

Study on Emulsification Tendency of Hydrate and Corrosion Inhibitors on Water-Hydrocarbon Mixture in Gas Pipelines

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Abstract

In gas production process, it is probable that gas condensation happens during fluid transmission from sea-platform to onshore because of fluid temperature decrease on the seabed. Although the presence of water mixed with hydrocarbon through pipelines motivate the formation of emulsion, parameters such as operational temperature or presence of chemical with surfactant based may intensify stability of emulsion resulting in difficulties for water-hydrocarbon separation process at the onshore. In this study, emulsification tendency of two commercial chemicals representatives of hydrate and corrosion inhibitor is investigated at two different operating temperatures. It is observed that water/hydrocarbon in the presence of KHI alone did not form emulsion phase while CI presence resulted in stable emulsion. The simultaneous presence of KHI and CI made the emulsion phase less stable and the efficiency of separation higher than the presence of CI alone.

Keywords: Emulsion stability; Gas condensate; Kinetic hydrate inhibitor; Corrosion inhibitor.

1. Introduction

Emulsion is a non-homogenous system containing mixture of two or more immiscible liquids that one phase is dispersed through the other [1]. For water-hydrocarbon emulsion formations generally (A) two immiscible water and hydrocarbon phases are in contact with each other, (B) surface agent chemicals are present as emulsifier and (C) proper mixing for phase dispersion is applied [2]. In chemical structure of the emulsifiers, there is a hydrophile group with polar function to be absorbed by water molecules and a hydrophobic group with a non-polar relatively long hydrocarbon chain to be absorbed by hydrocarbon molecules [3].

Since there are natural emulsifiers in crude oil such as resins and asphaltenes, main portion of water along with crude oil form stable w/o emulsion [4]. If there are chemicals with characteristic of emulsifying in gas production wells and then pipelines, it is expected emulsion be formed due to high mixing of two immiscible liquid phases [1].

Chemical treatment, having a critical place in deep-water flow assurance, requires special attention in monitoring the probable side effects on down-stream processes. Various chemical inhibitors are injected to gas pipeline preventing solid formation such as hydrate plugs or corrosion; therefore, it is necessary to study the effect of these chemicals on immiscible liquid phases interactions and water-hydrocarbon emulsion stability [1, 5].

Stable emulsion may reduce chemical inhibitors performance and on the other hand these inhibitors may play the role of emulsifier producing difficulties for water-hydrocarbon separation process at waste water treatment unit. In this work, probable effect of kinetic hydrate inhibitor and corrosion inhibitor is investigated on stability of water-hydrocarbon emulsion.

2. Experimental

2.1. Materials and apparatus

Kinetic hydrate inhibitor (KHI) and corrosion inhibitor (CI) was commercially supplied. Distilled water was used in preparation of aqueous solutions. liquid gas condensate was supplied from south pars gas field. The experimental apparatus was consisting of a 100-mL jacketed glass container, a jacketed graduated decanter, a water bath and a high speed homogenizer.

2.2. Method

Characteristic of experimental runs was shown in Table 1. First, aqueous solutions were prepared as Table 1. Then, 10 mL of aqueous solution with 60 mL of the gas condensate liquid were loaded in jacketed glass container. Stirrer was switched on (10000 rpm) for 30 seconds and then switched off for 5 minutes. This was repeated four times to obtain suitable mixing of two immiscible liquid phase. The container temperature was kept constant during the stirring. The whole of Liquid phases were transferred to a jacketed graduated decanter to measuring volume separation of phases at constant temperature. Finally, separation of aqueous phase from hydrocarbon phase was investigated based on the separated volume of each phase over 24 hours.

Table 1. Characteristic of experimental runs

Runs	Temperature (°C)	KHI (wt%)	CI (wt%)
1	12	2	0
2	12	0	0.5
3	12	2	2
4	70	2	0
5	70	0	0.5
6	70	2	2

3. Results and discussion

Here, maximum and minimum temperatures are considered due to the temperature profile of the fluid flow in the gas/condensate sea-pipelines of south pars gas filed. Maximum temperature was observed on the three phase separator on the sea-platform of about 70°C while the minimum one is considered as the worst case temperature of sea bed of about 12°C. moreover, the water to gas condensate ratio used in the experiments was taken based on the ratio reported for south pars gas pipelines.

