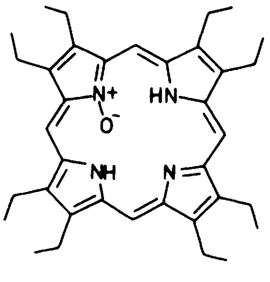
Porphyrin *N*-Oxides

By Raymond Bonnett* and Richard J. Ridge
(*Chemistry Department, Queen Mary College, Mile End Road, London* E1 4NS)
and Evan H. Appelman
(*Chemistry Division, Argonne National Laboratory, Argonne, Illinois* 60439)

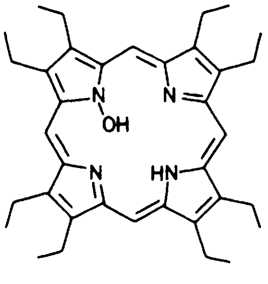
Summary Hypofluorous acid reacts with octaethylporphyrin to give octaethylporphyrin *N*-oxide, the first porphyrin *N*-oxide to be described; a possible biological role for metal complexes of porphyrin *N*-oxides is suggested.

Hypofluorous acid[1] (and, less effectively, peroxyacids such as peroxyacetic acid) reacts with octaethylporphyrin in chloroform to give (in *ca.* 64% yield) a polar brown crystalline compound, $C_{36}H_{46}N_4O$ (total elemental analysis and accurate molecular ion), which is formulated as a porphyrin *N*-oxide (**1**), apparently a previously unknown system. A second even more polar product is formed in this reaction, and is possibly the *NN'*-dioxide, since on heating it gives a mixture of (**1**) and octaethylporphyrin (see below).

The evidence which leads to the formulation of (**1**) is as follows. The electronic spectrum ($CHCl_3$) shows a broad Soret band at 395 nm (ε 106,000) with broad structured absorption in the visible with a maximum at 528 nm (ε 8500). This does not correspond to the known products of *meso*-attack (octaethyloxophlorin)[2] or of β-attack followed by rearrangement (the isomeric 2-oxochlorin).[2] Benzylic attack would be expected to give an etio type spectrum [for 2-(1-hydroxyethyl)] or a rhodo type spectrum (for 2-acetyl) so these structures are also unlikely. Although the 2,3-oxide formulation appears attractive a substance of this structure would be expected to have a spectrum of the chlorin type[3] and to give the oxochlorin on treatment with sulphuric acid, which was not observed.



(1)



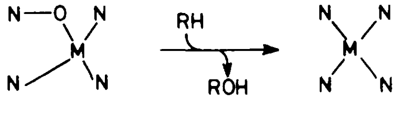
(2)

The strong Soret absorption suggests macrocyclic conjugation (thus arguing against *e.g.* a 4,5-epoxide structure), and this is confirmed by the n.m.r. spectrum where two singlets (each 2H) are observed at low field (δ 9·78 and 9·96 in $CDCl_3$); the signals from one pair of ethyl groups are shifted to high field. The n.m.r. spectrum accords with the *N*-oxide structure (**1**).

The *N*-oxide (**1**) loses the oxygen atom rather readily (*e.g.* on repeated chromatography on silica gel; on heating).

Mass spectrometry (147 °C) gives a molecular ion at 550 (60%) but the peak at 534 (octaethylporphyrin) is the base peak. Oxygen transfer to phosphorus trichloride gives octaethylporphyrin (t.l.c., m.s.) in 61% yield. Deoxygenation also occurs with sodium dithionite. On refluxing (**1**) with HCl–$CHCl_3$ the products are octaethylporphyrin and 5-chloro-octaethylporphyrin. Evidently the *N*-oxide (**1**) is a much more reactive oxidant than (say) pyridine *N*-oxide.

The presence of the tautomeric hydroxylamine (**2**) is possible, and awaits investigation, as does the potential of (**1**)–(**2**) as a ligand. An interesting possibility arises here in that metal complexes (**3**) may be capable of existence (*cf.* the analogous complexes with a methylene group inserted in the metal–nitrogen bond).[4] However, the 'normal' square-planar co-ordination (**4**) is likely to be much more stable thermodynamically. A complex of structure (**3**) could conceivably play some part in the interaction of natural metalloporphyrin complexes with oxygen: in particular (**3**) might be expected to insert oxygen into appropriate substrates (RH). Such a reaction would be of interest in relation to the mechanism of action of cytochrome P_{450} and is being explored.



(3) (4)

We thank Dr. B. Mateen for preliminary experiments, and the British Council, the Medical Research Council, and the Division of Basic Energy Sciences of the U.S. Department of Energy for support.

(*Received, 27th January* 1978; *Com.* 088.)

---

[1] E. H. Appelman, R. Bonnett, and B. Mateen, *Tetrahedron*, 1977, **33**, 2119, and references therein.

[2] R. Bonnett, M. J. Dimsdale, and G. F. Stephenson, *J. Chem. Soc.* (*C*), 1969, 564.

[3] R. Grigg, A. W. Johnson, K. Richardson, and K. W. Shelton, *J. Chem. Soc.* (*C*), 1969, 655.

[4] A. W. Johnson, D. Ward, P. Batten, A. J. Hamilton, G. Shelton, and C. M. Elson, *J.C.S. Perkin I*, 1975, 2076.