Effects of Asphaltene content of Nigerian Waxy crude oil on Performance of Chemical additives as wax deposition inhibitors

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Abstract - The amount of asphaltene in the crude oil affects its propensity to deposit paraffin wax. The purpose of this study is to determine how the amount of asphaltene in crude oil affects the effectiveness of wax deposition inhibitors (chemical additives) in Nigerian waxy crude. The waxy crude oil samples obtained from the Niger Delta area of Nigeria were analysed using standard methods; ASTM D97 for pour point determination and cold finger test for wax deposition tendency. The wax deposition inhibitors considered were xylene and castor seed oil. The findings of the cold finger test demonstrated that chemical additions significantly decreased the wax deposition tendencies of the crude oil samples. Increasing droplets of xylene and castor seed oil were added to crude oil samples with varied amounts of asphaltene concentration (0.0 ml - 0.15 ml each). According to the results, the specific gravity and pour points of the combination in sample A, which contains 3.4 percent asphaltene, decreased with increasing amounts of the chemical additives. The similar occurrence, albeit less consistently, was seen in sample B with a 5.2 percent asphaltene concentration, suggesting that higher asphaltene content might lessen the negative effects of the wax deposition inhibitors (chemical additives) in the crude oil sample. It could be concluded from the results obtained that content of asphaltene in crude oil has moderate effects on the paraffin inhibition efficiency of the wax inhibitors and minor effects on their performance as pour depressants.

Index Terms— Wax deposition, asphaltene, chemical additive, pour point,

1 INTRODUCTION

THere is sizeable reserve ofparaffiniccrudeoilin NIgeria thatis renowned forits high quality with moderate to high content of paraffinic waxes [1], [2], [3]. Wax molecules often dissolve in crude oil under reservoir conditions because of the intense temperatures and pressures, resulting in a single continuous hydrocarbon liquid phase. Wax crystals may begin to form from this continuous phase while running through pipelines, especially in subsea conditions, as a result of cooling, and consequently the fluid may lose its fluidity characteristic. This shift in flow pattern often begins when the crude temperature drops below the cloud point [4].

It is known that the composition of a crude oil will determine its properties and behavior. Various researchers have investigated the composition of crude oil on their behaviuors. Some researchers applied the wax deposition dynamic model to consider the influence of resin and asphaltene on the deposition mechanism of paraffin in crude oil [5]. Application of the rotary dynamic waxing device to explore the influence of different crude oil composition on the wax deposition of crude oil pipelines was carried out by [6]. Furthermore, the composition of the crude oil may have some impacts on the operations of the chemical additives being used to address various challenges face during crude oil production and transportation. Zhang et al. [7] noted that wax inhibitor which is a pour point depressant could not only affect the crystallization behavior of wax, but also synergistically improve the rheology of oil samples with asphaltenes. The pour point depressant molecules can adsorb on asphaltenes, and then enhance the dispersion stability of asphaltene and improve the flowability of waxy oils [8], [9], [10]. In this study the effects of asphaltene composition of the crude oil on performance of two wax inhibitors were investigated,

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2 MATERIALS AND METHOD

2.1 Materials

The Castor seed oil was purchased from vendors at market in Epe, Lagos State-Nigeriaw whilethe xylene used was an analytical grade product of BDH Chemical Ltd, Poole England. The crude oil samples were obtained through the Department of Petroleum Resources (DPR) now Nigeria Upstream Regulation Commision (NURC) from major oil companies in the Niger Delta region of Nigeria. Coldfinger apparatus described by Akinyemi et al, [3] was used to determine the wax deposition tendency of the crude oil samples.

2.2 Preparation of Crudeoil Sample

In the laboratory, before testing, crude oil samples were reconditioned by heating them to a temperature of around 60°C for over 10 hours, with hand-rocking intermittently throughout heating to remove any possible earlier history. In order to remove all heat and shear histories and provide homogeneous samples for testing, reconditioning the samples to make sure that all pre-crystallized wax was re-dissolved into the oil.

2.3 Determination of Effects of Chemical Additives on Specific Gravity and Pour points of Crude oil Samples

The specific gravity of the crude oil samples doped and doped with the chemical additives were determined using density bottle and digital weighing balance with additives added in 0.1%, 0.2% and 0.3%v/v proportions. The ASTM D-97 standard method was used to determine the pour points of the samples with ASTM-IP pour point test apparatus (Herzog MC 850). The pour point for the pure crude oil samples and oil doped with the chemical additive in 0.1%, 0.2% and 0.3% by volume were determined and recorded.

