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On the Chemistry of Pyrrole Pigments, XCII [1]: Syntheses of 1,2-*bis*-Pyrrolylethanes

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Summary. 1,2-*bis*-Pyrrolylethanes are potential synthesis precursors of *b*-homorubins. They were synthesized in two ways: by self coupling of a 5-halomethylpyrrole using $VCl_3/LiAlH_4$ or by the reduction of 1,2-*bis*-pyrrolylethenes using Mg-MeOH/Pd-C as catalyst. The yields were 30–40% for the first method and reached 80% for the second one.

Keywords. 1,2-*bis*-Pyrrolylethanes; 1,2-*bis*-Pyrrolylethenes; Self-coupling; Reduction.

Zur Chemie von Pyrrolpigmenten, 92. Mitt. [1]: Synthesen von 1,2-*bis*-Pyrrolylethanen

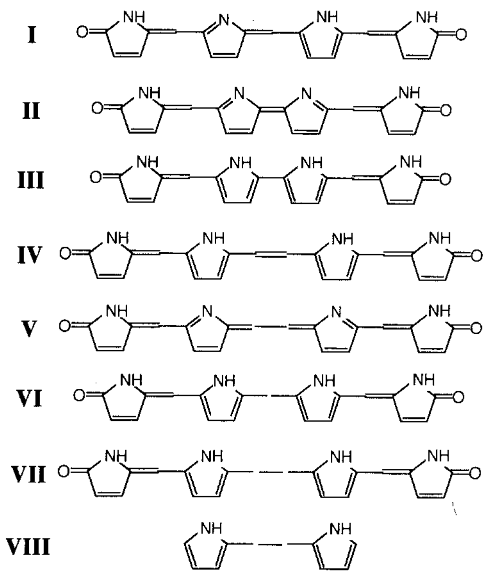
Zusammenfassung. 1,2-*bis*-Pyrrolylethane als potentielle Synthesevorstufen von *b*-Homorubinen konnten auf zwei Wegen synthetisiert werden. Beim ersten wurden 5-Halogenmethylpyrrole mit $VCl_3/LiAlH_4$ dimerisiert; der zweite Weg beruht auf der Reduktion von 1,2-*bis*-Pyrrolylethenen mit Mg-MeOH/Pd-C als Katalysator. Die Ausbeuten betrugen im ersten Fall um 30–40% und erreichten im zweiten Fall 80%.

Introduction

Following our approach to vary natural bile pigments synthetically into novel chromophore and ligand systems [1–6], the fundamental chromophore of the verdins **I** may be transformed in several ways. One possibility is to shorten the conjugation path in position 10, which leads to *b*-nor-pigment systems **II** and **III**. They differ in their oxidation states. This approach has been followed successfully [5, 6] and has led to the first examples of artificially altered bile pigments. Such pigments can also be envisaged as catabolites of the vigorously growing palette of natural and artificial porphyrin varieties [7, 8]. Other shortening transformations involved pyridinologous derivatives which have been shown to yield novel ligands. They are active as catalysts when complexed to transition metal ions [1, 9].

Extensions of the verdin system have been accomplished in principle already with the insertion of additional ring systems at position 10 [2–4, 10]. However, homologous C-10 extended compounds to be termed *b*-homoverdins (**IV** or **V**), which differ in their oxidation state, have not yet been prepared to our knowledge.

The same line of reasoning holds for the rubins **VI** as well. The *b*-homorubin **VII** could provide an interesting system to study conformational and association

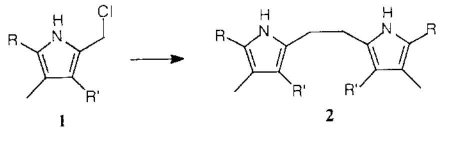


Scheme 1

behavior in comparison to the rubins **VI**. Following the disconnection approach [11], the synthesis of extended derivatives of type **IV**, **V**, and **VII** might be envisaged on two convergent routes. The first one involves the dimerization of a suited dipyrrinone, the second one would start with a *bis*-pyrrolylethane derivative, attaching the lactam rings in the last step. Therefore, we set out to study the accessibility of the fundamental partial structure **VIII** of such systems.

