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Demulsifiers Effect on Water Content and Surface Tention of Oil Tight Emulsion Stability

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Abstract

Typically, water in oil emulsion presence in a production facility always gives rise to an increased flow assurance issues such as corrosion, increased cost of managing surface equipment such as pumps, tanks etc, overloading of surface equipment, increased cost of pumping wet crude, etc. This can ultimately affect oil production rate from the wellbore to surface facility.

Chemical de-emulsifiers (amine group) were added in varied proportions to crude oil emulsions in a virtual production flow station models to replicate an improved oil recovery project in the Niger Delta area. In order to enhance the demulsification process of the crude oil emulsion, simulation tests were run to determine the effects of the demulsifiers on water content and surface tension of electrically stable emulsions. The factors influencing stability and results on how they can enhance dmulsification of a tight crude oil emulsion were discussed. The water content of the tight crude oil emulsion was observed to have increased by some percent in value after de-emulsifier injection at a constant temperature and flow rate.

A proportional reduction in surface tention was also observed when the concentration and flow rate of the demulsifiers were increased at a constant temperature. When matched against established electrical stability trendline,it showed a decrease in the electrical stability of the emulsion formed as a result of these activities as described above.

Keywords — *Emulsion, demulsifiers; demulsification; stability; virtual modelling; amine; simulation; viscosity; water content, sensitivity.*

INTRODUCTION

Water-in-oil crude oil emulsions may be encountered at all stages in the petroleum production and in processing industry. With presence of water, they are typically undesirable and can result in high pumping costs and pipeline corrosions and increase the cost of transportation (M. Hanapi, S. Ariffin, A. Aizan, and I. R. Siti, 2006). Reduced throughput is needed to introduce special handling equipment, contribute to plugging of gravel pack at the sand phase,(R. Espinoza and W. Kleinitz, 2003) and affect oil spill cleanup (F. Merv and F. Ben,2003).

Despite the success of enhanced oil recovery (EOR) process, one of the problems associated with the process is emulsion problem. Efeovbokhan et al. observed that physical factors that enhance oil recovery can also greatly contribute to the formation of very stable emulsions because EOR-induced emulsions are established by surfactant/polymer (SP) and alkaline/surfactant/polymer (ASP) processes which makes breaking of emulsion different from naturally occurring emulsions which are stabilized by asphaltenes and resins (Efeovbokhan et al., 2010). Traditional demulsifiers are often not effective on emulsions created by chemical floods; therefore, the performance of demulsifier in surfactant/polymer–flooding-induced emulsion depends on the selection of the best demulsifier with respect to the system under consideration (Nguyen et al., 2011). In breaking of surfactant/polymer-flooding-induced emulsion with the use of surfactant, Oseghale et al. worked on separation of oil-water emulsions expected during chemical enhanced recovery operations using crude oil from a field in Niger delta during surfactant/polymer flooding operation. Surfactant N-octyltrimethyammonium bromide (C8TAB) was used as the demulsifier and a dosage between 200 and 300ppm was the optimum dose that yielded oil and water phases with oil content reduction from 550 to 70 ppm after 4 hrs. Microscopy test confirmed that addition of N-octyltrimethyammonium bromide (C8TAB) produced significant coalescence shortly after it was added to the emulsion, which is in agreement with an increase of the oil droplet size in the presence of the demulsifier. Their findings show that this investigation worked with the principles of using cationic surfactants as demulsifier [Oseghale et al., 2012].

.Crude oil emulsions are complex and should be characterized as completely as possible. Droplet-size distribution, interfacial phenomena, and the nature of organic and inorganic components are important. The viscosity of the emulsion is affected by both the water content and droplet size distribution (Taylor, 1988; Thompson et al., 1987). The increase in aqueous phase of the emulsion leads to an increase in viscosity of emulsion which in turn aggravates flow of emulsion in conduct either at the sand phase or through the surface facilities (Espinoza et al., 2003; Jones et al., 1978). Stable water-in-oil emulsions have been generally found to exhibit high interfacial viscosity and/or elasticity modulus. Viscosity of crude oil emulsion was found to increase with increase in water and decreased with increase in speed of rotation of spindle when demulsifier is added (Abdurahman et al., 2012). The increase of the interfacial rheological parameters has been attributed to non-Newtonian nature of emulsion (Abdurahman et al., 2012) and physical cross-links between the asphaltene particles adsorbed at the water-oil interface (McLean et al., 1997). Demulsification of tight emulsion proved to be a tough method of breaking emulsions with an influence of improper selection of chemicals still unaccounted for in most of the researches.

