Synthesis of 2-(Substituted Methyl)-3,4-Disubstituted Pyrroles and Their Conversion into the Corresponding Porphyrins

Hideki KINOSHITA,* Shingo TANAKA, Natsu NISHIMORI,
Hiroshi DEJIMA, and Katsuhiko INOMATA*
Department of Chemistry, Faculty of Science,
Kanazawa University, Marunouchi 1-1, Kanazawa 920
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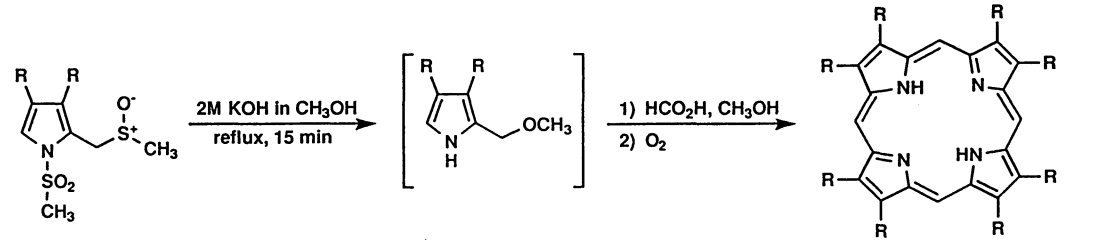
2-Hydroxymethyl-1-methylsulfonyl-3,4-disubstituted pyrroles and 2-hydroxymethyl-3,4-disubstituted pyrroles were effectively converted into the corresponding 2-(substituted methyl)pyrrole derivatives by the reaction with various nucleophiles in the presence of base. These products were further transformed to the corresponding porphyrins regioselectively under almost neutral or basic conditions.

In the previous paper,[1] we have briefly reported that 2-methoxymethyl-3,4-disubstituted pyrrole (**2**), which was easily derived from 2-methylsulfinylmethyl-1-methylsulfonyl-3,4-disubstituted pyrrole (**1**) with methanolic potassium hydroxide, was a very useful precursor for the preparation of symmetrically substituted porphyrin (**3**) as shown in Scheme 1. For instance, 3,4-diethyl-2-methoxymethylpyrrole (2a, R=C_2H_5) was effectively converted into porphyrinogen in formic acid–methanol via an intermediary 2-methylene-2*H*-pyrrole (1-azafulvene). The subsequent oxidation under oxygen atmosphere gave the corresponding 2,3,7,8,12,13,17,18-octaethylporphyrin (**3a**) in 96% yield (Scheme 1). In this synthetic way, however, the more convenient method for the preparation of **2** was required for wide synthetic applications since the starting substance (**1**) was not so readily available. We therefore investigated the development of a convenient method for the preparation of 2-(substituted methyl)-3,4-disubstituted pyrroles (**6**) including **2** as precursors leading to the porphyrins. We now wish to describe the experimental details of the transformation of **1** to **3** and especially the new findings that 2-hydroxymethyl-1-methylsulfonyl-3,4-disubstituted pyrroles (**5a—d**) and 2-hydroxymethyl-3,4-disubstituted pyrroles (**7a,b**) could be transformed to the corresponding 2-(substituted methyl)-3,4-disubstituted pyrroles (**6a—p**) in high yields and some of them could be readily converted into the corresponding unsymmetrically substituted porphyrins (**8**) under almost neutral or basic conditions.

First, we examined the conversion of the compound **5**, which was prepared by 1-methylsulfonylation of readily available ethyl 3,4-disubstituted pyrrole 2-carboxylate[2] followed by the reduction with $LiAlH_4$,[3] to 2-alkoxymethylpyrrole derivative under alkaline conditions according to the scheme shown over Table 1. Treatment of **5a** with 8 molar amounts of sodium methoxide in refluxing methanol for 30 min afforded the desired product **6a** in 76% yield. Similarly, the compounds **5** were found to react with a variety of other nucleophiles such as thiolate, dimethylamine, pyrrolidine, and piperidine in the presence of additional base to give the corresponding 2-(substituted methyl) pyrrole derivatives (**6b—i**) in good yields, respectively. The results are summarized in Table 1.

The detailed observations of the progress of the reaction indicated that when potassium hydroxide was used as a base in methanol, 2-hydroxymethylpyrrole derivative (**7**) was formed at the beginning of the reaction in Runs 7—10 different from the case in Run 1 (Table 1). Thus, 2-hydroxymethyl-3,4-disubstituted pyrrole (**7a**) prepared easier than **5a** was treated with methanolic potassium hydroxide to afford the expected product **6a** in quantitative yield (Run 1 in Table 2). In a similar way, the reaction of the compounds (**7a,b**) with various kinds of nucleophiles proceeded very smoothly in the presence of base to give the corresponding 2-(substituted methyl)pyrrole derivatives (**6b,d—g,j—p**) in high yields,

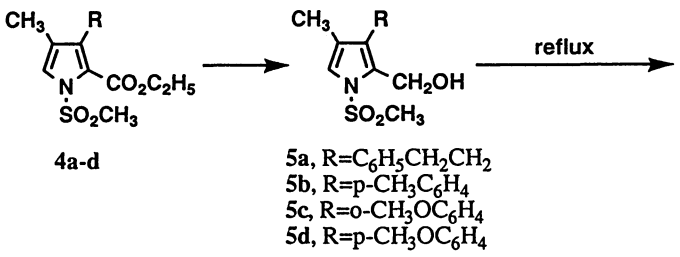


1a: R = C_2H_5
1b: R = CH_2=CH-CH_2
1c: R = $C_6H_5CH_2CH_2$

2a: R = C_2H_5
2b: R = CH_2=CH-CH_2
2c: R = $C_6H_5CH_2CH_2$

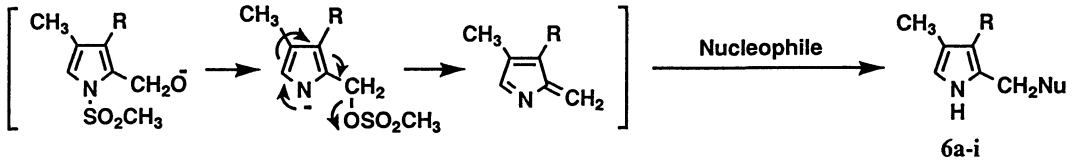
3a: R = C_2H_5, 96%
3b: R = CH_2=CH-CH_2, 93%
3c: R = $C_6H_5CH_2CH_2$, 77%

Scheme 1.



