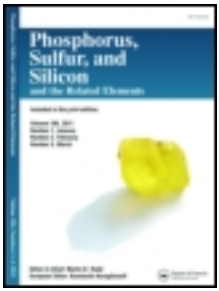

Phosphorus, Sulfur, and Silicon and the Related Elements

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http://www.tandfonline.com/loi/gpss20

Reactions with Hydrazonoyl Halides 58: Synthesis of 2,3-Dihydro-1,3,4-thiadiazoles and 5-Arylazothiazoles

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Version of record first published: 24 Jun 2008

To cite this article: Abdou O. Abdelhamid, Zeineb H. Ismail & Anhar Abdel-Aziem (2008): Reactions with Hydrazonoyl Halides 58: Synthesis of 2,3-Dihydro-1,3,4-thiadiazoles and 5-Arylazothiazoles, Phosphorus, Sulfur, and Silicon and the Related Elements, 183:7, 1735-1745

To link to this article: http://dx.doi.org/10.1080/10426500701734190

Phosphorus, Sulfur, and Silicon, 183:1735–1745, 2008

ISSN: 1042-6507 print / 1563-5325 online
DOI: 10.1080/10426500701734190

Reactions with Hydrazonoyl Halides 58[1]: Synthesis of 2,3-Dihydro-1,3,4-thiadiazoles and 5-Arylazothiazoles

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1,3,4-Thiadiazolines containing a chromone moiety and 5-{1-[4-substituted-5-phenyldiazenyl)(1,3-thiazol-2-yl]-5-phenyl-2-pyrazolin-3-yl)}-4-methoxybenzo[b]-furan-6-ol were synthetic from hydrazonoyl halide and alkyl carbodithioates and 5-[1-aminothiomethoxy)-5-phenyl-2-pyrazolin-3-yl)]-4-methoxybenzo[b]furan-6-ol, respectively. All structures of the newly synthesized compounds were elucidated by elemental analysis, spectral data, and alternative synthesis methods whenever possible.

Keywords 1,3,4-Thiadiazolines; chromones; hydrazonoyl halides; pyrazolines; thiazoles

INTRODUCTION

It is well known that chromones, 1,3,4-thidiazoles, and thiazoles possess pronounced biological activity. Thus, some chromone derivatives possess remarkable vasodilator activity,[2,3] and apasmolytic activity,[4,5] and some other derivatives were useful as bronchodilators.[6] In continuation of an interest in the chemistry of thiadiazole systems, we report some new heterocyclic systems, containing a chromone nucleus—a combination that are expected to possess high biological activity.

RESULTS AND DISCUSSION

Treatment of visnaginone[7] (**1**), 1-(6-hydroxy-4-methoxybenzo[*b*]furan-5-yl)ethan-1-one, with the appropriate alkyl hydrazinecarbodithioate[8,9]

Received 17 July 2007; accepted 1 Septmeber 2007.
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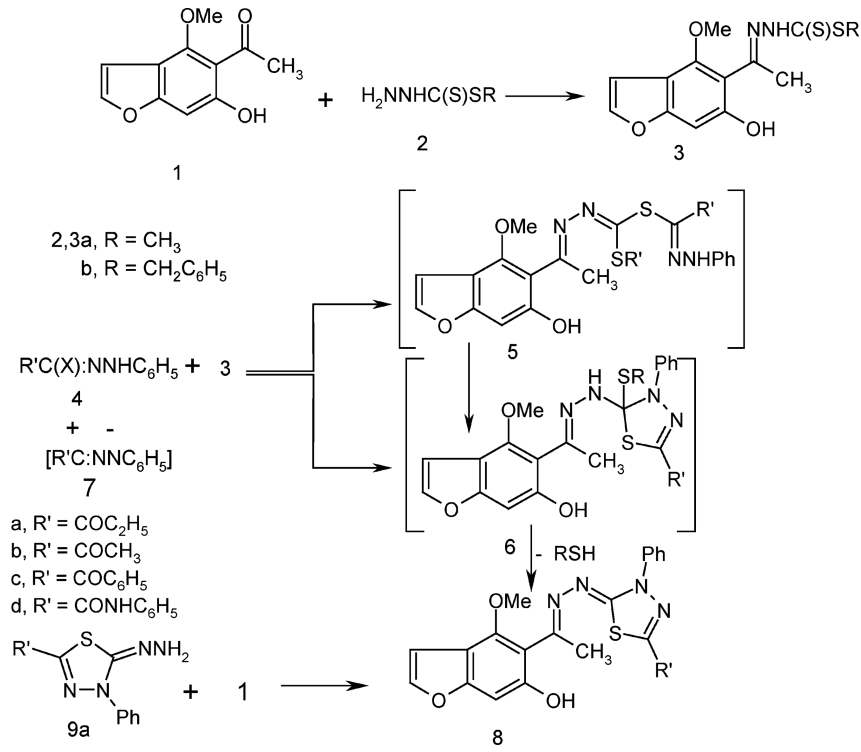


