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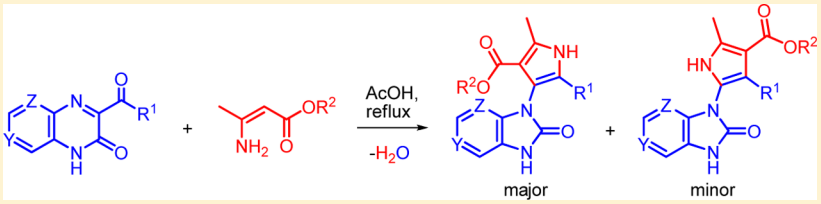
Reaction for the Synthesis of Benzimidazol-2-ones, Imidazo[5,4-*b*]-, and Imidazo[4,5-*c*]pyridin-2-ones via the Rearrangement of Quinoxalin-2-ones and Their Aza Analogues When Exposed to Enamines

Vakhid A. Mamedov,* Nataliya A. Zhukova, Anastasiya I. Zamaletdinova, Tat'yana N. Beschastnova, Milyausha S. Kadyrova, Il'dar Kh. Rizvanov, Victor V. Syakaev, and Shamil K. Latypov

A.E. Arbuzov Institute of Organic and Physical Chemistry, Kazan Scientific Center of the Russian Academy of Sciences, Arbuzov str. 8, Kazan 420088, Russian Federation

Supporting Information



ABSTRACT: A synthetically useful protocol has been developed for the preparation of highly functionalized *N*-pyrrolylbenzimidazol-2-ones. The reaction of variously substituted 3-aroyl- and 3-alkanoylquinoxalin-2(1*H*)-ones with commercially available enamines in acetic acid results in a rapid rearrangement and formation of *N*-pyrrolylbenzimidazol-2-ones in modest to excellent yields. The key step of the rearrangement involves the novel ring contraction of 3-aroyl- and 3-alkanoylquinoxalin-2(1*H*)-ones with enamines. In this case, the atom of carbon which is displaced from the pyrazine ring of quinoxalin-2(1*H*)-one becomes the fourth carbon atom of the newly formed pyrrole ring. The method is applicable for the aza analogues of quinoxalin-2(1*H*)-ones.

INTRODUCTION

1,3-Dihydrobenzimidazol-2-ones are an important class of compounds due to their selective vasopressin 1α receptor antagonists (**1**),[1] HIV-1 reverse transcriptase non-nucleoside inhibitors (**2**),[2] CGRP receptor antagonists (**3**),[3] p38 MAP kinase inhibitors (**4**),[4] respiratory syncytial virus fusion inhibitors (**5**),[5] and progesterone receptor antagonists (**6**)[6] (Figure 1). Therefore, much attention has been paid to the development of efficient methods for the preparation of 1,3-dihydrobenzimidazol-2-ones.

Due to the demand, various synthetic approaches have been developed toward these interesting compounds, most of them using benzene-1,2-diamines as key intermediates. Their subsequent cyclization to form the imidazolone core involves the use of phosgene,[7] triphosgene,[8] or carbonyldiimidazole.[9] To avoid the use of such toxic substances and often harsh reaction conditions, alternative protocols have been introduced that give access to imidazo[4,5-*b*]pyridine-2-ones[10] or benzimidazol-2-ones[11] catalyzed by palladium or copper.[12] In these reactions, the formation of the cyclic urea units occurs either by metal-catalyzed N-arylation or by coupling of ammonia with 2-iodoacetanilides followed by acid-catalyzed cyclization.[13] In this case, elevated temperatures (>80 °C) and additional activation modes such as microwave irradiation were required, as well.

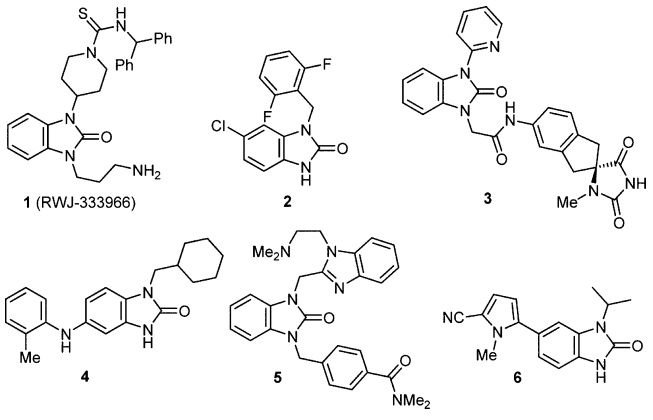


Figure 1. Structure of some biologically important N-substituted 1,3-dihydrobenzimidazol-2-ones.

We have recently discovered a new reaction for the synthesis of 2-(heteroaryl)benzimidazoles **9** with the reaction of 3-substituted quinoxalin-2(1*H*)-ones **7** and N-nucleophilic reagents (Scheme 1).[14]

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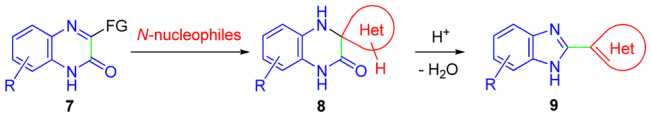
Scheme 1. Schematic Presentation of the Rearrangement for the Synthesis of 2-(Heteroaryl)benzimidazoles



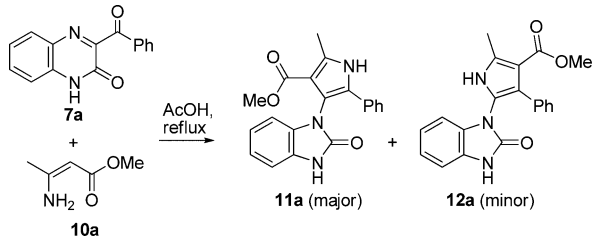
The key step of the reaction (Scheme 1) involved a novel acid-catalyzed rearrangement of intermediate spiro-quinoxalin-2(1*H*)-one derivatives **8**[14b−g] with a contraction of the pyrazine ring of the quinoxalin-2-one system. It was also shown that the necessary condition for rearrangement is the presence of at least one mobile hydrogen atom in the spiro-forming fragment, which is responsible for the elimination of water. As can be seen from Scheme 1, the formation of water takes place with the involvement of the oxygen atom of the carbonyl group. We assumed that if the spiro-quinoxalinone derivative with no mobile hydrogen atom in the spiro fragment was subjected to rearrangement, there might probably be two options. The first one is that the rearrangement would not occur at all; the second one is that another rearrangement would take place without any water elimination and with the preservation of the carbonyl oxygen atom, probably quinoxalinone benzimidazolone. To confirm this assumption, it was necessary to synthesize the spiro derivatives of the quinoxalinone without any mobile hydrogen atoms. To this end, after analyzing all of the possible nucleophilic reagents, we have chosen the enamines as CN-nucleophiles. Here, the results of our study on a novel rearrangement of 3-aroyl- and alkanoylquinoxalin-2(1*H*)-ones when exposed to the commercially available enamines (methyl- and ethyl 3-aminocrotonates) as CN-nucleophiles under acid catalysis condition are presented.

RESULTS AND DISCUSSION

Optimization of Reaction Conditions. To optimize the process, we initially carried out the reaction of 3-benzoylquinoxalin-2(1*H*)-one **7a** with methyl 3-aminocrotonate **10a** in boiling acetic acid with various ratios of reagents (1:1, 1:5, and 1:7 **7a**/**10a**) and at different reaction times (Table 1). When the reaction is carried out with the equimolar ratio of the reagents regardless of the reaction time (1, 3, 6, 8, or 12 h), no reaction takes place (Table 1, entries 1−5). The use of a 5-fold excess of methyl 3-aminocrotonate **10a** leads to the formation of two unexpected regioisomeric products of the rearrangement (**11a** and **12a**) in high overall yield. In these cases, a small amount (1−3%) of unimpaired 3-benzoylquinoxalin-2(1*H*)-one **7a** is reverted regardless of the reaction time (1, 3, 6, or 8 h) (Table 1, entries 6−9). Methyl 3-aminocrotonate **10a** apparently undergoes polymerization. The optimal condition for carrying out the investigated reaction appears to be the use of reagents in a ratio of (1:7 **7a**/**10a**) in boiling acetic acid for 6 h (Table 1, entry 12). At such reagent ratios, the reaction proceeds successfully for 1 h; however, the desired products of the rearrangement are allocated easily if the reaction has been carried out for 6 h. This is apparently due to the complete decomposition or polymerization of excess enamine.

Synthesis of *N*-Pyrrolylbenzimidazol-2-ones. Having the optimized reaction conditions at our disposal, we proceeded to explore the scope and limitations of the reaction. The procedure was extended to 3-aroylquinoxalin-2(1*H*)-ones **7a**−**i** having various substituents and methyl- (**10a**) and ethyl- (**10b**) 3-aminocrotonates. As shown in Table 2, the reaction proceeded very efficiently and led to the formation of the corresponding *N*-(pyrrol-3-yl)benzimidazol-2-ones (**11**) as major and *N*-(pyrrol-2-yl)benzimidazol-2-ones (**12**) as minor products with overall yields of 89−99%. The reaction proceeded so fast that we were unable to allocate the expected spiro compound. Under the reaction conditions, they immediately rearranged to *N*-pyrrolylbenzimidazol-2-ones in high yields.

Table 1. Optimization of Reaction Conditions



entry	ratio of **7a**/**10a**	time (h)	**11a**/**12a**[a]	overall yield **11a** + **12a** (%)
1	1:1	1	NR	
2	1:1	3	NR	
3	1:1	6	NR	
4	1:1	8	NR	
5	1:1	12	NR	
6	1:5	1	3.4:1	85[b]
7	1:5	3	3.3:1	85[b]
8	1:5	6	3.4:1	87[b]
9	1:5	8	3.3:1	86[b]
10	1:7	1	3.7:1	95
11	1:7	3	3.4:1	95
12	1:7	6	3.5:1	97

[a]The ratio was determined by ^{1}H NMR of the crude product. [b]Traces of **7a** were present in the crude product.

