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Research Article

Compositional Modeling for Optimum Design of Water-Alternating CO_2-LPG EOR under Complicated Wettability Conditions

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The addition of LPG to the CO_2 stream leads to minimum miscible pressure (MMP) reduction that causes more oil swelling and interfacial tension reduction compared to CO_2 EOR, resulting in improved oil recovery. Numerical study based on compositional simulation has been performed to examine the injectivity efficiency and transport behavior of water-alternating CO_2-LPG EOR. Based on oil, CO_2, and LPG prices, optimum LPG concentration and composition were designed for different wettability conditions. Results from this study indicate how injected LPG mole fraction and butane content in LPG affect lowering of interfacial tension. Interfacial tension reduction by supplement of LPG components leads to miscible condition causing more enhanced oil recovery. The maximum enhancement of oil recovery for oil-wet reservoir is 50% which is greater than 22% for water-wet reservoir. According to the result of net present value (NPV) analysis at designated oil, CO_2, propane, and butane prices, the optimal injected LPG mole fraction and composition exist for maximum NPV. At the case of maximum NPV for oil-wet reservoir, the LPG fraction is about 25% in which compositions of propane and butane are 37% and 63%, respectively. For water-wet reservoir, the LPG fraction is 20% and compositions of propane and butane are 0% and 100%.

1. Introduction

CO_2 injection has been found to be an efficient method for oil recovery worldwide through a miscible or an immiscible displacement process. Mechanism of CO_2 enhanced oil recovery (EOR) is divided into two different processes, miscible flood and immiscible flood. Although miscible gas injection is a widely applied EOR process, it can be only applied when the reservoir pressure is higher than minimum miscible pressure (MMP). The main process of miscible gas injection is displacement efficiency improvement by oil viscosity reduction and swelling effect to reduce residual oil saturation. When reservoir pressure is higher than MMP, the injected CO_2 and reservoir oil are completely miscible and the displacement efficiency can be enhanced by zero interfacial tension [1]. Immiscible flood is usually applied when reservoir pressure is insufficient to miscible flood or reservoir oil contains many heavy components. The effects of immiscible flood are similar to miscible flood, but one major disadvantage is the limited solubility of CO_2 in oil, resulting in the restricted swelling effect and viscosity reduction.

Injected CO_2 and reservoir oil can be miscible by continuous contact. At the fore-end of injected fluid, CO_2 is persistently contacted with fresh oil following flow direction, and they are eventually miscible by the vaporizing-gas drive process. In contrast, at the back-end of injected CO_2, near injection well, reservoir oil is continuously contacted with fresh CO_2 that causes the miscible state by the condensing-gas drive process [2]. CO_2 miscible flood making high enhanced oil recovery effect has a limit that it can be only applied when the reservoir pressure is higher than MMP. It can be settled by the application of CO_2-LPG EOR that is able to lower MMP less than that from the application of only CO_2 EOR. The addition of alkane solvents to the CO_2 injection generally accelerates swelling oil, reducing oil viscosity and decreasing the interfacial tension that can lead

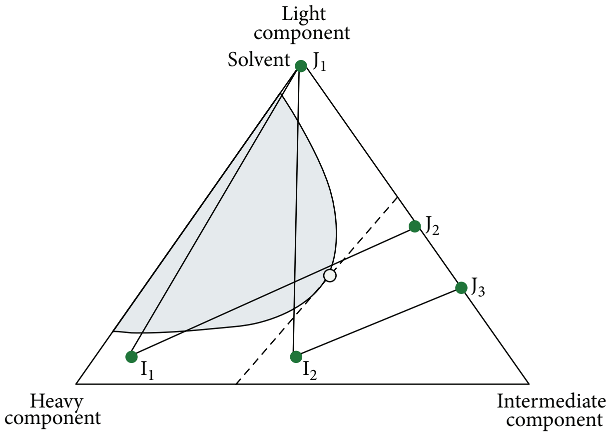


Figure 1: Phase ternary diagram for reservoir oil and injection gas relation [5].

Table 1: Modelled fluid composition for Weyburn oil.

Components	Mole fraction
N_2	0.0207
CO_2	0.0074
H_2S	0.0012
CH_4	0.0749
C_2H_6	0.0422
C_3H_8	0.0785
i-C_4 to n-C_4	0.0655
i-C_5 to n-C_5	0.0459
C_{6+}	0.6637
Total	1

to better performance in enhancing oil recovery [3]. The effects of CO_2-LPG injection are verified by the experiment [4].

Figure 1 indicates the ternary diagram of phase behavior of reservoir oil and injected solvent. J and I signify injected fluid and reservoir oil. In the inner area of the ternary diagram curve, two phases of the reservoir fluid exist. In case of J_1-I_2, only CO_2 is injected into reservoir oil I_2. J_1 and I_2 cannot be miscible at the first contact because the line passes through the two-phase area. However, they arrive at miscible condition by multiple contact miscibility process. The J_1-I_1 line lies on the two-phase territory and both points J_1 and I_1 are located in the same side on the basis of limiting tie line. Therefore, J_1-I_1 cannot be miscible by first and multiple contact miscibility process. At J_2-I_1 and J_3-I_1 cases, first and miscible contact miscibility process is available. By the addition of LPG to the CO_2 stream, the location of injected solvent is moved from J_1 to J_2 or J_3 depending on the amount of injected LPG. It makes miscible condition from J_1-I_1 case that was not supposed to be miscible.