2.4 Determination of Effects of Chemical Additives on Wax Deposition Tendencies of Crude oil Samples

The wax deposition tendencies of the crude oil samples were determined using the procedure described by Akinyemi et al., [3]. The cold finger test apparatus was filled with 200 ml of the crude oil sample. The bulk crude oil temperature was maintained at a temperature a little above its pour point (25 ^{o}C for both crude oil samples) for each depositional run. To induce temperature gradient in the sample, the cold spot (cold finger) dipped in the bulk crude oil was maintained at 6 ^{o}C in the test procedure for each sample. Magnetic stirrer was used to induce mixing of the sample. The cold finger was removed from the apparatus, after a deposition time of 60 min and the deposit weighed. The procedure was carried out with pure sample of crude oil and subsequently with sample treated the chemical additives in 0.1%, 0.2% and 0.3% by volume proportion with the crude oil. For each of the chemical additive tested, the Paraffin-inhibition efficiency (PIE) was determined by using equation (1).

$$PIE = \frac{M_p - M_c}{M_p} x\ 100 \quad (1)$$

where M_p = mass of paraffin deposition in pure sample, g.
M_c = mass of paraffin deposition in sample with chemical additive, g

3 RESULTS

From the results obtained , the asphaltene content of Sample A was 3.4% while that of sample was 5.2%. Figure 1 showed the effect of the chemical additive on the specific gravity of the crude oil sample A. Both xylene and castor seed oil reduced the specific gravity of the crude oil sample A. However, castor seed oil reduced it slightly more than the xylene chemical additive. The impacts of the two chemical additives on specific gravity of sample B follow the same trend (Figure 2). This behavior is in agreement with the findings of other previous researchers [2]. The higher the concentration of the chemical additive in the crude oil samples the lower the specific gravity within the small range of 0.1% to 0.3%v/v of chemical additives.

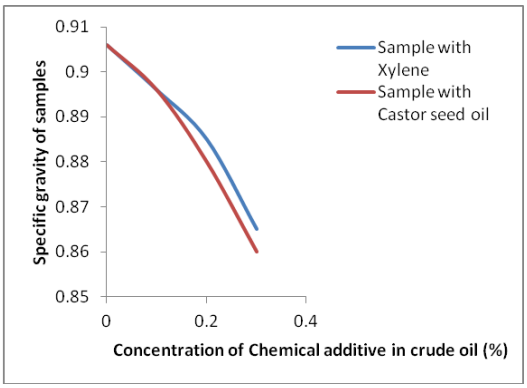

Figure 1 Graph of specific gravity of sample A versus concentration of chemical additive

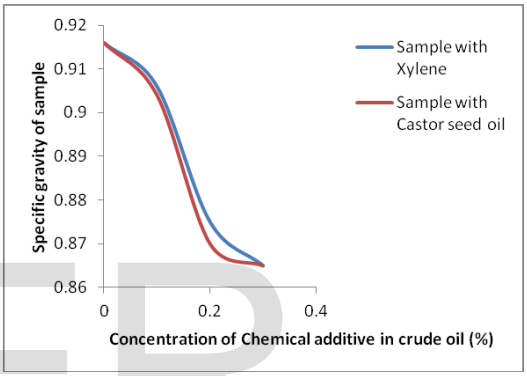

Figure 2 Graph of specific gravity of sample B versus concentration of chemical additive

It was observed that the chemical additives depressed the pour points of the oil samples (Figures 3 and 4). Although the asphaltene contents of the two crude oil samples were different, the chemical additives were still able to depress the pour point in the same trend. Thus, the asphaltene content has minor effects on the performance of the chemical additives as pour points depressants. The castor seed oil depressed the pour point of the two crude oil samples more than xylene at higher concentrations (Figures 3 and 4). This is in agreement with the findings of the previous researchers [2]. This better performance of the castor seed oil than the xylene may be due to better interactions of the castor seed oil molecules with the wax crystals molecules in crude oil samples.

