Monatshefte für Chemie 130, 661–669 (1999)

**Monatshefte für Chemie**
**Chemical Monthly**

Printed in Austria

# Diethyl 2-Aryl-3-cyanopropene-1,1-dicarboxylates: New Versatile Precursors in Heterocyclic Synthesis

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**Summary.** An expeditious synthetic route for the title precursor is reported. It provides access to a variety of polyfunctionally substituted pyridines, pyridazines, pyrazolopyridines, thiophenes, and thienopyridines.

**Keywords.** Pyridines; Pyridazines; Pyrazolopyridines; Thiophenes.

**Diethyl-2-aryl-3-cyanopropen-1,1-dicarboxylate: Neue vielseitige Vorstufen für die Heterocyclensynthese**

**Zusammenfassung.** Eine einfache Synthese zur Darstellung des im Titel genannten Synthons wird beschrieben. Es vermittelt den Zugang zu polyfunktionell substituierten Pyridinen, Pyridazinen, Pyrazolopyridinen, Thiophenen und Thienopyridinen.

## Introduction

$\pi$-Deficient alkyl reagents are highly reactive and are extensively utilized as reactants or intermediates for the construction of a variety of unique heterocyclic ring systems [1–3]. In continuation of our medicinal chemistry program [4–8], we report herein a simple synthetic methodology for the synthesis of diethyl 2-aryl-3-cyanopropene-1,1-dicarboxy-lates **3** as versatile precursors for the synthesis of some hitherto unreported polyfunctionally substituted heterocycles and some of their fused derivatives.

## Results and Discussion

Our attempts to prepare the target reagent **3** *via* direct condensation of diethyl malonate (**1**) with aroylacetonitriles **2** using a variety of acidic or alkaline conditions failed. However, **3** could be prepared stepwise. Condensation of **1** with the appropriate acetophenones **4** followed by bromination of the intermediate **5**

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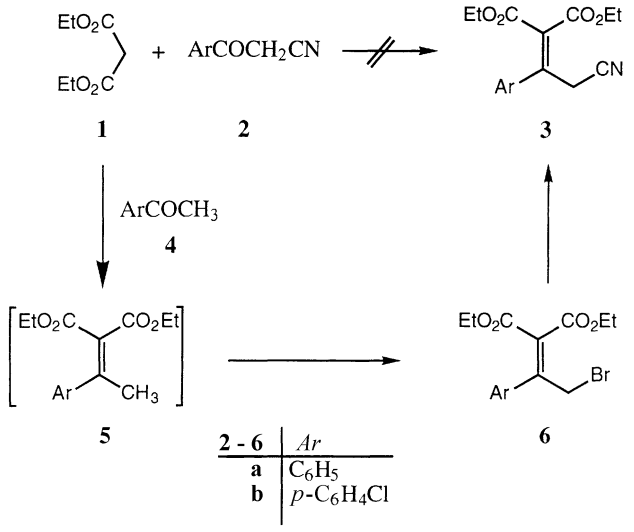


