Diverse Directions of Heterocyclizations Involving Derivatives of 5-Aminopyrazoles and *N*-Arylmaleimides

Roman V. Rudenko,[a] Sergey A. Komykhov,*[a] Sergey M. Desenko,[a,b] Vladimir I. Musatov,[a] Oleg V. Shishkin,[a] Irina S. Konovalova,[a] Elena V. Vashchenko,[a] Valentin A. Chebanov*[a]

[a] State Scientific Institution 'Institute for Single Crystals' of National Academy of Sciences of Ukraine, Lenin Ave. 60, 61001 Kharkiv, Ukraine
Fax +38(57)3410273; E-mail: komykhov@isc.kharkov.com; E-mail: chebanov@isc.kharkov.com

[b] Karazin Kharkiv National University, Svobody sq., 4, 61077 Kharkiv, Ukraine

Received 5 November 2010; revised 10 January 2011

Abstract: Heterocyclization reactions between derivatives of 5-aminopyrazoles and *N*-arylmaleimides were studied and it was established that several directions are possible. Cyclizations involving 1,3-unsubstituted 5-aminopyrazoles yielded mixtures of two regioisomeric compounds, pyrazolo[1,5-*a*]pyrimidine-7-carboxamides and pyrazolo[3,4-*b*]pyridine-4-carboxamides. Reactions of 4-substituted 5-aminopyrazoles in boiling acetic acid or *N*,*N*-dimethylformamide in most cases gave pyrazolo[1,5-*a*]pyrimidine-7-carboxamides as the sole product. The treatment of 1-substituted 5-aminopyrazoles with maleimides possesses high selectivity only in *N*,*N*-dimethylformamide yielding pyrazolopyridines while in acetic acid the formation mixtures with pyrrolopyrazolones is observed. The key intermediates of the reaction studied were isolated and discussed.

Key words: heterocycle, *N*-arylmaleimide, 5-aminopyrazole, pyrazolopyridine, pyrazolopyrimidine

Partially hydrogenated azoloazines are a challenging class of heterocyclic compounds due to their known pharmacological activity[1] and the possibility to utilize them as a facile model for studying principle matters of organic chemistry, like conformational flexibility, tautomerism, electronic effects, etc. One synthetic approach to these compounds is by two- or multicomponent reactions between aminoazoles and α,β-unsaturated carbonyls or their precursors.[2] Polyfunctional aminoazoles are most attractive for scientists because of the possibility of implementing several independent directions for their reactions with electrophiles. From this perspective, a versatile aminoazole that contains several competitive non-equivalent reaction centers is 5-aminopyrazole. It is known that cyclocondensation of its derivatives with 1,3-biselectrophiles like α,β-unsaturated ketones, acetoacetic acid esters, acetoacetamides, or acetylacetone can lead to the formation of different types of final product.[2] However, very often such heterocyclizations give mixtures of several heterocyclic compounds. This problem of chemoselectivity can be solved in several ways, for instance, by variation of the reaction parameters, such as temperature, solvent type, catalytic system, activation methods, etc. For example (Figure 1), in our recent publications several successful examples of such cyclocondensation tuning selectivity was exhibited involving 5-aminopyrazole derivatives and 1,3-cyclohexanones (compounds **I–III**),[3a,b] barbituric acids (compounds **IV** and **V**)[3c] or (phenyl)pyruvic acid (compounds **VI–VIII**).[3d–3f]

A promising reagent for such heterocyclizations are N-substituted maleimides, which are able to play the role of 1,2(1,3)-bielectrophiles or dipolarophiles in reactions with dienophiles. However, there are few publications dealing with the cyclizations of maleimides with thioureas,[4] *o*-aminothiophenols,[5a] aminopyrimidines,[5b] aliphatic diamines,[5c] 2-mercapto-1,2,4-triazole,[5d] and 3-aminocrotonate.[5e]

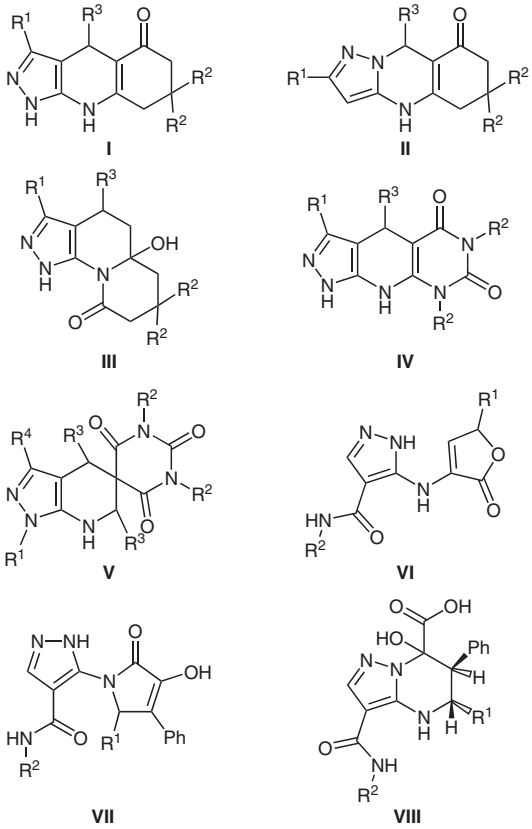


Figure 1 Some reaction products obtained in controlled heterocyclizations involving 5-aminopyrazoles

SYNTHESIS 2011, No. 5, pp 0783–0793
Advanced online publication: 03.02.2011
DOI: 10.1055/s-0030-1258421; Art ID: T21610SS

In our earlier publications[6] it was shown that the direction of the cyclocondensation of *N*-arylmaleimide with 3-amino-1,2,4-triazole depended on the type of solvent and led to different final heterocyclic systems, triazolo[4,3-*a*]- or triazolo[1,5-*a*]pyrimidinones[6] which are attractive as targets for medicinal chemistry.

In the present article we disclose our recent results in the study of heterocyclizations of 5-aminopyrazoles with *N*-arylmaleimides leading to several types of fused pyridine, pyrimidine, and imidazole derivatives. In our study, the 5-aminopyrazoles **1a**–**d**, which have free endocyclic 1-NH and 4-CH reaction centers, as well as aminopyrazoles **2a**–**d** or **3a**,**b**, containing a substituent at position 1 or 4, respectively, were used to cover all possible directions for the reactions.

It was found that short-term reflux (5–15 min) of equimolar amounts of aminopyrazole **1a**–**d** and *N*-arylmaleimide **4a**–**k** in acetic acid or *N*,*N*-dimethylformamide led to the formation of mixtures of two final heterocyclic compounds **5** and **6** in different ratios (Scheme 1, Table 1).

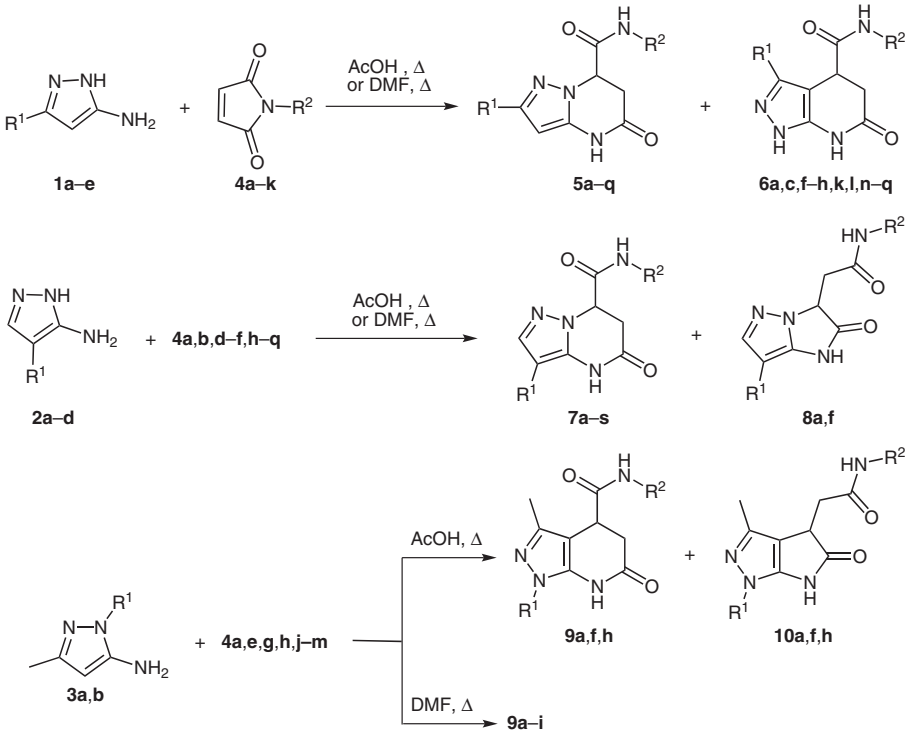
No correlation was found between the electronic or steric character of substituents R^1 and R^2 and the final compound ratios in the mixtures. All attempts to separate preparatively the mixtures obtained by recrystallization from polar or nonpolar solvents, by reprecipitation from *N*,*N*-dimethylformamide, dimethyl sulfoxide, or acetic acid, or by chromatography were unsuccessful.

Introducing an aryl or alkyl substituent at position 1 or 4 to the 5-aminopyrazole should lead to formation one of the possible regioisomers. However, it was established that heterocyclization of 5-amino-4-arylpyrazoles **2a**–**d** with *N*-arylmaleimides **4a**,**b**,**d**–**f**,**h**–**q** can also yield two different types of final heterocyclic system **7** and **8** (Scheme 1). The highest level of selectivity was found when the treatment was carried out in boiling *N*,*N*-dimethylformamide or acetic acid. In these cases, formation of minor products **8a**,**f** in 30% yield was observed only for reactions of 5-amino-4-phenyl-1*H*-pyrazole (**2a**) with maleimides **4a**,**k**, while for other starting materials no trace of such isomers was found even in the mother liquor.

