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PORPHYRINS. 39.* SYNTHESIS AND CHEMICAL TRANSFORMATIONS OF PORPHYRINS AND CHLORINS WITH 2-ACETYL-1-METHYL-3-OXOBUTYL SUBSTITUENTS

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Porphyrins and chlorins containing acetylacetone residues in the peripheral substituents [–CH(Me)CHAc$_2$] are converted under alkaline conditions into the corresponding deacetylated compounds with [–CH(Me)CH$_2$Ac] residues. Reduction of the latter as acids using sodium borohydride gives the corresponding alcohols and, after esterification, their acetates with branched peripheral [–CH(Me)CH$_2$CH(OAc)Me] substituents. Porphyrins and chlorins with such substituents in water-soluble form may hold interest as new photosensitizers in photodynamic cancer therapy.

Keywords: acetylacetone, deuteroporphyrin-IX, phaeophorbide A, chlorin e$_6$, ketonic splitting.

It has been possible to synthesize tetrapyrrole compounds with given properties using the structural-functional approach employed in the preparation of new photosensitizers for the photodynamic treatment of tumors with high tumorotropicity and high efficiency for the destruction of tumor tissue upon irradiation [2-7]. Porphyrins containing alkoxymethyl, 1-hydroxyethyl, or 1-alkoxyethyl substituents such as the tetramethyl ester of hematoporphyrin-IX [1, 8-11] readily react with acetylacetone and other β-diketones in the presence of zinc acetate to give zinc complexes such as **1** in high yield [1, 10]. Brief treatment of these complexes with hydrochloric acid gives porphyrins such as **2**.

In the present work, we continue an investigation of the chemical properties of porphyrins containing β-diketone residues and their derivatives in a search for compounds with selective tumorotropicity. Porphyrins containing β-diketone residues and their derivatives have not been studied relative to their use in photodynamic tumor therapy.

In order to elucidate the effect of the 2-acetyl-1-methyl-3-oxobutyl substituent on the photodynamic properties of porphyrins, we obtained new porphyrins **3-6**, containing only one such peripheral group. These compounds were obtained starting from the well-known dimethyl esters of 2- and 4-acetyldeuteroporphyrin-IX **7**

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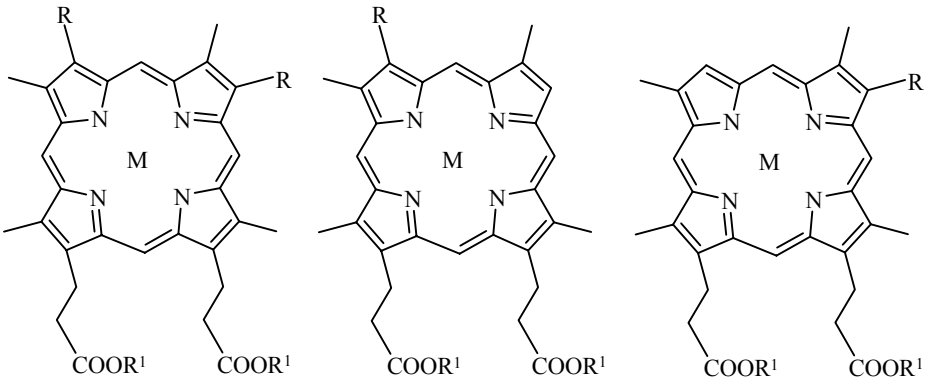
and **8** [12-15]. The reduction of **7** and **8** using sodium borohydride gave pure isomers, namely, the dimethyl ester of 2-(1-hydroxyethyl)deuteroporphyrin-IX (**9**) and the dimethyl ester of 4-(1-hydroxyethyl)deuteroporphyrin-IX (**10**). The structure of these products was established using ^{1}H NMR spectroscopy and the nuclear Overhauser effect. These experiments showed that the chromatographically more mobile isomer corresponds to the dimethyl ester of 2-(1-hydroxyethyl)deuteroporphyrin-IX (**9**), while the less mobile product corresponds to the dimethyl ester of 4-(1-hydroxyethyl)deuteroporphyrin-IX (**10**). These results are in accord with the data obtained by Smith [15] and Clezy [16] on the chromatographic mobility of these compounds.



1–**6** R = CH(Me)CHAc$_2$; **7**, **8** R = Ac; **9**,**10** R = CH(OH)Me; **11**–**19** R = CH(Me)CH$_2$Ac;
20–**28** R = CH(Me)CH$_2$CH(OH)Me; **29**–**31** R = CH(Me)CH$_2$CH(OAc)Me;
1–**10**, **14**–**19**, **23**–**31** R^1 = Me; **11**–**13**, **20**–**22** R^1 = K; **1**, **3**, **5**, **11**–**16**, **20**–**25** M = Zn;
2, **4**, **6**, **17**–**19**, **26**–**31** M = 2H

Heating isomers **9** and **10** in acetylacetone in the presence of zinc acetate leads to the zinc complexes of porphyrins **3** and **5** in high yield. The ^{1}H NMR spectra of porphyrins with CH(CH$_3$)CH(COCH$_3$)COCH$_3$ substituents, as noted in our previous work [1], have several distinguishing features: 1) very broad signals at 5.26 and 5.50-5.55 ppm, 2) a broad structureless signal for the –CH(C<u>H</u>$_3$)– group at 2.00-2.12 ppm, and 3) the methyl group protons of the acetyl substituents appear as a sharp singlet at 2.60-2.61 ppm and broad singlet at 1.50-1.58 ppm.

A double resonance study of **3** showed that irradiation of the proton giving rise to the signal at 5.26 ppm leads to improved resolution of the multiplet and an increase in the intensity of the signal at 5.55 ppm. Suppression of the coupling of the protons appearing at 5.55 and 2.12 ppm leads to a change in the structure of each of these signals, suggesting that the signals at 5.55 and 2.12 ppm are coupled and correspond to protons C<u>H</u>(C<u>H</u>$_3$)CH(COCH$_3$)COCH$_3$, respectively. The signal at 5.26 ppm was assigned to the methine proton CH(CH$_3$)C<u>H</u>(COCH$_3$)COCH$_3$.

The differences in the shape and shift of the signals in the acetyl methyl groups are probably related to differences in environment. One of these methyl groups is maximally removed from the macrocycle, while the other group is subject to the π-current of the macrocycle. An analogous assignment was established in the zinc complex of porphyrin **5**. A double resonance study of the free bases **4** and **6** as well as of disubstituted derivatives **1** and **2** supported these assignments. In order to study their biological properties, dimethyl esters of porphyrins **2**, **4**, and **6** were converted to the corresponding diacids by hydrolysis in hydrochloric acid according to our previous procedure [17].

