CO_2 Absorbent Particle Gel for Carbon Storage with Enhanced Oil Recovery

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Introduction

Synergies between carbon storage and enhanced oil recovery (EOR) operations are on the rise due to their industrial value and the global initiative to combat increasing CO_2 emissions. Preformed particle gels (PPGs) are an effective method for connecting carbon storage with EOR projects. The technology comprises swellable aqueous-gel particles that absorb acidic gases such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S), as well as provide solutions for conformance control and reservoir heterogeneity in EOR operations. This PPG technology has superior physicochemical properties and mechanical integrity compared to commercial PPGs.

Objectives

1. Develop particle gel technology to improve carbon storage with EOR operations.
2. Thermostable particle gel in the presence of CO_2 and H_2S.
3. Have high plugging efficiency under a broad range of physicochemical environments.

Methodology

The gel particles are manufactured at the surface and are pumped into the reservoir as dry particles. Once injected, these gel particles can be used as plugging agents after they swell in the surrounding fluid and absorb CO_2. These aqueous-gel particles will swell up to thirty times their original size or larger depending on the physicochemical environment.

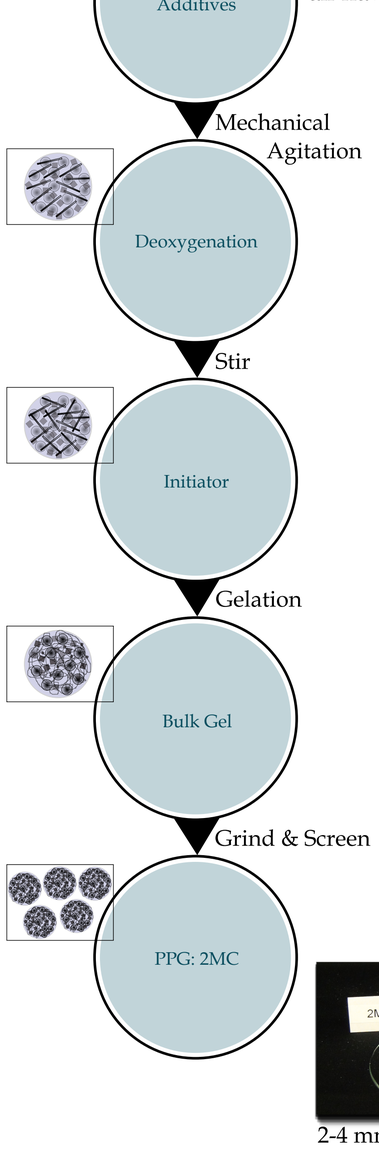
Particle-Based Gel Technology

Product: 2MC

1. Thermostable in 130°C for 6 months.
2. Stable in formation water with dissolved H_2S and CO_2.
3. pH tolerant 3.0–12.4.
4. No deformation in mono and divalent brines 0–30 wt%.
5. Maintains mechanical integrity in the presence of CO_2 saturated brine.

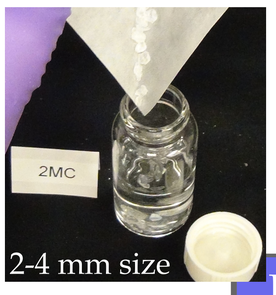
Synthesis of 2MC

Preformed particle gel 2MC is prepared by mixing monomers, crosslinkers, additives followed by deoxygenation and the initiator. After gelation, 2MC is dried out and ground into particles (nm–cm).



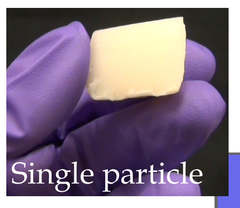
Swelling Dry 2MC Particles

Static swelling equilibrium of 2MC particles varies depending on the physicochemical environment. Salinity, pH, temperature, formation water, and CO_2 saturated brine all have little effect on the plugging efficiency and acidic gas absorption of 2MC.

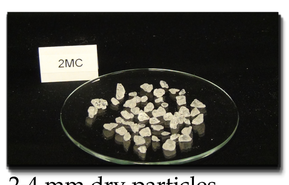


Immerse dry 2MC particles into brine solution or formation water

Time (hours/days)

