

Estimates have been made of the mobility of carriers in microcrystalline selenium with carrier densities based on the capacity of rectifiers. In view of the failure of rectifier theory to explain the observed results in selenium rectifiers and the demonstration of the presence of selenides at the intersurfaces of such rectifiers,² the results are considered unreliable. The existence of grain boundary resistance in the case of microcrystalline selenium can readily explain the large difference in mobilities of such samples and single crystals.

* This work was done under Naval Contract NObstr 42487.

¹ H. W. Henkels, *Phys. Rev.* **76**, 1737 (1949).

² H. W. Henkels, *Proc. Nat. Electronics Conf.* **5** (1949).

Production of C¹⁵

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January 19, 1950

THE bombardment of C¹⁴ with deuterons has been shown to yield d,n and d,α reactions, both of which were recently reported.¹ We have utilized the larger generator of the Carnegie Institution of Washington to make bombardments with deuterons of energy up to 2.8 Mev in order to look for the C¹⁴(d,p)C¹⁵ reaction. The mass estimated for C¹⁵ is² 15.0165, which would indicate that this reaction would have a Q -value of about -2 Mev.

A target of BaCO₃ (containing about 40 percent C¹⁴), of weight about 400 $\mu\text{g}/\text{cm}^2$, was used in our bombardments.³ A preliminary check showed that, when bombarding with deuterons of 2.4-Mev energy, a beta-emitter of half-life much greater than that of B¹² was also formed. We were able to measure the half-life by simply following the activity of the target with a stop-watch; counts were recorded after the bombarding beam had been shut off for varying lengths of time. The results of these observations are shown in Fig. 1, where the data for three separate runs have been combined and averaged. All of the sets of data indicated a half-life of 2.4 seconds, with an estimated error of about 0.3 second. Some scatter in the points is probably caused by non-uniformity of the target and slight variations in bombarding current.

When it was established that the half-life is so much greater than that of B¹² (formed in the competing (d,α) reaction) it was

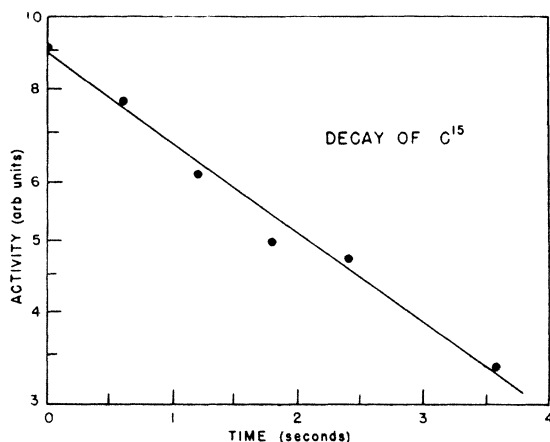


FIG. 1. Activity of C¹⁵ as measured by counting of beta-rays emitted at various times following deuteron bombardment of C¹⁴.

possible to make absorption measurements on the beta-rays from C¹⁵ decay—again by taking observations directly after bombardment was stopped. It was found that the extrapolated end point of the beta-ray spectrum corresponds to 4.6 g/cm² of aluminum absorber; this would indicate a beta-ray energy of 8.8 Mev, with a tentatively estimated error of about 0.5 Mev. This value of the energy, together with the half-life measurement, indicates that the postulated C¹⁵—N¹⁵ decay is a first-forbidden transition.

We have also obtained a rough excitation curve; it rises smoothly with increasing energy of deuterons in the region from 1.4 to 2.8 Mev, except for some indication of a resonance at about 1.9 Mev. This, however, must be confirmed.

The calculated mass of C¹⁵, based on the beta-ray data, is 15.01434, which makes the Q -value for C¹⁴(d,p)C¹⁵ only slightly negative. However, decay of C¹⁵ may not be to the ground state of N¹⁵, which would alter this mass value as calculated. Indeed, we have some evidence for delayed gamma-emission.

Bombardment of normal BaCO₃ was also made, and no beta-emitter of appreciable intensity and of half-life comparable to 2.4 seconds was observed.

