Wax Precipitation Tendency of Iranian Crude Oil : Experiment and Thermodynamic Modelling

Abstract

The thermodynamic modeling of solid wax precipitation in crude oil is essential for ensuring flow assurance in petroleum pipelines. The objective of this study was to evaluate the novel combination of the PC-SAFT equation of state for the liquid phase with three solid-phase activity coefficient models—UNIFAC, predictive UNIQUAC, and predictive Wilson—to model wax precipitation in complex natural petroleum systems. For validation, experimental data were measured for three Iranian crude oil samples using the standard BP-٢٣٧ protocol. The results indicate that while all three models show good qualitative agreement, the predictive Wilson model exhibits the highest accuracy, with a Normalized Root Mean Square Error (NRMSE) that is ٣٣٪ lower on average compared to the other solid-phase models (ranging from ٠,٠٨٨٦ to ٠,٢٠٥٠). Model accuracy systematically improved as the wax content of the samples increased, which is attributed to lower experimental measurement errors at higher sediment volumes. In conclusion, coupling PC-SAFT with the predictive Wilson model provides a highly reliable thermodynamic framework that can be confidently applied by flow assurance engineers to predict wax appearance temperatures and design mitigation strategies for waxy crude oil transport.

Keywords: Iranian crude oil, PC-SAFT equation of state, Predictive UNIQUAC, Predictive Wilson, Wax precipitation.

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١. Introduction

In shadow of global industrialization, energy requirements are constantly rising. Fossil fuels are one of the greatest sources of energy and crude oil is among the most important fossil fuels. Change in operational conditions such as temperature, pressure and also change in composition of light components of oil compound during production, transmission and processing cause Precipitation of solids including wax [١-٣]. Wax is a constituting group of crude oil, mainly composed of heavy normal paraffins with general formula $C_nH_{٢n+٢}$ [١]. At normal temperature and pressure, Paraffins with less than five carbons that are $C_١$ to $C_٤$ for simplicity, at normal temperature and pressure, are commonly in gas state. Paraffins from $C_٥$ to $C_{١٥}$ are liquid. Hydrocarbons with more than ١٥ carbons are highly viscous and have solid wax form. Waxes including paraffins with up to ٨٠ carbon atoms have been reported. To prevent wax Precipitation problem, prediction the Wax Appearance Temperature (WAT) and the Wax Disappearance Temperature (WDT), as well as the total amount of precipitation, is highly necessary [٢, ٤].

Thermodynamic models have two points of view. The first approach makes use of an equation of state in combination with activity coefficient and solid solution model to predict wax Precipitation. The second approach employs only one equation of state, which is called multi solid phase model [٥]. Based on Won model, Precipitation creates a solid phase and it is assumed that all compounds are soluble in the solid phase in any proportion [٦]. In Multi Solid-Phase Model presented by Lira Galeana et al. [٧] every solid phase is considered as a pure component which would not be mixed with other solid phases. It has been observed that sediment formed by cooling a normal alkane mixture could be partitioned to multi solid phases [٨]. These two approaches have been basis of lots of research in recent years.

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Coutinho et al., compared UNIQUAC and Wilson models to model wax Precipitation, and UNIQUAC prediction wax more accurate [٩]. Advantageously, the UNIQUAC model can be used in high pressure. Chen et al. employed modified SRK for Vapor-liquid equilibrium and molar volume calculation to study phase equilibrium of wax Precipitation in crude oil [١٠]. In another study, fugacity of liquid and vapor phases were calculated using modified Peng-Robinson (MPR)equation of state [١١]. Furthermore, Ghanaei et al. employed Wilson equation of state By assuming ideal solid phase and non-ideal liquid phase [١٢]. Farayola et al. used Patel-Teja equation of state to describe non ideality of liquid phase (oil) and applied UNIQUAC to describe non ideality wax solid phase [١٣]. Their approach gave more accurate results in comparison to Peng-Robinson equation. Derakhshan and Shariati applied Peng-Robinson equation of state for liquid-solid equilibrium[١٤]. Monroy and Loperena presented an efficient method using Peng-Robinson equation to calculate equilibrium state of liquid phase and multi solid solution of wax at constant temperature and pressure [١٥]. Rahimpour et al. evaluated wax formation in condensate of south pars gas line using a thermodynamic model based on the multi solid phase model [١٦]. Ghanaei et al. worked on a new thermodynamic model for high pressure phase equilibrium of wax and employed UNIQUAC equation of state to describe non ideal behavior of solid wax phase [١٧]. Aftab et al. applied PC-SAFT for liquid phase and UNIQUAC based on the solid solution model for solid phase [١٨]. Their study focused on prediction of wax disappearance temperature (WDT). Rocha et al. developed Won model for estimation of wax appearance temperature [١٩]. Pedersen et al. performed characterization of PNA analysis by making the assumption that both solid and liquid phases follow the theory solution regularly. Their results indicated that considering solid and liquid phases as ideal solutions will lead to lowest error in estimation of WAT. Behbahani et al. presented a model based on artificial neural