To improve sweep efficiency, WAG (water-alternating-gas) process is applied to CO_2-LPG EOR method in this research. At the same WAG condition, injected LPG amount and composition are the variables considered in the study. Many experimental researches about the effects of LPG and impurities on MMP with oil have been actively developed [6]. Several established researches demonstrate the MMP reduction and oil recovery enhancement by CO_2-LPG EOR through only experimental ways [7, 8], but numerical approach to analyze the effectiveness of CO_2-LPG EOR was not included. Shokir [9] developed ACE algorithm model to analyze the effects of impurities on MMP between injected fluid and oil, but it could not explain how lower MMP affects oil recovery. Talbi et al. [3] conducted experimental research on oil swelling, viscosity reduction, interfacial tension reduction, and oil recovery improvement that resulted from injecting solvents into CO_2. However, if it is applied to field scale, it should be time consuming, so reservoir simulation model for CO_2-LPG flood is positively necessary. Recently, Teklu et al. [10] showed MMP reduction effect by CO_2-LPG flood in various reservoir scenarios using simulation model, but it focused on only the relationship between pore confinement, permeability, and MMP in shale reservoirs. It also does not make connection between MMP reduction and oil recovery in consideration of gas transport in porous media. Recent studies based on the modeling of spontaneous imbibition also indicated that transport properties of oil are affected by wettability condition [11, 12]. For this reason, different wettability conditions are applied for analyzing the performance of CO_2-LPG EOR.

It has been identified that CO_2-LPG flood is an effective method for MMP reduction causing oil recovery enhancement through many experimental studies. Compositional model for CO_2-LPG EOR is necessary to investigate how gas transport affects MMP reduction and oil recovery enhancement. In this research, compositional fluid and multiphase simulation models are developed and injected LPG mole fraction and composition are optimized based on recent oil, CO_2, propane, and butane prices for maximum net present value (NPV).

2. Numerical Simulation

2.1. Fluid Modeling. Fluid data of Weyburn reservoir is referred for NPV based solvent injection simulation. Weyburn reservoir, located in southeast Saskatchewan and operated by PanCanadian Petroleum Ltd., has reached its economic limit of production by waterflooding. The reservoir is a target for CO_2 miscible flooding to enhance oil recovery. The oil composition is shown in Table 1 and comparison between computed fluid model properties and actual fluid data of Weyburn reservoir is given in Table 2 [13]. Oil gravity, formation volume factor, and gas-oil ratio are calculated through regression process to match separator experimental data. Saturation pressure is also computed by regression process. Details of the calculation techniques for saturation pressure can be found in [14]. Acceptable match of computed properties from fluid model and Weyburn's data increases reliability of the fluid model for compositional simulation.

Table 2: Comparison between properties of fluid model and Weyburn data.

Parameters	Fluid model	Weyburn
Saturation pressure (psi)	688	713
Oil gravity (°API)	47	31
Formation volume factor (bbl/STB)	1.11	1.12
Gas-oil ratio (SCF/STB)	166	32
Minimum miscibility pressure (psi)	1,996	2,059

Phase behavior of fluid model was determined by Peng-Robinson EOS [15] with the reservoir oil and injected fluid composition. The PR EOS is given by

$$p = \frac{RT}{v-b} - \frac{a}{v(v+b)+b(v-b)}, \tag{1}$$

or in terms of Z factor,

$$Z^3 - (1-B)Z^2 + \left(A - 3B^2 - 2B\right)Z - \left(AB - B^2 - B^3\right) = 0, \tag{2}$$

and $Z_c = 0.3074$.

The EOS constants for pure components are given by

$$\begin{aligned} A &= a\frac{p}{(RT)^2}, \\ B &= b\frac{p}{RT}, \\ a &= \Omega_a^o \frac{R^2T_c^2}{p_c}\alpha, \\ b &= \Omega_b^o \frac{RT_c}{p_c}, \\ \alpha &= \left[1 + m\left(1 - \sqrt{T_r}\right)\right]^2, \end{aligned} \tag{3}$$

where $\Omega_a^o = 0.45724$, $\Omega_b^o = 0.07780$, and

$$m = 0.37464 + 1.54226\omega - 0.26992\omega^2. \tag{4}$$

Robinson and Peng [16] proposed a modified m for heavier components ($\omega > 0.49$) as follows:

$$m = 0.3796 + 1.485\omega - 0.1644\omega^2 + 0.01667\omega^3. \tag{5}$$

Fugacity expressions are given by

$$\begin{aligned} \ln\phi_i &= Z - 1 - \ln(Z-B) \\ &\quad - \frac{A}{2\sqrt{2}B}\left(\frac{B_i}{B} - \frac{2}{A}\sum_{j=1}^{N} y_i A_{ij}\right)\ln\left[\frac{Z + \left(1+\sqrt{2}\right)B}{Z - \left(1-\sqrt{2}\right)B}\right], \end{aligned} \tag{6}$$

where mixing rules are used for multicomponent fugacity expression as follows:

$$\begin{aligned} A &= \sum_{i=1}^{N}\sum_{j=1}^{N} y_i y_j A_{ij}, \\ B &= \sum_{i=1}^{N} y_i B_i, \\ A_{ij} &= \left(1 - k_{ij}\right)\sqrt{A_i A_j}, \end{aligned} \tag{7}$$

where k_{ij} is binary-interaction parameters.