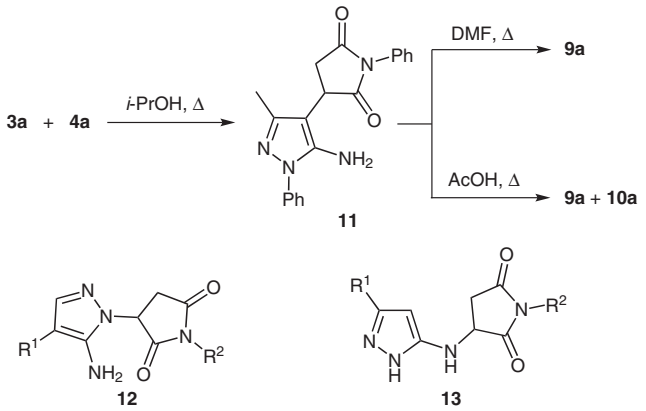
On the other hand, it was established that reactions of 1,3-disubstituted 5-aminopyrazoles **3a**,**b** with several *N*-arylmaleimides **4a**,**h**,**j** in boiling acetic acid also yielded mixtures of two isomeric heterocycles **9a**,**f**,**h** (80–85%) and **10a**,**f**,**h** (15–20%). The minor isomers **10** were not isolated and fully characterized. Carrying out the same reactions by refluxing of equimolar amounts of the starting materials in *N*,*N*-dimethylformamide led to a sufficient increase in the selectivity of the process and formation of a single, final compound, pyrazolopyrimidinones **9a**–**i**, in moderate yields (Scheme 1, Table 1).

In several articles published earlier[7a–c] it was reported that a similar reaction of *N*-arylmaleimides with 6-aminouracil in acetonitrile or propan-2-ol yielded adducts formed with the participation of the 5-CH or NH_2 groups of the aminoazine. But as both of these adducts were not further transformed into the corresponding heterocyclic compounds the question about possible intermediates in such a reaction arose.

In our study it was found that reaction of aminopyrazole **3a** with *N*-phenylmaleimide (**4a**) in boiling propan-2-ol gave an adduct **11** (Scheme 2). Subsequent reflux of **11** in *N*,*N*-dimethylformamide yielded the corresponding pyra-



Scheme 1



Scheme 2

zolo[3,4-*b*]pyridine-4-carboxamide **9a**, while boiling in acetic acid gave again a mixture of two compounds **9a** and **10a**.

Thus, adducts like **11** can be key intermediates in the heterocyclization reaction between 5-aminopyrazoles and *N*-arylmaleimides while the formation of several final products should be explained by competition between alternative reaction centers. For example, heterocyclization of **11** with participation of different carboxamide groups gives either pyridinone derivatives **9** or pyrrolopyrazolones **10**. In the case of aminopyrazoles **2** the key intermediates are compounds **12**, the cyclization of which yields the corresponding pyrazolopyrimidinones **7** or imidazopyrazolones **8**. For 1,4-unsubstituted aminopyrazoles **1**, the formation of adducts like **11** and **12** possibly accounts for the isolation of two types of heterocyclic systems, compounds **5** and **6**.

Table 1 Synthesis of Compounds **5a–r**, **6a**,**b**,**d**,**e**,**g–m**,**o–r**, **7a–r**, and **9a–i**

5-Aminopyrazole	R^1	*N*-Arylmaleimide	R^2	Products[a]	Yield (%)
1a	Me	**4b**	$4\text{-MeOC}_6\text{H}_4$	**5a** + **6a** (90:10)	64
1a	Me	**4c**	$2,5\text{-(MeO)}_2\text{C}_6\text{H}_3$	**5b**	68
1a	Me	**4d**	$2,4\text{-Cl}_2\text{C}_6\text{H}_3$	**5c** + **6c** (90:10)	58
1a	Me	**4e**	$4\text{-MeO-3-ClC}_6\text{H}_3$	**5d**	62
1b	Ph	**4a**	Ph	**5e**	64
1b	Ph	**4b**	$4\text{-MeOC}_6\text{H}_4$	**5f** + **6f** (80:20)	65
1b	Ph	**4f**	$3\text{-MeOC}_6\text{H}_4$	**5g** + **6g** (85:15)	55
1b	Ph	**4g**	$3,4\text{-(MeO)}_2\text{C}_6\text{H}_3$	**5h** + **6h** (95:5)	66
1b	Ph	**4h**	$2\text{-ClC}_6\text{H}_4$	**5i**	70
1c	$4\text{-MeOC}_6\text{H}_4$	**4i**	$2\text{-MeO-5-ClC}_6\text{H}_3$	**5j**	69
1c	$4\text{-MeOC}_6\text{H}_4$	**4j**	$2,4\text{-Me}_2\text{C}_6\text{H}_3$	**5k** + **6k** (95:5)	62
1c	$4\text{-MeOC}_6\text{H}_4$	**4k**	$4\text{-FC}_6\text{H}_4$	**5l** + **6l** (90:10)	65
1d	$4\text{-ClC}_6\text{H}_4$	**4i**	$2\text{-MeO-5-ClC}_6\text{H}_3$	**5m**	70
1d	$4\text{-ClC}_6\text{H}_4$	**4k**	$4\text{-FC}_6\text{H}_4$	**5n** + **6n** (90:10)	64
1d	$4\text{-ClC}_6\text{H}_4$	**4e**	$4\text{-MeO-3-ClC}_6\text{H}_3$	**5o** + **6o** (95:5)	67
1e	$4\text{-FC}_6\text{H}_4$	**4d**	$2,4\text{-Cl}_2\text{C}_6\text{H}_3$	**5p** + **6p** (90:10)	63
1e	$4\text{-FC}_6\text{H}_4$	**4e**	$4\text{-MeO-3-ClC}_6\text{H}_3$	**5q** + **6q** (50:50)	65
2a	Ph	**4a**	Ph	**7a** + **8a** (70:30)	70
2a	Ph	**4h**	$2\text{-ClC}_6\text{H}_4$	**7b**	74
2a	Ph	**4i**	$2\text{-MeO-5-ClC}_6\text{H}_3$	**7c**	78
2a	Ph	**4e**	$4\text{-MeO-3-ClC}_6\text{H}_3$	**7d**	68
2a	Ph	**4l**	$2\text{-F}_3\text{CC}_6\text{H}_4$	**7e**	72
2a	Ph	**4k**	$4\text{-FC}_6\text{H}_4$	**7f** + **8f** (65:35)	70
2a	Ph	**4m**	$4\text{-EtO}_2\text{CC}_6\text{H}_4$	**7g**	80
2b	$4\text{-ClC}_6\text{H}_4$	**4b**	$4\text{-MeOC}_6\text{H}_4$	**7h**	78
2b	$4\text{-ClC}_6\text{H}_4$	**4h**	$2\text{-ClC}_6\text{H}_4$	**7i**	75
2b	$4\text{-ClC}_6\text{H}_4$	**4n**	$3,4\text{-OCH}_2\text{OC}_6\text{H}_3$	**7j**	76
2b	$4\text{-ClC}_6\text{H}_4$	**4f**	$3\text{-MeOC}_6\text{H}_4$	**7k**	77
2c	$2\text{-MeOC}_6\text{H}_4$	**4o**	$2,4\text{-(MeO)}_2\text{C}_6\text{H}_3$	**7l**	65
2c	$2\text{-MeOC}_6\text{H}_4$	**4j**	$2,4\text{-Me}_2\text{C}_6\text{H}_3$	**7m**	71
2c	$2\text{-MeOC}_6\text{H}_4$	**4d**	$2,4\text{-Cl}_2\text{C}_6\text{H}_3$	**7n**	72
2c	$2\text{-MeOC}_6\text{H}_4$	**4p**	$4\text{-BrC}_6\text{H}_4$	**7o**	80
2c	$2\text{-MeOC}_6\text{H}_4$	**4q**	$3,4\text{-F}_2\text{C}_6\text{H}_3$	**7p**	74
2d	$4\text{-FC}_6\text{H}_4$	**4d**	$2,4\text{-Cl}_2\text{C}_6\text{H}_3$	**7q**	66
2d	$4\text{-FC}_6\text{H}_4$	**4h**	$2\text{-ClC}_6\text{H}_4$	**7r**	72
2d	$4\text{-FC}_6\text{H}_4$	**4q**	$3,4\text{-F}_2\text{C}_6\text{H}_3$	**7s**	75
3a	Ph	**4a**	Ph	**9a**	34
3a	Ph	**4g**	$3,4\text{-(MeO)}_2\text{C}_6\text{H}_3$	**9b**	46
3a	Ph	**4k**	$4\text{-FC}_6\text{H}_4$	**9c**	30
3a	Ph	**4e**	$4\text{-MeO-3-ClC}_6\text{H}_3$	**9d**	48
2a	Ph	**4l**	$2\text{-F}_3\text{CC}_6\text{H}_4$	**9e**	40
3a	Ph	**4j**	$2,4\text{-Me}_2\text{C}_6\text{H}_3$	**9f**	52
3a	Ph	**4m**	$4\text{-EtO}_2\text{CC}_6\text{H}_4$	**9g**	35
3a	Ph	**4h**	$4\text{-ClC}_6\text{H}_4$	**9h**	44
3b	Me	**4a**	Ph	**9i**	46

[a] Ratio of compounds (%) in the mixture isolated according to ^{1}H NMR data.

Additionally, it was established that adducts of type **13**, obtained by reaction of aminoazoles **1** with appropriate maleimides in acetic acid at ca. 50 °C, did not undergo further cyclization into heterocyclic compounds under reflux in *N*,*N*-dimethylformamide or acetic acid.

The structures of the compounds synthesized were established by mass spectrometry, ^{1}H and ^{13}C NMR spectroscopy, and elemental analysis.

For example, the isomeric character of compounds **5** and **6** was shown by mass spectra data and elemental analysis. ^{1}H and ^{13}C NMR spectra of these heterocycles exhibit similar sets of signals including doublets of doublets for the ABX system, broad singlets for the carboxamide and azine NH, multiplets for the aryl protons as well as the corresponding signals for the terminal substituents. The formation of the pyridine or pyrimidine ring was postulated on the basis of the presence of a singlet for either the pyrazole CH (compounds **5**) or the pyrazole NH (compounds **6**). Additional useful information was obtained from NOE experiments (Figure 2).