More complete details of this investigation will be published in the near future.

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† Assisted by the Joint Program of the ONR and AEC.

¹ E. L. Hudspeth and C. P. Swann, *Bull. Am. Phys. Soc.* **25**, No. 1, 32 (1950), New York Meeting.

² H. A. Bethe, *Elementary Nuclear Theory* (John Wiley and Sons, Inc., New York, 1947).

³ Target material was obtained from Oak Ridge; the estimated value of enrichment was supplied by L. D. Norris (private communication).

Dependence of the F¹⁹ Nuclear Resonance Position on Chemical Compound*

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January 9, 1950

MOST unexpectedly, it has been found that for F¹⁹ the value of the applied magnetic field H_0 for nuclear magnetic resonance at a fixed radiofrequency depends on the chemical compound containing the fluorine nucleus. The assumption has generally been made that the time average of all internal magnetic fields is zero, excluding of course the small diamagnetic field at the nucleus due to the Larmor precession of its atomic electrons in H_0 . Nuclear resonance shifts in metals,¹ interpreted as being due to the conduction electrons, are larger by about an order of magnitude than those reported here.²

To investigate the effect in fluorine, two identical magnetic resonance absorption bridges,³ both fed by the same oscillator, were employed. The two sample holders were placed side by side in the magnet so that the F¹⁹ resonance traces occurred simultaneously on separate recording milliammeters. This "null" method allows a precision of about 0.0005 percent of the applied field in measuring relative shifts of resonance position and has been used by the author in measuring such shifts due to the addition of paramagnetic ions.

The maximum separation of F¹⁹ resonances observed so far is 1.05 gauss (see Fig. 1) for C₂F₃Cl₃ (freon 113) and BeF₂ in a magnetic field $H_0 \approx 7000$ gauss, the freon resonance coming at the lower applied field. Although the resonances in SbF₃ and BeF₂ are separated by 0.99 gauss when observed in separate samples, the separation reduces to 0.82 gauss for a mixture of the two compounds (see Fig. 2). On the other hand, the resonances in SbF₃ and HF are separated by 0.83 gauss in separate samples, but a half and half mixture of the two results in a single resonance located halfway between the positions where the separate resonances would be expected. Increasing the relative amount of SbF₃ shifts

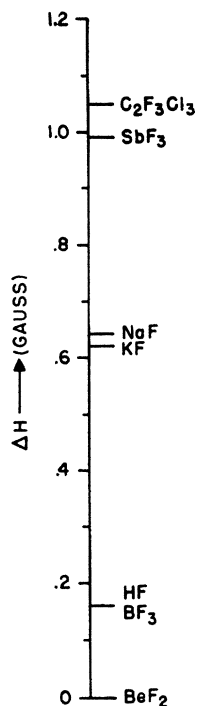


FIG. 1. Dependence of F^{19} nuclear resonance position on chemical compound. $H_0 \approx 7000$ gauss. ΔH represents an aiding field at the nucleus and has arbitrarily been set equal to zero for BeF_2 . All compounds except $C_2F_3Cl_3$ and BF_3 (ether complex) were in aqueous solution.

the single resonance toward the position of the resonance in pure SbF_3 . The observed line widths were about 0.15 gauss in all cases. The F^{19} resonance separations in the chemical compounds listed in Fig. 1 were remeasured at a resonance field of 2500 gauss (10.0 megacycles). Within the experimental error, proportionality of the separations with the applied field was found.

It might be added here that a discrepancy exists between the $F^{19}-H^1$ resonance frequency ratio measurements by Siegbahn and Lindstrom⁴ (using $C_2F_3Cl_3$) and by Poss⁵ (using HF). The magnitude and direction of the relative shift for these two compounds as observed here accounts for this discrepancy but of course the true value of this frequency ratio is now uncertain by at least 0.015 percent.

