Utility of Cyano Acid Hydrazide in Heterocyclic Chemistry:
A New Route for the Synthesis of New 1,2,4-Triazolo[1,5-a]pyridines
and 1,2,4-Triazolo[1,5-a]isoquinolines

Abdel Haleem Mostafa Hussein
Chemistry Department, Faculty of Science, Al-Azhar University, Assiut 71524, Egypt
Z. Naturforsch. 53b, 488–494 (1998); received October 27, 1997

1,2,4-Triazolo[1,5-a]pyridines, 1,2,4-Triazolo[1,5-a]isoquinolines

Cyano acid hydrazide 1 was condensed with cyclohexanone in refluxing ethanolic piperidine
to yield the hydrazone 4. Compound 4 reacts with arylidines 5a–i to yield the 1,2,4-
triazolo[1,5-a]pyridines 7a–i. Compound 4 also reacts with mixtures of aliphatic aldehydes
different active methylene reagents to yield 1,2,4-triazolo[1,5-a]pyridines 8a–d. Similarly
reaction of 4 with aromatic aldehydes gives 12a–e. Compound 8a reacts with elemental sulfur to yield
the thieno-1,2,4-triazolopyridine 13. This underwent cycloaddition with acrylonitrile, α-nitro-
styrene, chalcone, N-phenylmaleimide, dimethylacetylenedicarboxylate and tetracyanoethy-
lene yielding the isoquinolines 15–18. All new compounds have been characterized by their
IR, 1H NMR and mass spectra.

Introduction

Polyfunctionally substituted heteroaromatics are interesting as potential biodegradable agro-
chemicals [1,2] intermediates in dye industry [3,4] and as pharmaceuticals [5,6]. In spite of enormous
number of papers published every year describing synthesis of such compounds, general inexpensive
routes are rather limited. In recent years we were involved in program directed at developing ef-
cient synthesis of polyfunctionally heteroaromatics from simple and inexpensive starting materials
[7–10]. In previous publications we have shown that 1 is an excellent adduct for the synthesis of
heterocyclic systems [11]. In conjunction with this work we report here the results of our further in-
vestigation on cyano acid hydrazide 1.

Results and Discussion

It has been found that condensation of 1 with cyclohexanone in refluxing ethanolic piperidine
yields the hydrazone 4 or 3. The possibility that the ketone has condensed with the active methy-
lene function in 1 was excluded based on spectral data IR, 1H NMR and MS. The IR spectrum of
the reaction product reveals the absence of an NH2 group and the 1H NMR spectrum exhibits a
signal at δ 2.8 ppm for a CH2 moiety. Compound 4 reacts with arylidinemalononitrile 5a–d, arylidin-
ecyanoacetate 5e,f and arylidinecyanoacethylene 5g–i to yield product of addition and hy-
drogen elimination which may be formulated as the oxidized adduct 6 or the 1,2,4-triazolopyridines
7a–i. Structures 7a–i were considered to be the only reaction products based on spectroscopic
data. Thus no NH2 signal can be detected in the 1R spectrum of 7a whereas the 1H NMR spectrum of
7a shows two signals at δ 2.9 ppm and δ 3.2 ppm for two NH groups. Recently we have shown that mixture of al-
phatic aldehyde and malononitrile can be used as synthetic equivalents to alkylidinemalononitrile
[12]. Thus compound 4 reacts with mixtures of acetaldehyde/malononitrile, acetaldehyde/ethyl cyano-
acetate as well as with mixtures of formaldehyde/malononitrile and formaldehyde/ethyl cyanoacetate to yield the 1,2,4-triazolo[1,5-a]pyri-
dines 8a–d. The arylazalomalononitriles 9a–d re-
acts with compound 4 to yield the 1,2,4-tria-
zolo[1,5-a]pyridines 10a–d.

Attempts were made to condense 4 with aromatic aldehydes to form 11. However under a variety
of conditions only 12a–e were formed. The structure of compounds 12a–e were confirmed by
spectroscopic data (IR, 1H NMR and MS). It is interesting to report that compound 12 cannot be

* Reprint requests to A. H. M. Hussein.

