Synthesis of Bis-Heterocyclic 1*H*-Imidazole 3-Oxides from 3-Oxido-1*H*-imidazole-4-carbohydrazides

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The reaction of 1*H*-imidazole-4-carbohydrazides **1**, which are conveniently accessible by treatment of the corresponding esters with $NH_2NH_2 \cdot H_2O$, with isothiocyanates in refluxing EtOH led to thiosemicarbazides (= hydrazinecarbothioamides) **4** in high yields (*Scheme 2*). Whereas **4** in boiling aqueous NaOH yielded 2,4-dihydro-3*H*-1,2,4-triazole-3-thiones **5**, the reaction in concentrated H_2SO_4 at room temperature gave 1,3,4-thiadiazol-2-amines **6**. Similarly, the reaction of **1** with butyl isocyanate led to semicarbazides **7**, which, under basic conditions, undergo cyclization to give 2,4-dihydro-3*H*-1,2,4-triazol-3-ones **8** (*Scheme 3*). Treatment of **1** with Ac_2O yielded the diacylhydrazine derivatives **9** exclusively, and the alternative isomerization of **1** to imidazol-2-ones was not observed (*Scheme 4*). It is important to note that, in all these transformations, the imidazole *N*-oxide residue is retained. Furthermore, it was shown that imidazole *N*-oxides bearing a 1,2,4-triazole-3-thione or 1,3,4-thiadiazol-2-amine moiety undergo the S-transfer reaction to give bis-heterocyclic 1*H*-imidazole-2-thiones **11** by treatment with 2,2,4,4-tetramethylcyclobutane-1,3-dithione (*Scheme 5*).

1. Introduction. – Acid hydrazides (carbohydrazides) and the corresponding hydrazones are well known as a class of compounds with diverse biological activities [1]. Particularly important are derivatives bearing a heterocycle, and one of the best-known examples is isoniazid (isonicotinohydrazide) [2]. Imidazole-derived hydrazides were also reported to exhibit biological activities [3], and the majority of reports is restricted to patents (*e.g.*, [4]). However, in most cases, *N*,*N*-disubstituted hydrazides were described, which are of limited interest with respect to their use as building blocks for new heterocyclic systems.

The *N*-unsubstituted carbohydrazides are widely applied as unique building blocks for the synthesis of diverse five- and six-membered heterocycles such as pyrroles, pyrazoles, thiazolidines, 1,2,4-triazoles, phthalazines, pyrimidines, *etc.* [5]. A typical procedure for the preparation of unsubstituted hydrazides is the treatment of the corresponding carboxylate with $NH_2NH_2 \cdot H_2O$ [1][5]. Recently, we have reported on the application of this method for the preparation of diverse types of unsubstituted hydrazides containing the imidazole ring in their structure [6]. The precursors of 1*H*-

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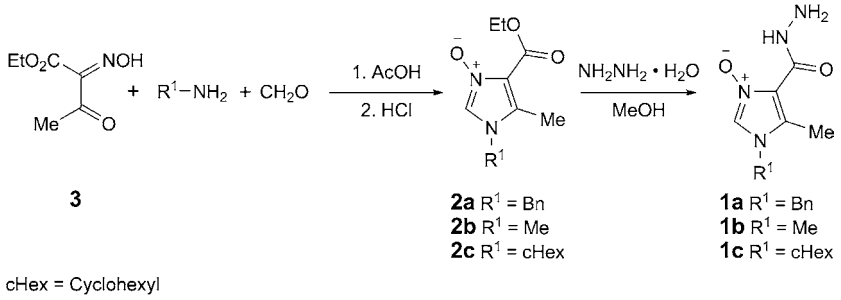
imidazole-4-carbohydrazides **1** were the corresponding esters **2**, available *via* condensation of ethyl 2-(hydroxyimino)-3-oxobutanoate (**3**), a primary amine, and formaldehyde [7] (*Scheme 1*).

Scheme 1



3

2a R^1 = Bn
2b R^1 = Me
2c R^1 = cHex

1a R^1 = Bn
1b R^1 = Me
1c R^1 = cHex

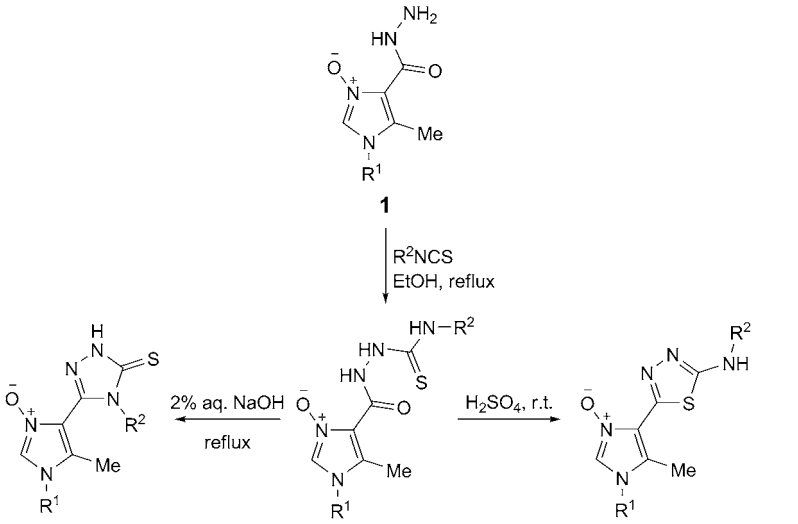
cHex = Cyclohexyl

In earlier reports, we presented the synthetic potential of the 'nitrone-like' fragment of 2-unsubstituted 1*H*-imidazole 3-oxides [8]. The aim of the present study was the synthesis of new bis-heterocycles with the preserved 1*H*-imidazole 3-oxide moiety by investigating of the reactivity of the carbohydrazido group in compounds **1**. In preliminary experiments, it was shown that **1** can be used for the preparation of bis-heterocycles [6]. To the best of our knowledge, there are no other bis-heterocycles with the reactive *N*-oxide function known to date (*cf.* [6]).

Results and Discussion. – As described earlier, 1*H*-imidazole 3-oxides **1** with the hydrazinocarbonyl moiety at C(4) are stable, colorless, crystalline materials [6]. In contrast to the corresponding esters, they did not undergo the thermal isomerization to imidazol-2-ones. Even more surprisingly, they could neither be converted to the corresponding imidazole-2-thiones *via* the 'S-transfer reaction' [8a] nor reduced to the parent system by treatment with *Raney*-Ni [8c].

It seems likely that this diminished reactivity of the N → O function is the result of a strong intramolecular H-bond [6][8d]. On the other hand, reactions with aldehydes and aliphatic ketones proceeded smoothly to yield the expected hydrazones [6]. In addition, a preliminary experiment revealed that thiosemicarbazide **4a** obtained from **1a** ($R = PhCH_2$) and methyl isothiocyanate underwent the cyclocondensation to give, depending on the reaction conditions, bis-heterocycles **5a** or **6a**. In analogy to **1a**, derivatives **1b** and **1c** were also reacted with other isothiocyanates (R^2 = Bu, Ph), and the thiosemicarbazides (= hydrazinecarbothioamides) **4** were heated in a 2% aqueous solution of NaOH to give the triazole-3-thiones **5** (*Scheme 2*). In addition, the sterically crowded *tert*-butyl isothiocyanate was used for the reaction with **1a**, and the expected thiosemicarbazide **4d** was obtained in good yield as a crystalline material. However, the attempted cyclization of **4d** under basic conditions was unsuccessful, and the starting material was recovered in nearly quantitative yield. Apparently, in this case, steric hindrance resulting from the presence of the bulky ^{t}Bu group at the N-atom does not allow the system to undergo the cyclization.

