Reaction with Hydrazonoyl Halides 64: Synthesis of Some New Triazolino[4,3-*a*]pyrimidines, 1,3,4-Thiadiazoles, and 5-Arylazothiazoles

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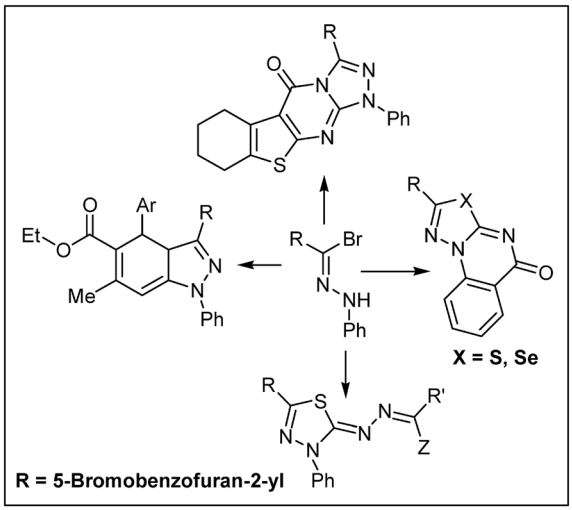

2,3-Dihydro-1,3,4-thiadiazoles, 2,3-dihydro-1,3,4-selenadiazoles, and triazolino[4,3-*a*]pyrimidines containing benzofuran moiety were prepared from the reaction of 2-(2-phenylhydrazono)-1-(5-bromobenzofuran-2-yl)-2-chloroethanone with each of potassium thiocyanate, potassium selenocyanate, alkyl carbodithioate, and pyrmidine-2-thione derivatives. All the newly synthesized compounds were confirmed by elemental analysis, spectral data, and alternative route synthesis whenever possible.

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INTRODUCTION

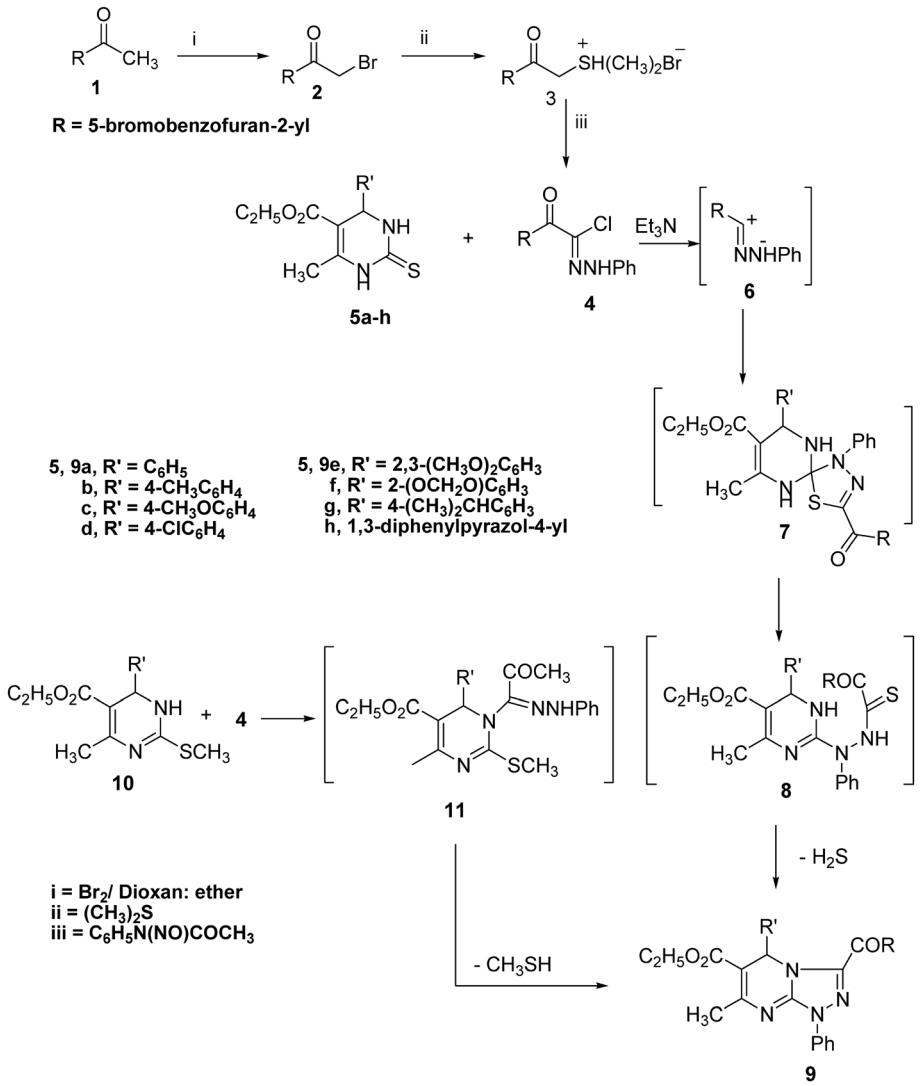
1,3,4-Thiadiazoles have been screened for their antibacterial and antifungal activities [1–4], anti-inflammatory [5], antituberculosis activity [6], and anticancer [7]. Also, the benzofuran ring system occurs widely in natural products as well as in synthetic substances, which have been reported to exhibit a variety of important pharmacological properties [8]. Moreover, a series of benzofuran derivatives have been reported to inhibit the fibril formation in the β-amyloid peptide [9], which is believed to be the underlying cause of Alzheimer's disease [10, 11]. Here, we report the convenient synthesis of triazolino[4,3-*a*]pyrimidines, 2,3-dihydro-1,3,4-thiadiazoles, 2,3-dihydro-1,3,4-selenadiazoles, and 5-arylazothiazole derivatives containing benzofuran moiety.

RESULTS AND DISCUSSION

Treatment of 2-(2-phenylhydrazono)-1-(5-bromobenzofuran-2-yl)-2-chloroethanone (**4**) with ethyl 4-methyl-6-phenyl-2-thioxo-1,3,6-trihydropyrimidine-5-carboxylate (**5a**) [12] in chloroform and triethylamine gave ethyl 1,5-dihydro-3-(5-bromobenzofuran-2-oyl)-7-dimethyl-1,5-diphenyl-[1,2,4]triazolo[4,3-*a*]pyrimidine-6-carboxylate (**9a**; Scheme 1). The structure of **9a** was elucidated on the basis of both elemental analysis and spectral data as well as alternative synthesis. ^{1}H NMR spectrum of **9a** showed signals at δ = 1.16 (t, 3H, CH_3CH_2), 2.24 (s, 3H, CH_3), 4.21 (q, 2H, CH_2CH_3), 6.15 (s, 1H, CH), and 7.12–8.11 (m, 14H, ArH). Its IR spectrum revealed bands at ν = 1735 cm^{-1} (CO).

Ethyl 6-methyl-4-[4-phenyl-2-methylthio-3,4-dihydropyrimidine-5-carboxylate (**10a**) [13] reacted with **4** in boiling ethanolic sodium ethoxide solution gave products identical in all aspects (mp, mixed mp, and spectral data) with the corresponding **9a**. Analogously, treatment of the appropriate **4** with the appropriate **5b–h** gave tiazolo[4,3-*a*]pyrimidines **9b–h**, respectively (Scheme 1). The formation of **9b–h** can be explained *via* 1,3-dipolar cycloaddition or 1,3-addition of nitrile imides **6** (prepared *in situ* from hydrazonoyl bromide **4** with triethylamine or sodium ethoxide) to C=S of **5** (or NH of **10**) to give intermediates **7–8** (or **11**), with ring opening and ring closure to afford the final products **9** by elimination of hydrogen sulfide (or methyl mercaptan; Scheme 1).

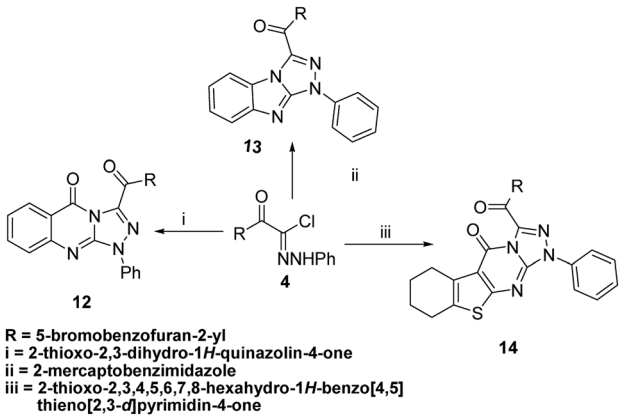
Scheme 1



Similarly, reactions of 2-thioxo-2,3-dihydro-1*H*-quinazolin-4-one [14], 2-mercaptobenzimidazole, and 2-thioxo-2,3,5,6,7,8-hexahydro-1*H*-benzo[4,5]thieno[2,3-*d*] pyrimidin-4-one [15] with hydrazonoyl bromide **4** were carried out in refluxing chloroform by triethylamine gave [1,2,4]triazolo[3,4-*b*]quinazolin-5-one **12**, 1*H*-benzo [4,5]imidazo[2,1-*c*][1,2,4]triazol-3-yl)-methanone **13**, and 1,2,3a,10-tetraaza-cyclopenta[*b*]fluoren-4-one **14**, respectively (Scheme 2).