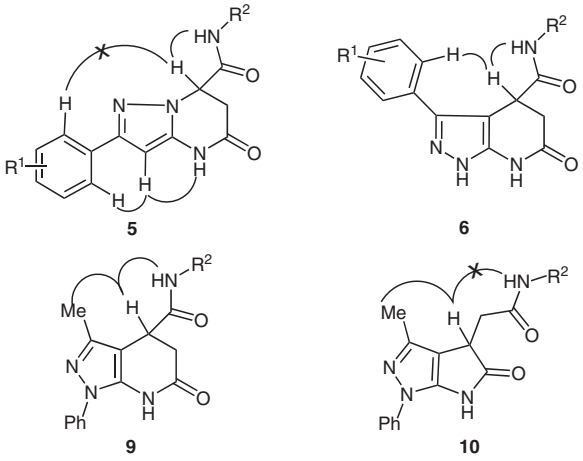


Figure 2 Some data of NOE experiments for compounds **5**, **6**, **9** and **10**

For instance, alternative structures (like **8** or **10**) for the products of heterocyclizations of compounds **1** and **4** were excluded according to the presence of NOE correlation between the carboxamide NH and the methyne CH, which was absent in the case of compounds **8** and **10** (Figure 2). Correlation between the *ortho*-proton of the aryl substituent and the methyne group gave additional evidence for pyridine, but not pyrimidine, ring formation in compounds **6**.

The structure of heterocycles **7** was also established using X-ray diffraction data obtained for compound **7l** (Figure 3).

It was additionally established that the tetrahydropyrimidine ring of **7l** adopts an asymmetric half-chair conformation (the puckering parameters[9] are $S = 0.52$, $Q = 41.9°$, $Y = 22.4°$).

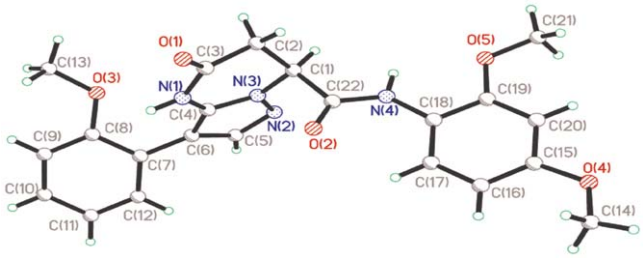


Figure 3 Molecular structure of compound **7l** (X-ray diffraction data)

In summary, the heterocyclizations of *N*-arylmaleimides with 5-aminopyrazoles were studied in detail, and the influence of the reaction parameters and the aminoazole structure on the direction of the reaction was established. It was found that the reaction involving 1,4-unsubstituted 5-aminopyrazoles always gave mixtures of two regioisomers. Introducing substituents in positions 1 or 4 of the aminopyrazoles and variation of the solvent significantly increased the selectivity of the heterocyclizations and the corresponding pyrazolopyridine or pyrazolopyrimidine derivatives to be synthesized. In both cases, the best results were observed when *N*,*N*-dimethylformamide was used as the reaction medium. The key intermediates of the heterocyclization were proposed and their behavior was analyzed.

Melting points were obtained on a standard melting point apparatus in open capillary tubes. ^{1}H and ^{13}C NMR spectra were recorded in DMSO-d_6 at 200 MHz (50 MHz for ^{13}C) on Varian Mercury VX-200 spectrometers. HRMS were measured on a GC-MS Varian 1200L (ionizing voltage 70 eV). Elemental analysis was made on a EuroVector EA-3000. TLC analyses were performed on pre-coated (silica gel 60 HF_{254}) plates.

All solvents and chemicals were obtained from standard commercial vendors and were used without any purification.

The starting 5-aminopyrazoles **1a**–**e** were synthesized by literature procedures.[8]

X-ray Diffraction Analysis of Compound 7l

Colorless crystals of **7l** ($C_{22}H_{22}N_4O_5$) are triclinic. At 293K, $a = 7.987(1)$, $b = 11.667(1)$, $c = 11.751(1)$ Å, $\alpha = 71.09(1)°$, $\beta = 80.27(1)°$, $\gamma = 81.78(1)°$, $V = 1016(1)$ Å^3, $Mr = 422.44$, $Z = 2$, space group $P1$, $d_{calc} = 1.380$ g/cm^3, μ(MoKα) = 0.100 mm^{-1}, $F(000) = 444$. Intensities of 6147 reflections (3528 independent, $R_{int} = 0.015$) were measured on the «Xcalibur-3» diffractometer (graphite monochromated MoKα radiation, CCD detector, ω-scanning, $2\Theta max = 50°$).

The structure was solved by direct method using SHELXTL package.[10] Positions of the hydrogen atoms were located from electron density difference maps and refined by riding model with $U_{iso} = nU_{eq}$ of the carrier atom (n = 1.5 for methyl group and n = 1.2 for other hydrogen atoms). Full-matrix least-squares refinement of the structures against F^2 in anisotropic approximation for non-hydrogen atoms using 3488 reflections was converged to: $wR_2 = 0.104$ ($R_1 = 0.040$ for 2544 reflections with $F>4\sigma(F)$, $S = 1.055$).[11]

_N_,2-Aryl- and _N_-Aryl-2-methyl-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamides 5a–q (Mixture with 6a,c,f–h,k,l,n–q); General Procedure

A mixture of 3-substituted 5-aminopyrazole **1a–e** (0.002 mol) and *N*-arylmaleimide **4a–k** (0.002 mol) in AcOH (0.5 mL) was placed in a vial and refluxed for 5–10 min. After cooling, acetone (10 mL) was added. The mixture was allowed to stand (up to 24 h) and then the precipitate that had formed was filtered to give the solid product, which was additionally washed with acetone and dried in air at r.t.

_N_-(4-Methoxyphenyl)-2-methyl-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5a)

Inseparable mixture with **6a**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.07 (s, 3 H, CH_3), 2.69 (dd, $^2J_{AB}$ = 16.8 Hz, $^3J_{AX}$ = 2.1 Hz, 1 H, 6-H_a), 3.29 (dd, $^3J_{BX}$ = 7.8 Hz, 1 H, 6-H_b), 3.72 (s, 3 H, CH_3O), 5.04 (dd, 1 H, 7-H_x), 5.42 (s, 1 H, 3-H), 6.89 (m, 2 H_{arom}), 7.49 (m, 2 H_{arom}), 10.32 (br s, 1 H, NH), 10.63 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 166.3, 164.5, 155.6, 148.0, 140.3, 131.0, 120.8, 113.7, 88.6, 56.5, 54.9, 33.5, 13.1.

MS (EI, 70 eV): *m*/*z* (%) = 300 (18) [M$^+$], 151 (32), 150 (100), 123 (14).

_N_-(2,5-Dimethoxyphenyl)-2-methyl-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5b)

Colorless solid; mp 183–184 °C.

IR (KBr): 3436, 3301, 2929, 1684, 1606, 1554, 1489, 1277, 1223 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.13 (s, 3 H, CH_3), 2.80 (dd, $^2J_{AB}$ = 16.9 Hz, $^3J_{AX}$ = 2.1 Hz, 1 H, 6-H_a), 3.26 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.66 (s, 3 H, CH_3O), 3.78 (s, 3 H, CH_3O), 5.40 (dd, 1 H, 7-H_x), 5.47 (s, 1 H, 3-H), 6.60–7.74 (m, 3 H_{arom}), 9.45 (br s, 1 H, NH), 10.74 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 167.2, 164.9, 152.9, 149.1, 142.8, 140.6, 127.4, 112.0, 108.6, 106.7, 89.2, 56.4, 56.2, 55.3, 33.1, 13.6.

MS (EI, 70 eV): *m*/*z* (%) = 330 (16) [M$^+$], 151 (15), 150 (100).

Anal. Calcd for $C_{16}H_{18}N_4O_4$: C, 58.17; H, 5.49; N, 16.96. Found: C, 58.0; H, 5.3; N, 16.6.

_N_-(2,4-Dichlorophenyl)-2-methyl-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5c)

Inseparable mixture with **6c**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.10 (s, 3 H, CH_3), 2.80 (dd, $^2J_{AB}$ = 17.1 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.31 (dd, $^3J_{BX}$ = 7.6 Hz, 1 H, 6-H_b), 5.33 (dd, 1 H, 7-H_x), 5.46 (s, 1 H, 3-H), 7.40–7.84 (m, 3 H_{arom}), 9.98 (br s, 1 H, NH), 10.74 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 167.6, 164.7, 149.0, 140.6, 133.2, 129.5, 128.8, 127.6, 126.4, 125.6, 89.2, 56.1, 33.3, 13.5.

MS (EI, 70 eV): *m*/*z* (%) = 338 (8) [M$^+$], 340 (3), 151 (23), 150 (100), 123 (8).

_N_-(3-Chloro-4-methoxyphenyl)-2-methyl-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5d)

Colorless solid; mp 195–196 °C.

IR (KBr): 3432, 2994, 1691, 1685, 1587, 1560, 1320, 1027 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.07 (s, 3 H, CH_3), 2.71 (dd, $^2J_{AB}$ = 16.8 Hz, $^3J_{AX}$ = 1.9 Hz, 1 H, 6-H_a), 3.30 (dd, $^3J_{BX}$ = 7.6 Hz, 1 H, 6-H_b), 3.82 (s, 3 H, CH_3O), 5.03 (dd, 1 H, 7-H_x), 5.42 (s, 1 H, 3-H), 7.10–7.76 (m, 3 H_{arom}), 10.5 (br s, 1 H, NH), 10.66 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 334 (15) [M$^+$], 336 (5), 151 (21), 150 (100), 123 (9).

Anal. Calcd for $C_{15}H_{15}ClN_4O_3$: C, 53.82; H, 4.52; N, 16.74. Found: C, 53.6; H, 4.5; N, 16.5.

5-Oxo-_N_,2-diphenyl-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5e)

Colorless solid; mp 272–273 °C.

IR (KBr): 3430, 2990, 1719, 1693, 1587, 1561, 1317 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.79 (dd, $^2J_{AB}$ = 17.1 Hz, $^3J_{AX}$ = 1.9 Hz, 1 H, 6-H_a), 3.45 (dd, $^3J_{BX}$ = 7.8 Hz, 1 H, 6-H_b), 5.31 (dd, 1 H, 7-H_x), 6.07 (s, 1 H, 3-H), 7.08–7.75 (m, 10 H_{arom}), 10.69 (br s, 1 H, NH), 10.91 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 167.2, 165.0, 150.7, 141.4, 138.2, 132.9, 128.8, 128.5, 127.7, 125.0, 123.9, 119.3, 86.5, 57.2, 33.9.

