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THE EFFECT OF JATROPHA BLEND FOR DUAL INHIBITION APPLICATION OF WAX AND SCALE

Mathanraj Jayagobi[1*], Amni Haslinda Alpandi[1,2], Hazlina Husin[1]

[1]Department of Petroleum Engineering, Universiti Teknologi PETRONAS, Malaysia
[2]School of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Malaysia

Email: mathanraj98@outlook.com

ABSTRACT

The oil and gas industry is exposed to flow assurance issues such as wax deposition and scale precipitation. The sector has been tackling this issue using the chemical method while extensive research is being conducted to find an effective solution. The conventional method is costly and not eco-friendly. This paper focuses on using Jatropha curcas seed oil (JSO) blended with Ethylenediaminetetraacetic acid (EDTA) as a promising dual inhibition application solution to counter wax and scale deposition simultaneously. The experiment manipulates the temperature and concentration to determine the efficiency of the inhibitor and its capability to improve flowability. Flowability and jar tests were conducted to analyze the blend's ability to act as a dual inhibitor. The results prove that the blend of JSO and EDTA at the concentrations of 3 wt% and 1 wt%, respectively, at 70°C showcased a robust result in wax inhibition by enhancing the flowability of the crude oil. On the other hand, effective scale inhibition is achieved when 1 wt% JSO is blended with 1 wt% of EDTA at 27°C. The results obtained signifies the compatibility of JSO and EDTA blend in dual inhibition application when optimal temperature and concentration are achieved. Dual inhibition application is expected to be a one-stop solution for both wax and scale precipitation that is economicallyviable and safe.

Keywords: *Wax precipitation, flowability test, jar test, wax inhibitor, scale inhibitor*

INTRODUCTION

Wax and scale precipitation issues are identified in the significant petroleum sectors such as upstream, midstream, and downstream. The flow assurance issue has challenged the industry economically and technologically. The flow of crude oil from one point to another in a safe, reliable, and profitable manner is known as flow assurance [1]. Hydrates, emulsion, scale, slugging, and wax deposition are common flow assurance issues [2]. The wax formation depends on the reservoir operating condition, either as paraffin wax suspension or solution in the crude oil [3]. Wax formations occur when the temperature is reduced below Wax Appearance Temperature (WAT) or cloud point during the transportation of crude oil from the reservoir to the processing facilities. It is known that the crude oil solubility depends on temperature variance [4]. This phenomenon is frequently observed at the surface facilities and pipelines, resulting in an abundance of wax crystals. This circumstance is also observed in the cold seabed where the transportation line is placed [5]. This deposition reduces pipeline inner surface and blockage [6]-[7]. Selecting the most suitable wax mitigation method is important because some wax removal methods are not cost-effective and may delay production time. The common wax mitigation method consists of the thermal, mechanical, and chemical methods [8]. The oldest conventional method, such as diluent, is not cost-effective and results in side effects. Wax mitigation method such as pour point depressant is capable of reducing the viscosity but has no effect on the deposition rate. The preferred wax mitigation method would be the prevention method which compromises of inhibitors that can dampen the wax crystallization time and interfere

with the agglomeration process to ensure production enhancement. Inhibitors that act as flow improver has the ability to reduce the viscosity and increase the flowability [8].

Another serious flow assurance issue would be scale formation, and scales are inorganic salts precipitation ing from water supersaturation [9]. Oilfield equipment is commonly subjected to scale precipitation. Scale interrupts the pipeline's fluid flow and operational capability [10]. Scale occurs naturally due to the ions present in the formation fluid. As a result, scale formation must be prevented because scale formation is difficult to handle [9]. Inhibitors are the standard mitigation method used to disrupt the agglomeration process of the nuclei.