The structure of regioisomers **11** and **12** can be unequivocally established by a variety of 1D/2D NMR correlation methods.[15,16] First, benzimidazole (BI) fragments are revealed from ^{1}H−^{15}N/^{1}H−^{13}C HSQC/HMBC connectivities starting from the NH (BI) protons (see Supporting Information). After that, the structures of pyrrole moieties of **11** and **12** are discerned from the NMR heteronuclear correlations. Finally, the regioisomeric structure of these compounds has been proven by the NOE data, which makes it possible to correlate the mutual spatial position of pyrrole substituents. Namely, there are key NOEs between the Ar and NH pyrrole (P) protons in **11** and between the Ar and OR (R = Me or Et) protons in **12** (e.g., for **11l** and **12l**, see Figure 2). There are also nontrivial NOEs between the OR and H7 (BI) protons in **11** which are absent in **12**. These assignments are also strongly supported by the ^{1}H chemical shift (CS) data; namely, in **11**, the OR protons occurred in the shielding zone of the BI aromatic system and as a result resonated at a higher field than in **12**. It is interesting to note that pyrrole nitrogen's CSs also depend on the regioisomeric structure. While in **11** the CSs are ca. 162 ppm, in **12**, its resonances are observed at lower fields (ca. 167 ppm).

Mechanism of the Reaction. On the basis of the known chemistry of imines,[17] ketones,[18] enamines,[19] quinoxalinones,[20] and the previous reports,[14a−f] a plausible reaction mechanism for the formation of *N*-pyrrolylbenzimidazol-2-ones **11** and

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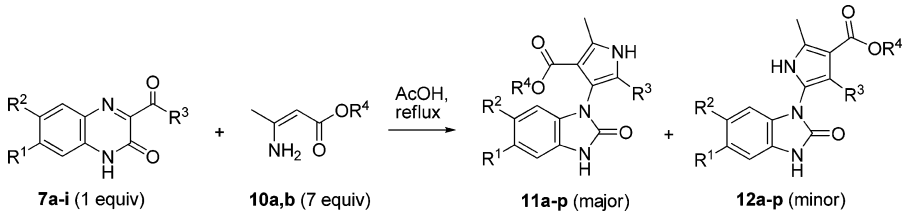
Table 2. Synthesis of *N*-Pyrrolylbenzimidazol-2-ones 11 and 12



entry	7	R^1	R^2	R^3	10	R^4	products (yield)[a,b]	overall yield (11/12)[c]
1	**7a**	H	H	Ph	**10a**	Me	**11a** (45%) + **12a** (n/i)	97%, 78:22
2	**7b**	H	H	C_6H_4F-4	**10a**	Me	**11b** (42%) + **12b** (n/i)	94%, 74:26
3	**7c**	H	H	C_6H_4Cl-4	**10a**	Me	**11c** (52%) + **12c** (n/i)	97%, 72:28
4	**7d**	H	H	C_6H_4Br-4	**10a**	Me	**11d** (51%) + **12d** (n/i)	97%, 70:30
5	**7e**	H	H	C_6H_4I-4	**10a**	Me	**11e** (53%) + **12e** (n/i)	98%, 75:25
6	**7f**	H	H	*n*-Pr	**10a**	Me	**11f** (39%) + **12f** (n/i)	97%, 91:9
7	**7g**	Me	Me	Ph	**10a**	Me	**11g** (62%) + **12g** (n/i)	97%, 83:17
8	**7h**	C(O)Ph	H	Ph	**10a**	Me	**11h** (43%) + **12h** (n/i)	97%, 79:21
9	**7a**	H	H	Ph	**10b**	Et	**11i** (58%, 24%[b]) + **12i** (4%)[b]	99%, 78:22
10	**7b**	H	H	C_6H_4F-4	**10b**	Et	**11j** (59%) + **12j** (n/i)	96%, 77:23
11	**7c**	H	H	C_6H_4Cl-4	**10b**	Et	**11k** (61%, 40%[b]) + **12k** (5%)[b]	97%, 67:33
12	**7d**	H	H	C_6H_4Br-4	**10b**	Et	**11l** (56%, 38%[b]) + **12l** (4%)[b]	99%, 67:33
13	**7e**	H	H	C_6H_4I-4	**10b**	Et	**11m** (56%) + **12m** (n/i)	98%, 60:40
14	**7g**	Me	Me	Ph	**10b**	Et	**11n** (65%) + **12n** (n/i)	99%, 84:16
15	**7h**	C(O)Ph	H	Ph	**10b**	Et	**11o** (41%) + **12o** (n/i)	98%, 72:28
16	**7i**	C(O)OH	H	Ph	**10b**	Et	**11p** + **12p** (77%)	89%, 75:25 (inseparable mixture)

[a,b]Yields refer to isolated products. [a]Method A. [b]Method B. See Experimental Section with regard to isolated yields. [c]Ratio determined by the ^{1}H NMR of the crude products.

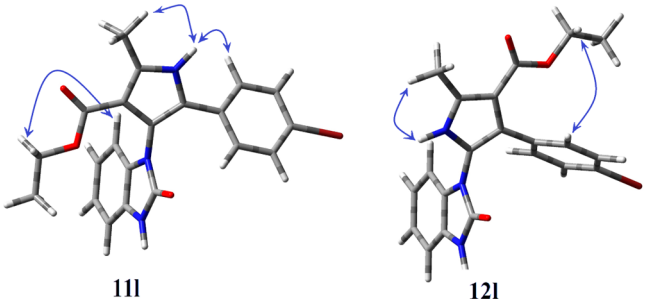


Figure 2. Optimized (B3LYP/6-31G(d)) structures of **11l** and **12l** with key NOEs (blue arrays).

12 has been proposed (Scheme 2). The formation of *N*-pyrrolylbenzimidazol-2-ones occurs in two different ways (pathway I and pathway II), differing in the initial stage of the process. In the case of the formation of *N*-(pyrrol-3-yl)-benzimidazol-2-ones **11**, the reaction starts (Scheme 2, pathway I) with the acid-catalyzed activation of the imine group (of **7a**) and subsequent Michael-type reaction[21] between **7a** and **10a** involving a nucleophilic attack by the enamino double bond (of **10a**) on the electron-deficient double bond (of **7a**), which leads to the formation of **A**. The intramolecular cyclization of **A** involving the attack by the imine nitrogen on the nearby −C(O)Ph moiety affords the spiroquinoxaline derivative **B**. The rearrangement of the spiroquinoxalinone **B** is then assumed to occur according to Scheme 2, which proceeds by cascade reactions involving (a) the intramolecular nucleophilic attack by the amino group on the carbonyl group with the intermediate formation of the hydroxy derivative **C**, (b) the ring opening with cleavage of the C2−C3 bond in the hydroxy derivative **C** with the elimination of water leading to the formation of the final product **11a**.

In the case of the formation of *N*-(pyrrol-2-yl)benzimidazol-2-ones **12a** at its initial stage, there occurs a nucleophilic attack by the enamino double bond (of **10a**) on the electron-deficient benzoyl carbonyl group (of **7a**) which leads to the formation of **D** (Scheme 2, pathway II). This brings about the rearrangement product via intermediates **E** and **F**.

Synthesis of the Aza Analogues of *N*-Pyrrolylbenzimidazol-2-ones. With this result at our disposal, we went on to study the scope of the methodology with respect to the 5- and 7-aza-quinoxalin-2(1*H*)-ones, namely, 3-benzoylpyrido[3,2-*b*]pyrazin-2(1*H*)-one **13** and 3-benzoylpyrido[3,4-*b*]pyrazin-2(1*H*)-one **14** (Scheme 3). As can be seen, this chemistry is not limited to the quinoxalin-2(1*H*)-ones, and the compounds composed of two heterocyclic fragments are acceptable substrates, as well.

The reactions proceed perfectly well with both **13** and **14** pyrazin-2(1*H*)-one derivatives, with the formation of easily separable regioisomeric products **15**/**16** and **17**/**18** with overall quantitative yields.

In comparison with the existing methods, the present approach offers the following advantages: (i) it proceeds faster and affords good to excellent yields under mild conditions with no additional activation modes such as microwave irradiation; (ii) it is very cost-effective and uses inexpensive, easy,[14a,22] and commercially available reagents; and (iii) it is applicable to a broader range of substrates, including 3-aroyl(alkanoyl)-quinoxalin-2(1*H*)-ones, 3-benzoylpyrido[3,2-*b*]pyrazin-2(1*H*)-one, and 3-benzoylpyrido[3,4-*b*]pyrazin-2(1*H*)-one and various enamines.

