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Reaction of 3-aminoquinoline-2,4-diones with isothiocyanic acid—an easy pathway to thioxo derivatives of imidazo[1,5-*c*]quinazolin-5-ones and imidazo-[4,5-*c*]quinolin-4-ones

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ABSTRACT

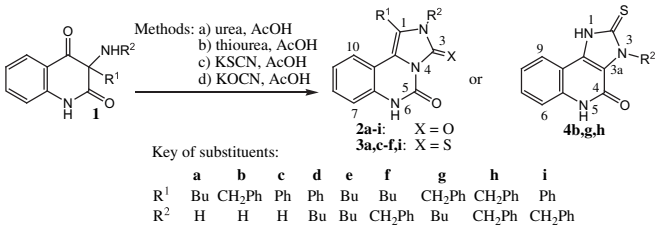
3-Amino-1*H*,3*H*-quinoline-2,4-diones react with thiourea or potassium thiocyanate in boiling acetic acid to give novel 2,3-dihydro-3-thioxoimidazo[1,5-*c*]quinazolin-5(6*H*)-ones in high yields. However, if the starting compounds are substituted with a benzyl group at position 3, a C-debenzylation proceeds to give 2,3-dihydro-2-thioxo-1*H*-imidazo[4,5-*c*]quinolin-4(5*H*)-ones. According to a proposed reaction mechanism, a molecular rearrangement of the primarily formed mono-substituted thiourea takes place. All compounds were characterized by ^{1}H, ^{13}C and ^{15}N NMR and IR spectroscopy as well as by mass spectrometry.

1. Introduction

In our laboratory, much attention has been paid to the reactivity of 3-alkyl/aryl-3-amino-quinolinediones **1**. The addition products of these compounds with isocyanic acid (from the decomposition of urea or nitrourea) or isocyanates rearrange in an acidic medium to give imidazoquinazolines, oxindoles, indolylureas, bis[2-(imidazolyl)phenyl]ureas, imidazol-ones, or spiro-linked imidazolidine-oxindoles, depending on the character of the substituents. An illustrative survey of these transformations is given in our last paper on this topic.[1]

The exceptional structural diversity of the reaction products of the molecular rearrangement mentioned above gave us incentive to perform an analogous reaction of 3-aminoquinolinediones **1** with isothiocyanates. We have found that the addition products of **1** with isothiocyanates also rearrange in an acidic medium, resulting in (*E*)- and/or (*Z*)-4-butylidene-2-thioxo-1′*H*-spiro[imidazoline-5,3′-indole]-2,2′-diones,[2] 4-(2-aminophenyl)-1*H*-imid-azole-2(3*H*)-thiones,[3] and 1,3-bis(2-(2,3-dihydro-2-thioxo-1*H*-imidazol-5-yl)phenyl)ureas.[3] Owing to the simple reaction protocols, these transformations open an easy pathway to the preparation of new types of heterocyclic compounds.

We have described the reaction of 3-amino-1*H*,3*H*-quinoline-2,4-diones **1** with urea in boiling acetic acid, which produces novel 2,6-dihydro-imidazo[1,5-*c*]quinazoline-3,5-diones **2** (Scheme 1, method A).[4] In anticipation of the possibility that 3-aminoquinolinediones **1** could have reacted analogously with isothiocyanic acid, we carried out experiments leading to this objective. We demonstrate in this work that the reaction of 3-aminoquinolinediones **1** with potassium thiocyanate in boiling acetic acid yields two structurally diverse products **3** and **4**, whereas the reaction of **1** with urea or potassium cyanate produces only single product **2**.



Scheme 1.

