recovery) as a clear, colorless oil.

5-(4-Chlorophenyl)-3-(4-pentynylsulfonyl)-1,2,4-triazine (22d). To a stirred solution of 5-(4-chlorophenyl)-3-(4-pentynylthio)-1,2,4-triazine (0.69 g, 2.38 mmol) in anhydrous methylene chloride (20 mL) at 0 °C was added, all at once, *m*-chloroperbenzoic acid (80–85% technical solid, 1.03 g, 5.07 mmol maximum, 2.13 equiv maximum). The resultant mixture was stirred at room temperature with exclusion of moisture for 5 h, concentrated by evaporation under reduced pressure, and the residual solid stirred in anhydrous ether (15 mL). The undissolved solid was collected by filtration to yield 5-(4-chlorophenyl)-3-(4-pentynylsulfonyl)-1,2,4-triazine (0.59 g, 1.83 mmol, 77%) as a white powder, mp 116.0–118.0 °C; IR (KBr) 3290, 2120, 1595, 1530, 1475, 1320, 1130 cm^{-1}; ^1H NMR ($CDCl_3$) δ 9.85 (s, 1 H), 8.34–8.19 (m, 2 H), 7.63–7.53 (m, 2 H), 3.94–3.77 (m, 2 H), 2.55–2.01 (m, 5 H); ^{13}C NMR ($CDCl_3$) δ 168.0, 156.4, 147.4, 141.0, 130.1, 129.9, 129.6, 81.7, 70.2, 51.0, 21.5, 17.5; LRMS, *m/z* (relative intensity) 295 (30), 294 (13% of M^+), 293 (M^+, 71), 244 (10), 230 (41), 228 (100), 166 (22).

Anal. Calcd for $C_{14}H_{12}ClN_3O_2S$: C, 52.26; H, 3.76; Cl, 11.02; N, 13.06; S, 9.96. Found: C, 52.09; H, 3.98; Cl, 11.09; N, 12.89; S, 10.06.

7-(4-Chlorophenyl)-1,1-dioxo-3,4-dihydro-2*H*-thiopyrano[2,3-*b*]pyridine (23d). A solution of 5-(4-chlorophenyl-3-(4-pentynylsulfonyl)-1,2,4-triazine (0.42 g, 1.31 mmol) in bromobenzene (5 mL) was heated at reflux under nitrogen for 14 h. Anhydrous ether (25 mL) was added to the reaction mixture, and the undissolved solid was collected by filtration to give 5-(4-chlorophenyl)-1,2,4-triazin-3-one (0.18 g, 0.87 mmol, 66%) as a gray solid which decomposed over 230 °C: ^1H NMR (Me_2SO-d_6) δ 8.73 (s, 1 H), 8.24 (d, J = 8.6 Hz, 2 H), 7.66 (d, J = 8.6 Hz, 2 H), 3.62 (br s, 1 H).[14] The above filtrate was passed through a silica gel filter (~30 g), which was then washed first with ether (100 mL) and then with ethyl acetate (150 mL). The ethyl acetate filtrate was evaporated under reduced pressure to yield 7-(4-chlorophenyl)-1,1-dioxo-3,4-dihydro-2*H*-thiopyrano[2,3-*b*]pyridine (0.08 g, 0.27 mmol, 21%) as a pale yellow solid: mp 191.0–194.0 °C; IR (KBr) 1590, 1535, 1490, 1455, 1425, 1310-1290, 1090 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.02 (d, J = 8.6 Hz, 2 H), 7.80 (d, J = 8.1 Hz, 1 H), 7.63 (d, J = 8.3 Hz, 1 H), 7.42 (d, J = 8.6 Hz, 2 H), 3.56–3.43 (m, 2 H), 3.05 (t, J = 5.7 Hz, 2 H), 2.65–2.36 (m, 2 H); LRMS, *m/z* (relative intensity) 294 (13% of M^+), 293 (M^+, 71), 230 (41), 228 (100), 166 (22); HRMS calcd for $C_{14}H_{12}ClNO_2S$ 293.0267, found 293.0267 ± 0.0050.

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Registry No. **3c**, 15969-28-5; **3d**, 98592-50-8; **4a**, 103020-26-4; **4b**, 109216-70-8; **4c**, 100037-88-5; **4e**, 59851-26-2; **4f**, 109216-71-9; **5b**, 109216-72-0; **5c**, 100037-77-2; **5d**, 109216-73-1; **7a**, 109216-74-2; **7b**, 109216-75-3; **7c**, 100037-78-3; **7f**, 109216-76-4; **9c**, 100037-79-4; **11a**, 272-23-1; **11b**, 109216-77-5; **11c**, 100037-80-7; **11d**, 109216-78-6; **11e**, 109216-79-7; **11f**, 18425-96-2; **14c**, 109216-65-1; **14d**, 109216-66-2; **15**, 109216-67-3; **16**, 109216-81-1; **19d**, 109216-68-4; **19f**, 109216-82-2; **20d**, 109216-83-3; **21d**, 109216-84-4; **21f**, 109216-85-5; **22d**, 109216-86-6; **23d**, 109216-87-7; $I(CH_2)_2C{\equiv}CH$, 43001-25-8; $H_2C{=}CH(CH_2)_2Br$, 5162-44-7; $HO(CH_2)_4Br$, 33036-62-3; $HC{\equiv}C(CH_2)_3Cl$, 14267-92-6; $H_2NN{=}C(NH_2)S(CH_2)_2C{\equiv}CH{\cdot}HI$, 109216-69-5; $H_2NC(S)NHNH_2$, 79-19-6; OHCCHO, 107-22-2; AcAc, 765-87-7; PhCOCHO, 1074-12-0; $4\text{-}ClC_6H_4COCHO$, 4998-15-6; $I(CH_2)_3C{\equiv}CH$, 2468-55-5; 1,2-cyclohexanedione, 765-87-7; phenanthrene-9,10-dione, 84-11-7; 1-oxophenanthreno[9,10-*e*]-2,3-dihydrothieno[2,3-*b*]pyridine, 109216-80-0; 5-(4-chlorophenyl)-1,2,4-triazin-3-one, 109216-88-8.

Intramolecular Diels–Alder Reactions of 1,2,4-Triazines. Synthesis of Condensed Pyrimidines

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1,2,4-Triazines with C5 tethered dienophilic side chains are sterically constrained to undergo intramolecular Diels–Alder reactions across the N2/C5 triazine positions; elimination of a nitrile from the intermediate adduct (N1 and C6 of the starting 1,2,4-triazine) leads to condensed pyrimidines. The reactivity of 5-(alkynyl-substituted)-1,2,4-triazines in the intramolecular Diels–Alder process is highly dependent on the steric and electronic disposition of the dienophilic side chain; cycloaddition is hindered when an electron-donating atom (O, N) is used to link the dienophilic side chain to the triazine nucleus, while the introduction of bulky groups into the side chain facilitates the process via the Thorpe–Ingold effect.

Introduction

Diels–Alder reactions of 1,2,4-triazines have been the subject of extensive investigations of scope and applications.[1] As electron-deficient heterocyclic azadienes, 1,2,4-triazines generally participate in inverse electron demand [4 + 2] cycloadditions with electron-rich dienophiles across C3/C6 of the 1,2,4-triazine nucleus with subsequent extrusion of molecular nitrogen. Such reactions have provided access to a host of novel pyridine systems.[2] Conversely, 1,2,4-triazines with simple dienophilic side chains tethered to C3 or C6 of the 1,2,4-triazine nucleus have been shown by our group[3a-d] and others[4] to afford fused pyridine species, often under extremely mild conditions. The "entropic assistance" inherent in the latter reaction eliminates the need for an electron-rich dienophile.

