### **Electronic Supplementary Information**

# Synthesis of $\beta$ -octaethylporphyrin conjugates with nitrogen and sulfur containing heterocycles

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#### Synthesis and characteristics of the synthesized compounds

**General.** Reactions were carried out under argon atmosphere using commercially available reagents that were purchased and used as received. Starting 2,3,7,8,12,13,17,18-octaethylporphyrin was obtained from commercial sources. Heating reaction vessels was performed with oil bath. Preparative thin layer chromatography (TLC) was performed using glass plates coated with 5-40  $\mu$ m silica gel (5 mm thick). <sup>1</sup>H and <sup>13</sup>C NMR spectra were recorded with a Bruker Avance III 600 MHz spectrometer at 303K in CDCl<sub>3</sub>. Chemical shifts are reported relative to signals of residual protons of solvents (CDCl<sub>3</sub> – 7.26 ppm). The assignment of the resonances in the <sup>1</sup>H and <sup>13</sup>C NMR spectra was achieved by the use of DEPT, COSY and HSQC techniques. The LDI-TOF mass-spectra were obtained on a Ultraflex-II mass spectrometer (Bruker Daltonics) in a positive ion mode using reflection mode (20 mV target voltage) without matrix. Electronic absorption spectra were recorded with U-2900 (Hitachi) spectrophotometer in quartz rectangular cells of 10 mm path length.

**Synthesis.** Nickel(II) complex of 2,3,7,8,12,13,17,18-octaethylporphyrin was first obtained and then formylated via the Vilsmeier-Haack reaction according to the reported procedure.<sup>1, 2</sup> to give Ni(II) 5-formyl-2,3,7,8,12,13,17,18-octaethylporphyrin **1**.

## General procedure of the condensation of Ni(II) 5-formyl-2,3,7,8,12,13,17,18-octaethylporphyrin 1 with CH-acids.

A solution of TiCl<sub>4</sub> (5.5 ml, 50 mmol) in 12 ml of dry CCl<sub>4</sub> was added dropwise to rapidly stirred dry THF (250 ml) at 0<sup>0</sup>C. The resulting mixture was stirred for 5 min, then the solution of Ni(II) 5-formyl-2,3,7,8,12,13,17,18-octaethylporphyrin **1** (50 mg, 0.08 mmol) and a CH-acid (1.61 mmol) in 12 ml of dry THF was added to the reaction mixture. The resulting mixture was stirred for 5 minutes at 0<sup>o</sup>C and then the Ni(II) complex of 5-formyl-2,3,7,8,12,13,17,18-octaethylporphyrin (50 mg, 0.08 mmol) and a solution of CH-acid (1.61 mmol) in 12 ml of dry THF was added to the reaction mixture. After that a solution of dry pyridine (8 ml, 99 mmol) in 15 ml of dry THF was added dropwise to the reaction mixture at 0<sup>o</sup>C over 3.5 hours (faster addition caused black tar formation), and the resulting mixture was stirred at room temperature or refluxed. After reaction completion, 30 ml of water and 30 ml of methyl tertbutyl ether were added to a solution, the organic phase was washed with water (4 x 30 ml), dried over anhydrous sodium sulphate, evaporated in vacuum and the product was purified with preparative TLC in dichloromethane : petroleum ether = 7 : 3.

Ni(II) 5-((2,3,7,8,12,13,17,18-octaethylporphyrin-5-yl)methylene)-2-thioxodihydropyrimidine-4,6(1H,5H)-dione (2). Yield was 33 mg (55 %) (brown amorphous solid) from 50 mg of 1 and 232 mg of thiobarbituric acid. <sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>, 303 K)  $\delta$  ppm: 10.24 (1H, s, 5<sup>1</sup>-CH), 8.82 (1H, m, 15-CH), 8.73 (2H, s, 10, 20-CH), 3.4-3.6 (16H, m, CH<sub>2</sub>CH<sub>3</sub>), 1.60-1.65 (18H, m, CH<sub>2</sub>CH<sub>3</sub>), 1.55 (6H, m, CH<sub>2</sub>CH<sub>3</sub>). <sup>13</sup>C NMR (150 MHz, CDCl<sub>3</sub>, 303 K)  $\delta$  ppm: 176.8 (C=S), 161.5 (C=O), 157.0 (C=O), 145.7 (5<sup>1</sup>-CH), 147.7, 145.4, 144.8, 144.6, 142.9, 142.0, 140.1 and 139.2 (pyrrole cycles), 114.6 (5<sup>2</sup>-C), 109.8 (5-C), 104.1 (15-CH), 102.3 (10, 20-CH), 21.3, 19.2, 19.1 and 18.9 (CH<sub>2</sub>), 17.9, 17.7, 17.4 and 17.1 (CH<sub>3</sub>). UV-Vis (CH<sub>2</sub>Cl<sub>2</sub>)  $\lambda_{max}$  (Arel.), nm: 401 (1.00), 507 (0.58), 669 (0.19). LDI TOF m/z: found 744.22, calc. for [M]<sup>+</sup> C<sub>41</sub>H<sub>46</sub>N<sub>6</sub>NiO<sub>2</sub>S 744.28.