Multiple mixing cell method [17] was applied to fluid model to estimate MMP between injected CO_2 and reservoir oil. Multiple mixing cell method follows the order below.

(1) Specify the reservoir temperature and an initial pressure.

(2) Calculate the tie-line length for each pressure step by using the equation below:

$$TL = \sqrt{\sum_{i=1}^{N_c}\left(x_i - y_i\right)^2}, \tag{8}$$

where N_c is the number of components and x_i and y_i are liquid and gas equilibrium compositions, respectively.

(3) Draw a tie-line length graph as a function of pressures.

(4) Perform a multiple-parameter regression of the minimum tie-line lengths to determine the exponent n in $TL^n = aP + b$ (power-law extrapolation). These parameters are determined when correlation coefficient exceeds 0.999.

(5) Determine the MMP when the power-law extrapolation gives zero of minimum tie-line length.

After generating the fluid model which has approximate MMP to Weyburn fluid, MMPs were computed between oil and LPGs. The composition of LPG is propane 63% and butane 37%, and the calculated MMPs are indicated in Table 3. MMPs of LPG (composition: propane 100% and butane 0%) mole fraction 20% and 25% are 1,747 psi and 1,614 psi.

2.2. Interfacial Tension Calculations.

The equation for calculating interfacial tension in multicomponent systems is as follows [18]:

$$\sigma^{1/4} = \sum_{i=1}^{n_c} p_{ar_i}\left(x_i\rho_L - y_i\rho_g\right), \tag{9}$$

where σ is the interfacial tension between liquid and gas phases (dyne/cm) and ρ_L and ρ_g are molar densities of liquid and gas phases (mole/cm^3), respectively. The parachor (p_{ar_i}) is defined as follows:

$$p_{ar_i} = \xi \mathrm{CN}_i, \tag{10}$$

Table 3: MMP estimates for injection gas according to LPG mole fraction.

LPG mole fraction (%)	MMP (psi)
0	1,996
5	1,995
10	1,825
15	1,820
20	1,412
25	1,354
30	1,046

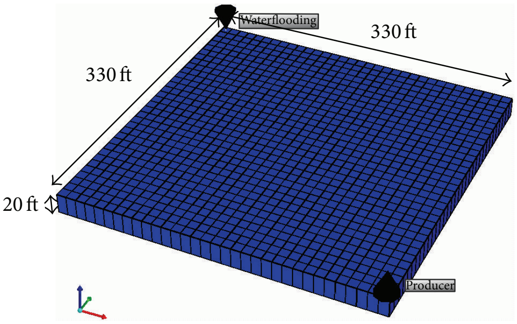


Figure 2: 3D view of simulation model.

where

$$\xi = \begin{cases} 40, & \mathrm{CN} \le 12, \\ 40.3, & \mathrm{CN} > 12, \end{cases} \tag{11}$$

and CN is the carbon number of the components i.

2.3. Reservoir Modeling. The reservoir model was assumed as 2D model which is discretized into 33 × 33 × 1 grid blocks. Each grid block has dimension as 10 ft × 10 ft × 20 ft as shown in Figure 2. The model size is general one injector-one producer scale of 10-acre five-spot model [19]. This simulation study utilized homogeneous 2D areal model not considering heterogeneity and gas overriding effect. Without these effects, oil recovery can be governed only by displacement efficiency from LPG addition and can be expected near 100% [20].

Contact angle which is a determinant for wettability is defined by Young's equation as follows:

$$\cos\theta = \frac{\sigma_{os} - \sigma_{ws}}{\sigma_{ow}}, \tag{12}$$

where σ_{os}, σ_{ws}, and σ_{ow} are oil-solid, water-solid, and oil-water interfacial tensions. As indicated in the above equation, if σ_{os} is greater than σ_{ws}, θ is smaller than 90°, so the reservoir rock exhibits water-wet solid. The inverse case is oil-wet condition. Water-wet and oil-wet reservoirs have the constant porosity and isotropic permeability is also assumed. Reservoir initial conditions are shown in Table 4. The porosity, permeability, and relative permeability were gained from the same reservoir, and two different relative permeability curves (Figure 3) are used in this simulation for establishing different residual oil saturation and mobility [21]. The relative permeability curves are predicted by simulations. Simulation methods to predict relative permeability are already verified by previous studies [22, 23] and similar water relative curve can be found. Residual oil saturations of oil- and water-wet reservoirs are 18% and 15%, respectively.

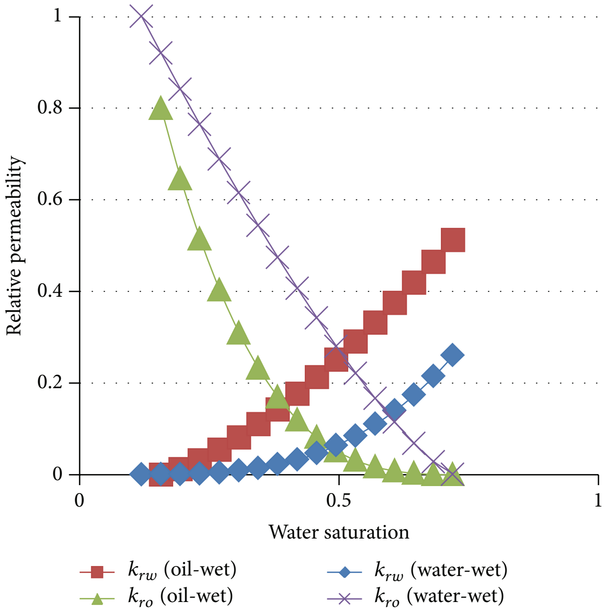


Figure 3: Relative permeability curves for different wettability conditions.

