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SYNTHESIS OF 1(3*H*)-IMINOBENZO[*c*]THIOPHENE DERIVATIVES BY HYDRIODIC ACID-MEDIATED CYCLIZATION OF 2-(VINYL)THIOBENZAMIDE DERIVATIVES

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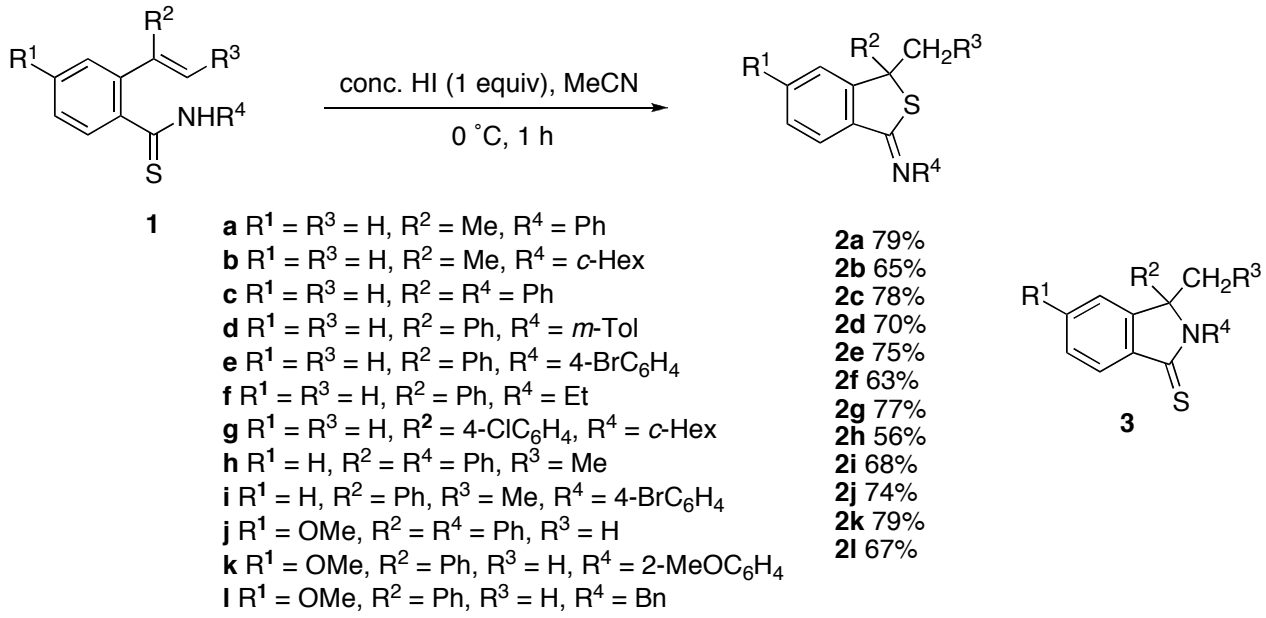
Abstract - Secondary 2-(vinyl)thiobenzamide derivatives, easily prepared by reacting 2-lithiostyrene derivatives with various isothiocyanates, undergo intramolecular cyclization on treatment with concentrated hydriodic acid to produce 1(3*H*)-iminobenzo[*c*]thiophene derivatives in fair-to-good yields. Some of them have been hydrolyzed under acidic conditions to afford benzo[*c*]thiophen-1(3*H*)-one derivatives in good yields.

We have previously reported that secondary 2-(vinyl)thiobenzamide derivatives were treated with iodine at 0 ˚C in acetonitrile to give 1(3*H*)-imino-3-(iodomethyl)benzo[*c*]thiophene derivatives.[1] This is the first general synthesis of 1(3*H*)-iminobenzo[*c*]thiophene derivatives. Unfortunately, however, the reduction of these somewhat unstable (light sensitive) iodides to the corresponding 3-methyl derivatives using tributyltin hydride[2] was unsuccessful, giving an intractable mixture of products in each case. Herein, we wish to report the successful use of concentrated hydriodic acid for the direct conversion of α-substituted secondary 2-(vinyl)thiobenzamide derivatives (**1**) into 3,3-disubstituted 1(3*H*)-iminobenzo[*c*]thiophene derivatives (**2**), which are stable and may be of biological interest. We also describe the transformation of some of these 1(3*H*)-iminobenzo[*c*]thiophene derivatives (**2**) into benzo[*c*]thiophen-1(3*H*)-one derivatives (**4**). Although several syntheses of benzo[*c*]thiophen-1(3*H*)-one have been reported,[3] there are only a few reports on the synthesis of benzo[*c*]thiophen-1(3*H*)-ones carrying substituents at the 3-position.[4,5] Benzo[*c*]thiophen-1(3*H*)-one derivatives have been utilized for the preparation of polycyclic compounds.[5] Molecules bearing a benzo[*c*]thiophen-1(3*H*)-one moiety exhibit potential biological activities.[6]

