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Synthesis of Spirooxindoles Bearing 1,3-Oxathiolane-2-thione Moiety From Isatin-Derived Propargylic Alcohols

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Spirooxindoles bearing 1,3-oxathiolane-2-thione moiety were synthesized from isatin-derived propargylic alcohols and carbon disulfide in the presence of 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU). The spirooxindoles were formed stereoselectively via attack of the alkoxide of propargylic alcohol to carbon disulfide to form xanthate anion and a following 5-*exo-dig* cyclization process.

Keywords: Spirooxindoles, 1,3-Oxathiolane-2-thione, Isatin-derived propargylic alcohols, Carbon disulfide

Introduction

Spirooxindoles exist in many natural compounds and phamaceutically important substances.[1] Due to their biological importance, various efficient methodologies have been developed for their synthesis over the past years.[1,2] Very recently, we reported the synthesis of spirooxindoles bearing 2,3-(or 2,5-)dihydrothiophene-2-thione moiety via [3 + 2] annulation of carbon disulfide with Morita–Baylis–Hillman (MBH) carbonates of isatins.[3] Recently, we were also interested in synthetic applications of isatin-derived propargylic alcohol **1a** (*vide infra*), and the syntheses of isatin-conjugated 3*H*-indole-*N*-oxides,[4a] spiroindenyl-2-oxindoles,[4b] dihydrofuranyl spirooxindoles,[4c] spiroindanyl-2-oxindoles,[4d] 3-(benzo[*e*]indol-2-yl)-2-oxindoles,[4e] and 3-naphtho[2,1-*b*]furanyl-2-oxindoles[4f] have been reported. Other research groups also reported numerous interesting synthetic applications of isatin-derived propargylic alcohols.[4g–j]

The synthesis of 1,3-oxathiolane-2-thione by the reaction of carbon disulfide and propargylic alcohols has been reported in some papers.[5] The use of potassium fluoride on alumina,[5a] NaH,[5b] or Na[5c,d] has been known for this transformation. Very recently, Wu and co-workers used 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) in their reaction of propargylic alcohols with *in situ* generated carbonyl sulfide (COS).[5e] On the other hand, the synthesis of spirooxindole **2a** (*vide infra*) has not been reported, to the best of our knowledge. Only four types of similar spirooxindoles **I–IV** have been reported.[6–9] These spirooxindoles have five-membered heterocyclic moieties including oxazolidine-2-thione-5-yl (Type **I**),[6] imidazolidine-2-thione-4-yl (Type **II**),[7] oxazolidine-2-thione-4-yl (Type **III**),[8] and thiazolidine-2-thione-5-yl (Type **IV**)[9] moieties (Figure 1).

Results and Discussion

In these contexts, we presumed that spirooxindole **2a**, bearing 1,3-oxathiolane-2-thione moiety, could be synthesized from **1a** and carbon disulfide, as shown in Scheme 1.

At the outset of our experiment, the reaction of **1a** and CS_2 (20 equiv) was examined in CH_3CN in the presence of DBU (20 mol %) at room temperature (22 °C).[5e] To our pleased, the formation of **2a** was observed in short time (1 h); however, the yield of **2a** was moderate (67%) due to the formation of some intractable polar side products. In order to find an optimum reaction condition, we carried out the reaction under some typical reaction conditions as summarized in Table 1. The amount of side products decreased at 0 °C to give **2a** in good yield (80%) for 1 h (entry 2). When we carried out the reaction at −15 °C (entry 3), **2a** was obtained in good yield (84%) although somewhat longer reaction time (3 h) was required. The use of 40 mol % of DBU did not increase the yield of **2a** (entry 4), although reaction time (2 h) was shortened.[10] The use of lesser amount of CS_2 (10 equiv) required a long reaction time (5 h, entry 5). The reaction in 1,2-dichloroethane also required a long reaction time (5 h) for the completion (entry 6), and the yield of **2a** was moderate (75%). The use of KF/Al_2O_3 (200%, w/w) afforded **2a** in moderate yield (74%) at −15 °C (entry 7). In the reaction, we used CS_2 as a solvent as reported.[5a] The reaction at room temperature (22 °C) gave **2a** in the same yield (74%, entry 8). When we used CH_3CN as a co-solvent with 20 equiv. of CS_2 (entry 9), the yield was similar (72%). The use of KO^{t}Bu was less effective (entry 10), although the reaction was ended in short time (15 min). Based on the experimental observation, we decided to use the condition of entry 3.

