One-Step Synthesis of Alkyl and Aryl Isoselenocyanates from Primary Amines

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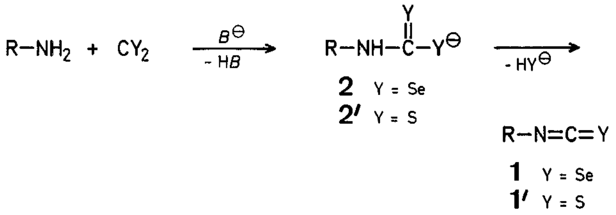
Organic isoselenocyanates (**1**) are important precursors for a number of organoselenium compounds such as selenoureas and selenosemicarbazides[2]. Several routes to **1** have been investigated[2], e.g. the reaction of isocyanides with elemental selenium[3], the alkylation of selenocyanate ion[4], the reaction of *N*-arylcarbimidic dichlorides with selenide ion[5], and the treatment of isocyanates with phosphorus(V) selenide[6]. Only the first of these methods has proved feasible for general use[6-9] and is well suited for the large-scale preparation of certain isoselenocyanates since the yields are moderate to high and elemental selenium is less expensive than the selenium reagents used in the other methods.

$$R{-}N{\equiv}\bar{C} + Se \longrightarrow \underset{\mathbf{1}}{R{-}N{=}C{=}Se}$$

However, the preparation of the isocyanides used as starting material may be troblesome and require rather drastic conditions[10] which are not applicable in the presence of sensitive functions.

The sulfur analogs of **1**, the isothiocyanates (**1'**), can be generally prepared from primary amines via dithiocarbamates (**2'**)[11]. We have recently shown[12] that a similar route can be followed for the synthesis of isoselenocyanates (**1**).



$$R{-}NH_2 + CY_2 \xrightarrow[-HB]{B^{\ominus}} R{-}NH{-}\overset{\overset{\displaystyle Y}{\|}}{C}{-}Y^{\ominus} \xrightarrow[-HY^{\ominus}]{} R{-}N{=}C{=}Y$$

2 Y = Se
2' Y = S

1 Y = Se
1' Y = S

However, the application of this two-step procedure is confined to amines which are themselves more nucleophilic than the resultant diselenocarbamate ion. Otherwise, a side reaction between **2** and carbon diselenide becomes the main reaction path. This is, for example, the case with *t*-alkylamines and arylamines.

We now report a one-step synthesis of isoselenocyanates (**1**) from primary amines and carbon diselenide which is based upon the carbamate route but not subject to the above-mentioned restrictions. Primary amines form a 1:1 adduct ($R{-}NH_2 \cdot HgCl_2$)[13] with mercury(II) chloride in inert solvents. This complex reacts with carbon diselenide in the presence of triethylamine to give the isoselenocyanates **1**.

$$R{-}NH_2 + HgCl_2 + CSe_2 + 2\,(C_2H_5)_3N \longrightarrow \underset{\mathbf{1}}{R{-}N{=}C{=}Se} + HgSe + 2\,(C_2H_5)_3N \cdot HCl$$

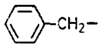
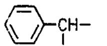
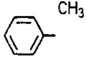
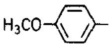
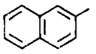
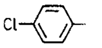
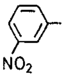
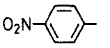
The reaction course can be rationalized in terms of the already described chemistry of **2**[12] as follows: Mercury(II) ion is an efficient trap for any diselenocarbamate (**2**) formed and thus prevents further reaction of **2** with carbon diselenide. At the same time it acts as an electrophilic catalyst which is necessary for the elimination step. In accord with this assumption it was found that almost as good yields of **1** are obtained when mercury(II) chloride is replaced by a zinc or lead salt.

The reactions are usually carried out in acetonitrile and the products are isolated by two-phase partition between water and petroleum ether (Method A). This method is not applicable to aliphatic isoselenocyanates with C_1 to C_4 groups since these low-boiling compounds form azeotropic mixtures with hydrocarbons [this may be one reason for the low yield of methyl isoselenocyanate previously reported[8]]. Instead, their preparation is performed in dichloromethane and the products are isolated by evaporation of the purified and dried reaction solution (Method B).

