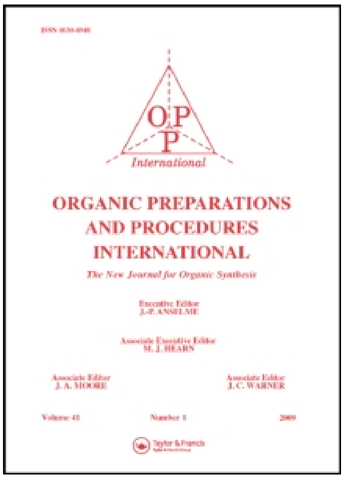

Organic Preparations and Procedures International
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t902189982

SELENIUM AND TELLURIUM ISOLOGUES OF CARBOXYLIC ACID DERIVATIVES

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To cite this Article Kato, Shinzi , Murai, Toshiaki and Ishida, Masaru(1986) 'SELENIUM AND TELLURIUM ISOLOGUES OF CARBOXYLIC ACID DERIVATIVES', Organic Preparations and Procedures International, 18: 6, 369 — 427
To link to this Article: DOI: 10.1080/00304948609457898
URL: http://dx.doi.org/10.1080/00304948609457898

ORGANIC PREPARATIONS AND PROCEDURES INT. 18(6), 369-427 (1986)

SELENIUM AND TELLURIUM ISOLOGUES OF CARBOXYLIC ACID DERIVATIVES

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INTRODUCTION

The chemistry of dithiocarboxylic acids and their derivatives, in which one or two oxygen atoms of carboxylic acids are replaced by sulfur atom, has been extensively developed.[1] In contrast, the chemistry of the selenium and tellurium isologues of carboxylic acids[2a,b] (hereafter cited as chalcogenocarboxylic acids)[2c] has rarely been explored, because of their difficult synthesis. However, this field has been attractive because of the findings of the liquid crystal properties of seleno- and tellurocarboxylic acid esters[3] and of an efficient synthetic method for steroids via the selenocarboxylic acid esters.[4] This review which covers the literature to the end of 1985 surveys the synthetic methods, reactions and spectra of the isolated chalcogenocarboxylic acid derivatives, which are collected in Table 8 and 9.

I. SYNTHESIS

1. Selenocarboxylic Acids

Selenocarboxylic acids (1) can be prepared by acidolysis with conc. HCl of the sodium salts (2) which are obtained from an acid chloride and sodium hydrogen selenide. However, their

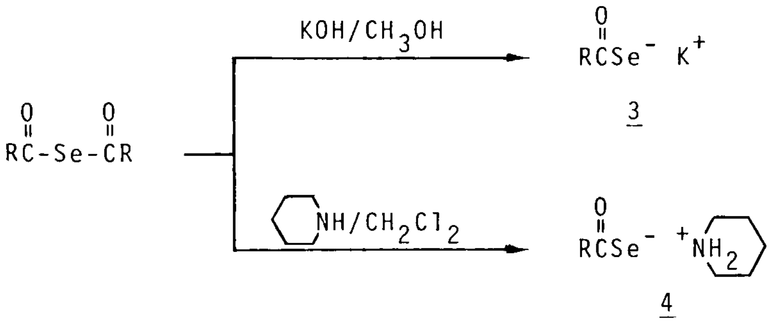
$$R\overset{\overset{O}{\|}}{C}Cl + NaHSe \longrightarrow [\, R\overset{\overset{O}{\|}}{C}Se^- \; Na^+ \,] \longrightarrow R\overset{\overset{O}{\|}}{C}SeH \qquad (1)$$

2 1

isolation is very difficult because the acids are extremely unstable toward oxygen and light. In 1972, Jensen *et al.*[5] obtained selenobenzoic acid as a yellow oil showing a signal at δ 3.85 assignable to SeH hydrogen. The acid is obtainable from hydrolysis of trimethylsilyl selenobenzoate as a reddish yellow oil showing a characteristic absorption band at 2310 cm^{-1} also assigned to the Se-H stretch.[6] Very recently, 4-biphenylselenocarboxylic acid was isolated for the first time as red crystals, mp. 39-40°C.[7]

2. Selenocarboxylic Acid Salts

Although sodium selenocarboxylates can be prepared by the reaction of an acyl chloride with sodium selenides or sodium hydrogen selenide, purification of the salts is very difficult.[5] Isolation of the potassium (3) and piperidinum salts (4) has been reported from the reaction of bis(acyl) selenides



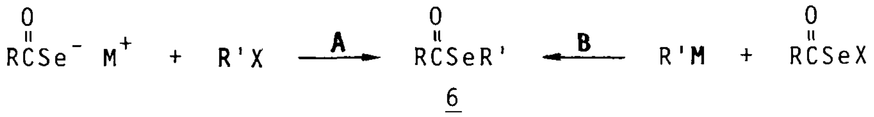
with potassium hydroxide or piperidine.[8,9] Recently, we have shown that bis(acyl) diselenide is more effective as a starting compound than the monoselenide because of its stability toward oxygen, moisture, and light,[10] and it was possible to isolate a variety of heavy metal selenocarboxylates such as tin, lead, and zinc.

3. Alkyl or Aryl Selenocarboxylates

Selenocarboxylic acid esters (6) are the largest number of compounds in the isolated chalcogenocarboxylic acid derivatives. Several synthetic methods have been developed. They seem to be divided into the following two types of bond formation: a) RCO- and R'Se-, b) RCOSe- and R'-. Historically the former, especially the reaction of an acyl chloride with selenol, is the oldest[11] and has been widely utilized.[4, 12-15] Instead of selenol and an acyl chloride, a number of selenolating and acylating agents have been examined: metal selenophenolates (Si,[16] Pb,[16] Cd,[17] Mg[3,18]), thallium butaneselenoxide and benzeneselenoxide,[19] and *O*-diselenabenzenezirconocene,[20] and N-acyl imidazolide[21a,b] and triazolide.[21b] In addition, high yields have been described for the following combinations: acylhydrazine and benzeneseleninic acid,[22] carboxylic acid and arylselenocyanate,[23a] N-phenylselenophthalide,[23b,c] or arylselenyl halogenide[24] in the presence of tris(n-butyl)phosphine, an acyl chloride or carboxylic acid and diaryl diselenide in the presence of trialkylphosphine or P_2I_4,[19b] alkyl esters and dimethylaluminium methylselenate.[19d] Very recently, a convenient preparation for the aromatic esters (6, R = aromatic) has been reported using desulfurization of S-acyl arylselenosulfenate (5) with triphenylphosphine.[25]

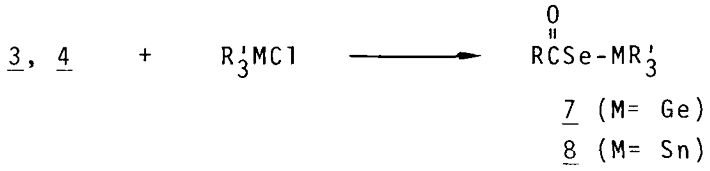
$$\underset{\underline{5}}{\mathrm{R\overset{O}{\overset{\|}{C}}SSeR'}} + \mathrm{Ph_3P} \longrightarrow \underset{\underline{6}}{\mathrm{R\overset{O}{\overset{\|}{C}}SeR'}} \qquad (3)$$

For the bond formation of method (b), the two routes shown in Eq. 4 can be considered. At the present stage, however, it



$$\mathrm{R\overset{O}{\overset{\|}{C}}Se^- \; M^+} + \mathrm{R'X} \xrightarrow{\mathbf{A}} \underset{\underline{6}}{\mathrm{R\overset{O}{\overset{\|}{C}}SeR'}} \xleftarrow{\mathbf{B}} \mathrm{R'M} + \mathrm{R\overset{O}{\overset{\|}{C}}SeX} \qquad (4)$$

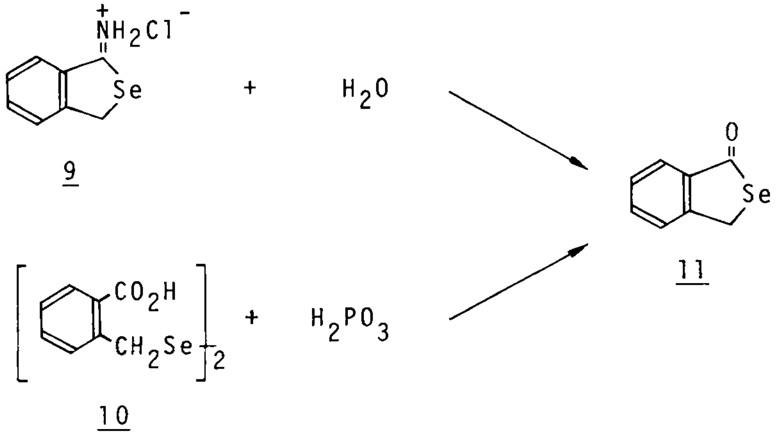
is limited to route **A**, because of non-availability of the starting materials such as acylselenenyl halides required by route **B**.[9,26] Organogermanium (7) and tin esters (8) have been isolated by method **A**.



$$\underline{3},\ \underline{4} + \mathrm{R'_3MCl} \longrightarrow \mathrm{R\overset{O}{\overset{\|}{C}}Se\text{-}MR'_3} \qquad (5)$$

$\underline{7}$ (M= Ge)
$\underline{8}$ (M= Sn)

There has been three reports concerning the preparation of cyclic selenolesters. The report of Drory in 1891 is the earliest one concerning selenophthalide (11), obtained from salt (9) of iminoselenoester.[27] Later, treatment of α,α'-



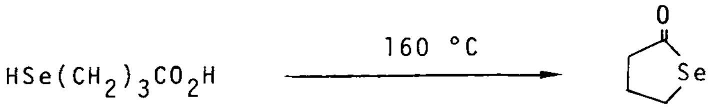
9

10

11

(6)

diseleno-*O*-toluic acid (10) with hypophosphoric acid was found to lead to 11 in good yield.[28] Isolation of γ-selenobutyrolactone (12)[29] and 1-selenocoumarin derivatives (13)[30] has been reported.



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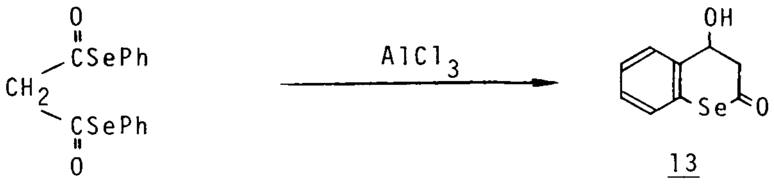

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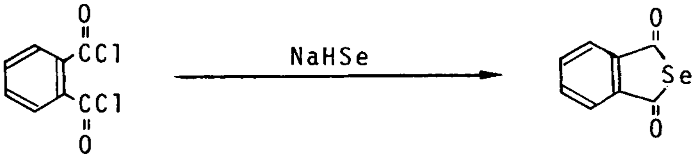
(8)

4. Bis(acyl) Selenides

Bis(acyl) selenides are one of the selenium isologues of carboxylic acid anhydrides. In 1972, Jensen *et al.* reported the first isolation of bis(benzoyl) selenide, utilizing the pyrolysis of selenobenzoic acid under a nitrogen atmosphere, and bis(propionyl) selenide, utilizing the reaction of propionyl chloride with hydrogen selenide.[5] Although sodium hydrogen selenide can be employed instead of hydrogen selenide, the formation of by-products reduces the yield of the product. From the standpoint of yield and isolation procedures, the most desirable method is the deselenylation of bis(acyl) diselenides using triphenylphosphine.[9] Recently an unsymmetrical bis(acyl) selenide (55) was isolated by the reaction of aromatic selenocarboxylic acid with phenyl isocyanate (Eq. 32).[7] A cyclic bis(acyl) selenide, phthaloyl selenide has been prepared by the phase-transfer catalyzed reaction of phthaloyl chloride and sodium hydrogen selenide.

$$\mathrm{R\overset{\overset{O}{\|}}{C}\text{-}Se\text{-}Se\text{-}\overset{\overset{O}{\|}}{C}R \xrightarrow{Ph_3P} R\overset{\overset{O}{\|}}{C}\text{-}Se\text{-}\overset{\overset{O}{\|}}{C}R + Ph_3PSe} \quad (9)$$

14 15



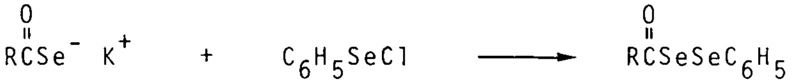
(10)

5. Bis(acyl) Diselenides

Bis(acyl) diselenides are one of the selenium isologues of diacyl peroxides. Bis(benzoyl) diselenide was found in the products obtained from the reaction of benzoyl chloride with hydrogen selenide.[32-34] In the early 1970's, it was reported that the pyrolysis of selenobenzoic acid gave bis(benzoyl) diselenide.[5] A practical method involves the reaction of an acyl chloride with sodium hydrogen selenide, followed by the oxidation with oxygen or iodine. When this procedure was employed, aromatic bis(acyl) diselenides were isolated in 70-90 % yields. Instead of sodium hydrogen selenide, disodium diselenide can also be employed to give 40-60% yields of the products, although the difficulty remains to obtain disodium diselenide in high purity.[35] No example of the preparation of cyclic derivatives has been reported.