The mode of cycloaddition in these reactions involves addition across C3 and C6 of the 1,2,4-triazine nucleus; the

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(3) (a) Thieno[2,3-*b*]pyridines and thieno[2,3-*c*]pyridines: Taylor, E. C.; Macor, J. E. *Tetrahedron Lett.* **1985**, *107*, 5745. (b) Dihydrofuro[2,3-*b*]pyridines and dihydropyrano[2,3-*b*]pyridines: Taylor, E. C.; Macor, J. E. *Tetrahedron Lett.* **1986**, *27*, 431. (c) Dihydropyrrolo[2,3-*b*]pyridines: Taylor, E. C.; Pont, J. L. *Tetrahedron Lett.* **1987**, *28*, 379. (d) Cyclopentenopyridines and 5,6,7,8-tetrahydroquinolines: Taylor, E. C.; French, L. G. *Tetrahedron Lett.* **1986**, *27*, 1967. Taylor, E. C.; Macor, J. E. *Tetrahedron Lett.* **1986**, *27*, 2107.
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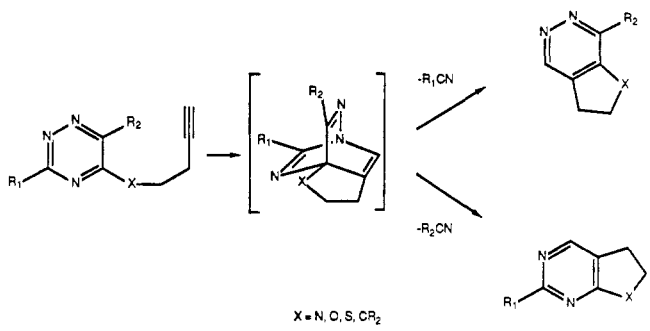
Scheme I



sole exception to this observation results from the use of ynamine dienophiles, which predominantly yields products arising from an N2/C5 cycloaddition.[5] However, it has been postulated that this is a stepwise process involving discrete zwitterionic intermediates.[1]

One should note that while the regioselectivity of cycloaddition in most *inter*molecular reactions of 1,2,4-triazines is under strict electronic control, the analogous *intra*molecular reactions are sterically constrained. We have applied this simple concept to intramolecular Diels–Alder reactions of 1,2,4-triazines with dienophilic side chains tethered to C5 of the 1,2,4-triazine nucleus, where cycloaddition must occur across the N2/C5 positions. Although the resulting cycloadduct could in principle lead either to condensed pyridazines (by elimination of R_1CN) or to condensed pyrimidines (by loss of R_2CN), the latter pathway in fact should be exclusively followed as a consequence of the fragility of the bridgehead N–N bond (see Scheme I).

Results and Discussion

The requisite 5-(alkynyl-substituted)-1,2,4-triazines (X = O, S, N, CR_2) were formed from the 1,2,4-triazin-5-ones **1a–e**, which are readily accessible by condensation of amidrazones[6] or S-alkylated isothiosemicarbazides[7] with α-keto acids or esters. Refluxing a solution of **1a–d** in $POCl_3$ or $SOCl_2$ yielded the 5-chloro-1,2,4-triazines **2a–d**, which when added in THF solution to a slurry of the sodium salt of 3-butyn-1-ol in THF provided the 5-(3-butynyloxy)-1,2,4-triazines **3a–d** in good yields[12] (Scheme II).

Refluxing **3a–d** at 232–236 °C in 1,3,5-triisopropylbenzene (TIPB) for 2–3 days led to formation of the dihydrofuro[2,3-*d*]pyrimidines **4a–b** in low yields (Table I). Consistent byproducts were the starting 1,2,4-triazin-5-ones **1a–d**, which presumably arose either by an ene reaction or by a thermally induced retrograde Michael reaction. These initial results, although disappointing, were not unexpected; lone pair repulsion (substituent oxygen, triazine N4) should strongly disfavor the initial reversible cycloaddition reaction, even though the initial cycloadduct would be expected to eliminate R_2CN with some ease (vide supra).

Table I. Synthesis of Condensed Pyrimidines from 1,2,4-Triazines (See Scheme II)

1,2,4-triazines			condensed pyrimidines		
	R_1	R_2		R_1	% yield
1a	*p*-$CH_3C_6H_4$	C_6H_5			
b	*p*-$CH_3C_6H_4$	CH_3			
c	CH_3S	C_6H_5			
d	CH_3S	CH_3			
e	CH_3S	CO_2Et			
2,3a	*p*-$CH_3C_6H_4$	C_6H_5	**4a**	*p*-$CH_3C_6H_4$	10
b	*p*-$CH_3C_6H_4$	CH_3	**b**	CH_3S	trace–10
c	CH_3S	C_6H_5			
d	CH_3S	CH_3			
5	CH_3S	C_6H_5	**6**	CH_3S	38
7,8a	*p*-$CH_3C_6H_4$	C_6H_5	**9a**	*p*-$CH_3C_6H_4$	18
b	*p*-$CH_3C_6H_4$	CH_3	**b**	CH_3S	33–59
c	CH_3S	C_6H_5			
d	CH_3S	CH_3			
e	CH_3S	CO_2Et			
10a	*p*-$CH_3C_6H_4$	C_6H_5	**11a**	*p*-$CH_3C_6H_4$	15
b	CH_3S	C_6H_5	**b**	CH_3S	16
12	*p*-$CH_3C_6H_4$	C_6H_5	**13**	*p*-$CH_3C_6H_4$	82

The Diels–Alder reactivity of the 5-(3-butynyloxy)-1,2,4-triazine system was substantially increased by addition of an ethyl substituent α to oxygen in the dienophilic side chain. [(1-Ethyl-3-butynyl)oxy]-3-(methylthio)-6-phenyl-1,2,4-triazine (**5**) was prepared from **2c** and the sodium salt of 5-hexyn-3-ol (60% yield) as described previously for the analogous species **3a–d**. Heating **5** at 225 °C in TIPB for 2 days yielded 2-ethyl-6-(methylthio)-2,3-dihydrofuro[2,3-*d*]pyrimidine (**6**) in 38% yield. The yield increase of this reaction relative to the earlier examples discussed above presumably is a consequence of "entropic assistance" provided by the ethyl substituent, which facilitates orientation of the (1-ethyl-3-butynyl)oxy side chain into a preferred conformation for cycloaddition (Thorpe–Ingold effect).

We then examined an analogous series of 1,2,4-triazine derivatives where the dienophilic side chains were tethered to the C5 position through sulfur rather than oxygen, since our previous work with both 3- and 6-substituted 1,2,4-triazines has shown that tethering the dienophilic side chain through sulfur rather than oxygen greatly facilitates cycloaddition. Treatment of the 1,2,4-triazin-5-ones **1a–e** with phosphorus pentasulfide in refluxing pyridine afforded the corresponding 5-thiones **7a–e**,[13] which were then smoothly alkylated with 4-iodo-1-butyne[17] in the presence of triethylamine to give the 5-(3-butynylthio)-1,2,4-triazines **8a–e**. Heating **8a–e** at 232–236 °C in TIPB yielded the dihydrothieno[2,3-*d*]pyrimidines **9a–b** in reasonable yields.

The above observations on oxygen- and sulfur-tethered dienophilic systems did not make us overly optimistic about extending these reactions to nitrogen-linked systems; our skepticism was unfortunately justified. Treatment of the 5-chloro-1,2,4-triazines **2a,c** with 4-amino-1-butyne[3c] afforded the 5-(3-butynylamino)-1,2,4-triazines **10a,b** in good yields. Heating **10a,b** for 3–4 days at 232–236 °C in TIPB resulted in complete consumption of starting material but did not yield the desired dihydropyrrolo[2,3-*d*]pyrimidines; the only products isolated were the corresponding 5-amino-1,2,4-triazines **11a,b**.