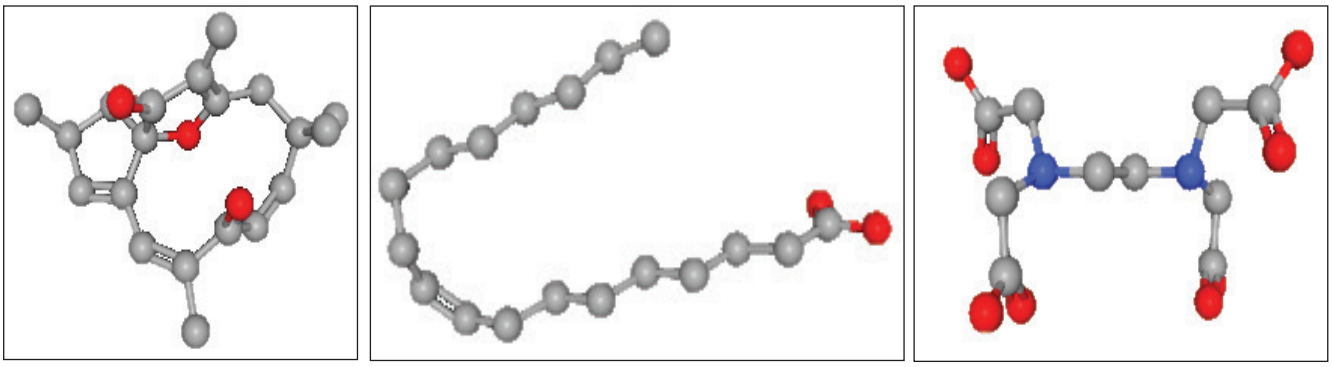
Research on green inhibitors has recently increased due to increasing environmental concerns [9]. This paper focuses on using plant extract as a relatively cheaper alternative to the conventional method and creating a single simultaneous inhibitor. Plant seed oil, especially Jatropha curcas seed oil (JSO), can act as a flow improver below the WAT [3],[11]. Besides, jatropha seed oil positively affects the inhibition and cost-effective. The oleic acid has the tendency to manipulate the pour point of the crude oil [11]. The advantage of Jatropha curcas is that it can sustain drought and grow in a dry climate suitable for the oil and gas industry [12]. Concurrently, ethylenediaminetetraacetic acid (EDTA), which is known as a chelating agent, is commonly used as an inhibitor in preventing tough scale. Previous research is also being conducted on plant extracts for scale inhibitors which leads to effective alternatives to natural molecule inhibitors [13]. Dual inhibition application has the tendency to inhibit both waxes and scale simultaneously using a single inhibitor type in this paper, creating a single solution for both the critical oil and gas problem.

MATERIAL AND METHODOLOGY

The methodology implemented in this paper was refined to exhibit dual inhibition application. The experiment focused on wax inhibition and scale inhibition using JSO and EDTA blend. Figure 1 shows the molecular structures of JSO, oleic acid found in JSO and EDTA. Characterization was conducted on the crude oil obtained from an undisclosed Malay Basin well using a Differential Scanning Calorimeter (DSC) and pour point tester by PSL Systemtechnik model 45150 to determine the properties of the crude oil.

Flowability Test

Flowability test was employed using Fann viscometer model 35 manufactured by Fann Instrument Company from Houston, Texas, USA. The critical material prepared was the crude oil which was obtained from the well of the Malaysian oilfield. The JSO was extracted from the jatropha seed in Universiti Teknologi Petronas. EDTA was obtained from R&M chemicals. The experiment began by heating the crude oil at 80°C for 2 hours with hand rocking the sample to eliminate any previous traits, including any pre crystallized wax deposits. Characterization of the crude oil was conducted to determine the API, specific gravity, and WAT using Differential Scanning Calorimeter (DSC). Next, the crude oil was segregated into 4 samples amounting to 150 ml each. The blank sample's viscosity was measured under three different temperatures, such as 60°C, 70°C, and



(a) (b) (c)

Figure 1 Molecular structures: (a) JSO, (b) Oleic acid found in JSO and (c) ethylenediaminetetraacetic acid (EDTA)

