UKCCS RESEARCH CENTRE

The University of Nottingham
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Measurement of Water Solubility Limits in CO_2 Mixtures to Ensure the Safe Pipeline Transportation of CO_2

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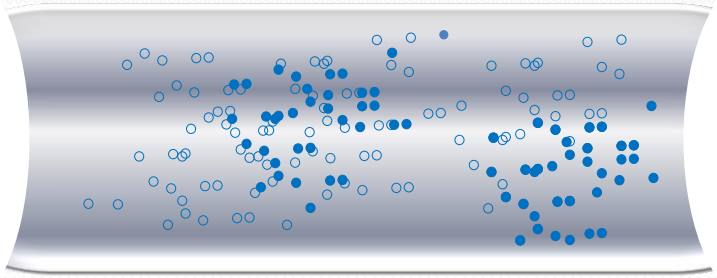
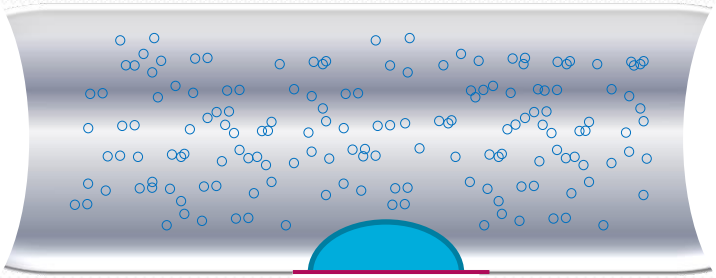
Context: CO_2 transport by pipeline

- Captured CO_2 will contain small percentages of impurities including gases such as N_2, H_2 or Ar and water*
- Understanding the phase behaviour of CO_2-rich mixtures is crucial

CO_2 + any H_2O must be in a single phase



If not…



Corrosion

*de Visser et al., Int.J.Greenh Gas Cont Vol.2, 2008, p.478.

Aim of our project

- To establish the solubility limit of water in impure CO_2 to ensure the safety of pipelines

Strategy

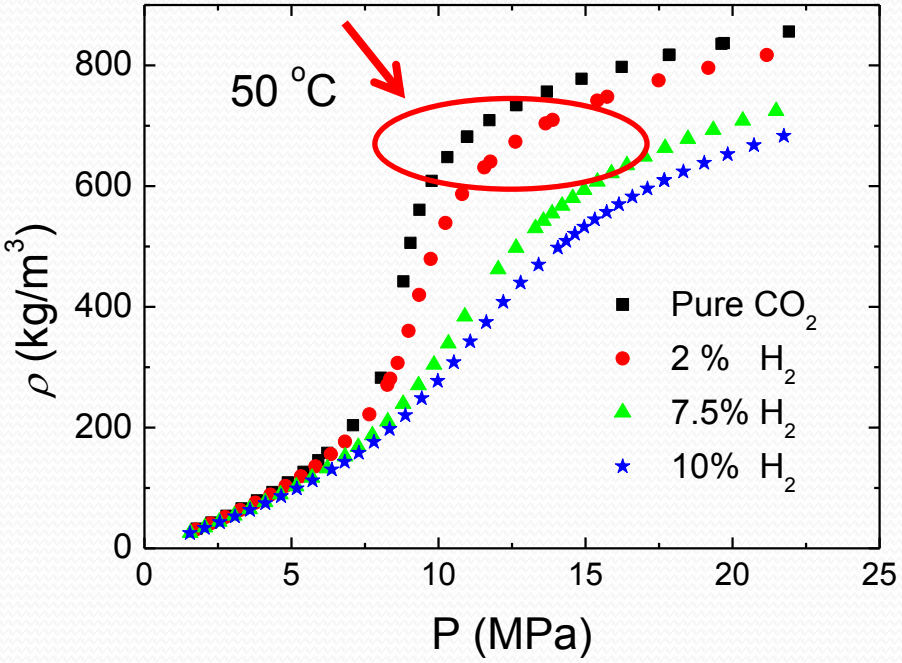
- Using two independents methods

FTIR spectroscopy method*	Karl Fischer titration method
✓	**In Progress**
○**Water highly absorbing in infrared;** ○**Long experience in the group coupling IR to high pressure device.**	○**Investigate lower temperatures.** ○**Confirm the results obtained by FTIR;**

*S. Foltran, M.E. Vosper, N.B. Suleiman, A. Wriglesworth, J. Ke, T.C. Drage, M. Poliakoff, M.W. George, Int. J. Greenh.Gas Control, 35, (2015), p.131.

Literature

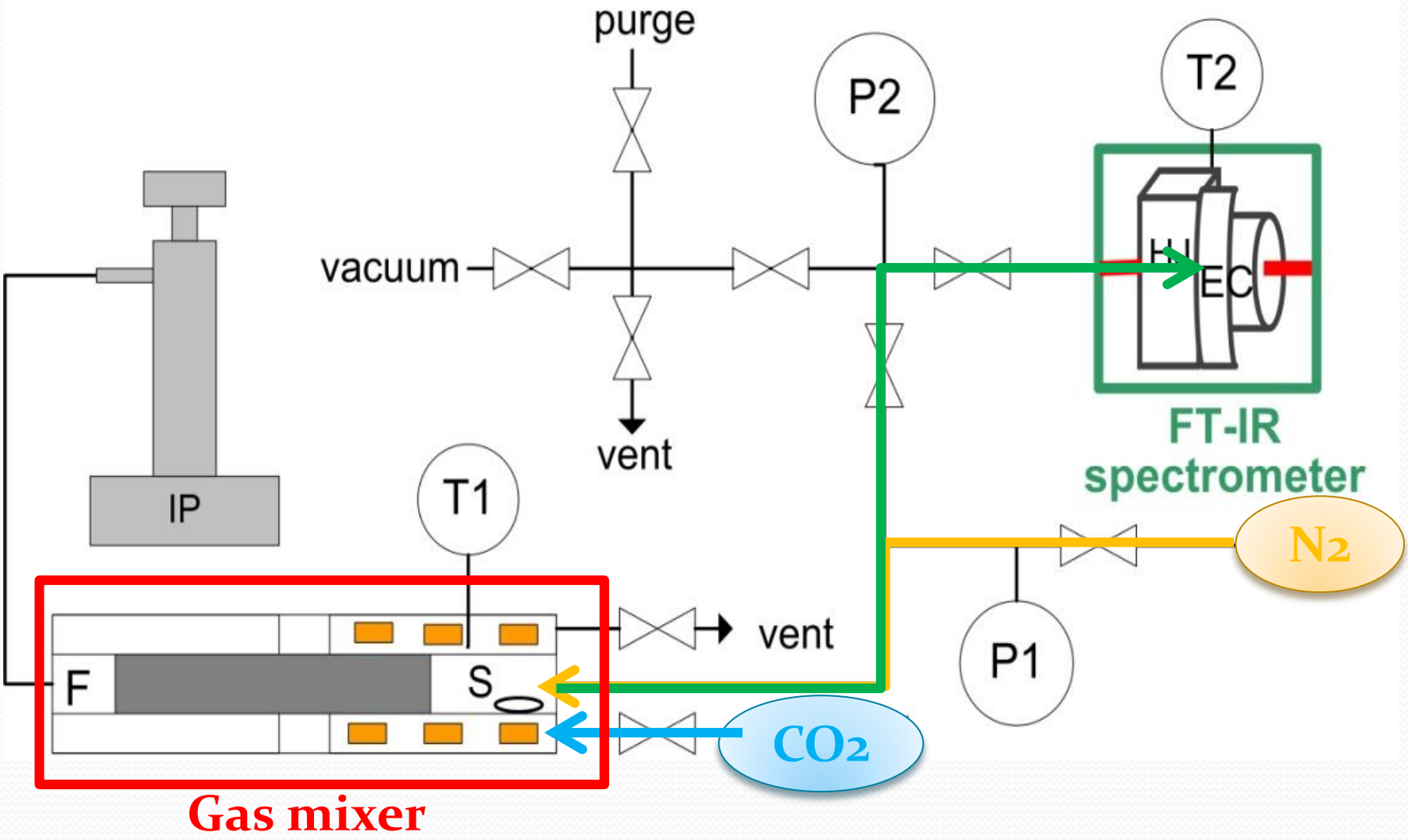
- Literature data on water solubility in pure CO_2;
- The presence of impurities changes the physico-chemical properties of CO_2!