MS (EI, 70 eV): *m*/*z* (%) = 332 (15) [M$^+$], 212 (100).

Anal. Calcd for $C_{19}H_{16}N_4O_2$: C, 68.66; H, 4.85; N, 16.86. Found: C, 68.7; H, 4.9; N, 16.7.

_N_-(4-Methoxyphenyl)-5-oxo-2-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5f)

Inseparable mixture with **6f**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.79 (dd, $^2J_{AB}$ = 16.9 Hz, $^3J_{AX}$ = 2.1 Hz, 1 H, 6-H_a), 3.45 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.77 (s, 3 H, CH_3O), 5.23 (dd, 1 H, 7-H_x), 6.00 (s, 1 H, 3-H), 6.92–7.70 (m, 9 H_{arom}), 10.57 (br s, 1 H, NH), 10.76 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 362 (20) [M$^+$], 213 (28), 212 (100), 123 (11).

_N_-(3-Methoxyphenyl)-5-oxo-2-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5g)

Inseparable mixture with **6g**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.80 (dd, $^2J_{AB}$ = 16.9 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.46 (dd, $^3J_{BX}$ = 7.8 Hz, 1 H, 6-H_b), 3.71 (s, 3 H, CH_3O), 5.27 (dd, 1 H, 7-H_x), 6.07 (s, 1 H, 3-H), 6.65–7.77 (m, 9 H_{arom}), 10.57 (br s, 1 H, NH), 10.91 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 167.1, 164.9, 159.5, 150.7, 141.4, 139.3, 132.9, 129.5, 128.4, 127.6, 125.0, 111.6, 109.6, 105.0, 86.4, 57.3, 55.9, 33.8.

MS (EI, 70 eV): *m*/*z* (%) = 362 (12) [M$^+$], 213 (28), 212 (100), 158 (11).

_N_-(3,4-Dimethoxyphenyl)-5-oxo-2-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5h)

Inseparable mixture with **6h**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.78 (dd, $^2J_{AB}$ = 16.8 Hz, $^3J_{AX}$ = 0.9 Hz, 1 H, 6-H_a), 3.44 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.71 (s, 6 H, 2 CH_3O), 5.22 (dd, 1 H, 7-H_x), 6.06 (s, 1 H, 3-H), 6.88–7.77 (m, 8 H_{arom}), 10.43 (br s, 1 H, NH), 10.86 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 166.2, 164.5, 150.5, 148.7, 145.4, 141.1, 132.7, 131.6, 128.0, 127.3, 124.7, 112.7, 111.6, 105.2, 86.1, 57.0, 55.8, 55.4, 33.6.

MS (EI, 70 eV): *m*/*z* (%) = 392 (14) [M$^+$], 213 (38), 212 (100).

_N_-(2-Chlorophenyl)-5-oxo-2-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-_a_]pyrimidine-7-carboxamide (5i)

Colorless solid; mp 267–268 °C.

IR (KBr): 3435, 3257, 2941, 2920, 1698, 1596, 1544, 1445, 1380.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.87 (dd, $^2J_{AB}$ = 16.9 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.47 (dd, $^3J_{BX}$ = 7.8 Hz, 1 H, 6-H_b), 5.52

(dd, 1 H, 7-H_x), 6.10 (s, 1 H, 3-H), 7.16–7.71 (m, 9 H_{arom}), 10.01 (br s, 1 H, NH), 10.96 (br s, 1 H, NH_{pyr}).

^{13}C NMR (50 MHz, DMSO-d_6): δ = 167.4, 164.8, 151.2, 141.4, 133.9, 132.8, 129.4, 128.5, 127.8, 127.5, 126.6, 125.9, 125.1, 86.6, 56.6, 33.5.

MS (EI, 70 eV): *m*/*z* (%) = 366 (15) [M$^+$], 368 (2), 213 (47), 212 (100), 169 (18).

Anal. Calcd for $C_{19}H_{15}ClN_4O_2$: C, 62.21; H, 4.12; N, 15.27. Found: C, 62.1; H, 4.1; N, 15.3.

_N_-(5-Chloro-2-methoxyphenyl)-2-(4-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5j)

Colorless solid; mp 244–245 °C.

IR (KBr): 3435, 3263, 2988, 2919, 1682, 1604, 1546, 1532, 1461, 1548, 1035 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.86 (dd, $^2J_{AB}$ = 17.0 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.43 (dd, $^3J_{BX}$ = 8.1 Hz, 1 H, 6-H_b), 3.76 (s, 3 H, CH_3O), 3.78 (s, 3 H, CH_3O), 5.56 (dd, 1 H, 7-H_x), 6.02 (s, 1 H, 3-H), 6.95–8.11 (m, 7 H_{arom}), 9.79 (br s, 1 H, NH), 10.95 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 426 (10) [M$^+$], 428 (5), 243 (24), 242 (100).

Anal. Calcd for $C_{21}H_{19}ClN_4O_4$: C, 59.09; H, 4.49; N, 13.13. Found: C, 58.8; H, 4.3; N, 12.9.

_N_-(2,4-Dimethylphenyl)-2-(4-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5k)

Inseparable mixture with **6k**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.13 (s, 3 H, CH_3), 2.23 (s, 3 H, CH_3), 2.81 (dd, $^2J_{AB}$ = 16.3 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.39 (dd, $^3J_{BX}$ = 7.0 Hz, 1 H, 6-H_b), 3.78 (s, 3 H, CH_3O), 5.32 (dd, 1 H, 7-H_x), 5.98 (s, 1 H, 3-H), 6.93–7.72 (m, 7 H_{arom}), 9.70 (br s, 1 H, NH), 10.84 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 390 (13) [M$^+$], 243 (33), 242 (100).

_N_-(4-Fluorophenyl)-2-(4-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5l)

Inseparable mixture with **6l**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.79 (dd, $^2J_{AB}$ = 17.1 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.43 (dd, $^3J_{BX}$ = 8.1 Hz, 1 H, 6-H_b), 3.76 (s, 3 H, CH_3O), 5.20 (dd, 1 H, 7-H_x), 5.99 (s, 1 H, 3-H), 6.92–7.70 (m, 8 H_{arom}), 10.62 (br s, 1 H, NH), 10.75 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 380 (16) [M$^+$], 243 (28), 242 (100).

_N_-(5-Chloro-2-methoxyphenyl)-2-(4-chlorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5m)

Colorless solid; mp 277–278 °C.

IR (KBr): 3435, 3291, 2926, 1687, 1683, 1603, 1542, 1486, 1254, 1090, 1026 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.86 (dd, $^2J_{AB}$ = 17.1 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.43 (dd, $^3J_{BX}$ = 8.1 Hz, 1 H, 6-H_b), 3.78 (s, 3 H, CH_3O), 5.60 (dd, 1 H, 7-H_x), 6.14 (s, 1 H, 3-H), 7.04–8.09 (m, 7 H_{arom}), 9.83 (br s, 1 H, NH), 11.0 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 430 (7) [M$^+$], 432 (5), 249 (11), 248 (39), 247 (27), 246 (100).

Anal. Calcd for $C_{20}H_{16}Cl_2N_4O_3$: C, 55.70; H, 3.74; N, 12.99. Found: C, 55.5; H, 3.7; N, 12.9.

2-(4-Chlorophenyl)-_N_-(4-fluorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5n)

Inseparable mixture with **6n**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.81 (dd, $^2J_{AB}$ = 17.1 Hz, $^3J_{AX}$ = 1.4 Hz, 1 H, 6-H_a), 3.45 (dd, $^3J_{BX}$ = 7.6 Hz, 1 H, 6-H_b), 5.26 (dd, 1 H, 7-H_x), 6.10 (s, 1 H, 3-H), 7.13–7.80 (m, 8 H_{arom}), 10.64 (br s, 1 H, NH), 10.75 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 384 (12) [M$^+$], 386 (5), 249 (7), 248 (29), 247 (20), 246 (100).

_N_-(3-Chloro-4-methoxyphenyl)-2-(4-chlorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5o)

Inseparable mixture with **6o**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.81 (dd, $^2J_{AB}$ = 16.8 Hz, $^3J_{AX}$ = 1.1 Hz, 1 H, 6-H_a), 3.44 (dd, $^3J_{BX}$ = 7.5 Hz, 1 H, 6-H_b), 3.81 (s, 3 H, CH_3O), 5.21 (dd, 1 H, 7-H_x), 6.10 (s, 1 H, 3-H), 7.10–7.80 (m, 7 H_{arom}), 10.61 (br s, 1 H, NH), 10.94 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 430 (15) [M$^+$], 432 (5), 249 (17), 248 (66), 247 (36), 246 (100).

_N_-(2,4-Dichlorophenyl)-2-(4-fluorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5p)

Inseparable mixture with **6p**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.85 (dd, $^2J_{AB}$ = 17.6 Hz, $^3J_{AX}$ = 1.5 Hz, 1 H, 6-H_a), 3.47 (dd, $^3J_{BX}$ = 7.7 Hz, 1 H, 6-H_b), 5.49 (dd, 1 H, 7-H_x), 6.09 (s, 1 H, 3-H), 7.18–7.86 (m, 7 H_{arom}), 10.1 (br s, 1 H, NH), 10.97 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 418 (5) [M$^+$], 231 (24), 230 (100), 187 (15), 120 (21).

_N_-(3-Chloro-4-methoxyphenyl)-2-(4-fluorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (5q)

Inseparable mixture with **6q**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.80 (dd, $^2J_{AB}$ = 16.8 Hz, $^3J_{AX}$ = 1.6 Hz, 1 H, 6-H_a), 3.43 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.80 (s, 3 H, CH_3O), 5.20 (dd, 1 H, 7-H_x), 6.06 (s, 1 H, 3-H), 7.05–7.82 (m, 7 H_{arom}), 10.55 (br s, 1 H, NH), 10.9 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 414 (10) [M$^+$], 231 (32), 230 (100), 187 (15).

_N_,3-Diaryl-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamides 7a–s; General Procedure

A mixture of 4-aryl-5-aminopyrazole **2a–d** (0.002 mol) and *N*-arylmaleimide **4a**,**b**,**d–f**,**h–q** (0.002 mol) in AcOH (1 mL) was placed in a vial and refluxed for 5–15 min. After cooling acetone (10 mL) was added. The mixture was allowed to stand (~24 h) and then the precipitate formed was filtered to give the solid product which was additionally washed with acetone and dried in air at r.t.