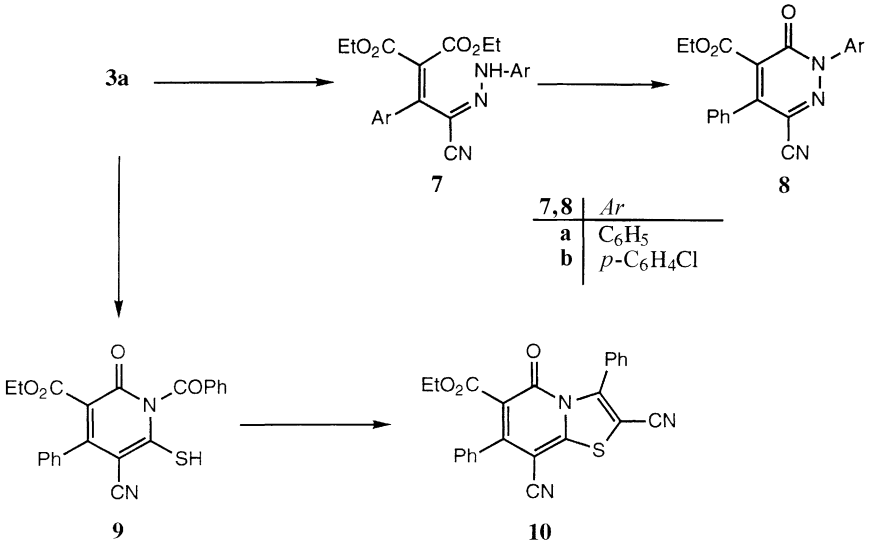

**Scheme 1**

with N-bromosuccinimide in dry benzene solution afforded the corresponding $\alpha$-bromo derivatives **6**. Reaction of the latter with equimolar proportions of sodium cyanide in boiling EtOH furnished the target precursors **3** in excellent yields (Scheme 1).

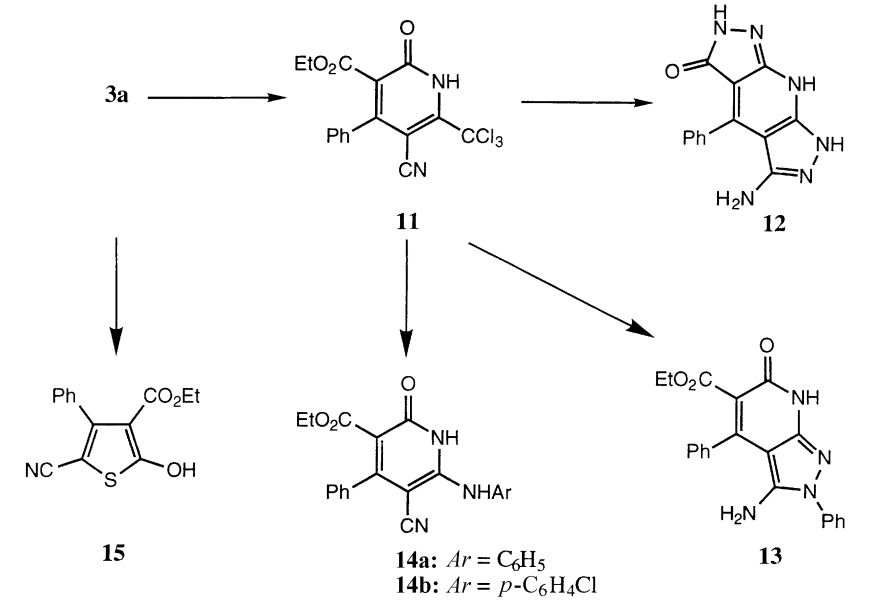
The versatility of the novel precursors **3** was proven by the following examples. **3a** underwent electrophilic substitution upon coupling with an equimolar amount of the appropriate aryldiazonium chloride to yield the corresponding acyclic hydrazone coupling products **7a**,**b**. Compounds **7** proved to exist in the hydrazone from rather than the azo form on the basis of $^1$H NMR data. Thus, *e.g.* **7a** revealed, besides the expected signals, the presence of one $D_2O$ exchangeable singlet at $\delta = 11.20$ ppm corresponding to the hydrazone NH function. Furthermore, its UV spectrum showed absorption maxima at 420 and 330 nm in accordance with those for hydrazo functions [9, 10]. Refluxing of compounds **7a**, **b** in EtOH/NaOAc resulted in their heterocyclization the corresponding pyridazine-3-carbonitrile derivatives **8a**, **b** *via* loss of EtOH (Scheme 2).

Treatment of **3a** with an equimolar amount of benzoyl isothiocyanate afforded the corresponding 1-benzoylpyridine-3-carbonitrile derivative **9**. S-Alkylation of **9** with an equimolar amount of chloroacetonitrile resulted in the formation of the corresponding thieno [3,2-*a*]pyridine **10**.