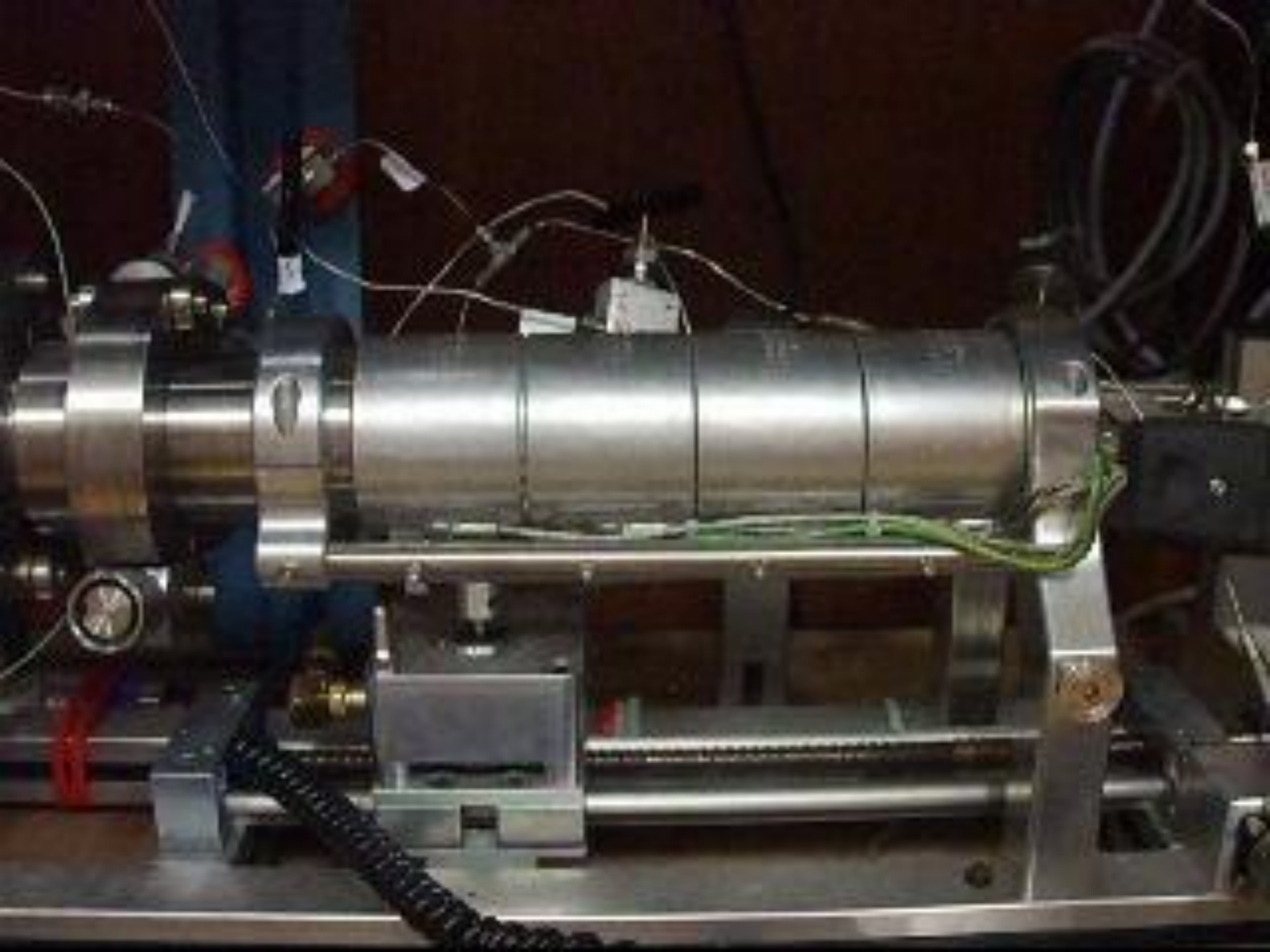


2% of H_2 in CO_2 can reduce the molar density up to 25% in the critical region

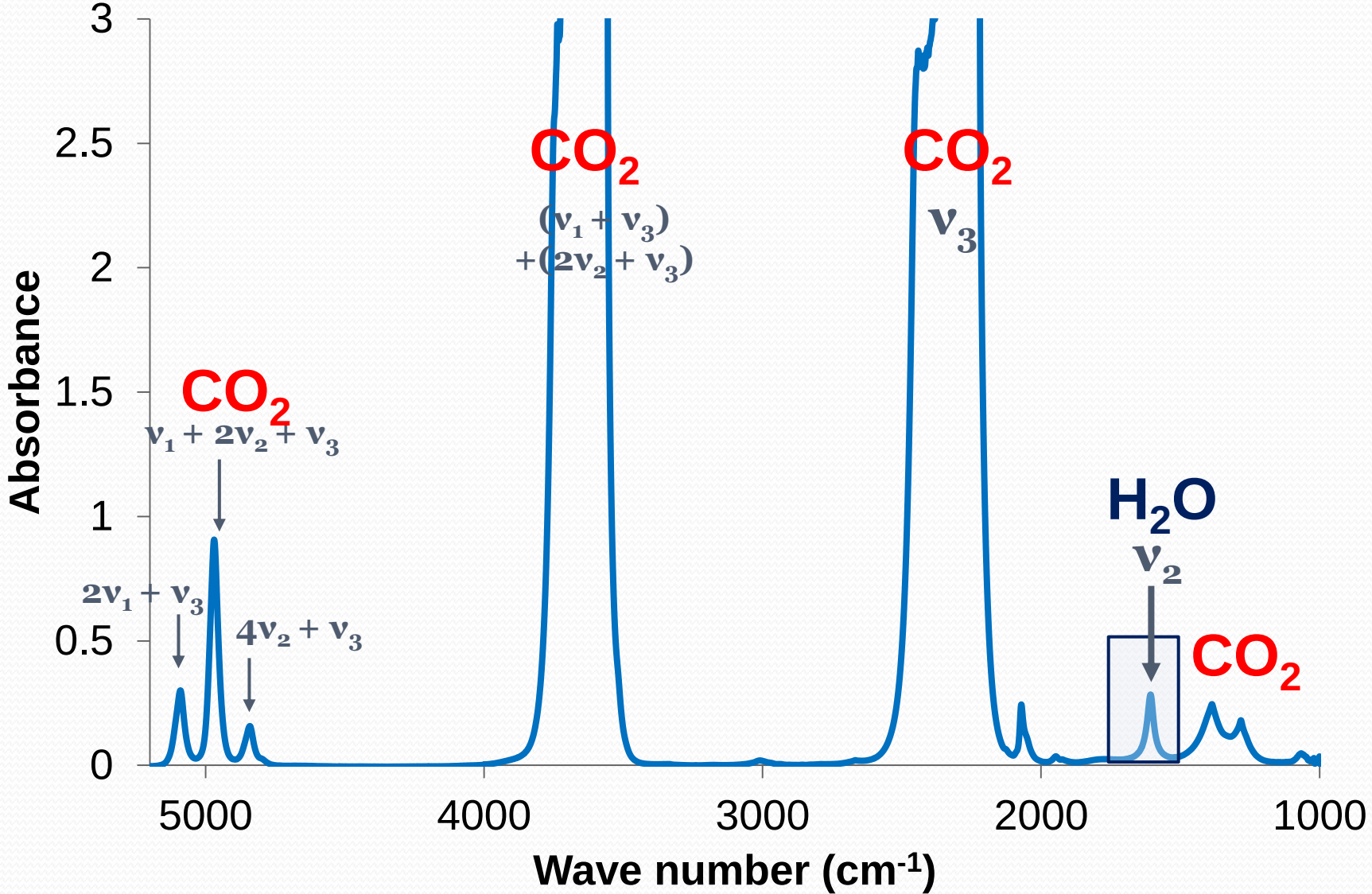
SANCHEZ-VICENTE, Y., DRAGE, T.C., POLIAKOFF, M., KE, J., GEORGE, M.W., Int. J. Greenh Gas Con, Vol.13, **2013**, p.78.