The IR spectra of 2,4-di(2-acetyl-1-methyl-3-oxobutyl)deuteroporphyrin-IX (**2**), 2-(2-acetyl-1-methyl-3-oxobutyl)deuteroporphyrin-IX (**4**), and 4-(2-acetyl-1-methyl-3-oxobutyl)deuteroporphyrin-IX (**6**), which are seen as structural analogs of 3-porphyrinyl-2,4-pentanedione (featuring a very bulky substituent at C$_{(3)}$), show a sharp peak at 1700 cm^{-1} characteristic for the ketone group and at 1730-1740 cm^{-1} characteristic for ester

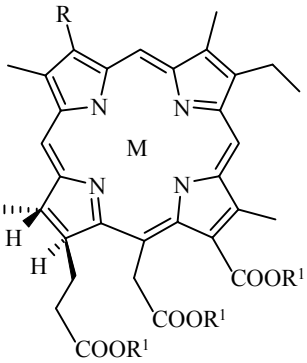
carbonyls. The difference of this spectrum from that of acetylacetone, which features a very broad band at 1639-1538 cm^{-1} with intensity more than 100 times the intensity for an ordinary carbonyl [18, 19], suggests the virtual absence of the enol form for such porphyrins.

In order to obtain water-soluble porphyrins, the corresponding methyl esters are usually subjected to alkaline saponification upon heating the porphyrins in dioxane or tetrahydrofuran at 50-60°C. In the case of porphyrins containing β-diketone residues, this reaction is also accompanied by deacetylation [20]. Thus, heating porphyrin **2** gave the deacetylation product, which, after esterification, corresponded to structure **17**. In the present work, we did not subject the free bases to alkaline saponification but rather their zinc complexes since the metal complexes of porphyrins are known to be more stable in alkaline media than the free bases. Alkaline saponification and deacetylation of complexes **1**, **3**, and **5** gave **11**, **12**, and **13**, which were esterified with diazomethane to give the corresponding dimethyl esters **14-16**. Demetallation using hydrochloric acid gave the dimethyl esters of porphyrins **17-19**. The acetyl methyl group in the $CH(CH_3)CH_2COC\underline{H}_3$ substituent appears in the ^1H NMR spectrum as a singlet at 2.10 ppm, while the methylene group protons were shown in a double resonance experiment to give rise to a signal in the region of the ring methyl groups at 3.80-3.60 ppm. The keto group IR signal for all these derivatives is shifted toward higher frequencies by about 15 cm^{-1} relative to the β-diketone derivatives. Subsequent alkaline hydrolysis of these porphyrins gave carboxyl derivatives suitable for use as photosensitizers.

An attempt to reduce the dimethyl esters of porphyrins **17-19** gave rise to a mixture of reduction products containing porphyrins with reduced propionic acid ester residues. The formation of such γ-hydroxypropyl derivatives using sodium borohydride as the reducing agent has already been observed in the reduction of dimethyl esters of monoacetylporphyrins [21]. Use of the corresponding porphyrin acids **11-13** under alkaline conditions permitted us to avoid reduction of the ester residues and obtain the desired hydroxybutylporphyrins **20-22** in high yield.

Since the deacetylation and concurrent saponification of ester groups proceeds with equal ease with both the free bases and zinc complexes, the optimal variant for obtaining the corresponding hydroxy derivatives involves alkaline deacetylation of zinc complexes **1**, **3**, and **5** to give complexes **11-13** and *in situ* reduction of these complexes in alkaline solution to give complexes **20-22**, which were then esterified with diazomethane to give complexes **23-25**. Treatment of complexes **23-25** with hydrochloric acid led to the corresponding dimethyl esters of porphyrins **26-28** containing a free hydroxyl group. In order to obtain satisfactory ^1H NMR spectra, esters **26-28** were treated with acetic anhydride in pyridine to give acetoxy derivatives **29-31**, which permit us to obtain an unequivocal molecular ion peak in the mass spectrum and improve the crystallizability of the products. Two asymmetric sites exist in **30** and **31**. Thus, for example, each of the groups of protons of the $CH(CH_3)CH_2CH(OCOCH_3)CH_3$ substituent appear as two unequal signals at 4.93 and 4.71, 2.13 and 2.11, 3.04 and 2.60, 5.30-5.24, 2.16 and 1.94, and 1.36 and 1.21 ppm, respectively. The diastereomer ratio was 3:1.

Water-soluble complexes of porphyrins **29-31** were obtained by alkaline hydrolysis to the diacids with subsequent treatment with N-methyl-D-glucosamine. An analogous approach was used for the synthesis of chlorin derivatives starting from the trimethyl ester of 2-desvinyl-2-(2-methoxyethyl)chlorin e_6 (**32**) obtained according to reported procedures [6, 22, 23, 29]. This chlorin consecutively yielded **33** and **34**, **35** and **36**, **37** and **38**, **39.** In contrast to the porphyrins, chlorins **33** and **34** give rise to ^1H NMR spectral signals for methine protons $C\underline{H}(CH_3)C\underline{H}(COCH_3)COCH_3$ hidden beneath the multiplets for 8-H and 7-H and the signal for methine proton $CH(CH_3)CH_2C\underline{H}(OAc)CH_3$ in **39** is hidden under the same multiplets. Thus, these protons could be detected only relative to the enhanced integral intensity of these multiplets. In order to study the biological activity of these compounds, the carboethoxyl derivatives of the porphyrins were dissolved in 1% aqueous solutions of N-methyl-D-glucosamine brought to pH 8.2 by adding 1 N hydrochloric acid and the concentration of the photosensitizers was determined spectrophotometrically [24].