5-Oxo-_N_,3-diphenyl-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7a)

Obtained as a mixture with **8a**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.83 (dd, $^2J_{AB}$ = 16.5 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H_a), 3.46 (dd, $^3J_{BX}$ = 7.6 Hz, 1 H, 6-H_b), 5.28 (dd, 1 H, 7-H_x), 7.06–7.61 (m, 10 H_{arom}), 7.69 (s, 1 H, 2-H), 10.54 (br s, 1 H, NH), 10.74 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 332 (33) [M$^+$], 333 (6), 213 (36), 212 (100), 185 (17), 184 (20).

2-(2-Oxo-7-phenyl-2,3-dihydro-1*H*-imidazo[1,2-*b*]pyrazol-3-yl)-*N*-phenylacetamide (8a)
Obtained as a mixture with **7a**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 3.09 (dd, $^2J_{AB}$ = 16.0Hz, $^3J_{AX}$ = 5.0 Hz, 1 H, H_a), 3.25 (dd, $^3J_{BX}$ = 5.0 Hz, 1 H, H_b), 4.99 (dd, 1 H, 3-H_x), 6.98–7.62 (m, 10 H_{arom}), 7.82 (s, 1 H, 6-H), 10.13 (br s, 1 H, NH), 11.7 (br s, 1 H, NH_{pyr}).

***N*-(2-Chlorophenyl)-5-oxo-3-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7b)**
Colorless solid; mp 240–241 °C.

IR (KBr): 3444, 3272, 3033, 2903, 1693, 1679, 1590, 1528, 1445, 1366, 1301, 1178 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.85 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 1.4 Hz, 1 H, 6-H_a), 3.51 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 5.49 (dd, 1 H, 7-H_x), 7.15–7.73 (m, 9 H_{arom}), 7.74 (s, 1 H, 2-H), 10.04 (br s, 1 H, NH), 10.65 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 366 (15) [M$^+$], 367 (5), 368 (10), 369 (4), 212 (100).

Anal. Calcd for $C_{19}H_{15}ClN_4O_2$: C, 62.21; H, 4.12; N, 15.27. Found: C, 62.15; H, 4.05; N, 15.3.

***N*-(5-Chloro-2-methoxyphenyl)-5-oxo-3-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7c)**
Colorless solid; mp 229–230 °C.

IR (KBr): 3436, 3289, 2939, 1702, 1690, 1594, 1543, 1257, 1225, 1026 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.82 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 1.7 Hz, 1 H, 6-H_a), 3.44 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.88 (s, 3 H, CH_3O), 5.59 (dd, 1 H, 7-H_x), 7.07–8.07 (m, 8 H_{arom}), 7.74 (s, 1 H, 2-H), 9.9 (br s, 2 H, NH).

MS (EI, 70 eV): *m*/*z* (%) = 396 (10) [M$^+$], 397 (3), 398 (4), 212 (100).

Anal. Calcd for $C_{20}H_{17}ClN_4O_3$: C, 60.53; H, 4.32; N, 14.12. Found: C, 60.35; H, 4.25; N, 14.3.

***N*-(3-Chloro-4-methoxyphenyl)-5-oxo-3-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7d)**
Colorless solid; mp 265–266 °C.

IR (KBr): 3430, 3247, 2908, 1689, 1680, 1600, 1504, 1368, 1235, 1187, 1065 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.83 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 1.8 Hz, 1 H, 6-H_a), 3.45 (dd, $^3J_{BX}$ = 7.8 Hz, 1 H, 6-H_b), 3.82 (s, 3 H, CH_3O), 5.20 (dd, 1 H, 7-H_x), 7.11–7.77 (m, 8 H_{arom}), 7.69 (s, 1 H, 2-H), 10.63 (br s, 1 H, NH), 10.76 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 166.6, 165.9, 150.9, 138.8, 136.1, 131.8, 131.1, 128.4, 126.5, 125.7, 121.0, 120.6, 119.3, 113.0, 105.4, 57.1, 56.1, 33.9.

MS (EI, 70 eV): *m*/*z* (%) = 396 (14) [M$^+$], 397 (5), 398 (7), 212 (100).

Anal. Calcd for $C_{20}H_{17}ClN_4O_3$: C, 60.53; H, 4.32; N, 14.12. Found: C, 60.32; H, 4.24; N, 14.2.

5-Oxo-3-phenyl-*N*-[2-(trifluoromethyl)phenyl]-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7e)
Colorless solid; mp 227–228 °C.

IR (KBr): 3429, 3280, 3025, 2906, 1699, 1684, 1610, 1532, 1496, 1370, 1311, 1175 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.78 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 1.8 Hz, 1 H, 6-H_a), 3.53 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 5.42 (dd, 1 H, 7-H_x), 7.17–7.78 (m, 9 H_{arom}), 7.73 (s, 1 H, 2-H), 10.12 (br s, 1 H, NH), 10.78 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 400 (13) [M$^+$], 212 (37), 185 (17), 169 (12), 168 (12).

Anal. Calcd for $C_{20}H_{15}F_3N_4O_2$: C, 60.00; H, 3.78; N, 13.99. Found: C, 59.95; H, 3.75; N, 14.0.

***N*-(4-Fluorophenyl)-5-oxo-3-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7f)**
Obtained as a mixture with **8f**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.83 (dd, $^2J_{AB}$ = 16.5 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H_a), 3.46 (dd, $^3J_{BX}$ = 7.5 Hz, 1 H, 6-H_b), 5.22 (dd, 1 H, 7-H_x), 7.05–7.65 (m, 9 H_{arom}), 7.69 (s, 1 H, 2-H), 10.62 (br s, 1 H, NH), 10.74 (br s, 1 H, NH_{pyr}).

***N*-(4-Fluorophenyl)-2-(2-oxo-7-phenyl-2,3-dihydro-1*H*-imidazo[1,2-*b*]pyrazol-3-yl)acetamide (8f)**
Obtained as a mixture with **7f**; colorless solid.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 3.08 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 5.0 Hz, 1 H, H_a), 3.23 (dd, $^3J_{BX}$ = 5.0 Hz, 1 H, H_b), 5.00 (dd, 1 H, 3-H_x), 7.05–7.65 (m, 9 H_{arom}), 7.82 (s, 1 H, 6-H), 10.2 (br s, 1 H, NH), 11.7 (br s, 1 H, NH_{pyr}).

Ethyl 4-(5-Oxo-3-phenyl-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamido)benzoate (7g)
Colorless solid; mp 290–291 °C.

IR (KBr): 3428, 3265, 3128, 2906, 1723, 1695, 1682, 1606, 1547, 1533, 1411, 1368, 1271, 1253 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 1.31 (t, *J* = 7.0 Hz, 3 H, CH_3), 2.88 (dd, $^2J_{AB}$ = 16.5 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H_a), 3.48 (dd, $^3J_{BX}$ = 7.6 Hz, 1 H, 6-H_b), 4.28 (q, 2 H, CH_2), 5.28 (dd, 1 H, 7-H_x), 7.18–7.97 (m, 9 H_{arom}), 7.70 (s, 1 H, 2-H), 10.58 (br s, 1 H, NH), 10.92 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 167.3, 165.8, 165.1, 142.3, 138.9, 136.1, 131.1, 130.1, 128.4, 126.5, 125.7, 125.0, 118.9, 105.5, 60.3, 57.3, 33.7, 14.0.

MS (EI, 70 eV): *m*/*z* (%) = 404 (6) [M$^+$], 212 (100), 185 (7).

Anal. Calcd for $C_{22}H_{20}N_4O_4$: C, 65.34; H, 4.98; N, 13.85. Found: C, 65.2; H, 4.75; N, 13.83.

3-(4-Chlorophenyl)-*N*-(4-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7h)
Colorless solid; mp 273–274 °C.

IR (KBr): 3447, 3257, 3139, 1698, 1666, 1606, 1509, 1237, 1036 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.79 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 1.7 Hz, 1 H, 6-H_a), 3.43 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.70 (s, 3 H, CH_3O), 5.19 (dd, 1 H, 7-H_x), 6.86–7.51 (m, 8 H_{arom}), 7.70 (s, 1 H, 2-H), 10.42 (br s, 1 H, NH). 10.79 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 396 (27) [M$^+$], 397 (7), 398 (10), 248 (23), 246 (100).

Anal. Calcd for $C_{20}H_{17}ClN_4O_3$: C, 60.53; H, 4.32; N, 14.12. Found: C, 60.4; H, 4.3; N, 14.2.

***N*-(2-Chlorophenyl)-3-(4-chlorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7i)**
Colorless solid; mp 243–244 °C.

IR (KBr): 3434, 2936, 1690, 1675, 1596, 1546, 1523, 1444, 1374, 1309 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.85 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 1.7 Hz, 1 H, 6-H_a), 3.51 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 5.48

(dd, 1 H, 7-H_x), 7.18–7.73 (m, 8 H_{arom}), 7.76 (s, 1 H, 2-H), 10.04 (br s, 1 H, NH), 10.80 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 400 (16) [M^+], 401 (8), 402 (9), 403 (3), 248 (35), 246 (100).

Anal. Calcd for $C_{19}H_{14}Cl_2N_4O_2$: C, 56.87; H, 3.52; N, 13.96. Found: C, 56.8; H, 3.4; N, 13.9.

***N*-(1,3-Benzodioxol-5-yl)-3-(4-chlorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7j)**
Colorless solid; mp 272–273 °C.

IR (KBr): 3438, 3256, 3080, 2907, 1694, 1663, 1487, 1449, 1222, 1037 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.81 (dd, $^2J_{AB}$ = 16.5 Hz, $^3J_{AX}$ = 1.8 Hz, 1 H, 6-H_a), 3.45 (dd, $^3J_{BX}$ = 7.8 Hz, 1 H, 6-H_b), 5.19 (dd, 1 H, 7-H_x), 5.99 (s, 2 H, OCH_2O), 6.85–7.51 (m, 7 H_{arom}), 7.72 (s, 1 H, 2-H), 10.48 (br s, 2 H, NH).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 166.5, 165.1, 147.1, 143.5, 138.8, 136.4, 132.5, 130.3, 130.1, 128.5, 128.3, 112.5, 108.1, 104.4, 101.5, 101.1, 57.3, 33.9.

