EFFECT OF FOAMING AGENTS ON CRUDE OIL SYSTEM

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ABSTRACT: This report entails the study of the effect of foaming agents on the physio-chemical properties of crude oil system; the report investigated if the addition of such foaming agents can improve production and also determines the properties of the crude oil with respect to the foaming agents used. The properties investigated are density, Specific gravity, API gravity, viscosity, Surface tension and Pour point before and after the addition of the foaming agents. The foaming agents were found to increase the density, viscosity and specific gravity of crude oil and decreases API gravity, surface tension, pour and cloud point of crude oil.

Statistical and graphical analysis was used to interpret the results of the experiments carried out. The results showed that foaming agents can alter the physio-chemical properties of the crude oil system, and it was also observed that such alteration was on a positive side

The study would help petroleum engineers to understand the positive impact of foaming agents in oil production especially during enhanced oil recovery (EOR).With such understanding and putting it into practice, production will be maximized.

Key Words: Foaming Agents, density, specific gravity, viscosity, surface tension, pour point and cloud point.

INTRODUCTION:

Crude Oil System

Crude Oil or Petroleum refers to any naturally-occurring flammable hydrocarbon mixture found in geologic formations, such as rock strata, formed through the heating and compression of organic material such as dead zooplankton and algae over a long period of time. Technically, the term petroleum only refers to crude oil, but sometimes it is applied to describe any solid, liquid or gaseous hydrocarbons. It is a hydrocarbon mixture having simple to most complex structures such as resins, asphaltenes etc. Crude oil can be refined to produce usable products such as gasoline, diesel and various forms of petrochemicals.

Crude oil is also a naturally occurring mixture, consisting of hydrocarbon with other element such as sulphur, nitrogen, oxygen, etc. appearing in the form of organic compounds which in some cases form complexes with metals. Elemental analysis of crude oil shows that it contains mainly carbon and hydrogen in the appropriate ration of six to one by weight. The mixture of hydrocarbon is highly complex, and the complexity increases with boiling range. Crude oil is formed by bacterial transformation of Organic matter (carbohydrates/proteins/ animal origin) by decay in presence and/or absence of air into HC rich sediments by undergoing biological/physical and chemical alterations In its strictest sense, crude oil, but in common usage it includes all liquid, gaseous, and solid hydrocarbons. Under surface pressure and temperature conditions, lighter hydrocarbons methane, ethane, propane and butane occur as gases, while pentane and heavier ones are in the form of liquids or solids. However, in an underground oil reservoir the proportions of gas, liquid, and solid depend on subsurface conditions and on the phase diagram of the crude mixture.

Properties of crude oil system:

Density

Density is defined as the mass per unit volume of a substance. It is most often reported for oils in units of g/mL or g/cm3, and less often in units of kg/m3. Density is temperature-dependent. Oil will float on water if the density of the oil is less than that of the water. This will be true of all fresh crude oils, and most fuel oils, for both salt and fresh water. Bitumen and certain residual fuel oils may have densities greater than 1.0 g/mL and their buoyancy behaviour will vary depending on the salinity and temperature of the water. The density of spilled oil will also increase with time, as the more volatile (and less dense) components are lost. After considerable evaporation, the density of some crude oils may increase enough for the oils to submerge below the water surface.

Pour Point

The pour point of oil is the lowest temperature at which the oil will just flow, under standard test conditions. The failure to flow at the pour point is usually attributed to the separation of waxes from the oil, but can also be due to the effect of viscosity in the case of very viscous oils. Also, particularly in the case of residual fuel oils, Pour points may be influenced by the thermal history of the sample, that is, the degree and duration of heating and cooling to which the sample has been exposed.

Viscosity

Viscosity is a measure of a fluid's resistance to flow; the lower the viscosity of a fluid, the more easily it flows. Like density, viscosity is affected by temperature. As temperature decreases, viscosity increases. Viscosity is a very important property of oils because it affects the rate at which crude oil will spread, the degree to which it will penetrate shoreline substrates, and the selection of mechanical spill countermeasures equipment.

Sulphur

The sulphur content of a crude oil is less importance for a number of reasons. Downstream processes such as catalytic cracking and refining will be adversely affected by high sulphur contents. Crude oil containing a high amount of the impurity (sulfur) is referred to as sour crude oil, when the total sulfur level in the oil is more than 0.5% the oil is called "sour”. The impurity needs to be removed before this lower-quality crude can be refined into petrol, thereby increasing the cost of processing.

Basic Sediments and Water (BS&W)

Basic sediment and water (BS&W) is a technical specification of certain impurities in crude oil. When extracted from an oil reservoir, the crude oil contains some amount of water and suspended solids from the reservoir. The particulate matter is known as sediment or mud. The water content can vary greatly from field to field, and may be present in large quantities for older fields, or if oil extraction is enhanced using water injection technology.

Flash Point

The flash point of crude oil is the temperature above which the oil will spontaneously combust. The flash point of a volatile material is the lowest temperature at which it can vaporizes to form an ignitable mixture in air

Foaming Agents

A foaming agent is a material that facilitates formation of foam such as a surfactant or a blowing agent. A surfactant, when present in small amounts of crude oil, reduces surface tension of the oil (reduces the work needed to create the foam) or increases its colloidal stability by inhibiting coalescence of bubbles. A blowing agent is a gas that forms the gaseous part of the foam. Foam on the other hand is a dispersion of gas in liquid, usually with a surface-active agent present. Foams are not thermo-dynamically stable and ultimately decay into their constituent phases, but can be mechanically stable.

The ability of foam to reduce gas mobility has led to its application in a number of processes, including gas flooding, steam flooding, and oil reservoir treatment techniques. It has been somewhat uncertain whether foam in these cases actually works by gas blockage and flow diversion, or whether it is better described as a “viscosifying agent” for the gas.

