

N₂O solubility at high amine concentration and validation of N₂O Analogy

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Introduction

- ❑ Physical CO₂ solubility is important for detailed thermodynamic modeling and design
- ❑ Expressed as the Henry's law Constant
- ❑ Can not measure directly in Amine solution
- ❑ But can be inferred from the N₂O solubility via N₂O analogy

$$H_{CO_2}^{Am} = H_{N_2O}^{Am} \cdot \left(\frac{H_{CO_2}^{H_2O}}{H_{N_2O}^{H_2O}} \right)$$

- ❑ N₂O Analogy (Versteeg & van Swaij, 1988)

$$\frac{H_{N_2O}^{H_2O}}{H_{CO_2}^{H_2O}} = 3.04 \cdot \exp\left(\frac{-240}{T}\right)$$

Drawbacks :

N₂O Analogy was challenged:

- ❑ Not valid over large range of concentrations (Pawlak and Zarzycki, 2002)**
- ❑ Valid for amine concentration less than 30 wt% (Hutenhous, et al. ,2008)**

Aims :

to measure the N₂O solubility at high amine concentrations and to test the N₂O analogy

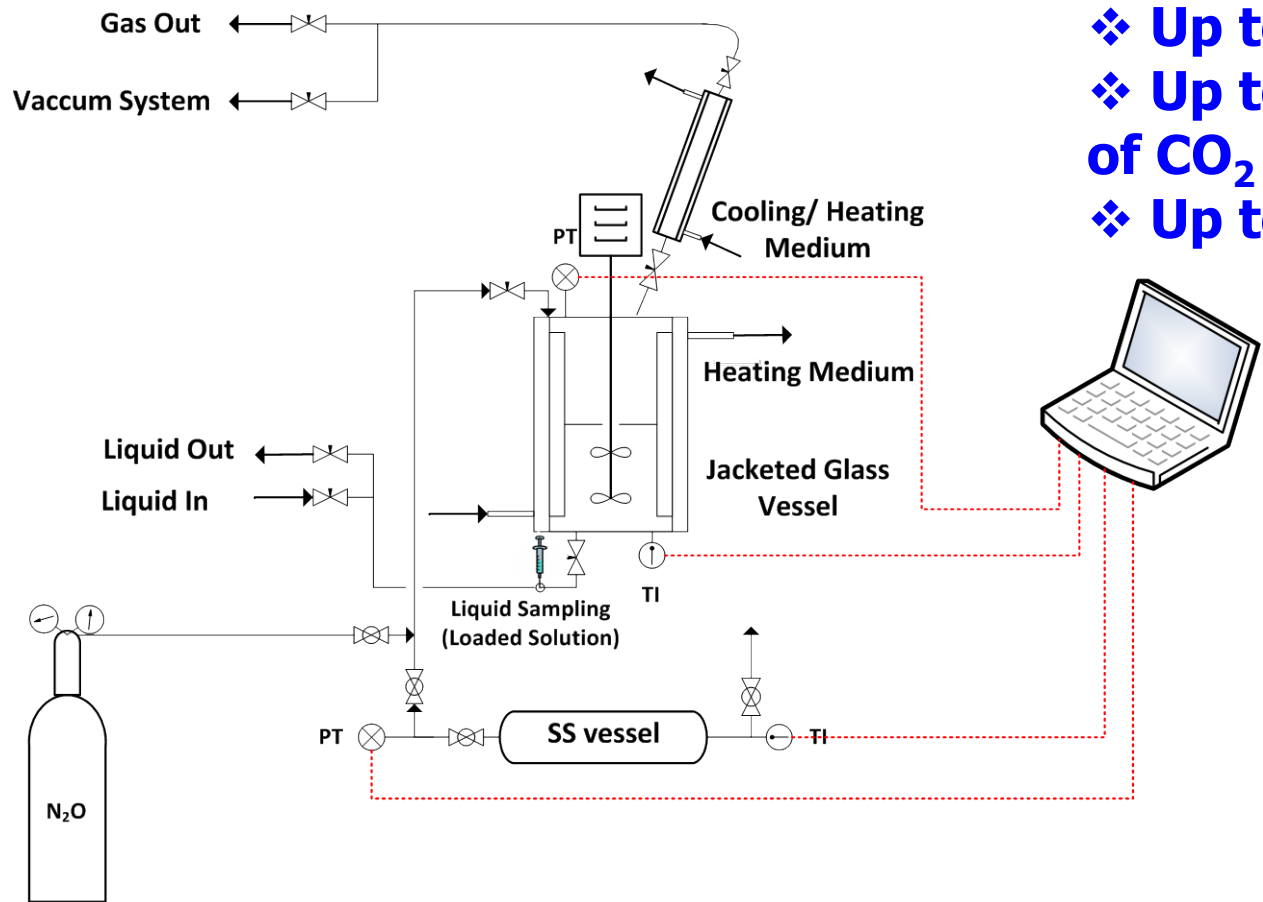
Experimental Section

Chemicals used

- ❑ CO₂ gas (purity ≥ 99.999 mol %, from YARA-PRAXAIR)
- ❑ N₂O gas (purity ≥ 99.99 mol %, from YARA-PRAXAIR)
- ❑ N₂ gas (purity ≥ 99.6 mol %, from YARA-PRAXAIR)
- ❑ H₂SO₄ (purity 95-97% from SIGMA-ALDRICH)
- ❑ MDEA (purity ≥ 99 mass%, from SIGMA-ALDRICH)
- ❑ De-ionised water was used as solvent throughout the experiment