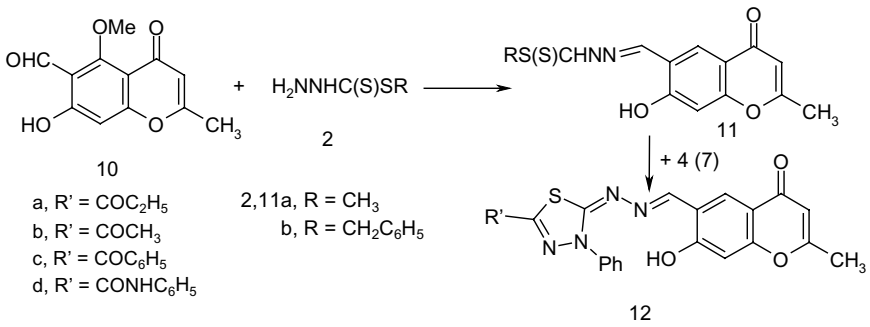
SCHEME 1

2a,**b** in 2-propanol gave 5-(2-aza-1-methyl-2-{[(substituted) thioxomethyl]amino}vinyl)-4-methoxybenzo-[*b*]furan-6-ols **3a** and **3b**, respectively (Scheme 1). Structures **3** were confirmed by elemental analyses, spectral data and chemical transformations. Thus, *C*-ethoxycarbonyl-*N*-phenylhydrazonoyl chloride (**4a**) reacted with methyl carbodithioate **3a** in ethanol containing triethylamine to afford ethyl 2-[1,2-diaza-3-(6-hydroxy-4-methoxybenzo[*b*]furan-5-yl)but-2-enylidene]-3-phenyl-1,3,4-thiadiazoline-5-carboxylate (**8a**). Structures **8** were established by elemental analyses, spectral data, and alternative syntheses. Thus, ethyl 2-hydrazono-3-phenyl-1,3,4-thidiazoline-5-carboxylate[10] (**9**) reacted with visnaginone **1** in ethanol to give a product identical in all aspects (m.p., mixed m.p. and spectra) with **8a**. In addition, benzyl carbodithioate **3b** reacted with **4a** in ethanolic triethylamine to give **8a**.

In the light of the foregoing results, the mechanism outlined in Scheme 1 seems to be the most plausible pathway for the formation of **8** from the reaction of the **4** with **3a** or **3b**. The reaction involves

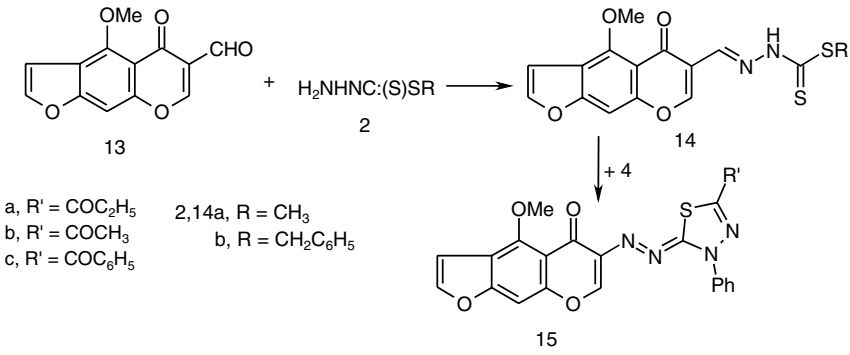
initial formation of thiohydrazonate **5**, which undergoes intermolecular cyclization as soon as it is formed to yield the intermediate **6** or via 1,3-dipolar cycloaddition of nitrilimine **7** (prepared in situ from **4** with triethylamine) to the C=S double bond of **3**. The formations of **5** and **6** are similar to the reaction of hydrazonoyl chloride with 1-phenyl-1,4-dihydrotetrazole-5-thione[11] and 5-phenyl-1,3,4-thiadiazole-2(3H)-thione.[12] Compound **6** was converted to **8** by elimination of alkyl mercaptan. Analogously, the appropriate **3a**, **b** reacted with the appropriate **4b–d** in ethanolic triethyamine to afford 2,3-dihydro-1,3,4-thiadiazoles **8b–d**, respectively.

