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Research Paper

Wax Deposition Effect on Concentration for Corrosion of Crude Oil Pipeline

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Abstract: *-This study aims to investigate wax deposition effect on concentration for corrosion of crude oil pipeline. Heavy paraffin deposits are unfavorable because they reduce the effective size of flow conduits and reduce the well's rate of production. When large amounts of paraffin are deposited, they must be removed mechanically, thermally, or otherwise, resulting in costly downtime and greater operating costs. Corrosion rate against time was conducted, to determine the effect of the paraffin wax deposit on corrosion of crude oil pipeline, the results of the corrosion rate were recorded and analyzed, the experiment was terminated by stopping the pump. The procedure is performed for concentration effect. The experiment was conducted by varying the time (3, 6, 9, 12, 15 and 18 minutes) at different temperature of (15, 20, 25, 30 and 35 °C), and flow rate (10.21, 20.37, 30.45, 40.28 and 50.70 L/min). It was observed at time 18 minutes with flow rate of 10.21 L/min. A significant reduction in corrosion rates and excellent corrosion protection was achieved at temperature of 15°C, while others gave only moderate or negligible protection to the crude oil pipeline. However, it can be deduced that the long chain paraffin layer was physically removed from the surface during periods of elevated flow rate or temperature, resulting in the loss of the majority of the corrosion protection.*

Keywords – *concentration, wax, deposition, crude oil, corrosion meter*

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I. INTRODUCTION

Paraffin wax deposition is a complex process that is one of the primary unsolved difficulties in Flow Assurance in pipelines and manufacturing equipment. In oil and gas transport processes pipelines play an important role in industry. When the temperature of the producing stream dips during normal flow, gas lifting, or pumping, paraffins precipitate and cling to the liner, tubing, sucker rods, and surface equipment (Gjermundsen, 2016). Heavy paraffin deposits are unfavorable because they reduce the effective size of flow conduits and reduce the well's rate of production. When large amounts of paraffin are deposited, they must be removed mechanically, thermally, or otherwise, resulting in costly downtime and greater operating costs. Procedures to remove waxy deposits from production tubes, as well as squeezing treatments to avoid wax deposition, have high operating costs. The costs are further inflated by the potential for formation damage and production loss as a result of these treatments. Paraffin deposits can be found in wellbores, production tubing, and flowlines. Under some circumstances, paraffin deposition can occur in the producing formation. These deposits generate problems due to limited flow, which causes increased flowline pressure, lower production, and mechanical issues (Gjermundsen, 2016).

There are a few phenomena - such as corrosion, scale and wax deposition or clathrate hydrate formation- which reduce the efficiency of these processes. In that, great portion is due to internal corrosion and wax deposition in transportation utilities. Moreover, CO_2 corrosion can cause damage in the pipeline material by deteriorating the pipelines material. Many experiments have been conducted individually on finding the factors that cause corrosion and factors causing wax precipitation. Only a few research relating both the problems together. There is not much research work that studies the relationship between paraffin wax deposition and corrosion behavior. Though paraffin wax restricts the flow in the pipeline, it acts as a corrosion inhibitor by covering the inner wall of pipeline. Paraffin wax and CO_2 corrosion have caused many problems in oil and gas industry (Gjermundsen, 2016). These problems mainly caused in the transportation and utilities where the pipelines are severely corroded. The paraffin wax on the surface provides excellent corrosion protection, while others provided only moderate or negligible protection in the crude oil pipeline, but most of the corrosion protection has been lost due to the long chain paraffin layer being physically removed from the surface during the periods of increased temperature or increased flow rates. The protection of paraffins can be assumed to be due to physisorption caused by relatively weak intermolecular forces such as van der Waals forces (Gjermundsen, 2016). Despite the lack of surface chemical activity, at low temperatures-below the so called wax appearance temperature (WAT), paraffins can precipitate and deposit on the pipe surface. When the wax layer covers the steel surface, it can slow down corrosion processes by hindering the diffusion of corrosive species to the surface. However, if the temperature stays below the WAT for extended period of time, the wax layer becomes thicker with time, and can, in the long run, cause partial or total blockage of the pipe. It was found that crude oils can generate corrosion inhibition, but the extent of inhibition varied from one crude oil to another.

Another issue that the oil and gas industry is grappling with is corrosion in steel pipes. Because of the heterogeneous nature of the bulk material and its surface, corrosion is an electrochemical reaction that occurs when anode and cathode sites arise on a material's surface. An electrolyte as well as an electrical connection are required for electrochemical corrosion.

