Adsorption of helium on zeolite NaA

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Isotherms of helium adsorption on zeolite NaA were measured by the volumetric method under static conditions at 23—50 K and pressures from 1 Pa to 65 kPa. The Henry constants and the initial heat of helium adsorption were calculated; the isosteric heat was calculated, and its dependence on the adsorption was determined.

Key words: helium, adsorption, zeolite NaA; adsorption isotherm, adsorption heat; Henry constant.

Adsorption of helium on various adsorbents was studied mainly at low temperatures (<20 K) and pressures.[1—3] Helium adsorption was studied most completely and sequentially on layers of condensed gases,[4,5] but literature data on the helium adsorption at $T > 20$ K on zeolites and active carbons are almost nonexistent. This information is necessary for the solution of several theoretical and practical problems that arise upon the development of cryotechnologies. In the present work, the results of the measurement of helium adsorption on zeolite NaA at 23, 30, 40, and 50 K within the pressure range from 1 Pa to 65 kPa are presented.

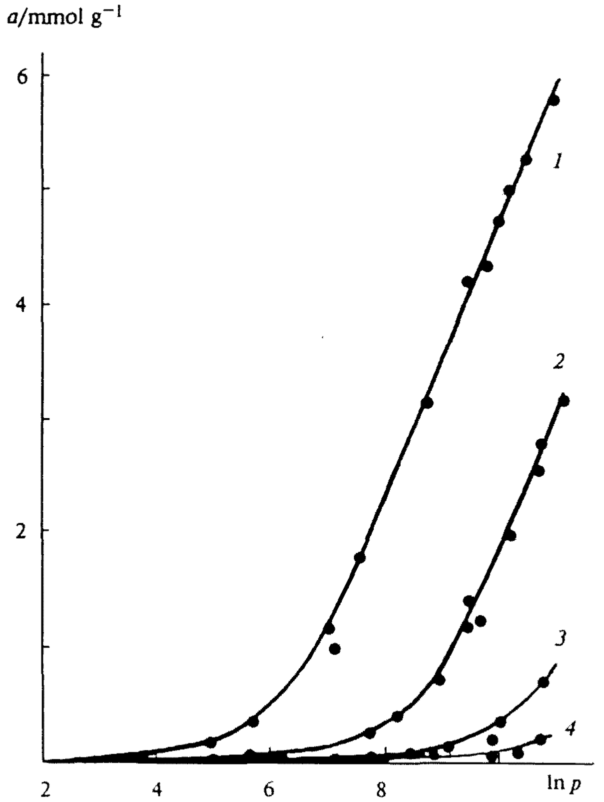

Fig. 1. Isotherms of helium adsorption at T/K = 23 (*1*), 30 (*2*), 40 (*3*), and 50 (*4*).

It is seen from the experimental adsorption isotherms (Fig. 1) that the value of adsorption depends strongly on temperature: the adsorption increases 3.2 times as the temperature decreases by 10 K (from 40 to 30 K), and in the temperature range from 50 to 40 K it 4.7-fold increases (at p = 60 kPa).

It is established that at 40 and 50 K the helium adsorption obeys Henry's law: $a = K_{\mathrm{H}}p$; at 30 K the Henry region is observed up to a = 1.4 mmol g^{-1} and p = 17 kPa, and at 23 K it is observed up to a = 1.8 mmol g^{-1} and p = 2.7 kPa. The following values of Henry constants (K_{H}) were calculated from the linear regions of the isotherms in the range from 23 to 50 K:

T/K	50	40	30	230
$K_{\mathrm{H}} \cdot 10^6$/mmol (g Pa)$^{-1}$	4.0	15.0	95.0	1000

The dependence $\ln K_{\mathrm{H}} = f(1/T)$ is linear under the experimental conditions, which allows one to calculate the initial heat of helium adsorption from the correlation $\ln K_{\mathrm{H}} = Q_0/(RT) + C$. The value of the initial adsorption heat obtained (1.95 kJ mol^{-1}) coincides with that calculated previously with accuracy within 10 %.[6]

The isosteres of helium adsorption were plotted on the basis of the adsorption isotherms (Fig. 2). The adsorption isosteres are well approximated by straight lines in the whole temperature and pressure range studied, which means that the isosteric heat is temperature-independent. The isosteric heat is calculated from the

Translated from *Izvestiya Akademii Nauk. Seriya Khimicheskaya*, No. 5, pp. 1291—1292, May, 1996.

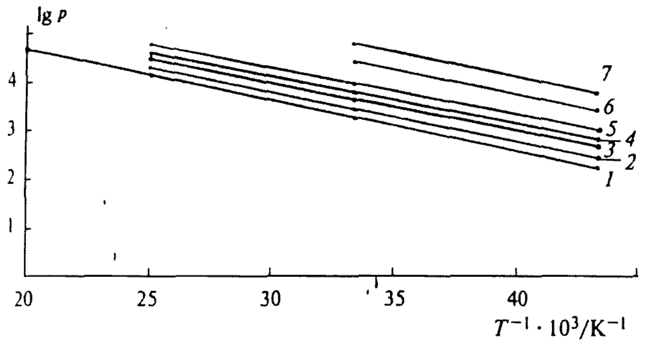

Fig. 2. Isosteres of helium adsorption for filling a_0/mmol g^{-1} = 0.2 (*1*), 0.3 (*2*), 0.5 (*3*), 0.7 (*4*), 0.9 (*5*), 2.0 (*6*), and 3.0 (*7*).

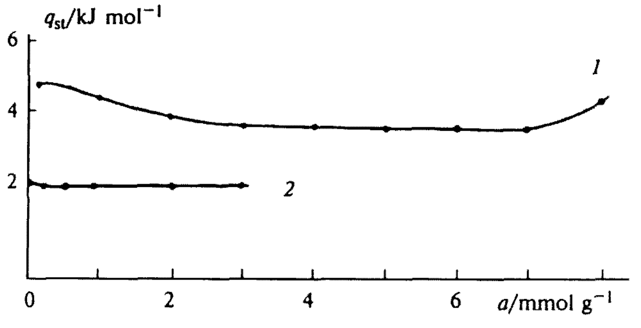

Fig. 3. Isosteric heats (q_{st}) of helium (*1*) and neon (*2*) as functions of the adsorption.

adsorption isosteres, and its dependence on the adsorption value is illustrated in Fig. 3 (curve *1*). The comparison of the run of this curve with the similar dependence for neon[7] (see Fig. 3, curve *2*) and other inert gases[8,9] demonstrates their identity, which is evidence of the same mechanism of the adsorption of inert gases on zeolites mainly caused by the dispersion interaction gas—solid.

Thus, the helium adsorption on zeolite NaA was studied at 23—50 K in the pressure range from 1 Pa to 65 kPa, and the thermodynamic parameters of the adsorption equilibrium were calculated.

Experimental

Isotherms of helium adsorption were measured by the volumetric method under static conditions using the procedure and instruments described previously.[10,11] Zeolite NaA (chemical composition $0.93Na_2O \cdot Al_2O_3 \cdot 2.06SiO_2 \cdot 0.07H_2O$) was activated by heating to ~650 K and pumping to the residual pressure of ~10^{-3} Pa. The content of admixtures in helium was not greater than 0.005 %. The establishment of the equilibrium was controlled by the coincidence of adsorption and desorption points under isothermal conditions.

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Received October 6, 1995;
in revised form January 16, 1996