Research Article

Synthesis of New Pyrazolo[1,5-*a*]pyrimidine, Triazolo[4,3-*a*]pyrimidine Derivatives, and Thieno[2,3-*b*]pyridine Derivatives from Sodium 3-(5-Methyl-1-phenyl-1*H*-pyrazol-4-yl)-3-oxoprop-1-en-1-olate

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Condensation of sodium 3-oxo-3-(1-phenyl-1*H*-pyrazol-4-yl)prop-1-en-1-olate (**2**) with several heterocyclic amines, cyanoacetamide, cyanothioacetamide, and 2-cyanoacetohydrazide gives pyrazolo[1,5-*a*]pyrimidines (**5a–d**), pyrido[2',3':3,4]pyrazolo[1,5-*a*]pyrimidine (**9**), benzo[4,5]imidazo[1,2-*a*]pyrimidine (**10**), [1,2,4]triazolo[1,5-*a*]pyrimidine (**11**), and pyridine derivatives (**12–14**). Also, thieno[2,3-*b*]pyridines (**15–18**) were synthesized via pyridinethione (**13**) with α -halo ketones and α -halo ester. Structures of the newly synthesized compounds were elucidated by elemental analysis, spectral data, alternative synthetic routes, and chemical transformation whenever possible.

1. Introduction

Several pyrazole derivatives received great attention due to their biological and pharmacological activities not only as potential inhibitors of HIV-1 [1], pesticides [2], fungicides [3], antihypertensive agents [4], and anticancer activity [5], but also as important and useful starting materials for the synthesis of other fused heterocyclic systems. Furthermore, compounds containing the pyrimidine nucleus are of significant biological importance and are used as antibacterial [6–9], antifungal [10, 11], antitumour [12, 13], antiviral [13–17], anti-inflammatory [18, 19], and antihypertensive [20–22] agents. In this work, we synthesized some new pyrazolo[1,5-*a*]pyrimidine, triazolo[4,3-*a*]pyrimidine, and thieno[2,3-*b*]pyridine derivatives.

2. Experimental

Melting points were measured on Electrothermal IA 9000 series digital melting point apparatus and are uncorrected.

The IR spectra were recorded in potassium bromide discs on a Pye Unicam SP 3300 and Shimadzu FT IR 8101 PC infrared spectrophotometer. ^1H NMR and ^{13}C NMR spectra were recorded in $\text{DMSO}-d_6$ using a Varian Gemini 300 NMR spectrometer (300 MHz for ^1H NMR and 75 MHz for ^{13}C NMR). Mass spectra were recorded on a Shimadzu GCMS-QP1000 EX mass spectrometer at 70 eV. Elemental analysis was carried out at the Microanalytical Centre of Cairo University, Giza, Egypt. All reactions were followed by TLC (Silica gel, Merck). 1-(5-Methyl-1-phenyl-1*H*-pyrazol-4-yl)ethanone [23] was prepared as reported in the literature.

2.1. Synthesis of Sodium 3-(5-Methyl-1-phenyl-1*H*-pyrazol-4-yl)-3-oxoprop-1-en-1-olate (2**).** A mixture of (0.01 mol) 1-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)ethanone **1** (2.0 g, 10 mmol) and ethyl formate (0.74 g, 10 mmol) was dropped over a solution of sodium methoxide (0.54 g, 10 mmol) in 20 mL dry ether with stirring. The formed solid product was collected and used directly in the following reactions.

2.2. Synthesis of 5a–d and 9–14.

Method A (general procedure). A mixture of sodium 3-(5-methyl-1-phenyl-1H-pyrazol-4-yl)-3-oxoprop-1-en-1-olate (**2**) (2.5 g, 10 mmol) and the appropriate 3-amino-5-methylpyrazole **3a**, 3-amino-5-phenylpyrazole **3b**, 3-amino-4-cyanopyrazole **3c**, 3-amino-4-methyl-5-phenylpyrazole **3d**, 4,6-dimethyl-2H-pyrazolo[3,4-*b*]pyridin-3-amine, 2-amino-benzimidazole, 4H-1,2,4-triazol-3-amine, cyanoacetamide, cyanothioacetamide, and 2-cyanoacetohydrazide (10 mmol) and few drops of acetic acid was grinded for 10–20 min (monitored by TLC). The solid products collected by filtration and recrystallized from the suitable solvent gave the respective products **5a–d** and **9–14** in an excellent yield.

Method B (general procedure). A solution of sodium 3-(5-methyl-1-phenyl-1H-pyrazol-4-yl)-3-oxoprop-1-en-1-olate (**2**) (2.5 g, 10 mmol), the appropriate 3-amino-5-methylpyrazole **3a**, 3-amino-5-phenylpyrazole **3b**, 3-amino-4-cyanopyrazole **3c**, 3-amino-4-methyl-5-phenylpyrazole **3d**, 4,6-dimethyl-2H-pyrazolo[3,4-*b*]pyridin-3-amine, 2-amino-benzimidazole, 4H-1,2,4-triazol-3-amine, cyanoacetamide, cyanothioacetamide, 2-cyanoacetohydrazide (10 mmol), and piperidine acetate (1 mL) in water (3 mL) was refluxed for 10 min. After completion of the reaction, the hot reaction mixture was neutralized with acetic acid (1.5 mL) and then cooled and the solid products collected by filtration and recrystallized from the suitable solvent gave products **5a–d** and **9–14** in a good yield, which were identical in all aspects (m.p., mixed m.p., and spectra) with those obtained from Method A.

2.2.1. 2-Methyl-7-(5-methyl-1-phenyl-1H-pyrazol-4-yl)pyrazolo[1,5-*a*]pyrimidine (5a). Yield 91%; yellow crystals; mp 202–204°C (from acetic acid) (Lit. mp 202–204°C [24]).

2.2.2. 7-(5-Methyl-1-phenyl-1H-pyrazol-4-yl)-2-phenylpyrazolo[1,5-*a*]pyrimidine (5b). Yield 90%; yellow crystals; m.p. 218–219°C (from acetic acid) (Lit. M.p. 216–218°C [24]).

2.2.3. 7-(5-Methyl-1-phenyl-1H-pyrazol-4-yl)pyrazolo[1,5-*a*]pyrimidine-3-carbonitrile (5c). Yield 92%; yellow crystals; m.p. 230–232°C (from acetic acid); IR (KBr): ν 1594 (C=N), 2231 (CN) cm^{-1} ; ^1H NMR (DMSO- d_6): δ 2.56 (s, 3H, CH_3), 6.38 (d, 1H, J = 4 Hz, pyrimidine H-5), 6.86 (s, 1H, pyrazole H-3), 7.28–7.66 (m, 5H, ArH's), 8.24 (s, 1H, pyrazole H-3), 8.71 (d, 1H, J = 4 Hz, pyrimidine H-4); ^{13}C NMR (DMSO- d_6): δ 9.42 (CH_3), 83.11, 105.21, 111.88, 112.76, 121.87, 125.74, 128.72, 130.11, 139.88, 140.15, 128.55, 152.37, 155.18; MS m/z (%): 301(M^+ + 1, 14), 300(M^+ , 41), 211(32), 84(76), 63(100). Anal. Calcd for $\text{C}_{17}\text{H}_{12}\text{N}_6$ (300.32): C, 67.99; H, 4.03; N, 27.98; Found C, 67.69; H, 4.08; N, 27.68%.

2.2.4. 3-Methyl-7-(5-methyl-1-phenyl-1H-pyrazol-4-yl)-2-phenylpyrazolo[1,5-*a*]pyrimidine (5d). Yield 90%; yellow crystals; m.p. 226°C (from acetic acid) (Lit. m.p. 226–228°C [25]).

2.2.5. 8,10-Dimethyl-4-(5-methyl-1-phenyl-1H-pyrazol-4-yl)pyrido[2',3':3,4]pyrazolo[1,5-*a*]pyrimidine (9). Yield 93%; yellow crystals; m.p. 290–292°C (from acetic acid); IR (KBr): ν 1588 (C=N) cm^{-1} ; ^1H NMR (DMSO- d_6): δ 2.49 (s, 3H, CH_3), 2.51 (s, 3H, CH_3), 2.74 (s, 3H, CH_3), 6.08 (d, 1H, J = 4 Hz, pyrimidine H-5), 6.85 (s, 1H, pyridine H), 7.50–7.59 (m, 5H, ArH's), 8.01 (s, 1H, pyrazole H-3), 8.24 (d, 1H, J = 4 Hz, pyrimidine H-4); ^{13}C NMR (DMSO- d_6): δ 8.44 (CH_3), 19.21 (CH_3), 21.47 (CH_3), 104.19, 110.12, 112.85, 117.11, 120.78, 122.13, 126.88, 129.45, 133.12, 135.48, 139.89, 140.46, 148.74, 150.12, 151.78, 165.15; MS m/z (%): 355(M^+ + 1, 41), 354(M^+ , 63), 262(45), 214(31), 119(28), 77(100). Anal. Calcd for $\text{C}_{21}\text{H}_{18}\text{N}_6$ (354.41): C, 71.17; H, 5.12; N, 23.71; Found C, 71.31; H, 5.06; N, 23.56%.

2.2.6. 4-(5-Methyl-1-phenyl-1H-pyrazol-4-yl)benzo[4,5]imidazo[1,2-*a*]pyrimidine (10). Yield 94%; yellow crystals; m.p. 203°C (from acetic acid) (Lit. m.p. 196–197°C [24]).

2.2.7. 7-(5-Methyl-1-phenyl-1H-pyrazol-4-yl)-[1,2,4]triazolo[1,5-*a*]pyrimidine (11). Yield 94%; yellow crystals; m.p. 180°C (from acetic acid) (Lit. m.p. 179–180°C [25]).

2.2.8. 6-(5-Methyl-1-phenyl-1H-pyrazol-4-yl)-2-oxo-1,2-dihydropyridine-3-carbonitrile (12). Yield 91%; yellow crystals; m.p. 266–268°C (from ethanol); IR (KBr): ν 1614 (C=N), 2213(CN), 3393(NH) cm^{-1} ; ^1H NMR (DMSO- d_6): δ 2.48 (s, 3H, CH_3), 6.97 (d, 1H, J = 8.0 Hz, pyridine H-5), 7.53–7.73 (m, 6H, ArH's and pyrazole H-3), 8.18 (d, 1H, J = 8.0 Hz, pyridine H-4), 10.21 (s, br., 1H, NH); MS m/z (%): 276(M^+ , 100), 231(34), 164(36), 118(54), 77(78). Anal. Calcd for $\text{C}_{16}\text{H}_{12}\text{N}_4\text{O}$ (276.29): C, 69.55; H, 4.38; N, 20.28; Found C, 69.45; H, 4.23; N, 20.21%.

2.2.9. 6-(5-Methyl-1-phenyl-1H-pyrazol-4-yl)-2-thioxo-1,2-dihydropyridine-3-carbonitrile (13). Yield 93%; yellow crystals; m.p. 236–238°C (from ethanol); IR (KBr): ν 1621 (C=N), 2218 (CN), 3420 (NH) cm^{-1} ; ^1H NMR (DMSO- d_6): δ 2.44 (s, 3H, CH_3), 6.93 (d, 1H, J = 7.8 Hz, pyridine H-5), 7.52–7.62 (m, 6H, ArH's and pyrazole H-3), 8.12 (d, 1H, J = 7.8 Hz, pyridine H-4), 14.01 (s, 1H, NH); MS m/z (%): 293(M^+ + 1, 38), 292(M^+ , 100), 264(16), 181(16), 118(26), 77(82). Anal. Calcd for $\text{C}_{16}\text{H}_{12}\text{N}_4\text{S}$ (292.36): C, 65.73; H, 4.14; N, 19.16; Found C, 65.67; H, 4.10; N, 19.02%.

