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Reducing the viscosity of missan heavy crude oil using combinations of low molecular weight hydrocarbon compounds

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This work studied the facilitation of the transportation of Missan heavy crude oil characterized with high viscosity 84.61 cp at 15 °C, low API 23.1, by reducing its viscosity from break down asphaltene agglomerates using five solvents with some novel combinations of chemical additives were used for this study (naphtha & toluene, naphtha & xylene, naphtha & kerosene, toluene & kerosene, and xylene & kerosene).The viscosity of crude oil was measured after being treated with these chemicals at different concentrations (4, 8, and 12 weight%) and temperatures 15, 25, 35, and 45 °C. It has been found that increasing the concentration of naphtha with xylene from 4% to 12% causes a decrease in viscosity, from 48.62 cp at 15°C to 30.11 cp. The viscosity of a mixture of naphtha and kerosene drops from 50.15 cp at 15°C to 31.70 cp when the concentration is raised from 4% to 12%. The addition of toluene to kerosene causes the viscosity to drop from 51.76 cp at 15°C to 33.67 cp when the concentration of toluene is raised from 4% to 12%. Increasing the xylene concentration from 4% to 12% in kerosene led to a decrease in viscosity from 53.65 cp at 15°C to 34.88 cp at the same temperature. The findings of the present work could be applied to the petroleum industry for the purpose of transporting heavy oil of Missan or any other heavy crude.

1. Introduction

Transportation of petroleum is now a highly specialized and complex. High viscosity fluids are a major challenge in pipeline transportation because they necessitate efficient and cost-effective methods of transporting heavy crude. Heavy crude oils have a density that meets or exceeds that of water. They can range in consistency from a thick molasses to a solid at room temperature, with the former being the most common. It is difficult to transport heavy crude oil due to the presence of metals such as nickel and vanadium, as well as high sulfur content. The production, separation, transportation, and refinement of crude oil can be complicated by the complexity of crude oil [1]. As the name suggests, heavy crude has a high viscosity, specific gravity, and molecular composition. Because of the high concentration of naphthenes and paraffins, it is thick and viscous [2].There are higher proportions of high-boiling constituents in heavy crude oil, such as greases and waxes, as well as residue from lubricating oils, lubricants, engine oils, cylindrical oils, and gear oils, in heavy crude oil (residual fuel oils, coke, tar and asphalt). Heavy petroleum also contains more aromatic and heteroatom-containing compounds (N, O, S, and metals) than light petroleum [3]. There are numerous costly issues with production loss and transportation difficulties that make this type of asphalting a vexing problem for those in the petroleum industry. In terms of recoverable oil reserves, heavy crudes account for a significant portion of the global total. They range in viscosity from 100 to more than 105 mPas at room

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temperature. An ideal condition for crude oil pipeline viscosity is 400 millipoise pounds per square inch (mPas) [4-5]. Heavy oil's high viscosity is a critical factor that has a significant impact on the extraction, surface transportation, and refinement processes upstream and downstream. Finding more efficient and cost-effective ways to recover heavy oil and reduce the associated investment and operating costs can be greatly aided by gaining a enhanced thoughtful of the causes of its high viscosity [6]. Heavy crude oil can be transported through pipelines in a less viscous state in a number of different ways. Oxidation and drag can be reduced through a variety of more general methods, including upgrading, diluting, heating, and using surfactants to stabilize emulsions. In order to overcome the difficulties of transporting heavy oil by pipeline, heating is a common method [7]. Dilution is approach that has been widely employed to reduce the viscosity of heavy crude oil. The dilution process is performed by adding condensates, Hydrocarbon liquids that are lighter in weight or alcohols, to heavy oil. This method is useful for lowering viscosity and increasing fluid flow in the reservoir and the pipeline [8]. Examined the influence of two diluents on reducing heavy oil viscosity to increase oil recovery. Two oil samples were used including a diesel based heavy oil, and light oil sample. The diluents were oil based and thus had a high solubility in the oil [9]. Attempted to clarify the mechanism of viscosity reduction using metal-lug and compounds by using Iron III para-Toluene sulfonate at varying degrees of heat and pressure. The main drawback of the chemical was the cost and the availability [10]. Examined the effect of different gasses including methane, carbon dioxide, and propane on the reduction of oil viscosity at different pressures and temperatures. He found that dissolving the gasses with the heavy oil using the same molar concentration will result in an almost equal reduction in oil viscosity [11]. proposed combining naphtha and kerosene in varying proportions. Iraqi heavy crude oil is blended with naphtha and kerosene at varying concentrations ranging from three to twelve weight percent to lower the oil's viscosity and increase its flow ability. Heavy oil can also be transported by heating it, as its viscosity rapidly decreases at higher temperatures. As the oil is heated, its viscosity is reduced, making it easier to pump. This is the underlying principle of this method. As a result, it's critical to reduce the oil's viscosity by heating it to a high temperature. Over long distances, the capital and operational costs of a heated pipeline are a major drawback [12]. Underwater transportation of heavy oil through a heated pipeline presents significant challenges due to the cooling effect of the surrounding water and the manageable difficulties of maintaining pumping stations and heating stations [13-14]. Asphaltenes, the oil's most polar and/or heavy constituents, have been shown in several experiments to have a significant impact on heavy oil viscosity in terms of volume fraction, chemical structure, and physical chemical [15]. Crude oil heavy components that are insoluble in nonpolar solvents have a solubility class called petroleum asphaltenes. Oil-derived asphaltenes can be found as colloidal dispersions that have been stabilized with the help of additional crude oil constituents.