2. Results and discussion

Reactions of aminoketones **1** with compounds providing isocyanic or isothiocyanic acid (potassium cyanate, urea, thiourea,

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potassium thiocyanate) were performed by boiling the reaction components in acetic acid (Table 1). The starting aminoketones **1** were obtained from the corresponding 3-chloro derivatives in accordance with procedures described earlier.[5]

Table 1
Reactions of 3-aminoquinolinediones **1** with urea (method A)[a], thiourea (method B), KSCN (method C) and KOCN (method D)

Ewntry	Starting compound			Method	Time (min)	Products (yield, %)
	1	R^1	R^2			
1	**a**	Bu	H	A	90	**2a** (73)
2				B	30	**3a** (5), **Ac-1a** (18)[b]
3				C	5	**3a** (93)
4				D	60	**2a** (62)
5	**b**	Bz	H	A	20	**2b** (71)
6				B	30	**1b** (22)[b]
7				C	5	**4b** (70)
8				D	30	**2b** (64)
9	**c**	Ph	H	A	5	**2c** (90)
10				B	30	**3c** (16)
11				C	9	**3c** (82)
12				D	50	**2c** (58)
13	**d**	Ph	Bu	A	30	**2d** (76)
14				B	30	**3d** (2), **1d** (12)[c]
15				C	30	**3d** (70)
16				D	25	**2d** (80)
17	**e**	Bu	Bu	A	30	**2e** (95)
18				B	25	**3e** (3), **1e** (45)[c]
19				C	30	**3e** (79)
20				D	40	**2e** (78)
21	**f**	Bu	Bz	A	30	**2f** (93)
22				B	65	**3f** (4), **1f** (24)[c]
23				C	30	**3f** (53)
24				D	60	**2f** (74)
25	**g**	Bz	Bu	A	120	**2g** (87)
26				B	20	**4g** (4), **1g** (57)[c]
27				C	5	**4g** (66)
28				D	120	**2g** (74)
29	**h**	Bz	Bz	A	120	**2h** (66)
30				B	30	**1h** (21)[a]
31				C	10	**4h** (71)
32				D	130	**2h** (64)
33	**i**	Ph	Bz	A	—	—
34				B	120	**3i** (33), **1i** (3)[c]
35				C	30	**3i** (78)
36				D	120	**2i** (67)

[a] Data from Ref. 4.
[b] *N*(3)-Acetylated compound **1a**, identical in all respects to the authentic compound.[6]
[c] Recovered starting material.

We have found that the reactions of **1** with thiourea (method B) are relatively unsuccessful and in many cases only the starting compound was recovered (Table 1).

In contrast to urea, thiourea decomposes to isothiocyanic acid in only small amounts under the given reaction conditions. Therefore, we focused our attention on the reaction of **1** with potassium thiocyanate (method C). This reaction affords two different sets of products (Table 1). The first group of the products has ^{1}H and ^{13}C NMR spectra that are very similar to those of compounds **2**.[4] The only exception is the presence of NMR signals in the δ 160.1–161.6 ppm region (Table 2). It is evident that these signals can be attributed to C=S carbon atoms at the position 3; therefore, compounds of the first group are 2,3-dihydro-3-thioxoimidazo[1,5-*c*]quinazolin-5(6*H*)-ones **3a**,**c**–**f**,**i**. In cases **3a** and **3c**, the NH proton signals appear at δ 12.87 and 10.98 or 13.22 and 11.11 ppm. The occurrence of ^1J (^{15}N,^{1}H) for all of these protons (Table 2) excludes the possibility of S–H tautomers.

Mass spectra of compounds in the second group exhibit a molecular peak, that is, *m*/*z* 90 less than expected. In addition, signals corresponding to the C-benzyl group were not found in ^{1}H and ^{13}C NMR spectra of the reaction products from **1b**,**g**,**h**, which shows that a C-debenzylation must occur during the reaction. We postulated that the reaction products were 2,3-dihydro-2-thioxo-1*H*-imidazo[4,5-*c*]quinolin-4(5*H*)-ones **4b**,**g**,**h**. These structures were confirmed by certain assignment of all resonances using 2D NMR spectra (Table 3). In the NOESY spectrum, the H-1 protons have a cross-peak with the H-9 protons and the CONH protons have a cross-peak with the H-6 protons, which evidences their spatial vicinity. The determination of ^1J (^{15}N,^{1}H) for all NH protons (Table 3) excludes the possibility of the presence of S–H tautomers.