32 R = CH(OH)Me, R^1= Me, M = 2H;
33 R = CH(Me)$CHAc_2$, R^1 = Me, M = Zn;
34 R = CH(Me)$CHAc_2$, R^1 = Me, M = 2H;
35 R = CH(Me)CH_2Ac, R^1 = K, M = Zn;
36 R = CH(Me)CH_2Ac, R^1 = Me, M = 2H;
37 R = CH(Me)$CH_2CH(OH)Me$, R^1 = K, M = Zn;
38 R = CH(Me)$CH_2CH(OH)Me$, R^1 = Me, M = 2H;
39 R = CH(Me)$CH_2CH(OAc)Me$, R^1 = Me, M = 2H

TABLE 1. Physical Characteristics of Compounds Synthesized

Com-pound	Empirical formula	Mass spectrum, *m/z* (I_{rel}, %)	Visible absorption spectrum, λ_{max} ($\varepsilon \cdot 10^{-3}$), nm	R_f
1	2	3	4	5
TMH	$C_{38}H_{36}N_4O_6$		402 (270.91); 499 (11.75); 533 (7.41); 568 (5.26); 595 (1.63); 621 (3.66)	0.52
1	$C_{46}H_{52}N_4O_8Zn$		404 (335.31); 495 (2.78); 533 (15.51); 568 (18.79)	0.39
2	$C_{46}H_{54}N_4O_8$		402 (197.13); 498 (13.45); 532 (9.29); 567 (6.33); 594 (1.19); 620 (4.35)	0.45
3	$C_{39}H_{42}N_4O_6Zn$		402 (258.51); 495 (2.91); 532 (14.75); 567 (16.93)	0.50
4	$C_{39}H_{44}N_4O_6$	664 (M^+, 85); 633 (4); 621 (3); 591 (2); 565 (100); 491 (5); 419 (5)	399 (195.62); 496 (15.79); 530 (9.97); 558 (7.15); 592 (1.33); 619 (4.82)	0.56
5	$C_{39}H_{42}N_4O_6Zn$		403 (250.68); 500 (2.55); 532 (12.02); 569 (14.02)	0.49
6	$C_{39}H_{44}N_4O_6$	664 (M^+, 100); 633 (3); 565 (47)	400 (195.62); 498 (15.46); 531 (9.64); 566 (6.81); 595 (1.16); 619 (4.65)	0.54
7	$C_{34}H_{36}N_4O_5$		415 (165.79); 508 (8.86); 545 (10.45); 575 (6.39); 632 (1.54)	0.56
8	$C_{34}H_{36}N_4O_5$		409 (158.53); 507 (8.86); 546 (10.45); 574 (6.82); 631 (1.60)	0.54
9	$C_{34}H_{38}N_4O_5$		400 (187.34); 496 (12.24); 530 (7.28); 566 (5.39); 594 (0.87); 618 (3.79)	0.33
10	$C_{34}H_{38}N_4O_5$		400 (185.74); 497 (12.67); 530 (8.03); 555 (6.07);593 (1.25); 619 (3.75)	0.29
17	$C_{42}H_{50}N_4O_6$	706 (M^+, 100); 675 (5); 663 (7); 649 (52); 633 (10); 605 (5); 591 (12); 577 (5); 531 (5); 517 (10)	399 (177.96); 498 (14.67); 531 (9.90); 594 (1.24); 619 (4.77)	0.48
18	$C_{37}H_{42}N_4O_5$	622 (M^+, 100); 591 (4); 579 (5); 565 (40); 549 (10); 505 (3); 491 (5); 417 (5)	400 (207.86); 498 (16.11); 532 (9.71); 568 (7.23); 592 (1.03); 619 (4.55)	0,57
19	$C_{37}H_{42}N_4O_5$	622 (M^+, 100); 591 (3); 579 (10); 565 (58); 549 (20); 505 (10); 491 (16); 419 (20)	400 (209.57); 495 (15.41); 530 (9.65); 565 (7.16); 592 (1.09); 617 (4.67)	0.56

TABLE 1 (continued)

1	2	3	4	5
26	$C_{42}H_{54}N_4O_6$		400 (200.07); 498 (16.52); 532 (11.50), 568 (7.74); 595 (1.25); 619 (5.85)	0.25* 0.05
27	$C_{37}H_{44}N_4O_5$		400 (161.13); 497 (12.87); 531 (8.96); 564 (7.70); 590 (2.85); 616 (4.64)	0.22
28	$C_{37}H_{44}N_4O_5$		400 (164.95); 497 (13.17); 531 (9.18); 564 (7.88); 590 (2.91); 616 (4.75)	0.27
29	$C_{46}H_{58}N_4O_8$	794 (M^+, 100); 763 (2); 721 (2); 693 (7); 633 (2); 591 (2)	400 (195.74); 498 (15.70); 532 (10.93); 568 (7.35); 595 (1.19); 619 (5.55)	0.61
30	$C_{39}H_{46}N_4O_6$	668 (M^+, 100); 635 (9); 626 (12); 584 (14); 566 (19)	398 (206.96); 495 (14.69); 530 (9.18); 564 (6.84); 591 (1.17); 618 (4.51)	0.63
31	$C_{39}H_{46}N_4O_6$	668 (M^+, 100); 626 (10); 605 (10); 584 (12)	398 (203.68); 496 (16.46); 531 (10.17), 565 (7.26); 592 (0.97); 618 (4.84)	0.60
32	$C_{38}H_{46}N_4O_7$	670 (M^+, 100); 654 (8); 638 (42); 623 (3); 611 (13); 597 (17); 579 (10); 565 (12); 511 (22); 479 (18)	411 (280.1); 498 (18.7); 530 (8.6); 558 (7.8); 602 (10.6); 659 (53.4)	0.58
33	$C_{42}H_{48}N_4OZn$	801 (M^+, 100); 759 (10); 743 (2); 729 (2); 701 (38); 653 (9); 541 (42)	410 (138.4); 512 (4.1); 555 (2.4); 591 (8.0); 632 (55.0)	0.25
34	$C_{42}H_{50}N_4O_8$		400 (142.31); 499 (15.15); 525 (5.17); 555 (2.36); 602 (6.28); 657 (59.48)	0.47
36	$C_{40}H_{48}N_4O_7$		401 (112.25); 498 (16.72); 525 (4.53); 544 (3.14); 599 (6.27); 654 (53.65)	0.49
38	$C_{40}H_{50}N_4O_7$		404 (232.7); 498 (17.8);525 (8.0); 561 (6.6); 600 (7.3); 656 (50.3)	0.22
39	$C_{42}H_{52}N_4O_8$	740 (M^+, 100); 709 (9); 681 (21); 667 (17); 653 (10); 639 (8); 593 (12); 581 (40)	398 (189.37); 496 (14.08); 523 (2.96); 555 (1.11); 598 (5.56); 654 (53.72)	0.53

* For the 5:1 chloroform–acetone system.

In this work, we developed and optimized methods for the preparation of porphyrin and chlorin derivatives **17-19, 29-31, 33, 34, 34, 36,** and **39.** The water-soluble forms of these derivatives containing bulky amphiphilic substituents have greater affinity for cancer cells in *in vitro* tests than other known tetrapyrrole derivatives. Studies were undertaken to study the correlation of structure and functional activity for these photosensitizers *in vitro* in cultures of ovarian adenocarcinoma CaOv [25, 26] and neuroglyoma PC 12.

