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Selective Synthesis of Diaryl and Monoaryl Substituted Porphyrins

Hermann K. Hombrecher,* Gaby Horter and Christiane Arp

Institut für Chemie der Medizinischen Universität zu Lübeck, Ratzeburger Allee 160, D-2400 Lübeck 1, Germany

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Abstract. A selective synthetic method to monoaryl and diaryl substituted porphyrins is described. Depending on the nature of the β-substituent the synthesized porphyrins show different degrees of ruffling of the chromophor.

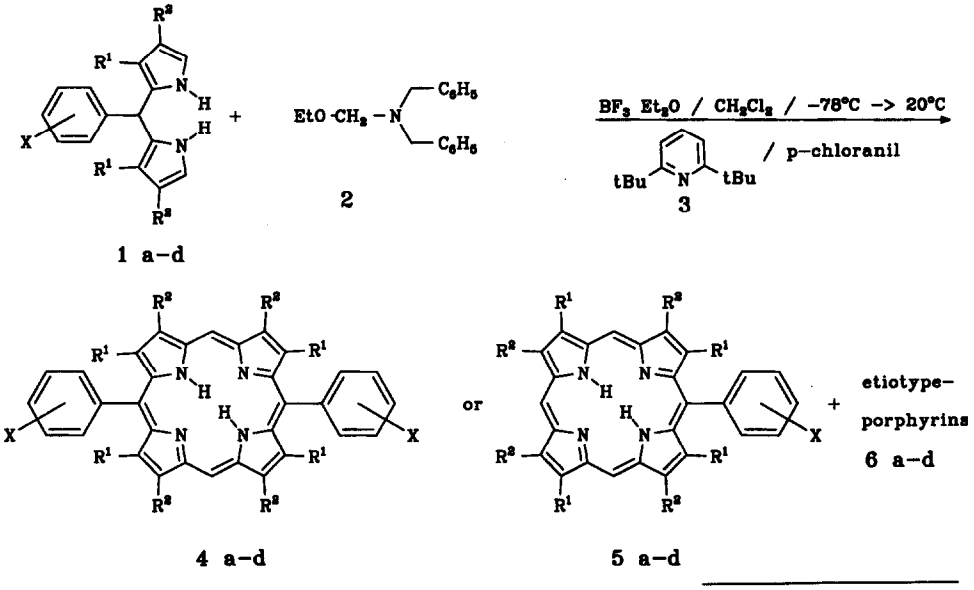
Synthesis of porphyrins gained much attention in the last few years. This is undoubtedly due to the applications of these systems in biomedical and natural sciences. Porphyrins are used for example to mimic some functions of bacterial photochemical reaction centers[1] and the function of cytochromes like cytochrome P-450.[2] Other important applications are the photodynamic therapy of cancer (PDT),[3] the boron neutron capture therapy (BNCT)[4] and the photosterilisation of transfusion blood.[5] In the rapidly growing field of molecular electronics[6] porphyrins can act as light absorbers (antenna molecules)[7], photodiodes[8] or light transformers.[9]

In spite of this, there are only a few good methods for the synthesis of diaryl substituted porphyrins.[10] These compounds are classically produced by using the Woodward-MacDonald procedure.[11] In this method a bis-formyl substituted dipyrrylmethane is reacted with a dipyrrylmethane unsubstituted at position-5. Though this method gives good yields for *meso*-alkyl substituted derivatives, the yield of *meso*-aryl substituted compounds is often very low. This seems to be mainly due to the increased acid-lability of the starting aryl substituted dipyrrylmethanes. These compounds lead easily to fragmentation products under acidic conditions. Therefore formylation of 5-unsubstituted derivatives using the Vilsmeier procedure often gives low yields of bis-formyl dipyrrylmethanes. It seems also reasonable that intermediately formed porphyrinogens or porphodimethenes are acid labile and form fragmentation products and rearranged compounds. To overcome this situation new synthetic methods and strategies have to be developed.

We recently reported the synthesis of diaryl substituted porphyrins via a Mannich-type reaction of imminium-ions with aryl substituted dipyrrylmethanes and coupling of the intermediately formed Mannich-base with a second dipyrrylmethane.[12] Though this reaction proceeds under very mild reaction conditions, the acidic medium leads to the formation of monoaryl substituted porphyrins and porphyrins unsubstituted in the

meso-position (etiotype).