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network for estimation of WAT and amount of sediment [۲۰]. The presented model was in better agreement with experimental data in comparison to the solid solution and the multi-solid phase models. Bagheri Nia et al. at ۲۰۱۶ employed PC-SAFT and UNIQUAC equations of state based on the solid solution model [۲۱].

Unlike prior studies in the literature that mostly focused on synthetic paraffin mixtures or utilized a single activity coefficient model, the main contribution and novelty of this study lies in the systematic and simultaneous evaluation of three different solid-phase activity coefficient models (UNIFAC, predictive UNIQUAC, and predictive Wilson) coupled with the PC-SAFT equation of state, specifically tailored and validated for real, complex Iranian crude oil systems from northern fields. This comprehensive comparison provides flow assurance engineers with a direct quantitative assessment of model performance, demonstrating how the predictive Wilson model, which accounts for the structural differences in wax crystals, outperforms traditional group-contribution methods under real reservoir fluid conditions.

۲. Experimental method and modeling

The three oil samples were collected under stabilized atmospheric wellhead conditions from production fields in northern Iran, followed by a standard degassing procedure at room temperature to ensure the removal of any residual dissolved volatile gases. In accordance with the standard BP-۲۳۷ protocol, acetone was utilized as the solvent with a strict solvent-to-sample ratio of ۳:۱ (volume to weight). The mixture was cooled to -۳۲ °C to facilitate complete wax crystallization and subsequent gravimetric determination of the wax mass percentage. To establish reliability and assess experimental uncertainty, all measurements were conducted in duplicate. The experimental repeatability showed an average standard deviation of ±۰٫۲۵ wt% for the precipitated wax content and ±۰٫۵ °C for the Wax

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Appearance Temperature (WAT). This quantitative uncertainty is represented as error bars in the experimental data points of Figs. ٢–٤.

Table ١. Samples specification

Carbon No.	Sp.Gr	M.W.	Oil ١	Oil ٢	Oil ٣
C١			٠,٠٠٥	٠,٠٠٥	٠,٠٠٥
C٢			٠,١٣٢	٠,١٣٢	٠,١٨٠
C٣			٢,١٢٤	١,٩٨٠	٢,٥٢٠
C٤			١,٠٠٢	١,٠٠٢	١,٠٠٢
C٥			٣,٠٠٨	٣,٠٠٨	٢,٩٥٨
C٦			٣,٢٥٦	٣,٢٥٦	٣,٤٧٠
C٧	٠,٧٢٧	٩٦	٢,٩٥٨	٢,٩٥٨	٢,٩٥٨
C٨	٠,٧٥٠	١٠٧	٨,٢٣٦	٨,٢٣٥	٧,١٦٠
C٩	٠,٧٧٠	١٢١	١٣,٢٤٧	١٣,٢٤٧	١٣,٢٤٦
C١٠	٠,٧٨٠	١٣٤	١٠,٢١٤	١٠,٢١٤	١٠,٢١٣
C١١	٠,٧٩٠	١٤٧	٨,٢١٥	٨,٢١٥	٨,٢١٥
C١٢	٠,٨٠٠	١٦١	٦,٢٥٨	٦,٢٥٨	٦,٢٥٨
C١٣	٠,٨٢٠	١٧٥	٤,٨٧٩	٤,٨٧٩	٤,٥٦٠
C١٤	٠,٨٣٠	١٩٠	٣,١٤٧	٣,١٤٧	٣,١٤٧
C١٥	٠,٨٣٦	٢٠٦	٣,٤٩٢	٣,٤٩٢	٣,٤٩٢
C١٦	٠,٨٤٣	٢٢٢	٢,٩٥٦	٢,٩٥٦	٢,٩٥٦
C١٧	٠,٨٥١	٢٣٧	٢,١٤٩	٣,٢٠٠	٢,١٠٠
C١٨	٠,٨٥٦	٢٥١	٢,١٣٦	٢,١٣٥	٢,٢٢٥
C١٩	٠,٨٦١	٢٦٣	٣,٥٠٠	٢,١٠٠	٤,١٠٠
C٢٠+			١٩,٠٨٦	١٩,٥٨٠	١٩,٦٣٠
Total			١٠٠,٠	١٠٠,٠	١٠٠,٤
MW C٢٠+			٣٩٥	٤١٢	٣٦٢
Sp.Gr. C٢٠+			٠,٨٨٤	٠,٨٧٤	٠,٨٨٢