Also, treatment **4** with potassium thiocyanate and potassium selenocyanate gave (5-bromobenzofuran-2-yl)(4,5-dihydro-5-imino-4-phenyl-1,3,4-thiadiazol-2-yl)methanone (**17a**) and (5-bromobenzofuran-2-yl)(4,5-dihydro-5-imino-4-phenyl-1,3,4-selenadiazol-2-yl)methanone (**17c**), respectively (Scheme 3). The structures of **17a** and **17c** were elucidated on the basis of elemental analyses, spectral data, alternative synthetic route, and its chemical transformation. These results indicate that hydrazone **16** is not the final products and readily gave **17** by cyclization (Scheme 3). Nitrosation of each **17a** and **17c** with saturated sodium nitrite in acetic acid at 0–5°C gave (5-bromobenzofuran-2-yl) (4,5-dihydro-5-nitrosoimino-4-phenyl-1,3,4-thiadiazol-2-yl)methanone (**18a**) and (5-bromobenzofuran-2-yl)(4,5-dihydro-5-nitrosoimino-4-phenyl-1,3,4-selenadiazol-2-yl) methanone (**18c**), respectively. 5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3*H*-[1,3,4]thiadiazol-2-one (**19a**) and 5-(5-bromo-benzofuran-2-carbonyl)-3-phenyl-3*H*-[1,3,4]selenadiazol-2-one (**19c**) were prepared by thermolysis of **18a** and **18c** in boiling xylene. IR spectra of **19a** and **19c** revealed bands at ν = 1685 cm^{-1} (CO). Acetylation of **17a** with acetic anhydride and benzoylation with benzoyl chloride in pyridine afforded *N*-[5-(5-bromo-benzofuran-2-carbonyl)-3-phenyl-3*H*-[1,3,4]thiadiazol-2-ylidene]-acetamide (**20a**) and *N*-[5-(5-bromo-benzofuran-

Scheme 2

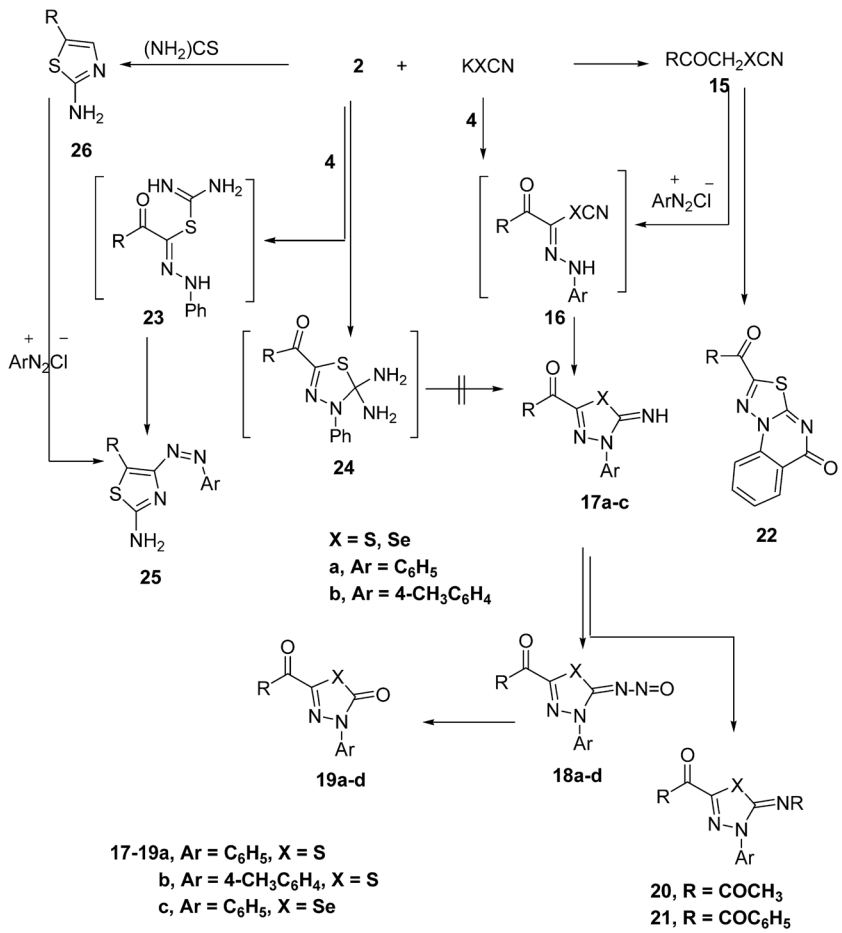


2-carbonyl)-3-phenyl-3*H*-[1,3,4]thiadiazol-2-ylidene]-benzamide (**21a**), respectively. ^{1}H NMR spectrum of **20a** showed signals at δ = 2.10 (s, 3H, CH_3CO), 2.40 (s, 3H, CH_3CON), 7.40 (d, 2H, *J* = 8 Hz, ArH′s), 7.50 (d, 2H, *J* = 8Hz, ArH′s), 8.00 (d, 4H, *J* = 8Hz, ArH′s).

More evidence on the correct structure of **17** came from reaction of arenediazonium chloride with **15** in ethanolic sodium acetate solution gave a products identical in all aspects (mp, mixed mp, and spectra) with **17**. Analogously, diazotization of each anthranilic acid and methyl anthranilate reacted with the appropriate **15a**,**b** gave one isolable product, in each case, as: 2-(5-bromo-benzofuran-2-carbonyl)-3-thia-1,4,9b-triaza-cyclopenta[*a*]naphthalen-5-one (**22a**) and 2-(5-bromo-benzofuran-2-carbonyl)-3-selena-1,4,9b-triaza-cyclopenta[*a*]naphthalen-5-one (**22b**), respectively, in a good yield (Scheme 3).

In contrast, treatment of **4** with thiourea in boiling ethanol gave 5-(2-phenyldiazenyl)-2-(5-bromobenzofuran-2-yl)thiazol-4-amine (**25a**; spectral data, elemental analysis, and alternative synthetic route confirmed the structure). ^{1}H NMR spectrum of **20a** showed signals at δ = 7.23–7.69 (m, 8H, ArH′s) and 8.25 (s, br., 2H, NH_2). Thus, treatment of benzenediazonium chloride with 2-(5-bromo-benzofuran-2-yl)-thiazol-4-ylamine (**26**), which prepared from reaction of thiourea with **2** in ethanol, gave product identical in all aspects (mp, mixed mp, and spectra) with **25**.

Scheme 3



Compound **4** reacted with alkyl carbodithioates **27a** [16, 17] to give [5-(benzylidene-hydrazono)-4-phenyl-4,5-dihydro-[1,3,4]thiadiazol-2-yl]-(5-bromo-benzofuran-2-yl)-methanone (**31a**; Scheme 4). The structure of **30a** was confirmed by elemental analysis, spectral data, and alternative synthetic route. ^{1}H NMR spectrum of **31a** showed signals at δ = 2.10 (s, 3H, CH_3), and 7.54–8.53 (m, 11H, ArH′s), 8.40 (d, 2H, ArH′s), and 8.52 CH (vinyl). Thus, treatment of **4** with **28a** in ethanolic triethylamine gave a product identical in all aspects (mp, mixed mp, and spectra) with **30a**. Analogously, treatment of **4** with the appropriate **27b–n** in ethanolic triethylamine afforded 1,3,4-thiadiazoline derivatives **31b–n**, respectively (Scheme 4).

Finally, (5-bromo-benzofuran-2-yl)-(4-phenyl-5-phenylimino-4,5-dihydro-[1,3,4]thiadiazol-2-yl)-methanone (**32**) was obtained from reaction of **4** with methyl phenyldithiocarbamate.

CONCLUSIONS

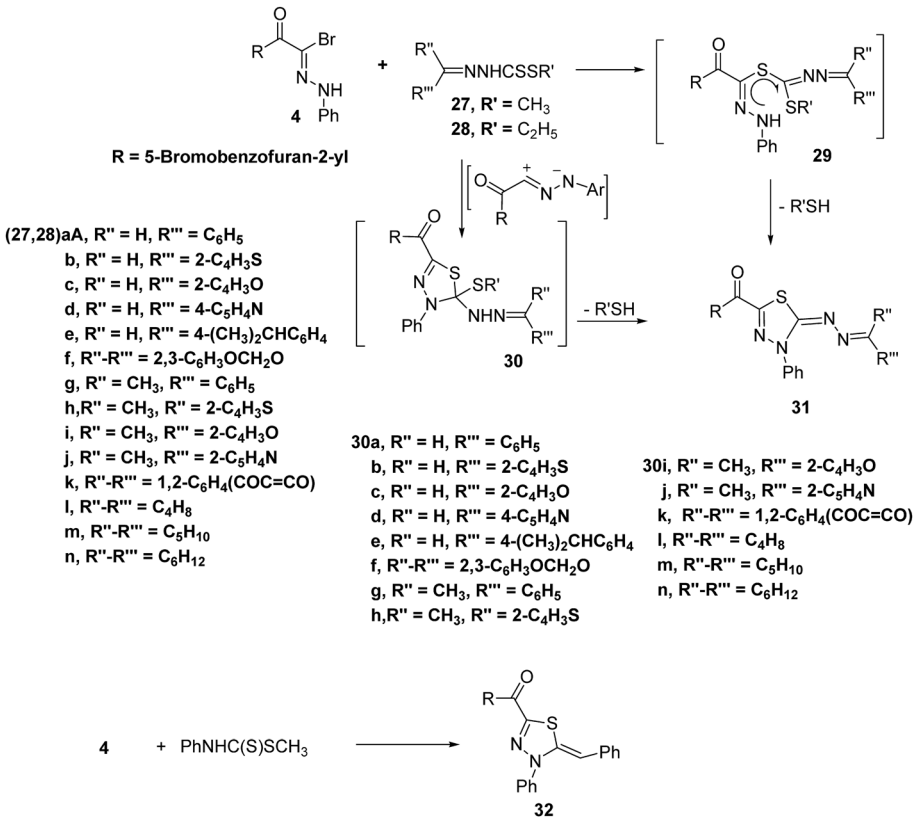
Some new triazolino[4,3-*a*]pyrimidine, 1,3,4-thiadiazole, 1,3,4-selenadiazole, and 5-arylazothiazole derivatives containing benzofuran moiety were obtained in a good yield *via* reaction of 2-(2-phenylhydrazono)-1-(5-bromobenzofuran-2-yl)-2-chloroethanone with the appropriate of ethyl 4-methyl-6-substituted 2-thioxo-1,3,6-trihydropyrimidine-5-carboxylate, potassium thiocyanate, potassium selenocyanate, alkyl carbodithioate.