The internal diamagnetic corrections⁶ H'/H_0 for the neutral fluorine atom and the singly charged negative ion have been

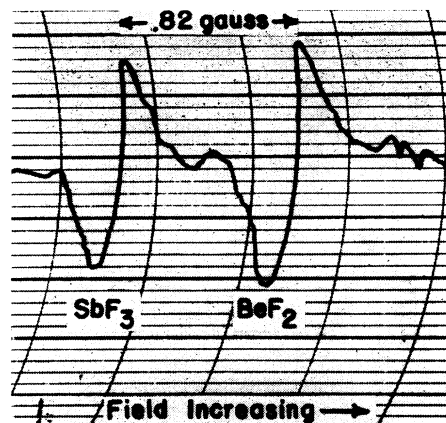


FIG. 2. The nuclear resonances of F^{19} in a single sample containing a half and half mixture of SbF_3 and BeF_2 (saturated aqueous solutions). The applied resonance magnetic field is about 7000 gauss at a radiofrequency of 28.0 megacycles.

calculated by the author using Hartree-Fock wave functions⁷ giving 0.0464 and 0.0472 percent, respectively. Thus for $H_0 = 7000$ gauss the difference between the two diamagnetic fields would be approximately 0.06 gauss. This seems to be the wrong order of magnitude to explain the observed shifts.⁸ Further investigation as to the nature and cause of these shifts is now in progress.

Proton resonances were compared with each other in acetone, mineral oil (Nujol), distilled water, glacial acetic acid, glycerin, and anhydrous ether. No shifts could be detected within the accuracy of the experiment of about 5 parts in 10^6 .

The author wishes to express his thanks to Professor F. Bitter for his advice and guidance during the course of this work.

* This work has been supported in part by the Signal Corps, the Air Materiel Command, and the ONR.

¹ W. D. Knight, *Phys. Rev.* **76**, 1259 (1949).
² In a private communication, Professor F. Bloch reports that W. G. Proctor and F. C. Yu at Stanford University, while recently working with N^{14} , found a similar but even more pronounced dependence of the resonance position on the chemical compound.
³ K. Siegbahn, Purcell, and Pound, *Phys. Rev.* **73**, 679 (1948).
⁴ K. Siegbahn and G. Lindström, *Arkiv. Mat. Astr. o. Fys.* **1**, 6, 193.
⁵ H. Poss, *Phys. Rev.* **75**, 600 (1949).
⁶ W. E. Lamb, Jr., *Phys. Rev.* **60**, 817 (1941).
⁷ F. W. Brown, *Phys. Rev.* **44**, 214 (1933).
⁸ Molecular perturbations of the electrons in the outer electronic shells would be expected to have only a small effect on the value of H'/H_0 since for F^- the entire contribution of the $(2s)^2(2p)^6$ shell to H'/H_0 is only about 30 percent.

Proceedings of the American Physical Society

MINUTES OF THE MEETING AT CHICAGO, NOVEMBER 25 AND 26, 1949

THE 295th meeting of the American Physical Society, being the 1949 Thanksgiving meeting, was held at Chicago in the buildings of the University of Chicago on Friday and Saturday, November 25 and 26, 1949. The Secretary thinks that in number of papers (143 contributed!) this was by far the largest meeting yet held west of Washington, D. C. Since by reason of the Thanksgiving holiday it was cramped into two days, the

number of papers per day fell short of that of our greatest meetings by about a third, whence the unwelcome necessity of scheduling four and even five simultaneous sessions. In number of people in attendance it fell much shorter of our New York and Washington meetings: the number of registrants, somewhat under 500, is supposed to be not far below the number who actually came. Arrangements were very capably handled by the Local

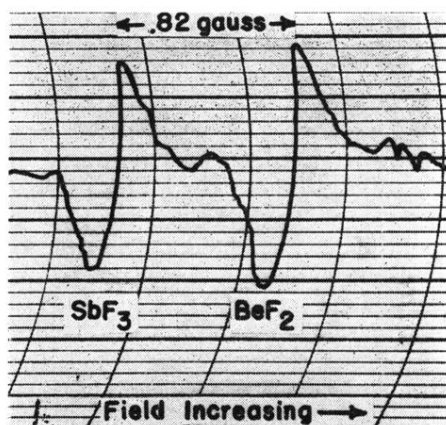


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