Scheme 2



	R1	R2
5a	Bn	Me
5b	Bn	Ph
5c	Bn	Bu
5d	Me	Me
5e	Me	Ph
5f	Me	Bu
5g	cHex	Me
5h	cHex	Ph
5i	cHex	Bu

	R1	R2
4a	Bn	Me
4b	Bn	Ph
4c	Bn	Bu
4d	Bn	*t*Bu
4e	Me	Me
4f	Me	Ph
4g	Me	Bu
4h	cHex	Me
4i	cHex	Ph
4j	cHex	Bu

	R1	R2
6a	Bn	Me
6b	Bn	4-($HOSO_2$)–C_6H_4
6c	Bn	Bu
6d	Me	Me
6e	cHex	4-($HOSO_2$)–C_6H_4

The structure of the triazole-3-thiones **5** was indicated by the C=S absorption in the ^{13}C-NMR spectra at 168–169 ppm. In addition, the unchanged *N*-oxide structure of the imidazole was confirmed by the characteristic ^{1}H-NMR absorption of H–C(2) at 8.6–8.1 ppm.

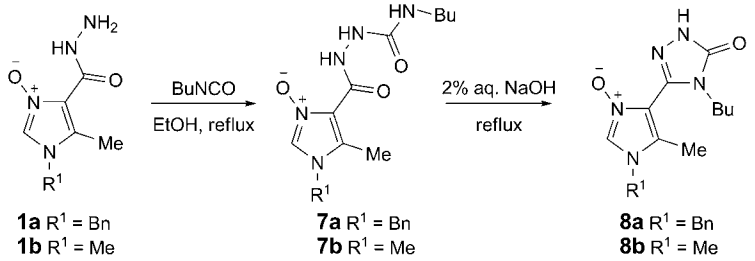
The alternative course of the cyclocondensation was observed when thiosemicarbazides of type **4** were stirred in conc. H_2SO_4 at room temperature for 1 d. Under these conditions, the only products formed were 5-amino-1,3,4-thiadiazol-2-yl-carrying 1*H*-imidazole 3-oxides **6** (*Scheme 2*). Unexpectedly, the reactions carried out under these conditions with **4b** and **4i**, which were derived from phenyl isothiocyanate, yielded **6b** and **6e**, respectively, bearing a 4-phenylsulfonic acid moiety (R^2 = 4-($HOSO_2$)–C_6H_4). It is very likely that these products result from the sulfonation of the intermediate 5-(phenylamino)-1,3,4-thiadiazole derivatives formed after the initial cyclocondensation step[2]). Based on the comparison of the chemical shifts of H–C(2) in **6b**, and in the

[2]) The sulfonation of aniline with conc. H_2SO_4 at elevated temperatures is a well known process [9] and has been studied in detail by *Khelevin* [10]. A study of the thermolysis of diphenylammonium hydrogen sulfate leading to 4-(phenylamino)benzenesulfonic acid has bee published recently [11].

analogous MeN and BuN derivatives **6a** and **6c**, respectively, a zwitterionic structure can be postulated for both arylsulfonic acids **6b** and **6e** (see *Scheme 5*). To the best of our knowledge, secondary sulfonation of 5-(phenylamino)-1,3,4-thiadiazoles obtained from corresponding thiosemicarbazides in the presence of H_2SO_4 under similar reaction conditions (room temperature) has not been reported so far [12][13].

Similarly to the reactions with isothiocyanates, carbohydrazides **1a** and **1b** reacted with butyl isocyanate in refluxing EtOH to yield semicarbazides **7a** and **7b**, respectively, as crystalline materials in high yields (*Scheme 3*). After isolation and purification, they were used for the synthesis of bis-heterocyclic 1,2,4-triazol-3-ones **8a** and **8b**, respectively, under basic conditions. Both products **7** and **8** were obtained with the preserved *N*-oxide function.

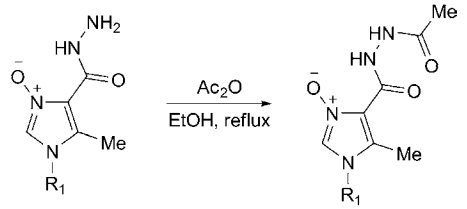
Scheme 3



1a R^1 = Bn
1b R^1 = Me
7a R^1 = Bn
7b R^1 = Me
8a R^1 = Bn
8b R^1 = Me

Transformation of carbohydrazides to 3-alkyl-1,3,4-oxadiazoles can be performed *via* cyclization of their *N*-acyl derivatives under acidic conditions [5]. In the case of **1a** and **1c**, the acetylation performed with a slight excess of Ac_2O in boiling EtOH afforded the expected *N*-Ac derivatives **9** (*Scheme 4*). Apparently, this conversion is much faster than the alternative isomerization to the corresponding imidazol-2-ones reported as a typical reaction of 2-unsubstituted imidazole *N*-oxides by treatment with Ac_2O [8b]. However, the attempted cyclocondensations of products **9** under acidic conditions (H_2SO_4, room temperature) were unsuccessful.

Scheme 4

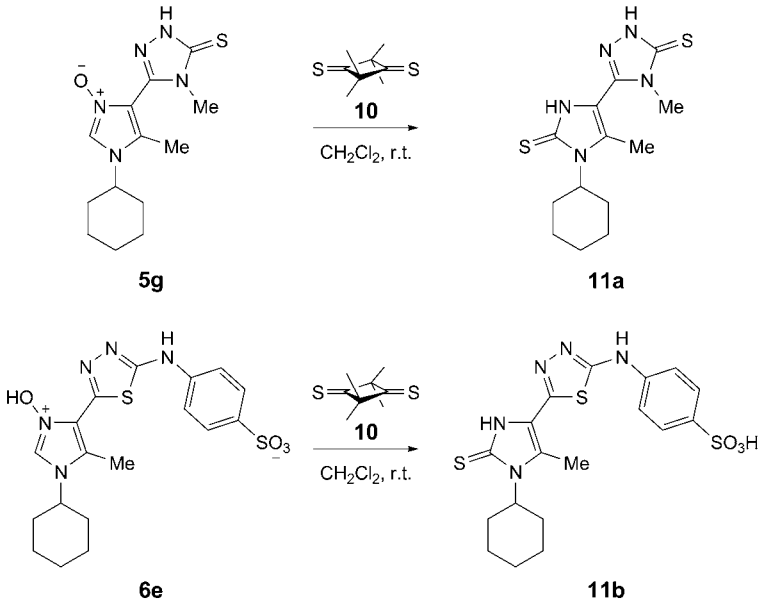


1a R^1 = Bn
1c R^1 = cHex
9a R^1 = Bn
9b R^1 = cHex

In a series of reports, we demonstrated that the treatment of 2-unsubstituted 1*H*-imidazole 3-oxides with a cycloaliphatic thioketone, *e.g.*, 2,2,4,4-tetramethylcyclobutane-1,3-dithione (**10**), opens an easy access to imidazole-2-thiones [8a][8c][8e][8f]. On the other hand, we found recently that the presence of a carbohydrazide moiety at

C(4) inhibits the S-transfer reaction [6]. Having in hand bis-heterocyclic imdazole *N*-oxides of type **5** and **6**, the S-transfer with **10** was tested. In both cases, *i.e.*, **5g** and **6e**, the desired imidazole-2-thiones were smoothly formed at room temperature (*Scheme 5*).

Scheme 5



This result evidences the influence of the intramolecular H-bond on the 'nitrone-like' reactivity of the imidazole *N*-oxides **1**. Whereas the strong H-bond in the hydrazides [6] causes reduced reactivity, there is no such H-bond present in the bis-heterocyclic imidazole *N*-oxides **5** and **6**, which easily enter a [2 + 3] cycloaddition with **10**.

