Novel Heterocyclic Systems from Selective Oxidation at the β-Pyrrolic Position of Porphyrins

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Novel heterocyclic systems in which a porphyrin pyrrole has been ring-expanded to a morpholine derivative (**5**), ring-contracted to an azetine derivative (**6**), and converted into the oxazolone derivatives (**4**) and (**9**) result from selective oxidation of 2-amino-5,10,15,20-tetraphenylporphyrin (**1**).

Previously, few methods have been developed for the introduction of oxygen functionality into the β-pyrrolic position of a porphyrin,[1—3] and none which allowed selective modification or removal of a pyrrole ring while keeping the macrocyclic ring intact. We report here some novel porphyrin chemistry leading to new heterocyclic systems which resulted from oxidation of 2-amino-5,10,15,20-tetraphenylporphyrin (**1**).

Photo-oxidation of a 0.07 M solution of (**1**)[4] in dry CH_2Cl_2 afforded the 17-imino-18-oxochlorin (**2**)† (66%) [ν_{max} (KBr): 1718, 1630 cm^{-1}] (Scheme 1). Hydrolysis of (**2**) occurred readily on silica gel to give the 17,18-dioxochlorin (**3**) (quantitative) (1722 cm^{-1}). The vicinal-disubstitution in (**3**) was apparent from the C_{2v} symmetry inherent in the ^1H and

† All new compounds have been fully characterized by analytical and spectroscopic means.

^{13}C n.m.r. spectra and was proved by the subsequent chemistry. The structures of (**2**) and (**3**) can also be written in tautomeric forms. The extent to which such tautomers contribute to the overall ground state composition of these compounds is under investigation.

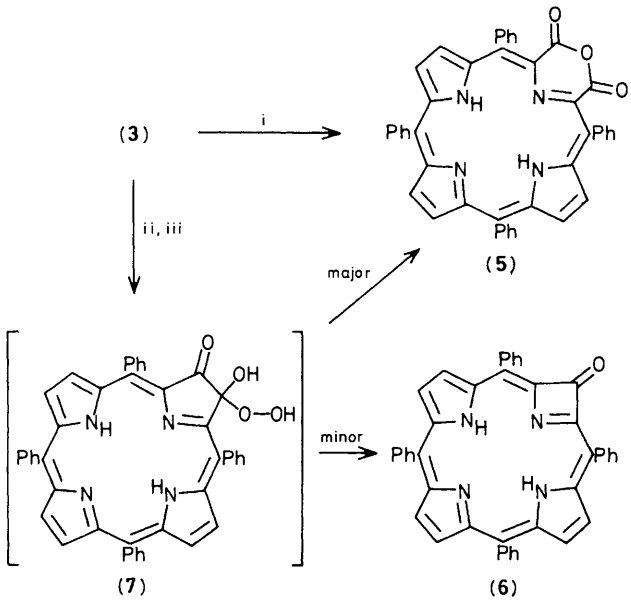
Treatment of (**1**) with *m*-chloroperbenzoic acid (MCPBA) (3 equiv.) gave the novel 18-oxo-17-oxachlorin (**4**) (55%) [1760 cm^{-1}; λ_{max} (log ε) ($CHCl_3$): 423(5.43), 525(4.07), 562(4.09), 592(3.87), 643 nm(3.49); *m/z* 632(100%)] and no dione (**3**). Treatment of the keto-imine (**2**) with MCPBA (1 equiv.) also gave (**4**) (55%); by comparison similar treatment of the dione (**3**) gave only a trace of (**4**). These observations suggested that the formation of (**4**) may have proceeded *via* the intermediacy of (**2**). Epoxidation of the imine[5] at this stage and rearrangement of the resultant α-keto-oxazirane in the extradiol sense followed by hydrolysis of the imino group and loss of CO from the α-ketolactone portion of the molecule would provide (**4**). An analogous process occurred in the oxidation of *o*-benzoquinones with potassium peroxomonosulphate to yield 2*H*-pyran-2-ones.[6]

The major product obtained from the treatment of (**3**) with MCPBA was the 17,18a-dioxo-18a-homo-17-oxachlorin (**5**) (64%) [1785, 1742 cm^{-1}; *m/z* 660(100%); C_{2v} symmetry from n.m.r. spectra] (Scheme 2). This anhydride is the expected product from Baeyer–Villiger oxidation of an α-dione. It was found that (**5**) could be obtained in better yield by treatment of (**3**) for 16 h with excess of NaH in CH_2Cl_2 exposed to air. This resulted in a precipitate which on treatment with 3 M aqueous hydrochloric acid gave (**5**) (80%) and a less polar green compound (**6**) (4%) [1780 cm^{-1}; *m/z* 616(100%); C_{2v} symmetry from n.m.r. spectra] with a contracted ring system.