The 2-(vinyl)thiobenzamides (**1**) used in this study were readily prepared by reacting 2-lithiostyrene derivatives, generated by the halogen-lithium exchange between 2-bromostyrene derivatives and butyllithium in diethyl ether at 0 ˚C, with aliphatic and aromatic isothiocyanates in satisfactory yields, as

described in our previous report.[1]



1

a $R^1 = R^3 = H$, $R^2 = Me$, $R^4 = Ph$
b $R^1 = R^3 = H$, $R^2 = Me$, $R^4 = c$-Hex
c $R^1 = R^3 = H$, $R^2 = R^4 = Ph$
d $R^1 = R^3 = H$, $R^2 = Ph$, $R^4 = m$-Tol
e $R^1 = R^3 = H$, $R^2 = Ph$, $R^4 = 4\text{-}BrC_6H_4$
f $R^1 = R^3 = H$, $R^2 = Ph$, $R^4 = Et$
g $R^1 = R^3 = H$, $R^2 = 4\text{-}ClC_6H_4$, $R^4 = c$-Hex
h $R^1 = H$, $R^2 = R^4 = Ph$, $R^3 = Me$
i $R^1 = H$, $R^2 = Ph$, $R^3 = Me$, $R^4 = 4\text{-}BrC_6H_4$
j $R^1 = OMe$, $R^2 = R^4 = Ph$, $R^3 = H$
k $R^1 = OMe$, $R^2 = Ph$, $R^3 = H$, $R^4 = 2\text{-}MeOC_6H_4$
l $R^1 = OMe$, $R^2 = Ph$, $R^3 = H$, $R^4 = Bn$

2a 79%
2b 65%
2c 78%
2d 70%
2e 75%
2f 63%
2g 77%
2h 56%
2i 68%
2j 74%
2k 79%
2l 67%

3

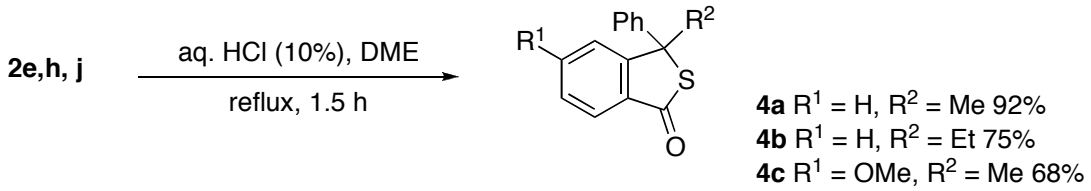
Scheme 1

The resulting 2-(vinyl)thiobenzamides (**1**) were transformed into 1(3*H*)-iminobenzo[*c*]thiophene derivatives (**2**), as depicted in Scheme 1. We first examined the conversion of **1a** into **2a**. We found that compound (**1a**) underwent very ready intramolecular cyclization on treatment with an equimolar amount of concentrated hydriodic acid in acetonitrile at 0 ˚C for 1 h to give, after the usual workup followed by recrystallization of the crude product, **2a** in good yield. Using a catalytic amount (0.1 equivalent) of this acid, the reaction proceeded more sluggishly even at room temperature to give only lower yield of the desired product, and the considerable quantity of the starting material (**1a**) was recovered after a prolonged reaction time (overnight). In order to extend the scope of this reaction, a range of 2-(vinyl)thiobenzamide derivatives (**1**) were subjected to the cyclization reaction conditions described above. The yields of the products (**2**) were generally fair-to-good independently of the substituents of the 2-(vinyl)thiobenzamides **1**, as summarized in Scheme 1. It should be noted that compounds (**1h**) and (**1i**), which possess a methyl substituent at the β-position, also underwent cyclization reaction under the same conditions to give the corresponding desired products (**2h**) and (**2i**), respectively, in comparable yields to those of others.

The formation of 1(3*H*)-iminobenzo[*c*]thiophene structure (**2**) [not isoindolin-1-thione structure (**3**)] is readily explained in terms of the higher nucleophilicity of sulfur atom than that of nitrogen atom. The iminobenzo[*c*]thiophene structure of **2** was determined on the basis of ^{13}C NMR analyses in a similar manner as described in our previous report.[1] A single stereoisomer was obtained in each reaction.

Although we determined the stereochemistry of the imino moiety of **2** to be *Z* tentatively, it cannot be established unambiguously.

