

The Synthesis of [1]Benzothieno[2,3-*c*]quinolines,
[1]Benzothieno[2,3-*c*][1,2,4]triazolo[4,3-*a*]quinoline, and
[1]Benzothieno[2,3-*c*]tetrazolo[1,5-*a*]quinoline

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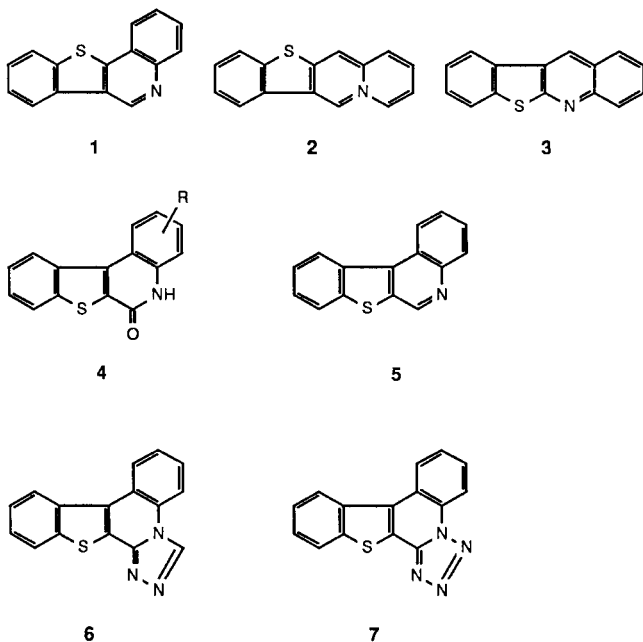
Photocyclization of 3-chloro-*N*-phenylbenzo[*b*]thiophene-2-carboxamide **10** afforded [1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one **11** which was chlorinated to 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** followed by dechlorination to give [1]benzothieno[2,3-*c*]quinoline **5**. A series of 6-substituted alkoxy and thioalkoxy[1]benzothieno[2,3-*c*]quinoline derivatives were prepared along with the *N*-methyl quaternary salt **13** of **5**. 6-Chloro[1]benzothieno[2,3-*c*]quinoline **12** was converted into 6-hydrazino[1]benzothieno[2,3-*c*]quinoline **23** which upon treatment with formic acid yielded [1]benzothieno[2,3-*c*][1,2,4]triazolo[4,3-*a*]quinoline **6**. Treatment of **23** with nitrous acid resulted in [1]benzothieno[2,3-*c*]tetrazolo[1,5-*a*]quinoline **7**. Compounds **6** and **7** are novel heterocyclic ring systems.

