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Heterocyclizations of 5-Methylpyrazol-3-amine with Unsaturated Arylaliphatic Carboxylic Acid Derivatives

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Abstract—Cyclocondensation of 5-methylpyrazol-3-amine with methyl cinnamate and arylmethylidenemalonic acids in DMF and methanol leads to the formation of 7-aryl-2-methyl-6,7-dihydropyrazolo[1,5-*a*]pyrimidin-5(4*H*)-ones. Arylmethylidenemalonic acids react with the title amine at a ratio of 1:2 in nitrobenzene to give 4-aryl-3,5-dimethyl-1,7-dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridines. Heterocyclizations of 5-methylpyrazol-3-amine with 5-arylmethylidene-2,2-dimethyl-1,3-dioxane-4,6-diones or their precursors, *para*-substituted benzaldehydes and 2,2-dimethyl-1,3-dioxane-4,6-dione (Meldrum's acid) in all solvents (methanol, DMF, and nitrobenzene) give the corresponding 4-aryl-3-methyl-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-ones. The structure of 3-methyl-4-(4-nitrophenyl)-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one was proved by X-ray analysis.

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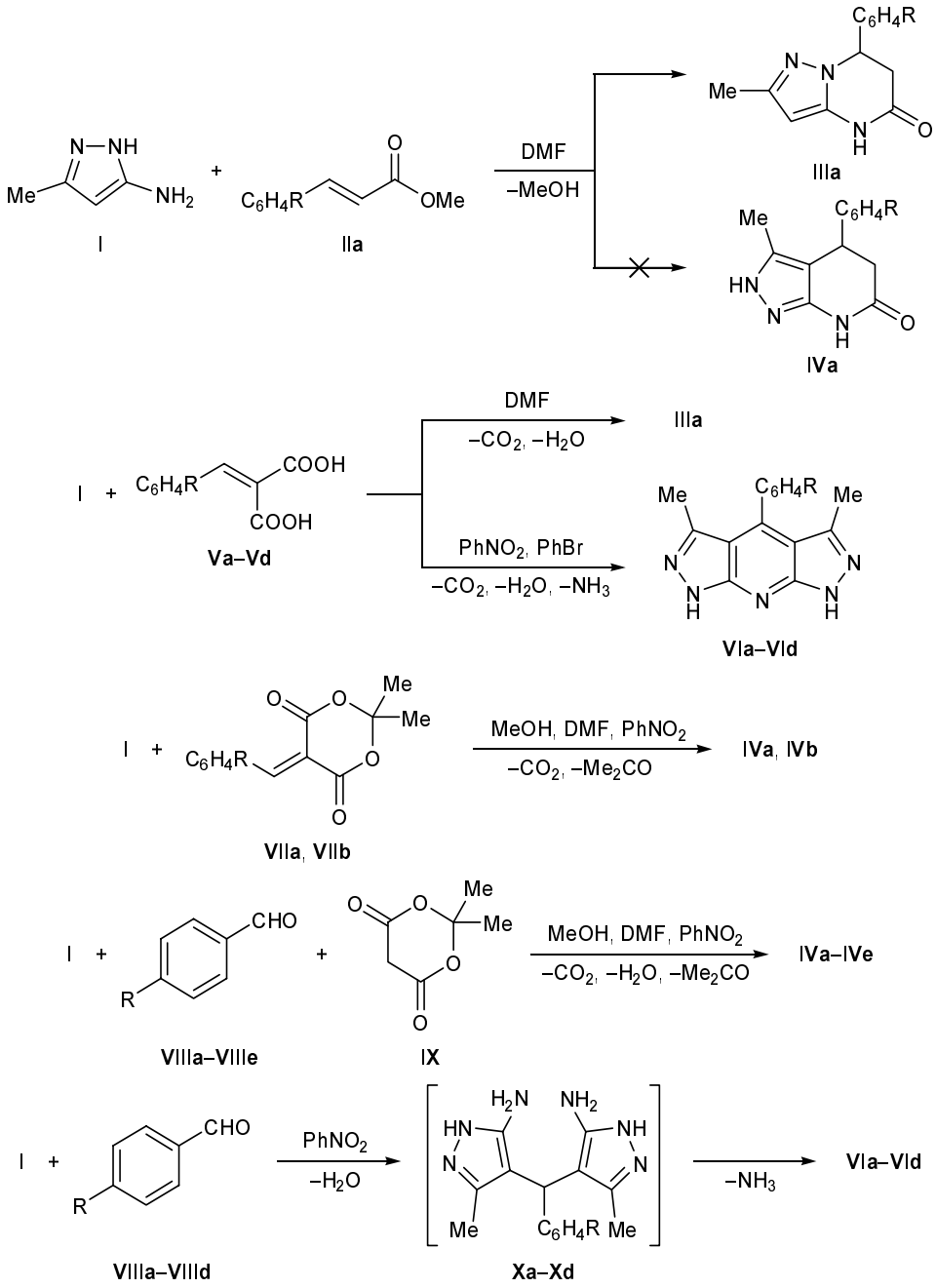
Cyclocondensations of aminoazoles having an amidine moiety with difunctional 1,3-electrophiles containing carbonyl groups underlie a widely used method for building up azoloazine systems [1–5]. Nevertheless, interest in such reactions remains fairly strong for both theoretical and applied reasons. As previously, the most frequently discussed problem is that concerning the regioselectivity of these reactions, which originates from nonequivalence of the reaction centers in both aminoazole and 1,3-bielectrophile molecules. In addition, the resulting azoloazines are in most cases so-called "drug-like" compounds which attract interest as potential pharmacologically active substances [6–8].

