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PUMMERER-LIKE REACTION OF SELENIUM(IV)-DICHLORIDES. SYNTHESIS OF α-CHLORO-α-PHENYLSELENENYLKETONES AND α,α-DICHLORO-α-PHENYLSELENENYLKETONES

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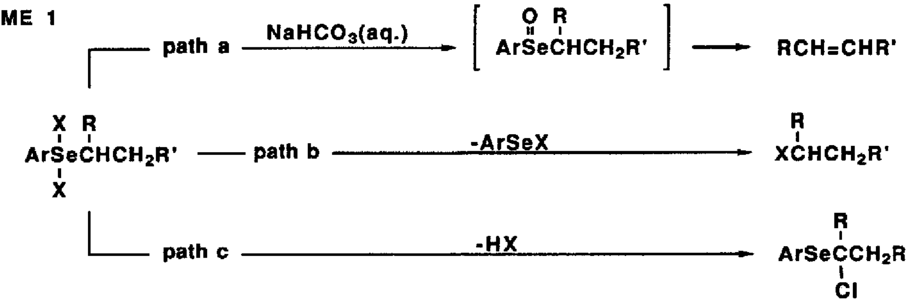
Selenium(IV)-dichlorides 1, readily available by treatment of methyl ketones with phenylselenium trichloride or selenium tetrachloride, were treated in methylene chloride with pyridine to give α-chloroselenides 2 in a Pummerer-like reaction. Sulfuryl chloride chlorination of these materials and repeated pyridine treatment similarly afforded α,α-dichloroselenides 4.

Selenium(IV)-dihalides have recently attracted attention as versatile intermediates in organic synthesis. Their ready hydrolysis to give selenoxides forms the basis for a new mild variation of the selenoxide elimination reaction, applicable to the preparation of enones,[1,2] allylic and vinylic chlorides[3,4] and esters[5] (Scheme 1, path a). The old finding[6] that alkyl aryl selenium dichlorides decompose upon heating to give alkyl halides and the respective arylselenenyl halides has recently been applied to the synthesis of alkyl halides from selenides,[7] selenoxides,[8] alcohols,[9] β-haloselenides,[4,10] β-methoxyselenides[11] and α-formylselenides[12] (Scheme 1, path b). Paulmier and coworkers[12] recently observed the formation of α-chloro-α-phenylselenenylaldehydes from the Se,Se-dichlorides of certain 2-phenylselenenylaldehydes (although the products were never isolated in pure form) (Scheme 1, path C; R=CHO).

SCHEME 1



We report here Pummerer-like reactions of selenium(IV)-dichlorides 1 and 3, leading, in high yields, to isolable α-chloro-α-phenylselenenylketones 2 (eq. 1; R' = Ph) and α,α-dichloro-α-phenylselenenylketones 4 (eq. 2; R'=Ph), respectively. The transformations were also applicable to bis-(acylmethyl)selenium dichlorides 1 and 3 as shown (eq. 1 - 2; $R'=R\overset{O}{C}CH_2$). A typical procedure involved treatment of the selenium(IV)-dichloride at ambient temperature in methylene chloride with an excess of pyridine (5 equivalents) for 1 h, followed by acidic (10% HCl aq.) workup and chromatographic purification of the product. The selenium(IV)-dichlorides 3 required were obtained in a separate step by treatment of selenides 2 in chloroform with a

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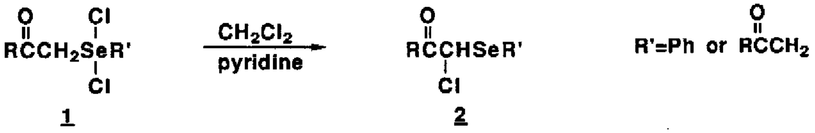
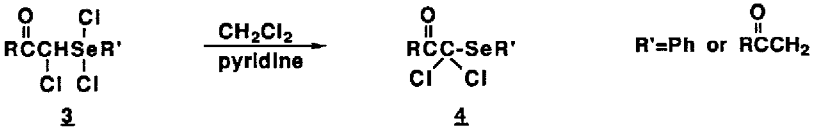


(2)


stoichiometric amount of sulfuryl chloride in chloroform.