For comparison, we also carried out the reaction of compounds **1** with potassium cyanate in boiling acetic acid (Table 1, method D). From these experiments, only compounds **2** were obtained in yields somewhat lower than those obtained by method A.[4] A C-debenzylation was not observed in any case. This result pointed to the decisive conclusion that potassium thiocyanate is required for the debenzylation process. From potassium thiocyanate, only weak thiocyanic acid H-SCN (pK_a 5.4)[7] can be liberated with acetic acid (pK_a 4.75). However, this weak acid isomerizes promptly to the more stable isothiocyanic acid H-NCS, which is very strong acid (pK_a −1.3).[7,8] The formation of this acid causes the strong acidification of the reaction mixture, which leads to C-debenzylation. We have observed a similar reaction (C-debutylation) in the case of 3-butyl-3-thiocyanato-quinoline-2,4-diones during their reaction with concentrated sulfuric acid in the presence of phosphorus pentoxide.[9] Isocyanic acid (pK_a 3.9), arising from potassium cyanate and acetic acid through the weak isomeric cyanic acid (pK_a 6.4), is a mesoscale acid and does not induce a debenzylation of compounds **1**.

The proposed reaction mechanism (Scheme 2) supposes the addition of α-aminoketone **1** to isocyanic or isothiocyanic acid. This would create the intermediate **A**, which cyclizes to intermediate **B** and subsequently converts into intermediate **D**. In a medium-acidity environment, both of these intermediates convert to the isocyanate intermediate **C**, which provides product **2** (X=O) or **3** (X=S). The rearrangement of intermediate **B** to isocyanate intermediate **C** was observed in the reaction of compounds **1** with isocyanates.[10] On the other hand, in a strong-acidic medium, protonation of intermediate **D** proceeds and the protonated intermediate **D** stabilizes by ejecting the benzylic cation. We presumed that this cation reacts with high nucleophilic thiocyanate anion. Indeed, the presence of benzyl thiocyanate as the main component of the benzene extract of the aqueous portion after reaction of **1g** with potassium thiocyanate was evidenced by TLC analysis in three different solvent systems. This extract contains also a small quantity of benzyl alcohol; however, the presence of benzyl acetate was not observed.

3. Conclusions

In conclusion, we would like to emphasize that the described reaction of 3-aminoquinolinediones **1** with isothiocyanic acid generated from potassium thiocyanate allows the preparation, in very good yields, of 2,3-dihydro-3-thioxoimidazo[1,5-*c*]quinazolin-5(6*H*)-ones (**3**) and 2,3-dihydro-2-thioxo-1*H*-imidazo[4,5-*c*]quinolin-4(5*H*)-ones (**4**). Compounds **3** have not been previously described in the literature. Since many biologically active compounds contain a sulfur atom,[11,12] compounds **3** could also be interesting structures for study.

The C-debenzylation of starting compounds **1** bearing a benzyl group at position 3 not only has theoretical significance, but enables the targeted preparation of compounds **4** through a simple procedure. To our surprise, only one compound of this type, described as tautomeric 5-butyl-2-mercapto-1-methyl-1*H*-imidazo

Table 2
^{1}H and ^{13}C chemical shifts of compounds **2i** and **3a**,**c**–**f**,**i** in DMSO-d_6

