Performance Evaluation of Surfactant and Demulsifier in Crude Oil Emulsion Treatment

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Abstract

The Oil and Gas Industry is faced with problems caused by the formation of water-in-crude oil emulsions and crude oil in water emulsion resulting in the loss of a huge sum of money to treat and for the market specification. The existence of water along with the crude oil that is being produced is undesirable because of problems directly correlated to foaming, corrosion of pipelines and tanks, higher power consumption, and increased volume and viscosity. Several methods have been employed to solve these problems, but still, open due to inefficiency and divergence of views. The choice of surfactant and what concentration have been a challenge for proper dissolution of the emulsion. Hence, this project work covers Chemical treatment of Crude oil emulsions which occurred in AGBD2 063T & OBGN 007L using different concentration (1, 2, 3 & 4ml) of Texapon (Surfactant) and 10ml of Hexane (Demulsifier) and repeated using different concentration (5, 7, 8 & 10mls) of Hexane (Demulsifier) and 1ml of Texapon (Surfactant). It was observed that after 4 hours at an increasing concentration (5, 7, 8 & 10mls) of Demulsifier and constant concentration (1ml) of Surfactant the percentage (20, 13, 35.6 & 37.7%) of water/crude oil recovered is minimal compared to the percentage (45.7, 41.2, 39.4 & 28.1%) of water/crude oil recovered at an increasing concentration (1, 2, 3 & 4ml) of Surfactant and constant concentration (10ml) of Demulsifier for AGBD2 063T crude oil sample. Also, it was noticed that after 4 hours at an increasing concentration (5, 7, 8 & 10mls) of Demulsifier and constant concentration (1ml) of Surfactant the percentage (10, 42.6, 40 & 48.6%) of water/crude oil recovered is minimal compared to the percentage (47.1, 41.2, 39.4 & 40.6%) of water/crude oil recovered at an increasing concentration (1,2,3 & 4ml) of Surfactant and constant concentration (10ml) of Demulsifier for OBGN 007L crude oil sample. Therefore, lower concentration (1ml) of surfactant and higher concentration (10ml) of demulsifier yields (37.7, 45.7, 48.6 & 47.1%) an efficient water/crude oil recovery percentage for both AGBD2 063T & OBGN 007L. Hence, it is recommended that different surfactants and demulsifiers should be used to carry out the same research to ascertain the validity of the conclusion.

Keywords: *Crude Oil, Emulsion, Hexane, Texapon, Chemical Treatment, Volume.*

I. INTRODUCTION

The coproduction of water with crude oil can give rise to a variety of problems such as the expense of pumping or transporting the water via pipeline or tanker, the corrosion of pipework pumps, production equipment, and downstream overhead distillation columns, the additional production equipment required to give export quality crude oil, the poisoning of downstream refinery catalysts, and the problems associated with increased oil viscosity as a consequence of finely dispersed water within crude oil [1]. An emulsion, a mixture of two immiscible liquids, typically oil and water, requires proper emulsification for adequate separation.

The emulsification of water in oil is usually difficult because of the associated miscibility issues between the phases. However, the presence of natural surfactants in the crude oil composition and the effect of shear mixing during production have been noted to contribute to the formation of such emulsions [2]. This mixing of oil and water is not as stable as a result of coalescence. Hence, in many cases, introducing a third agent called an emulsifier is often necessary [3].

Emulsion normally does not exist in the producing formation but are formed when oil and water are produced together with a great amount of agitation when water and oil in a reservoir enter the wellbore through the perforations in the casing, comparatively large pressure differences are created which violently mix the produced oil and water so that emulsion forms[4]. Emulsions can be formed either naturally or by human activities. Emulsions are mainly encountered during crude oil transportation in wellbores or pipelines.

Ovuema et al. [5] outlay conditions in which emulsions are formed during crude oil transportation, including the presence of two immiscible liquids, the presence of an emulsifying agent, and sufficient energy of agitation to disperse one phase into the other.

Fingas [6] pointed out that three main criteria are necessary for the formation of crude oil emulsion, including two immiscible liquids, a surface-active agent, and proper agitation. The immiscible liquids in question must be brought in contact and aided by a surface-active component (an emulsifying agent) and sufficient mixing or agitating effect.

Emulsions are generally formed by the dispersions of a liquid phase in another, which exhibit certain stability, in most cases thanks to the presence of an adsorbed surfactant at the interface. Hence, at least two immiscible liquid phases should be present to make an emulsion. The phase behavior of this liquid system made by the surfactant and the immiscible liquids is of paramount concern [7].

