Two ways of cyclization of 5-imidazolylthioureas with dimethyl acetylenedicarboxylate

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Abstract

Two ways of cyclization of imidazolyl derivatives of thiourea with dimethylacetylene dicarboxylate (DMAD) were studied. Reaction of *N,N'*-disubstituted thioureas with DMAD led to formation of a thiazoline ring whereas transformation of trisubstituted thioureas under the same conditions give the novel imidazo[1,5-*c*][1,3,5]thiadiazine heterocyclic system.

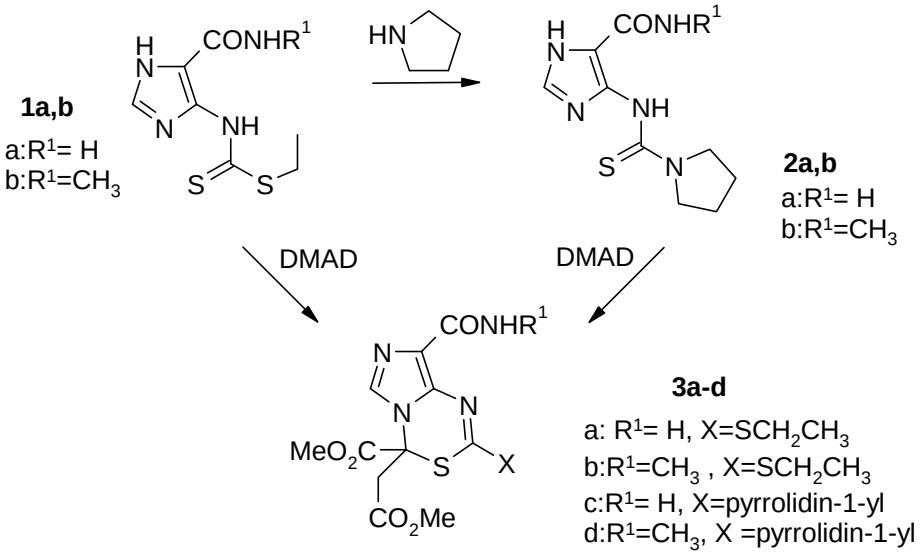
Keywords: Imidazolylthiourea, DMAD, heterocyclization, imidazo[1,5-*c*][1,3,5]thiadiazine, thiazolidine

Introduction

Organic dithiocarbamates and thioureas are valuable synthetic intermediates,[1] which are used widely in the synthesis of biologically active compounds.[2] Functionalization of such moieties offers an attractive method for the generation of derivatives which may possess interesting medicinal and biological properties.[3] For these reasons, the transformation of dithiocarbamate and thiourea derivatives with different substituents has become a field of increasing interest in synthetic organic chemistry during the past few years.

We have reported earlier some aspects of the chemistry of imidazolylthioureas.[4] Recently we communicated the reaction of imidazolylalkyl dithiocarbamates **1a,b** and thioureas **2a,b** with DMAD which are the first examples of the construction of the novel heterocyclic system of imidazo[1,5-*c*][1,3,5]thiadiazines[5] **3a-d** (Scheme 1). These compositions are close structural analogs of pyrazolo[1,3,5]thiadiazine which are a potent antifungal pro-drugs and inhibitors of photosynthetic electron transport.[6]