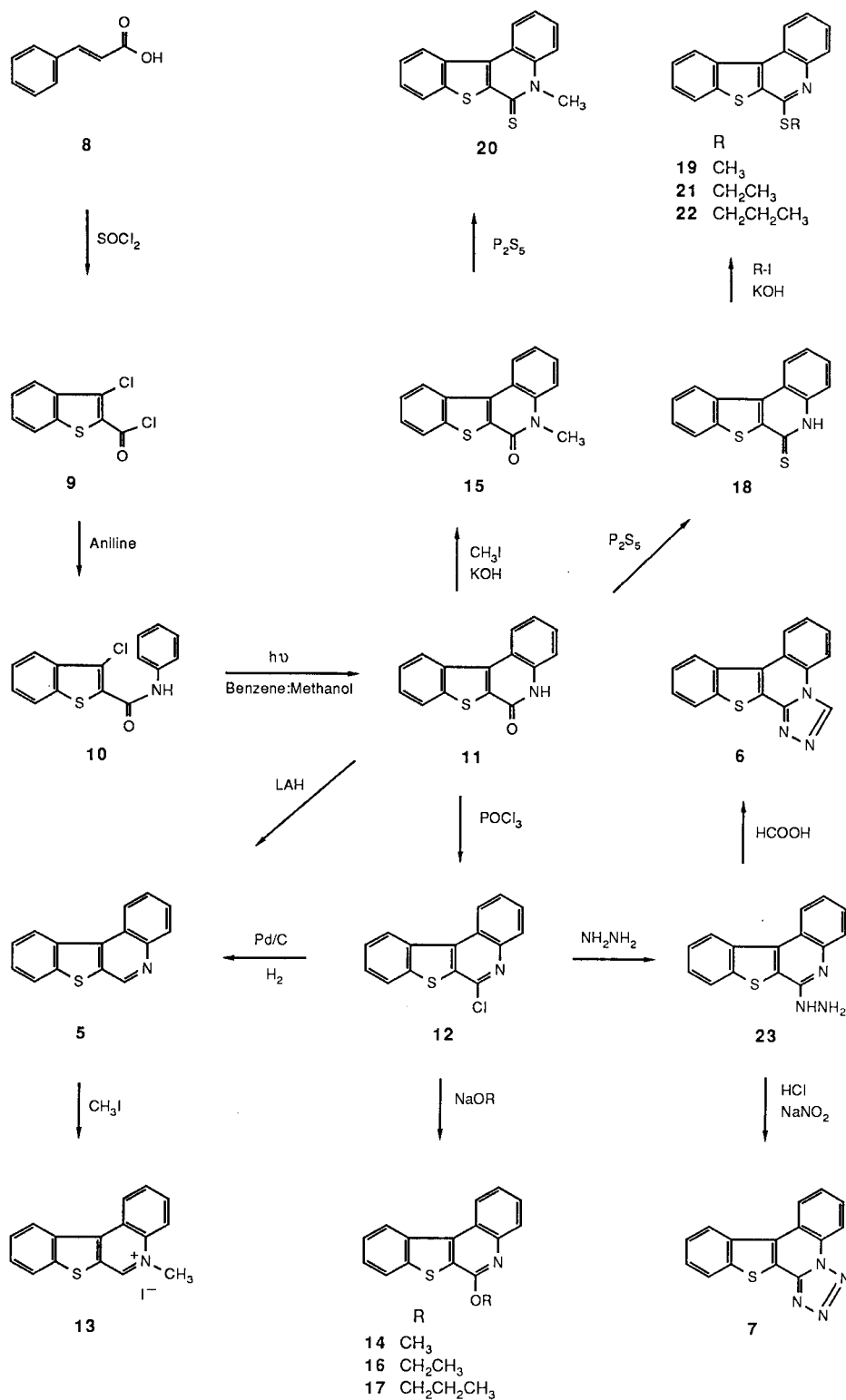
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A review of the literature has revealed three basic routes to the synthesis of fused benzo[*b*]thienoquinolines resulting in [3,2-*c*], [3,2-*b*], [2,3-*b*], or [2,3-*c*] ring fusion. Neidlein and Heid [1] reacted 2-bromo-3-formylbenzo[*b*]thiophene and aniline in glacial acetic acid to achieve a 40% yield of [1]benzothieno[3,2-*c*]quinoline **1**. Similarly, Bushkov and Lantsova [2] reported a 90% yield of [1]benzothieno[3,2-*b*]quinoline **2** following heating a two molar excess of aniline and the arylimine (from 3-chloro-2-formylbenzo[*b*]thiophene and aniline) at 140-170° for two hours in the absence of solvent. Starting with either 2-phenylquinoline or 3-phenylquinoline, Klemm and co-workers [3] have described the synthesis of [1]benzothieno[3,2-*b*]quinoline **2** (18%) or [1]benzothieno[3,2-*c*]quinoline **1** (5%) and [1]benzothieno[2,3-*b*]quinoline **3** (12%) by insertion of sulfur by

means of hydrogen sulfide and an alumina catalyst at 630°. In an effort to obtain a variety of 4-phenylquinolin-2(1*H*)-ones, Kano *et al.* [4] developed a synthetic scheme in which 3-chlorobenzo[*b*]thiophene-2-carboxanilides were photocyclized to [1]benzothieno[2,3-*c*]quinolin-6(5*H*)-ones **4** followed by removal of sulfur *via* treatment with Raney Ni. Photocyclization to produce the [1]benzothieno[2,3-*c*]quinoline ring system has previously been reported [5-7]. Therefore, in this paper we would like to report the synthesis of [1]benzothieno[2,3-*c*]quinoline **5**, its methyl iodide salt, and a series of alkoxy and thioalkoxy derivatives. Also, the synthesis of two novel ring systems, namely [1]benzothieno[2,3-*c*][1,2,4]triazolo[4,3-*a*]quinoline **6** and [1]benzothieno[2,3-*c*]tetrazolo[1,5-*a*]quinoline **7** are described.

Preparation of 3-chlorobenzo[*b*]thiophene-2-carboxoyl chloride **9** (62%) was carried out in a similar manner to that described by Wright and Brabander [8], starting with cinnamic acid **8**. Reaction of 3-chlorobenzo[*b*]thiophene-2-carboxoyl chloride **9** with aniline in benzene afforded a 92% yield of 3-chloro-*N*-phenylbenzo[*b*]thiophene-2-carboxamide **10**. Oxidative dehydrochlorinative photocyclization of **10** was accomplished under three different solvent conditions in the presence of an equal molar amount of triethylaniline. Utilizing benzene or acetone as the photocyclization solvent resulted in a 57% and 77% yield of [1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one **11**, respectively. However, a combination of benzene:methanol (4:1) under the same conditions afforded 92% of **11**. The lactam was chlorinated in refluxing phosphorus oxychloride to give 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** (49%). [1]Benzothieno[2,3-*c*]quinoline **5** was obtained in 82% yield by dechlorination with hydrogen and a 10% Pd-C catalyst in a solution of potassium hydroxide, methanol, and benzene (experimental method A). Synthesis of **5** (experimental method B) was also achieved in a 44% yield by





lithium aluminum hydride reduction of the lactam **11** to give a mixture of the lactam **5** and its dihydro counterpart (based on tlc and ¹H-nmr of the reduction product). This mixture was air oxidized in benzene with a 10% Pd-C catalyst

to afford **5**. Treatment of **5** with methyl iodide in refluxing benzene resulted in 5-methyl[1]benzothieno[2,3-c]quinolinium iodide **13** (57%).

