

# Investigation of the Effect of Hybrid of Mono-Ethylene Glycol and Vinylcaprolactum on Hydrate Formation Temperature using Hysys

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## ABSTRACT

Hysy Software was used to Simulate hydrate formation temperature at different pressure using a pressure range of 3000 psi to 5000, a hybrid of Mono-Ethylene Glycol (MEG) and Vinylcaprolactum (VP) was used to determine the Hydrate Formation temperature at different pressure. 10% weight and 40% weight concentration of MEG were added to 0.4% weight and 0.8% weight of VP respectively, it was observed that an increase in the weight concentration of MEG increases the hydrate formation Temperature at a specific pressure. 10% weight concentration of MEG and 0.8% weight concentration of VP gave the least Hydrate Formation Temperature and highest temperature depression. This study will help a flow assurance engineer know the right proportion of MEG and VP to get the least Hydrate Formation Temperature at different pressure.

**Keywords:** Hydrate formation temperature, Hybrid, mono-ethylene glycol, Vinylcaprolactum, Hysy software, Different pressure

## I. INTRODUCTION

The gas hydrate stability region extends beyond the seabed, usually 10 – 100m beneath the

seabed. Methane gas is found at this depth causing strong reflection in seismic surveys. The reflections approximately follow a line of constant temperature. The importance of Gas hydrates cannot be overemphasized. Gas hydrate causes serious flow assurance problems in most offshore hydrocarbon drilling and production operations.

Hydrate formation is prevalent on seabed because of the high pressure and low-temperature experience. Methods like heating and insulation have been used in the past also some chemicals have been used in the past to control hydrate formation in subsea pipelined, however they are expensive, controlling hydrates using chemicals is cost effective hence, this study examines controlling hydrates using a hybrid of Mono-Ethylene Glycol and Vinlycaprolatum which has not been used in deep offshore Nigeria. The analysis in this study is done using Hysys software.

## II. MATERIALS AND METHODS

In this work, combination of Mono-Ethylene Glycol and Vinlycaprolatum were considered in the prevention of hydrate formation at different pressures.

**Table1: Composition of the Gas Stream**

Component	Mole Fraction ( $y_i$ )	Molecular Weight (MW)
CO <sub>2</sub>	0.0651	44
Nitrogen	0.0597	28
Methane	0.7662	16
Ethane	0.0688	30.1
Propane	0.0184	44.1

n-Butane	0.0025	58.1
i-butane	0.0075	58.1
i-pentane	0.0018	72.2
n-pentane	0.0021	72.2
Hexane	0.0019	86
Heptanes	0.0061	100
Octane	0	114
<b>Total</b>	<b>1.0000</b>	

Source: Odutola et al, (2014).

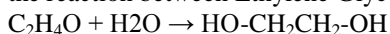
**Table2: Properties of the Inhibitors Used**

Component	Molecular Weight (g/mol)	K- Value	Boiling Point(°C)	Density (g/ml)	Molecular Formular
MEG	62.07	2700	197.3	1.1132	C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>
VP	139.19		128	1.029	C <sub>8</sub> H <sub>13</sub> NO

### Theoretical Analysis

#### Mono-Ethylene Glycol (MEG)

Mono-ethylene glycol is an organic compound with the molecular formula (CH<sub>2</sub>OH)<sub>2</sub>, Molar mass of 62.07g/mol, Boiling point is 197.3°C, melting point is -12.9°C, Density 1.11g/mol<sup>3</sup>. Mainly used for two purposes, as a raw material in the manufacturing of polyester fibers and for antifreeze formulations. It is odorless, colorless. Mono-ethylene Glycol is produced with the reaction between Ethylene Glycol and water.



#### Vinylcaprolactum (VP)

Vinylcaprolactum is a nonionic, nontoxic, water soluble, thermally sensitive and biocompatible polymer. It contains hydrophilic carboxylic and amide groups. It has a Molar mass of 139.195, boiling point of 128°C, melting point of 35 - 38°C, density of 1.029g/ml and molecular formula of CH<sub>8</sub>H<sub>13</sub>NO.