The presence in the 5-methylpyrazol-3-amine molecule of nonequivalent endocyclic reaction centers, N^1 and C^4, could give rise to alternative pathways in its reactions with difunctional 1,3-electrophiles, which could lead to the formation of both pyrazolo[3,4-*b*]-pyridine and pyrazolo[1,5-*a*]pyrimidine systems. There are published data on cyclocondensations of 5-substituted 3-aminopyrazoles with ethyl acetoacetate [1, 2, 9, 10], acrylic and propynoic acid esters [1, 11], oxo and cyano esters [12, 13], 5-methoxymethylidene-2,2-dimethyl-1,3-dioxane-4,6-dione [14], Mannich base hydrochlorides [15], β-diketones [16, 17], and α,β-unsaturated ketones [18–20]. Depending on the reaction conditions and the degree of differentiation of electronic properties of the electrophilic centers in the carbonyl component, these reactions gave both individual products and isomer mixtures. From the viewpoint of development of synthetic routes to azoloazines as potential pharmacological agents, the most interesting are regioselective multicomponent cyclocondensations.

The goal of the present work was to estimate the regioselectivity in the reactions of 5-methylpyrazol-3-amine (**I**) with methyl cinnamate **IIa** and arylmethylidenemalonic acids **Va**–**Vd**, as well as with 5-arylmethylidene-2,2-dimethyl-1,3-dioxane-4,6-diones **VIIa**–**VIIe** and their synthetic precursors, *para*-substituted benzaldehydes **VIIIa**–**VIIIe** and Meldrum's acid (**IX**), under various conditions.

By heating equimolar amounts of amine **I** and methyl cinnamate (**IIa**) in DMF we obtained 2-methyl-7-phenyl-6,7-dihydropyrazolo[1,5-*a*]pyrimidin-5(4*H*)-one (**IIIa**) (Scheme 1). The same product was isolated in the reaction of aminopyrazole **I** with benzylidenemalonic acid (**Va**) under analogous conditions. No

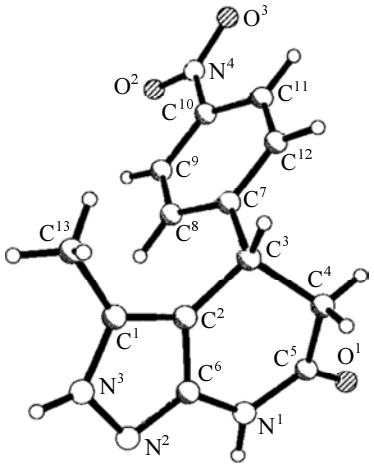
Scheme 1.