Objective of Study

This paper will investigate the effect of selecting and using proper chemicals on tight emulsion samples treated with chemical for two different water in oil tight crude emulsions (electrically stable) collected from different EOR fields from different operators in Niger delta. The aim is to demonstrate the effectiveness of readily available chemical demulsifiers as mentioned above on tight water in oil emulsions as experienced in EOR operations via virtual modelling techniques.

MATERIALS AND METHODS

VIRTUAL EXPERIMENTAL METHOD

A virtual experiment approach was unutilized for this study. A commercialprocess simulation software; with compositional analysis of default crude oil properties relevant to the Niger Delta production scenario which describesa tight emulsion prone crude oil. Closely related materials that were also utilized include the polymer (decylamine) de-emulsifier reaction set, C7+ and de-emulsifier characterization set.

The experimental methods had the following key approaches:

Virtual modelling of the tight emulsion crude oil properties, compositional analysis, the physical and chemical properties of crude oil used for the experiment such as molar concentrations, API gravity, viscosity, the asphaltene content etc. were obtained and used to build the model.

2.1 Simulation Set-up.

Data used for the simulation study was sourced from a specific flow station as built drawings, flow station equipment data sheet, PVT reports, production chemistry laboratory data and surveillance data from site visit. A quality assurance and quality control analysis were performed on the PVT data gathered to further validate the data and determine the degree of accuracy using the mole balance plot.

This describes the approach taken to model the crude oil stabilization station as it is on the field, this however allows the Engineer to run different de-emulsification scenarios and make optimum decisions.

Basic equipment's used for the simulation includes separator, surge vessel, mixer and valve.

To enable the demulsifier to be effective, it must contact the emulsion and the oil/water interface. Agitation and mixing is required to provide an opportunity for the chemical to mix well with the emulsion. This agitation paves the way for droplet coalescence; which is the point at which the demulsifier is added to the mixture – this is an important phase of the process. The first operation installed in the model is a mixer used to combine the reservoir fluid stream and the de-emulsifier stream. As in most commercial tools installing a mixer can be accomplished by a number of ways. Also separators where installed in the model to separate the gas and liquid phases. Surge Vessels were added to the model to further define the direction of the gas and liquid streams and to control the flow of the two phases. Then pressure valves were added to the model to control the pressure of the inlet and outlet streams in the model.

De-emulsifier Characterization

De-emulsifier characterization was also performed in the compositional analysis. De-emulsifier characterization can be defined as the determination of the critical temperatures, critical pressure, acentric factor and interaction parameters. In this study, de-emulsifier was characterized in the petroleum fraction sub-section using the boiling point, molecular weight and specific gravity as input parameter. The composition is then added to the main composition and an amount entered before calculating the critical properties and acentric factor. Amine group de-emulsifier (decyl-amine) was used for this process model

SIMULATION TEST AND RESULTS ON EFFECT ON WATER CONTENT AND SURFACE TENTION

3.1 Test number 1: WATER CONTENT

Water is often present in crude oil as emulsified salt water. The presence of water is a typical feature of all known petroleum and natural gas deposits. Gases and solids in crude are relatively easy to remove from hydrocarbon fluids. Formation water (also referred to as connate water or produced water) is harder to separate out, apart from a more or less low percentage that naturally separates from the crude (indicated as Free Water: FW). The water that does not separate naturally from the crude in which it is present in the form of emulsion (BS: Base Settlement) and can be removed by chemical products called de-emulsifiers. The total water content of crude is generally indicated with the term Water Cut (WC).