A wide range of mechanistic and physicochemical factors involved in oil scope recovery and production can easily disturb these naturally occurring dispersion systems. Increased asphaltene destabilization is caused by a variety of factors including changes in heat and pressure, the blend of crude and condensate streams, as well as better recovery methods. There are numerous issues for crude oil producers when asphaltenes are built up on the surface [16]. Asphaltenes have been found to have properties that are similar to those of colloids in some studies. In the heavy oil matrix, micelles of these colloids can be seen. The micelles in petroleum are more resin-rich because the mole part of resins is larger than that of asphaltenes. Aggregates begin to form at a concentration known as the "critical micelle concentration" (CMC) in asphaltenes. For asphaltene degradation to occur in response to polar solvents it is reasonable to assume a decrease in hydrocarbon medium polarity (or solubility parameter) [17-18]. As a result of the interaction between different asphaltene species, micelles are thought to form. We don't know exactly how Asphaltene micelles can be formed due to the interaction of intermolecular or intramolecular forces. Possible interactions include: porphyrin interaction, electron transfer between aromatics (-bonding), porphyrin-aromatic hydrogen bonding, porphyrin-porphyrin hydrogen bonding, and porphyrin-porphyrin dipole-dipole interaction [19-20].

The purpose of this study is to examine the reduction of viscosity of heavy crude oil obtained from Missan oil field using formulations of different hydrocarbons (naphtha, toluene, xylene, kerosene) with different concentrations (4, 8 and 12 wt%) and different temperatures (15 °C to 25 °C, 35 °C, and 45 °C) and thus increasing oil production and reducing transportation problems and costs.

2. Experimental work

2.1 Feedstock

The feedstocks in this research was Missan crude oil, acquired from Amara oil fields. These are some of the characteristics of the crude oil are specified in table 1.

Table 1. Properties of heavy crude oil from Amara field before treatment

Property	Value
API gravity at 15.6 C	23.100
Sp.Gravity at 15.60 C	00.915
Density at 15 C	00.915
Kin. Viscosity (CST). at 37.8 ℃	34.100
Water content (%vol.)	07.000
Salt content (% wt**)**	03.670
Salt content PPM	7139.3
Sulfur content (%wt)	03.670
Asphaltenes (%wt.)	05.420

Light Naphtha

AL-Diwaniya refinery provided the dynamic viscosity and density light naphtha 0.41 (cp) and 0.6950 g/cm^3, respectively.

Toluene Solvent (C_7H_8)

Toluene was obtained from the AL-Diwaniya refinery, and its molecular weight, boiling point, and density are (92.14 kg/mole, 110-111 °C, and 0.870 g/cm3).

Xylene Solvent *(C_8H_{10})*

The AL-Diwaniya refinery provided the xylene, which has a molecular weight of 106.17, a boiling point of 136-140 °C, and a density of 0.860 g/cm3.

Kerosene solvent

Al-Diwaniya Refinery supplied the kerosene, which had a dynamic viscosity of 1.79 (cp) and a density of 0.7884 (g/cm3).

2.2 Devices

a) Viscometer:To determine the viscosity of the oil mixed with the different additives using a device DV-E VISCOMETER(BROOKFIELD ,USA made) as shown in fig. 1.
b) Hot plate: The vessel containing the oil was placed in the hot plate to be heated to the desired temperature and at desired rotary speed as shown in fig. 2.
c) Thermometer: used to measure the core temperature of the oil after heating to ensure that the temperature reached the requiredvalue.
d) Various containers and beakers as well as stirrer device with magnet rotation were used in the current study.

Figure 1. DV-EViscometer used for viscosity measurements.

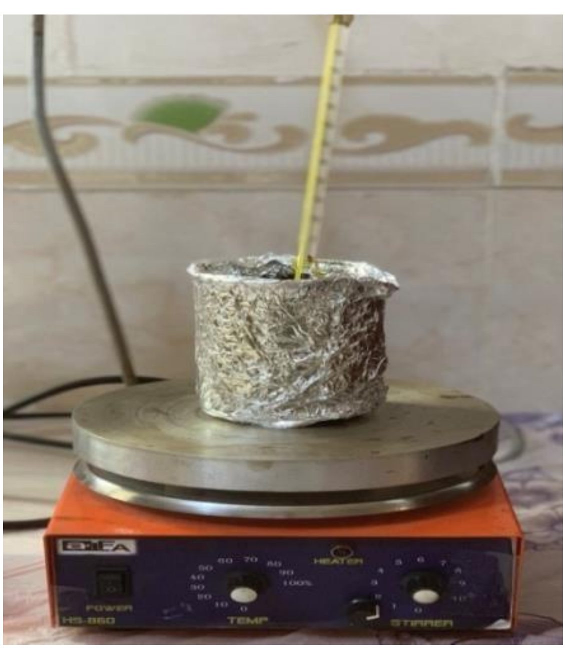

Figure 2. Hotplate used in the experimental work.

2.3 Procedure

2.3.1 Mixing

The spindle of a DV-E (Dynamic viscometer class E) is rotated in a circle during operation. In milli Pascal or centipoises, the DV-E viscometer reads viscosity. Depending on the setting, the viscometer was either set to speed or spindle selection. The speed of rotation can be set by the user. Once the set is in the correct position, the operator can select the spindle by moving it to the left. The DV-E viscometer comes with a set of four spindles. A unique entry code number is required for each spindle before the viscosity value can be calculated. In total, the DV-E viscometer offers 18 different rotational speeds, from 0.3 to 100 rpm, for measuring viscosity. Crude oil's viscosity can be determined using the following steps:

- A beaker with 200 ml of crude oil poured init.
- Increasingtemperaturefrom 15 degrees Celsius to 25, 35 and 45 degrees Celsius by using the heater of the hot plate.
- Monitoring the viscosity of the oil over a range of temperatures.
- Finally, a mixture of chemical additives such as (naphtha & toluene, naphtha & xylene, naphtha &kerosene , toluene & kerosene and xylene & kerosene) are added to the heavy crude oil at various concentrations and temperatures in order to observe the changes in viscosity.
- For this experiment, a stirrer device that rotated using magnetswasapplied, so that the volatile components of crude oil would not be disturbed. After 15 minutes of mixing, the mixture is declared homogeneous.
- A thermometer should be used to make sure that the beaker's interior remains at room temperature throughout your experiment.
- The shear rate (speed) of the DV-E viscometer has been set at 100 rpm.
- To get the most accurate results, the proper spindleshould be used.
- At each temperature, the viscosity was measured by running a test at a set speed.

3. Results and discussions

The investigation conducted to lessen the viscosity of Missan heavy crude oil through the oxidation of asphaltenes at various temperatures and concentrations of hydrocarbons of low molecular weight yielded the following findings:

Missan heavy crude oil's viscosity reduction was analyzed as a function of the concentration of combination solvents used and the temperature at which they were applied. The figures 3, 5, 7, 9, and 11 display the impact on crude oil viscosity at various temperatures of varying concentrations of (naphtha and toluene), (naphtha and xylene), (naphtha and kerosene), (toluene and kerosene), and (xylene and kerosene). As the concentration of the solvent increased, the viscosity decreased. Naphtha and toluene are the most decrease.