EXPERIMENTAL

All melting points were determined on an Electrothermal melting point apparatus and are uncorrected. IR spectra were recorded (KBr discs) on a Shimadzu FT-IR 8201 PC spectrophotometer. The ^{1}H NMR and ^{13}C NMR spectra were taken on a Varian Gemini 300 MHz spectrometer in CDl_3 or DMSO-d_6 using TMS as internal standard, and chemical shifts are expressed in δ (ppm) values. Mass spectra were taken on a Shimadzu GCMS-GB PX and Shimadzu GCMS-QP1000 EX mass spectrometer and operating at 70 eV. Elemental analyses were carried out at Microanalytical Center of the University of Cairo, Giza, Egypt. 2-Mercaptobenzimidazole was supplied by MERCK (Germany).

2-Bromo-1-(5-bromobenzofuran-2-yl)ethanone (2). Bromine [16 g (5 mL), 0.1 mmol] was added portion wise to 2-acetyl-5-bromobenzofuran (23.8 g, 0.1 mmol) in dioxan–ether (50 mL) while stirring for 15 min. The reaction mixture was then poured on ice cold water (200 mL). The resultant solid residue was collected and recrystallized from ethanol to give pale yellow crystals, yield (75%), mp 132–33°C; IR (KBr): 3098 (CH, aromatic), 1690 (CO), 1594 (C=C); ^{1}H NMR: δ = 4.43 (s, 2H, CH_2); 7.65–7.94 (m, 4H, ArH′s); ^{13}C NMR δ = 25.68, 107.85, 113.25, 116.45, 124.21, 127.65, 129.11, 142.77, 153.21, 185.87; Anal. Calcd. For $C_{10}H_6Br_2O_2$ requires (317.96): C, 37.77; H, 1.90; Br, 50.26. Found: C, 37.65; H, 2.10; Br, 50.34%.

Scheme 4



1-(5-Bromobenzofuran-2-yl)ethanone-2-oxodimethylsulfonium bromide (3). A mixture of **2** (30.3 g, 0.1 mol) and dimethylsulfide (6.8 g, 0.11 mol) in ethanol (75 mL) was boiled under reflux for 30 min. The reaction mixture was then cooled, and the solid collected by filtration and recrystallized from ethanol to give yellow crystals, yield (70%), mp 162–64°C; IR (KBr): 3081 (CH, aromatic), 1665 (CO), 1592 (C═C); ^{1}H NMR: 3.18 (s, 6H, $2CH_3$), 4.11 (s, 2H, CH_2), 7.52–7.85 (m, 4H, ArH′s); Anal. Calcd. For $C_{12}H_{12}Br_2O_2S$ requires (380.1): C, 37.92; H, 3.18; Br, 42.04; S, 8.44. Found: C, 38.12; H, 3.31; Br, 41.88; S, 8.56%.

2-(2-Phenylhydrazono)-2-bromo-1-(5-bromobenzofuran-2-yl)ethanone (4). A mixture of **3** (36.5 g, 0.1 mol) and the appropriate *N*-nitrosoacetanilide (16 g, 0.11 mol) was stirred in ethanol (100 mL) for 3 h at room temperature. The resulting solid was collected and recrystallized from acetic acid to give yellow crystals. Yield (75%), mp 198–200°C; IR (KBr): 3075 (CH, aromatic), 1662 (CO), 1596 (C═C); ^{1}H NMR: δ = 6.82 (t, 1H, *J* = 8Hz, ArH), 7.22 (t, 2H, *J* = 8 Hz, ArH′s), 7.25 (d, 2H, *J* = 8Hz, ArH′s), 7.82–7.92 (m, 4H, ArH′s), 11.80 (s, br., 1H, NH); ^{13}C NMR δ = 113.21, 114.34, 115.21, 116.01, 122.11, 124.45, 125.78, 127.31, 129.11, 131.32, 146.71, 147.62, 156.25, 174.13; Anal. Calcd. For $C_{16}H_{10}Br_2N_2O_2$ requires (422.07): C, 45.53; H, 2.39; Br, 37.86; N, 6.64. Found: C, 45.37; H, 2.42; Br, 37.68; N, 6.55%.

Synthesis of ethyl 3-(5-bromo-benzofuran-2-carbonyl)-7-methyl-1-phenyl-5-substituted 1,5-dihydro-[1,2,4]triazolo[4,3-*a*]pyrimidine-6-carboxylate 9a–h and 12–14. ***Method A.*** A suspension of the appropriate ethyl 4-methyl-6-substituted 2-thioxo-1,3,6-trihydropyrimidine-5-carboxylate **5a–h** (5 mmol) in chloroform (25 mL) was refluxed with 2-(2-phenylhydrazono)-2-bromo-1-(5-bromobenzofuran-2-yl)ethanone (**4**; 1.97 g, 5 mmol) and triethylamine (0.7 mL, 5 mmol) for 20 h. The excess solvent was evaporated, and the residue was triturated with methanol (10 mL). The solid formed was collected and crystallized from acetic acid to give analytically pure product.

Method B. Equimolar amounts of the appropriate hydrazonoyl chlorides **4**, **10a–h**, and sodium ethoxide (0.005 mol each) in ethanol (20 mL) were refluxed for 3 h. The reaction mixture was cooled, and the resulting solid was collected and recrystallized from the acetic acid to give products identical in all aspects (mp, mixed mp, and spectra) with the corresponding products obtained by method A.

Ethyl 3-(5-bromo-benzofuran-2-carbonyl)-7-methyl-1,5-diphenyl-1,5-dihydro-[1,2,4]triazolo[4,3-a]pyrimidine-6-carboxylate (9a). This compound was obtained as red crystals (acetic acid), yield (82%), mp 185–88°C; IR (KBr): 3098 (CH, aromatic), 1718 (CO, ester), 1662 (CO), 1617 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.23 (t, 3H, *J* = 7.5 Hz, CH_2CH_3), 2.57 (s, 3H, CH_3), 4.08 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), 6.15 (s, 1H, pyrimidine H-4), 7.14–8.14 (m, 14H, ArH′s); ^{13}C NMR δ = 13.25, 17.65, 55.12, 58.62, 101.42, 113.21, 115.41, 118.38, 123.95, 123.99, 126.58, 127.62, 129.42, 130.11, 138.92, 142.54, 149.24, 151.28, 153.19, 159.78, 164.78, 174.58; MS, *m/z* (%) = 582 (M^+, 5.6%), 584 (M+2, 5.6%), 359 (49%), 255 (17%), 222 (23%), 105 (84%), 77 (100%), 65 (32%); Anal. Calcd. For $C_{30}H_{24}N_4O_4$ requires (583.43): C, 71.42; H, 4.79; N, 11.10. Found: C, 71.28; H, 4.87; N, 11.21%.

Ethyl 3-(5-bromo-benzofuran-2-carbonyl)-7-methyl-1-phenyl-5-p-tolyl-1,5-dihydro-[1,2,4]triazolo[4,3-a]pyrimidine-6-carboxylate (9b). This compound was obtained as orange crystals (acetic acid), yield (80%), mp 162–5°C; IR (KBr): 3098 (CH, aromatic), 1710 (CO, ester), 1659 (CO), 1617 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.23 (t, 3H, *J* = 7.5 Hz, CH_2CH_3), 2.21 (s, 3H, CH_3), 2.25 (s, 3H, CH_3), 4.11 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), 6.15 (s, 1H, pyrimidine H-4), 7.14–8.14 (m, 13H, ArH′s); ^{13}C NMR δ = 13.25, 17.51, 19.89, 55.12, 58.62, 101.42, 113.21, 115.41, 118.38, 123.95, 123.99, 126.58, 127.62, 129.42, 130.11, 133.12, 137.92, 142.54, 149.24, 151.28, 153.19, 160.78, 164.78, 173.58; Anal. Calcd. For $C_{31}H_{25}BrN_4O_4$ requires (597.46): C, 62.32; H, 4.22; Br, 13.37; N, 9.38. Found: C, 62.23; H, 4.34; Br, 13.42; N, 9.51%.

Ethyl 3-(5-bromo-benzofuran-2-carbonyl)-5-(4-methoxyphenyl)-7-methyl-1-phenyl-1,5-dihydro-[1,2,4]triazolo[4,3-a]pyrimidine-6-carboxylate (9c). This compound was obtained as red crystals (acetic acid), yield (72%), mp 157–60°C; IR (KBr): 3098 (CH, aromatic), 1715 (CO, ester), 1658 (CO), 1612 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.23 (t, 3H, *J* = 7.5 Hz, CH_2CH_3), 2.58 (s, 3H, CH_3), 3.69 (s, 3H, OCH3), 4.12 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), (s, 1H, pyrimidine H-4), 7.14–8.14 (m, 13H, ArH′s); ^{13}C NMR δ = 13.25, 17.51, 55.12, 55.30, 58.62, 101.42, 113.21, 115.41, 118.38, 123.95, 123.99, 126.58, 127.62, 129.42, 130.11, 133.12, 137.92, 142.54, 149.24, 151.28, 153.19, 160.78, 164.78, 173.58; Anal. Calcd. For $C_{31}H_{25}BrN_4O_5$ requires (616.05): C, 60.69; H, 4.11; Br, 13.03; N, 9.13. Found: C, 60.85; H, 4.23; Br, 13.30; N, 9.32%.