Encouraged by the results, spirooxindoles **2b–2k** were synthesized from **1b–1k** by following the optimized

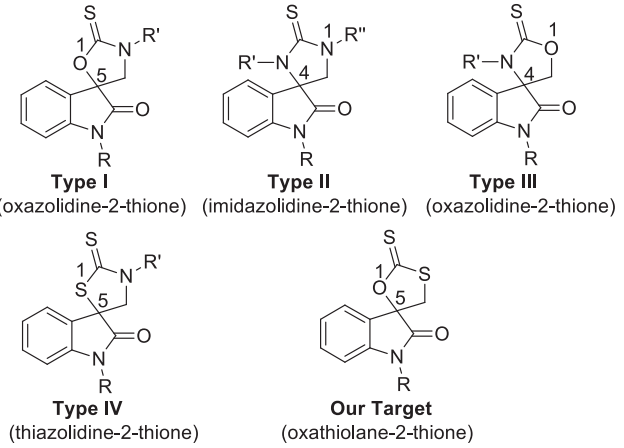
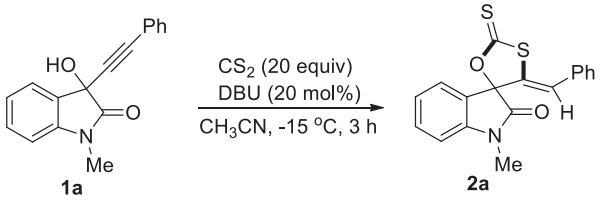


Figure 1. Five-membered heterocyclic spirooxindoles bearing 2-thione moiety.



Scheme 1. Synthesis of spirooxindole **2a** bearing 1,3-oxathiolane-2-thione.

reaction conditions, and the results are summarized in Table 2. The reactions of propargylic alcohols **1b**–**1g**, derived from 5-methyl-, 5-chloro-, 6-chloro-, 5-methoxy, 5,7-dimethyl, and 5-nitroisatins, afforded spirooxindoles **2b**–**2g** in good to moderate yields (65–78%). The reactions of propargylic alcohols **1h**–**1j**, derived from substituted aryl acetylenes, also afforded spirooxindoles **2h**–**2j** in good yields (74–82%). However, the reactivity of *n*-octyl derivative **1k** was very sluggish to produce **2k** in small amount (<10%) at −15 °C even after 5 h. The low reactivity of **1k** might be due to less electrophilic nature of the triple bond by the presence of an electron-donating *n*-octyl group. Fortunately, the reaction of **1k** at room temperature afforded **2k** in moderate yield (46%) for 4 h. However, the reaction of **1l**, the NH derivative of **1a**, failed under the typical reaction condition presumably due to selective deprotonation of NH moiety.

The plausible reaction mechanism is proposed in Scheme 2. Deprotonation of **1a** with DBU to produce an alkoxide **I**, reaction of **I** and CS_2 to give the xanthate anion **II**, and subsequent 5-*exo-dig* cyclization of **II** afforded **2a**. The *Z* stereochemistry of benzylidene moiety of **2a** might be controlled by a back-side attack of the xanthate anion to a carbon–carbon triple bond coordinating with the bulky protonated DBU ($DBUH^+$), as reported in the literature.[5e]

As a last entry, we examined the synthesis of nitrogen analog **4**, as shown in Scheme 3. The propargylic amine *N*-Boc derivative **3a** was prepared by the reaction of isatin-derived *N*-Boc ketimine and phenylethynylmagnesium bromide.[11] The reaction of **3a** under the typical reaction condition (−15 °C) did not produce spirooxindole **4a**, and no reaction was also observed even at elevated temperature (50 °C). The failure might be due to steric hindrance around the nitrogen atom and delocalization of the anion at nitrogen atom to oxygen atom of the Boc moiety. Thus, the propargylic amine derivative **3b** was prepared from **3a** in good yield (86%) by removal of the Boc group by BF_3 etherate as reported.[12,13] The reaction of **3b** also failed under the typical reaction condition involving the use of DBU. To our pleased, the reaction of **3b** and CS_2 provided spirooxindole **4b** bearing 1,3-thiazolidine-2-thione moiety in good yield (82%) in the absence of DBU in refluxing ethanol (15 h). The reported reaction between propargylic amines and CS_2 was also conducted in refluxing ethanol.[14,15]