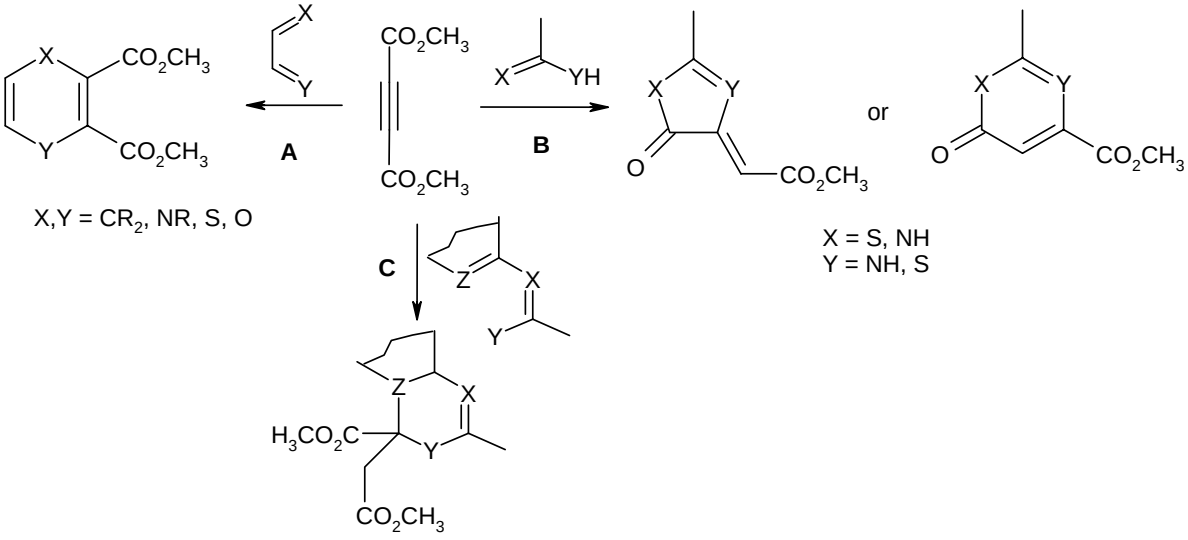
Due to our interest to the chemistry of imidazolyl derivatives of alkyldithiocarbamate and thiourea, now we present the extended studies of reaction of imidazolylthioureas with DMAD. The aim of this work was to determine the scope and limitations of annelation of 1,3,5-thiadiazine ring to imidazoles.



Scheme 1

Results and Discussion

It is well known that acetylenedicarboxylic acid esters are very reactive dienophiles and may form both cycloaddition products (way **A**, for example: 1,4-diazines, pyrimidines, etc.)[7] and cyclocondensation products with elimination of one alcohol molecule (way **B**, for example: thiazolidines, thiazines, etc.).[8] Therefore it was very surprising to find another type of cyclization involving only one carbon atom of acetylene component resulting in formation of 1,3,5-thiadiazines ring (way **C**) (Scheme 2).



Scheme 2

Most reported 1,3,5-thadiazines contain carbonyl or thiocarbonyl groups in the ring: such compounds were previously synthesized by treatment of heterocyclic primary thioamides with phenoxycarbonyl isocyanate,[9] cyclization of perchloroethyl isocyanate with thioamides;[10] reaction of thiobenzoyl isocyanates with arylhydrazones,[11] benzaldazines,[12] carbodiimides,[13] or anils;[14] [4+2] cycloaddition of 1-thia-3-azadienes with electron-deficient nitriles;[15] dimerization of thiocarbamoyl isothiocyanates[16] or dimerization of carbamoyl isothiocyanates[17] and 1,3,5-oxathiazines.[15] Previously reported condensed azolo[1,3,5]thiadiazines were made by reaction of isothiocarbamoylisothiocyanates with isocyanoacetate,[19] by transformation of 2-mercapto-imidazolines,[20] or pyrazolylcarbothioamides.[6a, 6c, 6d]

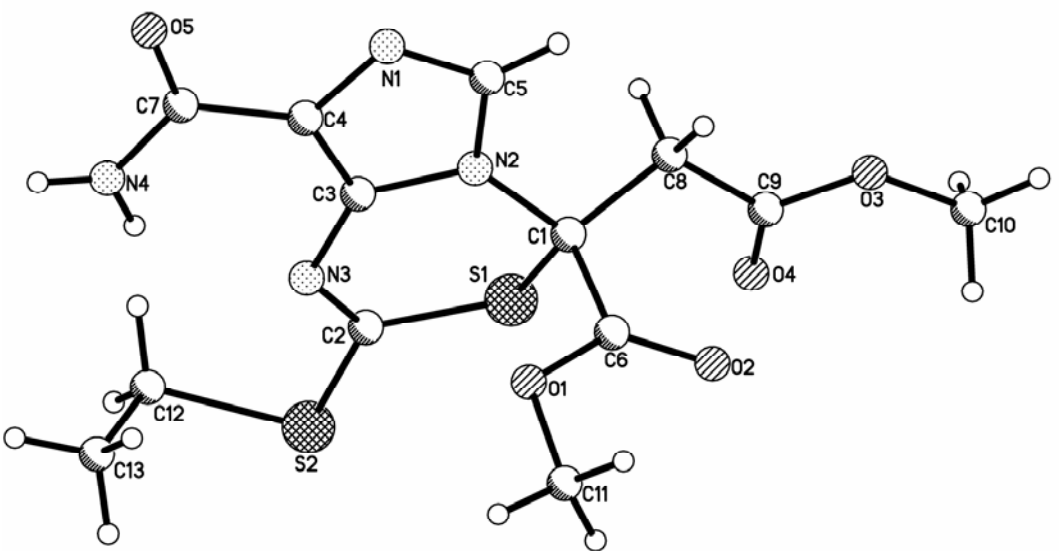
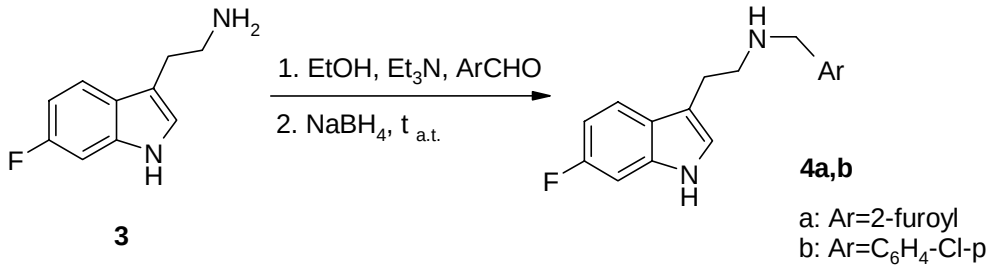


