Nigerian Research Journal of Engineering and Environmental Sciences 2(2) 2017 pp. 494-499

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Original Research Article

DEMULSIFICATION OF CRUDE OIL EMULSION USING SOLUBLE AND NON-SOLUBLE EMUSIFIERS

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ARTICLE INFORMATION

Article history:
Received 05 May, 2017
Revised 30 August, 2017
Accepted 07 September, 2017
Available online 29 December, 2017

Keywords:
Crude oil
Demulsification
Emulsion
Glycerol
Xylene

ABSTRACT

Water in oil emulsion occurs at the early stages in the production and treatment of crude oil. Removal of water (demulsification) in the course of crude oil production has been a costly process and it has hampered the production activities in some oil wells in Delta State and many parts of the world. The present work studied the demulsification of crude oil emulsion obtained from three crude oil wells. Demulsification was conducted with Triethanolamine (TEA), Glycerol and Xylene as the chemical demulsifiers. Effectiveness was determined by measuring the percent water removal at time intervals. The process was repeated at various temperature to test the effect of temperature on demulsification. The result showed that using Glycerol gave the best water removal (71.93%) compared to TEA (70.25%) and Xylene (65.20%)..

1. INTRODUCTION

The formation of water-in-crude oil emulsion is often encountered in many stages of crude oil production process such as, drilling, transporting, and downstream processing (Abdel-Raouf et al., 2010). Due to the complexity of the water-in-crude emulsions, there has been challenges in the development of efficient separation techniques in the petroleum industry (Al-Sabagh et al., 2017). The water-in-crude oil emulsions scenario is typically present during the production of heavy oils (Yau et al., 2017). It is expedient for the separation of water from crude oil to be carried out because is a perquisite prior to the oil refining process (Martínez-Palou et al., 2015). The non-removal of the water from the crude oil could result in economic loses which could arise from damaging the equipment and low quality of the processed crude. To tackle this challenge, several techniques, such as the use of chemical additives, thermal treatment, centrifugal, freeze/thaw, and electric demulsification have been employed in past years (Yau et al., 2017). Amongst these techniques, the use chemical additives

otherwise known as chemical emulsification is most widely used. Nevertheless, some of the chemical additives are costly, toxic and non-environmental friendly (Wang et al., 2016). Besides, the thermal method entails the use of saturated steam to reduce the viscosity of the heavy oil (Martinez-Palou et al., 2013) In addition, the water-in-crude emulsion phenomenon can be by-passed by using submersible pumps for artificially lifting of the produced fluids (Zolfaghari et al., 2016).

The use of chemical emulsification for separation of water from water-in-crude emulsions basically require some amounts of chemical additives or surfactant (Silva et al., 2014). The mechanism of the chemical emulsification process entails the replacement of the emulsifier within the water-in-crude oil with demulsifier which are usually chemical additives or using polymeric additives (Zhang et al., 2013). Several authors have investigated the use of different demulsifies for the treatment of water-in crude oil emulsions. Hafiz et al. (2005) employed a novel emulsifier prepared from cationic polymer of ethanol amine esters for the treatment of water-in-crude oil emulsions. The study revealed that the cationic polymer was effective in the demulsifying the emulsions of refinery wastewater. In another, Alejandro et al. (2005) employed a modified alkylphenol polyalkoxylated resin and polyurethanes as demulsifier for the treatment of the water-in-crude oil emulsion and the results were found to be efficient. Several other demusifiers such as phenol-formaldehyde resin polyoxyethylene, polyoxypropylene and polyoxyethylene polymers have been employed for the treatment of water-in-crude oil emulsions. All of these demusifier demonstrated different degree of efficiency in the treatment of the water-in-crude oil emulsions. However, the focus of this study is to investigate the demulsification of water-in-crude oil emulsion using glycerol, Triethanolamine and Xylene. In addition, the specific capacity and performance of the chemical demulsifiers in different oil wells, were investigated.

2. MATERIALS AND METHODS

2.1. Materials

The water-in-crude oil emulsion used in this study was obtained from four different crude oil wells located in different parts of Delta State, Nigeria. The samples were stable emulsions obtained from the wellhead of the rig site in an untreated form. The chemical demulsifiers were made of Glycerol (Analytical grade of 98% purity, Loba Chemie Mumbai, India), Triethanolamine (Analytical grade 99% purity, Guangzhou Jinhuada Chemical Reagent Company, China), and Xylene (Analytical grade reagent of 99% purity, JHD Chemicals, Guangdong China).