Conclusions. – The present study reveals that imidazole-carbohydrazides of type **1**, containing a *N*-oxide function, react with isothiocyanates, isocyanates, and Ac_2O in a typical manner to yield the corresponding thiosemicarbazides **4**, semicarbazides **7**, and *N*-Ac derivatives **9**, respectively, in high yields. In the case of thiosemicarbazides, cyclizations to 1,2,4-triazole-3-thiones **5** and 2-amino-1,3,4-thiadiazoles **6** were performed under corresponding basic and acidic conditions. Similarly, semicarbazides **7** were converted to 1,2,4-triazole-3-ones **8** in aqueous NaOH solution. In all these reactions, the *N*-oxide function in the imidazole ring was preserved. However, attempted acid-catalyzed cyclizations of **7** and **9** to the corresponding 3-amino- and 3-methyl-1,3,4-oxadiazoles, respectively, were unsuccessful.

In contrast to carbohydrazides **1**, which do not undergo the S-transfer reaction upon treatment with the dithione **10** under standard conditions [6], bis-heterocyclic imidazole *N*-oxides of type **5** and **6** smoothly undergo this reaction.

To the best of our knowledge, the elaborated protocol offers a unique route for the synthesis of bis-heterocyclic *N*-oxides, which cannot be prepared by an oxidative approach. This novel type of *N*-oxides may be of interest as a new group of ligands for coordination chemistry. Moreover, in a recent study, derivatives of 5-amino-1,3,4-thiadiazoles obtained from 5-methylimidazole-4-carbohydrazide according to the general method described in the present paper, displayed high anti-*Toxoplasma gondi* and antimicrobial activities [13].

The authors thank PD Dr. *L. Bigler*, University of Zurich, for recording of the HR-ESI mass spectra. *A. M. P.* is grateful for financial support within the project *European Social Fund 'HUMAN – BEST INVESTMENT!'*, co-funded by the *European Union*.

Experimental Part

1. *General*. M.p.: *STUART SMP30*; uncorrected. IR Spectra: *NEXUS FT-IR* spectrophotometer; in KBr; absorptions in cm^{-1}. ^1H- and $^{13}C\{^1H\}$-NMR Spectra: *Bruker Avance III 600*, in $(D_6)DMSO$, using solvent signals as reference; δ in ppm; coupling constants J in Hz; assignments of signals in ^{13}C-NMR spectra accomplished by HMQC experiments. HR-ESI-MS: *Finnigan MAT-95*. HR-EI-MS: *Bruker Esquire LC* spectrometer.

2. *Starting Materials.* All solvents are commercially available and used as received. Carbohydrazides **1a**–**1c** were prepared from the corresponding esters by treatment with $NH_2NH_2 \cdot H_2O$ according to the protocol described in [6].

3. *Synthesis of Thiosemicarbazides* **4a**–**4j** *and Semicarbazides* **7a** *and* **7b**. *General Procedure.* A mixture of **1** (1 mmol) and the corresponding isothiocyanate (1.1 mmol) or isocyanate (1.1 mmol) in EtOH (5 ml) was heated to reflux for 2 h. Then, the product formed was filtered off, washed with Et_2O, and crystallized from MeOH.

*2-[(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*methylhydrazinecarbothioamide* (**4a**). See [6].

*2-[(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*phenylhydrazinecarbothioamide* (**4b**). Yield: 0.347 g (91%). Colorless crystals. M.p. 200–204° (dec., MeOH). IR (KBr): 3295*s* (NH), 3127*s*, 1663v*s* (C=O), 1599v*s*, 1497*m*, 708*m*. ^1H-NMR ($(D_6)DMSO$): 9.80 (br. *s*, NH); 8.72 (*s*, H–C(2′)); 7.48–7.12 (*m*, 10 arom. H); 5.26 (*s*, CH_2); 2.45 (*s*, Me); two NH absorptions missing. ^{13}C-NMR ($(D_6)DMSO$): 178.2 (C=O); 159.2 (C=S); 139.7, 135.9, 131.2, 121.3 (2 arom. C, C(4′), C(5′)); 126.7 (C(2′)); 129.5, 128.7, 128.6, 127.7, 127.6, 125.3 (10 arom. CH); 48.7 (CH_2); 9.8 (Me). HR-ESI-MS: 404.1149 ($[M+Na]^+$, $C_{19}H_{19}N_5NaO_2S^+$; calc. 404.1152), 382.1329 ($[M+H]^+$, $C_{19}H_{20}N_5O_2S^+$; calc. 382.1332).

*2-[(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*butylhydrazinecarbothioamide* (**4c**). Yield: 0.343 g (95%). Colorless crystals. M.p. 204–207° (MeOH). IR (KBr): 3243*m* (NH), 2955*s*, 1661v*s* (C=O), 1598v*s*, 1552*m*, 1456*m*, 737*m*. ^1H-NMR ($(D_6)DMSO$): 12.41, 9.31 (2 br. *s*, 2 NH); 8.72 (*s*, H–C(2′)); 8.03 (br. *s*, NH); 7.42–7.25 (*m*, 5 arom. H); 5.25 (*s*, CH_2); 3.40 (*q*, $J=6.6$, CH_2N); 2.43 (*s*, Me); 1.49–1.44, 1.28–1.22 (2*m*, 2 CH_2); 0.86 (*t*, $J=7.2$, Me). ^{13}C-NMR ($(D_6)DMSO$): 181.7 (C=O); 159.6 (C=S); 135.9, 131.2, 121.3 (1 arom. C, C(4′), C(5′)); 126.7 (C(2′)); 129.5, 128.7, 127.7 (5 arom. CH); 48.7 (Ph*C*H_2); 43.9 (CH_2N); 31.3, 19.9 (2 CH_2); 14.2 (Me); 9.8 (Me–C(5′)). HR-ESI-MS: 384.1467 ($[M+Na]^+$, $C_{17}H_{23}N_5NaO_2S^+$; calc. 384.1465), 362.1643 ($[M+H]^+$, $C_{17}H_{24}N_5O_2S^+$; calc. 362.1645).

*2-[(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-(tert-*butyl)hydrazinecarbothioamide* (**4d**). Yield: 0.235 g (65%). Colorless crystals. M.p. 201–203° (MeOH). IR (KBr): 3235*m* (NH), 3088*s*, 1668v*s* (C=O), 1599v*s*, 1541*m*, 1362*m*, 709*m*. ^1H-NMR ($(D_6)DMSO$): 9.51 (br. *s*, NH); 8.67 (*s*, H–C(2′)); 7.41–7.25 (*m*, 5 arom. H); 5.24 (*s*, CH_2); 2.43 (*s*, Me); 1.44 (*s*, *t*Bu); two NH absorptions missing. ^{13}C-NMR ($(D_6)DMSO$): 178.9 (C=O); 159.8 (C=S); 135.8, 131.1, 120.9 (1 arom. C, C(4′), C(5′)); 126.7 (C(2′)); 129.4, 128.6, 127.7 (5 arom. CH); 53.2 (Me_3C); 48.7 (CH_2); 29.1 (Me_3C); 9.8 (Me–C(5′)). HR-ESI-MS: 384.1469 ($[M+Na]^+$, $C_{17}H_{23}N_5NaO_2S^+$; calc. 384.1465), 362.1646 ($[M+H]^+$, $C_{17}H_{24}N_5O_2S^+$; calc. 362.1645).