EXPERIMENTAL

Monitoring of the isolation and purification of these products was carried out by thin-layer chromatography on Merck Kieselgel 60 F_{254} using 99:1:10 or 49.5:0.5:10 chloroform–ethanol–acetone as the eluent. Column chromatography was carried on columns packed with silica gel 100/160 or Lachema alumina obtained from Chemapol, Czech Republic. The mass spectra were obtained on VG 7070E mass spectrometer

supplied by VG Analytical (Manchester, England) or SFQ-710 mass spectrometer (Finnigan, US). The ionizing electron energy was 70 eV. The ^{1}H NMR spectra were taken on Bruker WM-250 and JEOL L400 (Jeol, Tokyo, Japan) spectrometers for solutions in $CDCl_3$ with TMS as the internal standard. The IR spectra were taken on Perkin–Elmer 683 (US) and Unicam SP-1000 (Cambridge) spectrometers for KBr pellets. The visible spectra were taken on a Hitachi 557 spectrometer (Japan).

Dimethyl Ester of 2,4-Di[2-acetyl-1-methyl-3-oxobutyl)deuteroporphyrin-IX (2) and Its Zinc Complex (1). Preparation and properties given in our previous work [1, 10].

Dimethyl Ester of 2-(2-Acetyl-1-methyl-3-oxobutyl)deuteroporphyrin-IX (4) and Its Zinc Complex (3). A solution of dimethyl ester of 2-(1-hydroxyethyl)deuteroporphyrin-IX (**9**) (1 g, 1.72 mmol) in freshly distilled acetylacetone (25 ml) containing $Zn(OAc)_2 \cdot 2H_2O$ (10 g) was heated for several minutes at 60°C in order to convert ester **9** into its zinc complex and then the temperature was raised to 110°C for 70 min. Acetylacetone was removed in vacuum and the residue was washed with warm water. The residue was dissolved in methylene chloride and subjected to chromatography on alumina (act. IV) and then silica gel using 30:1 methylene chloride–methanol as the eluent. Crystallization of the product from ethanol gave 0.75 g (60%) of complex **3**. IR spectrum, ν, cm^{-1}: 1697, 1700, 1732, 1740 (CO). ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.28, 9.98, 9.76, 9.62 (4H, all s, *meso*-H); 9.06 (1H, s, β-H); 5.50 (1H, br. m, C<u>H</u>CH$_3$); 5.26 (1H, br. m, CHAc$_2$); 4.16, 4.22 (4H, two t, *J* = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.83, 3.74, 3.61, 3.54, 3.44 (3H, 3H, 6H, 3H, 3H, all s, 6 × CH$_3$); 3.15, 3.11 (4H, two t, *J* = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.60 (3H, s, COCH$_3$); 2.12 (3H, br. d, *J* = 5, CHC<u>H</u>$_3$); 1.50 (3H, s, COCH$_3$).

Treatment of complex **3** in chloroform with an equal volume of 6 N hydrochloric acid for 2 min led to demetallation. The organic layer was removed, neutralized with aqueous ammonia, washed with water, and filtered through 2 cm alumina (act. I) to give 0.65 g (95%) porphyrin **4**, which was crystallized from chloroform–methanol. IR spectrum, ν, cm^{-1}: 3315 (NH), 1697, 1700, 1732, 1740 (CO). ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.27, 10.13, 10.09, 10.04 (4H, all s, *meso*-H); 9.12 (1H, s, β-H); 5.53 (1H, br. m, C<u>H</u>CH$_3$); 5.26 (1H, br. m, CHAc$_2$); 4.42, 4.41 (4H, two t, *J* = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.83, 3.74, 3.66, 3.65, 3.64, 3.62 (18H, all s, 6 × CH$_3$); 3.28 (4H, two t, *J* = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.60 (3H, s, COCH$_3$); 2.05 (3H, br. d, CHC<u>H</u>$_3$); 1.54 (3H, s, –COCH$_3$); -3.78 (2H, s, NH).

Dimethyl Ester of 4-(2-Acetyl-1-methyl-3-oxobutyl)deuteroporphyrin-IX (6) and Its Zinc Complex (5) were obtained analogously to **4** and **3**.

Complex 5. IR spectrum, ν, cm^{-1}: 1700, 1732, 1739 (CO). ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.28, 10.00, 9.96, 9.90 (4H, all s, *meso*-H); 9.04 (1H, s, β-H); 5.50 (1H, br. m, C<u>H</u>CH$_3$); 5.26 (1H, br. m, CHAc$_2$); 4.42, 4.29 (4H, two t, *J* = 7.8, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.74, 3.73, 3.70, 3.66, 3.64, 3.51 (all 3H, all s, 6 × CH$_3$); 3.29, 3.21 (4H, two t, *J* = 7.8, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.61 (3H, s, COCH$_3$); 2.00 (3H, br. d, CHC<u>H</u>$_3$); 1.53 (3H, s, COCH$_3$).

Porphyrin 6. IR spectrum, ν, cm^{-1}: 3315 (NH), 1700, 1732, 1739 (CO). ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.24, 10.14, 10.13, 10.05 (4H, all s, *meso*-H); 9.10 (1H, s, β-H); 5.50 (1H, br. m, C<u>H</u>CH$_3$); 5.26 (1H, s, CHAc$_2$); 4.46, 4.43 (4H, two t, *J* = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.75, 3.74, 3.71, 3.68, 3.65 (all 3H, remaining 6H, all s, 6 × CH$_3$); 3.31, 3.27 (4H, two t, *J* = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.61 (3H, s, COCH$_3$); 2.03 (3H, br. d, CHC<u>H</u>$_3$); 1.55 (3H, s, COCH$_3$); -3.79 (2H, s, 2 × NH).

Dimethyl Ester of 2-Acetyldeuteroporphyrin-IX (7) and Dimethyl Ester of 4-Acetyldeuteroporphyrin-IX (8) were obtained according to reported procedures [12-14].

Porphyrin 7. ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.75, 9.94, 9.87, (1H, 2H, 1H, all s, *meso*-H); 9.06 (1H, s, β-H); 4.37, 4.28 (4H, two t, *J* = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.77, 3.75, 3.66, 3.63, 3.57, 3.50 (all 3H, all s, 6 × CH$_3$); 3.26 (3H, s, COCH$_3$); 3.23 (4H, two t, *J* = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); -2.86 (2H, s, NH).