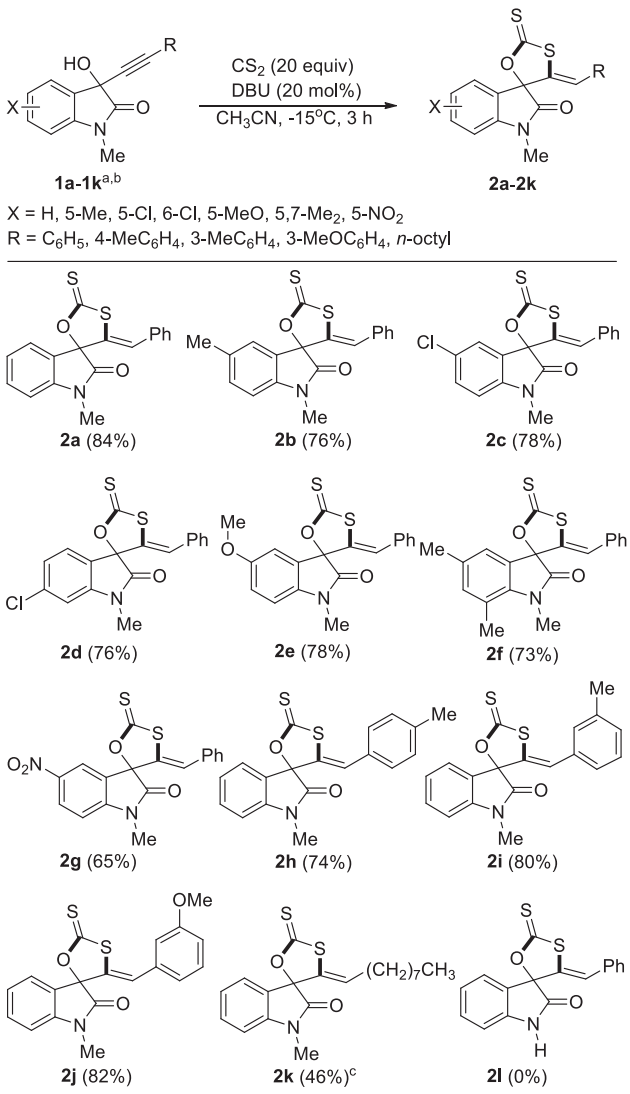
In summary, spirooxindoles bearing 1,3-oxathiolane-2-thione moiety were synthesized from isatin-derived propargylic alcohols and carbon disulfide in the presence of DBU. The spirooxindoles were formed stereoselectively via attack of the alkoxide of propargylic alcohol to carbon disulfide to form xanthate anion and a following 5-*exo-dig* cyclization process.

Table 1. Optimization of reaction conditions for the synthesis of **2a**.[a]

Entry	CS_2 (equiv)	Base	Solvent	Temp (°C)	Time (h)	Yield (%)
1	20	DBU (20 mol %)	CH_3CN	22	1	67
2	20	DBU (20 mol %)	CH_3CN	0	1	80
3	20	DBU (20 mol %)	CH_3CN	−15	3	84
4	20	DBU (40 mol %)	CH_3CN	−15	2	83
5	10	DBU (20 mol %)	CH_3CN	−15	5	78
6	20	DBU (20 mol %)	$ClCH_2CH_2Cl$	−15	5	75
7	50	KF/Al_2O_3 (200%, w/w)	-	−15	3	74
8	50	KF/Al_2O_3 (200%, w/w)	-	22	1	74
9	20	KF/Al_2O_3 (200%, w/w)	CH_3CN	−15	2	72
10	20	KO^tBu (20 mol %)	CH_3CN	22	0.25	67

[a] Conditions: Starting material **1a** (0.5 mmol), and the yields are isolated.