Corrosion of carbon steels in the oil industry is caused by the presence of dissolved carbon dioxide CO_2 (sweet corrosion), hydrogen sulfide H_2S (sour corrosion), oxygen, and sodium chloride dissolved in water injections, as well as the usage of acids during the acidizing of oil and gas wells. (Villamizar *et al.,* 2017; Rodriguez-valdez *et al.,* 2019). When materials are acidified with acid solutions in pickling operations, during industrial acid cleaning, in various aqueous electrolyte storage tanks, in boilers, and when rust, scale, and corrosion products are eliminated, corrosion occurs in a variety of industries. (Lebrini *et al.,* 2017; Shein and Denisva, 2016; Bentiss *et al.,* 2018; Morad and Kamal, 2016). The most frequent method of mitigating internal-wall corrosion in industrial buildings is corrosion inhibition (pipelines, tanks, reactors, etc). Organic compounds containing nitrogen, sulfur, and/or oxygen atoms make up the majority of well-known corrosion inhibitors (Alsabagh *et al.,* 2015; Deyab, 2017). Surface adsorption of these molecules and the creation of a protective (blocking) surface layer that prevents the corrosive electrolyte from reaching the surface are the primary mechanisms by which these inhibitors provide corrosion prevention. SAMs on metal surfaces are of special interest since non-structured (amorphous) adsorbed layers have been found to have greater protection and tailoring (functionalization) qualities. Corrosion inhibitors have become more widely employed and improved throughout time. Individual tests have been carried out to determine the elements that produce corrosion and wax deposition. There have been countless studies on how to avoid specific difficulties, but there has been relatively little research on the probable synergism/competition between different processes. On the other hand, such participation can be crucial. Wax deposits, on the other hand, can help to prevent corrosion by forming wax layers on the interior pipeline surface, which prevent corrosive water from reaching the surface and thereby minimizing metal loss due to corrosion. Waxy crudes have different properties depending on where they're found.

II. MATERIALS AND METHODS

- **MATERIALS**

An experimental flow loop system was designed and fabricated which can give a better scenario of crude oil pipeline and accurate result to investigate the effect of concentration on corrosion of crude oil pipeline. The flow-loop was built in form of a water fountain with 1" steel pipe. Two cylindrical open stainless-steel reservoir (waxy crude oil reservoir 1 and return reservoir 2), 6 Litre stainless steel reservoirs with (internal diameter = 0.152m; Height = 0.33m), with a 0.5hp pump for recirculating the waxy crude oil. A flow meter with a temperature probe, ball valves for regulating the flow of the fluid and handheld infrared thermometer for temperature measurement. A straight stainless-steel pipe with (0.0266m x 0.0133m (internal diameter and inside radius) x 0.0334m x 0.0167m (outer diameter and outside radius) x 2.007m x 0.0034m (pipe length and thickness) and MS1000 Corrosion Meter were used in this study. The materials and equipment used in the experiment are shown below

Plate 3.1: Samples of waxy crude oil

Plate 3.2: MS1000 LPR corrosion meter connected with the probe

Plate 3.3: Complete experimental flow loop setup.

METHODS

The experimental methodology used in achieving this study are properly stated below.

Waxy crude oil laboratory flow loop system was design and fabricated to carry out series of experiment. The experimental flow loop can give a better scenario of crude oil pipeline and accurate result to investigate the effect of concentration on wax deposit on corrosion rate in mils per year (mpy) against time in minutes on crude oil pipeline. The crude oil used in this study is one of the oilfields pipelines with waxing problems of Shell Petroleum Development Company in Niger Delta and was procured from Agbada 1 flow station in Ikwerre Local Government Area Rivers State. The characterization of the waxy crude was investigated to determine the Wax Physical Properties and Operating Conditions. Characterizations of waxy crude were performed in consonance with the requirement of ASTM D5442-17 (2021). The ASTM is a standard testing method for petroleum waxes. The experimental program included variables that affect wax deposition process. The variables studied experimentally were effect of concentration between mixture and pipe wall. The corrosion rate in mil per year (mpy) against time (min) of the wax deposit on crude oil pipeline were tested using MS1000 Corrosion Meter. The results were recorded and analyzed.