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(12) The 5-chloro-1,2,4-triazines **2a–d** were carried on without further purification (and were assumed to have been prepared quantitatively). Yields of the 5-(3-butynyloxy)-1,2,4-triazines **3a–d** were thus based upon the 1,2,4-triazin-5-ones **1a–d**.
(13) The 1,2,4-triazine-5-thiones **7a–e** were prepared by using a procedure modified from that of: Taft, W. E.; Shepard, R. G. *J. Med. Chem.* **1967**, *10*, 883.
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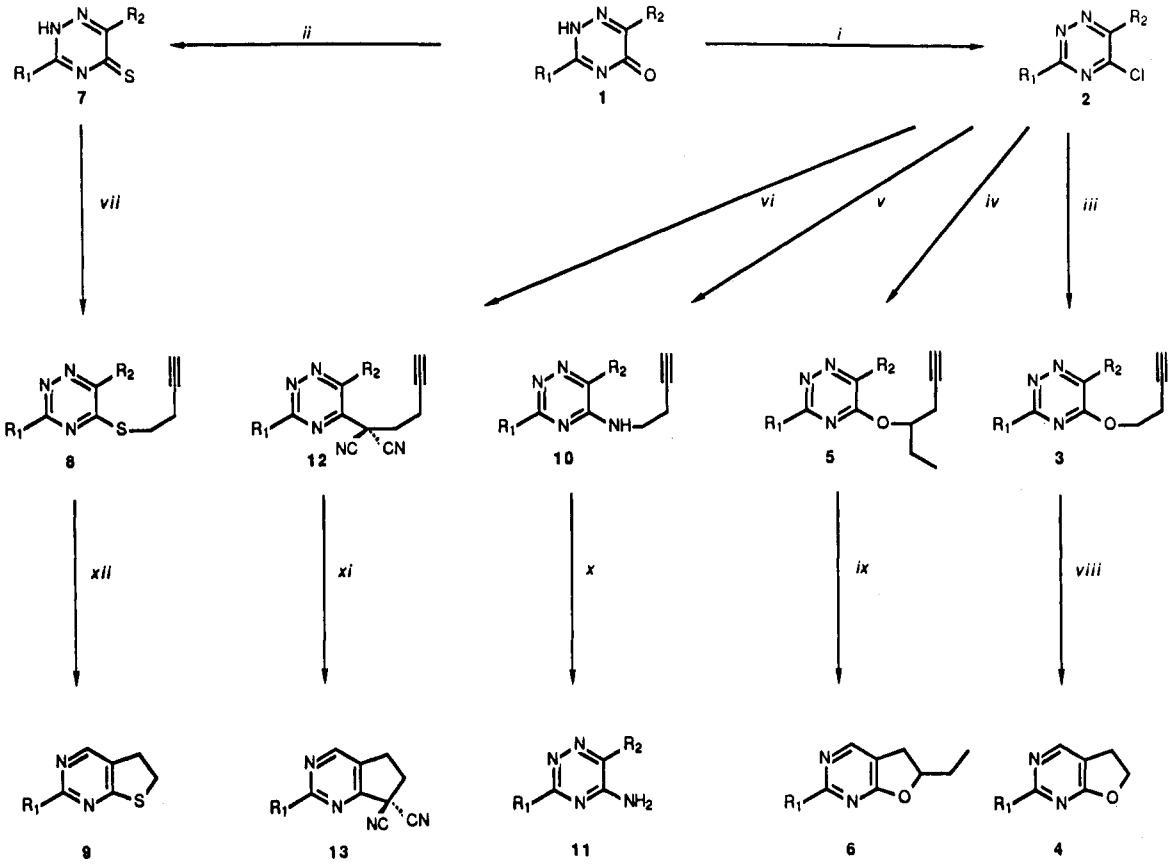
Scheme II[a]



[a] (i) $POCl_3$ or $SOCl_2$, Δ, 2 h; (ii) P_2S_5, pyridine, Δ, 4 h; (iii) 3-butyn-1-oxide, THF; (iv) 5-hexyn-3-oxide, THF; (v) 4-amino-1-butyne, THF; (vi) 1,1-dicyano-4-pentyne, NaH, THF; (vii) 4-iodo-1-butyne, Et_3N, THF; (viii) TIPB, Δ, 2–3 days; (ix) TIPB, 220–225 °C, 2 days; (x) $C_6H_5NO_2$, Δ, 4 days; (xi) C_6H_5Br, Δ, 7.5 h; (xii) TIPB, Δ, 7 h–2 days.

The observed trends in yields and relative reaction rates in the three systems examined above (X = O, S, N, Scheme I) can be summarized as S > O > N, where an increase in the electron-donating ability of X has a clearly deleterious effect on the desired Diels–Alder reaction. Confirmation of this generalization was found in the carbon-tethered system **12**, which was prepared as follows: 1,1-Dicyano-4-pentyne[18] was treated with sodium hydride in THF to generate the corresponding carbanion, which when treated with a THF solution of the 5-chloro-1,2,4-triazine **2a** yielded 5-(1,1-dicyano-4-pentynyl)-6-phenyl-3-*p*-tolyl-1,2,4-triazine[19] (**12**) in 72% yield. This compound underwent intramolecular cycloaddition with extrusion of benzonitrile under relatively mild conditions (156 °C in refluxing bromobenzene, 7.5 h) to afford 1,1-dicyano-6-*p*-tolylcyclopenteno[*d*]pyrimidine (**13**) in 82% yield. In addition to the lack of debilitating electronic effects, this cycloaddition reaction is greatly facilitated by the *gem*-dicyano-substituted side chain, an effect which we have previously noted in the isomeric 3-substituted series.[3d]

It is clear that with judicious selection of dienophilic side chains at position 5, intramolecular Diels–Alder reactions of 1,2,4-triazines can provide access to an array of fused pyrimidines. Our continuing efforts in the field of intramolecular Diels–Alder reactions of 1,2,4-triazines are being directed toward the preparation of biologically significant synthetic targets.

(18) Macor, J. E. Ph.D. Thesis, Princeton University, 1986, 297.

(19) Neither satisfactory elemental analyses nor a high-resolution mass spectrum of **12** could be obtained due to extensive room temperature decomposition upon standing. However, the identity of **12** is confirmed by the fully characterized **13**, its derived intramolecular Diels–Alder product.

Experimental Section

General. Melting points were determined in open capillary tubes by using a Thomas-Hoover apparatus and are uncorrected. IR spectra were recorded on a Perkin-Elmer 1320 instrument and are reported in cm^{-1}. ^1H NMR data were obtained with a General Electric QE300 300-MHz instrument, and chemical shifts are reported in ppm downfield from Me_4Si. Mass spectral data were obtained by Dr. Dorothy Little on AEI MS-902 and Kratos MS50TC spectrometers. Elemental analyses were performed by Eli Lilly and Co., Indianapolis, IN. Column chromatography was performed on Merck silica gel 60 (240–400 mesh). TLC analyses were carried out on Bakerflex IB2-F plates by utilizing UV and I_2 visualization. Preparative TLC was carried out on Analtech silica gel GF uniplates (1500 μm).

Materials. Commercial reagents were utilized without further purification. Anhydrous solvents were distilled before use–tetrahydrofuran from benzophenone ketyl and methylene chloride from calcium hydride.