6. Acyl, Alkyl or Aryl Diselenides

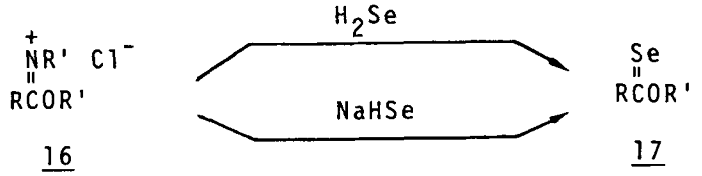
As a selenium isologue of peracid ester, 4-chlorobenzoyl phenyl diselenide has been reported to be easily prepared by the reaction of the corresponding selenocarboxylic acid potassium salt with phenylselenenyl chloride.[7]



$$\overset{O}{\overset{\|}{RC}}Se^{-}\ K^{+} + C_6H_5SeCl \longrightarrow \overset{O}{\overset{\|}{RC}}SeSeC_6H_5 \qquad (11)$$

7. *O*-Alkyl or *O*-Aryl Selenoncarboxylates

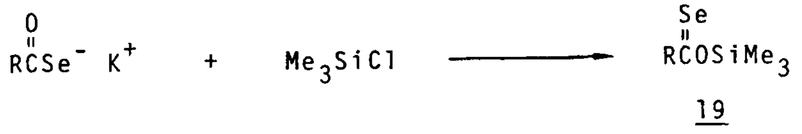
Synthetic methods for selenoncarboxylates (17) have been limited, because of the fact that it has been impossible to prepare selenoncarboxylic acids (RCSeOH) or their metal salts (RCSeOM). The method involving the reaction of iminoester hydrochloride (16) with hydrogen selenide gave the product only in low yields[36,37] and is not applicable to the preparation of aliphatic derivatives such as *O*-methyl selenonacetate.[38] Cohen[39] has prepared alkyl and aryl selenoncarboxylates in good yields by improving the preparative method of imidoesters. Furthermore, Barton *et al.*[40,41] have reported a more general method involving the treatment of N,N-dimethyliminoester hydrochloride (16, R = CH_3) with sodium hydrogen selenide to give *O*-alkyl selenoncarboxylates in high yields. Instead of imidoesters, alkoxycarbene chromium complexes (18) are also employable,[42] although the preparation of starting complex limits this method.



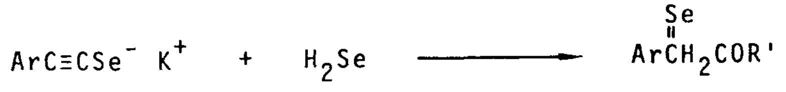
$$\underset{\underline{16}}{\mathrm{R}\overset{\overset{+}{\mathrm{N}}\mathrm{R'}\ \mathrm{Cl}^-}{\overset{\|}{\mathrm{C}}}\mathrm{OR'}} \xrightarrow[\mathrm{NaHSe}]{\mathrm{H_2Se}} \underset{\underline{17}}{\mathrm{R}\overset{\mathrm{Se}}{\overset{\|}{\mathrm{C}}}\mathrm{OR'}} \qquad (12)$$

$$\underset{\underline{18}}{\mathrm{Ar}\overset{\mathrm{Cr(CO)_5}}{\overset{\|}{\mathrm{C}}}\mathrm{OCH_3}} + \mathrm{Se} \longrightarrow \mathrm{Ar}\overset{\mathrm{Se}}{\overset{\|}{\mathrm{C}}}\mathrm{OCH_3} \qquad (13)$$

In contrast to a variety of thioacylating agents,[43] no example of selenoacylating agents has been reported. Our attempts to generate selenoacylating agent using *O*-trimethylsilyl selenoncarboxylates (<u>19</u>), which were prepared by the silylation of potassium selenocaboxylates (<u>3</u>), failed.[26] Although the synthetic generality were limited, potassium ethynylselenolate has been shown to play a role as an equivalent of selenoacyl group.[44]

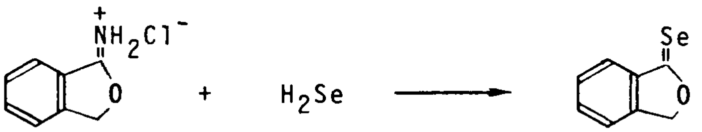


$$\mathrm{R}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{Se^-\ K^+} + \mathrm{Me_3SiCl} \longrightarrow \underset{\underline{19}}{\mathrm{R}\overset{\mathrm{Se}}{\overset{\|}{\mathrm{C}}}\mathrm{OSiMe_3}} \qquad (14)$$



$$\mathrm{ArC{\equiv}CSe^-\ K^+} + \mathrm{H_2Se} \longrightarrow \mathrm{ArCH_2}\overset{\mathrm{Se}}{\overset{\|}{\mathrm{C}}}\mathrm{OR'} \qquad (15)$$

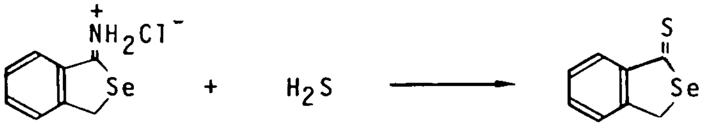
A cyclic selenoncarboxylates such as selenoncarbonylphthalide has been prepared by treating iminophthalide with hydrogen selenide.[45,46]



(16)

8. Selenothioncarboxylates

In 1964, the first isolation of a selenothioncarboxylate such as selenothionphthalide (20), utilizing the reaction of iminoselenophthalide with hydrogen sulfide, was reported by Renson and Collienne.[45]



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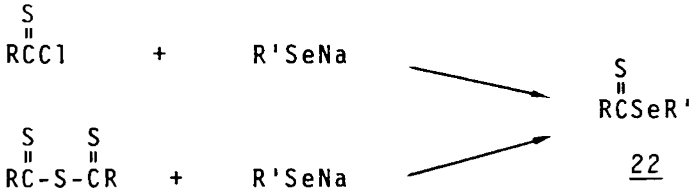


$$\overset{S}{\overset{\|}{RCCl}} + R'SeNa \longrightarrow \overset{S}{\overset{\|}{RCSeR'}}$$

$$\overset{S}{\overset{\|}{RC}}\text{-}S\text{-}\overset{S}{\overset{\|}{CR}} + R'SeNa \longrightarrow \overset{S}{\overset{\|}{RCSeR'}}$$

22

(18)

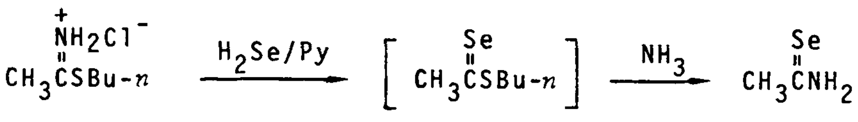
$$(CF_3)_2C{=}C{=}S + C_6H_5SeH \longrightarrow (CF_3)_2CH\overset{S}{\overset{\|}{C}}SeC_6H_5 \qquad (19)$$

After that, acyclic derivatives were synthesized by the reaction of thioacyl chloride with sodium selenolate.[47] This method seems to be most desirable, but is limited to prepare aromatic derivatives (22, R = Ar). (It is difficult to prepare aliphatic thioacyl chloride.) The methods using dithiocarboxylic acid anhydrides[48] or thioketene[49] as thioacylating agents has also been reported, although the use of the latter is not a practical method because of the difficulty to prepare it.

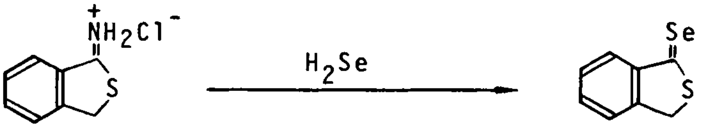
9. Thioselenoncarboxylates

No example of the isolation of thioselenoncarboxylates has been reported. Renson *et al.*[36] have reported that the treatment of butane thiol iminoacetate hydrochloride with hydrogen selenide in the presence of pyridine gave the dark purple oil, which would be S-*n*-butyl thioselenonethanoate (24). Since 24 was thermally very unstable, it was identified by converting to selenoamide (25).

In a similar manner, a cyclic derivative, thioselenonphthalide (26), has been prepared from iminothiophthalide hydrochloride.



$$\underset{\underline{23}}{CH_3\overset{\overset{+}{N}H_2Cl^-}{\overset{\|}{C}}SBu\text{-}n} \xrightarrow{H_2Se/Py} \underset{\underline{24}}{\left[CH_3\overset{Se}{\overset{\|}{C}}SBu\text{-}n\right]} \xrightarrow{NH_3} \underset{\underline{25}}{CH_3\overset{Se}{\overset{\|}{C}}NH_2} \qquad (20)$$



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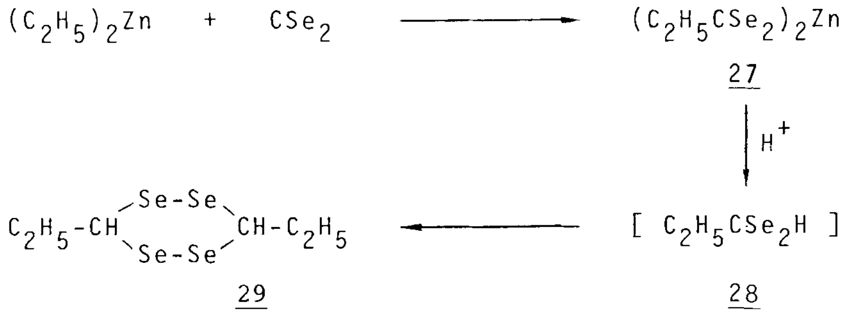
(21)

10. Diselenocarboxylic Acids and their Salts

No isolation of diselenocarboxylic acids has been described in the literature. The reaction of a Grignard reagent with carbon diselenide did not produce the expected insertion product ($RCSe_2MgX$). Instead, the reaction of diethylzinc with CSe_2 followed by acidolysis with HCl, gave the tetraselenane (29), which is considered to be the dimer of the expected diselenopropionic acid (28).[50]



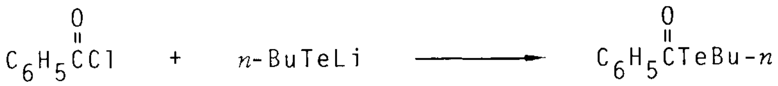
(22)

11. Alkyl or Aryl Tellurocarboxylates

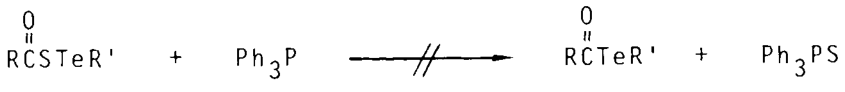
Most of the isolated tellurium isologues of carboxylic acid derivatives are tellurocarboxylic acid esters (30). The preparative method has been limited to the reaction of acyl chloride[52,53] or acid anhydride[54] with sodium aryltellurolate, because of the difficult preparation of aliphatic tellurols and tellurocarboxylic acids (1) and their salts. Only *n*-butyl tellurobenzoate has been described in the literature, using lithium[52] or sodium[54] *n*-butyltelluroate. Attempts to prepare aryl tellurocarboxylates (30, R, R'= aryl) by desulfurization of S-aryltellurosulfenate (31) with phosphines failed.[24] The

$$\mathrm{R}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{X} \quad + \quad \mathrm{R'TeNa} \longrightarrow \mathrm{R}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{TeR'} \qquad (23)$$

$X = Cl, RCO_2$ 30



$$C_6H_5\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{Cl} \quad + \quad n\text{-}\mathrm{BuTeLi} \longrightarrow C_6H_5\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{TeBu}\text{-}n \qquad (24)$$

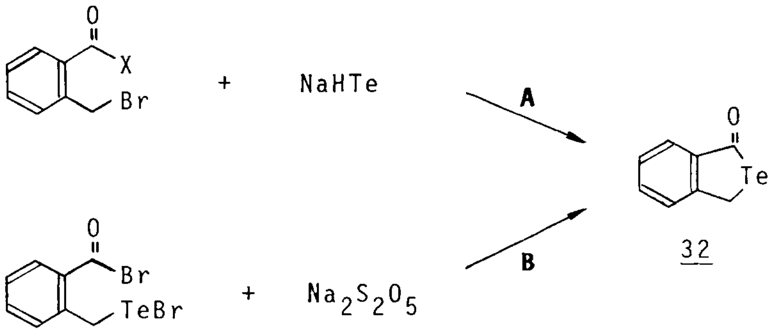


$$\mathrm{R}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{STeR'} \quad + \quad \mathrm{Ph_3P} \not\longrightarrow \mathrm{R}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}\mathrm{TeR'} \quad + \quad \mathrm{Ph_3PS} \qquad (25)$$

31 30

tellurosulfenate (31) is unexpectedly inactive toward phosphine. (See Ref. 107)

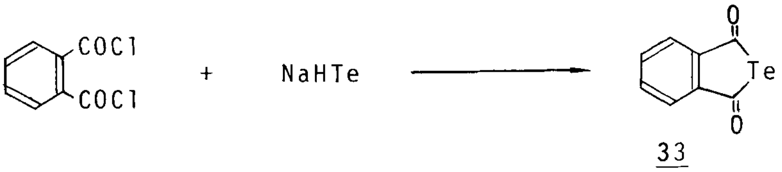
Tellurophthalides (32), cyclic tellurocarboxylates, can be synthesized from the following two routes[55] (Eq. 26). The route **A** using *O*-bromomethylbenzoyl bromide lead to quantitative yields.



