Abstract

A good prediction of mass transfer rate in packed columns is crucial for an efficient column design. Liquid viscosity is one of the physical properties that affects gas-liquid mass transfer rate in different separation tasks including post-combustion CO₂ capture. Amine solvents typically have viscosity 5-15 times greater than water. The increased liquid viscosity will impede mass transfer in the absorber and the stripper by slowing diffusion of CO₂ and loaded amine to the bulk liquid, the diffusion of free amine to the liquid-gas interface, and reducing liquid turbulence on the packing surface.

In this work, effective mass transfer area (\(a_e\)) and liquid phase mass transfer coefficient (\(k_L\)) were measured with three structured packings (GT-OPTIMPAK 250Y, RSP 250Y, and MP 250Y) in a pilot-scale PVC column (0.43 m I.D.) at viscosities of 1, 4, 15, and 60 cP. Glycerol was added at 0-85 wt% to enhance the liquid viscosity.

Effective mass transfer area was measured by absorption of ambient CO₂ into aqueous glycerol containing 0.1 M NaOH. The reaction rate was calculated from a kinetic model based on previous wetted-wall column data. The liquid viscosity has an insignificant effect on \(a_e\) at medium to high liquid rate (25-60 m³/m²·hr), while at low liquid rate (6-25 m³/m²·hr) the \(a_e\) of viscous liquid is about 20% lower than that of water, which is still within the noise range of the experiment considering the relatively large column size and varying ambient air conditions on different days.

The liquid film mass transfer coefficient was measured by desorption of toluene from aqueous glycerol. With increasing liquid viscosity, \(k_L\) decreases rapidly at a total dependence (including the diffusivity effect) of -0.60, ranging from \(2 \times 10^{-6}\) m/s to \(1 \times 10^{-4}\) m/s at the examined viscosities and liquid rates.

Other physical properties (Henry’s constant, surface tension) of the CO₂/NaOH/H₂O/glycerol system were calculated from models based on literature data. The data of \(a_e\) and \(k_L\) for GT-OPTIMPAK 250Y are shown in the figures below.
Figure 1: Effect of liquid viscosity on effective mass transfer area for GT-OPTIMPAK 250Y

Figure 2: Effect of liquid viscosity on liquid phase mass transfer coefficient for GT-OPTIMPAK 250Y
Figure 3: Total dependence on liquid viscosity of liquid phase mass transfer coefficient for GT-OPTIMPAK 250Y

\[ y = 0.00026 x^{-0.60048} \]