Effect of sodium cloisite Na^+ nanoparticle in the castor oil on the wax deposition of Malaysian crude oil

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ABSTRACT: In this research, castor oil with and without the incorporation of sodium cloisite Na^+ nanoparticle was used as pour point depressant (PPD) to evaluate the performance as a wax inhibitor of Malaysia crude oil. PPD can be used to manage wax precipitation and deposition in oil production. From the results obtained, the wax deposition by adding sole castor oil (CO) as PPD and sole sodium cloisite Na^+ nanoparticle as wax inhibitor were reduced compared to blank crude oil. However, by adding sodium cloisite Na^+ nanoparticle to the CO, the wax deposition was not decreased significantly. The best concentration of wax inhibitors was 200 ppm sodium cloisite Na^+, 0.83v/v% CO and 2.4v/v% CO+200 ppm sodium cloisite Na^+. Castor oil is a cheap and effective PPD for reducing wax deposition in Malaysian crude oil, and sodium cloisite Na^+ nanoparticles should be used separately from castor oil as a wax inhibitor to get the highest wax deposition rate.

Keywords: *Crude oil; wax inhibition; cold finger: nanparticle: castor oil*

1. INTRODUCTION

Wax deposition occurs when the bulk temperature of the crude oil gets lower than wax appearance temperature (WAT), soluble wax in the crude oil gets crystallized causing deposition and accumulation on the pipeline walls [1]. As a result, the wax or paraffin deposition will cause an increase in pressure drop and could cause pipe blockage. There are various methods to reduce and prevent wax deposition, but chemical methods have become more popular as wax deposition inhibitor due to economic consideration [2]. There is a wide range of chemical inhibitors that can be used for inhibiting wax deposition. But they also have their limitation ranging from high cost to a limited spread of crude oil that an inhibitor can handle. According to the research of Akinyemi et al. [3], it was investigating the effect of the castor seed oil (CSO) on wax inhibition of crude oil, it was found out that CSO can reduce wax deposition at below the WAT.

Therefore, a cheap natural chemical inhibitor named castor oil is introduced as a wax deposition inhibitor or PPD. To increase the effectiveness of PPD, nanoparticles could be added, addition of the nanohybrid PPD could decrease the number of wax crystals, inhibit their aggregation, and lower the temperature at which the crude oil started to crystallize [4].

2. EXPERIMENTAL

2..1 *Test procedures for cold finger analysis*

A crude oil sample was supplied by Petronas. Cold finger equipment was used to study the amount of deposit wax. 300 mL of the crude oil samples were conditioned above the WAT for 1 hour to solubilize the precipitated wax. The impeller rotation rate was set at 200 rpm and the experiment was performed for 1 hour. The water bath was maintained at 50 °C and the cold finger temperature was fixed at 5°C. By using one factor at time (OFAT), the concentration of sodium cloisite Na^+ nanoparticles were varied from 200 ppm to 800 ppm while for castor oil the concentration were varied between 0.83v/v% 3.23v/v%. The PPD were added in the crude oil by simple mixing into the cold finger. The performance of PPD can be evaluated by calculate the paraffin inhibition efficiency (PIE) using Equation (1) .

$$PIE = \frac{W_f - W_t}{W_f} \times 100 \quad (1)$$

w_f is the amount of wax deposition before the addition or treatment of wax inhibitor (in gram) and w_t is the amount of wax deposition after the wax inhibitor treatment (in g).

3. RESULTS AND DISCUSSION

3.1 Effect of inhibitor concentration on wax deposition using different type of wax inhibitors

From Figure 1, the lowest amount of wax deposit was obtained which is 0.51 g using 200 ppm of sodium cloisite Na^+ nanoparticle while at 400 ppm shows the highest which is 0.59 g. After the inclusion of nanoparticles, the amount of wax crystals decreased, the wax crystals were sparse, and the interspace between wax crystals was wide, which result in the wax deposition decreased The amount of wax deposit for blank crude oil is 0.8333 g. 200 ppm of sodium cloisite Na^+ nanoparticle can reduce the wax inhibition from 0.8333 g to 0.5133 g. The PIE of 200 ppm sodium cloisite Na^+ nanoparticle achieved 38.4%. Nanoparticles helped in dispersing and stabilizing asphaltenes in the crude oil due to the nature of high adsorption affinity and large surface area of nanoparticles. It prevents the aggregation of wax crystal which adsorbed on the surface of nanoparticle.

From Figure 2, it was recorded that the lowest wax deposition was 0.5867 g using 0.83v/v% of castor oil as

a wax inhibitor. The wax deposition increased when the concentration of CO increased. The behavior of the castor oil may be attributed to the fact that the mono-unsaturated molecules present in them can actually bind to the larger paraffin molecules in solution and thereby sequester them from being available for wax aggregation and deposition.

