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Synthesis and biological evaluation of 4,4-dimethyl-5,5-di(1-methylethyl)-2,3,4,5-tetrahydro-1 *H*-dipyrrolo[3,4-*d*:2,1-*f*][1,2]azasiline-1,3-dione and other pyrrolediones as new antibacterial active agents

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Dedicated to Prof. Dr. M. Liefländer, University of Regensburg, on the occasion of his 69th birthday

The UV-light induced photosubstitution of 3,4-dibromo-2,5-dihydro-1*H*-2,5-pyrroledione (**2**) [1] with pyrrole derivatives leads to 3-mono- and 3,4-disubstituted pyrrolediones depending on the starting material. These pyrrole homologues of arcyriarubin A (**1**) are further processed by nucleophilic substitution of the remaining bromine substituent with pyrrolidine. Cleavage of the protecting group affords the free pyrrole substituents. By UV-light irradiation the azasiline-system (**6**) is accessible, and its structure was established by X-ray methods. The *in vitro* antibacterial activity of the pyrrolediones was evaluated, and a strong activity of the compounds **4**, **7**, **8** and **12** against the methicillin- and ciprofloxacin-resistant bacterium *Staphylococcus aureus* 134/94 was established.

1. Introduction

Substituted 2,5-dihydro-1*H*-2,5-pyrrolediones **1a**–**g** have interesting biological activities. For example, arcyriarubin A (**1a**) and related compounds, in which one indole substituent can also be replaced by various heterocycles, show high antimicrobial [2] and antiviral [3–6] activity and are potent protein kinase C (PKC)-inhibitors [7]. For this reason we synthesized some pyrrole homologues of **1** and examined their antimicrobial activity.

These homologues comprise one or two pyrrole (or substituted pyrrole) substituents instead of indole and bromine or pyrrolidine. As the photoinduced reaction of dihalomaleinimides (firstly reported by Vermont et al. [8]) with heterocycles is a known method for the preparation of substituted pyrrolediones [1, 9, 10] we chose this way to introduce several pyrrole derivatives.

2. Investigations and results

2.1. Synthesis of the compounds

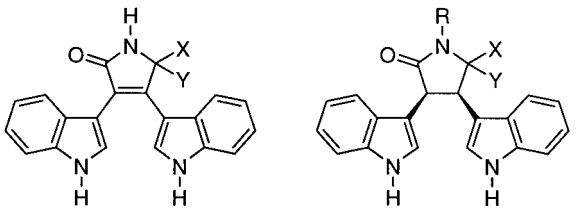
The reaction of 3,4-dibromo-2,5-dihydro-1*H*-2,5-pyrroledione (**2**) with *N*-(triisopropylsilyl)pyrrole (**3**) (*N*-(triisopropylsilyl) = tips) seemed promising for introducing two pyrrole rings by their 3-positions to give the disubstituted product. The tips-protecting group has a directing effect to the pyrrole-3-position because of steric hindrance of the 2-position [11]. We assumed a similar influence even under the conditions of a photoinduced reaction, but this assumption could not be confirmed. The first step, the irradiation of **2** and **3** with UV-light ($\lambda > 313$ nm) in dioxane in the presence of benzophenone as the photosensitizer, led to a mixture of the 2- and 3-isomers **4** and **5** of the monosubstituted maleinimide (Scheme 1) at a ratio of about 2:1. The two isomers could easily be separated by column chromatography, and the substitution pattern was determined by analyzing the coupling constants of the pyrrole protons [12]. Formation of the disubstituted product was not observed. This was in contrast to the observations of Wamhoff et al. [9] who used thiophene and furane as substitution partners, affording disubstituted products in moderate yields.

Thus we irradiated the monosubstituted compound **4** in the presence of *N*-(triisopropylsilyl)pyrrole (**3**) under the conditions described above, but instead of the substitution of the bromine by an second pyrrole molecule, compound **4** underwent an intramolecular photosubstitution forming the azasiline ring **6** (Scheme 2).