Emulsions are thermodynamically unstable; hence changes of emulsion properties are bound to occur,

and the more slowly the properties change, the more stable the emulsion is. Pichot[3]shows that coalescence, flocculation, and creaming can alter emulsion properties. The same study showed that two or more of these instability phenomena might occur simultaneously. Hence, knowledge of the viable causes of instability is necessary to select suitable components to form stable emulsions. Flocculation of dispersed particles is not considered a serious sign of instability compared with coalescence or emulsion breaking [3].

The adverse and beneficial effects of the emulsion can be realized only if the emulsions are stable. If the emulsions are unstable, they will soon separate into two distinguished phases of water and oil [8].

The majority of emulsion technology problems are related to the stabilization and destabilization of emulsions [7]. Though many studies have been related to emulsion stability, the extreme variability and complexity of the systems involved in any specific application often lead to the adoption of technologically viable results without developing a detailed understanding of the fundamental process. To attain a technological breakthrough in the design of emulsions with a very delicate equilibrium between stability and instability, a proper understanding of the underlying mechanisms is needed. Notwithstanding their thermodynamic instability, many emulsions are kinetically stable and do not change appreciably for a prolonged period. These systems exist in the metastable state [7]. The fundamentals of emulsion stability (destabilization) comprise emulsion surface chemistry and physicochemical kinetics.

In contrast to the large success in industrial applications of emulsion surface chemistry, physicochemical kinetics' potential as the basis for emulsion dynamics modeling is almost not comparing this result with the delineation procedure characterized in one experimental and theoretical approach to the dynamic behavior of emulsions used in emulsion technology. This situation has started to change during the last decade. Although the coupling of the sub-processes in emulsion dynamics modeling (EDM) continues to represent a large problem yet not solved, models are elaborated for macro emulsions and mini-emulsions.

Several factors have been identified to influence emulsion stability. These factors include mixing speed/duration, pH and temperature of the solution. Ashrafizadeh et al. [9] showed that higher mixing speed and longer mixing duration would produce smaller emulsion droplets that have interfacial area and droplet-to-droplet interaction resulting in the formation of a more stable emulsion. Yang et al. [10] and Bozkir et al. [11] emphasized that oil in water emulsion with higher pH will promote surfactant affinity to aggregation, which would result in the formation of a more stable emulsion for oil in water emulsion; higher pH would promote more affinity of surfactant molecules towards aggregation resulting in a more stable emulsion. Several studies have shown the effect of temperature to reduce emulsion viscosity, leading to destabilization and emulsion breakdown.

In this study, the effects of surfactants and demulsifiers on crude oil emulsion treatment are evaluated at different mixing conditions.

II. Materials and Method

The Performance of surfactants and demulsifiers on crude oil emulsion treatment have been investigated in this study using laboratory procedures. Two crude oil samples (AGBD2 063T & OBGN 007L) were tested under different scenarios of varying surfactants and demulsifier volume and constant volume of xylene stabilizer. In each crude oil sample, four (4) special samples (A-D) were formulated to represent the different test scenarios. The laboratory procedures, sample composition, and the materials/apparatus are presented.

A. Materials and Apparatus

In this study, the materials/apparatus used include: Two (2) different crude oil samples (AGBD2 063T & OBGN 007L), distilled water, xylene (used as a stabilizer), Texapon (surfactant), Hexane (demulsifier), sets of beakers, 100ml measuring cylinder, 25ml pycnometer, Red Wood Viscometer, weighing balance, separating funnels, air coolers, wash bottles and spatulas.

B. Sample Preparation

The data in Table 1 and Table 2 shows the various compositions of the samples under the test scenario considered. Each sample is made up of a total of 50ml of a solution comprising of 24-40% water, 40% crude oil, 8%of xylene, 2-8% Texapon, and 10-20% of Hexane.

Table 1: Sample Preparation Ratio for the Evaluation of the Effect of Demulsifier

	Sample A (ml)	Sample B (ml)	Sample C (ml)	Sample D (ml)
Crude Oil	20	20	20	20
Water	20	18	17	15
Stabilizer (Xylene)	4	4	4	4
Surfactant (Texapon)	1	1	1	1
Demulsifiers (Hexane)	5	7	8	10

Table 2: Sample Preparation Ratio for the Evaluation of the Effect of Surfactant

	Sample A (ml)	Sample B (ml)	Sample C (ml)	Sample D (ml)
Crude Oil	20	20	20	20
Water	15	14	13	12
Stabilizer (Xylene)	4	4	4	4
Surfactant (Texapon)	1	2	3	4
Demulsifiers (Hexane)	10	10	10	10

C. Experimental Procedure

In this study, two test case scenario were employed:

- Case A: Varying Hexane (Demulsifier) volume and constant Texapon volume
- Case B: Constant Hexane (Demulsifier) volume and varying Texapon volume

The measuring cylinders and beakers were washed and dried accordingly. Four (4)100ml graduated measuring cylinders were labeled for different samples A-D prepared in section (2.2) above. A known sample of xylene was added for the emulsion's stability with different volumes of Hexane (demulsifiers) and constant volume of Texapon (surfactant) as given in Table 1 above, representing test case A. The sample mixture was agitated for about 2 minutes at room temperature, and the volume ratio of water recovered was recorded hourly for 4hours. The above procedure was repeated for test case B, and the results are presented.

