



# Novel ammonia sorbents “porous matrix modified by active salt” for adsorptive heat transformation: 6. The ways of adsorption dynamics enhancement

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## ARTICLE INFO

### Article history:

Received 21 October 2011

Accepted 4 January 2012

Available online 10 January 2012

### Keywords:

Adsorption

Dynamics

Composite

Barium chloride

Barium bromide

Vermiculite

Ammonia

Performance

## ABSTRACT

The dynamics of ammonia sorption was investigated by means of a Large Temperature Jump (LTJ) method for loose grains of “BaCl<sub>2</sub>/vermiculite” and “BaCl<sub>2</sub>/BaBr<sub>2</sub>/vermiculite” composites which are promising materials for adsorption air-conditioning. The influence of the grain size, the adsorbent composition and the adsorbent load was studied. The heat transfer coefficients were calculated for adsorbents with different grain sizes. The results of LTJ experiments were used for modeling the adsorption air-conditioning cycle operating in the cyclic steady state mode. The potential of using a proper ratio of durations for the adsorption and desorption stages of the cycle along with a harmonization of the driving forces for the enhancement the dynamic performance of the adsorption chiller was discussed. Appropriate recommendations on optimization of the adsorbent composition and load were made.

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## 1. Introduction

Performance of an adsorption chiller (AC) is essentially affected by dynamics of adsorption and desorption stages of its working cycle [1,2]. It was revealed that when ammonia and an inorganic salt are used as a working pair the gas–solid reaction requires a certain driving force to proceed at a reasonable rate [3–7]. For isobaric desorption, the driving force is  $\Delta T = T_{\text{reg}} - T_r(P_c)$ , where  $T_{\text{reg}}$  is the temperature of the heat source and  $T_r(P_c)$  is the equilibrium temperature of reaction at condensation pressure. In [5]  $\Delta T$  was called as the temperature equilibrium drop; in this work it will be named as the driving temperature difference (DTD). Accordingly, for isobaric adsorption, the DTD can be introduced as  $\Delta T = T_r(P_e) - T_{\text{hs}}$ , where  $T_{\text{hs}}$  is the heat sink temperature and  $T_r(P_e)$  is the equilibrium reaction temperature at evaporation pressure.

Recently the composite ammonia adsorbent «BaCl<sub>2</sub>/vermiculite» has been presented as a promising material for adsorption cooling [8,9]. This composite has a high ammonia sorption ability (up to 0.24 g/g) resulted from the reaction between

ammonia and barium chloride confined to the vermiculite pores. One mole of the salt absorbs 8 mol of ammonia:



with the heat release of 36.7 kJ per 1 mol of ammonia [10].

Dynamics of ammonia sorption on 1–2 mm grains of «45 wt.% BaCl<sub>2</sub>/vermiculite» composite was measured by the LTJ method under conditions which closely imitated the isobaric stages of AC unit [11]. In this method sorption and desorption of the refrigerant were initiated by a sharp change of the temperature of a metal plate supported the adsorbent [12].

It was revealed that experimental conversion  $x$  obeyed a simple exponential dependence on time  $t$ :

$$x(t) = 1 - \exp(-kt), \quad (2)$$

where  $k$  is the rate constant of adsorption process. This constant depends linearly on the DTD:

$$k = 1/\tau = \frac{\alpha \cdot S}{\Delta H_r \cdot \Delta N} \cdot \Delta T = C \cdot \Delta T, \quad (3)$$

where  $\tau$  is the characteristic time of adsorption,  $\Delta H_r$  is the reaction heat,  $\Delta N$  is the maximal amount of adsorbed ammonia,  $\alpha$  is the heat

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