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Application of Xylene for Niger Delta Crude Oil Viscosity Reduction

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Abstract
Crude oil still is a significant source of income for Nigeria, which has necessitated the search for crude oil in the cold offshore environment. Offshore crude oil production may have various flow assurance challenges, such as wax precipitation. This research studies the effectiveness of using xylene to reduce the viscosity of a Niger Delta waxy crude oil sample. The crude oil sample was conditioned to temperatures ranging from 35°C to 10°C at a 5°C interval, and the crude viscosity was measured at each temperature. The crude sample was blended with 1wt%, 2wt%, 3wt%, 4wt% and 5wt% xylene and the viscosity was measured at the temperatures considered in the uninhibited crude sample experiment. The viscosity of the crude sample increased with reducing temperature, even in the inhibited sample. The 5wt% xylene performed best, giving the highest viscosity reduction (50%) at 20 °C. Xylene effectively reduced the viscosity of waxy crude oil and can be combined with other wax inhibitors for optimum performance.

Keywords: *Niger Delta, Flow assurance, Waxy crude, Xylene, Viscosity reduction*

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1. Introduction

Since the mid-18th century, the petroleum industry has been the life wire of industrialization and modern civilization because petroleum has many applications and a high calorific value. The petroleum industry has been challenged to explore crude oil in places with extreme conditions, like the offshore environment, to meet the ever-growing demand for energy in the world. Common challenges encountered when producing and transporting crude oil in the offshore environment include hydrate formation, sand production, corrosion, scale, and wax formation.

Most Niger Delta crude oils have an amount of heavy paraffinic molecules (C^{18+}) dissolved under reservoir conditions (Taiwo et al., 2012). Wax remains in solution until operating conditions are favourable to its precipitation, a condition caused by changes in the temperature–pressure equilibrium of the crude oil. Upon precipitation, wax can be deposited anywhere on the components of the production system, both on the subsurface and surface equipment. It could deposit in the reservoir, wellbore, tubing, flow lines, and surface facilities. Also, when wax precipitates in the crude oil, the crude oil gels, resulting in wax deposits in the production tubing which causes an increase in the pressure drop thus, requiring higher pressure to transport the crude oil.

In the Niger Delta, wax precipitation has affected many wells. The operational problems associated with wax precipitation have resulted in huge losses that amount to billions of dollars annually for the oil industry worldwide. Most crude oils contain some amounts of wax and paraffin, which changes in structure from linear or branching to cyclic form or aromatic hydrocarbons (Behbahani, 2005). This dynamic behaviour can influence the wax's melting point and solubility. The severity of this wax deposition challenge depends on the type of crude oil transported and the composition of the formed wax. Straight-chain compounds easily crystallize, while cyclo-paraffins (naphthene) do not quickly crystallize or deposit on surfaces (Maria del Carmen et al., 2001). When uncontrolled, wax precipitation can plug the pipeline and prevent the transportation of waxy crude to the end user. Wax precipitation is severe in an offshore environment where access to subsea facilities is limited.

Solving waxy crude oil challenges can be done using a preventive or corrective approach. The preventive approach is adopted when steps are taken to inhibit the growth of paraffin crystals. This involves thermal insulation of the facility (Owodunni and Ajienka, 2007), optimized pipeline design for effective flow (Salam et al., 2014), and injection of chemical inhibitors like polymers (Odutola and Idemili, 2020), dispersants (Deshmukh and Bharambe, 2012) or nanoparticles (Odutola and Allaputa, 2020). The corrective approach involves the routine removal of wax deposits which have accumulated on walls of equipment over time since wax precipitation may not be preventable in all instances using mechanical (Weidong et al., 2019), thermal (Stanko et al., 2019) and chemical treatment using solvents (Afdhol et al., 2019). This research examines the effect of xylene on waxy crude viscosity at varying temperatures. The crude sample studied was obtained from the Niger Delta.