Structure **6** of this unexpected and rather exceptional molecule was clarified by X-ray analysis (Fig.).

The two isolated monosubstituted compounds **4** and **5** were desilylated by tetra-*n*-butylammoniumfluoride (TBAF) [13], to yield the free pyrrole isomers **7** and **8** (Scheme 3). Converting compounds **4** and **5** to the 1-pyrrolidine derivatives **9** and **10**, respectively, by treating them with pyrrolidine was accompanied by the cleavage of the silyl protecting group.

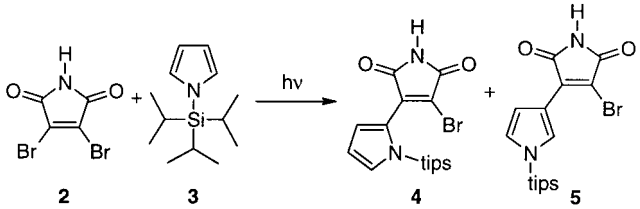
To further monitor the generality of the photosubstitution method, pyrrole derivatives were irradiated under the conditions mentioned above. The desilylated compound **7** was reacted with **3**, but instead of undergoing a second substitution with the *N*-protected pyrrole ring, the molecule dimerised in an intermolecular photosubstitution, affording



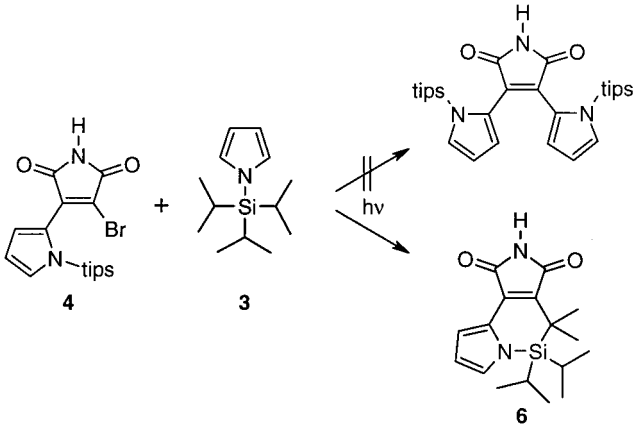
1a: X + Y = O
1b: X = H; Y = OH
1c: X = Y = H

1d: X + Y = O; R = H
1e: X = H; Y = OH; R = H
1f: X = Y = H; R = H
1g: X + Y = O; R = CH_2OH

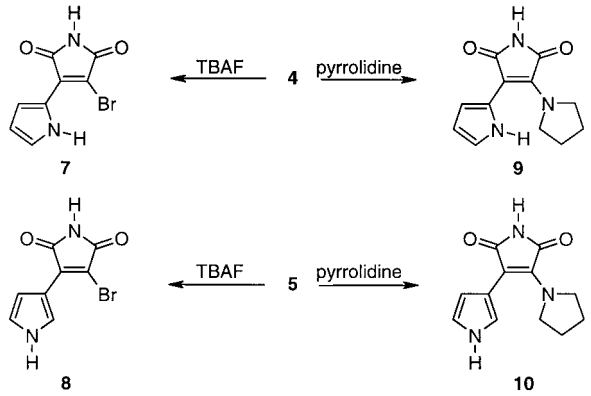
Scheme 1



Scheme 2



Scheme 3



compound **11** (Scheme 4), while the protected pyrrole **3** was almost quantitatively recovered. The reaction of **2** and 2-(1*H*-2-pyrrolylmethyl)-1*H*-pyrrole [15] afforded the monosubstituted pyrroledione **12**.

In contrast to the results of the reaction of *N*-silylated pyrrole derivatives, the reaction of **2** with 4-bromo-2-methoxycarbonylpyrrole [16] yielded the disubstituted pyrroledione **14** as well as the monosubstituted compound **13**. The substitution pattern was determined by examining the NOESY-spectrum of **14**. Based on the lack of NOE-signals containing the pyrrole-N-H we propose a substitution at the pyrrol-2-position.