III. Results and Discussion

The rate of separation of the two different crude oil samples (AGBD2 063T, OBGN 007L) with API gravity of 14.602 ^{0}API & 17.620 ^{0}API respectively are comparatively analyzed at the different test scenarios.

For the crude oil sample(AGBD2 063T) under test case A, it was observed from sample A that at 1 hour, 2 hours, 3 hours, and 4 hours the following percentage(10%, 12.5%, 15%, and 20%) of water was recovered; hence an increase in time increases the percentage of water recovered. Similarly in sample B, C and D, the percentage of water recovered (2.6%, 7.9%, 12.5% and 13%), (29.7%, 35.1%, 35.1% and 35.6%) and (37.1%, 37.1%, 37.7% and 37.7%) are presented in Table 3.Therefore, it can be infer that as demulsifier volume increases (from sample A to D), a non-linear relationship exists. This is characterized by the decrease in water per sample recovery ratio from sample A to B and an increase in water recovery from sample B to D as observed at each time interval. However, there is little or negligible increase in the volume of water per sample recovered on an hourly basis as demulsifier volume increases. The observed trend for crude oil sample (OBNG 007L) did not exhibit a similar behavior at a varying volume of demulsifier (Hexane) and constant surfactant and stabilizer volume. The results explain why different emulsion mixtures will respond differently to a variety of factors. The percentage of water recovered for sample A, B, C and D after 1hr, 2hrs, 3hrs and 4hrs from Table 4 are (1.25%, 5%, 7.5% and 10%), (42.1%42.1%, 42.1% and 42.6%), (32.4%, 37.8%, 38.4% and 40%) and (48.6%, 48.6%, 48.6% and 48.6%) respectively.

Table 3: Rate of separation for AGBD2 063T

Volume ratio of water/ crude oil recovered				
(ml)	1hr	2hrs	3hrs	4hrs
Sample A	4/40	5/40	6/40	8/40
Sample B	1/38	3/38	4/38	5/38
Sample C	11/37	13/37	13/37	13.2/37
Sample D	13/35	13/35	13.2/35	13.2/35

Table 4: Rate of separation for OBGN OO7L

	Volume ratio of water/ crude oil recovered (ml)			
	1hr	2hrs	3hrs	4hrs
Sample A	0.5/40	2/40	3/40	4/40
Sample B	16/48	16/38	16/38	16.2/38
Sample C	12/37	14/37	14.2/37	14.8/37
Sample D	17/35	17/35	17/35	17/35

Table 5 and 6 shows results for test case B in which the surfactant volume was varied at constant demulsifier and stabilizer volume. For the crude oil sample(AGBD2 063T), the water percentage volume recovered at 1hr, 2hrs, 3hrs and 4hrs for samples A, B, C and D are (45.7%, 45.7%, 45.7% and 45.7%), (38.2%, 39.7%, 39.7% and 41.2%), (39.4%, 39.4%, 39.4% and 39.4%) and (17.2%, 21.9%, 28.1%, and 28.1%) respectively.

Hence, increase in the surfactant volume from sample A-D, decreases the water recovered. The hourly recovery unlike the case A shows a near constant variation. The results of the crude oil sample(OBGN 007L) shows a similar behavior except at 4ml surfactant volume, were the water recovered increases. The percentage volumes of water recovered are: (45.7%, 47.1%, 47.1% and 47.1%), (35.3%, 38.2%, 38.2%, and 41.2%), (34.8%, 37.9%, 39.4% and 39.4%) and (37.5%, 40%, 40.6%, and 40.6%).

Table 5: Rate of separation for AGBD2 063T

	Volume ratio of water/ crude oil recovered (ml)			
	1hr	2hrs	3hrs	4hrs
Sample A	16/35	16/35	16/35	16/35
Sample B	13/34	13.5/34	13.5/34	14/34
Sample C	13/33	13/33	13/33	13/33
Sample D	5.5/32	7/32	9/32	9/32

Table 6: Rate of separation for OBGN 007L

	Volume ratio of water/ crude oil recovered (ml)			
	1hr	2hrs	3hrs	4hrs
Sample A	16/35	16.5/35	16.5/35	16.5/35
Sample B	12/34	13/34	13/34	14/34
Sample C	11.5/33	12.5/33	13/33	13/33
Sample D	12/32	12.8/32	13/32	13/32

The effectiveness of surfactants and demulsifiers on emulsion treatment and their stability depends on the actual crude oil type and the emulsion system. The rate of separation of water/crude oil recovery at a different volume of demulsifier and surfactant are presented in Fig. 1, 2, 3, and 4.