(26)

12. Bis(acyl) Tellurides

Bis(acyl) tellurides are one of the tellurium isologues of acid anhydrides. Only phthaloyl telluride (33) has been isolated from the reaction of phthaloyl chloride with sodium hydrogen telluride[31] (Eq. 27) as yellow crystals which are fairly stable toward heat, light, and oxygen. In contrast,



(27)

$$2\ R\overset{O}{\overset{\|}{C}}Cl + Na_2Te \longrightarrow R\overset{O}{\overset{\|}{C}}\text{-Te-}\overset{O}{\overset{\|}{C}}R \qquad (28)$$

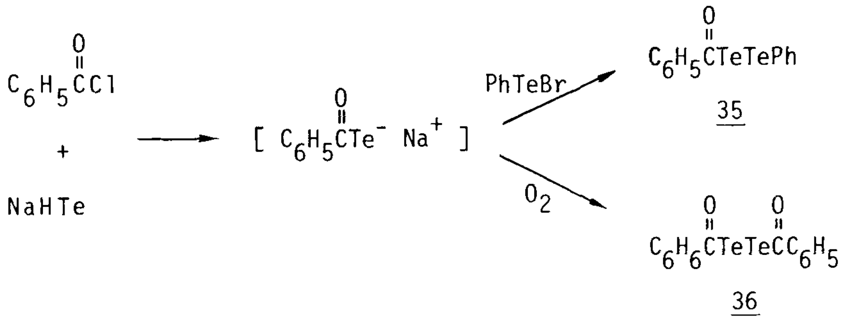
34

a) $R = 2\text{-}ClC_6H_4$ b) $R = 2\text{-}CH_3OC_6H_4$ c) $R = 1\text{-}C_{10}H_7$

isolation of the acyclic derivatives (34) has been thwarted, because of their extreme instability toward oxygen. Recently, we have succeeded in the isolation of the aromatic bis(acyl) tellurides (34) as yellow crystals.[56a] In addition, du Mont *et al.* reported the isolation of simple aliphatic bis(acyl) tellurides using bis(trimethylsilyl) telluride.[56b]

13. Alkyl, Aryl or Acyl Ditellurides and Bis(acyl) Ditellurides

Alkyl, aryl or acyl ditellurides and bis(acyl) ditellurides are one of the tellurium isologues of peracid esters and bis(acyl) peroxide, respectively. To our knowledge, none of them have been isolated yet. Attempts to prepare benzoyl benzene ditelluride (35) from sodium tellurobenzoate and benzenetellurenyl bromide and bis(benzoyl) ditelluride (36) from oxidation of sodium tellurobenzoate with iodine failed because of the extreme instability toward oxygen and light (Eq. 29).

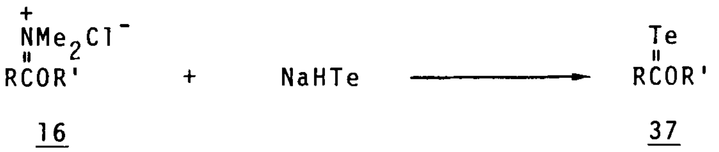


(29)

14. *O*-Alkyl or *O*-Aryl Telluroncarboxylates

Telluroncarboxylic acid esters (37) like selenonesters (17) appear to be too unstable to isolate. However, Barton *et al.*[57] in 1979 succeeded in the isolation of *O*-cholesteryl telluronpivalate as crystals from the reaction of N,N-dimethylimidoester hydrochloride (16) with sodium hydrogen telluride. It is noted that they used both sterically hindered *tert*-butyl group for the R attached to tellurocarbonyl group and chloesteryl group which becomes effective crystallizing group for the R' attached to oxygen.

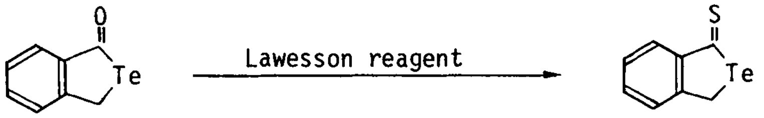
Telluronesters (37) are fairly stable in the solid state when pure in the dark toward oxygen and irradiation of the light of 500 nm. No synthesis of cyclic telluronesters has been described in literature.



$$\underset{\underline{16}}{\mathrm{R}\overset{\overset{+}{\mathrm{N}}\mathrm{Me_2Cl^-}}{\overset{\|}{\mathrm{C}}}\mathrm{OR'}} + \mathrm{NaHTe} \longrightarrow \underset{\underline{37}}{\mathrm{R}\overset{\mathrm{Te}}{\overset{\|}{\mathrm{C}}}\mathrm{OR'}} \qquad (30)$$

15. Tellurothioncarboxylates

Only a cyclic tellurothionester, tellurothionphthalide (38) has been isolated from the thionation of tellurophthalide (32) with Lawesson reagent.[55]

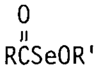


32 38 (31)

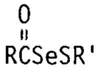
16. Miscellaneous

As mentioned above, the number of synthesized and isolated chalcogenocarboxylic acid derivatives is relatively small, compared with carboxylic acids and their sulfur isologues. Based on the relatively small extent of our experience, we would expect that the following derivatives could be isolated in the near future:

Selenium Isologues


$R\overset{O}{\overset{\|}{C}}SeOR'$

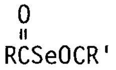
39


$R\overset{O}{\overset{\|}{C}}SeSR'$

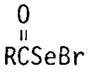
40


$R\overset{O}{\overset{\|}{C}}SeTeR'$

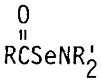
41


$R\overset{O}{\overset{\|}{C}}SeOCR'$

42


$R\overset{O}{\overset{\|}{C}}SeBr$

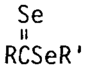
43


$R\overset{O}{\overset{\|}{C}}SeNR'_2$

44

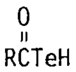

$R\overset{S}{\overset{\|}{C}}Se\overset{S}{\overset{\|}{C}}R'$

45

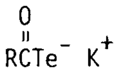

$R\overset{Se}{\overset{\|}{C}}SeR'$

46

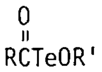
Tellurium Isologues


$R\overset{O}{\overset{\|}{C}}TeH$

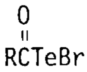
47


$R\overset{O}{\overset{\|}{C}}Te^- \; K^+$

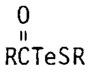
48


$R\overset{O}{\overset{\|}{C}}TeOR'$

49


$R\overset{O}{\overset{\|}{C}}TeBr$

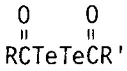
50


$R\overset{O}{\overset{\|}{C}}TeSR'$

51


$R\overset{O}{\overset{\|}{C}}TeTeR'$

52


$R\overset{O}{\overset{\|}{C}}TeTe\overset{O}{\overset{\|}{C}}R'$

53


$R\overset{S}{\overset{\|}{C}}TeTe\overset{S}{\overset{\|}{C}}R$

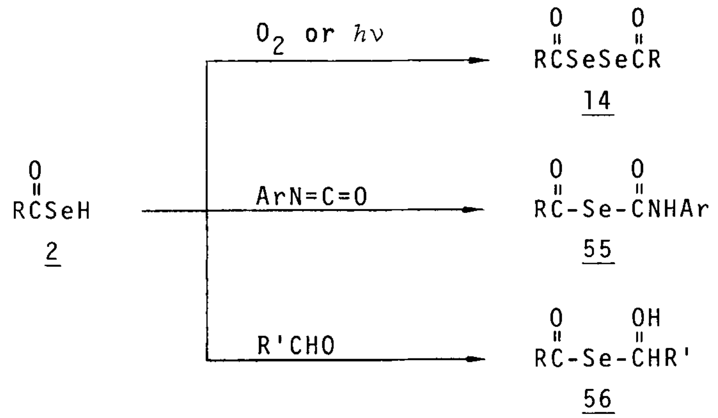
54

II. REACTIONS

A few reactions of selenocarboxylic acids, selenol-, selenon- and tellurolesters, and bis(acyl) selenides and tellurides have been investigated.

1. Selenocarboxylic Acids

Selenocarboxylic acids (2) are readily oxidized by light and oxygen to give bis(acyl) diselenides.[5] In analogy to thio- and dithiocarboxylic acids,[58] the reaction of 2 with an arylisocyanate gave a crystalline acyl carbamoyl selenide (55), whereas with an aldehyde, the addition product (56) to the carbonyl group is obtained.[7]



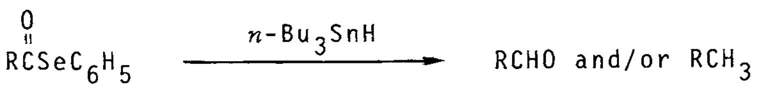
$$\mathrm{R\overset{O}{\overset{\|}{C}}SeH}\ (\mathbf{2}) \xrightarrow{O_2 \text{ or } h\nu} \mathrm{R\overset{O}{\overset{\|}{C}}SeSe\overset{O}{\overset{\|}{C}}R}\ (\mathbf{14})$$

$$\mathrm{R\overset{O}{\overset{\|}{C}}SeH}\ (\mathbf{2}) \xrightarrow{ArN=C=O} \mathrm{R\overset{O}{\overset{\|}{C}}\text{-}Se\text{-}\overset{O}{\overset{\|}{C}}NHAr}\ (\mathbf{55}) \qquad (32)$$

$$\mathrm{R\overset{O}{\overset{\|}{C}}SeH}\ (\mathbf{2}) \xrightarrow{R'CHO} \mathrm{R\overset{O}{\overset{\|}{C}}\text{-}Se\text{-}\overset{OH}{\overset{\|}{C}}HR'}\ (\mathbf{56})$$

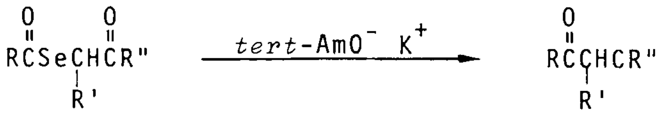
2. Alkyl or Aryl Selenocarboxylates

In contrast to selenocarboxylic acids, the esters (6) are fairly stable toward oxygen, light and heat. The aromatic derivatives (6, R, R' = aromatic) do not decompose when exposed to the atmosphere for a long time, and even by heating neat at their melting point. Reduction of phenyl selenocarboxylates (57) with tri(*n*-butyl)tin hydride was found to give an aldehyde or an alkane, and this reaction has been applied for the synthesis of steroids and sex-hormones.[4]



$$\mathrm{R\overset{O}{\overset{\|}{C}}SeC_6H_5} \xrightarrow{n\text{-}Bu_3SnH} \mathrm{RCHO \text{ and/or } RCH_3} \qquad (33)$$

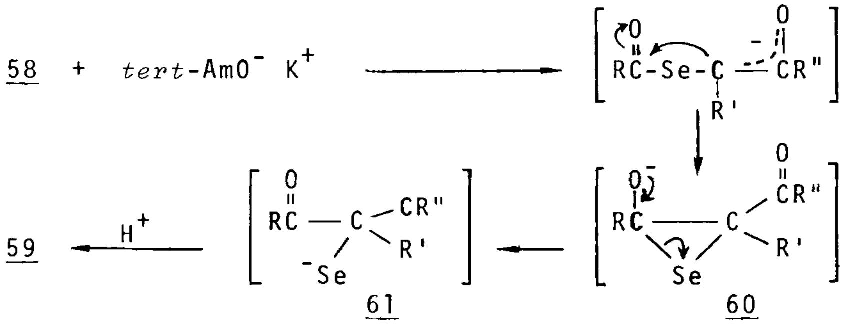
Cyclic α-ketoselenocarboxylates (58) are deselenized by potassium *tert*-pentanolate at room temperature to give 1,3-diketone (59) in good yield.[59] The following mechanism for the deselenization has been postulated (Scheme 1). In the case of thiolesters, heating for a long time in the presence of de-



$$\mathrm{R\overset{O}{\overset{\|}{C}}Se\underset{R'}{CH}\overset{O}{\overset{\|}{C}}R''} \xrightarrow{tert\text{-}\mathrm{AmO^-\ K^+}} \mathrm{R\overset{O}{\overset{\|}{C}}\underset{R'}{C}H\overset{O}{\overset{\|}{C}}R''} \qquad (34)$$

58 59

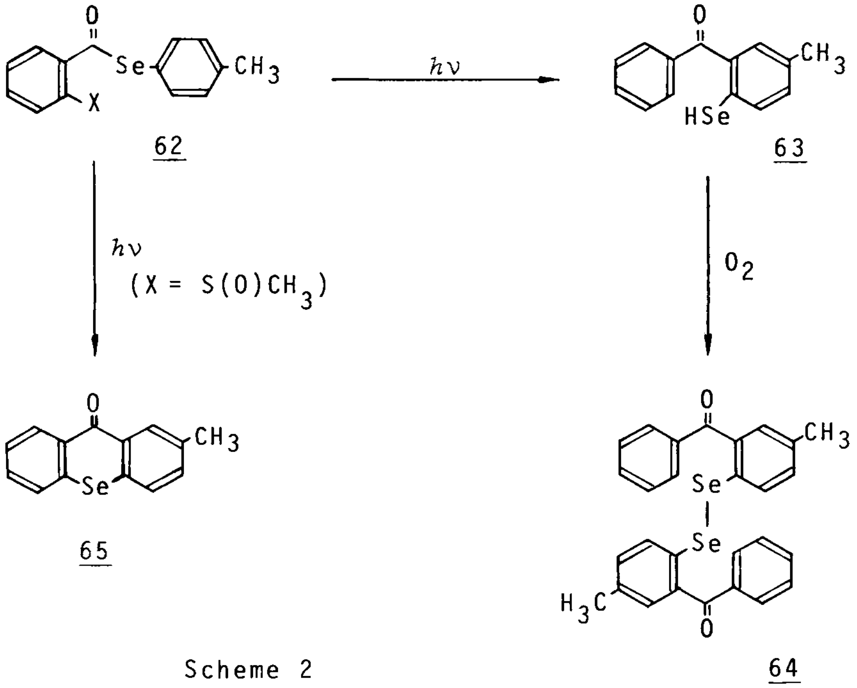
sulfurization agent such as triphenylphosphine is required.[60]



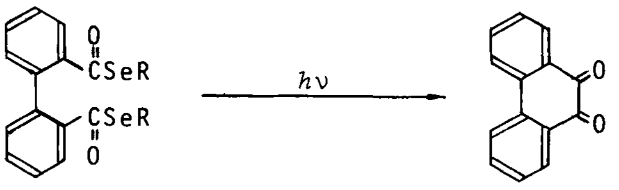
Scheme 1

Scheme 1

Irradiation of aromatic selenoates (62, 66) has been found to give the Fries rearrangement products (64, 65) or a cyclic product (67), depending on the structure (Scheme 2 and Eq.