We wish to report here a convenient synthetic procedure which allows the synthesis of diaryl substituted or monoaryl substituted porphyrins nearly exclusively by controlling the amount of the free protons in the reaction medium. The reaction sequence is given in Scheme 1. This method is very easy and efficient. BF_3-etherate and di-tert-butylpyridine (3) are added to a solution of the N,O-acetal **2**[13] in dry CH_2Cl_2 at -78°C (method A). Then the required dipyrrylmethane **1a-d** is added and the reaction mixture is stirred for several hours at -78°C and then warmed gently up to 20°C. After oxidation with p-chloranil the diaryl substituted porphyrin[14] is isolated by column chromatography. Only small amounts of the monoaryl substituted porphyrin and traces of the *meso*-unsubstituted derivatives are formed. If this reaction is carried out without adding the pyridine (method B), however only traces of the diaryl substituted porphyrin are obtained and the monoaryl substituted porphyrin is formed as the main product. For example the ratio of **4a / 5a** is 9 to 1 using method A, and 1 to 30 using method B. In our opinion this selectivity makes our method very attractive for the synthesis of monoaryl substituted porphyrins. Our method avoids the often



a R^1 = Me, R^2 = Et

b R^1 = Et, R^2 = Pr

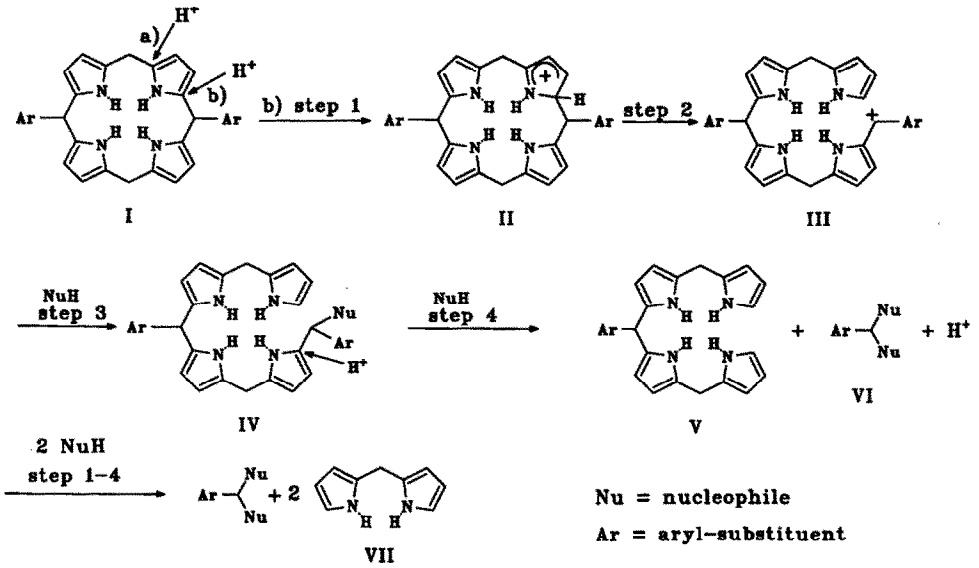
c R^1–R^2 = $-(CH_2)_4-$

d R^1 = Me, R^2 = iBu

Scheme 1.

tedious multistep synthesis of linear tetrapyrroles[15] which are often used as starting material for the synthesis of monoaryl substituted porphyrins.[16] Another advantage is that in our procedure only one dipyrrylmethane has to be synthesized. In the classically used MacDonald procedure two different dipyrrylmethanes are coupled to the monoaryl substituted porphyrin.[17] The dipyrrylmethanes used in our methodology as starting materials are conveniently prepared from pyrroles **7 a - d** and 2,5-dimethoxy benzaldehyde via a condensation - saponification - decarboxylation procedure.[12,18] This standard procedure gives high yields of the appropriate compounds. The yields of monoaryl substituted porphyrins obtained by our method (Table 1) are good compared to other methods.[17]

The proposed mechanism for the formation of compounds **5** and **6** starts with an attack of a proton on the α-position of a pyrrole ring of the intermediately formed porphyrinogen and subsequent fragmentation (Scheme 2, β-alkyl groups not drawn for clarity).[12] Attack via path b) leads to the formation of the stable cation III, which may be attacked by a nucleophile (dipyrrylmethane, H_2O, ROH) present in the reaction medium. After several fragmentation steps the porphyrinogen is completely destroyed and two new dipyrrylmethanes are formed. These new compounds can be aminomethylated, or they can react with already



