Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 148 (2016) 122 – 127

Procedia Engineering

www.elsevier.com/locate/procedia

4th International Conference on Process Engineering and Advanced Materials

CO_2 Adsorption Study using Deca-Dodecasil 3 Rhombohedral (DDR3) Zeolite Synthesized via Ultrasonic Irradiation coupled with Hydrothermal Heating Method

Muhammad Mubashir[a], Yeong Yin Fong*[,a], Lau Kok Keong[a], Sam Sung Ting[b]

[a] *Universiti Teknologi PETRONAS, Bandar Seri Iskandar 32610 Perak, Malaysia*
[b] *Universiti Malaysia Perlis, Arau 02600 Parlis, Malaysia*

Abstract

DDR3 zeolite has been attracted by the researchers for its characteristics which are potential in various applications including CO_2 adsorption. Thus, in the current work, DDR3 zeolite synthesized via ultrasonic irradiation method reported in our previous work [14] are characterized by BET surface area and tested for CO_2 adsorption at room temperature. DDR3 sample synthesized in 10 days via hydrothermal heating and ultrasonic pre-treatment of 3 h showed the BET surface area of 297 m^2/g with CO_2 adsorbed amount of 1.86 mmol/g (28cm^3/g STP). Subsequently, samples synthesized in 1 day and 0.5 day with ultrasonic pre-treatment of 1 h showed the BET surface area of 201 m^2/g and 2.0 m^2/g, respectively, with CO_2 adsorbed amount of 1.61 mmol/g (14 cm^3/g STP) and 0.3 mmol/g (2 cm^3/g STP), respectively. Subsequently, reference DDR3 sample which was synthesized in 25 days as reported in literature showed the BET surface area of 323 m^2/g with CO_2 adsorbed amount of 1.91 mmol/g (31cm^3/g STP). Consequently, in the present work, it was observed that BET surface area and CO_2 adsorption decreases with decrease in synthesis duration. This result was mainly because of the effect of growth duration and ultrasonic pre-treatment. Overall, it was concluded that DDR3 zeolite synthesized in 1 day via ultrasonic irradiation coupled with hydrothermal heating method showed comparable CO_2 adsorption results with the DDR3 reference sample obtained in the present work as well as the DDR3 samples reported in the literature.

Peer-review under responsibility of the organizing committee of ICPEAM 2016

Keywords: DDR3 zeolite; ultrasonic irradiation; BET surface area; CO_2 adsorption

* Corresponding author. Tel.: +605 - 368 7564
E-mail address: yinfong.yeong@petronas.com.my

Peer-review under responsibility of the organizing committee of ICPEAM 2016
doi:10.1016/j.proeng.2016.06.492

1. Introduction

In the recent years, zeolites are widely reported for industrial applications because of their diverse properties including, chemical and thermal stability [1]. To date, more than 200 frameworks of zeolite are verified for various applications [2]. Deca-Dodecasil 3 Rhombohedral (DDR3) is one of the high silica zeolite contains 8-Si atoms with the pore channel of 0.33 nm x 0.44 nm [3]. Chemical stability and molecular-sieving behavior of DDR3 zeolite has attracted the researchers to focus on its applications in CO_2 adsorption [4]. Gies. [5], Tomita et al. [6], Alves. [7], Qi-Liang et al. [8] and Gucuyener et al. [9] reported DDR3 zeolite in 25 days using hydrothermal growth method. Recently, Zhang et al. [10] reported the DDR3 zeolite in 3 days using microwave-assisted growth method. Although, microwave-assisted method has reduced the synthesis duration of DDR3 zeolite, it involves complicated and expensive process [11]. So far, few studies have been done on the synthesis of DDR3 zeolite mainly due to its long synthesis process which is hurdle for further development as well as applications [12, 13].

From the literature, it was found that ultrasonically-assisted hydrothermal heating method is relatively a new technique which has been successfully reported to reduce the synthesis duration of zeolite materials [14]. Firstly, Wu et al. [15] reduced synthesis duration of the MCM-22 using this method. Subsequently, Azizi et al. [16] focused on ANA particles to reduce its synthesis duration. They effectively reduce the synthesis duration from 96 h to 48 h and produced rod like ANA particles. Similarly, Abrishamkar et al. [17], Askari et al. [18] and Pal et al. [19] has successfully used this method to reduce the synthesis duration of SaPO-34 and NaP, respectively. Recently Izzati and her coworkers [20] also have effectively reduced the synthesis duration of T-type zeolite using similar method. Subsequently, Enomoto et al. [11] has reported that this method required low temperature and it grow the crystals in short duration compared to the conventional hydrothermal growth method. In fact, we have successfully reduced the synthesis duration of DDR3 zeolite as reported in our previous work [14]. However, the study on CO_2 adsorption study of these samples is still yet to be conducted. Therefore, in this work, the resultant DDR3 samples synthesized in our previous work were further characterized through BET surface area and CO_2 adsorption capacity.

2. Experimental work

2.1. Chemicals and Materials

1-adamantaneamine (Fisher Scientific, $\geqslant$ 96%), tetramethoxysilane (Merck, $\geqslant$ 98%), ethylenediamine (Merck, $\geqslant$ 98%) and di-ionized water were used to synthesize the DDR3 zeolite.

2.2. Synthesis of DDR3 zeolite

Firstly, 1-adamantaneamine, tetramethoxysilane, ethylenediamine and water were mixed accordingly in order to prepare the solution mixture [14]. A reference sample (sample 1) was synthesized in 25 days using hydrothermal heating method without ultrasonic pre-treatment. Subsequently, sample 2 was synthesized in 10 days using the same solution pretreated with ultrasonic irradiation for 3 h prior to the hydrothermal growth. Similarly, samples 3 and 4 were synthesized in 1 day and 0.5 day, respectively using the same solution pretreated with ultrasonic irradiation for 1 h. Then, all four samples were preceded for washing, drying and calcination, respectively at 500 ºC. After calcination, crystallinity and morphology of all samples were characterized by using X-ray diffractometer (Philips 1710 diffractometer) and field emission scanning electron microscopy (Zeiss Supra 55 VP). Subsequently, the measurement of BET surface area and CO_2 adsorption study was conducted using BEL-SORP-MAX (Japan). Table 1 show the samples synthesized in the current study.