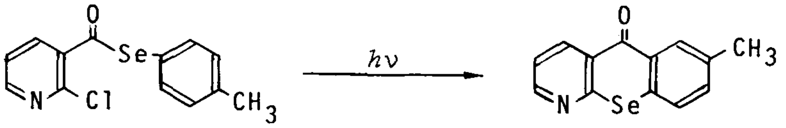
Scheme 2



(35)

66 ($R = 4\text{-}CH_3C_6H_4$) 67

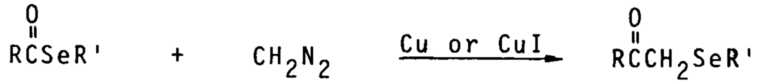
35).[61-63] Such a photoreaction has been applied to the synthesis of benzeneselenopyridine derivatives (68), which are difficult to synthesize by other methods.[63b]



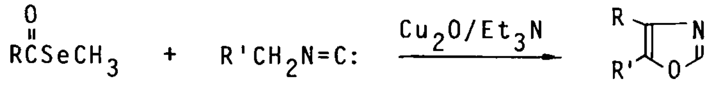
(36)

68

In general, the carbon-selenium bond has been considered to be weaker than the carbon-sulfur bond. Masamune *et al.*[19a] however, have observed that alkyl selenocarboxylates were not activated by silver and copper ions, while the carbon-sulfur bond of the corresponding thiocarboxylates were readily cleaved by these metal ions. It is noted that in the presence of



$$R\overset{O}{\overset{\|}{C}}SeR' + CH_2N_2 \xrightarrow{\text{Cu or CuI}} R\overset{O}{\overset{\|}{C}}CH_2SeR' \qquad (37)$$

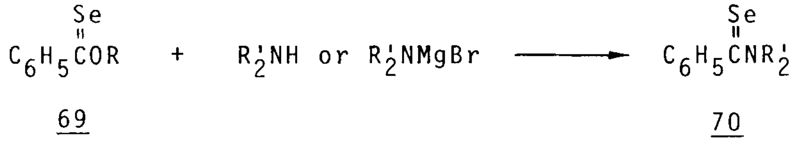


(38)

copper or cuprous iodide, diazomethane readily inserts into the acyl-selenium linkage of selenolesters,[64a,b] and that selenolesters react with isonitriles in the presence of Et_3N and anhydrous cuprous oxide to afford the 2-substituted oxazole in high yield (Eq. 38).[64c]

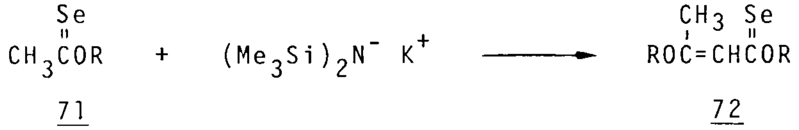
3. *O*-Alkyl or *O*-Aryl Selenoncarboxylates

Selenonesters (17) are readily decomposed by heat, light and oxygen. Some reactions of 17 with nucleophiles such as amines and phosphorus ylides, etc. have been investigated. For example, selenonbenzoates (69) react with primary or secondary amines or its magnesium bromide derivatives to yield the corresponding selenobenzamides (70).[39] Treatment of *O*-phenyl selenonethanoate (71) (R = C_6H_5) with a strong base such as potassium bis(trimethylsilyl) amide affords the condensation product (72) in good yield.[41] Treatment of thioncarboxylic acid esters gives Claisen-rearrangement products under the similar conditions.[65]



$$C_6H_5\overset{\overset{Se}{\|}}{C}OR + R'_2NH \text{ or } R'_2NMgBr \longrightarrow C_6H_5\overset{\overset{Se}{\|}}{C}NR'_2 \qquad (39)$$

69 70

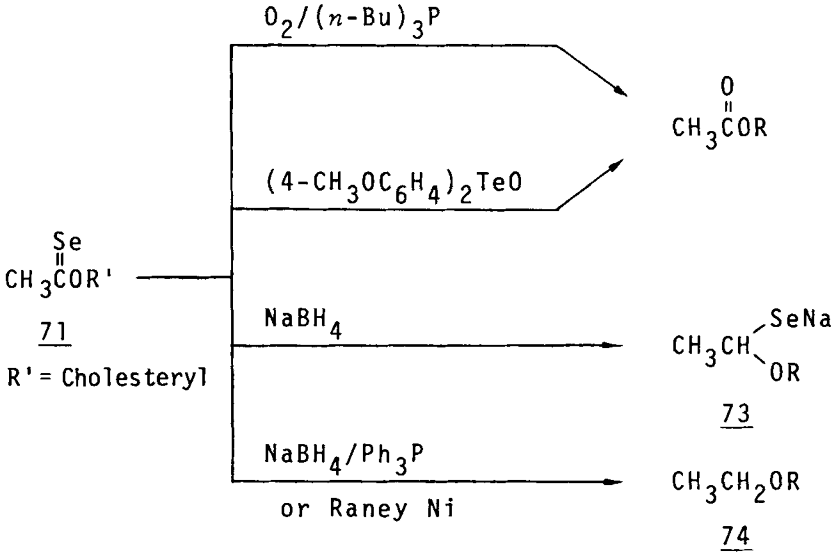


$$CH_3\overset{\overset{Se}{\|}}{C}OR + (Me_3Si)_2N^- \; K^+ \longrightarrow RO\overset{\overset{CH_3}{|}}{C}{=}CH\overset{\overset{Se}{\|}}{C}OR \qquad (40)$$

71 72

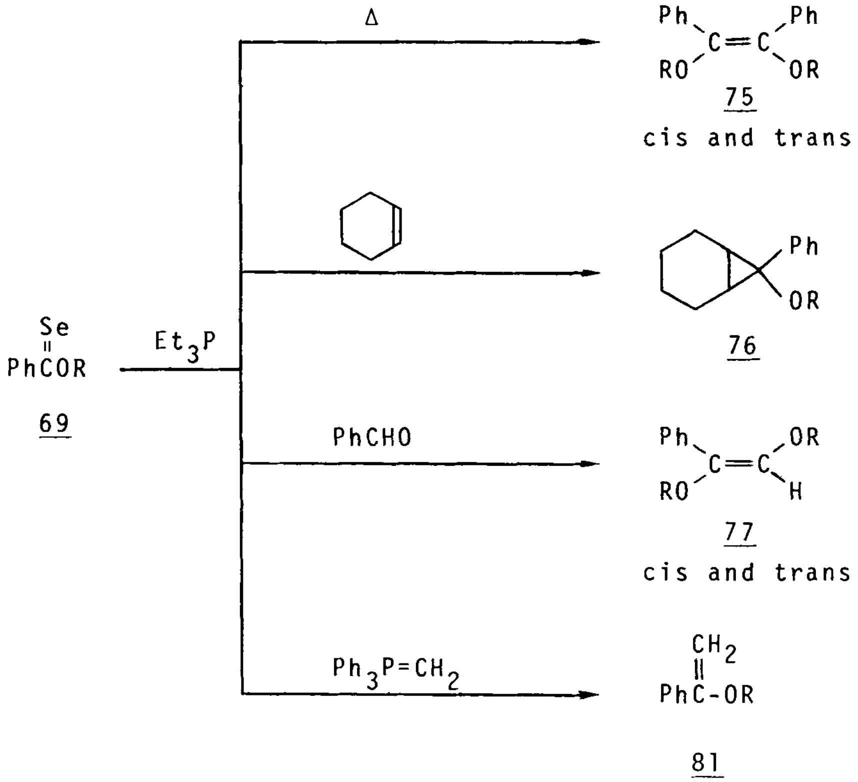
In general selenon esters are gradually oxidized in air to give the corresponding oxo compounds together with elemental black selenium. This oxidation is promoted in the presence of tris(*n*-butyl)phosphine[41] and bis(4-methoxyphenyl)telluroxide.[66] Reduction of the selenonester (71) with $NaBH_4$ affords α-alkoxyselenolates (73) (Eq. 41). In the presence of triphenylphosphine or Raney-Ni instead of $NaBH_4$, 71 is reduced to the ether (74).[41] These redox conditions of the selenon esters are much milder in comparison with those of the corresponding thion esters.[67]

In the presence of triethylphosphine, *O*-alkyl selenon-



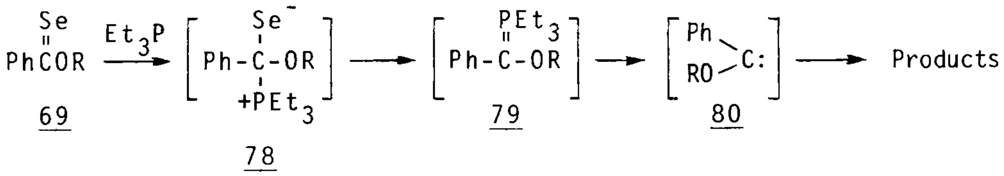
(41)

benzoate reacts with cyclohexene,[68] benzaldehyde[68] and tri-



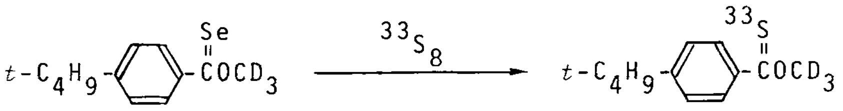
(42)

phenylphosphinemethylide,[68] to give α,α'-dialkoxystilbene (75), norcarane (76), α-alkoxystilbene (77), and α-alkoxystyrene (81), respectively. The following mechanism *via* the ylide (79) and carbene (80) has been proposed. It is noted that the similar reaction of *O*-alkyl thionbenzoate afforded both the Wittig[69] and thioacylated products.[70]

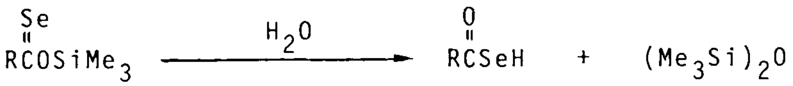


Scheme 3

The selenium atom in the selenoncarboxylates (82) has been found to be replaced through the use of elemental sulfur atom.[71,72] *O*-Trimethylsilyl selenocarboxylates are readily hydrolyzed to give selenocarboxylic acids (Eq. 44).[6]



82 83 (43)



$$\mathrm{R\overset{\overset{Se}{\|}}{C}OSiMe_3} \xrightarrow{H_2O} \mathrm{R\overset{\overset{O}{\|}}{C}SeH} + (\mathrm{Me_3Si})_2\mathrm{O} \qquad (44)$$

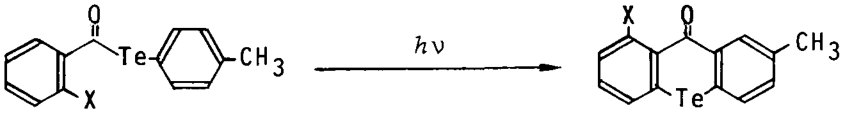
4. Bis(acyl) Selenides and Diselenides

Bis(acyl) selenides (15) are sensitive to oxygen and moisture. Bis(benzoyl) selenide is hydrolyzed to give bis(benzoyl) diselenide together with benzoic acid. In contrast, bis(acyl) diselenides are relatively stable toward moisture and oxygen.

Both aromatic bis(acyl) monoselenides and diselenides react with potassium hydroxide and piperidine to produce the corresponding potassium (3) and piperidinium compounds (4) (Eq. 2).

