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Alteration of IFT by Phase Inversion Emulsification to Enhance Recovery of Oil Wet Limestone

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Abstract Objectives/Scope: To synthesize a phase inversion emulsion that reduces interfacial tension effectively and improves oil recovery for a crushed limestone sample. Phase inversion emulsification has been chosen on the basis of critical micelle concentration (CMC) by conductivity test.
Methods, Procedures, Process: Emulsion tests have been conducted to find out suitable proportion for chemical flooding .The size of an emulsion has been reduced by increasing temperature and it has been observed by conductivity test. Selection of phase inversion micelle has been done by conductivity test at different temperature levels. The stability of synthesized micelle has enhanced by rapid cooling.
Results, Observations, Conclusions: Critical micelle concentration (CMC) of SDS has been found to be 550ppm by conductivity test. Phase inversion stage was recorded near to 80 degree Celsius with the help of conductance at low CMC level. Rock minerals make surfactants ineffective.. Sodium Dodecyl Sulphonate (SDS) anionic surfactant of 8 HLB has been chosen through emulsion test for reducing IFT. The recovery of crude has been observed to increase 15% of its pore volume after phase inversion emulsion injection through core flooding. This emulsion has potential application in field samples to recover additional crude from any carbonate reservoirs
Novelty: Phase inversion emulsion is an effective solvent prepared at specific temperature to reduce IFT at optimum level.It is a new form of solvent, which has the best CMC level that could be miscible with organic as well as polar solvents.

I. INTRODUCTION

More than 60% of reservoirs globally are carbonates and 90% of them are oil wet to mixed wet. The major form of crude will be in emulsion at reservoir conditions. The Recovery of crude can be improved by reducing IFT with an effective surfactant emulsification [1].

The complex nature of carbonate reservoirs leads more challenges in chemical flooding operations. Almost an average of 60% of original oil in-place (OOIP) are left behind primary and secondary operations at deep wells for oil wet to mixed wet reservoirs [2]. Application of surfactants successfully on carbonate reservoir has been limited in laboratories than field. As per the literature, limited work has been cited based on surfactant flooding related to carbonate reservoirs. There are so many carbonate fields with decline production rate can be improved by this process.

The molecular structure and ability to alter the properties at interface makes surfactant more reliable for an oil recovery mechanism. Although surfactant has a great impact on oil recovery the size of CMC is being a greater concern. The main application of surfactants is to reduce Interfacial Tension (IFT) between oil and water to improve recovery efficiency. The potential capacity of this emulsion in a large scale has a great impact on field applications [3]. Preparing a micro emulsion with low CMC has an optimum impact on IFT. It can be prepared by phase inversion emulsification, where different proportions of emulsion were treated at different temperatures. Under core analysis reduction of IFT by application of phase inversion emulsion on crushed limestone sample has been reported.

II. METHODOLOGY

A. *Conductance for CMC*

Critical micelle concentration is considered at a particular concentration of surfactant where complete micelle can be observed [4]. Micelle is a droplet of two phases bombarded at specific conditions. The formation of micelle indicates the lowest size of droplet. At this concentration of surfactant, the interfacial tension between an emulsion could be minimized. Conductivity rises with increasing concentration of surfactant due to solubility in hydrophilic and lipophillic groups[5]. Until the interface is completely ouccupied by surfactants conductivity would be gradually rising. Beyond addition of surfactants it leads to increase the size of a micelle rather than conductance, which remains constant.

B. Emulsion Tests

Emulsion studies are conducted to find a specific proportion of surfactant, brine and alkaline suitable for core flooding[6]. Emulsions are prepared by different concentrations with constant phase oil and kept for two to three days for emulsification. After these days emulsions were observed for three layers, which indicate oil and water were completely separated by the proportion applied. This proportion is chosen for further applications in core flooding[7].

C. Phase Inversion Emulsion

Phase inversion temperature is the temperature where a non-wetting fluid starts to convert itself into wetting fluid [8]. When these observations were observed for an emulsion then it is phase inversion emulsion as shown in figure.1. After selecting a surfactant concentration through emulsion studies, the whole emulsion is been observed at different temperatures in ascending order. The drop in conductance of this emulsion is estimated at specific temperature as shown in figure 1. Rapid cooling for this emulsion leads stability, which indeed can be carried for core floods.