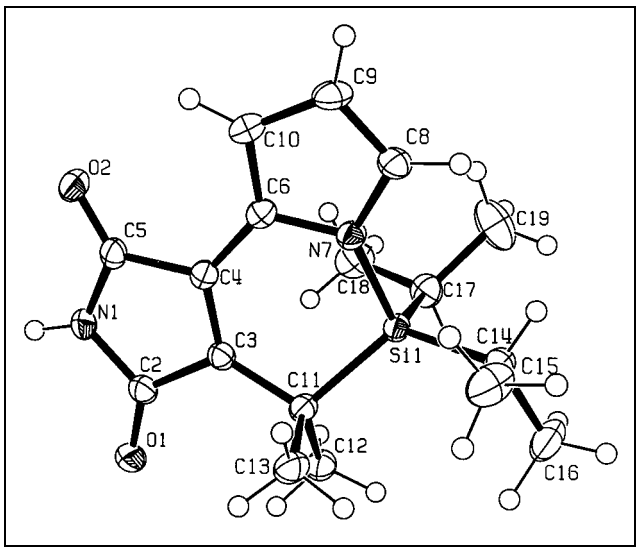
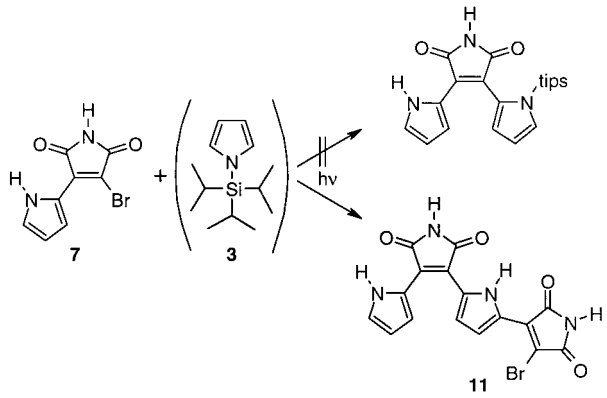
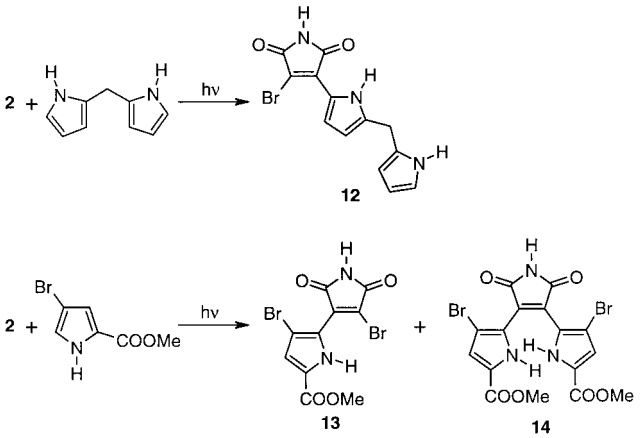


Fig.: ORTEP-diagram [14] of compound **6** (50% probability for thermal ellipsoids)

Scheme 4



Scheme 5



2.2. Biological studies

All the compounds were tested for antibacterial activity against the methicillin- and ciprofloxacin-resistant bacterium *Staphylococcus aureus* 134/94 (Table). A standardized agar well diffusion assay was used. All compounds were dissolved in DMSO, each well contained 100 µg. Test medium for *S. aureus* 134/94 was Standard I Nutrient Agar (SERVA, Germany).

Interestingly the compounds **7** and **13** also show a good activity against *Candida albicans*. All other compounds have no effect against this pathogenic yeast.

