Cyclofunctionalisation of *ortho*-Alkenyl Phenols: a New Method for Introducing the Benzeneseleno-group

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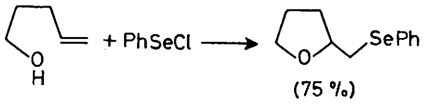
Summary *ortho*-Alkenyl phenols react rapidly with PhSeCl to produce derivatives of 2,3-dihydrobenzofuran or 3,4-dihydro-2*H*-benzo[*b*]pyran (depending on the nature of the *ortho*-substituent) in a process shown to belong to the general class of cyclofunctionalisations.

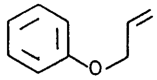
trans-ADDITION of PhSe–Z (Z = $\mathrm{OCOCF_3}$,[1] OAC,[2] OMe[2]) across double bonds is characterised by low regioselectivity.[1] However, strict regiochemical control is possible if the addition is arranged to be of a (formally) intramolecular type,[3] *e.g.*, equation (1).[3a] It was necessary to establish whether similar cyclisations could be accomplished with phenols because the resulting selenides[4] would have carbon skeletons similar to those that occur in many natural products. Simple phenols react instantaneously at room temperature with areneselenenyl halides[5] to produce *para*-substitution products in very high yield and so it was not predictable whether cyclisation [*e.g.*, (**1**) → (**2**), see Table] would compete effectively with electrophilic substitution of the aromatic ring. We examined the response of several olefinic phenols towards PhSeCl and have found conditions under which cyclisation occurs both very efficiently and at a low temperature (see Table).

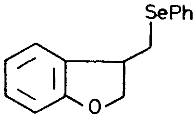


(1)

In each experiment a dry EtOAc solution of PhSeCl (1 equiv., *ca.* 0·15 M) was added slowly (*ca.* 1 mmol h^{-1}) to a stirred EtOAc solution of the phenol (*ca.* 0·15 M) at −75 °C. The mixture was maintained for 1—4 h at this temperature after the addition and the cyclised products were isolated with the results shown.

The general procedure is not applicable to allyl ethers such as (**14**). Thus, none of the cyclised product (**15**) was isolated from experiments using PhSeCl, PhSe–$\mathrm{OCOCF_3}$, or $\mathrm{PhSe^+SbF_6^-}$.[6]


(**14**)

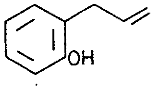
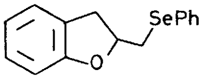
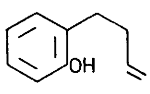
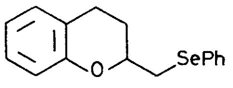
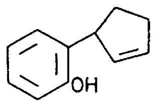
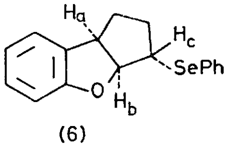
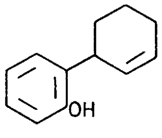
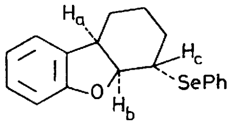
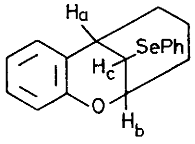
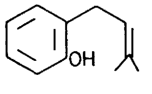
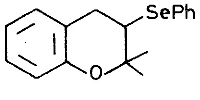
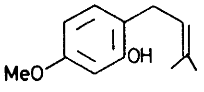
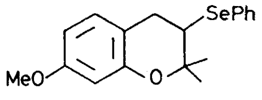


(**15**)

Selenoxide fragmentation[7] of (**13**) gave (54%) the natural insecticide, Precocene-I.[8]

The new reactions reported here as well as the cyclisation of olefinic alcohols[3a,3b] (equation 1) and acids[3c,3d] with PhSeCl conform to a general pattern of intramolecular ring closure in which one terminus of the double bond involved in the ring-forming process becomes attached to a group specifically chosen to allow (in principle) further modification at that site. We propose the term cyclofunctionalisation for this synthetic strategy.[9]

TABLE

Phenol[a]	Cyclisation product[b]	Yield %
 (**1**)	 (**2**)	81[c]
 (**3**)	 (**4**)	80
 (**5**)	 (**6**)	92
 (**7**)	 (**8**)	67
	 (**9**)	—[d]
 (**10**)	 (**11**)	81
 (**12**)	 (**13**)	79

[a] The phenols are known compounds and were made by literature methods: (**3**) (M. Ōki and H. Iwamura, *Bull. Chem. Soc. Japan*, 1960, **33**, 681); (**5**) and (**7**) (Gy Fráter and H. Schmid, *Helv. Chim. Acta*, 1967, **50**, 255); (**10**) (C. D. Hurd and W. A. Hoffman, *J. Org. Chem.*, 1940, **5**, 212); (**12**) (J. Hlubucek, E. Ritchie, and W. C. Taylor, *Austral. J. Chem.*, 1971, **24**, 2355).

[b] The cyclisation products are new compounds for which both satisfactory analytical data (±0·3%) and mass measurements were obtained. With the exception of (**2**), m.p. 64—65 °C, the products are liquids distillable under reduced pressure (*ca.* 0·01 Torr) using a Kugelrohr oven temp. of *ca.* 130 °C (**6**): δ ($\mathrm{CDCl_3}$) 3·82—4·12 (H_a and H_c, m) and 5·19 (H_b, dd, J_{ab} 8, J_{bc} 1 Hz); (**8**): δ ($\mathrm{CDCl_3}$) 3·2—3·63 (H_a and H_c, m) and 4·69 (H_b, t, $J_{ab}=J_{bc}$ = 7·2 Hz); (**9**): δ($\mathrm{CDCl_3}$) 3·15 (H_a, br), 3·74 (H_c, br), and 4·6 (H_b, br).

[c] If $\mathrm{PhSeOCOCF_3}$ is used (in $\mathrm{CH_2Cl_2}$) the yield is *ca.* 50%.

[d] Appreciable quantities of (**9**) were generated in one experiment when the reaction mixture was kept for *ca.* 15 h at room temp. after the addition of PhSeCl. In this case (**8**) and (**9**) were formed in a ratio of *ca.* 3 : 1.

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[3] (a) D. L. J. Clive, G. Chittattu, and C. K. Wong, *Canad. J. Chem.*, in the press; (b) K. C. Nicolaou and Z. Lysenko, *Tetrahedron Letters*, 1977, 1257; (c) D. L. J. Clive and G. Chittattu, *J.C.S. Chem. Comm.*, 1977, 484; (d) K. C. Nicolaou and Z. Lysenko, *J. Amer. Chem. Soc.*, 1977, **99**, 3185.

[4] For recent examples demonstrating the use of selenides in synthesis, see G. Stork and S. Raucher, *J. Amer. Chem. Soc.*, 1976, **98**, 1583; P. A. Grieco, M. Nishizawa, S. D. Burke, and N. Marinovic, *ibid.*, p. 1612.

[5] L. R. M. Pitombo, *Chem. Ber.*, 1959, **92**, 745.

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[7] D. L. J. Clive, *J.C.S. Chem. Comm.*, 1973, 695; K. B. Sharpless, M. W. Young, and R. F. Lauer, *Tetrahedron Letters*, 1973, 1979; H. J. Reich, I. L. Reich, and J. M. Renga, *J. Amer. Chem. Soc.*, 1973, **95**, 5813.

[8] W. S. Bowers, T. Ohta, J. S. Cleere, and P. A. Marsella, *Science*, 1976, **193**, 542.

[9] For a theoretical treatment of ring closures see J. E. Baldwin, *J.C.S. Chem. Comm.*, 1976, 734.