2. Materials and methods

Materials used in the experiment include the crude oil sample gotten from Oloma field in the Niger Delta, 99% pure xylene (obtained from Supelco) as an inhibitor, some water for the water bath used in heating the crude to desired temperature and ice used in cooling the crude sample to the desired temperature before viscosity measurement. The equipment used includes a measuring cylinder for measuring the crude sample, thermometer for monitoring the crude temperature, water bath for conditioning the crude temperature to the desired temperature and viscometer for measuring the crude oil viscosity. The viscosity of the crude oil at various temperatures in the presence and absence of xylene was measured using a 12speed viscometer. The degree of viscosity reduction (DVR) shows how much viscosity reduction was attained from using the inhibitor at varying temperatures. It is computed using Equation (1).

$$DVR\ (\%) = \frac{\mu_{ref} - \mu_{treat}}{\mu_{ref}} * 100 \qquad (1)$$

2.1 Experimental procedure

The experimental procedures are outlined below:

i. 350mls of crude oil was measured using the measuring cylinder.
ii. The temperature of the crude sample was regulated using a water bath or ice to the desired temperature. The temperatures considered in this study are 10 ºC, 15ºC, 20ºC, 25ºC, 30ºC and 35ºC.
iii. The viscometer was used to measure the viscosity.
iv. The procedure (i – iii.) was repeated for crude oil samples made up to 350 ml when blended with 1wt%, 2wt%, 3wt%, 4 wt% and 5wt% of xylene, respectively.

3. Results and discussion

At sufficiently high temperature, waxy crude oil exists as simple Newtonian fluids. As the crude temperature reduces, the flow properties of change from Newtonian flow to a very complex non-Newtonian behaviour due to the crystallization of wax. To study the change in fluid behaviour, the viscosity of the crude sample was plotted against temperature (Fig. 1). The broken line indicates the likely path for viscosity if the crude sample remained Newtonian as the temperature was reduced from 35°C to 10°C. Notice that the plot of viscosity against temperature shows a non-Newtonian flow behaviour. The fluid viscosity rapidly increased when the temperature was reduced to 25°C. This implies that wax crystals formed as the fluid temperature was reduced below the Wax Appearance Temperature (WAT), causing the fluid to change from a single-phase Newtonian flow to a complex non-Newtonian flow causing the precipitated wax crystals to impede the fluid movement. The WAT is the temperature at which wax crystals precipitate out of solution. The wax crystals increased in size and quantity as the crude oil is cooled from 25°C to 5°C. This was indicated by the subsequent rise in viscosity as the crude sample was cooled to 5°C. When this persists unchecked, it can result in increased fluid viscosity and may cause difficulty in crude oil transportation and damage to some downstream equipment.