Similarly, treatment of the appropriate of 6-{2-aza-2-[(substituted thioxomethyl)amino]vinyl}-7-hydroxy-5-methoxy-2-methyl-4H-chromen-4-ones **11a**, **b**, which was prepared from 7-hydroxy-5-methoxy-2-methyl-4-oxo-4H-chromene-6-carbaldehyde[13] (**10**) with the appropriate **2a**, **b** in 2-propanol followed by the appropriate hydrazonoyl halides **4a–e**, gave 6-[2,3-diaza-3-(5-substituted-3-phenyl(1,3,4-thiadiazolin-2-ylidene)prop-1-enyl]-7-hydroxy-5-methoxy-2-methyl-4H-chromen-4-ones **12a-e**, respectively (Scheme 2). Structures **12** were confirmed by elemental analyses, spectral data, and alternative syntheses.



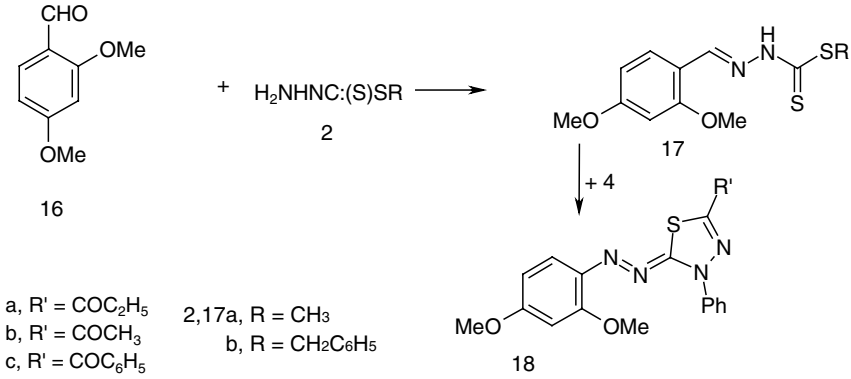
SCHEME 2

Treatment of the appropriate of 3-{2-aza-2-[(substituted thioxomethyl)mino]-vinyl}5-methoxyfurano[3,2-*g*]-4H-chromen-4-one **14a,b**, which was prepared from 5-methoxy-4-oxofurano[3,2-g]-4H-chromene-3-carbaldehyde,[14] and the appropriate **2a,b** followed by with the appropriate hydrazonoyl halides **4a-c**, afforded 3-[2,3-diaza-3-(5- substituted 3-methyl(1,3,4-thiadiazolin-2-ylidene))prop-1-enyl]-5-methoxyfurano [3,2-*g*]-4H-chromen-4-ones **15a–c**, respectively (Scheme 3).



SCHEME 3

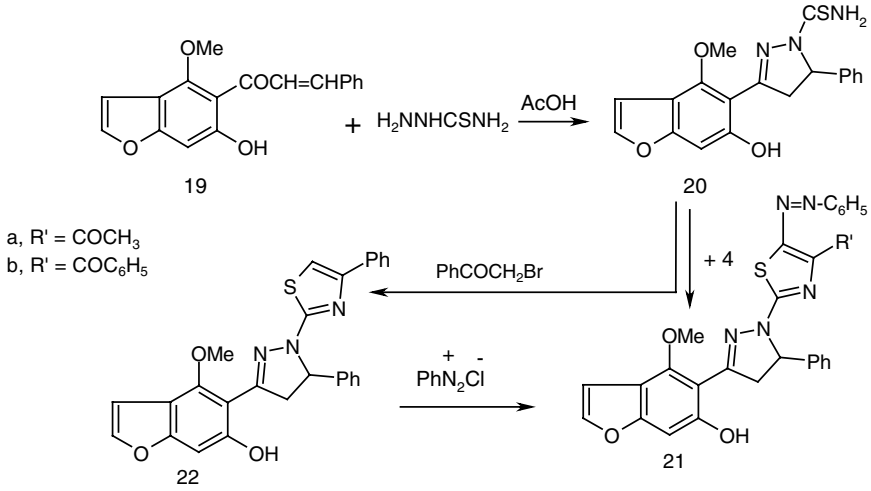
2,4-Dimethoxybenzaldehyde (**16**) reacted with the appropriate alkyl hydrazinecarbodithioate **2a**, **b** in 2-propanol to give {[-1-aza-2-(2,4-dimethoxy)vinyl]amino}substituted thiomethane-1-thiones **17a**, **b** (Scheme 4).