80°C, without inhibitor addition at 600 rpm by adjusting the viscometer switch at high and shifting the gear shift down. The step was repeated with the addition of JSO with a concentration of 1 wt%, 3 wt% and 5 wt%, along with a constant EDTA concentration of 1 wt% for each temperature. The dial reading obtained was used to calculate the viscosity as:

$$Apparent\ Viscosity,\ cP = \frac{Reading\ at\ 600\ rpm}{2} \quad (1)$$

The degree of viscosity reduction (DVR %) is calculated as:

$$DVR, \% = \frac{\mu_{intial} - \mu_{final}}{\mu_{intial}} \times 100 \quad (2)$$

where, $\mu_{initial}$ was the initial viscosity (μ) without inhibitor addition and μ_{final} was viscosity after inhibitor addition [14],[8]. The measurements were repeated twice and the results acquired were averaged to ensure the accuracy and reliability of the results [15]-[16].

Jar Test

Jar test was employed by creating an artificially induced tough scale barium sulfate using barium chloride and sodium sulfate obtained from R&M chemicals. The barium sulfate was induced by preparing a 50:50 ratio of barium chloride and sodium sulfate. The mixture was placed on a hot plate and stirred at 500 rpm for 20 minutes. The step was repeated using three different concentrations of JSO, which are 1 wt%, 3 wt%, and 5 wt% blended with 1 wt% of EDTA at a room temperature of 27°C. The sample was filtered after the stirring process and dried in the oven at 90°C for 2 hours. The dried sample is weight, and the scale inhibition efficiency was calculated as:

$$E, \% = \frac{m_{intial} - m_{final}}{m_{intial}} \times 100 \quad (3)$$

while the weight difference was used as a reference where signifies the initial mass without inhibitor blend and signifies the precipitate weight after the addition of inhibitor blend.

RESULT AND DISCUSSION

The results obtained were mainly dependent on the properties of the crude oil. The characteristics of the crude oil were tabulated in Table 1. It was observed that the well crude oil has high WAT, which was 72.24°C with a pour point of 59.25°C.

Table 1 Properties of crude oil

Parameters	Value
Wax appearance temperature	72.24°C
API	22.8 °API
Specific gravity (γ)	0.917
Pour point	59.25°C

Flowability Test

The flowability test results are dependent on the temperature and concentration. The viscosity of the blank sample of crude oil for 60°C, 70°C, and 80°C was 150 cP, 150 cP, and 105 cP, respectively. The viscosity reading shows a decreasing trend indicating viscosity reduction as temperature increases, as illustrated in Figure 2. The viscosity obtained for different temperatures for each concentration of JSO blended with 1 wt% EDTA is presented in Table 2 along with DVR.

Figure 3 illustrates a combo chart of the manipulated temperature and concentration for the viscosity study. The most significant DVR of 50.7% was obtained at 70°C with a concentration of 3 wt% JSO blended with 1 wt% of EDTA. The lowest DVR was obtained at 60°C with a concentration of 1 wt% JSO blended with 1 wt% EDTA. The significant impact of JSO blended with EDTA was portrayed as it was capable of reducing the viscosity by about 50.7% below the WAT of the well crude oil. The increase of flowability was observed below the WAT due to oleic acid's significant role in JSO forming a barrier between the interlocking wax crystal and inhibiting the formation of wax. This was further justified due to oleic acid present in JSO to act as a flow improver [3],[11].