2.2.10. 1-Amino-6-(5-methyl-1-phenyl-1H-pyrazol-4-yl)-2-oxo-1,2-dihydropyridine-3-carbonitrile (14). Yield 92%; yellow crystals; m.p. 238–140°C (from ethanol); IR (KBr): ν 1603 (C=N), 2214 (CN), 3148, 3427 (NH_2) cm^{-1} ; ^1H NMR (DMSO- d_6): δ 2.52 (s, 3H, CH_3), 7.37 (d, 1H, J = 8.1 Hz, pyridine H-5), 6.88 (s, br., 2H, NH_2), 7.50–7.56 (m, 5H, ArH's), 7.83 (s, 1H, pyrazole H-3), 8.09 (d, 1H, J = 8.1 Hz, pyridine H-4); ^{13}C NMR (DMSO- d_6): δ 10.89 (CH_3), 105.22, 110.46, 113.21, 118.24, 120.58, 126.87, 128.57, 128.89, 136.78, 139.25, 143.22, 146.57, 150.27; MS m/z (%): 292(M^+ + 1, 38), 291(M^+ , 100), 118(11), 77(61). Anal. Calcd for $\text{C}_{16}\text{H}_{13}\text{N}_5\text{O}$ (291.31): C, 65.97; H, 4.50; N, 24.04; Found C, 65.78; H, 4.54; N, 23.94%.

2.3. 3-Amino-2-substituted-6-(5-methyl-1-phenyl-1H-pyrazol-4-yl)thieno[2,3-b]pyridine Derivatives (**15**–**18**).

Method A. A mixture of **13** (0.29 g, 1 mmol) and the appropriate ethyl chloroacetate, chloroacetone, ω -bromoacetophenone or chloroacetonitrile (1 mmol), and 3–5 drops of acetic acid was grinded for 15 min. The resulting solid was collected and recrystallized from ethanol to give the respective compounds, **15**–**18**, in excellent yields.

Method B. A mixture of **13** (0.29 g, 1 mmol) and potassium hydroxide (0.0056 g, 1 mmol) in *N,N*-dimethylformamide (10 mL) was stirred for 2 h at room temperature. The appropriate ethyl chloroacetate, chloroacetone, ω -bromoacetophenone, or chloroacetonitrile (1 mmol each) was added and stirring was continued for 2 h. The resulting solid was collected and recrystallized from ethanol to give **15**–**18**, respectively.

2.3.1. Ethyl 3-Amino-6-(5-methyl-1-phenyl-1H-pyrazol-4-yl)thieno[2,3-b]pyridine-2-carboxylate (15**).** Yield 88%; yellow crystals; m.p. 145–146°C; IR (KBr): ν 1720 (C=O), 3320, 3418 (NH₂) cm⁻¹; ¹H NMR (DMSO-*d*₆): δ 1.32 (t, *J* = 7.5 Hz, 3H, CH₃CH₂), 2.49 (s, 3H, CH₃), 4.16 (q, *J* = 7.5 Hz, 2H, CH₂CH₃), 7.82 (d, 1H, *J* = 8.4 Hz, pyridine H-5), 7.45–7.82 (m, 7H, ArH's and NH₂), 7.82 (s, 1H, pyrazole H-3), 8.48 (d, 1H, *J* = 8.4 Hz, pyridine H-4); ¹³C NMR (DMSO-*d*₆): δ 11.32, 14.58, 60.12, 105.42, 117.45, 122.57, 126.51, 126.89, 127.74, 128.48, 132.25, 136.75, 140.25, 143.11, 144.87, 148.28, 155.28, 165.78; MS *m/z* (%): 381(M⁺ + 1, 43), 380(M⁺, 21), 176(57), 148(57), 102(57), 71(86), 53(100). Anal. Calcd for C₂₀H₁₈N₄O₂S (378.45): C, 63.47; H, 4.79; N, 14.80; Found C, 63.49; H, 4.68; N, 14.65%.