III. DEVELOPMENT OF FLOW LOOP

In this design, the flow loop is made up to two waxy fluid reservoirs (The Oil and Return reservoir). Figure 3.1 shows the schematic diagram of the experimental flow loop. Two hole was drilled on the bottom of the 6 Litre receiving oil reservoirs. The flow loop has two holes at the bottom, one is to enable the entrance of the feed to oil receiving reservoir which operate in form of a water fountain, another was for recycling the fluid back to oil reservoir to the pump, flow meter was connected to the fountain pipe to measure the flow rate of the fluid and a ball valve was also connected to the return pipe connected to the return reservoir to regulate the flow of the waxy crude oil. A 0.33 x 0.0266m (L x ID) stainless steel pipe was welded to the hole on the side of the oil reservoir and connected to a stainless steel 1" nipple and socket joint with stainless steel pipe threaded at both ends which was screwed into a socket along with 0.127 x 0.0266m (L x ID) stainless steel pipe leading to the inlet of a centrifugal pump. A threaded pipe 1.041 x 0.0266m (L x ID) was connected into the pump and 1" union was connected to the threaded pipe 0.0508 x 0.0266m which was in turn connected to a 90° stainless steel elbow to a threaded pipe with 0.17 x 0.0266m (L x ID) and the other connected to a flow meter which was fixed to another union joint together to a threaded pipe 0.13 x 0.0266m (L x ID) to a 90° stainless steel elbow to a 1" nipple joint which is welded to a socket connected to a threaded discharge oil fountain pipe to the reservoir while a socket was welded to the bottom of the return reservoir connected to a threaded pipe with 0.3m x 0.0266m (L x ID) connected to a stainless steel valve which was connected to a 90° stainless steel elbow connected to the threaded pipe with 0.24 x 0.0266m (L x ID) while a socket was welded on top of the oil reservoir connected to the nipple which in turn connected to a 90° stainless steel elbow that discharge the wax sample to the oil reservoir. The oil reservoir also has an outlet drain connected with a ball valve used for discharging of the waxy crude oil.

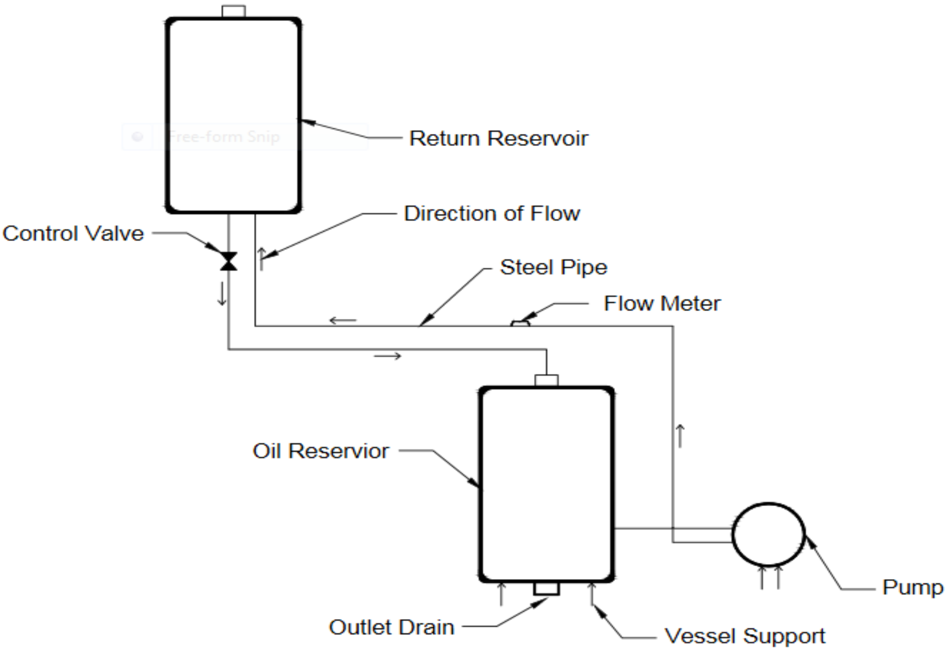

Figure 2.1: Schematic Diagram of the Experimental Laboratory Flow Loop

- **EXPERIMENTAL PROCEDURE**

The experiment was setup and performed in the Materials Laboratory of the Department of Mechanical Engineering at University of Port Harcourt, Choba. The experimental studies were carried out to determine the effect of wax deposition on corrosion of crude oil pipeline by investigating the effect of concentration between the waxy crude oil and pipe wall at varying time, temperature and flow rate. The procedure of the experiments is as follows, the flow loop was assembled and 6L waxy crude was poured into the receiving reservoir and the pump was turned on. The deposition process was commenced by circulating the waxy crude oil in the flow loop system and the valve was adjusted which was connected to the return pipe to achieve the desired flow rate. The waxy crude was pumped into the the steel pipe at constant flow rate. The experiment was conducted using flow meter with a temperature probe which were used to regulate the temperature and the flow meter measures flow rate between the range of 1-60L/min. The range of the inlet temperature of the waxy crude oil were varied between (10-40ºC). The waxy crude flow from oil reservoir connected to the pump through the section pipe, and discharge pipe connected to the pump transfer the fluid to the fountain pipe connected under to the receiving reservoir, and the fountain pipe discharges the fluid which passes through the return pipe back to oil reservoir.

