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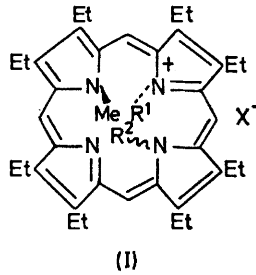
# *N*-Methylation of Octaethylporphyrin and Octaethylchlorin

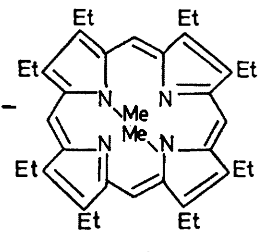
By R. Grigg* and A. Sweeney
(*University of Nottingham, Nottingham* NG7 2RD)
G. R. Dearden and A. H. Jackson
(*University College, Cardiff* CF1 1XL)
and A. W. Johnson
(*University of Sussex, Brighton* BN1 9QJ)

*Summary* Methyl fluorosulphonate *N*-methylates octaethylporphyrin and octaethylchlorin to give, depending upon the reaction conditions, *N*-methyloctaethylporphyrin, two *NN'*-dimethylporphins, *NN'N''*-trimethyloctaethylporphin, and an *N*-methyloctaethylchlorin.

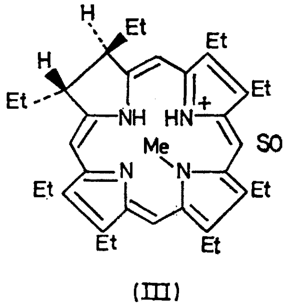
We have previously shown that methylation of octaethylporphyrin with methyl iodide gives both the *N*-methyl- and the *NN'*-dimethyl-porphin (I; $R^1$ = Me, $R^2$ = H, X = I).[1,2] Methylation with methyl fluorosulphonate,[3] in the cold, gave the same two products, *N*-methyloctaethylporphyrin (22%), m.p. 225—227°, and the *NN'*-dimethylporphin (I; $R^1$ = Me, $R^2$ = H, X = $SO_3F$; 28%), m.p. 198—199°. However, when the methylation was carried out in boiling chloroform, as well as some *N*-methylporphin (24%), a new *NN'*-dimethylporphin (35%) was obtained, m.p. >300°, $\lambda_{max}$ ($CHCl_3$) 308, 402, 542, 593, 621, and 647 nm; $\epsilon$, 26,390, 131,700, 15,120, 14,590, 6740, and 7380, respectively. The *N*-methyl groups of the new *NN'*-dimethylporphin appeared as a singlet (6H) at $\tau$ 13·6 in the n.m.r. spectrum ($CDCl_3$) and the *meso*-protons also gave rise to a singlet (4H) at $\tau$ 0·15† indicating the product was the AC *NN'*-dimethylporphin (I; $R^1$ = H, $R^2$ = Me, X = $SO_3F$). The AB isomer (I; $R^1$ = Me, $R^2$ = H, X = $SO_3F$) was unchanged in boiling chloroform, indicating that it was not interconverting with the AC isomer (I; $R^1$ = H, $R^2$ = Me, X = $SO_3F$). However, treatment of the AB isomer with methyl fluorosulphonate gave a product (presumed to be the *NN'N''*-trimethylporphin) which decomposed on chrom[2] atography (alumina) to the AC isomer (I; $R^1$ = H, R- = Me, X = $SO_3F$). When octaethylporphyrin was heated in methyl fluorosulphonate at 100° for five days (sealed tube) the *NN'N''*-trimethylporphin (I; $R^1$ = $R^2$ = Me, X = Cl,



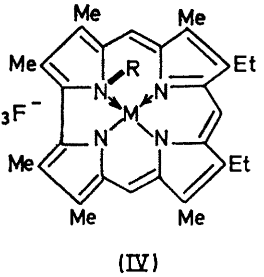
(I)



(II)



(III)



(IV)

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† In a previous communication[2] we suggested that in the n.m.r. spectrum of AC *NN'*-dimethylporphin (I; $R^1$ = H, $R^2$ = Me): "the *meso*-protons should give rise to two 2H singlets, *or a 4H singlet* assuming the proton on nitrogen is not fixed but shared between the two remaining nitrogen atoms." The phrase in italics was unfortunately omitted; see Corrigenda, *Chem. Comm.*, 1970, 572.