Figure 1. Crystal structure of **3a**.

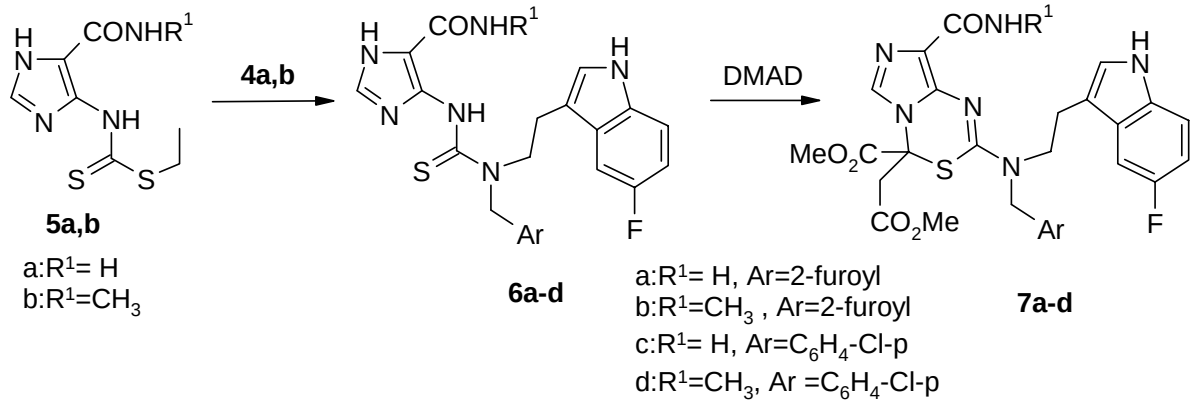
To get more information about the structure of novel heterocyclic system of imidazo[1,5-c][1,3,5]thiadiazine we grew a crystal of compound **3a** and performed its X-ray analysis (Figure 1). According to the X-ray data, the imidazo[1,5-c][1,3,5]thia-diazine is non-planar. It is worthwhile to note that the N(3) atom is close to the plane of the imidazole ring whereas the sp^3-hybrid C(1) atom is situated above the plane (the dihedral angle between the planes is 172.31°) and S(1) and C(2) atom are located under the plane of the imidazole ring (the dihedral angles between the planes are -167.37° and -173.40° respectively).

For expansion of the series of new imidazo[1,5-c][1,3,5]thiadiazines we used the secondary amines **4a,b** with a tryptamine core prepared by means of reductive amination of aromatic and heteroaromatic aldehydes (Scheme 3).



Scheme 3

Heating of compounds **5a**,**b** in ethanol with amines **4a,b** for a short time afforded thiourea derivatives **6a-d**. Reaction with DMAD led to imidazo[1,5-*c*][1,3,5]thiadiazines **7a-d** containing the tryptamine pharmacophoric moiety. Their ^{1}H NMR spectra display signals of protons of a tryptamine fragment, imidazole core, both OMe groups (3.75 and 3.70 ppm), and the AB-system of protons of the CH_2 group (3.65-3.67 ppm, and 3.52-3.57 ppm, *J* 12.9-17.3 Hz). In the ^{13}C NMR spectra, the characteristic signals for a CH_2 group (50.5-50.9 ppm, *J* 134.6-135.4 Hz) and the sp^3-hybrid C- atom of the thiadiazine ring (63.3–63.4 ppm, *J* 4.7-5.2 Hz) were observed. Parent ions in the mass-spectra of compounds **7a-d** corresponded to addition products (Scheme 4).