Subsequently, acid hydrolysis of the 1(3*H*)-iminobenzo[*c*]thiophenes (**2e**), (**2h**), and (**2j**) was attempted to obtain the corresponding benzo[*c*]thiophene-1(3*H*)-one derivatives (**4**). These iminobenzo[*c*]thiophene derivatives were unchangeable in 10% hydrochloric acid–1,2-dimethoxyethane (DME) (1:3, v/v) at room temperature for a day. However, when the solutions were heated at reflux temperature for 1.5 h, hydrolysis took place cleanly to lead to the formation of the desired products **4** in good yields, as illustrated in Scheme 2. The formation of **4** by hydrolysis of **2** gives further support for the iminobenzo[*c*]thiophene structure of **2**.



Scheme 2

In conclusion, we have developed a facile method for the preparation of 1(3*H*)-iminobenzo[*c*]thiophene derivatives. Some of them have been converted into 3,3-disubstituted benzo[*c*]thiophen-1(3*H*)-ones, which are hard to prepare by conventional methods. The method may be of value in organic synthesis because of the operational simplicity as well as the ready availability of the starting materials.

EXPERIMENTAL

The melting points were determined on a Laboratory Devices MEL-TEMP II melting-point apparatus and are uncorrected. The IR spectra were recorded on a Shimadzu FTIR-8300 spectrometer. ^{1}H NMR spectra were determined using $SiMe_4$ as an internal reference in $CDCl_3$ with a JEOL ECP500 FT NMR spectrometer operating at 500 MHz or a JEOL LA400 FT NMR spectrometer operating at 400 MHz. ^{13}C NMR spectra were determined using $SiMe_4$ as an internal reference with a JEOL ECP500 FT NMR spectrometer operating at 125 MHz in $CDCl_3$. Low-resolution mass spectra (EI, 70 eV) were recorded on a JEOL JMS-AX505 HA spectrometer. Thin-layer chromatography (TLC) was carried out using Merck Kieselgel 60 PF_{254}. Column chromatography was performed using Merck Kieselgel 60 (0.063–0.200 mm).

Starting Materials. 1-Bromo-4-methoxy-2-(1-phenylethenyl)benzene and *o*-(vinyl)thiobenzamide derivatives (**1a–g**) and (**1j**) were prepared according to the procedure previously reported by us.[1] (2-Bromophenyl)phenylmethanone[7] was prepared by the Wagner's method. All other chemical used in

this study were commercially available.

1-(2-Bromophenyl)-1-phenylpropan-1-ol. This compound was prepared by treating (2-bromophenyl)phenylmethanone[7] with EtMgBr in THF at 0 °C in 80% yield; a pale-yellow oil; R_f 0.39 (Et_2O–hexane, 1:9); IR (neat) 3554, 3460 cm^{-1}; ^1H NMR (400 MHz) δ 0.87 (t, J = 7.3 Hz, 3H), 2.21–2.28 (m, 1H), 2.57–2.64 (m, 1H), 3.14 (s, 1H), 7.15 (ddd, J = 7.7, 7.3, 1.4 Hz, 1H), 7.21–7.30 (m, 5H), 7.39 (ddd, J = 7.7, 7.3, 1.4 Hz, 1H), 7.52 (dd, J = 7.7, 1.4 Hz, 1H), 7.83 (dd, J = 7.7, 1.4 Hz, 1H). Anal. Calcd for $C_{15}H_{15}BrO$: C, 61.87; H, 5.19. Found: C, 61.79; H, 5.18.

1-Bromo-2-(1-phenyl-1-propen-1-yl)benzene. This compound was prepared by the thermal dehydration of the above alcohol at 220 °C for 4 h (neat) in 72% yield; a mixture of stereoisomers (*E*:*Z* = *ca*. 4:1); a pale-yellow oil; R_f = 0.70 (Et_2O–hexane, 1:9); IR (neat) 1597 cm^{-1}; ^1H NMR (400 MHz) δ 1.62 (d, J = 7.0 Hz, 2.4H), 1.91 (d, J = 7.0 Hz, 0.6H), 5.84 (q, J = 7.0 Hz, 0.2H), 6.34 (q, J = 7.0 Hz, 0.8H), 7.08–7.37 (m, 8H), 7.52 (dd, J = 7.3, 1.4 Hz, 0.2H), 7.65 (dd, J = 7.3, 1.4 Hz, 0.8H). Anal. Calcd for $C_{15}H_{13}Br$: C, 65.95; H, 4.80. Found: C, 65.76; H, 5.05.

