Evaluation of Hexane Performance in Wax Treatments at Fang Oilfield

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Abstract. Wax deposition occurs in various locations in the petroleum production chain. It can cause many problems for oil production. Chemical method is one of the practical methods for wax prevention treatment. In Fang oilfield, there are problems from wax as well. Therefore, the objective of this study is to evaluate of hexane to reduce the wax problem. For this study, oil samples from the wells located in Mae Soon Reservoir in Fang oil field. Hexane is used as a chemical for this treatment for wax appearance temperature (WAT), pour point and wax deposited weight tests. Also, other factors such as temperature, hexane concentration and time are also studied. The results show that hexane can reduce the wax precipitation by reducing pour point and WAT. Wax deposited weight is reduced as well. Hexane effectiveness can be evaluated and also applied in the region in the oil field with wax problems. Understanding of physics and chemistry of wax precipitation will lead to develop the area economically effective prevention and mitigation methods.

1. Introduction  
Wax deposition is a critical operational challenge. When the temperature is relatively high, n-paraffins are normally dissolved in the oil but when temperature falls below the wax appearance temperature (WAT), they can precipitate and form solids, resulting in higher pressure drop and plugging. Significant operational hazards due to wax deposition have been reported over the past few decades. It is extremely important to have a sufficient and rigorous understanding of the physics and chemistry of wax precipitation/deposition in order to develop economically viable prevention/mitigation strategies [1].  
Petroleum reservoir fluids are complex multicomponent mixtures. The wax components can precipitate when the original reservoir equilibrium conditions are changed. The solid/liquid-phase boundary is nearly vertical for waxes illustrating the wax precipitation is strong dependence on temperature and weak dependence on pressure [2].  
Direct methods such as pigging and the take-out method, in which a section of pipe is removed and the volume of wax inside measured. Additionally, pressure drop, and heat transfer methods can be used to measure wax deposits indirectly without down time. Different methods are tested with small-scale laboratory representation of actual systems and use these methods to actual pipelines [3].  
With carbon numbers ranging approximately from 18 to 65, petroleum waxes are complex mixtures of n-alkanes, i-alkanes, and cycloalkanes. Two general classes of petroleum waxes are paraffin: normal alkanes crystallize in large flat plates (macrocrystalline structures) and microcrystalline: cycloalkanes and i-alkanes crystallize as small needle structures. Solid-wax formation consists of two distinct stages:
nucleation and crystal growth. The crystal-growth process occurs as further molecules are laid down in a lamellar or plate-like structure [2]. The wax deposit formation mechanisms are: 1. molecular diffusion: the diffusion of the dissolved molecules of the waxy components toward the wall, 2. shear dispersion: dispersion of the precipitated particles of the waxy components toward the wall, 3. Brownian diffusion: diffusion of the precipitated particles toward the wall caused by Brownian motion and 4. gravity settling: the settling of the precipitated particles of the waxy components toward the bottom of the pipe. The dissolved wax molecules in the oil are the subject of deposition in the first mechanism. The precipitated suspended wax particles in the oil are the main reason for the rest three mechanisms [1]. The last three mechanisms are considered as secondary mechanisms while molecular diffusion is the main mechanism [4].

Removal and prevention are two categories for wax deposition [5]. Paraffin accumulations are removed by mechanical, use of solvents and heat [6]. Dispersants and crystal modifiers are also employed in the field for prevention or inhibition [5]. This study chose solvent method which modify oil and tubing surface [7]. Selection of a solvent should be based on its cost effectiveness in dissolving a specific organic deposit and must be adapted to fit well conditions [8].

Pour Point Test, the lowest temperature at which a liquid remains pourable [9], is also done as one of the tests to adjust chemical effectiveness. One of the thermodynamic parameter, WAT will answer what temperature wax will start to precipitate. In this paper, WAT’s determined by the viscometry method to evaluate selected solvent, hexane. Viscosity increases at a higher rate with decreasing temperature for the oil at temperatures slightly below the WAT compared to above the WAT. Extrapolation from the Newtonian region is performed to determine the WAT in the viscosity–temperature curve of a fluid. Lab-scale wax deposition experiments has become a standard industrial practice to benchmark the wax deposition models with lab-scale or pilot-scale wax deposition experiments prior to their application in the field. Cold-finger wax deposition apparatus, less costly and requires a smaller volume of oil for testing, is use in this study to evaluate selected chemical [1].

Fang oil field is facing with wax deposition problem. To solve the problem, the chemical method is used. In this work, the selected chemical is hexane to solve this problem with different conditions. The objective of this study is to evaluate of hexane to reduce the wax problem. For this study, oil samples from the wells located in Mae Soon reservoir in Fang oilfield. Hexane is used as a chemical for this treatment for WAT, pour point and wax deposited weight tests. Also, other factors such as temperature, hexane concentration and time are also studied. With the good understanding of physics and chemistry of wax precipitation will lead to develop the area economically effective prevention and mitigation methods.