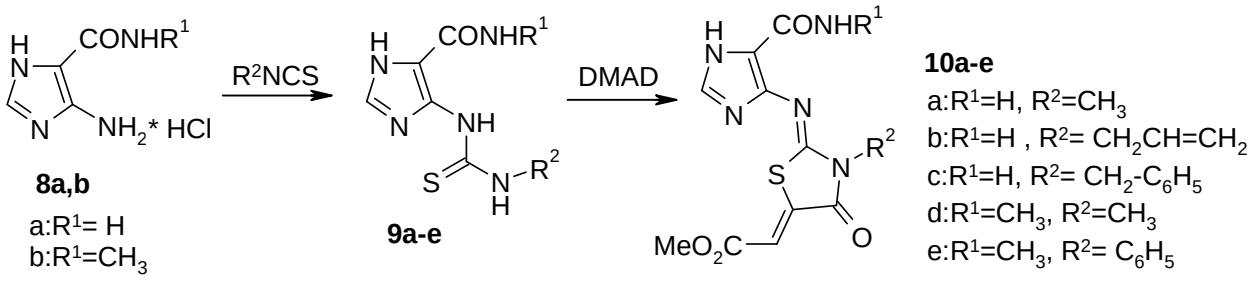


Scheme 4

To determine the influence of substituents on the new transformation of 5-imidazolyl-thioureas we synthesized disubstituted thioureas **9a-e** by reacting 5-amino-imidazoles with isothiocyanates (Scheme 5). In this case, reaction of imidazolyl derivatives with DMAD led to a thiazoline ring and formation of compounds **10a-e**. The ^{1}H NMR spectra of **10a-e** show one OMe and a CH singlet on the exocyclic double bond. The ^{13}C NMR spectrum has characteristic doublets for the CH group (134.3-134.9 ppm, *J* 157.9-161.2 Hz). Parent ions in mass-spectra confirm the formation of cyclocondensation products resulting from the elimination of one methanol molecule. As a result of conjugation of a carbon-carbon double bond with two heterocycles, all substances **10a-e** have a bright yellow color.

Table 1. ^{1}H NMR data of compounds **6,7a-d (**all *J* values are in Hz)

Cpd	CH	CONHR[1]	Ar and Indolyl	CH_2	CO_2 Me	NH (all s, 1xH)
6a	7.53 (s)	7.68 (br s, 1H), 6.53 (br s, 1H)	7.38-7.30 (m, 5H), 6.94 (m, 1H), 6.45 (br s, 1H)	5.04 (br s, 2H), 3.90 (br s, 2H), 2.93 (t, 2H, *J* 7.02)		12.86, 11.32, 11.02
6b	7.52 (s)	8.14 (br s, 1H, NH), 2.80 (br s, 3H, CH_3)	7.52-7.30 (m, 6H), 6.90 (m, 1H)	5.15 (br s, 2H), 3.84 (br s, 2H), 3.00 (t, 2H, *J* 7.02)		12.87, 11.40 (br), 11.02
6c	7.53 (s)	8.24 (br s, 1H), 6.53 (br s, 1H)	7.59-7.30 (m, 6H), 6.90 (m, 1H), 6.45 (br s, 1H)	5.10 (br s, 2H), 3.83 (br s, 2H), 3.01 (t, 2H, *J* 7.02)		12.87, 11.32 (br), 11.04
6d	7.50 (s)	7.43 (br s, 1H, NH), 2.81 (s, 3H, CH_3)	7.39-7.29 (m, 7H), 6.89 (m, 1H)	5.06 (br s, 2H), 3.88 (br s, 2H), 3.05 (t, 2H. *J* 7.32)		12.87, 11.35, 11.01
7a	7.53 (s)	7.15 (br s, 1H), 6.87 (br s, 1H)	7.51 (s, 1H), 7.28 (m, 1H), 7.24 (dd, 1H, *J* 9.8, 2.8), 7.15 (br s, 1H), 6.82 (td, 1H, *J* 9.3, 2.5), 6.45 (br s, 1H), 6.37 (dd, 1H, *J* 3.0, 1.5),	4.75 (br s, 2H), 3.80 (br s, 2H), 3.61 (AB, 1H, *J* 16.8), 3.55 (AB, 1H, *J* 16.8), 2.98 (t, 2H, *J* 7.6)	3.76, 3.70	10.85
7b	7.52 (s)	7.15 (br s, 1H), 2.76 (d, 3H, CH_3, *J* 5.0)	7.51 (m, 2H, H_{Ar}), 7.31-7.23 (m, 2H, H_{Ar}), 6.82 (td, 1H, *J* 9.3, 2.5), 6.47 (br s, 1H), 6.37 (dd, 1H, *J* 3.2, 1.6),	4.75 (br s, 2H): 3.81 (br s, 2H), 3.61 (AB, 1H, *J* 17.3), 3.55 (AB, 1H, *J* 17.3), 2.98 (t, 2H, *J* 7.2)	3.75, 3.70	10.85
7c	7.33 (s)	7.17-6.78 (br s, 2H, $CONH_2$),	7.31-7.27 (m, 5H), 7.21 (br s, 1H), 7.20 (br d, 1H, *J* 4.5), 6.81 (td, 1H, *J* 9.0, 2.0)	4.79 (br s, 2H), 3.78 (br s, 2H), 3.67 (AB, 1H, *J* 12.9), 3.57 (AB, 1H, *J* 12.9), 2.98 (t, 2H, *J* 7.5)	3.75, 3.70	10.84
7d	7.34 (s)	7.17-6.78 (br s, 1H, NH), 2.66 (d, 3H, CH_3, *J* 5.0)	7.32-7.24 (m, 4H), 7.24 (dd, 1H, *J* 9.8, 2.5), 7.20 (br d, 1H), 6.81 (td, 1H, *J* 9.0, 2.0)	4.82 (br s, 2H), 3.82 (br s, 2H), 3.65 (AB, 1H, *J* 17.3), 3.52 (AB, 1H, *J* 17.3), 2.98 (br s, 2H)	3.75, 3.70	10.85