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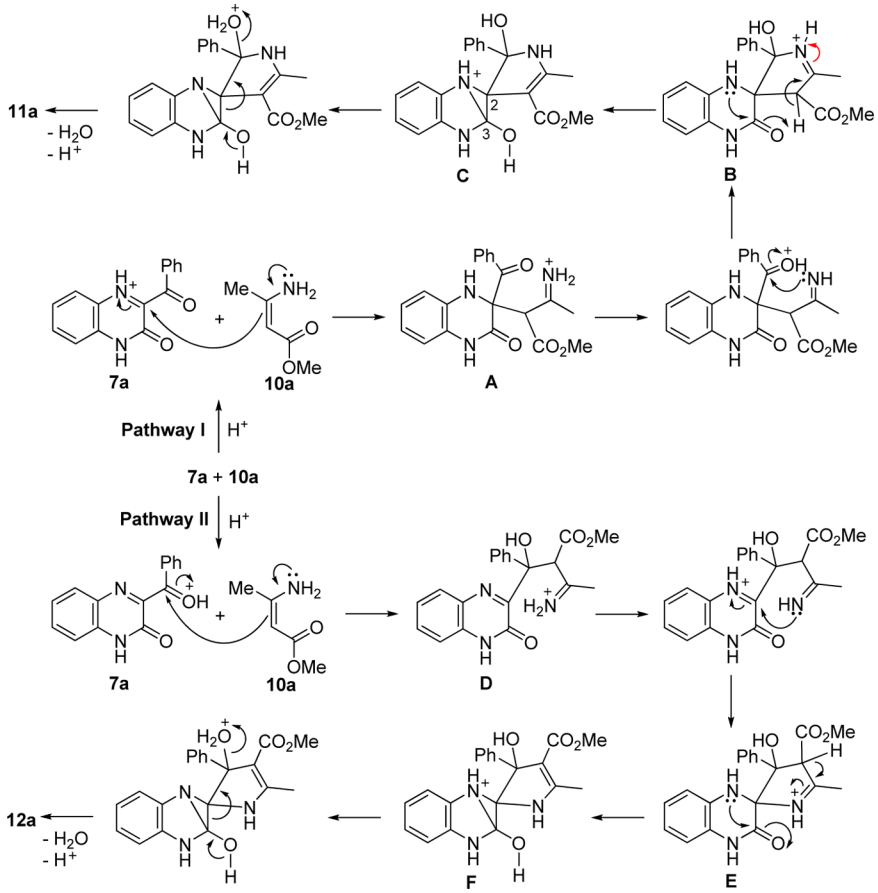
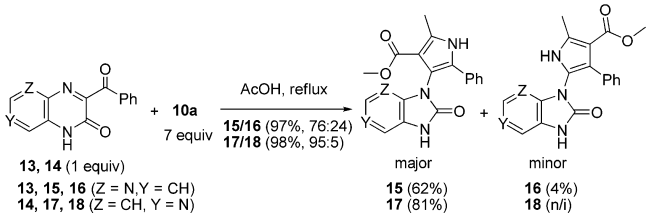
Scheme 2. Proposed Mechanisms for the Formation of 11a (Pathway I via an Initial Attack on the C3 Atom of Quinoxalin-2(1*H*)-one) and 12a (Pathway II via an Initial Attack on the C Atom of the Benzoyl Group)



Scheme 3. Synthesis of *N*-Pyrrolyl-1*H*-imidazo[5,4-*b*]-(15/16) and *N*-Pyrrolyl-1*H*-imidazo[4,5-*c*]pyridin-2(3*H*)-ones (17/18)



CONCLUSION

In conclusion, we have developed an effective synthetic strategy via the novel quinoxalin-2(1*H*)-one/benzimidazol-2-one rearrangement that permits a rapid access to the *N*-pyrrolylbenzimidazol-2-ones from the readily available 3-aroylquinoxalin-2(1*H*)-ones having various substituents and commercially available enamines (methyl and ethyl 3-aminocrotonates). The methodology is found to be general, and a wide variety of *N*-pyrrolylbenzimidazol-2-one derivatives are prepared in good yields. Due to the availability of the starting materials and the potential applications of products, this method is highly prospective in organic synthesis and medicinal chemistry. This protocol also represents an extremely simple, efficient, and metal-free environmentally friendly way to construct substituted pyrroles and benzimidazol-2-ones in overall high yields. Aza analogues of benzimidazol-2-ones can be obtained using aza analogues of quinoxalin-2(1*H*)-one. Thus, it complements the method for rapid formation of multifunctional heterocycles.

EXPERIMENTAL SECTION

General Information. All NMR experiments were performed with 600, 500, and 400 MHz (600 and 500 MHz for ^{1}H NMR; 376 MHz for ^{19}F NMR; 100 MHz for ^{13}C NMR; 60 MHz for ^{15}N NMR, respectively) spectrometers equipped with a 5 mm diameter gradient inverse broad band probehead and a pulsed gradient unit capable of producing magnetic field pulse gradients in the *z*-direction of 53.5 G·cm^{-1}. NMR experiments were carried out at 303 K. DPFGROE[23] and TOCSY spectra were obtained using a Hermite-shaped pulse for selective excitation. Chemical shifts (δ in ppm) are referenced to the solvent DMSO-d_6 (δ = 2.49 ppm for ^{1}H and 39.5 ppm for ^{13}C NMR), to external CD_3NO_2 (380.2 ppm) for ^{15}N NMR spectra (conversion factor to NH_3, −380.2 ppm), and to external C_6F_6 (−164.9 ppm) for ^{19}F NMR spectra. The quantum chemical calculations were performed using a Gaussian 98w software package.[24] Full geometry optimizations have been carried out within the framework of the DFT (B3LYP) method using 6-31G(d) basis sets. Melting points were determined on a hot-stage apparatus. The IR spectra were recorded on a FT-IR spectrometer. The electron ionization mass spectra (EI-MS) were obtained on gas chromatography mode using "GC MS QP2010" with the following conditions: capillary column = 15 m; 0.25 mm; 0.25 μm "Rxi-1ms"; carrier gas is helium with constant flow of 3 mL/min used; constant temperature of oven = 280 °C, and injection temperature = 280 °C. The masses of ions had more than 10% relative intensity on a mass range from 70 to 500 Da. MALDI experiments (MALDI-MS) were performed with a mass spectrometer equipped with an Nd:YAG laser. The mass spectra were measured in the positive ion linear mode. The data were processed using the software FlexAnalysis 3.0 from

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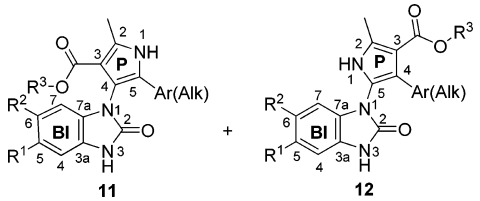
Bruker Daltonics. The *p*-nitroaniline was used as a matrix. The dried-droplet spotting technique (matrix, analyte) was applied. For each sample, 0.5 μL of the analyte solution in DMSO was coated onto a target plate with the matrix solution of 10 mg/mL in acetonitrile MTP AnchorChip.

General Procedure for the Synthesis of *N*-Pyrrolylbenzimidazol-2-one Derivatives 11a−p/12a−p. A mixture of quinoxalin-2(1*H*)-one **7** (1.0 equiv) and enamine **10** (7.0 equiv) in glacial acetic acid (10 mL) was refluxed for 6 h. After the solvent was cooled, it was removed under vacuum and the residue was treated with a 5% $NaHCO_3$ solution (15 mL); the precipitate was filtered off, washed with water (5 × 5 mL), and dried in air. A mixture of isomers **11a−p/12a−p** was obtained.



The individual compounds were isolated according to the following methods. *Method A.* The mixture of isomers **11/12** (with the exception of the mixtures of benzoyl derivatives of methyl and ethyl esters **11h/12h** and **11o/12o**) was treated with cooled chloroform (2 mL); the insoluble residue was filtered off, washed with chloroform (2 × 2 mL), and dried in air to give the predominant isomers **11a−g** and **11i−n** in individual form as analytically pure samples. The same procedure for the isomers **11p/12p** results in the isolation of isomers **11p** and **12p** as an analytically pure mixture in the ratio of 4:1. In the cases of **11h** and **11o**, the predominant isomers were allocated by column chromatography on silica gel (0.060−0.200 mm, 40 Å) with a mixture of ethyl acetate/hexane (10:90 → 70:30) as eluents. *Method B.* The mixture of isomers **11i/12i**, **11k/12k**, and **11l/12l** was treated with ether (2 × 5 mL); the precipitate was filtered off, dried in air, and refluxed in toluene (25 mL). The insoluble portion was filtered off to give the predominant isomers **11i**, **11k**, and **11l**. The precipitate was filtered off from the filtrate to give the minor isomers **12k** and **12l**. In the case of processing the mixture of isomers **11i/12i**, the toluene filtrate was evaporated to dryness and the residue was purified by column chromatography on silica gel (0.060−0.200 mm, 40 Å) with a mixture of *i*-PrOH/hexane (5:95) as eluents. As a result, an analytical pure minor isomer **12i** was obtained.

*1-[(3-Methoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]benzimidazol-2(3H)-one (**11a**) and 1-[(3-Methoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12a**). Method A:* Yield 311 mg (45%), **11a**, beige solid, mp 310−312 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 2.53 (s, 3H, CH_3), 3.41 (s, 3H, OCH_3), 6.46 (d, *J* = 7.6 Hz, 1H, H7), 6.84 (dd, *J* = 7.6, 7.6 Hz, 1H, H6), 6.94 (dd, *J* = 7.6, 7.6 Hz, 1H, H5), 7.00 (d, *J* = 7.6 Hz, 1H, H4), 7.20 (dd, *J* = 7.6, 7.1 Hz, 1H, H4-Ar), 7.30 (dd, *J* = 7.6, 7.6 Hz, 2H, H3-Ar, H5-Ar), 7.37 (d, *J* = 7.6 Hz, 2H, H2-Ar, H6-Ar), 10.83 (s, 1H, NH-BI), 11.96 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.5 (C(O)OCH_3), 154.6 (C2), 135.8 (C2-P), 132.2 (C7a), 130.2 (C1-Ar), 128.8 (C3a), 128.7 (C3-Ar, C5-Ar), 127.6 (C5-P), 127.1 (C4-Ar), 125.3 (C2-Ar, C6-Ar), 120.9 (C5), 120.5 (C6), 113.9 (C4-P), 108.6 (C4), 108.6 (C3-P), 108.0 (C7), 50.3 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.6 (N1-P), 121.2 (N1), 118.4 (N3); IR (KBr) ν 3392, 3129, 3063, 1704, 1675, 1615, 1480, 1451, 1394, 1370, 1347, 1295, 1262, 1245, 1193, 1104, 763, 733, 702 cm^{-1}; MALDI-MS MH^+ 348. Anal. Calcd for $C_{20}H_{17}N_3O_3$: C, 69.15; H, 4.93; N, 12.10. Found: C, 69.01; H, 4.85; N, 11.90%.