Ethyl 3-(5-bromo-benzofuran-2-carbonyl)-5-(4-chlorophenyl)-7-methyl-1-phenyl-1,5-dihydro-[1,2,4]triazolo[4,3-a]pyrimidine-6-carboxylate (9d). This compound was obtained as red crystals (acetic acid), yield (78%), mp 190–93°C; IR (KBr): 3098 (CH, aromatic), 1712 (CO, ester), 1660 (CO), 1617 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.23 (t, 3H, *J* = 7.5 Hz, CH_2CH_3), 2.56 (s, 3H, CH_3), 4.12 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), (s, 1H, pyrimidine H-4), 7.14–8.14 (m, 14H, ArH′s); ^{13}C NMR δ = 13.25, 17.51, 55.30, 58.62, 101.42, 113.21, 115.41, 118.38, 123.95, 123.99, 126.58, 127.62, 129.42, 130.11, 133.12, 137.92, 142.54, 149.24, 151.28, 153.19, 160.78, 164.78, 173.58; Anal. Calcd. For $C_{30}H_{22}BrClN_4O_4$ requires (617.88): C, 58.32; H, 3.59; Br, 12.93; Cl, 5.74; N, 9.07. Found: C, 58.23; H, 3.65; Br, 13.13; Cl, 5.81; N, 8.88%.

3-(5-Bromo-benzofuran-2-carbonyl)-5-(2,3-dimethoxy-phenyl)-7-methyl-1-phenyl-1,5-dihydro-[1,2,4]triazolo[4,3-a]pyrimidine-6-carboxylate (9e). This compound was obtained as yellow crystals (acetic acid), yield (68%), mp 146–48°C; IR (KBr): 3071 (CH, aromatic), 2960 (CH, aliphatic), 1700 (CO, ester), 1660 (CO), 1611 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.21 (t, 3H, *J* =7.5 Hz, CH_2CH_3), 2.45 (s, 3H, CH_3), 3.75 (s, 3H, OCH_3), 3.81 (s, 3H, OCH_3), 4.11 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), 5.58 (s, 2H, CH_2), (s, 1H, pyrimidine H-4), 7.14–8.14 (m, 12H, ArH′s); ^{13}C NMR δ = 13.14, 17.82, 50.24, 56.30, 58.62, 60.14, 102.22, 110.56, 113.21, 115.41, 118.38, 123.95, 123.99, 126.58, 127.62, 129.42, 130.11, 133.12, 137.92, 142.54, 149.24, 151.28, 153.19, 160.78, 164.78, 174.28; Anal. Calcd. For $C_{32}H_{27}BrN_4O_6$ requires (643.48): C, 59.73; H, 4.23; Br, 12.42; N, 8.71. Found: C, 59.62; H, 4.38; Br, 12.61; N, 8.52%.

Ethyl 5-benzo[1,3]dioxol-4-yl-3-(5-bromobenzofuran-2-carbonyl)-7-methyl-1-phenyl-1,5-dihydro-[1,2,4]triazolo[4,3-a]pyrimidine-6-carboxylate (9f). This compound was obtained as yellow crystals (acetic acid), yield (77%), mp 142–44°C; IR (KBr): 3098 (CH, aromatic), 1721 (CO, ester), 1661 (CO), 1615 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.16 (t, 3H, *J* = 7.5 Hz, CH_2CH_3), 2.20 (s, 3H, CH_3), 4.11 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), 5.92 (s, 2H, OCH_2O), 6.21 (s, 1H, pyrimidine H-4), 7.14–8.14 (m, 13H, ArH′s); ^{13}C NMR δ = 13.14, 17.82, 50.24, 58.62, 100.87, 108.22, 113.21, 115.41, 118.38, 122.95, 123.99, 126.58, 127.62, 129.42, 130.11, 137.12, 142.54, 147.12, 149.24, 153.28, 154.19, 160.78, 164.78, 174.28; Anal. Calcd. For $C_{31}H_{23}BrN_4O_6$ requires (627.44): C, 59.34; H, 3.69; Br, 12.73; N, 8.93. Found: C, 59.53; H, 3.86; Br, 12.66; N, 9.13%.

Ethyl 3-(5-bromo-benzofuran-2-carbonyl)-5-(4-isopropylphenyl)-7-methyl-1-phenyl-1,5-dihydro-[1,2,4]triazolo[4,3-a]pyrimidine-6-carboxylate (9g). This compound was obtained as yellow crystals (acetic acid), yield (68%), mp 162–64°C; IR (KBr): 3098 (CH, aromatic), 1700 (CO),1662 (CO), 1615 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.22 (t, 3H, *J* = 7.5 Hz, CH_2CH_3), 1.29 (d, 6H, *J* = 7.5 Hz, $((CH_3)_2CH)$, 2.87 (hept., 1H, *J* = 7.5 Hz, $((CH_3)_2CH)$, 4.02 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), 6.08 (s, 1H), 7.16 (d, 1H, ArH), 7.41–7.66 (m, 5H, ArH′s), 7.74 (d, 1H, ArH), 7.91 (d, 2H, *J* = 8 Hz, ArH), 8.21 (d, 1H, *J* = 4 ArH), 8.42 (s, 1H, ArH); ^{13}C NMR δ = 13.14, 17.82, 24.24, 33.62, 54.58, 57.68, 101.23, 113.78, 115.21, 118,34, 123.88, 124.12, 126.21, 127.85, 129.57, 129.98, 130.12, 137.15, 142.78, 144.35, 147.84, 149.23, 151.32, 153.41, 160.24, 165.53, 172.85; MS, *m*/*z* (%) = 627 (7.2%), 626 (18%), 625 (21.7%), 624 (19.3%), 623 (18.1%), 597 (15%), 595 (15%), 552 (49%), 551 (51%), 550 (48%), 507 (56%), 506 (35%), 505 (76%), 504 (54%), 226 (12%), 225 (91%), 224 (53%), 223 (49%), 169 (43%), 168 (32%), 167 (42%), 166 (33%), 155 (15%), 143 (15%), 128 (30%), 115 (30%), 105 (13%), 77 (100%), 65 (27%); Anal. Calcd. For $C_{33}H_{29}BrN_4O_4$ requires (625.51): C, 63.36; H, 4.67; Br, 12.77; N, 8.96. Found: C, 63.45; H, 4.78; Br, 12.91; N, 9.26%.

Ethyl 3-(5-bromo-benzofuran-2-carbonyl)-5-(1,3-diphenyl-1H-pyrazol-4-yl)-7-methyl-1-phenyl-1,5-dihydro-[1,2,4]triazolo[4,3-a] pyrimidine-6-carboxylate (9h). This compound was obtained as yellow crystals (acetic acid), yield (72%), mp 146–48°C; IR (KBr): 3098 (CH, aromatic), 1700 (CO),1662 (CO), 1615 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.22 (t, 3H, *J* = 7.5 Hz, CH_2CH_3), 4.02 (q, 2H, *J* = 7.5 Hz, CH_2CH_3), 6.16 (s, 1H), 7.12–7.95 (m, 22 H, ArH′s), 8.12 (s, 1H, pyrazole H-5); ^{13}C NMR δ = 13.14, 17.82, 45.58, 59.68, 99.23, 113.78, 115.21, 116.23, 117.46, 118,34, 122.88, 126.21, 127.85, 129.57, 128.48, 129.98, 131.12, 134.15, 135.24, 141.48, 142.78, 144.35, 147.84, 149.23, 153.32, 156.41, 165.53, 175.85; MS, *m*/*z* (%) = 627 (707%), 625 (18%), 555 (28%), 552 (15%), 485 (15%), 224 (23%), 223 (30%), 222 (23%), 169 (25%), 167 (30.8%), 166 (30%), 143 (12%), 136 (15%), 93 (38%), 77 (100%), 65 (25%); Anal. Calcd. For $C_{39}H_{29}BrN_6O_4$:requires (724.14): C, 64.56; H, 4.03; Br, 11.01; N, 11.58. Found: C, 64.85; H, 4.16; Br, 11.32; N, 11.72%.

3-(5-Bromo-benzofuran-2-carbonyl)-1-phenyl-1H-[1,2,4] triazolo[3,4-*b*]quinazolin-5-one (12). This compound was obtained as yellow crystals (acetic acid), yield (57%), mp 220–22°C; IR (KBr): 3069 (CH, aromatic), 2917 (CH, aliphatic), 1662 (CO), 1607 (C═N), 1594 (C═C); ^{1}H NMR: δ = 7.50 (t, 1H, *J* = 6H, ArH), 7.63–7.70 (m, 8H, ArH′s), 7.89 (d, 1H, *J* = 8 Hz, ArH), 8.12 (d, 1H, *J* = 8 Hz, ArH), 8.19 (d, 1H, *J* = 8 Hz, ArH), 8.38 (d, 1H, *J* = 8 Hz, ArH); MS, *m*/*z* (%) = 481.6 (52%), 314.8 (85%), 299.4 (66%), 271 (60%), 269 (60%), 228 (57%), 226 (56%), 222 (90%), 210 (71%), 172 (56%), 170 (57%), 62%), 155 (53%), 120 (100%), 111 (82%), 108 (575), 98 (72%); Anal. Calcd. For $C_{24}H_{13}BrN_4O_3$ requires (485.29): C, 59.40; H, 2.70; Br, 16.47; N, 11.55. Found: C, 59.12; H, 2.53; Br, 16.68; N, 11.71%.

(5-Bromo-benzofuran-2-yl)-(1-phenyl-1H-benzo[4,5]imidazo [2,1-*c*][1,2,4]triazol-3-yl)-methanone (13). This compound was obtained as yellow crystals (acetic acid), yield (82%), mp 218–21°C; IR (KBr): 3098 (CH, aromatic), 1662 (CO), 1617 (C═N), 1594 (C═C); ^{1}H NMR: δ = 7.50 (d, 1H, *J* = 10 Hz, ArH), 7.63–7.70 (m, 8H, ArH′s), 7.89 (d, 1H, *J* = 10 Hz, ArH), 8.12 (d, 1H, *J* = 10 Hz, ArH), 8.19 (d, 1H, *J* = 10 Hz, ArH), 8.38 (d, 1H, *J* = 10 Hz, ArH); Anal. Calcd. For $C_{23}H_{13}BrN_4O_2$ requires (457.28): C, 60.41; H, 2.87; Br, 17.47; N, 12.25. Found: C, 60.24; H, 2.62; Br, 17.31; N, 12.00%.