Reaction of sodium methoxide (generated *in situ* from

sodium metal and methanol) with 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** furnished 6-methoxy[1]benzothieno[2,3-*c*]quinoline **14** in 82% yield. Attempted *O*-methylation of the lactam **11** with dimethyl sulfate in dimethyl sulfoxide and potassium hydroxide resulted in recovery of starting material. An alternative approach to the preparation of **14** involved the direct *O*-methylation of **11** with methyl iodide in potassium hydroxide and methanol, however, *N*-methylation resulted in a 38% yield of 5-methyl[1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one **15**. In a similar fashion to that utilized in the preparation of **14**, the 6-ethoxy and 6-(1-propoxy) derivatives, namely 6-ethoxy[1]benzothieno[2,3-*c*]quinoline **16** and 6-(1-propoxy)[1]benzothieno[2,3-*c*]quinoline **17**, were synthesized in 58% and 55% yields, respectively.

The lactam **11** could readily be converted to [1]benzothieno[2,3-*c*]quinoline-6(5*H*)-thione **18** (94%) by action of phosphorus pentasulfide in refluxing pyridine. *S*-Methylation was accomplished with methyl iodide in a refluxing suspension of **18**, potassium hydroxide, and methanol to give a 57% yield of 6-methylthio[1]benzothieno[2,3-*c*]quinoline **19**. Under the above reaction conditions, *S*-methylation rather than *N*-methylation was confirmed by conversion of 5-methyl[1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one **15** to 5-methyl[1]benzothieno[2,3-*c*]quinoline-6(5*H*)-thione **20** (75%) with phosphorus pentasulfide and compared to **19**. In addition, 6-ethylthio[1]benzothieno[2,3-*c*]quinoline **21** (54%) and 6-(1-propylthio)[1]benzothieno[2,3-*c*]quinoline **22** (45%) were prepared from the appropriate iodoalkanes in a manner similar to that described for **19**.

Treatment of 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** with anhydrous hydrazine in ethanol afforded 6-hydrazino[1]benzothieno[2,3-*c*]quinoline **23** (71%). The hydrazino derivative **23** in refluxing formic acid produced [1]benzothieno[2,3-*c*][1,2,4]triazolo[4,3-*a*]quinoline **6** (38%) whereas the addition of 1.5 *M* hydrochloric acid to a mixture of **23** and sodium nitrite resulted in a 76% yield of [1]benzothieno[2,3-*c*]tetrazolo[1,5-*a*]quinoline **7**.

EXPERIMENTAL

Melting points were determined on a Thomas Hoover melting point apparatus (<280°) or a Melt Temp apparatus (>280°) and are uncorrected. The ir spectra were recorded on a Beckman FT 1100 spectrometer as potassium bromide pellets and frequencies are expressed in cm⁻¹. Routine ¹H-nmr and ¹³C-nmr spectra were obtained on a JEOL FX90Q spectrometer in the solvent indicated with TMS as the internal standard and chemical shifts reported in ppm (δ) and J values in Hz. The mass spectra were determined on a Hewlett-Packard model 5980A mass spectrometer. Elemental analyses were performed by MHW Laboratories, Phoenix, Arizona.

3-Chlorobenzo[*b*]thiophene-2-carboxoyl Chloride (**9**).

To a stirred suspension of cinnamic acid **8** (59.3 g, 0.4 mole) in chlorobenzene (400 ml) at room temperature was added thionyl chloride (146.0 ml, 2.0 moles). This suspension was allowed to stir for 30 minutes, then

pyridine (3.2 ml, 0.04 mole) was added dropwise. After the addition was complete, the solution was heated at reflux for 72 hours. Excess solvent was removed under reduced pressure, and the residual material was suspended in 1.0 liter of hot hexane. While hot, solids were removed by filtration and the filtrate treated with charcoal. After standing at room temperature for 24 hours, the precipitate was collected by filtration to give 57.3 g (62%) of **9** as thick light yellow needles, mp 112-114° (lit [9] mp 114.5-115.1°); ir: 1766, 1597, 1484, 1152, 758; ¹H-nmr (deuteriochloroform): 7.41-8.03 (m, 4H); ¹³C-nmr (deuteriochloroform): 122.76; 124.71; 126.23; 129.64; 129.75, 130.61; 137.17; 140.42; 158.14.

3-Chloro-*N*-phenylbenzo[*b*]thiophene-2-carboxamide (**10**).