It was necessary to introduce the viscosity reduction percentage VR percent in order to gauge the degree to which viscosity had been reduced and it was calculated by Eq. 1 [21].

$$DVR\% = [(\eta r - \eta c)/(\eta r)] * 100 \qquad (1)$$

Where ηr and ηc crude oil cp viscosity reference and its corresponding. The percentage reduction in viscosity versus temperature for various solvent concentrations and temperatures is shown in Figures 4, 6, 8, 10, and 12.

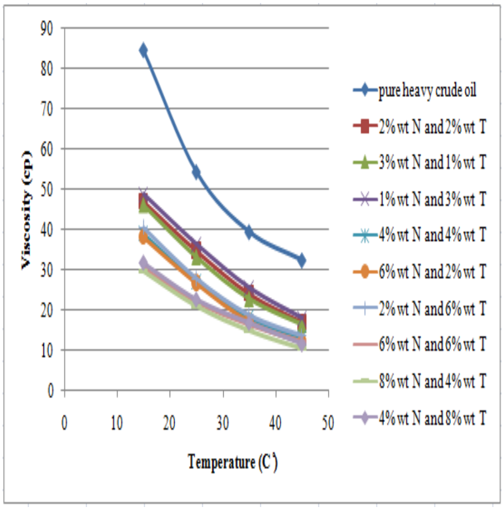

Figure 3. Effect of naphtha & toluene weight fraction on the viscosity of Missan crude oil.

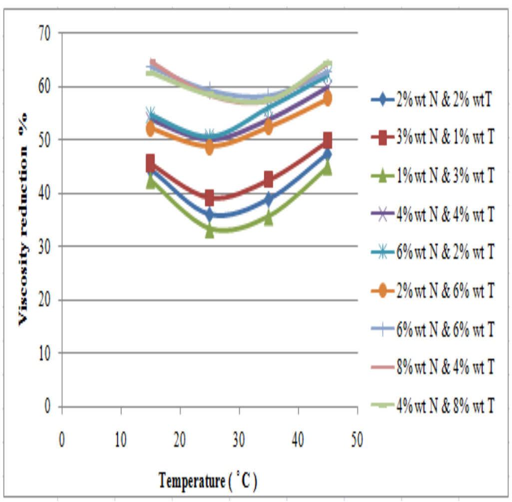

Figure 4. Effect of naphtha & toluene weight fraction on viscosity reduction of Missan crude oil.

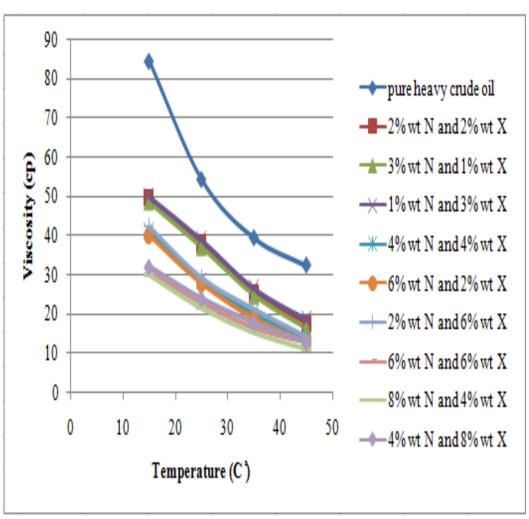

Figure 5. Effect of naphtha & xylene weight fraction on the viscosity of Missan viscous oil.

Figures 3 and 4 show that naphtha and toluene gave the best viscosity reduction at 45 °C; naphtha and toluene are strong solvents with a high ability to disperse asphaltene agglomerates.

As shown in Figures 5 and 6, naphtha and xylene were the second best viscosity reducers, where the viscosity decreases from 48.62 to 30.11 at 15°C.

After naphtha & xylene, a combination of naphtha and kerosene was used to investigate the viscosity drop as shown in Figures 7 and 8 where the third best viscosity reducers, as the viscosity decreases from 50.15 to 31.70cPat 15°C.