II–**IV**, R = H (**a**), 4-Br (**b**), 4-MeO (**c**), 4-Me_2N (**d**), 4-O_2N (**e**); **V**, **VI**, **X**, R = H (**a**), 4-Cl (**b**), 4-Me (**c**), 4-MeO (**d**).

isomeric products like **IV** were detected in the reaction mixtures. The reactions of aminoazole **I** with arylmethylidenemalonic acids **Va**–**Vd** in nitro- or bromobenzene gave 4-aryl-3,5-dimethyl-1,7-dihydrodipyrazolo-[3,4-*b*:4',3'-*e*]pyridines **VIa**–**VId** in poor yields. As expected, the yield of **VIa**–**VId** increased when 2 equiv of initial amine **I** was taken. On the other hand, the condensation of aminopyrazole **I** with arylmethylidene derivatives **VIIa** and **VIIb**, as well as with *para*-substituted benzaldehydes **VIIIa**–**VIIIe** and Meldrum's acid (**IX**), in methanol, DMF, nitrobenzene, or bromobenzene resulted in the formation of 4-aryl-3-methyl-1,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-ones **IVa**–**IVe**, while no pyrazolo[1,5-*a*]pyrimidinones **III** were detected.

The structure of compounds **IIIa**, **IVa**–**IVe**, and **VIa**–**VId** was determined on the basis of their spectral data, and the structure of pyrazolopyridinone **IVe** was



Structure of the molecule of 3-methyl-4-(4-nitrophenyl)-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (**IVe**) according to the X-ray diffraction data.

proved by X-ray analysis. Compound **IIIa** showed in the IR spectrum absorption bands corresponding to cyclic amide fragment, ν, cm^{-1}: 3250–3150 (NH), 1688 (amide I), 1592 (amide II). The ^1H NMR spectrum of **IIIa** contained signals from protons in the phenyl ring, NH group, and pyrimidine $C^7H–C^6H_2$ fragment (*ABX* spin system), as well as from 3-H and CH_3 group in the pyrazole ring. The downfield position of the NH signal (δ 10.81 ppm) is typical of azolopyrimidinones having an NH–C=O fragment [21]. These data indicate that the pyrimidine ring in **IIIa** is formed as a result of acylation at the exocyclic amino group rather than at the endocyclic center in molecule **I**.

The IR spectra of compounds **IVa**–**IVe** are also characterized by the presence of a set of bands typical of amides, cm^{-1}: ν 3380–2500 (N–H), 1652 (C=O, amide I), δ 1556 (amide II); however, the IR spectra cannot distinguish between positional isomers **III** and **IV**. Compounds **IVa**–**IVe** displayed in the ^1H NMR spectra signals from two NH groups, aromatic ring, $C^4H–C^5H_2$ fragment in the partially hydrogenated pyridine ring (*ABX* system), and CH_3 group. Just the presence of two singlets belonging to the NH protons and the absence of pyrazole CH signal differentiate structure **IV** from isomers **III**. The choice between the 1-H and 2-H tautomers was made on the basis of NOE experiment performed for compound **IVa**. Irradiation at a resonance frequency corresponding to protons of the methyl group on C^3 (δ 1.83 ppm) gave responses on the pyrazole NH proton (δ 11.81 ppm), *ortho*-protons in the phenyl ring, and CH proton in the pyridine ring (δ 4.14 ppm), indicating that these protons are spatially close to the CH_3 group.

