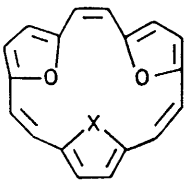
Macrocyclic Unsaturated Sulphur Heterocycles

By T. M. CRESP and M. V. SARGENT*

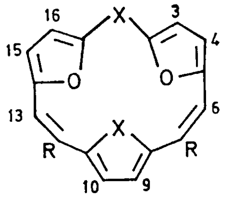
(*Department of Organic Chemistry, University of Western Australia, Nedlands, Western Australia*)

Summary Syntheses of three heteroatom-bridged vinylogues of thiophen containing 17- and 21-membered rings are described.

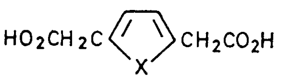
REPLACEMENT of the six internal hydrogen atoms of [18]-annulene[1] by three oxygen bridges (**1**)[2] or by two oxygen and one sulphur bridge (**2**)[3] does not significantly perturb the planarity of the system and both (**1**) and (**2**) are aromatic $(4n + 2)\pi$ electron systems which sustain diamagnetic ring currents. Insertion of a ketone group in place of one double bond in (**1**) leads to a planar [17]annulenone (**3**)[4] which supports a paramagnetic ring current. Similar substitution of a sulphur atom should lead to compounds which are related to their parent annulenes as is thiophen to benzene. It was thus of interest to synthesise these macrocycles and to determine their properties since the highest known vinylogues of furan, thiophen, and pyrrole, other than benzo-annelated derivatives,[5] contain only nine-membered rings.[6]



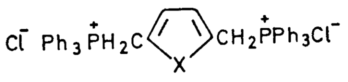
(1) X = O
(2) X = S



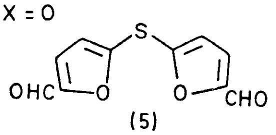
(3) X = CO; Y = O; R = H
(6) X = Y = S; R = CO_2Me
(7) X = Y = S; R = H
(9) X = S; Y = O; R = H
(11) X = S; Y = O; R = CO_2Me



(4) X = S
(10) X = O



(8) X = S
(12) X = O



(5)

Perkin-type condensation of the thiophen (**4**)[7] with the dialdehyde (**5**)[8] gave, after esterification and chromatography of the crude product, the ester (**6**) as brick-red prisms, m.p. 193—195°. On hydrolysis and decarboxylation this afforded the dioxide-sulphide (**7**) (4·3%). A more convenient synthesis of this macrocycle (18·7% yield) was by Wittig reaction between the dialdehyde (**5**) and the bis(phosphonium chloride) (**8**). The macrocycle (**7**) formed orange blades, m.p. 81—83°; τ (all $CDCl_3$, all 60 MHz) 3·22 (s, 2H, 9-, 10-H), 3·37, 4·02 (ABq, 4H, J 3·5 Hz, 3-, 4-,15-, 16-H), and 3·47, 4·04 (ABq, 4H, J 12 Hz, 6-, 7-, 12-, 13-H); λ_{max} (all ether) 266, 287, and 418 nm (ϵ 25,200, 25,600, and 2700 respectively). The n.m.r. spectrum† clearly indicates that the molecule does not support a diamagnetic ring current, and examination of Stuart–Briegleb models suggested that the size of the thiophen sulphur atom may interfere with the planarity of the system. When the thiophen was replaced by a furan examination of models suggested that the trioxide (**9**) would be planar.‡

Condensation of the dialdehyde (**5**) with the diacetic acid (**10**),[9] followed by esterification and chromatography, gave the methyl ester (**11**) as yellow prisms, m.p. 205—206° (29%). Decarboxylation of the derived dicarboxylic aicd gave only traces of the desired macrocycle (**9**) which was subsequently prepared in 10·1% yield by Wittig reaction between the dialdehyde (**5**) and the furan (**12**).[10] The trioxide (**9**) formed orange prisms, m.p. 97—99°; τ 3·33, 3·95 (ABq, 4H, J 3·5 Hz, 3,- 4-, 15-, 16-H), 3·52 (s, 2H, 9-, 10-H), and 3·99(s, 4H, 6-, 7-, 12-, 13-H); λ_{max} 253, 296sh, 305, and 417 nm (ϵ 19,600, 30,000, 35,500, and 6000 respectively). The chemical shift of the protons of this system are similar to those of the macrocycle (**7**), and (**9**) does not support a diamagnetic ring current. In view of the aro-

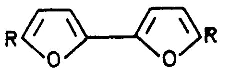
---

† The chemical shifts of the furan protons are similar to those in linear model systems (these will be published later). The olefinic proton signals of *cis*-2,2′-vinylenedifuran are at τ 3·88 (see A. A. Zimmerman, C. M. Orlando, jun., and M. H. Gianni, *J. Org. Chem.*, 1969, **34**, 73).