Scheme 2: Proposed mechanism of porphyrinogen fragmentation

aminomethylated compounds and thus form the monoaryl substituted and the etiotype porphyrins. If the aryl-substituent is substituted with an electron withdrawing group or if no aryl group is present, attack may occur via path a) due to the decreased stability of cation III. Recently, Rose et al.[19] also reported the formation of etiotype-(II)-porphyrin and mono-aryl substituted porphyrins by a condensation reaction of dipyrrylmethanes with 2,6-disubstituted benzaldehydes. The authors explained the formation of the etiotype-(II) and the

monoaryl substituted compound via elimination of a phenyl moiety. In our opinion this mechanism is unlikely, because a proton has to attack the ipso-position of an electron deficient (nitro or acetamido substituted) phenyl-ring system. We think that attack via path a) (Scheme 2) is much more likely and is also explaining the observed products. However, the reaction conditions are different from our conditions. Nevertheless, the mechanism earlier proposed by us and our new results clearly prove that the protons formed or present in the reaction are responsible for fragmentation of the porphyrinogen and that we are now able to control the reaction by controlling the amount of free protons.

The synthesized porphyrins have interesting spectroscopic properties. Compared with the *meso*-unsubstituted and the monoaryl substituted derivatives all diaryl substituted porphyrins show a significant bathochromic shift of the UV-vis absorption bands (Table 1). in our opinion two effects are responsible for the observed bathochromic shifts. Due to pertubation theory, introduction of *meso*-aryl systems will generally lead to a bathochromic shift of all absorptions. For example the Soret absorption of *meso* unsubstituted etiotype porphyrins is 398 nm the Soret absorption of TPP is 419 nm in $CHCl_3$. But there is also a significant bathochromic shift of these absorptions for compound **4b** compared with **4a** and for **5b** compared with **5a**. We think that these changes in the absorption spectra are due to the interaction of the *meso*-aryl group with

Table 1. Yield and selected spectroscopic data of the synthesized porphyrins

compound	yield [%] method A	yield [%] method B	δ_{NH} [ppm]	λ [nm]				
4a	18	<0.5	-2.30	408	505	539	573	623
5a	2	15	-3.27	402	501	525	570	622
6a	<0.5	<0.5	-3.60	398	497	531	566	619
4b	18	2	-1.80	413	510	542	576	629
5b	2	15	-2.50	407	505	539	572	625
6b	<0.5	<0.5	-3.75	400	498	534	566	620
4c	15	<0.5	-2.45	408	506	539	571	625
5c	3	23	-3.50	404	503	538	570	622
6c	<0.5	5	-3.81	398	497	534	565	619
4d	14	<0.5	-2.27	412	510	540	575	626
5d	3	13	-3.19	405	503	537	571	624
6d	<0.5	<0.5	-3.60	398	497	533	566	619

method A = 2,6-di-tert-butyl-pyridine added, method B = no 2,6-di-tert-butyl-pyridine added

the β-alkyl substituent. This interaction leads to a ruffling of the porphyrin chromophor as mentioned by Hombrecher[12] and Smith.[20] Due to this deviation from planarity the HOMO-LUMO difference will decrease

as shown by Smith[21] by theoretical calculations. Therefore more ruffled systems must show an absorption at longer wavelenghts, as we found experimentally.

The ruffling of the chromophor must also lead to a decreased ring current and therefore must influence the ^{1}H-NMR spectra of the porphyrins. Especially the NH-resonance must be very sensitive to the ruffling. As can be seen in table 1, this assumption is in accordance with the experimental results. The more ruffled diaryl substituted porphyrins show the NH-absorption at a lower field than the mono-aryl substituted porphyrins. The absorption at δ = -1.80 for compound **4b** is to the best of our knowledge the most down-field shifted resonance for a NH-proton in a porphyrinic macrocycle ever observed. From the data reported in the table, it is obvious that especially NMR-spectroscopy is a very sensitive tool for studying the ruffling of porphyrinic macrocycles.

As a conclusion we can say, that we are now able to synthesize the mono- or diaryl substituted porphyrins nearly exclusively in a good yield. In our opinion our method is especially valuable for the synthesis of monoaryl substituted porphyrins. Furthermore we are able to synthesize porphyrins with a different deviation from planarity and we are able to control the degree of ruffling of these compounds by introducing different β-alkyl-groups.