Table 1. Bond lengths in the molecule of 3-methyl-4-(4-nitrophenyl)-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (**IVe**)

Bond	*d*, Å	Bond	*d*, Å
$O^1–C^5$	1.229(2)	$O^2–N^4$	1.220(3)
$O^3–N^4$	1.223(3)	$N^1–C^5$	1.357(3)
$N^1–C^6$	1.402(3)	$N^2–C^6$	1.328(3)
$N^2–N^3$	1.367(3)	$N^3–C^1$	1.358(3)
$N^4–C^{10}$	1.475(3)	$C^1–C^2$	1.390(3)
$C^1–C^{13}$	1.488(4)	$C^2–C^6$	1.402(3)
$C^2–C^3$	1.512(3)	$C^3–C^7$	1.523(3)
$C^3–C^4$	1.559(3)	$C^4–C^5$	1.516(3)
$C^7–C^{12}$	1.393(3)	$C^7–C^8$	1.395(3)
$C^8–C^9$	1.388(4)	$C^9–C^{10}$	1.378(3)
$C^{10}–C^{11}$	1.378(4)	$C^{11}–C^{12}$	1.383(4)

The structure of compounds **IVa**–**IVe** as pyrazolo-[3,4-*b*]pyridinones was unambiguously proved by the X-ray diffraction data, according to which product **IVe** had the structure of 3-methyl-4-(4-nitrophenyl)-2,4,5,6-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (see figure; Tables 1, 2). The tetrahydropyridine ring in molecule **IVe** adopts a slightly distorted *sofa* conformation with the following puckering parameters: $S = 0.59$, $\theta = 50.64$, $\psi = 8.63°$ [22]. The C^4 and C^5 atoms deviate by 0.66 and 0.15 Å, respectively, from the mean-square plane formed by the other atoms of the ring. The phenyl substituent occupies axial position: the torsion angle $C^6C^2C^3C^7$ is 100.0(2)°. The benzene ring plane is turned through an angle of –16.1(3)° about the $C^2–C^3$ bond (torsion angle $C^2C^3C^7C^8$), despite shortened intramolecular contact $H^8\cdots C^2$ 2.67 Å (the sum of the corresponding van der Waals radii is 2.87 Å [23]). Presumably, repulsion between the H^8 and C^2 atoms is responsible for extension of the $C^3–C^7$ bond to 1.523(3) Å relative to the standard value 1.490 Å [24]. The nitro group attached to C^{10} is almost coplanar to the benzene ring plane: the torsion angle $O^2N^4C^{10}C^9$ is 8.3(4)°, although the intramolecular distance $H^9\cdots O^2$ is shortened to 2.38 Å (the sum of the corresponding van der Waals radii is 2.46 Å).

We can conclude that electrophilic attack by the β-carbon atom of unsaturated carbonyl compound is directed at the C^4 atom rather than at the endocyclic nitrogen atom in aminopyrazole **I**.

According to the mass spectra and elemental compositions of compounds **VIa**–**VId**, they were formed from two molecules of aminoazole **I** and one molecule of arylmethylidenemalonic acid **Va**–**Vd**. The IR spec-

tra of **VIa**–**VId** lack bands typical of amide fragment. In the ^{1}H NMR spectra of these compounds we observed only resonance signals from aromatic protons and two equivalent NH and CH_3 groups; the NH and CH_3 signals appeared as singlets with their intensities corresponding to 4H and 6H, respectively. On the basis of these data, compounds **VIa**–**VId** were assigned the structure of 4-aryl-3,5-dimethyl-1,7-dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridines. Presumably, the pyridine ring therein is built up via electrophilic attack on C^4 in pyrazole **I** by the carbonyl group of aldehyde **VIIIa**–**VIIId**, followed by intramolecular ring closure in adduct **X** with elimination of ammonia molecule. Benzaldehydes **VIIIa**–**VIIId** are likely to be formed *in situ* as a result of oxidative pyrolysis of acids **Va**–**Vd**. This assumption was confirmed by independent synthesis of dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridines **VIa**–**VId** from aldehydes **VIIIa**–**VIIId** and amine **I** (Scheme 1). We thus succeeded in isolating compounds **VIa**–**VId** in good yields.

