

Secondary Emission and Electron Diffraction on the Glass Surface

The optical surfaces of some optical glasses especially those containing a high percentage of barium and lead often show stain or interference hues due to very thin films of compounds formed on the glass surface as a result of attack by moisture or by various vapors contained in the atmosphere.

Because of the minute quantities involved, these compounds can hardly be analyzed chemically or by x-rays. We have succeeded, however, in obtaining electron diffraction patterns of such surfaces.

The difficulty with obtaining diffraction photographs from the surface of a good insulator results from the charging up of this surface. The method here used has obviated that difficulty. Measurements¹ show that the secondary emission of electrons from a glass surface increases from 1 to a maximum of about 2 as the velocity of the primary electron beam increases to a few hundred volts. As the velocity is further increased the emission factor decreases and becomes smaller than 1.

In the present experiments a beam of high velocity electrons (40–50 kv) which is to be diffracted was projected on the surface. At the same time a beam of low velocity electrons ($\sim 300v$) was projected on the same surface in a direction perpendicular to the high velocity beam and at about 30° to the surface normal. By adjusting the intensity of this beam the resulting secondary emission factor for the two beams could be made zero and as a consequence the surface would remain electrically neutral.

With this technique it was found that a freshly polished surface of glass shows amorphous halos as indicated in Fig. 1A at $\sin \frac{1}{2}\theta/\lambda = 0.13, 0.20, 0.37$. These values differ somewhat from previous results of transmission experiments on an amorphous silica film.² This suggests that the polished layer has a structure different from that of the base glass.³

Surfaces which have become tarnished give various diffraction rings which differ according to atmospheric conditions, time, and kind of glass. Polished surfaces of optical glass containing a high percentage of BaO (e.g., SK₄, BaLF₄) and a high percentage of PbO (e.g., SF₂, SF₆) after being kept about two months in an atmosphere rich in humid SO₂ gas at room temperature show interference colors produced by a film the thickness of which is of the order of the wave-length of light. Investigation shows that this film is BaSO₄ in the case of barium glass (Fig. 1B) and

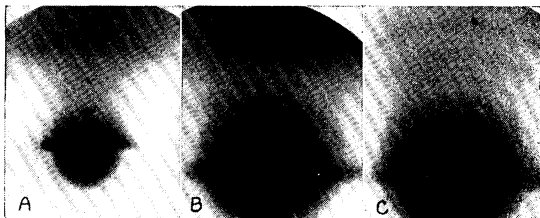


FIG. 1. A, Amorphous diffraction halos from a polished glass surface. B, Diffraction rings from the surface of a tarnished barium optical glass (BaLF₄). C, Diffraction rings from a tarnished lead optical glass (SF₂).

that it is a mixture of PbS and PbSO₄ in the case of the lead glass (Fig. 1C). A detailed account will be reported in a Japanese journal.

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HIROSI KAMOGAWA

Research Laboratory,
Tokyo Shibaura Electric Company,
Matsuda Division,
Kawasaki, Japan,
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- ¹ H. Salow, *Zeits. f. Physik* **21**, 8 (1940).
² L. R. Maxwell and V. M. Mosley, *Phys. Rev.* **47**, 331 (1935); H. Kamogawa, *ibid.* **54**, 91 (1938).
³ Beilby, *Proc. Roy. Soc. A* **72**, 220 (1903); Lord Rayleigh, *ibid.* **A156**, 329 (1936).

Fission Products of Uranium by Fast Neutrons

Under the above title we reported¹ the results of investigations on silver, cadmium and indium isotopes obtained from uranium by bombardment of fast neutrons. In continuing our experiments we found that palladium isotopes are also produced by fission, and one of them is the mother substance of the 3.5-hour silver isotope, Ag¹¹², which was mentioned in the above note. The experimental procedure was as follows.

The palladium fraction, which was separated as dimethylglyoxime salt from an irradiated sample and was carefully freed from the known fission products of uranium such as silver, antimony, tellurium, iodine, molybdenum, barium, lanthanum, cadmium, indium, etc., as well as from uranium itself, was examined for its activity. The decay curve, which was obtained from samples of long exposure, shows two periods, the longer one being 17 hours and the shorter one 26 minutes.

Under the supposition that the 17-hour palladium probably forms the mother substance of the 3.5-hour silver isotope mentioned above, we tried the search for this daughter product in the following manner. After 15 hours from the time of separation, the palladium compound was ignited, the residue was fused with sodium bisulphate and the melt was dissolved in water. From this solution, after adding silver nitrate as carrier, silver was precipitated as silver chloride. From the filtrate, palladium was precipitated with hydrogen sulphide. Both precipitates were then tested for the activity. The decay curve of the silver chloride showed a half-value period of 3.5 hours, which was ascribed to Ag¹¹² as mentioned in the above note in *Nature*. A similar method was tried to see if any silver isotope is produced from the 26-min. palladium but the result was negative. It is thus clear that the 3.5-hour silver grows from the 17-hour palladium, which therefore is identified with Pd¹¹². On the other hand, the identification of mass number of the 26-min. palladium is not yet certain.