٣. Thermodynamic Modeling

٣,١. Liquid phase

PC-SAFT equation of state is based on the Perturbed-Chain theory and reduced Helmholtz free energy contribution relative to ideal gas. In this study, We used the exact formulations and same calculation method of PC-SAFT model in the previous paper [٢٢].

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PC-SAFT equation of state has three unknown parameters (m ، σ ، $\varepsilon/_k$). Following expressions have been reported recently for estimating those parameters based on molecular weight and specific gravity of component [۲۳, ۲٤].

$$m = ۳۳.٥۸ + ۰.۰۸۸۱٦Mw - ۹۰.۷٥S - ۰.۰۷۷۲۷Mw \times S + ٦۱.۰۱S^{۲} \quad (۱)$$

$$m.\sigma^{۳} = -۷٥.۱٤ + ۲.۸٤۸Mw + ۲۳۱.۷S - ۱.۲۸۸Mw \times S - ۱۸٦.۹S^{۲} \quad (۲)$$

$$m.\frac{\varepsilon}{k} = ۳۳۷۲ + ۱۱.۲٤Mw - ۸۹۰٥S - ٥.۹۲٥Mw \times S + ٦۱۳٦S^{۲} \quad (۳)$$

The three PC-SAFT molecular parameters (m, σ, ε/k) for the C۷ to C۱۹ cuts and the heavy C۲۰+ fraction were calculated using the highly robust correlations of Assareh et al. [۲۳] and Hosseinifar et al. [۲٤]. These specific correlations were developed for Iranian crude oil cuts and have been previously validated against a vast database of independent experimental liquid densities, vapor pressures, and bubble point pressures, yielding deviations of less than ۱٫٥٪. Consequently, further validation against independent properties was deemed redundant. For the solid phase, the UNIFAC group interaction parameters were obtained from the standard Hansen group database, whereas the binary interaction parameters for predictive UNIQUAC and predictive Wilson were calculated entirely from the pure-component physical properties (e.g., sublimation and fusion enthalpies) as outlined by Coutinho et al. [۹] and Dalirsefat & Feyzi [۱۱], preserving the purely predictive nature of the thermodynamic models without regressing any experimental wax precipitation data.

۳٫۲. Solid phase

Fugacity of pure components comprising the solid phase was calculated based on solid solution model of liquid pure component mathematically:

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$$\ln\left(\frac{f^s}{f^l}\right)_{pure,i} = \frac{\Delta H_i^f}{RT_i^f}\left(\frac{T}{T_i^f} - ١\right)\frac{\Delta C_{Pi}}{R}\left[١ - \frac{T}{T_i^f} + \ln\left(\frac{T_i^f}{T}\right)\right] \quad (٤)$$

Where T^f represents fusion temperature of pure component *i,* obtained by Won's equation (Won, K. ١٩٨٦):

$$T_i^f = ٣٧٤.٥ + ٠.٠٢٦١٧\, Mw_i - \frac{٢٠١٧٢}{Mw_i} \quad (٥)$$

To obtain ΔC_{pi} $(C_{pi}^l - C_{pi}^s)$, Pedersen estimation is handy:

$$\Delta C_{pi} = C_{pi}^l - C_{pi}^s = ٠.٣٠٣٣\, Mw_i - ٤.٦٣٥ \times ١٠^{-٤} Mw_i T \quad (٦)$$

Dalirsefat and Feyzi's expression was used forΔH_i^f (Dalirsefat, R., & Feyzi, F. ٢٠٠٧):

$$\Delta H_i^f = ٠.٠٦٥٩٩\, Mw_i T_i^f \quad (٧)$$

Figure ١ illustrates the calculation procedure for obtaining the wax Precipitation.

