Novel Ring-Opening Reactions of 3-Substituted 1-Amino-2-thioxo-4-imidazolidinones: Preparation of Functionalized 3,6-Dihydro-2*H*-1,3,4-thiadiazines and 3,4-Dihydro-1*H*-1,2,4-triazoles

Pedro Molina,* Antonio Arques, Inmaculada Cartagena, José María Olmos

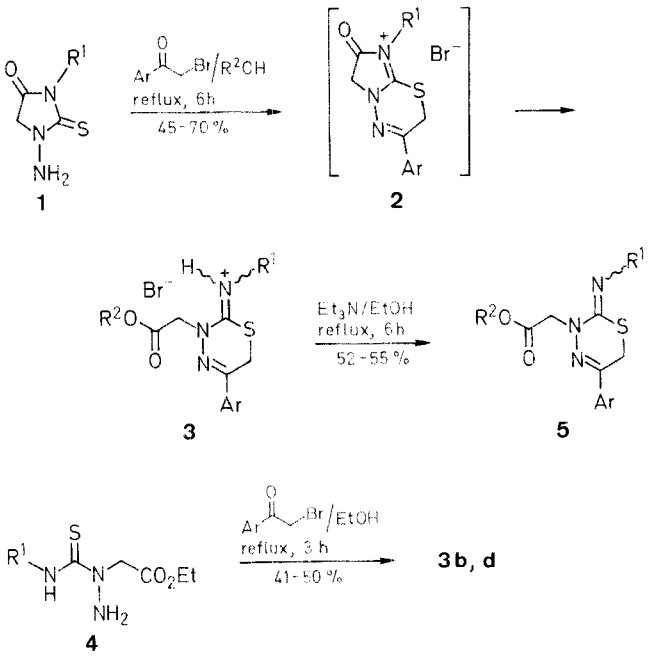
Departamento de Química Orgánica, Facultad de Ciencias, Universidad de Murcia, E-30001 Murcia, Spain

1-Amino-2-thioxo-4-imidazolidinones **1** react with phenacyl bromides to yield 3-alkoxycarbonylmethyl-5-aryl-2-iminio-3,6-dihydro-2*H*-1,3,4-thiadiazine salts **3**. Compounds **1** also react with aryl isothiocyanates to give *N*-aryl-*N'*-(3-aryl/alkyl-4-oxo-2-thioxoimidazolidinyl)thioureas **6**, which by the action of amines undergo a ring-closure/ring-opening reaction to give 4-aryl-1-aryl/alkylaminocarbonylmethyl-3-sulfido-5-thioxo-3,4-dihydro-1*H*-1,2,4-triazole derivatives **7**

The chemistry of 1-aminothiohydantoins remains nearly unexplored; only their preparation, from aryl isothiocyanates and ethyl hydrazinoacetate, and reactions with acetic anhydride and acetone have been reported.[1] As a part of our synthetic program on *N*-aminoheterocycles,[2] we wish to expand the versatility of 3-substituted 1-amino-2-thioxo-4-imidazolidinones (1-aminothiohydantoins) **1**, as suitable synthons for the preparation of highly functionalized 3,6-dihydro-2*H*-1,3,4-thiadiazines **5** and 3,4-dihydro-1*H*-1,2,4-triazoles **7**.

Our approach to the preparation of 3,6-dihydro-2*H*-1,3,4-thiadiazines **5** is based on the ring opening of **1** by the reaction of phenacyl bromides. Thus, compounds **1** react with several phenacyl bromides in alcoholic solution at reflux temperature to give the corresponding 2-iminio-3,6-dihydro-2*H*-1,3,4-thiadiazine salts **3** as crystalline solids in moderate yields (Table 1). Similar results can be achieved from *N*-amino-*N*-ethoxycarbonylmethyl-*N'*-arylthioureas **4** and phenacyl bromides. When ethanolic solutions of salts **3** are treated with triethylamine at room temperature the corresponding 3,6-dihydro-2*H*-1,3,4-thiadiazines **5** are obtained in moderate yields.

Support for the formulation of **3** is clearly provided by their elemental analyses and spectral data. The IR spectra of **3** show absorption bands in the region 1791–1732 cm^{-1} for the carbonyl group and a strong band in the region 1585–1551 cm^{-1} attributable to the C=N bond. In the ^{1}H-NMR spectra, the chemical shifts of *S*-methylene and *N*-methylene groups are characteristic[3] at $\delta = 4.14–4.63$ and $\delta = 4.88–5.18$, respectively.