The waxy crude oil forms an impingement in the bottom of the oil reservoir which effect lead to precipitation and deposition of wax samples at the bottom of the oil reservoir and the corrosion rate with time were tested using MS1000 Corrosion Meter as the waxy crude oil flow into the oil reservoir by inserting the Linear Polarization Resistance (LPR) meter probe into the waxy oil reservoir, making sure that the probe touched the steel pipe and waxy crude oil in order to test for the corrosion rate in mils per year (mpy) against time in minutes. The corrosion testing started by pressing the LPR button " ON" to turn it on. Next, the "COR" button was then pressed to measure instantaneous corrosion rate. After approximately 60 seconds, a short beep sounds to indicate that the measurement is complete, the measured corrosion rate is shifted to the screen and the value is saved. Corrosion rate against time was conducted, to determine the effect of the paraffin wax deposit on corrosion of crude oil pipeline, the results of the corrosion rate were recorded and analyzed, the experiment was terminated by stopping the pump. The procedure is performed for concentration effect. The experiment was conducted by varying temperature of (15, 20, 25, 30 and 35 ºC), time (3, 6, 9, 12, 15 and 18 minutes) and flow rate (10.21, 20.37, 30.45, 40.28 and 50.70 L/min). The results were recorded, the graph of corrosion rate (mpy) against time (min) was plotted and the result analyzed.

IV. RESULTS AND DISCUSSION

Table shows the results of Concentration Effect on Wax Deposition on Corrosion of Crude Oil Pipeline

Table 1: Effect of Concentration at 10.21 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

Time (min)	Corrosion Rate (mpy) @15°C	Corrosion Rate (mpy) @ 20°C	Corrosion Rate (mpy) @ 25°C	Corrosion Rate (mpy) @ 30°C	Corrosion Rate (mpy) @ 35°C
3	0.68	0.82	0.57	0.71	0.92
6	0.82	0.93	0.66	0.85	0.78
9	0.54	0.74	0.85	0.63	0.67
12	0.61	0.57	0.62	0.48	0.56
15	0.35	0.25	0.46	0.53	0.88
18	0.15	0.19	0.32	0.65	0.42

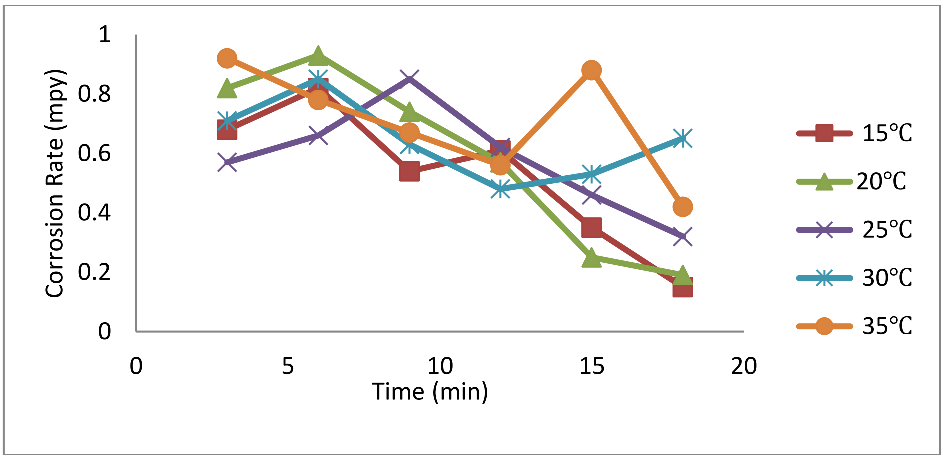

Figure 1: Graph of the Effect of Concentration at 10.21 L/min on Corrosion Rate (mpy against Time (min) on Wax Deposition

Table 2: Effect of Concentration at 20.34 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

Time (min)	Corrosion Rate (mpy) @15°C	Corrosion Rate (mpy) @ 20°C	Corrosion Rate (mpy) @ 25°C	Corrosion Rate (mpy) @ 30°C	Corrosion Rate (mpy) @ 35°C
3	0.88	0.92	0.78	0.65	0.74
6	0.66	0.75	0.67	0.72	0.52
9	0.74	0.83	0.73	0.55	0.67
12	0.59	0.62	0.81	0.69	0.75
15	0.16	0.41	0.32	0.52	0.38
18	0.36	0.29	0.45	0.36	0.56

