Advanced Powder Technology 23 (2012) 757–760

Contents lists available at SciVerse ScienceDirect

Advanced Powder Technology

journal homepage: www.elsevier.com/locate/apt

Original Research Paper

Synthesis of mordenite zeolite in absence of organic template

Hisham M. Aly, Moustafa E. Moustafa *, Ehab A. Abdelrahman

Chemistry Department, Faculty of Science, Benha University, Benha 13518, Egypt

ARTICLE INFO

Article history:
Received 23 July 2011
Received in revised form 5 October 2011
Accepted 6 October 2011
Available online 20 October 2011

Keywords:
Nanoparticles
Mordenite
X-ray techniques
Crystal size

ABSTRACT

Mordenite is a zeolite that has been used as a selective adsorbent and as a catalyst. Mordenite zeolite with crystal diameter 65 nm and crystal length 7 μm was successively synthesized in the absence of organic template by hydrothermal method at 180 °C for 5 days after stirring at high speed and aging in the synthesis mixture with the molar composition of $12Na_2O:100SiO_2:2Al_2O_3:500H_2O$. The produced samples were investigated using XRD, SEM, FT-IR, EDS, DTA/TG and BET surface area. The prepared sample, crystallized in needle shape crystals. Total (BET) surface area was 52.14 m^2/g whereas, total pore volume was 0.2 cm^3/g. Average pore diameter was 24.16 Å. Thermogravimetry analysis (DTA/TG) showed that, at room temperature to 800 °C, mordenite mass loss is 6%.

1. Introduction

Mordenite is a zeolite with an ideal composition of $Na_8Al_8Si_{40}O_{96}{\cdot}nH_2O$. The unit cell of sodium mordenite has dimensions *a*: 18.121 Å, *b*: 20.517 Å, and *c*: 7.544 Å [1]. The most common morphology of mordenite is characterized by needles with *c* direction elongation [2]. The micropore system of mordenite consists of two pore channels; an elliptical pore channel (6.7 × 7.0 Å) which runs parallel to the *c*-axis and, another pore channel which runs parallel to the *b*-axis (2.6 × 5.7 Å) [3]. Due to its high thermal and acid stability, mordenite has been used as a catalyst for important reactions such as hydrocracking, hydroisomerization, alkylation, reforming, dewaxing, and the production of dimethylamines [4,5]. Mordenite has also been used in the adsorptive separation of gas or liquid mixtures [6]. In addition, mordenite has been considered for applications in semiconductors, chemical sensors, and nonlinear optics [7]. Nanosized zeolites are important in catalytic and adsorptive applications. Smaller crystals of zeolites will have larger surface areas and less diffusion limitations compared to zeolites with micrometer-sized crystals. Nanometer-sized zeolites also offer advantages in supramolecular catalysis, photochemistry, nanochemistry, electrochemistry, and optoelectronics [8]. Zeolite nanocrystals can also be used in the construction of other geometries such as thin films, fibers, and self-standing zeolite membranes [9]. Recently, a polycrystalline mordenite membrane with a small crystallite size was prepared using tetraethylammonium bromide as a template and by aging. The smallest crystals obtained were around 4–5 μm [10]. Although the templating effect of organic compounds such as TPA^+ cation is excellent, it can cause many problems such as its producing poison and high production cost, the contamination of waste water by organic templates agent, air pollution arising from thermal decomposition of organic templates agent, and coke deposit due to incomplete decomposition, in some fields of the unsuitable handling in high temperature that needs to use nanosized zeolite as assembly component, nonreversible polymerization easily occur in the course of thermal decomposition of organic templates agent and thereby losing assembly performance. To the best of our knowledge there are no reports on the synthesis of mordenite with crystal diameter 65 nm and crystal length 7 μm in the absence of organic templates. In this study we have prepared mordenite crystals by adjusting gel compositions and crystallization conditions.

2. Experimental

2.1. Preparation of nanosized template-free mordenite zeolite

A template-free mordenite with an average size of 65 nm was synthesized from a synthesis solution by dissolving 7.98 g sodium hydroxide pellets (A.R.) and 12.485 g aluminum nitrate (Aldrich) in 69.5 g deionized water in a beaker. The mixtures in the beaker were thoroughly mixed and a 50 g Ludox AS30 colloidal silica (Aldrich) was slowly added to the above solution under stirring at high speed. The molar composition of the resulting synthesis gel was $12Na_2O:100SiO_2:2Al_2O_3:500H_2O$. Prior to being transferred to a Teflon-lined stainless steel autoclave, the above synthesis solution was aged for 20 h at room temperature and then hydrothermally treated for 5 days in an oven at a temperature of 180 °C. After the hydrothermal treatment, the products were recovered, thoroughly washed with deionized water, and then dried at 120 °C.

* Corresponding author. Fax: +20 2013 3222578.
E-mail address: dr.moustafa1955@yahoo.com (M.E. Moustafa).

0921-8831/$ - see front matter © 2011 The Society of Powder Technology Japan. Published by Elsevier B.V. and The Society of Powder Technology Japan. All rights reserved.
doi:10.1016/j.apt.2011.10.003