Foams often forms in crude oil by adding foaming agents, it also formed as the crude oil pressure is reduced in the reservoir, well bore, tubing string or flow line. In short, foam forms essentially instantaneously after a pressure drop. Many crude oils have the potential of creating foam carryover, even though it is popular to blame a factor such as asphaltenes, paraffin, emulsions, high crude viscosities, or poorly designed internals around the crude oil.

Materials and Method.

The experiments carried out tailored towards determing the physio-chemical properties of the crude oil such as Density, Specific Gravity, API gravity , viscosity, Surface tension, Pour point, pH etc before and after the addition of the foaming agents, and the foaming agents used were Laureth sulphate (omo) and Ammonium Dodecysulate (vinoz shampoo).

Apparatus:

The following apparatus were used in this research work: Hydrometer, Rheometer, Tensionmeter, cloud and pour point equipment, Pycnometer, weighing balance, thermometer etc.

Experimental procedure:

Determination of the effect of Sodium Laureth Sulphate (Omo) and Ammonium Dodecysulate (Vinoz Shampoo) on the Density of Crude Oil:

The Pycnometer was rinsed with distilled water and dries with acetone and weighed. The weight is called 'dry weight' .The Pycnometer bottle was filled with Sample A (50ml mixture of Laureth sulphate (omo) in water with 250m of crude oil) , inserted the stopper, making sure that the hole in the stopper is also filled with the mixture and wipe the Pycnometer clean. The Pycnometer bottle was weighed on a balance and the value was recorded as 'wet weight'. The wet weight was subtracted from dry weight and divided by 50ml since Density = Mass/Volume. The experiment was repeated for different Volume of Sample A at 100ml, 150ml, 200ml, and 250ml.The values were recorded for the corresponding density.

In the same manner, the effect of Ammonium Dodecysulfate (vinoz shampoo) on the density of crude oil was determined and recorded.

Determination of the effect of Sodium Laureth Sulphate (Omo) and Ammonium Dodecysulate (Vinoz Shampoo) on the Specific Gravity of Crude Oil:

50ml mixture of omo in water was mixed with 250ml of crude oil (sample C) and was transferred into the clean hydrometer cylinder and the hydrometer was lowered gently into the sample, when it has settled, It was depressed to about two scale divisions into the liquid and then released; the rest of the stem was kept dry. Sufficient time was allowed for the hydrometer to become completely stationary and for all air bubbles to come to the surface. It is particularly necessary in the case of the more viscous samples.

When the hydrometer has come to rest, floating freely, and the temperature of the sample was constant, the hydrometer was read to the nearest scale division. The correct reading is that point on the hydrometer scale at which the surface of the liquid cuts the scale. This point was determined by placing the eye slightly below the level of the liquid and slowly raising it until the surface, first seen as a distorted ellipse, appears to become a straight line cutting the hydrometer scale. The experiment was repeated for different quantities of Sample C at 100ml, 150ml, 200ml, and 250ml respectively and the values of the corresponding Specific gravities were recorded,

In the same manner, the effect of Ammonium Dodecysulfate (vinoz shampoo) on the specific gravity of the crude oil was determined and recorded

Determination of the effect of Sodium Laureth Sulphate (Omo) and Ammonium Dodecysulate (Vinoz Shampoo) on the Viscosity of Crude Oil:

50ml of a mixture of omo and distilled was mixed with 250ml of crude oil (Sample E). Sample E was poured into a beaker and placed on the adjustable table of the Rheometer, it is adjusted up to the spindle of the Rheometer. The sample was stirred for seconds at 600rpm and 300rpm and the dial readings were taken. Apparent Viscosity (AV) was then calculated using AV=600rpm reading/2, Plastic viscosity (PV) was calculated using PV=600rpm reading - 300rpm reading. The experiment was repeated for different Volume of Sample E at 100ml, 150ml, 200ml, and 250ml and the values were recorded for the corresponding viscosity (cp).

In the same manner, the effect of Ammonium Dodecysulfate (vinoz shampoo) on the viscosity of crude oil was determined and recorded.

Determination of the effect of Sodium Laureth Sulphate (Omo) and Ammonium Dodecysulate (Vinoz Shampoo) on the Surface Tension of Crude Oil:

50ml of a mixture of omo and distilled water was mixed with 250ml of crude oil (Sample G). Sample G was poured into a round flat open container. Using the Tensiometer, a thin plate (usually made of platinum and iridium) was used. It was dipped into sample G whose surface tension is to be measured, the vessel containing sample G was gradually lowered and the force measured by the balance at the point of detachment was noted. The experiment was repeated for different Volumes of Sample G at 100ml, 150ml, 200ml, and 250ml. The values were recorded for the corresponding Surface tension in dynes/cm.

In the same manner, the effect of Ammonium Dodecysulfate (vinoz shampoo) on the surface tension of crude oil was determined and recorded.

Determination of the effect of Sodium Laureth Sulphate (Omo) and Ammonium Dodecysulate (Vinoz Shampoo) on Cloud Point and Pour Point of Crude Oil.

50ml (mixture of omo and distilled water) was mixed with 250ml of crude oil (Sample I). Sample I was poured into the test jar. The jar was closed tightly by the cork carrying a thermometer. The position of the cork was adjusted so that the thermometer bulb fixed coaxial with the test jar and its capillary immersed 3mm below the surface of the oil. The test jar was then placed in the bath of the cloud and pour point machine and at every1°C, the sample was taken out and inspected for cloud then quickly replaced. The highest temperature at which haziness occurs is observed (cloud point) and also the bath surrounding temperature on the equipment display was observed, the reading of the thermometer on the cork of the test jar is recorded. The test jar is returned back inside the bath and at every1°C change in temperature, the sample was inspected for pour point. The lowest temperature at which the oil ceased to flow is observed (pour point) and also the bath surrounding temperature on the equipment displayed, the temperature from the thermometer on the cork of the test jar was recorded.The experiment was repeated for different Volumes of Sample I at 100ml, 150ml, 200ml, and 250ml. The values were recorded for the corresponding cloud and pour points.