1°) FTIR spectroscopic approach





FTIR spectrum of $CO_2 + H_2O$



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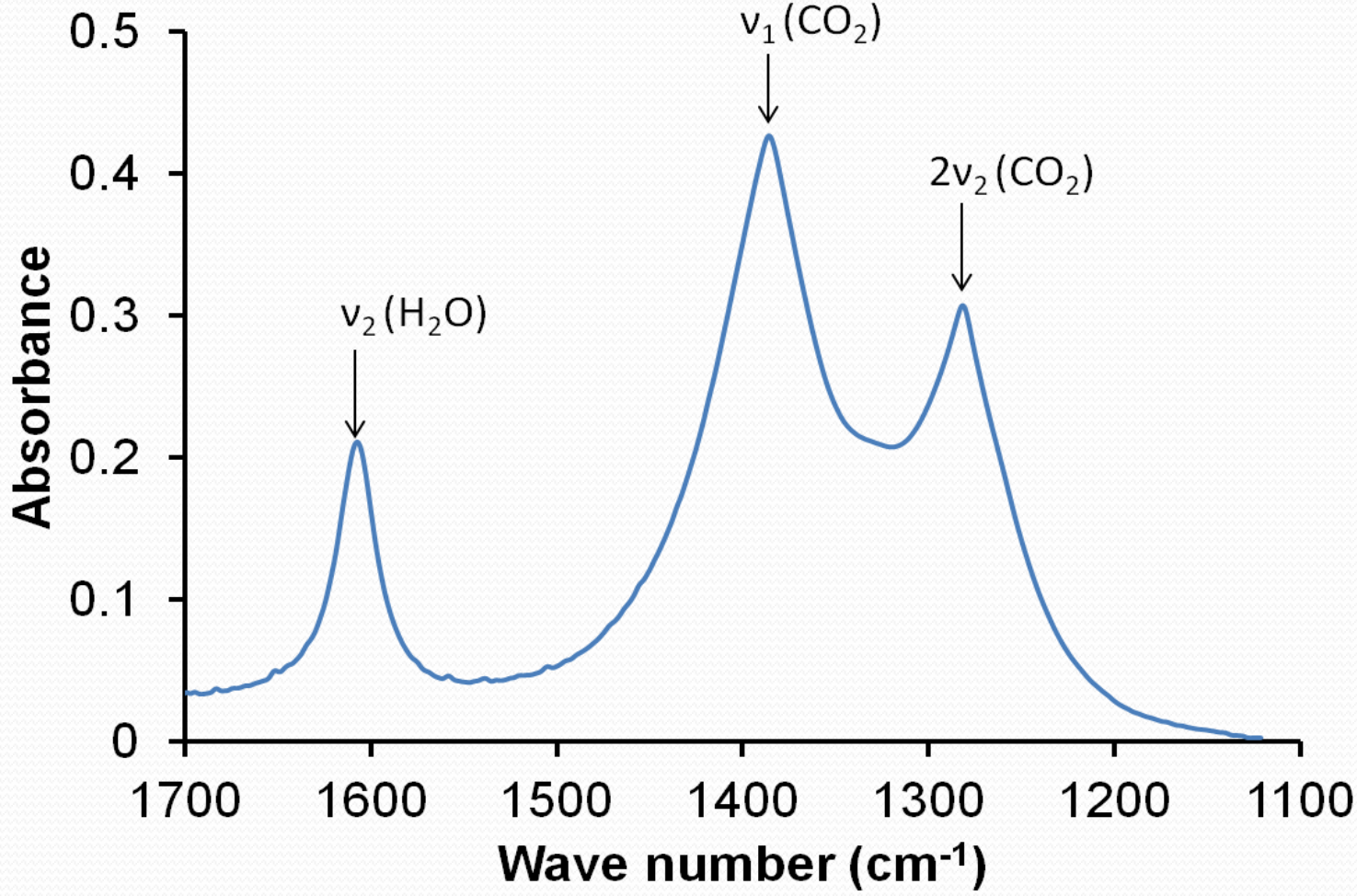
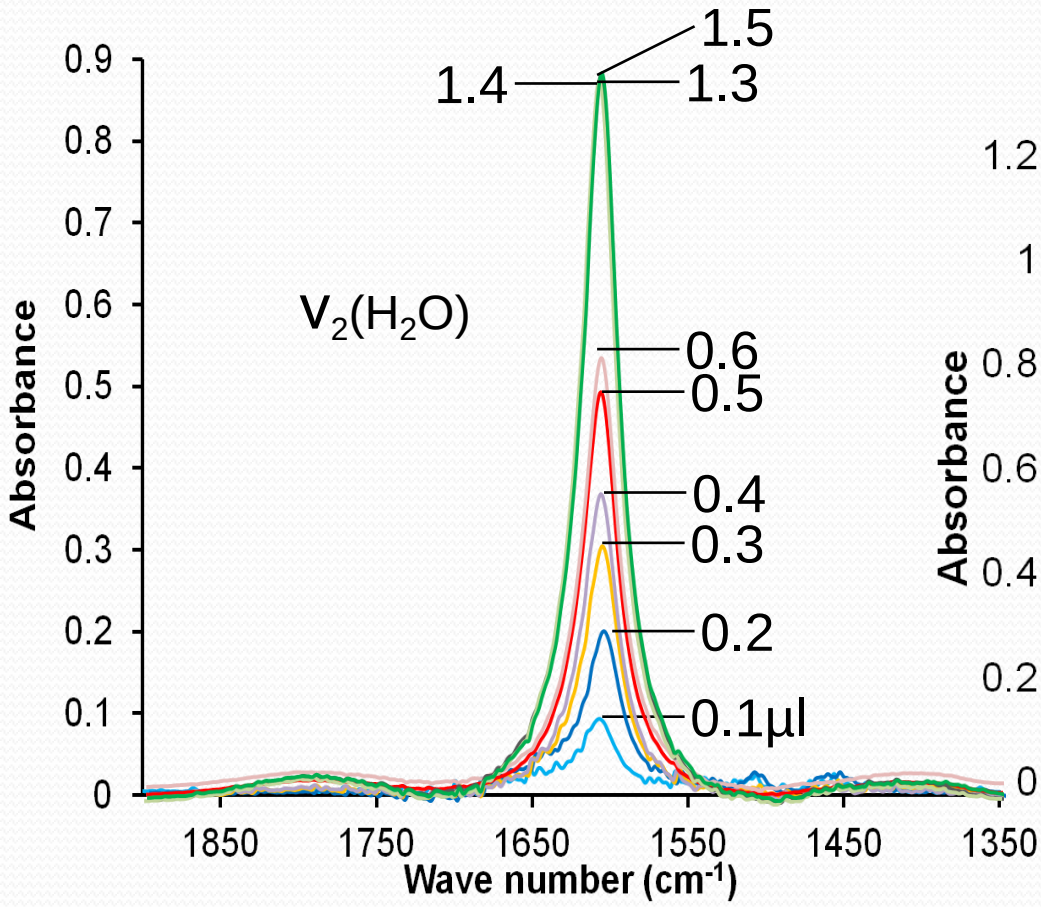
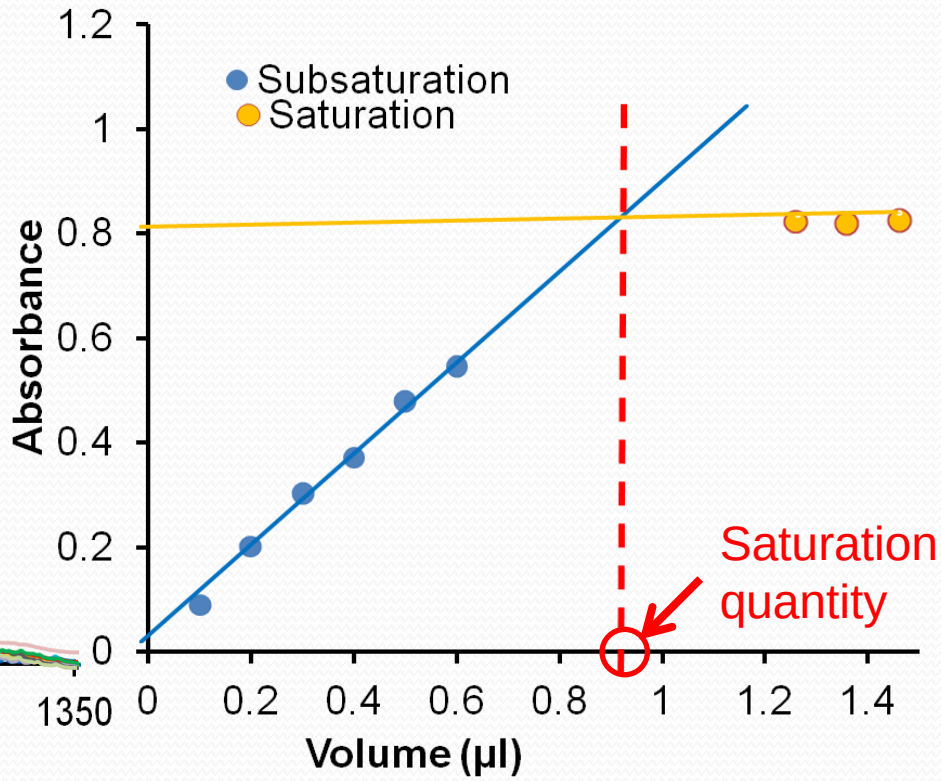