Results and Discussion

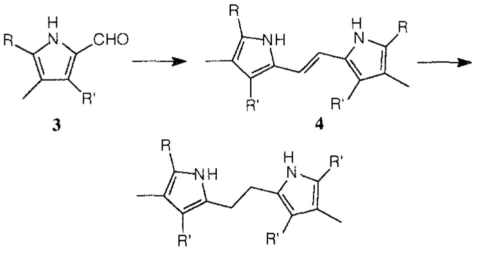
Using 2-bromomethylpyrrole as a starting material, *H. Fischer* first synthesized a 1,2-*bis*-pyrrolylethane in two steps [12]. It has been also reported that a 1,2-*bis*-pyrrolylethane is formed as a by-product in a reaction of tetradecane-3,6,9,12-tetraone with benzylamine [13]. However, these two methods did not seem to give efficient access to the 1,2-*bis*-pyrrolylethanes wanted. Therefore, two routes to 1,2-*bis*-pyrrolylethane derivatives were conceived.



	R	R′
a	$CH{=}C(COOC_2H_5)CN$	CH_3
b	$CH{=}C(COOCH_3)CN$	CH_3
c	$COOCH_2Ph$	CH_3
d	$COOC_2H_5$	$CH_2CH_2COOCH_3$

Scheme 2

The first one was based on a reductive dimerization of conveniently substituted 5-halomethylpyrroles. Thus, the 5-chloromethylpyrroles **1a–c** could be easily obtained following standard procedures [14, 15]. These were then subjected to reductive dimerization. The best reducing system for that purpose was found to be $VCl_3/LiAlH_4$ as described in Ref. [16]. Similarly, the 5-bromomethyl derivatives could also be used. Thereby, **2a–c** were obtained in yields between 30 and 45%.



	R	R'	R'(2)
2c	$CH{=}C(COOC_2H_5)CN$	CH_3	$CH{=}C(COOC_2H_5)CN$
3a	$COOBu^t$	CH_3	
3b	$COOBu^t$	$CH_2CH_2COOCH_3$	
3c	$CH{=}C(COOC_2H_5)CN$	CH_3	
4a	$COOBu^t$	CH_3	
4b	$COOBu^t$	$CH_2CH_2COOCH_3$	
4c	$CH{=}C(COOC_2H_5)CN$	CH_3	
5a	$COOBu^t$	CH_3	$COOBu^t$
5b	$COOBu^t$	$CH_2CH_2COOCH_3$	$COOBu^t$
6	Bu^t	CH_3	CHO

Scheme 3

The second route followed the easy reductive dimerization of the pyrrole aldehyde **3** using the *McMurry* [17] reaction to yield the *bis*-pyrrolylethene **4**. This dimerization has been achieved recently involving a different substitution pattern [18]. In the case of $COCH_3$ or $COOC_2H_5$ substituents in positions 3,3′ it has been shown that the product consisted of a mixture of the (*Z*)- and (*E*)-diastereomers. In all other cases, the (*E*)-diastereomer had been obtained specifically. According to the chemical shifts given in Ref. [18], **4** was assigned the (*E*) configuration. It should be mentioned that ethene singlets and NOEs between them and both the NH and the methyl signals of the adjacent rings were observed for **4**. These data pointed to a rapid interconverting system between the more or less coplanar (*syn,syn*), (*anti, anti*), and (*anti,syn*) conformers (the latter was arbitrarily drawn in the formula scheme). Hydrogenation of **4** to the 1,2-*bis*-pyrrolylethane **5** proved to be unexpectedly difficult by Pd-C, $NaBH_4$, and $LiAlH_4$. Success was achieved by means of the Mg-methanol/Pd-C systems, which has been previously used to reduce stilbene to 1,2-*bis*-phenylethane [19]. Using this method, **5** was obtained in 80–95% yield.

In an attempt to synthesize the corresponding dialdehyde, we found that reacting **5** with trifluoroacetic acid (*TFA*) and then trimethyl orthoformate, the product was an unexpected one, namely **6**. Accordingly, formylation occurred only on one side, the other one underwent electrophilic substitution with a *tert*-butyl group! Although the conditions were varied as follows: (i) *TFA*, 60 min at room temperature, then trimethyl orthoformate; (ii) *TFA*, 30 min at 50 °C, then trimethyl orthoformate; (iii) *TFA*, 45 min at 60 °C, then trimethyl orthoformate, the results were the same. In all these cases trimethyl orthoformate was used in a 2.20 fold molar excess and added at 0 °C.