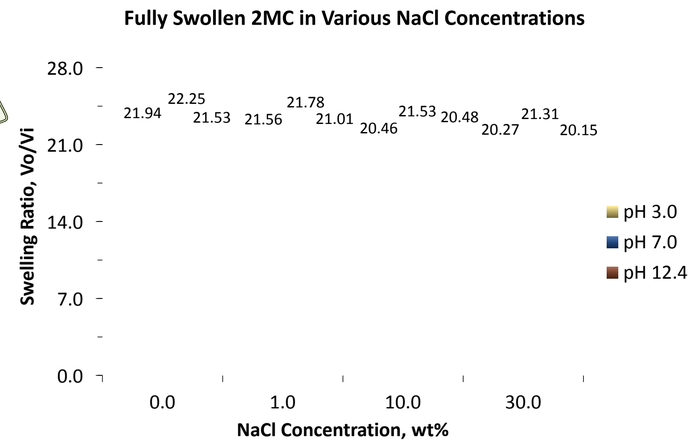


Swollen particles

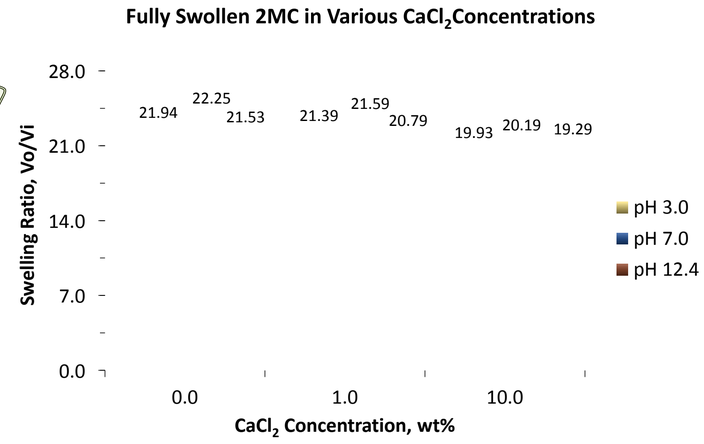


2-4 mm dry particles

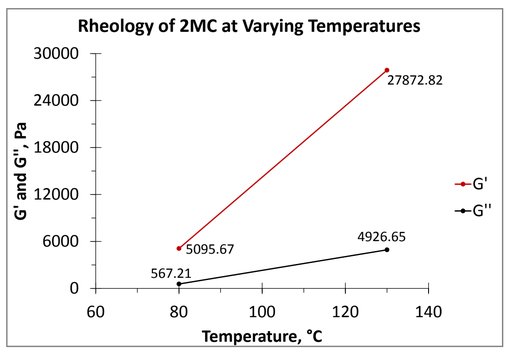
Experimental Results

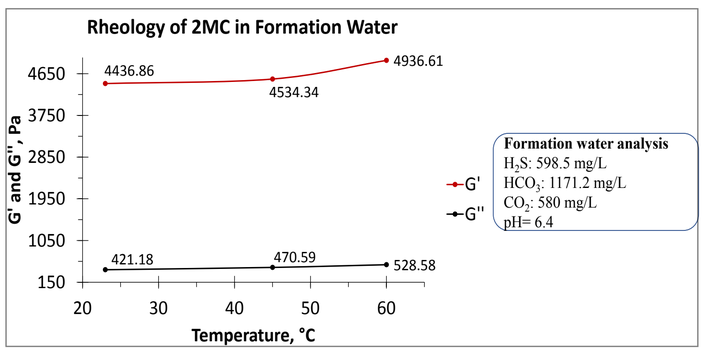


Static swelling equilibrium of 2MC in various NaCl weight percents at 23°C in 50 mL test tubes using 2-4 mm size dry particles, shows less than 8.0% decrease in swelling ratio from deionized water to NaCl 30.0 wt% in all pH conditions.



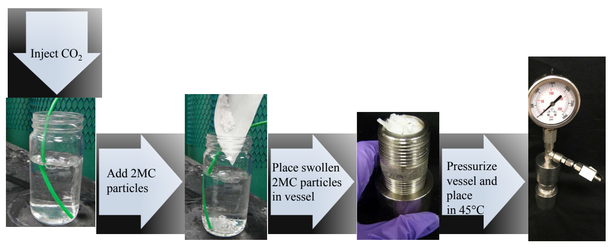
Static swelling equilibrium of 2MC in various $CaCl_2$ weight percents at 23°C in 50 mL test tubes using 2-4 mm size dry particles, shows less than 12.0% decrease in swelling ratio from deionized water to $CaCl_2$ 30.0 wt% in all pH conditions.



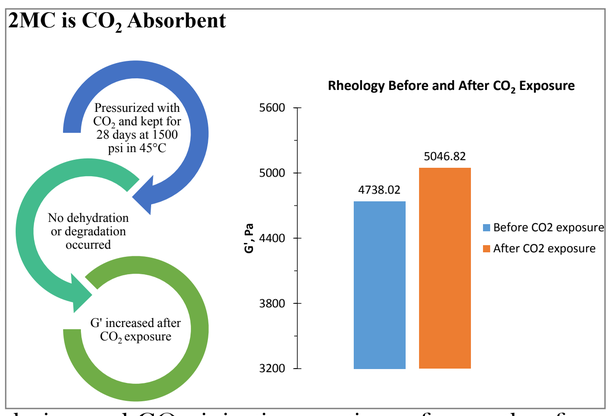


Rheology of 2MC was taken after 6 months in excess NaCl 1.0 wt%, pH= 3.0. The swollen 2MC particles show an incredible mechanical strength increase of 446.99% from 80°C to 130°C. Rheology of 2MC in formation water was taken after 6 months in excess liquid. The 2MC particles continue to show an increase in mechanical strength even in the presence of dissolved H_2S and CO_2.

2MC Vessel Test Procedure



2MC is CO_2 Absorbent



During the vessel test compressed CO_2 is injected into NaCl 1.0 wt%, pH= 7.0 brine for several hours, then 2-4 mm dry 2MC particles are poured into the solution and CO_2 injection continues for another few hours. After the particles are fully swollen the vessel is pressurized to 1500 psi and placed in 45°C oven. 2MC shows an increase in density and mechanical strength after being in the presence of CO_2 saturated brine in 45°C at 1500 psi for 28 days.

Conclusion

This technology is the "next generation" of environmentally safe particle-based gels which can be used for carbon storage in combination with enhanced oil recovery operations to solve low oil production rates and increasing global carbon dioxide emissions.

Acknowledgement

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