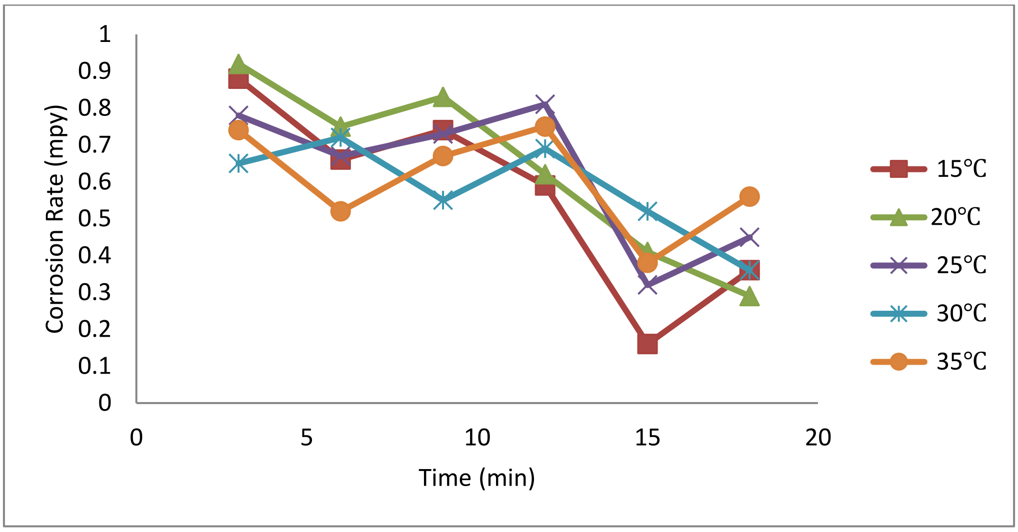

Figure 2: Graph of the Effect of Concentration at 20.34 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

Time (min)	Corrosion Rate (mpy) @15ºC	Corrosion Rate (mpy) @ 20ºC	Corrosion Rate (mpy) @ 25ºC	Corrosion Rate (mpy) @ 30ºC	Corrosion Rate (mpy) @ 35ºC
3	0.98	0.78	0.94	0.86	0.89
6	0.76	0.88	0.67	0.79	0.65
9	0.91	0.73	0.82	0.65	0.81
12	0.65	0.54	0.71	0.66	0.57
15	0.33	0.24	0.69	0.48	0.64
18	0.42	0.21	0.51	0.36	0.43

Table 3: Effect of Concentration at 30.45 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

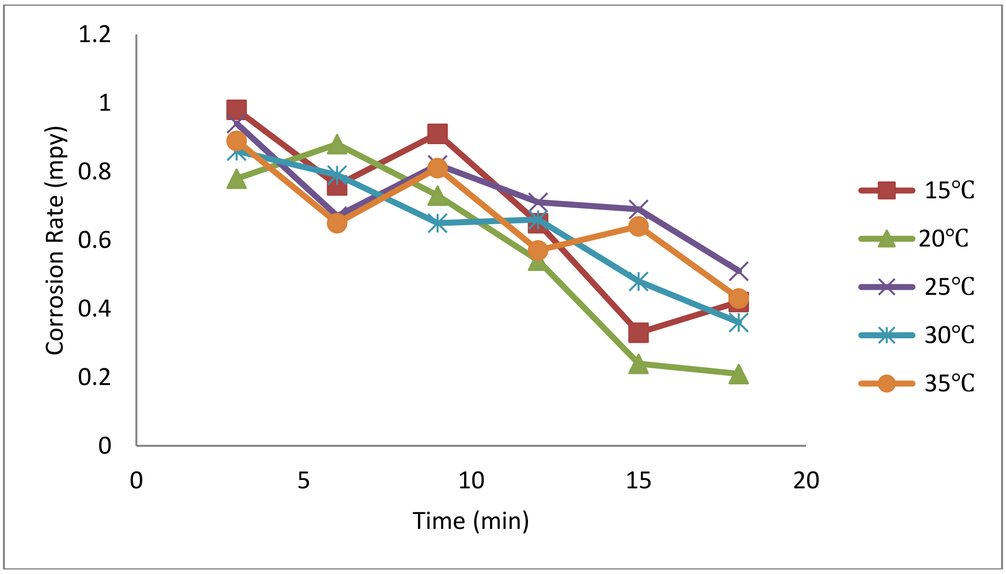

Figure 3: Graph of Effect of Concentration at 30.45 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

Time (min)	Corrosion Rate (mpy) @15ºC	Corrosion Rate (mpy) @ 20ºC	Corrosion Rate (mpy) @ 25ºC	Corrosion Rate (mpy) @ 30ºC	Corrosion Rate (mpy) @ 35ºC
3	0.88	0.68	0.89	0.98	0.77
6	0.95	0.56	0.73	0.62	0.91