3	Ar	R^1	R^2
a	4-$O_2NC_6H_4$	Ph	Me
b	4-$O_2NC_6H_4$	Ph	Et
c	4-$MeOC_6H_4$	Ph	Me
d	4-$MeOC_6H_4$	Ph	Et
e	Ph	Ph	Me
f	4-BrC_6H_4	Ph	Me
g	4-$O_2NC_6H_4$	Et	Me
h	4-BrC_6H_4	Et	Me
i	Ph	Et	Me
j	4-ClC_6H_4	Et	Me

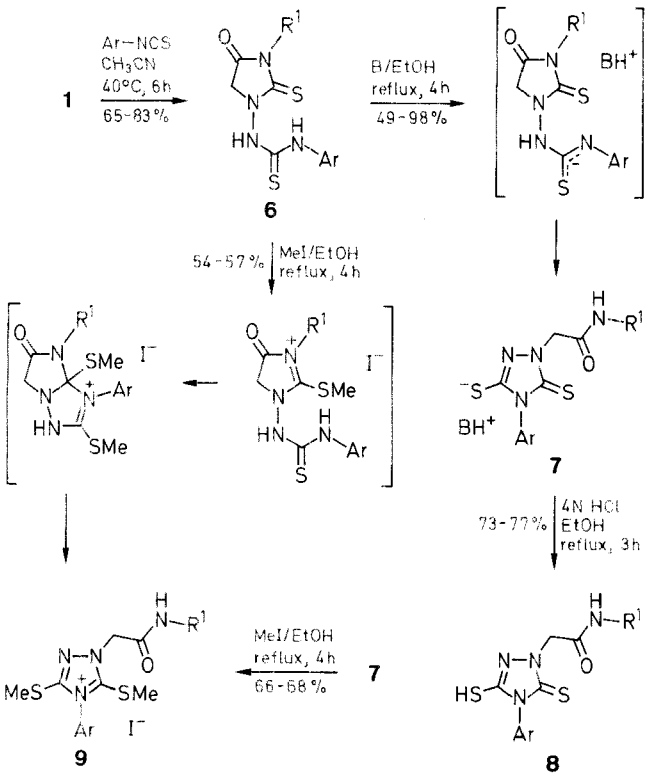
Scheme A

Mass spectra do not show the molecular ion peaks; peaks are found at m/z [$M^+ - HBr$], [$R^1 - NCNH$], being [Ar—CN^+] the base peak.

We believe that the conversion **1** → **3** involves initial cyclocondensation of the *N*-aminoheterocycle **1** with the phenacyl bromide to give the bicyclic salts **2** which by the action of the alcohol undergo ring opening of the five-membered ring to give **3**.

On the other hand, 4-imidazolidinones **1** react with aromatic isothiocyanates in dry acetonitrile at 40°C for 6 h to give the corresponding thioureas **6** as crystalline solids in good yields (65–83%) (Table 2). When ethanolic solutions of compounds **6** are treated with amines at reflux temperature the corresponding salts **7** are isolated as crystalline solids in moderate to excellent yields (49–98%) (Table 2). Presumably, the **6** → **7** transformation involves initial proton abstraction from the thiourea moiety and subsequent cyclization by intramolecular nucleophilic attack of the nitrogen atom of the thiourea group and concomitant ring-opening of the 4-imidazolidine would give the corresponding salts **7**. Neutral 3,4-dihydro-1*H*-1,2,4-triazoles **8** can be obtained from **7** in almost quantitative yields by treatment with concentrated hydrochloric acid. When ethanolic solutions of compound **7** are treated with an excess of methyl iodide at reflux temperature for 4 h the corresponding 1,4-disubstituted 3,5-bis(methylthio)-4,5-dihydro-1*H*-1,2,4-triazol-4-ium iodides **9** are isolated in good yields. Similar results can be achieved from thioureas **6** under the same reaction conditions. A tentative mechanism for the conversion **6** → **9** involves an intramolecular attack of the nitrogen atom of the thiourea group on the isothiourea moiety of the five-membered ring to form the 1,2,4-triazole ring and subsequent *S*-methylation and ring-opening of the imidazoline ring to give **9**.

Determination of the structure of compounds **6** and **7** is accomplished on the basis of spectral data and microanalyses. Salient features of the IR, ^{1}H-NMR, and MS are given in Table 2. The IR spectra of compounds **8** show absorption bands in the region 3284–3267 cm^{-1} due to the NH group and a strong absorption band at ν = 1670 cm^{-1} attributable to the carbonyl group. In the ^{1}H-NMR spectra, the chemical shift of the methylene group is characteristic at δ = 5.20. Mass spectra show the expected molecular ion peaks, being the fragment at m/z [Ar—NCS] the base peak. The IR spectra of compound **9** show bands in the region 3199–3165 cm^{-1} corresponding to the NH group and a strong band in the region 1698–1676 cm^{-1} due to the carbonyl group. ^{1}H-NMR spectra show among others a singlet at δ = 5.65 corresponding to the methylene protons and singlets at δ = 2.40 and δ = 2.80 corresponding to the methylthio groups on positions 3 and 5, respectively. Mass spectra do not show the molecular ion peaks, being the more characteristic peaks those corresponding to the fragment [$M^+ - CH_3I$] and [Ar—NCS].