2.3.2. 1-(3-Amino-6-(5-methyl-1-phenyl-1H-pyrazol-4-yl)thieno[2,3-b]pyridin-2-yl)ethanone (16**).** Yield 86%; yellow crystals; m.p. 137–138°C; IR (KBr): ν 1713 (CO), 3310, 3414 (NH₂) cm⁻¹; ¹H NMR (DMSO-*d*₆): δ 2.12 (s, 3H, CH₃), 2.38 (s, 3H, CH₃), 7.38–7.62 (m, 8H, ArH's, NH₂ and pyridine H-5), 7.72 (s, 1H, pyrazole H-3), 8.59 (d, 1H, *J* = 8.4 Hz, pyridine H-4); ¹³C NMR (DMSO-*d*₆): δ 11.38 (CH₃), 31.25 (CH₃), 117.28, 122.58, 126.24, 126.78, 127.34, 128.48, 132.57, 136.57, 140.38, 142.28, 144.37, 147.81, 156.37, 191.28; MS *m/z* (%): 349(M⁺ + 1, 21), 348(M⁺, 41), 292(32), 149(38), 105(32), 77(100), 64(77). Anal. Calcd for C₁₉H₁₆N₄OS (348.42): C, 65.50; H, 4.63; N, 16.08; Found C, 65.43; H, 4.67; N, 15.87%.

2.3.3. (3-Amino-6-(5-methyl-1-phenyl-1H-pyrazol-4-yl)thieno[2,3-b]pyridin-2-yl)(phenyl)methanone (17**).** Yield 88%; yellow crystals; m.p. 127–128°C; IR (KBr): ν 1660 (CO), 3404 (NH₂) cm⁻¹; ¹H NMR (DMSO-*d*₆): δ 2.48 (s, 3H, CH₃), 7.18–7.58 (m, 14H, ArH's, NH₂, pyrazole H-3 and pyridine H-5), 8.54 (d, 1H, *J* = 8.4 Hz, pyridine H-4); MS *m/z* (%): 411(M⁺ + 1, 3), 410(M⁺, 10), 293(13), 253(18), 105(100), 77(81). Anal. Calcd for C₂₄H₁₈N₄OS (410.49): C, 70.22; H, 4.42; N, 13.65; Found C, 70.18; H, 4.32; N, 13.39%.

2.3.4. 3-Amino-6-(5-methyl-1-phenyl-1H-pyrazol-4-yl)thieno[2,3-b]pyridine-2-carbonitrile (18**).** Yield 84%; yellow crystals; m.p. 196–198°C; IR (KBr): ν 1637 (C=N), 3200 (CN), 3343, 3410 (NH₂) cm⁻¹; ¹H NMR (DMSO-*d*₆): δ 2.29 (s, 3H, CH₃), 7.48–7.60 (m, 7H, ArH's, NH₂ and pyrimidine H-5), 7.79 (s, 1H, pyrazole H-3), 8.88 (d, 1H, *J* = 8.4 Hz, pyridine H-4); MS *m/z* (%): 331(M⁺, 10), 302(17), 179(11), 133(16), 84(100), 77(81). Anal. Calcd for C₁₈H₁₃N₅S (331.39): C, 65.24; H, 3.95; N, 21.13; Found C, 65.12; H, 3.91; N, 20.83%.

2.4. 6-(5-Methyl-1-phenyl-1H-pyrazol-4-yl)-2H-pyrazolo[3,4-b]pyridin-3-amine (19**).** To a solution of the thione **13** (0.29 g, 0.01 mol) in ethanol (10 mL) hydrazine hydrate was added (1 mL) and the mixture was heated under reflux for 12 h. The solution was poured over ice-water mixture and then neutralized by HCl. The solid product was filtered off, dried, and recrystallized from ethanol to afford compound **15**. Yield 72%; yellow crystals; m.p. 204–206°C; IR (KBr): ν 1592 (C=N), 3190, 3322 (NH₂ and NH) cm⁻¹; ¹H NMR (DMSO-*d*₆): δ 2.89 (s, 3H, CH₃), 5.94 (s, br, 3H, NH₂ and NH), 6.92 (d, 1H, *J* = 8.1 Hz, pyridine H-4), 7.48–7.56 (m, 5H, ArH's), 8.14 (s, 1H, pyrazole H-3), 8.48 (d, 1H, *J* = 8.1 Hz, pyridine H-4); MS *m/z* (%): 291(M⁺ + 1, 18), 290(M⁺, 31), 274(52), 224(30), 171(28), 118(42), 77(100). Anal. Calcd for C₁₆H₁₄N₆ (290.32): C, 66.19; H, 4.86; N, 28.95; Found C, 66.08; H, 4.91; N, 28.76%.