5. Alkyl or Aryl Tellurocarboxylates

Irradiation of aromatic tellurocarboxylic acid esters (84) afforded Fries rearrangement product (85).[73] Tellurophthalide (32) proved to be surprisingly stable toward irradiation at 300 nm and flash thermolysis over 500°C.[55] However, treatment of 32 with sulfenyl chloride, bromide, or iodide gave the corresponding acyl halides (86). The reaction in the presence of ethanol leads to alkyltellurium tribromide (87).[55] Tellurophthalide (32) can be successfully thionated by Lawesson reagent (Eq. 31).[55]



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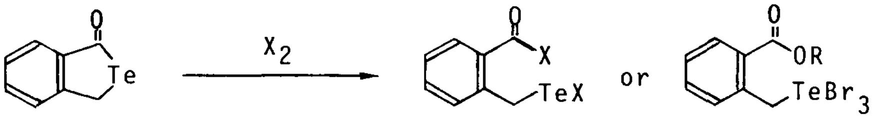
84

X = H, OCH_3

85



(46)

32

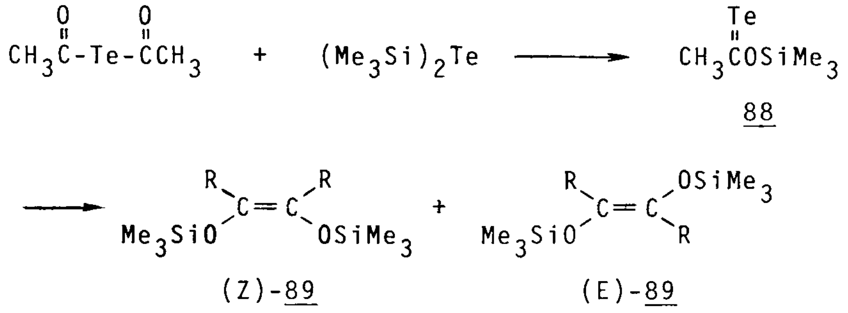
86

87

X = Halogen

6. Bis(acyl) Tellurides

Bis(acyl) tellurides are extremely sensitive to air and moisture. In the hydrolysis products of bis(acyl) tellurides, bis(acyl) ditellurides have been detected.[56a] The reaction of bis(acyl) ditelluride with bis(trimethylsilyl) telluride yields 2,3-bis(trimethylsiloxy)-2-butene *via* *O*-trimethylsilyl telluroacetate (Eq. 47).[56b] Like the selenium analogues (15) in Eq. 2,[8,9] aromatic bis(acyl) tellurides react with piperidine to give piperidinium tellurocarboxylates (90) (Eq. 48).[74]



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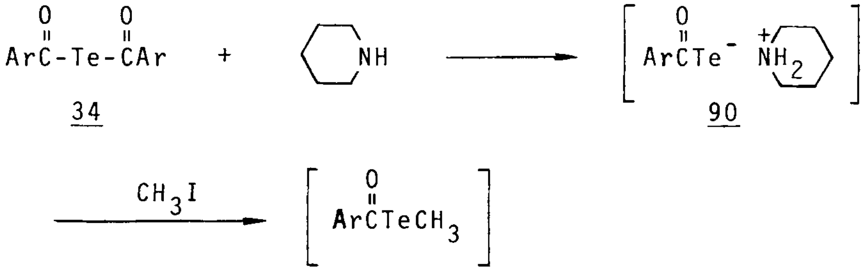
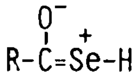


(48)

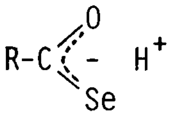
III. SPECTRA

Electron spectra: Aromatic selenocarboxylic acids are orange to red color, showing a characteristic absorption maxima near 520 nm due to $n \rightarrow \pi^*$ transition of the carbonyl group. This suggests the importance of the resonance forms 106 and

107, in which the double bond property between the carbonyl carbon and selenium atoms increased.


$R\text{-}\overset{O^-}{\overset{|}{C}}=\overset{+}{Se}\text{-}H$

106



107

Selenolesters [RC(O)SeR'] and Tellurolesters [RC(O)TeR'] are pale yellow to orange yellow. However, they do not show any absorption maxima in visible region. Selenonesters [RC(Se)OR']

Table 1. The n → π* transitions of some chalcogeno esters

Compound	Solvent	UV, Vis [nm] λmax (log ε)	Ref
$CH_3C(S)OC_2H_5$	*n*-C_6H_{14}	377 (1.29)	75
	C_2H_5OH	369 (1.26)	75
$C_6H_5C(S)OCH_3$	*n*-C_6H_{14}	418 (2.20)	76
$C_6H_5C(S)OC_6H_5$	*n*-C_6H_{14}	437 (2.21)	77
	C_2H_5OH	433 (2.13)	77
tert-$C_4H_9C(Se)OC_2H_5$	C_2H_5OH	450 (1.70)	41
$C_6H_5C(Se)OC_2H_5$	CH_2Cl_2	489 (2.30)	40
$C_6H_5C(Se)OC_6H_5$	C_2H_5OH	523 (2.20)	41
tert-$C_4H_9C(Te)O\text{-}R^a$		592 (2.50)	57

[a] R = cholesteryl

and telluronesters [RC(Te)OR'] are dark violet to blue. The n → π* transitions of the seleno- and tellurocarbonyl groups of some selenon- and telluronesters are listed up together with those of the corresponding thionesters [RC(S)OR']. In passing from carbonyl to thiocarbonyl, selenocarbonyl, and tellurocarbonyl group.

IR spectra: The νSe-H frequencies of selenobenzoic acid and 4-biphenylselenocarboxylic acid appear at 2310[6] and 2290 cm^{-1},[7] respectively. The carbonyl stretching frequencies of these acids fall in the analogous region with those of the corresponding carboxylic and thiocarboxylic acids.[1a]

Selenolesters and tellurolesters show the νC=O bands in the region of 1660 - 1775 cm^{-1}. Comparing with thiolesters,

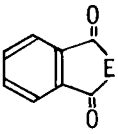
Table 2. The νC=O bands of some aromatic chalcogeno esters

Compound	E	νC=O $[cm^{-1}]^a$	Ref
$C_6H_5C(O)$-E-C_6H_5	O	1735	54b
		1740	78
	S	1675	54b
		1680	79
	Se	1686	54b
	Te	1725	12
		1682^b	53

[a] 1% CCl_4; [b] Fermi resonance (?).

the lower frequency shifts of the νC=O by vicinal selenium and tellurium atoms are not observed. In contrast, selenophthalic and tellurophthalic acid anhydrides show two characteristic carbonyl stretching frequencies in the regions of 1660 - 1680 cm^{-1} and 1710 - 1750 cm^{-1}. Both bands shift to lower frequency in passing from phthalic to thiophthalic, selenophthalic, and tellurophthalic acid anhydride.

Table 3. The νC=O bands of chalcogeno phthalic acid anhydrides

Compound	E	IR (KBr) [cm^{-1}]		Ref
		ν_{as}C=O	ν_sC=O	
	O	1845	1775	80, 81
	S	1788	1690	82
	Se	1748	1680	31, 80
	Te	1718	1661	31, 80

The νC=Se of the selenonesters has been reported to appear at 1220 - 1230 cm^{-1} [36] and 962 cm^{-1} (O-trimethylsilyl thionselenobenzoate). Considering observation of the νC=S bands of thion- and dithioesters at 1170 - 1260 cm^{-1} region,[83] the νC=Se bands of selenonesters could be observed below 1000 cm^{-1}. There has been no report concerning νC=Te band.

NMR spectra: The carbonyl carbon spectra of selenolesters and tellurolesters [RC(CO)ER', E = Se, Te] are observed at δ190 - 200 (Table 8 and 9). As shown in Table 4, the ^{13}C=O spectra show the tendency of downfield shift in passing from esters to thiolesters, selenolesters, and tellurolesters. While, the methylene carbon spectra ajacent to chalcogen atoms in [RC(O)E-CH_2-R'] shift to upperfield with the order of O, S, Se, and Te atom.[54,85]

Table 4. The C-13 NMR spectra for some chalcogeno esters

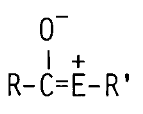
Compound	δ (^{13}C=O) ($CDCl_3$)				Ref
E =	O	S	Se	Te	
$C_6H_5C(O)EC_4H_9$-*n*	166.3	191.5	194.0	195.2	54b, 84
$C_6H_5C(O)EC_6H_5$	164.9	189.7	192.7	195.9	54b, 84
$C_6H_5C(E)C_6H_4CH_3$-4	165.3	190.4	193.7	196.3	84, 85
	δ ($^{13}CH_2$) ($CDCl_3$)				
$CH_3C(O)ECH_2$(Pr-*i*)	64.2	28.7	25.5	11.2	54b, 84
$C_6H_5C(O)ECH_2$(Pr-*i*)	64.6	28.7	25.2	11.2	54b, 84

The ^{13}C=Se of selenonesters [RC(Se)OR'] and the ^{13}C=Te of Telluronesters [RC(Te)OR'] appear near δ220 and δ230, respectively. The ^{13}C=E values in the chalcogeno esters [RC(E)OR'] shift to downfield in passing from esters to thionesters, selenonesters, and tellurolesters.

Table 5. The carbonyl and thio-, seleno- and tellurocarbonyl C-13 NMR spectra of some chalcogeno esters

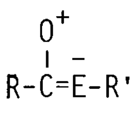
RC(E)OR'	$^{13}C=E$ $(CDCl_3)$ [δ]	Ref
$C_6H_5C(O)OC_2H_5$	166.3	86
$4\text{-}(t\text{-}C_4H_9)C_6H_4C(S)OC_2H_5$	212.2	71
$C_6H_5C(Se)OC_2H_5$	222.4	86
$t\text{-}C_4H_9C(Te)O\text{-cholesteryl}$	229.0	57

In general, ^{77}Se and ^{125}Te-NMR spectra are measured by using dimethyl selenide and telluride as the standard compounds, respectively.[87] As shown in Table 6, the ^{77}Se spectra of selenolesters are observed at lower field of δ500 - 640, whereas the ^{125}Te spectra are observed at lower fields of δ1150 - 1190 than the standard compounds, suggesting contribution of the resonance form <u>108</u> or <u>109</u>.[84,88,89] These results agree with a study by ^{13}C-NMR of the selenol- and tellurolesters. In addition, the results of the molecular orbital calculation level for thio- and dithioformic acids support the resonance



$R\text{-}\overset{O^{-}}{\overset{|}{C}}=\overset{+}{E}\text{-}R'$

<u>108</u>



$R\text{-}\overset{O^{+}}{\overset{|}{C}}=\overset{-}{E}\text{-}R'$

<u>109</u>

E = S, Se, Te

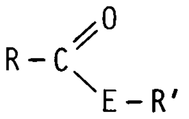
Table 6. The ^{77}Se and ^{125}Te NMR spectra of some selenon- and telluronesters

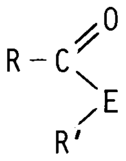
Compound	δ (CDCl$_3$)		Ref
E=	^{77}Se	^{125}Te	
$CH_3C(O)$-E-C_6H_5	600^{a}		90
$C_6H_5C(O)$-E-$C_6H_4CH_3$-4	633.3^{a}	1185.4^{b}	89
	634.4^{a}		91
	157.4^{c}	502.4^{c}	88
4-$CH_3OC_6H_4C(O)$-E-$C_6H_4CH_3$-4	620.7^{a}	1160.7^{b}	89
	144.8^{c}	477.7^{d}	88
n-$C_8H_{17}OC_6H_4C(O)$-E-$C_6H_4C_5H_{11}$-n	619.1^{a}	1155.9^{b}	89
	143.2^{c}	472.9^{d}	88

^{a}Internal standard: CH_3SeCH_3; $^{b}CH_3TeCH_3$; $^{c}(4\text{-}CH_3C_6H_4Se)_2$; $^{d}(4\text{-}CH_3C_6H_4Te)_2$.

form of 108.[92] It is noted that the dipole moment of γ-thiol- and γ-selenolbutyrolactones suggests the contribution of the resonance form 109 rather than 108.[46]

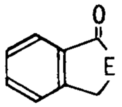
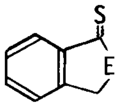
Dipole moments: Some dipole moment data of chalcogeno esters are listed in Table 7. Exner *et al.* have reported that the dipole moment data of these chalcogeno esters indicate the planer **Z** conformation 110 (previously denoted as trans), which may be a priori strongly preferred to the **E** conformation 111 (previously denoted as cis).[93,94]


110


111

E = Se, Te

Table 7. Dipole moment data of some chalcogeno esters

Compound	Dipole moment [D] (Benzene)			
	O	S	Se	Te
$CH_3C(O)\text{-}E\text{-}C_6H_5$	1.67[a]	1.50[b]	1.65[c]	-
$C_6H_5C(O)\text{-}E\text{-}C_6H_5$	1.80[a]	-	1.05[c]	1.84[d]
	4.76[e]	4.31[e]	4.09[e]	-
	4.87[e]	4.54[e]	4.24[e]	-
	4.98[e]	4.61[e]	-	-

[a] Ref. 95; [b] Ref. 96; [c] Ref. 93; [d] Ref. 94; [e] Ref. 46.

IV. SUMMARY

Ninety five years have been passed since selenophthalide, the first chalcogenocarboxylic acid derivative, was synthesized in 1891. By the end of 1985, the isolated chalcogenocarboxylic acid derivatives number 330 for the selenium, and 60 for tellurium isologues. Most of these isologues have been synthesized after 1970. Some of seleno- and tellurocarboxylic acid esters have been shown to have liquid crystalline properties[3] and to display blocking action for the synaptic and axonal transmission of nerve impulse.[97] Carboxylic acids have been mass-produced and widely used in industry. In addition, some of them have been known to play a biologically crucial role. The systematic synthesis and applications of the selenium and tellurium isologues of carboxylic acid derivatives may become a very fruitful area of research.

Acknowledgment.- The authors wish to express their sincere thanks to Professors J.-P. Anselme and M. J. Hearn for their useful advice during the preparation of this manuscript.