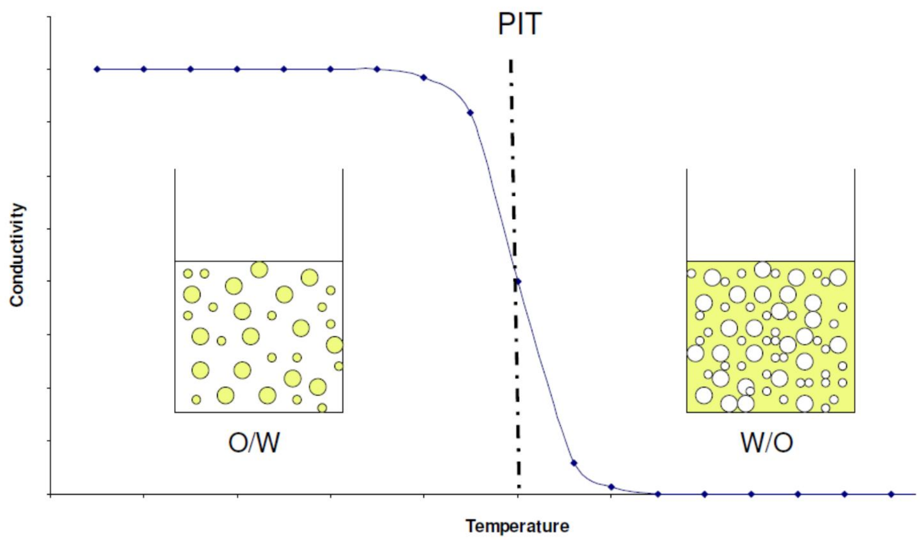

Figure 1. conductivity with temperature as a function of phase inversion

D. Coreflooding

The coreflood operations were carried after selecting phase inversion emulsion. Initially the core would be treated by water and aged by oil. The oil after aging would be recovered by water and surfactants through flooding [9]. The process would carry primary, secondary and tertiary mechanisms. The recovery after water flooding by phase inversion emulsion would be considered as enhanced oil recovery. The results from these tests are upscaled to reservoir condition.

III. RESULTS

Different concentrations of SDS has been tested with respect to conductivity. A graph of different concentrations were plotted against conductivities as shown in figure.2. Deviation in trend was observed near 550ppm with 32 ohm and considered as CMC. The CMC solution as a wetting phase was emulsified with oil. This emulsion has been treated with different temperatures. simultaneously conductivities were recorded at each temperature. Form the graph Conductivity vs temperature phase inversion was found to be at 80 degree Celsius as shown in Figure 3. The emulsion at 80 degree Celsius was cooled rapidly and considered as phase inversion emulsion.

The core of following specifications was chosen for flooding as shown in table 1. Initially, core was flooded by river water to make it water wet naturally. Then 5 PV (pore volumes) of oil has been flooded to displace water. The left out water after displacement is 0.15 PV . Remaining oil was flooded by water.

The left out oil was 0.35PV was treated with phase inversion emulsion. And the recovery of oil observed to be 0.27PV out of 0.35PV.

Specifications	Width	Height	porosity	type	texture
Core	3 inch	3 inch	26%	sandstone	Fine and Slightly Silty