6-Phenyl-3-*p*-tolyl-1,2,4-triazin-5-one (1a). A stirred solution of *p*-methylbenzamidrazone[6] (7.00 g, 47.0 mmol) in anhydrous DMF (75 mL) at 0 °C was treated with benzoylformic acid (7.56 g, 48.9 mmol), allowed with stirring to warm to room temperature (0.5 h), and then heated under reflux for 3 h. Upon cooling, the reaction mixture was poured into ice–water, and the precipitated 6-phenyl-3-*p*-tolyl-1,2,4-triazin-5-one (**1a**) was collected by vacuum filtration to give 10.79 g (87%) of a white solid. It was obtained as white plates, mp 294–295 °C, upon recrystallization from ethanol/dimethylformamide (lit.[8] mp 299–301 °C): IR (KBr) 3200, 3050, 2800, 1580, 1520, 1450, 1365, 1325, 1240, 1170, 1115, 1005, 805 cm^{-1}; ^1H NMR (Me_2SO-d_6) δ 8.16–8.12 (m, 2 H), 8.03 (d, J = 8.2 Hz, 2 H), 7.50–7.48 (m, 3 H), 7.4 (d, J = 8.1 Hz, 2 H), 2.41 (s, 3 H).

6-Methyl-3-*p*-tolyl-1,2,4-triazin-5-one (1b) was prepared in analogous fashion with the substitution of pyruvic acid for benzoylformic acid (63% yield). It was recrystallized from ethyl acetate/ethanol: mp 251.5–252 °C; IR (KBr) 3160, 3040, 2960,

2910, 2880, 1600, 1575, 1505, 1470, 1370, 1315, 1210, 1090, 955, 830, 780, 735 cm^{-1}; ^1H NMR (Me_2SO-d_6) δ 7.93 (d, J = 8.2 Hz, 2 H), 7.38 (d, J = 8.1 Hz, 2 H), 2.38 (s, 3 H); HRMS calcd for $C_{11}H_{11}N_3O$ 201.0902, found 201.0900.

Anal. Calcd for $C_{11}H_{11}N_3O$: C, 65.66; H, 5.51; N, 20.88. Found: C, 65.54; H, 5.55; N, 20.59.

3-(Methylthio)-6-phenyl-1,2,4-triazin-5-one (1c). A stirred suspension of *S*-methylisothiosemicarbazide hydrogen iodide (10.00 g, 42.9 mmol) in absolute ethanol (100 mL) was heated at reflux until a homogeneous solution was obtained. After this time, sodium bicarbonate (3.64 g, 43.3 mmol) followed by benzoylformic acid (6.38 g, 42.5 mmol) was added to the mixture, which was subsequently heated at reflux for 3 h. Upon cooling, the precipitated 3-(methylthio)-6-phenyl-1,2,4-triazin-5-one (**1c**) was collected by vacuum filtration to give 7.96 g (85%) of white plates: mp 236–238 °C (lit.[9] mp 239–240 °C); IR (KBr) 3170, 3050, 2800, 1610, 1550, 1485, 1435, 1345, 1280, 1150, 1010, 800, 750 cm^{-1}; ^1H NMR (Me_2SO-d_6) δ 8.02–7.98 (m, 2 H), 7.45–7.43 (m, 3 H), 2.52 (s, 3 H).

6-Methyl-3-(methylthio)-1,2,4-triazin-5-one (1d) was prepared in analogous fashion with the substitution of pyruvic acid for benzoylformic acid (51% yield): mp 198–199 °C (lit.[10] mp 224–225 °C); IR (KBr) 3170, 2980, 2910, 1575, 1515, 1450, 1420, 1370, 1355, 1260, 1010, 980, 775 cm^{-1}; ^1H NMR (Me_2SO-d_6) δ 2.45 (s, 3 H), 2.08 (s, 3 H).

6-Carbethoxy-3-(methylthio)-1,2,4-triazin-5-one (1e) was prepared by the method of Taylor and Martin[6] and was identical in every respect with the same compound prepared by the method of Pessom and co-workers.[11]

General Procedures for the Preparation of 5-Chloro-1,2,4-triazines[12] 2a–d. Method A. A stirred suspension of the 1,2,4-triazin-5-one in a large excess of phosphorus oxychloride was heated to reflux under nitrogen to give a homogeneous solution. After 2 h, the reaction mixture was evaporated under reduced pressure and was subsequently washed with two portions of toluene. The resultant yellow residue was taken up in methylene chloride and washed twice with saturated aqueous sodium bicarbonate. The organic layer was dried (anhydrous $MgSO_4$) and evaporated under reduced pressure to afford the crude 5-chloro-1,2,4-triazines **2a–d**, which were used immediately as needed.

Method B. A stirred suspension of the 1,2,4-triazin-5-one in a large excess of thionyl chloride was heated to reflux under nitrogen to give a homogeneous solution. After 2 h, thionyl chloride was distilled from the reaction mixture at aspirator pressure, and the resultant residue was washed with two portions of benzene to afford the crude 5-chloro-1,2,4-triazines **2a–d** which were used immediately as needed.

5-(3-Butynyloxy)-6-phenyl-3-*p*-tolyl-1,2,4-triazine (3a). To a stirred suspension of sodium hydride (0.42 g, 10.5 mmol, 60% oil dispersion) in anhydrous tetrahydrofuran (25 mL) at 0 °C under nitrogen was added 3-butyn-1-ol (0.76 g, 10.8 mmol) at once. When the initial effervescence had subsided, cooling was removed, and a solution of a slight molar excess of freshly prepared **2a**[12] in 1:1 methylene chloride/tetrahydrofuran (50 mL) was added rapidly to the reaction mixture. The resultant mixture was stirred under nitrogen for 6 h. After this time, the reaction mixture was evaporated under reduced pressure, and the residual oil was taken up in methylene chloride (150 mL) and washed respectively with water (100 mL, 75 mL) and brine (75 mL). The organic layer was dried (anhyd $MgSO_4$) and evaporated under reduced pressure to afford a yellow oil. Trituration of this oil in 1:2 ether/petroleum ether caused 5-(3-butynyloxy)-6-phenyl-3-*p*-tolyl-1,2,4-triazine (**3a**) to crystallize out as 2.15 g (71%) of a pale yellow solid: mp 104–105 °C; IR (KBr) 3280, 3050, 2980, 2940, 2900, 1600, 1570, 1530, 1505, 1440, 1390, 1350 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.43 (d, J = 8.1 Hz, 2 H), 8.23–8.20 (m, 2 H), 7.51–7.49 (m, 3 H), 7.34 (d, J = 8.1 Hz, 2 H), 4.76 (t, J = 6.6 Hz, 2 H), 2.83 (dt, J_1 = 6.6 Hz, J_2 = 2.9 Hz, 2 H), 2.45 (s, 3 H), 2.10 (t, J= 2.7 Hz, 1 H).

Anal. Calcd for $C_{20}H_{17}N_3O$: C, 76.17; H, 5.43; N, 13.32. Found: C, 76.43; H, 5.47; N, 13.23.

5-(3-Butynyloxy)-6-methyl-3-*p*-tolyl-1,2,4-triazine (3b): from 0.19 g (4.7 mmol, 60% oil dispersion) of sodium hydride, 0.35 g (4.9 mmol) of 3-butyn-1-ol, and a slight molar excess of **2b**[12] as described above; yield 1.00 g (92%) of **3b** as a pale yellow solid, mp 90–91 °C; IR (KBr) 3220, 2960, 2920, 1620, 1550, 1520, 1425, 1390, 1350, 1215, 1170, 1140, 1055, 1000, 985, 830, 780 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.37 (d, J = 8.2 Hz, 2 H), 7.33 (d, J = 8.1 Hz, 2 H), 4.68 (t, J = 6.9 Hz, 2 H), 2.81 (dt, J_1 = 6.7 Hz, J_2 = 2.6 Hz, 2 H), 2.64 (s, 3 H), 2.45 (s, 3 H), 2.08 (t, J = 2.7 Hz, 1 H).

