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ORIGINAL PAPER

Investigation of CO_2 and ethylethanolamine reaction kinetics in aqueous solutions using the stopped-flow technique‡

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Kinetics of the reaction of CO_2 and ethylethanolamine (EMEA) in aqueous solutions has been studied using the stopped-flow technique with conductivity detection. Measurements were performed at 288 K, 293 K, 298 K, and 303 K. Amine concentration ranged from 10 mol m^{-3} to 37.5 mol m^{-3}. The termolecular mechanism was applied to interpret the kinetic data. In this mechanism, carbamate formation occurs in a single-step reaction without the formation of a zwitterion intermediate. An original method of analyzing the experimental data was proposed allowing the derivation of pseudo second order rate constants from the measured kinetic traces. Based on these values, the third order rate constants (k_{H_2O}) of the reaction of CO_2, water, and EMEA were derived and correlated by the Arrhenius equation.

Keywords: CO_2 removal, secondary amines, termolecular mechanism, kinetics, stopped-flow technique

Introduction

Removal of carbon dioxide from different gas streams is an important industrial operation. It is produced by many industries including steel production, chemical and petrochemical manufacturing, and natural gas processing. Since CO_2 is regarded as a greenhouse gas potentially contributing to global warming, there has been considerable interest in developing effective technologies for its capture from flue gases from fossil fuel power plants.

Absorption using amine-based solvents is generally recognized as the most efficient post-combustion CO_2 separation technology at present. Amines proved to be of principal commercial interest are: 2-aminoethanol (monoethanolamine, MEA), 2,2′-dihydroxydiethylamine (diethanolamine, DEA), and *N*-methyl-2,2′-iminodiethanol (methyldiethanolamine, MDEA) (Kohl & Nielsen, 1997). In the last decade, interest in using MDEA, which is a tertiary amine, has increased significantly. The main advantages of MDEA over the extensively used MEA are its relatively high capacity, low enthalpy of reaction with CO_2, and low vapor pressure. Other properties of MDEA include higher resistance to degradation and fewer corrosion problems compared to MEA. MDEA has, however, very low reactivity with respect to CO_2 due to its tertiary amine characteristics. The relatively low rate of absorption in MDEA solutions can be increased by an addition of low concentrations of primary and secondary amines or selected diamines (Kierzkowska-Pawlak & Chacuk, 2010). Compounds added to the base solvent to increase the overall absorption rate are typically called activators.

According to Vaidya and Kenig (2007), 2-(ethylamino)ethanol (ethylethanolamine, EMEA) represents a secondary amine which can be applied as an efficient activator of MDEA. EMEA is especially promising as it can be prepared from renewable resources. Only a few studies on the kinetics of the reaction of CO_2 with

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