Chilled ammonia process for CO_2 capture

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Carbon dioxide capture consists of separating the CO_2 from the flue gas from power plants instead of releasing the CO_2 into the atmosphere. The main objective is to obtain a nearly pure CO_2 stream that can be compressed and sequestrated or used for an application. This work deals with the study of a post combustion carbon dioxide capture process using chilled aqueous solutions of ammonia as solvent.

The heat of absorption of carbon dioxide by ammonia is significantly lower than for alkanolamines that are commonly used for carbon dioxide capture. In addition, by using ammonia, degradation problems can be avoided and a high carbon dioxide capacity is achieved. Hence, this process shows good perspectives. The absorption occurs at low temperature in order to limit the transfer of ammonia to the gas phase.

In order to simulate and optimize the process, a thermodynamic model for the system is required. The properties of the NH_3-CO_2-H_2O system was previously modeled using the Extended UNIQUAC electrolyte model in the temperature range from 0 to 110°C, the pressure range from 0 to 100 bars and for a molality of ammonia up to approximately 80. [Thomsen and Rasmussen, 1999] The temperature range of interest for a CO_2 capture process using aqueous ammonia is from 0 to 150 °C. In this work, the validity of this model was extended up to 150°C. Also additional data for the enthalpy of evaporation of NH_3-CO_2-H_2O mixtures were used in order to improve the ability of the model to calculate the energy requirement of the process.

Software based on this model has been used to study the equilibrium composition and enthalpy of the different streams of the process. The compositions and temperatures of each stream were taken from the patent. [Gal, 2006] The software gives the speciation of the liquid phase, the composition of the gas phase and the composition and amount of solid phases.

The results show that solid phases consisting of ammonium carbonate and ammonium bicarbonate are formed in the absorber. It also shows that the pure CO_2 stream that leaves the stripper is pressurized, and therefore energy savings can be made compared to conventional processes that require a compression of carbon dioxide before its transport and use. The quantity of ammonia that is swept along in the gas phase in the desorber per quantity of carbon dioxide captured has also been studied.

The energy requirement is a key parameter of the process, as it is strongly linked to the cost of the capture. The model also allows the calculation of the enthalpy of each stream at equilibrium. Both the energy produced in the absorber and the energy requirement of the stripper have been studied. The influence of several parameters on the energy requirement have also been studied.

Gal E, Ultra cleaning combustion gas including the removal of CO2, World Intellectual Property, Patent WO 2006022885, 2006

Thomsen K and Rasmussen P, Modeling of Vapor-liquid-solid equilibrium in gas-aqueous electrolyte system, Department of Chemical Engineering, IVC-SEP, Technical University of Denmark, Modeling of Vapor-liquid-solid equilibrium in gas-aqueous electrolyte systems, Chemical Engineering Science, 54(1999)1787-1802, 1999

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