SCHEME 4

Structures **17** were confirmed by elemental analyses, spectral data, alternative syntheses, and chemical transportation. Hydrazonoyl chloride **4a** reacted with **17a** or **17b** in ethanolic triethylamine to give ethyl 2-[1,2-diaza-3-(dimethoxyphenyl)orop-2-enylidine]-3-phenyl-1,3,4-thiadiazoline-5-carboxylate (**18a**). Analogously, each **17a** and **17b** reacted with the appropriate hydrazonoyl halides **4b, c** to afford 1,3,4-thiadiazolines **18b** and **18c**, respectively.

Finally, treatment of 1-(6-hydroxy-4-methoxybenzo[b]furan-5-yl)-3-phenylprop-2-en-1-one[13] (**19**) with thiosemicarbazide in boiling acetic acid to give 5-[1-aminothiomethoxy)-5-phenyl-2-pyrazolin-3-yl)]-4-methoxybenzo[*b*]furan-6-ol (**20**) (Scheme 5). Compound **20**



SCHEME 5

reacted with the appropriate hydrazonoyl halides **4c** and **4d** in boiling chloroform (or ethanol) containing triethylamine to give 5-1-[4-substituted-5-phenyldiazenyl)(1,3-thiazol-2-yl]-5-phenyl-2-pyrazolin-3-yl)-4-methoxybenzo[*b*]-furan-6-ols **21a**, and **21b**, respectively.

Structures **21** were confirmed by elemental analyses, spectral data, and alternative syntheses. Thus, benzenediazonium chloride reacted with 4-methoxy-5-[5-phenyl-1-(4-phenyl(1,3-thiazol-2-yl)]benzo[*b*]furan-6-ol (**22**) in pyridine to give a product identical in all aspects (m.p., mixed m.p., and spectra) with **21b**.

Biological Activity

The tested microorganisms were gram-positive bacteria [*Staphylococcus aureus(ATCC25923)* and *Streptococcus pyrogenes (ATCC19615)*], gram negative bacteria [*Pseudomonas Phaseolicola (GSPB 2828) and Pseudomonas Fluorescens (S 97)*] and some fungal pathogens *(Fusarium oxysporum and Aspergillus funigatus)*. The tested compounds were dissolved N,N-dimethylformamide, which possessed no inhibition activity, to concentrations of 2 mg/1 mL and 1 mg/1 mL. The test was performed on medium potato dextrose agar (PDA) which contained infusion 200 g of potato, 6 g of dextrose, and 15 g of agar. Uniform size filter paper disks (3 disks per compound) were impregnated by an equal volume (10 μ) from the specific concentration of dissolved tested compounds and carefully placed on inoculated agar surface. After incubation for 36 h

TABLE I Response of Various Microorganisms to Some Synthesized Compounds in vitro Culture