### Hydrate Prediction

Hydrate prediction was carried out without the use of inhibitors by using Hysys software, the composition of the gas stream alone was use to determine the hydrate formation temperature at different pressure. Also hydrate prediction was carried out with the use of Inhibitors by the use of Hysys software, the composition of the gas stream and the weight percentages of the various inhibitors were used to predict hydrate formation temperature at different pressure

### III. RESULTS AND DISCUSSION

#### Results

Table 3 shows the hydrate formation temperature without the use of Inhibitor, 10% wt and 40% wt of Mono-Ethylene Glycol and 0.4% wt and 0.8% wt of Vinylcaprolactum and a hybrid of 10% wt of Mono-Ethylene Glycol with 0.4% wt and 0.8% wt of Vinylcaprolactum respectively and a hybrid of 40% wt of Mono-Ethylene Glycol with 0.4% wt and 0.8% wt of Vinylcaprolactum respectively were used at different pressure.

**Table 3: Hydrate Formation Temperature at different pressure**

Pressure (Psi)	Without Inhibitor (°F)	10%wt MEG (°F)	40% wt MEG (°F)	0.4%wt VP (°F)	0.8%wt VP (°F)	10%wt MEG& 0.4%wt VP (°F)	10% wt MEG & 0.8%wt VP (°F)	40%wt MEG & 0.4%wt VP (°F)	40%wt MEG& 0.8%wt VP (°F)

3000	70.9573	70.9655	71.0552	71.1415	70.7456	71.1815	70.8211	71.2266	70.8410
3010	70.9967	71.0050	71.0948	71.8102	70.7858	71.2204	70.8613	71.2657	70.8814
3276	72.0025	72.0134	72.0736	72.1685	71.8052	72.2103	71.8840	72.2614	71.9090
4000	74.4948	74.4219	74.5254	74.5100	74.2098	74.5566	74.2971	74.6216	74.3339
4500	75.8531	75.8740	75.9848	75.9074	75.6384	75.9574	75.7314	76.0310	75.7752
4867	76.8324	76.8577	76.9737	76.8469	76.5968	76.8995	76.6738	76.9790	76.7424
5000	77.1751	77.1995	77.3174	77.1719	74.6836	77.2254	77.0265	77.3070	77.0768

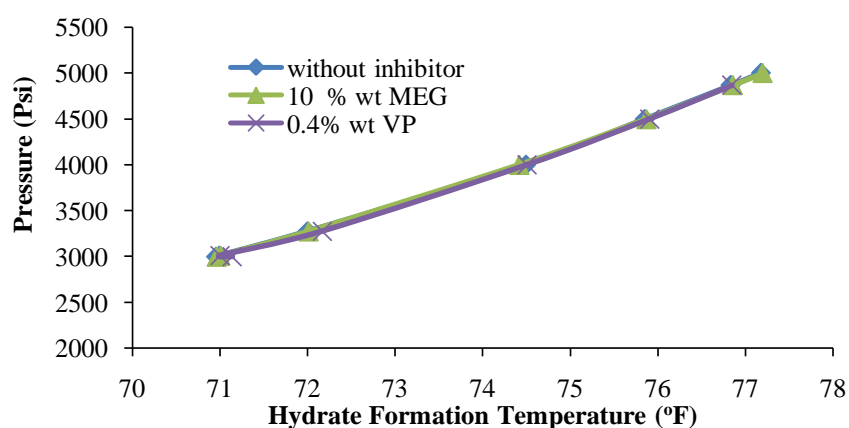


Figure 1: Effect of 10% wt of MEG and 10% wt VP on hydrate formation temperature

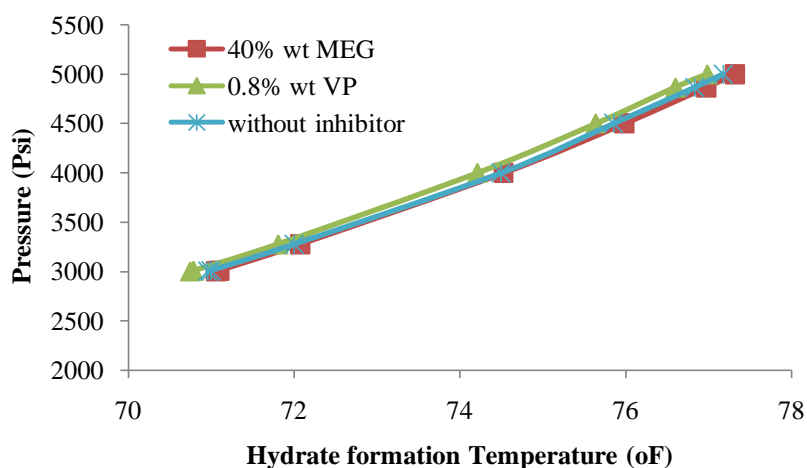


Figure 2: Effect of 40% wt of MEG and 0.8% wt VP on hydrate formation temperature.