Compound **3a** reacted readily with an equimolar amount of trichloroacetonitrile to yield exclusively the corresponding pyridine-3-carbonitrile **11**. The trichloromethyl moiety of **11** proved to be highly reactive towards nucleophilic reagents. Thus, fusion of **11** with an excess of hydrazine hydrate resulted in the formation of the corresponding dipyrazolopyridine **12**. Similarly, reaction of **11** with an equimolar amount of phenylhydrazine lead to the corresponding pyrazolopyridine derivative **13**. Also, the trichloromethyl moiety in **11** underwent facile nucleophilic substitution upon reaction with equimolar amounts of the appropriate aniline to yield the corresponding 2-aryl-aminopyridines **14**. With



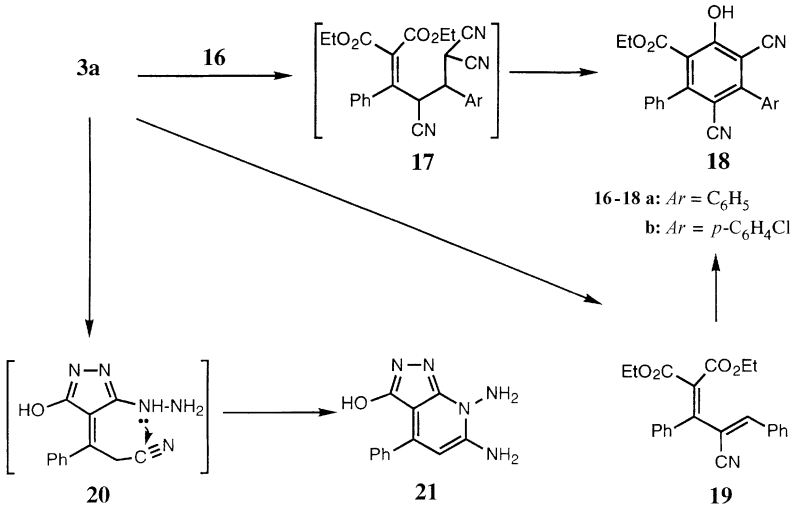

**Scheme 2**




**Scheme 3**

respect to thiophenes [11–13], the *Gewald* reaction of **3a** was investigated. Thus, compound **3a** reacted with an equimolar amount of elemental sulfur to yield exclusively the corresponding ethyl thiophene-3-carboxylate **15**.

The behaviour of **3** towards $\alpha$-cinnamonitriles **16** was also investigated with respect to the synthesis of highly substituted benzenes. Thus, **3a** reacted with equimolar amounts of the appropriate arylidenemalononitriles **16a**,**b** to yield the corresponding ethyl benzoate derivatives **18a**,**b**. Formation of **18** is assumed to




**Scheme 4**

proceed *via Michael* addition of the active methylene moiety of **3a** to the activated $\alpha,\beta$-unsaturated center in **16** to give the acyclic *Michael* adduct **17** which spontaneously cyclizes, and aromatizes to the final products **18** (Scheme 4). A similar reaction has been reported previously [14, 15]. Alternatively, **18a** could be obtained *via* an independent synthesis involving the condensation of **3a** with benzaldehyde to afford **19**. The latter reacted with an equimolar proportion of malononitrile to yield **18a**.

Finally, our study was extended to investigate the behaviour of **3** towards nitrogen nucleophiles. Thus, **3a** reacted with two equivalents of hydrazine hydrochloride to afford the corresponding pyrazolo[3,4-*b*]pyridine **21**. The reaction apparently involves the formation of the intermediate **20**.

## Experimental

Melting points are uncorrected; IR spectra (KBr): Pye Unicam SP-1000; $^1$H NMR spectra: Varian Gemini 200 MHz spectrometer, *TMS* as internal standard; mass spectra: AEI MS 30 mass spectrometer operating at 70 eV; microanalytical data: Microanalytical Data Unit at Cairo University; the results were in satisfactory agreement with the calculated data.

