# Nanoparticle Technology for Remediating Leaks of $CO_2$ Storage Formation

**Award Number: DE-FE0026514**

**Project Summary:**

The University of Colorado developed a new technology that can be used to repair wellbore leakage through the electrochemical injection of nanoparticles while simultaneously removing harmful ions from the wellbore. Wellbore healing agents were tested and selected based upon their ability to penetrate deep into the leaking areas and better enhance the mechanical and transport properties of well cement (Figure 1). A small-scale laboratory prototype wellbore test system was developed which extends the electro-migration effect. The effectiveness of the proposed technology was evaluated through systematic testing of the cementitious materials that are enhanced with the select nanoparticles. Finally, a multiphysics numerical model was developed to simulate the remediation process utilizing this new technology.

**Prime Performer:**
*University of Colorado*

**Principal Investigator:**
*Yunping Xi*

**Project Duration:**
*10/1/2015 – 9/30/2019*

**Performer Location:**
*Boulder, Colorado*

**Program:**
*Carbon Transport & Storage*

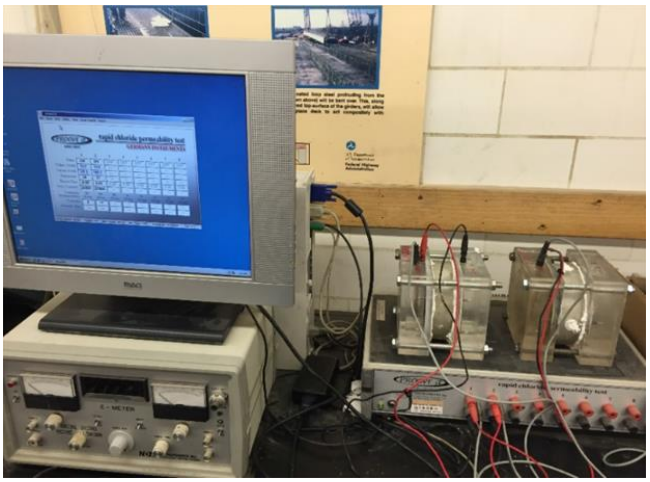

**Figure 1: An electro-migration test unit.**

**Project Outcomes:**

A desktop device was successfully developed for the nanoparticle injection technology. Various types and sizes of nanoparticles were selected and used by the new injection technology to repair the leakage pathways in a wellbore system such as colloidal nanosilica solution (CNS) and nanoalumina solution (AL). The CNS provided better injection performance than AL, the CNS can decrease the porosity of cement sample up to 4.5%. Different repair agents were used and optimized in a comprehensive study that showed that the injection of nanoparticles can improve the fracture toughness, strength, and transport properties of the cement. Specifically, the chloride permeability of the repaired cement can be decreased by as much as 25%. A small-scale wellbore testing system was designed, built, and used to test samples with optimized repair agents under 80 °C and 1000 psi. Five analytical and numerical models were developed for simulating the deterioration of a wellbore system in a carbon dioxide ($CO_2$) storage formation and characterization of the nanoparticle injection process. The new technology has many potential applications; it can be used for repairing distressed cementitious materials in underground wellbore systems as well as in aboveground concrete structures.

**Presentations, Papers, and Publications**

**Final Report:** Nanoparticle Injection Technology for Remediating Leaks of $CO_2$ Storage Formation (December 2019) – Yunping Xi, Mija Hubler, Jiri Nemecek, Linfei Li, Yige Zhang, Shahlaa Al Wakeel, David Culp, Tom Dewers, Pania Newell, Bang He