MS (EI, 70 eV): *m*/*z* (%) = 410 (10) [M^+], 411 (2), 412 (4), 248 (50), 246 (100).

Anal. Calcd for $C_{20}H_{15}ClN_4O_4$: C, 58.47; H, 3.68; N, 13.64. Found: C, 58.4; H, 3.7; N, 13.7.

3-(4-Chlorophenyl)-*N*-(3-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7k)
Colorless solid; mp 267–268 °C.

IR (KBr): 3435, 3307, 2918, 1698, 1674, 1369, 1284, 1023 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.82 (dd, $^2J_{AB}$ = 16.5 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H_a), 3.47 (dd, $^3J_{BX}$ = 7.6 Hz, 1 H, 6-H_b), 3.72 (s, 3 H, CH_3O), 5.23 (dd, 1 H, 7-H_x), 6.65–7.51 (m, 8 H_{arom}), 7.72 (s, 1 H, 2-H), 10.54 (br s, 1 H, NH), 10.7 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 396 (17) [M^+], 397 (4), 398 (5), 248 (33), 246 (100).

Anal. Calcd for $C_{20}H_{17}ClN_4O_3$: C, 60.53; H, 4.32; N, 14.12. Found: C, 60.3; H, 4.3; N, 14.1.

***N*-(2,4-Dimethoxyphenyl)-3-(2-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7l)**
Colorless solid; mp 188–189 °C.

IR (KBr): 3434, 3345, 3190, 2939, 1695, 1681, 1618, 1537, 1373, 1225, 1078 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.86 (dd, $^2J_{AB}$ = 16.6 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H_a), 3.39 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.73 (s, 3 H, CH_3O), 3.78 (s, 3 H, CH_3O), 3.83 (s, 3 H, CH_3O), 5.47 (dd, 1 H, 7-H_x), 6.45–7.78 (m, 7 H_{arom}), 7.57 (s, 1 H, 2-H), 9.42 (br s, 1 H, NH), 10.2 (br s, 1 H, NH_{pyr}).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 166.1, 164.5, 156.8, 155.5, 150.7, 140.0, 136.3, 129.2, 127.4, 122.0, 120.3, 119.8, 119.7, 111.5, 104.4, 101.7, 99.0, 56.6, 55.7, 55.1, 55.0, 33.1.

MS (EI, 70 eV): *m*/*z* (%) = 422 (26) [M^+], 423 (12), 243 (19), 242 (66), 212 (100).

Anal. Calcd for $C_{22}H_{22}N_4O_5$: C, 62.55; H, 5.25; N, 13.26. Found: C, 62.4; H, 5.2; N, 13.2.

***N*-(2,4-Dimethylphenyl)-3-(2-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7m)**
Colorless solid; mp 239–240 °C.

IR (KBr): 3436, 3304, 2918, 1698, 1664, 1529, 1369, 1301, 1236, 1023 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.15 (s, 3 H, CH_3), 2.24 (s, 3 H, CH_3), 2.82 (dd, $^2J_{AB}$ = 16.4 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H_a), 3.45 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.78 (s, 3 H, CH_3O), 5.33 (dd, 1 H, 7-H_x), 6.91–7.31 (m, 7 H_{arom}), 7.55 (s, 1 H, 2-H), 9.70 (br s, 1 H, NH), 10.14 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 390 (12) [M^+], 391 (4), 243 (16), 242 (59), 212 (100).

Anal. Calcd for $C_{22}H_{22}N_4O_3$: C, 67.68; H, 5.68; N, 14.35. Found: C, 67.6; H, 5.5; N, 14.2.

***N*-(2,4-Dichlorophenyl)-3-(2-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7n)**
Colorless solid; mp 223–224 °C.

IR (KBr): 3435, 3328, 3075, 1706, 1694, 1592, 1520, 1020 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.85 (dd, $^2J_{AB}$ = 16.9 Hz, $^3J_{AX}$ = 2.3 Hz, 1 H, 6-H_a), 3.45 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.76 (s, 3 H, CH_3O), 5.46 (dd, 1 H, 7-H_x), 6.92–7.80 (m, 7 H_{arom}), 7.57 (s, 1 H, 2-H), 10.05 (br s, 2 H, NH).

MS (EI, 70 eV): *m*/*z* (%) = 430 (10) [M^+], 432 (6), 243 (15), 242 (55), 213 (15), 212 (100).

Anal. Calcd for $C_{20}H_{16}Cl_2N_4O_3$: C, 55.7; H, 3.74; N, 12.99. Found: C, 55.6; H, 3.8; N, 13.1.

***N*-(4-Bromophenyl)-3-(2-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7o)**
Colorless solid; mp 271–272 °C.

IR (KBr): 3434, 3315, 3061, 1698, 1681, 1595, 1543, 1489, 1396, 1245, 1182, 1026 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.83 (dd, $^2J_{AB}$ = 16.9 Hz, $^3J_{AX}$ = 2.3 Hz, 1 H, 6-H_a), 3.43 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.78 (s, 3 H, CH_3O), 5.22 (dd, 1 H, 7-H_x), 6.92–7.65 (m, 8 H_{arom}), 7.52 (s, 1 H, 2-H), 9.97 (br s, 1 H, NH), 10.7 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 442 (16) [M^+], 440 (14), 243 (18), 242 (47), 213 (14), 212 (100).

Anal. Calcd for $C_{20}H_{17}BrN_4O_3$: C, 54.44; H, 3.88; N, 12.7. Found: C, 54.3; H, 3.8; N, 12.8.

***N*-(3,4-Difluorophenyl)-3-(2-methoxyphenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7p)**
Colorless solid; mp 257–258 °C.

IR (KBr): 3436, 3341, 3082, 1693, 1676, 1621, 1521, 1219, 1024 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.83 (dd, $^2J_{AB}$ = 17.1 Hz, $^3J_{AX}$ = 2.6 Hz, 1 H, 6-H_a), 3.44 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 3.78 (s, 3 H, CH_3O), 5.20 (dd, 1 H, 7-H_x), 6.91–7.82 (m, 7 H_{arom}), 7.53 (s, 1 H, 2-H), 10.18 (br s, 1 H, NH), 10.82 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 398 (72) [M^+], 399 (19), 243 (19), 242 (83), 213 (23), 212 (100).

Anal. Calcd for $C_{20}H_{16}F_2N_4O_3$: C, 60.3; H, 4.05; N, 14.06. Found: C, 60.2; H, 3.9; N, 14.1.

***N*-(2,4-Dichlorophenyl)-3-(4-fluorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7q)**
Colorless solid; mp 265–266 °C.

IR (KBr): 3435, 3309, 2934, 1694, 1587, 1525, 1448, 1382, 1299, 1235 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.84 (dd, $^2J_{AB}$ = 17.1 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H_a), 3.47 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H_b), 5.48 (dd, 1 H, 7-H_x), 7.15–7.76 (m, 7 H_{arom}), 7.71 (s, 1 H, 2-H), 10.14 (br s, 1 H, NH), 10.84 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 418 (16) [M$^+$], 420 (5), 231 (15), 230 (100).

Anal. Calcd for $C_{19}H_{13}Cl_2FN_4O_2$: C, 54.43; H, 3.13; N, 13.36. Found: C, 54. 6; H, 3.1; N, 13.2.

_N_-(2-Chlorophenyl)-3-(4-fluorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7r)
Colorless solid; mp 231–232 °C.

IR (KBr): 3433, 3330, 2946, 1693, 1595, 1525, 1442, 1377, 1233, 1060 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.84 (dd, $^2J_{AB}$ = 16.4 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H$_a$), 3.50 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H$_b$), 5.48 (dd, 1 H, 7-H$_x$), 7.15–7.71 (m, 8 H$_{arom}$), 7.72 (s, 1 H, 2-H), 10.04 (br s, 1 H, NH), 10.83 (br s, 1 H, NH$_{pyr}$).

MS (EI, 70 eV): *m*/*z* (%) = 384 (9) [M$^+$], 386 (3), 231 (25), 230 (100).

Anal. Calcd for $C_{19}H_{14}ClFN_4O_2$: C, 59.31; H, 3.67; N, 14.56. Found: C, 59.2; H, 3.6; N, 14.5.

_N_-(3,4-Difluorophenyl)-3-(4-fluorophenyl)-5-oxo-4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyrimidine-7-carboxamide (7s)
Colorless solid; mp 270–271 °C.

IR (KBr): 3435, 3288, 2928, 1687, 1664, 1601, 1441, 1380, 1061 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.84 (dd, $^2J_{AB}$ = 16.4 Hz, $^3J_{AX}$ = 2.0 Hz, 1 H, 6-H$_a$), 3.23 (dd, $^3J_{BX}$ = 7.9 Hz, 1 H, 6-H$_b$), 5.21 (dd, 1 H, 7-H$_x$), 7.15–7.80 (m, 7 H$_{arom}$), 7.68 (s, 1 H, 2-H), 10.82 (br s, 2 H, NH).

MS (EI, 70 eV): *m*/*z* (%) = 386 (17) [M$^+$], 387 (5), 231 (22), 230 (100).

Anal. Calcd for $C_{19}H_{13}F_3N_4O_2$: C, 59.07; H, 3.39; N, 14.5. Found: C, 58.9; H, 3.3; N, 14.5.

_N_-Aryl-3-methyl-6-oxo-1-phenyl- or _N_-Aryl-1,3-dimethyl-6-oxo-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamides 9a–i; General Procedure
A mixture of 5-aminopyrazole **3a**,**b** (0.002 mol) and *N*-arylmaleimide **4a**,**e**,**g**,**h**,**j**–**m** (0.002 mol) in DMF (1 mL) was placed in a flask and refluxed for 3 h. After cooling, acetone (10 mL) was added. The mixture was allowed to stand and then the precipitate that had formed was filtered to give the solid product which was additionally washed with acetone and dried in air at r.t.

3-Methyl-6-oxo-_N_,1-diphenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9a)
Colorless solid; mp 250–251 °C.