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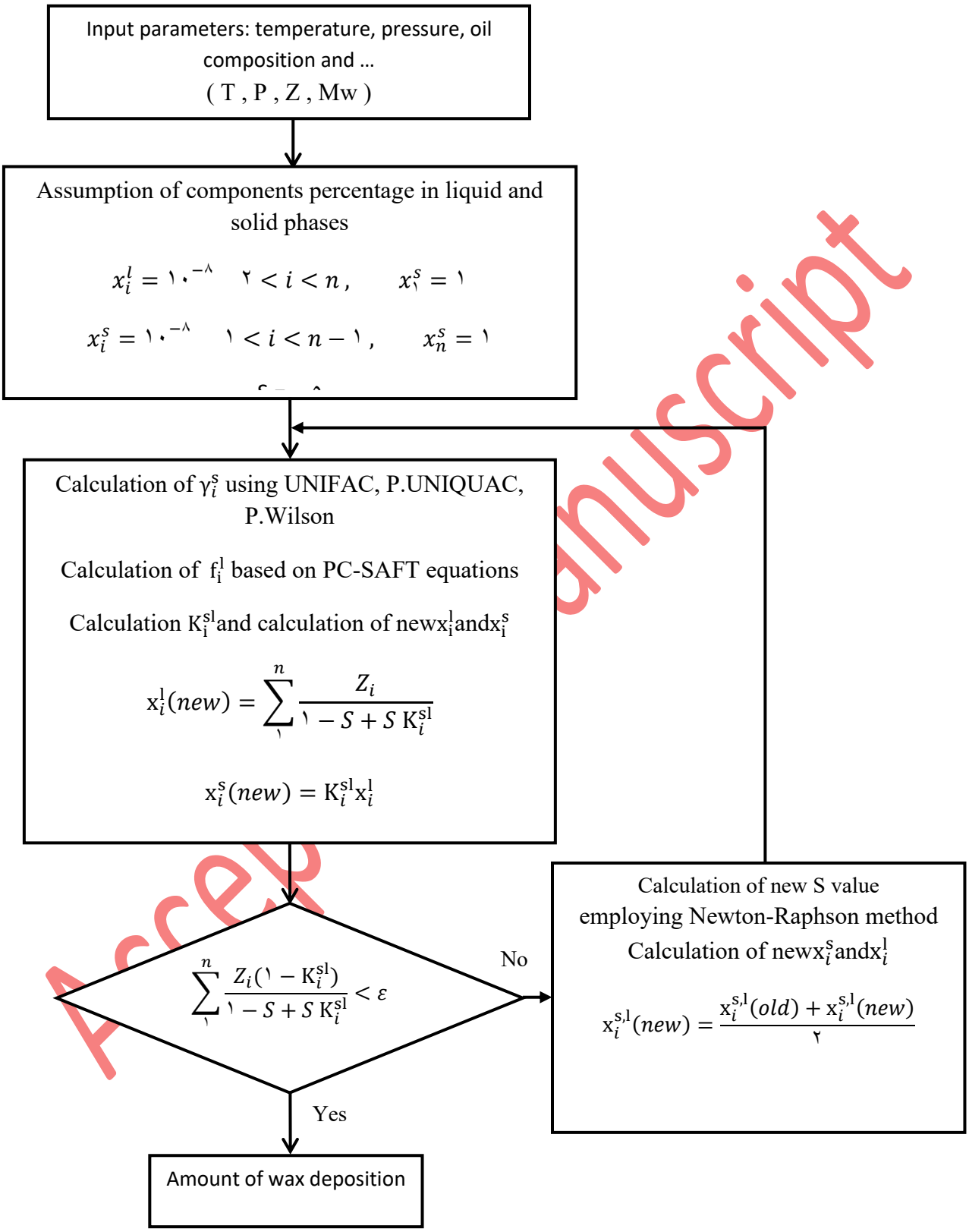

Figure ۱. Algorithm of precipitation amount calculation.