Position	**2i**		**3a**		**3c**		**3d**		**3e**		**3f**		**3i**	
	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C
1	—	117.8	—	123.9	—	122.6	—	123.8	—	125.0	—	125.2	—	123.9
3	—	148.3	—	160.7	—	161.6	—	160.2	—	160.1	—	161.4	—	161.4
5	—	145.0	—	145.1	—	145.1	—	144.8	—	144.8	—	144.8	—	144.8
6	10.81	—	10.98[a]	—	11.11[b]	—	11.17	—	11.06	—	11.13	—	11.23	—
6a	—	134.5	—	134.3	—	134.6	—	134.4	—	134.2	—	134.3	—	134.5
7	7.04	115.3	7.09	115.1	7.10	115.3	7.10	115.2	7.11	115.1	7.13	115.2	7.12	115.3
8	7.18	128.3	7.29	128.0	7.27	128.8	7.25	128.9	7.32	128.3	7.32	128.5	7.26	129.0
9	6.79	122.6	7.15	123.2	6.90	122.6	6.84	122.7	7.19	123.3	7.18	123.3	6.83	122.7
10	6.73	121.2	7.63	121.8	7.19	120.9	6.67	121.4	7.66	122.0	7.61	122.1	6.68	121.5
10a	—	112.9	—	113.4	—	112.7	—	112.2	—	112.7	—	112.6	—	112.2
10b	—	113.5	—	119.8	—	120.3	—	120.3	—	119.3	—	119.7	—	120.8
1′(R^1)	—	128.1	2.83	24.2	—	128.2	—	128.0	2.99	23.7	2.84	24.1	—	127.7
2′(R^1)	7.40	131.0	1.62	30.0	7.60	129.2	7.63	131.2	1.60	30.1	1.20	29.4	7.36	131.0
3′(R^1)	7.55	129.4	1.40	21.7	7.60	129.9	7.70	129.8	1.53	21.9	1.34	21.8	7.54	129.5
4′(R^1)	7.58	130.1	0.94	13.8	7.60	129.9	7.70	130.6	0.99	13.7	0.81	13.6	7.61	130.5
1′(R^2)	4.72	43.9	12.87[c]	—	13.22[d]	—	3.91	43.7	4.18	43.2	5.65	46.2	5.29	46.9
2′(R^2)	—	137.0	—	—	—	—	1.52	28.9	1.69	29.5	—	136.4	—	136.0
3′(R^2)	6.99	126.7	—	—	—	—	1.14	19.3	1.43	19.6	7.28	126.7	6.98	126.7
4′(R^2)	7.27	128.5	—	—	—	—	0.72	13.5	0.99	13.7	7.39	128.7	7.24	128.3
5′(R^2)	7.27	127.3	—	—	—	—	—	—	—	—	7.32	127.5	7.24	127.2

[a] ^1J (15N, 1H)=97.4 Hz.
[b] ^1J (15N, 1H)=91.5 Hz.
[c] ^1J (15N, 1H)=92.1 Hz.
[d] ^1J (15N, 1H)=97.6 Hz.

Table 3
^{1}H, ^{13}C and ^{15}N chemical shifts of compounds **4b**,**g**,**h** in DMSO-d_6

Position	**4b**		**4g**		**4h**	
	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C
1 (NH)	13.57[a]	−219.4[b]	13.81	[b,c]	13.96[d]	—
2	—	167.1	—	166.2	—	167.5
3 (NR^2)	13.30[e]	−221.9[b]	—	−214.1[b]	—	—
3a	—	119.3	—	118.0	—	117.9
4	—	152.4	—	152.9	—	152.8
5 (NH)	11.90[f]	−233.9[b]	11.93[g]	−232.6[b]	11.95	—
5a	—	136.4	—	136.3	—	136.4
6	7.46	116.2	7.47	116.1	7.47	116.2
7	7.52	128.9	7.53	129.2	7.54	129.3
8	7.30	122.3	7.31	122.4	7.29	122.5
9	8.05	121.7	8.09	121.7	8.11	121.8
9a	—	109.7	—	109.5	—	109.5
9b	—	133.4	—	132.8	—	133.1
1′(R^2)	13.30[g]	−221.9[b]	4.50	44.4	5.76	47.3
2′(R^2)	—	—	1.79	30.9	—	137.3
3′(R^2)	—	—	1.38	19.4	7.43	127.7
4′(R^2)	—	—	0.96	13.8	7.32	128.3
5′(R^2	—	—	—	—	7.26	127.3

[a] ^1J (^{15}N, ^{1}H)=98.1 Hz.
[b] δ (^{15}N).
[c] Not found.
[d] Broadened signal.
[e] ^1J (^{15}N, ^{1}H)=99.4 Hz.
[f] ^1J (^{15}N, ^{1}H)=89.7 Hz.
[g] ^1J (^{15}N, ^{1}H)=90.0 Hz.