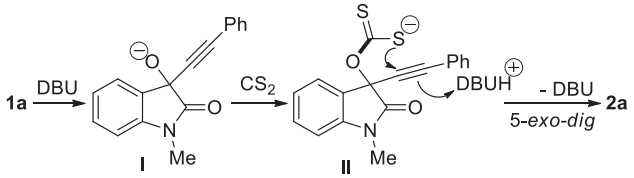
Table 2. Synthesis of spirooxindoles **2**.



[a]Substrate **1a**: X = H, R = C_6H_5; **1b**: X = 5-Me, R = C_6H_5; **1c**: X = 5-Cl, R = C_6H_5; **1d**: X = 6-Cl, R = C_6H_5; **1e**: X = 5-OMe, R = C_6H_5; **1f**: X = 5,7-Me_2, R = C_6H_5; **1g**: X = 5-NO_2, R = C_6H_5; **1h**: X = H, R = 4-MeC_6H_4; **1i**: X = H, R = 3-MeC_6H_4; **1j**: X = H, R = 3-$MeOC_6H_4$; **1k**: X = H, R = *n*-octyl; **1L**: NH derivative of **1a**.
[b]Propargyl alcohol **1** (0.5 mmol).
[c]Reaction time was 4 h at room temperature.

Experimental

Typical procedure for the synthesis of 2a**.** To a stirred solution of **1a**[4a–f] (132 mg, 0.5 mmol) and carbon disulfide (760 mg, 20 equiv) in CH_3CN (2 mL) was added dropwise DBU (15 mg, 20 mol %) for 5 min at −15 °C, and the reaction mixture was stirred for 3 h under N_2 balloon atmosphere. After the usual aqueous extractive workup and column chromatographic purification process (CH_2Cl_2/*n*-hexane, 1:1), spirooxindole **2a** (143 mg, 84%) was obtained as a pale yellow solid. Other compounds were synthesized similarly, and the spectroscopic data of **2a**–**2k** are as follows.

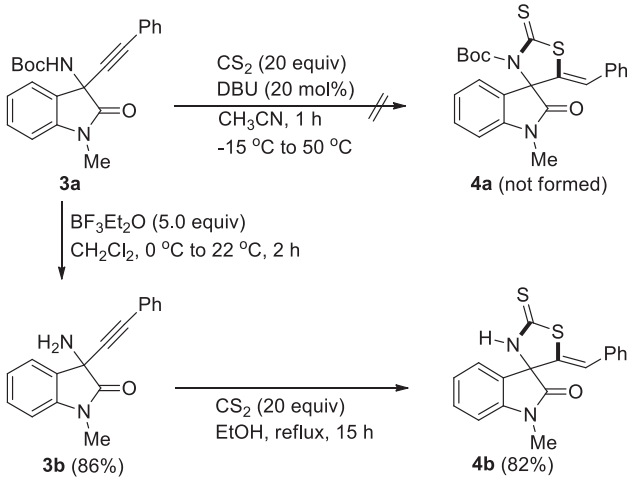


Scheme 2. Proposed reaction mechanism.

(*Z*)-4'-Benylidene-1-methyl-2′-thioxospiro(indoline-3,5'-[1,3]oxathiolan)-2-one (2a)**.** Pale yellow solid, mp 126–128 °C; IR (KBr) 1737, 1616, 1473, 1370, 1210 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 3.26 (s, 3H), 6.07 (s, 1H), 6.96 (d, J = 7.9 Hz, 1H), 7.17 (d, J = 7.9 Hz, 2H), 7.22 (t, J = 7.6 Hz, 1H), 7.29 (t, J = 7.4 Hz, 1H), 7.36 (t, J = 7.5 Hz, 2H), 7.48 (d, J = 7.6 Hz, 1H), 7.52 (t, J = 7.9 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.0, 97.0, 109.3, 123.0, 124.1, 124.3, 126.5, 128.6, 128.8, 129.0, 132.5, 132.7, 134.2, 144.9, 170.1, 205.8; ESIMS *m/z* 340 $[M + H]^+$. Anal. Calcd for $C_{18}H_{13}NO_2S_2$: C, 63.69; H, 3.86; N, 4.13. Found: C, 63.81; H, 4.03; N, 4.02.