*1-[(5-(4-Fluorophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11b**) and 1-[(4-(4-Fluorophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12b**). Method A:* Yield 286 mg (42%), **11b**, beige solid, mp 307−309 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 2.53 (s, 3H, CH_3), 3.41 (s, 3H, OCH_3), 6.46 (d, *J* = 7.6 Hz, 1H, H7), 6.84 (dd, *J* = 7.6, 7.6 Hz, 1H, H6), 6.95 (dd, *J* = 7.6, 7.1 Hz, 1H, H5), 6.99 (d, *J* = 7.6 Hz, 1H, H4), 7.17 (dd, *J* = 9.0, 9.0 Hz, 2H, H3-Ar, H5-Ar), 7.39 (dd, *J* = 9.0, 7.4 Hz, H2-Ar, H6-Ar), 10.85 (s, 1H, NH-BI), 11.96 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.5 (C(O)OCH_3), 161.2 (d, $^1J_{CF}$ = 244.2 Hz, C4-Ar), 154.6 (C2), 135.7 (C2-P), 132.2 (C7a), 128.8 (C3a), 127.4 (d, $^3J_{CF}$ = 8.1 Hz, C2-Ar, C6-Ar), 126.8 (C5-P), 126.7 (C1-Ar), 120.97 (C5), 120.56 (C6), 115.7 ($^2J_{CF}$ = 21.6 Hz, C3-Ar, C5-Ar), 113.8 (C4-P), 108.7 (C4), 108.5 (C3-P), 108.0 (C7), 50.3 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.5 (N1-P), 121.5 (N1), 118.5 (N3); ^{19}F{^{1}H} NMR (376 MHz, DMSO-d_6) δ −114.4; IR (KBr) ν 3406, 3117, 3061, 1702, 1678, 1618, 1516, 1481, 1455, 1370, 1262, 1239, 1191, 1100, 833, 727, 700 cm^{-1}; EI-MS (*m*/*z* (I_{rel} %)) 366(20), 365(77) M^+, 334(28), 333(100), 332(29), 306(10), 305(28), 304(36), 167(23). Anal. Calcd for $C_{20}H_{16}FN_3O_3$: C, 65.75; H, 4.41; N, 11.50. Found: C, 65.96; H, 4.52; N, 11.33%.

*1-[(5-(4-Chlorophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11c**) and 1-[(4-(4-Chlorophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12c**). Method A:* Yield 349 mg (52%), **11c**, beige solid, mp 338−341 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 2.52 (s, 3H, CH_3), 3.41 (s, 3H, OCH_3), 6.44 (d, *J* = 7.6 Hz, 1H, H7), 6.84 (dd, *J* = 7.6, 7.6 Hz, 1H, H6), 6.95 (dd, *J* = 7.6, 7.6 Hz, 1H, H5), 7.05 (d, *J* = 7.6 Hz, 1H, H4), 7.35 (d, *J* = 9.0 Hz, 2H, H2-Ar, H6-Ar), 7.36 (d, *J* = 9.0 Hz, H3-Ar, H5-Ar), 10.89 (s, 1H, NH-BI), 12.04 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.5 (C(O)OCH_3), 154.6 (C2), 136.2 (C2-P), 131.9 (C7a), 131.7 (C4-Ar), 128.96 (C1-Ar), 128.77 (C3-Ar, C5-Ar, C3a), 126.9 (C2-Ar, C6-Ar), 126.5 (C5-P), 121.1 (C5), 120.7 (C6), 114.4 (C4-P), 108.8 (C4), 108.6 (C3-P), 108.0 (C7), 50.3 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.6 (N1-P), 120.9 (N1), 118.5 (N3); IR (KBr) ν 3391, 3117, 3060, 1700, 1676, 1614, 1502, 1480, 1453, 1410, 1369, 1344, 1295, 1265, 1245, 1190, 1096, 826, 724, 697 cm^{-1}; EI-MS (*m*/*z* (I_{rel} %)) 383(26), 382(17), 381(74) M^+, 351(35), 350(35), 349(100), 348(23), 323(20), 322(16), 321(22), 320(25), 286(10), 175(16), 166(9), 157(11). Anal. Calcd for $C_{20}H_{16}ClN_3O_3$: C, 62.91; H, 4.22; N, 11.01. Found: C, 62.97; H, 4.29; N, 11.10%.

*1-[(5-(4-Bromophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11d**) and 1-[(4-(4-Bromophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12d**). Method A:* Yield 330 mg (51%), **11d**, beige solid, mp 345−347 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 2.53 (s, 3H, CH_3), 3.42 (s, 3H, OCH_3), 6.45 (d, *J* = 7.6 Hz, 1H, H7), 6.84 (dd, *J* = 7.6, 7.6 Hz, 1H, H6), 6.95 (dd, *J* = 7.6, 7.6 Hz, 1H, H5), 7.01 (d, *J* = 7.6 Hz, 1H, H4), 7.30 (d, *J* = 8.6 Hz, 2H, H2-Ar, H6-Ar), 7.39 (d, *J* = 8.6 Hz, H3-Ar, H5-Ar), 10.87 (s, 1H, NH-BI), 12.03 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.4 (C(O)OCH_3), 154.5 (C2), 136.2 (C2-P), 131.97 (C7a), 131.67 (C3-Ar, C5-Ar), 129.4 (C1-Ar), 128.8 (C3a), 127.2 (C2-Ar, C6-Ar), 126.5 (C5-P), 121.0 (C5), 120.6 (C6), 120.1 (C4-Ar), 114.5 (C4-P), 108.7 (C4, C3-P), 108.0 (C7), 50.3 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.4 (N1-P), 120.9 (N1), 118.4 (N3); IR (KBr) ν 3387, 3117, 3059, 1700, 1676, 1613, 1500, 1479, 1453, 1406, 1369, 1344, 1295, 1264, 1190, 1098, 823, 725, 704 cm^{-1}; EI-MS (*m*/*z* (I_{rel} %)) 441(17), 439(16), 428(18), 427(78) M^+, 426(17), 425(78), 409(16), 407(118), 396(25), 395(100), 394(41), 393(98), 392(19), 369(23), 368(12), 367(39), 366(28), 365(20), 364(22), 314(10), 286(19), 184(21), 157(52), 156(23), 135(40), 129(17), 128(11), 123(12), 122(15), 115(13). Anal. Calcd for $C_{20}H_{16}BrN_3O_3$: C, 56.35; H, 3.78; N, 9.86. Found: C, 56.28; H, 3.70; N, 9.91%.

*1-[(5-(4-Iodophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11e**) and 1-[(4-(4-Iodophenyl)-3-methoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12e**). Method A:* Yield 334 mg (53%), **11e**, beige solid, mp >350 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 2.53 (s, 3H, CH_3), 3.42 (s, 3H, OCH_3), 6.45 (d, *J* = 7.6 Hz, 1H, H 7), 6.84 (dd, *J* = 7.6, 7.6 Hz, 1H, H6), 6.95 (dd, *J* = 7.6, 7.6 Hz, 1H, H5), 7.01 (d, *J* = 7.6 Hz, 1H, H4), 7.16 (d, *J* = 8.6 Hz, 2H, H2-Ar, H6-Ar), 7.67 (d, *J* = 8.6 Hz, 2H, H3-Ar, H5-Ar), 10.87 (s, 1H, NH-BI), 12.00 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.4 (C(O)OCH_3), 154.5 (C2),

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137.5 (C3-Ar, C5-Ar), 136.2 (C2-P), 132.0 (C7a), 129.7 (C1-Ar), 128.8 (C3a), 127.2 (C2-Ar, C6-Ar), 126.6 (C5-P), 121.0 (C5), 120.6 (C6), 114.5 (C4-P), 108.7 (C3-P), 108.7 (C4), 108.0 (C7), 92.9 (C4-Ar), 50.3 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.4 (N1-P), 120.9 (N1), 118.6 (N3); IR (KBr) ν 3383, 3119, 3057, 1699, 1675, 1612, 1479, 1449, 1402, 1366, 1343, 1293, 1265, 1189, 1098, 819, 731, 702 cm^{-1}; EI-MS (m/z (I_{rel} %)) 487(37), 474(22), 473(100) M^+, 455(31), 442(24), 441(94), 440(12), 429(13), 415(36), 413(15), 412(19), 315(10), 314(14), 286(17), 157(36), 144(10), 135(25), 129(12), 123(12), 122(14), 115(11). Anal. Calcd for $C_{20}H_{16}IN_3O_3$: C, 50.76; H, 3.41; N, 8.88. Found: C, 50.59; H, 3.28; N, 9.04%.

*1-[(5-Propyl-3-methoxycarbonyl-2-methyl)pyrrol-4-yl]benzimidazol-2(3H)-one (**11f**) and 1-[(4-Propyl-3-methoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12f**). Method A:* Yield 281 mg (39%), **11f**, beige solid, mp 249−251 °C; ^1H NMR (600 MHz, DMSO-d_6) δ 0.76 (dd, J = 7.6, 7.1 Hz, 3H, $CH_2CH_2C\underline{H}_3$), 1.40−1.48 (m, 2H, $CH_2C\underline{H}_2CH_3$), 2.19−2.23 (m, 2H, $C\underline{H}_2CH_2CH_3$), 2.42 (s, 3H, CH_3), 3.37 (s, 3H, OCH_3), 6.50 (d, J = 7.6 Hz, 1H, H7), 6.88 (dd, J = 7.6, 7.1 Hz, 1H, H6), 6.94 (dd, J = 7.6, 7.1 Hz, H5), 6.98 (d, J = 7.6 Hz, 1H, H4), 10.73 (s, 1H, NH-BI), 11.37 (s, 1H, NH-P); $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 163.8 ($\underline{C}$(O)OCH_3), 154.4 (C2), 133.6 (C2-P), 132.6 (C7a), 129.1 (C5-P), 128.5 (C3a), 120.6 (C5), 120.4 (C6), 113.2 (C4-P), 108.5 (C4), 107.8 (C7), 106.7 (C3-P), 50.0 (OCH_3), 26.2 ($\underline{C}H_2CH_2CH_3$), 21.8 ($CH_2\underline{C}H_2CH_3$), 13.5 ($CH_2CH_2\underline{C}H_3$), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 164.1 (N1-P), 121.1 (N1), 118.0 (N3); IR (KBr) ν 3355, 3174, 3133, 2957, 1702, 1674, 1617, 1482, 1467, 1397, 1269, 1248, 1192, 1166, 1095, 734 cm^{-1}; EI-MS (m/z (I_{rel} %)) 314(11), 313(60) M^+, 282(11), 281(36), 280(57), 266(33), 252(34), 224(23), 181(13), 180(100), 148(11), 126(30), 125(10), 120(16). Anal. Calcd for $C_{17}H_{19}N_3O_3$: C, 65.16; H, 6.11; N, 13.41. Found: C, 65.05; H, 6.02; N, 13.26%.