Porphyrin 8. ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.73, 9.95, 9.92, 9.91 (4H, all s, *meso*-H); 9.04 (1H, s, β-H); 4.40, 4.28 (4H, two t, *J* = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$), 3.78, 3.70, 3.66, 3.64, 3.51 (6H, 3H, 3H, 3H, 3H, all s, 6 × CH$_3$); 3.27 (3H, s, COCH$_3$); 3.25, 3.23 (4H, two t, *J* = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); -2.90 (2H, s, 2 × NH).

Dimethyl ester of 2-(1-hydroxyethyl)deuteroporphyrin-IX (9). A solution of porphyrin **7** (1 g, 1.72 mmol) in 2:1 chloroform–methanol (320 ml) was heated to 40°C and, then, sodium borohydride (1.3 g, 37.14 mmol) was added with vigorous stirring. After 9 min, the mixture was cooled to 0°C and neutralized by adding 6 N hydrochloric acid (5.8 ml). The organic solvents were removed in vacuum and the porphyrin was extracted from the neutral suspension with chloroform (2 × 20 ml). The extracts were evaporated and the residue was subjected to chromatography on a 35 × 200 mm column packed with alumina (act. IV) using 95:5 chloroform–acetone as the eluent. The product was crystallized from chloroform–methanol to give 0.91 g (91%) of porphyrin **9** as fine needles. ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.12 (1H, s, α-*meso*-H); 9.90 (1H, s, β-*meso*-H); 9.84 (1H, s, γ-*meso*-H); 9.80 (1H, s, δ-*meso*-H); 9.00 (1H, s, β-H); 6.01 (1H, q, *J* = 7.9, C<u>H</u>CH$_3$); 4.27 (1H, t, *J* = 7.3, 6-C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 4.24 (2H, t, *J* = 7.3, 7-C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.66 (3H, s, 7-CH$_2$CH$_2$CO$_2$C<u>H</u>$_3$); 3.64 (3H, s, 6-CH$_2$CH$_2$CO$_2$C<u>H</u>$_3$); 3.60 (3H, s, 3-CH$_3$); 3.52 (3H, s, 5-CH$_3$); 3.48 (3H, s, 8-CH$_3$); 3.33 (3H, s, 1-CH$_3$); 3.22 (2H, t, *J* = 7.3, 6-CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 3.20 (2H, t, *J* = 7.3, 7-CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.12 (1H, s, OH); 2.00 (3H, d, *J* = 7.9, CHC<u>H</u>$_3$); -4.16 (2H, s, 2 × NH).

Dimethyl Ester of 4-(1-Hydroxyethyl)deuteroporphyrin-IX (10). A solution of dimethyl ester of 4-acetyldeuteroporphyrin-IX (**8**) (1 g, 1.72 mmol) in 2:1 chloroform–methanol (300 ml) was heated to 40°C and, then, sodium borohydride (1.4 g, 40 mmol) was added with vigorous stirring. After 15 min, the mixture was cooled to 0°C and 6 N hydrochloric acid (6 ml) was added with stirring. The solvents were distilled off in vacuum and the porphyrin was extracted from the neutral suspension by chloroform (2 × 20 ml). Chloroform was evaporated and the residue was subjected to chromatography on a 35 × 200 mm column packed with alumina (act. IV) using 19:1 chloroform–acetone as the eluent. The product was crystallized from chloroform–methanol to give 0.92 g (92%) of porphyrin **10** as large crystals. ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.25 (1H, s, β-*meso*-H); 10.03 (1H, s, δ-*meso*-H); 10.00 (1H, s, γ-*meso*-H); 9.92 (1H, s, α-*meso*-H); 9.05 (1H, s, β-H); 6.24 (1H, q, *J* = 7.3, C<u>H</u>CH$_3$); 4.38 (2H, t, *J* = 7.5 6-C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 4.35 (2H, t, *J* = 7.5, 7-C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.71 (3H, s, 1-CH$_3$); 3.66 (6H, s, 2 × CH$_2$CH$_2$CO$_2$C<u>H</u>$_3$); 3.57 (3H, s, 8-CH$_3$); 3.55 (3H, s, 5-CH$_3$); 3.48 (3H, s, 3-CH$_3$); 3.26 (4H, t, *J* = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.32 (1H, s, OH); 2.11 (3H, d, *J* = 7.3, CHC<u>H</u>$_3$); -3.99 (2H, s, 2 × NH).

Dimethyl Ester of 2,4-Di(1-methyl-3-oxobutyl)deuteroporphyrin-IX (17). 20% Aq. KOH (7.2 ml) was added to a solution of zinc complex **1** (0.72 g, 0.91 mmol) in freshly distilled dioxane (7.2 ml). The mixture was stirred for 4 h at 50-55°C and then neutralized to pH 4 by adding about 6 N hydrochloric acid (5 ml) with cooling to 0°C and vigorous stirring. Dioxane was evaporated. Then, chloroform (20 ml) and water (10 ml) were added to the residue, which was esterified by adding a solution of diazomethane in diethyl ether. The organic layer was evaporated and the residue was filtered through 2 cm alumina (act. I) covered with a layer of dry sodium sulfate using chloroform as the eluent. The product was subjected to chromatography on a 30 × 200 mm silica gel column using 15:1 chloroform–acetone as the eluent. The most mobile fraction was evaporated to give 0.385 g of product, which was demetallized as described above to give 0.34 g (53%) of porphyrin **17** as prisms. IR spectrum, ν, cm^{-1}: 3310 (NH), 1713, 1734, 1738 (CO). ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.24, 10.23, 10.11, 10.09 (4H, all s, *meso*-H); 5.20 (2H, br. m, 2 × C<u>H</u>CH$_3$); 4.43 (4H, two br. t, *J* = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.76, 3.73, 3.69, 3.66, 3.65 (3H, 3H, 3H, 3H, 6H, all s, 6 × CH$_3$); 3.80-3.60 (4H, br. m, 2 × CH$_2$Ac); 3.29 (4H, two t, *J* = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.13, 2.12 (6H, two d, *J* = 5.5 and 6.5, CHC<u>H</u>$_3$); 2.10 (6H, s, 2 × COCH$_3$); -3.78 (2H, s, 2 × NH).