0932–0776/98/0400–0488 $06.00 © 1998 Verlag der Zeitschrift für Naturforschung. All rights reserved.
readily obtained by direct condensation of cyclo-
hexanonehydrazone and aromatic aldehyde or by
condensation of arylhydrazone with cyclo-
hexanone.

\[
\text{Scheme 1}
\]

\[
\text{Scheme 2}
\]

In the last few years a new synthesis of benzoa-
azines utilizing alkylazinylcarbonitriles as starting
materials has been reported [7,13]. We have found
that compound 8a reacts with elemental sulfur in
ethanolic triethylamine to yield thieno-1,2,4-tria-
zolopyridine 13. This underwent, cycloaddition
with acrylonitrile, \(\omega\)-nitrostyrene, chalcone, N-
phenylmaleimide, dimethylacetylenedicarboxylate
and tetracyanoethylene yielding the isoquinolines
15a–c and 16–18. All new compounds have been

\[
\text{Scheme 5}
\]
characterized by their IR, ¹H NMR and mass spectra. Compound 15a was produced either from reaction of 13 with acrylonitrile or from the reaction of 8a with formaldehyde and malononitrile.

**Experimental**

All melting points are uncorrected. IR spectra were recorded on a Shimadzu 470 spectrophotometer. ¹H NMR spectra were measured with a Varian EM-390 spectrometer. Microanalyses were performed by the microanalytical data unit at Cairo University. Mass spectra were recorded with a mass spectrometer MS 30 MS 9 (AEI) at 70 ev.

**Preparation of N-cyclohexanomethylidene-2-cyanoacetohydrazide (4)**

To a solution of 1 (0.01 mol) in 30 ml ethanol, cyclohexanone 2 (0.01 mol) was added. The reaction mixture was treated with few drops of piperidine and refluxed for 3 h. The solid product was collected by filtration and recrystallized from ethanol as colourless crystals from ethanol (69%); m.p. 280 °C; IR: 3420-3300 cm⁻¹ (2NH); 2224, 2220 cm⁻¹ (2CN); 1650 cm⁻¹ (CO); ¹H NMR: δ 1.2-1.4 (m, 10H, cyclohexyl-H); 2.9 (s, 1H, NH); 3.2 (s, 1H, NH); 7.0-7.6 (m, 5H, aromatic CH); MS: m/z 179 (M⁺).

**C₉H₁₅N₃O**

Caled C 60.32 H 7.31 N 23.45%,
Found C 60.5 H 7.4 N 23.6%.

**General procedure for the preparation of 7a–i**

To a solution of 4 (0.01 mol) in ethanol (50 ml), the appropriate arylidines reagent (0.01 mol) were added. The reaction mixture was treated with few drops of piperidine, then refluxed for 3 h. The solid product was collected by filtration and recrystallized from the proper solvent.

**5-Oxo-1H-2,3-dihydro-7-phenyl-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6,8-dicarbonitriles (7a)**

Compound 7a was obtained as brown crystals from ethanol (69%); m.p. 310 °C; IR: 3420-3300 cm⁻¹ (2NH); 2224, 2220 cm⁻¹ (2CN); 1650 cm⁻¹ (CO); ¹H NMR: (insoluble); MS: m/z 331 (M⁺).

**C₁₉H₁₇N₄O₃ (331.38)**

Caled C 68.87 H 5.17 N 21.13%,
Found C 68.9 H 5.4 N 21.3%.

**5-Oxo-1H-2,3-dihydro-7-p-anisyl-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6,8-dicarbonitriles (7b)**

Compound 7b was obtained as colourless crystals from ethanol (73%); m.p. 265 °C; IR: 3410-3320 cm⁻¹ (2NH); 2222, 2220 cm⁻¹ (2CN); 1650 cm⁻¹ (CO); ¹H NMR: δ 1.2-1.4 (m, 10H, cyclohexyl-H); 2.8 (s, 2H, CH₂); 7.20-7.7 (m, 5H, aromatic H); 8.4 (s, 1H, NH); MS: m/z 361 (M⁺).