2. Materials and methods

2.1 Materials
Crude oil sample is collected from Mae Soon reservoir in Fang oilfield. Hexane is purchased from Sigma Aldrich. Hexane concentrations from 5 % to 20 % are used to evaluate solvent effectiveness with these tests, pour point tests, WAT tests and wax deposited weight tests.

2.2 Pour point tests
The temperature measurements are performed by Kimo model KTT 220 and thermocouples J-Type. By following ASTM D 5853-11, pour points of crude oil are tested with original condition and inhibitors with different concentrations. First, the sample is heated at least 20 °C above expected pour point with water bath. Second, the temperature is reduced in the multiple of 3 °C and begins to examine the appearance of sample. The test tube is tilted just enough to ascertain every 3 °C down whether there is movement of the sample in the test tube or not. Then, if the movement of the test sample is shown, the test tube is replaced immediately in the water bath and repeat a test for the flow at the next temperature, 3 °C lower. After that, when the test sample shows no movement, stops the test and the test tube is held in a horizontal position. Finally, record that temperature [10]. That recorded temperature is the pour pint temperature.
2.3 Wax appearance temperature (WAT) tests
WAT is measured by using viscometry method. Brookfield Viscometer model DV2TLV with spindle number 52Z is used to perform the viscosity measurements. Julabo F26 model heating or cooling bath machine is utilized to control temperature and glycol is used as a heating and cooling media. First, the crude oil is heated up to 80 °C before the test and the crude oil without inhibitor and with inhibitors at different concentrations is transferred to the viscometer cup. Finally, the temperature is cooled down ranging from 80°C to 40°C with 3 shear rates, 6 s⁻¹, 12 s⁻¹ and 24 s⁻¹ and constant cooling rate 12 °C/hour [10].

2.4 Wax deposited weight tests
The Rod finger, a 25 cm long of copper stick, is equipped at rubber cork together with thermocouple J-type. Crude oil temperature is controlled by using temperature controller bath Julabo immersion circulator ME model heating or cooling bath machine and water is used as a heating and cooling media to control temperature. This test is conducted by cold finger technique. First, the weight of the naked rod is measured. Second, crude oil is melted down at 65 °C before commencing wax deposition test with inhibitors in different concentrations and without inhibitors. And transfer sample into test tube and close with cork carrying cold finger and thermocouple. Then, conducted for 3-hour period with different temperatures and concentrations to investigate the temperature gradient effect. After that, wax deposits mass measured by the precision 4 digits weighing machine. Finally, the experiment is repeated for 3 times and gets the average result [10].

3. Results and discussion

3.1 Effect of hexane concentration on pour points
The results from pour point tests are illustrated in Figure 1. It can clearly see that when hexane concentration is increased, the pour point temperature is reduced. Higher hexane concentration at 15 % and 20 % gives significantly reduction of pour point temperature.

![Figure 1. Effect of hexane concentration on pour points](image)

3.2 Effect of hexane on wax appearance temperature (WAT)
Figure 2 to Figure 6 present the results of hexane on wax appearance temperature (WAT) for original oil and oil with hexane from 5-20 %, respectively. At lower temperature, the development of wax crystal growth will reach larger size. Moreover, wax crystal size also decreases with shear rate increasing [11]. From WAT tests, Figure 3 to Figure 6, WAT is decreased either increasing share rate 6 s⁻¹ to 24 s⁻¹, or hexane concentration increasing, 5 % to 20 %. However, using more hexane concentration can slightly reduce WAT.
**Figure 2.** WAT of original oil

**Figure 3.** Effect of shear rate on wax appearance temperature of crude oil at 5% N-hexane.

**Figure 4.** Effect of shear rate on wax appearance temperature of crude oil at 10% N-hexane.
Figure 5. Effect of shear rate on wax appearance temperature of crude oil at 15% N-hexane.

Figure 6. Effect of shear rate on wax appearance temperature of crude oil at 20% N-hexane.

3.3 Effect of hexane on wax deposited weight test

Figure 7 and Figure 8 show the results of hexane on wax deposited weight test as a function of hexane concentration and temperature, respectively. It is obvious that hexane at high concentration can reduce deposited wax weight clearly during 3-hours tests. Temperature from 35 °C to 55 °C during tests [12] is another influencing factor on deposited weight tests. Higher temperature can reduce wax formation.

Figure 7. Effect of hexane concentration on wax precipitation
4. Conclusions

Fang oilfield has the problem of wax precipitation and the way to solve this problem is to use chemical method to prevent wax. Hexane is selected as a chemical for this study. Based on the results, hexane can act as one of the practical solvents to reduce the wax problem for Fang oilfield. An increase in hexane concentration can reduce obviously the pour points, wax appearance temperature and the amount of wax deposit of oil from Fang oilfield. Other factors such as temperature, shear rate and time are also influencing the wax precipitation process. The results present that like hexane concentration, an increase in temperature and shear rate can reduce pour points, wax appearance temperature and the amount of wax deposit. This chemical can be applied in Fang oilfield for the design of the process for wax prevention in the future. For the future study, the correlation of this work will be developed for the prediction of wax deposition in Fang oilfield with various working conditions to save time and cost in the future operation.

5. References

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