9	0.66	0.75	0.58	0.86	0.75
12	0.71	0.64	0.81	0.69	0.72
15	0.42	0.35	0.67	0.74	0.54
18	0.26	0.51	0.46	0.63	0.45

Table 4: Effect of Concentration at 40.28 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

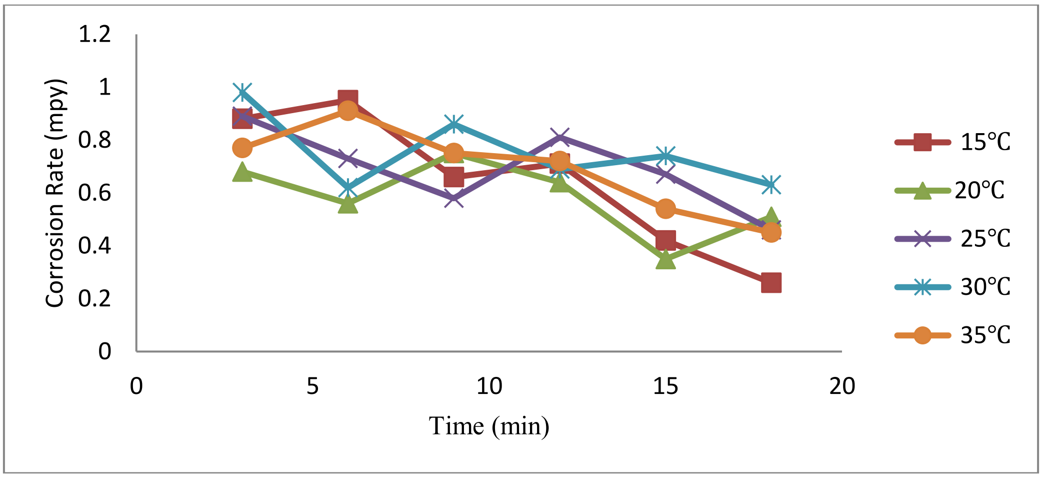

Figure 4: Graph of the Effect of Concentration at 40.28 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition.

Table 5: Effect of Concentration at 50.70 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

Time (min)	Corrosion Rate (mpy) @15°C	Corrosion Rate (mpy) @ 20°C	Corrosion Rate (mpy) @ 25°C	Corrosion Rate (mpy) @ 30°C	Corrosion Rate (mpy) @ 35°C
3	0.79	0.86	0.75	0.69	0.93
6	0.82	0.53	0.66	0.82	0.71
9	0.57	0.61	0.49	0.65	0.59
12	0.68	0.72	0.57	0.78	0.38
15	0.44	0.48	0.77	0.51	0.64
18	0.52	0.31	0.25	0.45	0.87

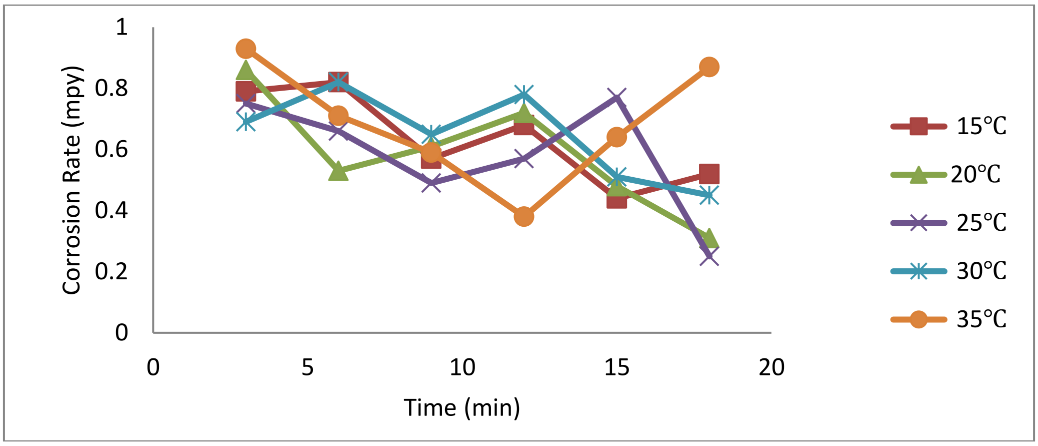

Figure 5; Graph of Effect of Concentration at 50.70 L/min on Corrosion Rate (mpy) against Time (min) on Wax Deposition

The graph of effect of concentration on corrosion rate against time at different temperature of wax deposition during the corrosion inhibition.