Thus, WC = FW + BS

Water content in crude is a major factor that determines the Electrical Stability of water-in-crude oil emulsion and also acts as a solid when dissolved in synthetic oil by giving it buoyancy. Directly speaking, increasing water content reduces the emulsification action thereby reducing the electrical stability value. Also it reduces the viscosity of the crude thereby affirming the reduction in emulsion stability. For the purpose of this simulation, we expect increased water content after de-emulsifier injection.

Simulation Test 1 Effect on Water content

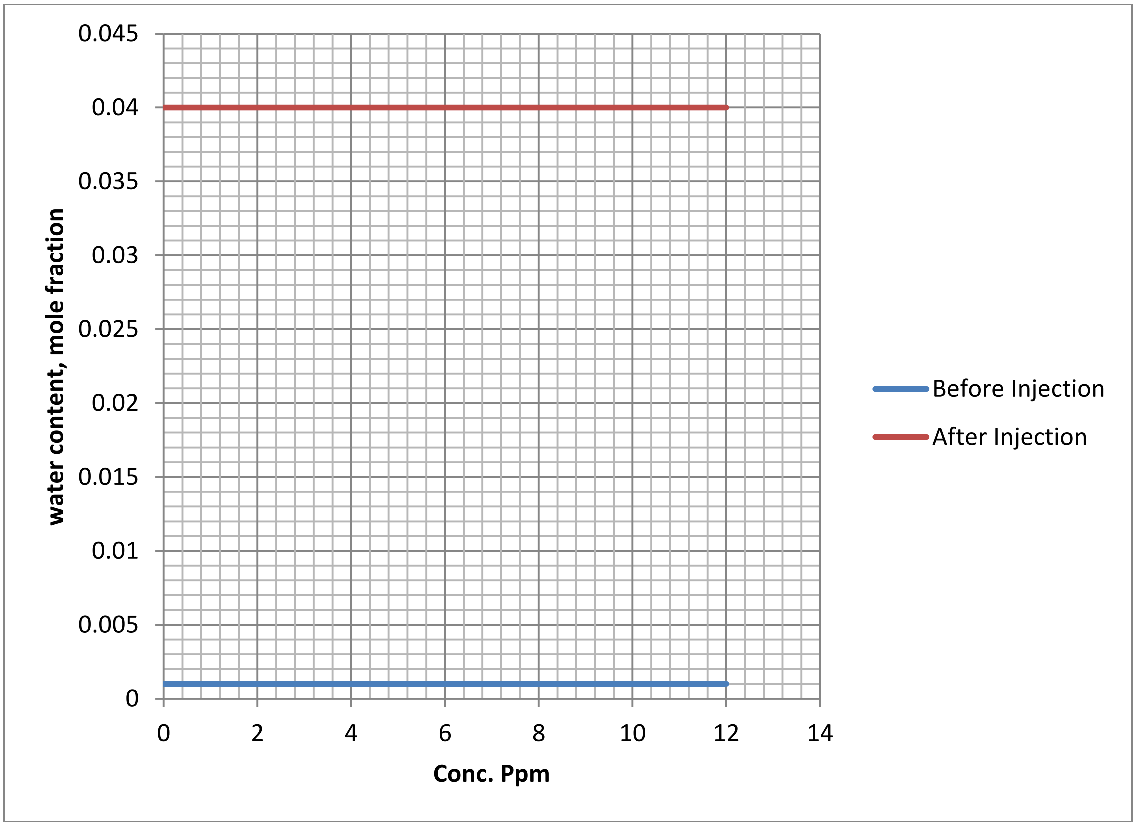

Fig 1- Simulation 1 effect on Water Content

Simulation Test 2, Effect on Water Content (Conc)