The results obtained indicate that the present procedure affords relatively good yields of **1** with all types of primary alkylamines whereas in the case of arylamines the yields decrease considerably when the aromatic ring carries electron-withdrawing substituents.

The only observed by-product in the alkyl series is the corresponding isocyanide (as evidenced by T.L.C. of the reaction product). This contamination is difficult to remove by distillation; accordingly, alkyl isoselenocyanates can only be obtained in a pure state when recrystallization is possible. In the aromatic series, the two major by-products were identified (by I.R.- and mass spectra) as the corresponding

Table. Alkyl- and Aryl Isoselenocyanates (**1**) from Primary Amines, Carbon Diselenide, Mercury(II) Chloride, and Triethylamine

R	Reaction time [min]	Method	Yield[a] [%]	Purity[b] [%]	m.p. (m.p. Lit.)	Molecular formulae
CH_3	20	B I	50	100	65–66° (68°)[8]	C_2H_3NSe (120.0)
C_2H_5	20	B I	49	99	22–24° (25°)[8]	C_3H_5NSe (134.0)
i-C_3H_7	20	B II	72	89	b.p. 25–26°/0.2 torr	C_4H_7NSe (148.1)[c]
t-C_4H_9	180	B I	51	100	51–53°	C_5H_9NSe (162.1)
c-C_6H_{11}	20	A I	62	97	4–5°	$C_7H_{11}NSe$ (188.1)[c]
	30	A I	61	99	~ −8°	C_8H_7NSe (196.1)[d]
	30	A III	73	89	—	C_9H_9NSe (210.1)[d]
	120	A I	54	100	14–16°	C_7H_5NSe (182.1)
	30	A I	67	—	50–51° (48–49°)[16] (60–61°)[9]	C_8H_7NOSe (212.1)[c,f]
	30	A I	47	—	88–90°	$C_{11}H_7NSe$ (232.1)[c]
	30	A I	36	—	68–70° (69–70°)[9] (70–71°)[16]	C_7H_4ClNSe (216.6)[c]
	120	A I	10	—	73–75°	$C_7H_4N_2O_2Se$ (227.1)[c,f]
	120	A I	<1	—		

[a] Calculated on pure compound and based on carbon diselenide.

[b] Estimated by the piperidine method.

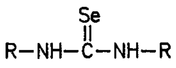
[c] Reported previonsly but no m.p. or b.p. given.

[d] New compound, analyses not available due to air sensitivity.

[e] The elemental analyses are in good agreement with the calculated values (C ± 0.28%, H ± 0.30%, N ± 0.15%).

[f] New compound.

selenoureas (**3**) and carbodiimides (**4**). Both compounds are formed from the isoselenocyanate **1** and the amine-mercury(II) chloride adduct under the reaction conditions.



$R{-}NH{-}\overset{\overset{\displaystyle Se}{\|}}{C}{-}NH{-}R$

3

$R{-}N{=}C{=}N{-}R$

4

Materials. Carbon diselenide (98% purity) was prepared according to the literature[15]. Amines and solvents were commercially available reagent-grade materials used without further purification.

Analytical procedures: The identity of each product was verified by mass spectrometry. In each case, a selenium cluster (M − 2, M − 1, M + 1, M + 3) around the molecular weight and a more or less prominent peak at M − Se were observed. As a purity check, the solid aryl isoselenocyanates were subjected to elemental analysis and gave correct values (C, H, N). In all other cases the isoselenocyanate was treated with a slight excess of piperidine in petroleum ether and the resultant 1-(alkylaminoselenocarbonyl)-piperidine determined gravimetrically.

Preparation of Alkyl- and Aryl-isoselenocyanates (1); General Procedures:

Method A: Mercury(II) chloride (2.72 g, 10 mmol) is dissolved in acetonitrile (40 ml) and the primary amine (10 mmol) is added. To the stirred mixture, carbon diselenide (1.7 g, 10 mmol) is added, followed by triethylamine (2.03 g, 20 mmol). This mixture is stirred for the period indicated in the Table and then filtered by suction through a glass filter covered by a porous material, e.g. dry magnesium sulfate to remove the precipitated black magnesium selenide. The filtrate is poured into 4 vol of half-concentrated aqueous sodium chloride and the product extracted with petroleum ether. The extract is dried with magnesium sulfate and filtered through a short column containing alumina (Woelm W 200, neutral; 3–4 g for aliphatic compounds and 6–8 g for aromatic compounds).