*5,6-Dimethyl-1-[(3-methoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]benzimidazol-2(3H)-one (**11g**) and 5,6-Dimethyl-1-[(3-methoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12g**). Method A:* Yield 415 mg (62%), **11g**, off-white solid, mp 256−258 °C; ^1H NMR (600 MHz, DMSO-d_6) δ 2.06 (s, 3H, $CH_3$6-BI), 2.18 (s, 3H, $CH_3$5-BI), 2.53 (s, 3H, CH_3), 3.43 (s, 3H, OCH_3), 6.27 (s, 1H, H7), 6.79 (s, 1H, H4), 7.19 (dd, J = 7.6, 7.1 Hz, 1H, H4-Ar), 7.30 (dd, J = 8.1, 7.6 Hz, 2H, H3-Ar, H5-Ar), 7.37 (d, J = 8.1 Hz, 2H, H2-Ar, H6-Ar), 10.61 (s, 1H, NH-BI), 11.91 (s, 1H, NH-P); $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 163.5 ($\underline{C}$(O)OCH_3), 154.7 (C2), 135.7 (C2-P), 130.4 (C7a), 130.2 (C1-Ar), 128.7 (C3-Ar, C5-Ar), 128.4 (C5), 127.9 (C6), 127.5 (C5-P), 126.97 (C4-Ar), 126.85 (C3a), 125.2 (C2-Ar, C6-Ar), 114.3 (C4-P), 109.8 (C4), 108.97 (C7), 108.65 (C3-P), 50.3 (OCH_3), 19.4 ($CH_3$5-BI), 19.3 ($CH_3$6-BI), 13.4 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.3 (N1-P), 119.8 (N1), 116.9 (N3); IR (KBr) ν 3407, 3236, 3024, 1702, 1681, 1612, 1481, 1448, 1387, 1371, 1346, 1295, 1263, 1194, 1099, 755, 714 cm^{-1}; EI-MS (m/z (I_{rel} %)) 376(25), 375(100) M^+, 344(13), 343(34), 342(16), 329(22), 328(88), 314(11), 301(10), 172(16), 150(14). Anal. Calcd for $C_{22}H_{21}N_3O_3$: C, 70.38; H, 5.64; N, 11.19. Found: C, 70.28; H, 5.71; N, 11.13%.

*5-Benzoyl-1-[(3-methoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]benzimidazol-2(3H)-one (**11h**) and 5-Benzoyl-1-[(3-methoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12h**). Method A:* Yield 274 mg (43%), **11h**, off-white solid, mp 261−263 °C; ^1H NMR (600 MHz, DMSO-d_6) δ 2.53 (s, 3H, CH_3), 3.45 (s, 3H, OCH_3), 6.62 (d, J = 8.1 Hz, 1H, H7), 7.22 (dd, J = 7.6, 7.1 Hz, 1H, H4-Ar), 7.31 (dd, J = 7.6, 7.6 Hz, 2H, H3-Ar, H5-Ar), 7.34−7.37 (m, 3H, H2-Ar, H6-Ar, H6), 7.44 (d, J = 1.0 Hz, 1H, H4), 7.52 (dd, J = 7.6, 7.6 Hz, 2H, H3-Ar′, H5-Ar′), 7.62 (dd, J = 7.7, 7.6 Hz, 1H, H4-Ar′), 7.66 (d, J = 7.1 Hz, 2H, H2-Ar′, H6-Ar′), 11.23 (s, 1H, NH-BI), 12.06 (s, 1H, NH-P); $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 195.1 (C(O)Ar′), 163.5 ($\underline{C}$(O)OCH_3), 154.8 (C2), 138.0 (C1-Ar′), 136.2 (C7a), 136.1 (C2-P), 131.9 (C4-Ar′), 130.1 (C5), 129.9 (C1-Ar), 129.1 (C2-Ar′, C6-Ar′), 128.8 (C3-Ar, C5-Ar), 128.7 (C3a), 128.4 (C3-Ar′, C5-Ar′), 127.9 (C5-P), 127.4 (C4-Ar), 125.4 (C2-Ar, C6-Ar), 124.7 (C6), 113.1 (C4-P), 110.0 (C4), 108.4 (C3-P), 107.6 (C7), 50.4 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 162.3 (N1-P), 125.2 (N1), 119.1 (N3); IR (KBr) ν 3424, 3064, 1702, 1649, 1620, 1472, 1446, 1305, 1265, 1189, 1092, 1026, 701 cm^{-1}; MALDI-MS MH^+ 452. Anal. Calcd for $C_{27}H_{21}N_3O_4$: C, 71.83; H, 4.69; N, 9.31. Found: C, 72.04; H, 4.77; N, 9.15%.

*1-[(3-Ethoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]benzimidazol-2(3H)-one (**11i**) and 1-[(3-Ethoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12i**). Method A:* Yield 418 mg (58%), **11i**, off-white solid. *Method B*: Yield 173 mg (24%), **11i**, off-white solid and 29 mg (4%), **12i**, white solid. Data for **11i**: mp 305−307 °C; ^1H NMR (600 MHz, DMSO-d_6) δ 0.75 (t, J = 7.1 Hz, 3H, $OCH_2C\underline{H}_3$), 2.54 (s, 3H, CH_3), 3.82 (q, J = 7.1 Hz, 2H, $OC\underline{H}_2CH_3$), 6.49 (d, J = 7.6 Hz, 1H, H7), 6.85 (ddd, J = 7.6, 7.6, 1.0 Hz, 1H, H6), 6.95 (ddd, J = 7.6, 7.6, 1.0 Hz, 1H, H5), 7.00 (d, J = 7.6 Hz, 1H, H4), 7.20 (dd, J = 7.6, 7.1 Hz, 1H, H4-Ar), 7.30 (dd, J = 7.6, 7.1 Hz, 2H, H3-Ar, H5-Ar), 7.39 (d, J = 7.1 Hz, 2H, H2-Ar, H6-Ar), 10.85 (s, 1H, NH-BI), 11.94 (s, 1H, NH-P); $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 163.3 ($\underline{C}$(O)OCH_2CH_3), 154.7 (C2), 136.2 (C2-P), 132.5 (C7a), 130.3 (C1-Ar), 128.9 (C3a), 128.7 (C3-Ar, C5-Ar), 127.6 (C5-P), 127.1 (C4-Ar), 125.4 (C2-Ar, C6-Ar), 120.9 (C5), 120.5 (C6), 113.6 (C4-P), 108.9 (C3-P), 108.6 (C4), 108.1 (C7), 58.5 ($O\underline{C}H_2CH_3$), 13.4 ($OCH_2\underline{C}H_3$), 13.1 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.5 (N1-P), 121.7 (N1), 118.4 (N3); IR (KBr) ν 3394, 3173, 3060, 1706, 1673, 1612, 1481, 1448, 1397, 1376, 1340, 1294, 1263, 1244, 1189, 1105, 762, 733, 698 cm^{-1}; EI-MS (m/z (I_{rel} %)) 362(15), 361(66) M^+, 316(30), 315(100), 314(22), 288(11), 287(22), 286(29), 158(10). Anal. Calcd for $C_{21}H_{19}N_3O_3$: C, 69.79; H, 5.30; N, 11.63. Found: C, 70.10; H, 5.19; N, 11.46%. Data for **12i**: mp 205−208 °C; ^1H NMR (600 MHz, DMSO-d_6) δ 1.05 (t, J = 6.7 Hz, 3H, $OCH_2C\underline{H}_3$), 2.47 (s, 3H, CH_3), 4.03 (q, J = 6.7 Hz, 2H, $OC\underline{H}_2CH_3$), 6.55 (d, J = 7.6 Hz, 1H, H7), 6.83−6.88 (m, 1H, H6), 6.94−6.96 (m, 2H, H4, H5), 7.09 (dddd, J = 7.1, 6.7, 1.9, 1.9 Hz, 1H, H4-Ar), 7.12−7.19 (m, 4H, H-Ar), 10.97 (s, 1H, NH-BI), 11.90 (s, 1H, NH-P); $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 164.3 ($\underline{C}$(O)OCH_2CH_3), 154.3 (C2), 134.1 (C2-P), 133.7 (C1-Ar), 131.4 (C7a), 129.3 (C2-Ar, C6-Ar), 128.1 (C3a), 127.1 (C3-Ar, C5-Ar), 126.1 (C4-Ar), 122.5 (C4-P), 121.7 (C5), 120.9 (C6), 116.7 (C5-P), 109.4 (C3-P), 108.9 (C4), 108.1 (C7), 58.6 ($O\underline{C}H_2CH_3$), 13.9 ($OCH_2\underline{C}H_3$), 13.2 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 166.7 (N1-P), 121.4 (N1), 118.2 (N3); IR (KBr) ν 3426, 3255, 1703, 1621, 1479, 1447, 1192, 1096, 700 cm^{-1}; EI-MS (m/z (I_{rel} %)) 362(24), 361(100) M^+, 333(14), 332(39), 316(10), 315(10), 289(14), 288(10), 286(11), 228(12). Anal. Calcd for $C_{21}H_{19}N_3O_3$: C, 69.79; H, 5.30; N, 11.63. Found: C, 70.04; H, 5.39; N, 11.76%.

