



## Review

A critical review on new and efficient adsorbents for CO<sub>2</sub> captureKaiqing Zhang, Rui Wang<sup>\*</sup>*School of Environmental Science and Engineering, Shandong University, No.27 Shanda South Road, Jinan 250199, PR China*

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## ABSTRACT

Carbon dioxide (CO<sub>2</sub>) is the main anthropogenic greenhouse gas that causes global warming and has a huge impact on the global ecosystem. In order to reduce the impact of carbon dioxide emissions from human society on the entire earth's ecological environment, researchers have conducted in-depth research on various new materials for CO<sub>2</sub> capture. Metal organic Frameworks (MOFs), porous organic polymers (POPs), ionic liquids (ILs), and deep eutectic solvents (DESSs) have garnered the attention of researchers worldwide. Factors including the specific surface area, physical and chemical properties and surface modification of the adsorbent material play a vital role in the carbon dioxide adsorption process. This review summarizes and evaluates the physical and chemical properties of MOFs, POPs, ILs and DESSs and their effects on carbon dioxide capture performance. Although these materials have shown progress in carbon dioxide capture, further research is needed to develop cost-effective and sustainable adsorption materials for large-scale applications.

## 1. Introduction

Carbon dioxide (CO<sub>2</sub>) is a common compound in the air and also the most important component of greenhouse gases [1]. At present, about 44 % of carbon dioxide comes from the combustion of fossil fuels such as petroleum, coal and compressed natural gas [2,3]. In 1958, the concentration of carbon dioxide gas in the environment was about 315 ppm. By 1986 it had reached 350 ppm and in 2013 it exceeded 400 ppm. By 2021, carbon dioxide levels will reach a staggering 410 ppm. In addition, carbon dioxide emissions in 2040 are expected to increase by more than 40 % compared to 2010 emissions [4].

Amine scrubbing is a widely used technology in the industrialization of carbon capture, with varying operating costs. It is commonly employed in industry. However, the lack of large-scale (>50 t/d) pilot plants in the cement industry is currently the biggest obstacle to further development and commercialization of capture technology [5]. In the petrochemical industry, absorbers, which are typically strong or weak alkaline solutions, are commonly used to react with CO<sub>2</sub> in flue gas [6]. However, current industrial carbon dioxide capture faces issues such as low adsorption capacity, high cost, and poor selectivity. Therefore, there is an urgent need to develop new measures to reduce emissions.

Several measures are currently being developed for CO<sub>2</sub> capture, including the development of new CO<sub>2</sub> capture technologies, improving the use of existing energy sources and replacing fossil fuels with new energy sources [7]. However, many drawbacks of renewable energy

sources themselves limit their practical application, such as geothermal, wind, solar and nuclear energy sources. The existence of these drawbacks also prevents humans from getting rid of their dependence on fossil fuels at present [8]. CO<sub>2</sub> capture technology has been extensively developed in the past few decades [9]. Many techniques for capturing CO<sub>2</sub> from the atmosphere, such as membrane separation, chemical absorption by various solvents (ionic liquids [10–12]), nanofluids [13,14], amino acid salt solutions [15,16] etc.), electrochemical separation, low-temperature separation, solid adsorption and other carbon capture technologies, have been studied.

Solid adsorption technology has become one of the most commonly used methods for CO<sub>2</sub> capture due to the low cost of solid adsorbents and the low energy consumption in the adsorption process [17]. Previously studied silicon-based materials were limited by insufficient adsorption capacity, and several modified functionalization attempts have been made to increase the current adsorption capacity, such as functionalized-polyethyleneimine (PEI)/silica adsorbent [18]. However, their structural properties and present performance still limit silicon-based materials.

Metal organic framework compounds (MOFs) are common carbon dioxide solid adsorbents, which are crystalline porous materials with a periodic network structure formed by inorganic metal centers (metal ions or metal clusters) and organic ligands interconnected by self-assembly. Due to the advantages of MOFs such as large specific surface area, more metal sites, higher porosity porous and tunable pore

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