**C₂₀H₁₉N₅O₂ (361.40)**

Caled C 66.47 H 5.30 N 15.38%,
Found C 66.6 H 5.4 N 19.5%.

**5-Oxo-1H-2,3-dihydro-7-(p-Cl-phenyl)-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6,8-dicarbonitriles (7c)**

Compound 7c was obtained as colourless crystals from ethanol (69%); m.p. 120 °C; IR: 3420-3300 cm⁻¹ (2NH); 2225, 2220 cm⁻¹ (2CN); 1650 cm⁻¹ (CO); ¹H NMR: δ 1.2-1.4 (m, 10H, cyclohexyl-H); 7.2-7.6 (m, 4H, aromatic H); 11.3 (s, 2H, 2NH); MS: m/z 265 (M⁺).

**C₁₉H₁₅N₄O₃Cl (265.82)**

Caled C 62.38 H 4.41 N 19.14 Cl 9.96%,
Found C 62.5 H 4.6 N 19.3 C 19.6%.

**5-Oxo-1H-2,3-dihydro-7-furyl-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6,8-dicarbonitriles (7d)**

Compound 7d was obtained as brown crystals from ethanol (69%); m.p. 280 °C; IR: 3420-3300 cm⁻¹ (2NH); 2224, 2220 cm⁻¹ (2CN); 1650 cm⁻¹ (CO); ¹H NMR: (insoluble); MS: m/z 321 (M⁺).

**C₁₃H₁₅N₄O₂ (321.34)**

Caled C 63.54 H 4.71 N 21.79%,
Found C 63.8 H 4.9 N 21.9%.

**Ethyl-6-cyano-7-phenyl-5-oxo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-8-carboxylate (7e)**

Compound 7e was obtained as orange crystals from diethyl ether (65%); m.p. 110 °C; IR: 3390-3350 cm⁻¹ (2NH); 2200 cm⁻¹ (2CN); 1720 cm⁻¹ (CO ester); 1650 cm⁻¹ (CO); ¹H NMR: δ 1.2-1.4 (m, 10H, cyclohexyl-H); 1.7 (t, 3H, CH₃); 3.2 (s, 2H, 2NH); 4.2 (q, 2H, CH₂); 7.20-7.7 (m, 5H, aromatic CH); MS: m/z 378 (M⁺).

**C₂₁H₂₂N₄O₄ (378.43)**

Caled C 66.65 H 5.86 N 14.81%,
Found C 66.8 H 6.0 N 15.0%.
Ethyl-6-cyano-7-furyl-5-oxo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-8-carboxylate (7f)

Compound 7f was obtained as red crystals from ethanol (65%); mp 280 °C; IR: 3400–3350 cm⁻¹ (2NH), 2200 cm⁻¹ (CN); 1730 cm⁻¹ (CO ester); 1650 cm⁻¹ (CO); ¹H NMR: δ 1.0–1.4 (m, 10H, cyclohexyl-H); 1.6 (t, 3H, CH₃); 3.2 (s, 2H, 2NH); 7.2–7.7 (m, 4H, aromatic CH); MS: m/z 302 (M⁺).

C₁₉H₂₀N₄O₄ (368.39)
Calcd C 63.5 H 5.8 N 18.5 S 8.3%
Found C 62.6 H 5.8 N 18.5%

Ethyl-6-cyano-7-(p-tolyl)-5-oxo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-8-thiocarboxamide (7g)

Compound 7g was obtained as gray crystals from ethanol (70%); mp 180 °C; IR: 3400–3350 cm⁻¹ (NH₂); 3350–3100 cm⁻¹ (2NH); 2200 cm⁻¹ (CN); 1650 cm⁻¹ (CO); ¹H NMR: δ 1.3–1.5 (m, 10H, cyclohexyl-H); 2.0 (s, 3H, CH₃); 3.1 (s, 2H, 2NH); 7.2–7.7 (m, 4H, aromatic CH); MS: m/z 379 (M⁺).

