proof hereof is that the crystals are piezoelectric, which effect cannot occur if there is a center of symmetry.

In the perovskite system and in WO_3 it appeared that ferroelectricity occurred when the metal oxygen octahedra fulfilled certain conditions for size and electronic configuration.[2,3] A comparison between metatitanates, columbates and tantalates showed that the ferroelectric behavior was much more sensitive to a change of lattice constant in the case of Ti than in that of Cb or Ta, because all metacolumbates or tantalates of the perovskite system were ferroelectric. This fact now seems to extend even to a quite different crystal system such as the ilmenite structure. There the octahedra do not share corners with each other as in perovskite, but edges and faces, and the crystal symmetry is lower. It might be added that none of the ferroelectric crystals mentioned fits into the scheme of adding over-all polarizabilities, which was first suggested by Jonkers and van Santen[4] and then extended to non-ferroelectric crystals by Roberts.[5]

Any investigation of $LiTaO_3$ and $LiCbO_3$ has to be carried out with single crystals because ceramics show hardly any effect. The reason for this is the rather low crystal symmetry, compared to the perovskite system; another consequence of the low symmetry is the absence of domains.

We are very grateful to Dr. E. A. Wood for doing all the x-ray work.

---

[1] W. H. Zachariasen, Skr. Norske Vid.-Akad., Oslo, Mat. Naturv. No. 4 (1928).
[2] Matthias, Wood, and Holden, Phys. Rev. **75**, 1771 (1949).
[3] B. T. Matthias, Phys. Rev. **76**, 430 (1949).
[4] G. H. Jonkers and J. H. van Santen, Chem. Weekbl. **43**, 672 (1947).
[5] S. Roberts, Phys. Rev. **76**, 1215 (1949).

Optical Absorption in Barium Oxide Films

WINFIELD W. TYLER*
Department of Physics, Cornell University, Ithaca, New York
November 3, 1949

MEASUREMENTS of the optical absorption of small single crystals of barium oxide[1] indicated that any information concerning structure in the absorption band could only be obtained from the study of thin films. Absorption in such films has recently been measured as part of the study of photo-conductivity and optical properties of BaO.

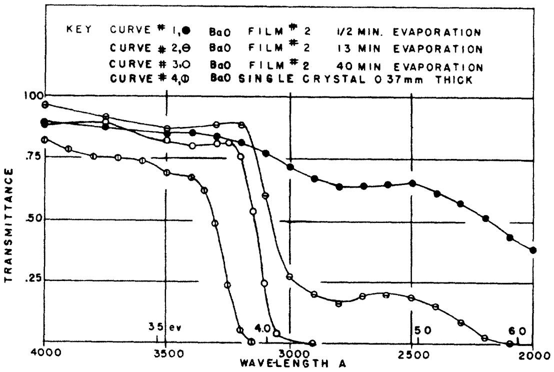

FIG. 1. Transmittance as a function of wave-length for a BaO film at different thicknesses and for a BaO single crystal.

BaO films from 2×10^{-5} cm to 4×10^{-5} cm thick were evaporated from a coated platinum filament onto a quartz plate. Evaporation and subsequent measurements were carried out in the same vacuum system. The filament was initially coated with c.p. $BaCO_3$ in nitrocellulose and amyl acetate. This was converted to BaO and outgassed before the quartz plate was moved into position to receive the film. After the absorption measurements were completed, the quartz plate was removed from the vacuum and the film was weighed as $Ba(OH)_2$. The thickness of the original film was then obtained by assuming a density of 5.7 for BaO. Film thicknesses for intermediate evaporation times were obtained by using the absorption data to interpolate between zero thickness and final thickness. Film thickness was nearly proportional to evaporation time for all films studied. The transmission of the film was measured by moving the quartz plate so that the light beam passed through the quartz alone and then through quartz plus the BaO film. A Hanovia hydrogen discharge tube and a Bausch & Lomb quartz ultraviolet monochromator provided fairly continuous monochromatic radiation in the spectral region from 4000A to 2000A. At several wave-lengths, a high pressure Hg arc was used to study the effect of changing light intensity on the absorption constant. The detector used was an RCA 1P28 photo-multiplier tube.