Experimental

^{1}H NMR and ^{13}C NMR spectra were recorded on a Bruker-AC 200 instrument. Proton and carbon signal assignments were achieved using NOE and ^{1}H-^{13}C COSY. UV-Vis and IR spectra were run on the Hitachi-U-3210 and Biorad-FT-IR-45 spectrophotometers. Mass spectra were measured on a Hewlett-Packard 5989A instrument. Melting points were determined by means of a Kofler hot stage microscope (Reichert, Vienna). Silica GF_{254} was used for column chromatography. The educts **1a–c** and **3** were prepared according to Ref. [14, 20].

Dimerization of 5-halomethylpyrroles

0.28 g $LiAlH_4$ (7.4 mmol) was added to 3.4 g VCl_3 (21.6 mmol) suspended in 50 ml dry tetrahydrofuran. The mixture was stirred under an argon atmosphere for 5 min at room temperature. Then a solution of 7.2 mmol 5-chloromethylpyrrole (or its 5-bromomethyl derivative) in 50 ml tetrahydrofuran was added. After refluxing for 2 hours, the reaction mixture was quenched with 80 ml water. Dichloromethane (2 × 50 ml) was used to extract the aqueous solution. After drying and evaporating the solvent, the solid was recrystallized from methanol.

1,2-bis-[5-(2-Cyano-2-ethoxycarbonylvinyl)-3,4-dimethyl-pyrrolyl]-ethane (**2a**; $C_{26}H_{30}N_4O_4$)

Prepared according to the procedure above to yield 30%; m.p.: 208–10 °C; ^{1}H NMR (200 MHz, δ, $CDCl_3$): 1.35 (t, $J = 7$ Hz, 2 OCH_2CH_3), 1.87 (s, CH_3-3,3′), 2.29 (s, CH_3-4,4′), 2.93 (s, CH_2–CH_2), 4.32 (q, $J = 7$ Hz, 2 OCH_2CH_3), 7.91 (s, 2 CH=), 9.26 (br s, NH-1,1′) ppm; NOE ($CDCl_3$): CH_2-CH_2↔CH_3-3,3′, CH_2–CH_2↔NH-1,1′; IR (KBr): $\nu = 3421, 3330, 2970, 1746, 1698, 1685, 1566, 1541, 1220\,cm^{-1}$; UV-Vis ($CH_2Cl_2$): $\lambda_{max} = 413$ (46 000), 385 (41 700), 275 (80 400) nm (ε); UV-Vis (CH_3OH): $\lambda_{max} = 413$ (36 700), 382 (36 800), 271 (48 700) nm (ε); UV-Vis (*DMSO*): $\lambda_{max} = 418$ (49 600), 274 (59 400) nm (ε); MS (70 eV, 205 °C): *m/e* (%) = 462 (3, M^+), 231 (100), 203 (23), 153 (11).

1,2-bis-[5-(2-Cyano-2-methoxycarbonylvinyl)-3,4-dimethyl-pyrrolyl]-ethane (**2d**; $C_{24}H_{26}N_4O_4$)

Prepared according to the procedure above to yield 30% of a rather sensitive material; m.p.: 233–235 °C; ^{1}H NMR (200 MHz, δ, $CDCl_3$): 1.87 (s, CH_3-3,3′), 2.16 (s, CH_3-4,4′), 2.94 (s, CH_2–CH_2), 3.85 (s, 2 OCH_3), 7.92 (s, 2 CH=), 9.27 (br s, NH-1,1′) ppm; NOE ($CDCl_3$): CH_2–CH_2↔CH_3-3,3′, CH_2–CH_2↔NH-1,1′.