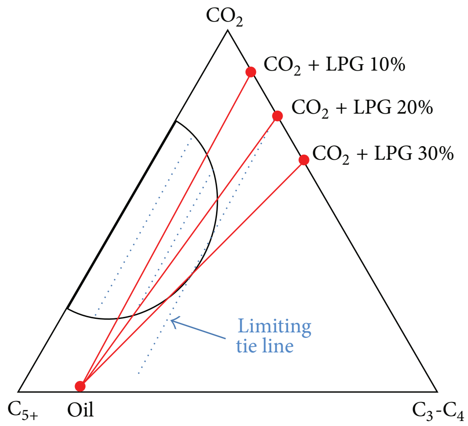


Figure 4: Ternary diagram for CO_2/LPG/Oil system at reservoir pressure 1,500 psi.

After waterflooding for three years, water-alternating CO_2 EOR and CO_2-LPG EOR were applied to water- and oil-wet reservoirs for ten years. WAG cycle of CO_2 and CO_2-LPG EOR is 1 : 1, and one cycle period is 6 months. Production pressure is 1,500 psi which is within a limitation of miscible condition by first or multiple contact miscibility process when added LPG concentration is larger than 20% (Figure 4). Injected LPG mole fraction and composition are indicated in Table 5.

Table 4: Properties of reservoir rock and fluids.

Properties	Values
Depth (ft)	4,000
Pressure (psi)	2,000
Temperature (°F)	145
Permeability (md)	122
Porosity (%)	24
Oil saturation (S_o)	0.64
Water saturation (S_w)	0.36

Table 5: Operating conditions and injection design parameters.

Properties	Values
Producing pressure at bottom hole (psi)	1,500
Total injection (PV)	1.5
Period (years)	10
WAG ratio	1 : 1
Injected LPG mole fraction (%)	0, 10, 15, 20, 25, and 30
Injected LPG composition (propane : butane)	100 : 0, 63 : 37, 37 : 63, and 0 : 100

2.4. Net Present Value. The NPV of a time series of cash flows is defined as the sum of the present values. NPV considering prices of oil, CO_2, propane, and butane and costs of water injection and produced water handling is calculated by the following equation [24]:

$$\text{NPV} = \sum_{t=1}^{T} \frac{R_t}{(1+I)^t}, \tag{13}$$

where T is total production period (day), t is time, R_t is net profit at time t, and I is daily discount rate. I is estimated by yearly discount rate as

$$I = e^{\ln(1+\text{Yearly discount rate})/365} - 1, \tag{14}$$

where yearly discount rate is 10% and R_t is defined by the difference between the profit from oil production and total investment costs at time t:

$$\begin{aligned} R_t = Q_o P_o - \big(&Q_{CO_2} P_{CO_2} + Q_{C_3} P_{C_3} \\ &+ Q_{C_4} P_{C_4} + Q_{w_1} P_{w_1} + Q_{w_2} P_{w_2}\big), \end{aligned} \tag{15}$$

where Q_o, Q_{CO_2}, Q_{C_3}, Q_{C_4}, Q_{w_1}, and Q_{w_2} are oil production rate (bbl/day), CO_2 injection rate (lb/day), propane injection rate (lb/day), butane injection rate (lb/day), water injection rate (bbl/day), and water production rate (bbl/day). Parameters P_o, P_{CO_2}, P_{C_3}, P_{C_4}, P_{w_1}, and P_{w_2} are oil price (\$/bbl), CO_2 price (\$/lb), propane price (\$/lb), butane price (\$/lb), water injection cost (\$/bbl), and produced water handling cost (\$/bbl). All values of parameters for NPV calculation are shown in Table 6 [25, 26].

Table 6: Economic parameters for optimal design.

Parameters	Values
Oil (\$/bbl)	80
CO_2 (\$/ton)	80
Propane (\$/ton)	800
Butane (\$/ton)	850
Water injection (\$/bbl)	0.25
Produced water handling (\$/bbl)	1.5