*2-[(1,5-Dimethyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*methylhydrazinecarbothioamide* (**4e**). Yield: 0.173 g (71%). Colorless crystals. M.p. 229–231° (MeOH). IR (KBr): 3160*s*, 2974*s*, 1638v*s* (C=O), 1602v*s*, 1485*s*, 1285*m*, 606*m*. ^{1}H-NMR ((D$_6$)DMSO): 9.35 (br. *s*, NH); 8.48 (*s*, H–C(2′)); 8.01 (br. *s*, NH); 3.58 (*s*, imidazole Me); 2.85 (*d*, J = 4.1, MeN); 2.48 (*s*, Me); one NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 182.6 (C=O); 159.8 (C=S); 131.8, 120.7 (C(4′), C(5′)); 126.8 (C(2′)); 32.4 (MeN(1′)); 31.4 (MeN); 9.5 (Me–C(5′)). HR-ESI-MS: 266.0682 ([M + Na]$^+$, $C_8H_{13}N_5NaO_2S^+$; calc. 266.0682), 244.0859 ([M + H]$^+$, $C_8H_{14}N_5O_2S^+$; calc. 244.0863).

*2-[(1,5-Dimethyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*phenylhydrazinecarbothioamide* (**4f**). Yield: 0.262 g (86%). Colorless crystals. M.p. 223–225° (MeOH). IR (KBr): 3245*m* (NH), 3093*s*, 3036*s*, 1667v*s* (C=O), 1600v*s*, 1497*s*, 1321*s*, 760*m*. ^{1}H-NMR ((D$_6$)DMSO): 9.79 (br. *s*, NH); 8.48 (*s*, H–C(2′)); 7.50–7.11 (*m*, 5 arom. H); 3.58 (*s*, MeN); 2.50 (*s*, Me; overlaps with DMSO signal); two NH absorptions missing. ^{13}C-NMR ((D$_6$)DMSO): 179.0 (C=O); 160.8 (C=S); 139.8, 131.6, 120.7 (1 arom. C, C(4′), C(5′)); 128.8, 128.6, 125.1 (5 arom. CH); 126.8 (C(2′)); 32.4 (MeN); 9.5 (Me–C(5′)). HR-ESI-MS: 328.0835 ([M + Na]$^+$, $C_{13}H_{15}N_5NaO_2S^+$; calc. 328.0839), 306.1013 ([M + H]$^+$, $C_{13}H_{16}N_5O_2S^+$; calc. 306.1019).

N-*Butyl-2-[(1,5-dimethyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]hydrazinecarbothioamide* (**4g**). Yield: 0.262 g (92%). Colorless crystals. M.p. 208–210° (MeOH). IR (KBr): 3189*s*, 2957*s*, 1640v*s* (C=O), 1599v*s*, 1483*s*, 1277*m*, 616*m*. ^{1}H-NMR ((D$_6$)DMSO): 12.44, 9.30 (2 br. *s*, 2 NH); 8.47 (*s*, H–C(2′)); 8.01 (br. *s*, NH); 3.58 (*s*, MeN); 3.40 (*q*, J = 6.6, CH_2N); 2.48 (*s*, Me); 1.49–1.44, 1.29–1.22 (2*m*, 2 CH_2); 0.87 (*t*, J = 7.2, Me). ^{13}C-NMR ((D$_6$)DMSO): 181.7 (C=O); 159.5 (C=S); 131.7, 120.7 (C(4′), C(5′)); 126.8 (C(2′)); 43.9 (CH_2N); 31.4 (MeN); 31.3, 19.9 (2 CH_2); 14.2 (Me); 9.5 (Me–C(5′)). HR-ESI-MS: 308.1151 ([M + Na]$^+$, $C_{11}H_{19}N_5NaO_2S^+$; calc. 308.1152), 286.1329 ([M + H]$^+$, $C_{11}H_{20}N_5O_2S^+$; calc. 286.1332).

*2-[(1-Cyclohexyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*methylhydrazinecarbothioamide* (**4h**). Yield: 0.258 g (83%). Colorless crystals. M.p. 207–211° (MeOH). IR (KBr): 3250*s* (NH), 3139*s*, 1664v*s* (C=O), 1596v*s*, 1552*m*, 1495*m*, 1259*m*. ^{1}H-NMR ((D$_6$)DMSO): 12.45, 9.35 (2 br. *s*, 2 NH); 8.72 (*s*, H–C(2′)); 8.00 (br. *s*, NH); 4.12–4.07 (*m*, CH); 2.85 (*d*, J = 4.4, MeN); 2.55 (*s*, Me); 1.92–1.79 (*m*, 4 cyclohexyl H); 1.67–1.60 (*m*, 3 cyclohexyl H); 1.44–1.38 (*m*, 2 cyclohexyl H); 1.21–1.13 (*m*, 1 cyclohexyl H). ^{13}C-NMR ((D$_6$)DMSO): 182.6 (C=O); 159.9 (C=S); 130.7, 120.3 (C(4′), C(5′)); 124.5 (C(2′)); 55.1 (CH); 33.0, 25.3, 25.0 (5 cyclohexyl CH_2); 31.4 (MeN); 9.5 (Me–C(5′)). HR-ESI-MS: 334.1306 ([M + Na]$^+$, $C_{13}H_{21}N_5NaO_2S^+$; calc. 334.1308), 312.1488 ([M + H]$^+$, $C_{13}H_{22}N_5O_2S^+$; calc. 312.1489).

*2-[(1-Cyclohexyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*phenylhydrazinecarbothioamide* (**4i**). Yield: 0.332 g (89%). Colorless crystals. M.p. 174–176° (MeOH). IR (KBr): 3231*s* (NH), 3139*s*, 2934*s*, 1675v*s* (C=O), 1600v*s*, 1497*m*, 1257*m*. ^{1}H-NMR ((D$_6$)DMSO): 9.81 (br. *s*, NH); 8.73 (*s*, H–C(2′)); 7.50–7.12 (*m*, 5 arom. H); 4.12–4.07 (*m*, CH); 2.57 (*s*, Me); 1.93–1.80 (*m*, 4 cyclohexyl H); 1.67–1.61 (*m*, 3 cyclohexyl H); 1.45–1.38 (*m*, 2 cyclohexyl H); 1.22–1.14 (*m*, 1 cyclohexyl H); two NH absorptions missing. ^{13}C-NMR ((D$_6$)DMSO): 172.4 (C=O); 156.2 (C=S); 139.7, 130.6, 120.3 (1 arom. C, C(4′), C(5′)); 129.4, 129.1, 128.6 (5 arom. CH); 124.4 (C(2′)); 55.1 (CH); 33.0, 25.4, 25.0 (5 cyclohexyl CH_2); 9.5 (MeC(5′)). HR-ESI-MS: 396.1469 ([M + Na]$^+$, $C_{18}H_{23}N_5NaO_2S^+$; calc. 396.1465), 374.1649 ([M + H]$^+$, $C_{18}H_{24}N_5O_2S^+$; calc. 374.1645).

N-*Butyl-2-[(1-cyclohexyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]hydrazinecarbothioamide* (**4j**). Yield: 0.318 g (90%). Colorless crystals. M.p. 176–180° (MeOH). IR (KBr): 3302*s* (NH), 3143*s*, 2934*s*, 1681v*s* (C=O), 1604v*s*, 1545*m*, 1265*m*. ^{1}H-NMR ((D$_6$)DMSO): 12.48, 9.26 (2 br. *s*, 2 NH); 8.72 (*s*, H–C(2′)); 8.02 (br. *s*, NH); 4.11–4.07 (*m*, CH); 3.43–3.38 (*m*, CH_2N); 2.55 (*s*, Me); 1.92–1.79 (*m*, 4 cyclohexyl H); 1.67–1.60 (*m*, 3 cyclohexyl H); 1.49–1.38 (*m*, 2 cyclohexyl H, Bu CH_2); 1.28–1.15 (*m*, 1 cyclohexyl H, Bu CH_2); 0.87 (*t*, J = 7.6, Me). ^{13}C-NMR ((D$_6$)DMSO): 181.7 (C=O); 159.8 (C=S); 130.6, 120.3 (C(4′), C(5′)); 124.4 (C(2′)); 55.0 (CH); 43.9 (CH_2N); 33.0, 25.3, 25.0 (5 cyclohexyl CH_2); 31.3, 19.9 (2 Bu CH_2); 14.2 (Me); 9.5 (Me–C(5′)). HR-ESI-MS: 376.1777 ([M + Na]$^+$, $C_{16}H_{27}N_5NaO_2S^+$; calc. 376.1778), 354.1955 ([M + H]$^+$, $C_{16}H_{28}N_5O_2S^+$; calc. 354.1958).