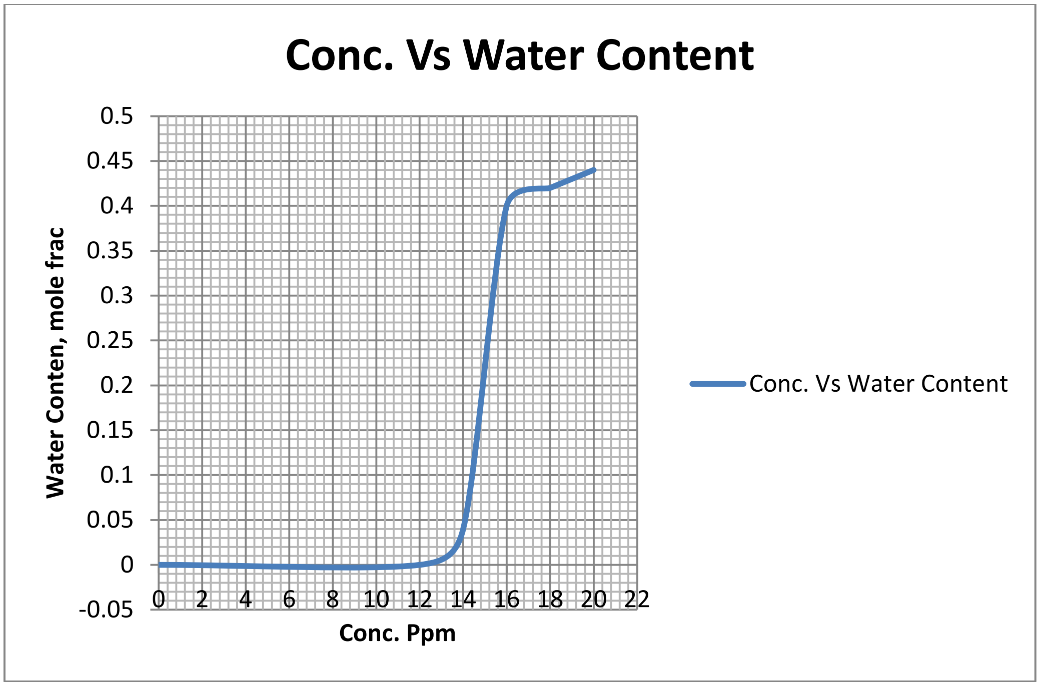

Fig 2- Simulation Test 2 effect on Water Conte

RESULT ANALYSIS

Simulation Test 1 Effect on Water content

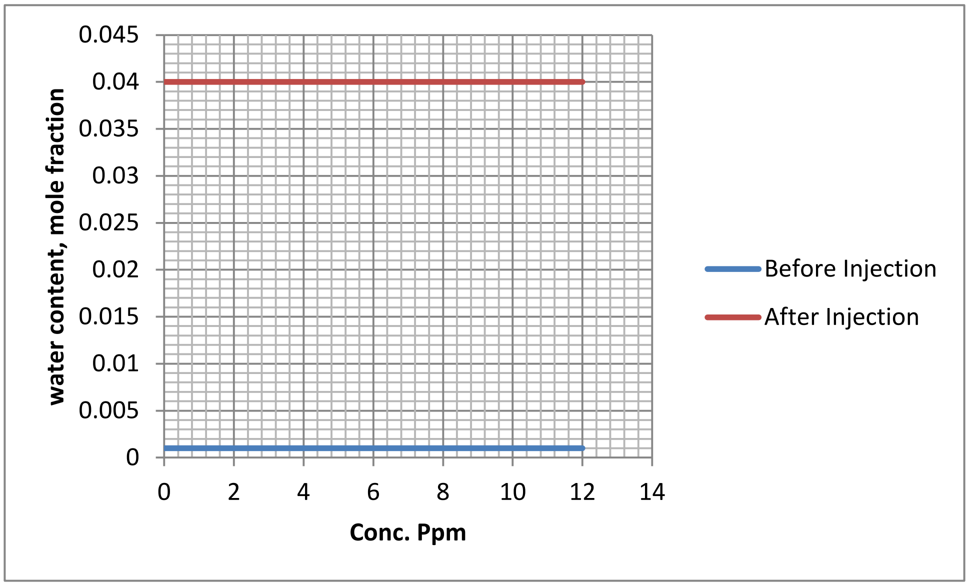

Fig 3- Simulation 1 effect on Water Content

Fig. 3 result simulation interface shows that there was a 1% increment in the water composition after de-emulsifier injection at constant temperature and flow rate. This when matched against the electrical stability trendline established above delineates that there was a decrease in the stability of the emulsion formed as increase in water content leads to a decrease in electrical stability.

