ABSTRACT

One of the main global challenges in the years to come is to reduce the carbon dioxide (CO_2) emissions in view of its apparent contribution to global warming. Aqueous amine based absorption-regeneration process for removing CO_2 is a mature technology. Monoethanolamine (MEA), diethhanolamine (DEA) are the conventional solvents for rapid capture of CO_2. However, implementation of the conventional amine solvent for capturing CO_2 from power plant flue gas streams leads to high energy requirement, large solvent circulation rate and high solvent degradation rate, all of which in turn increases the operating and capital cost of carbon capture. So, the focus of CO_2 capture research is to develop more efficient solvents with high CO_2 absorption rate and capacity with lower regeneration energy requirement.

This work focuses on the development of an effective solvent for the post-combustion CO_2 capture by evaluating the absorption properties (physico-chemical property, kinetics, vapour-liquid equilibrium and absorption enthalpy) of hexamethylenedimaine (HMDA) based solvent. Five aqueous solvent systems are studied in the wide range of temperature (303-333K) and composition. The solvent systems studied in this work are aqueous HMDA, sodium glycinate (SG), (HMDA+MDEA), (HMDA+AMP) and (HMDA+SG).

Physico-chemical (density, viscosity, and physical solubility) properties of aqueous single and blended amine solvents are measured in the temperature range of 303-333K and suitable model (Redlich-Kister model for density, Grunberg and Nissan model for viscosity, Wang model for physical solubility and empirical model) is proposed to correlate the experimental data. These physico-chemical property data are used to analyse the kinetics of CO_2 absorption.

Kinetic of CO_2 absorption in the formulated solvents are investigated under pseudo-first order reaction condition using a reaction calorimeter set-up. Second order rate constant for HMDA-CO_2 reaction system is found to be one order higher than that of the benchmark amine MEA. For the mixed amine systems (HMDA+MDEA, HMDA+AMP and HMDA+SG), reaction rate is found to enhance significantly due to presence of HMDA.

Vapour-liquid equilibrium (VLE) of CO_2 in the aqueous single (HMDA, SG) and blended amine solvent systems are measured using a stirred equilibrium cell set-up. VLE data is expressed in CO_2 loading (mole CO_2 absorbed per mole total amine, α_{CO_2}). For aqueous HMDA system, α_{CO_2} is found to be 2.5 times higher than the MEA system of same concentration. α_{CO_2} of the blended solvent appears to improve due to the presence of HMDA.

CO_2 absorption enthalpy in the formulated single and blended solvent systems is studied using a reaction calorimeter system. CO_2 absorption enthalpy of HMDA is found to be higher than that of the MEA solvent. So, to reduce absorption enthalpy, HMDA is mixed with the low energy solvents (MDEA, AMP, SG). The blended solvents show lower absorption enthalpy compared to the MEA system.

Key Words: CO_2 capture, VLE, Kinetics, enthalpy, HMDA, SG, MDEA, AMP.