[4,5-*c*]quinolin-4(5*H*)-one, was found in the literature. This compound, which induces contraction in tracheal strips of passively sensitized guinea pigs, was prepared by five different multi-step reactions starting from 3-nitroquinolin-2-ones bearing a hydroxy, chloro, or methylamino substituent in position 4.[13]

4. Experimental

4.1. General

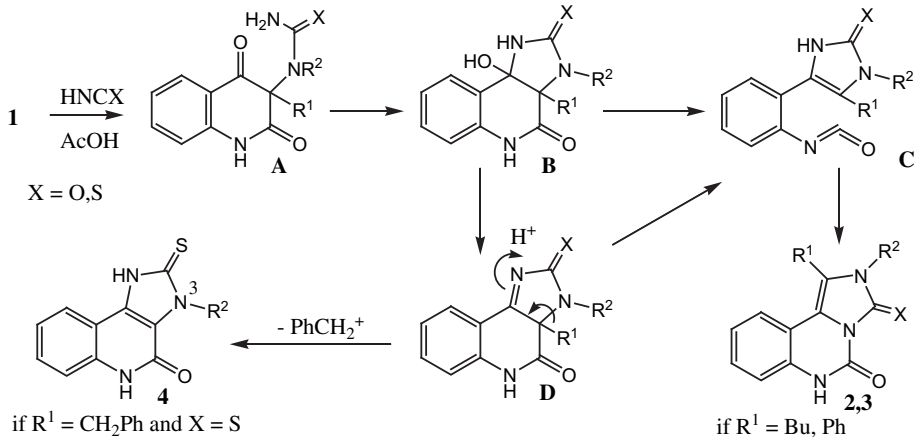
Melting points were determined on a Kofler block or Gallencamp apparatus. IR (KBr) spectra were recorded on a Mattson 3000 spectrophotometer. NMR spectra were recorded on a Bruker Avance spectrometer (500.13 MHz for ^{1}H, 125.76 MHz for ^{13}C, 50.68 MHz for ^{15}N) in DMSO-d_6 or $CDCl_3$. ^{1}H and ^{13}C chemical shifts are given on the δ scale (ppm) and are referenced to internal TMS. ^{15}N chemical shifts were referred to external neat nitromethane in co-axial capillary (δ=0.0). All 2D experiments (gradient-selected (gs)-COSY, NOESY, gs-HMQC, gs-HMBC) were performed using manufacturer's software. Proton spectra were assigned using gs-COSY. Protonated carbons were assigned by gs-HMQC. Quaternary carbons were assigned by gs-HMBC. The positive-ion EI mass spectra were measured on a Shimadzu QP-2010 instrument within the mass range m/z=50–600 using direct inlet probe (DI). Samples were dissolved in dichloromethane (30 μg/mL) and 10 μL of the solution was evaporated in DI cuvette at 50 °C. The ion source temperature was 200 °C; the energy of the electrons was 70 eV. Only signals exceeding relative abundance of 5% are listed. Column chromatography was carried out on Silica gel (Merck, grade 60, 70–230 mesh) using chloroform and then successive mixtures of chloroform/ethanol (in rations from 99:1 to 8:2) or benzene and then successive mixtures of benzene/ethyl acetate (in rations from 99:1 to 8:2). Reactions as well as the course of separation and also the purity of substances were monitored by TLC in elution systems benzene/ethyl acetate (4:1), chloroform/ethanol (9:1 and/or 19:1) and chloroform/ethyl acetate (7:3) on Alugram® SIL G/UV_{254} foils (Macherey–Nagel). Elemental analyses (C, H, N) were performed with a EA 1108 Elemental Analyzer (Fisons Instrument) at our Institute.