٣,٢,١. UNIFAC model

To capture non-ideality of a solution, UNIFAC takes activity coefficient by two parts including combinatorial and residual. Activity coefficient is calculated based on Staverman-Guggenheim method:

$$\ln \gamma_i = \ln(\frac{\Phi_i}{x_i}) + ١ - \left(\frac{\Phi_i}{x_i}\right) - \frac{Z}{٢} q_i \left(\ln(\frac{\Phi_i}{\theta_i}) + ١ - \frac{\Phi_i}{\theta_i}\right) \quad (٨)$$

Here Z stands for coordination number. Since structure of wax crystals is assumed orthorhombic, Z number for wax was considered equal to six. In Eq. (٨), Φ_i and θ_i Obtained as follows:

$$\Phi_i = \frac{x_i q_i}{\sum_j^n x_i q_i} \quad (٩.a)$$

$$\theta_i = \frac{x_i r_i}{\sum_j^n x_i r_i} \quad (٩.b)$$

Where:

$$r_i = ٠.٦٧٤٤\ C_{ni} + ٠.٤٥٣٤ \quad (١٠)$$

$$q_i = ٠.٥٤\ C_{ni} + ٠.٦١٦ \quad (١١)$$

Where C_{ni} represents number of carbons for components.

٣,٢,٢. Predictive_UNIQUAC Model

Predictive UNIQUAC is another model used to account for non-ideality of the solid phase:

$$\ln \gamma_i = \ln(\frac{\Phi_i}{x_i}) + ١ - \left(\frac{\Phi_i}{x_i}\right) - \frac{Z}{٢} q_i \left(\ln(\frac{\Phi_i}{\theta_i}) + ١ - \frac{\Phi_i}{\theta_i}\right) + q_i \left(١ - \ln\left(\sum_{j=١}^{n} \theta_j \tau_{ji}\right) - \sum_{j=١}^{n} \frac{\theta_j \tau_{ij}}{\sum_{k=١}^{n} \theta_k \tau_{kj}}\right) \quad (١٢)$$

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Here Φ_i, θ_i and $q_i$parameters are calculated just same as UNIFAC model τ_{ji} is acquired by:

$$\tau_{ji} = exp\left(-\frac{\lambda_{ji} - \lambda_{ii}}{q_i RT}\right) \quad (١٣)$$

Whereλ_{ii} value is:

$$\lambda_{ii} = -\frac{٢}{Z}\left(\Delta H_i^{sub} - RT\right) \quad (١٤)$$

When j component has shorter chain length, we have following expression for unlike segments:

$$\lambda_{ij} = \lambda_{ji} = \lambda_{jj} \quad (١٥)$$

In fact, for two unlike segments, λ value is equal to that of shorter segment. Enthalpy changes due to sublimation were calculated as follows:

$$\Delta H_i^{sub} = \Delta H_i^{vap} + \Delta H_i^{f} + \Delta H_i^{tr} \quad (١٦)$$

Where tr, f and vap represent enthalpy changes due to sublimation, transformation in solid-solid phase, fusion and vaporization respectively.

٣,٣,٣. Predictive_Wilson Model

Predictive Wilson is another model for dealing with non-ideality of multi component mixtures:

$$\ln \gamma_i = ١ - \ln\left(\sum_j x_j \Lambda_{ij}\right) - \sum_k \frac{x_k \Lambda_{ki}}{\sum_j x_j \Lambda_{kj}} \quad (١٧)$$

WhereΛ_{ij} is:

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$$\Lambda_{ij} = exp\left[-\frac{\lambda_{ij} - \lambda_{ii}}{RT}\right] \qquad (١٨)$$

λ is obtained similar to that of predictive UNIQUAC, presented through Eqs (١٤)

٤. Results and Discussion

In this study, a liquid-solid equilibrium was considered for phase calculations. PC-SAFT equation of state was employed to model liquid phase due to its high predictability for behavior of heavy and polar hydrocarbons. Moreover, performance of three models was based on the solid-solution approach. To evaluate reliability and validity, output of the models is compared to experimental results of three oil samples. Results of modeling oil sample ١ using PC-SAFT for the liquid phase and the three models for estimation of solid phase non ideality is presented in Figure ٢.