*Diethyl 2-aryl-3-bromopropene-1,1-dicarboxylates (general procedure)*

A mixture of 0.02 mol diethyl malonate (**1**), 0.02 mol of the appropriate acetophenone **2a**, **b** and 3 g anhydrous $NH_4OAc$ in 80 ml dry benzene containing 5 ml glacial AcOH was refluxed under $H_2O$ for 7 h. The solvent was distilled off *in vacuo*, the residue was triturated with 30 ml $H_2O$, and the organic product was extracted 3 times with 50 ml benzene. The benzene layer was dried over anhydrous $CaCl_2$ for 24 h, filtered off, and the solvent was distilled off *in vacuo*.

To a solution of 0.02 mol **5** in 50 ml dry benzene, 0.02 mol *N*-bromo-succinimide were added. The reaction mixture was refluxed for 3 h, and the solvent was evaporated *in vacuo*. The residue (highly lachrymatory) was triturated with ethanol; the solid product was collected by filtration, washed with water, dried over $CaCl_2$, and crystallized from an appropriate solvent.

*Diethyl 3-bromo-2-phenylpropene-1,1-dicarboxylate* (**6a**; $C_{15}H_{17}BrO_4$)

Yield: 4.0 g (59%); m.p.: 56°C (EtOH); Ir: $\nu = 3000–2950$ ($CH_2$), 1715, 1700 (2 CO) $cm^{-1}$; $^1H$ NMR: (*DMSO*-$d_6$, $\delta$, 200 MHz): 0.95–1.30 (m, $2CH_3$), 3.95–4.23 (m, $2CH_2$), 4.40 (s, $CH_2$), 6.79–7.10 (m, $5H_{atom}$) ppm; MS: *m/z* (%) = 342 ($M^+$, 16), 261 (100), 297 (24).

*Diethyl 3-bromo-2-(p-chlorophenyl)propene-1,1-dicarboxylate* (**6b**; $C_{15}H_{16}BrClO_4$)

Yield: 4.65 g (62%); m.p.: 64°C (EtOH); IR; $\nu = 3308–2952$ ($CH_2$), 1712, 1700 (2CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.05–1.29 (m, $2CH_3$), 3.90–4.25 (m, $2CH_2$), 4.56 (s, $CH_2$), 6.88–7.25 (m, $4H_{arom}$) ppm.

*Diethyl 2-aryl-3-cyanopropene-1,1-dicarboxylates (general procedure)*

To a solution of 0.02 mol **6a**,**b** in 50 ml ethanol, 0.02 mol NaCN was added. The reaction mixture was refluxed for 3 h, and the solvent was then evaporated *in vacuo*. The residue was triturated with 20 ml $H_2O$; the solid product was collected by filtration, washed with $H_2O$, dried over $CaCl_2$, and crystallized from an appropriate solvent.

*Diethyl 3-cyano-2-phenylpropene-1,1-dicarboxylate* (**3a**; $C_{16}H_{17}NO_4$)

Yield: 3.90 g (68%); m.p.: 101°C (EtOH); IR: $\nu = 3000–2950$ ($CH_2$), 2221 (CN). 1725, 1710 (2 CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 0.96–1.35 (m, $2CH_3$), 3.80–4.23 (m, $2CH_2$), 4.52 (s, $CH_2$), 6.74–7.20 (m, $5H_{arom}$) ppm; MS: *m/z* (%) = 287 ($M^+$, 24), 242 (100), 197 (28).

*Diethyl 2-(p-chlorophenyl)-3-cyanopropene-1,1-dicarboxylate* (**3b**: $C_{16}H_{16}ClNO_4$)

Yield: 4.56 g (71%); m.p.: 109°C (EtOH); IR: $\nu = 3010–2955$ ($CH_2$), 2218 (CN), 1710, 1700 (2CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.05–1.29 (m, $2CH_3$), 3.86–4.29 (m, 4H, $2CH_2$), 4.82 (s, 2H, $CH_2$), 6.92–7.15 (m, $4H_{arom}$) ppm.