*2-[(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)carbonyl]*-N-*butylhydrazinecarboxamide* (**7a**). Yield: 0.338 g (98%). Colorless crystals. M.p. 201–205° (MeOH). IR (KBr): 3304*s* (NH), 3105*m*, 2960*m*, 1656v*s* (C=O), 1603*s*, 1544*m*. ^{1}H-NMR ((D$_6$)DMSO): 12.08 (br. *s*, NH); 8.67 (*s*, H–C(2′)); 7.41–7.23 (*m*, 5 arom. H); 7.94, 6.42 (2 br. *s*, 2 NH); 5.24 (*s*, CH_2); 3.01 (*q*, J = 7.0, CH_2N); 2.42 (*s*, Me); 1.38–1.34, 1.29–1.22 (2*m*, 2 CH_2); 0.86 (*t*, J = 7.0, Me). ^{13}C-NMR ((D$_6$)DMSO): 159.5, 158.0 (2 C=O); 135.9,

131.0, 121.3 (1 arom. C, C(4′), C(5′)); 126.8 (C(2′)); 129.4, 128.6, 127.6 (5 arom. CH); 48.7 (PhCH_2); 39.4 (CH_2N); 32.4, 19.9 (2 CH_2); 14.2 (Me); 9.7 (Me–C(5′)). HR-ESI-MS: 368.1697 ($[M+Na]^+$, $C_{17}H_{23}N_5NaO_3^+$; calc. 368.1693), 346.1875 ($[M+H]^+$, $C_{17}H_{24}N_5O_3^+$; calc. 346.1874).

N-*Butyl-2-[(1,5-dimethyl-3-oxido-1*H-*imidazol-4-yl)carbonyl]hydrazinecarboxamide* (**7b**). Yield: 0.256 g (95%). Colorless crystals. M.p. 190–193° (MeOH). IR (KBr): 3308v*s*, 3132*m*, 2957*s*, 1644v*s* (C=O), 1602*s*, 1534*s*, 1254*m*, 608*m*. ^{1}H-NMR ((D$_6$)DMSO): 12.10 (br. *s*, NH); 8.44 (*s*, H–C(2′)); 7.93, 6.39 (2 br. *s*, 2 NH); 3.56 (*s*, MeN); 3.00 (*q*, $J=5.8$, CH_2N); 2.47 (*s*, Me); 1.39–1.34, 1.29–1.23 (2*m*, 2 CH_2); 0.87 (*t*, $J=7.0$, Me). ^{13}C-NMR ((D$_6$)DMSO): 159.5, 158.0 (2 C=O); 131.4, 120.7 (C(4′), C(5′)); 126.8 (C(2′)); 39.4 (CH_2N); 32.4 (MeN); 32.3, 19.9 (2 CH_2); 14.2 (Me); 9.4 (Me–C(5′)). HR-ESI-MS: 292.1383 ($[M+Na]^+$, $C_{11}H_{19}N_5NaO_3^+$; calc. 292.1380), 270.1560 ($[M+H]^+$, $C_{11}H_{20}N_5O_3^+$; calc. 270.1561).

4. *Synthesis of 1,2,4-Triazole-3-thiones* **5**. *General Procedure.* A mixture of **4** (1 mmol) and a 2% aq. soln. of NaOH (5 ml) was heated to reflux for 2 h. Then, the soln. was neutralized with AcOH, and the formed precipitate was filtered off and crystallized from MeOH.

*5-(1-Benzyl-5-methyl-3-oxido-1*H-*imidazol-4-yl)-2,4-dihydro-4-methyl-3*H-*1,2,4-triazole-3-thione* (**5a**). See [6].

*5-(1-Benzyl-5-methyl-3-oxido-1*H-*imidazol-4-yl)-2,4-dihydro-4-phenyl-3*H-*1,2,4-triazole-3-thione* (**5b**). Yield: 0.192 g (53%). Colorless crystals. M.p. 262–264° (dec. MeOH). IR (KBr): 3110*s*, 3044*m*, 1497*s*, 1319*m*, 688*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.35 (*s*, H–C(2′)); 7.47–7.28 (*m*, 10 arom. H); 5.11 (*s*, CH_2N); 1.92 (*s*, Me); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 168.8 (C=S); 141.4 (triazole C(3)); 134.3, 128.8, 136.2, 117.6 (2 arom. C, imidazole C(4), C(5)); 129.3, 129.2, 128.4, 127.7, 127.2, 126.8 (10 arom. CH); 126.2 (imidazole C(2)); 48.8 (CH_2N); 8.9 (Me). HR-ESI-MS: 386.1041 ($[M+Na]^+$, $C_{19}H_{17}N_5NaOS^+$; calc. 386.1046), 364.1221 ($[M+H]^+$, $C_{19}H_{18}N_5OS^+$; calc. 364.1227).

*5-(1-Benzyl-5-methyl-3-oxido-1*H-*imidazol-4-yl)-4-butyl-2,4-dihydro-3*H-*1,2,4-triazole-3-thione* (**5c**). Yield: 0.240 g (70%). Colorless crystals. M.p. 256–258° (MeOH). IR (KBr): 3129*m*, 2930*m*, 1455*m*, 1294*m*, 730*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.60 (*s*, H–C(2′)); 7.41–7.25 (*m*, 5 arom. H); 5.26 (*s*, CH_2N); 4.12 (*t*, $J=6.8$, CH_2N); 2.08 (*s*, Me); 1.45–1.40 (*m*, CH_2); 1.04–0.98 (*m*, CH_2); 0.67 (*t*, $J=6.8$, Me); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 167.9 (C=S); 141.7 (C(3)); 136.1, 128.4, 118.5 (1 arom. C, imidazole C(4), C(5)); 129.4, 128.6, 127.6 (5 arom. CH); 126.7 (imidazole C(2)); 49.2 (CH_2N); 44.0 (Bu CH_2N); 30.1, 19.4 (2 Bu CH_2); 13.7 (Bu Me); 9.1 (Me). HR-ESI-MS: 366.1359 ($[M+Na]^+$, $C_{17}H_{21}N_5NaOS^+$; calc. 366.1359), 344.1537 ($[M+H]^+$, $C_{17}H_{22}N_5OS^+$; calc. 344.1540).

*5-(1,5-Dimethyl-3-oxido-1*H-*imidazol-4-yl)-2,4-dihydro-4-methyl-3*H-*1,2,4-triazole-3-thione* (**5d**). Yield: 0.144 g (64%). Colorless crystals. M.p. 321–323° (MeOH). IR (KBr): 3147v*s* (NH), 1515*m*, 1455*m*, 1329*m*, 929*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.31 (*s*, H–C(2′)); 3.58, 3.44 (2*s*, 2 MeN); 2.17 (*s*, Me); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 168.2 (C=S); 142.3 (C(3)); 128.1, 118.7 (imidazole C(4), C(5)); 126.2 (imidazole C(2)); 32.7, 31.4 (2 MeN); 9.1 (Me). HR-ESI-MS: 248.0574 ($[M+Na]^+$, $C_8H_{11}N_5NaOS^+$; calc. 248.0577), 226.0755 ($[M+H]^+$, $C_8H_{12}N_5OS^+$; calc. 226.0757).