A solution of aniline (18.6 g, 0.2 mole) in benzene (50 ml) was added dropwise to a stirred solution of 3-chlorobenzo[*b*]thiophene-2-carboxoyl chloride **9** (23.1 g, 0.1 mole) in benzene (350 ml) at room temperature. After the addition was complete, the mixture was allowed to stir for 30 minutes, then it was diluted with water (200 ml) and stirring continued for 10 minutes. The precipitate was collected by filtration and recrystallized from ethanol to give 26.6 g (92%) of **10** as a white solid, mp 169-171° (lit [10] mp 169°); ir: 3332, 1643, 1597, 1542, 753, 739, 690; ¹H-nmr (deuteriochloroform): 7.14-7.93 (m, 9H), 8.84 (bs, 1H); ¹³C-nmr (deuteriochloroform): 120.43, 122.87, 123.19, 125.03, 125.52, 127.58, 129.15, 137.28, 138.20, 158.62.

[1]Benzothieno[2,3-*c*]quinolin-6(5*H*)-one (**11**).

A stirred solution of 3-chloro-*N*-phenylbenzo[*b*]thiophene-2-carboxamide **10** (3.0 g, 11 mmoles) and triethylamine (1.5 ml, 11 mmoles) in 500 ml of benzene:methanol (4:1) was irradiated under a slow stream of air for 4 hours with a 450 watt Hanovia medium pressure mercury vapor lamp. The precipitate was collected by filtration, washed with water (10 ml), then with ether (10 ml), and dried at room temperature to afford 2.5 g (92%) of **11** as a white solid, mp >280° (lit [6] mp >310°); Beilstein test negative; ir: 3296, 1658, 1594, 1514, 741, 714, 646; ¹H-nmr (DMSO-*d*₆): 8.0°, 7.35-7.72 (m, 5H), 8.17-8.27 (m, 1H), 8.69-8.93 (m, 2H); ¹³C-nmr (DMSO-*d*₆): 100°, 127.64, 128.45, 133.43, 134.30, 134.84, 136.47, 138.15, 139.50, 148.71. This compound was utilized in the next reaction without further purification.

6-Chloro[1]benzothieno[2,3-*c*]quinoline (**12**).

A mixture of [1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one **11** (1.5 g, 6 mmoles) and triethylamine (0.8 ml, 6 mmoles) in phosphorus oxychloride (40 ml) was heated at reflux for 4 hours. Excess phosphorus oxychloride was removed under reduced pressure, and the residual material cooled to ice bath temperature before treatment with ice water (50 ml) portionwise. After standing 1 hour, the precipitate was collected by filtration then dissolved in hot benzene (ca 25 ml) and treated with charcoal. The precipitate was collected by filtration to give 1.3 g of **12** as a white solid, mp 162-163°. Recrystallization from hexane (2 ×) afforded 0.8 g (49%) of **12** as a white solid, mp 163-164°; Beilstein test positive; ir: 3070, 1563, 1496, 1003, 752, 711; ¹H-nmr (deuteriochloroform): 7.53-7.75 (m, 4H), 7.91-8.02 (m, 1H), 8.11-8.22 (m, 1H), 8.63-8.79 (m, 2H); ¹³C-nmr (deuteriochloroform): 122.71, 123.46, 124.44, 125.52, 125.68, 127.47, 127.85, 128.39, 129.80, 135.33; ms: *m/z* 269.5 (100), 271.5 (38.4), 233.5 (22.7), 234.5 (22.3).

Anal. Calcd. C₁₅H₈ClNS: C, 66.79; H, 2.99; N, 5.19; S, 11.89. Found: C, 66.65; H, 3.05; N, 4.90; S, 11.73.

[1]Benzothieno[2,3-*c*]quinoline (**5**).

Method A. A 10% Pd-C catalyst (0.1 g) was added portionwise to a stirred solution of 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** (1.5 g, 6 mmoles), potassium hydroxide (0.3 g, 6 mmoles), methanol (80 ml), and benzene (80 ml). This mixture was stirred at room temperature under a hydrogen atmosphere for 24 hours. The catalyst was removed by filtration through a pad of Celite, and excess solvent removed under reduced pressure to give an off-white solid. This solid was dissolved in hot hexane, treated with charcoal, allowed to cool to room temperature and the precipitate collected by filtration. Recrystallization from hexane (2 ×) yielded 1.1 g (82%) of **5** as white irregular plates, mp 118-119°; Beilstein test negative; ir: 3028, 1568, 1538, 1502, 761, 726; ms: *m/z* 235.4 (100),

234.4 (19.4), 236.4 (17.8). Total assignment of the ^1H -nmr and ^{13}C -nmr spectra have been reported [11].

Anal. Calcd. for $\text{C}_{15}\text{H}_9\text{NS}$: C, 76.56; H, 3.86; N, 5.95; S, 13.63. Found: C, 76.46; H, 4.01; N, 5.78; S, 13.47.