4.2. Starting 3-amino-1*H*,3*H*-quinoline-2,4-diones (1)

Compounds (**1**) were prepared from corresponding 3-chloro derivatives according to the protocol described in literature.[6]

4.3. General procedure for the preparation of compounds 2, 3 and 4

A mixture of appropriate 3-amino-1*H*,3*H*-quinoline-2,4-dione (**1a**–**i**) (1 mmol) and appropriate reagent (see below) in acetic acid (3 mL) was heated to reflux for the time given in Table 1. The



Scheme 2.

course of reaction was monitored by TLC. After cooling, the reaction mixture was poured onto ice (50 g). The precipitated product was filtered off and triturated with a solution of sodium hydroxide (1 M, 50 mL) to remove cyanuric acid or 1,3,5-trithiocyanuric acid. The insoluble portion was filtered off with suction and recrystallized from an appropriate solvent. Using method B, the aqueous portion after filtration of the precipitated product was basified with ammonia and extracted three times with chloroform. The collected extracts were evaporated and the residue was crystallized from appropriate solvent or column chromatographed.

Method A: Urea was used as reagent; see Ref. 4.

Method B. Thiourea (457 mg, 6 mmol) was used as reagent.

Method C. Potassium thiocyanate (583 mg, 6 mmol) was used as reagent.

Method D. Potassium cyanate (487 mg, 6 mmol) was used as reagent.

In the case of **1g**, the aqueous portion after filtration of **4g** was extracted with benzene. The extract was dried with anhydrous potassium carbonate and analyzed by TLC using benzyl acetate, benzyl thiocyanate and benzyl alcohol as reference compounds.

*4.3.1. 2-Benzyl-1-phenyl-2,6-dihydroimidazo[1,5-c]quin-azoline-3,5-dione (**2i**).* Yield 246 mg (67%, method D). Colourless prisms, mp 290–296 °C (acetic acid). IR: 3295, 3250, 3065, 2931, 2865, 1763, 1751, 1679, 1635, 1614, 1589, 1495, 1483, 1445, 1376, 1365, 1347, 1326, 1315, 1266, 1174, 1071, 1030, 1011, 970, 924, 915, 884, 790, 755, 740, 697, 669, 654, 599, 583, 521 cm^{-1}. For ^{1}H and ^{13}C NMR see Table 2. EIMS *m*/*z* (%): 368 (21), 367 (M^+, 81), 277 (19), 276 (99), 248 (10), 235 (13), 234 (71), 206 (22), 205 (10), 161 (6), 149 (7), 133 (6), 132 (8), 118 (6), 117 (6), 106 (6), 105 (43), 104 (16), 92 (11), 91 (100), 90 (13), 77 (34), 76 (6), 72 (8), 71 (6), 65 (26), 57 (10), 55 (7), 51 (13), 41 (7). Anal. Calcd (found) for $C_{23}H_{17}N_3O_2$: C 75.19 (75.15); H 4.66 (4.67); N 11.44 (11.35).

*4.3.2. 1-Butyl-2,3-dihydro-3-thioxoimidazo[1,5-c]quin-azolin-5(6H)-one (**3a**).* Yield 14 mg (5%, method B) or 254 mg (93%, method C). Colourless needles, mp 305–313 °C dec (AcOH). IR: 3080, 2947, 2925, 2865, 2748, 1721, 1636, 1615, 1589, 1498, 1448, 1386, 1360, 1285, 1253, 1226, 1127, 1075, 826, 779, 753, 741, 527, 485 cm^{-1}. EIMS: *m*/*z* (%): 273 (M^+, 59), 230 (100), 201(9), 187 (5), 172 (50), 144 (10), 130 (27), 116 (15), 102 (20), 90 (9), 77 (8), 63 (6), 52 (8). Anal. Calcd (found) for $C_{14}H_{15}N_3OS$: C 61.51 (61.55); H 5.53 (5.50); N 15.37 (15.31); S 11.73 (11.71).

