CO_2 CAPTURE BY ADSORPTION ON MESOPOROUS MCM-68 SOLID SORBENT MATERIALS

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Summary
Solid sorbents adsorption is considered as one of the potential options for CO_2 capture process. The success of this approach is dependent on the development of an adsorbent with a high CO_2 adsorption capacity, in a broad temperature window. In this study, we have investigated the CO_2 adsorption on highly ordered three dimensional mesoporous MCM-68 (Si/Al ratio 22) as a sorbent material. The interesting features such as high surface area, high thermal stability with ordered mesoporous structure of MCM-68 were found to be advantageous for the CO_2 adsorption in broad temperature window.

Keywords CO_2 capture, CO_2 adsorption, solid sorbent, MCM-68

Introduction

Global warming, believed to be caused by the greenhouse effect, has received increasing attention in recent years. Since fossil fuels account for 80 % of global energy consumption currently and cannot be phased out rapidly, we must rely on fossil fuels as the main energy source for the next several decades. Thus carbon capture and sequestration to reduce the release of CO_2 to atmosphere from stationary sources like fossil fuel fired power plants is of critical importance. Solid sorbents adsorption is considered as one of the potential options for CO_2 capture process [1]. One key component for the development of these systems is obviously the sorbent itself, that has to have good CO_2 adsorption capacity and chemical and mechanical stability for long periods of operation in repeated cycles.

MCM-68 is far more attractive than MCM-41 for potential applications in adsorption and heterogeneous catalysis due to its three dimensional pore channel structure. With the three dimensional pore structures variety of heteroatoms can be doped, which provide tunable catalytic properties for the final material. In this study, we report the synthesis, characterization and CO_2 adsorption capacity of MCM-68 sorbents. Investigations of dry CO_2 adsorption at low and high temperatures are carried out by using dry CO_2 gas.

Experimental

The synthesis of N,N,N',N'-tetraethylbicyclo[2.2.2]oct-7-ene-2,3:5,6-dipyrrolidinium diiodide ($TEBOP^{2+}(I^-)_2$) - structure-directing agent (SDA) and MCM-68 sorbent were performed as mentioned in Ref [2]. CO_2 adsorption measurements were performed in a fixed bed quartz reactor. At a given temperature, CO_2 was adsorbed using a gas flow of 20 ml/min, containing 1 % CO_2 and balance He. When the CO_2 concentration of the outlet gases reached a constant level, CO_2 gas flow was closed and He flow was maintained for desorption to take place at the adsorption temperature. The outlet gases from the reactor were analyzed by on-line by mass spectrometer (MS, Hiden HPR - 20 QIC).

Results & Discussions

Powder XRD diffraction patterns on the MCM-68 the powder closely resemble those reported in the literature showing the structural integrity and crystallinity of the samples [2]. The XRD patterns of the as-synthesized MCM-68 consisted of the typical reflection at

6.80°, 10.1°, 20.4°, 22.5 ° and 27.6° and weak reflections at 15.1° and 28.5°. The N_2 adsorption-desorption isotherms results are: Surface area (456 m^2/g) and the average pore diameter was around 5.55 nm.

The CO_2 adsorption capacities have been corrected by a temperature dependent 'blank' value due to the CO_2 adsorption of the apparatus. The CO_2 adsorption capacity at 60 °C was 88 mg CO_2 /g sorbent. The adsorption capacity is very much higher than that of MCM-41 sorbent, which is the standard mesoporous material used in CO_2 adsorption [3]. In order to check the CO_2 adsorption at higher temperatures, fresh MCM-68 was used for measurements. Measurements were carried out at 300 °C and 400 °C. The high temperature values are reasonably good when MCM-68 is compared with high temperature sorbents (table 1). When CO_2 supply was closed after complete adsorption, CO_2 desorption started to take place. Almost all the adsorbed CO_2 was desorbed as the concentration of CO_2 reached 0 ppm. These results indicate that since almost all adsorbed CO_2 is desorbed, this material potentially has good regeneration ability.

Table 1: CO_2 adsorption performance of MCM-68 material with other sorbents

Sorbent	Temperature [°C]	CO_2 adsorption capacity [mg/g sorbent]	Reference
MCM-68	60	88	This study
	300	10	This Study
	400	4	This Study
MCM-41	75	8.6	[3]
MCM-41-PEI-75	75	133	[3]
13 X	25	160	[4]
Activated carbon	25	135	[4]
4A	25	110	[4]
Alumina	20	44	[5]
Hydrotalcite	400	22	[1]

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