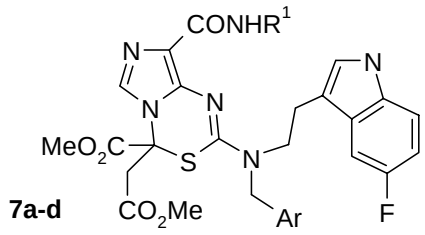


Scheme 5

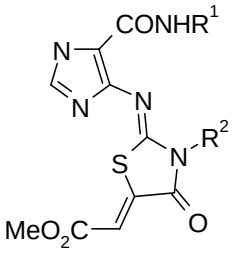
Table 2. ^{1}H NMR data of compounds **9a-c** and **10a-e** (all *J* values in Hz).

Cpd	CH (s)	CONHR^1	R^2	CO_2Me	NH (all 1xH)
9a	7.67	7.27 (br s, 2H)	3.10 (d, 3H, *J* 4.58)		12.47 (br s), 10.29 (d, *J* 3.97), 9.83 (s, 1H)
9b	7.64	7.27 (s, 2H)	6.01-5.88 (m, 1H), 5.30-5.12 (d, 2H, *J* 5.6), 4.26 (d, 2H, *J* 8.80)		12.47 (t, *J* 4.60), 10.70 (br s), 9.88 (s)
9c	7.58	7.25 (s, 2H)	7.37-7.20 (m, 5H), 4.86 (d, 2H, *J* 4.5)		12.44 (br s), 10.76 (br s), 9.94 (s)
10a	7.81, 6.75	7.62, (s, 1H), 7.27 (s, 2H)	3.21 (s, 3H,)	3.79	13.03 (br s)
10b	7.65, 6.71	7.41 (s, 1H), 7.14 (s, 1H),	5.91 (m, 1H), 5.24 (t, 2H, *J* 7.53), 4.54 (d, 2H, *J* 5.4)	3.83	12.93 (br s)
10c	7.64, 6.9	7.41 (s, 2H), 7.14 (s, 1H)	7.34-7.25 (m, 5H), 5.11 (s, 2H)	3.79	12.9 (br s), 6.82 (s)
10d	7.65, 6.76	7.64 (q, 2H, *J* 7.14), 2.91 (d, 3H, *J* 4.8)	3.4 (s, 3H)	3.82	12.96 (br s)
10e	7.64, 6.8	7.01 (br s, 1H), 2.41 (d, 3H, *J* 4.9)	7.63-7.46 (5H, m)	3.84	12.96 (br s)

Table 3. Selected chemical shifts of ^{13}C NMR of compounds **7a-d** and **10a-e**



