

### A NOVEL SYNTHESIS OF SELENOPHENES

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**Abstract:** Reduction of  $\alpha, \alpha'$ -diketo selenides with a low-valent titanium reagent usually affords 3,4-dihydroxyselenolanes, from which the corresponding selenophenes are obtained by acid-catalyzed dehydration. A surprising exception is the formation of 2,4-dihydroxy-2,4-di-*t*-butylselenolane from bis(2-*t*-butyl-2-oxoethyl) selenide, the former being converted to 2,4-di-*t*-butylselenophene by acid treatment.

In spite of the explosive growth of the organoselenium chemistry in recent years, general syntheses of selenophenes are still rather limited.<sup>1</sup> Herein we report a novel synthesis of selenophenes from  $\alpha, \alpha'$ -diketo selenides (2). Selenides (2) are easily obtained in excellent yields by reaction of commercially available selenium oxychloride with 2 equiv of ketones followed by reduction of the resulting dichlorides (1).<sup>2</sup>

A solution of diphenacyl selenide (10 mmol) in THF (20 ml) was added dropwise to a stirred and cooled (ca. -10 °C) mixture of a low-valent titanium reagent,<sup>3</sup> prepared from titanium(IV) chloride (45 mmol) and zinc powder (90 mg. atoms) in THF (60 ml). The mixture was stirred for 15 min, warmed to 0 °C, and stirred for additional 3 h. Usual workup of the mixture followed

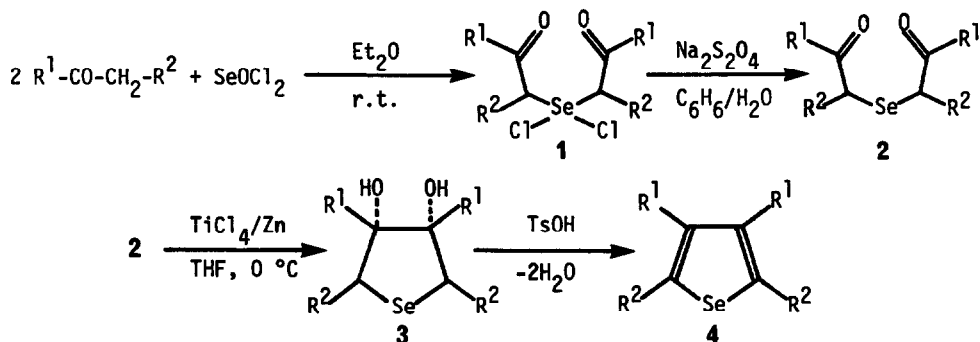


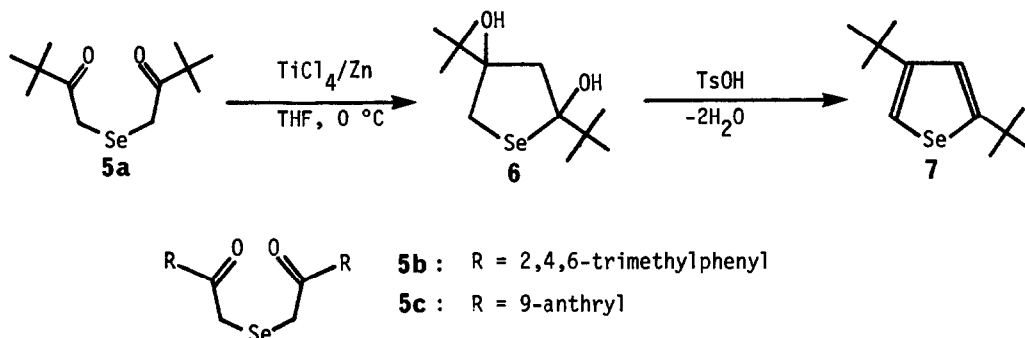
Table 1. Preparation of Selenophenes (4) from Diketo Selenides (2)

Run	R <sup>1</sup>	R <sup>2</sup>	Yield (%) 2 → 3	Yield (%) 3 → 4
1	C <sub>6</sub> H <sub>5</sub>	H	60	97
2	4-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	H	48	97
3	4-ClC <sub>6</sub> H <sub>4</sub>	H	70	97
4	2-thienyl	H	56	98
5	C <sub>6</sub> H <sub>5</sub>	CH <sub>3</sub>	55	94

by column chromatography gave *cis*-3,4-dihydroxy-3,4-diphenylselenolane in 60% yield. The *cis*-configuration of this diol was established by deselenation with Raney nickel in refluxing ethanol, which afforded *meso*-2,3-dihydroxy-2,3-diphenylbutane (44%) and interestingly *meso*-2,3-diphenylbutane (28%). Heating of the above diol with a catalytic amount of *p*-toluenesulfonic acid in refluxing toluene for 1 h afforded 3,4-diphenylselenophene in 97% yield.