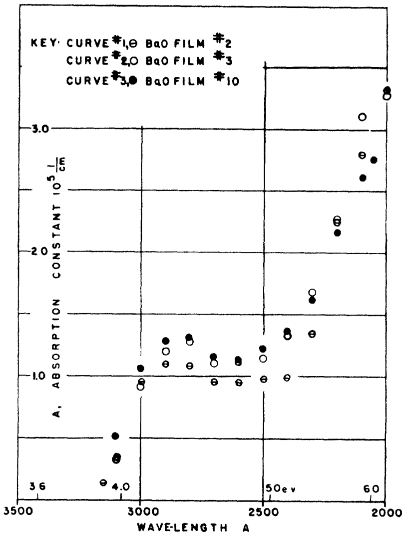

FIG. 2. Absorption constant as a function of wave-length for three different BaO films.

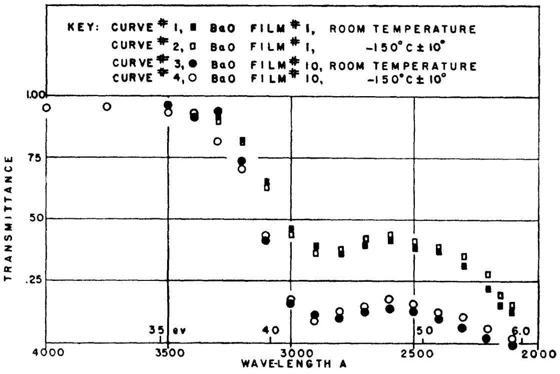

FIG. 3. Transmittance as a function of wave-length for two BaO films showing temperature dependence.

Curves 1, 2, and 3 of Fig. 1 show the transmittance of a BaO film as a function of wave-length for three different thicknesses. The crossing over of transmission curves in the region from 3200A to 4000A as the film is built up has been observed in all of the films studied and is probably due to interference effects. Curve 4 of Fig. 1 shows the transmittance of a 0.37-mm single crystal of BaO. The agreement between transmission data for evaporated films and single crystals indicates that the BaO film is deposited in the form of small crystals of the same form as the larger single crystals studied. Figure 2 shows the absorption constant A as a function of wave-length for three different films. A is defined by the expression $T=\exp(-Ax)$ where T is the transmittance and x the thickness of the film. A has been calculated from the transmission curves without correcting for reflection and interference effects. Figure 3 shows the effect of film temperature on absorption for two different films.

These studies of BaO films confirm the fact that the optical absorption threshold coincides with the threshold for photoconductivity[1] at about 3.8 ev. The magnitude of the absorption constant is so large that the absorption process cannot be attributed to impurity centers in the crystal lattice. Temperature variation of the absorption constant from room temperature down to about −150°C is small but appears to indicate a slight accenting of the structure in the absorption constant curve near 2900A. The absorption constant does not change appreciably for variation of light intensity by a factor of 20.

The author is indebted to Professor Robert L. Sproull, who directed the research, and to Dr. Arnold R. Moore for valuable discussions. The work has been assisted by the ONR and the Research Corporation.

---

* Charles A. Coffin Fellow, 1948–49.

[1] W. W. Tyler, Phys. Rev. **76**, 179 (1949).

Beta-Spectrum of Praeseodymium 143

L. Feldman, L. Lidofsky, P. Macklin, and C. S. Wu
Pupin Physics Laboratories, Columbia University, New York, New York
November 7, 1949

PRAESEODYMIUM 143, a radioactive daughter substance of Ce^{143} which has a half-life of 33 hr., can be produced either by ordinary nuclear reactions,[1] such as $Ce^{142}(d, p)Ce^{143}$ and $Ce^{142}(n, \gamma)Ce^{143}$, or by nuclear fission process. Pr^{143} emits beta-particles with half-life determinations varying from 12.7 to 14.2 days,[1] and it does not emit gamma-rays. The beta-spectrum end point, investigated by means of aluminum absorption methods and estimated by Feather's empirical method, has been reported in the range between 0.83 and 1.0 Mev.[1] Recent spectrometer measurements[2] with sources containing a mixture of Ce^{141} and Pr^{143} yield straight line Fermi plots of the beta-spectrum from 565 kev, the end point of the Ce^{141} spectrum, to the end point of the Pr^{143} spectrum. The upper limit to the energy of the Pr^{143} spectrum is reported as 920±10 kev by Ter-Pogossian *et al.* and as 930±20 kev by Shepherd.[2]

Recently, a strong source of Pr^{143} of very high specific activity was obtained from the Isotopes Branch of the AEC at Oak Ridge in the form of a PrCl solution. This high specific activity material is suitable for beta-spectrum investigation in a beta-ray spectrometer. The Pr^{143} source was prepared by depositing, on a collodion film of 10 $\mu g/cm^2$ thickness, a drop of PrCl solution to which an extremely small quantity of detergent (Anotrox X) had been added. The total amount of solid contained in the source is around 20 μg and is spread over a circular area of 0.5 cm^2.