3-(5-Bromo-benzofuran-2-carbonyl)-1-phenyl-5,6,7,8-tetrahydro-1H-9-thia-1,2,3a,10-tetraaza-cyclopenta[*b*]fluoren-4-one (14). This compound was obtained as yellow crystals (DMF), yield (75%), mp 246–48°C; IR (KBr): 3098 (CH, aromatic), 1662 (CO), 1617 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.61–1.85 (m, 4H), 2.80–2.95 (m, 4H), 7.23 (t, 1H, *J* = 8 Hz, ArH′s), 7.41 (s, 1H, ArH), 7.42–7.52 (m, 2H, ArH′s), 7.89 (d, 1H, *J* = 8 Hz, ArH), 8.12 (d, 1H, *J* = 8 Hz, ArH), 8.19 (d, 1H, *J* = 8 Hz, ArH), 8.38 (s, 1H, ArH); ^{13}C NMR δ = 21.23, 22.45, 25.43, 27.11, 113.25, 115.78, 123.11, 12345, 123.78, 124.25, 126.45, 127.45, 128.36, 129.15, 131.54, 142.89, 152.25, 154.78, 162.32, 165.18; Anal. Calcd. For $C_{26}H_{17}BrN_4O_3S$ requires (545.41): C, 57.26; H, 3.14; Br, 14.65; N, 10.27; S, 5.88. Found: C, 57.41; H, 2.97; Br, 14.47; N, 10.15, S, 6.02%.

1-(5-Bromobenzofuran-2-yl)-2-thiocyanatoethanone (15a) and 1-(5-bromobenzofuran-2-yl)-2-selenocyanatoethanone (15b). A mixture of 2-bromo-1-(5-bromobenzofuran-2-yl)ethanone (**4**; 3.15 g, 0.001 mol) and potassium thio/selenacyanate (0.01 mol) in ethanol (25 mL) was stirred for 4 h. The resulting solid was collected and recrystallized from ethanol *N*,*N*-dimethylformamide gave **15a** and **15b**, respectively, as a buff crystals.

1-(5-Bromobenzofuran-2-yl)-2-thiocyanatoethanone (15a). Yield (82%), mp 124–26°C; IR (KBr): 3095 (CH, aromatic), 2990, 2947 (CH aliphatic), 2152 (CN), 1665 (CO); ^{1}H NMR: δ = 4.19 (s, 2H), 7.14–7.54 (m, 4H, ArH′s); ^{13}C NMR δ = 34.52 (CH_2), 110.25, 111.42, 113.84, 115.75, 122.35, 127.45, 131.12, 149.14, 153.75, 182.89; Anal. Calcd. For $C_{11}H_6BrNO_2S$ requires (296.14): C, 44.61; H, 2.04; Br, 26.98; N, 4.73; S, 10.81. Found: C, 44.54; H, 2.12; Br, 26.87; N, 4.64; S, 10.98%.

Bromobenzofuran-2-yl)-2-selenocyanatoethanone (15b). Yield (75%), mp >300°C; IR (KBr): 3098 (CH, aromatic), 2947 (CH aliphatic), 2161 (CN), 1662 (CO); ^{1}H NMR: δ = 4.23 (s, 2H), 7.15–7.54 (m, 4H, ArH′s); ^{13}C NMR δ = 33.52 (CH_2), 102.25, 111.42, 115.84, 118.75, 122.35, 129.45, 148.14, 153.75, 185.89; Anal. Calcd. For $C_{11}H_6BrNO_2Se$ requires (343.03): C, 38.51; H, 1.76; Br, 23.29; N, 4.08. Found: C, 38.32; H, 1.67; Br, 23.43; N, 4.21%.

1,3,4-Thiadiazoline 17a,b and 1,3,4-selenadiazoline 17c. ***Method A.*** A mixture of **4** (2.11 g, 0.005 mol) and the appropriate amount of potassium thiocyanate (or potassium selenocyanate; 0.006 mol) in ethanol (25 mL) was stirred at room temperature for 4 h. The resulting solid was collected, washed with water, and crystallized from ethanol to give yellow crystals **17a** and **17c**, respectively.

Method B. Benzenediazonium chloride (5 mmol), which prepared from aniline (0.45 mL, 5 mmol), hydrochloric acid (6 N, 6 mL), and sodium nitrite (0.35g, 5 mmol), was added dropwise with stirring to a cold solution of a mixture of the appropriate 1-(5-bromobenzofuran-2-yl)-2-thiocyanatoethanone (**15a**) and 1-(5-bromobenzofuran-2-yl)-2-selenocyanatoethanone (**15b**; 5 mmol) and sodium acetate trihydrate (1.3 g, 10 mmol) in ethanol (50 mL). The resulting solid was collected and recrystallized from ethanol to give a product identical in all respects (mp, mixed mp, and spectral data) with that obtained from method A.

(5-Bromobenzofuran-2-yl)(4,5-dihydro-5-imino-4-phenyl-1,3,4-thiadiazol-2-yl)methanone (17a). Yield (75%), mp 172–74°C; IR (KBr): 3291 (NH), 3070 (CH, aromatic), 1640 (CO), 1594 (C═C); ^{1}H NMR: δ = 7.57–8.06 (m, ArH′s and NH); ^{13}C NMR δ = 113.45, 115.32, 119.78, 124.25, 127.23, 127.74, 129.78, 130.45, 141.78, 143.45, 150.25, 152.78, 154.65, 174.12; Anal. Calcd. For $C_{17}H_{10}BrN_3O_2S$ requires (400.25): C, 51.01; H, 2.52; Br, 19.96; N, 10.50; S, 8.01. Found: C, 51.24; H, 2.37; Br, 20.11; N, 10.42; S, 7.76%.

(5-Bromobenzofuran-2-yl)(4,5-dihydro-5-imino-4-p-tolyl-1,3,4-thiadiazol-2-yl)methanone (17b). Yield (72%), mp 186–88°C; IR (KBr): 3308 (NH), 3098 (CH, aromatic), 1640 (CO), 1594 (C=C); ^{1}H NMR: δ = 2.17 (s, 3H, CH_3), 7.57–7.92 (m, 8H, ArH′s and NH protons); ^{13}C NMR δ = 19.58, 113.75, 115.92, 119.78, 120.58, 124.25, 127.23, 133.45, 141.58, 144.75, 150.38, 153.28, 154.83, 173.79; Anal. Calcd. For $C_{18}H_{12}BrN_3O_2S$ requires (414.28): C, 52.19; H, 2.92; Br, 19.29; N, 10.14; S, 7.74 Found: C, 51.85; H, 3.21; Br, 19.32; N, 10.25; S, 7.91%.

(5-Bromobenzofuran-2-yl)(4,5-dihydro-5-imino-4-phenyl-1,3,4-selenadiazol-2-yl)methanone (17c). Yield (78%), mp 164–66°C; IR (KBr): 3209 (NH), 3092 (CH, aromatic), 1640 (CO), 1598 (C=C); ^{1}H NMR: δ = 7.68–8.32 (m, ArH′s and NH proton); Anal. Calcd. For $C_{17}H_{10}BrN_3O_2Se$ requires (447.14): C, 45.66; H, 2.25; Br, 17.87; N, 9.40.Found: C, 45.86; H, 2.32; Br, 17.68; N, 9.12%.

5-Nitrosoimino-4-substituted 1,3,4-thiad/selenadiazol-2-yl) methanone 18a–c. A cold saturated solution of sodium nitrite (10 mL) was added dropwise to a solution of the appropriate **17a–c** (1 g) in acetic acid (20 mL) in an ice bath while stirring. The reaction mixture was stirred for 30 min. The resulting solid was collected, washed with water, and crystallized from acetone to give a rosy products **18a–c**, respectively.

(5-Bromobenzofuran-2-yl)(4,5-dihydro-5-nitrosoimino-4-phenyl-1,3,4-thiadiazol-2-yl)methanone (18a). Yield (78%), mp 158–60°C; IR (KBr): 3098 (CH, aromatic), 1643 (CO), 1594 (C=C), 1360 (NO); ^{1}H NMR: δ = 7.57–7.92 (m, ArH′s); ^{13}C NMR δ = 112.85, 115.25, 119.89, 124.35, 125.78, 127.25, 127.84, 130.58, 132.48, 142.49, 151.78, 152.45, 154.65, 154.89, 173.45; Anal. Calcd. For $C_{17}H_9BrN_4O_3S$ requires (429.25): C, 47.57; H, 2.11; Br, 18.61; N, 13.05; S, 7.47. Found: C, 47.75; H, 2.24; Br, 18.75; N, 13.21; S, 7.64%.

(5-Bromobenzofuran-2-yl)(4,5-dihydro-5-nitrosoimino-4-p-tolyl-1,3,4-thiadiazol-2-yl)methanone (18b). Yield (84%), mp 160–62°C; IR (KBr): 3098 (CH, aromatic), 1662 (CO), 1594 (C=C), 1350 (NO); ^{1}H NMR: δ = 2.32 (s, 3H, CH_3), 7.57–7.92 (m, 8H, ArH′s); ^{13}C NMR δ = 21.18, 112.85, 115.25, 119.89, 124.35, 127.84, 130.58, 133.48, 134.42, 143.49, 151.78, 152.45, 154.65, 154.89, 173.45; Anal. Calcd. For $C_{18}H_{11}BrN_4O_3S$ requires (443.27): C, 48.77; H, 2.50; Br, 18.03; N, 12.64; S, 7.23. Found: C, 48.65; H, 2.32; Br, 18.15; N, 12.46; S, 7.12%.

(5-Bromobenzofuran-2-yl)(4,5-dihydro-5-nitrosoimino-4-phenyl-1,3,4-selenadiazol-2-yl)methanone (18c). Yield (68%), mp 176–78°C; IR (KBr): 3093 (CH, aromatic), 1642 (CO), 1594 (C=C), 1355 (NO); ^{1}H NMR: δ = 7.57–7.92 (m, ArH′s); Anal. Calcd. For $C_{17}H_9BrN_4O_3Se$ requires (476.14): C, 42.88; H, 1.91; Br, 16.78; N, 11.77. Found: C, 42.92; H, 2.22; Br, 16.87; N, 11.65%.