Anal. Calcd for $C_{15}H_{15}N_3O$: C, 71.13; H, 5.97; N, 16.59. Found: C, 70.93; H, 5.79; N, 16.34.

5-(3-Butynyloxy)-3-(methylthio)-6-phenyl-1,2,4-triazine (3c): from 0.42 g (10.5 mmol, 60% oil dispersion) of sodium hydride, 0.75 g (10.7 mmol) of 3-butyn-1-ol, and a slight molar excess of **2c**[12] as described above; yield 1.14 g (41%) of **3c** as a pale beige solid, mp 85–86 °C; IR (KBr) 3240, 2970, 2920, 1620, 1570, 1520, 1500, 1435, 1410, 1340, 1310, 1280, 1230, 1175, 1100, 1065, 1010, 980, 930, 800, 750, 665 cm^{-1}; ^1H HMR ($CDCl_3$) δ 8.11–8.08 (m, 2 H), 7.48–7.46 (m, 3 H), 4.61 (t, J = 6.6 Hz, 2 H), 2.75 (dt, J_1 = 6.6 Hz, J_2 = 2.6 Hz, 2 H), 2.70 (s, 3 H), 2.08 (t, J = 2.7 Hz, 1 H).

Anal. Calcd for $C_{14}H_{13}N_3OS$: C, 61.97; H, 4.83; N, 15.49; S, 11.81. Found: C, 61.83; H, 4.87; N, 15.39; S, 12.04.

5-(3-Butynyloxy)-6-methyl-3-(methylthio)-1,2,4-triazine (3d): From 0.53 g (13.1 mmol, 60% oil dispersion) of sodium hydride, a slight molar excess of **2d**,[12] and 0.93 g (13.3 mmol) of 3-butyn-1-ol as described above; yield 1.04 g (39%); mp 76–77 °C; IR (KBr) 3220, 3000, 2960, 2920, 1545, 1510, 1460, 1420, 1380, 1350, 1335, 1320, 1295, 1260, 1220, 1165, 1065, 1045, 1010, 970, 935, 770, 695 cm^{-1}; ^1H NMR ($CDCl_3$) δ 4.53 (t, J = 6.8 Hz, 2 H), 2.73 (dt, J_1 = 6.7 Hz, J_2 = 2.8 Hz, 2 H), 2.64 (s, 3 H), 2.53 (s, 3 H), 2.05 (t, J = 2.7 Hz, 1 H).

Anal. Calcd for $C_9H_{11}N_3OS$: C, 51.66; H, 5.30; N, 20.08; S, 15.32. Found: C, 51.91; H, 5.27; N, 20.28; S, 15.47.

6-*p*-Tolyl-2,3-dihydrofuro[2,3-*d*]pyrimidine (4a). A stirred suspension of **3a** (0.31 g, 0.98 mmol) in TIPB (6 mL) was heated at reflux (232–236 °C) under nitrogen for 3 days. After this time, the reaction mixture was cooled to room temperature and filtered through a silica gel pad which was then eluted with hexanes (200 mL) followed by 1% methanol/methylene chloride (2 × 250 mL). The second methylene chloride fraction was evaporated under reduced pressure, and the residual oil was purified by preparative TLC (1:1 hexanes/ethyl acetate) to afford 6-*p*-tolyl-2,3-dihydrofuro[2,3-*d*]pyrimidine (**4a**) as 0.02 g (10%) of a tan solid; mp 159–160 °C; ^1H NMR ($CDCl_3$) δ 8.42 (s, 1 H), 8.29 (d, J = 8.2 Hz, 2 H), 7.26 (d, J = 8.2 Hz, 2 H), 4.71 (t, J = 8.6 Hz, 2 H), 3.30 (t, J = 8.5 Hz, 2 H), 2.40 (s, 3 H); HRMS calcd for $C_{13}H_{12}N_2O$ 212.0950, found 212.0947.

6-(Methylthio)-2,3-dihydrofuro[2,3-*d*]pyrimidine (4b). Method A. A stirred suspension of **3c** (0.27 g, 1.00 mmol) in TIPB (7 mL) was heated to reflux (232–236 °C) under nitrogen for 3 days and then worked up as described above for **4a**: yield, 0.02 g (12%) of a yellow solid; mp 63–64 °C; ^1H NMR ($CDCl_3$) δ 8.20 (s, 1 H), 4.71 (t, J = 8.7 Hz, 2 H), 3.25 (t, J = 8.6 Hz, 2 H), 2.56 (s, 3 H); HRMS calcd for $C_7H_8N_2OS$ 168.0357, found 168.0354.

Method B. A stirred suspension of **3d** (0.22 g, 1.05 mmol) in TIPB (5 mL) was heated to reflux (232–236 °C) under nitrogen for 2.5 days and then worked up as described above for **4a** to provide **4b** in trace yield (as determined by 300-MHz ^1H NMR). The spectral and physical properties of this material were identical with the spectral and physical properties of the compound prepared as described above in method A.

[(1-Ethyl-3-butynyl)oxy]-3-(methylthio)-6-phenyl-1,2,4-triazine (5). To a stirred suspension of sodium hydride (0.43 g, 10.8 mmol, 60% oil dispersion) in anhydrous tetrahydrofuran (30 mL) was added 5-hexyn-3-ol (1.06 g, 10.82 mmol) at once. When the initial vigorous effervescence had subsided, a freshly prepared solution of **2c** (10.82 mmol) in methylene chloride was added rapidly to the reaction mixture. The resultant mixture was stirred under nitrogen for 6 h. After this time, the reaction mixture was partially evaporated under reduced pressure to a volume of 20 mL, then taken up in methylene chloride (75 mL), and washed first with water (70 mL) and then with brine (70 mL). The organic layer was dried (anhyd $MgSO_4$) and evaporated under reduced pressure to afford a yellow oil. This material was purified by column chromatography (elution with methylene chloride) to yield 1.93 g (60%) of [(1-ethyl-3-butynyl)oxy]-3-(methylthio)-6-phenyl-1,2,4-triazine (**5**) as a pale yellow oil: IR (neat) 3290, 3040, 2960, 2920, 2880, 2120, 1530, 1495, 1435, 1400, 1340, 1310, 1190, 1100, 1000, 960, 915, 865, 800, 755, 730, 690, 630 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.13–8.09 (m, 2 H), 7.49–7.47 (m, 3 H), 5.44 (quintet,

J = 5.8 Hz, 1H), 2.78–2.68 (m, 2 H), 2.70 (s, 3 H), 2.05 (t, J = 2.7 Hz, 1 H), 1.98–1.89 (m, 2 H), 0.99 (t, J = 7.5 Hz, 3 H); HRMS calcd for $C_{16}H_{17}N_3OS$ 299.1092, found 299.1092.

