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Economic Optimization of Enhanced Oil Recovery and Carbon Storage Using Mixed Dimethyl Ether-Impure CO_2 Solvent in a Heterogeneous Reservoir

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Abstract: CO_2 is the main solvent used in enhanced oil recovery (EOR). However, its low density and viscosity compared to oil cause a decrease in sweep efficiency. Recently, dimethyl ether (DME), which is more efficient than CO_2, has been introduced into the process. DME improves oil recovery by reducing minimum miscible pressure (MMP), interfacial tension (IFT), and oil viscosity. Since DME is an expensive solvent, price reduction and appropriate injection scenarios are needed for economic feasibility. In this study, a compositional model was developed to inject DME with impure CO_2 streams, where the CO_2 was derived from one of these three purification methods: dehydration, double flash, and distillation. It was assumed that such a mixed solvent was injected into a heterogeneous reservoir where gravity override was maximized. As a result, lower oil recovery is achieved for the higher impurity content of the CO_2 stream, lower DME content, and more heterogeneous reservoir. When a high-purity CO_2 stream is used, the change in oil recovery according to DME content and heterogeneity of the reservoir is increased. When the lowest-purity CO_2 stream is used, the net present value (NPV) is the highest. For a homogeneous reservoir, the NPV is highest for all impure CO_2 streams. This optimization indicates a greater impact on revenue from reduced CO_2 purchase cost than on profit loss due to reduced oil recovery by impurities. Additional benefits can be expected when considering solvent reuse and carbon capture and storage (CCS) credits.

Keywords: dimethyl ether (DME); impure CO_2; water-alternating-gas (WAG); heterogeneous reservoir; enhanced oil recovery (EOR); economic evaluation

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1. Introduction

Enhanced oil recovery (EOR) is a method of increasing the amount of oil recovery by injecting a fluid such as steam, polymer, or surfactant into the oil reservoir, ultimately increasing economic returns [1,2]. CO_2 has often been used as a solvent in EOR due to its environmental friendliness as well as being mixed with oil under temperature and pressure conditions in the reservoir [3]. However, the density of CO_2 is slightly lower than that of oil, and the viscosity is much lower [4]. Therefore, the viscous fingering effect, reduction in sweep efficiency, early breakthrough, and unfavorable mobility ratios occur [5,6]. To solve this problem, dimethyl ether (DME), used in fuel additives, aerosol propellants, and heating fuels, was recently introduced as a solvent for EOR [7–9]. DME is converted from methane-rich syngas produced by techniques such as methane reforming [10]. Therefore,

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