International Journal of Greenhouse Gas Control 88 (2019) 109–117

Contents lists available at ScienceDirect

International Journal of Greenhouse Gas Control

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

Absorption-microalgae hybrid CO_2 capture and biotransformation strategy—A review

Chunfeng Song[a,b,*], Qingling Liu[a], Yun Qi[a], Guanyi Chen[a], Yingjin Song[a], Yasuki Kansha[c], Yutaka Kitamura[d]

[a] Tianjin Key Laboratory of Indoor Air Environmental Quality Control, School of Environmental Science and Engineering, Tianjin University, 92 Weijin Road, Nankai District, Tianjin, PR China

[b] Key Laboratory of Efficient Utilization of Low and Medium Grade Energy (Tianjin University), Ministry of Education, Tianjin, 300072, PR China

[c] Organization for Programs on Environmental Sciences, Graduate School of Arts and Sciences, The University of Tokyo, 3-8-1 Komaba, Meguro-ku, Tokyo, 153-8902, Japan

[d] Graduate School of Life and Environmental Sciences, University of Tsukuba, 1-1-1, Tennodai, Tsukuba, Ibaraki, 305-8572, Japan

ARTICLE INFO

Keywords:
Hybrid CO_2 capture
Bicarbonate
Absorption
Microalgae

ABSTRACT

CO_2 capture, storage and utilization (CCUS) is one of the dominant strategies to mitigate climate change. Absorption, adsorption, membrane, cryogenic and microalgae are the typical CO_2 capture technologies, and high capture cost is still a common challenge of existing techniques. To overcome the challenge of energy consumption, hybrid CO_2 capture/utilization processes have been widely researched in the last decade. In this review, the existing absorption-microalgae hybrid CO_2 capture processes were summarized. The advantages and challenges of carbon capture and microalgae biotransformation integrated strategy were discussed. In the hybrid system, carbon could be more efficient utilized *via* microalgae in form of bicarbonate, and converted into value-added ingredients without energy-intensive regeneration. The influence factors on the absorption-microalgae hybrid system were investigated. In addition, the potential solutions to intensifying absorption-microalgae hybrid process were also put forward. Compared to the conventional CO_2 absorption and microalgae fixation method, hybrid process could be a competitive alternative to capture CO_2 from industrial emissions.

1. Introduction

Climate change caused by greenhouse gas emission has become a crucial issue. Carbon dioxide (CO_2) concentration in the atmosphere has significantly increased over the past century, compared to the pre-industrial era level of about 280 ppm (ppm). In 2015, the average concentration of CO_2 (399 ppm) was about 40% higher than that in the mid-1800s, with an average growth of 2 ppm/year in the last ten years (International Energy Agency (IEA, 2017). Among the top-10 CO_2 emitting countries, China discharged approximately 9 billion tons CO_2 (represented 28% of global CO_2 emissions in 2015) due to fossil fuel combustion (International Energy Agency (IEA, 2017).

As one of the dominant mitigation strategies, CO_2 capture, utilization and storage (CCUS) has been recognized as a significant strategy. Until now, different CO_2 capture technologies have been developed, such as absorption, adsorption, membrane, hydrate and cryogenic, etc. (Olajire, 2010; Leung et al., 2014). Among them, post combustion CO_2 capture based on chemical absorption is the most mature technology (Bernhardsen and Knuutila, 2017; Wang et al., 2017). As typical sorbent, alkanolamines have some key advantages such as high efficiency and low cost compared to the other chemicals (Borhani et al., 2015; Aghel et al., 2018). However, high energy consumption caused by solvents regeneration is the main bottleneck that limits its commercial application, which will lead to a net efficiency decrease (approximately 10%) in a coal-fired power plant (Goto et al., 2013; Liu et al., 2019). To improve large-scale implementation feasibility of CCUS, a target of 2.0 $MJ_{thermal}$/kg CO_2 (including both of capture and compression steps) is often mentioned and corresponds to the European Union recommendations (Belaissaoui et al., 2012). Therefore, extensive effort has been paid on the development of new materials and processes with the aim to reduce capture costs.

Recent year, hybrid CO_2 capture *via* integrating two or more conventional technologies has attracted more and more attention. Different hybrid materials, arrangements and configurations have been put

* Corresponding author at: Tianjin Key Laboratory of Indoor Air Environmental Quality Control, School of Environmental Science and Engineering, Tianjin University, 92 Weijin Road, Nankai District, Tianjin, PR China.

E-mail address: chunfeng.song@tju.edu.cn (C. Song).

https://doi.org/10.1016/j.ijggc.2019.06.002
Received 14 January 2019; Received in revised form 22 April 2019; Accepted 2 June 2019
Available online 06 June 2019
1750-5836/