2-Ethyl-6-(methylthio)-2,3-dihydrofuro[2,3-*d*]pyrimidine (6). A stirred solution of **5** (0.52 g, 1.74 mmol) in TIPB (7 mL) was heated to 220–225 °C under nitrogen for 2 days. After this time, the reaction mixture was cooled to room temperature and filtered through a silica gel pad, which was then eluted first with hexanes (250 mL) and then with 2% methanol/methylene chloride (3 × 250 mL). The third methylene chloride fraction was evaporated under reduced pressure, and the residual oil was purified by TLC to afford 0.13 g (38%) of 2-ethyl-6-(methylthio)-2,3-dihydrofuro[2,3-*d*]pyrimidine (**6**) as a reddish oil; IR (neat) 2960, 2920, 2880, 1595, 1555, 1430, 1360, 1320, 1290, 1230, 1200, 1120, 1085, 1050, 950, 825, 800, 770 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 8.14 (s, 1 H), 4.92–4.84 (m, 1 H), 3.34–3.25 (m, 1 H), 2.89–2.81 (m, 1 H), 2.54 (s, 3 H), 1.94–1.73 (m, 2 H), 1.06 (t, J = 7.4 Hz, 3 H); HRMS calcd for $C_9H_{12}N_2OS$ 196.0670, found 196.0667.

6-Phenyl-3-*p*-tolyl-1,2,4-triazine-5-thione (7a).[13] A stirred solution of **1a** (5.00 g, 19.0 mmol) in pyridine (100 mL) containing phosphorus pentasulfide (2.60 g, 11.7 mmol, 0.62 eq) was heated at reflux under nitrogen for 4 h. The reaction mixture was evaporated under reduced pressure, and the resulting paste was slurried in water (250 mL) for 15 min. Following this period, the slurry was extracted with methylene chloride (250 mL), and the methylene chloride layer was washed with saturated sodium bicarbonate (100 mL), dried (anhydrous $MgSO_4$), and evaporated under reduced pressure to afford a red-orange solid. Trituration of this material with ether yielded 4.28 g (81%) of 6-phenyl-3-*p*-tolyl-1,2,4-triazine-5-thione (**7a**) as a fine orange solid, which was obtained as orange plates, mp 214–215 °C, upon recrystallization from ethyl acetate: IR (KBr) 3160, 3000, 2810, 1600, 1550, 1500, 1435, 1325, 1300, 1255, 1190, 1175, 1055, 1000, 825, 720 cm^{-1}; ^{1}H NMR (acetone-d_6) δ 8.15 (d, J = 8.3 Hz, 2 H), 7.89–7.86 (m, 2 H), 7.47–7.42 (m, 5 H), 2.46 (s, 3 H); HRMS calcd for $C_{16}H_{13}N_3S$ 279.0830, found 279.0832.

6-Methyl-3-*p*-tolyl-1,2,4-triazine-5-thione (7b) was prepared from **1b** as described above for the preparation of **7a** (99%): mp 183–185 °C; IR (KBr) 3160, 3080, 2960, 2900, 2840, 1570, 1520, 1490, 1440, 1430, 1360, 1350, 1310, 1290, 1250, 1170, 1080 cm^{-1}; ^{1}H NMR (acetone-d_6) δ 7.91 (d, J = 8.3 Hz, 2 H), 7.34 (d, J = 8.1 Hz, 2 H), 2.61 (br s, 3 H), 2.44 (s, 3 H); HRMS calcd for $C_{11}H_{11}N_3S$ 217.0674, found 217.0677.

3-(Methylthio)-6-phenyl-1,2,4-triazine-5-thione (7c) was analogously prepared from **1c** (91% yield): mp 182–184 °C (lit.[14] mp 186–188 °C); IR (KBr) 3110, 2910, 2800, 1545, 1490, 1479, 1430, 1395, 1330, 1280, 1210, 1140, 1075, 1000, 885, 750, 680, cm^{-1}; ^{1}H NMR (acetone-d_6) δ 7.77–7.74 (m, 2 H), 7.40–7.34 (m, 3 H), 2.66 (s, 3 H).

6-Methyl-3-(methylthio)-1,2,4-triazine-5-thione (7d) was prepared analogously from **1d** (68% yield): mp 170.5–171.5 °C (lit.[15] mp 178–179 °C); IR (KBr) 3140, 3090, 2800, 1570, 1500, 1425, 1405, 1365, 1320, 1250, 1070 cm^{-1}; ^{1}H NMR (acetone-d_6) δ 2.61 (s, 3 H), 2.36 (s, 3 H).

6-Carbethoxy-3-(methylthio)-1,2,4-triazine-5-thione (7e) was prepared in analogous fashion from **1e** (26% yield): mp 77–79 °C (lit.[16] mp 79–80 °C); IR (KBr) 2960, 1730, 1510, 1460, 1320, 1290, 1230, 1210, 1170, 1080, 1050 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 4.50 (q, J = 7.1 Hz, 2 H), 2.70 (s, 3 H), 1.45 (t, J = 7.2 Hz, 3 H.

5-(3-Butynylthio)-6-phenyl-3-*p*-tolyl-1,2,4-triazine (8a). To a solution of **7a** (1.02 g, 3.66 mmol) in anhydrous tetrahydrofuran (50 mL) containing triethylamine (0.39 g, 3.80 mmol) which had been stirred under nitrogen for 5 min was added 4-iodo-1-butyne (0.70 g, 3.80 mmol), and the mixture was then further stirred under nitrogen for 6 h. Methylene chloride (150 mL) was added to the reaction mixture, which was then washed with water (100 mL) followed by saturated aqueous sodium bicarbonate (100 mL). The organic layer was dried (anhyd $MgSO_4$) and evaporated under reduced pressure to afford a white solid. Trituration of this material in ether provided 1.01 g (83%) of 5-(3-butynylthio)-6-phenyl-3-*p*-tolyl-1,2,4-triazine (**8a**) as a white, flaky solid: mp 123.5–124.5 °C; IR (KBr) 3220, 3060, 3030, 2910, 1605, 1475, 1440, 1390, 1170, 1110, 1100, 1060, 795 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 8.47 (d, J = 8.2 Hz, 2 H), 7.86–7.83 (m, 2 H), 7.55–7.53 (m, 3 H), 7.37 (d, J = 8.1 Hz, 2 H), 3.48 (t, J = 7.2 Hz, 2 H), 2.74 (dt, J_1 = 7.1 Hz, J_2 = 2.5 Hz, 2 H), 2.47 (s, 3 H), 2.09 (t, J = 2.8 Hz, 1 H).

Anal. Calcd for $C_{20}H_{17}N_3S$: C, 72.48; H, 5.17; N, 12.68; S, 9.67. Found: C, 72.26; H, 5.27; N, 12.52; S, 9.57.

5-(3-Butynylthio)-6-methyl-3-*p*-tolyl-1,2,4-triazine (8b) was prepared as described above from 0.74 g (3.41 mmol) of **7b**, 0.37 g (3.61 mmol) of triethylamine, and 0.65 g (3.61 mmol) of 4-iodo-1-butyne: yield, 0.88 g (96%) of **8b** as a pale yellow solid, mp 105–106 °C; IR (KBr) 3220, 1600, 1485, 1425, 1380, 1310, 1290, 1220, 1170, 1100, 1020, 975, 870, 830, 770 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 8.40 (d, J = 8.2 Hz, 2 H), 7.34 (d, J = 8.1 Hz, 2 H), 3.52 (t, J = 7.1 Hz, 2 H), 2.77 (dt, J_1 = 7.2 Hz, J_2 = 2.7 Hz, 2 H), 2.64 (s, 3 H), 2.46 (s, 3 H), 2.13 (t, J = 2.8 Hz, 1 H).

Anal. Calcd for $C_{15}H_{15}N_3S$: C, 66.89; H, 5.61; N, 15.60; S, 11.90. Found: C, 66.67; H, 5.74; N, 15.53; S, 11.69.