Table 2 shows the picture of the fluid (two immiscible aqueous and hydrocarbon phases) before and after stirring at constant temperature. As shown in Table 2, due to mixing of two immiscible aqueous and hydrocarbon phases, no emulsion was observed in the presence of KHI. In contrary of the presence of just CI, the aqueous phase was converted to emulsion completely. In simultaneous presence of CI and KHI, it was also observed emulsion formation, regardless of the temperature.

Tables 3 and 4 were illustrated the pictures of phase separation in the presence of CI and KHI during time at constant temperature of 12 and 70 °C, respectively. In Tables 3 and 4, the effect of CI and KHI presence on the phase separation were qualitatively monitored.

Table 5 were given amount of phase volume changes in the presence of CI and KHI during time at constant temperature of 12 and 70°C.

In the presence of KHI (run 1), it was observed that although two phases of aqueous and hydrocarbon was immediately separated about 99%, hydrocarbon phase was opaque indicating remained water droplets in the hydrocarbon bulk. However, hydrocarbon phase was stripped from water getting transparent over time (during 24 hours).

Table 2. Quality of liquid fluid before and after stirring at constant temperature

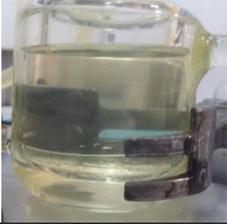
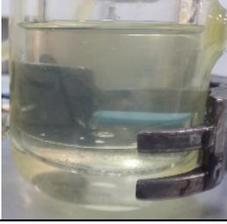
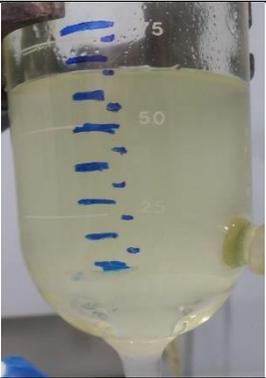
Runs	At 12 °C		At 70 °C	
	Before stirring	After stirring	Before stirring	After stirring
KHI				
CI				
KHI+CI				

Table 3. Picture of phases quality vs. time at 12°C

Runs	At 12°C		
	0 hour	5 hours	24 hours
1 (KHI)			
2 (CI)			

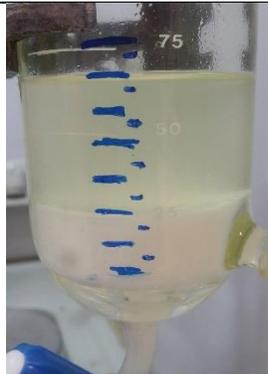
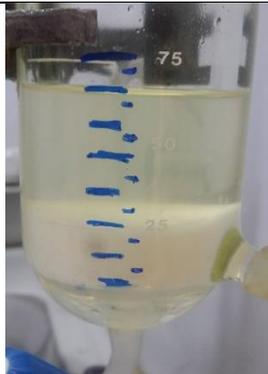
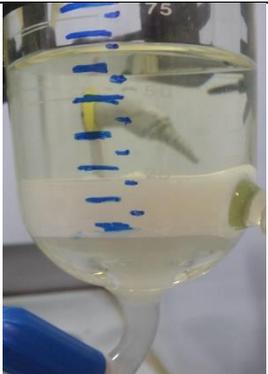
Runs	At 12°C		
	0 hour	5 hours	24 hours
3 (KHI+CI)			