15%) could be isolated as its chloride, m.p. 186—189° (d), $\lambda_{max}$ ($CHCl_3$) 424, 554, 596, and 648 nm, $\epsilon$, 85,110, 5010, 5880, and 3500. The n.m.r. spectrum ($CDCl_3$) demonstrated the different environments of the *N*-methyl groups which occurred at $\tau$ 13·92 (S, 6H) and 17·08 (S, 3H). The *meso*-protons gave rise to signals at $\tau$ 0·04 (S, 2H) and 0·09 (S, 2H). The assignment of stereochemistry to (I; $R^1 = H$, $R^2 = Me$, $X = SO_3F$) and (I; $R^1 = R^2 = Me$, $X = Cl$) must await an *X*-ray investigation, but their n.m.r. spectra are consistent with the *N*-methyl substituents on adjacent rings bearing a *trans*-relationship (*cf.* ref. 2) and the *N*-methyl groups on rings A and C a *cis*-relationship. On keeping, the *NN'N''*-trimethylporphin (I; $R^1 = R^2 = Me$, $X = Cl$) slowly decomposed to give the free base of the AC *NN'*-dimethylporphin (II), m.p. 200—201°, $\lambda_{max}$ ($CHCl_3$) 422, 517, 607, 640, and 665 nm; $\epsilon_{max}$ 107,200, 10,470, 3020, 1740, and 1620; $\lambda_{infl}$ 544 and 588 nm; $\epsilon_{infl}$ 5010 and 1860.

Methylation of octaethylchlorin‡ with methyl fluorosulphonate in methylene chloride at room temperature gave a charged mono-*N*-methyl derivative (87%, allowing for recovered chlorin). The electronic spectrum of this product was typical of a monoprotonated chlorin and had a split Soret band (399 and 415 nm) indicating distortion of the $\pi$-electron chromophore.[4] The n.m.r. spectrum ($CDCl_3$) demonstrated the non-equivalence of the two ethyl groups on the reduced ring since two triplets were observed at $\tau$ 8·75 (3H) and 9·0 (3H). The remaining ethyl groups gave rise to methyl triplets at $\tau$ 8·15 (12H) and 8·57 (6H). The upfield shift of the protons of $\beta$-substituents on *N*-alkylated rings appears to be characteristic,[2] and since the *meso*-protons occurred as two 2H singlets at $\tau$ 0·0 and 0·8, suggests that methylation occurs on the ring opposite to the reduced ring (*i.e.*, III). The *N*-methyl group occurred at $\tau$ 13·9 in the n.m.r. spectrum.§ Deuterium-exchange studies on approximately 0·1 M-solutions of octaethylchlorin and (III) in $CD_3CO_2D$ at 78° showed that the *meso*-protons flanking the reduced ring in octaethylchlorin exchanged faster (10 h) than the corresponding protons in (III) (160 h).

The preparation of these poly-*N*-methylated macrocycles demonstrates the flexibility of the porphin and chlorin rings and raises interesting questions about the hybridisation of the nitrogen atoms, which we are investigating by *X*-ray analysis. We have recently shown[5] that the nitrogen bearing the alkyl group in the metal complexes of the *N*-alkylated macrocycles (IV; $M = Cu$, $R = Me$; $M = Ni$, $R = Et$) is essentially $sp^3$ hybridised.

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‡ *trans*-Chlorin prepared by Na–alcohol reduction.

§ Methylation of octaethylchlorin with methyl iodide in a sealed tube at 100° led to the isolation of an *NN'N''*-trimethylated macrocycle. The n.m.r. spectrum contained *N*-methyl singlets at $\tau$ 13·3, 13·4, and 15·85 and the *meso*-protons occurred at $\tau$ 0·45 (S, 2H), 1·10 (S, 1H), and 1·16 (S, 1H). N.m.r. evidence was also obtained for two intermediate *NN'*-dimethylated derivatives. R. Grigg, A. W. Johnson, and G. Shelton, unpublished observations.

[1] G. R. Dearden and A. H. Jackson, *Chem. Comm.*, 1970, 205.
[2] M. J. Broadhurst, R. Grigg, G. Shelton, and A. W. Johnson, *Chem. Comm.*, 1970, 231.
[3] M. G. Ahmed, R. W. Alder, G. H. James, M. L. Sinott, and M. C. Whiting, *Chem. Comm.*, 1968, 1533.
[4] J. E. Falk, "Porphyrins and Metalloporphyrins," Elsevier, Amsterdam, 1964, 75.
[5] R. Grigg, T. J. King, and G. Shelton, *Chem. Comm.*, 1970, 56; and unpublished observations.