6	Ar	R^1	7	Ar	R^1	B
a	Ph	Ph	a	4-BrC_6H_4	Ph	Et_3N
b	4-ClC_6H_4	Ph	b	4-BrC_6H_4	Ph	pyrrolidine
c	4-BrC_6H_4	Ph	c	4-BrC_6H_4	Ph	piperidine
d	4-ClC_6H_4	C_2H_5	d	4-BrC_6H_4	Ph	morpholine
e	4-BrC_6H_4	C_2H_5	e	4-ClC_6H_4	Ph	Et_3N
			f	4-ClC_6H_4	Ph	pyrrolidine
			g	4-BrC_6H_4	Ph	DBU
			h	4-BrC_6H_4	Et	Et_3N

Scheme **B**

3-Alkoxycarbonylmethyl-2-iminio-3,6-dihydro-2*H*-1,3,4-thiadiazine Bromides 3; General Procedure:

Method A: To a well stirred solution of 1-amino-2-thioxo-4-imidazolidinone **1**[1] (3 mmol) in the appropriate alcohol (20 mL), the corresponding phenacyl bromide (3 mmol) is added. The reaction mixture is stirred at reflux for 6 h. After cooling, the solution is concentrated to dryness, and the residual material is recrystallized from EtOH to give **3** (Table 1).

Method B: To a well stirred solution of *N*-amino-*N*-ethoxycarbonylmethyl-*N'*-phenylthiourea (**4**)[1] (3 mmol) in EtOH (20 mL) the appropriate phenacyl bromide (3 mmol) is added. The reaction mixture is stirred at reflux for 3 h. Work-up as in the above method gives **3b** (50%) and **3d** (41%).

3-Alkoxycarbonylmethyl-5-aryl-2-imino-3,6-dihydro-2*H*-1,3,4-thiadiazines 5; General Procedure:

To a well stirred solution of the appropriate 2-iminio-3,6-dihydro-2*H*-1,3,4-thiadiazine bromide **3** (3 mmol) in EtOH (30 mL), Et_3N (0.30 g, 3 mmol) is added. The resultant solution is stirred at reflux for 6 h. After cooling, the solution is concentrated to dryness, and the residual material is washed with H_2O (10 mL) and recrystallized from EtOH to give **5**.

5-(4-Bromophenyl)-3-methoxycarbonylmethyl-2-phenylimino-3,6-dihydro-2H-1,3,4-thiadiazine (**5a**; R^1 = Ph, R^2 = CH_3, Ar = 4-BrC_6H_4): yield: 52%; colorless prisms; mp 143°C.

$C_{18}H_{16}BrN_3O_2S$ (418.3) calc. C 51.68 H 3.86 N 10.04; found 51.70 3.78 9.89

IR (Nujol): ν = 1727 cm^{-1}.

^{1}H-NMR (DMSO-d_6): δ = 3.67 (s, 3H); 3.98 (s, 2H); 4.79 (s, 2H); 6.72 (d, 2H, J = 6.8 Hz); 7.18 (m, 4H); 7.65 (m, 3H).

MS (EI, 70 eV): m/z (%) = 419 (M^+ + 2, 5); 417 (M^+, 5); 360 (4); 358 (4); 284 (10); 282 (10); 183 (96); 181 (100); 135 (24).

3-Methoxycarbonylmethyl-5-(4-nitrophenyl)-2-phenylimino-3,6-dihydro-2H-1,3,4-thiadiazine (**5b**; R^1 = Ph, R^2 = CH_3, Ar = 4-$O_2NC_6H_4$): yield: 55%; yellow prisms; mp 153°C.

$C_{18}H_{16}N_4O_4$ (384.4) Scalc. C 56.24 H 4.20 N 14.58; found 55.98 4.11 14.56

IR (Nujol): ν = 1761 cm^{-1}.

^{1}H-NMR ($CDCl_3$): δ = 3.72 (s, 3H); 3.86 (s, 2H); 5.03 (s, 2H); 6.81–7.63 (m, 5H); 8.05 (d, 2H, J = 9 Hz); 8.40 (d, 2H, J = 9 Hz).

MS (EI, 70 eV): m/z (%) = 384 (M^+, 20); 281 (12); 249 (23); 189 (10); 177 (30); 148 (100).