5-(5-Bromo-benzofuran-2-carbonyl)-3-substituted 3H-[1,3,4] thiadiazol-2-one 19a and 19b and 5-(5-bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4]selenadiazol-2-one 19c. A solution of the appropriate **18a–c** (0.5 g) in xylene (20 mL) was refluxed for 15 min. The solvent was evaporated under reduced pressure. The residual oil was triturated with petroleum ether (40–60°C), and the solid formed was collected and recrystallized from ethanol to give a yellow crystals of 1,3,4-thiadiazolinone **19a**,**b** and 1,3,4-selenadiazolinone **19c**, respectively.

5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] thiadiazol-2-one (19a). Yield (75%), mp 184–86°C; IR (KBr): 3098 (CH, aromatic), 1693 (CO), 1640 (CO), 1594 (C=C); ^{1}H NMR: δ = 7.57–7.92 (m, ArH′s); MS, *m/z* (%) = 402 (M+2, 21%), 400 (M^+, 21%), 340 (20%), 338 (20%), 223, 100%), 221 (100%), 167 (42%), 169 (42%), 144 (17%), 117 (10%), 88 (23%), 77 (17%); Anal. Calcd. For $C_{17}H_9BrN_2O_3S$ requires (401.23): C, 50.89; H, 2.26; Br, 19.91; N, 6.98; S, 7.99. Found: C, 51.08; H, 2.42; Br, 19.72; N, 6.79; S, 8.22%.

5-(5-Bromo-benzofuran-2-carbonyl)-3-p-tolyl-3H-[1,3,4] thiadiazol-2-one (19b). Yield (70%), mp 182–84°C; IR (KBr): 3090 (CH, aromatic), 1693 (CO), 1640 (CO), 1594 (C=C), 1365 (NO); ^{1}H NMR: δ = 2.34 (s, 3H, CH_3), 7.26–8.03 (m, 8H, ArH′s); ^{13}C NMR δ = 20.85, 113.25, 115.45, 119.45, 119.89, 124.62, 127.25, 130.89, 134.25, 143.58, 150.24, 153.11, 154.75, 171.98; Anal. Calcd. For $C_{18}H_{11}BrN_2O_3S$ requires (415.26): C, 52.06; H, 2.67; Br, 19.24; N, 6.75; S, 7.72. Found: C, 52.14; H, 2.86; Br, 19.42; N, 6.56; S, 7.60%.

5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] selenadiazol-2-one (19c). Yield (68%), mp 176–78°C; IR (KBr): 3075 (CH, aromatic), 1693 (CO), 1635 (CO), 1594 (C=C); ^{1}H NMR: δ = 7.57–7.92 (m, ArH′s); Anal. Calcd. For $C_{17}H_9BrN_2O_3Se$ requires (448.13): C, 45.56; H, 2.02; Br, 17.83; N, 6.25. Found: C, 45.75; H, 2.21; Br, 17.71; N, 6.40%.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-substituted 3H-[1,3,4]thia/selenadiazol-2-ylidene]-acetamide 20a–20c.** A mixture of the appropriate **17a–c** (1 g) in acetic acid (10 mL) and acetic anhydride (5 mL) was warmed for 5 min at 70°C. The reaction mixture was poured onto ice water (40 mL). The solid was collected and recrystallized from ethanol to give the *N*-acetyl derivatives **20a–c**, respectively, as a pale yellow crystals.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] thiadiazol-2-ylidene]-acetamide (20a).** Yield (88%), mp 240–42°C; IR (KBr): 3108 (CH, aromatic), 2923 (CH aliphatic), 1643 (CH_3CON=), 1594 (C=C), 1362 (CH_3); ^{1}H NMR: δ = 2.27 (s, 3H, CH_3), 7.26–8.05 (m, 9H, ArH′s); Anal. Calcd. For $C_{19}H_{12}BrN_3O_3S$ requires (*442.29*): C, 51.60; H, 2.73; Br, 18.07; N, 9.50; S, 7.25. Found: C, 51.58; H, 2.55; Br, 18.17; N, 9.72; S, 7.14%.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-p-tolyl-3H-[1,3,4] thiadiazol-2-ylidene]-acetamide (20b).** Yield (80%), mp 218–20; IR (KBr): 3108 (CH, aromatic), 2923 (CH aliphatic), 1643 (CH_3CON=), 1594 (C=C), 1362 (CH_3); ^{1}H NMR: δ = 2.22 (s, 3H, CH_3), 2.34 (s, 3H, CH_3), 7.57–7.92 (m, 8H, ArH′s); Anal. Calcd. For $C_{20}H_{14}BrN_3O_3S$ requires (*456.31*): C, 52.64; H, 3.09; Br, 17.51; N, 9.21; S, 7.03. Found: C, 52.38; H, 3.12; Br, 17.73; N, 9.05; S, 7.18%.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] selenadiazol-2-ylidene]-acetamide (20c).** Yield (75%), mp 251–53°C; IR (KBr): 3098 (CH, aromatic), 1640 (CO), 1594 (C=C); ^{1}H NMR: δ = 2.23 (s, 3H, CH_3), 7.57–7.92 (m, 9H, ArH′s); Anal. Calcd. For $C_{19}H_{12}BrN_3O_3Se$ requires (*489.18*): C, 46.65; H, 2.47; Br, 16.33; N, 8.59; Se, 16.14. Found: C, 46.86; H, 2.65; Br, 16.12; N, 8.87%.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-substituted 3H-[1,3,4]thia/selenadiazol-2-ylidene] benzamide 21a–c.** Benzoyl chloride (1 mL) was added to a solution of the appropriate **17a–c** (0.5 g) in pyridine (15 mL), and the mixture was refluxed for 10 min, then poured onto ice water (50 mL) then acidified with hydrochloric acid. The resulting product was collected and washed several times with boiling water. The solid was recrystallized from ethanol to give yellow crystals.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] thiadiazol-2-ylidene]-benzamide (21a).** Yield (78%), mp 228–30°C; IR (KBr): 3098 (CH, aromatic), 1639 (CO), 1594 (C=C); ^{1}H NMR: δ = 7.57–7.92 (m, ArH′s); Anal. Calcd. For $C_{24}H_{14}BrN_3O_3S$ requires (504.36): C, 57.15; H, 2.80; Br, 15.84; N, 8.33; S, 6.36. Found: C, 57.24; H, 2.95; Br, 15.72; N, 8.12; S, 6.47%.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] thiadiazol-2-ylidene]-4-methyl-benzamide (21b).** Yield (75%), mp 268–88°C; IR (KBr): 3090 (CH, aromatic), 1645 (CO), 1594 (C═C); ^{1}H NMR: δ = 2.42 (s, 3H, CH_3), 7.57–7.92 (m, 9H, ArH′s); 13C NMR δ = 19.88, 113.23, 115.45, 119.25, 119.78, 124.56, 127.46, 128.45, 129.23, 131.78, 132.87, 134.25, 136.49, 144.25, 146.31, 151.23, 152.48, 154.34, 173.25, 174.28; Anal. Calcd. For $C_{25}H_{16}BrN_3O_3S$ requires (518.38): C, 57.92; H, 3.11; Br, 15.41; N, 8.11; S, 6.19. Found: C, 58.12; H, 3.25; Br, 15.27; N, 8.23; S, 6.00%.

***N*-[5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] selenadiazol-2-ylidene]-benzamide (21c).** Yield (70%), mp 223–26°C; IR (KBr): 3098 (CH, aromatic), 1639 (CO), 1594 (C═C); ^{1}H NMR: δ = 7.57–7.92 (m, ArH′s); Anal. Calcd. For $C_{24}H_{14}BrN_3O_3Se$ requires (550.94): C, 52.29; H, 2.56; Br, 14.50; N, 7.62; Se, 14.32. Found: C, 52.41; H, 2.32; Br, 14.74; N, 7.83%.

2-(5-Bromo-benzofuran-2-carbonyl)-3-thia-1,4,9b-triaza-cyclopenta[*a*]naphthalen-5-one (22a) and 2-(5-bromo-benzofuran-2-carbonyl)-3-selena-1,4,9b-triaza-cyclopenta[*a*]naphthalen-5-one (22b). Diazotization of anthranilic acid or methyl anthranilate was added dropwise with stirring to a cold solution of a mixture of the appropriate 1-(5-bromobenzofuran-2-yl)-2-thiocyanatoethanone (**15a**) and 1-(5-bromobenzofuran-2-yl)-2-selenocyanatoethanone (**15b**; 1.81 g, 5 mmol) and sodium acetate trihydrate (1.3 g, 10 mmol) in ethanol (50 mL). The resulting solid was collected and recrystallized from *N*,*N*-dimethylformamide to give yellow crystals **22a** and **22b**, respectively.

2-(5-Bromo-benzofuran-2-carbonyl)-3-thia-1,4,9b-triaza-cyclopenta[a]naphthalen-5-one (22a). Yield (75%), mp 326–28°C; IR (KBr): 3066 (CH, aromatic), 1643 (CO), 1596 (C═C); ^{1}H NMR: δ = 7.71–8.67 (m, ArH′s); MS, *m*/*z* (%) = 427 (M+2), 52%, 427 (M^+), 55%),225 (87%), 223 (74%)169 (43%), 167 (55%); Anal. Calcd. For $C_{18}H_8BrN_3O_3S$ requires (426.24): C, 50.72; H, 1.89; Br, 18.75; N, 9.86; S, 7.52. Found: C, 50.52; H, 2.10; Br, 18.47; N, 9.68; S, 7.45%.

2-(5-Bromo-benzofuran-2-carbonyl)-3-selena-1,4,9b-triaza-cyclopenta[a]naphthalen-5-one (22b). Yield (70%), mp >300°C; IR (KBr): 3098 (CH, aromatic), 1780 (CO), 1658 (CO), 1594 (C═C); ^{1}H NMR: δ = 7.57–7.92 (m, ArH′s); Anal. Calcd. For $C_{18}H_8BrN_3O_3Se$ requires (473.14): C, 45.69; H, 1.70; Br, 16.89; N, 8.88. Found: C, 45.84; H, 1.95; Br, 16.67; N, 9.00%.