Table 1. Core dimension and property specifications

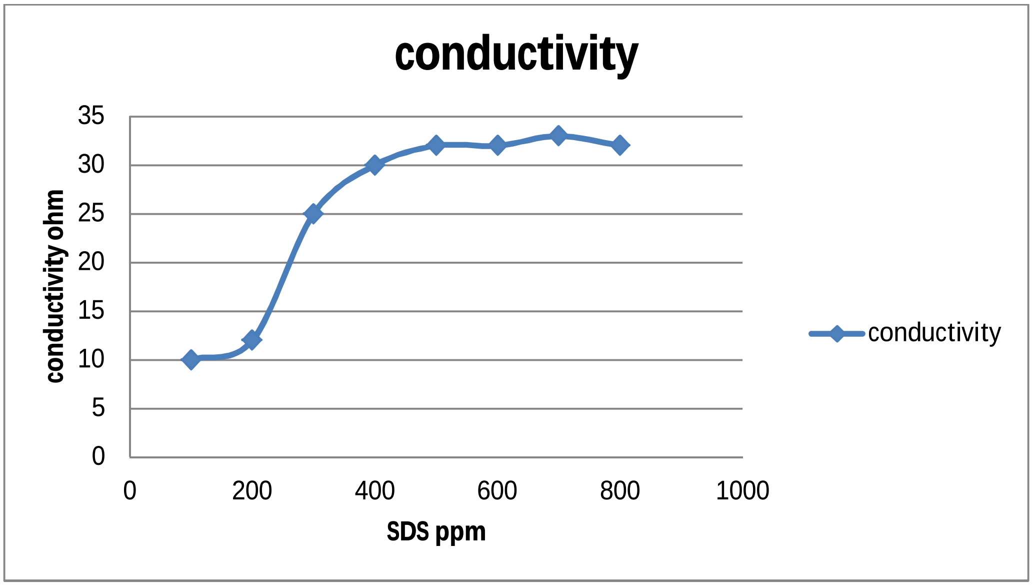

Figure 2. Criticle micelle concentration for conductivity

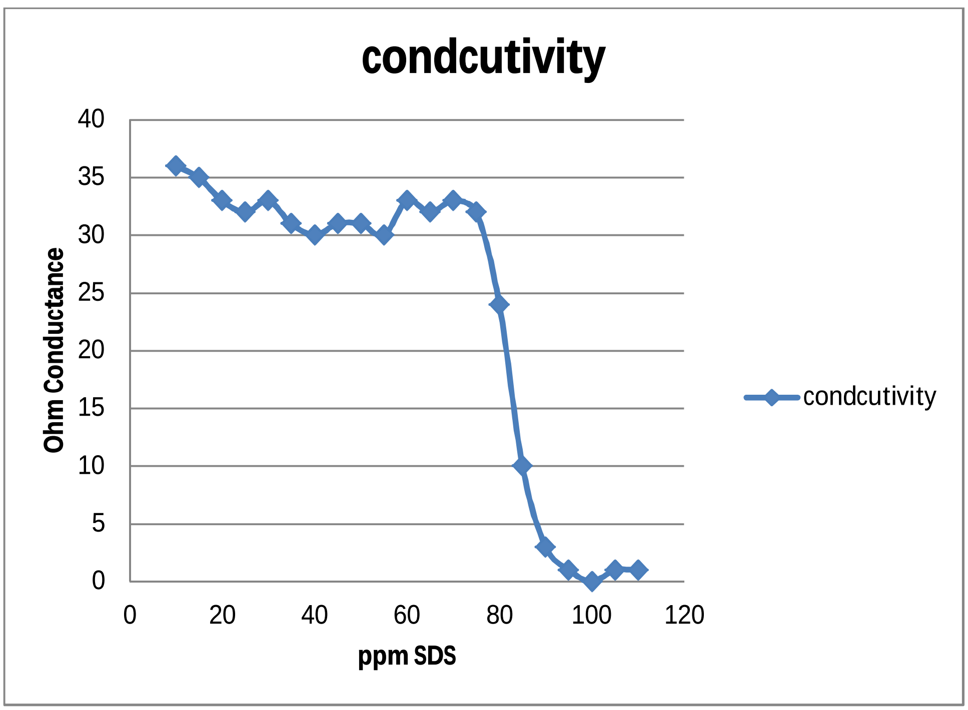

Figure 3 Condcutivity for phase inversion emulsification

IV. DISCUSSION

Phase inversion method was observed to be effective in recovering additional oil next to water flooding. This emulsion has a property of deep dissolution with reservoir fluids to interact and reach the edges. For choosing an emulsion SDS has been preferred to be effective. Since it has shown positive results in the application of sandstones for its non adsorbant behavior. CMC has been chosen at 550 ppm. Hence the rise in conductance has been ceased. Means the micelle formation with wetting phase has been optimum. At this concentration of SDS it will exhibit ultra-low interfacial tension which will separate oil and water from emulsion state. For phase inversion emulsion the conductivity will be high for oil in water as an emulsion and vice versa. When the oil in water emulsions was treated at different temperatures, conductivities were observed to fall gradually. A drastic fall of conductance was observed between 60 and 100 degree Celsius as shown in figure 3. So as an average of 80 degree Celsius has been considered as phase inversion temperature. The emulsion with rapid cooling was treated for core flooding successfully.