*5-(1,5-Dimethyl-3-oxido-1*H-*imidazol-4-yl)-2,4-dihydro-4-phenyl-3*H-*1,2,4-triazole-3-thione* (**5e**). Yield: 0.155 g (54%). Colorless crystals. M.p. 270–274° (dec. MeOH). IR (KBr): 3156v*s* (NH), 1506*m*, 1497*s*, 1326*m*, 694*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.14 (*s*, H–C(2′)); 7.51–7.38 (*m*, 5 arom. H); 3.45 (*s*, MeN); 2.09 (*s*, Me); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 169.0 (C=S); 141.7 (C(3)); 136.9, 128.9, 117.1 (1 arom. C, imidazole C(4), C(5)); 129.4, 129.1, 127.8 (5 arom. CH); 126.2 (imidazole C(2)); 32.6 (MeN); 8.7 (Me). HR-ESI-MS: 310.0733 ($[M+Na]^+$, $C_{13}H_{13}N_5NaOS^+$; calc. 310.0733), 288.0911 ($[M+H]^+$, $C_{13}H_{14}N_5OS^+$; calc. 288.0914).

*4-Butyl-5-(1,5-dimethyl-3-oxido-1*H-*imidazol-4-yl)-2,4-dihydro-3*H-*1,2,4-triazole-3-thione* (**5f**). Yield: 0.143 g (50%). Colorless crystals. M.p. 240–242° (MeOH). IR (KBr): 3162*s* (NH), 2953*s*, 1570*m*, 1449*m*, 1348*m*, 1295*m*, 926*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.38 (*s*, H–C(2′)); 4.14 (*t*, $J=7.7$, CH_2N); 3.59 (*s*, MeN); 2.17 (*s*, Me); 1.51–1.46, 1.12–1.05 (2*m*, 2 CH_2); 0.74 (*t*, $J=7.7$, Me); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 167.9 (C=S); 142.2 (C(3)); 128.8, 117.5 (imidazole C(4), C(5)); 126.7 (imidazole C(2)); 44.1 (CH_2N); 32.8 (MeN); 30.0, 19.5 (2 CH_2); 13.7, 8.9 (2 Me). HR-ESI-MS: 290.1042 ($[M+Na]^+$, $C_{11}H_{17}N_5NaOS^+$; calc. 290.1046), 268.1225 ($[M+H]^+$, $C_{11}H_{18}N_5OS^+$; calc. 268.1227).

*5-(1-Cyclohexyl-5-methyl-3-oxido-1*H-*imidazol-4-yl)-2,4-dihydro-4-methyl-3*H-*1,2,4-triazole-3-thione* (**5g**). Yield: 0.240 g (82%). Colorless crystals. M.p. 212–216° (MeOH). IR (KBr): 3115*s* (NH),

2941*s*, 1559*m*, 1418*m*, 1324*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.49 (*s*, H–C(2′)); 4.05–4.00 (*m*, CH); 3.42 (*s*, MeN); 2.20 (*s*, Me); 1.97–1.80 (*m*, 4 cyclohexyl H); 1.69–1.62 (*m*, 3 cyclohexyl H); 1.45–1.38 (*m*, 2 cyclohexyl H); 1.23–1.14 (*m*, 1 cyclohexyl H); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 168.3 (C=S); 142.1 (C(3)); 126.7, 118.7 (imidazole C(4), C(5)); 123.6 (imidazole C(2)); 55.5 (CH); 33.2 (MeN); 31.4, 25.4, 23.1 (5 cyclohexyl CH_2); 9.2 (Me). HR-ESI-MS: 316.1200 ([M + Na]$^+$, $C_{13}H_{19}N_5NaOS^+$; calc. 316.1203), 294.1379 ([M + H]$^+$, $C_{13}H_{20}N_5OS^+$; calc. 294.1383).

*5-(1-Cyclohexyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)-2,4-dihydro-4-phenyl-3*H*-1,2,4-triazole-3-thione* (**5h**). Yield: 0.185 g (52%). Colorless crystals. M.p. 282–284° (MeOH). IR (KBr): 3231*m* (NH), 2936*m*, 1601*m*, 1497*m*, 1320*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.34 (*s*, H–C(2′)); 7.45–7.37 (*m*, 5 arom. H); 3.92–3.85 (*m*, CH); 2.07 (*s*, Me); 1.79–1.74 (*m*, 4 cyclohexyl H); 1.62–1.49 (*m*, 3 cyclohexyl H); 1.37–1.30 (*m*, 2 cyclohexyl H); 1.15–1.12 (*m*, 1 cyclohexyl H); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 168.9 (C=S); 141.6 (C(3)); 134.1, 126.1, 118.4 (1 arom. C, imidazole C(4), C(5)); 129.3, 129.0, 127.7 (5 arom. CH); 123.6 (imidazole C(2)); 55.4 (CH); 33.0, 25.3, 24.9 (5 cyclohexyl CH_2); 8.9 (Me). HR-ESI-MS: 378.1361 ([M + Na]$^+$, $C_{18}H_{21}N_5NaOS^+$; calc. 378.1359), 356.1541 ([M + H]$^+$, $C_{18}H_{22}N_5OS^+$; calc. 356.1540).

*4-Butyl-5-(1-cyclohexyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)-2,4-dihydro-3*H*-1,2,4-triazole-3-thione* (**5i**). Yield: 0.251 g (75%). Colorless crystals. M.p. 248–250° (MeOH). IR (KBr): 3066*m*, 2936*m*, 1356*m*, 1295*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.55 (*s*, H–C(2′)); 4.12 (*t*, J = 6.8, CH_2N); 4.07–4.02 (*m*, CH); 2.20 (*s*, Me); 1.95–1.81 (*m*, 4 cyclohexyl H); 1.69–1.62 (*m*, 3 cyclohexyl H); 1.48–1.38 (*m*, 2 cyclohexyl H, Bu CH_2); 1.22–1.17 (*m*, 1 cyclohexyl H); 1.07–1.01 (*m*, Bu CH_2); 0.69 (*t*, J = 6.8, Me); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 167.9 (C=S); 141.9 (C(3)); 123.1, 118.4 (imidazole C(4), C(5)); 123.9 (imidazole C(2)); 55.6 (CH); 43.7 (CH_2N); 33.2, 25.4, 25.0 (5 cyclohexyl CH_2); 30.0, 19.3 (2 Bu CH_2); 13.6, 9.0 (2 Me). HR-ESI-MS: 358.1677 ([M + Na]$^+$, $C_{16}H_{25}N_5NaOS^+$; calc. 358.1672), 336.1856 ([M + H]$^+$, $C_{16}H_{26}N_5OS^+$; calc. 336.1853).

5. *Synthesis of 1,3,4-Thiadiazoles* **6**. *General Procedure.* A soln. of **4** (1 mmol) in conc. H_2SO_4 (5 ml) was kept at r.t. for 1 d. After neutralization of the soln. with dil. NH_4OH, the solid product was filtered off, dried, and crystallized from MeOH.

*5-(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)-*N*-methyl-1,3,4-thiadiazol-2-amine* (**6a**). See [6].