5-(2-Phenyldiazenyl)-4-(5-bromobenzofuran-2-yl)thiazol-2-amine (25) ***Method A.*** A mixture of **4** (2.11 g, 0.005 mol) and thiourea (0.46 g, 0.006 mol) in ethanol (25 mL) was stirred at room temperature for 4 h. The resulting solid was collected, washed with water, and crystallized from ethanol to give **25a**.

Method B. Arenediazonium chloride (5 mmol), which prepared from aromatic amines (5 mmol), hydrochloric acid (6 N, 6 mL), and sodium nitrite (0.35g, 5 mmol), was added dropwise with stirring to a cold solution of a mixture of 4-(5-bromobenzofuran-2-yl)thiazol-2-amine (**26**; 1.81 g, 5 mmol) and sodium acetate trihydrate (1.3 g, 10 mmol) in ethanol (50 mL). The resulting solid was collected and recrystallized from ethanol to give red crystals **25a** and **25b**.

5-(2-Phenyldiazenyl)-4-(5-bromobenzofuran-2-yl)thiazol-2-amine (25a). Yield (75%), mp 228–30°C; IR (KBr): 3210, 2180 (NH_2), 3098 (CH, aromatic), 1625 (C═N), 1594 (C═C); ^{1}H NMR: δ = 4.12 (s, br., 2H, NH_2) 7.57–7.92 (m, 9H, ArH′s); MS, *m*/*z* (%) = 400 (100.0%), 398 (98.0%), 399 (18.2%), 401 (17.8%), 229 (26%), 105 (57%), 77 (100%), 65 (28%); Anal. Calcd. For $C_{17}H_{11}BrN_4OS$ requires (399.26): C, 51.14; H, 2.78; Br, 20.01; N, 14.03; S, 8.03. Found: C, 51.25; H, 2.87; Br, 20.22; N, 14.13; S, 8.25%.

5-(2-p-Tolyldiazenyl)-4-(5-bromobenzofuran-2-yl)thiazol-2-amine (25b). Yield (68%), mp 240–42°C; IR (KBr): 3210, 2180 (NH_2), 3098 (CH, aromatic), 1620 (C═N), 1596 (C═C); ^{1}H NMR: δ = 2.42 (s, 3H, $CH_3C_6H_4$), 4.25 (s, br., 2H, NH_2) 7.57–7.92 (m, 8H, ArH′s); ^{13}C NMR δ = 21.23, 99.78, 104.25, 110.28, 114.24, 116.32, 122.48, 125.23, 127.24, 129.57, 131.28, 136.78, 145.21, 153.45, 156.32, 168.54; Anal. Calcd. For $C_{18}H_{13}BrN_4OS$ requires (413.29): C, 52.31; H, 3.17; Br, 19.33; N, 13.56; S, 7.76. Found: C, 52.45; H, 3.28; Br, 19.55; N, 13.68; S, 7.57.

4-(5-Bromobenzofuran-2-yl)thiazol-2-amine (26). A mixture of **2** (3.03 g, 0.01 mol) and thiourea (0.46 g, 0.006 mol) in ethanol (25 mL) was heated under reflux for 2 h. The reaction mixture was poured onto ice cold water (100 mL) and few drops of ammonium hydroxide. The resulting solid was collected, washed with water, and crystallized from ethanol to give yellow crystals (ethanol), yield (77%), mp 218–20°C; IR (KBr): 3098 (CH, aromatic), 1625 (C═N), 1594 (C═C); ^{1}H NMR: δ = 4.25 (s, br., 2H, NH_2) 7.57–7.92 (m, 4H, ArH′s); MS, *m*/*z* (%) = 296 (100%), 294 (100%), 254 (24%), 252 (22%), 225 (17%), 223 (15%), 182 (14%), 180 (14%), 145 (74%), 107 (18%), 93 (10%); Anal. Calcd. For $C_{11}H_7BrN_2OS$ requires (295.16): C, 44.76; H, 2.39; Br, 27.07; N, 9.49; S, 10.86. Found: C, 44.67; H, 2.45; Br, 27.15; N, 9.58; S, 10.67%.

Thiadiazolines 31a–n and (5-bromo-1-benzofuran-2-yl)[4-phenyl-5-(phenylimino)-4,5-dihydro-1,3,4-thiadiazol-2-yl] methanone (32). Triethylamine (0.75 mL, 0.005 mol) was added dropwise with stirring to a mixture of the appropriate alkyl carbodithioates **27a**–**n**, **28a**,**b**, or methyl phenylcarbamodithioate (0.005 mol) and compound **4** (1.8 g, 0.005 mol) in ethanol (20 mL). The resulting solid, which formed after 30 min, was collected and recrystallized from the proper solvent and gave the corresponding thiadiazolines **31a**–**n** and **32**, respectively, in a good yield.

[5-(Benzylidenehydrazono)-4-phenyl-4,5-dihydro-[1,3,4] thiadiazol-2-yl]-(5-bromo-benzofuran-2-yl)-methanone (31a). This compound was obtained as red crystals (dioxan), yield (70%), mp 245–48°C; IR (KBr): 3098 (CH, aromatic), 1650 (CO), 1625 (C═N), 1594 (C═C); ^{1}H NMR: δ = 7.24 (t, 1H, *J* = 8 Hz, ArH), 7.58 (t, 1H, *J* = 8 Hz, ArH), 7.72–7.92 (m, H, ArH′s), 8.32 (s, 1H, CH vinyl); MS, *m*/*z* (%) = 504 (100.0%), 502 (97.3%), 279 (38%), 222 (100%), 162 (23%), 118 (17%), 77 (27%); Anal. Calcd. For $C_{24}H_{15}BrN_4O_2S$ requires (503.37): C, 57.27; H, 3.00; Br, 15.87; N, 11.13; S, 6.37. Found: C, 57.32; H, 2.86; Br, 15.78; N, 11.25; S, 6.43%.

(5-Bromo-benzofuran-2-yl)-[4-phenyl-5-(thien-2-ylmethylenehydrazono)-4,5-dihydro-[1,3,4]thiadiazol-2-yl]-methanone (31b). This compound was obtained as yellow crystals (dioxan), yield (73%), mp 229–32°C; IR (KBr): 3075 (CH, aromatic), 1648 (CO), 1620 (C═N), 1594 (C═C); ^{1}H NMR: δ = 7.05 (t, 1H, *J* = 8 Hz, thiophene H-3), 7.24 (t, 1H, *J* = 8 Hz, ArH), 7.33 (d, 2H, thiophene H-2 and H-4), 7.57–7.92 (m, 9H, ArH′s and CH═, vineyl); Anal. Calcd. For $C_{22}H_{13}BrN_4O_2S_2$ requires (509.4): C, 51.87; H, 2.57; Br, 15.69; N, 11.00; S, 12.59 Found: C, 51.78; H, 2.75; Br, 15.86; N, 11.12; S, 12.68%.

(5-Bromo-benzofuran-2-yl)-[5-(furan-2-ylmethylenehydrazono)-4-phenyl-4,5-dihydro-[1,3,4]thiadiazol-2-yl]-methanone (31c). This compound was obtained as yellow crystals (dioxan), yield (61%), mp 235–38°C; IR (KBr): 3140 (CH, vinyl), 3057 (CH, aromatic), 1650 (CO), 1618 (C═N), 1596 (C═C); ^{1}H NMR: δ = 6.35 (t, 1H, *J* = 8 Hz, furan H-3), 7.25 (t, 1H, *J* = 8 Hz, ArH), 7.70–7.92 (m, 10H, ArH′s); Anal. Calcd. For $C_{22}H_{13}BrN_4O_3S$

requires (493.33): C, 53.56; H, 2.66; Br, 16.20; N, 11.36; S, 6.50. Found: C, 53.45; H, 2.71; Br, 16.10; N, 11.41; S, 6.57%.

(5-Bromobenzofuran-2-yl)-[4-phenyl-5-(pyridin-4-ylmethylenehydrazono)-4,5-dihydro-[1,3,4]thiadiazol-2-yl]-methanone (31d). This compound was obtained as yellow crystals (dioxan), yield (63%), mp 228–30°C; IR (KBr): 3098 (CH vinyl), 3055 (CH, aromatic), 1648 (CO), 1615 (C═N), 1590 (C═C); ^{1}H NMR: δ = 7.21 (t, 1H, *J* = 8 Hz, ArH), 7.60–7.93 (m, 10, ArH′s), 8.25 (s, 1H, vinyl), 8.24 (d, 2H, *J* = 8 Hz, ArH′s); Anal. Calcd. For $C_{23}H_{14}BrN_5O_2S$ requires (504.36): C, 54.77; H, 2.80; Br, 15.84; N, 13.89; S, 6.36. Found: C, 54.65; H, 2.68; Br, 15.92; N, 13.98; S, 6.46%.

(5-Bromo-benzofuran-2-yl)-{5-[(4-isopropyl-benzylidene) hydrazono]-4-phenyl-4,5-dihydro-[1,3,4]thiadiazol-2-yl}-methanone (31e). This compound was obtained as yellow crystals (AcOH), yield (70%), mp 207–10°C; IR (KBr): 3085 (CH, aromatic), 1639 (CO), 1608 (C═N), 1594 (C═C); ^{1}H NMR: δ = 1.26 (d, 6H, *J* = 7 Hz, $(CH_3)_2CH$), 2.95 (hept, 1H, *J* = 7 Hz, $(CH_3)_2CH$), 7.26–8.15 (m, 13H, ArH′s), 8.42 (s, 1H, vinyl CH═N); ^{13}C NMR δ = 24.35, 33.58, 113.25, 115.04, 119.48, 124.45, 126.25, 127.28, 128.45, 130.28, 130.58, 131.87, 147.28, 150.35, 151.65, 153.48, 154.75, 158.92, 173.45; Anal. Calcd. For $C_{27}H_{21}BrN_4O_2S$ requires (545.45): C, 59.45; H, 3.88; Br, 14.65; N, 10.27; S, 5.88. Found: C, 59.54; H, 3.72; Br, 14.56; N, 10.35; S, 5.80%.