(*Z*)-4'-Benylidene-1,5-dimethyl-2'-thioxospiro(indoline-3,5'-[1,3]oxathiolan)-2-one (2b)**.** Pale orange solid, mp 128–130 °C; IR (KBr) 1734, 1621, 1498, 1358, 1215 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 2.38 (s, 3H), 3.24 (s, 3H), 6.08 (s, 1H), 6.84 (d, J = 7.9 Hz, 1H), 7.19 (d, J = 8.0 Hz, 2H), 7.27–7.33 (m, 3H), 7.36 (t, J = 7.5 Hz, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 21.2, 27.0, 97.3, 109.1, 122.9, 124.1, 127.0, 128.6, 128.7, 129.0, 132.6, 132.9, 134.18, 134.21, 142.4, 170.1, 205.9; ESIMS *m/z* 354 $[M + H]^+$. Anal. Calcd for $C_{19}H_{15}NO_2S_2$: C, 64.56; H, 4.28; N, 3.96. Found: C, 64.93; H, 4.51; N, 3.86.

(*Z*)-4'-Benylidene-5-chloro-1-methyl-2'-thioxospiro (indoline-3,5'-[1,3]oxathiolan)-2-one (2c)**.** Yellow solid, mp 130–132 °C; IR (KBr) 1739, 1611, 1488, 1360, 1205 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 3.26 (s, 3H),



Scheme 3. Synthesis of nitrogen analog **4b**.

6.09 (s, 1H), 6.90 (d, J = 8.3 Hz, 1H), 7.19 (d, J = 7.4 Hz, 2H), 7.30 (t, J = 7.4 Hz, 1H), 7.38 (t, J = 7.5 Hz, 2H), 7.47–7.51 (m, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.1 96.2, 110.4, 123.2, 125.6, 126.8, 128.6, 128.98, 129.04, 129.7, 131.9, 132.6, 133.9, 143.4, 169.8, 205.1; ESIMS *m/z* 374 $[M + H]^+$, 376 $[M + H + 2]^+$. Anal. Calcd for $C_{18}H_{12}ClNO_2S_2$: C, 57.82; H, 3.24; N, 3.75. Found: C, 57.81; H, 3.54; N, 3.59.

(*Z*)-4'-Benylidene-6-chloro-1-methyl-2'-thioxospiro (indoline-3,5'-[1,3]oxathiolan)-2-one (2d)**.** Pale orange solid, mp 130–132 °C; IR (KBr) 1744, 1614, 1496, 1367, 1207 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 3.25 (s, 3H), 6.07 (s, 1H), 6.97 (d, J = 1.8 Hz, 1H), 7.16–7.22 (m, 3H), 7.30 (t, J = 7.4 Hz, 1H), 7.37 (t, J = 7.4 Hz, 2H), 7.40 (d, J = 8.1 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.1, 96.2, 110.2, 122.3, 123.2, 124.3, 127.5, 128.6, 128.95, 129.04, 132.0, 133.9, 138.8, 146.1, 170.1, 205.3; ESIMS *m/z* 374 $[M + H]^+$, 376 $[M + H + 2]^+$. Anal. Calcd for $C_{18}H_{12}ClNO_2S_2$: C, 57.82; H, 3.24; N, 3.75. Found: C, 57.90; H, 3.57; N, 3.59.

(*Z*)-4'-Benylidene-5-methoxy-1-methyl-2′-thioxospiro (indoline-3,5′-[1,3]oxathiolan)-2-one (2e)**.** Pale brown solid, mp 122–124 °C; IR (KBr) 1734, 1498, 1498, 1471, 1358, 1289, 1203 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 3.23 (s, 3H), 3.82 (s, 3H), 6.08 (s, 1H), 6.87 (d, J = 8.5 Hz, 1H), 7.02–7.07 (m, 2H), 7.18 (d, J = 7.3 Hz, 2H), 7.29 (t, J = 7.4 Hz, 1H), 7.36 (t, J = 7.4 Hz, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.0, 56.2, 97.3, 110.0, 112.7, 117.7, 123.0, 125.0, 128.6, 128.8, 129.0, 132.5, 134.1, 138.1, 157.1, 170.0, 205.9; ESIMS *m/z* 370 $[M + H]^+$. Anal. Calcd for $C_{19}H_{15}NO_3S_2$: C, 61.77; H, 4.09; N, 3.79. Found: C, 62.01; H, 3.96; N, 3.66.