Apparatus used

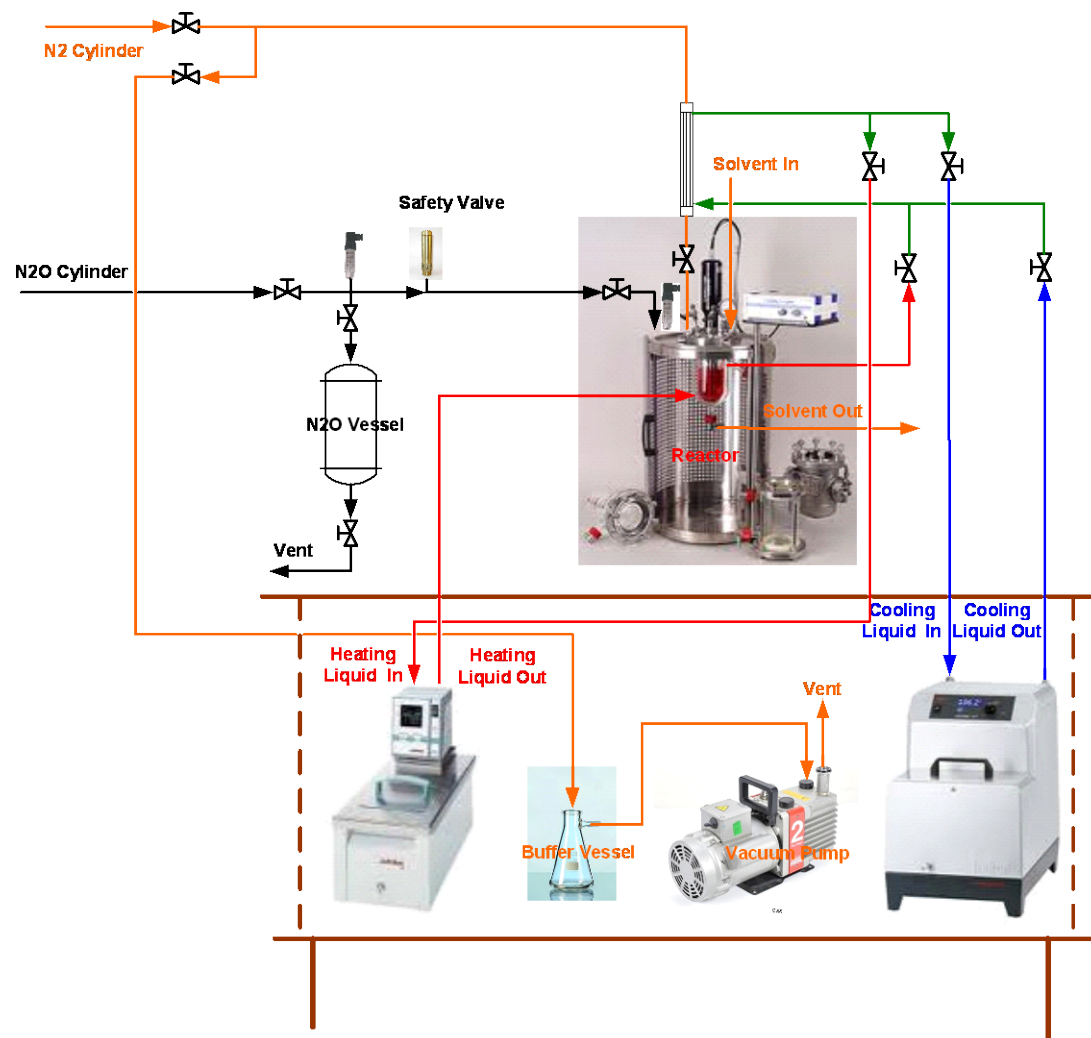
1. Low Pressure Apparatus



- ❖ Up to 2 bar (abs)
- ❖ Up to middle range of CO₂ loading
- ❖ Up to 90C

Hartono, et al. (2008)

2. Moderate/High Pressure Apparatus



- ❖ Up to 6 bar
- ❖ Up to 200 C



- ❖ Up to 60 bar
- ❖ Up to 250 C

❖ Higher CO₂ loading

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N₂O and CO₂ solubility was measured:

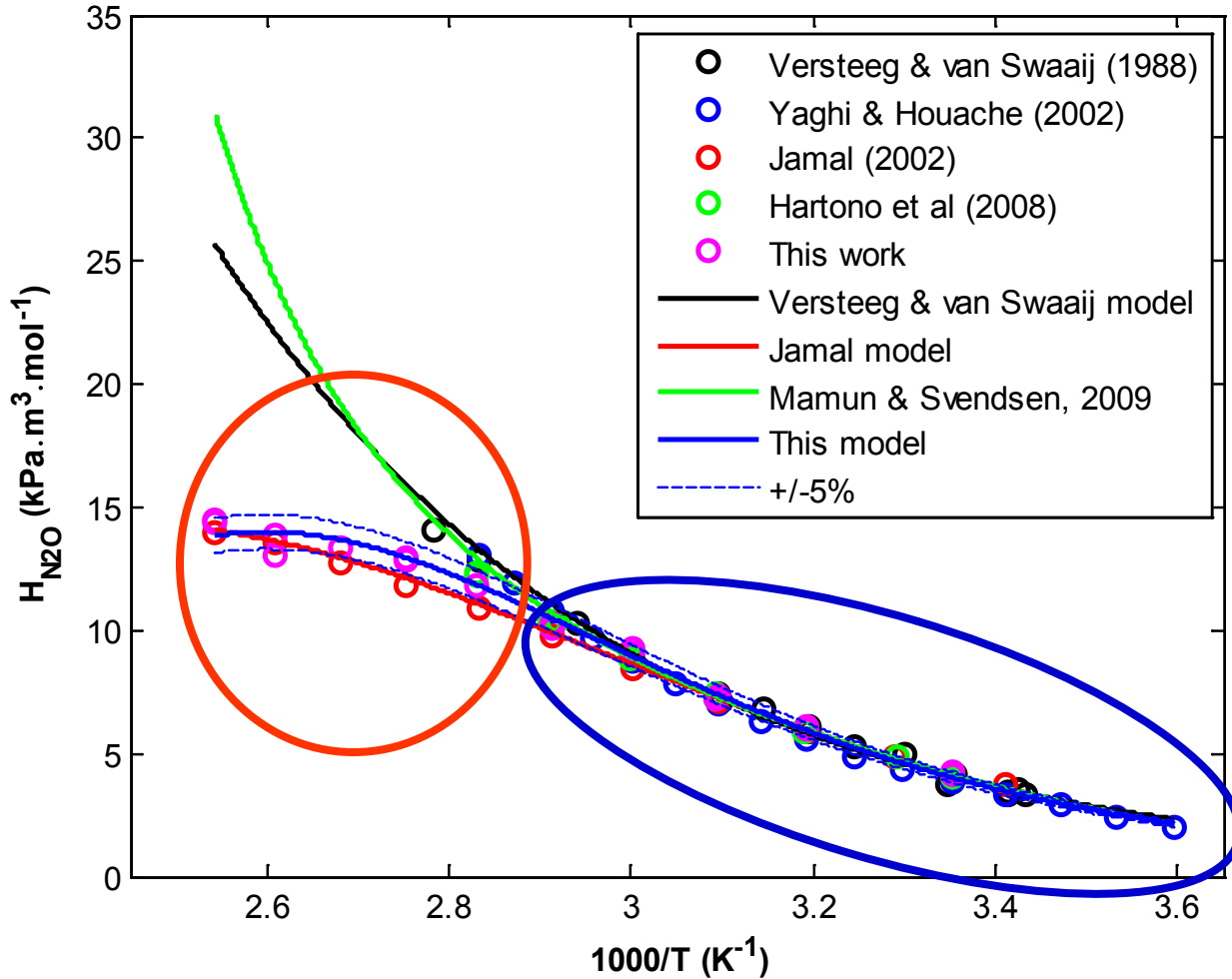
- 1. Water**
- 2. Neutralized amine system
with equinormal amount of amine and H₂SO₄**