4a-d

5a, R=$C_6H_5CH_2CH_2$
5b, R=p-$CH_3C_6H_4$
5c, R=o-$CH_3OC_6H_4$
5d, R=p-$CH_3OC_6H_4$

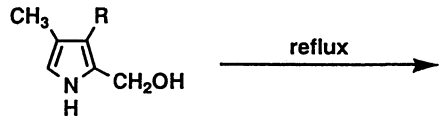


6a-i

Table 1. Preparation of 2-(Substituted Methyl)pyrrole Derivatives (**6a—i**) from the Compounds **5a—d**

Run	Substrate	Nucleophile(mol. amount)	Conditions(mol. amount)	Time/h	**6a—i** (R, Nu),	Yield/%
1	**5a**	$NaOCH_3$ (8)	$NaOCH_3$ (8)/CH_3OH	0.5	**6a** ($C_6H_5CH_2CH_2$, CH_3O),	76
2	**5a**	$NaSCH_3$ aq (2)	$NaOC_2H_5$ (2)/C_2H_5OH	4.5	**6b** ($C_6H_5CH_2CH_2$, CH_3S),	80
3	**5a**	$NaSC_6H_5$ (3)	$NaOC_2H_5$ (3.3)/DMSO[a]	4.0	**6c** ($C_6H_5CH_2CH_2$, C_6H_5S),	59
4	**5a**	$HN(CH_3)_2$ aq (2)	$NaOC_2H_5$ (3)/C_2H_5OH	3.5	**6d** ($C_6H_5CH_2CH_2$, $(CH_3)_2N$),	78
5	**5a**	$HN(CH_2)_4$ (2)	$NaOC_2H_5$ (1)/THF-C_2H_5OH	1.0[b]	**6e** ($C_6H_5CH_2CH_2$, $(CH_2)_4N$),	85
6	**5a**	$HN(CH_2)_5$ (20)	$NaOC_2H_5$ (1)/THF-C_2H_5OH	1.5[c]	**6f** ($C_6H_5CH_2CH_2$, $(CH_2)_5N$),	82
7	**5a**	$HOCH_3$ (excess)	KOH (excess)/CH_3OH	1.0	**6a** ($C_6H_5CH_2CH_2$, CH_3O),	Quant.
8	**5b**	$HOCH_3$ (excess)	KOH (excess)/CH_3OH	1.0	**6g** (*p*-$CH_3C_6H_4$, CH_3O),	Quant.
9	**5c**	$HOCH_3$ (excess)	KOH (excess)/CH_3OH	1.0	**6h** (*o*-$CH_3OC_6H_4$, CH_3O),	Quant.
10	**5d**	$HOCH_3$ (excess)	KOH (excess)/CH_3OH	1.0	**6i** (*p*-$CH_3OC_6H_4$, CH_3O),	Quant.

a) Carried out at 110 °C. b, c) Reacted for 2 and 4 h at room temperature before refluxing, respectively.



7a, R=$C_6H_5CH_2CH_2$
7b, R=p-$CH_3C_6H_4$

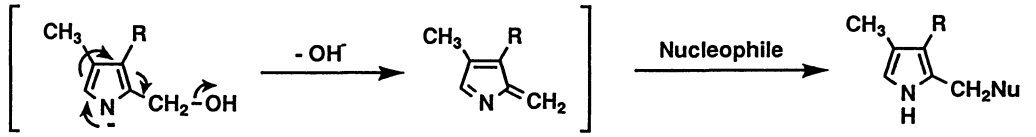


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Table 2. Preparation of 2-(Substituted Methyl)pyrrole Derivatives (**6**) from the Compounds **7**

Run	Substrate	Nucleophile(mol. amount)	Conditions(mol. amount)	Time/h	**6** (R, Nu),	Yield/%
1	**7a**	$HOCH_3$ (excess)	KOH (60)/CH_3OH	0.5	**6a** ($C_6H_5CH_2CH_2$, CH_3O),	Quant.
2	**7a**	$NaSCH_3$ aq (5)	$NaOCH_3$ (30)/CH_3OH	5	**6b** ($C_6H_5CH_2CH_2$, CH_3S),	76
3	**7a**	$HN(CH_3)_2$ aq (40)	$NaOCH_3$ (80)/CH_3OH	4	**6d** ($C_6H_5CH_2CH_2$, $(CH_3)_2N$),	81
4	**7a**	$HN(CH_2)_4$ (8)	$NaOCH_3$ (10)/CH_3OH	13	**6e** ($C_6H_5CH_2CH_2$, $(CH_2)_4N$),	89
5	**7a**	$HN(CH_2)_5$ (3)	$NaOCH_3$ (10)/CH_3OH	30	**6f** ($C_6H_5CH_2CH_2$, $(CH_2)_5N$),	80
6	**7b**	$HOCH_3$ (excess)	KOH (60)/CH_3OH	0.5	**6g** (*p*-$CH_3C_6H_4$, CH_3O),	96
7	**7b**	$NaSCH_3$ aq (5)	$NaOCH_3$ (40)/CH_3OH	3.5	**6j** (*p*-$CH_3C_6H_4$, CH_3S),	93
8	**7b**	$NaSC_6H_5$ (20)	$NaOCH_3$ (21)/CH_3OH	40	**6k** (*p*-$CH_3C_6H_4$, C_6H_5S),	48[a]
9	**7b**	KCN aq (40)	KOH (5)/CH_3OH	10	**6l** (*p*-$CH_3C_6H_4$, NC),	75
10	**7b**	$H_2NCH_2C_6H_5$ (10)	KOH (60)/CH_3OH	20	**6m** (*p*-$CH_3C_6H_4$, $C_6H_5CH_2NH$),	70
11	**7b**	$HN(CH_3)_2$ aq (40)	KOH (40)/CH_3OH	3.5	**6n** (*p*-$CH_3C_6H_4$, $(CH_3)_2N$),	93
12	**7b**	$HN(CH_2)_4$ (8)	$NaOCH_3$ (10)/CH_3OH-THF	40	**6o** (*p*-$CH_3C_6H_4$, $(CH_2)_4N$),	92
13	**7b**	$HN(CH_2)_5$ (3)	$NaOCH_3$ (10)/CH_3OH-THF	48	**6p** (*p*-$CH_3C_6H_4$, $(CH_2)_5N$),	93

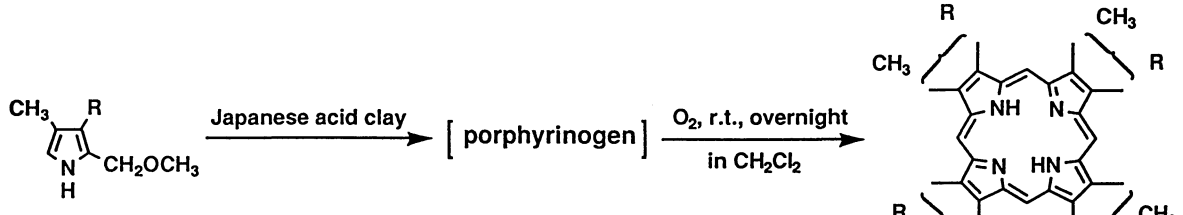
a) Performed at 70 °C and 37% of **6a** was produced.

respectively. The results are shown in Table 2. These reactions seem to proceed through elimination of the hydroxide anion to produce an intermediary 1-azafulvene followed by attack of a nucleophile to form the corresponding pyrrole derivative.

As we could realize the convenient preparative method for the compound **6**, we next examined to convert **6** thus obtained to the porphyrin **8**. Although the reaction conditions used for **2** were first applied to **6a**, both chemical yield and structurally isomeric purity of the resulting porphyrin were unsatisfactory (68% yield and the ratio of type I was 52%). Recently, Ono and Maruyama have reported that the isomerization during cyclization could be minimized in the heterogeneous reaction using silica gel as an acid catalyst.[4] In order to improve the selectivity for structural isomers of resulting porphyrin, we therefore tried to cyclize **6a** under heterogeneous reaction conditions using silica gel, Monmorillonite,[5] acid Kaolin, Florisil, or Japanese acid clay as an acid catalyst. Consequently, Japanese acid clay was found to be superior among them examined. Namely, treatment of **6a** with Japanese acid clay in 1,2-dichloroethane–methanol (5/1, v/v) at 3 °C for 16 h followed by oxidation with oxygen in dichloromethane at room temperature gave the desired porphyrin **8a** in 46% yield with 81% structurally isomeric purity (Type I). In the same way, the porphyrins (**8b—d**) were synthesized in satisfactory yields with high isomeric purity, respectively. The results are listed in Table 3.