FT-IR spectrum of H_2O in CO_2 at 25°C, 9 MPa and with 0.2µl of H_2O

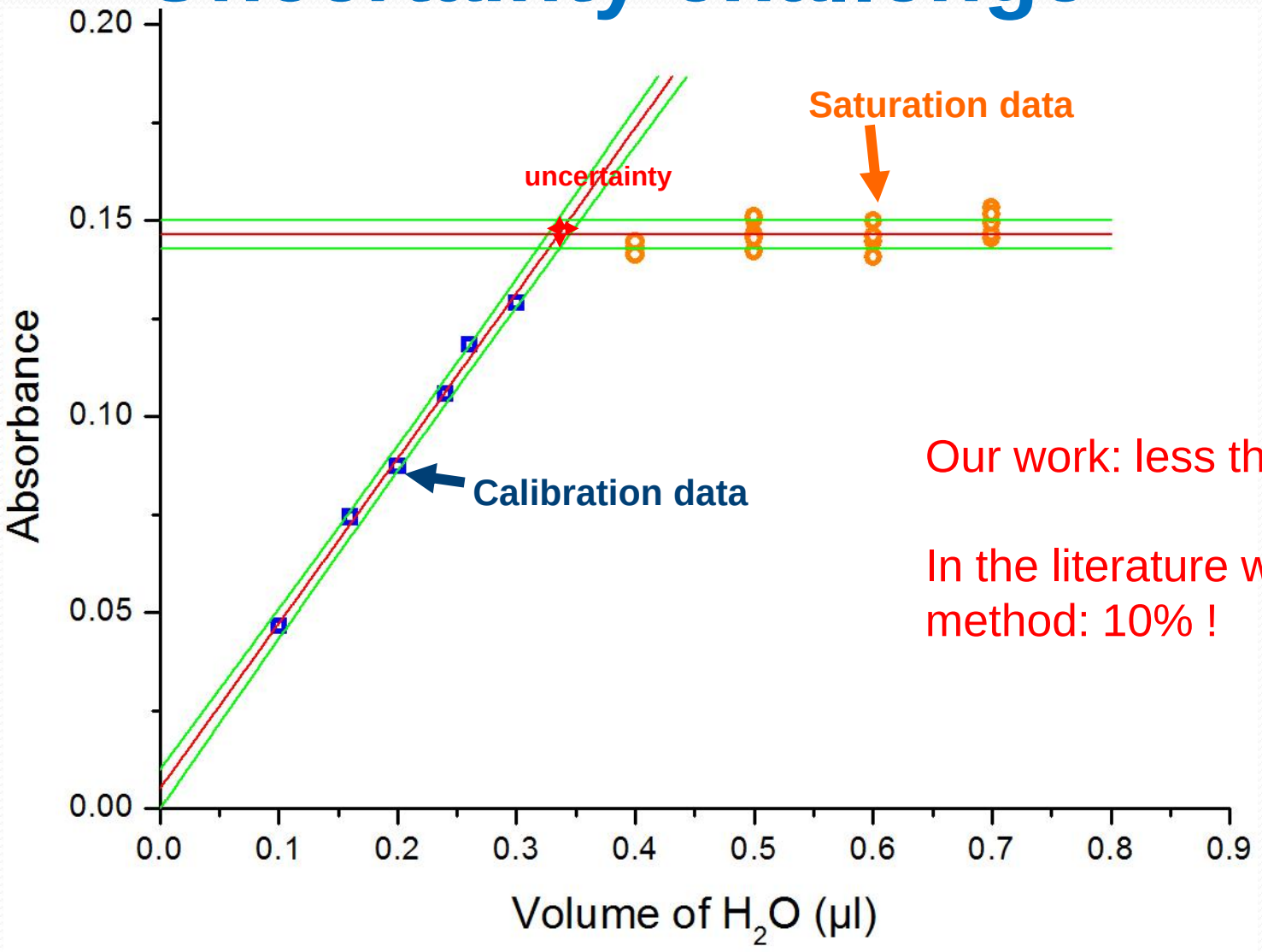
Procedure





Bending mode of H_2O for different concentrations at T and P fixed

Uncertainty challenge



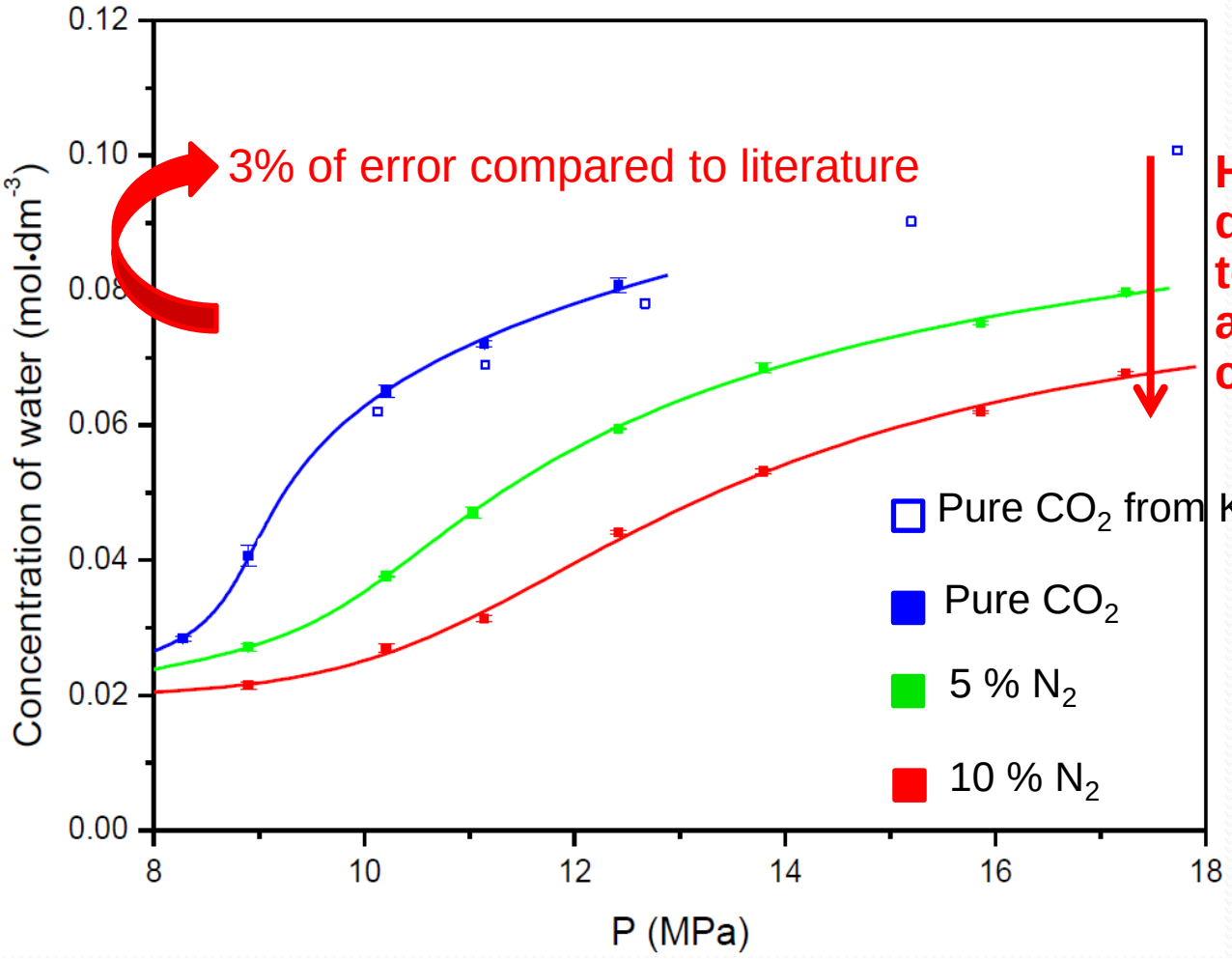
Our work: less than 4%

In the literature with a similar method: 10% !

Z. Wang et al. Fluid Phase Equilibria *338 (2013) 155– 163*

Concentration of water in CO_2 mixtures

At = 40°C and P = 8 - 18 MPa in pure CO_2 and in CO_2 + (5-10%) N_2 mixtures