*1-[(5-(4-Fluorophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11j**) and 1-[(4-(4-Fluorophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12j**). Method A:* Yield 417 mg (59%), **11j**, beige solid, mp 315−318 °C; ^1H NMR (600 MHz, DMSO-d_6) δ 0.74 (t, J = 7.1 Hz, 3H, $OCH_2C\underline{H}_3$), 2.54 (s, 3H, CH_3), 3.81 (q, J = 7.1 Hz, 2H, $OC\underline{H}_2CH_3$), 6.49 (d, J = 8.1 Hz, 1H, H7), 6.85 (dd, J = 8.1, 7.6 Hz, 1H, H6), 6.95 (dd, J = 7.6, 7.6 Hz, 1H, H5), 7.00 (d, J = 7.6 Hz, 1H, H4), 7.18 (dd, J = 9.1, 8.6 Hz, 2H, H3-Ar, H5-Ar), 7.42 (dd, J = 9.0, 7.4 Hz, 2H, H2-Ar, H6-Ar), 10.86 (s, 1H, NH-BI), 11.95 (s, 1H, NH-P); $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 163.2 ($\underline{C}$(O)OCH_2CH_3), 161.1 (d, $^1J_{CF}$ = 244.6 Hz, C4-Ar), 154.7 (C2), 136.1 (C2-P), 132.4 (C7a), 128.9 (C3a), 127.5 (d, $^3J_{CF}$ = 8.4, C2-Ar, C6-Ar), 126.8 (d, $^4J_{CF}$ = 3.1, C1-Ar), 126.8 (C5-P), 120.9 (C5), 120.5 (C6), 115.7 (d, $^2J_{CF}$ = 21.8, C3-Ar, C5-Ar), 113.5 (C4-P), 108.8 (C3-P), 108.6 (C4), 108.0 (C7), 58.4 ($O\underline{C}H_2CH_3$), 13.3 ($OCH_2\underline{C}H_3$), 13.1 (CH_3); ^{15}N NMR (DMSO-d_6, 60 MHz) δ 161.7 (N1-P), 121.5 (N1), 118.6 (N3); $^{19}F\{^1H\}$ NMR (376 MHz, DMSO-d_6) δ −114.5; IR (KBr) ν 3396, 3116, 3058, 2982, 1703, 1671, 1617, 1516, 1482, 1452, 1414, 1380, 1340, 1295, 1262, 1240, 1185, 1099, 833, 727, 699 cm^{-1}; EI-MS (m/z (I_{rel} %)) 380(17), 379(70) M^+, 361(27), 334(30), 333(100), 332(23), 316(13), 315(42), 306(13), 305(26), 304(28), 287(10), 286(13), 167(13). Anal. Calcd for $C_{21}H_{18}FN_3O_3$: C, 66.48; H, 4.78; N, 11.08. Found: C, 66.39; H, 4.74; N, 11.04%.

*1-[(5-(4-Chlorophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11k**) and 1-[(4-(4-Chlorophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12k**). Method A:* Yield 424 mg (61%), **11k**, beige solid. *Method B*: Yield 278 mg (40%), **11k**, beige solid and 35 mg (5%), **12k**, white

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solid. Data for **11k**: mp >350 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 0.75 (t, J = 7.1 Hz, 3H, OCH$_2$C<u>H$_3$</u>), 2.54 (s, 3H, CH$_3$), 3.81 (q, J = 7.1 Hz, 2H, OC<u>H$_2$</u>CH$_3$), 6.48 (d, J = 7.6 Hz, 1H, H7), 6.86 (dd, J = 7.6, 7.6 Hz, 1H, H6), 6.96 (dd, J = 7.6, 7.6 Hz, 1H, H5), 7.00 (d, J = 7.6 Hz, 1H, H4), 7.39 (s, 4H, H-Ar), 10.88 (s, 1H, NH-BI), 12.01 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.1 (<u>C</u>(O)OCH$_2$CH$_3$), 154.6 (C2), 136.5 (C2-P), 132.3 (C7a), 131.6 (C4-Ar), 129.1 (C1-Ar), 128.9 (C3a), 128.8 (C3-Ar, C5-Ar), 126.9 (C2-Ar, C6-Ar), 126.4 (C5-P), 121.0 (C5), 120.6 (C6), 114.1 (C4-P), 109.0 (C3-P), 108.6 (C4), 108.0 (C7), 58.5 (O<u>C</u>H$_2$CH$_3$), 13.3 (OCH$_2$<u>C</u>H$_3$), 13.1 (CH$_3$); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.5 (N1-P), 121.4 (N1), 118.5 (N3); IR (KBr) ν 3393, 3119, 3059, 2982, 1702, 1671, 1614, 1502, 1481, 1450, 1410, 1375, 1339, 1294, 1260, 1245, 1186, 1096, 827, 729, 696 cm^{-1}; EI-MS (m/z (I_{rel} %)) 397(22), 396(15), 395(62) M$^+$, 351(36), 350(35), 349(100), 348(18), 323(11), 322(16), 321(19), 320(19), 315(12), 286(11). Anal. Calcd for $C_{21}H_{18}ClN_3O_3$: C, 63.72; H, 4.58; N, 10.62. Found: C, 63.58; H, 4.49; N, 10.48%. Data for **12k**: mp 222−224 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 1.07 (t, J = 7.1 Hz, 3H, OCH$_2$C<u>H$_3$</u>), 2.47 (s, 3H, CH$_3$), 4.05 (q, J = 7.1 Hz, 2H, OC<u>H$_2$</u>CH$_3$), 6.56 (d, J = 7.6 Hz, 1H, H7), 6.86−6.90 (m, 1H, H6), 6.96−6.98 (m, 2H, H4, H5), 7.17 (d, J = 8.6 Hz, 2H, H2-Ar, H6-Ar), 7.22 (d, J = 8.6 Hz, 2H, H3-Ar, H5-Ar), 11.02 (s, 1H, NH-BI), 11.98 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 164.2 (<u>C</u>(O)OCH$_2$CH$_3$), 154.2 (C2), 134.5 (C2-P), 132.7 (C1-Ar), 131.2 (C4-Ar), 131.1 (C2-Ar, C6-Ar), 130.9 (C7a), 128.1 (C3a), 127.3 (C3-Ar, C5-Ar), 121.8 (C5), 121.3 (C4-P), 121.0 (C6), 117.0 (C5-P), 109.3 (C3-P), 109.1 (C4), 108.1 (C7), 58.7 (O<u>C</u>H$_2$CH$_3$), 14.0 (OCH$_2$<u>C</u>H$_3$), 13.3 (CH$_3$); ^{15}N NMR (60 MHz, DMSO-d_6) δ 167.3 (N1-P), 121.0 (N1), 118.2 (N3); IR (KBr) ν 3207, 3065, 2981, 1712, 1698, 1615, 1537, 1493, 1478, 1446, 1389, 1282, 1245, 1193, 1111, 1097, 1016, 745, 732, 696 cm^{-1}; EI-MS (m/z (I_{rel} %)) 397(36), 396(26), 395(100) M$^+$, 368(15), 367(16), 366(40), 361(38), 350(11), 349(11), 323(26), 322(12). Anal. Calcd for $C_{21}H_{18}ClN_3O_3$: C, 63.72; H, 4.58; N, 10.62. Found: C, 63.91; H, 4.68; N, 10.73%.

*1-[(5-(4-Bromophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11l**) and 1-[(4-(4-Bromophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12l**). Method A:* Yield 375 mg (56%), **11l**, beige solid. *Method B*: Yield 254 mg (38%), **11l**, off-white solid and 27 mg (4%), **12l**, off-white solid. Data for **11l**: mp >350 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 0.75 (t, J = 7.1 Hz, 3H, OCH$_2$C<u>H$_3$</u>), 2.54 (s, 3H, CH$_3$), 3.81 (q, J = 7.1 Hz, 2H, OC<u>H$_2$</u>CH$_3$), 6.48 (d, J = 7.6 Hz, 1H, H7), 6.85 (dd, J = 7.6, 7.6 Hz, 1H, H6), 6.96 (dd, J = 7.6, 7.6 Hz, 1H, H5), 7.01 (d, J = 7.6 Hz, 1H, H4), 7.33 (d, J = 8.6 Hz, 2H, H2-Ar, H6-Ar), 7.52 (d, J = 8.6 Hz, 2H, H3-Ar, H5-Ar), 10.88 (s, 1H, NH-BI), 12.03 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.1 (<u>C</u>(O)OCH$_2$CH$_3$), 154.6 (C2), 136.5 (C2-P), 132.2 (C7a), 131.7 (C3-Ar, C5-Ar), 129.4 (C1-Ar), 128.9 (C3a), 127.2 (C2-Ar, C6-Ar), 126.4 (C5-P), 121.0 (C5), 120.5 (C6), 120.1 (C4-Ar), 114.2 (C4-P), 109.0 (C3-P), 108.6 (C4), 108.0 (C7), 58.5 (O<u>C</u>H$_2$CH$_3$), 13.3 (OCH$_2$<u>C</u>H$_3$), 13.1 (CH$_3$); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.6 (N1-P), 121.3 (N1), 118.6 (N3); IR (KBr) ν 3389, 3117, 3056, 1701, 1670, 1612, 1481, 1448, 1405, 1376, 1358, 1338, 1295, 1265, 1244, 1187, 1099, 823, 725 cm^{-1}; EI-MS (m/z (I_{rel} %)) 442(14), 441(59), 440(17), 439(59) M$^+$, 396(28), 395(100), 394(37), 393(88), 392(14), 367(18), 366(23), 365(16), 364(14), 349(14), 286(16), 157(17), 135(14). Anal. Calcd for $C_{21}H_{18}BrN_3O_3$: C, 57.29; H, 4.12; N, 9.54. Found: C, 57.18; H, 4.07; N, 9.47%. Data for **12l**: mp 217−219 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 1.08 (t, J = 7.1 Hz, 3H, OCH$_2$C<u>H$_3$</u>), 2.47 (s, 3H, CH$_3$), 4.06 (q, J = 7.1 Hz, 2H, OC<u>H$_2$</u>CH$_3$), 6.56 (d, J = 7.6 Hz, 1H, H7), 6.86−6.91 (m, 1H, H6), 6.96−6.98 (m, 2H, H4, H5), 7.11 (d, J = 8.6 Hz, 2H, H2-Ar, H6-Ar), 7.36 (d, J = 8.6 Hz, 2H, H3-Ar, H5-Ar), 11.01 (s, 1H, NH-BI), 11.99 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 164.10 (<u>C</u>(O)OCH$_2$CH$_3$), 154.16 (C2), 134.45 (C2-P), 133.01 (C1-Ar), 131.41 (C2-Ar, C6-Ar), 131.21 (C7a), 130.14 (C3-Ar, C5-Ar), 128.09 (C3a), 121.81 (C6), 121.27 (C4-P), 120.95 (C5), 119.48 (C4-Ar), 116.95 (C5-P), 109.24 (C3-P), 109.05 (C4), 108.04 (C7), 58.69 (O<u>C</u>H$_2$CH$_3$), 13.95 (OCH$_2$<u>C</u>H$_3$), 13.25 (CH$_3$); ^{15}N NMR (60 MHz, DMSO-d_6) δ 167.3 (N1-P), 121.0 (N1), 118.3 (N3); IR (KBr) ν 3211, 3065, 1712, 1699, 1479, 1445, 1285, 1193, 1110, 1097, 734 cm^{-1}; EI-MS (m/z (I_{rel} %)) 442(23), 441(99), 440(27), 439(100) M$^+$, 413(12), 412(38), 411(13), 410(37), 396(12), 395(30), 369(11), 368(10), 367(16), 366(19), 361(11), 134(15). Anal. Calcd for $C_{21}H_{18}BrN_3O_3$: C, 57.29; H, 4.12; N, 9.54. Found: C, 57.05; H, 4.21; N, 9.36%.