Table: Activity of the tested compounds on *S. aureus*

Compd.	Antibacterial activity (100 µg) Diameter of inhibition zone (mm)
Vancomycin	17
Doxycyclin	16
Ciprofloxacin	12
7	42
12	34
4	32
8	27
13	21
11	18
5	17
9	0
14	0
10	0
6	0

3. Discussion

In summary we have reported a method to introduce various pyrrole derivatives into the pyrroledione system. Some of these derivatives show a strong activity against *Staphylococcus aureus* 134/94. This is of great importance and interest because methicillin-resistance is a big problem in our hospitals [17–19]. Therefore, worldwide compounds with new mechanisms (no cross resistance against clinically used antibiotics) are developed. Our compounds are part of a new class of antibacterial substances. This class will be further investigated in order to gain more information about structure-activity-relationships. Up to now it seems, that the undistorted monobromopyrrolidione system is essential for the biological activity. Compound **7**, e.g., shows a very good activity whereas compounds **9** (the bromine atom is replaced by a pyrrolidine moiety) and **6** (the pyrroledione moiety is part of the azasiline system) have no influence on the bacterium. The same effect can be observed comparing compounds **5** and **10**.

4. Experimental

4.1. Chemistry

Melting points were recorded on a Reichert Thermovar 300419 microscope heating stage and are not corrected. ^{1}H NMR spectra were recorded on a Bruker AC250 (250 MHz) spectrometer. FT-IR-spectroscopy was performed on a Nicolet 510 FT-IR-spectrometer. MS were recorded on a Varian MAT 112 S, 70 eV using electron impact ionisation (EI). Microanalyses were performed by Analytisches Lab. Univ. Regensburg, and were within ±0.4% of theoretical values. A lot of maleimides crystallize with solvents, which could not be removed in spite of prolonged heating of the ground materials in vacuo. The presence of these solvents was assured by ^{1}H NMR spectra. TLC was carried out on Al-sheets coated with $60F_{245}$ silica. CC was carried out using Merck 60 (70–230 msh ASTM) silica. Solvents and commercially available reagents were dried and purified before use according to standard procedures. All reactions were carried out under dried N_2 in flame- or oven-dried vessels.

Photoreaction of 3,4-dibromo-2,5-dihydro-1*H*-2,5-pyrroledione with pyrrole derivatives: 3,4-Dibromo-2,5-dihydro-1*H*-2,5-pyrroledione (**2**) and the corresponding pyrrole derivatives were dissolved in dry dioxane. Benzophenone (10 mol% related to the pyrroledione compound) was added, and the mixture was irradiated for the given time (Hg high pressure burner, Philips HPK 125, pyrex-filter). The reaction was monitored by TLC until no further change was observed. Then the solvent was evaporated under reduced pressure and the residue purified by CC and recrystallization.

4.1.1. 3-Bromo-4-(1-triisopropylsilyl-1H-2-pyrrolyl)-2,5-dihydro-1H-pyrrole-2,5-dione (**4**) *and 3-Bromo-4-(1-triisopropylsilyl-1H-3-pyrrolyl)-2,5-dihydro-1H-pyrrole-2,5-dione* (**5**)

After irradiating 6.40 g (25.1 mmol) **2** and 13.0 g (58.2 mmol) **3** for 30 min in 250 ml of dry dioxane the residue was purified by CC (CH_2Cl_2) to afford 0.50 g (1.26 mmol, 5%) of **4** and 0.20 g (0.50 mmol, 2%) of **5** as yellow powders:

4: m.p. 174–175 °C (hexane); ^{1}H NMR ($CDCl_3$) δ 1.09 (d; J = 7.3 Hz, 18 H, CH_3), 1.35 (sept.; J = 7.3 Hz, 3 H, CH), 6.45 (dd; $J_{5\text{-}H}$ = 2.8 Hz, $J_{3\text{-}H}$ = 3.4 Hz, 1 H, 4-H), 6.64 (dd; $J_{5\text{-}H}$ = 1.4 Hz, $J_{4\text{-}H}$ = 3.4 Hz, 1 H, 3-H), 7.10 (dd; $J_{3\text{-}H}$ = 1.4 Hz, $J_{4\text{-}H}$ = 2.8 Hz, 1 H, 5-H), 7.57 (br. s; 1 H, NH); IR (KBr) ν̃: 3244, 3068, 2952, 2871, 1766, 1729, 1586 cm^{-1}; MS m/z (^{79}Br) 396 [M$^{+\cdot}$].
$C_{17}H_{25}BrN_2O_2Si$ (397.4)

