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The Determination of Zeolite Sorption Properties

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Abstract

The installation and the measurement data procedure were established for the sorbent characteristics determination. Sorption isotherms of the three gases (nitrogen, oxygen and carbon dioxide) are obtained on the industrial zeolites NaX, NaX-BKO and NaA in a pressure range (0;7) bar.

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Keywords: nanomaterials, sorption, zeolites, air separation, gas separation, sorption isotherm, NaX, carbon dioxide removal

Nomenclature

ν	amount of substance, mole
ν_0	initial amount of substance in receiver, mole
V_0	Reciever volume, m^3
P_0	initial receiver pressure, Pa
ν_1	initial amount of substance in adsorber and neighbouring transportation links, mole
P_1	initial pressure in adsorber and neighbouring transportation links, Pa
V_f	free volume in adsorber, m^3

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V_1	transportation links volume, m^3
P_2	System pressure, consisted from adsorber and receiver, connected between each other, Pa
ν_2	amount of substance in receiver and adsorber, being in the gas phase, mole
ν_{ads}	amount of substance, adsorbed on the zeolite, mole
R	gas constant, J/(mole K)
T	temperature, K
a	amount of sorbed substance, mole/g

1. Introduction

Nowadays sorption materials are applied widely in the treatment of liquid and gas environment; particularly, these materials are used in the adsorption air separation processes. Air separation by adsorption method is related to cycle adsorption processes of gas mixtures treatment and separation; adsorbent regeneration is occurred cause of pressure (PSA process means “Pressure Swing Adsorption”). At present PSA processes are widespread due to effective methods of sorbent-regeneration problem solution. In this paper, basing on PSA process, hybrid membrane-sorption system of the air enrichment with air is offered for the artificial breathing atmosphere creation. Hybrid membrane-sorption system is used for gas-mixtures separation and consists of membrane and adsorption separation modules combination. This combo allows raising the content of targeted component, its extraction degree, and, also, to reduce the energy inputs. The complication of gas separation systems requires precision increase for sorption parameters determining, so as it is needed to match the work of a few single modules in the gas separation system, using different physical separation principles. Furthermore, sorption characteristics are needed to be determined not only for individual gas, but for the gas mixture.

The aim of this work is the zeolite NaX, NaA and NaX-BKO adsorption properties determination for main air components – nitrogen, oxygen, and the minor component – carbon dioxide.

2. Body

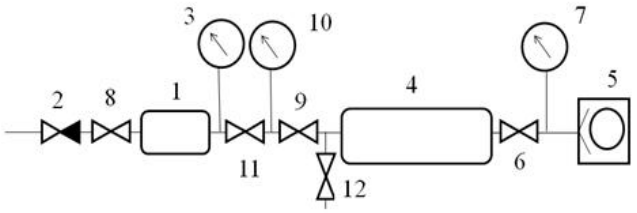

Fig. 1. Installation principle scheme: 1- receiver; 2-check valve; 3,7,10 - manometers; 4 – steel-wired case; 5 – vacuum pump; 6,8,9,11,12 - valve.

The main installation element is steel-wired adsorber, equipped with manometer and vacuum gauge. Gas is supplied to adsorber from receiver, equipped with manometer. The principle of operation is to measure the gas pressure, changing in the adsorber with the sorbent at its connection with the receiver.

Before the research was started, the zeolite, loaded to the adsorber, had been dehydrogenated with the help of evacuation, using the vacuum pump under raised temperature (100ºC). After the sorbent cooling to standard temperature, using helium, free volume was detected in the adsorber.

Free volume can be defined by the state equations of ideal gas in the adsorber and receiver, before and after gas expansion (under opened valves 9,11):

$$V_0 P_0 = \nu_0 RT \tag{1}$$

In adsorber before the expansion of gas: