Laboratory Investigation of the Interaction Between CO_2 and Reservoir Fluids During the CCUS Process Using the IRHPOC Method

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IInfrared High Pressure Optic Cell (IRHPOC) is a new method for investigation of Carbon Capture and Storage (CCS) and CO2-driven EOR study for principle investigation of interaction between CO2/water/rocks and oils or CAG (Chemicals-Alternating-Gas) and WAG (Water–Alternating-Gas) flooding process. IRHPOC could be seen as an ideal pore-throat in reservoirs conditions. When coupling with PES IR-image and 532nm GeoRaman Microprobe this method is not only documenting visible features in digital formats in real time but also connecting and comparing these data with other various experiment data. Using a comprehensive suite of software, additional evaluations can be carried out with regard e.g. to crude oil expansion, CO_2 diffusion rate in water and interactive band between CO_2 and crude oil. Cell images in real time allow to describe the principle of interaction between CO_2 and crude oil and CO_2 storage in CO_2-driven EOR process. The use of this method has proven to be accurate, quick, and, hence economical comparing with CT, X-ray methods.

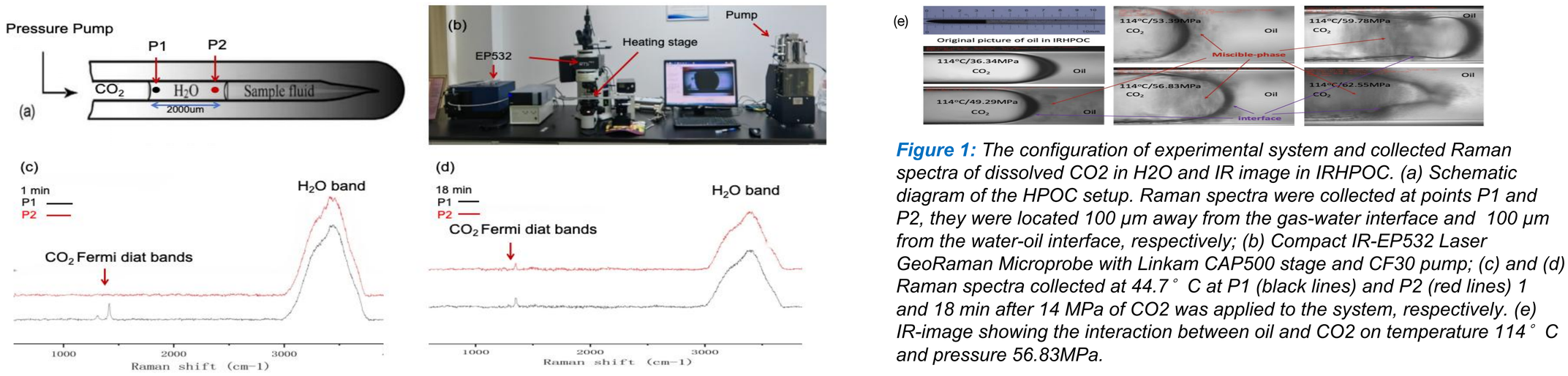


Figure 1: *The configuration of experimental system and collected Raman spectra of dissolved CO2 in H2O and IR image in IRHPOC. (a) Schematic diagram of the HPOC setup. Raman spectra were collected at points P1 and P2, they were located 100 μm away from the gas-water interface and 100 μm from the water-oil interface, respectively; (b) Compact IR-EP532 Laser GeoRaman Microprobe with Linkam CAP500 stage and CF30 pump; (c) and (d) Raman spectra collected at 44.7° C at P1 (black lines) and P2 (red lines) 1 and 18 min after 14 MPa of CO2 was applied to the system, respectively. (e) IR-image showing the interaction between oil and CO2 on temperature 114° C and pressure 56.83MPa.*

1. Interaction between CO2 and wollastonite

Previous study is mostly like "black box". Researcher could not see what happened in reservoir when injecting CO_2 and only describe the possible principle accoring to input and output. With new method the cell images and in situ raman spectroscopy could very clearly show what happed (Fig.2 and Fig.3, Qing Zhou, 2021).

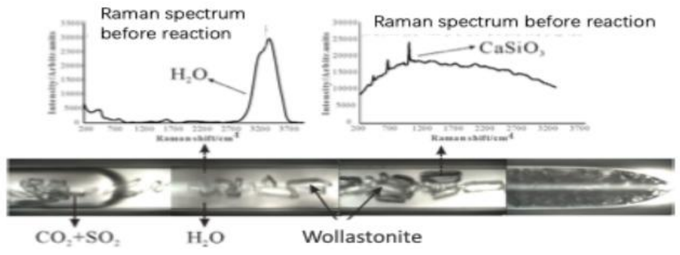
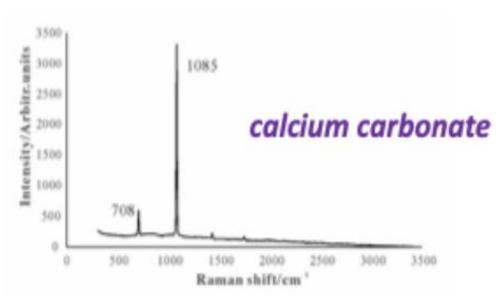