EXPERIMENTAL SECTION

NMR-spectra were obtained in $CDCl_3$ and recorded with a Varian XL 200 spectrometer. Chemical shift values were given in ppm relative to TMS. Coupling constants were given in Hz. Mass spectra were measured with a VG-Analytical VG70:250 E instrument. Electronic spectra were recorded on a Kontron Uvikon 860 instrument. Infrared spectra were recorded on a Shimadzu IR-435 spectrometer. Melting points were measured on a Büchi 510 apparatus and are uncorrected. Column chromatography was carried out with Merck silica gel mesh size 0.060 - 0.2 mm.

Synthesis of Ethyl-(N,N-dimethylamino)methyl-ether **(2):** Dibenzylamine (0.5 mol, 98.64 g) was added to a suspension of 0.6 mol (84.0 g) Na_2CO_3 in 1 mol (46.0 g) ethanol at 0°C. The mixture was stirred for 30 min and then 0.5 mol (15.0 g) para-formaldehyde was added. The mixture was warmed up to room-temperature and stirred for 20 h. The reaction mixture was filtered and the solvent evaporated. The residue was purified by vacuum destillation.- **2**: Yield: 29.4 g (28 %). bp.: 160 - 163°C (2 hPa). ^{1}H-NMR ($CDCl_3$): δ = 7.25 (m, 10 H), 4.10 (s, 2 H), 3.85 (s, 4 H), 3.40 (q, J = 7.5, 2 H), 1.15 (t, J = 7.5, 3 H).

Synthesis of pyrroles **7 a - d:** The pyrroles were prepared according to a literature procedure.[22] The spectroscopic data of pyrroles **7 a - c** are those reported in the literature.[22]

2-Carboethoxy-4-methyl-3-(2-methylpropyl)pyrrole **(7d):** Yield: 32 %. Fp.: 70 - 71°C.

^{1}H-NMR ($CDCl_3$): δ = 8.84 (s, br, 1 H), 6.66 (d, J = 3.0, 1 H), 4.30 (q, J = 7.14, 2 H), 2.60 (d, J = 7.30, 2 H), 2.02 (s, 3 H), 1.93 (m, 1 H), 1.35 (t, J = 7.14, 3 H), 0.91 (d, J = 6.66, 6 H).- ^{13}C-NMR ($CDCl_3$): δ = 161.70 (s), 158.40 (s), 130.76 (s), 120.60 (s), 120.29 (d), 59.80 (t), 33.90 (t), 30.11 (d), 22.55 (sept), 14.48 (q), 10.30 (q).- MS (EI): m/e = 209 (M^+), 166 (100 %).- IR (KBr): 3300, 1660 cm^{-1}.- Anal. calc. for $C_{12}H_{19}NO_2$: C 68.87 H 9.15 N 6.69 Found C 68.13 H 9.20 N 6.42.

***Synthesis of (2,5-Dimethoxypenyl)bis(3,4-dialkyl-2-pyrryl)methanes* 1 a - d:** The dipyrrylmethanes **1 a-d** were prepared according to a literature procedure.[12,18] The spectroscopic data of dipyrrylmethane **1 a** are in accordance with those reported in the literature.[12]

***(2,5-Dimethoxyphenyl)bis(3-ethyl-4-propyl-2pyrryl)methane* (1b)**: Fp. (dec.): 52°C.- ^{1}H-NMR ($CDCl_3$): δ = 7.59 (s, br., 2 H), 6.79 (s, 1 H), 6.74 (d, J = 3.00, 1 H), 6.63 (d, J = 3.00, 1 H), 6.33 (d, J = 2.19, 2 H), 5.73 (s, 1 H), 3.70 (s, 3 H), 3.62 (s, 3 H), 2.40 - 2.23 (m, 8 H), 1.58 (m, 4 H), 0.95 (t, J = 7.43, 6 H), 0.90 (t, J = 7.50, 6 H).- MS (FAB): m/e = 286 (M^+-136).- IR (KBr): 3300, 1610 cm^{-1}.- Anal. calc. for $C_{27}H_{38}N_2O_2$: C 76.74 H 9.06 N 6.63. Found: C 76.01 H 8.67 N 6.39.