2.5. 2,4-Dimethyl-8-(5-methyl-1-phenyl-1H-pyrazol-4-yl)pyrido[2',3':3,4]pyrazolo[1,5-a]pyrimidine (20**).** To a solution of **19** (1.45 g, 5 mmol) and acetylacetone (0.5 g, 5 mmol), in acetic acid (20 mL) was refluxed for 10 min. The solid product was collected by filtration and recrystallized from acetic acid to afford compound **20**. Yield 72%; yellow crystals; m.p. 206°C; IR (KBr): ν 1592 (C=N) cm⁻¹; ¹H NMR (DMSO-*d*₆): δ 2.19 (s, 3H, CH₃), 2.38 (s, 3H, CH₃), 2.45 (s, 3H, CH₃), 6.40 (s, 1H, pyrimidine H-5), 6.50 (d, 1H, *J* = 8 Hz, pyridine H-5), 7.39–7.50 (m, 5H, ArH's), 8.00 (s, 1H, pyrazole H-3), 8.40 (d, 1H, *J* = 12 Hz, pyridine H-4); ¹³C NMR (DMSO-*d*₆): δ 10.15 (CH₃), 15.68 (CH₃), 19.36 (CH₃), 104.60, 108.10, 118.00, 119.90, 122.65, 123.38, 126.00, 129.82, 134.65, 140.21, 142.95, 143.42, 146.00, 146.84, 161.10, 164.44; MS *m/z* (%): 355(M⁺ + 1, 1), 354(M⁺, 3), 211(12), 185(31), 157(36), 105(23), 80(100). Anal. Calcd for C₂₁H₁₈N₆ (354.41): C, 71.17; H, 5.12; N, 23.71; Found C, 71.10; H, 5.19; N, 23.56%.

3. Results and Discussion

The starting sodium 3-(5-methyl-1-phenyl-1H-pyrazol-4-yl)-3-oxoprop-1-en-1-olate (**2**) was prepared via reaction of 1-(5-methyl-1-phenyl-1H-pyrazol-4-yl)ethanone [23] (**1**) with ethyl formate in the presence of sodium methoxide. Thus, condensation of **2** with 5-amino-3-methylpyrazole (**3a**) in acetic acid containing piperidine acetate or grinding afforded one isolable product formulated as 2-methyl-7-(5-methyl-1-phenyl-1H-pyrazol-4-yl)pyrazolo[1,5-*a*]pyrimidine (**5a**) in good yield (Scheme 1). ¹H NMR for the product revealed the

SCHEME 1: Synthesis of pyrazolo[1,5-*a*]pyrimidines (**5a-d**).

signals at $\delta = 2.61$ (s, 3H, CH₃), 2.69 (s, 3H, CH₃), 6.36 (d, 1H, $J = 4$ Hz, pyrimidine H-5), 6.78 (s, 1H, pyrazole H-4), 7.37–7.50 (m, 5H, ArH's), 8.45 (s, 1H, pyrazole H-3), and 8.74 (d, 1H, $J = 4$ Hz, pyrimidine H-4). The reaction seemed to be via the initial nucleophilic attack by the exocyclic amino group at the formyl group, which formed *in situ* from **1** with water, followed by cyclization and elimination of one molecule of water leading to the formation of the product **5a** (Scheme 1). The suggestion of the formation of the alternative isomeric product **7a** is based on the initial attack of endocyclic amino group at the formyl group for the formation of **7a**. As the spectroscopic data above does not allow one to distinguish between possible products **5a** and **7a**. The latter suggestion is excluded due to the higher nucleophilicity of the exocyclic primary amino group than the endocyclic amino group. Thus, the mechanism proposed in Scheme 1 seems to be acceptable. In order to establish unambiguously the structure of the product, the crystal structure of a similar previous work has been reported [26–29]. Also, product was obtained by an alternative synthesis route by reaction of 3-(dimethylamino)-1-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)prop-2-en-1-one (**8**) [25] with **3a**. Analogously, condensation of **3b-d** with **2** gave corresponding 7-substituted pyrazolo[1,5-*a*]pyrimidines **5b-d**, respectively.