Simulation Test 2, Effect on Water Content (Conc)

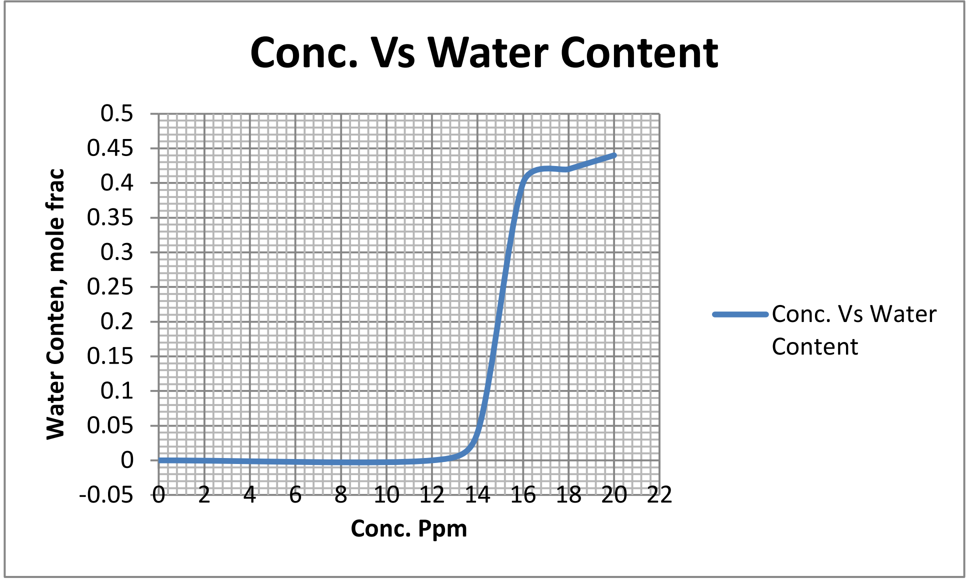

Fig 4- Simulation Test 2 effect on Water Content

From the previous discussion on increasing concentration effect on viscosity, it can be deduced that increased coalescence leads to larger water molecules which settles out due to gravity thereby increasing the molar volume of water in the crude oil thus making it easier to separate via decantation.

Test number 2: Surface Tension

Surface tension is the energy, or work required to increase the surface area of a liquid by a unit area due to their intermolecular forces. Measured in dyne/cm. Surface tension is an important factor in determining the emulsion stability of water-in-oil crude oil emulsion. High surface tension shows high emulsion stability while low surface tension shows low emulsion stable.