***(2,5-Dimethoxyphenyl)bis(3,4-tetramethylene-2-pyrryl)methane* (1c)**: Fp. (dec.) 112°C.- ^{1}H-NMR ($CDCl_3$): δ = 7.77 (s, br., 2 H), 6.85 - 6.68 (m, 3 H), 6.33 (d, J = 2.20, 2 H), 5.57 (s, 1 H), 3.72 (s, 3 H), 3.64 (s, 3 H), 2.55 (m, 4 H), 2.35 (m, 4 H), 1.65 (m, 8 H).- ^{13}C-NMR ($CDCl_3$): δ = 153.93 (s), 151.36 (s), 132.06 (s), 125.43 (s), 120.09 (s), 116.21 (d), 115.80 (s), 113.39 (d), 111.61 (d), 110.87 (d), 56.96 (q), 55.64 (q), 36.23 (d), 24.08 (t), 24.02 (t), 22.34 (t), 21.25 (t).- MS (EI): m/e = 390 (M^+), 270 (100 %, M^+- 120).- IR (KBr): 3350, 1665 cm^{-1}.- Anal. calc. for $C_{25}H_{30}N_2O_2$: C 76.89 H 7.74 N 7.17. Found: C 76.76 H 7.76 N 7.10.

***(2,5-Dimethoxyphenyl)bis(4-methyl-3-(2-methylpropyl)-2-pyrryl)methane* (1d)**: Yellow oil.- ^{1}H-NMR ($CDCl_3$, 90 MHz.): δ = 7.75 (s, br., 2 H), 6.75 - 6.60 (m, 3 H), 6.35 (d, J = 2.20, 2 H), 5.75 (s, 1 H), 3.67 (s, 3 H), 3.55 (s, 3 H), 2.30 (d, J = 7.0, 4 H), 1.80 (s, 6 H), 1.75 (m, 2 H), 0.90 (d, J = 7.50, 6 H).- MS (EI): m/e = 422 (M^+), 288 (100 %).- IR (KBr): 3330, 1630 cm^{-1}.- Anal. calc. for $C_{27}H_{38}N_2O_2$: C 76.74 H 9.06 N 6.63. Found: C 76.11 H 8.95 N 6.51.

***Synthesis of porphyrins*:**

General Procedure: Method A: 4 mmol 2,6-di-tert-butyl-pyridine and 3 mmol of BF_3-etherate were added to a solution of 1 mmol N,O-acetal **2** in 50 ml CH_2Cl_2 at -78°C. The mixture was stirred for 1h at -78°C. Then 1 mmol of the required dipyrrylmethane (**1 a-d**) dissolved in 20 ml CH_2Cl_2 was added over a period of 30 min. The mixture was stirred for 4 h at -78°C and was then warmed up gently to room temperature and stirred for 10 h. Then 3 mmol triethylamine and 1.8 mmol p-chloranil were added and the mixture stirred for 1 h at room temperature. The mixture was poured in 100 ml 10 % NaOH solution. The organic layer was separated and shaken with 100 ml 5% HCl solution. After adding 100 ml CH_2Cl_2 the organic layer was separated and washed with brine and water and dried with Na_2SO_4. The solvent was

evaporated and the residue chromatographed on a silica gel column (25 cm x 5 cm) with $CHCl_3$ as eluent. The first porphyrinic fraction collected was the etiotype, the second fraction the monoaryl substituted, and the third fraction the diaryl substituted porphyrin.

Method B: The procedure was exactly the same as described for method A with the exception, that no 2,6-di-tert-butyl-pyridine was added.

All reactions were carried out under nitrogen with 1 mmol dipyrrylmethane (**1 a-d**), 1 mmol **2** and 3 mmol BF_3-etherate.

5,15-Bis(2,5-dimethoxyphenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphin **(4a):**[12]

Method A: Yield 18 % (68 mg). Method B: Yield 0.3 % (1.5 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.19 (s, 2 H), 7.29 (m, 6 H), 3.90 - 4.04 (m, 8 H), 3,85 (s, 6 H), 3.65 (s, 6 H), 2.61 (s, 12 H), 1.77 (t, J = 7.5 Hz, 12 H), - 2.30 (s, 2 H).- FAB-MS: m/e = 751 (M^+). UV-Vis (CH_2Cl_2): λ = 408, 505, 539, 573, 623 nm.

