AD No. 24982
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NSF-tr-187
January, 1954

Physics Translated from Doklady Akademii Nauk SSSR, 92, 273-75 (1953)

# X-Ray Absorption Spectra of Zinc in Molecules of $ZnCl_2$, $ZnBr_2$, and ZnS

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In reference 1 the author investigated the x-ray absorption spectrum of free atoms of zinc. That paper set forth new details of the structure of the *K*-spectrum of free atoms of zinc which had not been found by Hanawalt[2] and gave a possible interpretation of the spectrum structure observed.

The present paper, an extension of reference 1, proceeds to an investigation of the free molecules which contain a zinc atom and which follow next in the order of complexity of formation. The experiment consisted essentially in photographing the x-ray absorption spectra of the substances under study in the gaseous state. The substance was placed in a quartz absorption cell with spherical thin-walled windows (Fig. 1). The quantity used was appropriate for the volume of the absorption cell, with consideration of the fact that at the temperature of the experiment the substance would be in the state of superheated vapor. The absorption cell was connected to a vacuum apparatus and evacuated to $10^{-5}$ mm Hg, then sealed off from the vacuum apparatus and placed into a tubular electric furnace mounted on the swinging arm of the x-ray spectrograph along the axis of the focused beam of x-rays.

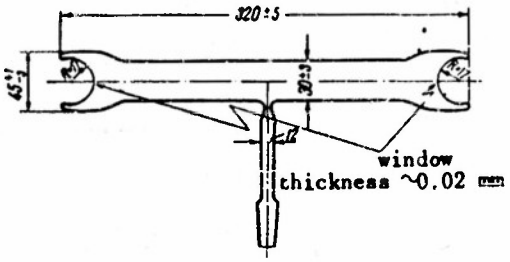


Fig. 1. Quartz absorption cell with thin-walled spherical windows.

The analyzer of the x-ray spectrograph was used in accordance with the results of reference 3, and the reflections were from the $(10\bar{1}0)$ planes of a quartz crystal in the second order. The dispersion was 4.23 X-units/mm. The spectra were recorded photographically and subsequently analyzed with a microphotometer, ten curves being taken of each spectrogram. The photometric results were averaged, and the curves of photodensity $S = \varphi(E)$ were converted into curves of absorption $\mu x = f(E)$ according to the sensitometric curve of the photographic film being used. Exposure was 8 to 12 hours, with the x-ray tube operating at 40 kv, 75 ma.

The *K* absorption spectrum of the zinc in $ZnCl_2$ molecules is shown in Fig. 2, $\alpha$. The conditions of the experiment were: temperature of the absorption cell 680 degrees; effective thickness of the absorbing layer of zinc 5.7 $\mu$; the effective length of the absorption cell 29.5 cm; the volume of the absorption cell 240 $cm^3$, the weight of the dry zinc-chloride filling 70 mg.

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The curve given represents the analysis of one of the most distinct spectrograms. The figures on the graph, which characterize elements of the fine structure of the spectrum, are the averaged measurements of all eight spectrograms.

Fig. 2, *b* shows the absorption spectrum of zinc in $ZnBr_2$ molecules. Conditions of the experiment: temperature of the absorber 630 degrees; effective thickness of the absorbing layer of the zinc 8.3 μ; effective length of the absorption cell 30 cm; volume of the absorption cell 250 $cm^3$; weight of the dry zinc-bromide filling 170 mg.

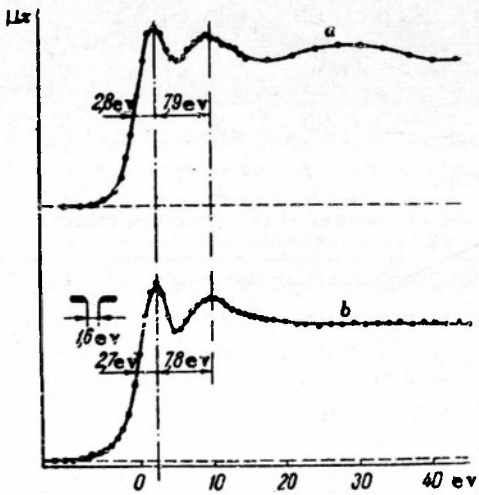


Fig. 2. *K* absorption spectra of zinc in molecules of $ZnCl_2$ (*a*) and $ZnBr_2$ (*b*).

