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CASE STUDY

CO_2–Oil Miscibility and Minimum Miscibility Pressure (MMP) Prediction*

This case study focuses exclusively on the use of CHEMCAD process simulation software to predict CO_2–oil minimum miscibility pressure (MMP) and phase behavior. CHEMCAD was applied as a thermodynamic and phase-equilibrium modeling tool, enabling rapid miscibility assessment without the need for specialized reservoir simulation software.

CHALLENGE

Accurate determination of the minimum miscibility pressure (MMP) between injected CO_2 and crude oil is a critical design requirement for miscible CO_2-EOR projects. However:

- Experimental MMP measurements are time-consuming and expensive
- Early-stage studies often lack access to dedicated reservoir simulators
- Crude oils exhibit complex, multicomponent compositions

The challenge was to determine whether CHEMCAD, a process simulator, could reliably predict CO_2–oil miscibility and MMP values without tuning to experimental PVT data.

SOLUTION

CHEMCAD v7.1.8 was used to model CO_2–oil phase behavior using the FLASH unit operation.

Modeling Approach

- Crude oils represented as n-alkane pseudo-components (C6–C25+)
- Heavy fractions lumped into a C25 pseudo-component
- Soave–Redlich–Kwong (SRK) equation of state
- Standard van der Waals mixing rules
- No EOS tuning or experimental matching applied

Sensitivity Studies

- CO_2-to-oil mass ratio
- Gas–oil ratio (GOR)
- Dead oil vs. live oil systems

Simulation Configuration

- Gaseous CO_2 feed stream
- Liquid crude-oil feed stream
- Optional light-gas stream (95 mol% CH_4, 5 mol% C_2H_6) to represent live oil
- Iterative pressure increase to identify the lowest pressure at which no free CO_2 gas phase remained after flashing → defined as first-contact MMP

**Adapted from Energies 2020, 13, 6456; doi:10.3390/en13236456.*

RESULTS

CHEMCAD successfully predicted CO_2–oil MMP values with **strong agreement to published experimental data.**

Key Findings

- Benchmark validation against CO_2–n-decane showed close alignment with slim-tube, VIT, and RBA measurements
- For multiple crude oils, predicted MMP values at 313 K clustered around 8.3 MPa
- Increasing reservoir temperature and dissolved gas content increased predicted MMP
- MMP predictions were robust across a wide range of CO_2/oil mass ratios

REPRESENTATIVE CHEMCAD RESULTS

SYSTEM	TEMPERATURE (K)	PREDICTED MMP (MPa)
CO_2 – n-Decane	310.95	~7.8–8.3
CO_2 – Crude Oil (average)	313	~8.3

TANGIBLE BENEFITS

Using CHEMCAD for CO_2–oil miscibility analysis delivers measurable value:

- Rapid screening of CO_2-EOR feasibility
- Reduced reliance on costly laboratory MMP experiments
- Transparent, repeatable thermodynamic workflow
- Flexible sensitivity analysis for:
  - Temperature
  - Oil composition
  - Dissolved gas and impurities
- Enables early-stage decision-making without reservoir simulation software

FIGURE 1 - Streams configuration for MMP calculation using CHEMCAD's FLASH tool

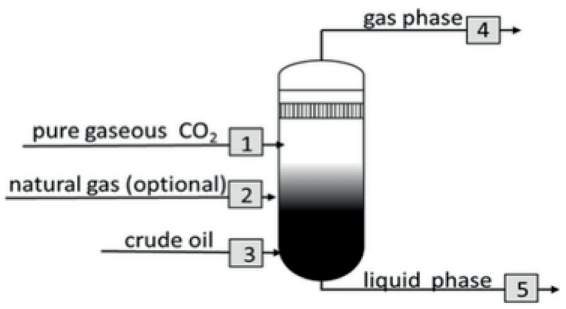

FIGURE 2 - Comparison between experimental MMP values reported by references [38–41] and results calculated by SRK EoS in the CHEMCAD simulator.