PHYSICS

G. G. DEVYATYKH, G. K. BORISOV

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Fig. 1

Figure 1: Fig. 1

Abstract

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PHYSICS

G. G. DEVYATYKH, G. K. BORISOV

SEPARATION OF SILICON ISOTOPES IN MONOSILANE BY THE THERMODIFFUSION METHOD

(Presented by Academician N. M. Zhavoronkov, October 4, 1962)

Natural silicon contains three stable isotopes, Si^{28}, Si^{29}, Si^{30}. In small quantities, separation of silicon isotopes has been carried out on a calutron ([1,2]). This method is still very expensive. A small separation was obtained in the rectification of monosilane ([3]). The isotope effect in the vapor pressure of monosilane is very small; therefore separation of silicon isotopes by rectification of monosilane is a technically difficult problem.

In the present work the possibility of separating silicon isotopes by the thermodiffusion method was investigated. Monosilane was used as the working gas, because the relative difference in the masses of its isotopic molecules is greater than for any other silicon compound. At temperatures above 300°, the rate of thermal decomposition of monosilane becomes appreciable ([4]). Therefore the temperature of the hot wall cannot be maintained above 300°.

Experiments were carried out in a metal column of the coaxial-cylinder type. Such columns are more effective than wire-type columns when operating with low values of the hot-wall temperature. The length of the working part of the column was 102 cm, the diameter of the inner cylinder 46 mm, and the width of the gap between the cylinders 2 mm. The inner cylinder was maintained at a temperature of 250°, and the outer one was cooled with tap water to a temperature of ∼ 15°. Samples of monosilane taken during the separation process were converted into silicon tetrafluoride and analyzed on an MI-1305 mass spectrometer. From the results of the analysis the separation factor was determined.

Fig. 1. Dependence of the separation factor on pressure. a –$Si^{30}H_4$, b –$Si^{29}H_4$

$$F = \frac{(N_1/N_2)_{\text{bottom of column}}}{(N_1/N_2)_{\text{top of column}}};$$

N_1 is the atomic fraction of the isotope Si^{30} or Si^{29}; N_2 is the atomic fraction of the isotope Si^{28}.

The experimental results are shown in Fig. 1. They are described by the equations

$$\ln F_{30} = \frac{0.134P^2}{1 + 0.0847P^4}, \qquad \ln F_{29} = \frac{0.0645P^2}{1 + 0.0759P^4},$$

in which P is the pressure of monosilane in atmospheres (the subscripts 30 and 29 refer to the isotopes Si^{30} and Si^{29}, respectively).

By comparing the experimental results with the theory of the thermodiffusion method ([5]), the value of the ratio $K_p/K_c = 1.81$ was determined, where K_c is the coefficient of convective mixing and K_p is the coefficient of para-

mixing. This ratio has an admissible value. It is smaller than, for example, the average value of K_p/K_c in the thermodiffusion separation of carbon isotopes in carbon monoxide [(6)]. In calculating the value of F from [(5)], the value of the viscosity of monosilane was taken from [(7)].

The theoretical ratio $\ln F_{30}/\ln F_{29} = 1.97$. In our experiments the mean value of this ratio was 1.96.

The walls of the column (steel 3) catalyze the decomposition of monosilane. In the first (preliminary) experiments, partial decomposition of monosilane occurred. After the walls of the column became coated with a thin film of silicon, decomposition of monosilane was not observed*.

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Scientific Research Institute of Chemistry
at Gorky State University
named after N. I. Lobachevsky

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* Duration of one experiment: 6 h.

Note: Figure translations are in progress. See original paper for figures.