In the same manner, the effect of Ammonium Dodecysulfate (vinoz shampoo) on the cloud point and pour point of crude oil was determined and recorded.

Results and Discussions:

Foaming agent [Sodium Laureth Sulphate (omo)] was found to increase the density of crude oil as shown in table 1 below, the higher the volume of omo (foaming agent), the higher the density of the crude oil as indicated on the table. The graph as shown in figure 1 below is a linear relationship which supports the relationship of the presence of omo in crude oil. Much omo, may be as a surfactant in preparing drilling mud or in an enhanced oil recovery does favour crude oil state as it decreases the surface tension of the crude. Care should be taken while using omo in drilling and production operations. The addition of shampoo (foaming agent) to crude oil exhibits the same behaviour as that of omo as shown on table 1 and the figure 2 below.

Table 2 and figure 3 below show the effect of Sodium Laureth Sulphate (omo) on the Specific gravity of crude oil. The graph shows an increase in crude oil specific gravity, with initial sharp increase before gradual increase. The graph is a linear relationship. The plot shows that after sometimes, no matter the quantity of omo been added to the crude oil, the specific gravity will remain constant. Too much omo in crude oil does favour the specific gravity of crude oil. Ammonium Dodecysulate (vinoz shampoo) on the specific gravity of crude oil shows a linear relationship as that of omo, From the plot (fig.4), at a point further increase in shampoo does not affect the specific gravity of crude oil.

Table 3, and figure 5 show the effect of Sodium Laureth Sulphate (omo as a foaming agant) on the apparent viscosity of crude oil. The effect was not completely positive either was it negative. The viscosity increases and decreases as the mass of omo increases, It’s like a sinusoidal behaviour showing increase and decrease as the volume of omo increases. It should also be noted that the presence of foaming agent in crude oil decreases the surface tension of the crude, thereby breaking down the bonds holding the oil molecules together and this results to decrease in the oil viscosity. The variation in the result may be as a result of some experimental errors. On the contrary shampoo was observed to increase the apparent viscosity of crude oil. This goes to show that shampoo as a foaming agent should not be introduced to oil activities as it plays a negative role, figure 6 below explain this more

Table 4 and Figure 7 show the effect of Sodium Laureth Sulphate (omo) on the surface tension of crude oil. The graph is a negative one. The Sodium Laureth Sulphate (omo) and the crude oil used have a surface tension of 65.19(dynes/cm) and 67.48(dynes/cm) respectively. The results show that increase in Sodium Laureth Sulphate (omo) decreases the Surface tension of crude oil, thus, foaming agents' decreases Surface tension of crude oil and this has a positive impact in oil production. Similar result was obtained on the effect of shampoo on the surface tension of crude oil. This shows that increase in Sodium Laureth Sulphate (shampoo) as foaming agent decreases the Surface Tension of crude oil, figure 8, thus, foaming agents decreases the surface tension of crude oil.

Figure 5 and figure 9 show the effect of Sodium Laureth Sulphate (omo) on crude oil cloud point. The graph is a negative graph. Sodium Laureth Sulphate (omo) and the crude oil used have a cloud point of 12(^{0}c) and 10(^{0}c) respectively. This shows that increase in Sodium Laureth Sulphate (omo) decreases the cloud point (^{0}c) of crude oil, thus, foaming agent's decreases Cloud point of crude oil. Similar result was obtained with shampoo as shown in figure 10. Figure 10 shows the effect of Ammonium Dodecysulate (vinoz shampoo) on crude oil cloud point. The graph is a negative graph. The Ammonium Dodecysulate (vinoz shampoo) and the crude oil used have a cloud point of 2(^{0}c) and 10(^{0}c) respectively. It was observed that increase in Ammonium Dodecysulate (vinoz shampoo) decreases the cloud point of crude oil, thus, foaming agents decreases the cloud point of crude oil.

Table 6 and Figure 11 show the effect of Sodium Laureth Sulphate (omo) on crude oil Pour point. Sodium Laureth Sulphate (omo) and the crude oil used have a Pour point of -1(^{0}c) and -3(^{0}c) respectively. The graph is a negative linear plot showing a negative relationship between the dependent and independent variables. This shows that increase in Sodium Laureth Sulphate (omo) decreases the Pour point (^{0}c) of crude oil, thus, foaming agent's decreases the Pour point of crude oil. In the case of shampoo, similar result was observed. Increase in Ammonium Dodecysulate (vinoz shampoo) decreases the Pour point of crude oil, figure 12.

