1st Post Combustion Capture Conference

Modeling CO_2 capture using concentrated piperazine

Jorge M. Plaza[a], David Van Wagener[a], Eric Chen[a], Gary T. Rochelle[a]1*

[a]The University of Texas at Austin, 1 University Station C0400, Austin, TX 78712

Keywords: Carbon dioxide, absorption, stripping, modeling, piperazine

Advanced amine solvents and innovative configurations have been proposed as a strategy to minimize the impact of a carbon capture unit on the efficiency of a power plant. This paper presents pilot plant and modeling results of the concentrated piperazine solvent using an intercooled (40 °C) absorber and a high temperature (150 °C) two-stage flash stripper configuration. Concentrated piperazine (PZ) is considered an evolutionary step from the state of the art monoethanolamine (MEA). It has almost double the capacity of 7 molal (m) MEA while displaying similar volatility and higher resistance to oxidative and thermal degradation. Intercooling has been proven to increase absorber CO_2 removal as much as 10%. A high temperature two-stage flash can reduce the energy demand of the stripper, require less capital investment and a have smaller footprint.

In order to assess PZ performance, an Aspen Plus® model was developed for 8 m (40 wt%) PZ. It uses a modified version of the Hilliard thermodynamic representation that incorporates new 8 m data for partial pressure of CO_2 vs. loading. It uses a reduced reaction set based on the more relevant species present at the expected operating loading (0.25–0.4 mol CO_2/mol alkalinity). Kinetics were regressed to match reported carbon dioxide flux data for 8 m PZ absorption using a wetted wall column (WWC). Density and viscosity were satisfactorily regressed (<5% deviation) to match experimental data. The activity coefficient of CO_2 was also examined and compared to values previously found as a function of amine concentration and loading and modified to include newly obtained CO_2 solvent solubility data.

Both the absorber and the stripper were modeled in RateSep™. Model accuracy was evaluated using pilot plant campaigns with PZ at 5 m, 8 m and 9 m. Two different types of packings were tested (Mellapak 2X in the stripper and absorber and RSP-250 in the absorber). The absorber was operated with and without intercooling, and it was coupled to a simple stripper and a two stage flash in two separate pilot plant campaigns. Intercooling was installed in the middle of the column to lower liquid temperature to 40°C. Absorber loading and removal were adequately matched in the model and the temperature profile was approached within 6°C. The mass and energy balance around the stripper was also matched within reasonable error.

The validated models were used to define optimum capture process conditions for a 500 MW coal power plant. Four optimums are proposed: simple absorber + simple stripper, intercooled absorber + simple stripper, simple absorber+ two stage flash, and intercooled absorber + two stage flash.

* Corresponding author. Tel.: +1-512-471-7230; fax:+1-512-475-7824.
E-mail address: gtr@che.utexas.edu.