Table 1. 3-Alkoxycarbonylmethyl-5-aryl-2-iminio-3,6-dihydro-2*H*-1,3,4-thiadiazines **3** Prepared

Product	Yield[a] (%)	mp (°C)[b] (solvent)	Molecular Formula[c]	IR (Nujol)[d] ν (cm^{-1})	^{1}H-NMR (DMSO-d_6)[e] δ, J (Hz)	MS (70 eV)[f] m/z (%)
3a	50	205–207 (MeOH)	$C_{18}H_{17}BrN_4O_4S$ (465.3)	1748, 1552, 1530, 1350, 1246, 856, 730, 690	3.68 (s, 3H); 4.14 (s, 2H); 4.88 (s, 2H); 6.80 (d, 2H, J = 7.7); 7.09 (t, 1H, J = 7.4); 7.31 (t, 2H, J = 7.7); 8.05 (d, 2H, J = 8.9); 8.27 (d, 2H, J = 8.9)	384 (M$^+$ – HBr, 15); 325 (10); 281 (11); 249 (13); 177 (30); 149 (15); 148 (100); 135 (46); 118 (63); 120 (40); 77 (49)
3b	53	124–125 (EtOH)	$C_{19}H_{19}BrN_4O_4S$ (479.3)	1732, 1568, 1517, 1342, 1245, 1200, 1132, 1019, 911, 854, 752, 724, 696	1.20 (t, 3H, J = 7); 4.20 (s, 2H); 4.25 (q, 2H, J = 7); 4.90 (s, 2H); 6.70–7.00 (m, 2H); 7.20–7.60 (m, 3H); 8.25 (d, 2H, J = 8); 8.50 (d, 2H, J = 8)	398 (M$^+$ – HBr, 15); 325 (12); 295 (10); 222 (14); 177 (30); 149 (15); 148 (100); 136 (15); 135 (33); 118 (21); 102 (41); 77 (50)
3c	70	154–156 (EtOH)	$C_{19}H_{20}BrN_3O_3S$ (450.3)	1746, 1598, 1556, 1428, 1329, 1262, 1188, 1027, 930, 838, 721, 696	3.80 (s, 3H); 3.90 (s, 3H); 4.20 (s, 2H); 5.06 (s, 2H); 7.00–7.60 (m, 7H); 8.00 (d, 2H, J = 8.5)	369 (M$^+$ – HBr, 10); 234 (10); 177 (8); 135 (15); 134 (20); 133 (100); 118 (10); 77 (18)
3d	63	143–145 (EtOH)	$C_{20}H_{22}BrN_3O_3S$ (464.4)	1791, 1558, 1518, 1335, 1261, 1221, 1033, 929, 849, 825, 696	1.35 (t, 3H, J = 7); 3.96 (s, 3H); 4.20 (s, 2H); 4.40 (q, 2H, J = 7); 5.15 (s, 2H); 7.15 (d, 2H, J = 8.5); 7.60 (s, 5H); 8.10 (d, 2H, J = 8.5)	383 (M$^+$ – HBr, 8); 338 (7); 248 (10); 177 (10); 135 (15); 134 (20); 133 (100); 118 (10); 77 (20)
3e	49	204–206 (EtOH)	$C_{18}H_{18}BrN_3O_2S$ (420.3)	1746, 1553, 1436, 1362, 1258, 1230, 1181, 987, 921, 765, 722, 695	3.68 (s, 3H); 4.14 (s, 2H); 4.95 (s, 2H); 6.92–7.79 (m, 10H)	339 (M$^+$ – HBr, 15); 280 (25); 236 (18); 204 (10); 177 (20); 135 (15); 131 (10); 118 (10); 104 (12); 103 (100); 77 (40)
3f	55	174–175 (MeOH)	$C_{18}H_{17}Br_2N_3O_2S$ (499.2)	1736, 1591, 1551, 1438, 1398, 1245, 1070, 1007, 990, 820, 730, 696	3.77 (s, 3H); 4.15 (s, 2H); 5.00 (s, 2H); 6.90–7.95 (m, 9H)	419 (M$^+$ + 2 – HBr, 5); 417 (M$^+$ – HBr, 5); 284 (10); 282 (10); 184 (15); 183 (100); 182 (15); 181 (93); 135 (25); 118 (10); 102 (63); 77 (40)
3g	45	206–208 (EtOH)	$C_{14}H_{17}BrN_4O_4S$ (417.3)	1748, 1584, 1531, 1350, 1232, 1139, 980, 857, 822, 752, 687	1.33 (t, 3H, J = 7.15); 3.70 (q, 2H, J = 7.15); 3.90 (s, 3H); 4.53 (s, 2H); 5.13 (s, 2H); 8.30 (d, 2H, J = 9); 8.55 (d, 2H, J = 9)	336 (M$^+$ – HBr, 15); 305 (10); 281 (60); 249 (20); 149 (15); 148 (100); 132 (15); 102 (40); 59 (15)
3h	45	179–181 (EtOH)	$C_{14}H_{17}Br_2N_3O_2S$ (451.2)	1738, 1579, 1489, 1329, 1232, 1184, 1072, 1008, 987, 925, 896, 817, 758	1.35 (t, 3H, J = 7.20); 3.70 (q, 2H, J = 7.20); 3.72 (s, 3H); 4.63 (s, 2H); 5.10 (s, 2H); 8.08 (m, 4H)	371 (M$^+$ + 2 – HBr, 5); 369 (M$^+$ – HBr, 5); 340 (10); 338 (10); 316 (20); 314 (20); 284 (10); 282 (10); 184 (15); 183 (96); 182 (15); 181 (100); 102 (78)
3i	49	187–189 (EtOH)	$C_{14}H_{18}BrN_3O_2S$ (372.3)	1736, 1585, 1257, 1228, 1143, 1047, 985, 939, 928, 764, 718, 690	1.30 (t, 3H, J = 8); 3.60 (q, 2H, J = 8); 3.85 (s, 3H); 4.53 (s, 2H); 5.17 (s, 2H); 7.55–7.80 (m, 3H); 7.95–8.30 (m, 2H)	291 (M$^+$ – HBr, 5); 236 (20); 204 (10); 104 (12); 103 (100); 77 (28); 59 (10)
3j	51	186–188 (EtOH)	$C_{14}H_{17}BrClN_3O_2S$ (406.7)	1744, 1585, 1494, 1410, 1330, 1240, 1087, 1033, 820, 758	1.30 (t, 3H, J = 8); 3.70 (q, 2H, J = 8); 3.90 (s, 3H); 4.55 (s, 2H); 5.18 (s, 2H); 7.80 (d, 2H, J = 8); 8.15 (d, 2H, J = 8)	327 (M$^+$ + 2 – HBr, 5); 325 (M$^+$ – HBr, 15); 272 (15); 270 (45); 240 (3); 238 (10); 140 (4); 139 (34); 138 (12); 137 (100); 102 (17); 59 (5)