EXPERIMENTAL

The IR spectra were recorded in KBr on a Specord M-82 spectrometer. The ^{1}H NMR spectra were measured on a Varian-200 spectrometer from solutions in DMSO-d_6 using TMS as internal reference. The positive- and negative-ion mass spectra of **IIIa**, **IVa**, and **IVb** were obtained on an MSBC SELMI instrument (^{252}Cf source, 10 μCi; accelerating voltage ±20 kV); and the electron-impact mass spectra (70 eV) of **VIa**, **VIc**, and **VId** were run on a Varian 1200L mass spectrometer. The reaction mixtures were analyzed, and the purity of products was checked, by TLC on Silufol UV-254 plates using hexane–acetone (1:1) as eluent. The melting points were determined on a Kofler melting point apparatus.

Arylmethylidenemalonic acids **Va**–**Vd** and Meldrum's acid derivatives **VIIa** and **VIIb** were synthesized according to the procedures described in [25, 26].

2-Methyl-7-phenyl-6,7-dihydropyrazolo[1,5-*a*]-pyrimidin-5(4*H*)-one (IIIa). *a*. A mixture of 1 mmol of 5-methylpyrazol-3-amine (**I**) and 1 mmol of methyl cinnamate (**IIa**) in 1 ml of DMF was heated for 1 h at the boiling point. The mixture was cooled and diluted with 5 ml of propan-2-ol, and the precipitate was filtered off and recrystallized from DMF–propan-2-ol (1:2). Yield 0.51 mmol (51%), mp 192–194°C. IR spectrum, ν, cm^{-1}: 3250–2652 (NH), 1688 (CO), 1592 (δNH), 1528 (C=N). ^{1}H NMR spectrum, δ, ppm: 2.08 s (3H, CH_3), 2.55 and 2.76 (2H, CH_2, *AB* system, J_{AB} = –16.2 Hz), 5.58 t (1H, CH_X, J_{AX} = 6.0, J_{BX} = 7.5 Hz), 6.97 s (1H, 3-H), 7.20–7.41 m (5H, C_6H_5), 10.80 br.s (1H, NH). Mass spectrum, *m*/*z*: 228 [*M* + H], 226 [*M* – H]. Found, %: C 68.67; H 5.66; N 18.45. $C_{13}H_{13}N_3O$. Calculated, %: C 68.72; H 5.73; N 18.50.

b. A mixture of 1 mmol of 5-methylpyrazol-3-amine (**I**) and 1 mmol of benzylidenemalonic acid (**Va**) in 1 ml of DMF was heated for 1 h at the boiling point. The product was isolated as described above in *a*. Yield 58%.

3-Methyl-4-phenyl-2,4,5,7-tetrahydropyrazolo-[3,4-*b*]pyridin-6-one (IVa). *a*. A mixture of 1 mmol of aminopyrazole **I** and 1 mmol of compound **VIIa** in 1 ml of DMF (or methanol, or nitrobenzene) was heated for 7–10 min at the boiling point until CO_2 no longer evolved and a solid began to separate from the solution. The mixture was cooled and diluted with 5 ml of propan-2-ol, and the precipitate was filtered off and recrystallized from DMF–propan-2-ol (1:2). Yield 0.77 mmol (77%), mp >300°C. IR spectrum, ν, cm^{-1}: 3380–2500 (NH), 1652 (CO), 1556 (δNH), 1528 (C=N). ^{1}H NMR spectrum, δ, ppm: 1.83 s (3H, CH_3), 2.57 and 2.80 (2H, CH_2, *AB* part of *ABX* system, J_{AB} = –15.9 Hz), 4.14 t (1H, CH_X, $J_{AX} = J_{BX}$ = 6.0 Hz), 7.20–7.33 m (5H, C_6H_5), 10.30 br.s (1H, 7-H), 11.81 br.s (1H, 2-H). Mass spectrum, *m*/*z*: 228 [*M* + H], 226 [*M* –

Table 2. Bond angles in the molecule of 3-methyl-4-(4-nitrophenyl)-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (**IVe**)

