

PREFACE

The rapid increase in population leads to industrialization, afforestation, imbalance of energy demand, disturbance in natural habitats, soil/land degradation, and climate change. Various anthropogenic activities release harmful greenhouse gases in the atmosphere, which adversely pollute the environment. A large fraction of greenhouse gas is composed of carbon dioxide (CO₂), and its large emission is not favorable from an environmental point of view. Burning fossil fuels such as coal, natural gas, and oil is primarily responsible for the vast CO₂ emissions in the environment. Intergovernmental Panel on Climate Change (IPCC) has projected that if CO₂ emissions continue unchecked, the earth's temperature will rise by 2 °C by the year 2100. The anticipated data is horrifying since increasing CO₂ is responsible for increasing sea level, drought, flooding, storms, and other natural calamities. Therefore, it is necessary to capture CO₂ emitted from the flue gas.

Three main techniques are available for CO₂ capture: pre-combustion, post-combustion, and oxy-combustion. Among these techniques, post-combustion is the most mature way of CO₂ capturing; it has retrofitting properties with the existing units and its commercialization has also started. The post-combustion technique can be employed through different methodologies such as absorption, adsorption, membrane technology, cryogenic separation, and microalgae process. However, post-combustion CO₂ absorption by amine solvents is the well-established and most suitable method because of its high CO₂ capture recovery (80–95 %), low sensitive to acid gases, high mass transfer rate, and energy-intensive process. Monoethanolamine (MEA) is considered an industrial benchmark amine, but due to their disadvantages of high degradation, corrosive behavior, high vapor pressure, and costly regeneration process, researchers targeted different aqueous amine

blends to capture CO₂. Therefore, to overcome the challenges of the single amines, researchers are working on different amine blends to enhance the overall CO₂ absorption and desorption performance.

The least amount of research has been carried out in CO₂ capture through 2-Dimethylaminoethanol (DMAE), which is a novel tertiary amine and is considered an alternative to conventional Methyldiethanolamine (MDAE). When DMAE blended with some activators such as 2-(Butylamino)ethanol (BAE), Hexamethylenediamine (HMDA), and Triethylenetetramine (TETA) showed promising results. Therefore, the research objectives were decided to investigate the novel amine blends of BAE+DMAE, HMDA+DMAE, and TETA+DMAE for post-combustion CO₂ capture. The entire investigation of these novel amine blends has been incorporated in this thesis work, and they are summarized in separate chapters.

Chapter 1 describes the introduction of CO₂ emission, its global impacts, and its solution by using carbon capture and storage (CCS) technique. This chapter conducts an in-depth literature review on various CO₂ capture technologies and methodologies. Emerging biphasic amine solvents, their research progress, and various investigations conducted by different researchers on biphasic solvents are targeted.

Chapter 2 includes the literature review of screening of various tertiary amines for post-combustion CO₂ capture. Experimental investigations of CO₂ absorption and desorption have been targeted for screening purposes. Based on screening results, DMAE was selected, and previous experimental investigation on DMAE-based amine blends was deeply studied. Finally, the scope and objectives of the present work have been incorporated in this chapter.

Chapter 3 discusses the CO₂ absorption and desorption investigation by selecting the novel aqueous amine blend of 2-(Butylamino)ethanol (BAE) and 2-Dimethylaminoethanol (DMAE). In this work, equilibrium CO₂ loading was mainly targeted in the CO₂ absorption study, whereas cyclic capacity and cyclic equilibrium CO₂ loading were focused in the CO₂ desorption investigation. Reaction mechanism, ¹³C NMR and FTIR characterization, pH estimation, toxicity, heat of CO₂ absorption (ΔH_{abs}), and optimization were the prime objectives of the research work.

Chapter 4 explains the CO₂ absorption-desorption performance of a novel aqueous binary amine blend of Hexamethylenediamine (HMDA) and 2-Dimethylaminoethanol (DMAE). CO₂ absorption and desorption rate, heat duty and regeneration efficiency, thermophysical property, i.e., density estimation, etc., were the important parameters that were estimated to evaluate the performance of the novel chosen amine blend for post-combustion CO₂ capture.

Chapter 5 describes the selection of a novel aqueous Triethylenetetramine (TETA) and 2-Dimethylaminoethanol (DMAE) amine blend for post-combustion CO₂ capture. Equilibrium CO₂ loading was estimated and the results were validated by empirical modeling. The effect of process parameters on equilibrium CO₂ loading was determined for the chosen operating conditions. The entire reaction mechanism of the novel amine blend has been suggested, and ¹³C NMR characterization authenticated the same. At last, response surface methodology (RSM) was used to optimize the equilibrium CO₂ loading.

Chapter 6 summarizes the overall conclusion of the present research work and based on current investigation, future recommendations have been suggested.