

peaks are broadened asymmetrically to lower electron energy. This is more than the symmetrical broadening due to spin-orbit splitting (0.024 eV).

The peaks in the hydrogen photoelectron spectrum (Fig. 3) also show marked asymmetrical broadening in this case to higher electron energy consistent with an increase in dimension on ionization (r_e 1.06 Å ← 0.74 Å).

In the case of hydrogen, however, the thermal velocity effect must give a spread of ~20 mV comparable with that expected from rotational energy.

It can be seen from this that large dimensional changes can be expected to be detected from the "shading" of vibrational bands in molecular photoelectron spectra.

Carbon K shell photoelectron spectra have recently been reported by Axelson *et al.*¹². These were obtained using solid samples so that at least part of the line width noted (~1 eV) can be ascribed to lattice effects.

We may expect to find more detailed fine structure associated with small changes in chemical environment in the case of complex substances if the corresponding molecular photoelectron spectra can be obtained. Extensive vibrational fine structure should be absent since the electrons removed may be essentially "non-bonding". Small differences in electron binding energy (0.1 eV) should in principle be readily detectable and lead to a valuable general method for structural diagnosis.

The development of the deflexion analyser was supported by a grant from the Paul Instrument Fund of the Royal Society and will be described in detail elsewhere.

D. W. TURNER

Organic Chemistry Laboratories,
Imperial College, London.

Received January 20, 1967.

¹ Turner, D. W., and Al-Joboury, M. I., *J. Chem. Phys.*, **37**, 3007 (1962). (Compare Kurbatov, B. L., Vilesov, F. I., and Terenin, A. N., *Sov. Phys. Dokl.*, **6**, 490 (1961); **6**, 883 (1962).)

² Al-Joboury, M. I., Turner, D. W., *J. Chem. Soc.*, 5141 (1963); 4434 (1964).

³ Al-Joboury, M. I., May, D. P., Turner, D. W., *J. Chem. Soc.*, **616**, 6350 (1965).

⁴ Turner, D. W., and May, D. P., *J. Chem. Phys.*, **45**, 471 (1966).

⁵ Schoen, R. I., *J. Chem. Phys.*, **40**, 1830 (1964).

⁶ Comes, F. J., and Saltzer, M. G., *Z. Naturforsch.*, **19A**, 1230 (1964).

⁷ Frost, D. C., McDowell, C. A., Vroom, D. A., *Phys. Rev. Lett.*, **15**, 612 (1965).

⁸ Berkowitz, J., and Erhardt, H., *Phys. Lett.*, **21**, 531 (1966).

⁹ Frost, D. C., Sandhu, J. S., and Vroom, D. A., *Nature*, **212**, 604 (1966).

¹⁰ Watanabe, K., and Inn, E. C. Y., *J. Opt. Soc. Amer.*, **43**, 32 (1953).

¹¹ Klemperer, O., *Rep. Phys. Prog.*, **28**, 77 (1965).

¹² Axelson, G., *et al.*, *Nature*, **213**, 70 (1967).

Antimony-125 Contamination in Antimonial Lead

LEAD containing 4 per cent of antimony (B.S.3909:1965) is commonly used for radiation shielding, and when the objective is the reduction of the background response of high sensitivity counting equipment, it is desirable that no radioactive contamination be present. Examples of contamination by ²¹⁰Pb (ref. 1) and by ^{110m}Ag (ref. 2) have been reported.

We have now confirmed the presence of antimony-125 (half-life 2.78 yr) in newly manufactured antimonial lead. Measurements were made with a sodium iodide (TI) crystal with two different cylindrical lead collimators. The first of these consisted of two parts weighing 15.8 kg and 7.5 kg, which were supplied in 1964 and 1965 respectively. The second was in one piece (21 kg) and was also manufactured in 1965. Gamma-ray spectra of the backgrounds of the crystal with the two collimators are shown in Fig. 1 (curves 1 and 2 respectively); the spectrum of the difference of 98 c.p.m. is also shown (curve 3). The two well defined peaks were identified as being due to the pairs of gamma-rays at about 0.43 MeV and 0.6 MeV respectively, which are characteristic of antimony-125. This inference was confirmed by the use of a standardized source of the radionuclide which was measured between pieces of lead 0.1 in. thick, assembled as a mock-up of part of the collimator. The gamma-ray spectrum obtained is shown in curve 4.