*4.3.3. 2,3-Dihydro-1-phenyl-3-thioxoimidazo[1,5-c]quin-azolin-5(6H)-one (**3c**).* Yield 241 mg (82%, method C). Yellowish plates, mp 356–362 °C (acetic acid). IR: 3077, 2986, 2919, 1731, 1633, 1615, 1591, 1506, 1488, 1445, 1388, 1345, 1256, 1224, 1159, 1131, 1101, 1067, 781, 754, 699, 669, 569 cm^{-1}. EIMS: *m*/*z* (%): 293 (M^+, 100), 260 (10), 234 (17), 206 (8), 190 (8), 117 (9), 104 (16), 89 (6), 77 (9), 51 (5). Anal. Calcd (found) for $C_{16}H_{11}N_3OS$: C 65.51 (65.30); H 3.78 (3.76); N 14.32 (14.44); S 10.93 (11.00).

*4.3.4. 2-Butyl-2,3-dihydro-1-phenyl-3-thioxoimidazo[1,5-c]quinazolin-5(6H)-one (**3d**).* Yield 7 mg (2%, method B) or 245 mg (70%, method C). Colourless needles, mp 265–267 °C (acetic acid). IR: 3226, 3163, 3098, 2955, 2932, 2871, 1727, 1654, 1615, 1592, 1484, 1394, 1375, 1330, 1292, 1266, 1229, 1183, 1134, 1076, 1061, 1025, 1000, 921, 864, 829, 790, 757, 742, 711, 696, 671, 588 cm^{-1}. EIMS *m*/*z* (%) 349 (M^+, 37), 316 (100), 293 (45), 260 (6), 233 (13), 206 (8), 190 (8), 149 (7), 135 (7), 111 (11), 104 (19), 97 (19), 85 (21), 71 (29), 57 (55). Anal. Calcd (found) for $C_{20}H_{19}N_3OS$: C 68.74 (68.55); H 5.48 (5.46); N 12.02 (11.98); S 9.18 (8.97).

*4.3.5. 1,2-Dibutyl-2,3-dihydro-3-thioxoimidazo[1,5-c]quinazolin-5(6H)-one (**3e**).* Yield 10 mg (3%, method C) or 260 mg (79%, method D). Colourless prisms, mp 273–274 °C (acetic acid). IR: 3239, 3190, 3130, 2956, 2930, 2871, 1727, 1629, 1612, 1590, 1490, 1467, 1377, 1342, 1291, 1261, 1231, 1154, 1134, 1080, 1052, 1016, 937, 909, 822, 741, 696, 682, 660, 574, 556, 537 cm^{-1}. EIMS: *m*/*z* (%): 329 (M^+, 44), 296 (100), 272 (12), 254 (7), 245 (8), 231 (31), 172 (15), 130 (10), 69 (6), 55 (16). Anal. Calcd (found) for $C_{18}H_{23}N_3OS$: C 65.62 (65.56); H 7.04 (7.03); N 12.75 (12.81); S 9.73 (9.68).

*4.3.6. 2-Benzyl-1-butyl-2,3-dihydro-3-thioxoimidazo[1,5-c]quinazolin-5(6H)-one (**3f**).* Yield 15 mg (4%, method B) or 193 mg (53%, method C). Colourless needles, mp 253–254 °C (acetic acid). IR: 3190, 2955, 2928, 2870, 1729, 1612, 1590, 1492, 1455, 1397, 1375, 1324, 1291, 1245, 1216, 1153, 1126, 1089, 1054, 1023, 967, 911, 841, 822, 754, 741, 710, 695, 585, 569, 550, 535 cm^{-1}. EIMS: *m*/*z* (%): 363 (M^+, 65), 330 (77), 321 (15), 288 (6), 272 (19), 230 (28), 218 (9), 172 (10), 130 (7), 97 (7), 91 (100), 85 (10), 71 (12), 65 (16), 57 (20). Anal. Calcd (found) for $C_{21}H_{21}N_3OS$: C 69.39 (69.52); H 5.82 (5.86); N 11.56 (11.58); S 8.82 (8.72).