*4-{[5-(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)-1,3,4-thiadiazol-2-yl]amino}benzenesulfonic Acid* (**6b**). Yield: 0.211 g (58%). Yellowish crystals. M.p. 300–303° (dec., MeOH). IR (KBr): 3400–2800*m* (br.), 3124*m*, 3064*m*, 1509*s*, 1176*m* (br.), 1034*m*, 708*m*. ^{1}H-NMR ((D$_6$)DMSO): 10.34 (br. *s*, NH); 8.66 (*s*, H–C(2′)); 7.60, 7.57 (*AA′BB′*, J_{AB} = 8.4, 4 arom. H); 7.42–7.28 (*m*, 5 arom. H); 5.29 (*s*, CH_2); 2.56 (*s*, Me). ^{13}C-NMR ((D$_6$)DMSO): 164.4, 146.4 (thiadiazole C(2), C(5)); 142.1, 141.4, 136.1, 122.7, 116.6 (3 arom. C, imidazole C(4), C(5)); 129.4, 128.6, 127.7, 127.0, 125.0 (9 arom. CH); 125.6 (imidazole C(2)); 49.0 (CH_2); 10.2 (Me). HR-ESI-MS: 488.0432 ([M − 1 + 2 Na]$^+$, $C_{19}H_{16}N_5Na_2O_4S_2^+$; calc. 488.0434), 466.0610 ([M + Na]$^+$, $C_{19}H_{17}N_5NaO_4S_2^+$; calc. 466.0614), 444.0791 ([M + H]$^+$, $C_{19}H_{18}N_5O_4S_2^+$; calc. 444.0795).

*5-(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)-*N*-butyl-1,3,4-thiadiazol-2-amine* (**6c**). Yield: 0.209 g (61%). Yellowish crystals. M.p. 206–208° (dec., MeOH). IR (KBr): 3185*m*, 3068*m*, 2958*s*, 1576*s*, 1454*m*, 748*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.57 (*s*, H–C(2′)); 7.58 (br. *s*, NH); 7.41–7.26 (*m*, 5 arom. H); 5.24 (*s*, PhCH_2); 3.34–3.23 (*m*, CH_2N); 2.49 (*s*, Me); 1.59–1.54 (*m*, CH_2); 1.39–1.33 (*m*, CH_2); 0.90 (*t*, J = 7.6, Me). ^{13}C-NMR ((D$_6$)DMSO): 169.2, 144.4 (C(2), C(5)); 136.3, 124.0, 123.0 (1 arom. C, imidazole C(4), C(5)); 129.4, 128.5, 127.6 (5 arom. CH); 125.3 (imidazole C(2)); 48.9 (PhCH_2); 44.9 (CH_2N); 31.2, 20.1 (2 CH_2); 14.1, 10.1 (2 Me). HR-ESI-MS: 366.1361 ([M + Na]$^+$, $C_{17}H_{21}N_5NaOS^+$; calc. 366.1359), 344.1541 ([M + H]$^+$, $C_{17}H_{22}N_5OS^+$; calc. 344.1540).

*5-(1,5-Dimethyl-3-oxido-1*H*-imidazol-4-yl)-*N*-methyl-1,3,4-thiadiazol-2-amine* (**6d**). Yield: 0.207 g (92%). Yellowish crystals. M.p. 228–230° (dec., MeOH). IR (KBr): 3375*s* (NH), 3120*s*, 2941*s*, 1541*m*, 1404*m*, 1097*m*, 1033*m*, 604*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.37 (*s*, H–C(2′)); 7.55 (br. *s*, NH); 3.59 (*s*, imidazole MeN); 2.89 (br. *s*, MeN); 2.54 (*s*, Me). ^{13}C-NMR ((D$_6$)DMSO): 169.8, 144.8 (C(2), C(5)); 125.4 (imidazole C(2)); 124.5, 122.3 (imidazole C(4), C(5)); 32.5, 31.6 (2 MeN); 9.8 (Me). HR-ESI-MS: 248.0578 ([M + Na]$^+$, $C_8H_{11}N_5NaOS^+$; calc. 248.0577), 226.0760 ([M + H]$^+$, $C_8H_{12}N_5OS^+$; calc. 226.0757).

*4-{[5-(1-Cyclohexyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)-1,3,4-thiadiazol-2-yl]amino}benzenesulfonic Acid* (**6e**). Yield: 0.249 g (70%). Colorless crystals. M.p. 310–312° (dec., MeOH). IR (KBr): 3400–2650*m* (br.), 3385*s* (NH), 3227*s*, 3038*s*, 1420*s* (br.), 1090*s* (br.), 613*m*. ^{1}H-NMR ((D$_6$)DMSO): 10.29 (br. *s*, NH); 8.65 (*s*, H–C(2′)); 7.60, 7.56 (*AA′BB′*, J_{AB} = 8.4, 4 arom. H); 4.14–4.09 (*m*, CH); 2.68 (*s*, Me); 1.99–1.81 (*m*, 4 cyclohexyl H); 1.68–1.63 (*m*, 3 cyclohexyl H); 1.47–1.41 (*m*, 2 cyclohexyl H); 1.24–1.21 (*m*, 1 cyclohexyl H). ^{13}C-NMR ((D$_6$)DMSO): 164.4, 146.7 (thiadiazole C(2), C(5)); 142.2, 116.6 (2 arom. C); 141.4, 127.0 (4 arom. CH); 124.2 (imidazole C(2)); 123.1, 121.6 (imidazole C(4), C(5)); 55.3 (CH); 33.1, 25.4, 25.0 (5 cyclohexyl CH$_2$); 9.9 (Me). HR-ESI-MS: 458.0926 ([M + Na]$^+$, $C_{18}H_{21}N_5NaO_4S_2^+$; calc. 458.0927), 436.1110 ([M + H]$^+$, $C_{18}H_{22}N_5O_4S_2^+$; calc. 436.1108).

6. *Synthesis of 1,2,4-Triazole-3-ones* **8**. *General Procedure.* A mixture of **7** (1 mmol) and a 2% aq. soln. of NaOH (5 ml) was heated to reflux for 8 h. Then, the soln. was neutralized with AcOH, and the formed precipitate was filtered off and crystallized from MeOH.

*5-(1-Benzyl-5-methyl-3-oxido-1*H*-imidazol-4-yl)-4-butyl-2,4-dihydro-3*H*-1,2,4-triazol-3-one* (**8a**). Yield: 0.216 g (66%). Colorless crystals. M.p. 224–228° (MeOH). IR (KBr): 3115*m*, 2938*m*, 1705v*s* (C=O), 1558*m*, 1416*m*, 734*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.55 (*s*, H–C(2′)); 7.41–7.24 (*m*, 5 arom. H); 5.23 (*s*, Ph*C*H$_2$); 3.73 (*t*, *J* = 6.8, CH$_2$N); 2.08 (*s*, Me); 1.58 (br. *s*, NH); 1.37–1.32, 1.06–1.00 (2*m*, 2 CH$_2$); 0.68 (*t*, *J* = 7.7, Me). ^{13}C-NMR ((D$_6$)DMSO): 155.4 (C=O); 137.4, 136.3, 127.8, 119.8 (1 arom. C, C(3), imidazole C(4), C(5)); 129.4, 128.6, 127.6 (5 arom. CH); 126.3 (imidazole C(2)); 49.1 (Ph*C*H$_2$); 41.0 (CH$_2$N); 30.7, 19.4 (2 CH$_2$); 13.6, 9.1 (2 Me). HR-ESI-MS: 350.1589 ([M + Na]$^+$, $C_{17}H_{21}N_5NaO_2^+$; calc. 350.1588), 328.1771 ([M + H]$^+$, $C_{17}H_{22}N_5O_2^+$; calc. 328.1768).