7a-d



10a-e

Comp.	COOMe	C_{sp^3}	CH_2	CH=	C_{sp^2}
7a	168.2, 166.8, 40.3,* 39.2*	63.3	50.7		
7b	168.2, 166.8, 40.5,* 39.2*,	63.3	50.5		
7c	168.2, 166.9, 40.5,* 38.8*	63.4	50.9		
7d	168.2, 166.9, 40.5,* 39.1*	63.3	50.8		
10a	161.5, 163.3, 51.7				134.5
10b	165.6, 163.3, 52.4				134.4
10c	165.0, 163.5, 51.7				134.5
10d	165.1, 163.3, 51.7				134.3
10e	165.8, 163.2, 52.5				134.9

*Signals are overlapped with signal of solvent.

In summary, contrary to prior art we have found that reactions of DMAD with 5-imidazolylthioureas bearing *tert*-amino group involves the nitrogen atom of the imidazole ring and the only one carbon atom of the acetylene component leading to formation of novel system of imidazo[1,5-*c*][1,3,5]thiadiazine.

Experimental Section

General Procedures. ^1H NMR spectra were recorded on a Bruker WM-250 instrument (250.13 MHz) and Bruker AVANCE II instrument (400 MHz) in DMSO-d_6 with Me_4Si as the internal

standard. ^{13}C NMR spectra were recorded on a Varian Mercury-300 (75.5 MHz) in DMSO-d_6. The course of the reaction was monitored and the purity of the products was checked by TLC on Sorbfil UV-254 plates in ethyl acetate Mass spectra (EI, 70 eV) were recorded on a Varian MATT 311A instrument. Melting points are uncorrected. ^{1}H NMR data of all compounds are in Tables 1 and 2.

Tryptamine derivatives **4a,b** were prepared according to known procedures.[21] Trisubstituted thioureas **6a-d** and imidazothiadiazines **7a-d** were synthesized by the conditions described in our earlier communication.[5]

5-{3-[2-(5-Fluoro-1*H*-indol-3-yl)-ethyl]-3-furan-2-yl-methyl)-thioureido}-3*H*-imidazole-4-carboxylic acid amide (6a). Colorless solid; yield 60%, mp 201-3 °C. *Anal.* Calcd. for $C_{20}H_{19}FN_6O_2S$ (%): C, 56.34; H, 4.49; N, 19.71; S, 7.52. Found (%): C 56.60, H 4.29; N 19.45; S 7.30. *m/z* 426 (60%) (M^+).

5-{3-[2-(5-Fluoro-1*H*-indol-3-yl)-ethyl]-3-furan-2-yl-methyl)-thioureido}-3*H*-imidazole-4-carboxylic acid methylamide (6b). Colorless solid; yield 51%, mp 169-170 °C. *Anal.* Calcd. for $C_{21}H_{21}FN_6O_2S$ (%): C, 57.26; H, 4.81; N, 19.08; S 7.28. Found (%): C, 57.49; H, 4.55; N, 19.00; S, 7.01. *m/z* 440 (52%) (M^+).

5-{3-(4-Chlorobenzyl)-3-[2-(5-fluoro-1*H*-indol-3-yl)-ethyl]-thioureido}-3*H*-imidazole-4-carboxylic acid amide (6c). Colorless solid; yield 60%, mp 189-190 °C. *Anal.* Calcd. for $C_{22}H_{20}ClFN_6OS$ (%): C, 56.11; H, 4.28; N, 17.84; S, 6.81. Found (%): C 56.02; H 4.40; N 17.69; S 7.00. MS *m/z* 470 (44%) (M^+).

5-{3-(4-Chlorobenzyl)-3-[2-(5-fluoro-1*H*-indol-3-yl)-ethyl]-thioureido}-3*H*-imidazole-4-carboxylic acid methylamide (6d). Colorless solid; yield 51%, mp 200-1 °C. *Anal.* Calcd. for $C_{23}H_{22}ClFN_6OS$ (%): C, 56.96;H 4.57; N 17.33; S 6.61. Found (%):C 57.16; H 4.80; N 17.58; S 6.41. *m/z* 484 (52%) (M^+).