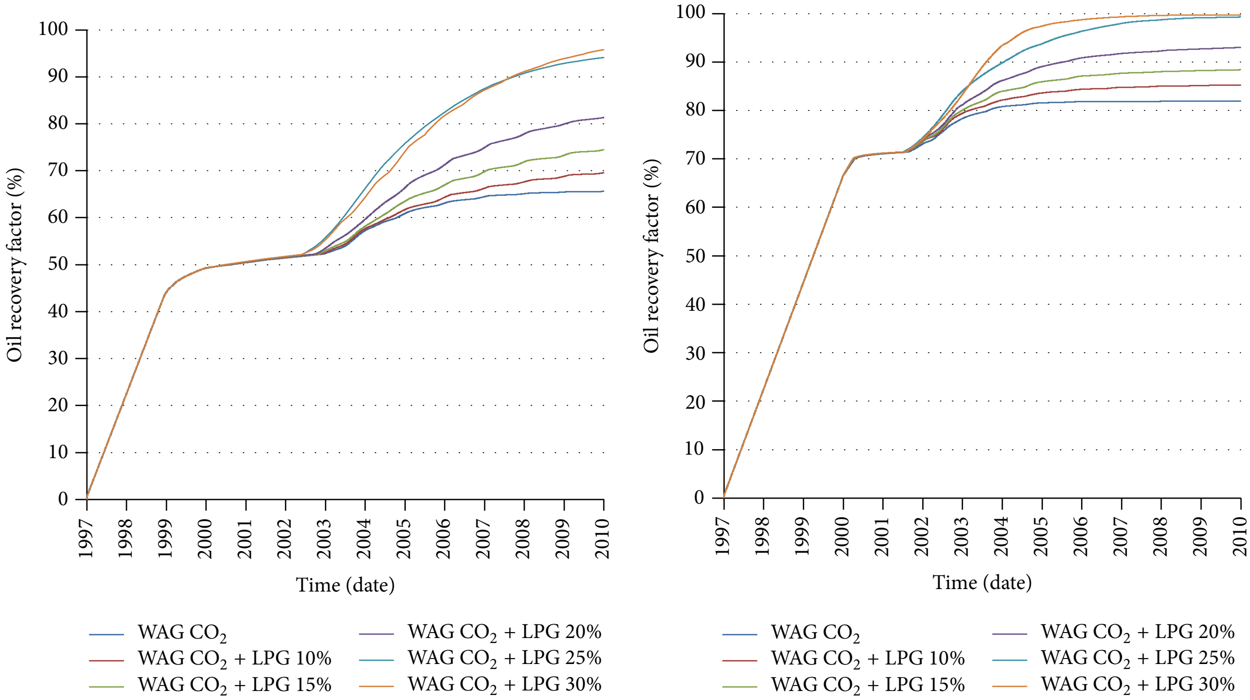
3. Results and Discussion

3.1. Oil Production. The aim of this study is to confirm the effectiveness of water-alternating CO_2-LPG EOR process in oil recovery for different reservoirs. The performance of CO_2-LPG injection process has been compared with that of CO_2 WAG process. LPG is composed of 63% propane and 37% butane. Results of oil recovery with various LPG concentrations are indicated in Figure 5. Increased oil recoveries for oil- and water-wet reservoirs by CO_2-LPG flood are 46% and 22%. For both wettability conditions, the higher LPG mole fraction is injected, the more oil is produced. However, significant differences are not found if LPG mole fraction is greater than 25%. The tendency is also identified by experimental results in the literature [7]. To detect the influence of LPG composition in the injected fluid, oil recoveries with different ratio of propane and butane (LPG 15%) are shown in Figure 6. Figure 6 shows that the higher fraction of butane causes more enhanced oil recovery. Increments of oil recovery for oil- and water-wet reservoirs are 25% and 15% as compared with CO_2 EOR. This phenomenon was already revealed by the experimental study and it was explained that the result is because of higher mole weight [27].

When reservoir oil and injected gas are miscible, gas saturation decreases further than immiscible condition (Figure 7). Injected gas reached production well at around 2004, so the gas saturation of WAG CO_2 case increased abruptly. However, in case of WAG CO_2 + LPG 30%, the gas saturation did not increase even though injected gas already reached production well. It indicates that miscible condition reduces gas saturation. The reduction of gas saturation causes a decrease in gas relative permeability (Figure 8). As both gas saturation and relative permeability decline, liquid saturation and relative permeability increase, which leads to the enhancement of oil recovery.

The addition of LPG to CO_2 stream is more effective to lower interfacial tension between oil and gas phases. In particular, if the reservoir is in miscibility condition, interfacial tension reaches zero [1]. As shown in Figure 9(a), the swept zone is left in nonzero interfacial area, so reservoir is not in miscible condition by only CO_2 injection. In contrast, the addition of LPG to CO_2 stream as 20% brings the swept area into zero interfacial zone indicating miscible condition (Figure 9(b)). Zero interfacial tension indicates that oil and gas become single-phase, so it flows easier than two-phase fluid.

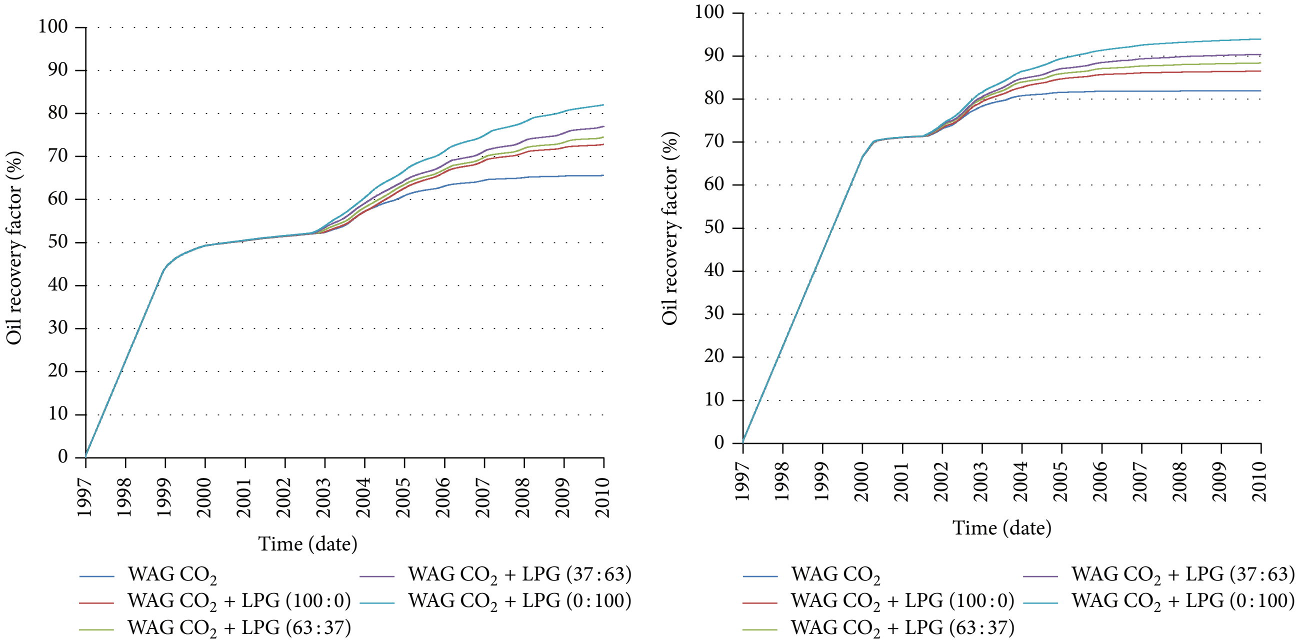
If more butane content is injected than propane, more oil recovery is expected because of its higher molecular weight.