*4-Butyl-5-(1,5-dimethyl-3-oxido-1*H*-imidazol-4-yl)-2,4-dihydro-3*H*-1,2,4-triazol-3-one* (**8b**). Yield: 0.176 g (70%). Colorless crystals. M.p. 214–216° (MeOH). IR (KBr): 3409v*s* (NH), 1698v*s* (C=O), 1559v*s*, 1410*s*, 649*m*. ^{1}H-NMR ((D$_6$)DMSO): 8.33 (*s*, H–C(2′)); 3.71 (*q*, *J* = 7.0, CH$_2$N); 3.58 (*s*, MeN); 2.16 (*s*, Me); 1.64 (br. *s*, NH); 1.39–1.35, 1.10–1.06 (2*m*, 2 CH$_2$); 0.74 (*t*, *J* = 7.4, Me). ^{13}C-NMR ((D$_6$)DMSO): 155.6 (C=O); 137.4, 128.2, 118.8 (C(3), imidazole C(4), C(5)); 126.4 (imidazole C(2)); 41.1 (CH$_2$N); 32.7 (MeN); 32.7, 19.5 (2 CH$_2$); 13.7, 8.9 (2 Me). HR-ESI-MS: 290.1012 ([M + K]$^+$, $C_{11}H_{17}KN_5O_2^+$; calc. 290.1014), 274.1273 ([M + Na]$^+$, $C_{11}H_{17}N_5NaO_2^+$; calc. 274.1275), 252.1451 ([M + H]$^+$, $C_{11}H_{18}N_5O_2^+$; calc. 252.1455).

7. *Synthesis of* N*-Acetylcarbohydrazides* **9**. *General Procedure.* A mixture of **1** (1 mmol) and Ac$_2$O (1.1 mmol) in EtOH (5 ml) was heated to reflux for 2 h. The product formed was then filtered off, washed with Et$_2$O, and crystallized from MeOH.

*4-[(2-Acetylhydrazinyl)carbonyl]-1-benzyl-5-methyl-1*H*-imidazol-1-ium 3-Oxide* (**9a**). Yield: 1.251 g (87%). Colorless crystals. M.p. 164–166° (MeOH). IR (KBr): 3119*s*, 1663v*s* (C=O), 1601v*s*, 1497*m*, 709*m*. ^{1}H-NMR ((D$_6$)DMSO): 12.65, 10.26 (2 br. *s*, 2 NH); 8.68 (*s*, H–C(2)); 7.41–7.23 (*m*, 5 arom. H); 5.24 (*s*, CH$_2$); 2.42, 1.90 (2*s*, 2 Me). ^{13}C-NMR ((D$_6$)DMSO): 167.3, 159.7 (2 C=O); 135.6, 131.2, 120.8 (1 arom. C, C(4), C(5)); 129.5, 128.6, 127.6 (5 arom. CH); 126.9 (C(2)); 48.7 (CH$_2$); 20.9, 9.6 (2 Me). HR-ESI-MS: 311.1118 ([M + Na]$^+$, $C_{14}H_{16}N_4NaO_3^+$; calc. 311.1115), 289.1297 ([M + H]$^+$, $C_{14}H_{17}N_4O_3^+$; calc. 289.1295).

*4-[(2-Acetylhydrazinyl)carbonyl]-1-cyclohexyl-5-methyl-1*H*-imidazol-1-ium 3-Oxide* (**9b**). Yield: 0.246 g (88%). Colorless crystals. M.p. 184–188° (MeOH). IR (KBr): 3247*s* (NH), 2937*s*, 1654v*s* (C=O), 1601v*s*, 1418*m*, 1047*m*. ^{1}H-NMR ((D$_6$)DMSO): 12.61 (br. *s*, NH); 8.68 (*s*, H–C(2)); 4.10–4.03 (*m*, CH); 2.55 (*s*, Me); 1.93–1.78 (*m*, 4 cyclohexyl H, Me); 1.66–1.59 (*m*, 3 cyclohexyl H); 1.43–1.36 (*m*, 2 cyclohexyl H); 1.20–1.13 (*m*, 1 cyclohexyl H). ^{13}C-NMR ((D$_6$)DMSO): 168.6, 158.0 (2 C=O); 130.7, 119.8 (C(4), C(5)); 124.5 (C(2)); 55.1 (CH); 33.0, 25.3, 24.9 (5 cyclohexyl CH$_2$); 20.9, 9.4 (2 Me). HR-ESI-MS: 303.1427 ([M + Na]$^+$, $C_{13}H_{20}N_4NaO_3^+$; calc. 303.1428), 281.1607 ([M + H]$^+$, $C_{13}H_{21}N_4O_3^+$; calc. 281.1608).

8. *Synthesis of Compounds* **11**. *General Procedure.* To a magnetically stirred soln. of **5g** or **6e** (1 mmol) in CH$_2$Cl$_2$ (1 ml), a soln. of 2,2,4,4-tetramethylcyclobutane-1,3-dithione (**10**, 0.6 mmol) in CH$_2$Cl$_2$ (1 ml) was added dropwise. The addition was complete after *ca.* 10 min, and stirring was continued for 48 h, while a precipitate was formed. Then, the solvent was removed under reduced pressure, and the resulting solid was washed with hexane and filtered. The crude product was recrystallized from MeOH.

*5-(1-Cyclohexyl-5-methyl-2-thioxo-2,3-dihydro-1*H*-imidazol-4-yl)-4-methyl-2,4-dihydro-3*H*-1,2,4-triazole-3-thione* (**11a**). Yield: 0.250 g (81%). Colorless crystals. M.p. 276–278° (MeOH). IR (KBr): 3092*s*, 2935*s*, 1560*m*, 1500*m*, 1416*m*, 1348*m*. ^{1}H-NMR ((D$_6$)DMSO): 3.72 (*s*, MeN); 3.35–3.29 (*m*, CH); 2.33 (*s*, Me); 1.83–1.64 (*m*, 6 cyclohexyl H); 1.36–1.16 (*m*, 4 cyclohexyl H); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 171.6, 163.2 (2 C=S); 141.2 (C(3)); 126.3, 116.5 (imidazole C(4), C(5)); 55.4 (CH); 31.7 (MeN); 26.3, 25.8, 21.9 (5 cyclohexyl CH_2); 11.9 (Me). HR-ESI-MS: 332.0973 ($[M+Na]^+$, $C_{13}H_{19}N_5NaS_2^+$; calc. 332.0974), 310.1150 ($[M+H]^+$, $C_{13}H_{20}N_5S_2^+$; calc. 310.1155).

*4-{[5-(1-Cyclohexyl-2,3-dihydro-5-methyl-2-thioxo-1*H*-imidazol-4-yl)-1,3,4-thiadiazol-2-yl]amino}-benzenesulfonic Acid* (**11b**). Yield: 0.338 g (91%). Colorless crystals. M.p. 314–316° (dec., MeOH). IR (KBr): 3400–2700*m* (br.), 3178*s*, 2935*s*, 1405*s* (br.), 1122*s* (br.), 616*m*. ^{1}H-NMR ((D$_6$)DMSO): 7.57 (br. *s*, 4 arom. H); 3.36–3.29 (*m*, CH); 2.57 (*s*, Me); 1.94–1.63 (*m*, 6 cyclohexyl H); 1.37–1.21 (*m*, 4 cyclohexyl H); NH absorption missing. ^{13}C-NMR ((D$_6$)DMSO): 163.9, 147.3 (thiadiazole C(2), C(5)); 162.9 (C=S); 142.9, 123.0, 120.2, 116.8 (2 arom. C, imidazole C(4), C(5)); 140.1, 127.1 (4 arom. CH); 57.1 (CH); 26.3, 25.3, 21.2 (5 cyclohexyl CH_2); 11.9 (Me). HR-ESI-MS: 474.0695 ($[M+Na]^+$, $C_{18}H_{21}N_5NaO_3S_3^+$; calc. 474.0699), 452.0877 ($[M+H]^+$, $C_{18}H_{22}N_5O_3S_3^+$; calc. 452.0879).

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