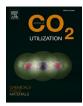


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# Microfluidic analysis of seawater-based CO<sub>2</sub> capture in an amine solution with nickel nanoparticle catalysts



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#### ABSTRACT

Post-combustion  $CO_2$  capture methods like amine scrubbing are currently being utilized to reduce  $CO_2$  emissions from fossil fuel power plants. Aqueous monoethanolamine (MEA) solutions are typically used in these processes due to their high  $CO_2$  absorption capacity and rapid reaction rate, but these solutions also produce environmentally harmful toxic wastewater and consume large amounts of freshwater. This research analyzes the effectiveness of seawater-based MEA solutions containing nickel nanoparticles (NiNPs) as catalysts, with the goal to minimize the amount of MEA required in the amine scrubbing process and eliminate the use of freshwater. This study is the first to use natural seawater solutions as an alternative to freshwater solutions for  $CO_2$  capture. In a microfluidic environment,  $CO_2$  microbubbles were generated and their change in size with respect to time was observed to determine the  $CO_2$  absorption capacity and rate of the test solutions. Pure seawater demonstrated comparable  $CO_2$  absorption to deionized (DI) water. Seawater-based amine solutions demonstrated faster  $CO_2$ absorption rates than their freshwater counterparts. Lastly, to further optimize  $CO_2$  absorption, NiNPs were added to each test solution. Seawater with MEA and NiNPs absorbed only 1.15 % less than its DI water counterpart, confirming seawater's potential as amine-based solvent for industrial  $CO_2$  capture applications.

### 1. Introduction

Excessive anthropogenic  $CO_2$  emissions have driven global temperature rise, ocean acidification, and sea level rise over the last decades [1]. At present, significant quantities of  $CO_2$  emissions are produced by fossil fuel combustion processes in power plants, accounting for 40 % of global  $CO_2$  emissions [2]. Projected  $CO_2$  emissions are expected to substantially exceed sustainable levels, resulting in dangerous long-term consequences for the environment and society [3]. A global temperature increase is associated with more intense precipitation events, including hurricanes, and mass extinction events in a variety of plant and animal species [4]. In addition, due to the continued rise of sea levels and resultant frequent flooding, over 300 million people are estimated to be displaced in the next decades; the economic and political strain caused by this extensive human displacement would be enormous [5]. As global energy demands continue to increase each year, innovative environmentally sustainable methods of power generation that actively address

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 $CO_2$  emission reduction are essential to combat climate change and mitigate its detrimental effects [6].

Currently, post-combustion  $CO_2$  capture is one of the most prominent technologies being utilized in commercial fossil fuel power plants to reduce their  $CO_2$  emissions [7]. Post-combustion  $CO_2$  capture is the process of removing  $CO_2$  from the flue gas after the combustion process is complete. Typically, the captured  $CO_2$  is then sequestered and stored utilizing complex chemical processes [8]. The modular nature of post-combustion  $CO_2$  capture is a great advantage over other  $CO_2$  capture methods such as pre-combustion carbon capture and oxy-fuel combustion. These methods are comparatively complex and costly to be retrofitted to current power plants [9,10]. Amine scrubbing is the dominant method for post-combustion carbon capture and has already been practically retrofitted to existing power plants [11]. In amine scrubbing,  $CO_2$  rich flue gas and amine solution flow into an absorber unit where the amine solution absorbs  $CO_2$  from the flue gas. After the reaction is complete, the  $CO_2$  depleted flue gas is directed out of the