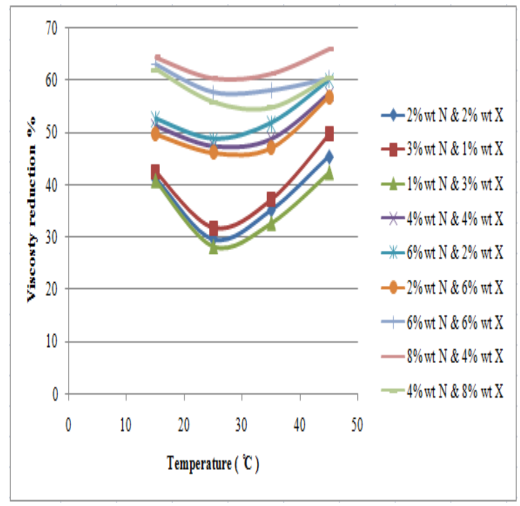

Figure 6. Effect of naphtha & xylene weight fraction on viscosity reduction of Missan heavy crude.

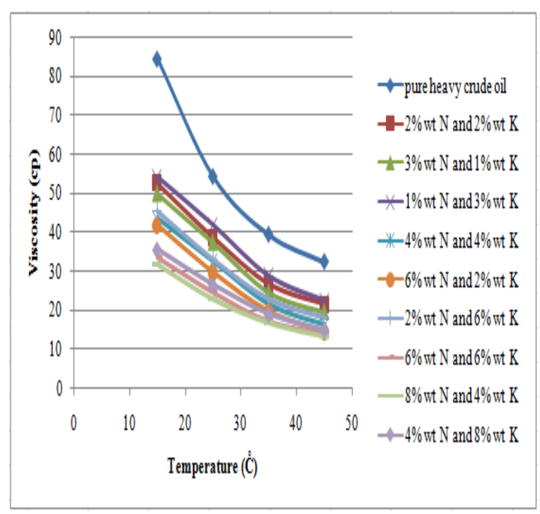

Figure 7. Effect of naphtha & kerosene weight fraction on the viscosity of Missan viscous crude oil

As shown in Figures 9 and 10, the combination of toluene and kerosene was found to be as the second less viscosity reducers, where the viscosity decreases from 51.76 to 33.67cP at 15°C.

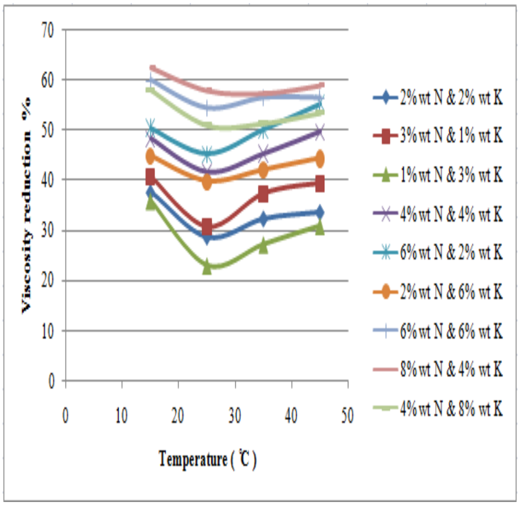

Figure 8. Effect of naphtha & kerosene weight fraction on viscosity reduction of Missan heavy oil.

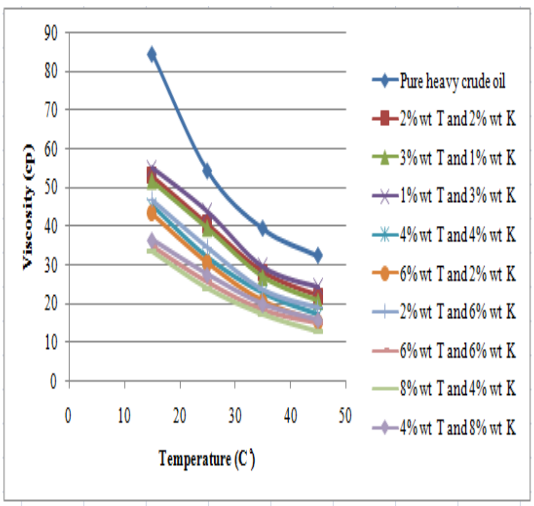

Figure 9. Effect of toluene & kerosene weight fraction on the viscosity of Missan heavy crude oil.