1,2-bis-(5-Benzoxycarbonyl-3,4-dimethylpyrrolyl)-ethane (**2c**; $C_{30}H_{32}N_2O_4$)

a) Prepared according to the procedure above to yield 30% **2c**
b) Prepared from **4c** by means of the reduction procedure described below to yield 85% **2c**

m.p.: 209–210 °C; ^{1}H NMR (200 MHz, δ, $CDCl_3$): 1.92 (s, CH_3-3,3′), 2.22 (s, CH_3-4,4′), 2.76 (s, CH_2–CH_2), 5.28 (s, 2CH_2–Ph), 7.36 (br s, 10 Ph-**H**), 8.42 (br s, NH-1,1′) ppm; NOE ($CDCl_3$):

CH_2–CH_2↔CH_3-3,3′, CH_2–CH_2↔NH-1,1′; ^{13}C NMR (90 MHz, δ, $CDCl_3$): 8.45 (CH_3-3,3′), 10.66 (CH_3-4,4′), 26.05 (–CH_2–CH_2–), 65.48 (–OCH_2–), 116.89 (C_{pyrr}), 117.51 (C_{pyrr}), 121.50 (C_{pyrr}), 128.02 (C_{phenyl}), 128.52 (C_{phenyl}), 136.52 (C_{pyrr}), 161.30 (CO) ppm; IR (KBr): ν = 3297, 2942, 1652, 1500, 1460, 1429, 1300 cm^{-1}; UV-Vis (CH_2Cl_2): λ_{max} = 277 (70 300) nm (ε); UV-Vis (CH_3OH): λ_{max} = 288 (37 300) nm (ε); UV-Vis (*DMSO*): λ_{max} = 284 (19 400) nm (ε); MS (70 eV, 160 °C): *m/e* (%) = 484 (1; M^+), 242 (25), 198 (7), 136 (5), 91 (100).

1,2-bis-(5-Ethoxycarbonyl-4-methyl-3-methoxycarbonylethylpyrrolyl)-ethane (**2d**; $C_{26}H_{36}N_2O_8$)

Prepared according to the procedure above to yield 31%; m.p.: 146–147 °C; ^1H NMR (200 MHz, δ, $CDCl_3$): 1.32 (t, *J* = 7.0 Hz, 2 OCH_2CH_3), 2.26 (s, CH_3C-4,4′), 2.34 (t, *J* = 7.5 Hz, 2 CH_2CH_2COO), 2.68 (t, *J* = 7.5 Hz, 2 CH_2CH_2COO), 2.83 (s, CH_2–CH_2), 3.65 (s, OCH_3), 4.28 (q, *J* = 7.0 Hz, 2 OCH_2CH_3), 8.90 (br s, NH-1,1′) ppm; NOE ($CDCl_3$): CH_2–CH_2↔CH_2CH_2COO-3,3′, CH_2–CH_2↔NH-1,1′; ^{13}C NMR (90 MHz, δ, $CDCl_3$): 10.45 (CH_3-4,4′), 14.59 (OCH_2CH_3), 19.24 ($CH_2CH_2CO_2$), 26.29 (–CH_2–CH_2–), 34.85 ($CH_2CH_2CO_2$), 51.58 (OCH_3), 59.69 (OCH_2CH_3), 117.85 (C_{pyrr}), 120.16 (C_{pyrr}), 126.67 (C_{pyrr}), 132.68 (C_{pyrr}), 162.52 ($COOC_2H_5$), 173.66 ($COOCH_3$) ppm; IR (KBr): ν = 3330, 2975, 1741, 1677, 1506, 1439, 1366, 1277 cm^{-1}; UV-Vis (CH_2Cl_2): λ_{max} = 281 (33 900) nm (ε); UV-Vis (CH_3OH): λ_{max} = 285 (30 900) nm (ε); UV-Vis (*DMSO*): λ_{max} = 282 (84 300) nm (ε); MS (70 eV, 191 °C): *m/e* (%) = 504 (M^+, 5), 427 (1), 252 (100), 206 (17), 134 (12), 91 (6).