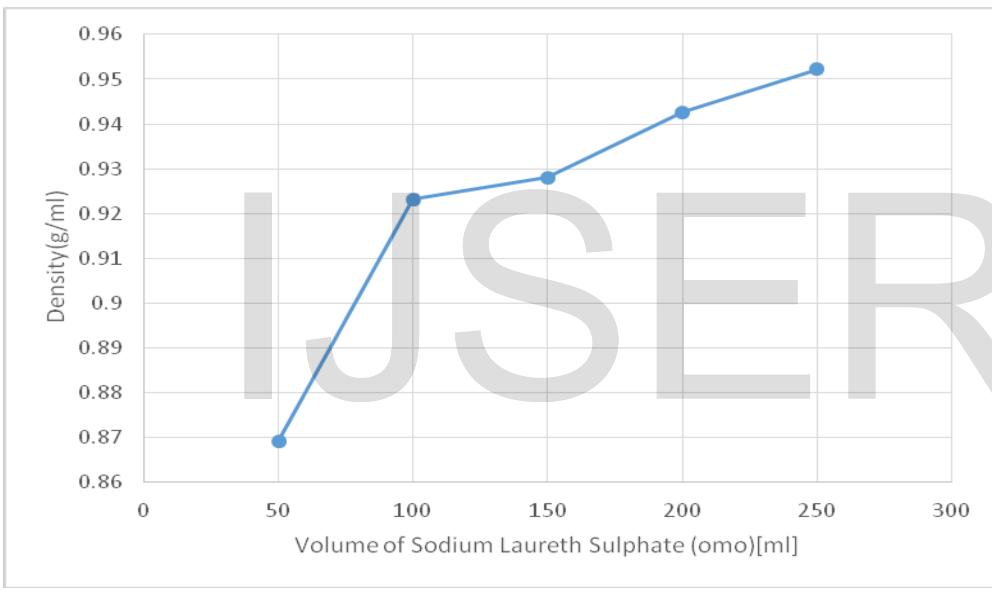

Figure 1: Plot of Crude oil density vs Volume of Sodium Laureth Sulphate (omo)

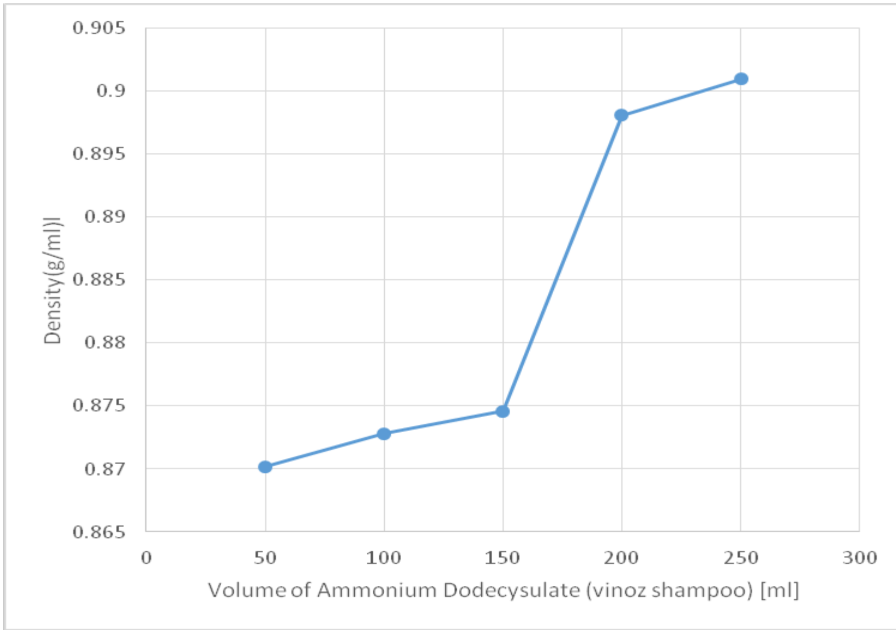

Figure 2: Plot of Crude oil density vs Volume of Ammonium Dodecysulate (vinoz shampoo)

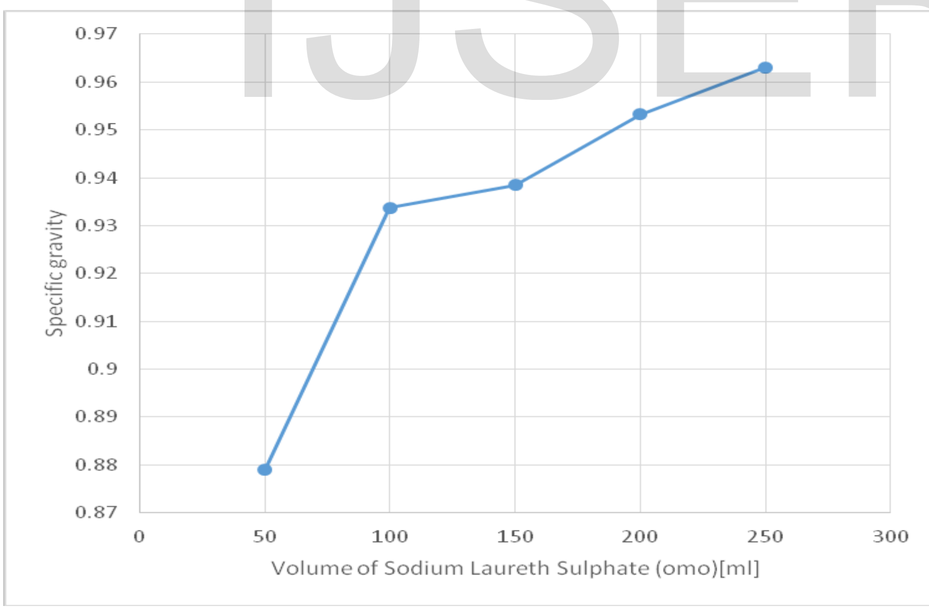

Figure 3: Plot of Specific Gravity vs Volume of Sodium Laureth Sulphate (omo)

