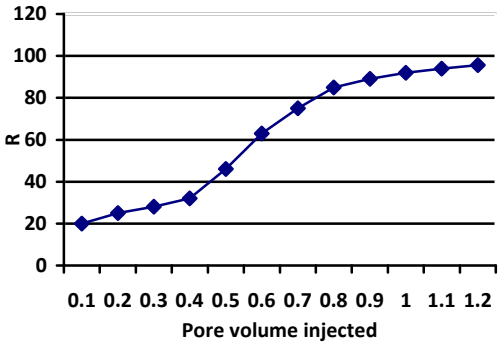



**Fig. (5) Pore volume injected versus total oil recovery R**

## Field application :

This work applied on an oil field and it gave results close to that obtained in the lab a certain quantity of this material (laurylamine hydrochloride) was bought by 320 dollars and it was enough to produce 80 barrels of oil, assuming that the price of one barrel 50 dollars that means 50 X 80 = 4000 dollars. Now the ratio of the cost to income = $\frac{320}{4000}$ = 0.08 or 8% and this means it is very economic.

## Conclusion :

1- Since the study showed that low concentration give the optimum oil recovery ($10^{-2}$M) that means little quantity of it give high quantity of oil and that leads to the conclusion it is an economic method.

2- Cationic type of surfactant solution has been used and it gave a high oil recovery.
3- Surfactant solution have low interfacial tension and hence it aid the oil production.
4- Cationic type of surfactants are suitable for some oil reservoirs while anionic are suitable for other oil reservoir because of the difference in electrical properties of reservoir rocks.

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# استخدام كلوريد أمين لوريل لاستخراج النفط الثانوي


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**الخلاصة :**

لقد تم اختيار كلوريد أمين لوريل من المحاليل فعالة السطح سالبة الشحنة (cationic) لاستخراج النفط الثانوي باستخدام موديل مختبري كما مبين في الشكل (1). درست العلاقة بين الشد البيني و(درجة الحرارة، الملوحة، وتركيز المحلول) كما مبين في الأشكال (2، 3، 4) على التوالي. أخذت أقصى القيم لهذه المتغيرات الثلاثة (تلك القيم التي تعطي أقل شد بيني). لقد تم قياس التشبع والنفاذية والمسامية في المختبر.

لقد تمت الإزاحة الأولية للنفط عن طريق حقن الماء إلى أن توقف إنتاج النفط. وبعد ذلك تم حقن محلول كلوريد أمين لوريل إن إنتاج النفط الكلي هو 96.6% أو 88.8% من النفط المتبقي بهذه التقنية كما مبين في الشكل (5). تم تطبيق في حقل نفطي فأعطت نتائج مقاربة للنموذج المختبري.