[a] Yield of isolated pure product.
[b] Uncorrected.
[c] Satisfactory microanalyses obtained: C ±0.3, H ±0.15, N ±0.35.
[d] Recorded on a Nicolet FT 5DX spectrophotometer.
[e] Recorded at 80 MHz on a Varian FT-80 spectrometer.
[f] Recorded on a Hewlett-Packard 5993 C instrument.

Table 2. Thioureas **6** and 3-Sulfido-5-thioxo-3,4-dihydro-1*H*-1,2,4-triazoles **7** Prepared

Product	Yield[a] (%)	mp (°C)[b] (solvent)	Molecular Formula[c]	IR (Nujol)[d] ν (cm^{-1})	^{1}H-NMR[e] δ, J (Hz)	MS (70 eV)[f] m/z (%)
6a	65	216–218 (MeOH)	$C_{16}H_{14}N_4OS_2$ (342.5)	3313, 3216, 1755, 1562, 1500, 1285, 1194, 1058, 1024, 758, 720, 696	4.70 (s, 2H); 7.66 (m, 10H); 10.06 (br s, 2H)	342 (M$^+$, 5); 304 (6); 224 (10); 209 (6); 207 (45); 136 (15); 135 (100); 93 (18)
6b	68	218–220 (EtOH)	$C_{16}H_{13}ClN_4OS_2$ (376.9)	3307, 3205, 1755, 1613 1557, 1285, 1194, 1067, 1013, 826, 741, 696	4.70 (s, 2H); 7.35 7.90 (m, 9H); 10.42 (s, 1H); 10.53 (s, 1H)	378 (M$^+$ + 2, 2); 376 (M$^+$, 6); 343 (10); 207 (68); 192 (13); 171 (34); 169 (100); 136 (13); 135 (89); 129 (9); 127 (36); 113 (10); 111 (33); 77 (43)

Table 2. (continued)