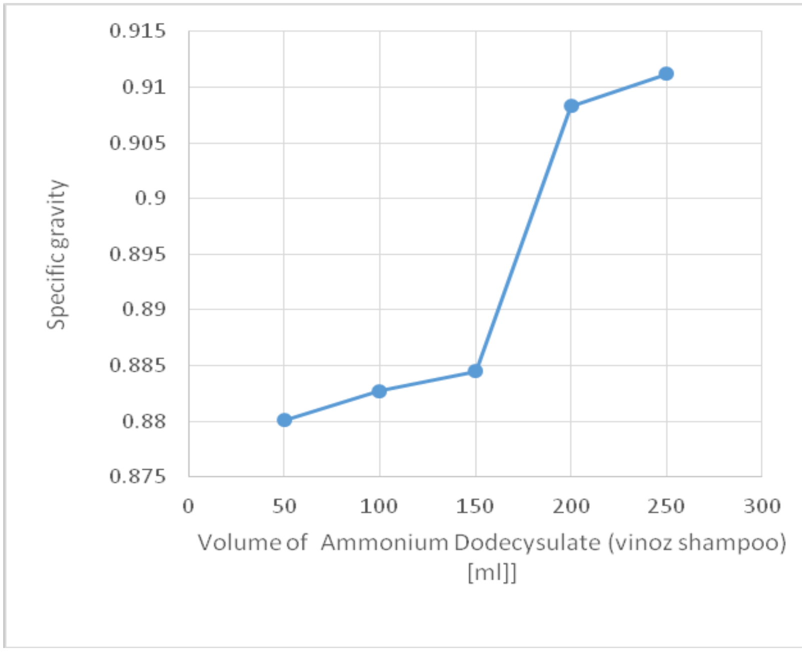

Figure 4: Plot of Specific Gravity vs Volume of Ammonium Dodecysulate (vinoz shampoo)

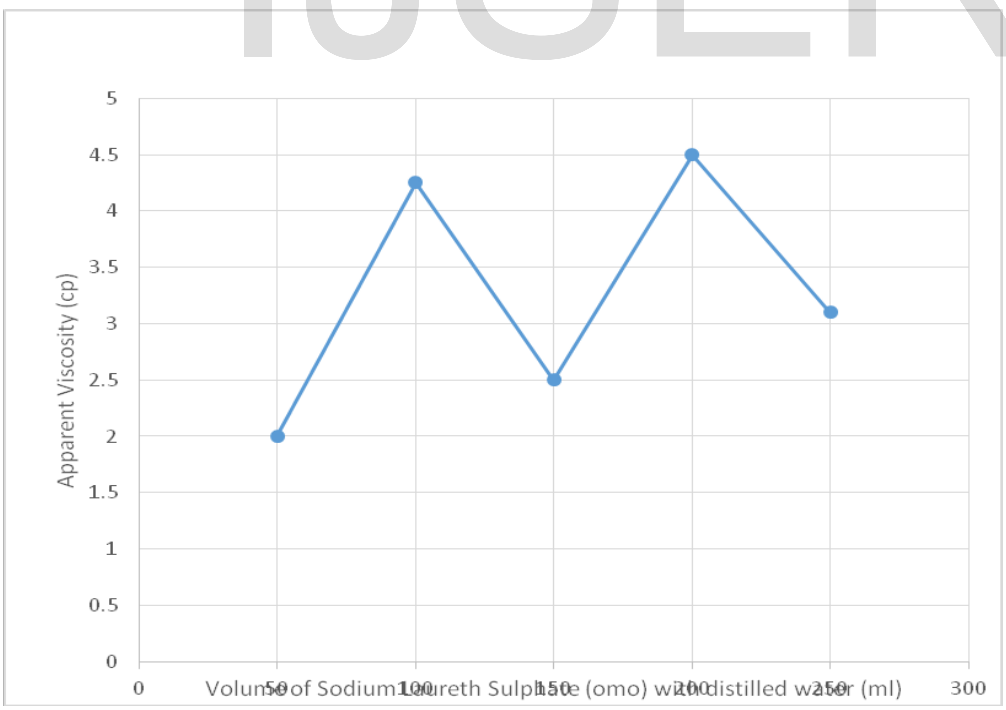

Figure 5: Plot of Apparent Viscosity vs volume of Sodium Laureth Sulphate (omo)

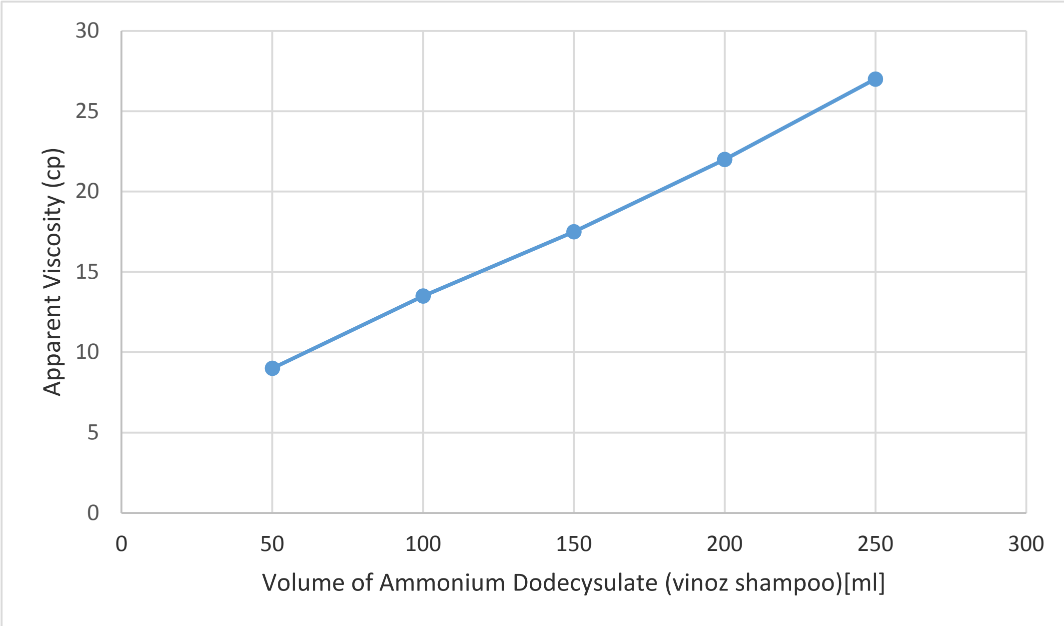

Figure 6: Plot of Apparent Viscosity vs Volume of Ammonium Dodecysulate (vinoz shampoo)