Methyl 8-carbamoyl-4-methoxycarbonylmethyl-2-{[2-(5-fluoro-1*H*-indol-3-yl)-ethyl]-furan-2-ylmethylamino}-imidazo[1,5-*c*][1,3,5]thiadiazine 4-carboxylate (7a). Colorless solid; yield 69%, mp 118-9 °C. *Anal.* Calcd. for $C_{26}H_{25}FN_6O_6S$ (%): C, 54.92; H, 4.43; N, 14.78; S, 5.64. Found (%): C, 54.80; H, 4.50; N, 15.01; S, 5.50. ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 168.2, 166.8, 163.4, 158.3, 155.2, 151.0, 149.9, 142.9, 137.9, 132.8, 129.9, 127.2, 125.4, 121.6, 112.4, 110.6, 109.3, 108.9, 102.9, 63.3, 54.1, 52.4, 50.7, 40.5,* 40.3,* 39.2.* *m/z* 568 (41%) (M^+).

4-Methoxycarbonylmethyl-8-methylcarbamoyl-2-{[2-(5-fluoro-1*H*-indol-3-yl)-ethyl]-furan-2-ylmethylamino}-imidazo[1,5-*c*][1,3,5]thiadiazine-4-carboxylic acid methyl ester (7b). Colorless solid; yield 59%, mp 195-7 °C. *Anal.* Calcd. for $C_{27}H_{27}FN_6O_6S$ (%): C 55.66; H 4.67; N 14.42; S 5.50. Found (%): C, 55.49; H, 4.95; N, 14.26; S 5.66. ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 168.2, 166.8, 162.4, 158.2, 155.2, 150.7, 150.1, 142.8, 137.3, 132.8, 129.1, 127.2, 125.3, 121.7, 112.3, 110.6, 108.9, 102.9, 102.6, 63.3, 54.1, 52.3, 50.5, 40.6*, 40.5*, 39.2*, 25.2. *m/z* 582 (50%) (M^+).

8-Carbamoyl-4-methoxycarbonylmethyl-2-{(4-chlorobenzyl)-[2-(5-fluoro-1*H*-indol-3-yl)-ethyl]-amino}-imidazo[1,5-*c*][1,3,5]thiadiazine-4-carboxylic acid methyl ester (7c). Colorless

solid; yield 65%, mp 122-4 °C. *Anal.* Calcd. for $C_{28}H_{26}ClFN_6O_5S$ (%): C, 54.86; H, 4.27; N, 13.71; S 5.50. Found (%): C, 55.00; H, 4.04; N, 13.89; S, 5.00. ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 168.2, 166.9, 163.4, 158.3, 155.2, 151.4, 137.9, 135.9, 132.8, 131.9, 128.8, 128.5, 127.2, 125.4, 121.5, 112.4, 110.5, 109.3, 108.9, 102.9, 102.6, 63.4, 54.1, 52.3, 50.9, 40.6,* 40.5,* 38.8.* MS *m/z* 611 (47%) (M^+).

4-Methoxycarbonylmethyl-8-methylcarbamoyl-2-{(4-chlorobenzyl)-[2-(5-fluoro-1*H*-indol-3-yl)-ethyl]-amino}-imidazo[1,5-*c*][1,3,5]thiadiazine-4-carboxylic acid methyl ester (7d). Colorless solid; yield 69%, mp 203-4 °C. *Anal.* Calcd. for $C_{29}H_{28}ClFN_6O_5S$ (%): C, 55.55; H, 4.50; N, 13.40; S, 5.11. Found (%): C, 55.80; H, 4.32; N, 13.66; S, 5.00. ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 168.2, 166.9, 162.4, 158.3, 155.2, 151.0, 137.4, 136.0, 132.8, 131.8, 129.1, 128.5, 127.2, 125.3, 121.7, 112.4, 110.7, 109.3, 108.9, 102.9, 102.7, 63.3, 54.1, 52.3, 50.8, 40.6,* 40.5,* 39.1,* 25.1. *m/z* 626 (50%) (M^+). Signals * overlap with those of the solvent

The *N,N′*-disubstituted thioureas (9a-c) were prepared according to procedures described for **9d,e** earlier.[3c,21]

5-(3-Methylthioureido)-3*H*-imidazole-4-carboxamide (9a). Colorless solid; yield 80%, mp >250 °C. *Anal.* Calcd. for $C_6H_9N_5OS$ (%): C, 36.17; H, 4.55; N, 35.15; S 16.09. Found (%): C, 36.33; H, 4.31; N, 35.00; S, 16.20. *m/z* 199 (55%) (M^+).

5-(3-Allylthioureido)-3*H*-imidazole-4-carboxamide (9b). Colorless solid; yield 75%, mp >250 °C. *Anal.* Calcd. for $C_8H_{11}N_5OS$ (%): C, 42.65; H, 4.92; N, 31.09; S, 14.23. Found (%): C, 42.99; H, 5.12; N, 31.40; S, 14.20. *m/z* 225 (62%) (M^+).