Angle	ω, deg	Angle	ω, deg
$C^5N^1C^6$	120.2(2)	$C^6N^2N^3$	102.7(2)
$C^1N^3N^2$	113.6(2)	$O^2N^4O^3$	122.7(2)
$O^2N^4C^{10}$	118.6(2)	$O^3N^4C^{10}$	118.7(2)
$N^3C^1C^2$	105.7(2)	$N^3C^1C^{13}$	122.5(2)
$C^2C^1C^{13}$	131.8(2)	$C^1C^2C^6$	104.4(2)
$C^2C^1C^3$	134.0(2)	$C^6C^2C^3$	121.6(2)
$C^2C^3C^7$	116.1(2)	$C^2C^3C^4$	106.1(2)
$C^7C^3C^4$	110.0(2)	$C^5C^4C^3$	115.8(2)
$O^1C^5N^1$	120.9(2)	$O^1C^5C^4$	123.0(2)
$N^1C^5C^4$	116.0(2)	$N^2C^6C^2$	113.6(2)
$N^2C^6N^1$	123.4(2)	$C^2C^6N^1$	122.9(2)
$C^{12}C^7C^8$	118.5(2)	$C^{12}C^7C^3$	118.8(2)
$C^8C^7C^3$	122.9(2)	$C^9C^8C^7$	121.4(2)
$C^{10}C^9C^8$	118.5(2)	$C^9C^{10}C^{11}$	121.9(2)
$C^9C^{10}N^4$	119.1(2)	$C^{11}C^{10}N^4$	119.0(2)
$C^{10}C^{11}C^{12}$	119.0(2)	$C^{11}C^{12}C^7$	121.1(2)

H]. Found, %: C 68.63; H 5.70; N 18.47. $C_{13}H_{13}N_3O$. Calculated, %: C 68.72; H 5.73; N 18.50.

4-(4-Bromophenyl)-3-methyl-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (IVb) was synthesized in a similar way. Yield 0.76 mmol (76%), mp >300°C. IR spectrum, ν, cm^{-1}: 3350–2650 (NH), 1652 (CO), 1556 (δNH), 1536 (C=N). ^{1}H NMR spectrum, δ, ppm: 1.85 s (3H, CH_3), 2.53 and 2.87 (2H, CH_2, *AB* part of *ABX* system, J_{AB} = –15.9 Hz), 4.16 t (1H, CH_X, J_{AX} = 6.0, J_{BX} = 7.2 Hz), 7.32 d.d (4H, C_6H_4, J = 8.0 Hz), 10.23 br.s (1H, 7-H), 11.80 br.s (1H, 2-H). Mass spectrum, *m*/*z*: 307 [M + H], 305 [M – H]. Found, %: C 51.04; H 3.85; Br 26.08; N 13.66. $C_{13}H_{12}BrN_3O$. Calculated, %: C 50.98; H 3.92; Br 26.14; N 13.73.

b. A mixture of 1 mmol of compound **I**, 1 mmol of freshly distilled benzaldehyde (**VIIIa**), and 1 mmol of Meldrum's acid (**IX**) in 1 ml of DMF (methanol, nitrobenzene, or bromobenzene) was heated for 7–10 min at the boiling point, and the product was isolated as described above in *a*. Compounds **IVc**–**IVe** were synthesized in a similar way.

4-(4-Methoxyphenyl)-3-methyl-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (IVc). Yield 0.77 mmol (77%), mp >300°C. IR spectrum, ν, cm^{-1}: 3250–2500 (NH), 1608 (CO), 1520 (δNH), 1508 (C=N). ^{1}H NMR spectrum, δ, ppm: 1.83 s (3H, CH_3), 2.56 and 2.77 (2H, CH_2, *AB* part of *ABX* system, J_{AB} = –15.6 Hz), 3.71 s (3H, CH_3O), 4.08 t (1H, CH_X, J_{AX} = J_{BX} = 6.6 Hz), 6.98 d.d (4H, C_6H_4, J = 8.2 Hz), 10.30 br.s (1H, 7-H), 11.81 br.s (1H, 2-H). Found, %: C 65.31; H 5.86; N 16.36. $C_{14}H_{15}N_3O_2$. Calculated, %: C 65.37; H 5.84; N 16.34.