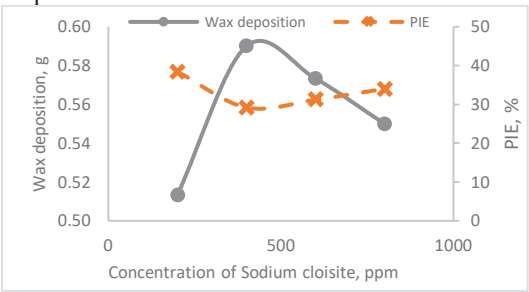
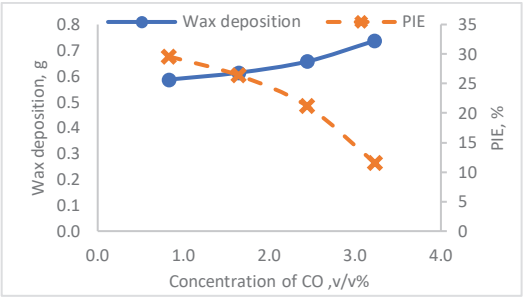


Figure 1 Wax deposition and PIE of different concentration of sodium cloisite Na^+ nanoparticle



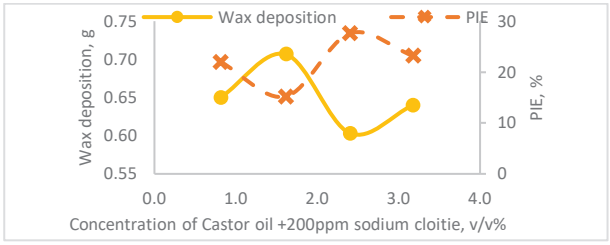
Footnote: 2.5 mL CO: 0.83v/v%, 5 mL CO: 1.64v/v%, 7.5 mL CO: 2.44v/v%, 10mL CO: 3.23v/v%

Figure 2 Wax deposition and PIE of different concentration of Castor oil

3.3 Effect of addition of sodium cloisite Na^+ nanoparticle in castor oil for wax deposition inhibition

To identify the effect of sodium cloisite Na^+ nanoparticles with castor oil in wax inhibition, castor oil and sodium cloisite Na^+ nanoparticle were added together in the crude oil sample. The best concentration of sodium cloisite Na^+ nanoparticles was determined in subtopic 3.1, which was 200 ppm. and used for further study. When the castor oil was combined with sodium cloisite Na^+ nanoparticles, the wax deposition was reduced compared to blank crude oil. However, the wax deposition did not reduce to a lower level than using sole castor oil and sole sodium cloisite Na^+ nanoparticle as wax inhibitors, as shown in Figure 3.

When castor oil was added with sodium cloisite Na^+ nanoparticles, the wax deposition fluctuated at around 0.65 g. The best inhibition performance was recorded at 0.6033 g using 2.4v/v% CO + 200 ppm sodium cloisite Na+ nanoparticle. This indicated that the combination of castor oil and sodium cloisite Na^+ was not improved the wax inhibition. It might be due to the cyclohexane present in nanoparticle solution, which affected the ricinoleic acid of castor oil as a wax inhibitor. The PIE fluctuated at around 20%. It reached the highest at 27.6% PIE using 2.4v/v% CO + 200 ppm sodium cloisite Na^+ nanoparticle. Castor oil added with sodium cloisite Na^+ nanoparticle did not increase the PIE significantly compared to using sole castor oil and sole sodium cloisite Na^+ nanoparticle as a wax inhibitor with the same reason as wax deposit trend.



Footnote: 2.5 mL CO: 0.81v/v%, 5 mL CO: 1.61v/v%, 7.5 mL CO: 2.4v/v%, 10 mL CO: 3.17v/v%

Figure 3 Wax deposition and PIE of different concentration of Castor oil with 200 ppm sodium cloisite Na^+ nanoparticle

4. CONCLUSION

The lowest wax deposition or highest PIE was recorded as the best concentration. It was found out that the 200 ppm sole sodium cloisite Na^+ nanoparticle and 0.83v/v% sole castor oil were the best concentration for wax inhibition. Both castor oil and sodium cloisite Na+ nanoparticles in crude oil had lower wax deposition than blank crude oil. When 200 ppm sodium cloisite Na+ nanoparticle was added to castor oil, it would affect the wax inhibition of castor oil. The order of performance on wax inhibition is 200 ppm sole sodium cloisite Na^+ nanoparticle > 2.5 mL sole castor oil > 2.4v/v% mL castor oil + 200 ppm sodium cloisite Na^+ nanoparticle

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