Product	Yield[a] (%)	mp (°C)[b] (solvent)	Molecular Formula[c]	IR (Nujol)[d] ν(cm^{-1})	^{1}H-NMR[e] δ, J(Hz)	MS (70 eV)[f] m/z (%)
6c	75	196–198 (EtOH)	$C_{16}H_{13}BrN_4OS_2$ (421.3)	3313, 3199, 1749, 1613, 1596, 1517, 1285, 1194, 1160, 1007, 939, 854, 820, 696	4.71 (s, 2H); 7.76 (m, 9H); 10.36–10.50 (m, 2H)	422 ($M^+ + 2$, 5); 420 (M^+, 5); 249 (11); 226 (30); 224 (100); 215 (66); 213 (42); 107 (99)
6d	70	189–191 (EtOH)	$C_{12}H_{13}ClN_4OS_2$ (328.8)	3273, 3202, 1761, 1591, 1545, 1262, 1223, 1121, 1087, 1041, 1013, 951, 837	1.20 (t, 3H, J = 8); 3.83 (q, 2H, J = 8); 4.56 (s, 2H); 7.20–8.00 (m, 4H); 10.36 (m, 2H)	330 ($M^+ + 2$, 3); 328 (M^+, 9); 297 (9); 295 (26); 180 (24); 176 (100); 171 (16); 169 (39); 154 (13); 152 (42); 144 (33); 143 (46); 129 (20); 127 (68)
6e	83	196–198 (EtOH)	$C_{12}H_{13}BrN_4OS_2$ (373.3)	3287, 3219, 1761, 1585, 1545, 1506, 1279, 1226, 1149, 1121, 1075, 1007, 951, 849, 781, 690	1.10 (t, 3H, J = 8); 3.85 (q, 2H, J = 8); 4.50 (s, 2H); 7.50–7.80 (s, 4H); 10.10 (br s, 2H)	374 ($M^+ + 2$, 5); 372 (M^+, 5); 216 (10); 215 (100); 214 (10); 213 (98); 173 (47); 171 (47); 159 (76); 156 (27); 155 (30); 144 (12); 142 (19); 92 (37); 90 (42)
7a	94	160–163 (MeOH)	$C_{22}H_{28}BrN_5OS_2$ (522.5)	3180, 2661, 2627, 1703, 1605, 1533, 1267, 1246, 1204, 1190, 1069, 870, 835, 756, 690	1.25 (t, 9H, J = 7.4); 3.08–3.17 (m, 6H); 4.92 (s, 2H); 7.05 (t, 1H, J = 8); 7.25 (t, 2H, J = 8.3); 7.31 (d, 2H, J = 8.6); 7.48 (d, 2H, J = 8.2); 7.50 (d, 2H, J = 8.6); 9.41 (s, 1H); 10.61 (s, 1H)	422 ($M^+ + 2 - Et_3N$, 13); 420 ($M^+ - Et_3N$, 13); 330 (36); 329 (41); 328 (34); 327 (39); 303 (15); 302 (44); 301 (15); 300 (44); 270 (7); 268 (7); 216 (44); 215 (46); 214 (42); 213 (55); 157 (30); 155 (28)
7b	98	208–210 (MeOH)	$C_{20}H_{22}BrN_5OS_2$ (492.5)	3307, 2684, 2622, 1671, 1603, 1546, 1268, 1246, 1200, 1070, 951, 866, 753, 719, 690	1.85 (m, 4H); 3.15 (m, 4H); 4.90 (s, 2H); 7.10–7.90 (m, 9H); 8.70 (m, 1H); 9.50 (s, 1H); 10.50 (s, 1H)	422 ($M^+ + 2 - C_4H_9N$, 24); 420 ($M^+ - C_4H_9N$, 23); 330 (40); 329 (43); 328 (36); 327 (37); 303 (22); 302 (50); 301 (18); 300 (49); 270 (7); 268 (7); 216 (37); 215 (50); 214 (53); 213 (48); 157 (31)
7c	84	199–201 (MeOH)	$C_{21}H_{24}BrN_5OS_2$ (506.5)	3205, 2503, 1681, 1602, 1579, 1540, 1268, 1206, 1160, 1092, 1064, 1013, 996, 815, 752, 718	1.60 (m, 6H); 3.10 (m, 4H); 3.70 (s, 2H); 5.00 (s, 2H); 7.10–7.90 (m, 9H); 9.65 (s, 1H)	422 ($M^+ + 2 - C_5H_{11}N$, 5); 420 ($M^+ - C_5H_{11}N$, 5); 330 (21); 329 (20); 328 (17); 327 (16); 302 (22); 300 (21); 216 (23); 215 (30); 214 (21); 213 (28); 157 (20); 155 (19); 87 (100)
7d	89	187–189 (EtOH)	$C_{20}H_{22}BrN_5O_2S_2$ (508.5)	3279, 2673, 2610, 1667, 1602, 1540, 1262, 1200, 1104, 1070, 1047, 996, 752, 718, 690	3.85 (m, 4H); 4.00 (m, 4H); 5.15 (s, 2H); 7.00–8.00 (m, 9H); 9.10 (m, 1H)	422 ($M^+ + 2 - C_4H_8NO$, 5); 420 ($M^+ - C_4H_8NO$, 5); 330 (14); 329 (15); 328 (13); 327 (12); 302 (22); 300 (21); 216 (32); 215 (39); 214 (27); 213 (38); 157 (27); 155 (25); 135 (49); 87 (100)
7e	79	147–148 (MeOH)	$C_{22}H_{28}ClN_5OS_2$ (478.1)	3262, 2661, 1704, 1602, 1545, 1500, 1245, 1186, 1092, 996, 871, 837, 758	1.20 (t, 9H, J = 7.8); 3.20 (q, 6H, J = 7.8); 5.00 (s, 2H); 7.20–7.90 (m, 9H); 9.60 (s, 1H); 10.40 (s, 1H)	378 ($M^+ + 2 - Et_3N$, 15); 376 ($M^+ - Et_3N$, 45); 286 (27); 285 (36); 284 (67); 283 (75); 259 (13); 258 (39); 257 (33); 256 (92); 172 (31); 171 (49); 170 (87); 169 (100)
7f	89	199–201 (MeOH)	$C_{20}H_{22}ClN_5OS_2$ (456.0)	3275, 2684, 1670, 1602, 1545, 1500, 1253, 1245, 1200, 1098, 956, 866, 758, 690	1.80 (m, 4H); 3.10 (m, 4H); 4.90 (s, 2H); 7.10–7.90 (m, 9H); 8.71 (m, 1H); 9.51 (s, 1H); 10.60 (s, 1H)	378 ($M^+ + 2 - C_4H_9N$, 2); 377 (13); 376 ($M^+ - C_4H_9N$, 6); 375 (32); 285 (25); 284 (38); 283 (65); 282 (69); 258 (13); 257 (41); 256 (36); 255 (100)
7g	76	224–227 (EtOH)	$C_{25}H_{29}BrN_6OS_2$ (573.6)	3216, 1698, 1642, 1602, 1585, 1545, 1262, 1245, 1194, 1160, 996, 758, 696	1.60 (m, 9H); 3.40 (m, 7H); 4.90 (s, 2H); 7.10–7.90 (m, 9H); 9.40 (s, 1H); 10.30 (s, 1H)	
7h	49	138–140 (MeOH)	$C_{18}H_{28}BrN_5OS_2$ (474.5)	3266, 2621, 1689, 1531, 1490, 1174, 1372, 1279, 1238, 1200, 1068, 1016, 998, 846, 825, 717	1.10–1.50 (m, 12H); 3.20 (q, 8H, J = 8); 4.85 (s, 2H); 7.10 (s, 1H); 7.00–8.00 (m, 4H); 10.95 (s, 1H)	374 ($M^+ + 2 - Et_3N$, 5); 372 ($M^+ - Et_3N$, 5); 290 (10); 288 (10); 216 (3); 215 (5); 214 (3); 213 (5); 136 (8); 134 (8); 101 (17); 87 (27); 86 (100)