IR (KBr): 3435, 3298, 3062, 2922, 1698, 1659, 1599, 1537, 1500, 1445, 1385 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.15 (s, 3 H, CH$_3$), 2.66 (dd, $^2J_{AB}$ = 15.9 Hz, $^3J_{AX}$ = 4.6 Hz, 1 H, 5-H$_a$), 2.87 (dd, $^3J_{BX}$ = 6.8 Hz, 1 H, 5-H$_b$), 3.89 (dd, 1 H, 4-H$_x$), 7.03–7.63 (m, 10 H$_{arom}$), 10.23 (br s, 1 H, NH), 10.40 (br s, 1 H, NH$_{pyr}$).

^{13}C NMR (50 MHz, DMSO-d_6): δ = 170.7, 169.7, 145.0, 139.7, 138.7, 137.9, 129.1, 128.6, 126.7, 123.5, 122.7, 119.4, 99.3, 36.3, 34.9, 12.0.

MS (EI, 70 eV): *m*/*z* (%) = 346 (5) [M$^+$], 227 (16), 226 (100), 77 (16).

Anal. Calcd for $C_{20}H_{18}N_4O_2$: C, 69.35; H, 5.24; N, 16.17. Found: C, 69.3; H, 5.2; N, 16.1.

_N_-(3,4-Dimethoxyphenyl)-3-methyl-6-oxo-1-phenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9b)
Colorless solid; mp 265–266 °C.

IR (KBr): 3435, 3284, 2919, 1680, 1650, 1517, 1237, 1027 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.16 (s, 3 H, CH$_3$), 2.64 (dd, $^2J_{AB}$ = 15.9 Hz, $^3J_{AX}$ = 4.0 Hz, 1 H, 5-H$_a$), 2.87 (dd, $^3J_{BX}$ = 6.9 Hz, 1 H, 5-H$_b$), 3.72 (s, 6 H, 2 CH$_3$O), 3.82 (dd, 1 H, 4-H$_x$), 6.87–7.49 (m, 8 H$_{arom}$), 10.08 (br s, 1 H, NH), 10.32 (br s, 1 H, NH$_{pyr}$).

MS (EI, 70 eV): *m*/*z* (%) = 406 (8) [M$^+$], 227 (17), 226 (100), 77 (17).

Anal. Calcd for $C_{22}H_{22}N_4O_4$: C, 65.01; H, 5.46; N, 13.78. Found: C, 64.8; H, 5.5; N, 13.6.

_N_-(4-Fluorophenyl)-3-methyl-6-oxo-1-phenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9c)
Colorless solid; mp 277–278 °C.

IR (KBr): 3435, 3266, 3079, 2920, 1681, 1656, 1615, 1509, 1408, 1215 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.14 (s, 3 H, CH$_3$), 2.66 (dd, $^2J_{AB}$ = 16.1 Hz, $^3J_{AX}$ = 4.2 Hz, 1 H, 5-H$_a$), 2.86 (dd, $^3J_{BX}$ = 7.0 Hz, 1 H, 5-H$_b$), 3.86 (dd, 1 H, 4-H$_x$), 7.11–7.66 (m, 9 H$_{arom}$), 10.30 (br s, 2 H, NH).

^{13}C NMR (50 MHz, DMSO-d_6): δ = 170.7, 169.7, 158.1 (d, ^1J = 240 Hz, 1 C, *p*-C$_{Ar}$), 145.0, 139.7, 137.9, 135.0 (d, *J* = 2.9 Hz, 1 C C$_{Ar}$-NH), 129.1, 126.8, 122.8, 122.2 (d, *J* = 7.6 Hz, 2 C, *o*-C$_{Ar}$), 115.25 (d, *J* = 22.3 Hz, 2 C, *m*-C$_{Ar}$), 99.3, 36.3, 34.9, 12.0.

MS (EI, 70 eV): *m*/*z* (%) = 364 (8) [M$^+$], 366 (2), 227 (9), 226 (100).

Anal. Calcd for $C_{20}H_{17}FN_4O_2$: C, 65.93; H, 4.70; N, 15.38. Found: C, 65.8; H, 4.65; N, 16.3.

_N_-(3-Chloro-4-methoxyphenyl)-3-methyl-6-oxo-1-phenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9d)
Colorless solid; mp 250–251 °C.

IR (KBr): 3434, 3288, 3053, 2918, 1677, 1654, 1650, 1603, 1501, 1441, 1382, 1061 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.14 (s, 3 H, CH$_3$), 2.65 (dd, $^2J_{AB}$ = 15.7 Hz, $^3J_{AX}$ = 4.2 Hz, 1 H, 5-H$_a$), 2.87 (dd, $^3J_{BX}$ = 7.0 Hz, 1 H, 5-H$_b$), 3.82 (s, 3 H, CH$_3$O), 3.88 (dd, 1 H, 4-H$_x$), 7.10–7.78 (m, 8 H$_{arom}$), 10.24 (br s, 1 H, NH), 10.42 (br s, 1 H, NH$_{pyr}$).

^{13}C NMR (50 MHz, DMSO-d_6): δ = 170.6, 169.6, 150.7, 145.0, 139.7, 137.8, 132.4, 129.1, 126.7, 122.8, 121.1, 120.1, 119.3, 112.9, 99.2, 56.1, 36.3, 34.8, 12.0.

MS (EI, 70 eV): *m*/*z* (%) = 410 (8) [M$^+$], 412 (3), 227 (18), 226 (100), 199 (24), 77 (24).

Anal. Calcd for $C_{21}H_{19}ClN_4O_3$: C, 61.39; H, 4.66; N, 13.64. Found: C, 61.2; H, 4.7; N, 13.6.

3-Methyl-6-oxo-1-phenyl-_N_-[2-(trifluoromethyl)phenyl]-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9e)
Colorless solid; mp 260–261 °C.

IR (KBr): 3433, 3280, 2916, 1680, 1655, 1518, 1237, 1030 cm^{-1}.

^{1}H NMR (200 MHz, DMSO-d_6): δ = 2.21 (s, 3 H, CH$_3$), 2.61 (dd, $^2J_{AB}$ = 16.1 Hz, $^3J_{AX}$ = 3.3 Hz, 1 H, 5-H$_a$), 2.94 (dd, $^3J_{BX}$ = 7.0 Hz, 1 H, 5-H$_b$), 4.00 (dd, 1 H, 4-H$_x$), 7.29–7.77 (m, 9 H$_{arom}$), 9.86 (br s, 1 H, NH), 10.43 (br s, 1 H, NH$_{pyr}$).

Anal. Calcd for $C_{21}H_{17}F_3N_4O_2$: C, 60.87; H, 4.14; N, 13.52. Found: C, 60.7; H, 4.0; N, 13.4.

N-(2,4-Dimethylphenyl)-3-methyl-6-oxo-1-phenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9f)
Colorless solid; mp 279–280 °C.

IR (KBr): 3436, 3280, 2920, 1682, 1650, 1532, 1501 cm^{-1}.

^1H NMR (50 MHz, DMSO-d_6): δ = 2.15 (s, 3 H, CH_3), 2.21 (s, 3 H, CH_3), 2.25 (s, 3 H, CH_3), 2.64 (dd, $^2J_{AB}$ = 16.1 Hz, $^3J_{AX}$ = 3.8 Hz, 1 H, 5-H_a), 2.89 (dd, $^3J_{BX}$ = 7.0 Hz, 1 H, 5-H_b), 3.94 (dd, 1 H, 4-H_x), 6.94–7.49 (m, 8 H_{arom}), 9.44 (br s, 1 H, NH), 10.00 (br s, 1 H, NH_{pyr}).

^{13}C NMR (50 MHz, DMSO-d_6): δ = 170.8, 169.6, 145.0, 139.7, 138.9, 134.5, 133.2, 131.9, 130.7, 129.0, 126.6, 126.3, 125.2, 122.7, 99.5, 35.6, 35.2, 20.3, 17.5, 11.9.

MS (EI, 70 eV): *m*/*z* (%) = 374 (16) [M^+], 375 (4), 227 (13), 226 (100), 77 (17).

Anal. Calcd for $C_{22}H_{22}N_4O_2$: C, 70.57; H, 5.92; N, 14.96. Found: C, 70.4; H, 5.9; N, 14.8.

Ethyl (3-Methyl-6-oxo-1-phenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamido)benzoate (9g)
Colorless solid; mp 195–196 °C.

IR (KBr): 3629, 3422, 3315, 2929, 1713, 1683, 1598, 1533, 1329, 1269, 1171, 1100 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 1.31 (t, *J* = 7.1 Hz, 3 H, CH_3), 2.15 (s, 3 H, CH_3), 2.68 (dd, $^2J_{AB}$ = 15.7 Hz, $^3J_{AX}$ = 4.0 Hz, 1 H, 5-H_a), 2.90 (dd, $^3J_{BX}$ = 7.0 Hz, 1 H, 5-H_b), 3.93 (dd, 1 H, 4-H_x), 4.28 (q, 2 H, CH_2), 730–7.95 (m, 9 H_{arom}), 10.39 (br s, 1 H, NH), 10.52 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 418 (12) [M^+], 419 (4), 227 (16), 226 (100).

Anal. Calcd for $C_{23}H_{22}N_4O_4$: C, 66.02; H, 5.30; N, 13.39. Found: C, 64.8; H, 5.5; N, 13.6.

N-(4-Chlorophenyl)-3-methyl-6-oxo-1-phenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9h)
Colorless solid; mp 290–291 °C.

IR (KBr): 3421, 3231, 2921, 1706, 1656, 1596, 1543, 1492, 1400, 1185, 1091 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.14 (s, 3 H, CH_3), 2.66 (dd, $^2J_{AB}$ = 16.3 Hz, $^3J_{AX}$ = 4.3 Hz, 1 H, 5-H_a), 2.88 (dd, $^3J_{BX}$ = 6.7 Hz, 1 H, 5-H_b), 3.86 (dd, 1 H, 4-H_x), 7.31–7.66 (m, 9 H_{arom}), 10.21 (br s, 1 H, NH), 10.36 (br s, 1 H, NH_{pyr}).

MS (EI, 70 eV): *m*/*z* (%) = 380 (11) [M^+], 382 (4), 227 (16), 226 (100), 77 (22).

Anal. Calcd for $C_{20}H_{17}ClN_4O_2$: C, 63.08; H, 4.50; N, 14.71. Found: C, 62.95; H, 4.6; N, 14.7.