C₂₀H₂₁N₅O₂S (379.48)
Calcd C 62.6 H 5.8 N 26.3%
Found C 62.5 H 5.8 N 26.4%

General procedure for the preparation of 8a–d

To a solution of 4 (0.01 mol) in ethanol (50 ml), the appropriate aliphatic aldehyde and the appropriate active methylene reagent (0.01 mol) were added. The reaction mixture was treated with few drops of piperidine, then refluxed for 3 h. The solid product was collected by filtration and recrystallized from the proper solvent.

7-Methyl-5-oxo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6,8-dicarbonitrides (8a)

Compound 8a was obtained as colourless crystals from DMF/ethanol (80%); mp 310 °C; IR: 3361–3316 cm⁻¹ (2NH); 2225 cm⁻¹ (CN); ¹H NMR: δ 1.0–1.4 (m, 10H, cyclohexyl-H); 1.8 (s, 3H, CH₃); 3.2 (s, 2H, 2NH); MS: m/z 269 (M⁺).

C₁₄H₁₃N₃O (269.31)
Calcd C 61.4 H 5.3 N 27.6%
Found C 61.3 H 5.4 N 27.5%

Ethyl-6-cyano-7-methyl-5-oxo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-8-carboxylate (8b)

Compound 8b was obtained as buff crystals from ethanol (75%); mp 200 °C; IR: 3422, 3330 cm⁻¹ (2NH); 2110 cm⁻¹ (CN); 1653 cm⁻¹ (CO ester); 1653 cm⁻¹ (CO); ¹H NMR: δ 1.0–1.3 (m, 13H, CH₂, cyclohexyl-H); 1.6 (t, 3H, CH₃); 3.2 (s, 2H, 2NH); 4.2 (q, 2H, CH₂); MS: m/z 316 (M⁺).

C₁₆H₂₀N₅O₃ (316.16)
Calcd C 60.75 H 6.37 N 17.71%
Found C 60.9 H 6.8 N 17.9%

5-Oxo-1H-2,3,7-trihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6,8-dicarbonitrides (8c)

Compound 8c was obtained as yellow crystals from DMF/ethanol (75%); mp 320 °C; IR: 3360–3330 cm⁻¹ (2NH); 2222, 2220 cm⁻¹ (2CN); 1650 cm⁻¹ (CO); MS: m/z 255 (M⁺).

C₁₃H₁₃N₅O₂ (255.28)
Calcd C 61.7 H 5.13 N 27.43%
Found C 61.4 H 5.3 N 27.6%

Ethyl-6-cyano-5-oxo-1H-2,3,7-trihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-8-carboxylate (8d)

Compound 8d was obtained as red crystals from ethanol (78%); mp 165 °C; IR: 3329–3230 cm⁻¹ (2NH); 2221 cm⁻¹ (CN); 1739 cm⁻¹ (CO ester); 1645 cm⁻¹ (CO); ¹H NMR: δ 1.0–1.3 (m, 10H, cyclohexyl-H); 1.5 (t, 3H, CH₃); 3.0 (s, 2H, 2NH); 4.2 (q, 2H, CH₂); 8.0 (s, 1H, pyridine-H); MS: m/z 302 (M⁺).
C_{15}H_{18}N_{4}O_{3} (302.33)
Calcd C 59.59 H 6.0 N 18.53%,
Found C 59.7 H 6.1 N 18.7%.

General procedure for the preparation of 10a-d
To a solution of 4 (0.05 mol) in ethanol (50 ml), arylazomalononitrile 9a-d (0.05 mol) and piperidine (2 drops) were added. The reaction mixture was heated under reflux for 3 h then left to stand. The solid product was collected by filtration and recrystallized from the proper solvent.

7-Amino-5-oxo-8-phenylazo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6-carbonitrile (10a)

Compound 10a was obtained as brown crystals from ethanol (80%); m.p. 260 °C; IR: 3390–3350 cm\(^{-1}\) (NH\(_2\)); 3340–3300 cm\(^{-1}\) (2NH); 2215 cm\(^{-1}\) (CN); 1653 cm\(^{-1}\) (CO); \(^1\)H NMR: \(\delta\) 1.0–1.3 (m, 10H, cyclohexyl-H); 3.3 (s, 2H, 2NH); 7.0–7.7 (m, 7H, aromatic CH and NH\(_2\)); MS: \(m/z\) 349 (M\(^+\)).