2.2. Methods

Prior to the experiment the physicochemical properties (specific gravity, water content, and salt content) of the water-in-crude emulsions obtained from the three wells were determined by the method reported by Adebayo and Ameen (2017). Untreated crude oil (700 ml) was measured into a beaker and placed in a homogenizer operated 1800 rpm for 5 min. This was to enable the untreated crude oil emulsion to effectively stabilize. An amount (100 ml) of the homogenized untreated crude oil sample was thereafter measured into four different measuring cylinder. The demulsifying agent (2% v/v) was added to three of the cylinders and mechanically shaken for it to completely dissolve while the fourth cylinder was taken as a control. The rate of water and other particulate matter separation was then carefully monitored in the cylinder in order to determine the effectiveness of the chemical demulsifying agents. The percent water removed was calculated using Equation (1)

$$\%\ \text{Water removed} = \frac{\text{Water separated}}{\text{Total volume of oil}} \quad (1)$$

3. RESULTS AND DISCUSSION

The physicochemical properties of the water-in-crude oil emulsion which include the specific gravity, the percentage water content and the salt content were analysed and summarized in Table 1. It can be seen that the physicochemical properties of the water-in-crude oil emulsion from the different wells were different from one another. Interestingly, physicochemical properties of the water-in-crude oil emulsion from well B was observed to be lower when compared to the other wells.

Table 1: Physico-chemical properties of water-in-crude oil emulsion analysed at 30 ^{o}C

Well	Specific gravity	% Water content	% Salt content
A	0.859	0.02	0.37
B	0.837	0.10	0.39
C	0.840	0.01	0.33

Figures 1 to 3 show the percentage of water removed by using oil-soluble demulsifiers for the treatment of the water-in-crude oil emulsion from wells A, B and C respectively. Each of the water-in-crude oil emulsion obtained from each of the respective oil wells were treated with the emulsifiers which consist of xylene, TEA, and glycerol. It can be seen from Figure 1, that the percentage of water removed from the water-in-crude oil emulsion from well A using each of the emulsifiers increased with time until a plateau was reached. The use of xylene, TEA and glycerol resulted in the maximum water removal of 58.33%, 64.9%, and 66% respectively. The variation in the percentage of water removed from the water-in-crude emulsion could be attributed to the unique properties of the emulsifier such as the miscibility with water. For instance Xylene is known to be non-water soluble while Triethanolamine (TEA) and Glycerol were both water and oil soluble. This justifies why both TEA and glycerol have a higher percentage of water removal compared with to xylene (Zolfaghari et al., 2016). The high percentage water removal recorded by glycerol could be attributed to the hydrophilic nature of the OH- functional group as reported by Patel et al. (2013). Also, the control experiment showed that the use of emulsifier for the removal of water from water-in-crude oil emulsion is very effective. The use of the three emulsifiers for the removal of the water-in-crude oil emulsion obtained from well B also followed the same trend as depicted in Figure 2. It can be seen that the mixture of xylene, TEA and glycerol with the water-in-crude oil emulsion obtained from well B resulted in the removal of 69.3%, 69.8% and 71.93% of water, respectively. Again, this trend can be explained in terms of the affinity of each of the emulsifiers for water. This trends shows xylene, TEA and glycerol can be ranked as xylene<TEA<glycerol in terms of their degree of affinity for water removal from the water-in-crude oil emulsifier. Following a similar trend obtained in Figure 1 and 2, the time profile of the percentage of water removal from well B is depicted in Figure 3. Similarly, it can be seen that the percentage of water removal from the water-in-crude oil emulsion obtained from well C varies with the nature of the emulsifier used. The use of xylene, TEA, and glycerol resulted in the removal of 68.24%, 64.31% and 70.46% of water, respectively. As explained earlier, the highest values of water removal recorded for glycerol could be as a result of its high affinity for water due to the presence of the OH group. It can be seen that glycerol was the most effective demulsifier in all the wells and specifically in well B (with 71.93% water removed). Glycerol effectiveness in this well was related to its ability to dissolve efficiently in it and produce micelle that got separated from the crude oil by coalescence (Mosayebi and Abedini 2013). The activity of these demulsifiers is best noticed in crude oil from well C when compared with the performance of no-demulsifier were only 57.28% of the water in the oil was removed compared to 68.99% water removed by glycerol.

