Synthesis of 'Gyroscope-like' Porphyrins

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'Gyroscope-like' porphyrins have been prepared and found to have a high conformational rigidity.

There is general continuing interest in models of haemoproteins.[1] In view of some recent reports on the synthesis of models based on *ansa* compounds[2] derived from porphyrins, we disclose our own results on the synthesis of gyroscope-like porphyrins, such as (**1**).

Condensation of the porphyrin (**2**)[3] with terephthaloyl chloride under high dilution conditions† afforded after flash chromatography the gyroscope-like porphyrin (**1a**) (34% yield) or the porphyrin (**3**) (14% yield), depending on the molar ratio of terephthaloyl chloride to (**2**). The porphyrin (**3**) could be transformed into (**1b**) by condensation with 3,5-bis(chlorocarbonyl)pyridine (45% yield). Alternatively, condensation of (**2**) with both terephthaloyl chloride and 3,5-bis(chlorocarbonyl)pyridine† afforded *inter alia,* the gyroscope-like porphyrin (**1b**) (18% yield).

Inspection of molecular models shows that porphyrins such as (**1**) exhibit considerable conformational rigidity, since both 'handles' are attached to the same two sites (*meso*-phenyl rings): their movements are to some extent mechanically linked. Evidence of this rigidity is provided by a comparison of the ^{1}H n.m.r. spectra of compounds (**1**)—(**3**) with those of their analogues (**4**)—(**6**) which are prepared from Collman's porphyrin (**5a**),[4] and are the alanine counterparts of the phenylalanine derivatives described by Mansuy *et al.*[2b]

Table 1 shows that the phenylene protons of the terephthal-

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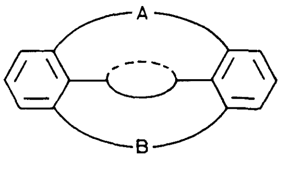
† Anhydrous tetrahydrofuran (THF) solutions of porphyrin and acid chloride were added during 3 h at room temperature under argon using a syringe pump.

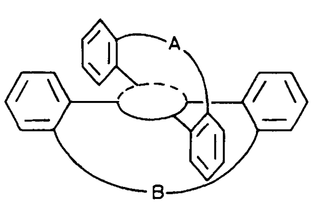
Table 1. Selected ^{1}H n.m.r. data (δ, $CDCl_3$) for **(1)**—**(6)**.

Proton	**(1a)**	**(1b)**	**(1c)**	**(2)**	**(3)**	**(4a)**	**(4b)**	**(5b)**	**(6)**
H-*meso*	9.98	9.86	9.68	10.08	10.07	—	—	—	—
$-C_6H_4-$	3.94	3.81	—	—	3.94	4.08	4.11	—	4.29
-C*H*Me-	4.24	4.25,[a,b] 3.91[c]	3.75	2.57	4.28,[a] 2.29	4.35	4.56,[d] 4.26[d]	2.86	4.28, 2.95
-CH*Me*-	1.36	1.19,[a] 0.84	0.86	0.49	1.30,[a] 0.58	1.23	1.19, 1.09	0.76	1.23,[a] 0.84
Pyrrole NH	−2.37	−3.00	−3.07	−2.30	—	−3.66	−4.02	−2.59	−3.21

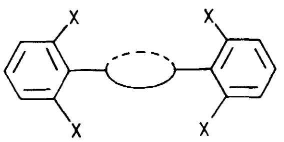
[a] $-C_6H_4-$ handle. [b] The pyrrole methyl groups are inequivalent in $CDCl_3$: δ 3.50, 3.47, 2.57, and 2.54, but are equivalent in $(CD_3)_2CO$: 3.53 and 2.59. [c] Pyridine handle. [d] The two expected quartets cannot be satisfactorily distinguished because of the presence of peaks due to other protons.



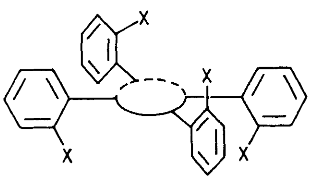
(1)
a; A = B = L^1
b; A = L^1, B = L^2
c; A = B = L^2



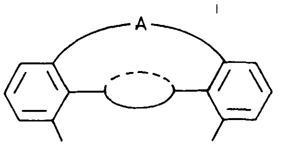
(4)
a; A = B = L^1
b; A = L^1, B = L^2



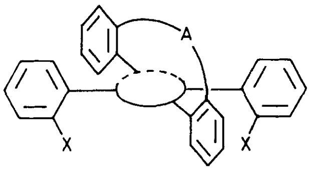
(2) X = NH—C(:O)—CHMe—NH$_2$



(5)
a; X = NH$_2$
b; X = NH—C(:O)—CHMe—NH$_2$



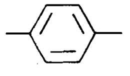
(3), A = L^1,
X = NH—C(:O)—CHMe—NH$_2$



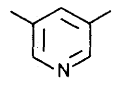
(6), A = L^1,
X = NH—C(:O)—CHMe—NH$_2$

L = -NH—C(:O)—CHMe-NH—C(:O)—Ar—C(:O)—NH—CHMe—C(:O)—NH

L^1, -Ar- =



L^2, -Ar- =



(1)—**(3)**: oval = *meso*-5,15-disubstituted octamethylporphyrin
(4)—**(6)**: oval = *meso*-5,10,15,20-tetrasubstituted porphyrin

oyl moiety are consistently more shielded in compounds **(1a)**, **(1b)**, and **(3)** than in compounds **(4a)**, **(4b)**, and **(6)**, suggesting a shorter average distance to the porphyrin ring in **(1)** and **(3)** and a greater conformational rigidity of the handles of **(1)** as compared with **(4)**.

On the other hand inspection of molecular models shows that, in the triple decker conformation (stacking of the porphyrin ring between two parallel phenylene rings), which seems to be the most stable one, the $CH-CH_3$ groups derived from L-alanine are more or less in the planes of the phenylene and phenyl rings, and pointing away from the porphyrin ring. This accounts for the large downfield shifts on handle formation: 1.67 and 0.87 p.p.m. for CH and CH_3 in the **(2)** → **(3)** → **(1a)** series, 1.49 and 0.47 p.p.m. (average) in the **(5b)** → **(6)** → **(4a)** series, the downfield shifts being smaller in the second series.

The special conformational rigidity imparted to the handles of the iron porphyrin prepared by treatment of **(1b)** with anhydrous $FeCl_2$‡ makes these metalloporphyrins interesting models for haemoproteins; the movement of the distal hydrophobic handle is inhibited by the ligation of the proximal pyridine axial base to the iron atom. Experiments devised to exploit this rigidity will be reported elsewhere.

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‡ Mass spectra (obtained on a Nermag R30-10 spectrometer) of the corresponding hydroxyironporphyrin (Fe–OH): *m/z* 1231, $(M-H-OH)^-$ and of the porphyrins described in Table 1 are in complete agreement with the indicated structures.