Jar Test

Jar test results showcased the capability of the inhibitor blend in countering scale formation. The texture of barium sulfate appeared to be very sticky and white, as Figure 4. It is witnessed that with an increase in the inhibitor blend concentration, the scale precipitate's weight increases. The most promising result was obtained at 1 wt% of JSO blended with 1 wt% of EDTA. Mass reduction of 7.891 g, equivalent to scale inhibition efficiency of 19.22 %, was observed at

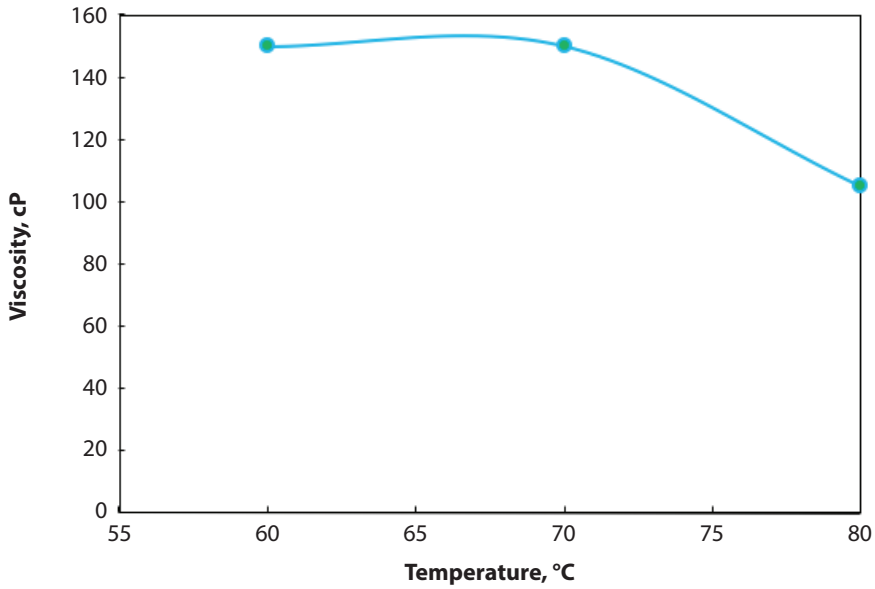


Figure 2 Blank sample viscosity chart

Table 2 Viscosity and DVR reading for temperature and concentration manipulated

Temperature (°C)	Concentration (wt%)	Final Viscosity, (cP)	DVR (%)
60	1	150	0
70		122	18.7
80		70	33.3
60	3	76	49.3
70		74	50.7
80		57.5	45.2
60	5	105	30.0
70		92.5	38.3
80		62.5	40.5