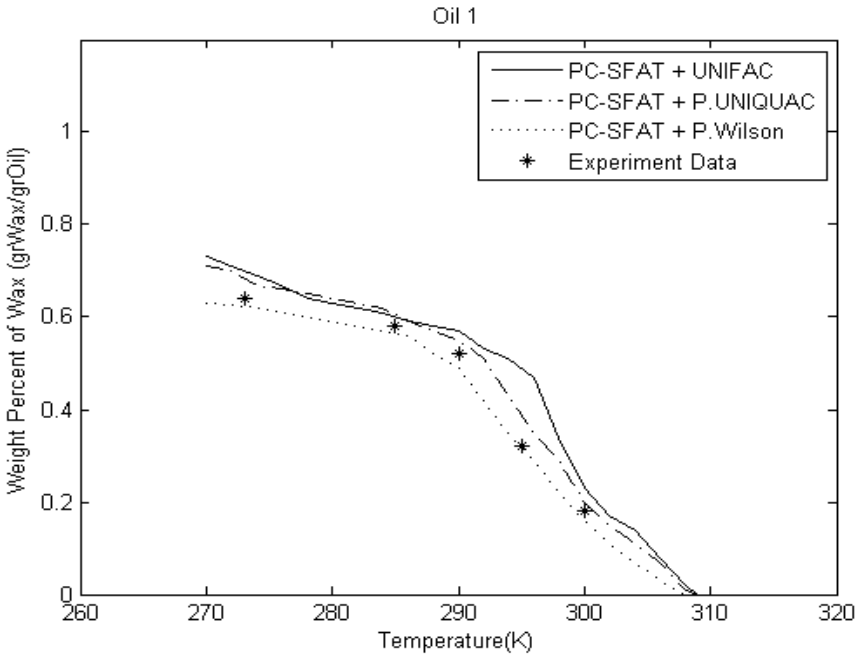

Figure ٢. Calculated and experimental amount of wax Precipitation for oil sample ١.

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As shown in Figure ٢, predictions of all three models are in good agreement with experimental data. Sample ٢ and ٣ gave same results (Figure ٣ and Figure ٤) which could be attributed to capability of PC-SAFT for representing non-ideal behavior of the liquid phase. In sample ١, predictive Wilson, predictive UNIQUAC and UNIFAC models respectively had highest performance and agreement with experimental data.

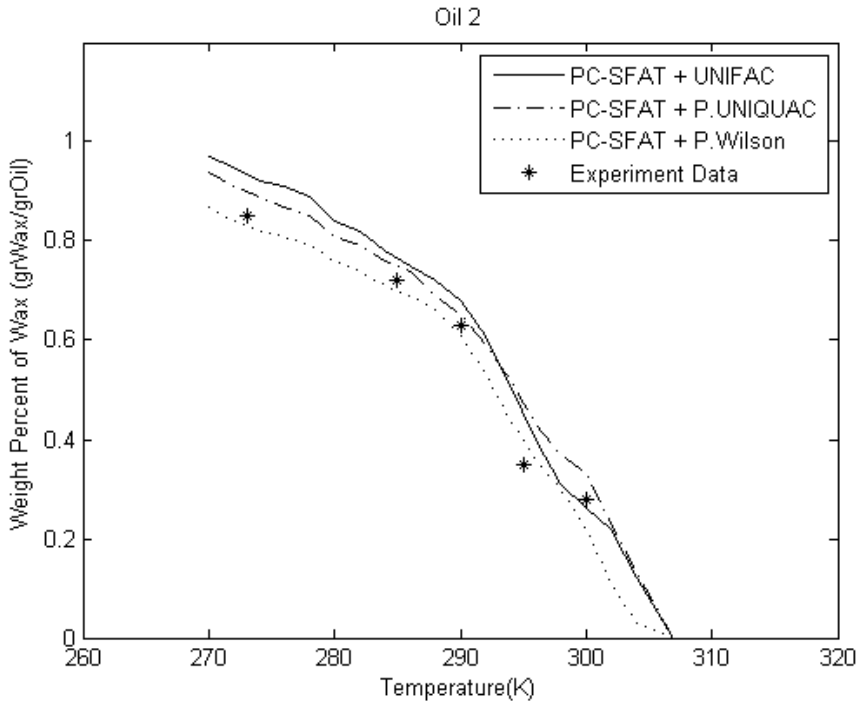

Figure ٣. Calculated and experimental amount of wax Precipitation for oil sample ٢.