(a) Oil-wet

(b) Water-wet

Figure 5: Oil recovery factors with LPG mole fraction of injection gas for different wettability conditions (composition of LPG: propane 63%, butane 37%).



(a) Oil-wet

(b) Water-wet

Figure 6: Oil recovery factors with LPG composition for different wettability conditions (LPG mole fraction of injection gas: 15%).

It was proved that butane is much more effective in MMP reduction [27]. The addition of alkane solvents to the CO_2 stream accelerates the process of reducing oil viscosity; thus, it leads to higher oil recovery [4]. To compare the aspect of oil recovery by injected LPG composition, oil saturation in reservoir is shown in Figure 10. Figure 10 indicates the oil saturation when LPG mole fraction is 25% for oil-wet reservoir after 6 months from the end of waterflooding. In case of 100% propane, oil saturation near injection well is zero because of immaculate expulsion and it is 0.5 at the fore-end

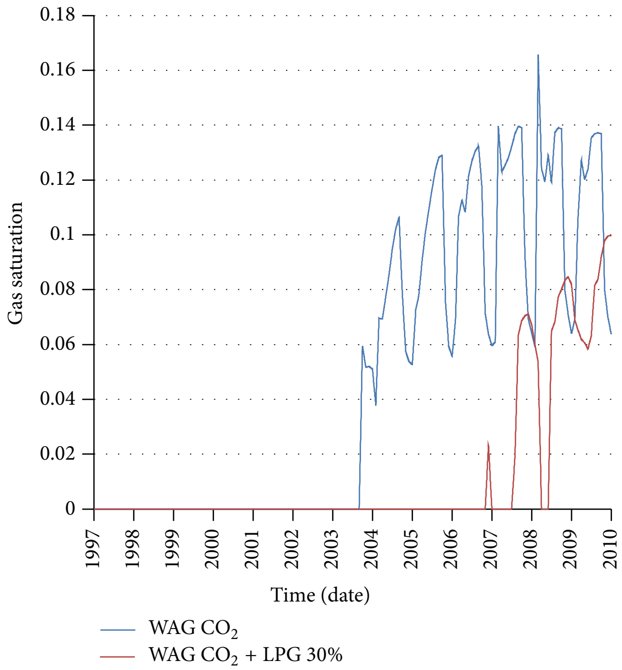


Figure 7: Gas saturation with LPG mole fraction of injection gas near production well for oil-wet condition.

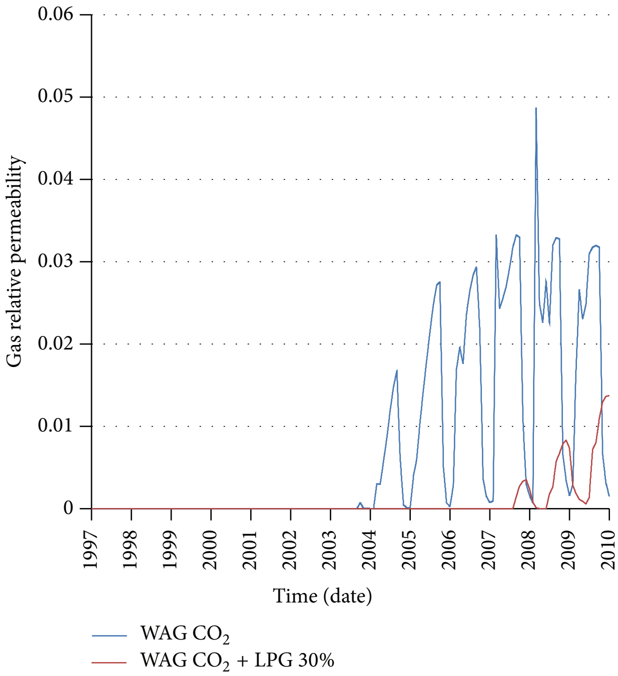


Figure 8: Gas relative permeability with LPG mole fraction of injection gas near production well for oil-wet condition.

of injected fluid (Figure 10(a)). In case of 100% butane, zero zone of oil saturation is more widespread with near wellbore as a center. Furthermore, oil saturation at the fore-end is 0.7 which is higher than that in the case of 100% propane because more oil is displaced from wider area (Figure 10(b)).