5-(2,5-Dimethoxyphenyl)-2,8,13,17-tetraethyl-3,7,12,18-tetramethylporphin **(5a):**[12]

Method A: Yield 2 % (6 mg). Method B: Yield 15 % (46 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.05 (s, 2H), 9.84 (s, 1 H), 7.12 - 7.21 (m, 3 H), 3.92 - 4.02 (m, 8 H), 3.75 (s, 3 H), 3.55 (s, 3 H), 3.51 (s, 6 H), 2.52 (s, 6 H), 1.78 (t, J = 7.6 Hz, 6 H), 1.69 (t, J = 7.4 Hz, 6 H), - 3.27 (s, 2 H).- FAB-MS: m/e = 615 (M^+).- UV-Vis (CH_2Cl_2): λ = 402, 501, 525, 570, 622 nm.

Etiotype-porphyrins **(6a):**[12] Method A: Yield traces. Method B: Yield 0.3 % (0.8 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.10, (s, 4 H), 4.10 (q, J = 7.6 Hz, 8 H), 3.64 (s, 12 H), 1.88 (t, J = 7.6 Hz, 12 H), - 3.60 (s, 2 H).- FAB-MS: m/e = 478 (M^+).- UV-Vis (CH_2Cl_2): λ = 398, 497, 531, 566, 619 nm.

5,15-Bis(2,5-dimethxyphenyl)-3,7,13,17-tetraethyl-2,8,12,18-tetrapropylporphin **(4b):**

Method A: Yield 18 % (78 mg). Method B: Yield 2 % (9 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.18 (s, 2 H), 7.57 (m, 2 H), 7.30 (m, 2 H), 7.15 (m, 2H), 3.95 (m, 8 H), 3.88 (2s, 6 H), 3.55 (2s, 6 H), 2.95 (m, 8 H), 2.30 (m, 8 H), 1.37 (t, J = 7.3, 6 H), 1.21 (t, J = 7.6, 6 H), -1.80 (s, 2 H).- FAB-MS: m/e = 863 (M^+).- UV-Vis (CH_2Cl_2): λ = 413, 510, 542, 576, 629.- Anal. calc. for $C_{56}H_{70}N_4O_4$: C 77.92 H 8.17 N 6.49. Found: C 77.18 H 8.02 N 6.15.

5-(2,5-Dimethoxyphenyl)-3,7,12,18-tetraethyl-2,8,13,17-tetrapropylporphin **(5b):**

Method A: Yield 2 % (7 mg). Method B: Yield 15 % (55 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.15 (s, 2 H), 9.90 (s, 1 H), 7.58 (m, 1 H), 7.30 (m, 1 H), 7.15 (m, 1 H), 4.03 (m, 12 H), 3.88 (s, 3 H), 3.54 (s, 3 H), 2.87 (m, 4 H), 2.35 (m, 8 H), 1.92 (t, J = 7.5, 6 H), 1.35 (2xt, 12 H), 1.18 (t, J = 7.5, 6 H), - 2.50 (s, 2 H).- FAB-MS: m/e = 727 (M^+).- UV-Vis (CH_2Cl_2): λ = 407, 505, 539, 572, 625nm.- Anal. calc. for $C_{48}H_{62}N_4O_4$: C 79.30 H 8.60 N 7.71. Found: C 78.97 H 8.45 N 7.66.

Etiotype-porphyrins **(6b):** Method A: Yield 0.3 % (1 mg). Method B: Yield 0.4 % (1.6 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.11 (s, br. 4 H), 4.00 - 4.17 (m, 16 H), 2.36 (m, 8 H), 1.94 (t, J = 7.66, 12 H), 1.33 (2t, 12 H), - 3.75 (s, 2 H).- FAB-MS: m/e = 591 (M^+).- UV-Vis (CH_2Cl_2): λ = 400, 498, 534, 566, 620 nm.- Anal. calc. for $C_{40}H_{54}N_4$: C 81.31 H 9.21 N 9.48. Found: C 80.92 H 8.98 N 9.21.

***5,15-Bis(2,5-dimethoxyphenyl)-2,3,7,8,12,13,17,18-tetra(tetramethylene)porphin* (4c):**

Method A: Yield 15 % (60 mg). Method B: Yield 0.4 % (1.5 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.15 (s, 2 H), 7.18 - 7.30 (m, 6 H), 4.18 (m, 8 H), 3.90 (s, 6 H), 3.65 (s, 6 H), 2.95 (m, 8 H), 2.00 - 2.45 (m, 16 H), -2.45 (s, 2 H).- FAB-MS: m/e = 799 (M^+).- UV-Vis: λ = 408, 506, 539, 571, 625 nm.- Anal. calc. for $C_{52}H_{54}N_4O_4$: C 78.17 H 6.81 N 7.01. Found: C 77.88 H 6.57 N 6.68.