Method B: Mercury(II) chloride is dissolved in acetonitrile and an equimolar amount of primary amine is added with stirring. The colorless precipitate of the composition $R{-}NH_2-HgCl_2$[13] is isolated by filtration, washed with dichloromethane, and dried. This adduct (10 mmol) is suspended in dichloromethane (40–50 ml). To the stirred suspension, carbon diselenide (1.7 g, 10 mmol) is added, followed by triethylamine (2.03 g, 20 mmol). Stirring is continued for the time indicated in the Table. The mixture is then filtered by suction through a glass filter covered with a porous material (e.g. dry magnesium sulfate) to remove the precipitated black magnesium selenide. The filtrate is washed with half-concentrated aqueous sodium chloride, dried with magnesium sulfate, and evaporated at reduced pressure. The residue is dissolved in petroleum ether (~15 ml) and filtered through a short column containing alumina (Woelm W 200, neutral; 3 g).

Purification of the Products:

Method I: The eluate from the column is concentrated to a volumn of 6–8 ml or until beginning crystallization, and then gradually cooled to a temperature below −40°. The precipitated material is isolated by filtration or by centrifugation/decantation and then dried, at first in a stream of nitrogen, then at 0.1 torr.

Method II: The eluate from the column is concentrated and then distilled at reduced pressure (0.2 torr).

Method III: The eluate from the column is concentrated, finally at ~30°/0.1 torr, and used without further purification.

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[1] Paper no. 5 in the series: Derivatives of Thio- and Selenocarbonic Acids; Previous paper: L. Henriksen, *Synthesis* **1974**, 501.

[2] D. L. Klayman, W. H. H. Günther, ed., *Organic Selenium Compounds*, John Wiley & Sons, New York, 1973, p. 274.

[3] K. A. Jensen, E. Frederiksen, *Z. anorg. allgem. Chem.* **230,** 31 (1936).

[4] C. T. Pedersen, *Acta Chem. Scand.* **17,** 1459 (1963).

[5] H. Stolte, *Ber. dtsch. chem. Ges.* **19,** 2350 (1886).

[6] C. Collard-Charon, M. Renson, *Bull. Soc. Chim. Belges* **71,** 531 (1962).

[7] M. Lipp, F. Dallacker, I. M. zu Köcker, *Monatsh. Chem.* **90,** 41 (1959).

[8] W. J. Franklin, R. L. Werner, *Tetrahedron Lett.* **1965,** 3003.

[9] E. Bulka, K. D. Ahlers, E. Tuček, *Chem. Ber.* **100,** 1369 (1967).

[10] I. Ugi, R. Meyr, *Org. Synth., Coll. Vol. V,* 1060 (1973).

[11] M. Bögemann, S. Petersen, O. E. Schultz, H. Söll, in: Houben-Weyl, *Methoden der Organischen Chemie*, 4th. Ed., edited by E. Müller, Vol. IX, Georg Thieme Verlag, Stuttgart, 1955, p. 869.

[12] L. Henriksen, *Int. J. Sulfur Chem.* **8,** 389 (1973).

[13] Composition in agreement with elemental analysis (C, H, N) and I.R.-spectra (two NH_2 bands at $\nu = 3150-3500\ cm^{-1}$) for $R = i\text{-}C_3H_7$ and $R = C_6H_5$.

[14] Mechanistically, the reaction course appears more complex. Thus, a colorless mixed mercuric selenide-chloride precipitates during the first half of the reaction.

[15] L. Henriksen, E. S. S. Kristiansen, *Int. J. Sulfur Chem.* **2A,** 33 (1972).

[16] P. Kristian, G. Suchar, *Collect. Czech. Chem. Commun.* **37,** 3066 (1972).