International Journal of Greenhouse Gas Control 93 (2020) 102904

Contents lists available at ScienceDirect

International Journal of Greenhouse Gas Control

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

# Emission and control of flue gas pollutants in $CO_2$ chemical absorption system – A review

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ARTICLE INFO

*Keywords:*
$CO_2$ capture
Chemical absorption
Emission control
Pollutant
Aerosol

ABSTRACT

Chemical absorption is currently the most promising large-scale $CO_2$ capture technology due to its high capture efficiency, mature process, and good compatibility. While this process uses solvent to absorb the $CO_2$ from flue gas in absorption column, part of the solvents and its degradation products are discharged with the flue gas, causing new environmental pollution. This paper introduces the pollutants emission situation of chemical absorption $CO_2$ capture process. The characteristics of three typical emission forms, including physical entrainment, gas and aerosol, are systematically depicted. Then, the formation mechanism and influencing factors of pollutant emissions are discussed. And the effect of flue gas nuclei and absorber conditions on aerosol emissions are also described. Finally, the paper summarizes the effects, advantages, and disadvantages of different emission control methods. This review can provide guidance for industrial applications of chemical absorption systems.

## 1. Introduction

Global warming is becoming a serious problem that attracts worldwide attention. Carbon Capture. Utilization and Storage (CCUS) is the only technology that can significantly reduce $CO_2$ emissions from using fossil energy (IEA, 2016). Chemical absorption is one of the most promising $CO_2$ capture technologies for large-scale applications due to its high capture rate and good adaptability (Rochelle, 2009). Its principle is to use alkaline solvent to react and separate $CO_2$ from flue gas. In recent years, remarkable progress has been made in this research area. New solvents like biphasic solvents greatly reduce the regenerative energy (Liu et al., 2019). Nanoparticle additives can enhance the $CO_2$ absorption and desorption (Wang et al., 2016). A number of demonstration projects have been completed, such as Boundary Dam integrated CCS project in Canada and Petra Nova CCS project in America (Mantripragada et al., 2019).

However, some solvent and its degradation products are discharged with the flue gas while the $CO_2$ capture system operating (Fig. 1). These emissions lead to solvent loss and a series of environmental problems. During the operation of typical MEA absorption system, the solvent loss caused by flue gas emission can reach 0.01–0.8 kg/t $CO_2$ (Karl et al., 2011). In addition to solvent emissions, there are many kinds of organic pollutants produced by oxidative degradation and thermal degradation, including other amines, ammonia, amine polymers, acids, aldehydes and ketones (Spietz et al., 2015). Once these substances are discharged into the atmosphere, they may react with rainwater and further photooxidation with $NO_X$, $HNO_3$, and $O_3$ to form more toxic products or strong carcinogens, such as nitrosamine and nitroamine (Nielsen et al., 2011; Jørgen et al., 2019).

## 2. Emissions of chemical absorption systems

There are mainly three emission forms of $CO_2$ chemical absorption systems: (1) physical entrainment; (2) gaseous emissions based on volatilization; (3) aerosol emissions (Wei et al., 2014). The demister has a very high eliminate rate on physical entrainment droplets, so this part of the emission is usually neglected. The volatile emission follows Henry's law, which is mainly affected by two factors: the temperature of the flue gas and the composition of the solvent. The gas-phase partial pressure rapidly increases with the temperature. The volatility of amine in water is ranked in the order: MDEA < DGA < PZ < 2-MPZ < MAPA < EDA < MEA < DAP < 1-MPZ < AMP (Nguyena et al., 2011). Research on gaseous emissions is relatively mature, and most of the gaseous amines can be effectively controlled by the water wash. The aerosol is a colloidal dispersion system formed by dispersing and suspending micron and submicron particles in a gas. After several years of study, it is found that aerosol is an important emission way in the process of chemical absorption. Its potential pollutant emissions can be

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https://doi.org/10.1016/j.ijggc.2019.102904
Received 29 September 2019; Received in revised form 15 November 2019; Accepted 15 November 2019
Available online 26 November 2019
1750-5836/ 