Behaviour of Perfluorocarbon Tracers under In Situ Storage Conditions

Matthew Myers¹, Cameron White¹, Alf Larcher¹, Martijn Woltering¹, Vincent Vandeweijer², Cor Hofstee²

¹CSIRO Energy, 26 Dick Perry Avenue, Kensington, WA 6151 Australia
²TNO Geological Survey of the Netherlands

Abstract

Perfluorocarbon tracers are widely used in monitoring and verification programs associated with the storage component of a CCS project. They are most often used as a tracer for CO₂ and assumed to behave identically to CO₂. However, this is often not the case; for example, CO₂ readily dissolves into water while perfluorocarbons are virtually insoluble in water. If perfluorocarbons were used as a tracer to detect a leak from the CO₂ store, it is important that the sediment not retain the tracers as this could lead to a “false negative”. Low pressure ambient temperature laboratory experiments have shown that perfluorocarbon tracers are retained by various types of sediment¹⁻². The retention was particularly pronounced for high surface area and dry sediment. For one type of sediment (from the Illinois FutureGen-II site) under dry conditions, they reported complete retention of perfluorocarbon tracers. They also found that retention was more pronounced for higher molecular weight perfluorocarbons. Furthermore, the behaviour of tracers is likely to be different whether the CO₂ phase is subcritical (i.e. exists as a gas phase) or supercritical (i.e. exists as a solvent). Indeed, field results at K12B (a gas field in the Dutch sector of the North Sea) have shown that presence of methane and the injection pressure influence the observed behaviour of perfluorocarbon tracers at a production well³. In 2004, a mixture of 1 L perfluoromethylcyclopentane (PMCP) and perfluorodimethylhexane (PDMH) was injected together with the first injection of CO₂ (gaseous phase) into the mature K12B gas field. This reservoir consists of moist sandstone, containing CH₄ and CO₂ (gaseous). The tracers were detected in both producers in the field. Evaluation showed that only part of the injected tracers was eventually recovered by the gas producers. As a result of both laboratory and field studies, there is a strong need to understand the behaviour of these tracers under high pressure and/or high temperature conditions.

In this study, high pressure/temperature experiments were conducted under a two pressure (50 bar and 150 bar) conditions and two temperature conditions (30 °C and 80 °C). These conditions allow a comparison in the behaviour at subcritical and supercritical conditions. Furthermore, we have also conducted experiments using 20% CH₄/80% CO₂ to provide information relevant to scenarios that might be present for injection into a depleted gas reservoirs. For these trials, several sediment conditions were analysed (dry quartz sand, water-saturated quartz sand, dry quartz sand containing 1% kaolinite and wet quartz sand containing 1% kaolinite). These experiments do show differences in the behaviour. For the subcritical experiments, the tracers behave very similar to that previous reported. However, under supercritical conditions where the CO₂ or CO₂/CH₄ can act as a solvent, the retention is much less. These results show that perfluorocarbon tracers can be used for the monitoring and verification component of a CCS project; however, care needs to be taken to understand the behaviour of the tracers to prevent a misinterpretation of subsequent field tracer results.
