# An Alternative Facile Preparation of Telluro- and Selenochromones from *o*-Bromophenyl Ethynyl Ketones[1]

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*Received 13 October 1997; revised 20 November 1997*

**Abstract:** Treatment of *o*-bromophenyl ethynyl ketones **2** with sodium hydrogen telluride and selenide gave telluro- **3A** and selenochromones **3B**, respectively, in one pot via the presumed intermediates **4**.

**Key words:** tellurochromones, selenochromones, *o*-bromophenyl ethynyl ketones, intramolecular cyclization

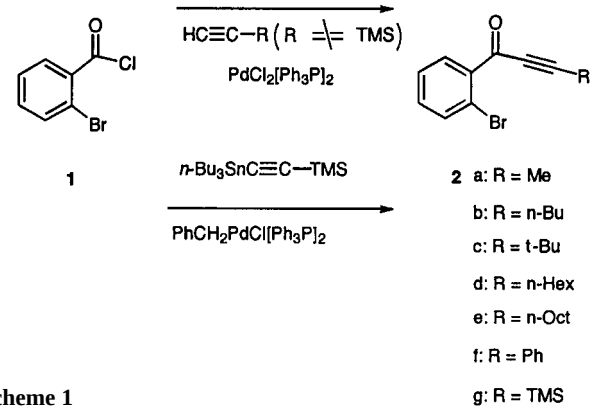
The chemistry of six-membered tellurium- or selenium-containing heterocyclic compounds[2] has recently been developed for their displays of certain characteristic elucidations of structures and reactions. Among these compounds, there are a few known heterocycles of the chromone type.[3–5]

The intramolecular Friedel–Crafts cyclization[4] of $\beta$-(arylseleno)cinnamic acids or the corresponding acid chlorides gives selenochromones, and this method is also useful for the preparation of the corresponding thio analogs.[4a] But, with respect to the synthesis of the corresponding tellurochromones, the Friedel–Crafts reaction of $\beta$-(aryltelluro)cinnamoyl chlorides is less effective.[4b] The reason is that this ring-closure reaction can proceed to give the chromones only in the case of the presence of a strong electron-donating group in positions 5 and (or) 7 on the benzene ring.[4c]

Renson and co-workers[5] have reported the synthesis of tellurochromones using the intramolecular cyclization of $\beta$-(*o*-bromotelluroaroyl) enamines[5a] under the action of hypophosphoric acid, and furthermore, the preparation of selenochromones[5b] by the hydrobromic acid induced ring closure of ethynyl *o*-(methylseleno)phenyl ketones. However, these procedures[4,5] for the preparation of seleno- and tellurochromones have limited success and generality, not only at the position and the variety of the substituents on the aromatic ring, but also for the kind of chalcogen element.

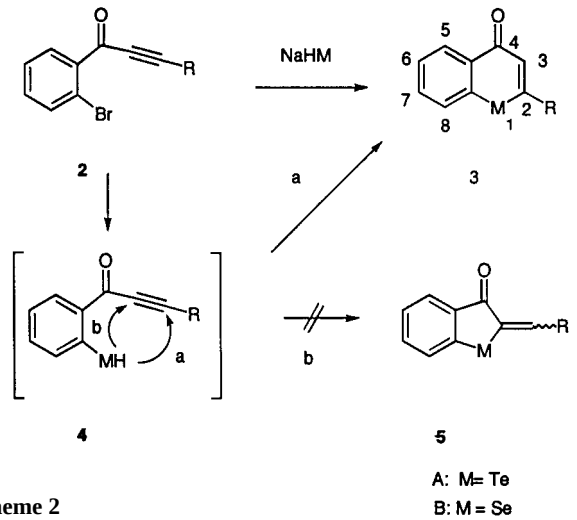
On the other hand, we have previously[6] presented synthetic methods for the preparation of chalcogen-containing heterocycles via the intramolecular ring closure of a -SeH or -TeH moiety to a triple bond. In this paper, the extension of our synthetic methodology for the preparation of the title compounds is described.

The key starting materials, *o*-bromophenyl ethynyl ketones **2**, were readily prepared from *o*-bromobenzoyl chloride (**1**) as shown in Scheme 1. Compound **1** was coupled with various 1-substituted acetylenes in the presence of a catalytic amount of dichlorobis(triphenylphosphine)palladium(II) and copper(I) iodide to give the corresponding product **2** in good yields.[7] In the case of trimethylsilyl derivatives, this hetero-coupling reaction did not proceed, and only the homo-coupling product of trimethylsilylacetylene was obtained. Therefore, the benzylchlorobis(triphenylphosphine)palladium(II)-induced coupling reaction of benzoyl chloride with organotin reagents as reported by Stille and co-workers[8] was applied. This palladium-catalyzed coupling reaction of **1** with tributyl[(trimethylsilyl)ethynyl]stannane[9] afforded the desired compound **2g** in 45% yield.