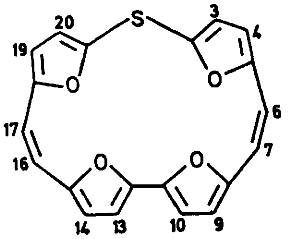
‡ The oxygen atoms of compound (**9**) appeared to be less crowded than those of the planar conformation of [18]annulene trioxide (**1**).

maticity of the closely related [18]annulene trioxide (**1**) we assume that the sum of the delocalisation energy of three isolated furan rings is greater than that obtained by 18π-electron peripheral delocalisation involving sulphur lone-pair participation.

We have also synthesised a thiaheneicosin. Reduction of the ester (**13**)[11] with $LiAlH_4$ in tetrahydrofuran afforded



(13) R = CO_2Bu
(14) R = CH_2OH
(15) R = $CH_2\overset{+}{P}Ph_3\ Br^-$



(16)

the alcohol (**14**) which on treatment with triphenylphosphonium bromide[12] in acetonitrile at 25° for 5 days yielded the bis(phosphonium bromide) (**15**) (22%). Wittig reaction of (**15**) and the dialdehyde (**5**) yielded the tetraoxide (**16**) (1·3%) as long orange needles, m.p. 170—171°; τ 3·48, 3·70 (ABq, 4H, J 3·5 Hz, furan H), 3·48, 3·88 (ABq, 4H, J 3·5 Hz, furan H), and 4·13, 4·19 (ABq, 4H, J 12 Hz, olefinic H); λ_{max} 282, 293sh, 322, and 460 nm (ϵ 44,500, 41,100, 43,000, and 2600 respectively. Again comparison of the chemical shifts of the protons of compound (**16**) with linear systems† suggests that there is no diamagnetic ring current. Although Stuart–Briegleb models indicate that this system could adopt a planar conformation as yet no suitable cyclic model compounds exist to assess the possible planarity of the system.

(*Received, September 20th,* 1971; *Com.* 1643.)

---

[1] F. Sondheimer, I. C. Calder, J. A. Elix, P. J. Garratt, K. Grohmann, G. di Maio, J. Mayer, M. V. Sargent and R. Wolovsky, *Chem. Soc. Special Publ.* No. 21, Chemical Society, London, 1967.

[2] G. M. Badger, J. A. Elix, and G. E. Lewis, *Austral. J. Chem.*, 1966, **19**, 1221.

[3] G. M. Badger, G. E. Lewis, and U. P. Singh, *Austral. J. Chem.*, 1966, **19**, 1461.

[4] T. M. Cresp and M. V. Sargent, preceeding communication.

[5] A. B. Holmes and F. Sondheimer, *J. Amer. Chem. Soc.*, 1970, **92**, 5284.

[6] A. G. Anastassiou and R. P. Cellura, *Chem. Comm.*, 1969, 903, 1521; A. G. Anastassiou and J. H. Gebrian, *J. Amer. Chem. Soc.*, 1969, **91**, 4011; *Tetrahedron Letters*, 1970, 825; S. Masamune, S. Takada, and R. T. Seidner, *J. Amer. Chem. Soc.*, 1969, **91**, 7769; S. Masamune, K. Hojo, S. Takada, *Chem. Comm.*, 1969, 1204; P. J. Garratt, A. B. Holmes, F. Sondheimer, and K. P. C. Vollhardt, *J. Amer. Chem. Soc.*, 1970, **92**, 4492.

[7] G. M. Badger, J. A. Elix, and G. E. Lewis, *Austral. J. Chem.*, 1965, **18**, 70.

[8] Z. N. Nazarova and Y. A. Babaev, *Zhur. obshchei Khim.*, 1964, **34**, 4010.

[9] K. Y. Novitskii, K. Y. Yurev, and V. N. Zhingareva, *Zhur. obshchei Khim.*, 1962, **32**, 3303.

[10] H. Saikachi, H. Ogawa, Y. Minami, and K. Sato, *Chem. and Pharm. Bull.* (*Japan*), 1970, **18**, 465.

[11] See R. Grigg, J. A. Knight, and M. V. Sargent, *J. Chem. Soc.* (*C*), 1966, 976. The known methyl ester, which was insufficiently soluble for efficient reduction, was converted into the butyl ester.

[12] J. D. Surmatis and A. Ofner, *J. Org. Chem.*, 1963, **28**, 2735.