1,3-Dimethyl-6-oxo-*N*-phenyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*b*]pyridine-4-carboxamide (9i)
Colorless solid; mp 298–299 °C.

IR (KBr): 3435, 3326, 3185, 3039, 1675, 1656, 1599, 1526, 1442, 1385 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.03 (s, 3 H, CH_3), 2.57 (dd, $^2J_{AB}$ = 16.1 Hz, $^3J_{AX}$ = 4.4 Hz, 1 H, 5-H_a), 2.75 (dd, $^3J_{BX}$ = 6.9 Hz, 1 H, 5-H_b), 3.55 (s, 3 H, 1-CH_3), 3.78 (dd, 1 H, 4-H_x), 7.00–7.60 (m, 5 H_{arom}), 10.10 (br s, 1 H, NH), 10.54 (br s, 1 H, NH_{pyr}).

^{13}C NMR (50 MHz, DMSO-d_6): δ = 170.9, 169.2, 142.3, 139.9, 138.6, 128.4, 123.2, 119.3, 96.4, 36.4, 34.7, 34.1, 11.7.

MS (EI, 70 eV): *m*/*z* (%) = 284 (5) [M^+], 164 (100), 77 (5).

Anal. Calcd for $C_{15}H_{16}N_4O_2$: C, 63.37; H, 5.67; N, 19.71. Found: C, 63.1; H, 5.2; N, 19.7.

3-(5-Amino-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)-1-phenylpyrrolidine-2,5-dione (11)
A mixture of aminopyrazole **3a** (0.005 mol) and *N*-phenylmaleimide (**4a**, 0.005 mol) in *i*-PrOH (10 mL) was refluxed for 3 h. The mixture was allowed to stand and then filtered to give the solid product which was washed with *i*-PrOH and dried in air at r.t. to give **11** as a colorless solid; mp 184–185 °C.

IR (KBr): 3428, 3359, 2921, 1708, 1630, 1595, 1500, 1374, 1159 cm^{-1}.

^1H NMR (200 MHz, DMSO-d_6): δ = 2.04 (s, 3 H, CH_3), 2.83 [dd, $^2J_{AB}$ = 18.1 Hz, $^3J_{AX}$ = 6.0 Hz, 1 H, H_a(pyr)], 3.25 (dd, $^3J_{BX}$ = 9.7 Hz, 1 H, 5-H_b), 4.36 (dd, 1 H, 4-H_x), 5.22 (br s, 2 H, NH_2). 7.27–7.60 (m, 10 H_{arom}).

^{13}C NMR (50 MHz, DMSO-d_6): δ = 177.3, 175.3, 146.0, 144.8, 139.1, 132.6, 128.9, 128.8, 128.2, 126.9, 125.9, 122.8, 98.4, 35.9, 35.5, 12.7.

MS (EI, 70 eV): *m*/*z* (%) = 346 (55) [M^+], 347 (15), 345 (41), 266 (84), 226 (45), 199 (30), 173 (30), 119 (100).

Anal. Calcd for $C_{20}H_{18}N_4O_2$: C, 69.35; H, 5.24; N, 16.17. Found: C, 69.3; H, 5.2; N, 16.1.

Transformation of 11 into 9a
Pyrrolidine-2,5-dione **11** (0.003 mol) and DMF (2 mL) were placed in a flask and the mixture refluxed for 3 h. The mixture was poured into H_2O (20 mL) and precipitated compound **9a** was filtered off and dried in air at r.t.

Acknowledgment

The authors thank Dr. Dmitry Sofronov for recording IR spectra.

References

(1) See, for example: (a) Alajarin, R.; Avarez-Buila, J.; Vaquero, J. J.; Sunkel, C.; Fau, J.; Statkov, P.; Sanz, J. *Tetrahedron: Asymmetry* **1993**, *4*, 617. (b) Bossert, F.; Vater, W. *Med. Res. Rev.* **1989**, *9*, 291. (c) Trigle, D. J.; Langs, D. A.; Janis, R. A. *Med. Res. Rev.* **1989**, *9*, 123. (d) Tsuda, Y.; Mishina, T.; Obata, M.; Araki, K.; Inui, J.; Nakamura, T. WO 8,504,172, **1985**; *Chem. Abstr.* **1986**, *104*, 207298. (e) Tsuda, Y.; Mishina, T.; Obata, M.; Araki, K.; Inui, J.; Nakamura, T. JP 61,227,584, **1986**; *Chem. Abstr.* **1988**, *109*, 120988. (f) Tsuda, Y.; Mishina, T.; Obata, M.; Araki, K.; Inui, J.; Nakamura, T. EP 0,217,142, **1987**; *Chem. Abstr.* **1987**, *106*, 213976. (g) Atwal, K. S.; Vaccaro, W.; Lloyd, J.; Finlay, H.; Yan, L.; Bhandaru, R. S. WO 0,140,231, **2001**; *Chem. Abstr.* **2003**, *135*, 19660. (h) Atwal, K. S.; Moreland, S. *Bioorg. Med. Chem. Lett.* **1991**, *1*, 291. (i) Kappe, C. O. *Eur. J. Med. Chem.* **2000**, *35*, 1043.

(2) (a) Chebanov, V. A.; Gura, K. A.; Desenko, S. M. *Top. Heterocycl. Chem.* **2010**, *23*, 41. (b) Chebanov, V. A.; Desenko, S. M.; Gurley, T. W. *Azaheterocycles Based on α,β-Unsaturated Carbonyls*; Springer: Heidelberg, **2008**. (c) Chebanov, V. A.; Desenko, S. M. *Curr. Org. Chem.* **2006**, *10*, 297.

(3) (a) Chebanov, V. A.; Saraev, V. E.; Desenko, S. M.; Chernenko, V. N.; Shishkina, S. V.; Shishkin, O. V.; Kobzar, K. M.; Kappe, C. O. *Org. Lett.* **2007**, *9*, 1691. (b) Chebanov, V. A.; Saraev, V. E.; Desenko, S. M.; Chernenko, V. N.; Knyazeva, I. V.; Groth, U.; Glasnov, T. N.; Kappe, C. O. *J. Org. Chem.* **2008**, *73*, 5110. (c) Muravyova, E. A.; Shishkina, S. V.; Musatov, V. I.; Shishkin, O. V.; Desenko, S. M.; Chebanov, V. A. *Synthesis* **2009**, 1375. (d) Chebanov, V. A.; Sakhno, Ya. I.; Desenko,

S. M.; Chernenko, V. N.; Musatov, V. I.; Shishkina, S. V.; Shishkin, O. V.; Kappe, C. O. *Tetrahedron* **2007**, *63*, 1229. (e) Sakhno, Ya. I.; Desenko, S. M.; Shishkina, S. V.; Shishkin, O. V.; Sysoyev, D. O.; Groth, U.; Kappe, C. O.; Chebanov, V. A. *Tetrahedron* **2008**, *64*, 11041. (f) Sakhno, Ya. I.; Shishkina, S. V.; Shishkin, O. V.; Musatov, V. I.; Vashchenko, E. V.; Desenko, S. M.; Chebanov, V. A. *Mol. Diversity* **2010**, *14*, 523.

(4) (a) Marrian, D. H. *J. Chem. Soc.* **1949**, 1797. (b) Augustin, M.; Rudoft, D.-W.; Pasche, R. *Z. Chem.* **1974**, *14*, 434. (c) Tetsuro, S.; Yuki, M.; Tetsuo, I.; Teruo, S.; Kenichi, S. *Heterocycles* **2007**, *71*, 1053. (d) Havrylyuk, D.; Zimenkovsky, B.; Lesyk, R. *Phosphorus, Sulfur Silicon Relat. Elem.* **2009**, *184*, 638. (e) Rudenko, R. V.; Komykhov, S. A.; Desenko, S. M. *Chem. Heterocycl. Compd. (Engl. Transl.)* **2009**, *45*, 1017.

(5) (a) Augustin, M.; Mueller, W. *J. Prakt. Chem.* **1985**, *327*, 789. (b) Ito, I.; Oda, N.; Kato, T. *Chem. Pharm. Bull.* **1976**, *24*, 1189. (c) Abelman, M. M.; Fisher, K. J.; Doerffler, E.; Edwards, P. J. *Tetrahedron Lett.* **2003**, *44*, 1823. (d) Lesyk, R.; Vladzimirska, O.; Holota, S.; Zaprutko, L.; Gzella, A. *Eur. J. Med. Chem.* **2007**, *42*, 641. (e) Shah, K. R.; Blanton, C. D. *J. Org. Chem.* **1982**, *47*, 502.

(6) Rudenko, R. V.; Komykhov, S. A.; Musatov, V. I.; Konovalova, I. S.; Shishkin, O. S.; Desenko, S. M. *J. Heterocycl. Chem.* **2011**, in press.

(7) (a) Cobo, J.; Sánchez, A.; Nogueras, M. *Tetrahedron* **1998**, *54*, 5753. (b) Velchinskaya, E.; Petsushak, B.; Rogal, A. *Chem. Heterocycl. Compd. (Engl. Transl.)* **2007**, *43*, 695. (c) Vel'chinskaya, E.; Kuzmenko, I.; Kulik, L. *Pharm. Chem. J.* **1999**, *33*, 155.

(8) (a) Nam, N. L.; Grandberg, I. I.; Sorokin, V. I. *Khim. Geterotsikl. Soedin.* **2000**, 342; *Chem. Heterocycl. Compd. (Engl. Transl.);* **2000**, *36*: 281. (b) Desenko, S. M.; Orlov, V. D. *Azaheterocycles Based on Aromatic Unsaturated Ketones*; Folio: Kharkov, **1998**.

(9) Zefirov, N. S.; Palyulin, V. A.; Dashevskaya, E. E. *J. Phys. Org. Chem.* **1990**, *3*, 147.

(10) Sheldrick, G. M. *Acta Crystallogr., Sect. A* **2008**, *64*, 112.

(11) The final atomic coordinates and crystallographic data for molecule **7l** have been deposited with the Cambridge Crystallographic Data Centre, 12 Union Road, CB2 1EZ, UK [fax: +44 (1223)336033; e-mail: deposit@ccdc.cam.ac.uk] and is available on request quoting the deposition number CCDC 792559.