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ARTICLE

Surfactant (UMP) for emulsification and stabilization of water-in-crude oil emulsions (W/O)

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ABSTRACT

The purpose of this research is to look into the formulation and evaluation of concentrated water-in-oil (W/O) emulsions stabilized by UMP NS-19-02 surfactant and their application for crude oil emulsion stabilization using gummy Malaysian crude oil. A two-petroleum oil from Malaysia oil refinery, i.e., Tapis petroleum oil and Tapis- Mesilla blend, were utilized to make water-in-oil emulsions. The various factors influencing emulsion characteristics and stability were evaluated. It was discovered that the stability of the water-in-oil emulsion improved by UMP NS-19-02 improved as the surfactant content rises, resulting in the decline of the crude oil-water interfacial tension (IFT). Nevertheless, the most optimum formulation of W/O emulsion was a 50:50 W/O ratio with 1.0% surfactant. Additionally, raising the oil content, salt concentration, duration and mixing speed, and pH of the emulsion resulted in higher emulsion stability. It also raised the temperature of the initial mixing, which significantly decreased the formulated emulsions' viscosity. The results showed that stable emulsions could be formed using the UMP NS-19-02 surfactant.

1. Introduction

The crude oils represent a small part of global oil production due to their high viscosities, which create issues in their pipeline shipping. The massive oil demand has traditionally long been considered due to their viscous and richness of composition, making them complex and costly to transport, generate, and modify. Previously, Venezuela's Orinoco Belt and Alberta in Canada were excellent examples of especially heavy oil-producing regions. Regardless, a rise in heavy crude oil production occurs in many areas, including the Northeastern China and Gulf of Mexico, because it will be required to replace decreasing mainstream middle and light oil production over the next two decades. Petroleum oil, also known as crude oil and fossil fuel, is a black, flammable, viscous fluid. Petroleum oil is a mixture of hydrogen and carbon found in the Earth's crust in liquid, gaseous, and solid forms. It consists of various complex mixtures containing a plethora of different individual components such as alkanes, aromatics, naphthene's, and benzene (Mehrotra et al., 2009). In this method, the crude product is distributed in the liquid state using acceptable surfactants, resulting in a balance oil-in-water mixture. The formation of a mixture remarkably decreases emulsified viscosity; perhaps an O/W emulsion may decrease rust with high sulphur crude oil; rust also may show up through the use of a liquid phase, including the use of salt-rich formation water.

The resulting emulsions have consistency in the 0.05-0.2 Pa.s range. This method can be highly effective in transiting petroleum oils with viscosities more significant than 1 Pa s.

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Table 1. Composition of the surfactants.

Mixture	Stabilizer	Wt. % Stabilizer in Ext. Phase (oil)	Emulsion Type	% Internal Phase
1	LSWR	0.50	w/o	50
2		0.75	w/o	55
3		2.00	w/o	60
4		5.00	w/o	70
5	Triton X-100	0.75	w/o	50
6		0.90	w/o	55
7		1.50	w/o	60
8		3.00	w/o	70
9	SDDS	1.00	w/o	65
10		1.50	w/o	70
11		3.00	w/o	75
12		3.50	w/o	80
13	UMP, NS-19-02	4.50	w/o	50
14		6.00	w/o	55
15		1.50	w/o	60
16		6.80	w/o	70

A detailed analysis of current innovations in cutting-edge crude oil demulsification methods to obtain a good knowledge of the development and processes of various crude oil demulsification methods to operate on the promotion of sustainable demulsifies from various sources were reviewed (Saad et al., 2019). It had been found that the stability of liquid in heavy oil emulsion is primarily related to the high interfacial viscosity of the interface, which results from the accumulation of much heavier components such as asphaltene and resin compared to thin oil (Sun et al., 2020). The recent techniques and influencing parameters in crude oil emulsion demulsification were reviewed. It was concluded that creating oil and water mixtures is a big issue in the context of ecological standards, the expense of oil extraction, generating and segregating it in refineries, and managing the waste. Researchers are interested in finding the basic science, financially and environmentally friendly viable techniques to inhibit the growth and treatment of the demulsification process due to these oil field issues (Saad et al., 2020; Ahmad et al., 2020).