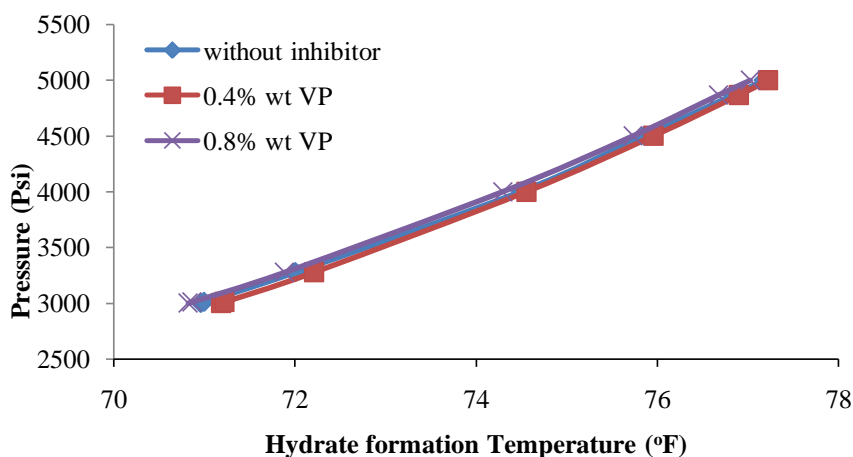


Figure 3: Effect of 10% wt of MEG with 0.4% wt and 0.8% wt of VP on hydrate formation temperature

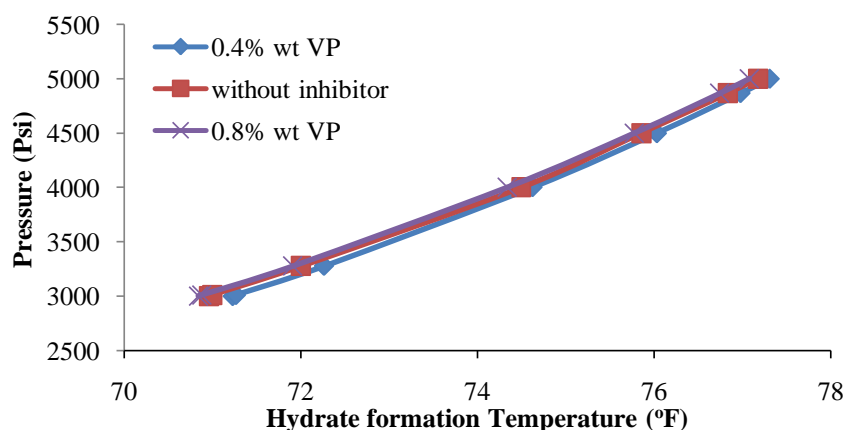


Figure 4: Effect of 40% wt of MEG with 0.4% wt and 0.8% wt of VP on hydrate formation temperature

#### IV. DISCUSSION

The hydrate formation curve slopes downwards from right to left at high pressure to low pressure, there is a relatively high hydrate formation temperature at low pressure. It was observed that increase in the weight concentration of Mono-Ethylene Glycol increases in hydrate formation temperature; it was also observed that the hydrate formation temperature increases as the pressure increases.

The hydrate risk zone is the region on the left-hand side of the hydrate formation curve while the region on the right hand side of the curve is the hydrate free zone. The hydrate risk zone covers temperature as high as 77.1751°F (5000psi) to temperature of 70.9573°F (3000psi). Without inhibitor the risk of hydrate formation is high, hydrate formation curves with 10% wt and 40% wt of Mono-Ethylene Glycol and 0.4% wt and 0.8% wt Vinylcaprolactum respectively were obtained by the use of hysys software, the curve shift to the left from the hydrate formation curve obtained without

the use of inhibitor thereby reducing the hydrate formation risk region, and increasing the hydrate free zone.

#### V. CONCLUSION

From the results obtained and graphs, it can be concluded that:

- The combination of 10% wt Mono-Ethylene Glycol (MEG) and 0.8% wt vinylcaprolactum (VP) gave the least hydrate formation temperature and a higher temperature depression at different pressures.
- Weight percentages of inhibitors affects the hydrate formation temperature. Increase in the concentration of Mono-Ethylene Glycol (MEG) inhibitors results to increase in the hydrate formation temperature and decrease in the temperature depression.
- It was also observed that increase in pressure result to increase in temperature

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