Communications to the Editor

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CHIRAL PORPHYRIN ATROPISOMERS[1)]

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Novel asymmetric conformations were found in the atropisomers of tetraarylporphyrins. 5α,10ß-di(o-aminophenyl)-15,20-diphenylporphyrin was synthesized, isolated, and identified by the NMR spectra as an example of the asymmetry.

KEYWORDS —— chiral porphyrin; tetraarylporphyrin; atropisomer; porphyrin stereochemistry; rotational isomer

A strategy to introduce asymmetry into a synthetic porphyrin molecule by attaching chiral parts to its periphery has been proposed and success in catalytic reactions has been reported.[2,3)] We wish to report here a new stereochemical chirality in the rotational isomers of the tetraarylporphyrins. The asymmetry of the porphyrin consists of some rotational axes and a central cavity for metal ions. Thus, it is recognized as a novel type of chirality in the tetragonal porphyrin atropisomer system.[4)]

The porphyrin synthetic reaction of pyrrole with a mixture of benzaldehyde and ortho-substituted benzaldehyde affords a complex mixture of products including geometrical and rotational isomers. Of these, the two molecules shown in Fig. 1 are asymmetric.

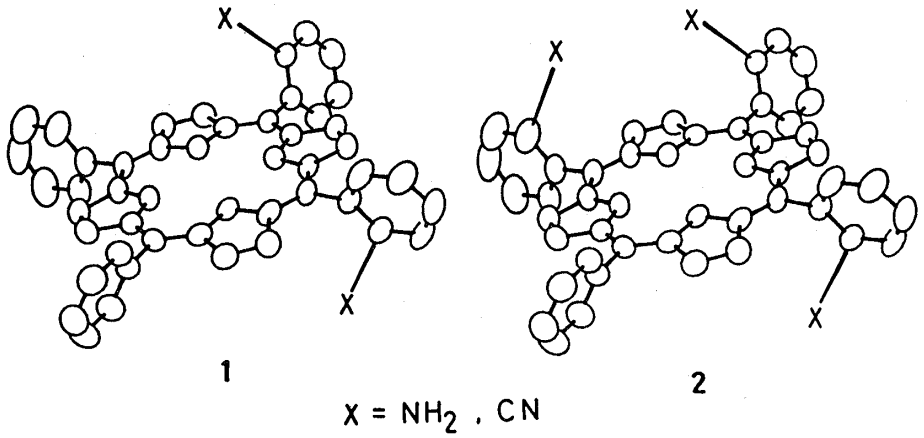

Fig. 1. Computer Aided Drawing of Molecular Structures of the Asymmetric Atropisomers of meso-((ortho-X)Phenyl)$_n$-(phenyl)$_m$-porphyrin(n+m = 4) (C.K.Johnson's ORTEP was used.)

1 has an apparent C_2 axis in the porphyrin plane whereas **2** has no symmetry element except C_1. The two could be isolated under laboratory conditions if the steric hindrance of the ortho-substituent restricted the rotation about the phenyl-porphyrin bond. We attempted to obtain asymmetric porphyrins which had NH_2 or CN substituents at ortho position of phenyl ring since atropisomers of the analogous tetraaryl derivatives could be isolated.[5,6] This communication describes a successful separation, isolation and identification of one of the asymmetric molecules, namely 5α,10ß-di(o-aminophenyl)-15,20-diphenylporphyrin.

The mixture of (ortho-aminophenyl)$_n$-(phenyl)$_m$porphyrins (n + m = 4) was prepared by methods similar to those described in the literature.[5,7] The product mixture was chromatographed at first on silica gel (BW-820 MH, Fuji Davison Chem. Co.), eluted with 98:2 chloroform:methanol, and the di(o-aminophenyl)-diphenylporphyrin (DADPP) fraction was collected. The DADPP fraction consists of four isomers; two geometrical configurations called trans and cis depending on whether the NH_2 substitutes are on adjacent or opposite phenyl rings, and two conformations, αα and αß, depending on whether the substitutent is above(α) or below(ß) the porphyrin plane. The mixture of DADPP isomers was separated into the four components by column chromatography carefully prepared on silica gel with dichloromethane. Two compounds eluted as the first (**1a**) and second (**1b**) bands were collected and recrystallized by vapor diffusion of methanol into the chloroform solution. Each of the two components gave a single spot on TLC plate (Silica gel 60, Merck #5721, Rf: 0.56 for **1a**, 0.54 for **1b** with 2 : 98 diethylether : chloroform). Both components showed identical elemental analysis and mass spectra, consistent with the isomers of DADPP.[8] Heating **1a** and **1b** in 1,1,2-trichloroethane solution at 100°C for long periods of time caused atropisomerization. The unique products from **1a** and **1b** were **1a'** and **1b'** (Rf: 0.21 for **1a'** , 0.15 for **1b'** on TLC), respectively, and these were the other isomers of DADPP. This result showed that either **1a** or **1b** corresponds to either trans or cis. Furthermore the distinct difference in the Rf of the unprimed group versus the primed one indicates that **1a** and **1b** must have the less polar αß conformation, and consequently **1a'** and **1b'** are of the αα conformation.[9]

The rate constant of the rotation of a single aminophenyl was estimated from our kinetic data[10] to be ca. 0.6 x $10^{-7}s^{-1}$ at 25°C. Thus, negligible rotation was expected in the time required for the usual NMR measurement. Fig. 2 shows spectra of the ß-pyrrole protons of **1a** and **1b** with the schematic representation of the structures.[11] The four lines in the spectrum of **1b** can be attributed to the four non-equivalent pyrrole protons distinguished by stereochemical environments with respect to the geometrical position of the amino group in the cis form. The two main lines of **1a** can also be assigned to the trans form although a portion of **1b** or an impurity is observed, each as a minor satellite peak.[12] The **1b** component has been conclusively assigned to the target asymmetric rotational isomer. The overall yield of the target **1b** was about 1.0% (2.5 mmol) at best on the basis of the starting pyrrole (1 mol).