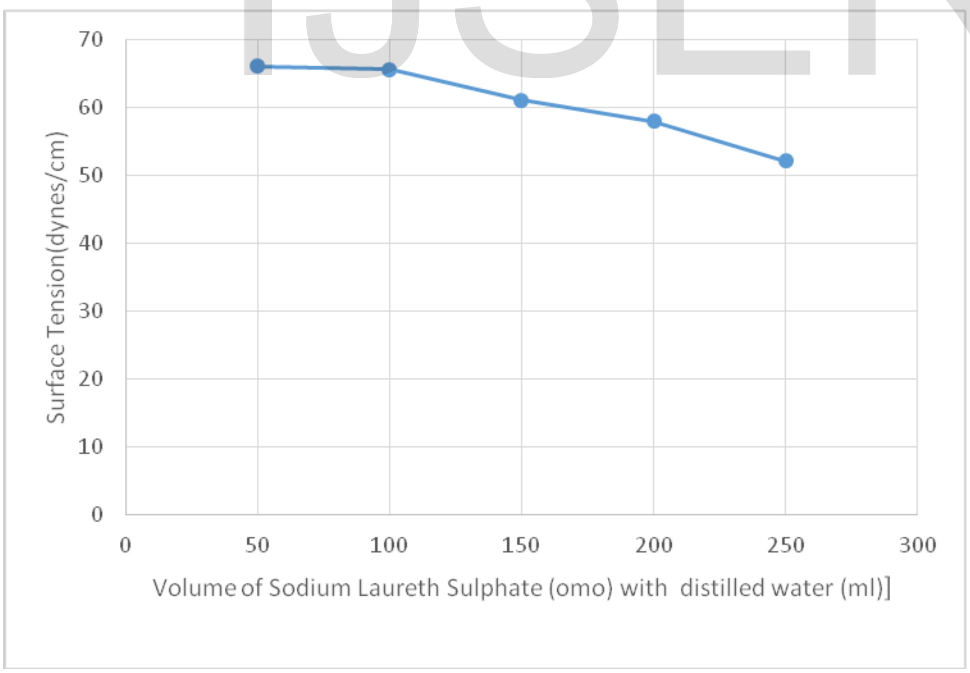

Figure 7: Plot of Surface Tension vs Volume of Sodium Laureth Sulphate (omo)

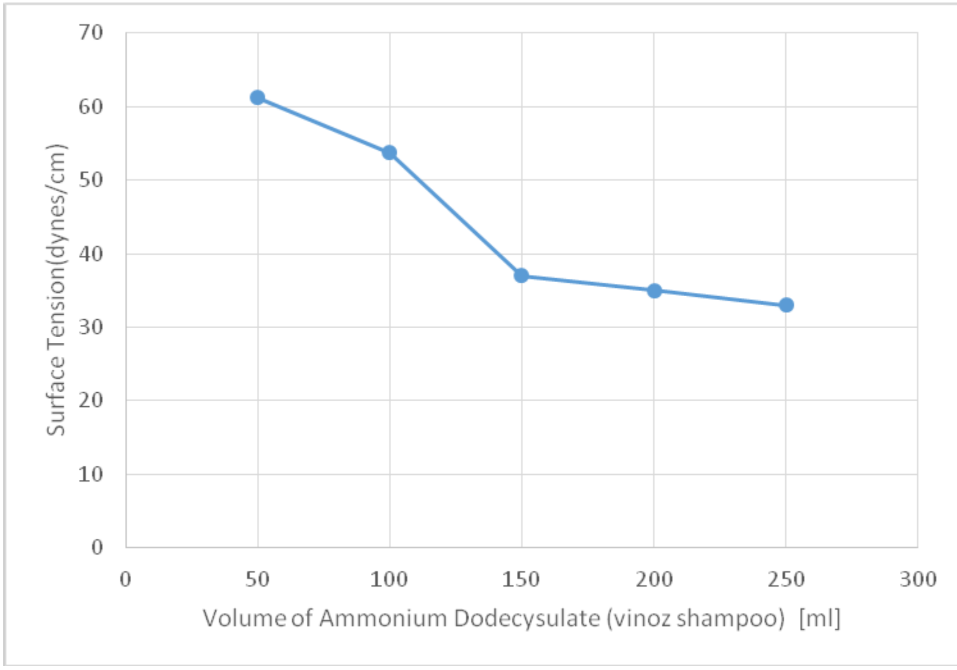

Figure 8: plot of Surface Tension vs Volume of Ammonium Dodecysulate (vinoz shampoo)