5: m.p. 130–132 °C (hexane); ^{1}H NMR ($CDCl_3$) δ 1.12 (d; J = 7.6 Hz, 18 H, CH_3), 1.49 (sept.; J = 7.6 Hz, 3 H, CH), 6.86 (dd; $J_{2\text{-}H}$ = 2.1 Hz, $J_{4\text{-}H}$ = 3.0 Hz, 1 H, 5-H), 7.26 (dd; $J_{2\text{-}H}$ = 1.4 Hz, $J_{5\text{-}H}$ = 3.0 Hz, 1 H, 4-H), 7.52 (br. s; 1 H, NH), 7.98 (dd; $J_{4\text{-}H}$ = 1.4 Hz, $J_{5\text{-}H}$ = 2.1 Hz, 1 H, 2-H); IR (KBr) ν̃: 3244, 3066, 2948, 2869, 1773, 1721, 1611 cm^{-1}; MS m/z (^{79}Br) 396 [M$^{+\cdot}$].
$C_{17}H_{25}BrN_2O_2Si$ (397.4)

4.1.2. 4,4-Dimethyl-5,5-di(1-methylethyl)-2,3,4,5-tetrahydro-1H-dipyrrolo[3,4-d:2,1-f][1,2]azasiline-1,3-dione (**6**)

Compounds **4** (1.00 g, 2.51 mmol) and **3** (0.80 g, 3.58 mmol) were irradiated for 4 h in 150 ml dry dioxane. The residue was purified by CC (CH_2Cl_2) to afford 0.05 g (0.15 mmol, 6%) of the azasiline **6** as yellow, fluorescing crystals: m.p. 150–151 °C (hexane); ^{1}H NMR ($CDCl_3$) δ 1.00 (d; J = 7.4 Hz, 6 H), 1.09 (d; J = 7.4 Hz, 6 H), 1.49 (m; 2 H, CH), 1.57 (s; 6 H), 6.48 (dd; $J_{5\text{-}H}$ = 2.6 Hz, $J_{3\text{-}H}$ = 3.6 Hz, 1 H, 4-H), 6.98 (dd; $J_{3\text{-}H}$ = 1.2 Hz, $J_{4\text{-}H}$ = 2.6 Hz, 1 H, 5-H), 7.09 (br. s; 1 H, NH), 7.28 (dd; $J_{5\text{-}H}$ = 1.2 Hz, $J_{4\text{-}H}$ = 3.6 Hz, 1 H, 3-H); IR (KBr) ν̃: 3191, 3056, 2948, 2965, 2946, 2867, 1764, 1704, 1611 cm^{-1}; MS m/z 316 [M$^{+\cdot}$].
$C_{17}H_{24}N_2O_2Si \cdot {}^1/_2\ H_2O$ (325.5)

4.1.3. 3-Bromo-4-(1H-2-pyrrolyl)–2,5-dihydro-1H-pyrrole-2,5-dione (**7**)

A 1 M solution of tetra-*n*-butylammonium fluoride in THF (2.5 ml) was added to a stirred solution of 1.00 g (2.52 mmol) **4** in 8 ml THF. After 5 min at RT, the solution was diluted with ether, and the organic phase was washed with H_2O and dried over Na_2SO_4. Evaporation of the solvent yielded 0.40 g (1.66 mmol, 66%) of dione **7** as a red powder: m.p. >160 °C (dec.) (methanol); ^{1}H NMR ($CDCl_3$) δ 6.36 (ddd; $J_{3\text{-}H}$ = 3.9 Hz, J_{NH} = 2.4 Hz, $J_{5\text{-}H}$ = 2.6 Hz, 1 H, 4-H), 7.20 (ddd; $J_{4\text{-}H}$ = 2.6 Hz, $J_{3\text{-}H}$ = 1.4 Hz, J_{NH} = 2.4 Hz, 1 H, 5-H), 7.30 (ddd; $J_{4\text{-}H}$ = 3.8 Hz, $J_{5\text{-}H}$ = 1.4 Hz, J_{NH} = 2.6 Hz, 1 H, 3-H), 11.31 (s; 1 H, pyrrole-NH), 11.38 (br. s; 1 H, imide-NH); IR (KBr) ν̃: 3381, 3247, 1767, 1719, 1703, 1611 cm^{-1}; MS m/z (^{79}Br) 240 [M$^{+\cdot}$].
$C_8H_5BrN_2O_2$ (241.0)