***N*-Phenyl-2-(1-phenyl-1-propen-1-yl)thiobenzamide (1h).** This compound was prepared by the reaction of 1-lithio-2-(1-phenyl-1-propen-1-yl)benzene, which was generated by treatment of 1-bromo-2-(1-phenyl-1-propen-1-yl)benzene with *n*-BuLi at 0 °C, with phenyl isothiocyanate as described previously for the preparation of **1a–g** and **1j**[1] in 65% yield; a mixture of stereoisomers (*E*:*Z* = 7:3). Analytical specimen of each isomer was isolated by preparative TLC on silica gel (Et_2O–hexane, 1:8). *E*-Isomer: a yellow solid; mp 126–128 °C (hexane); IR (KBr) 3353, 1372 cm^{-1}; ^1H NMR (400 MHz) δ 1.73 (d, J = 7.0 Hz, 3H), 6.43 (q, J = 7.0 Hz, 1H), 7.15–7.30 (m, 11H), 7.44 (ddd, J = 7.7, 7.3, 1.5 Hz, 1H), 7.49 (ddd, J = 7.7, 7.3, 1.5 Hz, 1H), 7.92 (dd, J = 7.7, 1.5 Hz, 1H), 8.56 (br s, 1H). Anal. Found: Calcd for $C_{22}H_{19}NS$: C, 80.20; H, 5.81; N, 4.25. C, 80.06; H, 5.95; N, 4.07. *Z*-Isomer: a yellow oil; R_f 0.22; IR (neat) 3346, 1360 cm^{-1}; ^1H NMR (400 MHz) δ 1.89 (d, J = 7.0 Hz, 3H), 6.12 (q, J = 7.0 Hz, 1H), 7.07 (dd, J = 7.7, 1.8 Hz, 2H), 7.21–7.25 (m, 5H), 7.31–7.42 (m, 4H), 7.52 (d, J = 7.7 Hz, 2H), 7.68 (d, J = 7.3 Hz, 1H), 8.68 (br s, 1H). Anal. Calcd for $C_{22}H_{19}NS$: C, 80.20; H, 5.81; N, 4.25. Found: C, 80.19; H, 5.87; N, 3.98.

***N*-(4-Bromophenyl)-2-(1-phenyl-1-propen-1-yl)thiobenzamide (1i).** This compound was prepared by the reaction of 1-lithio-2-(1-phenyl-1-propen-1-yl)benzene with 4-bromophenyl isothiocyanate as described previously for the preparation of **1a–g** and **1j**[1] in 56% yield; a mixture of stereoisomers (*E*:*Z* = 7:3). Analytical specimen of each isomer was isolated by preparative TLC on silica gel (Et_2O–hexane, 1:7). *E*-Isomer; a yellow solid; mp 161–163 °C (hexane–Et_2O); IR (KBr) 3348, 1366 cm^{-1}; ^1H NMR (400 MHz) δ 1.70 (d, J = 7.0 Hz, 3H), 6.42 (q, J = 7.0 Hz, 1H), 7.17 (d, J = 8.8 Hz, 2H), 7.20–7.27 (m, 6H), 7.36 (d, J = 8.8 Hz, 2H), 7.44 (t, J = 7.3 Hz, 1H), 7.50 (dd, J = 7.7, 7.3 Hz, 1H), 7.89 (d, J = 7.7 Hz, 1H), 8.49 (br s, 1H). Anal. Calcd for $C_{22}H_{18}BrNS$: C, 64.71; H, 4.44; N, 3.43. Found: C, 64.50; H, 4.49; N, 3.31. *Z*-Isomer: a yellow oil; R_f 0.28; IR (neat) 3338, 1353 cm^{-1}; ^1H NMR (400 MHz) δ 1.89 (d, J =

7.0 Hz, 3H), 6.10 (q, *J* = 7.0 Hz, 1H), 7.03 (dd, *J* = 7.7, 1.8 Hz, 2H), 7.18–7.23 (m, 4H), 7.33–7.47 (m, 6H), 7.65 (d, *J* = 7.7 Hz, 1H), 8.61 (br s, 1H). Anal. Calcd for $C_{22}H_{18}BrNS$: C, 64.71; H, 4.44; N, 3.43. Found: C, 64.55; H, 4.71; N, 3.19.

4-Methoxy-*N*-(2-methoxyophenyl)-2-(1-phenylethenyl)thiobenzamide (1k). This compound was prepared by the reaction of 1-lithio-4-methoxy-2-(1-phenylethenyl)benzene, which was generated by treatment of 1-bromo-4-methoxy-2-(1-phenylethenyl)benzene[1] with *n*-BuLi at 0 °C, with 2-methoxyphenyl isothiocyanate as described previously for the preparation of **1a–g** and **1j**[1] in 54% yield; a yellow oil; R_f 0.28 (THF–hexane, 1:9); IR (neat) 3350, 1364 cm^{-1}; ^1H NMR (500 MHz) δ 3.69 (s, 3H), 3.86 (s, 3H), 5.48 (s, 1H), 5.69 (s, 1H), 6.84–6.88 (m, 3H), 6.96 (dd, *J* = 8.7, 1.8 Hz, 1H), 7.10 (td, *J* = 7.8, 1.4 Hz, 1H), 7.18–7.23 (m, 5H), 7.89 (d, *J* = 8.7 Hz, 1H), 8.56 (dd, *J* = 8.2, 1.4 Hz, 1H), 9.32 (br s, 1H). Anal. Calcd for $C_{23}H_{21}NO_2S$: C, 73.57; H, 5.64; N, 3.73. Found: C, 73.32; H, 5.81; N, 3.91.