	Mean* of zone diameter, nearest whole mm.											
	Gram-positive bacteria				Gram-negative bacteria				Fungi**			
	Staphylococcus aureus(ATCC 25923)		*Streptococcus pyogenes*(ATCC 19615)		*Pseudomonas phaseolicola* (GSPB 2828)		*Pseudomonas fluorescens* (S 97)		*Fusarium oxysporum*		*Aspergillus fumigatus*	
Organisms	1	2	1	2	1	2	1	2	1	1	1	2
Conc. Sample	2 mg/ ml	1 mg/ml	2 mg/ml	1 mg/ml	2 mg/ml	1 mg/ml	2 mg/ml	1mg/ml	2 mg/ml	1 mg/ml	2 mg/ml	1mg/ml
3a	L	—	L	—	—	—	—	—	I	L	—	—
8a	H	I	H	I	I	—	—	—	I	I	L	L
8b	I	I	L	L	—	—	—	—	I	L	L	L
8c	I	I	I	I	—	—	I	L	—	—	H	L
8d	H	I	H	I	L	L	L	L	I	I	—	—
11a	I	L	L	L	L	L	I	—	L	L	L	L
12a	H	H	—	—	I	L	I	L	L	L	—	—
12b	H	H	I	I	L	L	L	L	H	I	H	I
12c	H	H	H	I	L	L	L	L	I	I	H	I
12d	H	I	H	L	—	—	—	—	L	L	L	L
14	H	L	H	I	I	L	—	—	I	L	—	—
15a	H	L	I	L	L	—	L	—	I	L	L	—
15b	I	L	I	—	—	—	—	—	—	—	L	—
15c	I	L	H	I	L	L	L	—	—	—	—	—
17	I	L	I	L	I	L	L	—	I	L	H	L
18a	I	—	I	L	H	I	—	—	I	L	—	—
18b	L	L	I	—	L	L	L	—	L	—	L	—
18c	I	L	I	L	L	—	I	L	L	—	I	L
20	L	—	L	—	H	I	I	L	L	—	I	L
21b	I	L	I	I	L	—	—	—	—	—	—	—
22	—	—	L	—	l	—	I	L	—	—	—	—
Control #	H	H	H	H	H	H	H	H	H	H	H	H

* = Calculate from 3 values; **= Identified depending on morphological and microscopical characters; — = No effect; L = low activity = mean of zone diameter ≤1/3 of mean zone diameter of control; I = intermediate activity = mean of zone diameter ≤2/3 of mean zone diameter of control; H = high activity = mean of zone diameter ≤2/3 of mean zone diameter of control; and # = chloramphencol in the case of gram + positive bacteria. Cephalothin in the case of gram-negative bacteria and cycloheximide in the case of fungi.

at 27°C, in the case of bacteria and 48 h at 24°C, in the case of fungi inhibition of the organisms was evidenced by a clear zone surrounding each disk the zone was measured and used to calculate mean inhibition zones.[15]

In general, all tested compounds possessed inhibitory spatiality of selected the growth of gram positive and gram negative bacteria. In addition, the tested compounds showed a high inhibition towards *Candida albicans (Fungus) and Aspergills flvus (Fungus).*

EXPERIMENTAL

All melting points were uncorrected. IR spectra were recorded (KBr disc) on a Shimadzu FT-IR 8201 PC Spectrophotometer. ^{1}H-NMR spectra were recorded in $CDCl_3$ or $(CD_3)_3SO$ on a Varian Gemini 200 MHz Spectrometer, and chemical shifts were expressed in δ units using TMS as an internal reference. Elemental analyses were carried out at the Microanalytical Center, Cairo University, Giza, Egypt. Hydrazonoyl halides **4a–d** were prepared as previously reported in literature.[16–19]

Synthesis of Alkyl Carbodithioates [3(a,b), 11(a,b), 14, and 17(a,b)]

A mixture of the appropriate of **1**, **10**, **13**, **14** (5 mmol), and the appropriate alkyl hydraziocarbodithioates **2a** and **2b** (5 mmol) in 2-propanol (20 mL) was stirred at room temperature for 2 h. The resulting solid was collected and recrystallized to give [**3**(a,b), **11**(a,b), **14,** and **17**(a,b)], respectively (Tables II and III).

Synthesis of 1,3,4-Thiadiazolines (8, 12)a–d, 15a–c, and 18a–c

Method A

Triethylamine [0.5 g (0.75 ml), 5 mmol] was added dropwise with stirring to a mixture of the appropriate alkyl carbodithioates [**3**(a,b), **11**(a,b), **14,** and **17**(a,b)], and the appropriate hydrazonoyl halides **4a–d** (5 mmol) in ethanol (20 mL). The resulting solid, which formed after 30 min, was collected and crystallized from the proper solvent to afford the corresponding thiadiazolines (**8**, **12**)**a–d**, **15a–c**, and **18a–c**, respectively (Tables II and III).