The experiment on photographing the *K* absorption spectrum of zinc in ZnS molecules presented the greatest difficulties. These difficulties were caused by the high temperature of vaporization of zinc sulfide and by the lack of data on its vapor pressure at various temperatures. However, the investigation of the *K*-spectrum of zinc sulfide is of especial interest, since ZnS molecules are characterized by binding forces of a type essentially different from that in molecules of halogen compounds. After a number of attempts a satisfactory x-ray absorption spectrum in ZnS vapor was obtained. The conditions of the experiment were: temperature of the absorption cell about 1100 degrees; length of the absorption cell 27 cm; volume 2.56 $cm^3$; weight of the zinc-sulfide filling 81 mg.

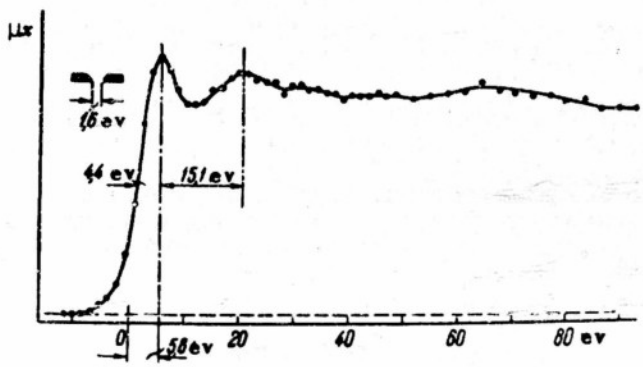


Fig. 3. *K* absorption spectrum of zinc in ZnS molecules.

The lack of data on the vapor pressure of zinc sulfide makes it impossible to compute the effective thickness of the absorber and to ascertain whether all the filling was converted into the vapor state. On the other hand, the presence in the absorption spectrum of the usual absorption edge, approximately equal to those in the spectra of the other substances ($ZnCl_2$, $ZnBr_2$, and so forth), indicates that the bulk of the filling (0.081 gm in the case of complete vaporization corresponds to an effective thickness of 8 μ) was converted into the vapor state.

The absorption spectrum of the zinc in ZnS molecules is shown in Fig. 3.

All the spectrograms were obtained under identical conditions. The geometry of the apparatus was not disturbed in going from one specimen to another. The $K$ absorption spectrum of free atoms of zinc was obtained repeatedly under the same experimental conditions. Fig. 4 shows all the spectra in a single energy scale and in the correct relative position on the energy scale.

To determine the wavelength of the principal absorption maximum, the emission lines $IIGeK\alpha_{1,2}$ and $IIGaK\alpha_{1,2}$ were used.

Values for the position of the principal absorption maximum were:

| Molecule | Wavelength of the principal absorption maximum (X-units) |
|---|---|
| Zn, atomic | 1280,70 ± 0,05 |
| $ZnCl_2$ | 1280,38 ± 0,05 |
| $ZnBr_2$ | 1280,40 ± 0,05 |
| ZnS | 1280,02 ± 0,05 |

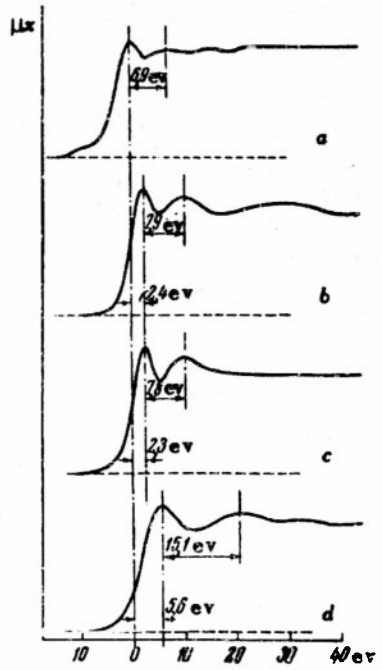


Fig. 4. Comparison of the $K$ absorption spectra of atomic zinc ($a$) and zinc in molecules of $ZnCl_2$ ($b$), $ZnBr_2$ ($c$), and ZnS ($d$).

The analysis of the spectra and the discussion of them must be dealt with in a separate paper.

In conclusion the author avails himself of the opportunity to express gratitude to A. I. Yermilov, who displayed true art in preparing the quartz absorption cells with thin-walled spherical windows.

[1]K. I. Narbutt, Izvest. Akad. Nauk SSSR, ser. fiz., 15, 231 (1951).

[2]J. D. Hanawalt, Phys. Rev., 37, 715 (1931).

[3]Vainshtein, Narbutt, and Gilvarg, Trudy Inst. kriat. Akad. Nauk SSSR, 6, 207 (1951).

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Received May 15, 1953; presented by Academician A. A. Lebedev June 10, 1953