Cyclization of pyrrole derivative to porphyrinogen has been performed in acidic medium so far. It is known that acidic reaction conditions cause the linear polymerized-pyrrole derivative and the porphyrinogen to isomerize during cyclization or on standing to result in formation of possible four isomers of porphyrins.[6] Accordingly, we attempted to convert the compound **6** to the corresponding porphyrinogen under nearly neutral or basic conditions so as to retard the isomerization. We found that the trimethylammonium salt derived from **6d** by methylation with iodomethane in situ could be cyclized to the porphyrinogen accompanied by elimination of trimethylammonium iodide. Subsequent oxidation under oxygen produced the desired porphyrin **8a** in 80% yield. However, the ratio of Type I porphyrin was very poor (Run 1 in Table 4). This is probably due to the isomerization by the action of hydrogen iodide formed in the reaction. Thus, the reaction was carried out in the presence of various additives like basic alumina, sodium carbonate, copper oxide, zinc oxide, molecular sieves, Florisil, or organic amine bases to scavenge the acid. Usage of basic alumina (activity stage I) as an additive afforded moderate results as shown in Table 4.

From the result mentioned above, we thought that porphyrin might be produced even under alkaline conditions if it is possible for the compound **7** or its anion to attack the initially formed 1-azafulvene at α-position of the pyrrole ring. Actually, when **7b** was treated with equimolar amount of sodium hydride in refluxing ether for 40 min and the reaction mixture was exposed to oxygen atmosphere, the desired porphyrin **8b** was obtained in 37% yield with ratio of type I porphyrin of 82%. A lot of attempts to improve chemical yield and isomeric purity were unsuccessful. These results indicate that the isomerization easily takes place not only



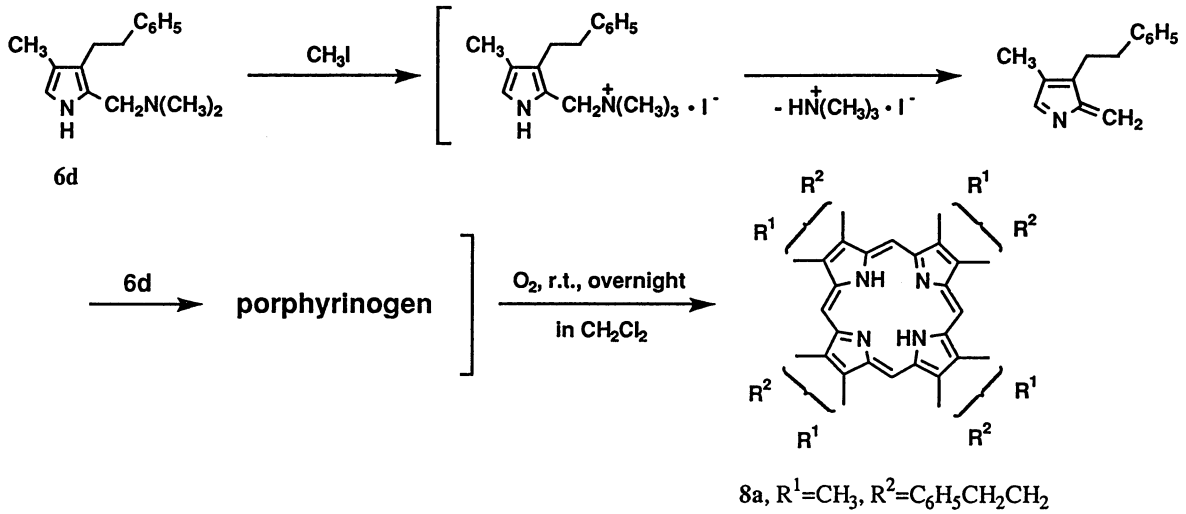
6a, R=$C_6H_5CH_2CH_2$
6g, R=p-$CH_3C_6H_4$
6h, R=o-$CH_3OC_6H_4$
6i, R=p-$CH_3OC_6H_4$

8a, R=$C_6H_5CH_2CH_2$
8b, R=p-$CH_3C_6H_4$
8c, R=o-$CH_3OC_6H_4$
8d, R=p-$CH_3OC_6H_4$

Table 3[a]. Conversion of 2-Methoxymethylpyrrole Derivatives (**6**) to Porphyrins (**8**)

Run	Substrate	Conditions	Solvent[b]	Yield/%	Ratio[c] of Type I/%
1	**6a**	3 °C, 16 h	$ClCH_2CH_2Cl$	**8a**, 46	81
2	**6g**	5 °C, 40 h	$ClCH_2CH_2Cl$	**8b**, 64	84
3	**6h**	−10 °C, 40 h	$ClCH_2CH_2Cl/CH_3OH$ (5/1)	**8c**, 87	82
4	**6i**	−15 °C, 48 h	$ClCH_2CH_2Cl/CH_3OH$ (5/1)	**8d**, 67	80

a) The reaction was performed in 0.076 mmol scale using 350 mg of the catalyst. b) 9 ml of the solvent was used. c) Determined by 400 MHz ^1H NMR spectra in comparison with the ratio of methyl protons at pyrrole rings in Runs 1,3, and 4, and meso protons in Run 2, respectively.

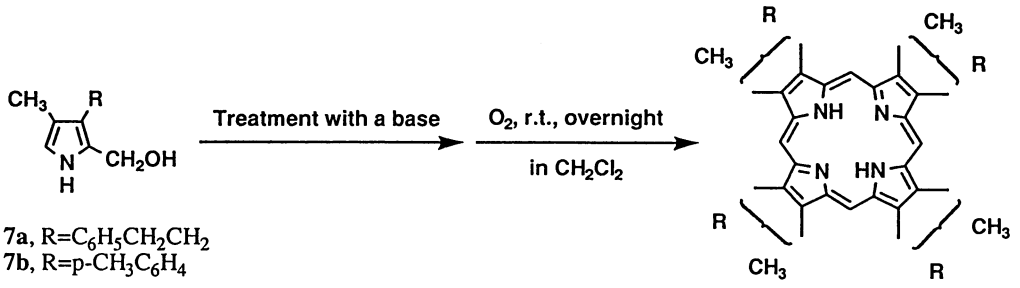


8a, $R^1=CH_3$, $R^2=C_6H_5CH_2CH_2$

Table 4[a]. Conversion of 2-(*N,N*-Dimethylaminomethyl)pyrrole Derivative (**6d**) to Porphyrins (**8a**)

Run	CH_3I(mol. amount)	Additive	Conditions	Yield/%	Ratio[b] of Type I/%
1	4	—	CH_2Cl_2, reflux, 42.5 h	73	52
2	4	—	$ClCH_2CH_2Cl$, reflux, 2 h	80	c)
3	4	Al_2O_3 (200 mg)[d]	$ClCH_2CH_2Cl$, reflux, 1.5 h	80	60
4	1.1	Al_2O_3 (200 mg)[d]	CH_2Cl_2, r.t., 23.5 h	50	81
5	1.1	Al_2O_3 (400 mg)[d]	CH_2Cl_2, r.t., 22 h	50	78
6	1.1	Al_2O_3 (800 mg)[d]	CH_2Cl_2, r.t., 1 h	25	89

a) The reaction was carried out in 0.21 mmol scale. b) Determined by 400 MHz ^{1}H NMR spectra in comparison with the ratio of methyl protons at pyrrole rings. c) Not determined. d) Al_2O_3 with activity stage I was used.