*Diethyl 3-arylhydrazono-3-cyano-2-phenylpropene-1,1-dicarboxylates (general procedure)*

To a stirred solution of 0.005 mol **3a** in 50 ml EtOH containing 4 g NaOAc, 0.005 mol of the appropriate arenediazonium chloride prepared by addition of 0.005 mol $NaNO_2$ to 0.005 mol primary aromatic amine in 2 ml concentrated HCl at 0–5°C under stirring were added dropwise while cooling at 0–5°C and stirring. The reaction mixture was left at room temperature fro 2 h; then, the solid product was collected by filtration and crystallized from an appropriate solvent.

*Diethyl 3-cyano-2-phenyl-3-phenylhydrazonopropene-1,1-dicarboxylate* (**7a**; $C_{22}H_{21}N_3O_4$)

Yield: 1.25 g (64%); m.p.: 186°C ($CHCl_3$); IR: $\nu = 3350–3318$ (NH), 2218 (CN), 1715, 1695 (2CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 0.95–1.23 (m, $2CH_3$), 3.87–4.02 (m, $2CH_2$), 6.72–7.21 (m, $7H_{arom}$), 7.32–7.41 (m, $3H_{arom}$), 11.20 (br s, 1H, NH, exchangeable) ppm; MS: *m/z* (%) = 391 ($M^+$, 18), 345(100), 364(10).

*Diethyl 3-(p-chlorophenylhydrazono)-3-cyano-2-phenylpropene-1,1-dicarboxylate* (**7b**; $C_{22}H_{20}ClN_3O_4$)

Yield: 1.44 g (68%); m.p.: 194°C ($CHCl_3$) IR: $\nu = 3370$ (NH), 2220 (CN), 1722, 1700 (2CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 0.96–1.25 (m, $2CH_3$), 3.61–3.93 (m, $2CH_2$), 6.91–7.33 (m, $6H_{arom}$), 7.29–7.40 (m, $3H_{arom}$), 10.95 (br s, 1H, NH, exchangeable) ppm.

*Ethyl 2-aryl-6-cyano-2,3-dihydro-3-oxo-5-phenylpyridazine-4-carboxylates (general procedure)*

A solution of 0.003 mol **7a**,**b** in 30 ml EtOH containing 1 g NaOAc was heated under reflux for 3 h. The reaction mixture was poured into cold water and neutralized with dilute HCl (*pH* 7). The resulting precipitated solid was collected by filtration, dried, and crystallized from the appropriate solvent.

*Ethyl 6-cyano-2,3-dihydro-2,5-diphenyl-3-oxopyridazine-4-carboxylate* (**8a**; $C_{20}H_{15}N_3O_3$)

Yield: 0.60 g (58%); m.p.: 202°C (EtOH); IR: $\nu = 2218$ (CN), 1715, 1665 (2CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.22 (t, $J = 8.0$ Hz, $CH_3$), 4.12 (q, $J = 8.2$ Hz, $CH_2$), 6.82–7.35 (m, $10H_{arom}$) ppm; MS: *m*/*z* (%) = 345 ($M^+$, 18)

*Ethyl 2-(p-chlorophenyl)-6-cyano-2,3-dihydro-3-oxo-5-phenylpyridazine-4-carboxylate* (**8b**; $C_{20}H_{14}ClN_3O_3$)

Yield: 0.71 g (62%); m.p.: 218°C (EtOH); IR: $\nu = 2220$ (CN), 1720, 1680 (2 CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.16 (t, $J = 8.0$ Hz, $CH_3$), 4.08 (q, $J = 8.2$ Hz, $CH_2$), 6.93–7.40 (m, $9H_{arom}$) ppm.

*Ethyl 1-benzol-5-cyano-1,2-dihydro-6-mercapto-2-oxo-4-phenyl-6-sulfonyl-pyridine-3-carboxylate* (**9**; $C_{22}H_{16}N_2O_4S$)

To a suspension of 0.005 mol $NH_4SCN$ in 50 ml dioxane, 0.005 mol benzoyl chloride were added. The reaction mixture was refluxed for 5 min and then treated with 0.005 mol **3a**. The mixture was refluxed for 2 h and subsequently poured onto ice/water; the separated solid product was filtered off and crystallized from dioxane.