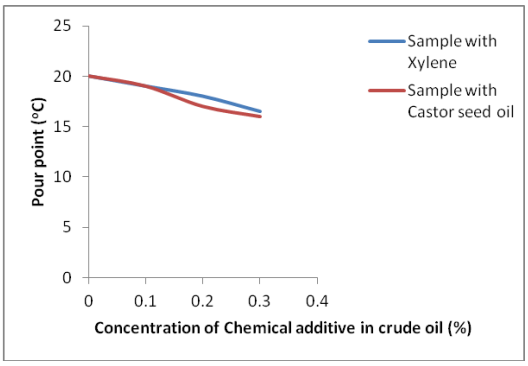

Figure 3 Pour point of the sample A versus Chemical additive concentration

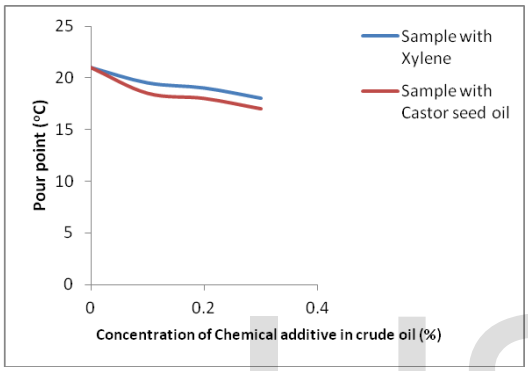

Figure 4 Pour point of the sample B versus Chemical additive concentration

The paraffin inhibition efficiency (PIE) of the chemical additives increased with increase in concentrations of additive in the crude oil samples (Figure 5 and 6). The PIE of xylene on sample B that contain less asphaltene content was higher than sample A which contains higher asphaltene content when concentration of the xylene in the crude oil sample is in appreciable quantity (Figure 5). This may be due to the fact that the chemical additive could be adsorbed onto the surface of aggregated asphaltene particles and the wax particles to form composites, thereby resulting in a significant improvement in the rheology of the waxy crude oil. This is in agreement with the findings of previous researchers [2], [11].

It was further observed that the castor seed oil has higher paraffin inhibition ability and the xylene for both crude oil samples (Figure 5 and 6). This may be as a result of the presence of the ricinoleic molecules in the castor seed oil which could interact with the wax molecules more than the xylene molecules. This is in agreement with the findings of the previous researchers [2].

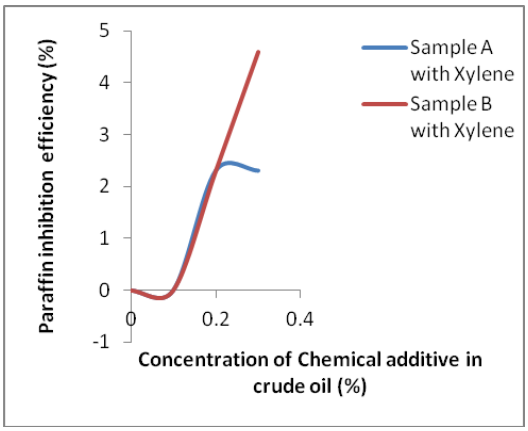

Figure 5 Paraffin inhibition efficiency of the xylene on crude oil samples A and B

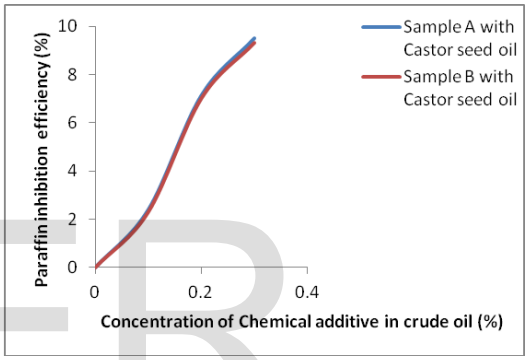

Figure 6 Paraffin inhibition efficiency of the castor seed oil on crude oil samples A and B

4 CONCLUSION

Impacts of presence of asphaltene on the performance of wax deposition inhibitors on waxy crude oil was investigated in this study using two different crude oil samples obtained from Niger Delta region of Nigeria. It could be concluded from the results obtained that content of asphaltene in crude oil has moderate effects on the paraffin inhibition efficiency of the wax inhibitors. The higher the asphaltene content the higher the performance of the inhibitors. Thus, the presence of asphaltene somehow, enhance the performance of the wax deposition inhibitors with respect to inhibition of wax deposition.

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