**Scheme 1**

For the preparation of the telluro- **3A** and selenochromones **3B**, we first examined the conversion to the phenylchalcogenols **4** from alkynyl phenyl ketones **2**. The method[10] presented by Liu and co-workers was used for this purpose. Treatment of **2** with sodium hydrogen telluride and selenide generated in situ from tellurium (selenium) powder and sodium borohydride in DMF resulted in a direct ring closure to afford the tellurochromones **3A**




**Scheme 2**

**Table.** Tellurochromones **3A** and Selenochromones **3B**

| Product | M | R | Yield (%) | Appearance | Formula HRMS Calcd (Found) | IR $\nu_{C=O}$ ($cm^{-1}$) | $^1H$ NMR (60 MHz) $\delta$, $J$ (Hz) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3-H | 5-H | Ar-H (6-, 7-, 8-H) | R-H |
| **3Aa** | Te | Me | 28 | pale-yellow prisms mp 98–99 °C (Lit.[5a] 99–100 °C) | $C_{10}H_8OTe$ 273.9637 (273.9645) | 1600 | listed in ref 5a | | | R = Me |
| **3Ab** | Te | *n*-Bu | 48 | orange oil | $C_{13}H_{14}OTe$ 316.0107 (316.0101) | 1608 | 7.20 (s) | 8.6–8.8 (m) | 7.3–7.7 (3H, m) | 0.90, 1.1–1.8, 2.72 (3H, t, $J$ = 6, 4H, m, 2H, t, $J$ = 6); R = *n*-Bu |
| **3Ac** | Te | *t*-Bu | 63 | orange oil | $C_{13}H_{14}OTe$ 316.0107 (316.0114) | 1608 | 7.31 (s) | 8.6–8.8 (m) | 7.3–7.7 (3H, m) | 1.27 (9H, s); R = *t*-Bu |
| **3Ad** | Te | *n*-Hex[a] | 39 | orange oil | $C_{15}H_{18}OTe$ 344.0420 (344.0417) | 1608 | 7.20 (br s) | 8.6–8.8 (m) | 7.3–7.8 (3H, m) | 0.87, 1.0–1.8, 2.72 (3H, t, $J$ = 5, 8H, m, 2H, t, $J$ = 7); R = *n*-Hex[a] |
| **3Ae** | Te | *n*-Oct[h] | 43 | orange oil | $C_{17}H_{22}OTe$ 372.0733 (372.0743) | 1608 | 7.18 (s) | 8.6–8.8 (m) | 7.3–7.7 (3H, m) | 0.87, 1.1–2.0, 2.77 (3H, t, $J$ = 5, 12H, m, 2H, t, $J$ = 7); R = *n*-Oct[b] |
| **3Af** | Te | Ph | 48 | yellow prisms mp 114–116 °C | $C_{15}H_{10}OTe$ 335.9794 (335.9790) | 1610 | 7.23 (s) | 8.7–8.9 (m) | 7.3–7.7 (8H, m) | R = Ph |
| **3Ah** | Te | H | 5 | yellow prims mp126–l28 °C (Lit.[5a] 130 °C) | $C_9H_6OTe$ 259.9481 (289.9488) | 1574 | listed in ref 11 | | | R = H |
| **3Ba** | Se | Me | 48 | pale-yellow prisms mp 97–98 °C (Lit.[5a] 96–98 °C) | $C_{10}H_8OSe$ 223.9741 (223.9743) | 1616 | 7.00 (d, $J$ = 1) | 8.5–8.7 (m) | 7.4–7.7 (3H, m) | 2.50 (3H, d, $J$ = 1); R = Me |
| **3Bb** | Se | *n*-Bu | 90 | yellow oil | $C_{13}H_{14}OSe$ 266.0210 (266.0213) | 1620 | 7.00 (br s) | 8.5–8.7 (m) | 7.2–7.6 (3H, m) | 0.93, 1.1–2.0, 2.70 (3H, t, $J$ = 6, 4H, m, 2H, br t, $J$ = 7); R = *n*-Bu |
| **3Bc** | Se | *t*-Bu | 93 | pale-yellow prisms mp 89–91 °C | $C_{13}H_{14}OSe$ 266.0210 (266.0209) | 1620 | 7.08 (s) | 8.5–8.7 (m) | 7.3–7.6 (3H, m) | 1.33 (9H, s); R = *t*-Bu |
| **3Bd** | Se | *n*-Hex[a] | 79 | ellow oil | $C_{15}H_{18}OSe$ 294.0523 (294.0526) | 1622 | 7.00 (br s) | 8.5–8.7 (m) | 7.3–7.7 (3H, m) | 0.90, 1.1–2.0, 2.67 (3H, t, $J$ = 5, 8H, m, 2H, br t, $J$ = 7); R = *n*-Hex[a] |
| **3Be** | Se | *n*-Oct[b] | 86 | yellow oil | $C_{17}H_{22}OSe$ 322.0837 (322.0842) | 1624 | 6.98 (s) | 8.5–8.7 (m) | 7.5–7.7 (3H, m) | 0.87, 1.1–2.0, 2.67 (3H, t, $J$ = 5, 12H, m, 2H, t, $J$ = 7); R = *n*-Oct[b] |
| **3Bf** | Se | Ph | 84 | pale-yellow prisms mp133–l34 °C (Lit.[5c] 133 °C) | $C_{15}H_{10}OSe$ 285.9897 (285.9899) | 1612 | listed in ref 4a | | | R = Ph |
| **3Bh** | Se | H | 59 | pale-yellow prisms mp 90–92 °C (Lit.[5c] 93–94 °C) | $C_9H_6OSe$ 209.9584 (209.9588) | 1610 | listed in ref 11 | | | R = H |