The isolated yields of products 2 and 4 and selenium(IV)-dichloride intermediates 3 are shown in Table 1. The reactions of compounds 3l-3o afforded only the *gem*-dichlorides 4l-4o. Repeated chlorination/pyridine treatment of these materials in order to obtain the corresponding α,α,α'-trichloro and α,α,α',α'-tetrachloro selenides turned out to be difficult. Attempts to extend the reactions shown in equations 1 and 2 to other selenium(IV)-dichlorides than those derived from methyl ketones also resulted in complex product mixtures.

The selenium(IV)-dichloride starting materials 1 are all readily available. Compounds 1a-1k were obtained by treatment of phenylselenium trichloride, $PhSeCl_3$, with a slight excess of the corresponding methyl ketone in dry ether or in acetic acid.[1] Compounds 1c, 1d, 1g and 1k, not previously prepared, were isolated in 71, 78, 96 and 61% yields, respectively. The high selectivity for methyl substitution observed with methyl isobutyl ketone (compound 1k) was usually not seen with other sterically less hindered unsymmetric dialkyl ketones.[1] Bis-(acylmethyl)selenium dichlorides are available by treatment of ketones with $SeOCl_2$[13] or SeO_2/HCl.[14] We find the old synthesis using selenium tetrachloride[15] very convenient for large-scale preparation of compounds 1l-1o.

The mechanism of the reactions shown in eq. 1-2 seems to be related to the well-known seleno-Pummerer reaction.[16] After proton abstraction and loss of pyridinium hydrochloride as shown in eq. 3, the resulting selenonium chloride 5 could rearrange to product via nucleophilic

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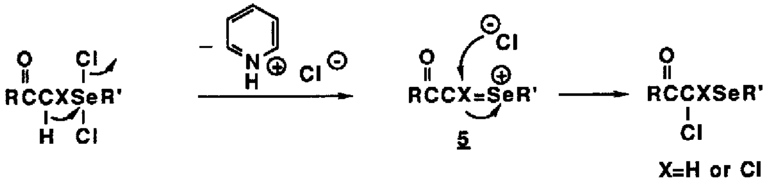

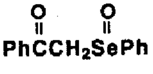

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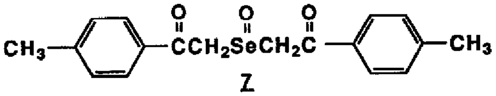

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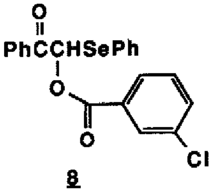

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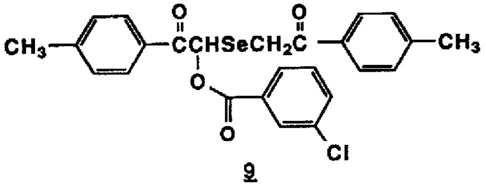

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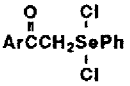
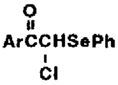
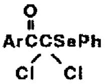
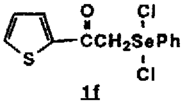
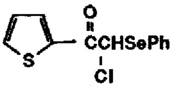
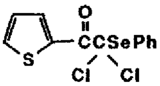
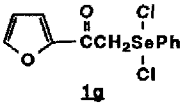
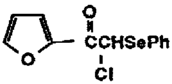
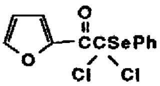
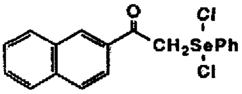
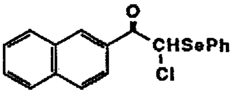
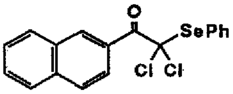
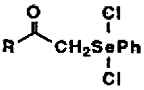
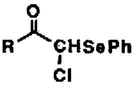
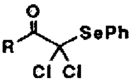
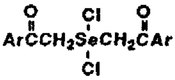
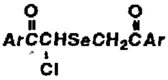
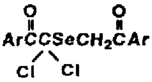
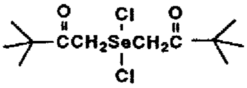
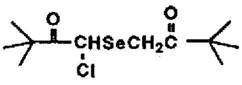
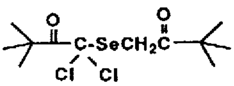
TABLE 1 Preparation of α-Chloro-α-phenylselenenylketones, α,α-Dichloro-α-phenylselenenylketones and Related Compounds from Selenium(IV)-dichlorides.