APPENDIXES

Table 8. Selenium Isologues of Carboxylic Acid Derivatives

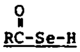
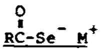
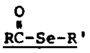
Compound	mp. (°C) bp. (°C/torr)	Yield (%)	Important physical properties	Ref
 $RC(O)\text{-}Se\text{-}H$				
$C_6H_5C(O)SeH$	oil	54^5	2310 cm^{-1} (SeH)[6] (Neat)	5,6
$4\text{-}(C_6H_5)C_6H_4C(O)SeH$	solid		2290 cm^{-1} (SeH) (Neat)	7
 $RC(O)\text{-}Se^- M^+$				
$C_6H_5C(O)Se^-\ Na^+$	solid			5,26
$4\text{-}(C_6H_5)C_6H_4C(O)Se^-\ Na^+$	solid		1538 cm^{-1} (CO) (Nujol)	7
$n\text{-}C_{17}H_{35}C(O)Se^-\ K^+$		94	1560 cm^{-1} (CO) (KBr)	7
$C_6H_5C(O)Se^-\ K^+$		95	1538 cm^{-1} (CO) (KBr)	8
$4\text{-}CH_3C_6H_4C(O)Se^-\ K^+$		90	1539 cm^{-1} (CO) (KBr)	8
$4\text{-}CH_3OC_6H_4C(O)Se^-\ K^+$		88	1540 cm^{-1} (CO) (KBr)	8
$4\text{-}ClC_6H_4C(O)Se^-\ K^+$		95	1540 cm^{-1} (CO) (KBr)	8
$n\text{-}C_{17}H_{35}C(O)Se^-$ 	66-69	58	1580 cm^{-1} (CO) (KBr)	8
$C_6H_5C(O)Se^-$ 	$80\text{-}82^{10}$	79^9, 80^{10}	1515 cm^{-1} $(CO)^{10}$ (KBr)	9,10
$2\text{-}CH_3C_6H_4C(O)Se^-$ 	92-94	95	1515 cm^{-1} (CO) (KBr)	10
$4\text{-}CH_3C_6H_4C(O)Se^-$ 	83-85	88	1560 cm^{-1} (CO) (KBr)	10
$4\text{-}CH_3OC_6H_4C(O)Se^-$ 	78-80	90	1500 cm^{-1} (CO) (KBr)	10
$2\text{-}ClC_6H_4C(O)Se^-$ 	93-94	72	1560 cm^{-1} (CO) (KBr)	10
$4\text{-}ClC_6H_4C(O)Se^-$ 	80-83	91	1505 cm^{-1} (CO) (KBr)	10
 $RC(O)\text{-}Se\text{-}R'$				
$CH_3C(O)SeC_4H_9\text{-}n$	$62/63^{13}$	83^{13}	1712 cm^{-1} $(CO)^{13}$ (CCl_4) 196.6 ppm $(CO)^{54b}$ $(CDCl_3)$	13,54b
C_6H_5	$80/0.5^{23a}$ $115/20^{84}$ $112\text{-}116^{19c}$	54^{13} 98^{19c} 94^{22} 94^{22} 79^{23a} 93^{26}	1720 cm^{-1} $(CO)^{22}$ (Neat)	13,19c 22,23a 26
$C_6H_4OCH_3\text{-}2$	liq	50	1710 cm^{-1} (CO) (Neat)	13

Table 8 —— continued

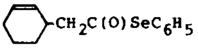
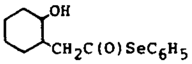
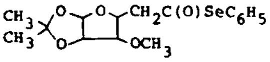
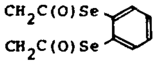
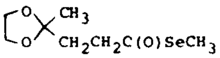
$C_6H_4CH_3$-4	oil	55	1725 cm^{-1} (CO) (Neat)	64b
$C_6H_4OCH_3$-4				16
$C_{10}H_7$-2				12,16
HBr.$H_2NCH_2C(O)SeC_6H_5$ and 60 of amino acid Se-phenyl esters				17b
cyclo-$C_6H_{11}CH_2C(O)SeC_6H_5$	148/1	78		23a
$CH(CH_3)C(O)C_6H_5$		91		23c
		82		23c
		80		19d
		94		23c
$C_6H_5CH_2C(O)SeC_6H_5$	41-43	73^{22} 98^{23c}	1710 cm^{-1} $(CO)^{22}$ (Neat)	22,23c
$C_6H_4CH_3$-4	43	62	1705 cm^{-1} (CO) (KBr)	64b
$C_2H_5C(O)SeCH_2C_6H_4CH_3$-4	liq	63	1715 cm^{-1} (CO) (CCl_4)	5
$C_6H_5CH{=}CHC(O)SeC_6H_5$		16		19b
$CH_3C(O)CH_2CH_2C(O)SeCH_3$				64c
$NO_2CH_2CH_2C(O)SeC_6H_4CH_3$-4			1715 cm^{-1} (CO) (CCl_4)	102
				20
n-$C_3H_7C(O)SeC_4H_9$-*n*	liq	74	1702 cm^{-1} (CO) (Neat)	26
C_6H_5	125-128/8	77	1716 cm^{-1} (CO) (Neat)	26
i-$C_3H_7C(O)SeC_6H_5$	liq	91	1723 cm^{-1} (CO) (Neat) 204.5 ppm (CO) ($CDCl_3$)	24b
cyclo-$C_3H_7C(O)SeCH_3$		96^{19d}		19d,64c
C_6H_5	liq	89	1717 cm^{-1} (CO) (Neat)	22
$C_6H_5C(CH_3)_2CH_2C(O)SeC_6H_5$	oil			
$CH_3CH{=}CHC(O)SeC_6H_5$	104.5/2	63	1693 cm^{-1} (CO) (Neat)	26
$HO(CH_2)_4C(O)SeC_6H_5$		80		19d
		93^{19d}		19d,64c

Table 8 —— continued

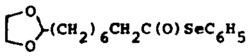
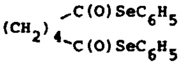
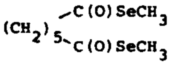
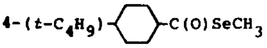
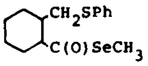
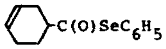
		75		23c
t-$C_4H_9C(O)SeC_6H_5$	liq	83	1724 cm^{-1} (CO) (Neat)	22
$(CH_3)_2C{=}CHC(O)SeC_4H_9$-*n*	69/0.8	75	1681 cm^{-1} (CO) (CCl_4)	13
C_6H_5	120/0.8		1695 cm^{-1} (CO) (CCl_4)	13
 $(CH_2)_4\begin{smallmatrix}C(O)SeC_6H_5\\C(O)SeC_6H_5\end{smallmatrix}$	66.5-67.5	70	1720 cm^{-1} (CO) (KBr)	26
 $(CH_2)_5\begin{smallmatrix}C(O)SeCH_3\\C(O)SeCH_3\end{smallmatrix}$		95		19d
$CH_3C(CH{=}CH)_2C(O)SeC_4H_9$-*n*	96/0.8	60	1675 cm^{-1} (CO) (Neat)	13
C_6H_5			1675 cm^{-1} (CO) (Neat)	22
n-$C_6H_{13}C(O)SeCH_3$		95[19d]		19d,64c
cyclo-$C_6H_{11}C(O)SeCH_3$		93		19d
cyclo-$C_6H_{11}C(O)SeC_6H_5$	liq[22]	91[21] 86[22] 88[23a] 94[23c]	1723 cm^{-1} (CO)[22] (Neat)	21,22 23a,23c
		92		105
		92		23c
	119-124/0.6	84		23a
$CH_3(CH_2)_6C(O)SeCH_3$		96		104
C_6H_5	140-143/1[23a]	78[23a] 90[23c]		23a,23c
$CH_2{=}CH(CH_2)_8C(O)SeC_6H_5$	liq	81	1720 cm^{-1} (CO) (Neat)	22
n-$C_8H_{17}CH{=}CH(CH_2)_6C(O)SeC_6H_5$		88		21
n-$C_7H_{15}CH(OH)(CH_2)_8C(O)SeC_6H_5$		88		101
n-$C_{17}H_{35}C(O)SeCH_3$	50-51	87	1708 cm^{-1} (CO) (KBr)	25
n-$C_{17}H_{35}C(O)Se$- $CH_2C(O)C_6H_4CH_3$-4	51.5-52.5	86	1716, 1689 cm^{-1} (CO) (KBr)	59
C_2H_5	36-37	77	1708 cm^{-1} (CO) (KBr)	26
C_3H_7-*n*	31-32	88	1708 cm^{-1} (CO) (KBr)	26
C_3H_7-*i*	29-30	57	1708 cm^{-1} (CO) (KBr)	26
C_4H_9-*n*	31-32	87	1708 cm^{-1} (CO) (KBr)	26

Table 8 —— continued

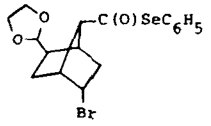
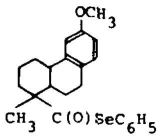
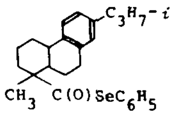
C_4H_9-*i*	22-23	59	1705 cm^{-1} (CO) (KBr)	26
C_4H_9-*sec*	18-19	14	1704 cm^{-1} (CO) (KBr)	26
C_5H_{11}-*n*	36-37	84	1708 cm^{-1} (CO) (KBr)	26
C_6H_{13}-*n*	32.5-33.5	77	1708 cm^{-1} (CO) (KBr)	26
C_7H_{15}-*n*	41-42	86	1708 cm^{-1} (CO) (KBr)	26
C_8H_{17}-*n*	37-38	77	1708 cm^{-1} (CO) (KBr)	26
n-$C_{17}H_{35}C(O)SeC_9H_{19}$-*n*	45-46	79	1708 cm^{-1} (CO) (KBr)	26
$C_{10}H_{21}$-*n*	44-45	81	1708 cm^{-1} (CO) (KBr)	26
$C_{11}H_{23}$-*n*	49-50	75	1708 cm^{-1} (CO) (KBr)	26
$C_{12}H_{25}$-*n*	48.5-49.5	79	1708 cm^{-1} (CO) (KBr)	26
$C_{14}H_{29}$-*n*	52.5-53.5	73	1708 cm^{-1} (CO) (KBr)	26
$C_{16}H_{33}$-*n*	56.5-57.5	82	1708 cm^{-1} (CO) (KBr)	26
$C_{17}H_{35}$-*n*	60-62	89	1708 cm^{-1} (CO) (KBr)	26
$C_{18}H_{37}$-*n*	60-61	73	1708 cm^{-1} (CO) (KBr)	26
C_6H_5	31.5-32.5[25]	94[21] 32[25]		21,25
[*n*-$C_{17}H_{35}C(O)Se]_2CH_2$	69-70[8]	97[8]	1710, 1677 cm^{-1} (CO)[4] (KBr) 1690 cm^{-1} (CO)[8] (KBr)	4,8
$PhCH_2CH[NHC(O)CH_2Ph]$- $C(O)SeC_6H_5$	107-108	89		21
6,8-Dimethylazulene-4-yl-methyl-$C(O)SeC_6H_5$		94		21
	123-125	46		23a
	133-134	84	1710 cm^{-1} (CO) ($CHCl_3$)	22
	86-87	80-90		4

Table 8 —— continued

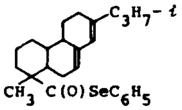
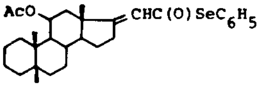
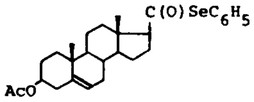
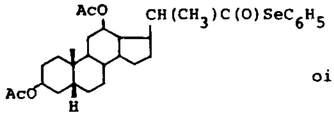
	liq	80-90		4
	oil	80-90		4
	192	80-90		4
	oil	80-90		4
$C_6H_5C(O)SeCH_3$	105-106/8^{8,9}	95^{8}, 90^{9} 99^{76}	1666 cm^{-1} (CO)^{8} (Neat)	8,9 76
CH_2CN	liq	45	2250 cm^{-1} (CN) (Neat) 1690 cm^{-1} (CO) (Neat)	94
$CH(OH)C_6H_4NO_2$-3	76-80	82		82
$CH_2C(O)CH_3$	liq	80	1708, 1664 cm^{-1} (CO) (Neat)	59
$CH(CH_3)C(O)CH_3$	liq	68	1705, 1676 cm^{-1} (CO) (Neat)	84
$CH_2C(O)C_2H_5$	liq	77	1732, 1678 cm^{-1} (CO) (Neat)	59
$CH_2C(O)C_6H_5$	60-61^{8} 61-62^{10}	93^{8,59} 92^{10}	1680, 1668 cm^{-1} (CO)^{10}(KBr)	8,10 59
$CH_2C(O)C_6H_4CH_3$-4	69-70	84	1690, 1665 cm^{-1} (CO) (KBr)	59
$CH_2C(O)C_6H_4Br$-4	112-113	95	1675, 1655 cm^{-1} (CO) (KBr)	10
$CH_2CO_2C_2H_5$	liq	77	1732, 1678 cm^{-1} (CO) (Neat)	84
$C_6H_5C(O)Se$- $CH_2CH_2\overset{+}{N}H(CH_3)_2Cl^-$				74
$CH_2CH_2\overset{+}{N}(CH_3)_3Cl^-$				74
C_4H_9-*n*	104.5/2^{26}	67^{26}	1675 cm^{-1} (CO)^{13} (CCl_4) 1670 cm^{-1} (CO)^{26} (Neat)	13,26