[a] *n*-Hexyl.
[b] *n*-Octyl.

and selenochromones **3B**, respectively, as the sole product in moderate to good yields except for **3Ah**. The TMS derivative **2g** gave the 2-unsubstituted telluro- **3Ah** and selenochromone **3Bh** with reductive removal of the TMS group under these reaction conditions. No five-membered cyclization products **5** were obtained.

These results for the formation of **3** clearly indicate the following two points: (1) the essential intermediates **4** are probably generated in situ by replacement of the bromo anion with the hydrotelluro or hydroseleno group because of an enhancement of the reactivity due to the presence of a carbonyl group as an electron-withdrawing group;[10] and (2) the intramolecular regioselective Michael-type addition in **4** proceeds via path a to afford the six-membered ring heterocycles **3**. The results and the spectral data of the products **3** are summarized in the Table.

In conclusion, the present results provide a new synthetic route for preparing telluro- and selenochromones. Studies on the utility of these compounds and their applications to other synthetic strategies are in progress.

Mps were measured on a Yanagimoto micro melting point hot stage apparatus and are uncorrected. IR spectra were determined with a Hitachi 270-30 spectrometer. MS and HRMS were recorded on a JEOL JMS-DX300 instrument.$^1$H NMR spectra were determined with a JEOL PMX-60SI (60 MHz) spectrometer in $CDCl_3$ using TMS as internal standard. Although *o*-bromobenzoyl chloride (**1**) is commercially available, it is easily prepared from *o*-bromobenzoic acid and thionyl chloride almost quantitatively.

***o*-Bromophenyl Ethynyl Ketones 2; Typical Procedure:**
To a mixture of a 1-alkyne (0.1 mol) and *o*-bromobenzoyl chloride (**1**) (21.95 g, 0.1 mol) in $Et_3N$ (160 mL) and benzene (40 mL) were added $PdCl_2[Ph_3P]_2$ (100 mg) and CuI (100 mg). The mixture was stirred at r.t. under argon for 12–15 h. After addition of MeOH (10 mL), the solvent was removed under reduced pressure. Benzene (300 mL) and water (200 mL) were added to the residue and the aqueous layer was extracted with benzene (2×200 mL). The combined organic extract was washed with water (5×200 mL), 5% $H_2SO_4$ (3 × 200 mL), sat. $NaHCO_3$ (2×200 mL) and brine (2×200 mL), and then dried ($MgSO_4$). Benzene was removed in vacuo. The red residual oil was purified by chromatography (silica gel, *n*-hexane) to give pure **2**. In the case of **2a**, a slow stream of methylacetylene, which was prepared from 1,2-dibromopropane and KOH in refluxing BuOH, was immediately passed through the mixture without isolation.

**2a** (R = Me): yellow oil; yield: 7.36 g (33%).
IR: $\nu$ = 2212 (CC), 1658 $cm^{-1}$(C=O).
$^1$H NMR (60 MHz): $\delta$ = 2.12 (3H, s, Me), 7.3–7.8 and 8.0–8.2 (3H, m and 1H, m, Ar-H).
HRMS *m/z*: $M^+$ Calcd for $C_{10}H_7OBr$: 221.9680, 223.9660. Found: 221.9677, 223.9696.

**2b** (R = *n*-Bu): yellow oil; yield: 18.82 g (71%).
IR: $\nu$ = 2204 (CC), 1658 $cm^{-1}$(C=O).
$^1$H NMR (60 MHz): $\delta$ = 0.93, 1.2–1.8 and 2.47 (3H, t, *J* = 7 Hz, 4H, m and 2H, t, *J* = 6 Hz, *n*-Bu), 7.3–7.8 and 8.0–8.2 (3H, m and 1H, m, Ar-H).
HRMS *m/z*: $M^+$ Calcd for $C_{13}H_{13}OBr$: 264.0150, 266.0130. Found: 264.0150, 266.0121.