*4.3.7. 2-Benzyl-2,3-dihydro-1-phenyl-3-thioxoimidazo [1,5-c]quinazolin-5(6H)-one (**3i**).* Yield 127 mg (33%, method B) or 299 mg (78%, method C). Colourless plates, mp 282–284 °C (acetic acid). IR: 3230, 3166, 3102, 3064, 3003, 2946, 1727, 1645, 1590, 1484, 1443, 1425, 1382, 1324, 1253, 1233, 1077, 836, 789, 758, 743, 712, 700, 670, 568 cm^{-1}. EIMS: *m*/*z* (%) 383 (M^+, 64), 350 (99), 234 (91), 206 (15), 149 (6), 135 (12), 111 (11), 104 (13), 97 (16), 91 (100), 85 (19), 71 (26), 65 (20), 57 (50). Anal. Calcd (found) for

$C_{23}H_{17}N_3OS$: C 72.04 (72.11); H 4.47 (4.51); N 10.96 (10.94); S 8.36 (8.16).

*4.3.8. 2,3-Dihydro-2-thioxo-1H-imidazo[4,5-c]quinolin-4(5H)-one (**4b**).* Yield 152 mg (70%, method C). Colourless needles, mp>350 °C dec (acetic acid). IR: 3071, 3009, 2928, 2844, 1709, 1655, 1619, 1573, 1500, 1481, 1450, 1426, 1384, 1340, 1257, 1200, 1164, 1154, 964, 941, 885, 769, 688, 624, 602, 516, 470 cm^{-1}. EIMS *m*/*z* (%): 217 (M^+, 100), 207 (9), 185 (18), 157 (7), 118 (5), 103 (23), 91 (5), 76 (14), 65 (7), 51 (9). Anal. Calcd (found) for $C_{10}H_7N_3OS$: C 55.29 (55.39); H 3.25 (3.41); N 19.34 (19.37); S 14.76 (14.64).

*4.3.9. 1-Butyl-2,3-dihydro-2-thioxo-1H-imidazo[4,5-c]quinolin-4 (5H)-one (**4g**).* Yield 11 mg (4%, method B) or 180 mg (66%, method C). Colourless needles, mp>350 °C (acetic acid). IR: 3101, 2993, 2870, 1661, 1615, 1571, 1520, 1500, 1466, 1442, 1370, 1347, 1289, 1256, 1243, 1208, 1151, 1101, 1035, 939, 853, 799, 746, 699, 679, 603, 536 cm^{-1}. EIMS: *m*/*z* (%): 273 (M^+, 47), 240 (62), 231 (8), 217 (100), 129 (12), 103 (11). Anal. Calcd (found) for $C_{14}H_{15}N_3OS$: C 61.51 (61.58); H 5.53 (5.53); N 15.37 (15.57); S 11.73 (11.59).

*4.3.10. 3-Benzyl-2,3-dihydro-2-thioxo-1H-imidazo[4,5-c]quinolin-4 (5H)-one (**4h**).* Yield 218 mg (71%, method C). Colourless prisms, mp>350 °C (acetic acid). IR: 3420, 3103, 3046, 2991, 2890, 2836, 1659, 1614, 1571, 1518, 1496, 1477, 1456, 1434, 1377, 1346, 1322, 1254, 1201, 1145, 1102, 1077, 1033, 993, 935, 868, 794, 751, 705, 674, 604, 585, 528 cm^{-1}. EIMS: *m*/*z* (%) 307 (M^+, 365), 274 (24), 137 (5), 129 (7), 97 (11), 92 (9), 91 (100), 83 (13), 71(13), 69 (15), 59 (22), 55 (33). Anal. Calcd (found) for $C_{17}H_{13}N_3OS$: C 66.43 (66.37); H 4.26 (4.27); N 13.67 (13.46); S 10.43 (10.15).

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