Syntheses of 1,2-bis-pyrrolylethenes

Active Zn dust (5.78 g, 89 mmol) was added in portions under a dry nitrogen atmosphere to a stirred solution of $TiCl_4$ (8.11 g, 42.7 mmol) in 100 ml dry tetrahydrofuran cooled with an ice/salt bath. When the reaction mixture was warmed slowly to room temperature, it turned dark brown-purple and finally black. After refluxing for 1 hr it was then treated with a mixture of 2.5 ml pyridine, pyrrole-aldehyde **3** (39.5 mmol), and 100 ml dry tetrahydrofuran. The mixture was heated under reflux for 5 h. After cooling to 0 °C, it was quenched with water and then neutralized with saturated aqueous $NaHCO_3$ solution. The resulting solution was extracted with dichloromethane. After drying, evaporation and crystallization from methanol it afforded the title compounds.

1,2-bis-(5-tert-Butoxycarbonyl-3,4-dimethylpyrrolyl)-ethene (**4a**; $C_{24}H_{34}N_2O_4$)

Prepared from **3a** according to the procedure above to yield 57%; m.p.: 250–252 °C; ^1H NMR (200 MHz, δ, $CDCl_3$) 1.55 (s, 2 $OC(CH_3)_3$), 2.05 (s, CH_3-3,3′), 2.23 (s, CH_3-4,4′), 6.56 (s, –CH=CH–), 8.69 (br, s, 2 NH) ppm; NOE ($CDCl_3$): –CH=CH–↔CH_3-3,3′ –CH=CH–↔NH_3-1,1′; ^{13}C NMR (90 MHz, δ, $CDCl_3$): 8.51 (CH_3-3,3′) 10.47 (CH_3-4,4′), 28.55 ($OC(CH_3)_3$), 63.12 (–CH=CH–), 80.80 ($OC(CH_3)_3$), 113.78 (C_{pyrr}), 120.57 (C_{pyrr}), 126.79 (C_{pyrr}), 130.01 (C_{pyrr}), 161.39 (COO) ppm; IR (KBr): ν = 3350, 2980, 2930, 1668, 1564, 1504, 1435 cm^{-1}; UV-Vis (CH_2Cl_2): λ_{max} = 384 (13 900), 273 (20 500) nm (ε); UV-Vis (CH_3OH): λ_{max} = 364 (12 300), 272 (91 300) nm (ε); UV-Vis (*DMSO*): λ_{max} = 412 (30 600), 388 (3 500) nm (ε); MS (70 eV, 190 °C): *m/e* (%) = 414 (26), 358 (12), 302 (100), 269 (41), 197 (11), 152 (24).

1,2-bis-(5-tert-Butoxycarbonyl-4-methyl-3-methoxycarbonylethylpyrrolyl)-ethene (**4b**; $C_{30}H_{42}N_2O_8$)

Prepared from **3b** according to the procedure above to yield 47%; m.p.: 167–169 °C; ^1H NMR (200 MHz, δ, $CDCl_3$) 1.58 (s, 2 $OC(CH_3)_3$), 2.25 (s, CH_3-4,4′), 2.47 (t, *J* = 7.5 Hz, 2 CH_2CH_2COO), 2.84 (t, *J* = 7.5 Hz, 2 $CH_2CH_2CO_2$), 3.65 (OCH_3), 6.66 (s, –CH=CH–), 9.00 (br s, 2 NH) ppm; NOE ($CDCl_3$): –CH=CH–↔CH_2CH_2COO-3,3′, –CH=CH–↔NH_3-1,1′; ^{13}C NMR (90 MHz, δ, $CDCl_3$): 10.90 (CH_3-4,4′), 20.01 ($CH_2CH_2CO_2$), 29.03 ($OC(CH_3)_3$), 34.84 ($CH_2CH_2CO_2$), 52.22 (OCH_3), 81.48 ($OC(CH_3)_3$), 114.23 (CH=CH), 121.54 (C_{pyrr}), 123.96 (C_{pyrr}), 126.71 (C_{pyrr}), 130.59 (C_{pyrr}), 161.79 ($COOBu^t$), 173.96 ($COOCH_3$) ppm; IR (KBr): ν = 3321, 2981, 2926, 1734, 1652, 1502, 1440, 1329, 1269, 1157, 1093 cm^{-1};

UV-Vis (CH_2Cl_2): λ_{max} = 380 (10 200), 273 (17 300) nm (ε); UV-Vis (CH_3OH): λ_{max} = 380 (22 800), 268 (32 700) nm (ε)UV-Vis (*DMSO*): λ_{max} = 410 (10 600), 387 (13 000), 274 (43 900) nm (ε); MS (70 eV, 220 °C): *m*/*e* (%) = 558 (M^+, 20), 502 (12), 446 (100), 402 (19), 341 (49), 297 (13), 224 (15), 154 (9), 138 (8).