Method B

A mixture of 1,3,4-thiadiazoline **9a** (1.32 g, 5 mmol) and the appropriate **1**, **10**, **13**, and **16** in 2-propanol (20 mL) was heated for 10 min and then cooled. The resulting solid was collected and recrystallized from

TABLE II Characterization Data of the Newly Synthesized Compounds

Comp. No	Mp.°C (solvent)	Color yield (%)	Mol. formula (mol. wt.)	Calcd./found (%) C	H	*N*	*S*
3a	133–135	White	$C_{13}H_{14}N_2O_3S_2$	50.30	4.55	9.02	20.65
	EtOH	75	31.38	50.03	4.45	8.95	20.56
3b	170–172	White	$C_{19}H_{18}N_2O_3S_2$	59.04	4.69	7.24	16.59
	EtOH	80	386.48	59.10	4.85	7.15	16.32
8a	180–181	Yellow	$C_{22}H_{20}N_4O_5S$	58.41	4.45	12.38	7.08
	EtOH	80	452.37	58.21	4.35	12.31	6.89
8b	170–172	Yellow	$C_{21}H_{18}N_4O_4S$	59.70	4.24	13.26	7.58
	EtOH	80	422.45	59.60	4.23	13.20	7.85
8c	120–121	Orange	$C_{26}H_{20}N_4O_4S$	64.45	4.16	11.56	6.61
	EtOH	75	484.53	64.54	4.25	11.65	6.42
8d	184–185	Yellow	$C_{26}H_{21}N_5O_4S$	62.51	4.32	14.02	6.41
	EtOH	80	499.63	62.31	4.52	14.24	6.23
11a	280–182	Pale yellow	$C_{14}H_{14}N_2O_4S_2$	49.69	4.17	8.28	18.95
	AcOH	90	338.39	49.72	4.12	8.32	18.85
11b	>300	Pale yellow	$C_{20}H_{18}N_2O_4S_2$	57.93	4.38	6.76	15.47
	AcOH	90	414.29	57.72	4.27	6.54	15.32
12a	230–132	Yellow	$C_{23}H_{20}N_4O_6S$	57.49	4.19	11.66	6.67
	AcOH	85	480.49	57.32	3.91	11.42	6.72
12b	180–183	Yellow	$C_{22}H_{18}N_4O_5S$	58.66	4.02	12.43	7.12
	EtOH	85	450.46	58.44	4.23	12.34	7.21
12c	>300	Yellow	$C_{27}H_{20}N_4O_5S$	63.27	3.93	10.93	6.25
	AcOH	85	512.53	63.42	4.20	11.12	6.45
12d	190–192	Yellow	$C_{27}H_{21}N_5O_5S$	61.47	4.01	13.27	6.07
	EtOH	85	527.55	61.23	3.88	13.58	5.86
14	230–232	Pale yellow	$C_{15}H_{12}N_2O_4S_2$	51.71	3.47	8.04	18.41
	AcOH	95	348.40	51.52	3.74	8.12	18.32
15a	240–242	Pale yellow	$C_{24}H_{18}N_4O_6S$	58.77	3.70	11.42	6.54
	AcOH	95	490.50	58.66	3.50	11.32	6.45
15b	280–282	Yellow	$C_{23}H_{16}N_4O_5S$	55.99	3.50	12.17	6.96
	AcOH	85	460.47	56.21	3.70	12.00	7.12
15c	255–256	Orange	$C_{28}H_{18}N_4O_5S$	64.36	3.47	10.72	6.14
	AcOH	95	522.54	64.63	3.64	10.52	6.43
17a	170–171	Pale yellow	$C_{11}H_{14}N_2O_2S_2$	48.96	5.22	10.36	23.74
	EtOH	90	270.36	48.85	5.11	10.25	23.54
18a	180–181	Yellow	$C_{20}H_{20}N_4O_4S$	58.24	4.88	13.58	7.78
	AcOH	85	412.46	58.14	4.52	13.32	7.95
18b	260–261	Orange	$C_{19}H_{18}N_4O_3S$	59.67	4.74	14.65	8.38
	AcOH	85	382.44	60.00	4.52	14.56	8.52
18c	230–232	Red	$C_{24}H_{20}N_4O_3S$	64.85	4.53	12.60	7.21
	AcOH	80	444.50	64.75	4.35	12.35	7.45
20	220–222	Yellow	$C_{19}H_{16}N_3O_3S$	62.28	4.40	11.46	8.74
	EtOH	70	366.41	62.32	4.32	11.32	8.62
21a	180–182	Red	$C_{28}H_{22}N_5O_3S$	66.12	4.35	13.77	6.30
	EtOH	80	508.57	66.22	4.36	13.66	6.20
21b	260–261	Red	$C_{33}H_{24}N_5O_3S$	69.45	4.23	12.27	5.61
	AcOH	80	570.64	69.25	4.32	12.52	5.81
22	238–240	Yellow	$C_{26}H_{19}N_3OS$	74.09	4.54	9.97	7.61
	EtOH	80	421.52	74.24	4.45	9.78	7.52