(*Z*)-4'-Benylidene-1,3,5-trimethyl-2'-thioxospiro (indoline-3,5'-[1,3]oxathiolan)-2-one (2f)**.** Pale brown solid, mp 120–122 °C; IR (KBr) 1732, 1483, 1461, 1348, 1222 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 2.31 (s, 3H), 2.58 (s, 3H), 3.49 (s, 3H), 6.06 (s, 1H), 7.03 (s, 1H), 7.11 (s, 1H), 7.19 (d, J = 7.9 Hz, 2H), 7.28 (t, J = 7.4 Hz, 1H), 7.36 (t, J = 7.4 Hz, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 19.0, 20.9, 30.3, 97.1, 120.7, 122.8, 124.8, 124.9, 128.6, 128.7, 128.9, 132.9, 134.0, 134.3, 136.8, 140.0, 170.9, 206.0; ESIMS *m/z* 368 $[M + H]^+$. Anal. Calcd for $C_{20}H_{17}NO_2S_2$: C, 65.37; H, 4.66; N, 3.81. Found: C, 65.29; H, 4.93; N, 3.60.

(*Z*)-4'-Benylidene-1-methyl-5-nitro-2′-thioxospiro (indoline-3,5′-[1,3]oxathiolan)-2-one (2g)**.** Pale orange solid, mp 128–130 °C; IR (KBr) 1749, 1616, 1520, 1493, 1338 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 3.35 (s, 3H), 6.08 (s, 1H), 7.09 (d, J = 8.7 Hz, 1H), 7.16–7.20 (m, 2H), 7.32 (t, J = 7.4 Hz, 1H), 7.38 (t, J = 7.4 Hz, 2H), 8.39 (d, J = 2.3 Hz, 1H), 8.49 (dd, J = 8.7 and 2.3 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.5, 94.9, 109.3, 122.4, 123.6, 125.1, 128.7, 129.1, 129.26, 129.34, 131.2, 133.6, 144.5, 150.1, 170.2, 204.2; ESIMS *m/z* 385 $[M + H]^+$. Anal. Calcd for $C_{18}H_{12}N_2O_4S_2$: C, 56.24; H, 3.15; N, 7.29. Found: C, 56.44; H, 3.40; N, 7.18.

(*Z*)-1-Methyl-4′-(4-methylbenylidene)-2′-thioxospiro (indoline-3,5′-[1,3]oxathiolan)-2-one (2h**)..** Yellow solid, mp 126–128 °C; IR (KBr) 1737, 1611, 1473, 1370, 1207 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 2.34 (s, 3H), 3.25 (s, 3H), 6.04 (s, 1H), 6.95 (d, J = 7.9 Hz, 1H), 7.06 (d, J = 8.2 Hz, 2H), 7.16 (d, J = 8.2 Hz, 2H), 7.21 (t, J = 7.6 Hz, 1H), 7.47 (d, J = 7.6 Hz, 1H), 7.52 (t, J = 7.9 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 21.5, 26.9, 97.0, 109.3, 123.1, 124.1, 124.3, 126.5, 128.5, 129.7, 131.1, 131.3, 132.7, 139.0, 144.9, 170.2, 206.2; ESIMS *m/z* 354 $[M + H]^+$. Anal. Calcd for $C_{19}H_{15}NO_2S_2$: C, 64.56; H, 4.28; N, 3.96. Found: C, 64.75; H, 4.51; N, 3.93.

