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Mesoporous adsorbent for CO_2 capture application under mild condition: A review

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ABSTRACT

Carbon dioxide (CO_2) capture and storage have been suggested as an effective strategy to reduce global greenhouse gas emissions. In recent years, many studies were carried out to develop highly efficient materials, such as zeolites, porous carbons, metal-organic frameworks (MOFs) and metal oxides for capturing CO_2. In addition, interest in studying amine species grafting with mesoporous materials to improve CO_2 capture by amino groups have increased tremendously. These modified materials provide excellent CO_2 uptake capacity, fast adsorption kinetics and easy regeneration with stable cycling performance. Not to mention, the utilisation of adsorbents derived from biomass sources for CO_2 capture under low adsorption temperature and ambient pressure was recently reported by many researchers. Such adsorbents are desirable for its high surface area, less energy consumption, less expenses during regeneration and highly available. Herein, mesoporous materials are thoroughly described for CO_2 capture under mild condition (ambient temperature and pressure). In addition, a recommendation of characteristics and properties for effective porous adsorbent, functionalisation of amine groups, and utilisation of biomass-based adsorbent were reviewed in this work. A concise conclusion and future outlook was also proposed.

1. Introduction

In the last couple of decades, there was a drastic overgrowing in CO_2 concentration which had exceeded 400 ppm was recorded in June 2015 [1]. The high CO_2 recorded concentration was due to mankind modern activities from different industrial sectors which resulted in severe climatic conditions manifested in the form of global warming and rising sea levels as a result of melting glaciers [2,3]. The rise in atmospheric CO_2 levels had a much wider ramification and its effects were not limited to the environment alone but also the growth and economy situation across continents, and hence had directly or indirectly affected every individual.

CO_2 capture and sequestration (CCS) technologies have been considered as an effective option to reduce CO_2 emission [4]. At present, a number of conventional methods are employed in large scale CO_2 capture from power plant flue gases, such as absorption in basic solutions, cryogenic distillations, membrane purification, and adsorption [5]. Out of these, chemical absorption by liquid amines, such as monoethanolamine (MEA), diethanolamine (DEA) and methydiethanolamine (MDEA) is currently the most common method used in industries [6].

However, there are major disadvantages associated with the sorption-based processes, such as low absorption capacity, poor stability, corrosion of equipment, loss of solvent, flow problems, owing to viscosity and high regeneration cost [7]. These problems can be overcome by developing porous solid adsorbents with high surface area and pore volume as adsorbents for CO_2 capture [8]. The adsorption process is significant because it is reversible and the adsorption efficiency can be improved by modifying the adsorbent material structures. Therefore, the CO_2 adsorption efficiency can be improved by selecting an appropriate adsorbent material. At present, a host of porous materials, such as porous carbon materials, zeolites, mesoporous silica, metal–organic-frameworks (MOFs), covalent–organic-frameworks (COFs) and metal oxide framework were widely investigated [9–14]. Among these materials, mesoporous based adsorbent has been thoroughly studied in recent years.

The presence of the mesopores in the crystallites of a given porous material should basically increase the accessibility of large molecules to the external pore openings. In other words, and from the standpoint of large reactant molecules, the presence of mesopores on the material would increase the external surface area, making a larger number of pore openings accessible to the reactant [15]. The mesoporous type of adsorbent can be a promising candidate in the CO_2 capture application due to its high surface area, easy-to-design pore structure, reasonably

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