Chapter 7

Using of Modified SBA–15 Mesoporous Silica Materials for CO2 Capture: A Review

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ABSTRACT

Carbon dioxide emissions cause global warming, and greenhouse gases and climate change are very serious problems. Mesoporous silica material SBA-15 has been preferred mostly as an ideal adsorbent for CO2 due to its excellent properties such as high surface areas and pore volumes, larger pore diameter, and thicker silica wall. In the literature studies, SBA-15 has been modified by different functional groups and the effects of modification methods on the CO2 adsorption have been investigated. Modified SBA-15 adsorbents showed high CO2 adsorption capacity. The aim of this chapter is to review the use of modified-SBA-15 mesoporous silica materials as adsorbent for CO2 capture.

INTRODUCTION

Carbon dioxide emission from fossil fuel combustion is one of the major causes of global warming and climate change and also has to be decreased in order to stabilize the CO2 concentration level in the atmosphere. Therefore, many researchers focus on searching of efficient and economical methods to control CO2 emissions. Various physical and chemical methods, such as adsorption, solvent absorption, membrane
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separation, and cryogenic distillation, have been used for CO2 capture (Zhang et al., 2011, Sanz et al., 2012, Zhang et al., 2013, Lakhi et al., 2016, Shi-Yaumi et al., 2017). The traditionally and commercially available technique for CO2 capture is chemical absorption with liquid alkanolamines, such as monoethanolamine, diethanolamine, and methyltriethanolamine (Gil et al., 2011, Sanz et al., 2012). The use of liquid amines includes many disadvantages, such as corrosion of processing equipment and high energy consumption due to solvent regeneration (Sanz et al., 2012, Yan et al., 2013, Sanz-Pérez et al., 2013). The adsorption method is preferred potentially due to it having a simple, energy-efficient, and inexpensive separation process. Solid adsorbents, having lower heat capacity, reduce the amount of necessary energy for generation as compared to aqueous amine solutions. On the other hand, capacity losses upon cycling and corrosion problems are eliminated with the use of solid adsorbents (Yan et al., 2013, Liu et al., 2017). Zeolite, activated carbon, and silica mesoporous materials, which have large and uniform pores, tunable pore sizes, and large surface areas, are given much attention for the CO2 capture. Zeolites, having microporous structure, large surface areas, and specific sites of adsorption, are mostly preferred in the gas separation adsorbents at low temperature. But gas diffusion to micropores of zeolites is difficult due to mass transfer limitation Linfang et al., 2007, Zhou et al., 2013, Chen et al., 2014, Shakerian et al., 2015). In recent years, ordered mesoporous silica materials, such as MCM-41, MCM-48, and SBA-15, have attracted attention for the CO2 capture studies due to their having high surface areas, uniform and tunable large pore sizes, and surface functional groups (Wei et al., 2008, Yan et al., 2013, Yaumi et al., 2017). These mesoporous silica materials are used generally by modified with basic amine groups in the CO2 capture. The modification of silica materials are performed by chemical (grafting and co-condensation method) or physical (impregnation method) surface modification methods. (Sanz et al., 2012, Yan et al., 2013, Ullah et al., 2015). The SBA-15 material as compared with other materials includes micropores together with mesopores in the silica wall and these micropores provide high surface area and high gas separation selectivity (Zhang et al., 2013, Yan et al., 2013). In the CO2 capture studies performed with SBA-15, modification and functionalization treatments applied to the SBA-15 significantly increase CO2 sorption due to the formation of carbamates. The modifications and functionalize treatments have been provided by amine groups (Da’na & Sayari, 2011, Sanz et al., 2012, Yan et al., 2013, Sanz-Pérez et al., 2013, Ullah et al., 2015, Sanz-Pérez et al., 2016), polyethylenimine (Wang & Song, 2012), aminopropyltriethoxysilane (Wang et al., 2007, Wei et al., 2010), octa(3-aminophenyl)octasilsesquioxane, 3-chloropropyltrimethoxysilane (CPTMS) (Bhagiyalakshmi et al., 2010), amine dendrimers (Jing et al., 2014), carboxylic acid (Khatun et al., 2017), and zirconia (Thunyaratchatanon et al., 2017).
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