V. CONCLUSIONS

There are number if techniques available to recover oil after water flooding. phase inversion emulsion had shown positive results for recovering residual oil. The same procedure can be applied to other reservoirs like limestones and shales. For choosing a surfactant, adsorption verification is required with reservoir. phase inversion technique is one of the most effective and time consuming for oil recovery process.

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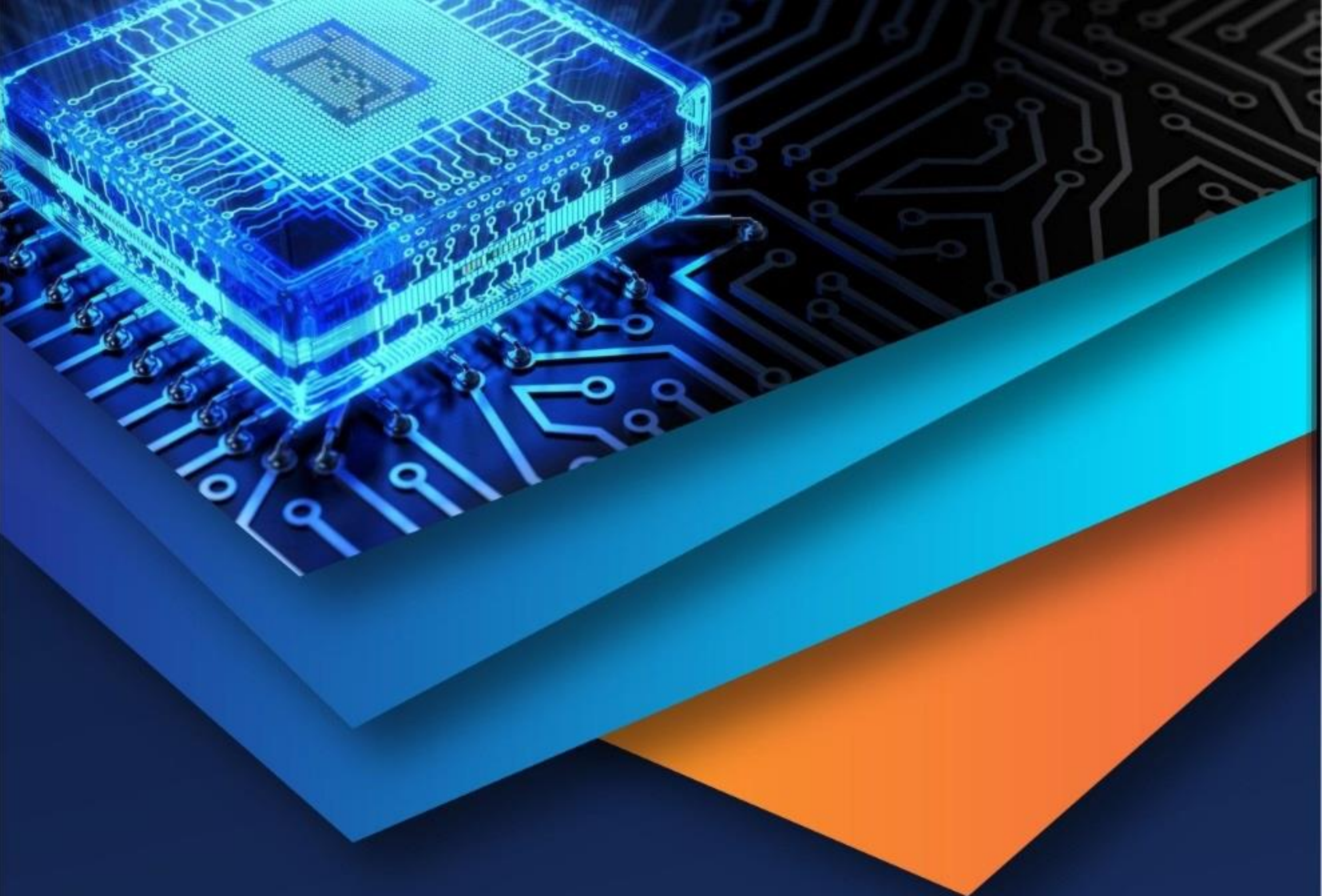

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