[a] Yield of isolated pure product.
[b] Uncorrected.
[c] Satisfactory microanalyses obtained: C ±0.3, H ±0.15, N ±0.35.
[d] Recorded on a Nicolet FT 5DX spectrophotometer.
[e] Recorded at 80 MHz on a Varian FT-80 spectrometer, using TMS as internal standard and DMSO-d_6 as solvent, except for compound **7d** for which $CDCl_3$ + TFA was used.
[f] Recorded on a Hewlett-Packard 5993 C instrument.

N-Aryl-N'-(3-aryl/alkyl-4-oxo-2-thioxoimidazolidinyl)thioureas 6; General Procedure:

To a solution of 1-amino-2-thioxo-4-imidazolidinone **1** (5 mmol) in dry CH_3CN (50 mL), the appropriate aryl isothiocyanate (5 mmol) is added. The resultant solution is stirred at 40°C for 6 h. After cooling, the solvent is evaporated under reduced pressure, and the residual material is recrystallized from EtOH to give **6** (Table 2).

1-Substituted 4-Aryl-3-sulfide-5-thioxo-4,5-dihydro-1*H*-1,2,4-triazoles 7; General Procedure:

To a well stirred solution of thioureas **6** (6 mmol) in EtOH (90 mL), the corresponding amine (6 mmol) is added. The resultant mixture is heated at reflux for 4 h. After cooling, the solvent is evaporated under reduced pressure. The residual material is slurried in cold Et_2O (20 mL), stirred for 30 min, and filtered off. The crude product is recrystallized from EtOH to give **7** as crystalline solids (Table 2).

1-Substituted 4-Aryl-3-mercapto-5-thioxo-4,5-dihydro-1*H*-1,2,4-triazoles 8; General Procedure:

To a suspension of 1,2,4-triazole **7** (3 mmol) in EtOH (30 mL), 4 N HCl (1 mL) is added. The resultant mixture is stirred at reflux for 3 h. After cooling, the solvent is removed off under reduced pressure, and the residue is washed with H_2O (10 mL) and recrystallized from EtOH to give **8**.