MDEA 50wt% + 2.2 M H₂SO₄

MDEA 70wt% + 3.1 M H₂SO₄

Results and discussion

Comparing N₂O solubility in H₂O with literature



❖ Very good agreement up to 70C within +/- 5%

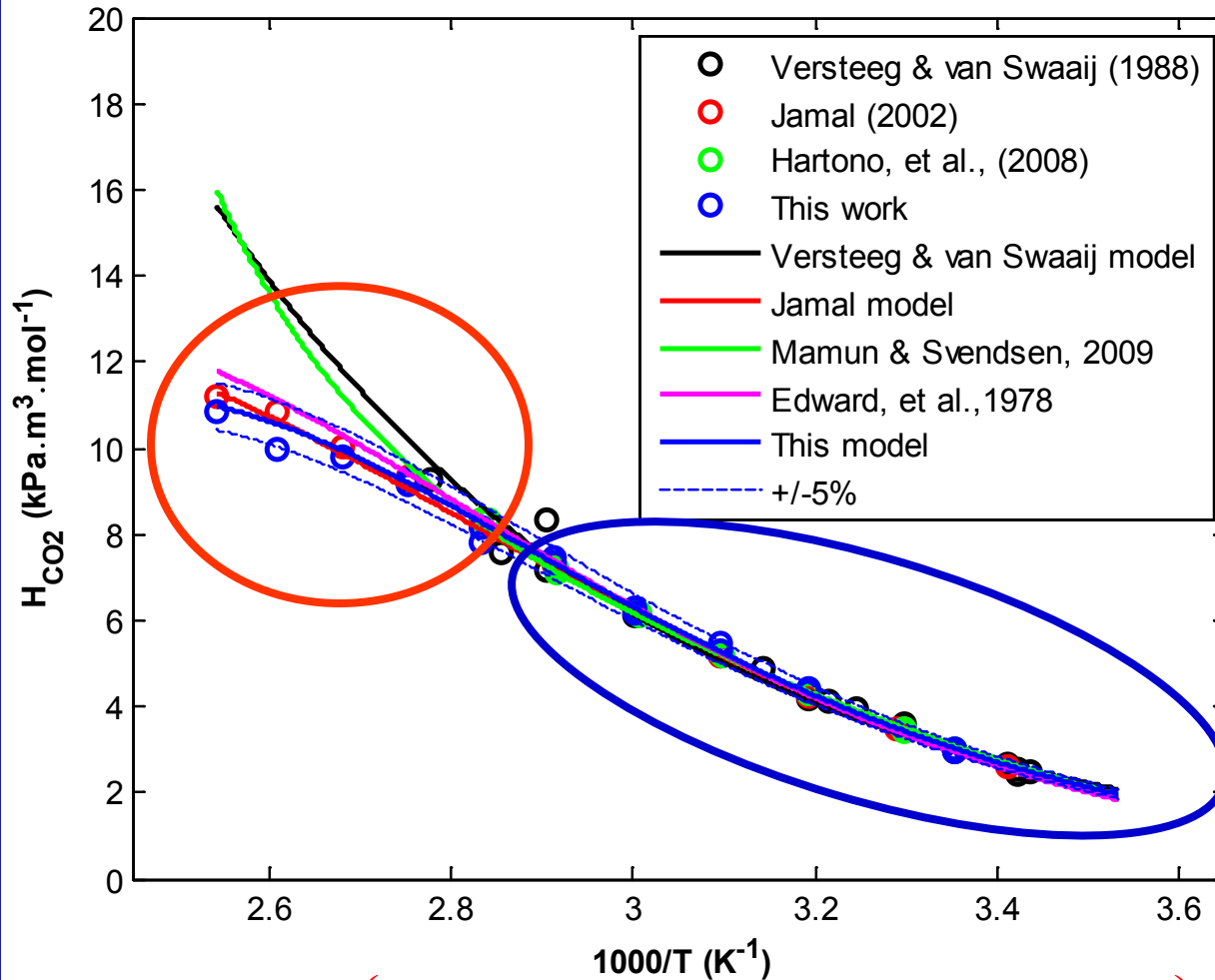
❖ Discrepancy at higher temperature

❖ New high pressure apparatus gave certainty at higher temperature

$$H_{N_2O}^{H_2O} = \exp\left(-700.65 + \frac{14905.5}{T} + 126.4 \cdot \log(T) - 0.238 \cdot T\right)$$