Ni(II) 5-((2,3,7,8,12,13,17,18-octaethylporphyrin-5-yl)methylene)-2-thioxoimidazolidin-4-one (3). Yield was 45 mg (78%) (green amorphous solid) from 50 mg of 1 and 187 mg of thiohydantoin. <sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>, 303 K)  $\delta$  ppm: 9.45 (3H, s, 10, 15, 20-CH), 8.89 (1H, s, 5<sup>1</sup>-CH), 8.37 (1H, s, NH), 6.80 (1H, s, NH), 3.82 (16H, m, <u>CH<sub>2</sub>CH<sub>3</sub></u>), 1.80 (12H, m, CH<sub>2</sub><u>CH<sub>3</sub></u>), 1.72 (12H, m, CH<sub>2</sub><u>CH<sub>3</sub></u>). <sup>13</sup>C NMR (150 MHz, CDCl<sub>3</sub>, 303 K)  $\delta$  ppm: 174.8 (C=S), 162.2 (C=O), 146.9, 144.0, 143.5, 143.3, 140.7, 140.5, 138.4 and 138.0 (pyrrole cycles), 131.8 (5<sup>1</sup>-CH), 112.8 (5<sup>2</sup>-C), 100.5 (5-C), 98.2 (10, 20-CH), 97.8 (15-CH), 22.1, 19.59, 19.54 and 19.50 (CH<sub>2</sub>), 18.17, 18.09, 18.02 and 17.3 (CH<sub>3</sub>). UV-Vis (CH<sub>2</sub>Cl<sub>2</sub>)  $\lambda_{max}$  (Arel.), nm: 402 (1.00), 530 (0.10), 566 (0.15). LDI TOF m/z: found 717.14, calc. for [M+H]<sup>+</sup> C<sub>40</sub>H<sub>47</sub>N<sub>6</sub>NiOS 717.29.

**Ni(II) diethyl 2-((2,3,7,8,12,13,17,18-octaethylporphyrin-5-yl)methylene)malonate (4)**. The reaction was carried out at room temperature for 12 h by the general procedure based on the slightly modified reported procedure.<sup>3</sup> Yield was 37 mg (61%) (brown amorphous solid) from 50 mg of 1 and 258 mg of diethyl malonate. <sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>, 303 K)  $\delta$  ppm: 10.35 (1H, s, 5<sup>1</sup>-CH), 9.54 (1H, s, 15-CH), 9.52 (2H, s, 10, 20-CH), 4.48 (2H, q, <sup>3</sup>*J*=7.2 Hz, <u>CH<sub>2</sub>CH<sub>3</sub></u>), 3.86 (16H, m, <u>CH<sub>2</sub>CH<sub>3</sub></u>), 2.50 (2H, q, <sup>3</sup>*J*=7.2 Hz, <u>CH<sub>2</sub>CH<sub>3</sub></u>), 1.86 (6H, t, <sup>3</sup>*J*=7.7 Hz, CH<sub>2</sub><u>CH<sub>3</sub></u>), 1.82 (6H, t, <sup>3</sup>*J*=7.7 Hz, CH<sub>2</sub><u>CH<sub>3</sub></u>), 1.77 (6H, t, <sup>3</sup>*J*=7.6 Hz, CH<sub>2</sub><u>CH<sub>3</sub></u>), 1.76 (6H, t, <sup>3</sup>*J*=7.6 Hz, CH<sub>2</sub><u>CH<sub>3</sub></u>), 1.45 (3H, t, <sup>3</sup>*J*=7.2 Hz, CH<sub>2</sub><u>CH<sub>3</sub></u>), -0.89 (3H, t, <sup>3</sup>*J*=7.2 Hz, CH<sub>2</sub><u>CH<sub>3</sub></u>). UV-Vis (CH<sub>2</sub>Cl<sub>2</sub>):  $\lambda$ , nm (A<sub>rel</sub>) 402 (1.00), 526 (0.06), 562 (0.11). LDI TOF m/z: found 761.23, calc. for [M+H]<sup>+</sup> C<sub>44</sub>H<sub>55</sub>N<sub>6</sub>NiO<sub>4</sub> 761.36.