4-(4-Bromophenyl)-3-mercapto-1-phenylaminocarbonylmethyl-5-thioxo-4,5-dihydro-1H-1,2,4-triazole (**8a**; R^1 = Ph, Ar = 4-BrC_6H_4): yield: 77%; colorless prisms; mp 198°C.

$C_{16}H_{13}BrN_4OS_2$	calc.	C 45.61	H 3.11	N 13.30
(421.4)	found	45.39	3.19	13.18

IR (Nujol): ν = 3284, 1670 cm^{-1}.

^{1}H-NMR (DMSO-d_6): δ = 5.20 (s, 2H); 7.11–8.00 (m, 9H); 10.50 (s, 1H).

MS (EI, 70 eV): *m/z* (%) = 422 (M^+ + 2, 2); 420 (M^+, 20); 375 (5); 373 (5); 330 (8); 329 (10); 328 (8); 327 (8); 302 (12); 300 (11); 216 (12); 215 (17); 214 (11); 213 (15); 57 (100).

4-(4-Chlorophenyl)-3-mercapto-1-phenylaminocarbonylmethyl-5-thioxo-4,5-dihydro-1H-1,2,4-triazole (**8b**; R^1 = Ph, Ar = 4-ClC_6H_4): yield: 73%; colorless prisms; mp 142°C.

$C_{16}H_{13}ClN_4OS_2$	calc.	C 50.99	H 3.47	N 14.86
(376.9)	found	51.22	3.31	14.74

IR (Nujol): ν = 3267, 1670 cm^{-1}.

^{1}H-NMR (DMSO-d_6): δ = 5.23 (s, 2H); 7.00–7.90 (m, 9H); 10.60 (s, 1H).

MS (EI, 70 eV): *m/z* (%) = 378 (M^+ + 2, 5), 376 (M^+, 15); 285 (28); 283 (67); 259 (15); 258 (51); 257 (39); 256 (99); 224 (16); 196 (22); 172 (30); 171 (43); 170 (78); 169 (100).

1-Substituted 4-Aryl-3,5-bis(methylthio)-3,4-dihydro-1*H*-1,2,4-triazol-4-ium Iodides 9; General Procedure:

To a solution of the thiourea **6** or 1,2,4-triazole **7** (4 mmol) in EtOH (30 mL), MeI (10 mmol) is added. The reaction mixture is stirred at reflux for 4 h. The solvent is removed off under reduced pressure, and the residual material is slurried with cold Et_2O (20 mL). The solid is collected by filtration and recrystallized from EtOH to give **9**.

3,5-Bis(methylthio)-4-(4-bromophenyl)-1-phenylaminocarbonylmethyl-3,4-dihydro-1H-1,2,4-triazol-4-ium Iodide (**9a**; R^1 = C_6H_5, Ar = 4-BrC_6H_4): yield: 62%; colorless prisms; mp 205–207°C.

$C_{18}H_{18}BrIN_4OS_2$	calc.	C 37.45	H 3.14	N 9.71
(577.3)	found	37.32	3.08	9.89

IR (Nujol): ν = 3199, 1698 cm^{-1}.

^{1}H-NMR (DMSO-d_6): δ = 2.40 (s, 3H); 2.80 (s, 3H); 5.65 (s, 2H); 7.10–8.70 (m, 9H); 10.90 (s, 1H).

MS (EI, 70 eV): *m/z* (%) = 436 (M^+ + 2 – CH_3I, 6); 434 (M^+ – CH_3I, 6); 344 (30); 342 (28); 216 (36); 215 (90); 214 (36); 213 (100); 209 (33); 162 (48); 157 (61); 155 (69); 149 (30); 135 (75).

3,5-Bis(methylthio)-4-(4-chlorophenyl)-1-phenylaminocarbonylmethyl-4,5-dihydro-1H-1,2,4-triazol-4-ium Iodide (**9b**; R^1 = C_6H_5, Ar = 4-ClC_6H_4): yield: 64%; colorless prisms; mp 186°C.

$C_{18}H_{18}ClIN_4OS_2$	calc.	C 40.57	H 3.40	N 10.52
(532.8)	found	40.31	3.36	10.48

IR (Nujol): ν = 3267, 1676 cm^{-1}.

^{1}H-NMR (DMSO-d_6): δ = 2.40 (s, 3H); 2.60 (s, 3H); 5.10 (s, 2H); 7.10–8.00 (m, 9H); 10.60 (s, 1H).

MS (EI, 70 eV): *m/z* (%) = 392 (M^+ + 2 – CH_3I, 24); 390 (M^+ – CH_3I, 64); 272 (32); 270 (80); 258 (20); 256 (48); 226 (8); 224 (16); 171 (30); 169 (100).

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