The Columbia solenoid magnetic spectrometer was used in this investigation. The resolution used was three percent defined as the full width at half-intensity. Both Nylon and collodion window counters were used to cover the upper and lower energy range of the spectrum. In plotting the Fermi plot, the explicit form[3] of the relativistic Coulomb factor

$$F(Z, \epsilon) \approx \frac{2\pi 8}{1-\rho^{-2\pi 8}} [\epsilon^2(1+4\gamma^2)-1]^S,$$

where $S=(1-\gamma^2)^{\frac{1}{2}}-1$, $\gamma = Z\alpha = Z/137$, $\delta = \gamma(\epsilon/\eta)$ was used.

This approximation is accurate to about 0.5 percent in this case. The Fermi plot thus obtained gives a straight line from the upper energy limit down to 170 kev (Fig. 1). Below 170 kev, the Fermi plot starts to deviate upward very gradually, which could be attributed to local variations in source thickness due to non-uniformity. The upper energy limit given by the intercept of the straight line in the Fermi plot is 932±2 kev. This spectrum was investigated in the spectrometer many times, using sources from two different shipments. The results were reproducible and consistent.

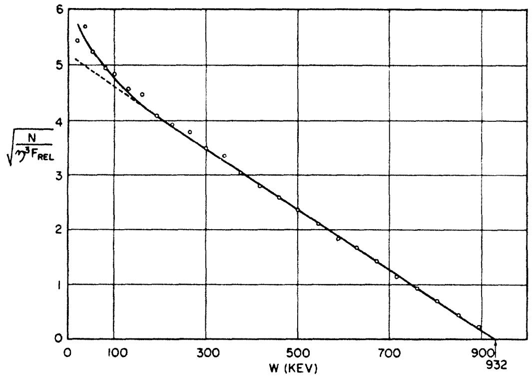

FIG. 1. Fermi plot of Pr^{143} beta-spectrum.

Other Pr^{143} sources were made from the same solutions, and the half-life was continuously followed in a G-M counter over a period of ten weeks. The decay curve (Fig. 2) is definitely a straight line on a semilogarithmic plot and gives a value of 13.7±0.1 days for the half-life.

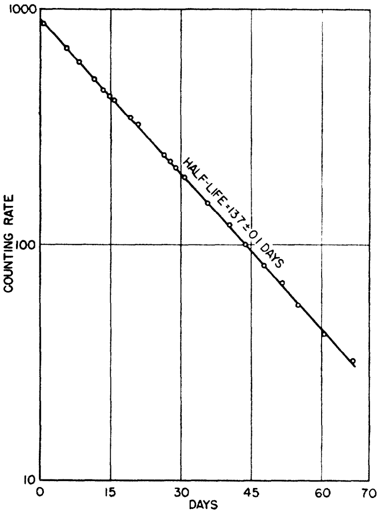

FIG. 2. Decay curve of Pr^{143}.

The *ft* value calculated is 1.3×10^7. For such a high atomic number ($Z=59$), the beta-radiation from Pr^{143} should be classified empirically into the group of first- or second-forbidden transitions. Nevertheless, the shape of the spectrum follows the allowed shape as in the many other cases where the *ft* value indicates a highly forbidden transition.

We should like to thank the United States AEC which aided materially in the performance of this research.

---

[1] G. T. Seaborg and I. Perlman, Rev. Mod. Phys. **20**, 622 (1948); C. E. Mandeville and E. Shapiro, Phys. Rev. **75**, 1834 (1949).

[2] L. R. Shepherd, Research **1**, 67 (1948); Ter-Pogossian, Cook, Goddard, and Robinson, Phys. Rev. **76**, 909 (1949).

[3] H. Bethe and R. F. Bacher, Rev. Mod. Phys. **8**, 194 (1936).

The Beta-Spectrum of ${}_{61}Pm^{147}$

L. Lidofsky, P. Macklin, and C. S. Wu
Pupin Physics Laboratories, Columbia University, New York, New York
November 7, 1949

HIGH specific activity Pm^{147} has recently become available from the Isotopes Division of the AEC at Oak Ridge where it is made as a fission product. This high specific activity material, when used in the high transmission solenoidal focusing β-ray spectrometer, makes it possible to investigate its beta-spectrum using sources less than 30 $\mu g/cm^2$ thick.