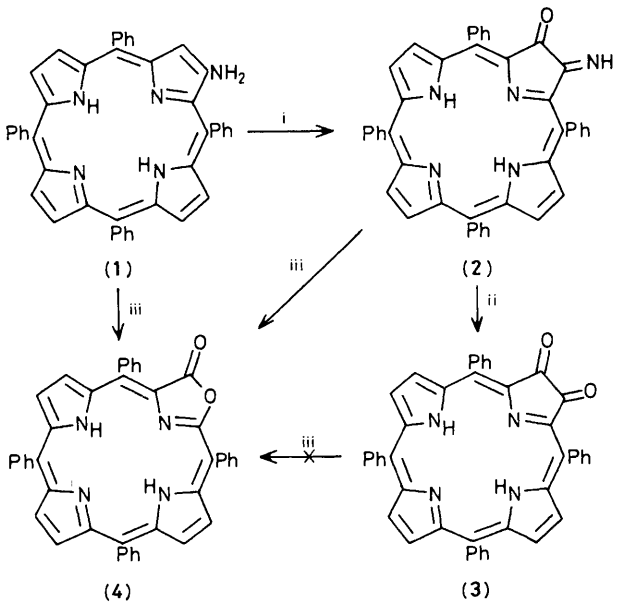
A plausible mechanism which accounts for the formation of (**5**) and (**6**) involves the intermediacy of a 18-hydroperoxy-18-hydroxy-17-oxochlorin (**7**) (Scheme 2). Baeyer–Villiger type rearrangement of (**7**) would afford (**5**), while a benzil–benzilic acid like rearrangement would afford an α-hydroxyperacid which would be expected to decompose to (**6**).

Attempts to degrade (**5**) to the seco system (**8**) (Scheme 3) by hydrolytic ring-opening followed by decarboxylation have not yet been successful. While the morpholine ring of (**5**) is readily opened by base, the resultant diacid derivatives rapidly close to oxazolones. Methanolysis of (**5**) in pyridine afforded the non-aromatic macrocycle (**9**) (70%), m.p. 230—231 °C [1796, 1741 cm^{-1}; *m/z* 692(6%), 632(100); δ 3.89 (s, 3H, OMe), 4.64 (s, 1H), 13.45 (br. s, 1H, NH), and 14.55 (br. s, 1H, NH)], which gave (**4**) (40%) on treatment with boiling quinoline–H_2O (98:2) presumably *via* successive ester hydrolysis, decarboxylation, and aerial oxidation processes. Direct hydrolysis of (**5**) with NaOH–H_2O–dimethylformamide (DMF) gave (**4**) (94%).

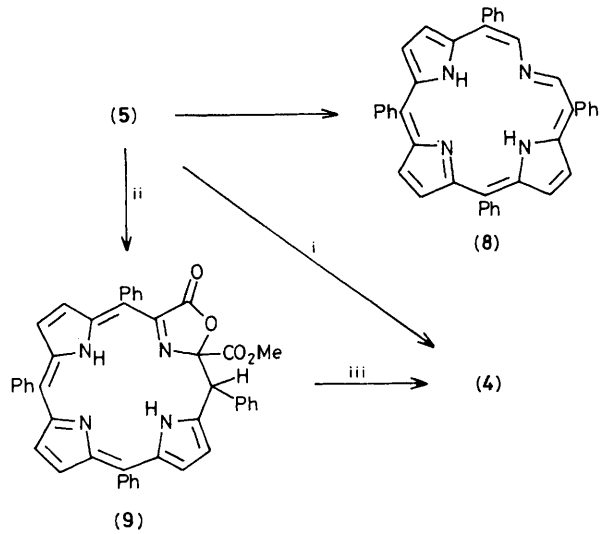
The ease with which oxidative reactions occur at porphyrin β-pyrrolic positions is evidently associated with the fact that aromaticity in the resultant novel heterocyclic systems is generally maintained through a chlorin-like electron delocalization pathway. In this sense the oxidative chemistry at the β-pyrrolic positions parallels the ease of reduction of porphyrins to chlorins.[7]



Scheme 2. i, MCPBA; ii, NaH, O_2, CH_2Cl_2; iii, 3 M aq. HCl.



Scheme 1. i, *hν*, O_2; ii, H^+/H_2O or silica gel; iii, MCPBA.



Scheme 3. i, NaOH, H_2O, DMF; ii, MeOH, pyridine; iii, quinoline–H_2O (98:2), reflux.

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