7a, $R=C_6H_5CH_2CH_2$
7b, R=p-$CH_3C_6H_4$

8a, $R=C_6H_5CH_2CH_2$
8b, R=p-$CH_3C_6H_4$

Table 5. Conversion of 2-Hydroxymethylpyrrole Derivatives (**7a,b**) to Porphyrins (**8a,b**) under Basic Conditions

Run	Substrate	Conditions				Yield/%	Ratio[a] of Type I/%
		Base(mol. amount)	Solv.	Temp	Time		
1	**7b**	NaH (1)	THF	Reflux	20 min	**8b**, 30	72
2	**7b**	NaH (1)	Ether	Reflux	40 min	**8b**, 37	82
3	**7b**	NaH (2)	Ether	Reflux	40 min	**8b**, 30	76
4	**7b**	C_2H_5MgBr (1)	THF	Reflux	18 h	**8b**, 35	70
5	**7a**	NaH (2)	Ether	r.t.	Overnight	**8a**, 35	86

a) Determined by 400 MHz ^{1}H NMR spectra in comparison with the ratio of methyl protons at pyrrole rings.

under acidic or nearly neutral conditions but also even under alkaline conditions. The results are summarized in Table 5.

As mentioned above, we could achieve the simple and general method for the preparation of 2-(substituted methyl)-3,4-disubstituted pyrroles, which are versatile substances for the synthesis of the corresponding porphyrins, starting from the readily available 2-

hydroxymethylpyrrole derivatives **5** and **7**.

Experimental

All the melting points were determined with a micro melting apparatus (Yanagimoto-Seisakusho) and were uncorrected. The ^{1}H NMR, IR, and MS spectra were recorded on JEOL JNM-GX 400 (400 MHz) FT NMR spectrometer, JASCO IRA-1 diffraction grating infrared spectrometer, Hitachi M-80 mass spectrometer, and JEOL JMS-DX 300 mass spectrometer, respectively. The chemical shifts of NMR are reported in the δ-scale relative to TMS as an internal standard.

Materials: All the solvents were distilled and stored over a drying agent. Thin-layer chromatography (TLC) and flash-column chromatography were performed by the use of Merck's silica gel 60 PF_{254} (Art. 7749) and Wakogel C-300, respectively. Japanese acid clay was purchased from Wako Pure Chemical Industries, Ltd. Aluminum oxide 90 (active basic) from Merck was used for column chromatography and as an additive shown in Table 4.

Preparation of 2-Methylsulfinylmethyl-1-methylsulfonyl-3,4-disubstituted Pyrroles (1a—c): To a solution of 1-methylsulfonyl-2-methylthiomethyl-3,4-disubstituted pyrrole[1] (0.25 mmol) in CH_3OH (4 ml) was added a solution of sodium metaperiodate (161 mg, 0.75 mmol) in water (2 ml) dropwise at room temperature. The solution was stirred for 100 min at the temperature and the solvent was removed in vacuo after quenching with aq$NaHSO_3$. The residue was partitioned between ether and water. The aqueous layer was extracted with ether and the combined extracts were washed with water and brine, dried over $MgSO_4$, and concentrated under reduced pressure. The resulting residue was subjected to preparative TLC (SiO_2, hexane/AcOEt=2/3, v/v).

Physical and spectral data of **1a—c** are shown in the following.

3,4-Diethyl-2-methylsulfinylmethyl-1-methylsulfonylpyrrole (1a): 88%; mp 103.0—104.0 °C (from benzene–hexane); IR (KBr) 3010, 2950, 2920, 2870, 1595, 1355, 1340, 1175, 1150, 1100, 1050, 970 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.13 (t, 3H, J=7.63 Hz), 1.21 (t, 3H, J=7.33 Hz), 2.40—2.51 (m, 4H), 2.66 (s, 3H), 3.24 (s, 3H), 4.27 (d, 1H, J=14.04 Hz), 4.31 (d, 1H, J=14.04 Hz), 6.92 (t, 1H, J=0.92 Hz). Found: C, 47.39; H, 7.09; N, 5.23%. Calcd for $C_{11}H_{19}NO_3S_2$: C, 47.39; N, 6.90; N, 5.05%.

2-Methylsulfinylmethyl-1-methylsulfonyl-3,4-diallylpyrrole (1b): Quant.; mp 71.0 °C (from benzene–hexane); IR (KBr) 3080, 2990, 2910, 1630, 1590, 1410, 1340, 1160, 1140, 1080, 1040, 970, 910 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.65 (s, 3H), 3.12 (m, 2H), 3.19—3.32 (m, 2H), 3.28 (s, 3H), 4.26 (d, 1H, J=14.04 Hz), 4.34 (d, 1H, J=14.04 Hz), 4.93—5.12 (m, 4H), 5.79—5.94 (m, 2H), 6.95 (t, 1H, J=1.22 Hz). Found: C, 51.86; H, 6.32; N, 4.53%. Calcd for $C_{13}H_{19}NO_3S_2$: C, 51.80; H, 6.35; N, 4.65%.

2-Methylsulfinylmethyl-1-methylsulfonyl-3,4-diphenethylpyrrole (1c): 92%; an oil; MS m/z 413 (M^+−16, 0.66%), 411 (1.95), 366 (100.00), 290 (52.01), 276 (26.47), 196 (60.68), 167 (5.95), 91 (34.30), 28 (65.59); IR (neat) 3050, 3020, 2920, 2850, 1595, 1485, 1442, 1350, 1155, 1090 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.55 (s, 3H), 2.67—2.80 (m, 6H), 2.84—2.90 (m, 2H), 3.10 (s, 3H), 3.83 (d, 1H, J=14.18 Hz), 3.87 (d, 1H, J=14.18 Hz), 6.91 (t, 1H, J=0.91 Hz), 7.04—7.33 (m, 10H).

Preparation of Ethyl 1-Methylsulfonyl-3,4-disubstituted 2-Pyrrolecarboxylates (4a—d): To a suspension of NaH (60% oil dispersion, 1.5 mmol) in dry THF (2 ml) was added a solution of the corresponding ethyl 3,4-disubstituted 2-pyrrolecarboxylate (1 mmol) in dry THF (1 ml) at room temperature under N_2. The reaction mixture was refluxed for 30 min and then a solution of methanesulfonyl chloride (3 mmol) in dry THF (2 ml) was added to it at 0 °C. The reaction mixture was allowed to stand overnight with stirring at room temperature. After quenching with brine, the solvent was removed in vacuo to give the residue which was partitioned between ether and water. The ethereal extract was dried over $MgSO_4$ and removal of the ether afforded the crude product which was purified with preparative TLC (SiO_2, hexane/ethyl acetate=5/1, v/v) or flash-column chromatography.

Physical and spectral data of **4a—d** are shown in the following.