1,2-bis-[5-(2-Cyano-2-ethoxycarbonylvinyl)-3,4-dimethyl-pyrrolyl]-ethene (**4c**; $C_{26}H_{28}N_4O_4$)

Prepared from **3c** according to the procedure above to yield 80%; m.p.: 180–182 °C; ^{1}H NMR (200 MHz, δ, $CDCl_3$): 1.36 (t, *J* = 7 Hz, 2 OCH_2CH_3), 1.94 (s, CH_3-3,3′), 2.01 (s, CH_3-4,4′), 4.33 (q, *J* = 7 Hz, 2 OCH_2CH_3), 6.74 (s, CH=CH), 7.94 (s, 2 CH=), 9.63 (br s, NH-1,1′) ppm; NOE ($CDCl_3$): CH_2–CH_2↔CH_3-3,3′, CH_2–CH_2↔NH-1,1′; IR (KBr): ν = 3429, 3330, 2970, 1746, 1698, 1566, 1541, 1220 cm^{-1}; UV-Vis (CH_2Cl_2): λ_{max} = 515 (11 500), 408 (16 500), 275 (108 600) nm (ε); UV-Vis (CH_3OH): λ_{max} = 523 (23 800), 406 (23 300), 272 (40 500) nm (ε); UV-Vis (*DMSO*): λ_{max} = 532 (14 600), 410 (12 700), 280 (157 800) nm (ε); MS (70 eV, 180 °C): *m*/*e* (%) = 460 (1, M^+), 231 (7), 218 (100), 186 (95), 171 (27), 157 (65), 143 (15), 132 (25), 91 (98).

Reduction of 1,2-bis-pyrrolylethenes

4 (3.43 mmol) was dissolved in 30 ml dichloromethane under argon protection, then 60 ml methanol, 100 mg Pd-C (10%), and 3.0 g Mg dust were added at room temperature. The reaction mixture was stirred for 24 hours. Before partition with water, the mixture was filtered. The filtrate was extracted 2x with 30 ml dichloromethane, then the combined extracts were washed 2x with 30 ml 2*N* aqueous hydrochloric acid, 30 ml water, and 20 ml brine. After drying over anhydrous Na_2SO_4 and removing the solvent, the solid obtained was crystallized from methanol to yield the title compounds.

1,2-bis-(5-tert-Butoxycarbonyl-3,4-dimethylpyrrolyl)-ethane (**5a**; $C_{24}H_{36}N_2O_4$)

Prepared from **4a** according to the procedure above to yield 80%; m.p.: 228–229 °C; ^{1}H NMR (200 MHz, δ, $CDCl_3$): 1.54 (s, 2$OC(CH_3)_3$), 1.85 (s, CH_3-3,3′), 2.22 (s, CH_3-4,4′), 2.77 (s, –CH_2–CH_2–), 8.26 (br s, NH-1,1′) ppm; NOE ($CDCl_3$): CH_2–CH_2↔CH_3-3,3′, CH_2–CH_2↔NH-1,1′; ^{13}C NMR (90 MHz, δ, $CDCl_3$): 8.59 (CH_3-3,3′), 10.57 (CH_3-4,4′), 26.00 ($OC(CH_3)_3$), 28.52 (–CH_2–CH_2–), 80.12 ($OC(CH_3)_3$), 117.09 (C_{pyrr}), 118.49 (C_{pyrr}), 126.48 (C_{pyrr}), 131.23 (C_{pyrr}), 161.17 (COO) ppm; IR (KBr): ν = 3343, 2986, 2929, 1668, 1550, 1504, 1421 cm^{-1}; UV-Vis (CH_2Cl_2): λ_{max} = 276 (80 800) nm (ε); UV-Vis (CH_3OH): λ_{max} = 285 (10 200) nm (ε); UV-Vis (CH_2Cl_2): λ_{max} = 285 (38 500) nm (ε); MS (70 eV, 152 °C): *m*/*e* (%) = 416 (5), 208 (19), 152 (100), 134 (25), 106 (8).

