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A review for Metal-Organic Frameworks (MOFs) utilization in capture and conversion of carbon dioxide into valuable products

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ABSTRACT

Carbon dioxide (CO_2) has become a primary atmospheric greenhouse gas that has stirred up numerous energies and environmental-related mishaps around the world. Its unwelcome contribution to the decay of the global ecosystem has generated alarming concerns. Therefore, it has triggered an urgent need to design reliable methods for capturing and converting atmospheric CO_2 into valuable chemical products and/or feedstocks. It is expected that these valuable chemical products will enhance significantly, the stability of the ecosystem and promote sustainable development of the energy sector. A few years back, metal-organic frameworks (MOFs) materials have displayed magnificent heterogeneous catalytic behavior owing to their appealing chemical features and high internal surface area. Because of the captivating properties possessed by these MOFs and their ease of synthesis, experimental tests to ascertain structure-function relationships for CO_2 conversion into some value-added chemical products became lucrative. Therefore, in this review, recent developments, and the participation of MOFs as reliable catalysts for capturing and converting CO_2 into valuable chemical products are critically reviewed. Finally, limitations and prospects of MOFs as heterogeneous catalysts for the capture and conversion of CO_2, are addressed as well.

1. Introduction

Global communities depend largely on the burning of fossil fuels such as petroleum, natural gas, and coal for the generation of enormous demand for energy. A major byproduct of this combustion process is a greenhouse gas (GHG) called carbon dioxide (CO_2). The uncontrolled discharge of this greenhouse gas byproduct has resulted in the deposition of a tremendous amount of the gas into the atmosphere. It has caused global warming, acidification of the ocean bodies, harsh weather conditions, and the complete termination of natural species [1,2]. Within the last 20th century, the concentration of atmospheric CO_2 has rapidly and continuously increased approximately from 280 ppm within the last 1800s [3] to more than 389 ppm in 2019 and 400 ppm in 2020 [4]. Due to minimal mitigative attention so far received by the ever-increasing CO_2 in the atmosphere, the Inter-Governmental Panel on Climate Change (IPCC) has foreseen the atmospheric CO_2 skyrocketing to a concentration of about 950 ppm in 2100 [5–7]. The excessive abundant atmospheric CO_2 has directly increased the mean temperature of the globe to about 1.9 °C at 570 ppm CO_2 concentrations by absorbing longwave radiations [7]. Therefore, controlling both the emission and the concentration of atmospheric CO_2 is as important now as never been in the past and requires undisturbed attention.

Knowing that fossil fuels will retain their position as the major sources of global energy for a long period, reducing the anthropogenic CO_2 emissions by capturing them at their source point, will be an action in the right direction. This ambitious strategy can be accomplished by utilizing efficient carbon capturing and storage technologies. Stages such as purification, separation, compression, transportation, and processes of storage [8], are the major drawback of this technology because of the energy consumption associated with the processes. Without doubts, these energy consumption stages are likely to be accompanied by further atmospheric CO_2 emissions, making the technology less effective in addressing the situation at hand. Moreover, different adsorbing materials for CO_2 capture and storage have been developed

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