Table 4. Picture of phases quality vs. time at 70°C

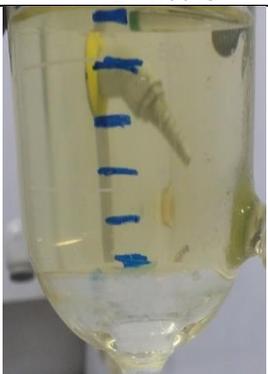
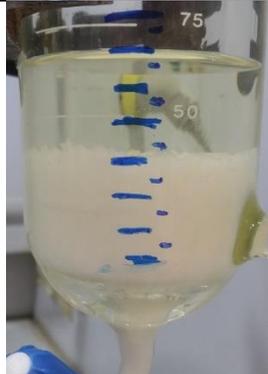
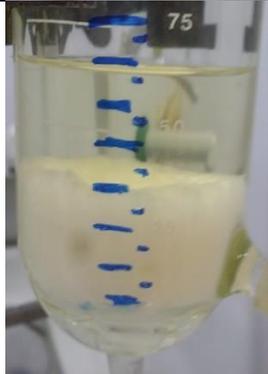
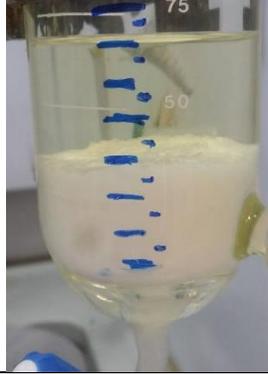
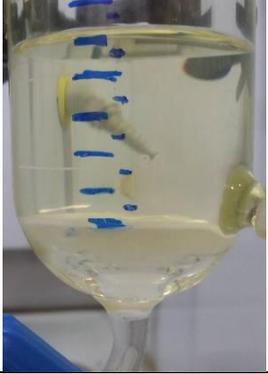
Runs	At 70 °C		
	0 hour	5 hours	24 hours
4 (KHI)			
5 (CI)			
6 (KHI+CI)			

Table 5. Separated phases volume (mL) vs. time (h) for each system

Runs	At 12 °C									At 70 °C								
	KHI			CI			KHI+CI			KHI			CI			KHI+CI		
	0 h	5 h	24 h	0 h	5 h	24 h	0 h	5 h	24 h	0 h	5 h	24 h	0 h	5 h	24 h	0 h	5 h	24 h
Condensate (mL)	60	60	60	25	26	28	43	45	45	60	60	60	30	30	30	30	37	50
Emulsion (mL)	-	-	-	39	37	33	20	17	17	-	-	-	33	30	25	30	20	4
Water (mL)	10	10	10	6	7	9	7	8	8	10	10	10	7	9	9	7	9	10
Total (mL)	70	70	70	70	70	70	70	70	70	70	70	70	70	69	64	67	66	64

In the presence of CI (run 2), the formed emulsion phase was considerably stable (volume reduction of 39 to 33 mL in Table 5) over 24 h after transferring to decanter. When KHI existed together with CI (run 3), both initial emulsion volume and stability of it were reduced passing time.

At 70°C, although similar trend of emulsion formation was observed in the presence of KHI and CI, the rates of phase separation were significantly affected by temperature. As shown in Table 4 regardless of which chemical was present, once stirring was stopped and fluids transferred to the decanter at 70°C, hydrocarbon phase became free of water droplet so faster than 12°C.

In comparison with 12°C, lower emulsion stability was observed at 70°C while in run 6 negligible emulsion amount (4 mL) was remained in the decanter over 24 h. The simultaneous presence of KHI and CI made the emulsion phase less stable and the efficiency of separation higher than the presence of CI alone.

4. Conclusion

In this study, the effect of the presence of chemical additives were investigated on water/hydrocarbon phase separation and probable emulsion formation. It was observed that water/hydrocarbon in the presence of KHI alone did not form emulsion phase while CI presence resulted in stable emulsion. The simultaneous presence of KHI and CI made the emulsion phase less stable and the efficiency of separation higher than the presence of CI alone.

Regardless of temperature, similar trend of emulsion formation was observed in the presence of KHI and CI while the rates of phase separation were significantly affected by higher temperature of 70°C in comparison to 12°C.

Stable emulsion especially in the presence of CI even after 24 hours represented future problem in flow assurance with sludge formation through pipeline. On the other hand, the necessity of de-emulsifiers to meet environmental regulation and special product specifications in on-shore water/hydrocarbon separators seems to be vital.

References

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