***5-(2,5-Dimethoxyphenyl)-2,3,7,8,12,13,17,18-tetra(tetramethylene)porphin* (5c):**

Method A: Yield 3 % (10 mg). Method B: Yield 23 % (43 mg).

^{1}H-NMR ($CDCl_3$): δ = 9.92 (s, 2 H), 9.75 (s, 1 H), 7.10 - 7.35 (m, 3 H), 4.00 - 4.13 (m, 12 H), 3.86 (s, 3 H), 3.63 (s, 3 H), 2.90 (m, 4 H), 2.50 (m, 8 H), 2.34 (m, 4 H), 2.20 (m, 4 H), - 3.50 (s, 2 H).- FAB-MS: m/e = 663 (M^+).- UV-Vis (CH_2Cl_2): λ = 404, 503, 538, 570, 622 nm.- Anal. calc. for $C_{44}H_{46}N_4O_2$: C 79.73 H 6.99 N 8.45. Found: C 79.15 H 6.37 N 8.33.

***2,3,7,8,12,13,17,18-Tetra(tetramethylene)porphin* (6c):**[23]

Method A: Yield 0.4 % (1 mg). Method B: Yield 5 % (13 mg).

^{1}H-NMR ($CDCl_3$): δ = 9.92 (s, 4 H), 4.10 (m, 16 H), 2.52 (m, 16 H), - 3.81 (s, 2 H).- FAB-MS: 527 (M^+).- UV-Vis (CH_2Cl_2): λ = 398, 497, 534, 565, 619 nm.

***5,15-Bis(2,5-dimethoxyphenyl)-3,7,13,17-tetramethyl-2,8,12,18-(2-methyl-propyl)porphin* (4d):**

Method A: Yield 14 % (60 mg). Method B: Yield 0.5 % (2 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.15 (s, 2 H), 7.22 - 7.36 (m, 6 H), 3.86 (s, 6 H), 3.84 (s, 6 H), 3.60 - 3.80 (m, 8 H), 2.60 (s, 12 H), 1.24 (s, 24 H), - 2.27 (s, 2 H).- FAB-MS: m/e = 863 (M^+).- UV-Vis (CH_2Cl_2): λ = 412, 510, 540, 575, 626 nm.- Anal. Calc. for $C_{56}H_{70}N_4O_4$: C 77.92 H 8.17 N 6.49. Found: C 77.48 H 8.11 N 6.15.

***5-(2,5-Dimethoxyphenyl)-3,7,12,18-tetramethyl-2,8,13,17-(2-methylpropyl)porphin* (5d):**

Method A: Yield 3 % (11 mg). Method B: Yield 13 % (47 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.10 (s, 2 H), 9.89 (s, 1 H), 7.33 (m, 3 H), 3.80 - 3.93 (m, 8 H), 3.84 (s, 3 H), 3.63 (s, 3 H), 3.61 (s, 3 H), 3.58 (s, 3 H), 2.60 (s, 6 H), 2.49 - 2.68 (m, 4 H), 1.29 (d, J = 6.64, 12 H), 1.24 (d, J = 6.59 Hz, 12 H), - 3.19 (s, 2 H).- FAB-MS: m/e = 727 (M^+).- UV-Vis (CH_2CL_2): λ = 405, 503, 537, 571, 624 nm.- Anal. calc. for $C_{48}H_{62}N_4O_2$: C 79.30 H 8.60 N 7.71. Found: C 78.89 H 8.06 N 7.35.

***Etiotype-porphyrins* (6d):** Method A: Yield 0.4 % (1 mg). Method B: Yield 0.5 % (1.5 mg).

^{1}H-NMR ($CDCl_3$): δ = 10.10 (s, 4 H), 3.87 (d, 8 H), 3.58 (s, 12 H), 2.60 - 2.80 (m, 4 H), 1.19 (s, 24 H), - 3.60 (s, 2 H).- FAB-MS: m/e = 591 (M^+).- UV-Vis (CH_2Cl_2): λ = 398, 497, 533, 566, 619 nm.