4-(4-Dimethylaminophenyl)-3-methyl-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (IVd). Yield 0.74 mmol (74%), mp >300°C. IR spectrum, ν, cm^{-1}: 3380–2500 (NH), 1652 (CO), 1556 (δNH), 1540 (C=N). ^{1}H NMR spectrum, δ, ppm: 1.83 s (3H, CH_3), 2.53 and 2.73 (2H, CH_2, *AB* part of *ABX* system, J_{AB} = –15.6 Hz), 2.84 s [6H, $(CH_3)_2N$], 4.00 t (1H, CH_X, J_{AX} = J_{BX} = 6.3 Hz), 6.87 d.d (4H, C_6H_4, J = 8.2 Hz), 10.10 br.s (1H, 7-H), 11.72 br.s (1H, 2-H). Found, %: C 66.71; H 6.59; N 20.72. $C_{15}H_{18}N_4O_2$. Calculated, %: C 66.67; H 6.67; N 20.74.

3-Methyl-4-(4-nitrophenyl)-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (IVe). Yield 0.61 mmol (61%), mp >300°C. IR spectrum, ν, cm^{-1}: 3400–2500 (NH), 1652 (CO), 1556 (δNH), 1520 (C=N), 1352 (NO_2). ^{1}H NMR spectrum, δ, ppm: 1.85 s (3H, CH_3), 2.60 and 2.88 (2H, CH_2, *AB* part of *ABX* system, J_{AB} = –16.1 Hz), 4.36 t (1H, CH_X, J_{AX} = 6.0, J_{BX} = 7.0 Hz), 7.87 d.d (4H, C_6H_4, J = 8.2 Hz), 10.32 br.s (1H, 7-H), 11.01 br.s (1H, 2-H). Found, %: C 61.72; H 4.44; N 20.63. $C_{13}H_{12}N_4O_3$. Calculated, %: C 61.76; H 4.41; N 20.59.

4-Aryl-3,5-dimethyl-1,7-dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridines VIa–VId (*general procedure*). *a*. A mixture of 2 mmol of compound **I** and 1 mmol of the corresponding arylmethylidenemalonic acid **Va**–**Vd** in 1 ml of nitrobenzene or bromobenzene was heated for 6 h at the boiling point. The mixture was cooled and diluted with 5–7 ml of propan-2-ol, and the precipitate was filtered off and recrystallized from nitrobenzene–propan-2-ol (1:5).

3,5-Dimethyl-4-phenyl-1,7-dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridine (VIa). Yield 0.33 mmol (33%), mp >300°C. IR spectrum: ν(NH) 3172 cm^{-1}. ^{1}H NMR spectrum, δ, ppm: 1.89 s (6H, CH_3), 7.51–7.58 m (5H, C_6H_5), 12.85 br.s (2H, NH). Mass spectrum, *m*/*z* (I_{rel}, %): 263 (100) $[M]^+$, 248 (2.9), 235 (3.8), 221 (2.8), 204 (4.0), 192 (4.8), 178 (4.1), 166 (7.4), 152 (5.0), 139 (7.1), 127 (6.3), 115 (5.8), 102 (7.7), 89 (9.8), 77 (16.7). Found, %: C 68.39; H 4.96; N 26.67. $C_{15}H_{13}N_5$. Calculated, %: C 68.44; H 4.94; N 26.62.

4-(4-Chlorophenyl)-3,5-dimethyl-1,7-dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridine (VIb). Yield 0.30 mmol (30%), mp >300°C. IR spectrum: ν(NH) 3176 cm^{-1}. ^{1}H NMR spectrum, δ, ppm: 1.92 s (6H, CH_3), 7.59 d.d (4H, C_6H_4, J = 8.0 Hz), 12.90 br.s (2H, NH). Mass spectrum, *m*/*z* (I_{rel}, %): 277 (100) $[M]^+$, 262 (3.7), 246 (3.3), 233 (2.9), 218 (2.3), 204 (3.2), 192 (2.8), 178 (3.3), 164 (2.8), 152 (2.4), 139 (3.5), 127 (1.6), 115 (4.6), 97 (7.4), 77 (2.2). Found, %: C 60.46; H 3.99; Cl 12.01; N 23.58. $C_{15}H_{12}ClN_5$. Calculated, %: C 60.50; H 4.03; Cl 11.93; N 23.53.

