CO$_2$ Microbubbles for Improved Sequestration and EOR

Alternate to conventional CO2 injection

Japan Trivedi, U of A

Japan Trivedi, PhD (jtrivedi@ualberta.ca)
Assistant Professor
School of Petroleum Engineering
University of Alberta
Objectives

**Storage:**
- Replace the traditional CO$_2$ injection into oil and gas reservoirs
- Alternative Safe and Secure method
- Leakage risk minimized
- Improved oil/gas recovery !!!

Capture : CO$_2$ / Flue gas as microbubbles - colloidal gas bubbles
Storage : Inject into oil/gas reservoirs

**Team**
Japan Trivedi, Ergun Kuru, Phillip Choi - UofA
Mingzhe Dong - UofC
Drawbacks of CO\textsubscript{2} - EOR

- Adverse mobility contrast - Viscous Fingering – Gas bypassing
  - Poor displacement
  - Early breakthrough
- Gravity override: Poor vertical sweep

- Needs for CO\textsubscript{2} – thickeners !!!
- CO\textsubscript{2} soluble Polymers – rare and expensive

- CO\textsubscript{2} microbubbles or Polymer enhanced foam
  (It’s not conventional foam)
Introduction

Structure of an aqueous colloidal gas aphron (after Gaurina-Medimuric and Pasic)
How Does CO2 microbubble Help?

✓ Ensures more even flooding in heterogeneous reservoirs

✓ reduces the viscosity of the oil up to 97%.
✓ Slow movement – longer oil contact than CO₂ gas, which has to be injected multiple times to have the same effect.

✓ Its higher viscosity allows a more uniform push.
Part – 1: CO2 microbubble generation

- Polymer / Surfactant Screening
  - Shear rheology and LSRV
  - Stability of bubbles over time
  - Bubble size (frequency) distribution

Bulk and porous media stability
Part – 2 : Stability under reservoir conditions

- High pressure – high temperature sustainability
- Tested up to 3000 psi and 75 deg C
  - Stable, compressible and regains shape after releasing pressure
  - not easily movable – hence leakage risk is extremely low

Alternative use:
Microbubbles can be compressed and pumped downhole to be used as
- Drilling fluid
- Fracturing fluid for shale gas
After pressurizing 2000 psi

- Under confinement – Stable and Compressible
Part – 3: Why CO$_2$ microbubble for EOR?

- Higher viscosity & stability than regular foams
- Good blocking ability & stable displacing front (for fractures)
- Shear-thinning fluid – improves injectivity
- Safe CO$_2$ sequestration
Conventional CO2 Foam EOR

The heavy crude turns from black to brown - an indication of a sharp viscosity drop and the oil is pushed out by the CO2 foam.
CO₂ Microbubble EOR

Sand pack

Foamy Samples after breakthrough
SHOWS stability even after flow through reservoir

Direction of flow

CO₂ PEF @ diff PV
CO$_2$ Microbubble EOR - Produced fluid

- Early oil production consisted of water-in-oil emulsion and free gas.
- Later, the oil was produced as oil-in-water emulsion and gas bubbles (foam).
Is it safe to store inside porous media?

Microscopic images of initially
Produced foamy sample

Produced sample from
CO2 microbubble
injection after many days
Pressure required for leakage is ~10 times higher than foam and ~100 times higher than CO2 gas.
Graduate Students

- Mousumi Ghosh
- Shivana Samuels (now with AER)
- Santhosh Veerabhadra (now with SRC)
- Ankit Doda
- Ali Telmadarreie

jtrivedi@ualberta.ca