**2c** (R = *t*-Bu): yellow oil; yield: 18.82 g (71%).
IR: $\nu$ = 2212 (CC), 1662 $cm^{-1}$(C=O).
$^1$H NMR (60 MHz): $\delta$ = 1.33 (9H, s, *t*-Bu), 7.3–7.7 and 8.0–8.2 (3H, m and 1H, m, Ar-H).
HRMS *m/z*: $M^+$ Calcd for $C_{13}H_{13}OBr$: 264.0150, 266.0130. Found: 264.0150, 266.0351.

**2d** (R = *n*-Hex): yellow oil; yield: 20.51 g (70%).
IR: $\nu$ = 2204 (CC), 1660 $cm^{-1}$ (C=O).
$^1$H NMR (60 MHz): $\delta$ = 0.90, 1.0–2.0 and 2.46 (3H, t, *J* = 6 Hz, 8H, m and 2H, t, *J* = 6 Hz, *n*-Hex), 7.4–7.9 and 8.0–8.3 (3H, m, and 1H, m, Ar-H).
HRMS *m/z*: $M^+$ Calcd for $C_{15}H_{17}OBr$: 292.0463, 294.0444. Found: 292.0070, 294.0036.

**2e** (R = *n*-Oct): yellow oil; yield: 22.79 g (7l%).
IR: $\nu$ = 2208 (CC), 1660 $cm^{-1}$(C=O).
$^1$H NMR (60 MHz): $\delta$ = 0.87, 1.0–1.8 and 2.43 (3H, t, *J* = 6 Hz, 12H, m and 2H, t, *J* = 6 Hz, *n*-Oct), 7.3–7.7 and 7.9–8.1 (3H, m and 1H, m, Ar-H).
HRMS *m/z*: $M^+$ Calcd for $C_{17}H_{21}OBr$: 320.0776, 322.0757. Found: 320.0783, 322.0743.

**2f** (R = Ph): yellow oil; yield: 22.96 g (89%).
IR: $\nu$ = 2196 (CC), 1652 $cm^{-1}$(C=O).
$^1$H NMR (60 MHz): $\delta$ = 7.3–7.8 and 8.0–8.2 (8H, m and 1H, m, Ar-H).
HRMS *m/z*: $M^+$ Calcd for $C_{15}H_9OBr$: 283.9837, 285.9818. Found: 283.9836, 285.9818.

***o*-Bromophenyl Trimethylsilylethynyl Ketone (2g):**
A mixture of benzoyl chloride **1** (10.98 g, 50 mmol), tributyl[(trimethylsilyl)ethynyl]stannane (20.18 g, 52 mmol) and benzylchlorobis(triphenylphosphine)palladium(II) (200 mg) in $CHCl_3$ (50 mL) was heated at 60 °C with stirring for 6 h. The mixture was cooled, diluted with $Et_2O$ (200 mL), and filtered through a Celite pad to remove the palladium precipitate. After evaporation oforganic solvent, the resulting residue was purified by chromatography (silica gel, *n*-hexane) to give **2g**; pale-yellow oil; yield: 6.32 g (45%).
IR: $\nu$ = 2156 (CC), 1660 $cm^{-1}$(C=O).
$^1$H NMR (60 MHz): $\delta$ = 0.35 (9H, s, TMS), 7.3–7.8 and 8.0–8.2 (3H, m and 1H, m, Ar-H).
HRMS *m/z*: $M^+$ Calcd for $C_{12}H_{13}OBrSi$: 279.9919, 281.9899. Found: 279.9886, 281.9869.

**Preparation of Tellurochromones 3A; Typical Procedure:**
A solution of *o*-bromophenyl ethynyl ketone **2** (10 mmol) in DMF (20 mL) was slowly added to a stirred solution of NaHTe (12 mmol), which was prepared from tellurium powder (1.54 g) and $NaBH_4$ (0.54 g) in DMF (40 mL), at about 100 °C for 1 h under argon. The mixture was stirred under these conditions for 2–5 h. After the addition of water (100 mL), the mixture was filtered. The filtrate was extracted with benzene (3 × 100 mL). The combined organic extracts were washed with water (3 × 200 mL) and brine (2 × 200 mL), dried ($MgSO_4$), and concentrated. The resulting residue was purified by chromatography (silica gel, *n*-hexane/acetone 50:1) to give **3A**. Crystalline products were recrystallized from *n*-hexane/acetone.

**Preparation of Selenochromones 3B; Typical Procedure:**
A solution of **2** (10 mmol) in EtOH (20 mL) was treated with NaHSe (12 mmol), prepared from selenium powder (0.95 g) and $NaBH_4$ (0.54 g), as described above. Similar workup gave **3B**.

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