The results of our investigations on the fission products of uranium so far obtained by fast neutrons are summarized in Table I.

TABLE I. Summary of the identifications of fine products of uranium bombarded by fast neutrons.

ELEMENT	HALF-PERIOD	ISOTOPE	RADIATION	MAXIMUM ENERGY (MEV)
Pd	26 min. 17 hr.	112	electrons	
Ag	7.5 day 3.5 hr.	111 112	electrons electrons	0.8 2.0
Cd	56 hr. 3 hr. 50 min.	115 117		
In	4.5 hr. 2 hr.	115* 117	γ -rays conversion electrons electrons	0.31-0.35 0.28 1.8

* Radioactive isomer of stable nucleus.

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Y. NISHINA
T. YASAKI

Nuclear Research Laboratory,
Institute of Physical and Chemical Research,

K. KIMURA
M. IKAWA

Chemical Institute,
Faculty of Science,
Imperial University of Tokyo,
Tokyo, Japan,
August 10, 1940.

¹ Y. Nishina, T. Yasaki, H. Ezoe, K. Kimura and M. Ikawa, *Nature*, in press (1940).

On the Temperature Assignments of Experimental Thermal Diffusion Coefficients

When one calculates coefficients of thermal diffusion from viscosity data on the basis of a particular molecular model, the isothermal nature of viscosity measurements enables one to evaluate theoretically the coefficients at definite temperatures. The thermal diffusion coefficient can only be directly measured, however, when a temperature gradient exists. Comparison of theory with experiment then becomes rather difficult, because the measured value is essentially the "effective" value of the coefficient over a temperature range that is usually quite large. The problem then arises as to what definite temperature to assign an experimentally determined value.

The fundamental equation of thermal diffusion is

$$\text{grad } c_1 = -(K_T/T) \text{ grad } T, \quad (1)$$

where c_1 , is the concentration (mol-fraction) of one of the constituents, T is the absolute temperature, and K_T is a quantity that for isotopes reduces to the form

$$K_T = \frac{105 M_2 - M_1}{118 M_2 + M_1} R_T c_1 c_2, \quad (2)$$

the M 's being the molecular weights and R_T being the

ratio of the thermal diffusion coefficient for the given gas to that for rigid elastic spheres.

Assuming R_T independent of temperature, we then have from Eqs. (1) and (2)

$$\frac{118 M_2 + M_1}{105 M_2 - M_1} \ln \frac{(c_1/c_2)_1}{(c_1/c_2)_2} = R_T \ln \frac{T_2}{T_1}. \quad (3)$$

If one then measures the concentrations of the constituents in the hot and cold sides of the apparatus, the value of R_T that one calculates from Eq. (3) will be an "effective" value of R_T over the temperature range T_1 to T_2 , that we shall hereafter designate as R_e to distinguish it from the true value of R_T at a given temperature.

Let us now take into consideration the fact that R_T varies with temperature by assuming that the variation can be described approximately by an equation of the form

$$R_T = R_\infty - B/T. \quad (4)$$

R_∞ is the value approached by R_T as T increases, and B is a constant for a given gas. We see that if $R_\infty = 1$ we have the equation derivable from Sutherland's model neglecting terms of higher order in ϵ/KT .¹ R_∞ is used in this case instead of unity in order to make our result more general.

We have from Eqs. (1), (2), and (4)

$$\frac{118 M_2 + M_1}{105 M_2 - M_1} \ln \frac{(c_1/c_2)_1}{(c_1/c_2)_2} = R_\infty \ln \frac{T_2}{T_1} - B \frac{T_2 - T_1}{T_1 T_2}. \quad (5)$$

We now want to find the temperature T_r at which our measured value, R_e becomes equal to the true value R_T . From Eqs. (3), (4) and (5), we find this to be

$$T_r = \frac{T_1 T_2}{T_2 - T_1} \ln \frac{T_2}{T_1}. \quad (6)$$

Actually one should use instead of Eq. (4) the equation derived from the particular model that one is comparing. However, Eq. (4) has two advantages. First, having two adjustable parameters, it can be made to represent with sufficient accuracy for our purpose the variation of R_T with temperature. Second, as we see from Eq. (6), the final result comes out independent of our constants R_∞ and B . For example, if one were to use the equation for the Sutherland model derived recently by Jones,² the final result, besides being much more complicated is dependent on the Sutherland constant, while at the same time values of T_r calculated in this manner differ but slightly from those calculated from Eq. (6).

In comparing the values for methane and neon measured by Nier^{3, 4} with those calculated from viscosity, Brown⁵ and Jones¹ have taken the measured value R_e to be roughly the value at the mean temperature $T_m = \frac{1}{2}(T_1 + T_2)$. However, inspection of Eq. (6) shows that T_r is often considerably smaller than T_m , and if R_T falls at all rapidly with the temperature, serious error can result.

Nier⁴ has measured R_e for neon over three temperature ranges. Jones calculates from Eq. (54) of his paper values of R_T at the mean temperature of the above temperature ranges, that are in rough agreement with experiment. For comparison, corresponding values of R_T calculated from Jones' equation at temperatures T_r as well as T_m are shown in Table I. We see that they are in somewhat better agree-