C\(_{18}\)H\(_{19}\)N\(_2\)O (349.40)
Calcd C 61.88 H 5.48 N 28.06%,
Found C 62.0 H 5.6 N 28.3%.

7-Amino-5-oxo-8-p-tolylazo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6-carbonitrile (10b)

Compound 10b was obtained as brown crystals from ethanol (80%); m.p. 250 °C; IR: 3400–3370 cm\(^{-1}\) (NH\(_2\)); 3370–3310 cm\(^{-1}\) (2NH); 2200 cm\(^{-1}\) (CN); 1650 cm\(^{-1}\) (CO); \(^1\)H NMR: \(\delta\) 1.0–1.3 (m, 10H, cyclohexyl-H); 3.0 (s, 2H, 2NH); 3.4 (s, 3H, CH\(_3\)); 7.0–7.9 (m, 7H, aromatic CH and NH\(_2\)); MS: \(m/z\) 363 (M\(^+\)).

C\(_{19}\)H\(_{21}\)N\(_2\)O (362.42)
Calcd C 62.79 H 5.82 N 26.98%,
Found C 62.9 H 6.0 N 27.3%.

7-Amino-5-oxo-8-(p-Cl-phenylazo)-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6-carbonitrile (10c)

Compound 10c was obtained as brown crystals from ethanol (78%); m.p. 262 °C; IR: 3400–3340 cm\(^{-1}\) (NH\(_2\)); 3340–3300 cm\(^{-1}\) (2NH); 2210 cm\(^{-1}\) (CN); 1655 cm\(^{-1}\) (CO); \(^1\)H NMR: \(\delta\) 1.0–1.3 (m, 10H, cyclohexyl-H); 3.2 (s, 2H, 2NH); 7.0–7.5 (m, 6H, aromatic CH and NH\(_2\)); MS: \(m/z\) 383 (M\(^+\)).

C\(_{19}\)H\(_{18}\)N\(_2\)OCl (383.84)
Calcd C 56.32 H 4.73 N 25.54%,
Found C 56.6 H 4.9 N 25.7%.

7-Amino-5-oxo-8-p-anisylazo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-6-carbonitrile (10d)

Compound 10d was obtained as brown crystals from ethanol (74%); m.p. 255 °C; IR: 3400–3350 cm\(^{-1}\) (NH\(_2\)); 3350–3320 cm\(^{-1}\) (2NH); 2220 cm\(^{-1}\) (CN); 1650 cm\(^{-1}\) (CO); \(^1\)H NMR: \(\delta\) 1.0–1.3 (m, 10H, cyclohexyl-H); 3.9 (s, 3H, OCH\(_3\)); 6.4 (s, 1H, NH); 6.8 (br, 2H, NH\(_2\)); 7.0–8.0 (m, 4H, aromatic CH); 8.0 (s, 1H, NH); MS: \(m/z\) 379 (M\(^+\)).

C\(_{19}\)H\(_{21}\)N\(_2\)O\(_2\) (379.42)
Calcd C 60.5 H 5.58 N 25.84%,
Found C 60.7 H 6.0 N 26.0%.

General procedure for the preparation of 3-arylcy clohexano[cf]-1H-pyrazole (12a–e)
A mixture of 2 (0.01 mol) and benzaldehyde (0.01 mol) in ethanol (30 ml) was treated with a little amount of triethylamine, then refluxed for 3 h. The reaction mixture left to stand and the solid product was collected by filtration and recrystallized from the proper solvent.

3-Phenylcyclohexano[cf]-1H-pyrazole (12a)

Compound 12a was obtained as orange crystals from ethanol (77%); m.p. 150 °C; IR: 3400–3300 cm\(^{-1}\) (NH); 3050 cm\(^{-1}\) (aliphatic CH); 1600–1590 cm\(^{-1}\) (aromatic CH); \(^1\)H NMR: \(\delta\) 1.4–1.8 (m, 8H, cyclohexyl-H); 7.2–7.6 (m, 5H, aromatic CH); 8.9 (s, 1H, NH); MS: \(m/z\) 198 (M\(^+\)).