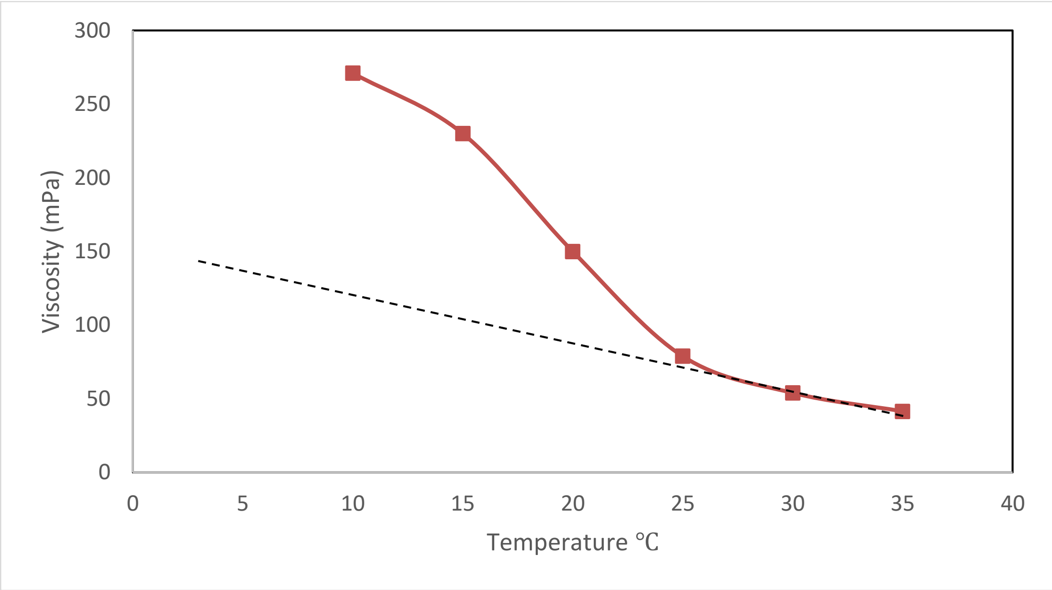

Fig. 1: Viscosity against temperature for blank crude

Fig. 2 is the plot of viscosity against temperature for experiments conducted with varying concentrations of xylene, from 1wt% xylene to 5wt% xylene. Notice that the viscosity of the crude sample at a specific temperature reduced with the increase in the xylene concentration. For instance, at the coldest temperature of 10ºC, the viscosity in the uninhibited sample was 271 mPa.s. As 1wt% xylene was added, the viscosity reduced to 251mPa.s, and a further increase in xylene concentration to 2wt% resulted in a further decline of the viscosity to 249mPa.s. This trend continued; as the xylene concentration was increased, the viscosity at a specific temperature reduced. The highest concentration of xylene in this study (5wt%) resulted in a viscosity reduction to 181 mPa.s Also, notice that the viscosities of fluid with varying concentrations of xylene rapidly increased at a temperature below 25 ºC. As the temperature was reduced from 35 ºC to 25 ºC, there was little increase in the viscosities. However, at a temperature below 25 ºC, there was a rapid increase in the fluid viscosity, implying that the WAT had been attained and wax crystals were precipitating and growing.

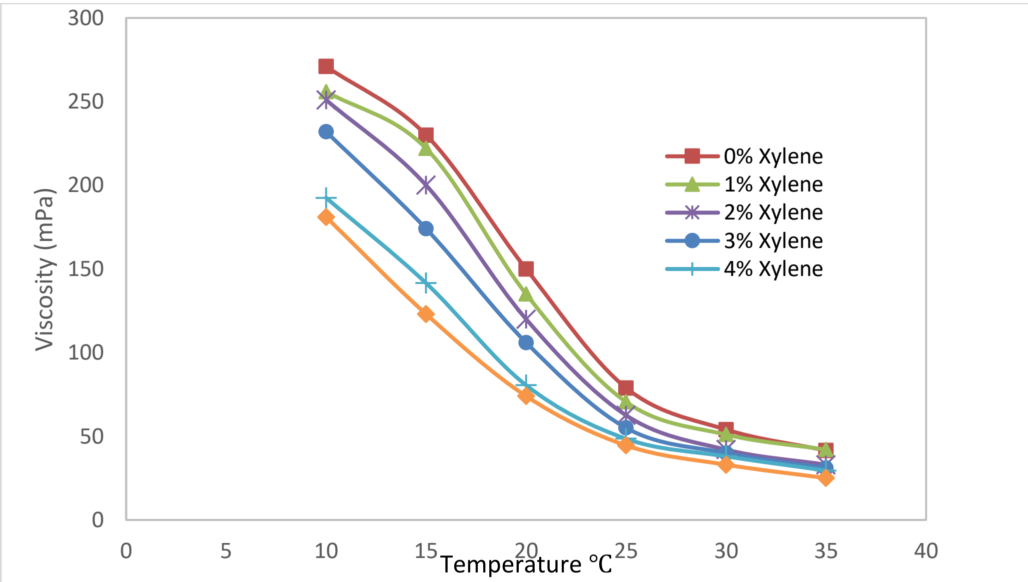

Fig. 2: Plot of viscosity against temperature for different concentrations of xylene

Fig. 3 is the plot of DVR against temperature for the varying concentrations of xylene used in this study. Notice that the highest degree of viscosity reduction occurred at around 20 °C for all the concentrations considered. This is because of the rapid wax precipitation and growth that occurred immediately after the WAT was attained. The best-performing concentration was 5wt% of xylene because it caused the highest DVR in all temperatures considered in this study.