Simulation Test 1, Effect on Surface Tension

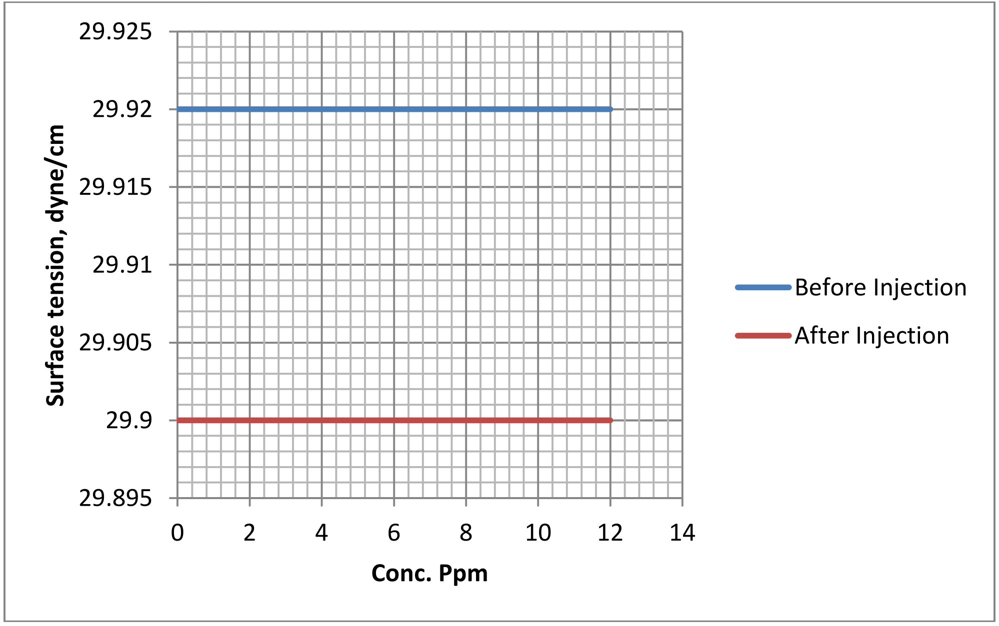

Fig 5- Simulation 1 effect on Surface Tension

Simulation Test 2, Effect on Surface Tension (Conc)