Ethyl 4-Methyl-1-methylsulfonyl-3-phenethyl-2-pyrrolecarboxylate (4a): 74%; mp 76.0—76.5 °C (from hexane); IR (KBr) 3120, 3050, 3020, 2980, 2900, 2820, 1680, 1590, 1350, 1240, 1160, 1040, 950 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.39 (t, 3H, J=7.30 Hz), 1.89 (s, 3H), 2.78 (m, 2H), 2.93 (m, 2H), 3.65 (s, 3H), 4.34 (q, 2H, J=7.30 Hz), 7.14—7.28 (m, 6H). Found: C, 60.87; H, 6.31; N, 4.18%. Calcd for $C_{17}H_{21}NO_4S$: C, 60.61; H, 6.47; N, 4.25%.

Ethyl 4-Methyl-1-methylsulfonyl-3-(*p*-tolyl)-2-pyrrolecarboxylate (4b): 51%; mp 132.5—133.0 °C (from cyclohexane); IR (KBr) 3120, 3040, 3000, 2920, 2860, 1700, 1352, 1240, 1158, 1107 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=0.97 (t, 3H, J=7.02 Hz), 1.90 (d, 3H, J=0.92 Hz), 2.39 (s, 3H), 3.70 (s, 3H), 4.08 (q, 2H, J=7.02 Hz), 7.11 (d, 2H, J=8.24 Hz), 7.18 (d, 2H, J=8.24 Hz), 7.22 (q, 1H, J=0.92 Hz). Found: C, 59.79; H, 6.10; N, 4.27%. Calcd for $C_{16}H_{19}NO_4S$: C, 59.79; H, 5.96; N, 4.36%.

Ethyl 4-Methyl-1-methylsulfonyl-3-(*o*-methoxyphenyl)-2-pyrrolecarboxylate (4c): 52%; mp 131.5—132.0 °C (from benzene); IR (KBr) 3120, 3020, 2980, 2920, 2820, 1700, 1591, 1560, 1352, 1230, 1160, 1120, 1110 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=0.89 (t, 3H, J=7.02 Hz), 1.87 (d, 3H, J=1.22 Hz), 3.72 (s, 3H), 3.75 (s, 3H), 4.03 (q, 2H, J=7.02 Hz), 6.92 (dd, 1H, J=0.92, 7.32 Hz), 6.97 (dt, 1H, J=0.92, 7.32 Hz), 7.12 (dd, 1H, J=1.83, 7.32 Hz), 7.22 (q, 1H, J=1.22 Hz), 7.32 (dt, 1H, J=1.83, 7.32 Hz). Found: C, 57.10; H, 5.77; N, 3.96%. Calcd for $C_{16}H_{19}NO_5S$: C, 56.96; H, 5.68; N, 4.15%.

Ethyl 4-Methyl-1-methylsulfonyl-3-(*p*-methoxyphenyl)-2-pyrrolecarboxylate (4d): 83%; mp 100.0—101.0 °C (from hexane); IR (KBr) 3140, 3040, 3010, 2980, 2920, 2840, 1700, 1600, 1578, 1355, 1250, 1160, 1120 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.00 (t, 3H, J=7.02 Hz), 1.91 (d, 3H, J=0.92 Hz), 3.69 (s, 3H), 3.84 (s, 3H), 4.09 (q, 2H, J=7.02 Hz), 6.91 (d, 2H, J=8.85 Hz), 7.16 (d, 2H, J=8.85 Hz), 7.22 (q, 1H, J=0.92 Hz). Found: C, 56.92; H, 5.74; N, 4.15%. Calcd for $C_{16}H_{19}NO_5S$: C, 56.96; H, 5.68; N, 4.15%.

Preparation of 2-Hydroxymethyl-1-methylsulfonylpyrrole Derivatives (5a—d): To a suspension of $LiAlH_4$ (57 mg, 1.5 mmol) in dry ether (15 ml) was added a solution of the foregoing 2-pyrrolecarboxylic esters (**4a—d**) (0.75 mmol) in dry ether (2 ml) dropwise slowly at 0 °C under N_2. After stirring for 30 min at 0 °C, the reaction mixture was worked up in the usual way. The alcohol derivatives (**5a—d**) obtained in high yields were used for the subsequent reaction without further purification.

Preparation of 2-(Substituted Methyl)-3,4-disubstituted Pyrroles (2a—c, 6a—p): Method A (Starting from the Compounds 1): A solution of **1a** (50 mg, 0.18 mmol) in 3 ml of 2

M methanolic potassium hydroxide (1 M=1 mol dm^{-3}) was refluxed for 10 min. The methanol was removed under reduced pressure to afford the residue which was partitioned between ether and water. The aqueous layer was extracted with ether after salting out. The combined extracts were washed with water and brine, dried over Na_2SO_4, and concentrated in vacuo to give the product **2a** in quantitative yield (30 mg); an oil; MS *m/z* 167 (M^+, 49.43%), 138 (26.14), 136 (100.00), 108 (8.29), 45 (17.40); IR (neat) 3360, 2920, 2850, 1730, 1440, 1360, 1305, 1225, 1185, 1160, 1070, 950, 880 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.10 (t, 3H, *J*=7.63 Hz), 1.19 (t, 3H, *J*=7.63 Hz), 2.45 (q, 4H, *J*=7.63 Hz), 3.31 (s, 3H), 4.37 (s, 2H), 6.49 (d, 1H, *J*=2.44 Hz), 7.97 (br, 1H).

In the same way, **2b** and **c** were prepared and used in the subsequent reaction.

Method B (Starting from the Compounds 5): To a methanolic solution of **5a** (85 mg, 0.3 mmol) was added 8 molar amounts of 2.6 M sodium methoxide in MeOH at room temperature under N_2. The solution was refluxed for 30 min. The solvent was evaporated and the residue was partitioned between benzene and water. The aqueous layer was extracted with benzene. The combined extracts were washed with water and brine, dried over Na_2SO_4, and concentrated under reduced pressure. The residual oil was subjected to basic alumina-column chromatography (activity stage III, benzene) to give the desired product **6a** in 76% yield. In a similar way, other products (**6b—i**) were prepared by the reaction of the compounds **5a—d** with a variety of nucleophiles under the reaction conditions shown in Table 1.

Method C (Starting from the Compounds 7): The compound **7b** (21 mg, 0.1 mmol), which was prepared according to the reported procedure[3] and used without further purification, was dissolved in abs MeOH (3 ml) at room temperature under N_2. To the solution was added 8 molar amounts of pyrrolidine (57 mg, 0.8 mmol) in THF (1 ml) followed by the addition of 10 molar amounts of 3 M sodium methoxide in abs MeOH. The reaction mixture was refluxed for 40 h and then the solvent was removed in vacuo to afford the residue which was partitioned between ether and water. The aqueous layer was extracted with ether. The combined extracts were washed with water and brine, dried over $MgSO_4$, and concentrated under reduced pressure. The residue was subjected to preparative TLC (SiO_2, chloroform/EtOH=10/1, v/v). The desired product **6o** was obtained in 92% yield. Similarly, other products (**6a,b,d—g,j—n,p**) were prepared under the reaction conditions listed in Table 2.

Physical and spectral data of **6a—p** are shown in the following.

2-Methoxymethyl-4-methyl-3-phenethylpyrrole (6a): An oil; MS *m/z* 229 (M^+, 17.58%), 181 (14.49), 163 (100.00), 91 (32.02), 28 (76.65); IR (neat) 3300, 3040, 3000, 2900, 2840, 1590, 1570, 1480, 1440, 1060 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.03 (s, 3H), 2.70—2.76 (m, 4H), 3.25 (s, 3H), 4.18 (s, 2H), 6.50 (d, 1H, *J*=0.98 Hz), 7.14—7.26 (m, 5H), 7.90 (br, 1H).