TABLE III ^{1}H NMR Spectra

Comp. No	^{1}H NMR Spectra
3a	^{1}H NMR: $\delta = 2.44$ (s, 3H), 2.69 (s, 3H), 4.09 (s, 3H), 6.72–7.50 (m, 3H), 9.95 (s, br., 1H), 10.15 (s, 1H).
3b	^{1}H NMR: $\delta = 2.64$ (s, 3H), 4.0 (s, 3H), 4.13 (s, 2H), 6.72–7.50 (m, 8H), 9.95 (s, br., 1H), 10.15 (s, 1H).
8a	^{1}H NMR: $\delta = 1.44$ (t, 3H), 2.61 (s, 3H), 4.05 (s, 3H), 4.44 (q, 2H), 6.82–8.06 (m, 8H), 11.45 (s, 1H).
8b	^{1}H NMR: $\delta = 2.29$ (s, 3H), 2.61 (s, 3H), 4.05 (s, 3H), 6.70–8.06 (m, 8H), 12.16 (s, 1H).
8c	^{1}H NMR: $\delta = 2.61$ (s, 3H), 4.05 (s, 3H), 6.70–8.06 (m, 13H), 12.16 (s, 1H).
8d	^{1}H NMR: $\delta = 2.61$ (s, 3H), 4.05 (s, 3H), 6.70–8.06 (m, 9H), 12.16 (s, 1H).
11a	^{1}H NMR: $\delta = 2.29$ (s, 3H), 2.59 (s, 3H), 3.83 (s, 3H), 6.03 (s, 1H), 6.79 (s, 1H), 8.74 (s, 1H), 11.41 (s, 1H), 13.50 (s, 1H).
11b	^{1}H NMR: $\delta = 2.59$ (s, 3H), 3.83 (s, 3H), 4.21 (s, 1H), 6.03 (s, 1H), 6.79 (s, 1H), 8.74 (s, 1H), 11.41 (s, 1H), 13.50 (s, 1H).
12a	^{1}H NMR: $\delta = 1.45$ (t, 3H), 2.30 (s, 3H), 3.95 (s, 3H), 5.99 (s, 1H), 6.73 (s, 1H), 7.25–7.94 (m, 5H), 8.90 (s, 1H), 12.12 (s, 1H).
12b	^{1}H NMR: $\delta = 2.30$ (s, 3H), 2.64 (s, 3H), 3.94 (s, 3H), 5.99 (s, 1H), 6.72 (s, 1H), 7.41–7.99 (m, 5H), 8.89 (s, 1H), 12.10 (s, 1H).
12c	^{1}H NMR: $\delta = 2.64$ (s, 3H), 3.94 (s, 3H), 5.99 (s, 1H), 6.72 (s, 1H), 7.41–7.99 (m, 10H), 8.89 (s, 1H), 12.10 (s, 1H).
12d	^{1}H NMR: $\delta = 2.64$ (s, 3H), 3.94 (s, 3H), 5.99 (s, 1H), 6.72 (s, 1H), 7.41–7.99 (m, 10H), 8.89 (s, 1H), 11.45 (s, 1H), 12.10 (s, 1H).
14	^{1}H NMR: $\delta = 2.73$ (s, 3H), 4.12 (s, 3H), 6.78 (s, 1H), 7.33 (s, 1H), 8.10 (s, 1H), 8.37 (s, 1H), 8.75 (s, 1H), 10.06 (s, 1H), 13.35 (s, 1H).
15a	^{1}H NMR: $\delta = 1.42$ (t, 3H), 4.19 (s, 3H), 4.47 (q, 2H), 7.04 (s, 1H), 7.26–7.61 (m, 7H), 8.51–8.66 (d, 1H).
15b	^{1}H NMR: $\delta = 2.58$ (s, 3H), 4.11 (s, 3H), 7.397.61 (m, 8H), 8.41 (s, 1H), 8.63 (s, 1H).
15c	^{1}H NMR: $\delta = 4.11$ (s, 3H), 7.397.61 (m, 8H), 8.41 (s, 1H), 8.63 (s, 1H).
17a	^{1}H NMR: $\delta = 2.67$ (s, 3H), 3.86 (s, 6H), 6.44 (s, 1H), 6.53–6.57 (d, 1H), 7.90–7.95 (d, 1H), 8.22 (s, 1H), 10.26 (s, 1H).
18a	^{1}H NMR: $\delta = 1.44$ (t, 3H), 3.84 (s, 6H), 6.43–6.58 (m, 2H), 7.27–7.50 (m, 3H), 7.97–8.01 (m, 3H), 8.78 (s, 1H).
18b	^{1}H NMR: $\delta = 2.67$ (s, 3H), 3.88 (s, 6H), 6.43–6.59 (m, 2H), 7.30–7.53 (m, 3H), 7.98–8.08 (m, 3H), 8.74 (s, 1H).
18c	^{1}H NMR: $\delta = 3.88$ (s, 6H), 6.43–6.59 (m, 2H), 7.30–7.53 (m, 8H), 7.98V8.08 (m, 3H), 8.74 (s, 1H).
20	^{1}H NMR: $\delta = 3.88$ (s, 3H), 3.46 (dd, 1H, J = 18.1, 5.8 Hz, $CH_{2\ (pyraz)}$, 3.82 ((dd, 1H, J = 18.1, 12.2 Hz, $CH_{2\ (pyraz)}$), 3.76 (s, 3H), 4.14 ((dd, 1H, J = 12.2, 5.8 Hz, $CH_{2\ (pyraz)}$), 6.84–7.51 (m, 7H), 8.57 (s, 1H), 10.60 (s, 1H).
21b	^{1}H NMR: $\delta = 2.54$ (s, 3H), 3.46 (dd, 1H, J = 18.1, 5.8 Hz, $CH_{2\ (pyraz)}$, 3.82 ((dd, 1H, J = 18.1, 12.2 Hz, $CH_{2\ (pyraz)}$), 4.03 (s, 3H), 4.14 ((dd, 1H, J = 12.2, 5.8 Hz, $CH_{2\ (pyraz)}$), 6.86–7.43 (m, 13H), 11.05 (s, 1H).