Method B. [1]Benzothieno[2,3-*c*]quinolin-6(5*H*)-one **11** (1.0 g, 4.0 mmoles) was added in one portion to a stirred suspension of lithium aluminum hydride (1.0 g, 26.4 mmoles) in dry tetrahydrofuran (300 ml) under a nitrogen atmosphere, and the mixture heated at reflux for 12 hours. The mixture was cooled to ice bath temperature, and excess lithium aluminum hydride was deactivated by the stepwise addition of water (1 ml), 10% sodium hydroxide (1 ml), and water (1 ml). Solids were removed by filtration then stirred with ether (50 ml) for 15 minutes and filtered. The combined filtrates were dried (magnesium sulfate); then excess solvent removed under reduced pressure to give a light yellow solid, mp 106–112°. This solid was dissolved in benzene (50 ml), treated with a 10% Pd-C catalyst (0.1 g) and allowed to stir at room temperature for 36 hours. The catalyst was removed by filtration through a pad of Celite, and the filtrate concentrated to dryness under reduced pressure to give 0.7 g of a light yellow solid, mp 104–110°. This solid was dissolved in hot hexane, treated with charcoal, and allowed to cool to room temperature whereupon 0.4 g (44%) of **5** was collected by filtration as white irregular flakes, mp 118–120°. Spectral data were consistent with that observed in method A.

5-Methyl[1]benzothieno[2,3-*c*]quinolinium Iodide (**13**).

Methyl iodide (2.0 ml, 32 mmoles) was added dropwise to a stirred solution of [1]benzothieno[2,3-*c*]quinoline **5** (1.0 g, 4 mmoles) in benzene (50 ml) at room temperature. After the addition was complete, the solution was heated at reflux for 8 hours, and allowed to cool to room temperature whereupon the precipitate was collected by filtration, washed with benzene (10 ml) resulting in 1.4 g of a yellow solid. This solid was recrystallized from methanol (2 ×) to give 0.9 g (57%) of **13** as long fine yellow needles, mp 314–316° dec; ir: 3466, 3111, 3047, 1607, 1525, 1371, 1232, 1137, 1039, 768, 727; ^1H -nmr (DMSO- d_6): 4.73 (s, 3H), 7.87–8.01 (m, 2H), 8.18–8.37 (m, 2H), 8.51–8.73 (m, 2H), 9.29–9.54 (m, 2H), 10.40 (s, 1H).

Anal. Calcd. $\text{C}_{16}\text{H}_{12}\text{INS}$: C, 50.94; H, 3.21; N, 3.71; S, 8.50. Found: C, 50.81; H, 3.27; N, 3.69; S, 8.40.

6-Methoxy[1]benzothieno[2,3-*c*]quinoline (**14**).

A solution of 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** (3.0 g, 11 mmoles) in benzene (100 ml) was added dropwise to a stirred solution of sodium metal (1.0 g, 44 mg-atoms) in methanol (25 ml) at ice bath temperature. After the addition was complete, the mixture was heated at reflux for 12 hours, allowed to cool at room temperature where solids were removed by filtration. The filtrate was concentrated to dryness under reduced pressure to give a light yellow oil which readily solidified upon standing. This solid was recrystallized from hexane (3 ×, treated with charcoal on the first two recrystallizations) to afford 2.4 g (82%) of **14** as white clusters, mp 123–124°; ^1H -nmr (deuteriochloroform): 4.23 (s, 3H), 7.45–7.63 (m, 4H), 7.89–8.06 (m, 2H), 8.62–8.73 (m, 2H).

Anal. Calcd. for $\text{C}_{16}\text{H}_{11}\text{NOS}$: C, 72.43; H, 4.18; N, 5.28; S, 12.09. Found: C, 72.40; H, 4.18; N, 5.33; S, 11.98.

5-Methyl[1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one (**15**).

Methyl iodide (2.4 ml, 39 mmoles) was added dropwise to a stirred suspension of [1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one **11** (0.5 g, 2 mmoles) in potassium hydroxide (0.1 g, 2 mmoles) and methanol (100 ml) at room temperature. After the addition was complete, the mixture was heated at reflux for 24 hours. Excess solvent was removed under reduced pressure to give a beige solid. The solid was suspended in water (25 ml), then the solids were collected by filtration and dried at room temperature. This solid was suspended in hot hexane (100 ml), and after boiling for 15 minutes, was filtered. The precipitate was collected by filtration to give 0.2 g (38%) of **15** as long white needles, mp 204–205°; ir: 3060, 1635, 1581, 1417, 1386, 1304, 1093, 758, 748, 725; ^1H -nmr (deuteriochloroform): 3.88 (s, 3H), 7.31–7.65 (m, 5H), 7.96–8.07 (m, 1H), 8.59–8.72 (m, 2H); ms: m/z 266 (30), 265 (100), 236 (44).

Anal. Calcd. for $\text{C}_{16}\text{H}_{11}\text{NOS}$: C, 72.43; H, 4.18; N, 5.28; S, 12.09. Found: C, 72.17; H, 4.23; N, 5.30; S, 11.93.

