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- USSR -

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FOREWORD

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THE "NEGATIVE" CONCENTRATION EFFECT IN THERMAL DIFFUSION OF GASES IN POROUS MEDIA

- USSR -

[Following is the translation of an article by B. N. Goshchitsky and I. S. Izrailevich in the Russian-language periodical Doklady Akademii nauk SSSR (Reports of the Academy of Sciences, USSR), Vol 147, No 4, Moscow, 1962, pages 817-818. The article was submitted to the editors 9 March 1962; it was read by Academician I. K. Kikoin on 25 July 1962.]

In a previous report (1) on the study of thermal diffusion in capillaries, there was observed a "negative" concentration effect in the pressure transition region (the region where capillary diameter d is on the same order as molecular mean free path λ), the effect being an increase in concentration of the lighter component in the cold end of the capillary. These authors suggested then the possibility of observing the same effect when using porous media rather than a capillary.

We have investigated the separation effect of the gaseous mixtures H_2-Ar, H_2-Kr and He-Kr, that occurs upon their passage through a porous medium in the presence of a temperature gradient. The apparatus used is shown in Fig. 1.

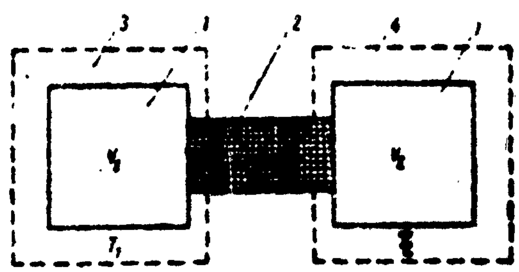

Fig. 1. Experimental scheme.
1 - Operating chambers
2 - Porous medium
3 - Heating jacket
4 - Cooling jacket
T_1, T_2 - Temperatures

As is known (2), when two such volumes V_1 and V_2 are separated by a porous partition and maintained at different temperatures T_1 and T_2, a pressure difference develops in the molecular and pressure transition region due to the phenomenon of thermal transpiration. The effect can be visualized as the simultaneous existence of two distinct kinds of gas flow, one caused by the temperature gradient, the other, flowing in the opposite direction, caused by the pressure gradient. We have undertaken measurements of the separation effect by using two methods. The first corresponded to the conditions under which the "negative" concentration effect of (1) was noted; in the second method, pressure differential was reduced to zero by means of a special feedback tube which connected the two volumes V_1 and V_2, and had adequate diffusion impedance together with a small "hydraulic" impedance. When the latter method was used in (1) a so-called "positive" effect was observed, i. e. the concentration of the lighter component took place in the "hot" chamber.

A basic difference in our experimental set-up from that of (1) consisted in careful thermostatic control of both chambers, in such a manner that their temperatures did not differ from the external temperature of the porous element where it adjoined the chambers -- that is, no temperature drop could occur in the chambers. The porous element was directly connected to the chambers without any transition stages.

Barium ferrite ($BaO \cdot 6Fe_2O_3$) was used as one porous element. Its effective pore radius has been determined by the relation between viscous and experimentally measured molecular flows (3). Initial mixture concentration C_0 was chosen to be 50%; mixture composition was analyzed by a thermal recorder based on measurement of thermal conductivity, with accuracy of analysis of 0.15%(absolute). A sample result is given in Fig. 2 (curve 1), showing the change in the separation effect, $\Delta C = C_{hot} - C_{cold}$, with respect to the ratio d/λ for a H_2-Ar mixture, under simultaneous pressure and temperature gradients along the porous element. Figure 3 shows the same relationship when only a temperature gradient exists.

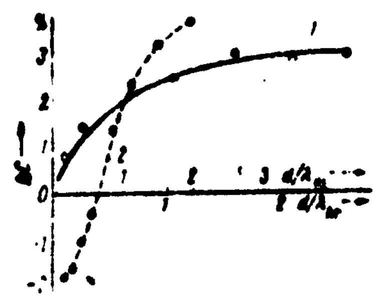

Fig. 2. Dispersion vs. d/λ for H_2-Ar(50% H_2). $T_1=473°K$ $T_2=293°K$

Curve 1: temperature in chambers=that of respective ends of porous element.
Curve 2: temperature drop due to feedback.

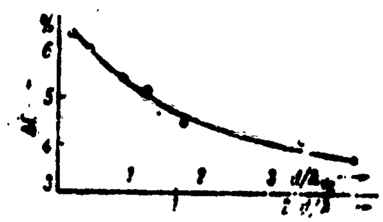

Fig. 3. Dispersion vs. d/λ for H_2-Ar. $T_1=477°K$ $T_2=295°K$

Temperature gradient only across porous element.

It is evident that in the first case (Fig. 2) the effect is "positive" for all pressure regions, going to zero at $P_0 = 0$. In the second case the effect falls off without inflection as pressure increases, having its maximum value at $P_0 = 0$, although even at relatively high pressures the large effect associated (4) with ordinary thermal diffusion in free space is not present. Results obtained with H_2-Kr and He-Ar mixtures as well as with various other porous elements did not differ essentially from those of Figs. 2 and 3.

For thermal diffusion in a porous medium the "negative" effect is thus not observed. Most probably this effect described in (1), and also observed in (5), was caused by parasitic feedback temperature drops in the experimental equipment used; we set up an experiment which substantiates this assertion, as may be seen by Curve 2 of Fig. 2. However the possibility must not be excluded that a partial "negative" effect may be linked to a movement of gaseous mixtures which is peculiar to long capillaries.

Our experimental results agree well with the theory previously developed by Yu. M. Kagan, who is also to be credited with the initiative for setting up the above described experiments.

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