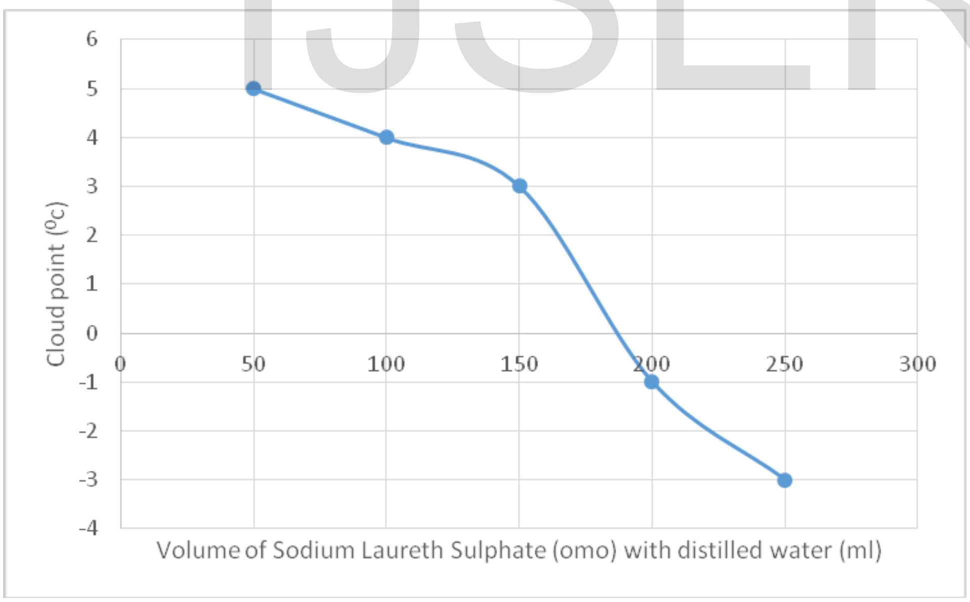

Figure 9: Plot of cloud point vs Volume of Sodium Laureth Sulphate (omo).

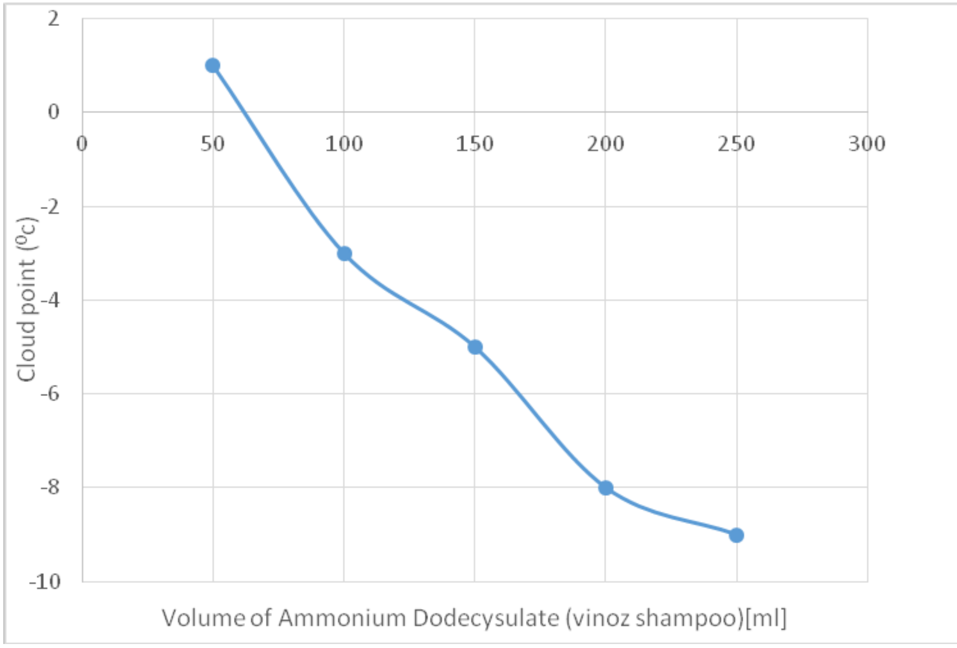

Figure 10: Plot of Cloud point vs Volume of Ammonium Dodecysulate (vinoz shampoo)

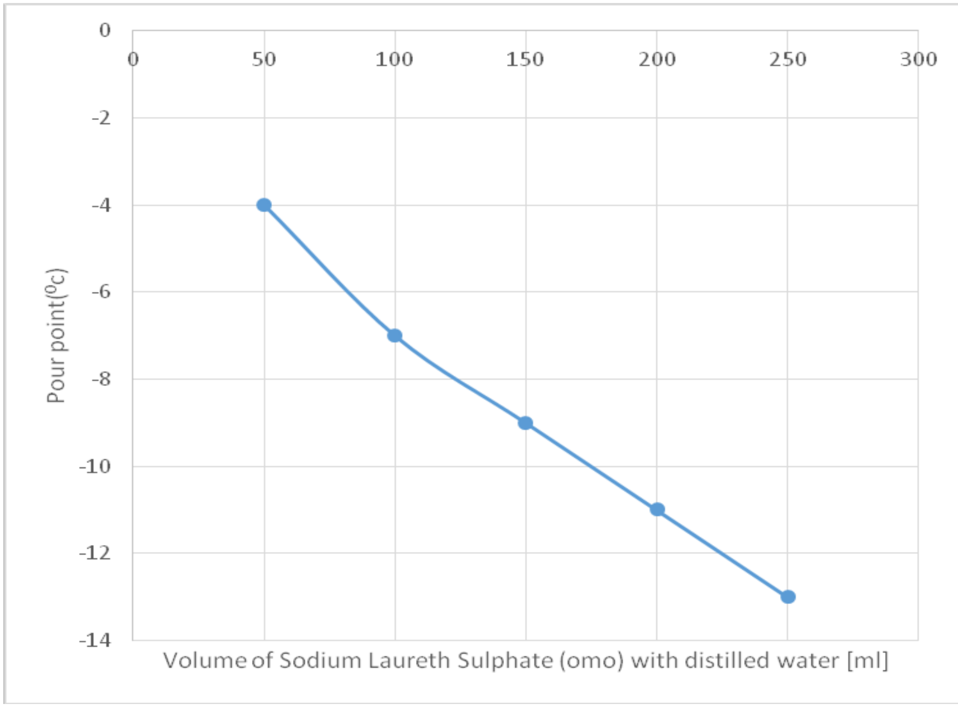

Figure 11: Plot of Pour point vs Volume of Sodium Laureth Sulphate (omo).

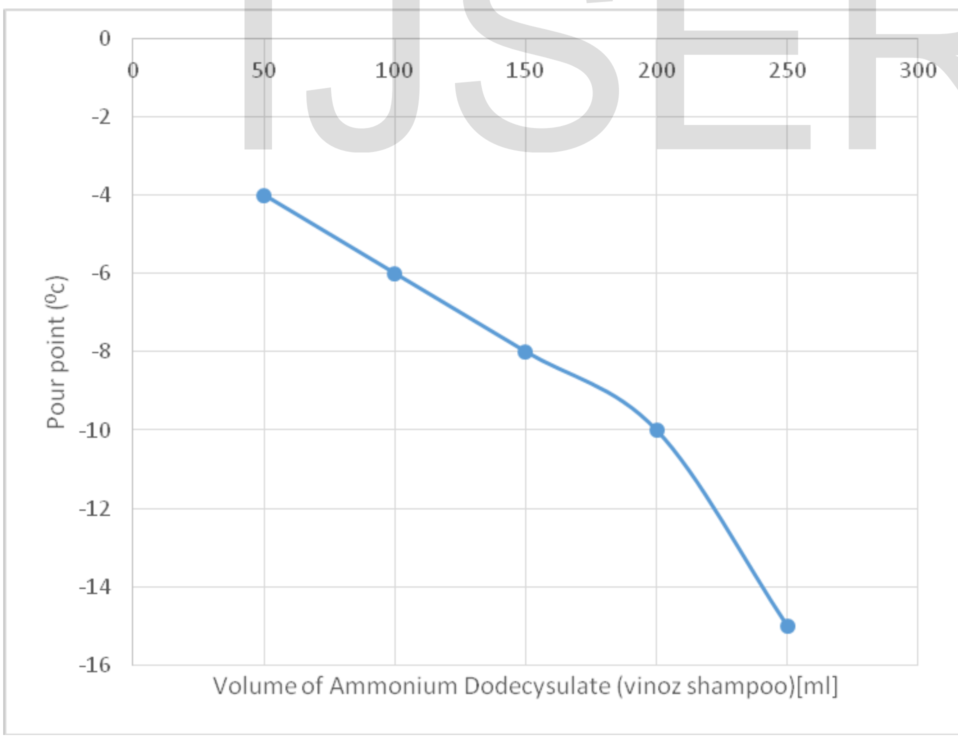

Figure 12: Plot of Pour point vs Volume of Ammonium Dodecysulate (vinoz shampoo)

Table 1:Volume of Sodium Laureth Sulphate (omo) and shampoo with the corresponding densities

Sample vol.(ml)	Density(g/ml) omo	Density (g/ml) shampoo
50	0.8692	0.8702
100	0.9232	0.8728
150	0.9280	0.8746
200	0.9426	0.8981
250	0.9523	0.9010

Table 2:Volume of Sodium Laureth Sulphate (omo) and shampoo with and the corresponding sp. Gravity.

Volume of sample (ml)	Sp. gr (omo)	Sp.gr (sampoo)
50	0.8790	0.8801
100	0.9337	0.8827
150	0.9385	0.8845
200	0.9533	0.9083
250	0.9631	0.9112

Table 3: Volume of Sodium Laureth Sulphate (omo) and shampoo with and the corresponding apparent viscosities

Vol of sample (ml)	Apparent Viscosity of omo (cp)	Apparent Viscosity of shampoo(cp)
50	2.00	9.0
100	4.25	13.5
150	2.50	17.5
200	4.50	22.0
250	3.10	27.0

Table 4: Volume of Sodium Laureth Sulphate (omo) and shampoo with and the corresponding surface tension.

Vol of sample (ml)	Surface Tension of omo (dynes/cm)	Shampoo (dynes/cm)
50	66.16	61.2
100	65.70	53.7
150	61.20	37.01
200	58.02	35.0
250	52.21	33.00

Table 5: Volume of Sodium Laureth Sulphate (omo) and shampoo with and the corresponding cloud points

Vol of sample (ml)	Cloud point (^{0}c) of omo	Cloud point (^{0}c) of shampoo
50	5	11
100	4	10
150	3	7
200	-1	5
250	-3	3

Table 6: Volume of Sodium Laureth Sulphate (omo) and shampoo with and the corresponding pour points

Vol of sample (ml)	pour point (^{0}c) of omo	pour point (^{0}c) of shampoo
50	-4	-4
100	-7	-6
150	-9	-8
200	-11	-10
250	-13	-15

Physio-chemical properties	Sodium Laureth Sulphate (omo)	Ammonium Dodecysulate (vinoz shampoo)	Crude Oil
Density(g/ml)	1.1246	1.0100	0.8666
Specific Gravity	1.1373	1.0214	0.8764
API Gravity (^{0} API)	-7.0825	7.0353	30
Apparent Viscosity(cp)	2.5000	112	6
Plastic Viscosity(cp)	2.0000	50	6
Surface Tension(Dynes/cm)	65.19	61.2	67.48
Cloud point	12	2	10
Pour point	-1	-4	-3

Table 7: Summary of the properties of the pure components (Foaming Agents and Crude Oil) Used

Conclusions.

From the analysis carried out, it was obvious that foaming agents alter the physio-chemical properties of crude oil. The following conclusions could be drawn: Foaming agents increases the density and specific gravity of crude oil, it decreases cloud point and pour point of crude oil. It was also observed that the viscosity of crude oil can increase or decrease depending on the volume of the foaming agent used. Most of these alterations favour the production of oil to the surface.

Recommendations.

Based on research work, the following recommendation could be given: it's recommended that other foaming agents should be tried on the physio-chemical properties of crude oil, this will help to ascertain if the results will be similar or otherwise. It will also give the knowledge of the foaming agents to be used in drilling and production operations.

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