

PhD defence by Lucas Farias Falcchi Correa

CO₂ capture by absorption: Experiment and modelling

Abstract

Carbon capture and storage is one of the main pathways to reduce the emission of carbon dioxide while coping with the increasing energy demand. The proposition and assessment of new solvents is crucial to increase the efficiency of the CO₂ capture process.

The amine scrubbing process is noteworthy for being a well-understood and robust technology for carbon dioxide (CO₂) capture. Despite being widely used, the process is energy-intensive and may significantly decrease the energy efficiency of a power plant. In any absorption-based CO₂ capture unit, the solvent regeneration step is the main contributor to the high power consumption.

Currently, the most mature alternatives for amine-based solvents are ammonia (NH₃) and potassium carbonate (K₂CO₃) based aqueous solutions. When combined, these solvents present high absorption capacity and, specially, lower energy requirement for solvent regeneration than the standard solvent for amine scrubbing. Furthermore, the use of other additives may enhance the performance of such mixed-salt solvent.

When using these solvents, CO₂ is chemically absorbed in the liquid phase. For this reason, the calculation of phase equilibrium is not straightforward, as it also depends on the chemical reaction equilibrium. These calculations require information on the temperature dependence of chemical equilibrium constants and thermodynamic models able to represent electrolyte solutions. The latter, in turn, rely on high quality experimental data to determine the parameters of the models accurately.

In this sense, the goal of this project was to create a reliable data-basis for a thermodynamic model suitable for simulation of absorption and desorption of CO₂ using a new solvent consisting of NH₃, MDEA, K₂CO₃, and water. The project involved the development of equipment for measurement of complex phase equilibrium phenomena. The data were used to develop a model that is applicable to the design of CO₂ capture processes using mixed electrolyte solutions.