4-Methyl-2-methylthiomethyl-3-phenethylpyrrole (6b): An oil; MS *m/z* 245 (M^+, 11.19%), 198 (100.00), 108 (63.06); IR (neat) 3440, 3020, 2900, 2840, 1590, 1480, 1470, 1440, 1060, 1020, 740 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.92 (s, 3H), 2.02 (d, 3H, *J*=0.92 Hz), 2.65—2.77 (m, 4H), 3.46 (s, 2H), 6.47 (dd, 1H, *J*=0.92, 2.44 Hz), 7.14—7.20 (m, 3H), 7.23—7.28 (m, 2H), 7.89 (br, 1H).

4-Methyl-3-phenethyl-2-phenylthiomethylpyrrole (6c): An oil; MS *m/z* 307 (M^+, 2.05%), 198 (100.00), 110 (11.46), 107 (26.02), 91 (14.18); IR (neat) 3200, 3020, 2900, 2840, 1590, 1460, 1440, 1340, 1150 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.07 (s, 3H), 2.75 (m, 4H), 4.37 (s, 2H), 6.49 (s, 1H), 7.16—7.24 (m, 10H), 8.10 (br, 1H).

2-(*N,N*-Dimethylaminomethyl)-4-methyl-3-phenethylpyrrole (6d): Mp 78.0—78.5 °C (from hexane); IR (KBr) 3150, 3060, 3040, 2930, 2860, 2830, 1595, 1580, 1445, 1350, 1240, 1025, 995, 825 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.03 (s, 3H), 2.17 (s, 6H), 2.71 (m, 4H), 3.21 (s, 2H), 6.47 (s, 1H), 7.16—7.29 (m, 5H), 8.14 (br, 1H). Found: C, 79.24; H, 9.26; N, 11.49%. Calcd for $C_{16}H_{22}N_2$: C, 79.29; H, 9.15; N, 11.56%.

4-Methyl-3-phenethyl-2-(1-pyrrolidinylmethyl)pyrrole (6e): An oil; MS *m/z* 268 (M^+, 6.66%), 198 (42.82), 197 (64.55), 196 (48.90), 136 (3.46), 108 (26.55), 91 (100.00), 71 (16.88), 70 (26.00), 43 (47.17); IR (neat) 3440, 3160, 3060, 3020, 2960, 2900, 2840, 2800, 1595, 1585, 1480, 1440, 1340, 1120, 1020, 870 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.75 (m, 4H), 2.02 (s, 3H), 2.44 (m, 4H), 2.66—2.76 (m, 4H), 3.40 (s, 2H), 6.44 (s, 1H), 7.15—7.18 (m, 3H), 7.23—7.28 (m, 2H), 8.37 (br, 1H).

4-Methyl-3-phenethyl-2-(1-piperidinylmethyl)pyrrole (6f): Mp 98.0—98.5 °C (from hexane); IR (KBr) 3160, 3060, 3030, 2930, 1595, 1580, 1445, 1340, 1200, 1080, 965 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.41 (m, 2H), 1.53 (m, 4H), 2.03 (s, 3H), 2.29 (m, 4H), 2.70 (m, 4H), 3.24 (s, 2H), 6.46 (d, 1H, *J*=1.22 Hz), 7.15—7.20 (m, 3H), 7.24—7.29 (m, 2H), 8.18 (br, 1H). Found: C, 80.70; H, 9.48; N, 9.84%. Calcd for $C_{19}H_{26}N_2$: C, 80.80; H, 9.28; N, 9.92%.

2-Methoxymethyl-4-methyl-3-(*p*-tolyl)pyrrole (6g): An oil; MS *m/z* 215 (M^+, 87.36%), 185 (17.52), 184 (100.00), 183 (18.65), 182 (11.77), 169 (7.80), 168 (19.77), 163 (22.22); IR (neat) 3300, 2920, 1600, 1580, 1525, 1440, 1070, 810 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.08 (d, 3H, *J*=0.92 Hz), 2.38 (s, 3H), 3.30 (s, 3H), 4.38 (s, 2H), 6.58 (dd, 1H, *J*=0.92, 2.44 Hz), 7.19 (s, 4H), 8.13 (br, 1H).

2-Methoxymethyl-3-(*o*-methoxyphenyl)-4-methylpyrrole (6h): An oil; MS *m/z* 231 (M^+, 100.00%), 201 (9.93), 200 (51.92), 169 (11.40), 164 (12.09), 163 (50.00), 116 (7.08), 69 (4.39); IR (neat) 3300, 3040, 2880, 1600, 1580, 1520, 1440, 1230, 1165, 1070, 985 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.97 (d, 3H, *J*=0.91 Hz), 3.25 (s, 3H), 3.78 (s, 3H), 4.30 (s, 2H), 6.62 (dd, 1H, *J*=0.91, 2.44 Hz), 6.94—7.30 (m, 4H), 8.22 (br, 1H).

2-Methoxymethyl-3-(*p*-methoxyphenyl)-4-methylpyrrole (6i): An oil; MS *m/z* 231 (M^+, 83.72%), 200 (100.00), 184 (23.33), 169 (7.75), 116 (4.11); IR (neat) 3300, 3020, 2900, 2820, 1600, 1580, 1520, 1440, 1275, 1230, 1165, 1070, 900, 820 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.07 (d, 3H, *J*=0.92 Hz), 3.29 (s, 3H), 3.83 (s, 3H), 4.36 (s, 2H), 6.57 (dd, 1H, *J*=0.92, 2.44 Hz), 6.93 (d, 2H, *J*=8.85 Hz), 7.22 (d, 2H, *J*=8.85 Hz), 8.24 (br, 1H).

4-Methyl-2-methylthiomethyl-3-(*p*-tolyl)pyrrole (6j): An oil; MS *m/z* 231 (M^+, 15.65%), 184 (100.00), 169 (14.90), 97 (5.86), 71 (6.16), 57 (4.90); IR (neat) 3240, 3020, 2920, 2860, 1605, 1580, 1530, 1440, 1250, 1100, 990, 810 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=1.94 (s, 3H), 2.05 (d, 2H, *J*=0.91 Hz), 2.38 (s, 3H), 3.71 (s, 2H), 6.59 (dd, 1H, *J*=0.91, 2.44 Hz), 7.19 (m, 4H), 8.16 (br, 1H).

4-Methyl-2-phenylthiomethyl-3-(*p*-tolyl)pyrrole (6k): An oil; MS *m/z* 293 (M^+, 2.68%), 184 (100.00), 169 (9.22), 168 (5.89); IR (neat) 3440, 3060, 3020, 2930, 1600, 1580, 1475, 1435, 1250, 1080, 990, 810 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ=2.03 (d, 3H, *J*=0.91 Hz), 2.37 (s, 3H), 4.13 (s, 2H), 6.54 (dd, 1H, *J*=0.91, 2.44 Hz), 7.13—7.24 (m, 9H), 8.03 (br, 1H).