acetic acid to give (**8**, **12**)**a–d**, **15a–c,** and **18a–c**, respectively (Tables II and III).

Synthesis of Pyrazolines 20

A mixture of 5-[1-aminothiomethoxy)-5-phenyl-2-pyrazolin-3-yl)]-4-methoxybenzo[*b*]furan-6-ol (**19**) (2.94 g, 10 mmol), thiosemicarbazide (0.91 g, 10 mmol) and acetic acid (20 mL) was heated for 6 h. The resulting solid was collected and recrystallized from ethanol to give pyrazoline **20** (Tables II and III).

Synthesis of 4-Methoxy-5-[5-phenyl-1-(4-phenyl(1,3-thiazol-2-yl)]benzo[*b*]furan-6-ol (22)

A mixture of **20** (1.8 g, 5 mmol) and phenacyl bromide (0.99 g, 5 mmol) in ethanol was heated for 3 h. The resulting solid was collected and recrystallized from ethanol to give **22** (Tables I and II).

5-{1-[4-Substituted-5-phenyldiazenyl)(1,3-thiazol-2-yl]-5-phenyl-2-pyrazolin-3-yl)}-4-methoxybenzo[*b*]furan-6-ols 21a, 21b

Method A

A mixture of **20** (1.9 g, 5 mmol), the appropriate hydrazonoyl halides **4c,d** (5 mmol), and triethylamine (0.75 mL, 5 mmol) in chloroform (20 mL) was heated for 10 hrs. The solvent was evaporated under reduce pressure, and the resulting solid was collected and recrystallized from the proper solvent to give **21a** and **21b**, respectively (Tables II and III).

Method B

Benzenediazonium chloride (5 mmol) was added dropwise to a cold solution of **22** (2.1 g, 5 mmol) in pyridine (25 mL) at 0–5°C while stirring. The reaction mixture was stirred for 3 h at 0–5°C, and the resulting solid was collected and recrystallized from acetic acid to give product identical in all aspects (mp, mixed mp, and spectra) with **21b**.

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