International Journal of Greenhouse Gas Control 96 (2020) 103010

Contents lists available at ScienceDirect

International Journal of Greenhouse Gas Control

journal homepage: www.elsevier.com/locate/ijggc

Review of modelling and simulation strategies for evaluating corrosive behavior of aqueous amine systems for CO_2 capture

Shaukat Ali Mazari[a,*], Lubna Ghalib[b], Abdul Sattar[a], Mir Muhammad Bozdar[a], Abdul Qayoom[a], Israr Ahmed[c], Atta Muhammad[a], Rashid Abro[a], Ahmed Abdulkareem[d], Sabzoi Nizamuddin[e], Humair Baloch[e], N.M. Mubarak[f]

[a] Department of Chemical Engineering, Dawood University of Engineering and Technology, Karachi 74800, Pakistan
[b] Materials Engineering Department, Mustansiriayah University, 14022 Baghdad, Iraq
[c] School of Chemical Engineering, University of Faisalabad, Faisalabad, Pakistan
[d] Mathematics Science, Directorate General of Education Rusafa 1, Baghdad, Iraq
[e] School of Engineering, RMIT University, Melbourne 3000, Australia
[f] Department of Chemical Engineering, Faculty of Engineering and Science, Curtin University, 98009 Sarawak, Malaysia

ARTICLE INFO

Keywords:
Corrosion models
Carbon steel corrosion
Electrochemical reactions
CO_2 corrosion
CO_2 capture
Polarization curve

ABSTRACT

Corrosion is one of the critical problems for process operations and plant life. Amine-based post-combustion CO_2 capture systems are known to be corrosive. This is because of the absorption of CO_2 by aqueous amine solution, which makes the system acidic and generates oxidizing agents through ionization leading to corrosion. Corrosion increases with CO_2 loading, process temperature, presence of oxygen (O_2), occurrence of sulfur compounds, low pH, velocity of solution and formation of some degradation products. Conducting experimental investigations to determine the rate of corrosion at various parts of process plant under a wide range of operating parameters is difficult and costly. Mathematical models and simulations play an important role in estimating the rate of corrosion under wide range of operating parameters for such systems. This study highlights the process of corrosion for amine-based CO_2 capture systems and development of corrosion models with critical analyses on their applications. Study also highlights the outlook of models and simulations.

1. Introduction

Industrialization, specially the coal dependency for energy is not going anywhere soon. Matter of the fact is that at present there is a list of 10,000 retired, operating and planned coal units, producing a total of almost 3,000 GW in 95 countries (Evans and Rosamund, 2019). It is reported that China and India are the leading countries with installation of new coalfired power plants in last decade. Installation of new coalfired power plants are reported to further thicken the atmospheric carbon dioxide (CO_2) layer beyond the repair. Records of Mauna LOA Observatory indicate that very unfortunately we already have crossed the mark of 415 ppm of CO_2 in atmosphere in May 2019 (Observatory, 2019). CO_2 is one the major greenhouse gases and it tends to accumulate in atmosphere leading to global warming and climate change. This means that the need for a retrofit technology for CO_2 capture cannot be ignored.

History of use of amines for sour gas treatment goes back to 1930s (Roger, 1930, 1931). The technology uses amines to capture CO_2 and sulfur dioxide (SO_2). The technology has already matured on sour natural gases treatment before its application for CO_2 capture from flue gases (Milton, 1963). Retrofitting option of post-combustion CO_2 capture technology makes it feasible for CO_2 capture from flue gases (Rochelle, 2009). However, process operating conditions differ in flue gas treatment than natural gas (Gao et al., 2012; Soosaiprakasam, 2007; Wattanaphan et al., 2013). The amine-based CO_2 absorption is a chemical process. Mass transfer takes place between the gas and the liquid phase. The tall absorber and desorber vessels are used for the absorption and desorption. The major equipment involved in amine-based absorption process are absorber also called scrubber, regenerator also called stripper and desorber, rich-lean solution cross heat exchanger, reboiler, overhead condenser and cooler. A typical amine-based absorption process is exhibited in Fig. 1.

The emitted flue gases from coalfired power plants are cooled before their entry to the major process equipment to enhance absorption efficiency and lower the risk of escape and degradation of solvent. In the process, aqueous amine reacts with CO_2 to produce water soluble ions,

* Corresponding author.
E-mail address: shaukat.mazari@duet.edu.pk (S.A. Mazari).

https://doi.org/10.1016/j.ijggc.2020.103010
Received 22 September 2019; Received in revised form 31 January 2020; Accepted 28 February 2020
Available online 03 March 2020
1750-5836/