Wellbore Seal Repair Using Nanocomposite Materials

Award Number: DE-FE0009562

Project Summary:

This project examined ways to repair leakage pathways by modifying polymer cements with various nanomaterials to produce polymer-cement nanocomposites that have superior repair characteristics compared to conventional materials. The first phase of this research effort involved modifying polymer-cement slurries with various nanomaterials to increase their long-term performance in preventing carbon dioxide (CO_2) leakage through the wellbore. The slurries were evaluated at the macro-scale to determine their rheological properties, bond strength, fracture toughness, permeability, and durability against CO_2 and brine water containing CO_2. Microstructural investigations of these nanocomposites were conducted using nuclear magnetic resonance, X-ray diffraction, thermogravimetric analysis, scanning electron microscopy, and nano-scratch tests. The second phase involved testing the ability of the developed nanocomposite materials to repair simulated flawed seal systems. The samples were placed in a pressure cell that mimics the pressures and temperatures found at CO_2 storage depths to measure repair effectiveness and bond testing. The ability of the repair material to withstand supercritical CO_2 was also tested using a specialized system capable of delivering mixtures of CO_2 and water at high pressures and specified flow rates.

Prime Performer:
University of New Mexico

Key Performers:
Epoxy Chemicals, Inc.

Principal Investigator:
John Stormont

Project Duration:
10/01/2012 – 08/31/2016

Performer Location:
Albuquerque, New Mexico

Program:
Carbon Transport & Storage

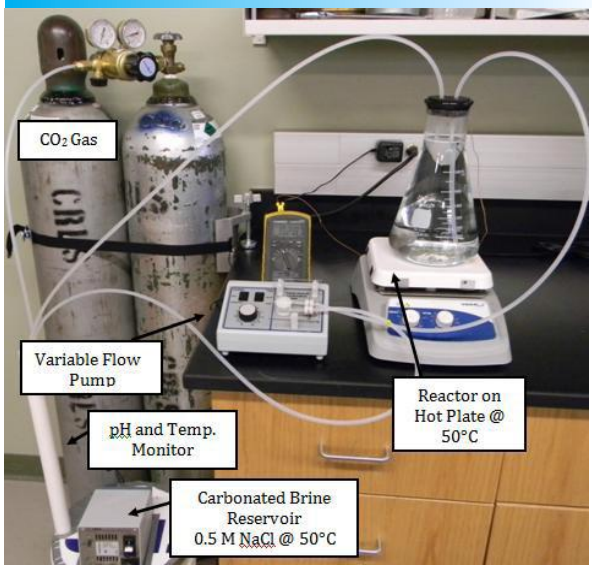

Figure 1: Carbonated-brine set-up to test polymer-cement nanocomposite degradation due to brine fluids like those in carbon storage systems.

Project Outcomes:

Nanocomposite wellbore repair materials were developed, tested, and modeled through an integrated program of laboratory testing and numerical modeling. Numerous polymer-cement nanocomposites were synthesized as candidate wellbore repair materials using various combinations of base polymers and nanoparticles. Novolac epoxy reinforced with multi-walled carbon nanotubes and/or alumina nanoparticles was found to be a superior wellbore seal material compared to conventional microfine cements based on tests of bond strength to steel and cement, ductility, stability, flowability, and penetrability in openings of 50 microns and less. Repair with the nanocomposite epoxy base material was successful in reducing the flow through flaws of various sizes and types and restoring the specimen's performance to compare with an intact condition. Post-test observations confirm the complete penetration and sealing of flaws using the nanocomposite epoxy base material.

Presentations, Papers, and Publications

Final Report: Wellbore Seal Repair Using Nanocomposite Materials (August 2016) – John Stormont