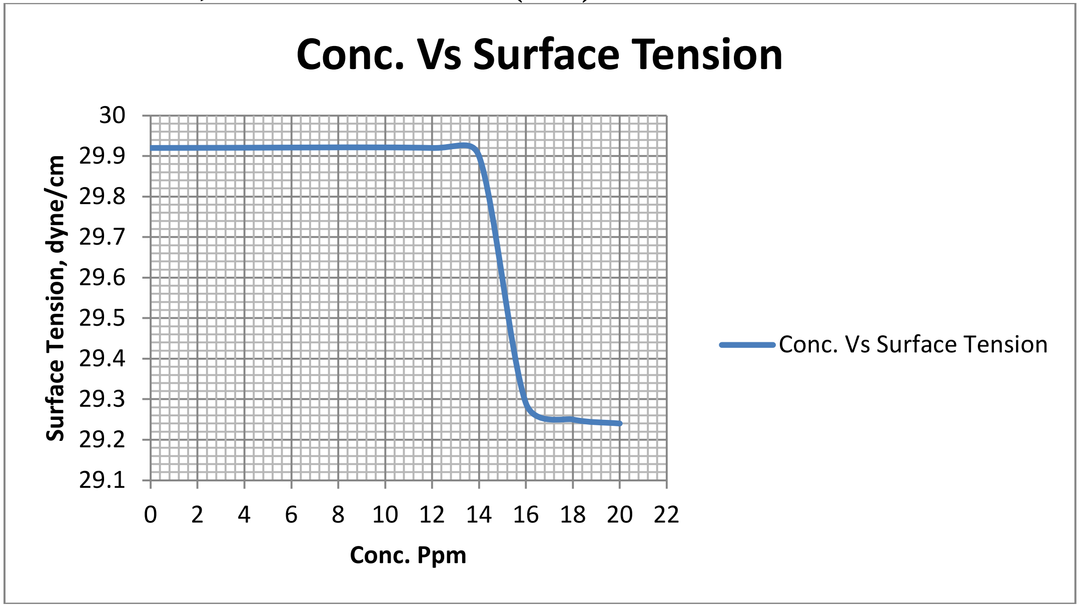

Fig 6 - Simulation Test 2 effect on Surface Tension

RESULT ANALYSIS

Simulation Test 1, Effect on Surface Tension

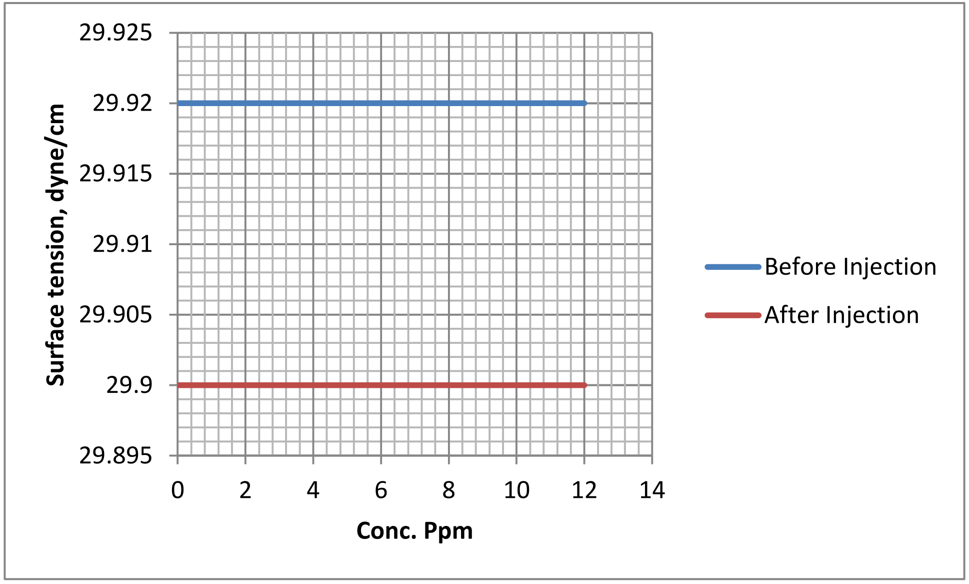

Fig 7- Simulation 1 effect on Surface Tension

From fig 7, the result simulation interface shows that there was a 2% reduction in the value of surface tension after de-emulsifier injection at constant temperature and flow rate. This when matched against the electrical stability trendline established above delineates that there was a decrease in the stability of the emulsion formed as decrease in surface tension leads to a decrease in electrical stability.

Simulation Test 2, Effect on Surface Tension (Conc)

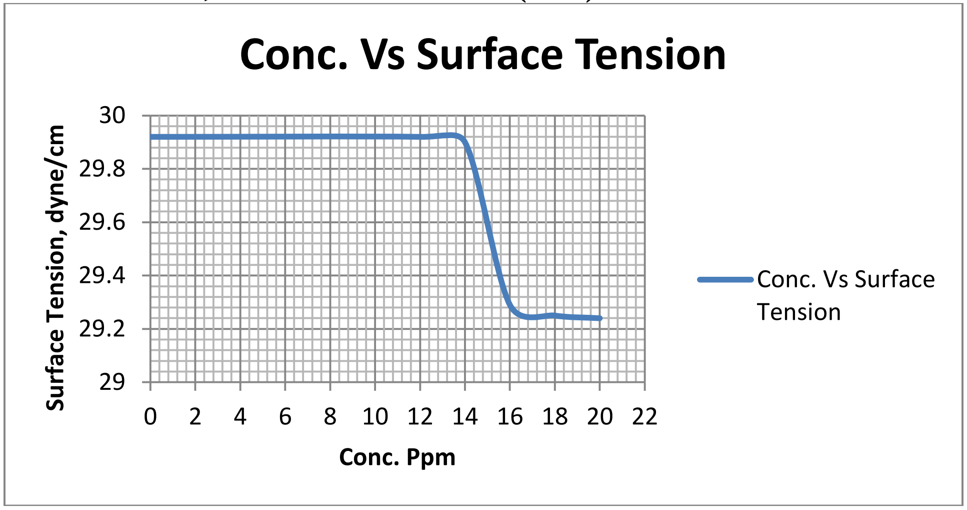

Fig 8 - Simulation Test 2 effect on Surface Tension

From fig. 8, increased de-emulsifier concentration results to a decrease in surface tension value which is in line with the laboratory established trendline during a de-emulsification process. Also concentrations above 16ppm lead to further de-emulsification which is not economical when compared to the cost of extra concentration injected.

Conclusion and Recommendation

In conclusion, the role of de-emulsifier in emulsion breaking cannot be over emphasized in the sense that, de-emulsifier plays an important role in oil production in preventing emulsion stability thereby saving cost of production which is of economic benefit. Finally, Understanding how the system will behave when everything is running smoothly is important, but it is the process upsets that are the real challenge in operating any system. By knowing what to expect, these process upsets can be assimilated into the operating philosophy, ensuring shorter downtime and generally higher profitability for a given system.

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