5-(3-Butynylthio)-3-(methylthio)-6-phenyl-1,2,4-triazine (8c) was prepared analogously from 1.00 g (4.26 mmol) of **7c**, 0.44 g (4.38 mmol) of triethylamine, and 0.78 g (4.34 mmol) of 4-iodo-1-butyne; yield, 1.09 g (89%) of **8c** as a fine off-white solid, mp 113–114 °C; IR (KBr) 3220, 2920, 1500, 1460, 1430, 1340, 1315, 1265, 1230, 1170, 1060, 990, 860, 790, 755, 685 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.77–7.74 (m, 2 H), 7.55–7.51 (m, 3 H), 3.35 (t, J = 7.3 Hz, 2 H), 2.71 (s, 3 H), 2.65 (dt, J_1 = 7.2 Hz, J_2 = 2.4 Hz, 2 H), 2.07 (t, J = 2.2 Hz, 3 H).

Anal. Calcd for $C_{14}H_{13}N_3S_2$: C, 58.51; H, 4.56; N, 14.62; S, 22.31. Found: C, 58.30; H, 4.51; N, 14.45; S, 22.39.

5-(3-Butynylthio)-6-methyl-3-(methylthio)-1,2,4-triazine (8d) was prepared from 0.90 g (5.20 mmol) of **7d**, 0.54 g (5.36 mmol) of triethylamine, and 0.96 g (5.31 mmol) of 4-iodo-1-butyne; yield, 0.79 g (68%) of **8d** as a fine beige solid, mp 57–58 °C; IR (KBr) 3220, 2920, 2110, 1490, 1420, 1370, 1300, 1230, 1190, 1110, 1055, 980, 980, 965, 870, 665 cm^{-1}; NMR ($CDCl_3$) δ 3.38 (t, J = 7.1 Hz, 2 H), 2.66 (dt, J_1 = 7.2 Hz, J_2 = 2.8 Hz, 2 H), 2.64 (s, 3 H), 2.54 (s, 3 H), 2.09 (t, J = 2.6 Hz, 1 H).

Anal. Calcd for $C_9H_{11}N_3S_2$: C, 47.97; H, 4.92; N, 18.65; S, 28.46. Found: C, 47.94; H, 5.00; N, 18.73; S, 28.52.

5-(3-Butynylthio)-6-carbethoxy-3-(methylthio)-1,2,4-triazine (8e) was prepared from 0.41 g (1.78 mmol) of **7e**, 0.18 g (1.78 mmol) of triethylamine, and 0.32 g (1.78 mmol) of 4-iodo-1-butyne as described above: yield, 0.32 g (64%) of **8e** as a yellow powder, mp 94–95 °C dec (effervescence); IR (KBr) 3240, 2970, 2920, 1700, 1610, 1545, 1460, 1420, 1370, 1330, 1300, 1210, 1160, 1080, 1060, 890 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 4.52 (q, J = 7.1 Hz, 2 H), 3.36 (t, J = 7.2 Hz, 2 H), 2.71 (s, 3 H), 2.64 (dt, J_1 = 7.2 Hz, J_2 = 2.5 Hz, 2 H), 2.09 (t, J = 2.4 Hz, 1 H), 1.47 (t, J = 7.3 Hz, 3 H).

Anal. Calcd for $C_{11}H_{13}N_3O_2S_2$: C, 46.63; H, 4.62; N, 14.83; S, 22.63. Found: C, 46.47; H, 4.66; N, 14.89; S, 22.75.

6-*p*-Tolyl-2,3-dihydrothieno[2,3-*d*]pyrimidine (9a). Method A. A stirred suspension of **8a** (0.22 g, 0.67 mmol) in TIPB (5 mL) was heated to 210–220 °C under nitrogen for 15 h. After this time, the reaction mixture was cooled to room temperature and filtered through a silica gel pad, which was then eluted first with hexanes (200 mL) and then with 2% methanol/methylene chloride (2 × 250 mL). The second methylene chloride fraction was evaporated under reduced pressure, and the residual oil was purified by TLC (1:1 hexanes/ethyl acetate as eluent) to afford 0.03 g (18%) of **9a** as pale tan crystals: mp 154.5–155.5 °C; ^{1}H NMR ($CDCl_3$) δ 8.33 (s, 1 H), 8.27 (d, J = 8.2 Hz, 2 H), 7.27 (d, J = 8.1 Hz, 2 H), 3.45 (m, 2 H), 3.34 (m, 2 H), 2.41 (s, 3 H); HRMS calcd for $C_{13}H_{12}N_2S$ 228.0721, found 228.0717.

Method B. A stirred suspension of **8b** (0.27 g, 1.00 mmol) in TIPB (4 mL) was heated to reflux (232–236 °C) under nitrogen for 48 h. After this time, the reaction mixture was cooled to room temperature and then worked up as described above to give 0.04 g (18%) of **9a**, identical in all respects with material prepared as described above under method A.

6-(Methylthio)-2,3-dihydrothieno[2,3-*d*]pyrimidine (9b). This material was prepared as described above from 0.29 g (0.01 mmol) of **8c** by heating at 220–225 °C for 7.25 h in TIPB (6 mL), followed by workup as described above for **9a** (method A) to give 0.09 g (48%) of a brown oil: IR (neat) 2920, 1680, 1555, 1510, 1430, 1375, 1315, 1270, 1220, 1205, 1170, 1110, 1080, 960, 860, 825, 765, 735 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 8.08 (s, 1 H), 3.43 (t, J = 7.4 Hz, 2 H), 3.27 (t, J = 7.4 Hz, 2 H), 2.55 (s, 3 H); HRMS calcd for $C_7H_8N_2S_2$ 184.0129, found 184.0127. Under the same reaction conditions, **9b** was obtained in 59% yield from **8d** and in 33% yield (44% based upon recovered starting material) from **8e**.

5-(3-Butynylamino)-6-phenyl-3-*p*-tolyl-1,2,4-triazine (10a). A mixture of freshly prepared **2a** (10.0 mmol) in anhydrous THF (35 mL) and 4-amino-1-butyne (1.42 g, 20.6 mmol, 2.06 equiv) was stirred under nitrogen for 5.5 h. After this period, methylene chloride (100 mL) was added, and the reaction mixture was washed first with water (100 mL) and then with saturated aqueous sodium bicarbonate (100 mL). The organic layer was dried (anhydrous $MgSO_4$) and evaporated under reduced pressure to afford a yellow oil, which when triturated in 1:1 ether/petroleum ether yielded 5-(3-butynylamino)-6-phenyl-1,2,4-triazine (3.06 g, 98%) as a fine white solid, mp 130–131 °C; IR (KBr) 3420, 3270, 3230, 3050, 2940, 2910, 1605, 1575, 1550, 1525, 1440, 1425, 1400, 1375, 1355, 1250, 1160, 1110, 1070, 1000, 800, 765, 725 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.42 (d, J = 8.2 Hz, 2 H), 7.79–7.75 (m, 2 H), 7.60–7.50 (m, 3 H), 7.33 (d, J = 8.2 Hz, 2 H), 5.86 (br s, 1 H), 3.80 (q, J = 6.2 Hz, 2 H), 2.66 (dt, J_1 = 6.2 Hz, J_2 = 2.4 Hz, 2 H), 2.46 (s, 3 H), 2.05 (t, J = 2.4 Hz, 1 H).

Anal. Calcd for $C_{20}H_{18}N_4$: C, 76.41; H, 5.77; N, 17.82. Found: C, 76.14; H, 5.80; N, 17.77.