Dimethyl Ester of 2-(1-Methyl-3-oxobutyl)deuteroporphyrin-IX (18) was obtained as described above for porphyrin **17** from porphyrin **3** (0.75 g, 1.03 mmol) in dioxane (7.5 ml) and 20% aq. KOH (7.5 ml). The reaction was carried out over 3 h at 50-55°C. The reaction mixture was brought to pH 3-3.5 by adding about 6 N hydrochloric acid (5.2 ml). The yield of zinc complex was 0.46 g (65%). Demetallation was carried out as described for **3** and **4**. Crystallization from chloroform-methanol over 72 h in a refrigerator gave 0.42 g (56%) of compound **18** as large transparent cherry-red crystals. IR spectrum, ν, cm^{-1}: 3315 (NH), 1710, 1715, 1734 (CO). ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 10.26, 10.13, 10.09, 10.04 (4H, all s, *meso*-H); 9.09 (1H, s, β-H); 5.21 (1H, q,

C<u>H</u>CH$_3$); 4.42 (4H, br. t, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.78, 3.75 (6H, s, 2 × CH$_3$); 3.70, 3.67 (2H, dd, J_{AB} = 5.0, CH$_2$Ac); 3.653, 3.648, 3.64 (3H, 6H, 3H, all s, 3 × CH$_3$); 3.28 (4H, br. t, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.13 (3H, d, J = 6.0, CHC<u>H</u>$_3$); 2.10 (3H, s, COCH$_3$); -3.79 (2H, s, 2 × NH).

Dimethyl Ester of 4-(1-Methyl-3-oxobutyl)deuteroporphyrin-IX (19) was obtained from **5** analogously to porphyrin **18**. IR spectrum, ν, cm^{-1}: 3315 (NH), 1715, 1719, 1735, 1739 (CO). ^{1}H NMR spectrum, δ, ppm, J, Hz: 10.23, 10.13, 10.12, 10.04 (4H, all s, *meso*-H); 9.07 (1H, s, β-H); 5.20 (1H, m, C<u>H</u>CH$_3$); 4.43 (4H, two t, J = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.74, 3.71, 3.68, 3.66, 3.65 (18H, s, 6 × CH$_3$); 4.08, 3.70 (2H, m, CH$_2$Ac); 3.29 (4H, two t, J = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 2.12 (3H, d, overlaps with singlet at 2.10, CHCH$_3$); 2.10 (3H, s, COCH$_3$); -3.80 (2H, s, 2 × NH).

Dimethyl Ester of 2,4-Di(1-methyl-3-hydroxybutyl)deuteroporphyrin-IX (26) and Dimethyl Ester of 2,4-Di(1-methyl-3-acetoxybutyl)deuteroporphyrin-IX (29) were obtained by reduction of intermediate complex **11** as the diacid. After ketonic splitting, the organic layer containing 0.626 g of complex **11** was separated and methanol (10 ml) and NaBH$_4$ (3.13 g) were added. The mixture was stirred for 6 h at 40°C. At the end of the reaction, the mixture was cooled to 0°C and carefully neutralized by adding about 6 N hydrochloric acid (13.7 ml). The organic solvents were partially evaporated and **20** was separated by centrifugation from the neutral solution. In order to obtain **23**, intermediate **20** was dissolved in methanol and a solution of diazomethane in diethyl ether was added until complete esterification was indicated by TLC. The solvents were evaporated and the residue was filtered through a 1-1.5 cm layer of alumina (act. III) using chloroform as the eluent. Chromatography was carried out on a 30 × 200 mm silica gel column using 5:1 chloroform–acetone or 3:1 methylene chloride–acetone as the eluent. The starting compound eluted first, followed by a mixture of monoreduction products and, finally, the desired compound. Yield of intermediate complex 0.386 g (60%). Demetallation was carried out as for **4**. Crystallization from chloroform–methanol gave 0.284 g (80%) of compound **26** as large red needles. ^{1}H NMR spectrum (selective), δ, ppm, J, Hz: 10.24, 10.22, 10.10, 10.07 (4H, all s, *meso*-H); 4.42 (4H, two br. t, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.72, 3.65, 3.63 (18H, all s, 6 × CH$_3$); 3.28 (4H, two t, J = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); -3.78 (2H, s, 2 × NH).

Dimethyl Ester of 2,4-Di(3-acetoxybutyl)-1-methyldeuteroporphyrin-IX (29) was obtained from porphyrin **26** as in the case of **30** and **31** by extending the reaction time to 24 h. IR spectrum, ν, cm^{-1}: 3312 (NH), 1732, 1736 (CO). ^{1}H NMR spectrum, δ, ppm, J, Hz: 10.18, 10.17, 10.12, 10.10 (4H, all s, *meso*-H); 5.32, 4.97 (2H, m, 2 × C$_{(1)}$H(CH$_3$)C$_{(2)}$H$_2$C$_{(3)}$<u>H</u>(OAc)C$_{(4)}$H$_3$); 4.67 (2H, m, 2 × C<u>H</u>CH$_3$); 4.43 (4H, two br. t, J = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.72, 3.71, 3.669, 3.670, 3.661, 3.660 (18H, all s, 6 × CH$_3$); 3.310, 3.300 (4H, two t, J = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 3.00, 2.60 (4H, m, 2 × C$_{(2)}$H$_2$); 2.14, 2.10 (6H, dd, J = 6.8, 2 × C$_{(1)}$CH$_3$); 1.55 (6H, s, 2 × Ac); 1.370, 1.360 (6H, two d, 2 × C$_{(3)}$CH$_3$); -3.77 (2H, s, 2 × NH).

Dimethyl Ester of 2-(3-Hydroxybutyl)-1-methyldeuteroporphyrin-IX (27) and Dimethyl Ester of 2-(1-Methyl-3-acetoxybutyl)deuteroporphyrin-IX (30) were obtained analogously to porphyrin **26** from complex **12** (0.67 g, 1.02 mmol) and NaBH$_4$ (3.36 g, 86.15 mmol) in methanol (10 ml) with stirring for 3.5 h at 40°C. The reaction mixture was neutralized by adding 6 N hydrochloric acid (14.6 ml). Yield of **24** 0.26 g (40%). Yield of **27** 0.22 g (37%). These compounds were obtained as large red needles after demetallation analogously to **3** and crystallization from chloroform–methanol. ^{1}H NMR spectrum (selective), δ, ppm, J, Hz: 10.26, 10.14, 10.08, 10.02 (4H, all s, *meso*-H); 9.07 (1H, s, β-H); 4.75 (1H, m, C<u>H</u>CH$_3$); 4.41 (4H, two t, J = 7.5, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 4.07 (1H, m, C<u>H</u>OH); 3.74, 3.64 (6H, 12H, s, 6 × CH$_3$); 3.28 (4H, two t, J = 7.5, 2 × CH$_2$C<u>H</u>$_2$CO$_2$CH$_3$); 3.45, 2.85 (2H, m, J_{AB} = 17.5, CH$_2$); 2.13 (3H, dd, $J_{H,CH3}$ = 7.2, C$_{(1)}$CH$_3$); 1.38 (3H, d, $J_{H,CH3}$ = 7.2, C$_{(4)}$H$_3$); -3.81 (2H, s, 2 × NH).