In a similar way, several diketo selenides (2) were treated with the foregoing low-valent titanium reagent and the resulting 3,4-dihydroxyselenolanes (3)<sup>4</sup> were converted to the corresponding selenophenes (4) by treatment with *p*-toluenesulfonic acid (Table 1).

The selenide 5a carrying bulky *t*-butyl groups surprisingly gave 2,4-dihydroxy-2,4-di-*t*-butylselenolane (6) under the same conditions as described above.<sup>5,6</sup> This indicates that, since intramolecular reductive coupling between two carbonyl groups is sterically disfavored, reductive cleavage of the carbon-selenium bond first occurs probably to give the enolate of pinacolone and *t*-BuCOCH<sub>2</sub>SeTiCl<sub>2</sub>, which then undergo recombination leading to 6 after hydrolysis. Such carbon-selenium bond cleavage is also observed with sterically crowded selenides 5b and 5c, which afforded acetylmesitylene and 9-acetylanthracene quantitatively along with selenium. Acid-catalyzed dehydration of 6 provides a convenient synthesis of hitherto unknown 2,4-di-*t*-butylselenophene (7)<sup>7</sup> (30% overall yield from 5a).



## References and Notes

1. a) C. W. Bird, G. W. H. Cheeseman, and A. -B. Hörnfeldt, "Comprehensive Heterocyclic Chemistry," Vol. 4, C. W. Bird and G. W. H. Cheeseman, Eds., Pergamon Press, London, 1984, Chapter 3.17. b) M. Renson, "The Chemistry of Organic Selenium and Tellurium Compounds," Vol. 1, S. Patai and Z. Rappoport, Eds., John Wiley, New York, 1986, Chapter 16.
2. J. Nakayama, M. Shibuya, and M. Hoshino, *Heterocycles*, **26**, 909 (1987).
3. T. Mukaiyama, T. Sato, and J. Hanna, *Chem. Lett.*, 1041 (1973).
4. The reaction carried out in refluxing THF affords 3,4-dihydroxyselenophenes and 1,3-dienes in comparable yields; J. Nakayama, Y. Ikuina, F. Murai, and M. Hoshino, *J. Chem. Soc., Chem. Commun.*, 1072 (1987).
5. Application of the present method to the corresponding sulfide affords 3,4-dihydroxy-3,4-di-*t*-butylthiolane in good yield. See also J. Nakayama, H. Machida, R. Saito, and M. Hoshino, *Tetrahedron Lett.*, **26**, 1983 (1985) and J. Nakayama, S. Yamaoka, and M. Hoshino, *Tetrahedron Lett.*, **26**, 1799 (1987).
6. **6**: mp 80–82 °C; <sup>1</sup>H-NMR (CDCl<sub>3</sub>) δ 1.05 (9H, s, *t*-Bu), 1.13 (9H, s, *t*-Bu), 2.03 (1H, dd, J=13, 1.5 Hz), 2.27 (1H, d, J=13 Hz), 2.85 (1H, s, OH), 3.05 (1H, dd, J=11, 1.5 Hz), 3.38 (1H, d, J=11 Hz), 4.84 (1H, s, OH); <sup>13</sup>C-NMR (CDCl<sub>3</sub>) δ 26.0, 26.2 [C(CH<sub>3</sub>)<sub>3</sub>], 27.2, 27.3 [C(CH<sub>3</sub>)<sub>3</sub>], 33.5, 38.0, 40.3, 45.1, 91.9, 105.1.
7. **7**: bp 60–62 °C/10 mmHg (bulb-to-bulb distillation); <sup>1</sup>H-NMR (CDCl<sub>3</sub>) δ 1.26 (9H, s, *t*-Bu), 1.38 (9H, s, *t*-Bu), 6.99 (1H, d, J=1.5 Hz), 7.33 (1H, d, J=1.5 Hz); <sup>13</sup>C-NMR (CDCl<sub>3</sub>) δ 30.8, 31.0 [C(CH<sub>3</sub>)<sub>3</sub>], 33.1, 33.2 [C(CH<sub>3</sub>)<sub>3</sub>], 34.9 [C(CH<sub>3</sub>)<sub>3</sub>], 36.3 [C(CH<sub>3</sub>)<sub>3</sub>], 118.1, 118.3 (ring carbon at C-3 or C-5), 122.9, 123.2 (ring carbon at C-3 or C-5), 153.9 (ring carbon at C-2 or C-4), 164.4 (ring carbon at C-2 or C-4).