Ni(II) 4-((2,3,7,8,12,13,17,18-octaethylporphyrin-5-yl)methylene)pyrazolidine-3,5-dione (5). To a solution of 4 (20 mg, 0.03 mmol) in 3 ml of ethanolic sodium ethoxide solution (obtained by dissolution of 0.1 g Na in 30 ml of absolute ethanol) hydrazine hydrate was added, and the resulting mixture was stirred under reflux for 10 hours. After reaction completion the solvent was evaporated, the residue was dissolved in 10 ml of CH<sub>2</sub>Cl<sub>2</sub> and washed with water (3x10 ml), dried over anhydrous sodium sulphate, evaporated in vacuum, and the product was isolated with preparative TLC in eluent CH<sub>2</sub>Cl<sub>2</sub> : MeOH : Et<sub>3</sub>N = 20 : 1 : 0.05, yielding 14 mg (76%) (pink amorphous solid) of the product 5. <sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>, 303 K)  $\delta$  ppm: 11.05 (1H, s, (5<sup>1</sup>-CH), 10.46 (2H, s, NH), 9.48 (2H, s, 10, 20-CH), 9.47 (1H, s, 15-H), 3.85 (12H, m, <u>CH<sub>2</sub>CH<sub>3</sub>), 3.73 (4H, m, <u>CH<sub>2</sub>CH<sub>3</sub>), 1.79 (12H, m, CH<sub>2</sub>CH<sub>3</sub>), 1.71 (6H, t, <sup>3</sup>*J*=7 Hz, CH<sub>2</sub><u>CH<sub>3</sub>), 1.52 (6H, t, <sup>3</sup>*J*=7 Hz, CH<sub>2</sub><u>CH<sub>3</sub>), 1.39 (4H, m, CH<sub>2</sub>CH<sub>3</sub>), 3.03 K)  $\delta$  ppm: 168.4 (C=O), 165.6 (C=O), 155.2 (5<sup>1</sup>-CH), 145.2, 143.8, 143.2, 143.0, 140.0, 139.6, 138.9 and 136.8 (pyrrole cycles), 127.7 (5-C), 108.4 (5<sup>2</sup>-C), 96.9 (10, 20-CH), 95.7 (15-CH), 22.0, 19.6, 19.5 and 19.4 (CH<sub>2</sub>), 18.3, 18.1 and 16.2 (CH<sub>3</sub>). UV-Vis (CH<sub>2</sub>Cl<sub>2</sub>)  $\lambda_{max}$  (Arel.), nm: 403 (1.00), 529 (0.07), 566 (0.11). LDI TOF m/z: found 701.33, calc. for [M+H]<sup>+</sup>C<sub>40</sub>H<sub>47</sub>N<sub>6</sub>NiO<sub>2</sub> 701.31.</u></u></u></u>







Figure S3. <sup>1</sup>H NMR spectrum of Ni(II) 5-((2,3,7,8,12,13,17,18-octaethylporphyrin-5-yl)methylene)-2-thioxoimidazolidin-4-one (3) in CDCl<sub>3</sub>.



Figure S4. <sup>13</sup>C NMR spectrum of Ni(II) 5-((2,3,7,8,12,13,17,18-octaethylporphyrin-5-yl)methylene)-2-thioxoimidazolidin-4-one (3) in CDCl<sub>3</sub>.



Figure S6. <sup>13</sup>C NMR spectrum of Ni(II) 4-((2,3,7,8,12,13,17,18-octaethylporphyrin-5-yl)methylene)pyrazolidine-3,5-dione (5) in CDCl<sub>3</sub>.



**Figure S7.** Normalized UV-Vis absorption spectra of the obtained new products **2**, **3**, **5**, recorded in the  $10^{-5}$  M solution in CH<sub>2</sub>Cl<sub>2</sub> at concentration of  $10^{-5}$  M.

#### References

- 1. W. W. Kalisch, M. O. Senge and K. Ruhlandt-Senge, *Photochemistry and Photobiology*, 1998, **67**, 312-323.
- 2. A. O. Shkirdova, I. A. Zamilatskov, N. M. Stanetskaya, V. A. Tafeenko, V. S. Tyurin, V. V. Chernyshev, G. V. Ponomarev and A. Y. Tsivadze, *Macroheterocycles*, 2017, **10**, 480-486.
- 3. L. Witte and J.-H. Fuhrhop, *Angewandte Chemie International Edition in English*, 1975, **14**, 361-363.