***N*-Benzyl-4-Methoxy-2-(1-phenylethenyl)thiobenzamide (1l).** This compound was prepared by the reaction of 1-lithio-4-methoxy-2-(1-phenylethenyl)benzene with benzyl isothiocyanate as described previously for the preparation of **1a–g** and **1j**[1] in 62% yield; a yellow oil; R_f 0.20 (THF–hexane, 1:9); IR (neat) 3369, 1327 cm^{-1}; ^1H NMR (500 MHz) δ 3.84 (s, 3H), 4.49 (d, *J* = 6.0 Hz, 2H), 5.35 (s, 1H), 5.69 (s, 1H), 6.77 (d, *J* = 2.8 Hz, 1H), 6.93 (dd, *J* = 8.7, 2.8 Hz, 1H), 7.09–7.11 (m, 2H), 7.18–7.20 (m, 2H), 7.24–7.29 (m, 6H), 7.46 (br s, 1H), 7.88 (d, *J* = 8.7 Hz, 1H). Anal. Calcd for $C_{23}H_{21}NOS$: C, 76.85; H, 5.89; N, 3.90. Found: C, 76.64; H, 5.93; N, 3.85.

Typical Procedure for the Preparation of 1(3*H*)-phenyliminobenzo[*c*]thiophenes (2). 3,3-Dimethyl-1(3*H*)-phenyliminobenzo[*c*]thiophene (2a). To a stirred solution of 2-(1-methylethenyl)-*N*-(phenyl)thiobenzamide (**1a**) (0.20 g, 0.79 mmol) in MeCN (5 mL) at 0 °C was added concentrated hydriodic acid (0.18 g, 0.79 mmol); the mixture was stirred for 1 h at the same temperature. Saturated aqueous $NaHCO_3$ (10 mL) was added and MeCN was evaporated. The organic materials were extracted with Et_2O three times (10 mL each) and combined extracts were dried over anhydrous Na_2SO_4. Evaporation of the solvent gave a residual solid, which was purified by recrystallization (hexane–Et_2O) to give **2a** (0.16 g, 79%); a pale-yellow solid; mp 96–98 °C; IR (KBr) 1624, 1612 cm^{-1}; ^1H NMR (500 MHz) δ 1.78 (s, 6H), 7.12 (dd, *J* = 8.2, 1.4 Hz, 2H), 7.15 (tt, *J* = 7.8, 1.4 Hz, 1H), 7.38 (dd, *J* = 8.2, 7.8 Hz, 2H), 7.41 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.43 (td, *J* = 7.8, 0.9 Hz, 1H), 7.54 (ddd, *J* = 7.8, 7.3, 1.4 Hz, 1H), 8.04 (d, *J* = 7.3 Hz, 1H); MS *m*/*z* 253 (M^+, 100). Anal. Calcd for $C_{16}H_{15}NS$: C, 75.85; H, 5.97; N, 5.53. Found: C, 75.61; H, 6.01; N, 5.31.

1(3*H*)-Cyclohexylimino-3,3-dimethylbenzo[*c*]thiophene (2b). This product was purified by preparative TLC on silica gel; a yellow oil R_f 0.47 (hexane–C_6H_6, 1:4); IR (neat) 1638, 1618 cm^{-1}; ^1H NMR (500 MHz) δ 1.24–1.42 (m, 3H), 1.49–1.57 (m, 2H), 1.64–1.68 (m, 1H), 1.79 (s, 6H), 1.81–1.91 (m, 4H), 3.12–3.19 (m, 1H), 7.33 (td, *J* = 7.8, 0.9 Hz, 1H), 7.35 (d, *J* = 7.8 Hz, 1H), 7.44 (td, *J* = 7.8, 1.4 Hz, 1H), 7.90 (d, *J* = 7.8 Hz, 1H). MS *m*/*z* 259 (M^+, 100). Anal. Calcd for $C_{16}H_{21}NS$: C, 74.08; H, 8.16;

N, 5.40. Found: C, 74.05; H, 8.20; N, 5.49.