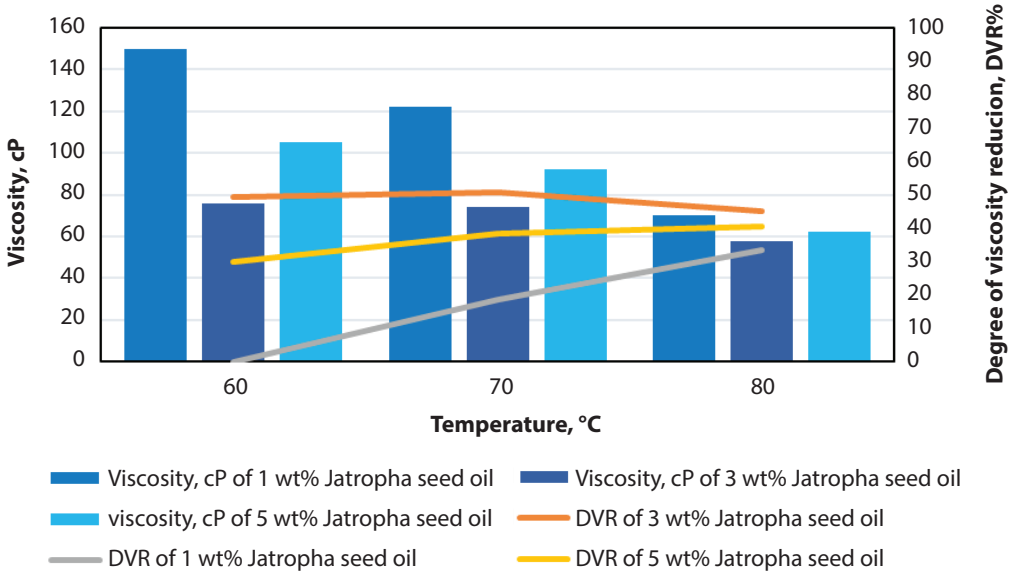


Figure 3 Viscosity and DVR % for all concentrations and temperatures

Figure 4 Barium sulfate scale

the inhibitor blend of 1 wt% JSO and 1 wt% EDTA at room temperature of 27°C as per Figure 5. The result portrayed the significance of the inhibitor blend in preventing barium sulfate with the help of EDTA, where the carboxylic arm in EDTA is used to trap the barium ion and prevent precipitation. However, as the concentration of JSO increases in the inhibitor blend, the inhibitor blend's effectiveness decreases as per Table 3. Hence, it can be concluded that the optimal concentration is achieved at 1 wt% JSO blended with 1 wt% of EDTA for that particular mixture quantity and increasing the concentration results in a retardation effect. The jar test has been used to determine plant extract inhibition tendency in the past [13].

Dual Inhibition Application

The dual inhibition application's significance can be observed based on the flowability and jar tests.

The DVR obtained from the flowability test proves the improvement of crude oil flowability by reducing the viscosity and preventing wax precipitation. Meanwhile, scale inhibition efficiency also showcased the capability of JSO and EDTA blend in countering the barium sulfate scale. The result obtained from both experiments signifies the JSO and EDTA blend's capability as a dual inhibitor capable of inhibiting wax and scale simultaneously if the optimum temperature and concentration are met.

Table 3 Scale inhibition efficiency for different concentration

Concentration	Scale Inhibition Efficiency, %
Blank	0.0
1 wt% JSO + 1 wt% EDTA	19.22
3 wt% JSO + 1 wt% EDTA	18.22
5 wt% JSO + 1 wt% EDTA	14.83

CONCLUSION

This paper discussed the potential of JSO blended with EDTA in acting as a dual inhibitor to counter wax and scale simultaneously under optimal temperature and concentration. The flowability test justified the capability of the inhibitor blend in reducing viscosity and preventing wax deposition by providing a DVR of 50.7% below the WAT, which is 70°C with a concentration of 3 wt% JSO blended with 1 wt% of EDTA. Jar test provided a significant result with 1 wt% of JSO combined with 1 wt% EDTA. The efficiency of both methods contributed to dual inhibition application, which can solve the most challenging flow assurance

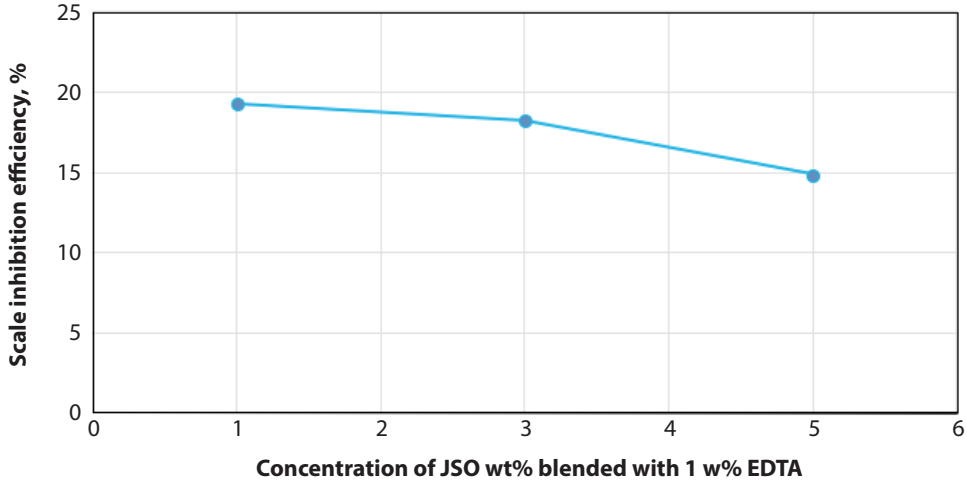


Figure 5 Scale inhibition efficiency chart

problem in an economically feasible method and environmentally safe.

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