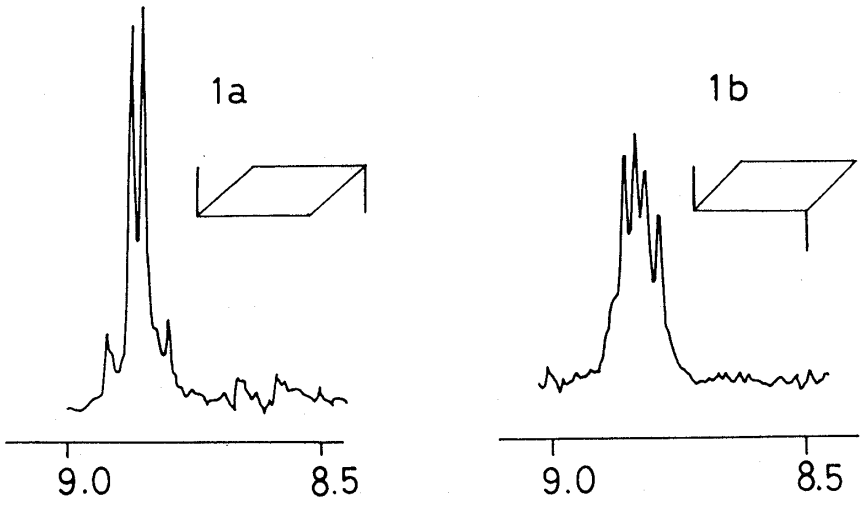

Fig. 2. NMR Spectra in the ß-Pyrrole Proton Region for the αß Conformation of trans- and cis-DADPP in $CDCl_3$

The **1b** porphyrin crystal was examined by the X-ray diffraction analysis. The preliminary test for a single-crystal of **1b** revealed the crystal of two molecules in a unit cell with the space group $P2_1$ or $P2_1/m$ and cell constants; a= 13.630, b= 11.208, c= 11.854 Å, and ß= 109.32°. The structural analysis is in progress.

The **1b** component should be racemic because there was no asymmetric operation in the synthesis and purification. Although effective asymmetric resolution is not yet available for this compound, the synthesis of stable atropisomers with reactive metal ions in the central porphyrin hole is currently pursued in this laboratory for the resolution and further characterization of chiral porphyrins.

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REFERENCES AND NOTES

1) This work was presented at the 105th Annual Meeting of the Pharmaceutical Society of Japan, Kanazawa, April, 1985.
2) J. T. Groves, and R. S. Myers, J. Am. Chem. Soc., 105, 5791 (1983).
3) K. Miyamoto et al., reported the synthesis of the chiral cylindrical porphyrins at the 34th Conference of Coordination Chemistry, Nagaoka, Japan., October, 1984.
4) Very recently similar chirality was reported. Y. Aoyama, K. Sakurai, H. Toi,

H. Ogosi, and Y. Okamoto, Preprint of the spring meeting of the Chemical Society of Japan, April, 1985.

5) J. P. Collman, R. R. Gagne, C. A. Reed, T. R, Halbert, G. Lang, and W. T. Robinson, J. Am. Chem. Soc., 97, 1427 (1975).

6) K. Hatano, K. Anzai, T. Kubo, and S. Tamai, Bull. Chem. Soc. Jpn., 54, 3518 (1981).

7) F. A. Walker, D. Reis, and V. L. Balke, J. Am. Chem. Soc., 106, 6888 (1984).

8) Anal. Calcd for $C_{44}H_{32}N_6$: C, 81.97; H, 5.01; N, 13.04. Found: C, 80.91; H, 4.61; N, 12.50 for **1a**. C, 81.03; H, 4.73; N, 12.90 for **1b**. MS spectrum (EI, 70eV), m/e 644(29%, M^+), 645(100%, $(M+1)^+$), 646(51%, $(M+2)^+$) for **1a**, m/e 644(25%, M^+), 645(100%, $(M+1)^+$), 646(47%, $(M+2)^+$) for **1b**.

9) This tendency is common in tetraarylporphyrin atropisomers, see references 5 & 6.

10) K. Hatano, K. Anzai, A. Nishino, and K. Fujii submitted for publication.

11) The NMR of other protons including various phenyl protons: ^1H ($CDCl_3$), 8.20(m, 4H, o-H of phenyl), 7.91(s, 2H, o-H of aminophenyl), 7.83-7.50(m, 8H, m-H of phenyl and aminophenyl), 7.16(t, 4H, p-H, 8Hz), 3.55(s, 4H, NH_2), -2.71(s, 2H, pyrrole NH) for **1b**. The spectrum of **1a** looked identical in these parts.

12) One of the reviewers pointed out that the lines could be explained by the quartet of the AB pattern instead of impurity and so on. This is possible but not confirmed at this time.

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