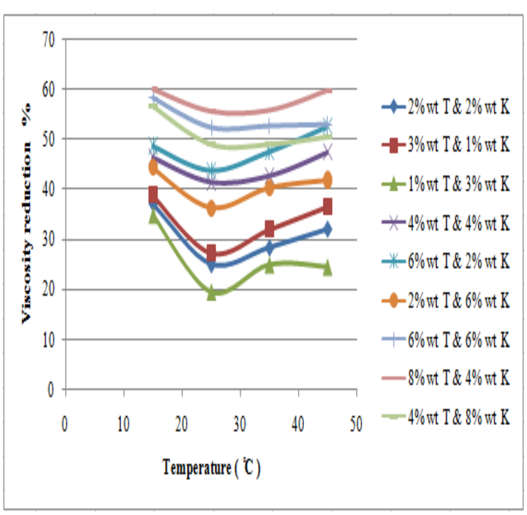

Figure 10. Effect of toluene & kerosene weight fraction on viscosity reduction of Missan crude oil.

As shown in Figures 11 and 12, xylene & kerosene was found to be asthe less viscosity reducers amongother combinations, where the viscosity decreases from 53.65 to 34.88 cP at 15°C ; In all cases, the solvent formulations listed here are powerful solvents that are capable of dispersing asphaltenes.

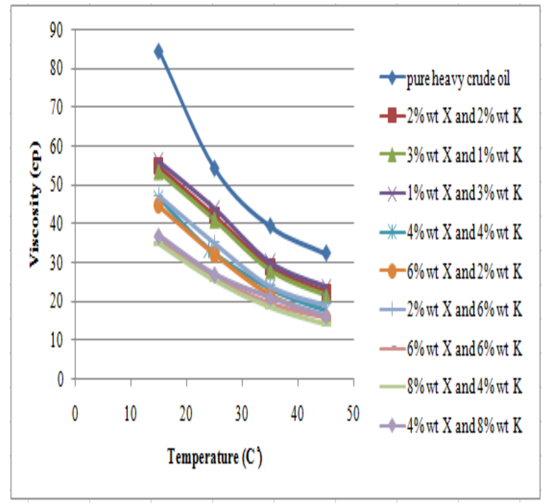

Figure 11. Effect of xylene & kerosene weight fraction on viscothe sity of Missan viscous crude oil.

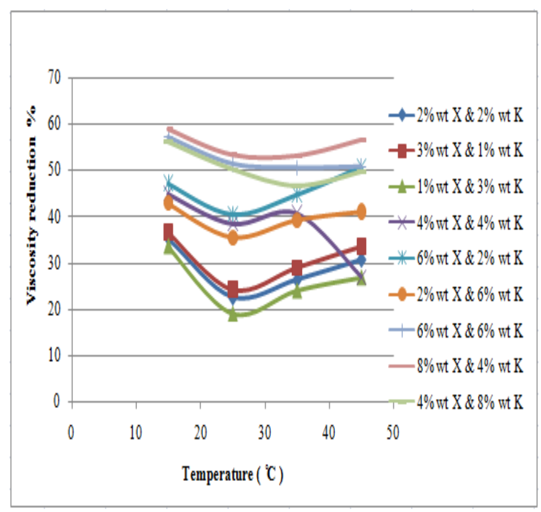

Figure 12. Effect of xylene & kerosene weight fraction on viscosity reduction of Missan heavy crude oil.

4. Conclusions

Various chemicals were used in this study to evaluate their ability to reduce Missan heavy oil viscosity in hopes of increasing oil recovery and oil transportation. The main conclusions from the current research are summarized below:

- Among all the chemical combinations being used in theresearch, it was concluded that the combination of naphtha and toluene is thmost effective viscosity reducer for Missan heavy crude oil compared to other chemicals being tested.
- Following, the combinations of naphtha and toluene, naphtha and

xylene are the second most effective viscosity reducer then followed by naphtha and kerosene, and finally xylene and kerosene which showed low viscosity reduction effect.

- It is worth mentioning that covering the beaker during the experimental work of viscosity measurements gives more accurate resultsof viscosity, due to the reason for controlling the volatility of fumes during heating.
- During mixing, the rotation speed should be reduced toabout 300 rpm with a period of 15 min to ensure the best reading for viscosity is obtained.

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