2-Cyanomethyl-4-methyl-3-(*p*-tolyl)pyrrole (6l): An oil; MS *m/z* 210 (M^+, 100.00%), 209 (34.47), 195 (24.38), 184

(11.70), 182 (6.84), 170 (5.17), 168 (12.03); IR (KBr) 3370, 3020, 2920, 2820, 2240, 1600, 1580, 1515, 1100, 990, 810 cm^{-1}; ^1H NMR ($CDCl_3$) δ=2.03 (d, 3H, J=0.91 Hz), 2.39 (s, 3H), 3.70 (s, 2H), 6.61 (dd, 1H, J=0.91, 2.44 Hz), 7.13 (d, 2H, J=8.24 Hz), 7.20 (d, 2H, J=8.24 Hz), 8.11 (br, 1H).

2-Benzylaminomethyl-4-methyl-3-(*p*-tolyl)pyrrole (6m): Mp 111.0—112.0 °C (from hexane); IR (KBr) 3310, 3140, 3080, 3040, 1605, 1580, 1530, 1445, 1075, 818, 745 cm^{-1}; ^1H NMR ($CDCl_3$) δ=1.92 (bs, 1H), 2.07 (d, 3H, J=0.92 Hz), 2.38 (s, 3H), 3.72 (s, 2H), 3.80 (s, 2H) , 6.56 (dd, 1H, J=0.92, 2.44 Hz), 7. 13 (d, 2H, J=8.55 Hz), 7.17 (d, 2H, J=8.55 Hz), 7.21—7.29 (m, 5H), 8.54 (br, 1H). Found: C, 82.65; H, 7.77; N, 9.59%. Calcd for $C_{20}H_{22}N_2$: C, 82.72; H, 7.64; N, 9.65%.

4-Methyl-2-(*N,N*-dimethylaminomethyl)-3-(*p*-tolyl)pyrrole (6n): Mp 103.5—104.0 °C (from hexane); IR (KBr) 3140, 3060, 2920, 2860, 2830, 1605, 1525, 1170, 990, 830, 810 cm^{-1}; ^1H NMR ($CDCl_3$) δ=2.05 (d, 3H, J=0.92 Hz), 2.22 (s, 6H), 2.38 (s, 3H), 3.49 (s, 2H), 6.58 (dd, 1H, J=0.92, 2.44 Hz), 7.14 (d, 2H, J=8.24 Hz), 7.18 (d, 2H, J=8.24 Hz), 8.72 (br, 1H). Found: C, 79.11; H, 9.07; N, 12.00%. Calcd for $C_{15}H_{20}N_2$: C, 78.90; H, 8.83; N, 12.27%.

4-Methyl-2-(1-pyrrolidinylmethyl)-3-(*p*-tolyl)pyrrole (6o): Mp 101.0 °C (from pet. ether); MS m/z 254 (M^+, 23.85%), 185 (21.45), 184 (100.00), 183 (31.07), 168 (24.80); IR (KBr) 3140, 3040, 2920, 2810, 1610, 1580, 1522, 1100, 805, 730 cm^{-1}; ^1H NMR ($CDCl_3$) δ=1.73 (m, 4H), 2.05 (d, 3H, J=0.91 Hz), 2.37 (s, 3H), 2.46 (m, 4H), 3.62 (s, 2H), 6.56 (dd, 1H, J=0.91, 2.44 Hz), 7.15 (d, 2H, J=8.54 Hz), 7.18 (d, 2H, J=8.54 Hz), 8.56 (br, 1H). Found: C, 80.06; H, 9.08; N, 10.96%. Calcd for $C_{17}H_{22}N_2$: C, 80.27; H, 8.72; N, 11.01%.

4-Methyl-2-(1-piperidinylmethyl)-3-(*p*-tolyl)pyrrole (6p): Mp 122.0—123.0 °C (from cyclohexane); MS m/z 268 (M^+, 32.54%), 185 (25.62), 184 (100.00), 183 (37.76), 168 (28.20), 84 (28.11); IR (KBr) 3180, 3080, 3040, 2960, 2820, 1615, 1590, 1530, 1338, 1100, 980, 815 cm^{-1}; ^1H NMR ($CDCl_3$) δ=1.40 (m, 2H), 1.45—1.60 (m, 4H), 2.05 (d, 2H, J=0.91 Hz), 2.32 (m, 4H), 2.38 (s, 3H), 3.45 (s, 2H), 6.56 (dd, 1H, J=0.91, 2.44 Hz), 7.15 (d, 2H, J=8.24 Hz), 7.18 (d, 2H, J=8.24 Hz), 8.73 (br, 1H). Found: C, 80.63; H, 9.41; N, 10.38%. Calcd for $C_{18}H_{24}N_2$: C, 80.55; H, 9.01; N, 10.44%.

Preparation of Porphyrins (8): Method A (from the Compounds 1a—c): A solution of **1** (0.18 mmol) in 3 ml of 2 M methanolic potassium hydroxide was refluxed for 10 min. The solvent was removed in vacuo to afford the residue which was partitioned between ether and water. The aqueous layer was extracted with ether and the combined extracts were washed with water and brine, dried over Na_2SO_4, and concentrated to ca. 1 ml of the solution. To the ethereal solution was added 3 ml of abs CH_3OH and the solution was concentrated to ca. 1 ml of the solution. This procedure was repeated once more to replace the solvent to methanol avoiding the decomposition of the unstable product **2**. To the resulting solution (ca. 1 ml) was added 2 ml of 99% formic acid under N_2. The solution was stirred for 2 h at room temperature and concentrated in vacuo to afford the residue which was placed in a desiccater in the pesence of solid NaOH under reduced pressure for a couple of hours. The residue was dissolved in 3 ml of dichloromethane and the solution was stirred for 3—5 h under oxygen atmosphere. After removal of the solvent, the resulting residue was passed through a silica-gel column using CH_2Cl_2 as eluent to afford **3**.

Method B (from the Compounds 6a,g—i): To a suspension of Japanese acid clay (350 mg) in 4 ml of the solvent (see Table 3) was added a solution of **6** (0.076 mmol) in 5 ml of the solvent at the temperature shown in Table 3. The reaction mixture was vigorously stirred. Then, the catalyst was filtered off and washed with a small amount of the solvent. The filtrate was concentrated in vacuo to give the residual oil which was dissolved in 4 ml of CH_2Cl_2. The solution was allowed to stand overnight under O_2 at room temperature with vigorous stirring. After evaporation of the solvent, the residue was passed through a silica-gel column using CH_2Cl_2 as eluent. The desired porphyrins **8a—d** were obtained as shown in Table 3. Ratio of type I porphyrin was determined by 400 MHz ^1H NMR.

Method C (from the Compound 6d): To **6d** (50 mg, 0.21 mmol) and basic alumina (200 mg, activity stage I) was added 5 ml of $ClCH_2CH_2Cl$ (passed through a basic alumina (activity stage I) column before use) at room temperature under N_2. Then, 0.84 ml (4 molar amounts) of 1 M CH_3I solution in $ClCH_2CH_2Cl$ was added to it. The reaction mixture was refluxed for 1.5 h and after cooling, it was allowed to stand overnight at room temperature under O_2 with stirring. After filtration of the alumina, the solvent was removed in vacuo to afford a residue. The desired porphyrin was isolated by silica-gel column chromatography using CH_2Cl_2 as eluent (80% yield). In a similar way, Runs 1, 2, 4, 5, and 6 were carried out under the reaction conditions listed in Table 4.