Acetate 30 was obtained analogously from **27** (0.21 g, 0.32 mmol) by treatment with pyridine (10 ml) and acetic anhydride (1 ml) for 6 h. Yield of acetate **30** 0.21 g (86%) as red needles (chloroform–methanol). IR spectrum, ν, cm^{-1}: 3312 (NH), 1733, 1739 (CO). ^{1}H NMR spectrum, δ, ppm, J, Hz: 10.20, 10.14, 10.08, 10.03 (4H, all s, *meso*-H); 9.08 (1H, s, β-H); 5.28 (1H, m, C$_{(3)}$<u>H</u>OAc); 4.71 (1H, m, C$_{(1)}$<u>H</u>CH$_3$); 4.43, 4.41 (4H, two t, J = 7.7, 2 × C<u>H</u>$_2$CH$_2$CO$_2$CH$_3$); 3.753, 3.739, 3.660, 3.657, 3.644, 3.636 (18H, s, 6 × CH$_3$); 3.294, 3.287 (4H,

two t, J = 7.8, 2 × $CH_2C\underline{H}_2CO_2CH_3$); 3.04, 2.60 (2H, m, $J_{HA,HB}$ = 13.0, $J_{HA,C(1)H} = J_{HA,C(3)H}$ = 8.2, $C_{(2)}H_2$); 2.16 (3H, s, $COCH_3$); 2.12 (3H, d, $C_{(1)}CH_3$); 1.36 (3H, d, $C_{(4)}H_3$); -3.80 (2H, s, 2 × NH).

Dimethyl Ester of 4-(3-Hydroxybutyl)-1-methyldeuteroporphyrin-IX (28) and Dimethyl Ester of 4-(3-acetoxybutyl-1-methyl)deuteroporphyrin-IX (31) were obtained analogously from **13**.

Porphyrin 28. ^{1}H NMR spectrum, δ, ppm, J, Hz: 10.31, 10.23, 10.11, 10.03 (4H, all s, *meso*-H); 9.07 (1H, s, β-H); 4.70 (1H, m, $C\underline{H}CH_3$); 4.43, 4.41 (4H, two t, J = 7.45, 2 × $C\underline{H}_2CH_2CO_2CH_3$); 4.10 (1H, m, $C\underline{H}OH$); 3.73, 3.71, 3.66, 3.65, 3.64 (3H, 3H, 6H, 3H, 3H, s, 6 × CH_3); 3.28 (4H, two t, J = 7.45, 2 × $CH_2C\underline{H}_2CO_2CH_3$); 2.83, 2.56 (1H, m, CH_2); 2.13 (3H, dd, $C_{(1)}HC\underline{H}_3$); 1.38 (3H, d, $C_{(4)}\underline{H}_3$); -3.86 (2H, s, 2 × NH).

Acetate 31. IR spectrum, cm^{-1} (CO): 3310 (ν_{NH}), 1732. ^{1}H NMR spectrum, δ, ppm, J, Hz: 10.18, 10.13, 10.12, 10.05, 10.03 (4H, all s, *meso*-H); 9.08 (1H, s, β-H); 5.35-5.23 (1H, m, $C\underline{H}OAc$); 4.72-4.39 (1H, br. m, $C\underline{H}CH_3$); 4.45, 4.43 (4H, two t, J = 7.5, 2 × $C\underline{H}_2CH_2CO_2CH_3$); 3.74, 3.71, 3.67, 3.65 (3H, 3H, 6H, 6H, s, 6 × CH_3); 3.30 (4H, two t, J = 7.5, 2 × $CH_2C\underline{H}_2CO_2CH_3$); 3.00, 2.60 (2H, m, $C_{(2)}H_2$); 2.17, 1.94 (3H, s, $COCH_3$); 2.14, 2.10 (3H, d, $C_{(1)}CH_3$); 1.36, 1.21, (3H, d, $C_{(4)}H_3$); -3.80 (2H, s, 2 × NH).

Trimethyl Ester of 2-Desvinyl-2-(1-methoxyethyl)chlorin e_6 (32) was obtained in 65% yield according to reported procedures [6, 22, 27] by maintaining chlorin e_6 (3 g) [28] in a solution of HBr in acetic acid (d = 1.44-1.46) (45 ml) and treatment of the intermediate perbromide with methanol. ^{1}H NMR spectrum, δ, ppm, J, Hz: 9.76, 9.69, 8.71 (3H, all s, *meso*-H); 5.87 (1H, m, $C\underline{H}CH_3$); 5.28 (2H, m, γ-*meso*-$C\underline{H}_2CO_2CH_3$); 4.42 (2H, m, 7-H, 8-H); 4.25 (3H, s, 6-CO_2CH_3); 3.79 (2H, q, 4-$C\underline{H}_2CH_3$); 3.76, 3.62, 3.57 (9H, all s, 3 × CH_3); 3.54 (3H, two s, $CHOC\underline{H}_3$); 3.44, 3.30 (6H, s, 2 × CH_3); 2.54, 2.20 (4H, m, $C\underline{H}_2C\underline{H}_2CO_2CH_3$); 2.12 (3H, d, $CHC\underline{H}_3$); 1.74 (3H, d, 8-CH_3); 1.70 (3H, t, 4-$CH_2C\underline{H}_3$); -1.36, -1.48 (2H, two s with unequal intensity, 2 × NH).

Trimethyl Ester of 2-Desvinyl-2-(2-acetyl-1-methyl-3-oxobutyl)chlorin e_6 (34) and Its Zinc Complex (33) were obtained analogously to porphyrins **3-6** from trimethyl ester of 2-desvinyl-2-(1-methoxyethyl)chlorin e_6 **32** (1 g, 1.49 mmol). Yield of complex **33** 0.78 g (65%); yield of chlorin **34** 0.71 g (64%).

