

**DETERMINATION AND PREDICTION OF THE ASPHALTENE  
INSTABILITY AT RESERVOIR CONDITIONS USING SOLUBILITY  
PARAMETER TECHNIQUE**

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**ABSTRACT**

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Asphaltenes precipitation and deposition caused by changes in composition, pressure, and temperature in the reservoir or any part of the production system are an undesirable situation that can cause economical losses in petroleum industry. Numerous studies have been conducted to predict the asphaltene instability at the reservoir conditions and the pressure depletion effect on the live oil. The existing models which have been developed for predicting asphaltene precipitation onset at reservoir conditions or any process conditions from the experimental data at ambient or near ambient conditions are based on the empirical extrapolations without accounting for thermodynamic theory. This theoretical approach based on the Gibbs free energy of mixing theory and the solubility parameter concept allows the onset solubility parameter to be predicted under any conditions from a few set of experiments. The experimental data at ambient and near ambient conditions were combined with standard PVT and compositional data from a simulator to predict the asphaltene instability at the reservoir conditions and the pressure depletion effect on the live oil.

## บทคัดย่อ

เกรียงไกร ไกรวัฒนวงศ์: การหาและการทำนายความไม่เสถียรของแอสฟัลต์ที่สภาวะของแหล่งน้ำมันโดยใช้วิธีโซลูบิลิตีพารามิเตอร์ (Determination and Prediction of Asphaltene Instability at Reservoir Conditions Using Solubility Parameter Technique) อ. ที่ปรึกษา: รศ. ดร. สุเมธ ชวเดช ศ. ดร. เอช สก๊อต ฟอกเลอร์ และ ผศ.ดร.ปมทอง มาลากุล ณ อยุธยา 57 หน้า ISBN 974-9651-95-2

การตกตะกอนและการสะสมของแอสฟัลต์ที่อันเนื่องมาจากการเปลี่ยนแปลงของส่วนประกอบ ความดัน และอุณหภูมิในแหล่งน้ำมันหรือส่วนใด ๆ ของระบบการผลิตเป็นเหตุการณ์ที่ไม่พึงประสงค์ซึ่งสามารถสร้างความเสียหายให้กับอุตสาหกรรมปิโตรเลียม มีการศึกษามากมายเพื่อที่จะทำนายความไม่เสถียรของแอสฟัลต์ที่สภาวะของแหล่งน้ำมันและผลกระทบของการสูญเสียความดันของน้ำมัน แบบจำลองที่มีอยู่ที่ถูกพัฒนาขึ้นเพื่อการทำนายจุดตกตะกอนของแอสฟัลต์ที่สภาวะของแหล่งน้ำมันหรือสภาวะใดๆ จากข้อมูลการทดลองที่สภาวะปกติหรือสภาวะใกล้เคียงนั้นมีพื้นฐานจากการประเมินค่าออกขอบเขตโดยการสังเกตโดยที่ไม่คำนึงถึงทฤษฎีทางเทอร์โมไดนามิก แบบจำลองทางทฤษฎีได้ถูกพัฒนาขึ้นบนพื้นฐานของทฤษฎีพลังงานอิสระของการผสมของกิบส์และโซลูบิลิตีพารามิเตอร์ ซึ่งทำให้สามารถทำนายโซลูบิลิตีพารามิเตอร์ที่จุดตกตะกอนที่สภาวะใดๆ จากการทดลองเพียงไม่กี่ชุด ข้อมูลการทดลองที่สภาวะปกติหรือสภาวะใกล้เคียงถูกใช้ร่วมกับข้อมูลพื้นฐานทางความดัน ปริมาตร อุณหภูมิ และข้อมูลส่วนประกอบจากโปรแกรมจำลอง เพื่อทำนายความไม่เสถียรของแอสฟัลต์ที่สภาวะของแหล่งน้ำมันและผลกระทบของการสูญเสียความดันของน้ำมัน