Yield: 1.31 g (65%); m.p.: 178°C; IR: $\nu = 2550$ (SH), 2221 (CN), 1715, 1675, 1660 (3CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.21 (t, $J = 8.0$ Hz, $CH_3$), 3.20 (s, SH), 4.20 (q, $J = 8.2$ Hz, $CH_2$), 6.82–7.35 (m, $8H_{arom}$), 7.42–7.56 (m, $2H_{arom}$) ppm; MS: *m*/*z* (%) = 404 ($M^+$, 19), 353 (100), 298 (80).

*Ethyl 2,8-dicyano-3,7-diphenyl-5-oxothiazolo [3,2-a]pyridine-6-carboxylate* (**10**; $C_{24}H_{15}N_3O_3S$)

To a suspension of 0.002 mol **9** in 30 ml, EtOH, an aqueous solution of $K_2CO_3$ (0.002 mol in 2 ml $H_2O$) and 0.002 mol chloroacetonitrile were added. The reaction mixture was refluxed for 2 h, left to cool at room temperature, and poured in water. The solid product formed was collected by filtration and crystallized from ethanol.

Yield: 0.54 g (64%); m.p.: 248°C; IR: $\nu = 2218$ (CN), 1710, 1680 (2CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$,$\delta$, 200 MHz): 1.19 (t, $J = 8.0$ Hz, $CH_3$), 4.18 (q, $J = 8.2$ Hz, $CH_2$), 6.82–7.45 (m, $10H_{arom}$) ppm; MS: *m*/*z*(%) = 425 ($M^+$, 8), 352 (100), 380 (30).

*Ethyl 5-cyano-1,2-dihydro-2-oxo-4-phenyl-6-trichloromethylpyridine-3-carboxylate* (**11**; $C_{16}H_{11}Cl_3N_2O_3$)

To a solution of 0.005 mol **3a** in 30 ml EtOH containing a few drops of $Et_3N$, 0.005 mol trichloroacetonitrile were added. The reaction mixture was heated under reflux for 4 h and left aside at room temperature overnight. The mixture was poured onto an ice/water mixture, neutralized with dilute HCl, filtered off, washed with water, dried over $CaCl_2$, and crystallized from ethanol.

Yield: 1.15 g (60%); m.p.: 155°C; IR: $\nu = 2220$ (CN), 1710, 1665 (2CO); $^1$H NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.10 (t, $J = 8.0$ Hz, $CH_3$), 4.07 (q, $J = 8.2$ Hz, $CH_2$), 6.72–7.12 (m, $5H_{arom}$), 9.95 (br s, NH, exchangeable) ppm; MS: *m/z* (%) = 385 ($M^+$, 16), 221(100), 266(60).

*5-Oxo-4-phenyl-1,5,6,8-tetrahydropyrazolo [3′,4′:2,3]pyrazolo [3,4-b]pyridine-3-amine* (**12**; $C_{13}H_{10}N_6O$)

A mixture of 0.003 mol **11** and 0.006 mol hydrazine hydrate was heated under reflux in an oil bath at 140°C for 1 h. The resulting residue was triturated with ethanol to give a solid product that was collected by filtration and crystallized from dioxane.

Yield: 0.47 g (59%); m.p.: 245°C; IR: $\nu = 3420$–$3380$ ($NH_2$, NH), 1665 (CO) $cm^{-1}$; $^1$H NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 3.22 (br s, $NH_2$, exchangeable), 6.24 (s, NH, exchangeable), 6.45 (s, NH, exchangeable), 6.81–7.25 (m, $5H_{arom}$), 8.31 (s, NH, exchangeable) ppm.