[5-(Benzo[1,3]dioxol-4-ylmethylenehydrazono)-4-phenyl-4,5-dihydro-1,3,4]-thiadiazol-2-yl]-(5-bromo-benzofuran-2-yl)-methanone (31f). This compound was obtained as orange crystals (ethanol), yield (82%), mp 211–14°C; IR (KBr): 3072 (CH, aromatic), 1640 (CO), 1620 (C═N), 1596 (C═C); ^{1}H NMR: δ = 6.01 (s, 2H, OCH_2O), 7.13–7.26 (m, 4H, ArH′s and CH═N), 7.63–7.93 (m, 9H, ArH′s); ^{13}C NMR: δ = 101.12, 113.45, 115.28, 117.85, 118.45, 119.39, 121.28, 122.40, 124.12, 124.75, 127.56, 130.12, 130.75, 142.10, 147.82, 150.54, 152.16, 152.78, 153.87, 154.62, 162.88, 174.24; Anal. Calcd. For $C_{25}H_{15}BrN_4O_4S$ requires (547.38): C, 54.86; H, 2.76; Br, 14.60; N, 10.24; S, 5.86. Found: C, 54.68; H, 2.67; Br, 14.72; N, 10.42; S, 5.60%.

(5-Bromo-benzofuran-2-yl)-{4-phenyl-5-[(1-phenyl-ethylidene-hydrazono]-4,5-dihydro-[1,3,4]thiadiazol-2-yl}-methanone (31g). This compound was obtained as yellow crystals (dioxan), yield (75%), mp 234–37°C; IR (KBr): 3098 (CH, aromatic), 1650 (CO), 1625 (C═N), 1594 (C═C); ^{1}H NMR: δ = 2.35 (s, 3H, CH_3), 7.22–7.93 (m, 14H, ArH′s); 13C NMR δ = 14.42, 113.25, 115.45, 119.67, 124.25, 126.23, 126.37, 127.12, 127.78, 128.16, 129.45, 130.58, 140.21, 144.58, 146.25, 150.23, 152.56, 154.38, 173.89; Anal. Calcd. For $C_{25}H_{17}BrN_4O_2S$ requires (517.4): C, 58.03; H, 3.31; Br, 15.44; N, 10.83; S, 6.20. Found: C, 58.03; H, 3.31; Br, 15.44; N, 10.83; S, 6.20%.

(5-Bromo-benzofuran-2-yl)-{4-phenyl-5-[(1-thien-2-yl-ethylidene)hydrazono]-4,5-dihydro-[1,3,4]thiadiazol-2-yl}-methanone (31h). This compound was obtained as yellow crystals (dioxan), yield (69%), mp 232–35°C; IR (KBr): 3098 (CH, aromatic), 1650 (CO), 1625 (C═N), 1594 (C═C); ^{1}H NMR: δ = 2.39 (s, 3H, CH_3), 7.16–8.17 (m, 12H, ArH′s); Anal. Calcd. For $C_{23}H_{15}BrN_4O_2S_2$ requires (523.42): C, 52.78; H, 2.89; Br, 15.27; N, 10.70; S, 12.25. Found: C, 52.87; H, 2.98; Br, 15.35; N, 10.54; S, 12.15%.

(5-[(5-Bromo-1-benzofuran-2-yl)carbonyl]-3-phenyl-1,3,4-thiadiazol-2(3H)-one [1-(2-furyl)ethylidene]hydrazone (31i). This compound was obtained as red crystals (dioxan), yield (76%), mp 220–23°C; IR (KBr): 3097 (CH, aromatic), 1639 (CO), 1612 (C═N), 1594 (C═C); ^{1}H NMR: δ = 2.35 (s, 3H, CH3), 6.35 (t, 1H, *J* = 5Hz, furan H-3), 7.27–7.93 (m, 11H, ArH′s); ^{13}C NMR: δ = 15.23, 110.89, 111.45, 115.28, 118.76, 124.25, 128.78, 127.16, 127.86, 130.15, 131.41, 143.25, 144.75, 145.94, 150.57, 152.72, 153.23, 154.75, 158.21, 174.54; Anal. Calcd. For $C_{23}H_{15}BrN_4O_3S$ requires (507.36): C, 54.45; H, 2.98; Br, 15.75; N, 11.04; S, 6.32. Found: C, 54.54; H, 2.98; Br, 15.57; N, 11.25; S, 6.32%.

(5-Bromo-benzofuran-2-yl)-{4-phenyl-5-[(1-pyridin-2-yl-ethylidene)-hydrazono]-4,5-dihydro-[1,3,4]thiadiazol-2-yl}-methanone (31j). This compound was obtained as red crystals (dioxan), yield (98%), mp 216–18°C; IR (KBr): 3098 (CH, aromatic), 1639 (CO), 1612 (C═N), 1596 (C═C); ^{1}H NMR: δ = 2.50 (s, 3H, CH_3), 7.57–7.92 (m, 11H, ArH′s), 8.58 (d, 1H, *J* = 8 Hz, ArH′s), 8.73 (d, 1H, *J* = 8 Hz, ArH′s); Anal. Calcd. For $C_{24}H_{16}BrN_5O_2S$ requires (518.39): C, 55.61; H, 3.11; Br, 15.41; N, 13.51; S, 6.19. Found: C, 55.52; H, 3.31; Br, 15.23; N, 13.68; S, 6.32%.

2-{[5-(5-Bromo-benzofuran-2-carbonyl)-3-phenyl-3H-[1,3,4] thiadiazol-2-ylidene]-hydrazono}-indan-1,3-dione (31k). This compound was obtained as brown crystals (ethanol), yield (69%), mp 152–55°C; IR (KBr): 3098 (CH, aromatic), 1728 (CO), 1685 (CO), 1635 (CO), 1618 (C═N), 1589 (C═C); ^{1}H NMR: δ = 7.22–7.25 (t, 1H, *J* = 9 Hz, ArH), 7.65–8.03 (m, 10H, ArH′s), 8.50 (t, 1H, ArH); Anal. Calcd. For $C_{26}H_{13}BrN_4O_4S$ requires (557.37): C, 56.03; H, 2.35; Br, 14.34; N, 10.05; S, 5.75. Found: C, 56.15; H, 2.43; Br, 14.52; N, 10.18; S, 5.84%.

5-[(5-Bromo-1-benzofuran-2-yl)carbonyl]-3-phenyl-1,3,4-thiadiazol-2(3H)-one cyclopentylidenehydrazone (31l). This compound was obtained as orange crystals (AcOH), yield (75%), mp 206–208°C; IR (KBr): 3098 (CH, aromatic), 1643 (CO), 1574 (C═C); ^{1}H NMR: δ = 1.83 (pent, 4H, *J* = 7 Hz, $CH_2CH_2CH_2$), 2.59 (t, 4H, *J* = 7 Hz, $CH_2CH_2CH_2$), 7.26–8.12 (m, 9H, ArH′s); Anal. Calcd. For $C_{22}H_{17}BrN_4O_2S$ requires (481.36): C, 54.89; H, 3.56; Br, 16.60; N, 11.64; S, 6.66. Found: C, 54.95; H, 3.65; Br, 16.48; N, 11.45; S, 6.78%.

5-[(5-Bromo-1-benzofuran-2-yl)carbonyl]-3-phenyl-1,3,4-thiadiazol-2(3H)-one cyclohexylidenehydrazone (31m). This compound was obtained as orange crystals (AcOH), yield (97%), mp 194–97°C; IR (KBr): 3098 (CH, aromatic), 1635 (CO), 1569 (C═C); ^{1}H NMR: δ = 1.68 (m, 4H), 2.46 (m, 4H), 2.66 (m, 2H), 7.26–8.12 (m, 9H, ArH′s; Anal. Calcd. For $C_{23}H_{19}BrN_4O_2S$ requires (495.39): C, 55.76; H, 3.87; Br, 16.13; N, 11.31; S, 6.47. Found: C, 55.67; H, 3.87; Br, 16.34; N, 11.44; S, 6.56%.

5-[(5-Bromo-1-benzofuran-2-yl)carbonyl]-3-phenyl-1,3,4-thiadiazol-2(3H)-one cycloheptylidenehydrazone (31n). This compound was obtained as orange (AcOH), yield (96%), mp 205–207°C; IR (KBr): 3098 (CH, aromatic), 1643 (CO), 1574 (C═C); ^{1}H NMR: δ = 1.83 (m, 2H), 2.06 (m, 4H), 2.58 (m, 6H), 7.57–7.92 (m, 9H, ArH′s); Anal. Calcd. For $C_{24}H_{21}BrN_4O_2S$ requires (509.42): C, 56.59; H, 4.16; Br, 15.69; N, 11.00; S, 6.29. Found: C, 56.65; H, 4.25; Br, 15.78; N, 11.22; S, 6.45%.

(5-Bromo-1-benzofuran-2-yl)[4-phenyl-5-(phenylimino)-4,5-dihydro-1,3,4-thiadiazol-2-yl]methanone (32). This compound was obtained as red crystals (AcOH), yield (84%), mp 203–206°C; IR (KBr): 3098 (CH, aromatic), 1635 (CO), 1569 (C═C); ^{1}H NMR: δ = 6.98 (m, 1H, ArH), 7.20–7.36 (m, 5H, ArH′s), 6.65–6.73 (m, 6H, ArH′s), 7.88–7.93 (4H, ArH′s); Anal. Calcd. For $C_{23}H_{14}BrN_3O_2S$ requires (476.35): C, 57.99; H, 2.96; Br, 16.77; N, 8.82; S, 6.73. Found: C, 58.09; H, 2.85; Br, 16.66; N, 8.92; S, 6.65%.

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