selenium(IV)-dichloride 1	product 2	yield (%)	product 3 yield (%)	product 4	yield (%)
 $\mathrm{Ar\overset{O}{C}CH_2\underset{Cl}{\overset{Cl}{Se}}Ph}$	 $\mathrm{Ar\overset{O}{C}\underset{Cl}{C}HSePh}$			 $\mathrm{Ar\overset{O}{C}\underset{Cl\ Cl}{C}SePh}$	
1 a Ar=C_6H_5	2 a Ar=C_6H_5	93	3a(95)	4 a Ar=C_6H_5	67
b Ar=4-Me-C_6H_4	b Ar=4-Me-C_6H_4	89	3b(87)	b Ar=4-Me-C_6H_4	78
c Ar=4-MeO-C_6H_4	c Ar=4-MeO-C_6H_4	82	3c(97)	c Ar=4-MeO-C_6H_4	74
d Ar=4-Cl-C_6H_4	d Ar=4-Cl-C_6H_4	89	3d(64)	d Ar=4-Cl-C_6H_4	82
e Ar=4-NO_2-C_6H_4	e Ar=4-NO_2-C_6H_4	84	3e[a]	e Ar=4-NO_2-C_6H_4	33[b]
 1f	 2f	79	3f(88)	 4f	97
 1g	 2g	86	3g(88)	 4g	77
 1h	 2h	92	3h(85)	 4h	64
					
1 i R=CH_3	2 i R=CH_3	89	3i(83)	4 i R=CH_3	83
j R=t-C_4H_9	j R=t-C_4H_9	90	3j[a]	j R=t-C_4H_9	57[b]
k R=i-C_4H_9	k R=i-C_4H_9	87	3k(46)	k R=i-C_4H_9	84
 $\mathrm{Ar\overset{O}{C}CH_2\underset{Cl}{\overset{Cl}{Se}}CH_2\overset{O}{C}Ar}$	 $\mathrm{Ar\overset{O}{C}\underset{Cl}{C}HSeCH_2\overset{O}{C}Ar}$			 $\mathrm{Ar\overset{O}{C}\underset{Cl\ Cl}{C}SeCH_2\overset{O}{C}Ar}$	
1 l Ar=C_6H_5	2 l Ar=C_6H_5	82	3l(99)	4 l Ar=C_6H_5	72
m Ar=4-Me-C_6H_4	m Ar=4-Me-C_6H_4	73	3m[a]	m Ar=4-Me-C_6H_4	76[b]
n Ar=4-Cl-C_6H_4	n Ar=4-Cl-C_6H_4	84	3n(97)	n Ar=4-Cl-C_6H_4	84
 1o	 2o	70	3o(83)	 4o	71

a yield not determined.

b yield based on the corresponding α-chloroselenide 2 (the corresponding selenium (IV)-dichloride 3 was prepared in CH_2Cl_2 without isolation and treated with pyridine).

attack of chloride ion. Since the reactions could be run under anhydrous reaction conditions,[17] a possible selenoxide intermediate (formed from traces of water present) was eliminated from consideration. Attempts to prepare the selenoxides 6 and 7 by m-chloroperbenzoic acid oxidation of the corresponding selenides resulted in the formation of α-acyloxyselenides 8 and 9, respectively. Similar Pummerer-type transformations were previously reported with other selenides carrying acidic protons in the α-position.[18]

α-Chloroselenides are available by a variety of methods.[19,20] The procedure described in this paper should be a useful addition to them due to its simple operation and ready availability of starting materials. The potential of α-chloroselenides as reaction intermediates in organic synthesis has so far been very little studied[20,21] and α,α-dichloroselenides have, to the best of our knowledge, never been previously prepared. Considering the versatility of the related α-chlorosulfides as synthetic intermediates,[22] much development is awaited in the future. We are presently studying the hydrolysis and oxidative deselenation of compounds 2 and 4 as a method of oxidizing methyl ketones in a controlled way to α-ketoaldehydes or α-ketoacids.

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