The purpose of this study was to investigate the variables that influence the development of a stable W/O emulsion from two Malaysian petroleum oil samples: Tapis petroleum oil and a Tapis-Masilla blend. The current work is novel in that it uses an environmentally friendly and natural surfactant to stabilize heavy crude oil in water (Na_2CO_3). The study looked into the effect of the emulsion's oil content. It also examined the mixing of velocity and time, the salinity of the water, pH, and, lastly, the concentration and type of surfactant.

2. Materials and Methods

2.1. Materials and methods

For this study, a sample of petroleum oil A and B was obtained from the PETRONAS Refinery Plant in Kerteh, Terengganu, Malaysia. The compositions of each are shown in Table 1. For petroleum oil A and B emulsion productions, purified water was utilized as the liquid phase and petroleum oil as the oil phase. In this research, industrially available low sulphur waxy residue (LSWR), sorbitan monooleate (Span 83), sodium dodecyl-sulphate (SDDS) and Triton X-100 were used to emulsify the emulsion. In a 900 ml beaker, a water and oil phase, mixtures were prepared. For 7 minutes, the mixtures were vigorously stirred with a conventional three-blade propeller at 1600 rpm at 28°C.

Water concentrations in samples ranged from 10 to 90 % by volume. The surfactants used in this study and the concentration of W/O mixture preparations and their correlating balances can be seen in Table 1. The agent-in-oil method was used to plan water-in-oil (w/o) mixtures: the mixture agents were collapsed in the liquid medium during this work, and then water was gradually added and stirred. At various times, the amount of water resolved to the lower part was measured using a measuring tool on the beaker. The percentage of water separated was intended by subtracting the amount of water observed in the beaker from the surface area (e), as shown below:

$$\text{\% of water separation (e)} = \frac{\text{Amount of water layer (ml)}}{\text{Original amount of water (ml)}} * 100\ \% \quad (1)$$

3. Results and Discussion

3.1. Emulsion stability

Four surfactants (stabilizers) were used for mixture stabilization: UMP Surfactant, UMP NS-19-02; LSWR; Triton X-100 and SDDS. The emulsified stability of petroleum oils A and B were studied for production duration, and the total water separated value is used to calculate stability. The evaluation was performed at 26.5°C for 30 minutes with an agitation speed of 1800 rpm.

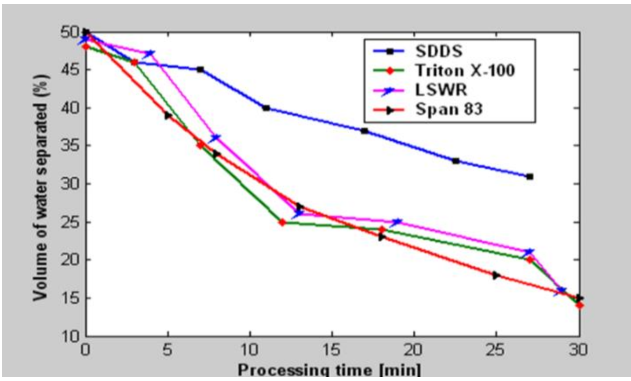

Fig. 1 Petroleum oil A mixtures (50-50 % w/o), with production time and emulsifier, applied.

As shown in Fig. 1 and 2, emulsion stability generally improved the production time. It is important to note that almost all the surfactants allow for quite a while for the aqueous phase to separate (mixture more stable). Even then, the highest volume of liquid segregated from petroleum oil A and B was 50 % and 60%. Based on the results, the following is the categorization of reducing stability efficiency: SDDS >Triton X-100 > LSWR > UMP NS-19-02. Furthermore, even at low emulsifier concentrations, rhamnolipid biosurfactants initiate high stable crude oil-water nanoemulsions. At 4 % rhamnolipid, the average size of the CO/W mixture droplet can be as minute as 50 nm, possibly reducing droplet size even more by enhancing the emulsifier dosage (Onaizi et al., 2021). Also, the effect of hydrate anti-agglomerates on crude oil-water was observed to destabilize and stabilize the W/O emulsion (Azizi et al., 2020).

