Journal of Environmental Chemical Engineering 9 (2021) 105957

Contents lists available at ScienceDirect

Journal of Environmental Chemical Engineering

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

Significance of re-engineered zeolites in climate mitigation – A review for carbon capture and separation

Satyaki Chatterjee [a], Sampathkumar Jeevanandham [b], Monalisa Mukherjee [b,*], Dai-Viet N. Vo [c], Vivek Mishra [b,*]

[a] Department of Chemistry, University of Delhi, Delhi 110007, India
[b] Amity Institute of Click Chemistry Research and Studies, Amity University, Noida 201313, India
[c] Center of Excellence for Green Energy and Environmental Nanomaterials (CE@GrEEN), Nguyen Tat Thanh University, Ho Chi Minh City 755414, Viet Nam

ARTICLE INFO

Editor: Teik Thye Lim

Keywords:
Carbon sequestration
Carbon utilization
Atmosphere chemistry
Environment mitigation

ABSTRACT

In the context of modern science, there is a growing interest in the creation of novel porous materials capable of acting as sorbefacients for small gas molecules. This is critical in terms of innovative energy alternatives as well as a healthier environment. In an effort to overcome the consequences of global industrialization, one of humanity's most severe problems, intensive attempts have been made to prevent CO_2 from entering the carbon cycle, as the ever-increasing CO_2 pollution in the earth's atmosphere. Owing to their high porosity, presence of ultra-small pores, structural diversity, high stability, and excellent recyclability, researchers claim that zeolite–an inexpensively accessible sorbent–could be an excellent prototype for CO_2 sorption. Here, we provide an exhaustive review of re-engineered zeolites as a sustainable material for selective CO_2 capture and storage; the progress so far indicates fast removal of CO_2, and more work conforming to simple scalability, energy and time efficiency application can be done to improve the challenges.

1. Introduction

Excessive combustion of fossil fuels results in emissions of the long-lived greenhouse gas CO_2 as well as other short-lived contaminants such as black carbon [1], organic aerosols [2], SOx, and NOx concentrations, all of which contribute significantly to air pollution that ultimately affects the global ecosystem [3]. Over the past few decades, the planet has wandered through an active period of potentially irreversible global warming caused by vitality lopsided characteristics triggered by greenhouse gas (GHG) outflows from anthropogenic activity [4]. Global warming, described as an enormous rise in the average temperature of the Earth's atmosphere as a result of an imbalance in arriving and vanishing heat (Fig. 1), is the disastrous result of environmental pollution caused by the blanket of greenhouse gases [5].

The predatory and rapid urban-industrial and economic revolution have pumped up the extensive use of fossil fuels such as petroleum, coal, and natural gas in sectors ranging from automobiles to households, amplifying the concentration of the main anthropogenic greenhouse gas and posing an adverse threat to human health and biodiversity in the form of pulmonary diseases [6–9]. Even in an assumption by Intergovernmental Panel on Climate Change; IPCC [10], it was suspected that the atmospheric CO_2 concentration will increase to 760 ppm by the beginning of the 22nd century; as a repercussion, the United Nations agreement showed grave concern on the reduction in emission of gas from fossil fuel at a Paris Climate conference [10].

In 2017, Ritchie and Roser found a comprehensive research on the impact of CO_2 on world health, which shows that CO_2 levels are rising at a rate of 1.7–2.1% per year, posing a threat to global health [11]. As a result, developing a socio-economic sustainable carbon capture and storage (CCS) model to achieve challenging carbon dioxide arrest at a dilute concentration under partial pressure in the ppm range, as well as selectivity towards CO_2, is important [12–19].

Out of all CO_2 removal processes such as forestation, seawater capture, and so on, physically zeolite responded affirmatively as high performance. Furthermore, the effectiveness of adsorption is dependent on the mutual interaction of adsorbate and adsorbent, which is affected by thermodynamic parameters, adsorbent character, and operational values of state variables (viz. energy). Through the continuous evolution and extensive screening of hundreds of zeolite frameworks on their capacity to capture CO_2 under humid conditions [20], the researchers have realized that amalgamation of zeolites with modern generation host

* Corresponding authors.
E-mail addresses: mmukherjee@amity.edu (M. Mukherjee), vmishra@amity.edu (V. Mishra).

https://doi.org/10.1016/j.jece.2021.105957
Received 4 May 2021; Received in revised form 21 June 2021; Accepted 26 June 2021
Available online 1 July 2021