Tables 7 and 8 indicate the amount of increase in maximum NPV after waterflooding for different wettability conditions. NPVs are calculated according to LPG concentration and composition. The maximum NPV increments by CO_2 WAG are 12% and 13% for oil- and water-wet reservoirs. As shown in Tables 7 and 8, the maximum value is 24.1% (LPG 25%: propane 63%, butane 37%) for oil-wet reservoir and 17.0% (LPG 20%: propane 0%, butane 100%) for water-wet reservoir. When LPG mole fraction is less than 15% and 20% (propane 100%), maximum increase in NPV is less than CO_2 WAG. These cases are in immiscible condition, so oil recovery is not high compared to the economic feasibility of LPG. Injected fluid and reservoir oil are in miscible condition, and maximum NPV improvements are higher than those of CO_2 WAG cases. Maximum NPV increment by CO_2-LPG EOR occurred for two different wettability conditions, but the effect in oil-wet reservoir is better than in water-wet reservoir because of higher residual oil saturation after waterflooding.

4. Conclusions

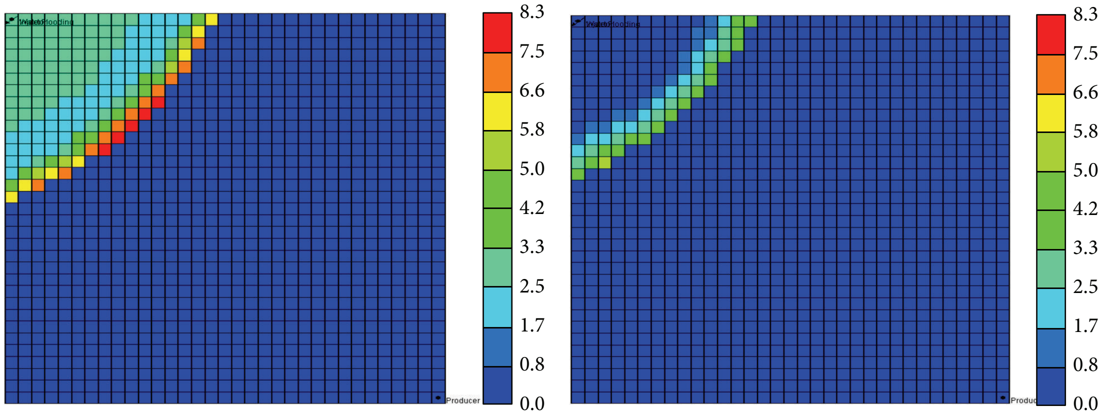
In this study, water-alternating CO_2-LPG EOR simulation model was developed. To examine the efficiency of CO_2-LPG EOR considering oil, CO_2, and LPG prices, extensive simulations have been performed for different wettability conditions and the following conclusions have been drawn.

Table 7: Maximum NPV improvements with LPG mole fraction and composition for oil-wet reservoir (base case: $2,652,887).

	Maximum NPV improvements (%)				
	LPG 10%	LPG 15%	LPG 20%	LPG 25%	LPG 30%
Propane 100% Butane 0%	10.7	11.0	11.8	12.8	20.0
Propane 63% Butane 37%	9.3	10.3	13.0	24.1	19.2
Propane 37% Butane 63%	9.0	10.9	18.4	19.2	15.4
Propane 0% Butane 100%	9.2	13.8	22.5	17.3	13.0

Table 8: Maximum NPV improvements with LPG mole fraction and composition for water-wet reservoir (base case: $3,387,572).

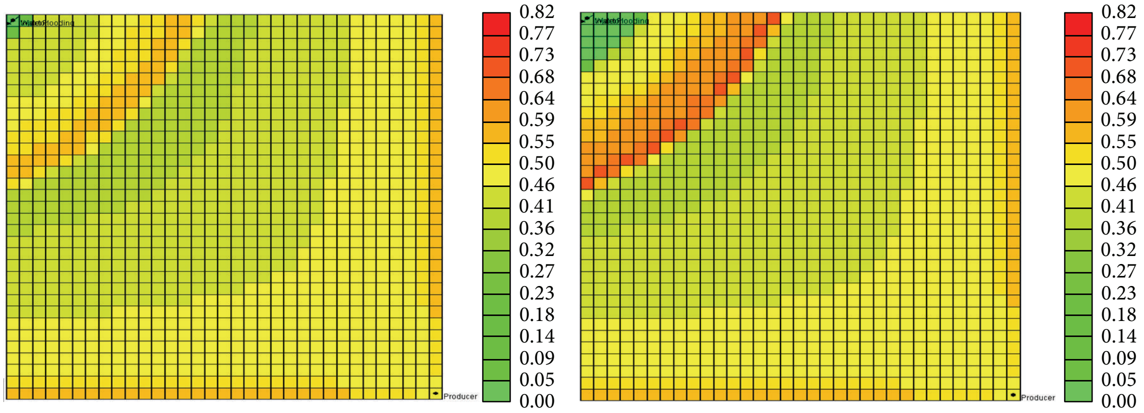
	Maximum NPV improvements (%)				
	LPG 10%	LPG 15%	LPG 20%	LPG 25%	LPG 30%
Propane 100% Butane 0%	12.2	12.0	12.3	12.6	15.5
Propane 63% Butane 37%	11.8	12.2	13.1	16.0	16.7
Propane 37% Butane 63%	11.8	12.5	15.6	16.7	14.2
Propane 0% Butane 100%	11.7	13.6	17.0	15.4	12.4



(a) CO_2 100%

(b) LPG 20%

Figure 9: Interfacial tension between oil and gas phases with injected gas mole fraction after six months of gas injection (LPG composition: 63% propane and 37% butane).