3-Methyl-3-phenyl-1(3*H*)-phenyliminobenzo[*c*]thiophene (2c): a white solid; mp 108–109 °C (hexane–Et_2O); IR (KBr) 1626 cm^{-1}; ^1H NMR (500 MHz) δ 2.20 (s, 3H), 7.12 (tt, *J* = 7.3, 1.4 Hz, 1H), 7.13 (d, *J* = 7.8 Hz, 2H), 7.18 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.22 (tt, *J* = 7.3, 1.4 Hz, 1H), 7.26–7.32 (m, 4H), 7.39 (dd, *J* = 7.8, 7.3 Hz, 2H), 7.45–7.51 (m, 2H), 8.12 (dd, *J* = 7.3, 1.4 Hz, 1H); ^{13}C NMR δ 30.00, 62.66, 120.48, 123.49, 124.67 (two overlapped C's), 126.63, 127.29, 128.03, 128.42, 129.05, 131.79, 137.27, 144.52, 151.81, 153.55, 166.94; MS *m/z* 315 (M^+, 100). Anal. Calcd for $C_{21}H_{17}NS$: C, 79.96; H, 5.43; N, 4.44. Found: C, 79.90; H, 5.44; N, 4.23.

3-Methyl-1(3*H*)-(3-methylphenylimino)-3-phenylbenzo[*c*]thiophene (2d). This product was purified by preparative TLC on silica gel; a yellow oil; R_f 0.41 (THF–hexane, 1:9); IR (neat): 1622 cm^{-1}; ^1H NMR (500 MHz) δ 2.20 (s, 3H), 2.34 (s, 3H), 6.93–6.94 (m, 3H), 7.17 (dd, *J* = 7.3, 1.4 Hz, 1H), 7.20–7.32 (m, 6H), 7.45–7.51 (m, 2H), 8.11 (dd, *J* = 7.8, 0.9 Hz, 1H); MS *m/z* 329 (M^+, 100). Anal. Calcd for $C_{22}H_{19}NS$: C, 80.20; H, 5.81; N, 4.25. Found: C, 80.12; H, 5.82; N, 4.22.

1(3*H*)-(4-Bromophenylimino)-3-methyl-3-phenylbenzo[*c*]thiophene (2e): a white solid; mp 138–139 °C (hexane–Et_2O); IR (KBr) 1614 cm^{-1}; ^1H NMR (500 MHz) δ 2.20 (s, 3H), 7.02 (d, *J* = 8.3 Hz, 2H), 7.18 (dd, *J* = 6.9, 0.9 Hz, 1H), 7.21–7.31 (m, 4H), 7.44–7.52 (m, 5H), 8.09 (dd, *J* = 7.8, 1.4 Hz, 1H). MS *m/z* 393 (M^+, 100). Anal. Calcd for $C_{21}H_{16}BrNS$: C, 63.96; H, 4.09; N, 3.55. Found: C, 63.93; H, 3.93; N, 3.45.

1(3*H*)-(Ethylimino)-3-methyl-3-phenylbenzo[*c*]thiophene (2f). This product was purified by preparative TLC on silica gel; a pale-yellow solid; mp 73–74 °C (hexane); IR (neat): 1634 cm^{-1}; ^1H NMR (500 MHz) δ 1.38 (t, *J* = 7.3 Hz, 3H), 2.21 (s, 3H), 3.47 (q, *J* = 7.3 Hz, 2H), 7.11 (dd, *J* = 7.3, 1.4 Hz, 1H), 7.22 (tt, *J* = 7.3, 1.4 Hz, 1H), 7.27 (dd, *J* = 7.8, 1.4 Hz, 2H), 7.31 (dd, *J* = 7.8, 7.3 Hz, 2H), 7.38 (td, *J* = 7.3, 1.4 Hz, 1H), 7.41 (td, *J* = 7.3, 0.9 Hz, 1H), 7.96 (d, *J* = 7.3 Hz, 1H); ^{13}C NMR δ 15.42, 30.20, 51.92, 62.21, 122.96, 124.57, 126.66, 127.18, 127.81, 128.37, 131.04, 136.91, 145.07, 153.10, 164.65; MS *m/z* 267 (M^+, 100). Anal. Calcd for $C_{17}H_{17}NS$: C, 76.36; H, 6.41; N, 5.24. Found: C, 76.07; H, 6.56; N, 5.19.

3-(4-Chlorophenyl)-1(3*H*)-cyclohexylimino-3-methylbenzo[*c*]thiophene (2g). This product was purified by preparative TLC on silica gel; a yellow oil; R_f = 0.32 (THF–hexane, 1:15); IR (neat) 1634, 1616 cm^{-1}; ^1H NMR (500 MHz) δ 1.24–1.42 (m, 3H), 1.50–1.57 (m, 2H), 1.64–1.68 (m, 1H), 1.81–1.89 (m, 4H), 2.18 (s, 3H), 3.09–3.15 (m, 1H), 7.07 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.24 (br s, 4H), 7.36–7.42 (m, 2H), 7.98 (dd, *J* = 7.8, 1.4 Hz, 1H); ^{13}C NMR δ 24.75, 24.82, 25.72, 30.18, 32.88, 32.97, 61.27, 67.07, 123.43, 124.33, 127.88, 128.11, 128.44, 131.05, 132.97, 137.08, 144.02, 152.52, 161.57; MS *m/z* 355 (M^+, 100). Anal. Calcd for $C_{21}H_{22}ClNS$: C, 70.86; H, 6.23; N, 3.94. Found: C, 70.69; H, 6.25; N, 3.79.