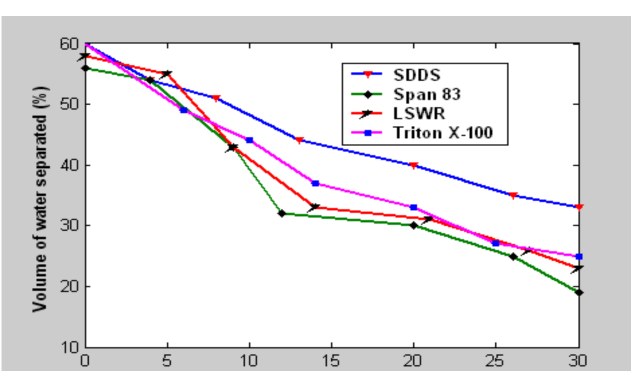

Fig. 2 Petroleum oil B emulsions (50-50 % w/o) applied with production time and emulsifier.

3.2. Effect of type of surfactant on viscosity

The effect of surfactant type on W/O emulsions' viscosity was studied, and their relationship was analyzed thoroughly in the following sub-sections (Abayomi et al., 2016). Nevertheless, the emulsions prepared using Triton X-100, Span 80 and UMPA were considered for the physical characterization.

3.3. Correlation of viscosity and temperature

The W/O emulsions preparation, storage, and transportation could all be done at different temperatures, so the effect of temperature on emulsion viscosities was also investigated and tabulated in Fig. 3 and 4. Significant reductions in viscosity with increasing temperature were observed for both W/O emulsions prepared with Span 80 and UMPA (Obi et al., 2021). Present results indicated that the viscosities of W/O emulsions were temperature-dependent and that temperature variations in the processing were a factor (Bala et al., 2018). This discovery followed a thermodynamic principle in which the molecules in W/O emulsions tended to move faster and farther apart, resulting in less resistance in the fluid flow. Furthermore, the Span 80 emulsions were found to have a higher viscosity than the NS-19-02 emulsions at lower temperatures, but the difference diminished as the temperature was raised.

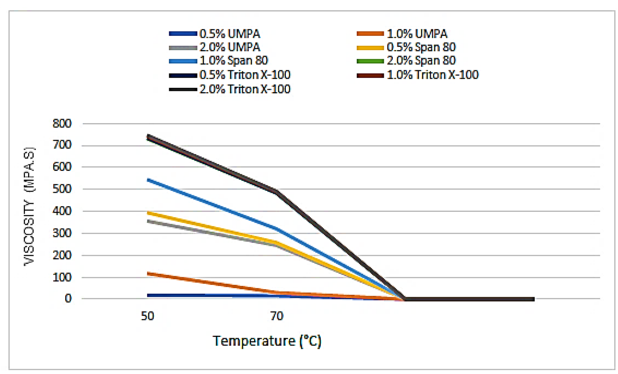

Fig. 3 Relation of viscosity and temperature for W/O emulsions with W/O ratios of (A) 50:50.

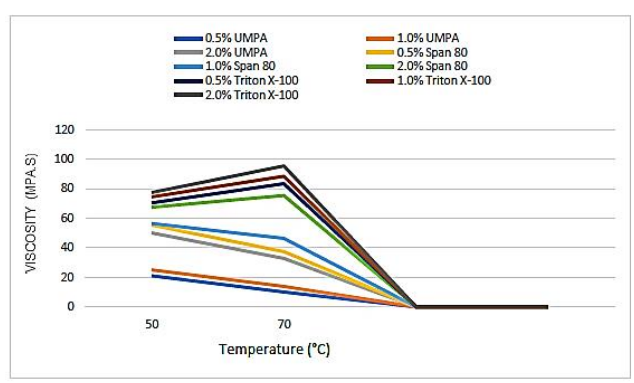

Fig. 4 Relation of viscosity and temperature for W/O emulsions with W/O ratios of (B) 30:70.

4. Conclusion

In this experimental study, the effects of surfactant types, water-oil ratio, and surfactant concentration on the stability, microscopic size of water droplets, and rheological properties of the W/O emulsified fuel were thoroughly investigated. The most optimal formulation of W/O emulsion was found to be a 50:50 W/O ratio with 1.0 % NS-19-02 as the emulsion was stable for one week with the highest water-to-oil ratio and most minor oil separation (3.0 vol %) apart from the absence of water separation. The NS-16-1 emulsion had the smallest water droplets size, followed by Span 80 and Triton x-100 emulsion. Furthermore, the viscosity of emulsions has been temperature-dependent over a range of temperature 20-100°C with a significant decrease as temperature increased. Also, increasing the W/O ratio was found to increase the viscosity of the emulsions. Therefore, stable emulsions could be formed using the UMP NS-19-02 surfactant.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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