1,2-bis-(5-Ethoxycarbonyl-4-methyl-3-methoxylcarbonylethylpyrrolyl)-ethane (**5b**; $C_{24}H_{36}N_2O_8$)

Prepared from **4b** according to the procedure above to yield 95%; m.p.: 88–90 °C; ^{1}H NMR (200 MHz, δ, $CDCl_3$): 1.54 (s, 2$OC(CH_3)_3$), 2.53 (s, CH_3-4,4′), 2.38 (t, *J* = 7.5 Hz, 2 CH_2CH_2COO), 2.67 (t, *J* = 7.5 Hz, 2 CH_2CH_2COO), 2.79 (s, CH_2–CH_2), 3.65 (s, OCH_3), 8.82 (br s, NH-1,1′) ppm; NOE ($CDCl_3$): CH_2–CH_2↔CH_2CH_2COO-3,3′, CH_2–CH_2↔NH-1,1′; ^{13}C NMR (90 MHz, δ, $CDCl_3$): 10.48 (CH_3-4,4′), 19.85 (CH_2CH_2COO), 27.32 (–CH_2–CH_2–), 28.45 ($OC(CH_3)_3$), 34.92 (CH_2CH_2COO), 51.68 (OCH_3), 80.25 ($OC(CH_3)_3$), 119.35 (C_{pyrr}), 120.54 (C_{pyrr}), 125.34 (C_{pyrr}), 131.82 (C_{pyrr}), 161.15 ($COOBu^t$), 173.24 ($COOCH_3$) ppm; IR (KBr): ν = 3366, 3331, 2975, 1737, 1680, 1507, 1434, 1366, 1276 cm^{-1}; UV-Vis (CH_2Cl_2): λ_{max} = 278 (229 200) nm (ε); UV-Vis (CH_3OH): λ_{max} = 285 (32 500) nm (ε); UV-Vis (*DMSO*): λ_{max} = 286 (30 400) nm (ε); MS (70 eV, 186 °C): *m*/*e* (%) = 560 (3, M^+), 487 (1), 280 (22), 224 (100), 206 (17), 152 (17), 134 (13).

1-(5-tert-Butyl-3,4-dimethylpyrrole)-2-(5-formyl-3,4-dimethylpyrrole)-ethane (**6**; $C_{19}H_{28}N_2O$)

300 mg **5a** (0.72 mmol) was stirred with 3 ml trifluoroacetic acid under argon protection at 40 °C for 30 min, then the solution was cooled to 0 °C, and 0.17 g trimethyl orthoformate (1.5 mmol) were added.

The mixture was stirred another 60 min before pouring it into 10 ml water of 0 °C. The solid material was collected by filtering and then extracted with dichloromethane. The extract was washed 2x with 30 ml satd. $NaHCO_3$, 2x with 10 ml water, 1x with 10 ml brine, and dried over anhydrous Na_2SO_4. After removing the solvent, the solid residue was crystallized from methanol affording 64 mg (30%) **6**; m.p.: 98–100 °C; ^1H NMR (200 MHz, δ, $CDCl_3$): 1.28 (s, $C(CH_3)_3$), 1.86 (s, CH_3), 1.91 (s, CH_3), 2.07 (s, CH_3), 2.22 (s, CH_3), 2.80 (s, $-CH_2-CH_2-$), 7.50 (br s, NH), 9.47 (s, CHO), 9.76 (br s, NH) ppm; IR (KBr): $\nu = 3247, 2958, 2922, 1682, 1624, 1441, 1382\ cm^{-1}$; UV-Vis ($CH_2Cl_2$): $\lambda_{max} = 275$ (55 700) nm (ε); UV-Vis (CH_3OH): $\lambda_{max} = 274$ (12 600) nm (ε); UV-Vis (*DMSO*): $\lambda_{max} = 276$ (56 600) nm (ε); MS (70 eV, 161 °C): m/e (%) = 298 (0.6; M-2), 164 (100), 136 (42), 77 (12).

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