Based on the results of table 1 at temperature of 15°C for 18 minutes at 10.21 L/min for the effect of concentration on corrosion rate against time at different temperature of wax deposition during the corrosion inhibition, a significant reduction in corrosion rates and excellent corrosion protection was achieved, while others gave only moderate or negligible protection to the crude oil pipeline.

It was observed that at time 3 min and at temperature of 15°C, the corrosion rate is 0.68mpy and 0.82 mpy at 20°C at the same time, 0.57 mpy at the same time and temperature of 25°C, 0.71 mpy at temperature of 30 °C, and 0.92mpy at temperature of 35 °C. At time 6 min and temperature of 15 °C, 20 °C, 25 °C, 30 °C and 35 °C, the corrosion rate was 0.82 mpy, 0.93 mpy, 0.66 mpy, 0.85 mpy and 0.78 mpy respectively. At time 9 min corrosion rate was 0.54 mpy, 0.74 mpy, 0.85 mpy, 0.63 mpy and 0.67 mpy in the order of the temperature respectively. At time 12 min in the order of the temperature was 0.61 mpy, 0.57 mpy, 0.62 mpy, 0.48 mpy and 0.56 mpy respectively. At time 15 min corrosion rate were 0.35 mpy, 0.25 mpy, 0.46 mpy, 0.53 mpy and 0.88 mpy in the order of the temperature respectively and at 18 min the corrosion rate was 0.15 mpy, 0.19 mpy, 0.32 mpy, 0.65 mpy and 0.42 mpy respectively.

Based on the results of table 2 at temperature of 15°C for 15 minutes at 20.34 L/min for the effect of concentration on corrosion rate against time at different temperature of wax deposition during the corrosion inhibition, a significant reduction in corrosion rates and excellent corrosion protection was achieved while others gave only moderate or negligible protection to the crude oil pipeline. It was observed that at time 3 min and at temperature of 15°C, the corrosion rate is 0.88mpy and 0.92 mpy at 20°C at the same time, 0.78 mpy at the same time and temperature of 25°C, 0.65 mpy at temperature of 30 °C, and 0.74mpy at temperature of 35 °C. At time 6 min and temperature of 15 °C, 20 °C, 25 °C, 30 °C, and 35 °C, the corrosion rate were 0.66 mpy, 0.75 mpy, 0.67 mpy, 0.72 mpy, and 0.52 mpy respectively. At time 9 min corrosion rate were 0.74 mpy, 0.83 mpy, 0.73 mpy, 0.55 mpy, and 0.67 mpy in the order of the temperature respectively. At time 12 min in the order of the temperature were 0.59 mpy, 0.62 mpy, 0.81 mpy, 0.69 mpy, and 0.75 mpy respectively. At time 15 min corrosion rate were 0.16 mpy, 0.41 mpy, 0.32 mpy, 0.52 mpy, and 0.38 mpy in the order of the temperature respectively and at 18 min the corrosion rate was 0.36 mpy, 0.29 mpy, 0.45 mpy, 0.36 mpy, and 0.56 mpy respectively.

Based on the results of table 3 at temperature of 20 °C for 18 minutes at 30.45 L/min for the effect of concentration on corrosion rate against time at different temperature of wax deposition during the corrosion inhibition, a significant reduction in corrosion rates and excellent corrosion protection was achieved while others gave only moderate or negligible protection to the crude oil pipeline. It was observed that at time 3 min and at temperature of 15°C, the corrosion rate is 0.98mpy and 0.78 mpy at 20°C at the same time, 0.94 mpy at the same time and temperature of 25°C, 0.86 mpy at temperature of 30 °C, and 0.89mpy at temperature of 35 °C. At time 6 min and temperature of 15 °C, 20 °C, 25 °C, 30 °C, and 35 °C, the corrosion rate was 0.76 mpy, 0.88 mpy, 0.67 mpy, 0.79 mpy, and 0.65 mpy respectively. At time 9 min corrosion rate were 0.91 mpy, 0.73 mpy, 0.82 mpy, 0.65 mpy, and 0.81 mpy in the order of the temperature respectively. At time 12 min in the order of the temperature were 0.65 mpy, 0.54 mpy, 0.71 mpy, 0.66 mpy, and 0.57 mpy respectively. At time 15 min corrosion rate were 0.33 mpy, 0.24 mpy, 0.69 mpy, 0.48 mpy, and 0.64 mpy in the order of the temperature respectively and at 18 min the corrosion rate was 0.42 mpy, 0.21 mpy, 0.51 mpy, 0.36 mpy, and 0.43 mpy respectively.