H_2O solubility decreases by up to 42% with the addition of N_2 at constant pressure

Mole fraction of water in CO_2 mixtures

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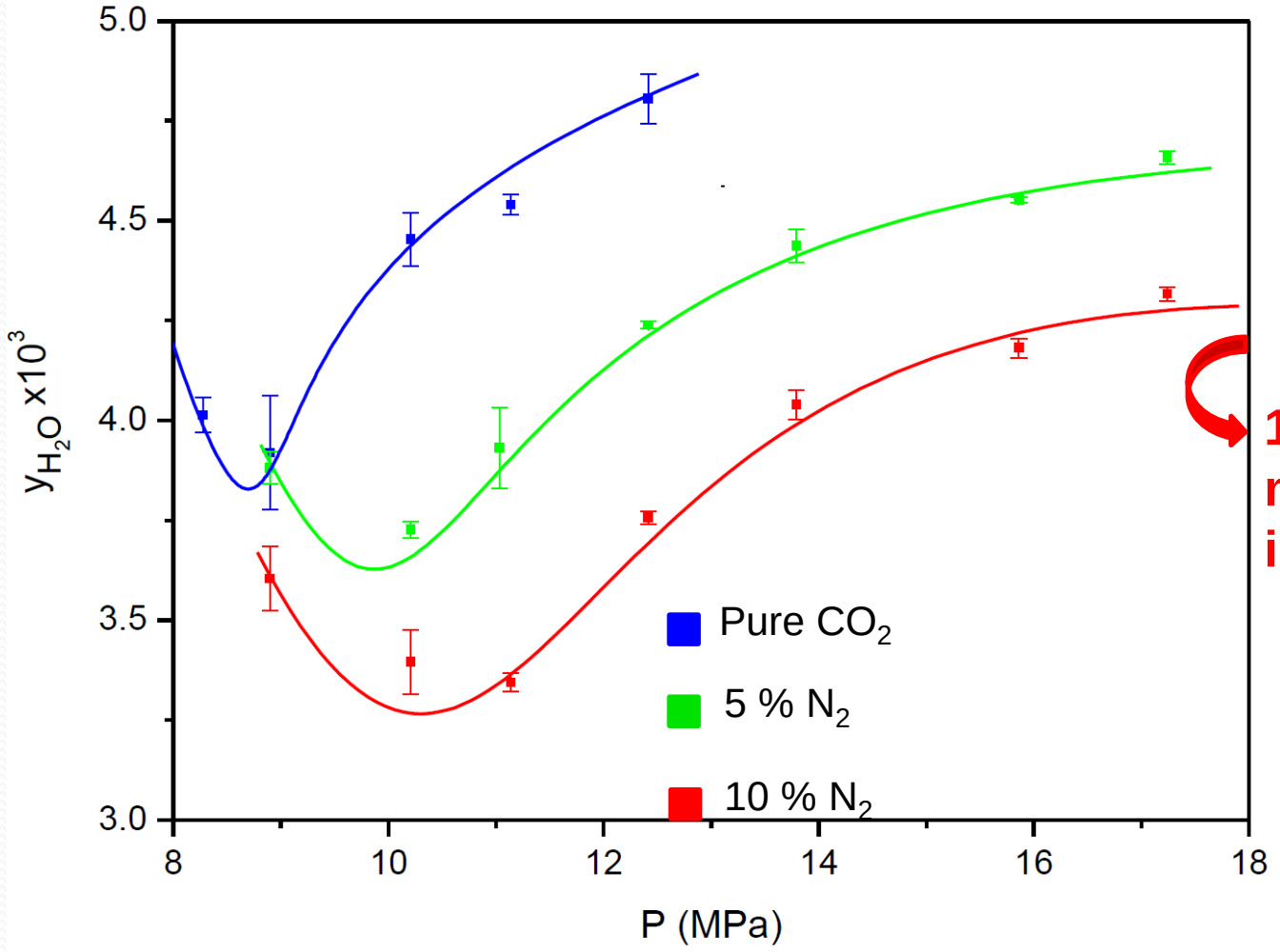

10% N_2 lowers the mole fraction of water in CO_2 by up to 26%

S. Foltran, M.E. Vosper, N.B. Suleiman, A. Wriglesworth, J. Ke, T.C. Drage, M. Poliakoff, M.W. George, Int. J. Greenh.Gas Control, 35, (2015), p.131.