3,5-Dimethyl-4-(4-methylphenyl)-1,7-dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridine (VIc). Yield 0.30 mmol (30%), mp >300°C. IR spectrum: ν(NH) 3164 cm^{-1}. ^{1}H NMR spectrum, δ, ppm: 1.90 s (6H, CH_3), 2.43 s (3H, CH_3), 7.36 m (4H, C_6H_4), 12.83 br.s (2H, NH). Found, %: C 69.27; H 5.37; N 25.20. $C_{16}H_{15}N_5$. Calculated, %: C 69.31; H 5.42; N 25.27.

4-(4-Methoxyphenyl)-3,5-dimethyl-1,7-dihydrodipyrazolo[3,4-*b*:4',3'-*e*]pyridine (VId). Yield 0.32 mmol (32%), mp >300°C. IR spectrum: ν(NH) 3158 cm^{-1}. ^{1}H NMR spectrum, δ, ppm: 1.93 s (6H, CH_3), 3.85 s (3H, CH_3O), 7.26 d.d (4H, C_6H_4, J = 8.0 Hz), 12.83 br.s (2H, NH). Mass spectrum, *m*/*z* (I_{rel}, %): 293 (100) $[M]^+$, 278 (2.8), 260 (2.0), 248 (3.4), 234 (3.1), 221 (4.4), 206 (2.5), 193 (2.4), 179

(2.8), 166 (2.5), 153 (3.0), 140 (2.2), 126 (2.2), 114 (5.0), 102 (3.8), 88 (6.0), 77 (4.3). Found, %: C 65.55; H 5.08; N 23.81. $C_{16}H_{15}N_5O$. Calculated, %: C 65.53; H 5.12; N 23.89.

b. A mixture of 2 mmol of compound **I** and 1 mmol of aldehyde **VIIIa**–**VIIId** in 1 ml of nitrobenzene or bromobenzene was heated for 2 h at the boiling point. The mixture was cooled and diluted with 5–7 ml of propan-2-ol, and the precipitate was filtered off and recrystallized from nitrobenzene–propan-2-ol (1:5). The yields of compounds **VIa**–**VId** were 53, 55, 57, and 55%, respectively.

X-Ray analysis of 3-methyl-4-(4-nitrophenyl)-2,4,5,7-tetrahydropyrazolo[3,4-*b*]pyridin-6-one (IVe). Triclinic crystals, $C_{13}H_{12}N_4O_3$, with the following unit cell parameters (at 20°C): a = 5.299(2), b = 8.319(3), c = 15.608(6) Å; α = 78.46(1), β = 81.43(2), γ = 71.99(1)°; V = 638.2(5) Å^3; M_r = 272.27; Z = 2; space group P-1; d_{calc} = 1.417 g/cm^3; μ(MoK_α) = 0.104 mm^{-1}; F(000) = 284. The unit cell parameters and intensities of 2487 reflections (2222 of which were independent with R_{int} = 0.03) were measured on a Siemens P3/PC automatic four-circle diffractometer (MoK_α irradiation, graphite monochromator, 2θ/θ scanning to $2\theta_{max}$ = 50°). The structure was solved by the direct method using SHELX97 software [27]. The positions of hydrogen atoms were determined from the difference synthesis of electron density and were refined in isotropic approximation. The structure was refined with respect to F^2 by the full-matrix least-squares procedure in anisotropic approximation for non-hydrogen atoms to wR_2 = 0.151 from 2222 reflections [R_1 = 0.053 from 1522 reflections with $F > 4\sigma(F)$, S = 1.009].

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