Reaction kinetics of carbon dioxide in hybrid MEA solutions

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Keywords (3-5 keywords): Chemical absorption; solvents; MEA

ABSTRACT

The CO_2 absorption process can be enhanced economically by using more efficient configurations and/or new solvents. 30wt.-% MEA aqueous solutions have been studied deeply along decades and nowadays, new alternatives are proposed. During the absorption of CO_2 in reactive solvents, two phenomena take place: physical absorption and chemical reaction. The importance of each of them will depend on the physical properties and the concentrations of the components implied. Typically, most of the effort is focused on the improvement of the chemical reaction between the CO_2 and the solvent. However, at low concentration of the reactive solvent, the physical absorption will play a significant role in the process. Organic solvents present a higher physical solubility of CO_2 than this of water. However, some organic compounds present high volatility than can increase the solvent loss during absorption and desorption. Additionally, the substitution of water frequently comprises a more viscous blend that will be more difficult to manage at industrial scale.

In this work, we aimed to combine both effects: a fast chemical reaction between the reactive solvent and the CO_2; and an increase of the physical solubility by the use of organic solvents. We present a comparison of the influence of organic solvents in the performance of 30wt.-% MEA. We analysed the influence of the organic solvents through mass transfer and kinetic experiments. The resulting physical properties of the solutions are examined to extract its influence on the kinetics. Lastly, an extrapolation of the advantages and disadvantages that those solutions will present at industrial scale is presented.

Methodology

Mass transfer and kinetic coefficients were measured from 303 to 353K using a Double Stirred Cell (DSC) (Figure 1). The procedure was carried out so that pseudo first order conditions were fulfilled and considering the zwitterion mechanism and two film theory. The equipment and methodology were validated with 30wt.-% MEA. Physical properties as density, viscosity and physical solubility of N_2O in the solutions were measured from 298 to 353K. The physical solubility of CO_2 in the solvents was calculated using the N_2O analogy and the diffusion of CO_2 was based on the equivalence in water. The effect of the organic solvents was analysed based on the results of the mass transfer and kinetic coefficients. Finally, advantages and disadvantages of the different organic solvents were discussed.

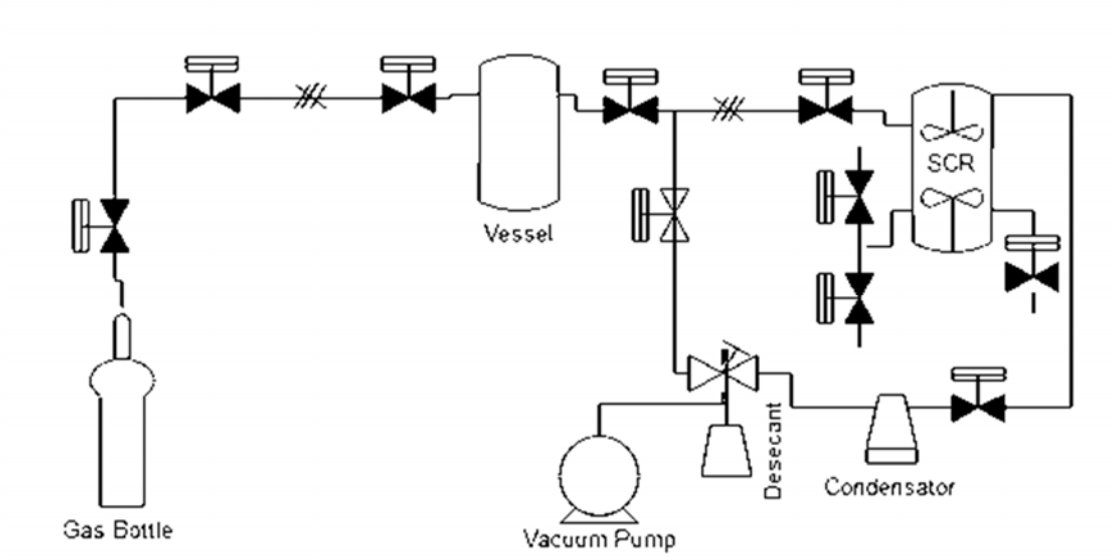

Figure 1 Schematic configuration of the Double Stirred Cell (DSC, also called SCR) used in this work