4.1.4. 3-Bromo-4-(1H-3-pyrrolyl)-2,5-dihydro-1H-pyrrole-2,5-dione (**8**)

The desilylation of **5** was effected as described for the desilylation of **4**. The crude product was purified by CC (CH_2Cl_2) and **8** was isolated as a red powder (0.28 g, 1.18 mmol, 47%): m.p. >160 °C (dec.); ^{1}H NMR ($CDCl_3$) δ 6.97 (m; 2 H), 7.82 (ddd; J = 1.6, 1.6, 2.6 Hz, 1 H), 11.16 (br. s; 1 H, NH), 11.66 (s; 1 H, NH); IR (KBr) ν̃: 3413, 3215, 1767, 1713, 1598 cm^{-1}; MS m/z (^{79}Br) 240 [M$^{+\cdot}$].
$C_8H_5BrN_2O_2$ (241.0)

4.1.5. 3-(1-Pyrrolidino)-4-(1H-2-pyrrolyl)-2,5-dihydro-1H-pyrrole-2,5-dione (**9**)

Compound **4** (0.17 g, 0.43 mmol) was dissolved in 2 ml of freshly distilled pyrrolidine and stirred for 12 h at RT. Pyrrolidine was evaporated under reduced pressure and the residue was purified by CC (EtOAc/CH_2Cl_2 1:1) to afford 0.06 g (0.26 mmol, 60%) of compound **9** as red crystals: m.p. 201–202 °C; ^{1}H NMR ($CDCl_3$) δ 1.76 (m; 4 H, CH_2), 3.41 (m; 4 H, N–CH_2), 5.86 (ddd; $J_{4\text{-}H}$ = 3.3 Hz, $J_{5\text{-}H}$ = 1.5 Hz, J_{NH} = 2.4 Hz, 1 H, 3-H), 5.99 (ddd; $J_{3\text{-}H}$ = 3.3 Hz, J_{NH} = 2.6 Hz, $J_{5\text{-}H}$ = 2.6 Hz, 1 H, 4-H), 6.69 (ddd; $J_{4\text{-}H}$ = 2.6 Hz, $J_{3\text{-}H}$ = 1.5 Hz, J_{NH} = 2.7 Hz, 1 H, 5-H), 10.12 (s; 1 H, pyrrole-NH), 10.74 (br. s; 1 H, imide-NH); IR (KBr) ν̃: 3325, 3166, 3041, 2875, 1762, 1675, 1563 cm^{-1}; MS m/z 231 [M$^{+\cdot}$].
$C_{12}H_{13}N_3O_2$ (231.3)

4.1.6. 3-(1-Pyrrolidino)-4-(1H-3-pyrrolyl)-2,5-dihydro-1H-pyrrole-2,5-dione (**10**)

The reaction of 0.20 g (0.50 mmol) **5** with pyrrolidine was effected in the same manner as described for compound **4**. The crude product was purified by recrystallization from MeOH/C_6H_{14} affording **10** as a red powder (0.06 g, 0.26 mmol, 52%): m.p. 255 °C (dec.); ^{1}H NMR ($CDCl_3$) δ 1.74 (m; 4 H, CH_2), 3.43 (t; J = 6.6 Hz, 4 H, N–CH_2), 5.96 (ddd; J_{NH} = 2.4 Hz, $J_{5\text{-}H}$ = 2.4 Hz, $J_{4\text{-}H}$ = 1.7 Hz, 1 H, 2-H), 6.66 (m; 2 H), 10.12 (s; 1 H, pyrrole-NH), 10.74 (br. s; 1 H, imid-NH); IR (KBr) ν̃: 3373, 3174, 3041, 2979, 1750, 1613 cm^{-1}; MS m/z 231 [M$^{+\cdot}$].
$C_{12}H_{13}N_3O_2$ (231.3)