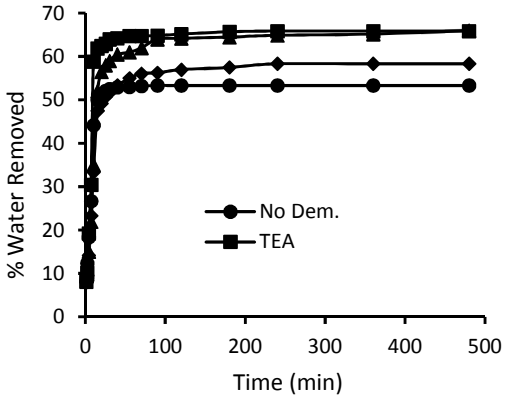

Figure 1: Effects of demulsifiers on crude oil on separation from well A

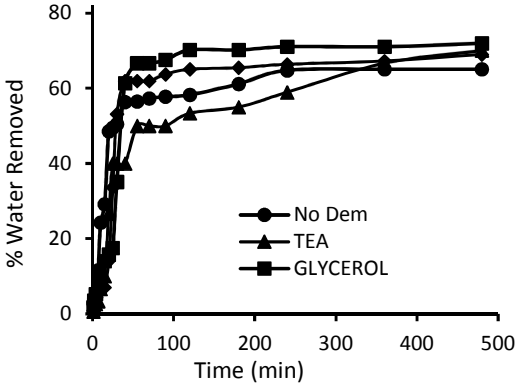

Figure 2: Effects of demulsifiers crude oil separation from well B

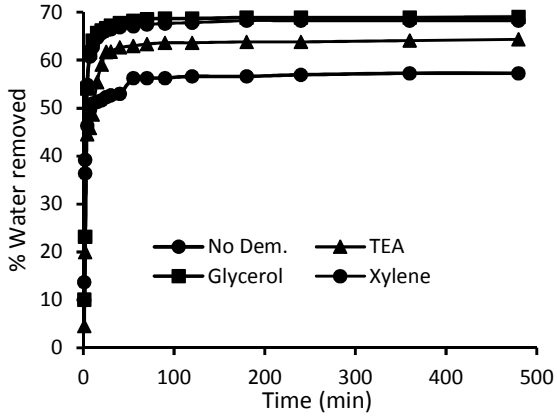

Figure 3: Effects of demulsifiers on crude oil separation from well C

The effect of temperature on the demulsification of water-in-crude oil emulsion obtained from the three well is depicted in Figure 4. It can be seen that the percentage of water removed from the water-in-crude oil emulsion increased in all cases with increase in temperature from 30°C to 70°C. This trend could be attributed to the important influence of temperature on the properties of the mixture of the demusilfier with the water-in-crude oil emulsions. At higher temperature, the viscosities of the liquids decrease whiles their diffusivities increase (Raju et al., 2017). The decrease in the viscosity which invariable leads to the increase in the diffusivity of the mixture as been reported to facilitate the removal of water from the emulsions and thus enhance the performance of the de-emulsifiers.

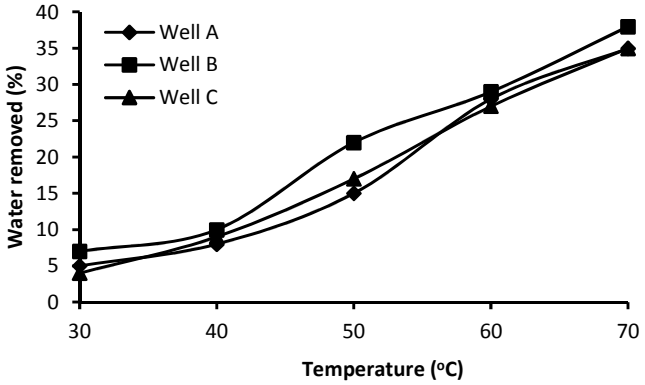

Figure 4: Effects of temperature on % water separation from crude oil samples

4. CONCLUSION

This study has successfully investigated the use of three chemical demulsifiers namely xylene TEA and glycerol for the demulsification of water-in-crude emulsion obtained in three crude oil well located in Delta State, Nigeria. The percentage removal of the water as a function of time and temperature were investigated. It is evident from the findings that the percentage of water removed from the water-in-crude oil emulsions from the three wells increases with time and temperature. The highest percentage water removal of 71.93% recorded when glycerol was used as emulfier for the water-in-crude oil emulsifier obtained from well B. While the lowest percentage water removal of 58.33% was obtained using xylene as emulsifier for the water-in-crude oil obtained from well A. Generally, the performance of the emulsifier in the demulsification process as be ranked in order of affinity for water removal from the water-in-crude oil emulsion as glycerol>TEA>xylene.

5. ACKNOWLEDGMENT

The authors wish to acknowledge the assistance and contributions of the laboratory staff of Department of Chemical Engineering, University of Benin, Benin City towards the success of this work.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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