*1-[(5-(4-Iodophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11m**) and 1-[(4-(4-Iodophenyl)-3-ethoxycarbonyl-2-methyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12m**). Method A:* Yield 363 mg (56%), **11m**, beige solid, mp >350 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 0.75 (t, J = 7.1 Hz, 3H, OCH$_2$C<u>H$_3$</u>), 2.53 (s, 3H, CH$_3$), 3.81 (q, J = 7.1 Hz, 2H, OC<u>H$_2$</u>CH$_3$), 6.47 (d, J = 7.6 Hz, 1H, H7), 6.85 (ddd, J = 7.6, 7.2, 1.0 Hz, 1H, H6), 6.96 (dd, J = 7.6, 7.6 Hz, 1H, H5), 7.00 (d, J = 7.6 Hz, 1H, H4), 7.18 (d, J = 8.6 Hz, 2H, H2-Ar, H6-Ar), 7.67 (d, J = 8.6 Hz, 2H, H3-Ar, H5-Ar), 10.88 (s, 1H, NH-BI), 12.00 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.1 (<u>C</u>(O)OCH$_2$CH$_3$), 154.6 (C2), 137.5 (C3-Ar, C5-Ar), 136.6 (C2-P), 132.2 (C7a), 129.7 (C1-Ar), 128.9 (C3a), 127.2 (C2-Ar, C6-Ar), 126.6 (C5-P), 121.0 (C5), 120.6 (C6), 114.2 (C4-P), 109.0 (C3-P), 108.6 (C4), 108.0 (C7), 92.9 (C4-Ar), 58.5 (O<u>C</u>H$_2$CH$_3$), 13.3 (OCH$_2$<u>C</u>H$_3$), 13.1 (CH$_3$); ^{15}N NMR (60 MHz, DMSO-d_6) δ 161.3 (N1-P), 121.5 (N1), 118.6 (N3); IR (KBr) ν 3385, 3126, 3055, 1700, 1669, 1612, 1480, 1448, 1404, 1293, 1264, 1186, 1099, 821 cm^{-1}; EI-MS (m/z (I_{rel} %)) 488(21), 487(82) M$^+$, 442(29), 441(100), 440(14), 413(14), 412(12), 395(14), 393(12), 315(14), 314(15), 286(17), 157(14). Anal. Calcd for $C_{21}H_{18}IN_3O_3$: C, 51.76; H, 3.72; N, 8.62. Found: C, 51.62; H, 3.79; N, 8.53%.

*5,6-Dimethyl-1-[(3-ethoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]benzimidazol-2(3H)-one (**11n**) and 5,6-Dimethyl-1-[(3-ethoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12n**). Method A:* Yield 455 mg (65%), **11n**, off-white solid, mp 250−255 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 0.81 (dd, J = 7.1, 7.1 Hz, 3H, OCH$_2$C<u>H$_3$</u>), 2.07 (s, 3H, CH$_3$6-BI), 2.18 (s, 3H, CH$_3$5-BI), 2.54 (s, 3H, CH$_3$), 3.80−3.86 (m, 2H, OC<u>H$_2$</u>CH$_3$), 6.28 (s, 1H, H7), 6.78 (s, 1H, H4), 7.20 (dd, J = 7.6, 7.1 Hz, 1H, H4-Ar), 7.30 (dd, J = 7.6, 7.1 Hz, 2H, H3-Ar, H5-Ar), 7.39 (d, J = 7.6 Hz, 2H, H2-Ar, H6-Ar), 10.61 (s, 1H, NH-BI), 11.89 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.2 (<u>C</u>(O)OCH$_2$CH$_3$), 154.8 (C2), 135.9 (C2-P), 130.6 (C7a), 130.3 (C1-Ar), 128.6 (C3-Ar, C5-Ar), 128.3 (C5), 127.9 (C6), 127.5 (C5-P), 126.9 (C4-Ar), 126.9 (C3a), 125.2 (C2-Ar, C6-Ar), 114.0 (C4-P), 109.7 (C4), 108.99 (C7), 108.95 (C3-P), 58.4 (O<u>C</u>H$_2$CH$_3$), 19.32 (CH$_3$5-BI), 19.28 (CH$_3$6-BI), 13.4 (OCH$_2$<u>C</u>H$_3$), 13.1 (CH$_3$); ^{15}N NMR (60 MHz, DMSO-d_6) δ 160.9 (N1-P), 120.2 (N1), 116.9 (N3); IR (KBr) ν 3203, 2979, 2924, 1700, 1685, 1613, 1507, 1481, 1446, 1387, 1368, 1261, 1198, 1171, 1088, 753, 717 cm^{-1}; EI-MS (m/z (I_{rel} %)) 390(26), 389(100) M$^+$, 344(17), 343(38), 342(10), 329(22), 328(88), 172(16). Anal. Calcd for $C_{23}H_{23}N_3O_3$: C, 70.93; H, 5.95; N, 10.79. Found: C, 70.85; H, 5.99; N, 10.84%.

*5-Benzoyl-1-[(3-ethoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]-benzimidazol-2(3H)-one (**11o**) and 5-Benzoyl-1-[(3-ethoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]benzimidazol-2(3H)-one (**12o**). Method A:* Yield 269 mg (41%), **11o**, off-white solid, mp 270−271 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 0.80 (dd, J = 7.1, 6.7 Hz, 3H, OCH$_2$C<u>H$_3$</u>), 2.56 (s, 3H, CH$_3$), 3.84−3.88 (m, 2H, OC<u>H$_2$</u>CH$_3$), 6.66 (d, J = 8.1 Hz, 1H, H7), 7.24 (dd, J = 7.6, 7.1 Hz, 1H, H4-Ar), 7.34 (dd, J = 8.1, 7.6 Hz, 2H, H3-Ar, H5-Ar), 7.36 (dd, J = 8.1, 1.4 Hz, 1H, H6), 7.39−7.42 (m, 3H, H2-Ar, H6-Ar, H4), 7.54 (dd, J = 7.6, 7.6 Hz, 2H, H3-Ar′, H5-Ar′), 7.63 (dd, J = 7.7, 7.1 Hz, 1H, H4-Ar′), 7.67 (d, J = 7.1 Hz, 2H, H2-Ar′, H6-Ar′), 11.18 (s, 1H, NH-BI), 12.03 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 194.9 (C(O)Ar′), 163.0 (<u>C</u>(O)OCH$_2$CH$_3$), 154.8 (C2), 138.1 (C1-Ar′), 136.4 (C7a), 136.3 (C2-P), 131.8 (C4-Ar′), 130.0 (C5), 130.0 (C1-Ar), 129.1 (C2-Ar′, C6-Ar′), 128.8 (C3a), 128.75 (C3-Ar, C5-Ar), 128.3 (C3-Ar′, C5-Ar′), 127.8 (C5-P), 127.2 (C4-Ar), 125.40 (C2-Ar, C6-Ar), 124.5 (C6), 112.8 (C4-P), 109.8 (C4), 108.7 (C3-P), 107.6 (C7), 58.5 (O<u>C</u>H$_2$CH$_3$), 13.4 (OCH$_2$<u>C</u>H$_3$), 13.1 (CH$_3$); ^{15}N NMR (60 MHz, DMSO-d_6) δ 162.5 (N1-P), 125.7 (N1), 119.3 (N3); IR (KBr) ν 3447, 3273, 1715, 1697, 1617, 1472, 1305, 1283, 1185, 1104, 706 cm^{-1}; MALDI-MS MH$^+$ 466. Anal. Calcd for

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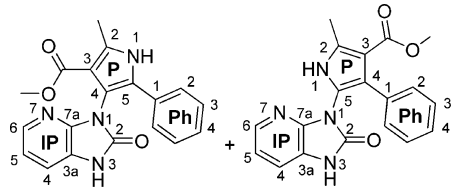
$C_{28}H_{23}N_3O_4$: C, 72.24; H, 4.98; N, 9.03. Found: C, 71.98; H, 4.93; N, 9.17%.