Table 8 —— continued

C_6H_5	40^{13} $35\text{-}37^{22}$ $37\text{-}38^{23a}$ $36.5\text{-}37.5^{24a}$ $34\text{-}36^{25}$ $39\text{-}40^{91}$ $130\text{-}135/1^{19c}$ $33\text{-}36^{103}$	88^{13} 98^{19c} 92^{21} 84^{23a} 62^{25} 93^{26}	1686 cm^{-1} $(CO)^{13,91}$ (KBr) 1690 cm^{-1} $(CO)^{22}$ ($CHCl_3$)	11a,12 13,17a 19c,21 22,23a 24b,25 26,91 103
$C_6H_4CH_3$-2			1683 cm^{-1} (CO) (CCl_4)	13
$C_6H_4CH_3$-4	$71\text{-}72^{11a}$ $70\text{-}71^{91}$		157.4 ppm $(^{77}Se)^{88}$ ($CDCl_3$) 1684 cm^{-1} $(CO)^{91}$ (KBr) 193.4 ppm $(CO)^{91}$ ($CDCl_3$)	11a,18 61,85 88,91
$C_6H_5C(O)SeC_6H_4OCH_3$-2			1685 cm^{-1} (CO) (CCl_4)	13
$C_6H_4OCH_3$-4	97^{11a} $97\text{-}99^{91}$		1680 cm^{-1} $(CO)^{91}$ (KBr) 193.9 ppm $(CO)^{91}$ ($CDCl_3$)	11a,18 91
$C_6H_4OC_2H_5$-4				18
C_6H_4F-4	56		1683 cm^{-1} (CO) (KBr) 192.9 ppm (CO) ($CDCl_3$)	91
C_6H_4Cl-4	74-75		1685 cm^{-1} (CO) (KBr) 192.4 ppm (CO) ($CDCl_3$)	91
C_6H_4Br-4	71^{91} $74\text{-}76^{103}$		1686 cm^{-1} $(CO)^{91}$ (KBr) 192.4 ppm $(CO)^{91}$ (KBr)	91,103
C_6H_4CN-4	93-94		1690 cm^{-1} (CO) (KBr) 191.0 ppm (CO) ($CDCl_3$)	91
$C_6H_4NO_2$-4			1690 cm^{-1} (CO) (KBr) 190.9 ppm (CO) ($CDCl_3$)	91
$C_6H_5C(O)SeC_6H_4(COCH_3)$-4	113		1690 cm^{-1} ?(CO) (KBr) 191.8 ppm (CO) ($CDCl_3$)	91
$C_6H_4(CO_2C_2H_5)$-4	81		1689 cm^{-1} (CO) (KBr) 191.9 ppm (CO) ($CDCl_3$)	91
$C_6H_4(NMe_2)$-4	r.t.(dec)		1676 cm^{-1} (CO) (KBr) 195.0 ppm (CO) ($CDCl_3$)	91
$C_{10}H_7$-2				12
$Ge(CH_3)_3$	oil	78	1673, 1650 cm^{-1} (CO) (Neat)	6
$Sn(CH_3)_3$	oil	82	1640 cm^{-1} (CO) (Neat)	6
$[C_6H_5C(O)Se]_2CHC_6H_5$	149-150			5

Table 8 —— continued

$2\text{-}CH_3C_6H_4C(O)Se\text{-}$ $CH_2C(O)C_6H_5$	60-61	88	1683, 1650 cm^{-1} (CO) (KBr)	10
$4\text{-}CH_3C_6H_4C(O)Se\text{-}$ $CH_2C(O)C_6H_5$	73-74	90	1680, 1653 cm^{-1} (CO) (KBr)	10
$4\text{-}CH_3C_6H_4C(O)SeC_6H_5$	93.5-94.5^{24a,26} 93-94^{25}	83^{24a,26} 57^{25}	1680 cm^{-1} (CO)^{25,26} (KBr)	24a 25,26
$4\text{-}(n\text{-}C_5H_{11})C_6H_4C(O)Se\text{-}$ $C_6H_4CH_3\text{-}4$	30	94	1690 cm^{-1} (CO) ($CHCl_3$)	3a
$4\text{-}(n\text{-}C_7H_{15})C_6H_4C(O)Se\text{-}$ $C_6H_4OCH_3\text{-}4$	40	83	1685 cm^{-1} (CO) ($CHCl_3$)	3a
$2\text{-}CH_3OC_6H_4C(O)SeC_4H_9\text{-}n$	130/0.6^{13}	60^{13}	1690, 1644 cm^{-1} (CO)^{13}(CCl_4) 590.6 ppm (^{77}Se)^{89} ($CDCl_3$)	13 89
C_6H_5	170/0.8^{13}	66^{13}	1702, 1670, 1530 cm^{-1} (CO)^{13} (CCl_4) 700.2ppm (^{77}Se)^{89} ($CDCl_3$)	13,89
$C_6H_4CH_3\text{-}2$	140/0.5^{13}	56^{13}	1680, 1650 cm^{-1} (CO)^{13}(CCl_4) 191.6 ppm (CO)^{84} ($CDCl_3$)	13 84
$C_6H_4OCH_3\text{-}2$	79	55	1700, 1680, 1654 cm^{-1} (CO) (CCl_4)	13
$4\text{-}CH_3OC_6H_4C(O)Se\text{-}$ $CH_2C(O)C_6H_5$	77.0-77.5	83	1685, 1662 cm^{-1} (CO) (KBr)	59
$CH_2C(O)C_6H_4CH_3\text{-}4$	96-98	82	1658 cm^{-1} (CO) (KBr)	10
C_6H_5	62-63^{23a} 61-62^{25}	27^{19b} 83^{23a} 56^{23c} 84^{24a} 60^{25}	1690 cm^{-1} (CO)^{26} (KBr)	19b,23a 23c,24a 25,26
$C_6H_4CH_3\text{-}4$	60^{3a} 58-59^{25}	28^{3a} 60^{25}	1685 cm^{-1} (CO)^{3a} ($CHCl_3$) 1680 cm^{-1} (CO)^{25} (KBr)	3a,25
$4\text{-}(n\text{-}C_7H_{15}O)C_6H_4\text{-}$ $C(O)SeC_6H_4CH_3\text{-}4$	49	56	1675 cm^{-1} (CO) ($CHCl_3$)	3a
$4\text{-}(n\text{-}C_8H_{17}O)C_6H_4\text{-}$ $C(O)SeC_6H_4(C_5H_{11}\text{-}n)\text{-}4$	55^{88}	16^{88}	1690 cm^{-1} (CO)^{88} (CCl_4) 191.6 ppm (CO)^{85} ($CDCl_3$)	85,88

Table 8 —— continued

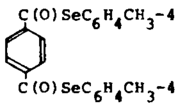
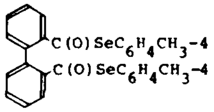
$2\text{-}FC_6H_4C(O)SeC_4H_9\text{-}n$	115/0.8[13]		1695, 1670, 1650 cm^{-1} (CO)[13] (CCl_4) 576.2, 582 ppm (^{77}Se, trans and cis)[89] ($CDCl_3$)	13,89
C_6H_5			1750, 1668 cm^{-1} (CO) (CCl_4)	13
$2\text{-}ClC_6H_4C(O)SeCH_2COC_6H_5$	49-50[10]	94[10]	1686, 1671 cm^{-1} (CO)[10] (KBr)	10,13
$C_4H_9\text{-}n$	109/0.9	65	1688 cm^{-1} (CO) (CCl_4)	13
C_6H_5	60	67	1700 cm^{-1} (CO) (CCl_4)	13
$4\text{-}ClC_6H_4C(O)SeCH_2C(O)C_6H_5$	89-90	81	1685, 1665 cm^{-1} (CO) (KBr)	59
$CH_2C(O)C_6H_4CH_3\text{-}4$	98-99	83	1667 cm^{-1} (CO) (KBr)	10
$CH_2C(O)C_6H_4Br\text{-}4$	144-146	98	1667 cm^{-1} (CO) (KBr)	10
C_6H_5	83.5-84.5[23a] 83-84[25] 82.0-83.5[24a,26]	79[24a,80] 91[23c]	1680 cm^{-1} (CO) (KBr)	23a,23c 24a,25 26
$2\text{-}BrC_6H_4C(O)SeC_4H_9\text{-}n$	128/0.9	66	1689 cm^{-1} (CO) (CCl_4)	13
C_6H_5	65	82	1699 cm^{-1} (CO) (CCl_4)	13
$C_6H_4CH_3\text{-}2$	68	62	1690 cm^{-1} (CO) (CCl_4)	13
$2\text{-}IC_6H_4C(O)SeC_4H_9\text{-}n$	145/0.7	66	1685 cm^{-1} (CO) (CCl_4)	13
C_6H_5	76	67	1695 cm^{-1} (CO) (CCl_4)	13
$C_6H_4OCH_3\text{-}2$	75	45	1694 cm^{-1} (CO) (CCl_4)	13
$2\text{-}NO_2C_6H_4C(O)SeC_6H_4CH_3\text{-}4$	59	31	1695 cm^{-1} (CO) ($CHCl_3$)	102
$2\text{-}CH_3SC_6H_4C(O)SeC_6H_4CH_3\text{-}4$	94-95	39	1690 cm^{-1} (CO) ($CHCl_3$)	62
$2\text{-}CH_3S(O)C_6H_4C(O)Se\text{-}$ $C_6H_4CH_3\text{-}4$	108-110	19	1680 cm^{-1} (CO) ($CHCl_3$)	62
$2\text{-}CH_3SeC_6H_4C(O)SeC_6H_5$			640.8 ppm (^{77}Se) ($CDCl_3$)	89
 $C(O)SeC_6H_4CH_3\text{-}4$ $C(O)SeC_6H_4CH_3\text{-}4$	186[3a]	55[3a]	1680 cm^{-1} (CO)[3a] ($CHCl_3$) 193.4 ppm (CO)[85] ($CDCl_3$)	3a,85
 $C(O)SeC_6H_4CH_3\text{-}4$ $C(O)SeC_6H_4CH_3\text{-}4$	101			61

Table 8 —— continued

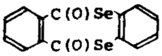
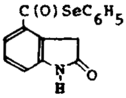
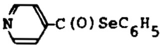
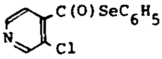
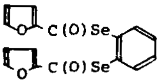
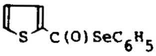
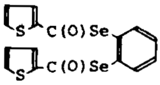
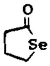
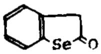
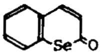
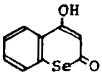
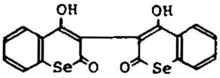
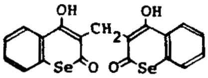
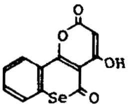
				20
$4\text{-}(C_6H_5)C_6H_4C(O)SeC_6H_5$			58	23c
			80	23c
	39-41	23	1692 cm^{-1} (CO) ($CHCl_3$)	22
	151-153	18	1686 cm^{-1} (CO) ($CHCl_3$)	64
				20
	63	89	1676 cm^{-1} (CO) ($CHCl_3$)	22
				20
	86-88/13	82		29
			584 ppm (^{77}Se)^{90} ($CDCl_3$)	90
			654 ppm (^{77}Se) ($CDCl_3$)	90
	202	80		30a
	216	87.5		30a
	253-254			30a
	220	90		30a

Table 8 —— continued

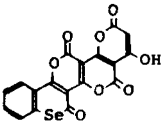
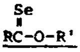
	300			30a
 $R\overset{Se}{\overset{\|}{C}}\text{-}O\text{-}R'$				
$CH_3C(Se)OCH_3$	108-110/703	80	443 nm (EtOH)	41
C_2H_5	129[39] 127-129[68]	26[30] 82[68]	443 nm (EtOH)	30,39 68
C_3H_7-*i*	139-141/772	76	443 nm (EtOH)	41
cholestanyl	104-105	74	435 nm ($CHCl_3$)	41
cholesteryl	144-145	83	435 nm ($CHCl_3$)	41
C_6H_5	80-84/770[38] 92/0.7[41]	41[38] 60[41]	469 nm (EtOH)[41]	38,41
$C_6H_5CH_2C(Se)OCH_3$	oil	38		41
$CH_2C_6H_5$	105/2	80		39
$C_2H_5C(Se)OC_2H_5$	147	34		39
cholesteryl	151-153	86	434 nm (EtOH)	41
i-$C_3H_7C(Se)OCH_3$	58-59/35	79	443 nm (EtOH)	68
C_2H_5	41/8[39] 72-73/34[41]	48[39] 69[41]		39,41
C_3H_7-*i*	82-84/33	61	444 nm (EtOH)	41
n-$C_4H_9C(Se)OC_2H_5$	60/9	57		39
t-$C_4H_9C(Se)OC_2H_5$	60/14	46	450 nm (EtOH)	41
t-$C_5H_{11}C(Se)OC_2H_5$	66/10	60		39
$(CH_2)_3\begin{array}{l}\diagup C(Se)OC_2H_5\\ \diagdown C(Se)OC_2H_5\end{array}$			446 nm (EtOH)	41
n-$C_{17}H_{35}C(Se)OCH_3$			436 nm (EtOH)	41
$C_6H_5C(Se)OCH_3$	90-91/1.8[36] 76/0.4[37] oil[42]	36[37] 89[41] 10[42]	443 nm (EtOH)[41]	36, 37 41, 42
C_2H_5	106/9[41] oil[40]	86[39] 97[40] 80[41]	489 nm (CH_2Cl_2)[44]	39, 40 41, 71 86