Figure 2: *Cell image and Raman spectrum before reaction*



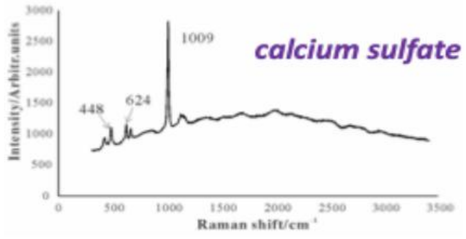


Figure 3*: Spectrum of calcium carbonate and calcium sulfate after reaction which show deposition has happend.*

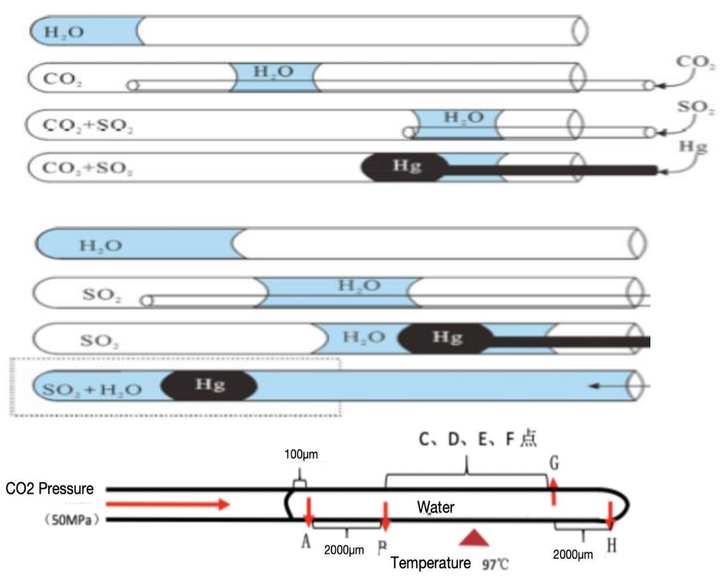


Figure 4: *Loading different samples in HPOC*

2. Diffusion of CO2 in water or brine

In-situ raman is very good monitoring measurement in CO2 storge study because concentration of CO2 in water or brine could be calculated. The method using HT-HP Optic Cell GeoRaman Microprobe was showed in Fig.4 and experiments data was showed in Fig.5.

Same method people could measure the diffusion of CO2 in brine on different salinity.

With standard concentration fluid the diffusion speed of CO2 in different brine could be calculated.

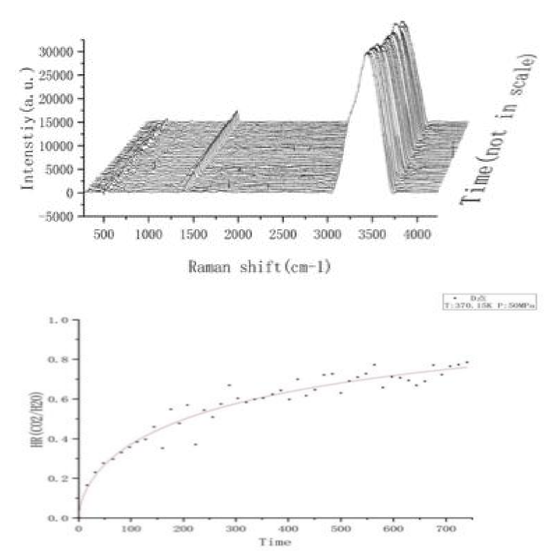


Figure 5: *Diffusion trend on point D with time, CO2 in water, with HT/HP Optical Cell GeoRaman Microprobe*

3. Cell images and expansion of crude oil when CO2 injected with chemicals

Cell images in black oil are difficut to get because fo density. But when using specifical IR technology with HPOC the cell images could be got clearly with different time (Fig.6). The relative expansion of oil volume (%) over time (hours) after the application of CO2 to oil with or without chemical additives in HPOC was showed in Fig.7.

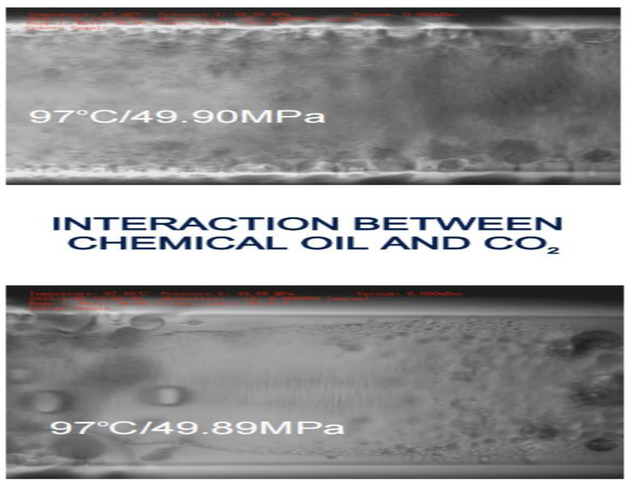


Figure 6: *Chemical oil expansion and interaction test with different time under microscope at high pressure 50MPa and temperature 97° C.*

Figure 7. *The relative expansion of oil volume (%) over time (hours) after the application of CO2 to oil with or without chemical additives in HPOC under 14MPa.*