Solubility of Carbon Dioxide in Aqueous Solution of Monoethanolamine and n-Methyldiethanolamine: Experimental Measurements and Modeling

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Chemical absorption with aqueous amines is a widely adopted technology for CO_2 capture in industrial processes, with monoethanolamine (MEA) as the benchmark absorbent. However, MEA has drawbacks, including high energy requirements for regeneration and significant corrosiveness. In contrast, n-methyldiethanolamine (MDEA), a tertiary amine, shows significant potential for CO_2 capture due to its substantial loading capacity [1].

This study focuses on determining CO_2 solubility in aqueous solutions of MEA and MDEA using a static-isochoric-synthetic method. The apparatus, which is designed for pressures up to 10 MPa, allows for the characterization of a broad range of CO_2 loadings for both amines: (0.2 – 1) mol CO_2/mol MEA and (0.1 – 1.6) mol CO_2/mol MDEA. The technique is validated by comparing the results obtained with those available in the literature for the system 30 wt.% MEA at T = (313.15 – 393.15) K and pressures up to 10 MPa. For MDEA, measurements are carried out at T = (313.15 – 353.15) K and pressures up to 9 MPa. A comprehensive uncertainty analysis is also performed taking into account the contributions of volume cell calibration, liquid mixture density, pressure, temperature, CO_2 charging method, water mass, and pure amine mass. This equipment is versatile over a wide range of CO_2 loadings, pressures and temperatures, and there is no need for phase analysis.

Finally, the experimental data are correlated with a modified mathematical model based on the Kent-Eisenberg and Deshmukh-Mather (D-M) models. The Krichevsky-Kasarnovsky equation is coupled with D-M to predict experimental data at CO_2 loadings exceeding 1 mol CO_2/mol amine at high pressures. These models predict amine speciation, including unreacted amine, protonated amine, carbamates, carbonates, and CO_2 solubilized without chemical reaction.

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References

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