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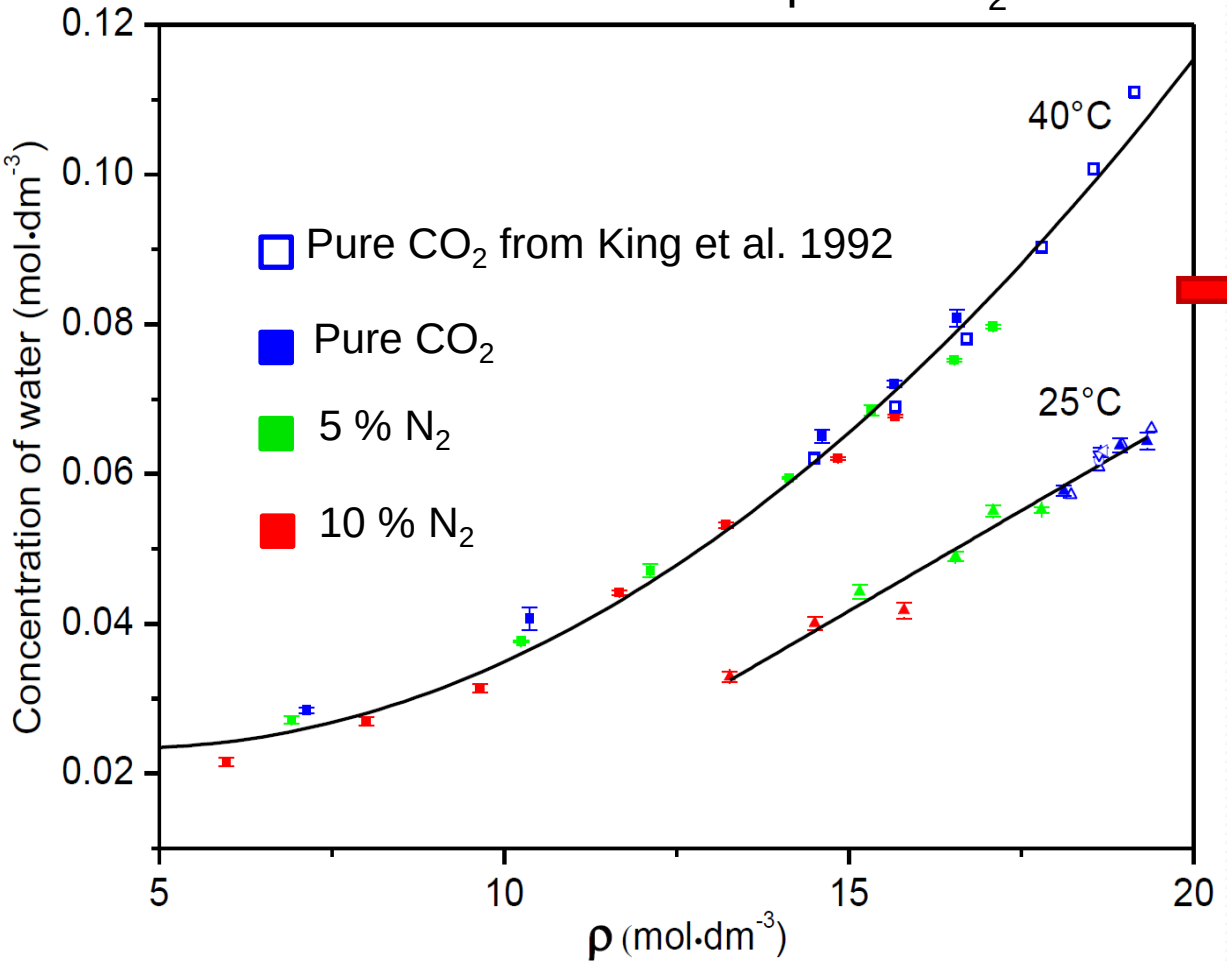

For a given density, C_{H_2O} remains constant whatever the mixture

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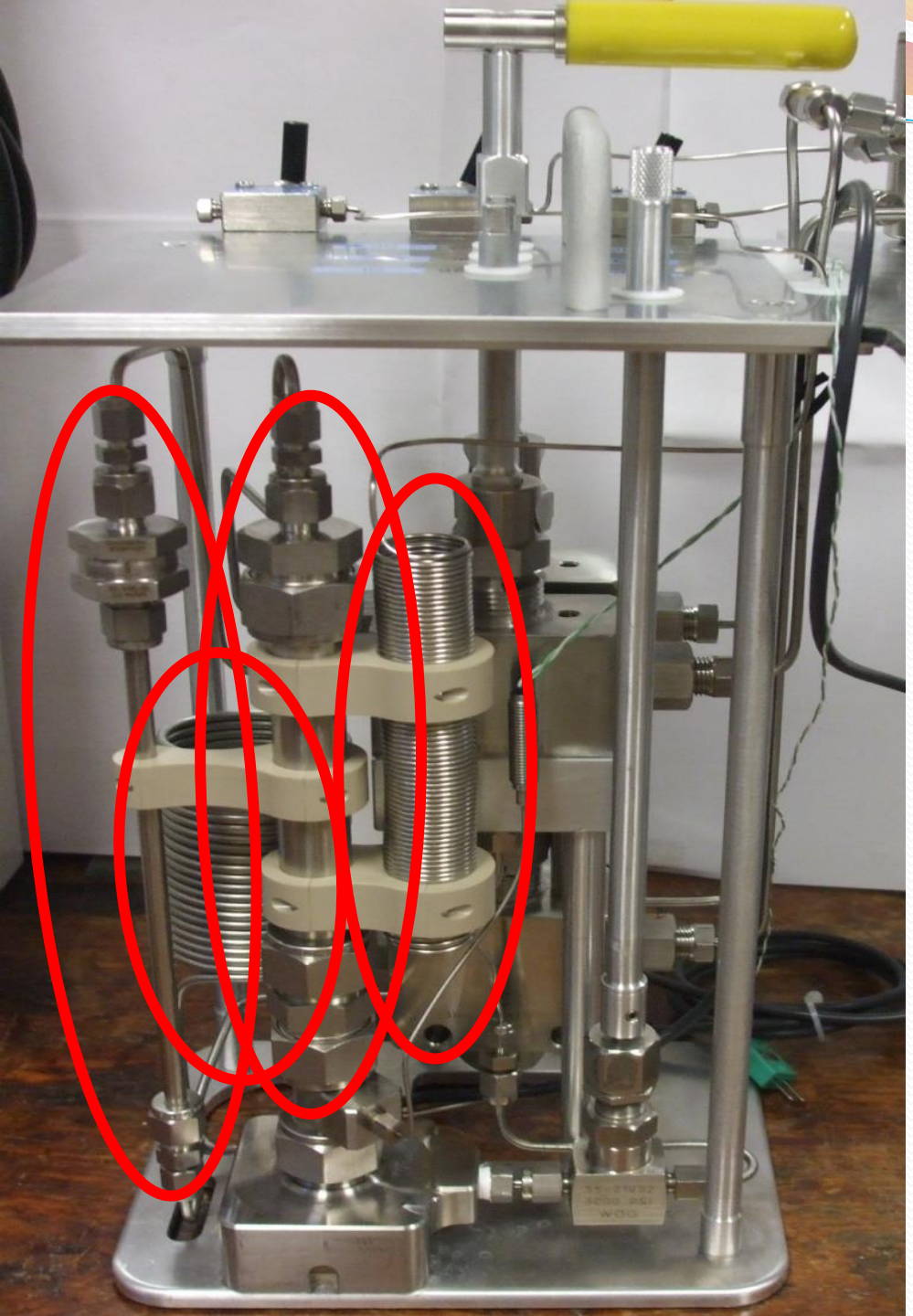
2°) Karl Fischer titration approach