6-Ethoxy[1]benzothieno[2,3-*c*]quinoline (**16**).

A solution of 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** (0.50 g, 1.9 mmoles) in benzene (50 ml) was added dropwise to a stirred solution of sodium metal (0.17 g, 7.4 mg-atoms) in absolute ethanol (15 ml) at room temperature. After the addition was complete, the clear solution was heated at reflux for 12 hours, allowed to cool to room temperature, and the solids removed by filtration. Excess solvent was removed under reduced pressure to give a light yellow solid, mp 122–124°. This solid was dissolved in hot hexane (ca 50 ml), treated with charcoal, and allowed to cool and to stand at room temperature overnight. The precipitate was collected by filtration and dried under high vacuum (0.15 mm at ca 50°) for 2 hours to afford 0.30 g (58%) of **16** as long thin white needles, mp 140–141°. The filtrate was concentrated to dryness under reduced pressure to give another 0.15 g of **16** as a white solid, mp 137–139°; ^1H -nmr (deuteriochloroform): 1.55 (dd, 3H, $J = 4.7$, $J' = 1.3$), 4.76 (q, 2H, $J = 4.7$), 7.54–7.74 (m, 4H), 7.99–8.10 (m, 2H), 8.75–8.85 (m, 2H); ms: m/z 280 (17), 279 (75), 264 (89), 251 (100), 235 (35), 222 (31).

Anal. Calcd. for $\text{C}_{17}\text{H}_{13}\text{NOS}$: C, 73.09; H, 4.69; N, 5.01; S, 11.48. Found: C, 73.07; H, 4.80; N, 4.93; S, 11.61.

6-(1-Propoxy)[1]benzothieno[2,3-*c*]quinoline (**17**).

A solution of 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** (0.50 g, 1.9 mmoles) in benzene (50 ml) was added dropwise to a stirred solution of sodium metal (0.17 g, 7.4 mg-atoms) in 1-propanol (15 ml) at room temperature. After the addition was complete, the clear solution was heated at reflux for 12 hours, the solids removed by filtration, the filtrate extracted with water (25 ml), and then dried (magnesium sulfate). Excess solvent was removed under reduced pressure to give an off-white solid, mp 78–80°. This solid was dissolved in hot hexane (ca 30 ml), treated with charcoal, then allowed to cool and to stand at room temperature for 24 hours followed by 24 hours at -15° . The precipitate was collected by filtration and dried under vacuum (0.15 mm at ca 50°) for 2 hours to afford 0.30 g (55%) of **17** as white irregular plates, mp 80–81°. The filtrate was concentrated to dryness under reduced pressure to give another 0.15 g of **17** as an off-white solid, mp 82–84°; ^1H -nmr (deuteriochloroform): 1.13 (t, 3H, $J = 4.7$), 1.94 (q, 2H, $J = 4.7$), 4.65 (t, 2H, $J = 4.7$), 7.47–7.73 (m, 4H), 7.97–8.09 (m, 2H), 8.72–8.85 (m, 2H); ms: m/z 293 (26), 265 (19), 251 (100), 222 (31).

Anal. Calcd. for $\text{C}_{18}\text{H}_{15}\text{NOS}$: C, 73.69; H, 5.15; N, 4.77; S, 10.93. Found: C, 73.71; H, 5.32; N, 4.78; S, 11.16.

[1]Benzothieno[2,3-*c*]quinoline-6(5*H*)-thione (**18**).

A stirred suspension of [1]benzothieno[2,3-*c*]quinolin-6(5*H*)-one **11** (2.0 g, 8 mmoles) and phosphorus pentasulfide (3.6 g, 8 mmoles) in pyridine (100 ml) was heated at reflux for 18 hours, then poured into boiling water (500 ml), and after stirring for 15 minutes, the precipitate was collected by filtration. This solid was suspended in hot methanol (300 ml) for 15 minutes, cooled, the precipitate collected by filtration, washed with hexane (20 ml), then dried at room temperature to give 2.0 g (94%) of **18** as a yellow solid, mp $>280^\circ$; ir: 1561, 1399, 1214, 748, 721; ^1H -nmr (DMSO- d_6): 7.48–7.96 (m, 5H), 8.20–8.30 (m, 1H), 8.85–9.03 (m, 2H); ms: m/z 268 (20), 267 (100), 234 (21). This compound was used in the next experiment without further purification.

6-Methylthio[1]benzothieno[2,3-*c*]quinoline (**19**).