C\(_{19}\)H\(_{19}\)N\(_2\) (198.27)
Calcd C 78.75 H 7.12 N 14.13%,
Found C 78.9 H 7.4 N 14.3%.

3-(p-Cl-Phenyl)cyclohexano[cf]-1H-pyrazole (12b)

Compound 12b was obtained as yellow crystals from ethanol (75%); m.p. 190 °C; IR: 3400–3100 cm\(^{-1}\) (NH); 3030 cm\(^{-1}\) (aliphatic CH); 1600–1590 cm\(^{-1}\) (aromatic CH); \(^1\)H NMR: \(\delta\) 1.3–1.9 (m, 8H, cyclohexyl-H); 7.2–7.6 (m, 4H, aromatic H); 8.8 (s, 1H, NH); MS: \(m/z\) 232 (M\(^+\)).

C\(_{19}\)H\(_{18}\)Cl\(_2\) (232.71)
Calcd C 67.1 H 5.63 N 12.04 Cl 15.23%,
Found C 67.3 H 5.8 N 12.3 Cl 15.3%.

3-(o-Cl-Phenyl)cyclohexano[cf]-1H-pyrazole (12c)

Compound 12c was obtained as orange crystals from ethanol (75%); m.p. 200 °C; IR: 3390–3290 cm\(^{-1}\) (NH); 3060 cm\(^{-1}\) (aliphatic CH); 1600–1590 cm\(^{-1}\) (aromatic CH); \(^1\)H NMR: \(\delta\) 1.2–1.6 (m, 8H,
3-p-Anisylcyclohexano[c]-1H-pyrazole (12d)

Compound 12d was obtained as yellow crystals from ethanol (78%); m.p. 290 °C; IR: 3350-3300 cm⁻¹ (NH₂); 1H NMR: 3.8 (s, 3H, OCCH₃); 7.0-7.6 (m, 5H, aromatic CH and NH₂); MS: m/z 440 (M⁺).

C₂₄H₂₀N₆O₃ (440.46)
Calcd C 65.45 H 4.58 N 19.08%,
Found C 65.7 H 4.8 N 19.3%.

3-Furylcyclohexano[c]-1H-pyrazole (12e)

Compound 12e was obtained as brown crystals from dioxane (82%); m.p. 188 °C; IR: 3380-3310 cm⁻¹ (NH₂); 3050 cm⁻¹ (CH); 1600-1590 cm⁻¹ (aromatic CH); 1H NMR: 3.05-3.18 (m, 10H, cyclohexyl-H); 2.8 (s, 1H, NH); 6.5-7.0 (m, 3H, furyl CH); MS: m/z 188 (M⁺).

C₁₄H₁₂N₂O (188.23)
Calcd C 73.8 H 7.3 N 13.3%.
Found C 70.3 H 6.8 N 15.0%.

6-Amino-5-oxo-1H-2,3-dihydrothieno[3,4-c]-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]pyridine]-9-carbonitrile (13)

A mixture of 8a (0.01 mol) and elemental sulfur (0.01 mol) in 50 ml ethanol was treated with a little amount of triethylamine, then refluxed for 3 h. The solid product formed was collected by filtration and recrystallized from the proper solvent.

C₂₅H₂₅N₆O₂ (427.51)
Calcd C 70.4 H 5.9 N 16.5%,
Found C 70.4 H 5.9 N 16.5%.

General procedure for the preparation of compounds 15a-c and 16-18

To a solution of 13 (0.01 mol) in dry pyridine, the appropriate dienophiles were added. The reaction mixture was refluxed for 3 h. Then poured on ice-cold water and neutralized with dilute HCl. The solid product was collected by filtration and recrystallized from the proper solvent.

C₁₇H₁₆N₆O (301.37)
Calcd C 55.8 H 5.02 N 23.24 S 10.64%,
Found C 55.9 H 5.2 N 23.5 S 10.8%.