*Ethyl 1,2-dihydro-4,6-diphenyl-2-oxopyrazolo[3,4-b]pyridine-5-amine* (**13**; $C_{21}H_{18}N_4O_3$)

To a solution of 0.003 mol **11** in 30 ml dioxane, 0.003 mol phenylhydrazine were added. The reaction mixture was heated under reflux for 3 h and then left with stirring overnight at room temperature. The mixture was poured onto 20 ml water; the solid product was filtered off and crystallized from ethanol.

Yield: 0.72 g (64%); m.p.: 175°C; IR: $\nu = 3450$–$3330$ ($NH_2$, NH), 1710, 1675 (2CO) $cm^{-1}$; $^1$H NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 0.95 (t, $J = 8.0$ Hz, $CH_3$), 4.01 (q, $J = 8.2$ Hz, $CH_2$), 4.56 (br s, $NH_2$, exchangeable), 6.82–7.41 (m, $10H_{arom}$) ppm; MS: *m/z*(%) = 274 ($M^+$, 21), 252 (100), 329 (80).

*Ethyl 6-arylamino-5-cyano-1,2-dihydro-2-oxo-4-phenylpyridine-3-carboxylates (general procedure)*

To a solution of 0.002 mol **11** in 30 ml dioxane, 0.002 mol aromatic amine was added. The reaction mixture was heated under reflux for 6 h. The solid product formed upon dilution with water was collected by filtration and crystallized from an appropriate solvent.

*Ethyl 5-cyano-1,2-dihydro-2-oxo-4-phenyl-6-phenylaminopyridine-3-carboxylate* (**14a**; $C_{21}H_{17}N_3O_3$)

Yield: 0.40 g (55%); m.p.: 177°C (EtOH); IR: $\nu = 3450$–$3420$ (NH), 2221 (CN), 1715, 1665 (2CO) $cm^{-1}$; $^1$H NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.12 (t, $J = 8.0$ Hz, $CH_3$), 4.15 (q, $J = 8.2$ Hz, $CH_2$), 6.28 (br s, NH, exchangeable), 6.81–7.38 (m, $10H_{arom}$), 11.90 (br s, NH, exchangeable) ppm; MS: *m/z* (%) = 359 ($M^+$, 9), 221 (100), 266 (60).

*Ethyl 6-(p-chlorophenylamino)-5-cyano-1,2-dihydro-2-oxo-4-phenyl-pyridine-3-carboxylate* (**14b**; $C_{21}H_{16}ClN_3O_3$)

Yield: 0.49 g (62%); m.p.: 205°C (EtOH); IR: $\nu = 3430$–$3415$ (NH), 2218 (CN), 1710, 1675 (2CO) $cm^{-1}$; $^1$H NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.10 (t, $J = 8.0$ Hz, $CH_3$), 4.20 (q, $J = 8.3$ Hz, $CH_3$), 6.31 (br s, NH, exchangeable), 6.92–7.29 (m, $9H_{arom}$), 11.32 (br s, NH, exchangeable) ppm.

*Ethyl 5-cyano-2-hydroxy-4-phenylthiophene-3-carboxylate* (**15**; $C_{14}H_{11}NO_3S$)

A mixture of 0.005 mol **3a** and 0.005 mol elemental sulfur in 30 ml ethanol containing 5 drops anhydrous $Et_3N$ was refluxed for 6 h. The reaction mixture was poured in cold water and neutralized

with dilute HCl (*pH* 7). The resulting solid precipitate was collected by filtration, washed with water, and crystallized from ethanol.

Yield: 0.93 g (68%); m.p.: 196°C; IR: $\nu = 3500–3330$ (OH), 2222 (CN), 1715 (CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 1.20 (t, $J = 8.0$ Hz, $CH_3$), 3.05 (s, OH, exchangeable), 4.12 (q, $J = 8.2$ Hz, $CH_2$), 6.91–7.25 (m, $5H_{arom}$) ppm; MS: *m/z* (%) = 273 ($M^+$, 35), 145 (100), 228 (46).