Methyl iodide (1.2 ml, 18.7 mmoles) was added dropwise to a stirred suspension of [1]benzothieno[2,3-*c*]quinoline-6(5*H*)-thione **18** (0.5 g, 18.7 mmoles) in potassium hydroxide (0.1 g, 18.7 mmoles) and methanol (100 ml) at room temperature. After the addition was complete, the mixture was allowed to stir for 30 minutes then heated at reflux for 3 hours. Excess solvent was removed under reduced pressure and the residual material suspended in water (25 ml), then the solid collected by filtration yielding a beige material, mp 135–138°. This solid was suspended in hot hexane (200 ml), treated with charcoal, cooled to room temperature, then allowed to stand at -15° for 1 hour. The precipitate was collected by

filtration then dissolved in hot hexane (ca 75 ml), treated with charcoal, cooled and the precipitate collected by filtration. This solid was treated as above to give 0.3 g (57%) of **19** as long white needles, mp 142-143°. The combined recrystallization filtrates were concentrated (ca 75%) under reduced pressure to afford another 0.2 g of **19** as white needles, mp 139-141°; ¹H-nmr (deuteriochloroform): 2.90 (s, 3H), 7.56-7.79 (m, 4H), 8.00-8.25 (m, 2H), 8.78-8.89 (m, 2H); ms: m/z 282 (24), 281 (100), 280 (50), 236 (24), 235 (43).

Anal. Calcd. for C₁₆H₁₁NS₂: C, 68.29; H, 3.94; N, 4.98; S, 22.79. Found: C, 68.31; H, 3.92; N, 5.04; S, 22.61.

5-Methyl[1]benzothieno[2,3-*c*]quinoline-6(5*H*)-thione (**20**).

A stirred suspension of 5-methyl[1]benzothieno[2,3-*c*]quinoline-6(5*H*)-one (**15**) (0.10 g, 0.38 mmole) and phosphorus pentasulfide (0.17 g, 0.38 mmole) in pyridine (25 ml) was heated at reflux for 18 hours then poured into boiling water (100 ml). After stirring for 15 minutes the precipitate was collected by filtration. This solid was suspended in hot methanol (ca 30 ml), treated with charcoal, then allowed to cool and to stand at room temperature (12 hours). The precipitate was collected by filtration to give 0.08 g (75%) of **20** as thick yellow needles, mp 215-216°; ir: 2923, 1514, 1463, 1414, 1335, 1216, 1144, 1098, 776, 751, 734; ¹H-nmr (deuteriochloroform): 3.90 (s, 3H), 7.43-7.78 (m, 5H), 7.95-8.09 (m, 1H), 8.65-8.76 (m, 2H); ms: m/z 282 (21), 281 (100), 280 (23), 235 (30).

Anal. Calcd. for C₁₆H₁₁NS₂: C, 68.29; H, 3.94; N, 4.98; S, 22.79. Found: C, 68.47; H, 4.09; N, 4.94; S, 22.57.

6-Ethylthio[1]benzothieno[2,3-*c*]quinoline (**21**).

Iodoethane (0.58 g, 3.7 mmole) was added dropwise to a stirred suspension of [1]benzothieno[2,3-*c*]quinoline-6(5*H*)-thione **18** (0.50 g, 1.9 mmole) in potassium hydroxide (0.11 g, 1.9 mmole) and methanol (100 ml) at room temperature. After stirring for 30 minutes, the mixture was heated at reflux for 3 hours. Excess solvent was removed under reduced pressure to give a beige solid, mp 127-130°. This solid was dissolved in hot hexane (ca 50 ml), treated with charcoal, cooled and the precipitate collected by filtration, and this same purification process repeated again to afford 0.30 g (54%) of **21** as long white needles, mp 131-132°; ¹H-nmr (deuteriochloroform): 1.53 (t, 3H, J = 5.0), 3.56 (q, 2H, J = 5.0), 7.53-7.76 (m, 4H), 7.96-8.22 (m, 2H), 8.70-8.81 (m, 2H); ms: m/z 295 (79), 279 (47), 267 (49), 262 (100), 235 (38), 234 (33), 190 (24).

Anal. Calcd. for C₁₇H₁₃NS₂: C, 69.11; H, 4.43; N, 4.74; S, 21.71. Found: C, 69.26; H, 4.27; N, 4.79; S, 21.66.

6-(1-Propylthio)[1]benzothieno[2,3-*c*]quinoline (**22**).

1-Iodopropane (0.70 g, 4.1 mmole) was added dropwise to a stirred suspension of [1]benzothieno[2,3-*c*]quinoline-6(5*H*)-thione **18** (0.50 g, 1.9 mmole) in potassium hydroxide (0.11 g, 1.9 mmole) and methanol (100 ml) at room temperature. After the addition was complete, the mixture was heated at reflux for 3 hours. Excess solvent was removed under reduced pressure to give a pink solid. This solid was suspended in hot hexane (ca 75 ml), treated with charcoal, allowed to stand at -15° for 12 hours, then the precipitate was collected by filtration, and the same purification process repeated again (ca 20 ml) to afford 0.26 g (45%) of **22** as white needles, mp 72-73°; ¹H-nmr (deuteriochloroform): 1.13 (t, 3H, J = 4.8), 1.91 (sextet, 2H, J = 4.8), 3.55 (t, 2H, J = 4.8), 7.54-7.77 (m, 4H), 7.98-8.23 (m, 2H), 8.75-8.86 (m, 2H); ms: m/z 309 (26), 281 (40), 280 (237), 276 (34), 267 (100), 234 (29), 233 (25).