Table 8 —— continued

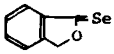
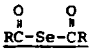
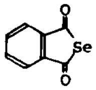
C_3H_7-*i*	76-78/0.1	92	504 nm (EtOH)	41
cholestanyl		89	435 nm (EtOH)	41
cholesteryl	$160\text{-}162^{40}$	78^{40} 87^{41}	489 nm $(CH_2Cl_2)^{40}$	40, 41
$C_6H_5C(Se)OC_6H_5$	164-166/0.4	87	523 nm (EtOH)	41
methyl 4,6-benzylidene-3-O-selenobenzoyl-α-O-glucopyranoside	158-160	49		41
$C_6H_5C(Se)OSi(CH_3)_3$	100/5	68		6
$4\text{-}CH_3C_6H_4C(Se)OCH_3$	$104/1.4^{36}$ oil^{42}	3^{36} 29^{42}		36,42
C_2H_5	105/8	90		39
4-(*t*-C_4H_9)$C_6H_4C(Se)OCH_3$	oil	63		71,72
OCD_3		63^{99}		72 99
$4\text{-}CH_3OC_6H_4C(Se)OC_2H_5$	$105/8^{39}$ oil^{42}	90^{39} 27^{42}		39,42
$4\text{-}ClC_6H_4C(Se)OCH_3$	57	12		42
	58	62		46
 $R\overset{O}{\overset{\|}{C}}\text{-}Se\text{-}\overset{O}{\overset{\|}{C}}R$				
$[C_2H_5C(O)]_2Se$	103-105/23	29	1780 cm^{-1} (CO) (Neat)	5
$[n\text{-}C_{17}H_{35}C(O)]_2Se$	75-76	98	1775, 1715 cm^{-1} (CO) (KBr)	9
$[C_6H_5C(O)]_2Se$	$60\text{-}61^{5}$ 60^{32} $61\text{-}62^{9}$	$27^{5},88^{9}$	1737, 1685 cm^{-1} $(CO)^{9}$(KBr)	5,9 32
$[4\text{-}CH_3C_6H_4C(O)]_2Se$	90-91	93	1733, 1690 cm^{-1} (CO) (KBr)	9
$[4\text{-}CH_3OC_6H_4C(O)]_2Se$	77-80	77	1735, 1687 cm^{-1} (CO) (KBr)	9
$[4\text{-}ClC_6H_4C(O)]_2Se$	118.5-120	91	1737, 1686 cm^{-1} (CO) (KBr)	9
$[4\text{-}(Ph)C_6H_4C(O)]_2Se$	110		1690, 1655 cm^{-1} (CO) (KBr)	100
	$112\text{-}113^{31}$	61^{31}	1750, 1690 cm^{-1} $(CO)^{31,80}$ (KBr)	31,80

Table 8 —— continued

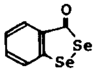
$R\overset{O}{\overset{\|}{C}}\text{-Se-Se-}\overset{O}{\overset{\|}{C}}R$				
$[n\text{-}C_{17}H_{35}C(O)]_2Se_2$	79-80	86	1732 cm^{-1} (CO) (KBr)	9
$[C_6H_5C(O)]_2Se_2$	130-131[5,8] 131-132[9] 129-130[32], 133[76]	77[9]	1732, 1682 cm^{-1} (CO)[8] (KBr) 1741, 1700 cm^{-1} (CO)[9] (KBr)	5,8 9,32 76
$[4\text{-}CH_3C_6H_4C(O)]_2Se_2$	110-111.5	80	1744, 1704 cm^{-1} (CO) (KBr)	9
$[4\text{-}CH_3OC_6H_4C(O)]_2Se_2$	106-107	65	1746, 1703 cm^{-1} (CO) (KBr)	9
$[4\text{-}ClC_6H_4C(O)]_2Se_2$	122-124	81	1739, 1700 cm^{-1} (CO) (KBr)	9
$R\overset{O}{\overset{\|}{C}}\text{-Se-Se-}R'$				
$C_6H_5C(O)SeSeC_6H_5$	liq	55	1684 cm^{-1} (CO) (Neat)	100
$C_6H_4CH_3\text{-}4$	60-62	50	1688 cm^{-1} (CO) (KBr)	100
$4\text{-}CH_3C_6H_4C(O)SeSeC_6H_5$	85-86	45	1698 cm^{-1} (CO) (KBr)	100
$4\text{-}CH_3C_6H_4C(O)SeSe\text{-}C_6H_4CH_3\text{-}4$	liq	70	1698 cm^{-1} (CO) (Neat)	100
$4\text{-}ClC_6H_4C(O)SeSeC_6H_5$	101-103[8] 78-80[100]	93[8] 55[100]	1690 cm^{-1} (CO)[100] (KBr)	8,100
$C_6H_4CH_3\text{-}4$	58-60	44	1688 cm^{-1} (CO) (KBr)	100
$C_6H_4Cl\text{-}4$	88-90	52	1688 cm^{-1} (CO) (KBr)	100
	91-92			106
$R\overset{S}{\overset{\|}{C}}\text{-Se-}R'$				
$C_2H_5C(S)SeC_6H_5$	oil	75	473 sh nm (*cyclo*-C_6H_{12})	48
$n\text{-}C_3H_7C(S)SeC_6H_5$	oil	27	456 sh nm (*cyclo*-C_6H_{12})	48
$i\text{-}C_3H_7C(S)SeC_6H_5$	oil	42	474 nm (*cyclo*-C_6H_{12})	48
$C_6H_5C(S)Se\text{-}CH_2CH_2\overset{+}{N}H(CH_3)_2Cl^-$	166-167	54		47
$CH_2CH_2\overset{+}{N}H(CH_3)_2Br^-$	193-194			47

Table 8 —— continued

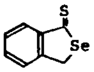
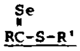
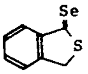
4-$CH_3C_6H_4C(S)SeC_6H_5$	81-83	71	540 nm (*cyclo*-C_6H_{12})	48
$C_6H_4CH_3$-4	107-109	52	532 nm (*n*-C_6H_{12})	48
4-$CH_3OC_6H_4C(S)SeC_6H_5$	53-59	63	534 nm (*cyclo*-C_6H_{12})	48
4-$ClC_6H_4C(S)SeC_6H_5$	oil	40	509 nm (CH_2Cl_2)	48
	63-64		365 nm (EtOH)	45
 $\underline{\overset{Se}{\overset{\Vert}{R C}}\text{-S-R'}}$				
$CH_3C(Se)SC_4H_9$-*n*				31
	81-81.5		392 nm (EtOH)	46

Table 9. Tellurium Isologs of Carboxylic Acid Derivatives

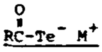
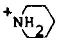
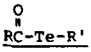
Compound	mp. (°C) bp. (°C/torr)	Yield (%)	Important physical properties	Ref
 $R\overset{O}{\overset{\|}{C}}\text{-}Te^{-}\;M^{+}$				
$2\text{-}CH_3OC_6H_4C(O)Te^{-}\;K^{+}$				74
$2\text{-}CH_3OC_6H_4C(O)Te^{-}$  $^{+}NH_2$				77
 $R\overset{O}{\overset{\|}{C}}\text{-}Te\text{-}R'$				
$CH_3C(O)TeC_4H_9\text{-}n$	67/3	70		54b
$CH_3C(O)TeC_6H_5$	105-110/0.3	80		52
$C_6H_4C_2H_5\text{-}2$	100-105/0.3	35		52
$C_2H_5C(O)TeC_6H_5$	108-110/0.3	65		52
$C_6H_5C(O)TeC_4H_9\text{-}n$	110-115/0.3[52] 136/3[54b]	20[52] 61[54b]		52,54b
C_6H_5	66-70[52] 70-72[53]	60[52] 70[53]	1682 cm^{-1} (CO)[52] (CCl_4) 1676 cm^{-1} (CO)[53] (Nujol) 196.2 ppm (CO)[53] ($CDCl_3$)	52,53
$C_6H_4CH_3\text{-}2$	69-70	60		52
$C_6H_4CH_3\text{-}4$	65-67[53]	54[53]	1672 cm^{-1} (CO)[53] (CCl_4) 196.2 ppm (CO)[53] ($CDCl_3$) 502.4 ppm (^{125}Te)[54b] ($CDCl_3$)	53,54b 73,88
$C_6H_5C(O)TeC_6H_4OCH_3\text{-}4$	100-103			52
$C_6H_4Br\text{-}4$	56-58	46	1674 cm^{-1} (CO) (CCl_4)	53
$2\text{-}CH_3C_6H_4C(O)TeC_6H_5$	30-34	50		52
$C_6H_4CH_3\text{-}2$	25-30	37		52
$4\text{-}CH_3C_6H_4C(O)TeC_6H_5$	69-71	54	1685 cm^{-1} (CO) (CCl_4)	53
$C_6H_4CH_3\text{-}4$	72-74	45	1683 cm^{-1} (CO) (CCl_4)	53
$C_6H_4OCH_3\text{-}4$	84-86[53] 75[85]	20[53]		53,85
$C_6H_4Br\text{-}4$	77-79	46	1683 cm^{-1} (CO) (CCl_4)	53
$C_{10}H_7\text{-}1$	93-95	34	1680 cm^{-1} (CO) (CCl_4)	53

Table 9 —— continued

4-$CF_3C_6H_4C(O)TeC_6H_5$	70-72	56	1680 cm^{-1} (CO) (CCl_4)	53
$C_6H_4CH_3$-4	115-117	52	1679 cm^{-1} (CO) (CCl_4) 196.1 ppm (CO) ($CDCl_3$)	53
C_6H_4Br-4	93-95	45	1682 cm^{-1} (CO) (CCl_4)	53
2-$CH_3OC_6H_4C(O)TeC_4H_9$-*n*	167/3	82		54b
C_6H_5	100-103	78		52
2-$CH_3SeC_6H_4C(O)TeC_6H_5$	78-79	80		52
2-$FC_6H_4C(O)TeCH_2C_6H_5$	13-14			51
$CH_2C_6H_4F$-2			1695, 1650 cm^{-1} (CO) (KBr)	51
C_4H_9-*n*	148/3	83		54b
C_6H_5	44-46	86		52
3-$FC_6H_4C(O)TeC_4H_9$-*n*	155	79		54b
4-$FC_6H_4C(O)TeC_4H_9$-*n*	127/3	70		54b
2-$ClC_6H_4C(O)TeC_4H_9$-*n*	170/3	62		54b
C_6H_5	42-43	53		52
4-$ClC_6H_4C(O)TeCH_2C_6H_4Cl$-4	71-72		1660 cm^{-1} (CO) (KBr)	51
2,4-$Cl_2C_6H_3C(O)Te$-$CH_2C_6H_3Cl_2$-4,2	67-68		1620 cm^{-1} (CO) (KBr)	51
4-$CH_3OC_6H_4C(O)Te$-$CH_2C_6H_4OCH_3$-4	63-64		1660, 1640 cm^{-1} (CO) (KBr)	52
C_6H_5	100-103[52] 103-105[53]	56[52]	1682 cm^{-1} (CO)[53] (CCl_4) 1665 cm^{-1} (CO)[53] (Nujol)	52,53
$C_6H_4CH_3$-2	58-63	32		52
$C_6H_4CH_3$-4	73-75[53]	71[53]	1675 cm^{-1} (CO)[53] (CCl_4) 477.7 ppm (^{125}Te)[88] ($CDCl_3$) 193.5 ppm (CO)[53] ($CDCl_3$)	53,73 85,88
C_6H_4Br-4	83-85	59	1679 cm^{-1} (CO) (CCl_4)	53
4-(*n*-$C_7H_{15}O)C_6H_4C(O)Te$-$C_6H_4(C_5H_{11}$-*n*)-4	40	47	1688 cm^{-1} (CO) (CCl_4) 193.5 ppm (CO) ($CDCl_3$)	88
4-(*n*-$C_8H_{17}O)C_6H_4C(O)Te$-$C_6H_4(C_5H_{11}$-*n*)-4	41	62	1682 cm^{-1} (CO) (CCl_4)	88
2-$CH_3SC_6H_4C(O)TeC_6H_5$	52-53	65		52

Table 9 —— continued

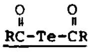
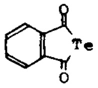
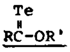
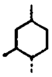
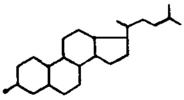
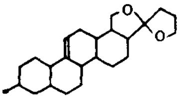
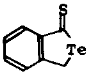
2-$BrC_6H_4C(O)TeC_4H_9$-*n*	165/3	70		54b
C_6H_5	65-68	86		52
4-$BrC_6H_4C(O)TeC_6H_5$	77-79	48	1678 cm^{-1} (CO) (CCl_4) 1665 cm^{-1} (CO) (Nujol)	53
$C_6H_4CH_3$-4	111-113	50	195.2 ppm (CO) ($CDCl_3$)	53
C_6H_4Br-4	88-90	21	1673 cm^{-1} (CO) (CCl_4)	53
2-$IC_6H_4C(O)TeC_4H_9$-*n*	155/3	59		54b
C_6H_5	70-72	75		52
$C_6H_4CH_3$-4	95-100	90		52
1-$C_{10}H_7C(O)TeC_6H_4Br$-4	87-89	24	1689 cm^{-1} (CO) (CCl_4)	53
 $\overset{O}{\overset{\Vert}{RC}}-Te-\overset{O}{\overset{\Vert}{CR}}$				
$[CH_3C(O)]_2Te$	liq	74	1756, 1712 cm^{-1} (CO) (Neat)	74
[*t*-$C_4H_9C(O)]_2Te$	liq	85	1752, 1702 cm^{-1} (CO) (Neat)	74
$[2\text{-}CH_3OC_6H_4C(O)]_2Te$	88 (dec)	61	1675, 1625 cm^{-1} (CO) (KBr) 192.1 ppm (CO) (C_6D_6)	56
$[2\text{-}ClC_6H_4C(O)]_2Te$	70 (dec)	3	1750, 1650 cm^{-1} (CO) (KBr)	56
$[1\text{-}C_{10}H_7C(O)]_2Te$	104 (dec)	40	1715, 1670 cm^{-1} (CO) (KBr) 195.3 ppm (C_6D_6)	56
	127[31]	40[31]	1770, 1660 cm^{-1} (CO)[31,80]	31,80
 $\overset{Te}{\overset{\Vert}{RC}}-OR'$				
t-$C_4H_9C(Te)O\text{-}CH_2C_4H_9$-*t*	oil	63		57

Table 9 —— continued

$t\text{-}C_4H_9C(Te)O\text{-}$				
	oil	6		57
	25	91		57
	116-120	89	592 nm (CH_2Cl_2) 229.3 ppm (C=Te) ($CDCl_3$)	57
	160-165	28		57
$Si(CH_3)_3$				56b
 $R\overset{S}{\overset{\|}{C}}\text{-}Te\text{-}R'$				
	96-98	62		25

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(Received February 28, 1986; in revised form July 2, 1986)