AARD = 4%

Comparing CO₂ solubility in H₂O with literature



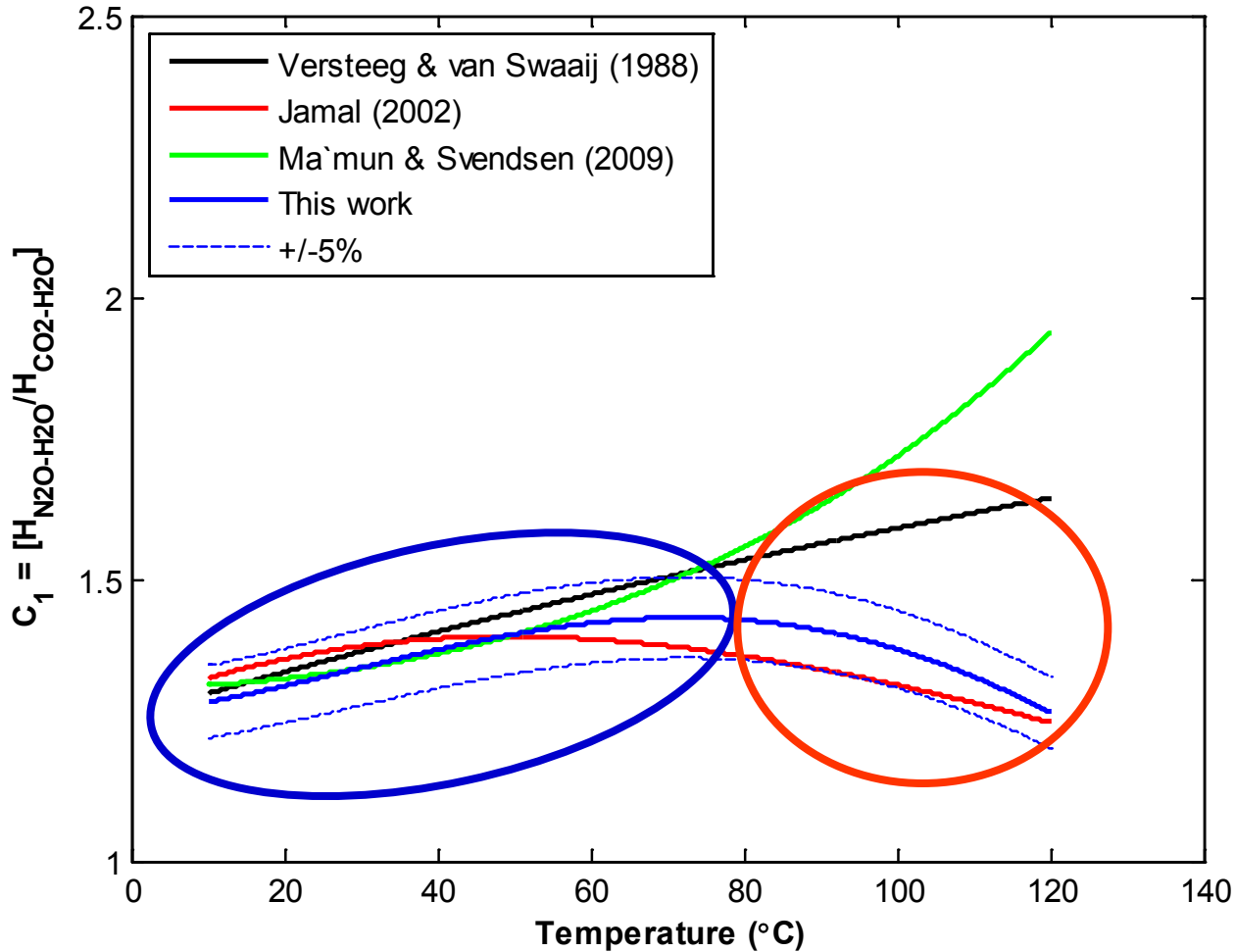
❖ Very good agreement up to 70C within +/- 5%

❖ New data for higher temperature

$$H_{CO_2}^{H_2O} = \exp\left(-212.73 + \frac{2078.2}{T} + 40.9 \cdot \log(T) - 0.09 \cdot T\right)$$