5-(3-Benzylthioureido)-3*H*-imidazole-4-carboxamide (9c). Colorless solid; yield 86%, mp >250 °C. *Anal.* Calcd. for $C_6H_9N_5OS$ (%): C, 52.35; H, 4.76; N, 25.44; S, 11.65. Found (%): C, 52.70; H, 4.39; N, 25.80; S, 11.31. *m/z* 275 (40%) (M^+).

General procedure for the synthesis of compounds (10a-e)

A solution of each of the compounds **9a-e** (0.69 mmol) and 0.09 ml (0.71 mmol) DMAD in 20 mL of methanol was stirred for 1-4 h. The precipitates of compounds **10a-e** were filtered off and recrystallized from methanol.

5-(5-Methoxycarbonylmethylen-4-oxo-3-methylthiazolidin-2-ylidenamino)-3*H*-imidazole-4-carboxamide (10a). Yiellow solid; yield 75%, mp >250 °C. *Anal.* Calcd. for $C_{11}H_{11}N_5O_4S$ (%): C, 42.72; H, 3.58; N, 22.64; S, 10.37. Found (%): C, 43.00; H, 3.90; N, 22.40; S, 10.31. *m/z* 309 (41%) (M^+). ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 161.5, 163.3, 159.9, 151.2, 143.1, 142.8, 134.5, 117.4, 115.0, 51.7, 28.8.

5-(3-Allyl-5-methoxycarbonylmethylen-4-oxo-thiazolidin-2-ylidenamino)-3*H*-imidazole-4-carboxamide (10b). Yellow solid; yield 71%, mp >250 °C. *Anal.* Calcd. for $C_{13}H_{13}N_5O_4S$ (%): C, 46.56; H, 3.91; N, 20.88; S, 9.56. Found (%): C, 46.25; H, 3.95; N, 20.50; S, 9.81. *m/z* 335 (45%) (M^+). ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 165.6, 163.3, 160.2, 150.6, 143.2, 143.1, 135.2, 134.4, 117.8, 117.1, 115.6, 52.4, 44.8.

5-(3-Benzyl-5-methoxycarbonylmethylen-4-oxo-thiazolidin-2-ylidenamino)-3*H*-imidazole-4-carboxamide (10c). Yellow solid; yield 68%, mp >250 °C. *Anal.* Calcd. for $C_{17}H_{15}N_5O_4S$ (%):

C, 52.98; H, 3.92; N, 18.17; S, 8.32. Found (%): C, 53.32; H, 3.80; N, 18.00; S, 8.00. *m/z* 385 (49%) (M^+). ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 165.0, 163.5, 159.6, 150.4, 142.7, 142.4, 135.2, 134.5, 128.1, 127.0, 126.4, 117.5, 115.6, 51.7, 45.6.

5-(5-Methoxycarbonylmethylen-4-oxo-3-methylthiazolidin-2-ylidenamino)-3*H*-imidazole-4-methylcarboxamide (10d). Yellow solid; yield 69%, mp >250 ^{o}C. *Anal.* Calcd. for $C_{12}H_{13}N_5O_4S$ (%): C, 44.58; H, 4.05; N, 21.66; S, 9.92. Found (%): C, 44.90; H, 3.80; N, 21.40; S, 10.00. *m/z* 323 (55%) (M^+). ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 165.1, 163.3, 159.1, 151.0, 142.8, 142.4, 134.3, 117.4, 115.0, 51.7, 28.9, 24.9.

5-(5-Methoxycarbonylmethylen-4-oxo-3-phenylthiazolidin-2-ylidenamino)-3*H*-imidazole-4-methylcarboxamide (10e). Yellow solid; yield 77%, mp >250 ^{o}C. *Anal.* Calcd. for $C_{17}H_{15}N_5O_4S$ (%): C, 52.98; H, 3.92; N, 18.17; S, 8.32. Found (%): C, 53.21; H, 3.81; N, 18.40; S, 8.44. *m/z* 385 (51%) (M^+). ^{13}C NMR (75.5 MHz, DMSO-d_6) δ 165.8, 163.2, 159.2, 151.7, 143.5, 142.4, 135.3, 134.9, 129.2, 129.1, 128.4, 117.6, 115.6, 52.5, 24.8.

Supplementary Materials

CCDC 694964 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.ac.uk/data_request.cif.

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