4.1.7. 3-(5-(4-Bromo-2,5-dioxo-2,5-dihydro-1H-3-pyrrolyl)-1H-2-pyrrolyl)-4-(1H-2-pyrrolyl)-2,5-dihydro-1H-pyrrole-2,5-dione (**11**)

Compounds **7** (0.40 g, 1.66 mmol) and **3** (0.40 g,1.80 mmol) were irradiated for 30 min in 32 ml of dry dioxane. The residue was purified by CC (CH_2Cl_2/EtOAc 1:4) to afford 25.0 mg (0.06 mmol, 3%) of compound **11** as a deep red powder: m.p. >200 °C (dec.); ^{1}H NMR ($CDCl_3$) δ 6.31 (ddd; $J_{3\text{-}H'}$ = 3.8 Hz, J_{NH} = 2.4 Hz, $J_{5\text{-}H'}$ = 2.6 Hz, 1 H, 4-H′), 6.97 (ddd; $J_{4\text{-}H'}$ = 3.8 Hz, J_{NH} = 2.5 Hz, $J_{5\text{-}H'}$ = 1.4 Hz, 1 H, 3-H′), 7.14 (ddd; J_{NH} = 2.7 Hz, $J_{4\text{-}H'}$ = 2.6 Hz, $J_{3\text{-}H'}$ = 1.4 Hz, 1 H, 5-H′), 7.19 (dd; $J_{4\text{-}H}$ = 4.3 Hz, J_{NH} = 2.6 Hz, 1 H, 3-H), 7.42 (dd; $J_{3\text{-}H}$ = 4.3 Hz, J_{NH} = 2.6 Hz, 1 H, 4-H), 11.25 (s; 1 H, pyrrole-NH), 11.35 (br. s; 1 H, imide-NH), 11.48 (s; 1 H, pyrrole-NH), 11.87 (br. s; 1 H, imide-NH); IR (KBr) ν̃: 3303, 1764, 1700, 1607 cm^{-1}; MS m/z (^{79}Br) 400 [M$^{+\cdot}$].
$C_{16}H_9BrN_4O_4 \cdot {}^1/_2$ ethyl acetate (445.2)

4.1.8. 3-Bromo-4-(5-(1H-2-pyrrolylmethyl)-1H-2-pyrrolyl)-2,5-dihydro-1H-pyrrole-2,5-dione (**12**)

Compound **2** (1.10 g, 4.31 mmol) and 0.80 g (5.47 mmol) 2-(1*H*-2-pyrrolylmethyl)-1*H*-pyrrole were irradiated for 30 min in 60 ml of dioxane. The residue was purified by CC (CH_2Cl_2/EtOAc 12:1) to afford 55.0 mg (0.16 mmol, 4%) of compound **12** as a deep red powder: m.p. >150 °C (dec.); ^{1}H NMR ($CDCl_3$) δ 3.99 (s; 2 H, CH_2), 5.80 (ddd; $J_{4\text{-}H}$ = 3.2 Hz, J_{NH} = 2.5 Hz, $J_{5\text{-}H}$ = 1.6 Hz, 1 H, 3-H), 5.91 (ddd; $J_{3\text{-}H}$ = 3.2 Hz, $J_{5\text{-}H}$ = 2.8 Hz, J_{NH} = 2.4 Hz, 1 H, 4-H), 6.14 (dd; $J_{4\text{-}H'}$ = 3.9 Hz, J_{NH} = 2.4 Hz,