Comparison of the counting-rates in the peaks of curves 3 and 4 led to an estimated antimony-125 concentration

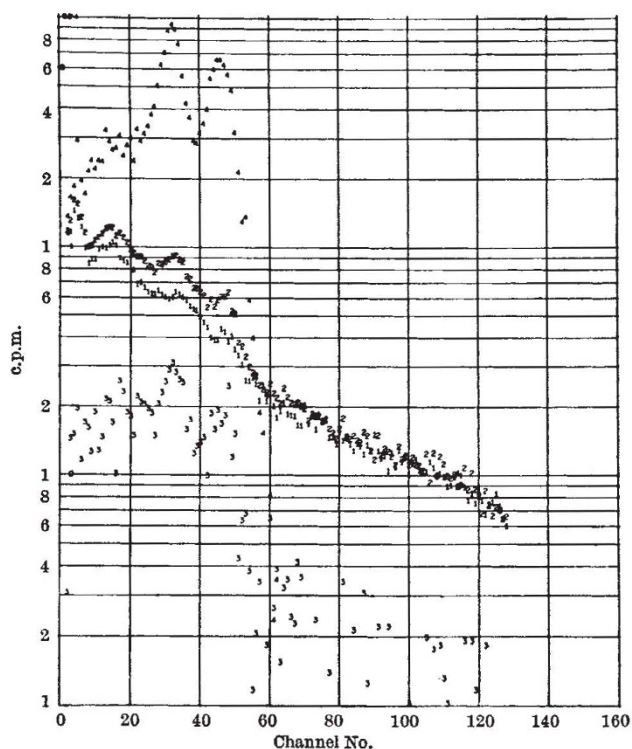


Fig. 1. Computer produced plots of gamma-ray spectra. Curves 1 and 2 are background spectra taken with the two collimators, curve 3 is the difference between them, and curve 4 is the spectrum of 13.6 mc. Sb-125 in a lead mock-up of the lower part of one collimator. The logarithmic counting-rate scale covers the range 10^{-1} – 10^2 c.p.m.

in the 21 kg collimator of $(3.6 \pm 0.2) \times 10^{-14}$ curie/g of lead or $(0.90 \pm 0.05) \times 10^{-12}$ curie/g of antimony. The uncertainties shown are those due only to the statistical errors of counting; there may be a systematic error due to the method of calibration, possibly as much as 50 per cent.

The origin of the contamination is unknown. Neither the manufacturers of the collimators nor their suppliers of antimonial lead used antimony-125 in any of their processes. One possible source might be radioactive fall-out from nuclear test explosions; antimony-125 has been measured at concentrations in the range 0.004–0.06 pc./kg of air, and 2–40 pc./l. of rain in the United Kingdom during 1963–65 (refs. 3 and 4). We could not detect antimony-125 in samples of pure antimony supplied in early 1964, although the levels in air and rain during 1963 were quite similar to those during 1964 (refs. 3 and 4), and we have evidence of antimony-125 in antimonial lead bricks which were received in late 1963.

Antimony-125 in lead shielding for low background gamma-ray spectrometers is considerably more of a nuisance than the naturally radioactive lead-210 found in some samples¹, because of the higher energy radiation emitted. It is also more annoying than ruthenium-103 which has been observed in steel, because of its much longer half-life (2.78 yr compared with 40 days), and somewhat more of a nuisance than ruthenium-106 which has been found in some steels at roughly the same concentration⁵.

J. RUNDO

Health Physics and Medical Division,
Atomic Energy Research Establishment,
Harwell, Berkshire.

Received January 12, 1967.

¹ Weller, R. I., Anderson, E. C., and Barker, J. L., *Nature*, **206**, 1211 (1965).

² Reynolds, E., *Nature*, **210**, 615 (1966).

³ Cambray, R. S., Fisher, F. M. R., Spicer, G. S., Wallace, C. G., and Webber, T. J., Atomic Energy Research Establishment Report AERE-R4687 (H.M.S.O., 1964).

⁴ Cambray, R. S., Fisher, F. M. R., Brooks, W. L., Hughes, A., and Spicer, G. S., Atomic Energy Research Establishment Report AERE-R4997 (H.M.S.O., 1965).

⁵ Anderson, E. C., Dean, P. N., and Rose, M. W., Los Alamos Sci. Lab. Rep. LA-3182-MS, 145 (1964).