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## LIST OF SYMBOLS

|                    |  |
|--------------------|--|
| $a$                | Absorptivity   |
| $A$                | Absorbance   |
| $B$                | Volume ratio of the live oil and stock tank oil at live condition      |
| $b$                | Path length  |
| $c$                | Concentration  |
| $F_{RI}$           | Refractive index function  |
| $n$                | Refractive index   |
| $R$                | Ideal gas constant (8.314 J/mol/K)                                     |
| $T$                | Temperature (K)  |
| $v$                | Molar volume (cm <sup>3</sup> /mol)                                    |
| $v^L$              | Molar volume of the liquid (cm <sup>3</sup> /mol)                      |
| $v_p$              | Molar volume of precipitant (cm <sup>3</sup> /mol)                     |
| $v_m$              | Molar volume of the mixture (cm <sup>3</sup> /mol)                     |
| $v_a$              | Molar volume of asphaltene (cm <sup>3</sup> /mol)                      |
| $V_o$              | Volume of crude oil (ml)   |
| $V_s$              | Volume of solvent (ml)   |
| $V_p$              | Volume of precipitant (ml)   |
| $x_i$              | Mole fraction of $i^{\text{th}}$ component                             |
| $\delta$           | Solubility parameter (MPa) <sup>1/2</sup>                              |
| $\delta_a$         | Solubility parameter of asphaltene (MPa) <sup>1/2</sup>                |
| $\delta_{DG}$      | Dissolved gas solubility parameter (MPa) <sup>1/2</sup>                |
| $\delta_i$         | Solubility parameter of $i^{\text{th}}$ component (MPa) <sup>1/2</sup> |
| $\delta_{LO}$      | Live oil solubility parameter (MPa) <sup>1/2</sup>                     |
| $\delta_{mixture}$ | Solubility parameter of a mixture (MPa) <sup>1/2</sup>                 |
| $\delta_o$         | Solubility parameter of crude oil (MPa) <sup>1/2</sup>                 |
| $\delta_{oil}$     | Crude oil solubility parameter (MPa) <sup>1/2</sup>                    |

|                      |   |
|----------------------|---|
| $\delta_{onset}$     | Onset solubility parameter (MPa) <sup>1/2</sup>   |
| $\delta_p$           | Solubility parameter of precipitant (MPa) <sup>1/2</sup>                                |
| $\delta_s$           | Solubility parameter of solvent (MPa) <sup>1/2</sup>                                    |
| $\delta_{STO}$       | Stock tank oil solubility parameter (MPa) <sup>1/2</sup>                                |
| $\delta^M$           | Molar solubility parameter ((MPa) <sup>1/2</sup> ml./mol)                               |
| $\delta_{DG}^M$      | Molar solubility parameter of dissolved gas ((MPa) <sup>1/2</sup> ml./mol)              |
| $\delta_i^M$         | Molar solubility parameter of i <sup>th</sup> component ((MPa) <sup>1/2</sup> ml./mol)  |
| $\delta_{mixture}^M$ | Molar solubility parameter of a normal alkanes mixture<br>(MPa) <sup>1/2</sup> ml./mol) |
| $\Delta G$           | Gibb's free energy of mixing (J/mol)  |
| $\Delta H$           | Enthalpy of mixing (J/mol)  |
| $\Delta H^{vap}$     | Heat of vaporization of the liquid (J/mol)  |
| $\Delta S$           | Entropy of mixing (J/K/mol)   |
| $\Delta U^{vap}$     | Energy of vaporization to the gas at zero pressure (J/mol)                              |
| $\phi$               | Volume fraction   |
| $\phi_a$             | Volume fraction of asphaltene   |
| $\phi_{DG}$          | Volume fraction of dissolved gas  |
| $\phi_i$             | Volume fraction of i <sup>th</sup> component  |
| $\phi_m$             | Volume fraction of the mixture  |
| $\phi_o$             | Crude oil volume fraction   |
| $\phi_p$             | Precipitant volume fraction   |
| $\phi_s$             | Solvent volume fraction   |
| $\phi_{STO}$         | Volume fraction of stock tank oil   |