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Electrospun graphene carbon nanofibers for CO_2 capture and storage: A review

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ABSTRACT

The never-ending increasing emissions of carbon dioxide (CO_2) to the atmosphere is at an alarming rate, associated with many serious environmental concerns such as climate change and global warming. In order to mitigate the effects induced by CO_2 emissions, many efforts have been dedicated to exploring practical strategies to reduce CO_2 emissions. One of the strategies is to capture CO_2 from point sources before its release to the atmosphere using adsorption technologies, commonly known as carbon capture and sequestration (CCS) technology. This review compares and discusses of currently available carbon-based materials as CO_2 sorbents with the special focus on electrospun graphene carbon nanofibers and their functionalization, which possess excellent physicochemical properties with high specific surface area, wide pore size distribution, and high concentration of active adsorption sites for improving CO_2 adsorption. Inclusively, this review will comprehensively focus on the development and modification of graphene electrospun carbon nanofibers (gCNFs) for optimizing CO_2 capture.

1. Introduction

Since the beginning of the industrialization era in the 1800 s, the rapid economic development in industrial power plants, transportation sectors, as well as commercial and residential buildings have tremendously increased the emission of greenhouse gases (GHGs) due to the burning of fossil fuels. The high concentration of GHGs in the atmosphere, including methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and sulfur hexafluoride (SF_6), have caused the greenhouse effect such as global warming [160]. Additionally, the environmental issues associated with global warming also resulted in serious public health issues. For example, global warming leads to deterioration of ecosystems, ocean warming, shrinking ice sheets, rises in sea levels, droughts, heat waves, floods, etc. Bijma et al., [15]. In the 21st century, CO_2 is known as the major anthropogenic GHGs, and it was reported that the atmospheric CO_2 concentration had increased from 280 ppm to 400 ppm [12], which corresponded to the increment of the global surface temperature of about 0.8 °C [211]. According to the 5th Assessment Report of Intergovernmental Panel on Climate Change (IPCC), the rise of global temperature must be kept between 1.5–2.0 °C in order to reduce the level of CO_2 emissions by more than 50% from 2009 to 2050 [IPA, 2021]. Since the outbreak of COVID-19 in earlier 2020, major human activities were affected, as well as global energy consumption and associated CO_2 emissions due to lockdown enforcement in mid of March. A study by [125] has found that global CO_2 emissions in the first half of 2020 decreased by 8.8% (1551 Mt CO_2) due to the COVID-19 outbreak. The decline in daily global emission was the highest in April but began to recover in May as the economic activities resumed. By June 2022, the estimated global daily CO_2 reported by Global Monitoring Laboratory [Carbon Cycle Greenhouse Gases] showed 417.45 ppm compared to the estimated value two years ago during COVID-19 outbreak, which was at 409.86 ppm. From this record, it can be concluded the emission reduction during lockdown was only a short-term effect but showed an insignificant effect for a long-term period [68].

Due to these unresolved global concerns, various methods have been proposed to mitigate the CO_2 emissions as well as their effect on the environment, such as the enforcement of the Kyoto Protocol. This protocol significantly focuses on self-reduction techniques for reducing CO_2 emissions rates and post-treatment of emitted CO_2 from various

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