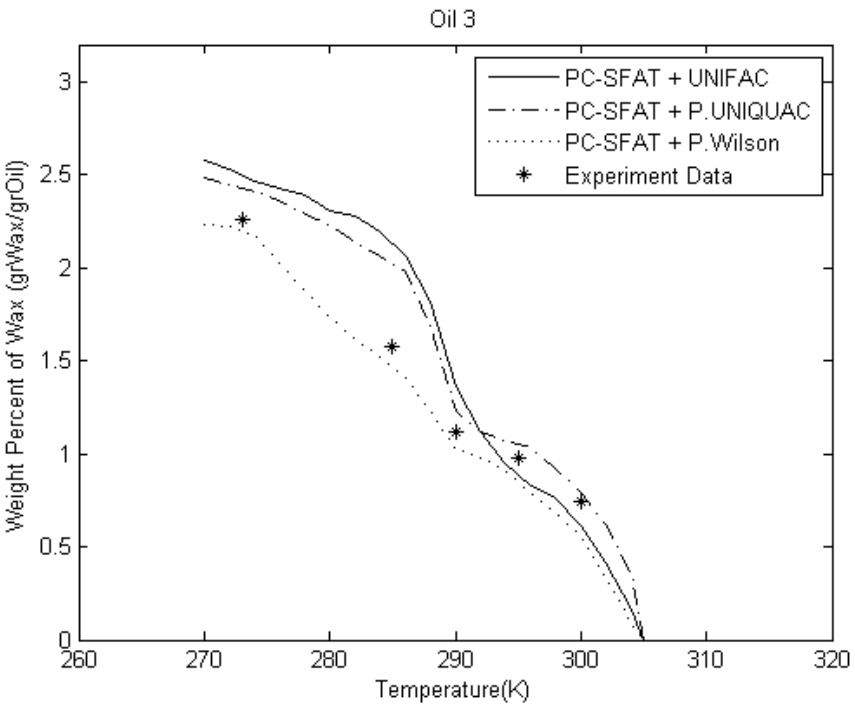

Figure ٤. Calculated and experimental amount of wax Precipitation for oil sample ٣.

As seen in Figures ٣ and ٤, all three models had proper performance similar to sample ١. For sample ٢, predictive Wilson, UNIFAC and predictive UNIQUAC models respectively had highest efficiency for solid phase. Performance of the models for sample ٣ was similar to sample ١.

Normalized Root Mean Square Error (NRMSE)was employed as a criterion to evaluate accuracy of models, defined by Eq. (١٩) and Eq. (٢٠) [٢٥]:

$$NRMSE = {RMSE}/{(x_{max} - x_{min})} \qquad (١٩)$$

$$RMSE = \sqrt{\sum_{١}^{n} \left({(x_{exp} - x_{model})^{٢}}/{n} \right)} \qquad (٢٠)$$

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The NRMSE was computed over the entire experimental temperature range, spanning from the Wax Appearance Temperature (WAT) down to the final cooled temperature of −٣٢ °C. The NRMSE values obtained for all three oil samples using the UNIFAC, predictive UNIQUAC, and predictive Wilson models are summarized in Table ٢. To evaluate potential systematic biases across different temperature regions, an additional zone-based error analysis was performed. The corresponding AAD (%) and MAE values for the near-WAT and low-temperature regions are summarized in Table ٣. Near the WAT region (T > ١٠ °C), the Average Absolute Deviation (AAD%) for all models was higher (averaging ١٢,٤٪), which can be attributed to minor kinetic delays in nucleation not captured by equilibrium thermodynamics. Conversely, in the low-temperature region (T < ٠ °C), the AAD% dropped significantly to less than ٤,٢٪, confirming that thermodynamic equilibrium is fully established at lower temperatures. The predictive Wilson model consistently demonstrated the lowest error across all temperature zones, confirming its statistical robustness.

Table ٢. NRMSE values for predicting wax Precipitation of oil samples with different models accounting for non-ideality of solid phase.

NRMSE	Sample ١	Sample ٢	Sample ٣
UNIFAC	٠,٥٩٨٢	٠,٢٦٦٤	٠,١٣٦٦
P. UNIQUAC	٠,٢٥٧٨	٠,٣١٩٣	٠,٠٩٤٢
P. Wilson	٠,١٢٥٧	٠,٢٠٥٠	٠,٠٨٨٦

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Table ٣. Zone-based quantitative error analysis (AAD% and MAE) for model performance

Model	Near WAT (T > ١٠ °C) AAD (%)	Near WAT MAE (wt%)	Low Temp (T < ٠ °C) AAD (%)	Low Temp MAE (wt%)
UNIFAC	١٨,٥	٠,٨٥	٦,٢	٠,٣١
P. UNIQUAC	١٢,٣	٠,٥٢	٤,٨	٠,٢٤
P. Wilson	٦,٤	٠,٢٨	١,٦	٠,٠٩

The molecular-level reason behind the superior performance of the predictive Wilson model compared to UNIFAC and predictive UNIQUAC lies in its unique formulation of local composition. While UNIFAC assumes random mixing of functional groups and ignores the long-chain structural integrity of heavy paraffins, and UNIQUAC is highly sensitive to the defined coordination number, the predictive Wilson model directly accounts for the differences in molecular size and the local concentration of unlike paraffin segments in the solid solution. This allows the predictive Wilson model to better capture the energetic non-ideality and local structural distortion of the solid wax lattice as different carbon-number paraffins co-crystallize.