1 H, 3-H′), 6.62 (ddd; $J_{4\text{-H}} = 2.8$ Hz, $J_{NH} = 2.5$ Hz, $J_{3\text{-H}} = 1.6$ Hz, 1 H, 5-H), 7.26 (dd; $J_{3\text{-H}'} = 3.9$ Hz, $J_{NH} = 2.5$ Hz, 1 H, 4-H′), 10.66 (s; 1 H), 11.26 (s; 1 H), 11.01 (s; 1 H); IR (KBr) $\tilde{\nu}$: 3394, 3367, 3210, 3060, 2900, 1764, 1717, 1613, 1472 cm^{-1}.
$C_{13}H_{10}BrN_3O_2 \cdot {}^1/_4$ ethyl acetate (342.2)

4.1.9. Methyl 4-bromo-5-(4-bromo-2,5-dioxo-2,5-dihydro-1H-pyrrol-3-yl)-1H-2-pyrrole-carboxylate (**13**) *and Methyl 4-bromo-5-(4-(3-bromo-5-methoxycarbonyl-1H-pyrrole-2-yl)-2,5-dioxo-2,5-dihydro-1H-pyrrole-3-yl)-1H-2-pyrrolecarboxylate* (**14**)

Compound **2** (3.20 g, 12.6 mmol) and 5.90 g (28.9 mmol) 4-bromo-2-methoxycarbonylpyrrole were irradiated for 2 h in 250 ml dry dioxane. The residue was purified by CC (EtOAc/C_6H_{14} 1 : 2) to afford 1.30 g (3.44 mmol, 27%) of **13** and 60 mg (0.11 mmol, 0.9%) of **14** as orange powders (1.50 g of methyl 4-bromo-1 *H*-2-pyrrolecarboxylate were recovered):
13: m.p. 243–245 °C; ^{1}H NMR ($CDCl_3$) δ 3.82 (s; 3 H, $COOCH_3$), 7.01 (s, 1 H, pyrrole-4-H), 11.74 (s; 1 H, imide-NH), 12.58 (s; 1 H, pyrrole-NH); IR (KBr) $\tilde{\nu}$: 3394, 3220, 3118, 2962, 1769, 1704, 1735, 1634 cm^{-1}; MS m/z 376 (^{79}Br) [$M^{+\cdot}$].
$C_{10}H_6Br_2N_2O_4$ (378,0)
14: m.p. 318 °C (dec.) (EtOH); ^{1}H NMR ($CDCl_3$) δ 3.81 (s; 6 H, $COOCH_3$), 6.88 (d, J = 2.6 Hz, 2 H, pyrrole-4-H), 11.53 (s; 1 H, imide-NH), 12.58 (d; J = 2.6 Hz, 2 H, pyrrole-NH); IR (KBr) $\tilde{\nu}$: 3346, 3276, 3139, 2956, 1767, 1711, 1561, 1438 cm^{-1}; MS m/z (^{79}Br) 499 [$M^{+\cdot}$].
$C_{16}H_{11}Br_2N_3O_6 \cdot$ EtOH (547,2)

4.2. Crystallography

Suitable prism shaped single crystals of **6** were obtained by slow evaporation from $CHCl_3$. Space group is $P-1$, $z = 4$, and cell constants $a = 8.0204(8)$ Å, $b = 15.303(2)$ Å, $c = 315.519(2)$ Å, $\alpha = 73.040(1)°$, $\beta = 77.440(10)°$, $\gamma = 89.780(10)°$, $V = 1774.7(4)$ Å^3. Intensities were collected in a Stoe IPDS diffractometer at 150(2) K with Mo-K_α radiation. Of the 17432 collected reflections (range: $2.26° \leq q \leq 25.59°$) 6189 were independent and 4919 were observed. Structure was established by direct methods, all non-hydrogen-atoms were refined anisotropically and hydrogen atoms were localized from difference fourier maps and were refined free. The final residuals were: R1 = 0.0305, wR2 = 0.0782 for the observed reflections.

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