(*Z*)-1-Methyl-4'-(3-methylbenylidene)-2'-thioxospiro (indoline-3,5'-[1,3]oxathiolan)-2-one (2i)**..** Pale yellow solid, mp 122–124 °C; IR (KBr) 1737, 1614, 1473, 1370, 1210 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 2.33 (s, 3H), 3.26 (s, 3H), 6.05 (s, 1H), 6.94–7.00 (m, 3H), 7.10 (d, J = 7.4 Hz, 1H), 7.19–7.26 (m, 2H), 7.47 (d, J = 7.5 Hz, 1H), 7.52 (t, J = 7.8 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 21.5, 26.9, 97.0, 109.3, 123.3, 124.1, 124.3, 125.7, 126.5, 128.9, 129.3, 129.6, 132.1, 132.7, 134.1, 138.7, 144.9, 170.2, 206.1; ESIMS *m/z* 354 $[M + H]^+$. Anal. Calcd for $C_{19}H_{15}NO_2S_2$: C, 64.56; H, 4.28; N, 3.96. Found: C, 64.60; H, 4.48; N, 3.72.

(*Z*)-1-Methyl-4'-(3-methoxybenylidene)-2'-thioxospiro (indoline-3,5'-[1,3]oxathiolan)-2-one (2j)**.** Pale orange solid, mp 114–116 °C; IR (KBr) 1737, 1614, 1473, 1367, 1207 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 3.26 (s, 3H), 3.80 (s, 3H), 6.04 (s, 1H), 6.69 (s, 1H), 6.76 (d, J = 7.7 Hz, 1H), 6.84 (dd, J = 8.3 and 1.9 Hz, 1H), 6.96 (d, J = 7.9 Hz, 1H), 7.22 (t, J = 7.5 Hz, 1H), 7.24–7.29 (m, 1H), 7.48 (d, J = 7.5 Hz, 1H), 7.52 (t, J = 7.9 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.0, 55.5, 96.9, 109.3, 113.5, 114.8, 121.1, 123.0, 124.1, 124.4, 126.5, 130.0, 132.7, 132.9, 135.5, 144.9, 160.0, 170.1, 205.8; ESIMS *m/z* 370 $[M + H]^+$. Anal. Calcd for $C_{19}H_{15}NO_3S_2$: C, 61.77; H, 4.09; N, 3.79. Found: C, 61.96; H, 3.98; N, 3.90.

(*Z*)-1-Methyl-4'-nonylidene-2'-thioxospiro(indoline-3,5'-[1,3]oxathiolan)-2-one (2k)**.** Yellow oil; IR (KBr) 2926, 1742, 1614, 1471, 1370, 1205 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz) δ 0.87 (t, J = 7.1 Hz, 3H), 1.20–1.40 (m, 12H), 1.90–2.01 (m, 2H), 3.22 (s, 3H), 5.15 (t, J = 7.4 Hz, 1H), 6.89 (d, J = 7.9 Hz, 1H), 7.16 (t, J = 7.6 Hz, 1H), 7.40 (d, J = 7.6 Hz, 1H), 7.46 (t, J = 7.9 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 14.3, 22.8, 26.8, 28.5, 29.1, 29.2, 29.3, 31.9, 32.3, 95.1, 109.1, 124.1, 124.4, 125.5, 126.2, 132.4, 133.4, 144.7, 170.3, 206.3; ESIMS *m/z* 376 $[M + H]^+$. Anal. Calcd for $C_{20}H_{25}NO_2S_2$: C, 63.96; H, 6.71; N, 3.73. Found: C, 63.79; H, 6.97; N, 3.46.

Synthesis of 3a. To a stirred solution of isatin-derived *N*-Boc ketimine (260 mg, 1.0 mmol) in anhydrous THF (2 mL) was added dropwise phenylethynylmagnesium bromide (1.0 M solution in THF, 4.0 mL, 2.0 mmol) for 10 min at 0 °C, and the reaction mixture was stirred for 2 h under N_2 balloon atmosphere.[11] After the usual aqueous extractive workup and column chromatographic purification

process (CH_2Cl_2/EtOAc, 15:1) propargylic amine *N*-Boc derivative **3a** (181 mg, 50%) was obtained as a pale yellow solid.[11] The spectroscopic data of **3a** are as follows. The starting material, isatin-derived *N*-Boc ketimine was prepared from *N*-methylisatin and *N*-Boc-triphenyliminophosphorane, according to the reported procedure.[16]