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REFERENCES AND NOTES

1. D. Gust, T. A. Moore, A. L. Moore, G. Seely, P. Liddell, D. Barret, L. D. Harding, X. C. Ma, S.-J. Lee, F. Gao, *Tetrahedron* **1989**, 45, 4867 - 4892. Review: S. G. Boxer, *Biophys. Biochem. Acta* **1983**, 726, 265 - 292.
2. L. Weber, G. Haufe, *Z. Chem.* **1989**, 29, 88 - 100.
3. T. J. Dougherty, *Photochem. Photobiol.* **1987**, 879 - 889. T. J. Dougherty, *Clin. Chest. Med.* **1985**, 6, 219 -236. C. J. Gomer, *Semin. Hematol.* **1989**, 26, 27 - 34.
4. D. N. Slatkin, R. D. Stoner, K. M. Rosander, J. A. Kalef Ezra, J. A. Laissue, *Proc. Nat. Acad. Sci. USA* **1985**, 85, 4020 - 4024.
5. J. L. Mathews, J. T. Newman, F. Sogandares Bernal, M. M. Judy, H. Skiles, J. E. Leveson, A. J. Marengo-Rove, T. C. Chanh, *Transfusion (Phil.)* **1988**, 28, 81.
6. H. C. Wolf, *Nachr. Chem. Tech. Lab.* **1989**, 37, 350 - 356. G. J. Ashwell (Ed.) *Molecular Electronics*; John Wiley & Sons.: Chichester 1992.
7. V. Balzani, L. Moggi, F. Scandola. Towards a supramolecular photochemistry: assembly of molecular components to obtain photochemical molecular devices. In *Supramolecular Photochemistry*; V. Balzani Ed.; D. Reidel Publishing Comp.: Dordrecht 1987; pp. 1 - 28.
8. P. Seta, E. Bienvenue, A. L. Moore, T. A. Moore, D. Gust, *Electrochim. Acta* **1989**,34, 1723 - 1727.
9. G. Blessing, N. Holl, H. Port, H. C. Wolf, F. Effenberger, T. Kesmarzky, H. Schlosser, *Mol. Cryst. Liq. Cryst.* **1990**, 183, 21 - 30.
10. A. Osuka, T. Nagata, F. Kobayashi, K. Maruyama, *Heterocycl. Chem.* **1990**, 27, 1657 - 1659. J. S. Manka, D. S. Lawrence, *Tetrahedron Lett.* **1989**, 30, 6989 - 6992.
11. R. B. Woodward, *Angew. Chem.* **1960**, 72, 651. S. F. Marcovac, S. F. MacDonald, *Can. J. Chem.* **1965**, 43, 3364.
12. H. K. Hombrecher, G. Horter, *Liebigs Ann. Chem.* **1991**, 219 - 227.
13. The compound was synthesized in analogy to a procedure given in the literature: C. Pochin, O. Babot, J. Dunogues, F. Duboudin, *Synthesis* **1985**, 857 - 858.
14. All synthesized compounds were checked for purity by TLC and HPLC. Etiotype porphyrins **6a**, **6b** and **6d** are probable a mixture of isomers.
15. H. Falk. *The Chemistry of Linear Oligopyrroles and Bile Pigments.* Springer. Wien 1989.
16. K. Maruyama, F. Kobajashi, A. Osuka, *Bull. Chem. Soc. Jpn.* **1991**, 64, 29 - 34. A. Osuka, H. Tomita, K. Maruyama, Chem. Lett. **1988**, 1205 - 1208. A. Osuka, K. Maruyama, *Chem. Lett.* **1987**, 825 - 828.
17. C. K. Chang, I. Abdalmuhdi, *J. Org. Chem.* **1983**, 48, 5388 - 5390.

18. J. L. Sessler, M. R. Johnson, *Angew. Chem.* **1987**, 99, 679 - 680. J. L. Sessler, M. R. Johnson, S. E. Creager, J. L. Fettinger, J. A. Ibers, *J. Am. Chem. Soc.* **1990**, 112, 9310 - 9329.
19. A. Lecas-Nawrocka, B. Boitrel, E. Rose, *Tetrahedron. Lett.* **1992**, 33, 481 - 484.
20. C. J. Medforth, M. D. Barber, K. M. Smith, *Tetrahedron Lett.* **1990**, 31, 3719 - 3722.
21. K. M. Barkigia, L. Chantranupong, K. M. Smith, J. Fajer, *J. Am. Chem. Soc.* **1988**, 110, 7566 - 7567.
22. H. K. Hombrecher, G. Horter, *Synthesis* **1990**, 389 - 390.
23. N. Ono, H. Kawamura, M. Bougauchi, K. Maruyama, *Tetrahedron* **1990**, 46, 7483 - 7496.