3-Ethyl-3-phenyl-1(3*H*)-phenyliminobenzo[*c*]thiophene (2h). This product was purified by preparative TLC on silica gel; a yellow oil; R_f 0.46 (Et_2O–hexane, 1:9); IR (neat): 1615 cm^{-1}; ^1H NMR

(400 MHz) δ 0.86 (t, *J* = 7.3 Hz, 3H), 2.40–2.49 (m, 1H), 2.60–2.69 (m, 1H), 7.12–7.38 (m, 11H), 7.44–7.51 (m, 2H), 8.10 (d, *J* = 7.0 Hz, 1H); MS *m/z* 329 (M^+, 40), 300 (100). Anal. Calcd for $C_{22}H_{19}NS$: C, 80.20; H, 5.81; N, 4.25. Found: C, 80.15; H, 6.01; N, 4.22.

1(3*H*)-(4-Bromophenyl)imino-3-ethyl-3-phenylbenzo[*c*]thiophene (2i). This product was purified by preparative TLC on silica gel; a yellow oil; R_f 0.57 (Et_2O–hexane, 1:9); IR (neat) 1614 cm^{-1}; ^1H NMR (500 MHz) δ 0.85 (t, *J* = 7.3 Hz, 3H), 2.41–2.48 (m, 1H), 2.61–2.68 (m, 1H), 7.04 (d, *J* = 8.2 Hz, 2H), 7.16 (d, *J* = 7.3 Hz, 1H), 7.23 (t, *J* = 7.3 Hz, 1H), 7.28 (dd, *J* = 7.8,d 7.3 Hz, 2H), 7.33 (d, *J* = 7.8 Hz, 2H), 7.45–7.48 (m, 3H), 7.50 (td, *J* = 7.3, 1.4 Hz, 1H), 8.07 (d, *J* = 7.3 Hz, 1H); ^{13}C NMR δ 9.47, 33.36, 68.80, 117.65, 122.45, 123.41, 124.86, 126.88, 127.38, 128.11, 128.50, 131.85, 132.10, 138.32, 144.06, 150.72, 151.16, 168.23; MS *m/z* 407 (M^+, 45), 378 (100). Anal. Calcd for $C_{22}H_{18}BrNS$: C, 64.71; H, 4.44; N, 3.43. Found: C, 64.63; H, 4.60; N, 3.39.

5-Methoxy-3-methyl-3-phenyl-1(3*H*)-phenyliminobenzo[*c*]thiophene (2j): a yellow solid; mp 142–144 °C (hexane–Et_2O); IR (KBr) 1618, 1605 cm^{-1}; ^1H NMR (500 MHz) δ 2.18 (s, 3H), 3.81 (s, 3H), 6.60 (d, *J* = 2.3 Hz, 1H), 7.02 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.09–7.12 (m, 3H), 7.22 (tt, *J* = 7.3, 2.3 Hz, 1H), 7.27–7.35 (m, 6H), 8.03 (d, *J* = 8.7 Hz, 1H); MS *m/z* 345 (M^+, 100). Anal. Calcd for $C_{22}H_{19}NOS$: C, 76.49; H, 5.54; N, 4.05. Found: C, 76.42; H, 5.57; N, 3.92.

5-Methoxy-1(3*H*)-(2-methoxyphenylimino)-3-methyl-3-phenylbenzo[*c*]thiophene (2k): a yellow solid; mp 50–53 °C (hexane); IR (KBr) 1626, 1601 cm^{-1}; ^1H NMR (500 MHz) δ 2.17 (s, 3H), 3.80 (s, 3H), 3.83 (s, 3H), 6.58 (d, *J* = 2.3 Hz, 1H), 6.90–6.93 (m, 2H), 7.01 (dd, *J* = 8.7,d 2.3 Hz, 1H), 7.04 (dd, *J* = 7.8,d 1.4 Hz, 1H), 7.08 (ddd, *J* = 7.8, 7.3, 1.4 Hz, 1H), 7.21 (t, *J* = 7.3 Hz, 1H), 7.27 (t, *J* = 7.3 Hz, 2H), 7.33 (d, *J* = 7.3 Hz, 2H), 8.09 (dd, *J* = 8.7 Hz, 1H); ^{13}C NMR δ 29.76, 55.65, 55.81, 61.77, 109.06, 111.78, 114.67, 120.51, 120.77, 124.89, 125.33, 126.66, 127.19, 128.37, 129.94, 141.43, 144.62, 150.64, 155.93, 162.90, 167.56; MS *m/z* 375 (M^+, 100). Anal. Calcd for $C_{23}H_{21}NO_2S$: C, 73.57; H, 5.64; N, 3.73. Found: C, 73.47; H, 5.65; N, 3.46.