Based on the results of table 4 at temperature of 15 °C for 18 minutes at 40.28 L/min for the effect of concentration on corrosion rate against time at different temperature of wax deposition during the corrosion inhibition, a significant reduction in corrosion rates and excellent corrosion protection was achieved while others gave only moderate or negligible protection to the crude oil pipeline. It was observed that at time 3 min and at temperature of 15ºC, the corrosion rate is 0.88mpy and 0.68 mpy at 20ºC at the same time, 0.89 mpy at the same time and temperature of 25ºC, 0.98 mpy at temperature of 30 ºC, and 0.77mpy at temperature of 35 ºC. At time 6 min and temperature of 15 ºC, 20 ºC, 25 ºC, 30 ºC, and 35 ºC, the corrosion rate was 0.95 mpy, 0.56 mpy, 0.73 mpy, 0.62 mpy, and 0.91 mpy respectively. At time 9 min corrosion rate were 0.66 mpy, 0.75 mpy, 0.58 mpy, 0.86 mpy, and 0.75 mpy in the order of the temperature respectively. At time 12 min in the order of the temperature were 0.71 mpy, 0.64 mpy, 0.81 mpy, 0.69 mpy, and 0.72 mpy respectively. At time 15 min corrosion rate were 0.42 mpy, 0.35 mpy, 0.67 mpy, 0.74 mpy, and 0.54 mpy in the order of the temperature respectively and at 18 min the corrosion rate were 0.26 mpy, 0.51 mpy, 0.46 mpy, 0.63 mpy, and 0.45 mpy respectively.

Based on the results of table 5 at temperature of 25 ºC for 18 minutes at 50.70 L/min for the effect of concentration on corrosion rate against time at different temperature of wax deposition during the corrosion inhibition, a significant reduction in corrosion rates and excellent corrosion protection was achieved while others gave only moderate or negligible protection to the crude oil pipeline. It was observed that at time 3 min and at temperature of 15ºC, the corrosion rate is 0.79mpy and 0.86 mpy at 20ºC at the same time, 0.75 mpy at the same time and temperature of 25ºC, 0.69 mpy at temperature of 30 ºC, and 0.93mpy at temperature of 35 ºC. At time 6 min and temperature of 15 ºC, 20 ºC, 25 ºC, 30 ºC, and 35 ºC, the corrosion rate was 0.82 mpy, 0.53 mpy, 0.66 mpy, 0.82 mpy, and 0.71 mpy respectively. At time 9 min corrosion rate were 0.57 mpy, 0.61 mpy, 0.49 mpy, 0.65 mpy, and 0.59 mpy in the order of the temperature respectively. At time 12 min in the order of the temperature were 0.68 mpy, 0.72 mpy, 0.57 mpy, 0.78 mpy, and 0.38 mpy respectively. At time 15 min corrosion rate were 0.44 mpy, 0.48 mpy, 0.77 mpy, 0.51 mpy, and 0.64 mpy in the order of the temperature respectively and at 18 min the corrosion rate was 0.52 mpy, 0.31 mpy, 0.25 mpy, 0.45 mpy, and 0.87 mpy respectively.

V. CONCLUSION

Corrosion inhibition can be produced by crude oils, albeit the degree of inhibition varies from one crude oil to the next. The effect of paraffin wax on steel corrosion could provide more insight into how to keep CO_2 from corroding steel pipelines. Paraffin wax is one of the most common components in crude oil. By depositing or forming wax on the inside surface of the pipeline, paraffin wax can limit corrosion and reduce corrosion. Wax deposition is caused by a variety of factors, including temperature, flow rate, and concentration. Paraffin wax coatings can provide significant corrosion protection at temperatures below the Wax Appearance Temperature. However, they should not be relied upon for corrosion protection because van der Waals interactions weaken their contacts with the metal surface, and they can be eliminated with heat and/or shear, potentially resulting in a localized attack on the steel surface. In the paraffin industry, heavy paraffin deposits are undesirable because they reduce the effective size of flow conduits and limit the well's output rate. When a wax layer is applied to a steel surface, it slows corrosion by preventing corrosive species from diffusing to the surface. By coating the inner wall of the pipeline with paraffin wax, it works as a corrosion inhibitor while also restricting flow. The paraffin wax on the surface of the crude oil pipeline provides good corrosion protection, whilst others only give poor or no protection. The protection provided by paraffin is assumed to be due to physisorption, which is caused by weak intermolecular interactions such as van der Waals forces. Despite the lack of surface chemical activity, paraffin can form on the pipe surface at low temperatures, below the so-called wax appearance temperature. When the wax layer covers the steel surface, it can slow down corrosion by preventing corrosive species from diffusing to the surface. If the temperature remains below the WAT for an extended length of time, the wax layer thickens, potentially obstructing part or all of the pipe.

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