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Protectiveness, morphology and composition of corrosion products formed on carbon steel in the presence of Cl^- , Ca^{2+} and Mg^{2+} in high pressure CO_2 environments

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Abstract

This study investigates the individual effects of chloride (Cl^-), calcium (Ca^{2+}), and magnesium (Mg^{2+}) ions on the CO_2 corrosion behaviour of carbon steel in simulated CO_2 geologic storage environments (60°C and 100 bar CO_2). The influence of the aforementioned ions was assessed over immersion times from 6 to 96 hours. The corrosion product growth was monitored over this period and related to the extent of both general and localised corrosion. For each test, corrosion product morphology and chemistry were analysed using a combination of scanning electron microscopy (SEM), focused ion beam (FIB) method, energy-dispersive X-ray spectroscopy (EDX) and X-ray diffraction (XRD).

Key words: CO_2 corrosion, supercritical, FeCO_3 , $\text{Fe}_x\text{Ca}_y\text{CO}_3$, $\text{Fe}_x\text{Mg}_y\text{CO}_3$

1. Introduction

As part of the carbon capture and storage process, carbon dioxide (CO_2) is injected into either depleted hydrocarbon reservoirs, or saline aquifers for the purposes of geological storage^[1]. Such formations consist of porous rock which, in the case of a saline aquifer, is filled with brine and can contain high concentrations of dissolved salts.

The pipelines facilitating the injection process receive CO_2 , which descends the vertical injection line and is compressed by its own weight, resulting in the fluid being heated. At the point of injection, CO_2 is generally in a liquid or supercritical state.^[2] For the selection of appropriate pipeline injection materials, two key types of corrosive environment should be considered. When continuous injection of CO_2 is performed, water is displaced from the

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