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Abstract

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EFFECT OF IRRADIATING INDIUM WITH THERMAL NEUTRONS ON THE MOLECULAR COMPOSITION OF ITS VAPOR

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Numerous works have been devoted to the study of the effect of penetrating radiation on the properties of substances in the solid state ([1]); however, the influence of irradiation on the rate of evaporation, the molecular composition, and the vapor pressure of various substances has practically not been studied. Only isolated works are known ([2,3]), in which it was established that the character of evaporation changes under the influence of irradiation.

In the present communication we set forth the results of a mass-spectrometric analysis of the molecular composition of the vapors of liquid indium irradiated in the solid state with thermal neutrons. The work was carried out on an MS-1 mass spectrometer according to the procedure described in ([4]).

Three indium specimens were studied in the form of films 40–50 μ thick, irradiated with an integral neutron flux of 10^{12}–10^{14} n/cm^2, and the results were compared with those obtained on nonirradiated films of the same thickness. The mechanical treatment of the specimens was the same in both cases. The films were placed in the mass spectrometer in a fused-quartz crucible, in which they were melted and degassed. Evaporation of the indium occurred from the free surface of the molten specimen. After elimination of the background in the region of mass numbers 200 and higher, the dependence of the ion currents of the dimer I_2 and monomer I_1 and of their ratio $i = (I_2/I_1)$ on temperature was studied in the interval 773–1373°K (the melting temperature of indium is 429.4°K).

The character of the temperature dependence of i for irradiated and nonirradiated specimens proved to be the same: i increases with temperature. However, the values of i at equal temperatures and under otherwise identical experimental conditions for the irradiated specimens exceeded by a factor of 15–50 the values for the nonirradiated specimens ($\sim 10^{-2}$ as against $\sim 3 \cdot 10^{-4}$) (see Fig. 1). This conclusion was confirmed in a special control experiment with a specimen of indium of 99.99% purity. The investigated specimen of the control sample was divided into two parts, one of which was not subjected to irradiation, while

Fig. 1 and Fig. 2

Figure 1: Fig. 1 and Fig. 2

the other was irradiated with thermal neutrons with the same integral flux as the first three specimens, after which the vapor composition of both parts was studied.

It is of interest to determine the influence on i of the time elapsed from irradiation to the study of the mass spectrum. For the first and second specimens this interval of time was approximately one year; for the third and fourth specimens, two weeks. In all cases a strong effect of the preceding irradiation was observed. Thus, the effects caused by irradiation may persist for a long time.

The data and conclusions presented above refer to specimens from which oxides had been completely removed and the lines of the latter were not observed at all in the mass spectrum. The presence of an oxide film on the surface of specimens may lead to quantitative and qualitative distortion of the results—an additional increase and a change in the character of the temperature dependence of i, and a loss of reproducibility of the results. In connection with this

We considered it necessary to analyze the role of impurities whose concentration did not exceed 0.01%. If, after neutron capture, some impurity were transformed into a radioactive isotope with a half-life of about a year or more, then the increase in i after irradiation and the great duration of the "memory" of the irradiated indium samples could be attributed to the action of the radiation from this radioactive impurity on the indium atoms. However, spectral analysis of the unirradiated control sample did not reveal in it impurities that, after irradiation, would be transformed into long-lived radioactive isotopes.

Fig. 1. *a*—irradiated samples; *b*—unirradiated sample

Fig. 2. *a*—before overheating; *b*—after overheating

In this connection it is interesting to note that after the short-term increase in temperature, carried out by us, of the second irradiated sample to 1423-1473° K, i.e., after overheating it by 50-100° relative to the maximum working temperature of the remaining samples, and after the subsequent switching off of the heater, this sample lost the properties acquired under the influence of irradiation: the curve of the dependence of i on temperature, within the scatter of the experimental points, coincided with the corresponding curve of the sample not subjected to irradiation (Fig. 2).

From the temperature dependence of the ratio i for the fourth sample, not subjected to irradiation, the binding energy of the dimer was estimated by the method described in (5). Data on the heat of evaporation of the monomer (2.34 eV) were taken from (6). In this case the binding energy of the dimer proved to be 1.3 ± 0.6 eV, which is in satisfactory agreement with the results of work (6): 1 ± 0.1 eV.

In conclusion, we consider it our pleasant duty to express our gratitude to A. R. Striganov for carrying out the spectral analysis and to Yu. F. Chernilina for assistance in irradiating the samples.

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