To address the generalizability of these findings, the proposed PC-SAFT + predictive Wilson thermodynamic framework is highly robust for waxy crude oils characterized by high paraffin-to-asphaltene ratios, where normal paraffins dominate the solid-phase behavior. However, for crude oil systems containing exceptionally high concentrations of asphaltenes (e.g., > ٥ wt%), the strong interaction between polar asphaltene aggregates and waxy molecules may induce co-precipitation or alter the wax nucleation kinetics. In such cases, additional cross-association parameters in PC-SAFT and modifications to the solid activity coefficients would be required to maintain high predictive accuracy.

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From a practical flow assurance engineering perspective, the accurate thermodynamic forecasting of both WAT and the cumulative wax precipitation curve provided by the predictive Wilson + PC-SAFT model is of paramount importance. Engineers can utilize this precise framework to establish optimal operating temperature safety margins for subsea pipelines, ensuring that the bulk fluid temperature remains safely above the WAT. Furthermore, by predicting the exact mass of wax expected to deposit at lower temperatures, operators can quantitatively optimize the dosage of chemical wax inhibitors and pour-point depressants, and scientifically schedule pigging frequencies, thereby minimizing production downtime and preventing catastrophic pipeline blockages.

Regarding NRMSE values given in table ٢, this approach confirms deductions from figure ٢-٤. Furthermore, there is a meaningful increase in precision of all three models with increase of wax in samples from sample ١ to sample٣. This difference in precision can be result of reduction in error of Precipitation amount measurement due to increase in amount of sediment.

٥. Conclusion

The core novelty of this work was the successful application and comparative analysis of UNIFAC, predictive UNIQUAC, and predictive Wilson models coupled with PC-SAFT for real Iranian crude oils. The findings demonstrate that while all models are qualitatively capable, the predictive Wilson model reduces NRMSE by an average of ٣٣٪, providing a superior thermodynamic framework for predicting wax precipitation in complex natural petroleum systems. This precise thermodynamic modeling allows flow assurance engineers to set safer operating temperature margins and cost-effectively plan pipeline design and maintenance protocols.

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Data Availability

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used generative AI technologies solely to improve the English language and grammar of the manuscript. After using these services, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Nomenclature

English Letters

Symbol	Definition	Unit
fl	Fugacity of component i in the liquid phase	Pa
fs	Fugacity of component i in the solid phase	Pa
m	PC-SAFT chain (segment) number	—
Mw	Molecular weight	g/mol
n	Number of experimental data points	—
NRMSE	Normalized root mean square error	—
qi	UNIQUAC surface area parameter	—
R	Universal gas constant	J/(mol.K)
ri	UNIQUAC volume parameter	—
RMSE	Root mean square error	—
S	Specific gravity	—
T	Temperature	K
Tif	Melting (fusion) temperature of component i	K
xexp	Experimental value	—
xi	Mole fraction of component i	—
xmax	Maximum experimental value	—
xmin	Minimum experimental value	—
xmodel	Model-predicted value	—
Z	Coordination number	—

Greek Letters

Symbol	Definition	Unit

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\Delta CPi	Difference between liquid and solid heat capacities	J/(mol.K)
\Delta Hif	Enthalpy of fusion	J/mol
\Delta Hisub	Enthalpy of sublimation	J/mol
\Delta Hitr	Solid–solid transition enthalpy	J/mol
\Delta Hivap	Enthalpy of vaporization	J/mol
\varepsilon/k	Dispersion energy parameter	K
\gammai	Activity coefficient of component i	—
\Lambdaij	Wilson interaction parameter	—
\Phii	Volume fraction	—
\sigma	Segment diameter	Å
\thetai	Surface area fraction	—

Abbreviations

Abbreviation	Definition
BP-٢٣٧	British Petroleum standard method for wax determination
EOS	Equation of State
MPR	Modified Peng–Robinson equation of state
PC-SAFT	Perturbed-Chain Statistical Associating Fluid Theory
UNIFAC	UNIversal Functional Activity Coefficient
UNIQUAC	UNIversal QUAsi-Chemical
WAT	Wax Appearance Temperature
WDT	Wax Disappearance Temperature

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