Treatment of **2** with the appropriate 4,6-dimethyl-2*H*-pyrazolo[3,4-*b*]pyridin-3-amine, 2-aminobenzimidazole, 4*H*-1,2,4-triazol-3-amine, cyanoacetamide and 2-cyanot-

hioacetamide, and 2-cyanoaceto-hydrazide gave 8,10-dimethyl-4-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)pyrido [2',3':3,4]pyrazolo[1,5-*a*]pyrimidine (**9**), 4-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)benzo[4,5]imidazo[1,2-*a*]pyrimidine (**10**), 5-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)-[1,2,4]triazolo[4,3-*a*]pyrimidine (**11**), 6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)-2-oxo-1,2-dihydropyridine-3-carbonitrile (**12**), 6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)-2-thioxo-1,2-dihydropyridine-3-carbonitrile (**13**), and 1-amino-6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)-2-oxo-1,2-dihydropyridine-3-carbonitrile (**14**), respectively (Scheme 2). Structures **9–14** were confirmed by elemental analysis, spectral data, and chemical transformation whenever possible.

Thus, compound **13** reacted with each of ethyl chloroacetate, chloroacetone, ω -bromoacetophenone, chloroacetonitrile and hydrazine hydrate, afforded ethyl 3-amino-6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)thieno[2,3-*b*]pyridine-2-carboxylate (**15**), 1-(3-amino-6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)thieno[2,3-*b*]pyridin-2-yl)ethanone (**16**), (3-amino-6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)thieno[2,3-*b*]pyridin-2-yl)(phenyl)methanone (**17**), 3-amino-6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)thieno[2,3-*b*]pyridine-2-carbonitrile (**18**), and 6-(5-methyl-1-phenyl-1*H*-pyrazol-4-yl)-1*H*-pyrazolo[3,4-*b*]pyridin-3-amine (**19**), respectively (Scheme 3).

Structures **15–18** were elucidated by elemental analysis and spectral data. Also, compound **19** reacted with

R = 5-methyl-1-phenyl-1*H*-pyrazol-4-yl

(i) 4,6-Dimethyl-2*H*-pyrazolo[3,4-*b*]pyridin-3-amine

(ii) 2-Aminobenzimidazole

(iii) 4*H*-1,2,4-Triazol-3-amine

(iv) 2-Cyanoacetamides

(v) 2-Cyanoethanethioamide

(vi) 2-Cyanoacetohydrazide

SCHEME 2: Synthesis of pyrido[2',3':3,4]pyrazolo[1,5-*a*]pyrimidine (**9**), benzoimidazo[1,2-*a*]pyrimidine (**10**), triazolo[4,3-*a*]pyrimidine (**11**), and pyrimidinones (**12–14**).

SCHEME 3: Synthesis of thieno[2,3-*b*]pyridines (**15–18**) and pyrido[2',3':3,4]pyrazolo[1,5-*a*]pyrimidine (**20**)

acetylacetone in acetic acid and gave 2,4-di-methyl-8-(5-methyl-1-phenyl-1H-pyrazol-4-yl)pyrido[2',3':3,4]pyrazolo[1,5-a]pyrimidine (**20**). Structure of **20** was elucidated via elemental analysis and spectral data.

4. Conclusion

In summary, we have developed a simple, efficient procedure for the synthesis of pyrazolo[1,5-a]pyrimidine, pyrido[2',3':3,4]pyrazolo[1,5-a]pyrimidine, [1, 2, 4]triazolo-[1,5-a]pyrimidine, pyridine, and thieno[2,3-b]pyridines derivatives.

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