AGBD2 063T

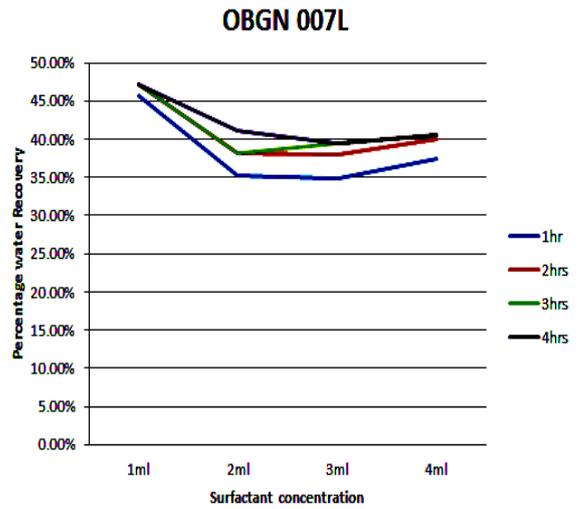**Figure 1: Effect of Demulsifier volume on AGBD2 063T Emulsion Systems**
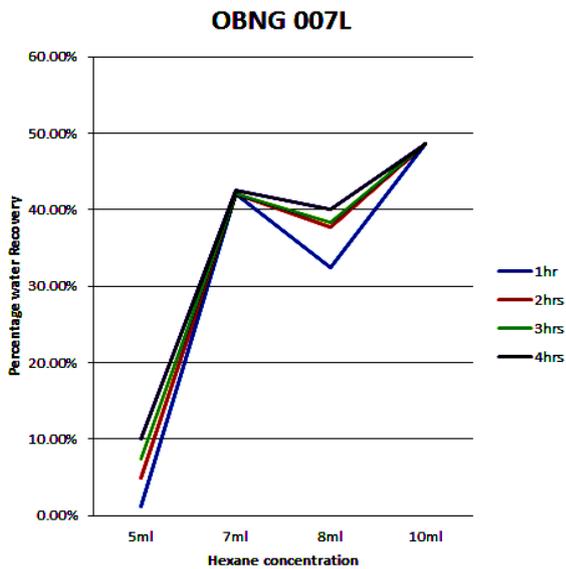
OBNG 007L

Figure 2: Effect of Demulsifier volume on OBNG 007L Emulsion Systems

AGBD2 063T

Figure 3: Effect of Surfactant (Texapon) volume on AGBD2 063T Emulsion Systems
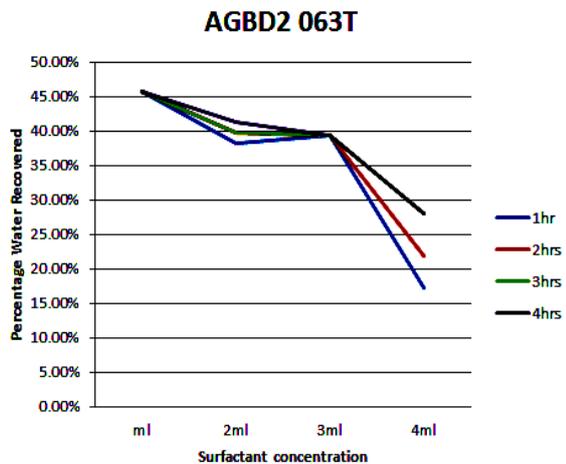
OBGN 007L

Figure 4: Effect of Surfactant (Texapon) volume on OBGN 007L Emulsion Systems

IV. CONCLUSION

The following conclusions were drawn from this study:

- The percentage of Water/Crude Oil recovered increased at an increasing time.
- The concentration of the Surfactant and Demulsifier affected the rate of separation, hence at an increasing volume (5, 7, 8 & 10ml) of demulsifier and constant volume (1ml) of surfactant, the percentage of water/crude oil recovered increases at an increasing time
- At an increasing volume (1, 2, 3 & 4ml) of surfactant and constant volume (10ml) of demulsifier, the percentage of water/crude oil recovered increases at an increasing time.
- At lower volume (1ml) of surfactant and higher volume (10ml) of demulsifier, the percentage of water/crude oil recovered is efficient.

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