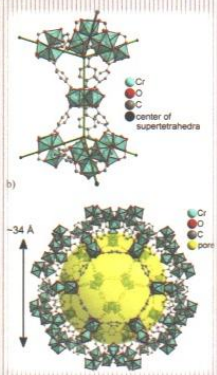
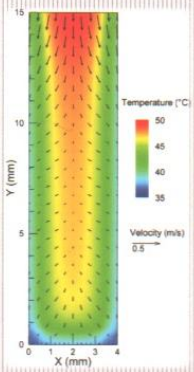
IMPRES

Chemical Science and Engineering Series 4

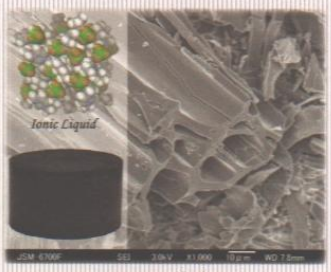
Innovative Materials for Processes in Energy Systems



MOF

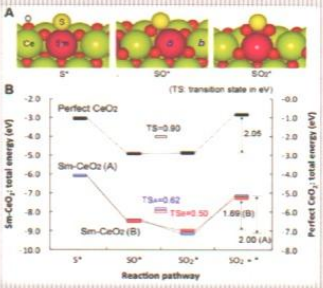


CFD analysis

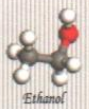


Composite adsorbent

$SiO_2 \cdot nH_2O$



SO_2 formation on CeO_2 and Sm-doped CeO_2



Editors:
Bidyut Baran Saha and Angelo Freni

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Hydrogen production and storage

Experimental and numerical study of effect of thermal management on storage capacity of the adsorbed natural gas vessel

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1. Introduction

Natural gas has become an alternative source of clean energy in the transport sector because of its combustion, which produces significantly lower pollutants than other fossil fuels. When natural gas is stored in the tank it must be compressed to a high pressure or liquefy at low temperature due to its low bulk density. In addition, traditional methods of storage (such as CNG and LNG) require large amounts of energy to operate and strictly safety regulations. Another way of storing methane is using adsorbent materials inside storage tanks where during charging process methane molecules can be attracted onto surface of pores of adsorbents by means of Van der Waals forces changing phase of the gas close to liquid [1]. Therefore, adsorbed natural gas vessel works under moderate pressure (3.5 – 4 MPa). Adsorbed natural gas (ANG) technology seems more cost effective than others, and there is no need for very expensive tools. Experimental studies show the influence of heat of adsorption on the rate of charge of the vessel and on storage capacity. Adsorption, which is exothermic process, occurs during charging of the vessel and adsorbent temperature will increase thus reducing adsorption capacity of porous material. It is concluded that the effective thermal control is important in order to increase the vessel charging rate and its storage capacity.

2. Mathematical Model

Methane is the primary component of natural gas (more than 94%), thus, its properties are used in this study. Mathematical model of ANG vessel based on mass, energy, momentum conservation equations and on linear driving force (LDF) model. Mass conservation equation is derived by spatial averaging technique. The gas motion inside of the porous medium is described by spatially averaged Navier-Stokes equations with the additional term which represents resistance of the porous medium. Amount of adsorbed gas at equilibrium pressure and temperature which is calculated by Dubinin-Astakhov equation [2].

3. Experimental study

Experimental prototype of ANG storage vessel was installed as shown in Fig. 1. It is mainly composed of stainless steel cylinder (316 SSL), finned heat exchanger mounted inside of the vessel which is filled with adsorbent (Maxsorb III), methane charging/discharging installation, apparatus designed to circulate water though tubes of the heat exchanger where temperature of the water is controlled by thermostat, the data acquisition system which consists of a laptop with special program written on LabView and data logger for real-time data acquisition. Experiment was carried out at the National University of Singapore.

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