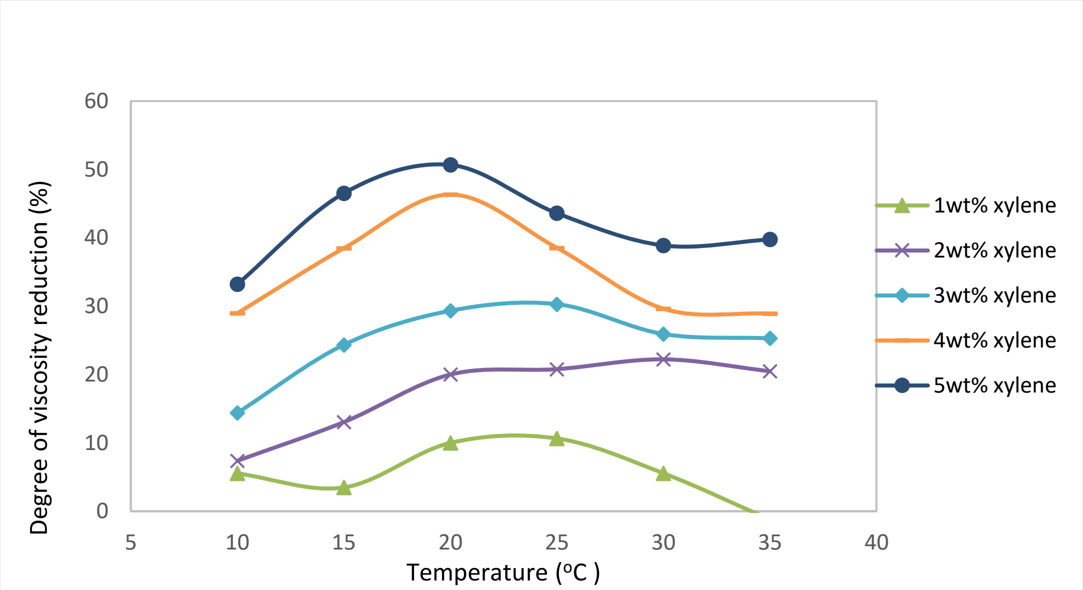

Fig. 3: Plot of DVR against temperature for varying concentrations of xylene

4. Conclusion

The viscosity of the fluid at a fixed temperature reduced with the increase in xylene concentration, implying that xylene was effective at reducing the crude oil viscosity. However, the inflexion in the viscosity-temperature curve suggests that wax precipitation persisted in crude samples containing xylene. When operating at low temperatures, it is suggested that xylene be combined with other chemicals, such as polymers or nanoparticles, to increase its performance in preventing wax gelation.

References

Afdhol, M.K., Abdurrahman, M., Hidayat, F., Chong, F.K. and Mohd-Zaid, H.F. (2019) Review of Solvents Based on Biomass for Mitigation of Wax Paraffin in Indonesian Oilfield *Applied Sciences*, 9, no. 24:5499.

Behbahani, T.J., Beigi, A.A.M., Taheri, Z. and Ghanbari, B. (2015) Investigation of wax precipitation in crude oil: experimental and modelling. Petroleum, 1:223–230.

Deshmukh, S. and Bharambe, D.P. (2012) Wax Dispersant Additives for Improving the Low Temperature Flow Behavior of Waxy Crude Oil. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 34(12): 1121-1129.

García, M., Orea, M., Carbognani, L. and Urbina, A. (2001) The Effect of Paraffinic Fractions on Crude Oil Wax Crystallization. Petroleum Science and Technology, 19(1-2):189-196.

Weidong, L., Qiyu, H., Wenda, W., Yijie, R., Xue, D., Qi, Z. and Hou, L. (2019) Study on Wax Removal During Pipeline-Pigging Operations." *SPE Production & Operation*, 34(2019):216–231.

Odutola, T.O. and Idemili, A. (2020) Effect of poly (ethylene-butene) and nano-aluminium oxide blend on the viscosity of Nigerian crude oil. Journal of Petroleum Exploration and Production Technology volume 10, pages 2531–2539.

Odutola, T.O. and Allaputa, V. (2020) Effect of Aluminum Oxide (Al_20_3) Nanoparticle on the Viscosity of Niger Delta Waxy Crude at Varying Temperatures, International Journal of Scientific & Engineering Research, 11(1):791-794.

Owodunni, O.L. and Ajienka, J.A. (2007) Use of Thermal Insulation to Prevent Hydrate and Paraffin Wax Deposition. Paper SPE-111903-MS presented at the Nigeria Annual International Conference and Exhibition, Abuja, Nigeria, August 2007.

Salam, K.K., Arinkoola, A.O., Oke, E.O. and

Adeleye, J.O. (2014) Optimization of Operating Parameters using Response Surface Methodology for Paraffin-Wax Deposition in Pipeline, Petroleum & Coal 56 (1) 19-28.

Stanko, T., Autry, S. and King, G. (2019) An Investigation into Practical Removal of Downhole Paraffin by Thermal Methods and Chemical Solvents. In Proceedings of the SPE Production & Operations, Olahoma City, OK, USA, 13–14 March 2019.

Taiwo, E., Otolorin, J. and Afolabi, T. (2012) Crude Oil Transportation: Nigerian Niger Delta Waxy Crude, Crude Oil Exploration in the World, Prof. Mohamed Younes (Ed.), ISBN: 978-953-51-0379-0, InTech,