Anal. Calcd. for C₁₈H₁₅NS₂: C, 69.86; H, 4.89; N, 4.53; S, 20.72. Found: C, 69.87; H, 5.00; N, 4.55; S, 20.86.

6-Hydrazino[1]benzothieno[2,3-*c*]quinoline (**23**).

A stirred suspension of 6-chloro[1]benzothieno[2,3-*c*]quinoline **12** (4.5 g, 17 mmole) in ethanol (100 ml) and anhydrous hydrazine (10 ml, 315 mmole) was heated at reflux for 12 hours. Excess solvent was removed under reduced pressure to give a pink solid. This solid was suspended in hot ethanol (ca 1000 ml), and filtered hot. The filtrate was treated with charcoal, then allowed to stand overnight at room temperature. The precipitate, was collected by filtration; then dissolved in hot ethanol (ca 800

ml). The solution was treated with charcoal, allowed to cool, and the precipitate was collected. This solid was treated as above to afford 3.2 g (71%) of **23** as short, light orange needles, mp 215-216°; ir: 3284, 1633, 1571, 1545, 1527, 1389, 1098, 991, 748, 718; ¹H-nmr (DMSO-d₆): 6.0°, 5.50 (very broad peak, 3H), 7.31-7.81 (m, 5H), 8.13-8.23 (m, 1H), 8.70-8.93 (m, 2H); ms: m/z 266 (19), 265 (100), 247 (18), 236 (22), 235 (56).

Anal. Calcd. for C₁₅H₁₁N₃S: C, 67.90; H, 4.18; N, 15.84; S, 12.09. Found: C, 67.89; H, 4.18; N, 15.78; S, 11.94.

[1]Benzothieno[2,3-*c*][1,2,4]triazolo[4,3-*a*]quinoline (**6**).

A stirred suspension of 6-hydrazino[1]benzothieno[2,3-*c*]quinoline **23** (1.0 g, 3.8 mmole) in formic acid (30 ml) was heated at reflux for 6 hours. Excess solvent was removed under reduced pressure. The resulting solid was suspended in hot benzene (800 ml), and after boiling for 15 minutes, the mixture was filtered hot. The filtrate was concentrated to dryness *in vacuo*, then the residual material dissolved in hot benzene, treated with charcoal, cooled, and the precipitate collected by filtration. This solid was recrystallized from benzene (2 ×) to give 0.4 g (38%) of **6** as small white clusters, mp 278-292° (started softening at 278° and decomposed by 292°); ir: 3086, 1656, 1597, 1558, 1460, 1401, 1221, 1086; ¹H-nmr (DMSO-d₆): 100°, 7.53-7.83 (m, 4H), 8.14-8.30 (m, 1H), 8.49-8.65 (m, 1H), 8.83-9.04 (m, 2H), 9.96 (s, 1H); ms: m/z 276 (20), 275 (100), 248 (14), 247 (31).

Anal. Calcd. for C₁₆H₈N₃S: C, 69.80; H, 3.30; N, 15.26; S, 11.65. Found: C, 69.99; H, 3.57; N, 15.05; S, 11.40.

[1]Benzothieno[2,3-*c*]tetrazolo[1,5-*a*]quinoline (**7**).

A solution of hydrochloric acid (1.5 M, 30 ml) was added dropwise to a stirred mixture of 6-hydrazino[1]benzothieno[2,3-*c*]quinoline **23** (1.0 g, 3.8 mmole) and sodium nitrite (1.3 g, 19.0 mmole) at room temperature. The mixture was stirred at room temperature for 24 hours, and the precipitate collected by filtration. The solid was suspended in hot methanol (ca 500 ml), boiled for 15 minutes, then the precipitate collected by filtration. The solid was treated similarly with benzene and ethyl acetate. The resulting pink solid was dried under high vacuum (0.15 mm at ca 50°) for 2 hours to give 0.8 g (76%) of **7**, mp 268-270° dec; ir: 3150, 3068, 1597, 1548, 1399, 1281, 1149, 777, 769, 741, 726; ¹H-nmr (DMSO-d₆): 100°, 7.68-7.84 (m, 2H), 7.90-8.01 (m, 2H), 8.27-8.38 (m, 1H), 8.70-8.81 (m, 1H), 8.92-9.18 (m, 2H); ms: m/z 276 (22), 249 (21), 248 (100), 247 (98), 222 (26).

Anal. Calcd. for C₁₅H₈N₄S: C, 65.20; H, 2.92; N, 20.28; S, 11.61. Found: C, 65.09; H, 3.18; N, 20.09; S, 11.43.

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