Method D (from the compounds 7): To a suspension of NaH (equimolar amount, 60% oil dispersion) in dry ether (1 ml) was added a solution of **7b** in dry ether (2 ml) at room temperature under N_2. The reaction mixture was refluxed for 40 min and quenched with brine after cooling to room temperature. The reaction mixture was extracted with ether. The combined extracts were washed with water and brine. After drying over Na_2SO_4, the ethereal solution was passed through alumina column (activity stage III) using ether as eluent. Removal of the solvent gave the residue which was oxidized to porphyrin and isolated in the same manner as described for Method B. The compound **8b** was obtained in 37% yield.

Physical and spectral data of the compounds **3a—c**, **8a—d** are shown in the following.

2,3,7,8,12,13,17,18-Octaethylporphyrin (3a): 96%, mp 328 °C (from CH_2Cl_2–hexane), lit, 324—325 °C[3]; MS m/z 534 (M^+); IR (KBr) 3290, 2945, 2910, 2850, 1590, 1455, 1360, 1305, 1260, 1175, 1130, 1105, 1045, 1000, 990, 940 cm^{-1}; ^1H NMR ($CDCl_3$) δ=−3.74 (br, 2H), 1.92 (t, 24H, J=7.30 Hz), 4.11 (q, 16H, J=7.30 Hz), 10.10 (s, 4H); UV (CH_2Cl_2) 397 (ε=1.76×10^5), 498 (1.45×10^4), 531 (1.05×10^4), 565 (7.01×10^3), 619 (5.01×10^3) nm. Found: C, 81.10; H, 8.84; N, 10.27%. Calcd for $C_{36}H_{46}N_4$: C, 80.85; H, 8.67; N, 10.48%.

2,3,7,8,12,13,17,18-Octaallylporphyrin (3b): 93%, mp 270 °C (from cyclohexane); MS m/z 630 (M^+); IR (KBr) 3320, 3080, 2980, 2900, 1620, 1430, 1205, 980, 900 cm^{-1}; ^1H NMR ($CDCl_3$) δ=−3.58 (br, 2H), 4.80 (d, 16H, J=6.34 Hz), 5.24 (dd, 8H, J=1.95, 10.25 Hz), 5.38 (dd, 8H, J=1.95, 17.09 Hz), 6.56 (ddt, 8H, J=6.34, 10.25, 17.09 Hz), 10.14 (s, 4H); UV (CH_2Cl_2) 404 (ε=2.52×10^5), 500 (2.20×10^4), 537 (1.44×10^4), 569 (9.97×10^3), 624 (5.79×10^3) nm. Found: C, 83.85; H, 7.27; N, 8.97%. Calcd for $C_{44}H_{46}N_4$: C, 83.77; H, 7.35; N, 8.87%.

2,3,7,8,12,13,17,18-Octaphenethylporphyrin (3c): 77%; mp 293 °C (from benzene); FAB-MS m/z 1037 (M^+−$C_6H_5CH_2CH_2$); IR (KBr) 3320, 3030, 2920, 2850, 1595, 1485, 1440, 1050, 1020, 820 cm^{-1}; ^1H NMR ($CDCl_3$) δ=−3.62 (br, 2H), 3.52 (t, 8H, J=7.81 Hz), 4.22 (t, 8H, J=7.81 Hz), 7.11—7.48 (m, 40H), 10.02 (s, 4H); UV (CH_2Cl_2) 404 (ε=1.62×10^5),

500 (1.32×10^4), 537 (9.81×10^3), 569 (6.23×10^3), 622 (4.36×10^3) nm. Found: C, 88.09; H, 6.90; N, 4.98%. Calcd for $C_{84}H_{78}N_4$: C, 88.23; H, 6.88; N, 4.90%.

2,7,12,17-Tetramethyl-3,8,13,18-tetraphenethylporphyrin (8a): Mp 265.0—266.0 °C (from benzene–hexane); FAB-MS *m/z* 782 (M^+); IR (KBr) 3300, 2920, 1595, 1495, 1440, 1220, 1190, 1100, 1020, 820, 735 cm^{-1}; ^1H NMR ($CDCl_3$) δ=−3.73 (br, 2H), 3.39 (m, 12H), 3.58 (m, 8H), 4.35 (m, 8H), 7.19—7.24 (m, 20H), 9.94 (s, 4H); UV (CH_2Cl_2) 399 ($\varepsilon=1.63\times10^5$), 498 ($1.33\times10^4$), 531 ($9.70\times10^3$), 566 ($6.57\times10^3$), 621 ($4.69\times10^3$) nm. Found: C, 89.62; H, 6.74; N, 7.10%. Calcd for $C_{56}H_{54}N_4$: C, 89.89; H, 6.95; N, 7.15%.

2,7,12,17-Tetramethyl-3,8,13,18-tetra(*p*-tolyl)porphyrin (8b):[4] Mp >300 °C (from CH_2Cl_2–hexane); FAB-MS *m/z* 727 (M^++1); IR (KBr) 3300, 2920, 1590, 1440, 1220, 1175, 1010, 990, 815 cm^{-1}; ^1H NMR ($CDCl_3$) δ=−3.42 (br, 2H), 2.68 (s, 12H), 3.58 (s, 12H), 7.66 (d, 8H, *J*=7.81 Hz), 8.06 (d, 8H, *J*=7.81 Hz), 10.15 (s, 4H); UV (CH_2Cl_2) 406 ($\varepsilon=1.35\times10^5$), 504 ($1.02\times10^4$), 539 ($8.39\times10^3$), 571 ($4.79\times10^3$), 625 ($2.94\times10^3$) nm.

2,7,12,17-Tetramethyl-3,8,13,18-tetra(*o*-methoxyphenyl)-porphyrin (8c):[4] Mp >300 °C (from CH_2Cl_2–hexane); FAB-MS *m/z* 792 (M^++2); IR (KBr) 3320, 2920, 1585, 1575, 1480, 1455, 1425, 1240, 1020, 1005, 990, 740 cm^{-1}; ^1H NMR ($CDCl_3$) δ=−3.34 (br, 2H), 3.41 (s, 12H), 3.84 (s, 3H), 3.85 (s, 3H), 3.87 (s, 3H), 3.88 (s, 3H), 7.35—7.43 (m, 8H), 7.67—7.71 (m, 4H), 7.94—7.98 (m, 4H), 9.98 (s, 4H); UV (CH_2Cl_2) 406 ($\varepsilon=2.22\times10^5$), 503 ($1.67\times10^4$), 538 ($1.23\times10^4$), 570 ($7.20\times10^3$), 623 ($5.11\times10^3$) nm.

2,7,12,17-Tetramethyl-3,8,13,18-tetra(*p*-methoxyphenyl)-porphyrin (8d):[4] Mp >300 °C (from CH_2Cl_2–hexane); FAB-MS *m/z* 791 (M^++1); IR (KBr) 3300, 2900, 1600, 1590, 1495, 1280, 1240, 1160, 820 cm^{-1}; ^1H NMR ($CDCl_3$) δ=−3.42 (br, 2H), 3.57 (s, 12H), 4.08 (s, 12H), 7.39 (d, 8H, *J*=8.30 Hz), 8.09 (d, 8H, *J*=8.30 Hz), 10.12 (s, 4H); UV (CH_2Cl_2) 406 ($\varepsilon=2.97\times10^5$), 506 ($2.24\times10^4$), 541 ($2.01\times10^4$), 571 ($1.04\times10^4$), 626 ($6.68\times10^3$) nm.

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