EC: Equilibrium cell



Equilibrium part

1. Pre-heater

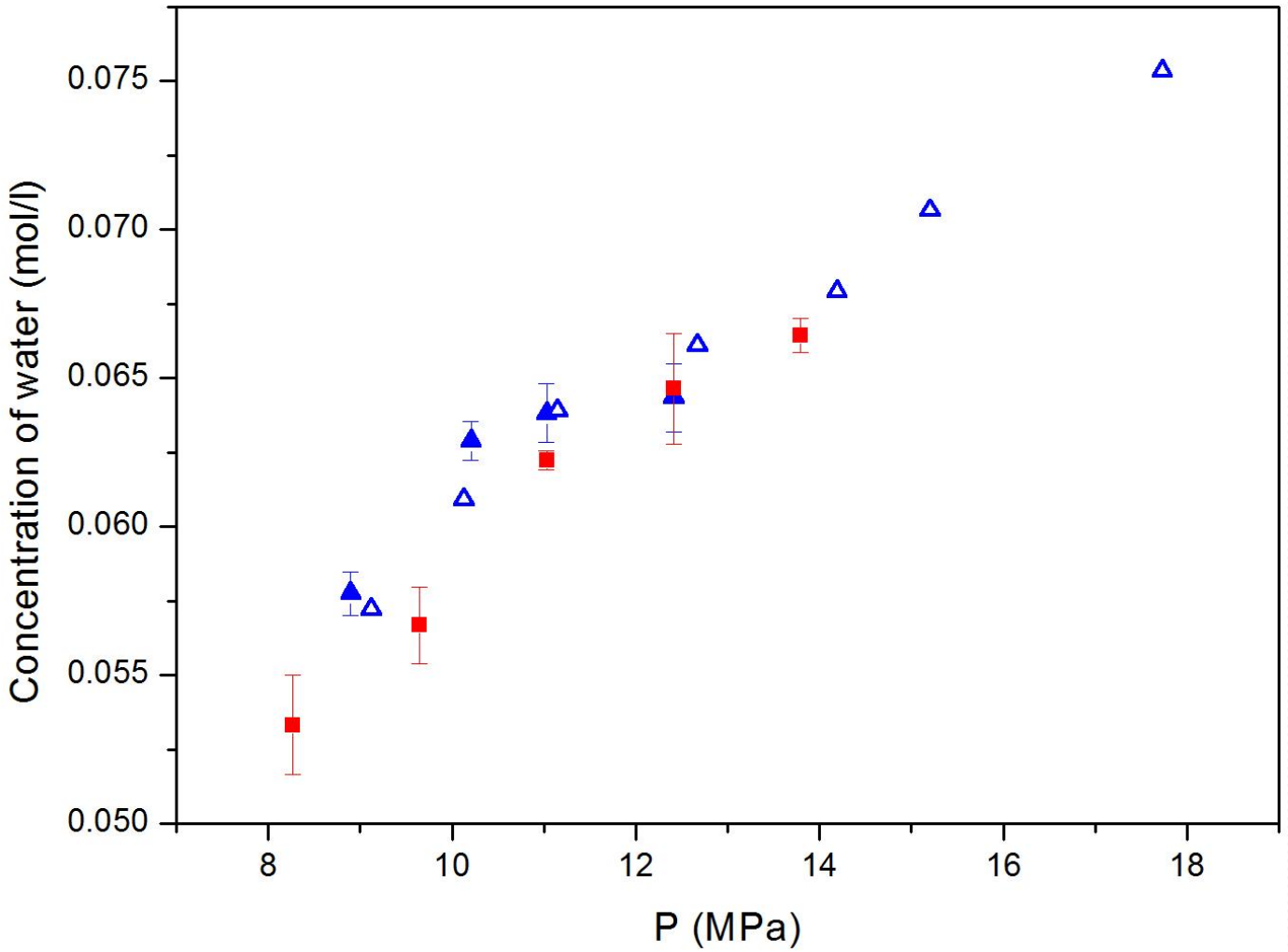
2. Equilibrium cell

3. Secondary equilibrium cell + Filter

4. Sample loop

First results

- T = 25 °C, P = 8 – 18 MPa in pure CO_2



△ King et al. 1992

▲ FT-IR results

■ Karl Fischer results

Conclusions

- **For a fixed T and P, small percentages of N_2 can lower significantly the solubility of water in CO_2;**
- **However, at a given density, the concentration of water does not seem affected by the presence of impurities;**
- Two simple techniques have been developed to understand the phase behaviour of water in CO_2 containing impurities.

Outlooks

- Investigating water solubility in more complex mixtures, ex: $CO_2 + H_2 + N_2$;
- Further experiments with the Karl Fischer titration method.

Acknowledgements

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- Norhidayah Suleiman
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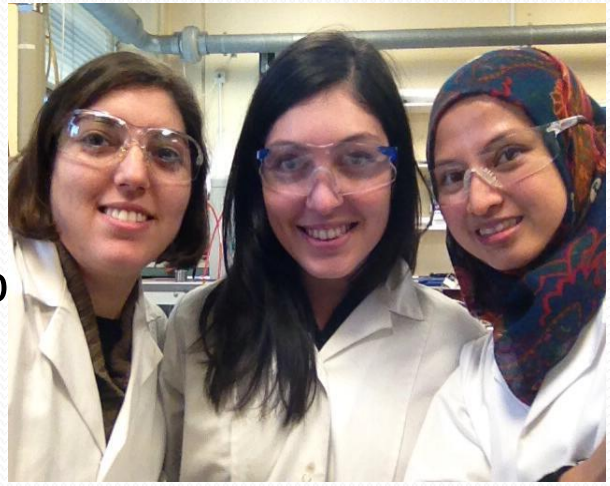
- Dr. Maria-José Tenorio

- Mark Guyler

- Workshop:
  - Richard Wilson
  - Peter Fields

- All the group



❑UKCCSRC for funding

Thank you for your attention!

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QUESTIONS ?

Solubility limit of H_2O in CO_2 using Karl Fischer titration for Carbon Capture and Storage

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