AARD = 3%

Comparing the obtained N₂O analogy for water with literature

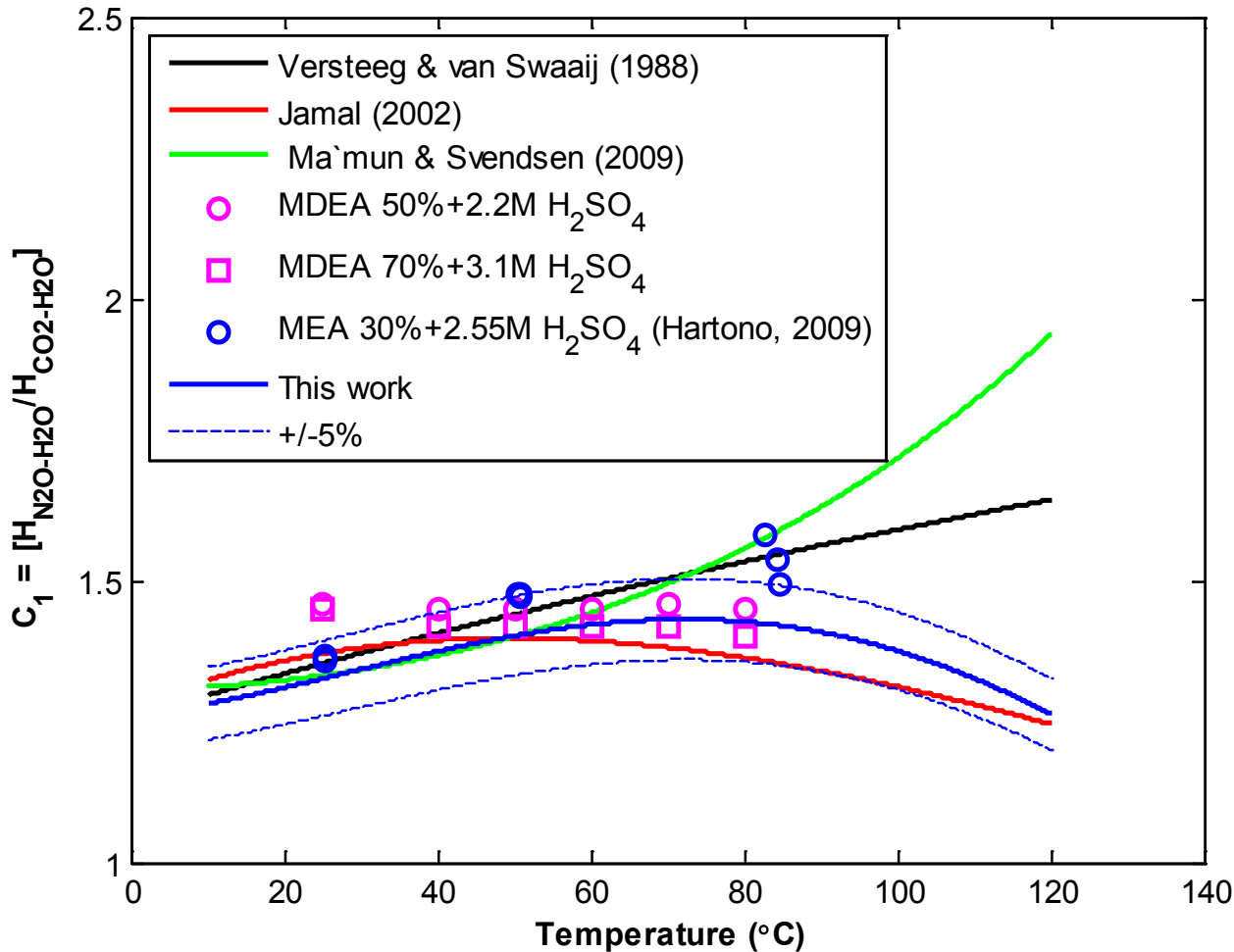


❖ Very good agreement up to 70C within +/- 5%

❖ Discrepancy at higher temperature

❖ We provide a new correlation for N₂O Analogy for a wider range of temperature

Comparing the obtained N₂O analogy from Neutralized Solution



❖ Very good agreement up to 70C within +/- 5%

❖ The neutralized solution follows the the N₂O analogy from water reasonably well

❖ Still need to work more at higher temperature (High Pressure Apparatus!!)

Conclusions

- ❑ The experimental procedure and apparatus was validated and the results obtained are consistent with literature data up to 70C
- ❑ N₂O Analogy was found to be valid even at high amine concentrations (50 wt% and 70 wt%)
- ❑ We provide a new correlation for the N₂O analogy

Future Work

- ❑ More work needed to measure the Henry's law constant at higher concentrations of amine and higher temperatures

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