Contents lists available at SciVerse ScienceDirect

Chemical Engineering Research and Design

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

Development of T type zeolite for separation of CO_2 from CH_4 in adsorption processes

Mina Doroudian Rad[a], *Shohreh Fatemi*[a,b,*], *S. Mojtaba Mirfendereski*[c]

[a] School of Chemical Engineering, College of Engineering, University of Tehran, Tehran, Iran
[b] Oil and Gas Center of Excellence, University of Tehran, Tehran, Iran
[c] Faculty of Chemical Engineering, University of Science and Technology, Narmak, Tehran, Iran

ABSTRACT

Influence of synthesis parameters; silica sources, relative alkalinity and silicon module, were investigated on preparation of T type zeolite by hydrothermal method, using a two level factorial design. Crystallization time and reaction temperature were held constant at 7 days and 378 K, respectively. The synthesized products were characterized by XRD and SEM techniques. The results showed that increasing silicon module and decreasing relative alkalinity in the synthesis gel improved the product relative crystallinity. It was also observed that using colloidal silica as the silica source improved crystallinity and phase purity of T type zeolites. The prepared zeolite T with the highest relative crystallinity was examined in the batch adsorption experiments at three temperatures of 288, 298 and 308 K and various pressures from 0.1 up to 2 MPa to verify the ability of the material for selective adsorption and separation of CO_2 from CH_4. The adsorption capacities and isotherms of CO_2 and CH_4 were determined at the studied temperatures. The results showed that the highest ideal selectivity of CO_2/CH_4 could be achieved at atmospheric pressure and 308 K. The performance of the adsorbent was confirmed with breakthrough curves and breakthrough times resulted from dynamic adsorption experiments of the mixed gases.

Keywords: Zeolite T; Hydrothermal synthesis; CO_2 adsorption; Natural gas purification

1. Introduction

Selective removal of carbon dioxide from methane is an important and critical process in natural gas purification. CO_2 reduces the heat content of natural gas; additionally it is an acidic and corrosive gas which causes some problems in natural gas storage and transportation (Delgado et al., 2006, 2007). The methods can be used for separation of CO_2/CH_4 mixture are cryogenic distillation, adsorption and membrane technology. In comparison to other techniques, adsorption could be an easy and economic method for separation of CO_2 from natural gas. The most important aspect of adsorption process is preparation of an appropriate adsorbent with high adsorption capacity and selectivity in ambient temperature and pressure.

Nowadays zeolite molecular sieves are discussed in terms of their unique properties which result in remarkable applications as catalysts or adsorbents (Cejka et al., 2007). Zeolite molecular sieves are nanostructure crystalline materials in which the aluminum and silicon atoms are present in the form of AlO_4 and SiO_4 tetrahedra (Thompson, 1998). In general, zeolite framework structures are composed of channels and cavities and its light framework has extended inner active surfaces which have the ability to interact with molecules and cations. In addition, the size and shape of molecules influence the selective adsorption by zeolites (Cejka et al., 2007; Breck et al., 1958).

T type zeolite is a molecular sieve which was described by Bennet and Gard for the first time (Gorring, 1973). T type zeolite belongs to the offretite–erionite intergrowth family of zeolites. The frameworks of offretite and erionite are different but closely related (Yang and Evmiridis, 1996). Offretite framework has two types of channels, 8-membered and 12-membered

* *Corresponding author at*: School of Chemical Engineering, College of Engineering, University of Tehran, POB 11365 4563, Tehran, Iran. Tel.: +98 21 66112229.
E-mail addresses: shfatemi@ut.ac.ir, m.doroudian88@gmail.com (S. Fatemi).
Received 9 December 2011; Accepted 24 January 2012
0263-8762/$ – see front matter © 2012 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.cherd.2012.01.010