*Ethyl 4-aryl-3,5-dicyano-2-hydroxy-6-phenylbenzoates (general procedure)*

A solution of 0.003 mol **3a** and 0.003 mol **16a**, **b** in 30 mol EtOH containing a few drops of $Et_3N$ was heated under reflux for 3 h. The reaction mixture was evaporated *in vacuo*, triturated with cold water, and neutralized with dilute HCl. The solid product precipitated was collected by filtration, dried over $CaCl_2$, and crystallized from the appropriate solvent.

*Ethyl 3,5-dicyano-4,6-diphenyl-2-hydroxybenzoate* (**18a**;$C_{23}H_{16}N_2O_3$)

Yield: 0.73 g (66%); m.p.: 182°C (EtOH); IR $\nu = 3500–3450$ (OH), 2220, 2216 (2CN), 1700 (CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 0.95 (t, $J = 8.0$ Hz, $CH_3$), 2.95 (s, OH, exchangeable), 4.05 (q, $J = 8.3$ Hz, $CH_2$), 6.75–7.38 (m, $10H_{arom}$) ppm; MS: *m/z* (%) = 368 ($M^+$, 15), 296 (100), 323 (72).

*Ethyl 4-(p-chlorophenyl)-3,5-dicyano-2-hydroxy-6-phenylbenzoate* (**18b**; $C_{23}H_{15}ClN_2O_3$)

Yield: 0.72 g (60%); m.p.: 216°C (EtOH); IR: $\nu = 3480–3445$ (OH), 2218, 2212 (2CN), 1695 (CO) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$ 200 MHz): 1.05 (t, $J = 8.0$ Hz, $CH_3$), 3.09 (s, OH, exchangeable), 4.10 (q, $J = 8.2$ Hz, $CH_2$), 6.90–7.35 (m, $9H_{arom}$) ppm.

*Diethyl 2,4-diphenyl-3-cyanobuta-1,3-diene-1,1-dicarboxylate* (**19**; $C_{23}H_{21}NO_4$)

*Method A*. A mixture of 0.003 mol **3a** and 0.003 mol benzaldehyde in 30 ml ethanol containing a few drops of $Et_3N$ was refluxed for 3 h. The reaction mixture was then poured in cold water and neutralized with dilute HCl. The solid product formed was filtered off and crystallized form ethanol.

Yield: 0.76 g (68%); m.p.: 134°C; IR: $\nu = 2220$ (CN), 1710, 1695 (2 CO), 1650 (C=C) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 0.95–1.34 (m, $2CH_3$), 3.80–4.20 (m, $2CH_2$), 6.71–7.32 (m, $11H_{arom}$+ylidene CH); MS: *m/z* (%) = 375 ($M^+$, 18), 284 (100), 330 (80).

*Method B*. A mixture of 0.002 mol **19** and 0.002 mol malononitrile in 25 ml ethanol containing a few drops of $Et_3N$ was refluxed for 3 h. The reaction mixture was poured in cold water and neutralized with dilute HCl. The solid product was collected by filtration and crystallized from EtOH. It was found to be identical (m.p., mixed m.p., and IR spectrum) with an authentic sample prepared according to method *A*.

*5-Hydroxy-4-phenylpyrazolo[3,4-b]pyridine-1,2-diamine* (**21**; $C_{12}H_{11}N_5O$)

To a solution of 0.003 mol **3a** in 30 ml ethanol, 0.006 mol hydrazine hydrochloride were added. The reaction mixture was heated under reflux for 3 h; the precipitated solid product formed at room temperature was filtered off, washed thoroughly water, and crystallized from ethanol.

Yield: 0.43 g (60%); m.p.: 200°C; IR: $\nu = 3550–3350$ (OH, $NH_2$) $cm^{-1}$; $^1H$ NMR (*DMSO*-$d_6$, $\delta$, 200 MHz): 3.25 (br s, $2NH_2$, exchangeable), 4.61 (br s, OH, exchangeable), 6.91–7.23 (m, $5H_{arom}$) ppm; MS: *m/z* (%) = 241 ($M^+$, 12), 147 (100), 226 (71).

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*Received June 25, 1998. Accepted (revised) September 15, 1998*