*1-[(3-Ethoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]benzimidazol-2(3H)-one-5-carboxylic Acid (**11p**) and 1-[(3-Ethoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]benzimidazol-2(3H)-one-5-carboxylic Acid (**12p***). *Method A:* Yield 530 mg (77%), a mixture of **11p**/**12p** (81:19), beige solid, mp 332−333 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 0.76 (t, J = 7.1 Hz, 3H, $OCH_2C\underline{H}_3$), 1.04 (t, J = 7.1 Hz, 3H, $OCH_2C\underline{H}_3$*), 2.48 (s, 3H, CH_3*), 2.55 (s, 3H, CH_3), 3.83 (q, J = 7.1 Hz, 2H, $OC\underline{H}_2CH_3$), 4.04 (q, J = 7.1 Hz, 2H, $OC\underline{H}_2CH_3$*), 6.58 (d, J = 8.1 Hz, 1H, H7), 6.66 (d, J = 8.1 Hz, 1H, H7*), 7.14−7.16 (m, 3H, H4-Ar*, H3-Ar*, H5-Ar*), 7.22 (dd, J = 7.1, 7.1 Hz, 1H, H4-Ar), 7.32 (dd, J = 8.1, 7.6 Hz, 2H, H3-Ar, H5-Ar), 7.35−7.39 (m, 4H, H2-Ar, H6-Ar, H2-Ar*, H6-Ar*), 7.53−7.55 (m, 2H, H6*, H4*), 7.55 (m, 1H, H4), 7.57 (dd, J = 8.1, 1.4 Hz, H6), 11.14 (s, 1H, NH-BI), 11.25 (s, 1H, NH-BI*), 11.97 (s, 1H, NH-P*), 12.01 (s, 1H, NH-P*); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 167.4 (C(O)OH), 167.1 (C(O)OH*), 164.2 ($\underline{C}$(O)OCH_2CH_3*), 163.1 ($\underline{C}$(O)OCH_2CH_3), 154.8 (C2), 154.4 (C2*), 136.3 (C7a), 136.1 (C2-P), 134.9 (C7a*), 134.4 (C2-P*), 133.5 (C1-Ar*), 130.0 (C1-Ar), 129.3 (C3-Ar*, C5-Ar*), 128.8 (C3-Ar, C5-Ar), 128.6 (C3a), 128.0 (C3a*), 127.7 (C5-P), 127.2 (C4-Ar), 126.2 (C4-Ar*), 125.4 (C2-Ar, C6-Ar), 125.1 (C2-Ar*, C6-Ar*), 124.3 (C5*), 123.5 (C5), 123.3 (C6*), 123.1 (C6), 122.7 (C4-P*), 116.2 (C5-P*), 113.0 (C4-P), 109.7 (C4*), 109.6 (C3-P*), 109.4 (C4), 108.7 (C3-P), 107.8 (C7-P*), 107.7 (C7), 58.6 ($O\underline{C}H_2CH_3$*), 58.5 ($O\underline{C}H_2CH_3$), 13.9 ($OCH_2\underline{C}H_3$*), 13.4 ($OCH_2\underline{C}H_3$), 13.3 (CH_3*), 13.1 (CH_3); IR (KBr) ν 3365, 3062, 1713, 1684, 1262, 1474, 1383, 1302, 1187, 1105, 770, 715 cm^{-1}; MALDI-MS MH$^+$ 406. Anal. Calcd for $C_{22}H_{19}N_3O_5$: C, 65.18; H, 4.72; N, 10.37. Found: C, 64.87; H, 4.60; N, 10.18%.

General Procedure for the Synthesis of *N*-Pyrrolyl-1*H*-imidazo[5,4-*b*]- (15/16) and *N*-Pyrrolyl-1*H*-imidazo[4,5-*c*]-pyridin-2(3*H*)-ones (17/18). The mixtures of compounds **15**/**16** and **17**/**18** were synthesized by the same procedure described above for the mixture of **11**/**12** starting with pyrazin-2(1*H*)-one derivatives **13** and **14**, respectively, instead of quinoxalin-2(1*H*)-one derivatives **7**. The prevailing isomers **15** and **17** have been isolated in the same manner as the dominant isomers **11a−g** and **11i−n** in method A. In the case of the treatment of the mixture of compounds **15**/**16**, the chloroform filtrate had been evaporated and the residue triturated with ether; the formed precipitate was filtered off and the minor isomer **16** obtained.

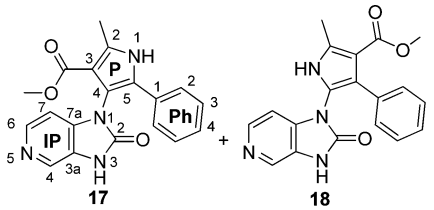
*1-[(3-Methoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]imidazo-[5,4-b]pyrazin-2(3H)-one (**15**) and 1-[(3-Methoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]imidazo[5,4-b]pyrazin-2(3H)-one (**16**):* Yield 428 mg (62%), **15**, light brown solid and 28 mg (4%), **16**, light brown solid.



15 **16**

Data for **15**: mp 310−312 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 2.53 (s, 3H, CH_3), 3.40 (s, 3H, OCH_3), 6.97 (dd, J = 7.7, 5.3 Hz, 1H, H5), 7.21 (dddd, J = 7.4, 7.3, 1.2, 1.2 Hz, 1H, H4-Ph), 7.64−7.66 (m, 3H, H4, H3-Ph, H5-Ph), 7.39−7.41 (m, 2H, H2-Ph, H6-Ph), 7.78 (dd, J = 5.3, 1.4 Hz, 1H, H6), 11.10 (s, 1H, NH-IP), 11.91 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.5 ($\underline{C}$(O)OCH_3), 154.0 (C2), 145.9 (C7a), 139.7 (C6), 135.5 (C2-P), 130.3 (C1-Ph), 128.6 (C3-Ph, C5-Ph), 128.2 (C5-P), 127.1 (C4-Ph), 125.5 (C2-Ph, C6-Ph), 123.3 (C3a), 117.2 (C5), 114.7 (C4), 113.1 (C4-P), 108.8 (C3-P), 50.2 (OCH_3), 13.3 (CH_3); ^{15}N NMR (DMSO-d_6, 60 MHz) δ 264.0 (N7), 161.9 (N1-P), 127.8 (N1), 116.4 (N3); IR (KBr) ν 3147, 3026, 2925, 1716, 1689, 1613, 1454, 1195, 1101, 772, 695 cm^{-1}; EI-MS (m/z (I_{rel} %)) 441(13), 439(13), 369(10), 367(11), 362(13), 349(23), 348(100) M$^+$, 330(12), 317(28), 316(80), 315(18), 290(26), 289(34), 288(82), 287(23), 274(17), 260(17), 259(12), 158(26), 144(11), 136(10), 129(11), 104(10). Anal. Calcd for $C_{19}H_{16}N_4O_3$: C, 65.51; H, 4.63; N, 16.08. Found: C, 65.62; H, 4.66; N, 16.01%. Data for **16**: mp 145−147 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 2.46 (s, 3H, CH_3), 3.56 (s, 3H, OCH_3), 7.02 (ddd, J = 8.7, 5.1, 1.0 Hz, 1H, H5), 7.07−7.16 (m, 5H, H-Ph), 7.30 (ddd, J = 8.7, 1.1, 1.0 Hz, 1H, H4), 7.85 (ddd, J = 5.1, 1.1, 1.0 Hz, 1H, H6), 11.21 (s, 1H, NH-IP), 11.88 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 164.8 ($\underline{C}$(O)OCH_3), 153.4 (C2), 145.1 (C7a), 140.1 (C6), 134.1 (C2-P), 133.7 (C1-Ph), 129.1 (C3-Ph, C5-Ph), 127.2 (C2-Ph, C6-Ph), 126.1 (C4-Ph), 123.1 (C4-P), 122.6 (C3a), 118.1 (C5), 115.7 (C5-P), 115.5 (C4), 109.3 (C3-P), 50.2 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 264.5 (N7), 167.7 (N1-P), 128.0 (N1), 116.0 (N3); IR (KBr) ν 3196, 2950, 1711, 1626, 1453, 1435, 1195, 1094, 767, 700 cm^{-1}; EI-MS of (m/z (I_{rel} %)) 363(11), 362(41), 349(22), 348(100) M$^+$, 347(10), 333(10), 316(24), 315(11), 291(12), 290(60), 289(32), 288(21), 287(13), 214(18), 182(11), 158(13), 149(11), 129(10). Anal. Calcd for $C_{19}H_{16}N_4O_3$: C, 65.51; H, 4.63; N, 16.08. Found: C, 65.13; H, 4.72; N, 16.22%.

*1-[(3-Methoxycarbonyl-2-methyl-5-phenyl)pyrrol-4-yl]imidazo-[4,5-c]pyrazin-2(3H)-one (**17**) and 1-[(3-Methoxycarbonyl-2-methyl-4-phenyl)pyrrol-5-yl]imidazo[4,5-c]pyrazin-2(3H)-one (**18**):*



17 **18**

Yield 559 mg (81%), **17**, beige solid, mp 258−260 °C; ^{1}H NMR (600 MHz, DMSO-d_6) δ 2.54 (s, 3H, CH_3), 3.45 (s, 3H, OCH_3), 6.58 (d, J = 5.2 Hz, 1H, H7), 7.22 (dddd, J = 7.1, 6.7, 1.9, 1.4 Hz, 1H, H4-Ph), 7.28−7.36 (m, 4H, H-Ph), 8.05 (d, J = 5.2 Hz, 1H, H6), 8.23 (s, 1H, H4), 11.14 (s, 1H, NH-IP), 12.03 (s, 1H, NH-P); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 163.4 ($\underline{C}$(O)OCH_3), 154.1 (C2), 142.3 (C6), 138.2 (C7a), 135.9 (C2-P), 129.8 (C1-Ph), 129.2 (C4), 128.8 (C3-Ph, C5-Ph), 127.8 (C5-P), 127.3 (C4-Ph), 126.4 (C3a), 125.3 (C2-Ph, C6-Ph), 112.7 (C4-P), 108.3 (C3-P), 103.8 (C7), 50.4 (OCH_3), 13.3 (CH_3); ^{15}N NMR (60 MHz, DMSO-d_6) δ 294.1 (N5), 162.4 (N1-P), 113.8 (N3); IR (KBr) ν 3163, 3044, 1706, 1612, 1475, 1191, 1098, 1086, 722, 689 cm^{-1}; MALDI-MS MH$^+$ 349. Anal. Calcd for $C_{19}H_{16}N_4O_3$: C, 65.51; H, 4.63; N, 16.08. Found: C, 65.44; H, 4.58; N, 16.12%.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Related 1D/2D NMR spectra for all new compounds. This material is available free of charge via the Internet at http://pubs.acs.org.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: mamedov@iopc.ru.

Notes

The authors declare no competing financial interest.

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