Complex 33. ^{1}H NMR spectrum, δ, ppm, J, Hz: 9.55, 9.54, 9.50, 9.49, 8.48 (0.5H, 0.5H, 0.5H, 0.5H, 1H, two s, two s, s, *meso*-H); 5.30-4.95 (2H, dd, γ-*meso*-$C\underline{H}_2CO_2CH_3$); 5.20 (1H, br. m under singlet for γ-*meso*-$C\underline{H}_2CO_2CH_3$, $C_{(1)}\underline{H}CH_3$); 5.05 (1H, br. m under singlet for γ-*meso*-$C\underline{H}_2CO_2CH_3$, $CHAc_2$); 4.32, 4.24 (2H, dd, 7-H, 8-H); 4.17 (3H, s, 6-CO_2CH_3); 3.80 (3H, s, CH_3); 3.78 (2H, q, 4-$C\underline{H}_2CH_3$); 3.54, 3.43, 3.38, 3.30 (12H, s, s, two s, two s, 4 × CH_3); 2.52, 2.48 (1.5H, 1.5H, s, 1 × $COCH_3$); 2.52, 2.22, 2.08 (1H, under singlet for $COCH_3$, 3H, m, $C\underline{H}_2C\underline{H}_2CO_2CH_3$); 1.82 (3H, br. d, $C_{(1)}HC\underline{H}_3$); 1.70 (6H, overlapping d and t, 8-CH_3, 4-$CH_2C\underline{H}_3$); 1.65, 1.61 (1.5H, 1.5H, br. s, 1 × $COCH_3$).

Chlorin 34. IR spectrum, ν, cm^{-1}: 3300 (NH), 1700, 1724, 1730, 1733, 1738 (CO). ^{1}H NMR spectrum, δ, ppm, J, Hz: 9.71, 9.57, 8.70 (3H, s, *meso*-H); 5.50-5.10 (2H, dd, γ-*meso*-$C\underline{H}_2CO_2CH_3$); 5.38 (1H, br. m under singlet for γ-*meso*-$C\underline{H}_2CO_2CH_3$, $C_{(1)}\underline{H}CH_3$); 5.16 (1H, br. m under singlet for γ-*meso*-$C\underline{H}_2CO_2CH_3$, $CHAc_2$); 4.41 (2H, dd, 7-H, 8-H); 4.25 (3H, s, 6-CO_2CH_3); 3.80 (2H, q, 4-$C\underline{H}_2CH_3$); 3.76, 3.63, 3.57, 3.45, 3.37 (15H, s, 5 × CH_3); 2.55 (3H, s, $COCH_3$); 2.50, 2.29, 2.16 (1H under singlet for $COCH_3$, 3H, m, $C\underline{H}_2C\underline{H}_2CO_2CH_3$); 1.90 (3H, br. s, $C_{(1)}CH_3$); 1.72 (6H, overlapping d and t, 8-CH_3, 4-$CH_2C\underline{H}_3$); 1.65 (3H, s, $COCH_3$); -1.54 (2H, s, 2 × NH).

Trimethyl Ester of 2-Desvinyl-2-(1-methyl-3-oxobutyl)chlorin e_6 (36) was obtained from zinc complex of trimethyl ester of 2-desvinyl-2-(2-acetyl-1-methyl-3-oxobutyl)chlorin e_6 **33** (0.78 g, 0.97 mmol) analogously to porphyrin **18** upon alkaline hydrolysis over 4 h. Yield of 2-desvinyl-2-(1-methyl-3-oxobutyl)chlorin **35** 0.57 g (90%). Treatment of **35** with 4% H_2SO_4 in methanol gave 0.52 g (85%) of trimethyl ester **36**. IR spectrum, ν, cm^{-1}: 3305 (NH), 1715, 1725, 1732, 1739 (CO). ^{1}H NMR spectrum, δ, ppm, J, Hz: 9.68, 9.51, 8.66 (3H, s, *meso*-H); 5.27 (2H, dd, γ-*meso*-$C\underline{H}_2CO_2CH_3$); 4.92 (1H, q, $C_{(1)}\underline{H}CH_3$); 4.40 (2H, dd, 7-H, 8-H); 4.24 (3H, s, 6-CO_2CH_3); 3.78 (2H, q, 4-$C\underline{H}_2CH_3$); 3.75, 3.62 (6H, s, 2 × CH_3); 3.58 (2H, m, CH_2); 3.56, 3.43, 3.32 (9H, s, 3 × CH_3); 2.49, 2.14 (4H, m, $C\underline{H}_2C\underline{H}_2CO_2CH_3$); 2.11 (3H, s, $COCH_3$); 2.00 (3H, two d, $C_{(1)}CH_3$); 1.70 (6H, overlapping d and t, 8-CH_3, 4-$CH_2C\underline{H}_3$); -1.34, -1.42 (2H, two s with unequal intensity, 2 × NH).

Trimethyl Ester of 2-Desvinyl-2-(3-acetoxybutyl-1-methyl)chlorin e_6 (39) was obtained analogously to porphyrin **30** from zinc complex of 2-desvinyl-2-(1-methyl-3-oxobutyl)chlorin e_6 **35** (0.57 g, 0.87 mmol). Yield of chlorin **39** 0.26 g (40%). IR spectrum, ν, cm^{-1}: 3310 (NH), 1726, 1731, 1735 (CO). ^{1}H NMR spectrum, δ, ppm, *J*, Hz: 9.67, 9.44, 8.66, 8.64 (1H, 1H, 0.5H, 0.5H, s, s, two s, *meso*-H); 5.40-5.10 (2H, dd, γ-*meso*-$C\underline{H}_2CO_2CH_3$); 5.22 (0.5H, m under singlet for γ-*meso*-$C\underline{H}_2CO_2CH_3$, 1/2 × CHOAc); 4.80 (1H, br. m, $C_{(1)}\underline{H}CH_3$); 4.50-4.30 (2H, m, 7-H, 8-H); 4.41 (0.5H, m under singlet for γ-*meso*-$C\underline{H}_2CO_2CH_3$, 1/2 × CHOAc); 4.24 (3H, s, 6-CO_2CH_3); 3.78 (2H, q, 4-$C\underline{H}_2CH_3$); 3.75, 3.61, 3.56, 3.41, 3.35, 3.34, 3.30 (3H, 3H, 3H, 2H, 0.5H, 0.5H, 3H, s, 5 × CH_3); 2.80, 2.50 (2H, m, $C_{(3)}H_2$); 2.50, 2.16 (4H, m, $C\underline{H}_2C\underline{H}_2CO_2CH_3$); 1.99 (3H, dd, $C_{(1)}HC\underline{H}_3$); 1.99, 1.95 (3H, s, $OCOCH_3$); 1.71, 1.70 (6H, overlapping d and t, 8-CH_3, 4-$CH_2C\underline{H}_3$); 1.34, 1.32 (3H, two d, $C_{(4)}H_3$); -1.32, -1.40 (2H, two s with unequal intensity, 2 × NH).

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