LETTERS TO THE EDITORS

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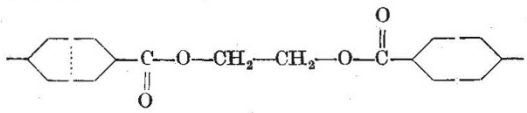
Structure of Terylene

THE recent joint announcement by the Calico Printers' Association and Imperial Chemical Industries, Ltd., of the discovery of a new fibre-forming polymer permits the publication of the following short account of an X-ray investigation carried out on this material in the summer of 1944. The fibres, now known to be terylene, were prepared by Dr. D. V. N. Hardy at the Chemical Research Laboratory, Department of Scientific and Industrial Research, Teddington, and they had been submitted for other examination.

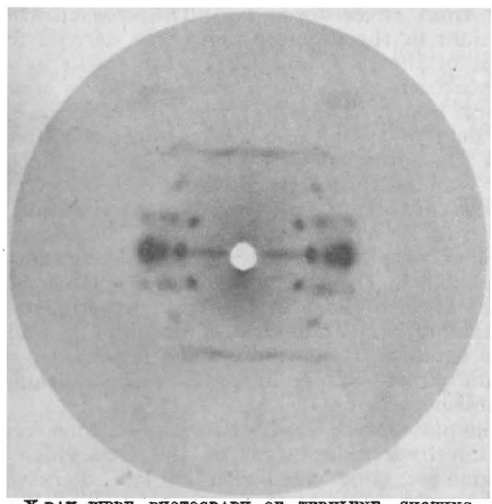
Polyethylene terephthalate (terylene) gives a well-oriented X-ray fibre diagram, and some forty spots have been indexed unequivocally on the basis of a one-molecule triclinic unit cell. The dimensions of this unit cell, taking [c] as the fibre axis, are [a] = $5{\cdot}5_4$ A.; [b] = $4{\cdot}1_4$ A.; [c] = $10{\cdot}8_6$ A.; $\alpha = 107°_{5'}$; $\beta = 112°_{24'}$; $\gamma = 92°_{23'}$. The repeating unit of terylene:



may possess a centre of symmetry, and the space group is probably $P\bar{1}$. The theoretical density required by the above unit cell is 1·47 gm./c.c., but the experimental determination is rendered somewhat uncertain by swelling, etc. Average values of 1·41 gm./c.c. have, however, been obtained by flotation in sodium iodide solutions.

Taking the bond-lengths C–C = 1·54 A., C–O = 1·42 A., C(ring)–C(aliphatic) = 1·48 A., and standard angles, the calculated period along the fibre axis comes to 10·9 A., in agreement with the value [c] = $10{\cdot}8_6$ A. given by the X-ray photographs.

In the usual way, X-ray fibre photographs reveal increasing disorientation simply by a drawing-out of the spots into arcs, but terylene is peculiar in that poorly oriented preparations give photographs like those produced by a single crystal rotating about an axis inclined at a small angle to a principal axis; the spots are displaced to varying extents out of the true layer-lines, and in particular the intense $1\bar{1}0$ reflexion is seen as two overlapping spots, one just above and the other just below the equator. This means that in the drawing process it is somehow more difficult to pull the $(1\bar{1}0)$ planes into parallelism with the fibre axis. The spacing of these planes is 3·38 A., and their intensity is far the strongest in the photograph, which suggests that the terylene chains are approximately flat and lie in the $(1\bar{1}0)$ planes. Presumably then, on drawing out a fibre, the chains or groups of chains are first pulled straight by slipping parallel to the $(1\bar{1}0)$ planes, and afterwards, with more difficulty, these planes themselves are pulled into parallelism.



X-RAY FIBRE PHOTOGRAPH OF TERYLENE, SHOWING CENTRAL PORTION ONLY. THE FIRST THREE SPOTS FROM THE CENTRE ALONG THE EQUATOR ARE 100, 010 AND $1\bar{1}0$

A three-dimensional model, in which the oxygen atoms in neighbouring chains are found to approach to approximately 3·1 A., has been constructed in accordance with the above scheme, and the X-ray intensities calculated from it are in good agreement with those observed. The full details will be published elsewhere.

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Determination of the Upper Limits of the Fission Cross-sections of Lead and Bismuth for Li-D Neutrons by a Chemical Method

THEORETICALLY, fission of elements of atomic number 83 and less is not excluded. The fission thresholds for the compound nuclei formed in neutron capture by lead and bismuth have been estimated as 9·3 MeV. for Bi^{210}, 10·0 for Pb^{207}, 10·4 for Pb^{208} and 10·7 for Pb^{209} [1]. If the neutron-binding energy is 5·4 MeV. for initial nuclei with an even, and 6·4 MeV. with an odd, number of neutrons, 3·9, 4·6, 4·0 and 5·3 MeV. have to be supplied as kinetic neutron energy to Bi^{209}, Pb^{206}, Pb^{207} and Pb^{208} to reach the presumed fission thresholds. We have searched for the fission of lead and bismuth with fast neutrons from the Li-D reaction by looking for any radio-iodine formed. In chemical methods for the measurement of fission-rates, very much larger amounts of material can be used than in fission chambers. On the other hand, chemical methods in a hypothetical process are based on the admittedly uncertain assumption that the element selected would appear as a fission product. We have chosen iodine as it is in the middle of one of the groups of fission products from uranium, and several of its isotopes are produced abundantly with this element. The ease of extraction of iodine was the reason why Libby[2] used it in an experiment to set a limit to the spontaneous fission-rate in uranium.

In separate runs, 7 kgm. lead oxide and 4·5 kgm. bismuth oxide were irradiated for 6½ hours in a tin fitting closely the lithium hydroxide target tube of the Cambridge High Tension set. The current of 900 keV. deuterons was 50 μ amp. After irradiation, the material was dissolved with stirring in nitric acid under a toluene layer containing 500 (lead run) or