***tert*-Butyl-(1-methyl-2-oxo-3-(phenylethynyl)indolin-3-yl) carbamate** (3a)**.** Pale yellow[11] solid, mp 168–170 °C; IR (KBr) 3313, 2233, 1735, 1710, 1614, 1495, 1371 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 1.27 (s, 9H), 3.29 (s, 3H), 5.64 (br s, 1H), 6.86 (d, J = 7.8 Hz, 1H), 7.12 (t, J = 7.6 Hz, 1H), 7.23–7.36 (m, 4H), 7.37–7.40 (m, 2H), 7.47 (d, J = 7.3 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.1, 28.2, 56.7, 81.0, 83.8, 85.1, 108.7, 121.5, 123.4, 123.5, 128.4, 129.2, 129.7, 132.2, 143.2, 153.2, 172.7 (one carbon was overlapped); ESIMS *m/z* 363 $[M + H]^+$.

Synthesis of 3b. To a stirred solution of propargylic *N*-Boc amine derivative **3a** (362 mg, 1.0 mmol) in CH_2Cl_2 (2 mL) was added dropwise $BF_3{\cdot}Et_2O$ (710 mg, 5.0 mmol) for 20 min at 0 °C, and the reaction mixture was stirred for 2 h under N_2 balloon atmosphere.[12] After the usual aqueous extractive workup and column chromatographic purification process (*n*-hexane/EtOAc, 1:1) propargylic amine derivative **3b** (225 mg, 86%) was obtained as pale yellow oil.[13] The spectroscopic data of **3b** are as follows.

3-Amino-1-methyl-3-(phenylethynyl)indolin-2-one (3b). Pale yellow (86%)[13] oil; IR (KBr) 3355, 3283, 2109, 1728, 1614, 1492, 1472 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 2.68 (br s, 2H), 3.25 (s, 3H), 6.87 (d, J = 7.8 Hz, 1H), 7.14 (t, J = 7.5 Hz, 1H), 7.23–7.32 (m, 3H), 7.36 (t, J = 7.8 Hz, 1H), 7.42 (d, J = 7.3 Hz, 2H), 7.58 (d, J = 7.5 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 26.9, 55.6, 84.2, 86.9, 108.9, 122.1, 123.7, 124.3, 128.3, 128.8, 130.0, 130.5, 132.1, 142.9, 175.0; ESIMS *m/z* 263 $[M + H]^+$.

Synthesis of spirooxindole 4b. To a stirred solution of propargylic amine derivative **3b** (131 mg, 0.5 mmol), and carbon disulfide (760 mg, 20 equiv) in ethanol (2.0 mL) was heated to reflux for 15 h.[14] After the usual aqueous extractive workup and column chromatographic purification process (CH_2Cl_2/*n*-hexane, 1:1) spirooxindole **4b** (139 mg, 82%) was obtained as a pale yellow solid. The spectroscopic data of **4b** are as follows.

(Z)-1-Methyl-5′-benzylidene-2'-thioxospiro(indoline-3,4'-thiazolidin)-2-one (4b). Pale yellow solid, mp 156–158 °C; IR (KBr) 3199, 1730, 1614, 1492, 1472 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 3.28 (s, 3H), 5.92 (s, 1H), 6.96 (d, J = 7.9 Hz, 1H), 7.14–7.27 (m, 4H), 7.32 (t, J = 7.6 Hz, 2H), 7.44 (d, J = 7.4 Hz, 1H), 7.47 (t, J = 7.8 Hz, 1H), 7.67 (br s, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 27.2, 77.9, 109.3, 121.9, 124.5, 125.7, 126.9, 128.3, 128.5, 128.8, 131.7, 134.6, 135.0, 143.9, 172.4, 198.0; ESIMS *m/z* 339 $[M + H]^+$. Anal. Calcd for $C_{18}H_{14}N_2OS_2$: C, 63.88; H, 4.17; N, 8.28. Found: C, 64.02; H, 4.39; N, 8.07.

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Supporting Information. Additional supporting information may be found online in the Supporting Information section at the end of the article.

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