



## Comparison between experimental and simulated phase envelopes of the methane/olefin mixture

André T. P. Falcade\*, Nara A. Policarpo, Nilo R. Kim, Paulo R. Ribeiro

### Abstract

The study aims to compare bubble pressures of methane/olefin mixture obtained experimentally with those simulated by WinProp®, building the respective phase envelopes for different methane molar fractions, pressures, and temperatures.

### Key words:

Olefin, Phase envelopes, WinProp®.

### Introduction

In well control, quantifying the formation gas dissolved in the drilling fluid is essential to avoid *kicks*. In the case of deep wells, where pressures and temperatures are high, it becomes even more fundamental to know PVT (pressure-volume-temperature) behavior of the gas/drilling fluid mixture, since the gas solubility can be infinity and its quantification more difficult at the supercritical regions<sup>1</sup>. For mixtures, the PVT behavior can be studied from its phase envelopes, which are regions that make up the phase diagram of a mixture, where the liquid and gas phases coexist, delimited by the bubble and dew lines. At the critical point, there is no liquid/gas interface and, above critical pressure and critical temperature, only one phase exists, called the supercritical region. In it, the fluid acquires intermediate properties of liquids and gases<sup>2</sup>. Phase envelopes can be experimentally obtained or through compositional phase behavior simulators, such as the PVT Pro (Schlumberger) and the CMG WinProp®. This work aims to compare the bubble pressures of the methane (formation gas) and olefin (drilling fluid base) mixtures obtained experimentally with those simulated by WinProp®.

### Results and Discussion

Experimental saturation pressures ( $P_{sat}$ ) or bubble points were measured in a PVT cell for the methane/olefin mixtures. The results were obtained for methane molar fraction of 10 to 40% and temperatures of 20, 25, 40, 60 and 80°C, that resemble petroleum reservoir conditions. The PVT results were feed into the CMG WinProp® (version 2016.1) simulator to obtain the phase envelopes of the methane/olefin mixture. The Equation of State (EOS) used was the Peng-Robinson and the binary interaction parameter ( $k_{ij}$ ) is calculated by correlation<sup>3</sup> shown in Equation 1, where  $v_c$  is the critical volume of species  $i$  or  $j$  and  $\theta$  is a parameter adjustable for the mixture.

$$k_{ij} = 1 - \frac{(2v_{ci}^{1/6}v_{cj}^{1/6})^\theta}{(v_{ci}^{1/3} + v_{cj}^{1/3})} \quad (1)$$

The simulated phase envelopes were obtained for two situations: (i) adjustment of the EOS through regression with the PVT experimental values, and (ii) without regression. Image 1 compares the phase envelopes obtained for the two mentioned situations and shows the saturation pressures experimentally measured. The figure shows that simulated bubble pressures are more accurate when the EOS is tuned by experimental data.

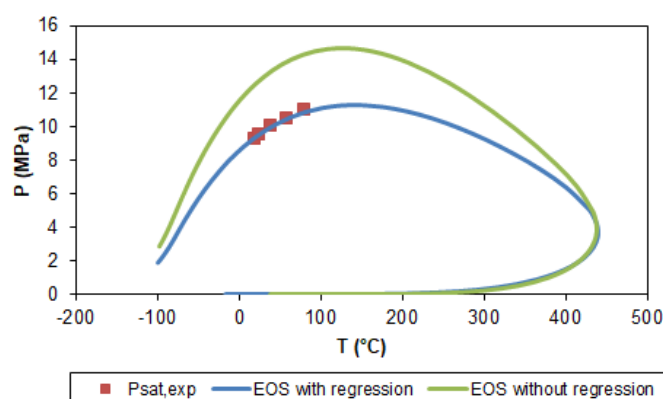


Image 1. Phase envelope of methane/olefin mixture – 10% of methane.

Chart 1 presents  $P_{sat}$  obtained experimentally and simulated. All deviation values between experimental and simulated  $P_{sat}$  (bubble points) were lower than 10%, except for the methane molar fraction of 30% that was 11% of error.

Chart 1. Experimental and simulated bubble points (MPa).

T(°C)	Methane Molar Fraction (%)							
	10		20		30		40	
	Exp	Sim	Exp	Sim	Exp	Sim	Exp	Sim
20	9,2	9,4	23,8	23,6	24,0	26,7	36,1	39,6
25	9,5	9,6	24,0	23,7	24,3	26,6	36,1	38,8
40	10,0	10,0	24,5	23,9	24,8	26,3	36,5	37,0
60	10,4	10,5	25,3	24,1	25,5	26,2	36,1	35,5
80	11,0	10,9	25,7	24,1	26,2	26,2	35,5	34,5

### Conclusions

It is concluded that the phase envelopes generated from experimental data better represent the PVT behavior of the methane/olefin mixture, under the conditions described in this work.

### Acknowledgement

The authors are thankful for Petrobras financial support.

<sup>1</sup> Atolini, T. M. *Estudo do comportamento PVT de misturas de metano em emulsões base n-parafina a altas temperaturas, pressões e concentrações de metano*. Campinas: Faculdade de Engenharia Mecânica e Instituto de Geociências, 2008. 143p. Dissertação (Mestrado).

<sup>2</sup> McCain Jr., W. D. *The Properties of Petroleum Fluids*. 2<sup>nd</sup> Ed. Oklahoma: PennWell Books, 1990.

<sup>3</sup> CMG, Computer Modelling Group Ltd. *WinProp User Guide*. Version 2016. 2018.