5.5-Amino-4-oxo-1H-2,3-dihydro-2-spirocyclohexan-1,2,4-triazolo[1,5-a]isoquinoline-7,10-dicarbonitriles (15a)

Compound 15a was obtained as orange crystals from ethanol (69%); m.p. 315 °C; IR: 3440-3350 cm⁻¹ (NH₂); 3317-3191 cm⁻¹ (2NH); 2222 cm⁻¹ (2CN); 1650 cm⁻¹ (CO); 1H NMR: 3.1-4.1 (m, 10H, cyclohexyl-H); 2.8 (s, 2H, 2NH); 7.8-8.0 (m, 4H, aromatic CH and NH₂).

C₁₇H₁₆N₆O (320.35)
Calcd C 63.7 H 5.3 N 26.4%,
Found C 63.9 H 5.3 N 26.4%.

6-Amino-7-nitro-8-phenyl-4-oxo-1H-2,3-dihydro-2-spirocyclohexan-1,2,4-triazolo[1,5-a]isoquinoline-10-carbonitrile (15b)

Compound 15b was obtained as gray crystals from dioxane (60%); m.p. 250 °C; IR: 3390-3350 cm⁻¹ (NH₂); 3300-3200 cm⁻¹ (2NH); 2200 cm⁻¹ (CN); 1645 cm⁻¹ (CO); MS: m/z 416 (M⁺).

C₂₂H₂₀N₆O₃ (416.44)
Calcd C 63.45 H 5.84 N 20.18%,
Found C 63.6 H 5.0 N 20.3%.

6-Amino-7-benzoyl-8-phenyl-4-oxo-1H-2,3-dihydro-2-spirocyclohexan-1,2,4-triazolo[1,5-a]isoquinoline-11-carbonitrile (15c)

Compound 15c was obtained as yellow crystals from DMF/ethanol (70%); m.p. 310 °C; IR: 3430 cm⁻¹ (NH₂); 3300-3200 cm⁻¹ (2NH); 2200 cm⁻¹ (CN); 1665 and 1650 cm⁻¹ (CO); 1H NMR: 3.1-4.1 (m, 10H, cyclohexyl-H); 2.8 (s, 2H, 2NH); 7.2-8.2 (m, 13H, aromatic CH and NH₂); MS: m/z 427 (M⁺).

C₂₅H₂₅N₆O₂ (440.46)
Calcd C 65.45 H 4.58 N 19.08%,
Found C 65.7 H 4.8 N 19.3%.
Methyl-6-amino-10-cyano-5-oxo-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]-isoquinoline]-7,8-dicarboxlyte (17)

Compound 17 was obtained as gray crystals from DMF/ethanol (73%); m.p. 310 °C; IR: 3400–3350 cm⁻¹ (NH₂); 3350–3220 cm⁻¹ (2NH); 2200 cm⁻¹ (CN); 1680 and 1650 cm⁻¹ (2CO); ¹H NMR: δ 3.7 (s, 6H, 2CH₃); 4.0–4.5 (m, 10H, cyclohexyl-H); 8.2 (m, 3H, aromatic CH and NH₂); 8.7 (2H, 2NH); MS: m/z 411 (M⁺).

C₂₀H₂₁N₅O₅ (411.42)
Calcd  C 58.39  H 5.4  N 17.02%,
Found C 58.6  H 5.4  N 17.3%.

6-Amino-5-oxo-10-mercapto-1H-2,3-dihydro-2-spiro[cyclohexan-1,2,4-triazolo[1,5-a]-isoquinoline]-7,8,10-pentacarbonitriles (18)

Compound 18 was obtained as gray crystals from DMF/ethanol (66%); m.p. 320 °C; IR: 3410–3330 cm⁻¹ (NH₂); 3320–3200 cm⁻¹ (2NH); 2200 cm⁻¹ (CN); 1650 cm⁻¹ (CO); ¹H NMR: (insoluble); MS: m/z 429 (M⁺).

C₂₀H₁₅N₉OS (429.46)
Calcd  C 55.94  H 3.52  N 29.35  S 7.47%,
Found C 56.2  H 3.8  N 29.5  S 7.5%.