1(3*H*)-Benzylimino-5-methoxy-3-methyl-3-phenylbenzo[*c*]thiophene (2l): a pale-yellow solid; mp 105–108 °C (hexane); IR (KBr) 1631, 1605 cm^{-1}; ^1H NMR (500 MHz) δ 2.21 (s, 3H), 3.77 (s, 3H), 4.59 (d, *J* = 15.6 Hz,1H), 4.60 (d, *J* = 15.6 Hz, 1H), 6.56 (d, *J* = 2.3 Hz, 1H), 6.94 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.22–7.27 (m, 2H), 7.29 (dd, *J* = 7.8, 7.3 Hz, 2H), 7.33–7.36 (m, 4H), 7.44 (d, *J* = 7.8 Hz, 2H), 7.94 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR δ 30.09, 55.58, 60.73, 62.13, 108.98, 114.65, 124.30, 126.66, 126.73, 127.25, 127.86, 128.34, 128.43, 129.95, 139.90, 144.85, 155.12, 162.46, 165.05; MS *m/z* 359 (M^+, 100). Anal. Calcd for $C_{23}H_{21}NOS$: C, 76.85; H, 5.89; N, 3.90. Found: C, 76.81; H, 6.01; N, 3.82.

Typical Procedure for the Preparation of Benzo[*c*]thiophene-1(3*H*)-one Derivatives (4). 3-Methyl-3-phenylbenzo[*c*]thiophene-1(3*H*)-one (4a). A solution of **2e** (0.15 g, 0.39 mmol) in DME (3 ml) containing 10% aqueous HCl (1.1 mL) was heated at reflux temperature for 1.5 h. After cooling to rt, water (10 mL) was added, and the resulting mixture was extracted with Et_2O three times (10 mL

each). The combined extracts were washed with saturated aqueous $NaHCO_3$ and brine (10 mL each), and dried over anhydrous Na_2SO_4. Evaporation of the solvent gave a residue, which was purified by preparative TLC on silica gel to afford **4a** (85 mg, 92%); a yellow oil; R_f 0.53 (Et_2O–hexane, 1:3); IR (neat) 1683 cm^{-1}; ^1H NMR (500 MHz) δ 2.27 (s, 3H), 7.24–7.32 (m, 6H), 7.48 (ddd, *J* = 7.8, 7.3, 1.4 Hz, 1H), 7.59 (ddd, *J* = 7.8, 7.3, 1.4 Hz, 1H), 7.83 (dd, *J* = 7.8, 1.4 Hz, 1H); ^{13}C NMR δ 29.27, 61.49, 123.64, 125.05, 126.67, 127.63, 128.27, 128.58, 133.84, 134.92, 142.89, 156.73, 196.60; MS *m/z* 240 (M^+, 73), 225 (100). Anal. Calcd for $C_{15}H_{12}OS$: C, 74.97; H, 5.03. Found: C, 74.88; H, 5.05.

3-Ethyl-3-phenylbenzo[*c*]thiophene-1(3*H*)-one (4b): a yellow oil; R_f 0.36 (C_6H_6–hexane, 2:3); IR (neat) 1682 cm^{-1}; ^1H NMR (400 MHz) δ 0.87 (t, *J* = 7.3 Hz, 3H), 2.46–2.55 (m, 1H), 2.73–2.82 (m, 1H), 7.22–7.26 (m, 2H), 7.30 (t, *J* = 7.3 Hz, 2H), 7.36 (d, *J* = 7.3 Hz, 2H), 7.46 (dd, *J* = 7.7, 7.3 Hz, 1H), 7.58 (dd, *J* = 7.7, 7.3 Hz, 1H), 7.82 (d, *J* = 7.7 Hz, 1H); MS *m/z* 254 (M^+, 12), 225 (100). Anal. Calcd for $C_{16}H_{14}OS$: C, 75.55; H, 5.55. Found: C, 75.38; H, 5.62.

5-Methoxy-3-methyl-3-phenylbenzo[*c*]thiophene-1(3*H*)-one (4c): a yellow oil; R_f 0.41 (THF–hexane, 1:7); IR (neat) 1682 cm^{-1}; ^1H NMR (500 MHz) δ 2.24 (s, 3H), 3.81 (s, 3H), 6.63 (d, *J* = 2.3 Hz, 1H), 6.99 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.25–7.34 (m, 5H), 7.75 (d, *J* = 8.7 Hz, 1H); MS *m/z* 270 (M^+, 92), 255 (100). Anal. Calcd for $C_{16}H_{14}O_2S$: C, 71.08; H, 5.22. Found: C, 71.05; H, 5.19.

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