(a) 100% propane

(b) 100% butane

Figure 10: Oil saturation with LPG composition after six months of gas injection (LPG volume fraction of injection gas: 15%).

(1) When LPG concentration is 30% and composition of butane is 100%, oil recovery increased by 46% and 25% for oil-wet reservoir. When LPG concentration is 30% and butane composition is 100%, the maximum increasing amounts are 22% and 15% in case of water-wet reservoir. As injected LPG concentration and butane composition increased, significantly enhanced oil recovery was observed from the reduction of MMP and interfacial tension. Oil recovery for different wettability by CO_2-LPG EOR has become close to 100%.

(2) When LPG concentration is 25% and butane composition is 37%, maximum NPV improvement is 24.1% for oil-wet reservoir. When LPG concentration is 20% and butane composition is 100%, maximum NPV improvement is 17.0% for water-wet reservoir. For both oil- and water-wet reservoirs, when LPG concentrations are 10%, 15%, 20% (propane 100%), and 25% (propane 100%), the reservoir condition is immiscible and maximum NPV increment is lower than CO_2 WAG process. When LPG concentration is higher than 20% (miscible condition), maximum NPV improved and optimum LPG concentration and composition exist for maximum NPV improvement.

(3) CO_2-LPG EOR can be applicable in low pressure reservoirs that CO_2 is not miscible. LPG addition to CO_2 stream can appreciably improve oil recovery by zero interfacial tension bringing miscible condition. Moreover, the optimization of LPG concentration and composition is absolutely necessary for economic feasibility. The necessity of optimization is required more in oil-wet reservoir due to better performance of displacement efficiency.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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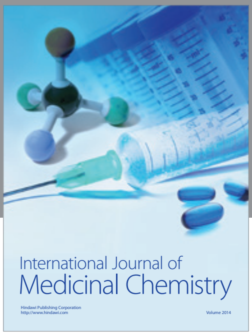
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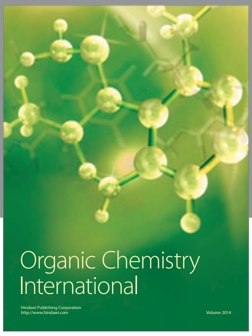
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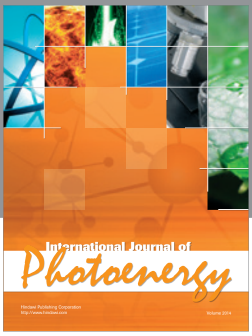
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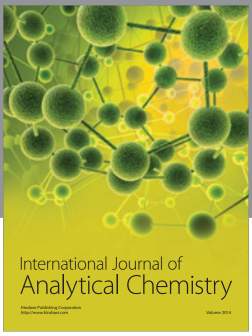
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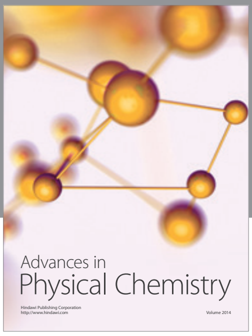
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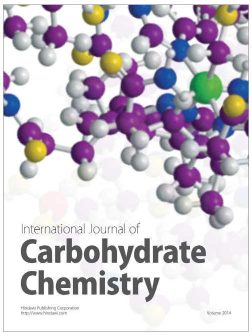
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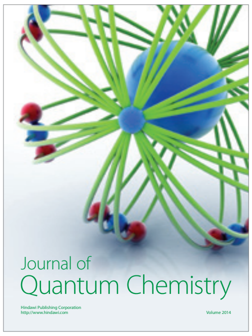
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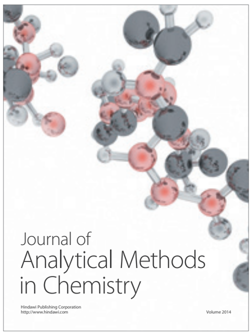
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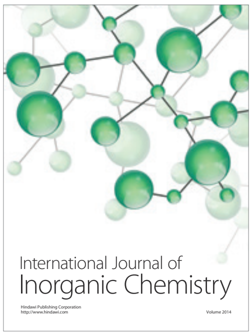
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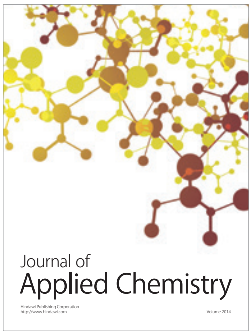
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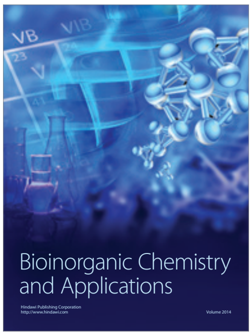
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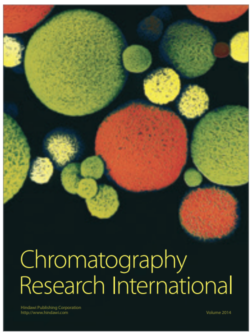
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