5-(3-Butynylamino)-3-(methylthio)-6-phenyl-1,2,4-triazine (10b). A mixture of freshly prepared **2c** in anhydrous THF (30 mL) and 4-amino-1-butyne (1.40 g, 20.3 mmol, 2.03 equiv) was stirred under nitrogen for 19 h. After this period, methylene chloride (100 mL) was added, and the reaction mixture was washed with water (100 mL) followed by saturated aqueous sodium bicarbonate (100 mL). The organic layer was dried (anhydrous $MgSO_4$) and evaporated under reduced pressure to afford a pale orange oil. Purification of this material by column chromatography (1:1 hexanes/ethyl acetate eluent) yielded 2.37 g (88%) of **10b** as an orange-yellow oil: IR (neat) 3400, 3280, 2920, 1560, 1440, 1345, 1310, 1260, 1215, 1170, 1105, 1065, 1000, 985, 755 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.69–7.66 (m, 2 H), 7.57–7.51 (m, 3 H), 5.85 (b s, 1 H), 3.66 (q, J = 6.3 Hz, 2 H), 2.64 (s, 3 H), 2.57 (dt, J_1 = 6.5 Hz, J_2 = 2.7 Hz, 2 H), 2.03 (t, J = 2.8 Hz, 1 H); HRMS calcd for $C_{14}H_{14}N_4S$ 270.0939, found 270.0942.

5-Amino-6-phenyl-3-*p*-tolyl-1,2,4-triazine (11a). A stirred solution of **10a** (0.32 g, 1.02 mmol) in nitrobenzene (10 mL) was heated at reflux under nitrogen for 4 days. After this time, the reaction mixture was cooled to room temperature and filtered through a silica gel pad, which was then eluted first with methylene chloride (200 mL) and then with 1:1 hexanes/ethyl acetate. The second fraction was evaporated under reduced pressure, and the residual black solid was purified by column chromatography (1:1 hexanes/ethyl acetate as eluent) to yield 0.04 g (15%) of **11a** as tan needles: mp 208–210 °C; IR (KBr) 3480, 3250, 3180, 3110, 1600, 1520, 1445, 1390, 1000, 800, 720 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.39 (d, J = 8.2 Hz, 2 H), 7.81–7.78 (m, 2 H), 7.61–7.53 (m, 3 H), 7.33 (d, J = 8.2 Hz, 2 H), 5.37 (b s, 2 H), 2.46 (s, 3 H): HRMS calcd for $C_{16}H_{14}N_4$ 262.1218, found 262.1209.

5-Amino-3-(methylthio)-6-phenyl-1,2,4-triazine (11b). A stirred solution of **10b** (0.47 g, 1.74 mmol) in nitrobenzene (10 mL) was heated at reflux under nitrogen for 3 days. After this time, the reaction mixture was cooled to room temperature and then worked up as described above for **11a** to give 0.06 g (16%) of **11b** as a tan solid: mp 144–146 °C; IR (KBr) 3470, 3230, 3160, 1610, 1515, 1495, 1430, 1340, 1205, 750 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.71–7.68 (m, 2 H), 7.57–7.53 (m, 3 H), 5.40 (b s, 2 H), 2.67 (s, 3 H); HRMS calcd for $C_{10}H_{10}N_4S$ 218.0626, found 218.0630.

5-(1,1-Dicyano-4-pentynyl)-6-phenyl-3-*p*-tolyl-1,2,4-triazine (12).[19] To a stirred suspension of sodium hydride (0.17 g, 4.27 mmol, 60% oil dispersion) in anhydrous tetrahydrofuran (20 mL) at room temperature under nitrogen was added 1,1-dicyano-4-pentyne[18] (0.51 g, 4.34 mmol). After the initial effervescent reaction had subsided, a freshly prepared solution of **2a** (3.88 mmol) was added rapidly to the mixture, which was then stirred under nitrogen for 8 h. After this time, the reaction mixture was partially evaporated under reduced pressure, and the residual material was taken up in methylene chloride (100 mL) and washed first with water (2 × 50 mL) and then with brine (2 × 50 mL). The organic layer was dried (anhydrous $MgSO_4$) and evaporated under reduced pressure to afford a light orange oil, which upon trituration in 1:5 ether/petroleum ether gave 1.02 g (72%) of **12** as a fine yellow solid: mp 113–114.5 °C; IR (KBr) 3300, 3280, 3060, 2920, 1600, 1520, 1490, 1475, 1440, 1390, 1175, 1010, 810, 760, 725 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.54 (d, J = 8.2 Hz, 2 H), 7.76–7.65 (m, 5 H), 7.43 (d, J = 8.1 Hz, 2 H), 2.81 (t, J = 7.9 Hz, 2 H), 2.61 (dt, J_1 = 8.0 Hz, J_2 = 2.7 Hz, 2 H), 2.51 (s, 3 H), 1.99 (t, J = 2.7 Hz, 1 H).

1,1-Dicyano-6-*p*-tolylcyclopenteno[*d*]pyrimidine (13). A stirred suspension of **12** (0.36 g, 0.99 mmol) in bromobenzene (7.5 mL) was heated to reflux (156 °C) under nitrogen for 7.5 h. After this time the reaction mixture was cooled to room temperature and filtered through a silica gel pad, which was then washed first with hexanes (200 mL), methylene chloride (200 mL), and then with 2% methanol/methylene chloride (250 mL). The second fraction was evaporated under reduced pressure to afford **13** as white plates (0.9 g). The third fraction was evaporated under reduced pressure, and the residual material was purified by TLC (elution with 1:1 hexanes/ethyl acetate) to yield additional product (0.12 g) as white plates (total yield 0.21 g, 82%): mp 202–204 °C dec; IR (KBr) 1585, 1540, 1410, 1385, 1170, 830, 790 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.86 (s, 1 H), 8.43 (d, J = 8.0 Hz, 2 H), 7.34 (d, J = 8.0 Hz, 2 H), 3.29 (t, J = 6.8 Hz, 2 H), 3.01 (t, J = 6.9 Hz, 2 H), 2.46 (s, 3 H); HRMS calcd for $C_{16}H_{12}N_4$ 260.1062, found 260.1056.

Registry No. **1a**, 36993-96-1; **1b**, 109306-98-1; **1c**, 1566-37-6; **1d**, 1566-32-1; **1e**, 31143-85-8; **2a**, 109306-99-2; **2b**, 109307-00-8; **2c**, 109307-01-9; **2d**, 109307-02-0; **3a**, 109307-03-1; **3b**, 109307-04-2; **3c**, 109307-05-3; **3d**, 109307-06-4; **4a**, 109307-07-5; **4b**, 109307-08-6; **5**, 109333-71-3; **6**, 109307-09-7; **7a**, 109307-10-0; **7b**, 109307-11-1; **7c**, 38119-45-8; **7d**, 7448-19-3; **7e**, 65763-91-9; **8a**, 109307-12-2; **8b**, 109307-13-3; **8c**, 109307-14-4; **8d**, 109307-15-5; **8e**, 109307-16-6; **9a**, 109307-17-7; **9b**, 109307-18-8; **10a**, 109307-19-9; **10b**, 109307-20-2; **11a**, 109307-21-3; **11b**, 109307-22-4; **12**, 109333-89-3; **13**, 109307-23-5; TIPB, 717-74-8; $NH_2N{=}C(SMe)NH_2{\cdot}HI$, 35600-34-1; p-$MeC_6H_4C(=NH)NHNH_2$, 62230-47-1; $PhCOCO_2H$, 611-73-4; HO_2CCOMe, 127-17-3; $CH{\equiv}C(CH_2)_2OH$, 927-74-2; $CH{\equiv}CCH_2CH(OH)Et$, 19780-84-8; $CH{\equiv}C(CH_2)_2I$, 43001-25-8; $CH{\equiv}C(CH_2)_2NH_2$, 14044-63-4; $CH{\equiv}C(CH_2)_2CH(CN)_2$, 106814-29-3.