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NOVEL RING TRANSFORMATION OF DIHYDROSELENINES TO SELENABICYCLO[3.1.0]HEXENES

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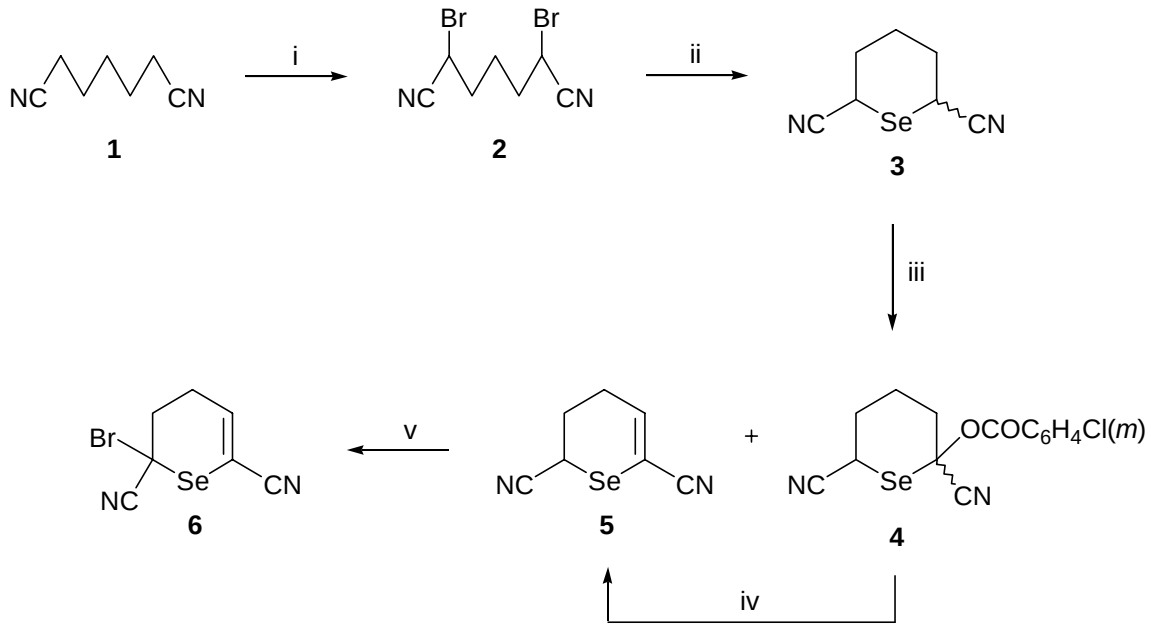
Abstract– Treatment of 2-bromo-2,6-dicyano-2,3-dihydroselenine (**6**) with triethylamine in ethanol gave 2-selenabicyclo[3.1.0]hex-3-ene (**7**) in 77% yield. Reaction of **7** with benzyne formed benzoselenophene (**11**) in 35% yield. Methylation of **7** with methyl triflate produced *Se*-methylselenonium salt (**12**), which was transformed into amide derivatives (**16**) and (**17**). Compound (**7**) was converted into alkynylcyclopropane (**13**) *via* selenonium salt (**12**).

We have been studying the chemistry of selenanaphthalenes[1] and selenabenzenes.[2,3] A novel ring conversion of dihydroselenines to selenabicyclo[3.1.0]hexenes was found in the course of the synthesis of selenabenzenes.[3] It has been reported that oxidation of 1-selenochromenes with selenium dioxide caused a ring contraction to afford 2-formylbenzo[*b*]selenophenes,[4] and the periodate oxidation of 5,6-dihydro-2*H*-selenines gave selenophenes.[5] However, the ring contraction which we now describe is unprecedented, and the product, selenobicyclo[3.1.0]hexane, is a new ring system[6] that can be converted into interesting compounds such as ethylcyclopropanes,[7] benzoselenophenes,[8] and selenabicyclohexenecarboxamides.

2,6-Dicyanodihydroselenine was synthesized as shown in Scheme 1. The ring closure of dibromopimeronitrile (**2**), which had been prepared from pimeronitrile (**1**) and bromine, with sodium selenide afforded a mixture of selenanes, ***trans*-3** (42%) and ***cis*-3** (38%). Oxidation of **3** with *m*-chloroperbenzoic acid (MCPBA) was attempted to convert it into dihydroselenine (**5**). The Pummerer products (***trans*-4**) and (***cis*-4**) were formed as major products (30–60%; *trans*:*cis*=4:1), and the desired dihydroselenine (**5**) was obtained in 16–17% yield. Then, a mixture of *trans*- and *cis*-benzoates (**4**) was treated with polyphosphoric acid trimethylsilyl ester (PPSE), giving **5** in 80% yield. Bromination of **5** with 2 equivalents of *N*-bromosuccinimide afforded 2-bromodihydroselenine (**6**) in 91% yield.

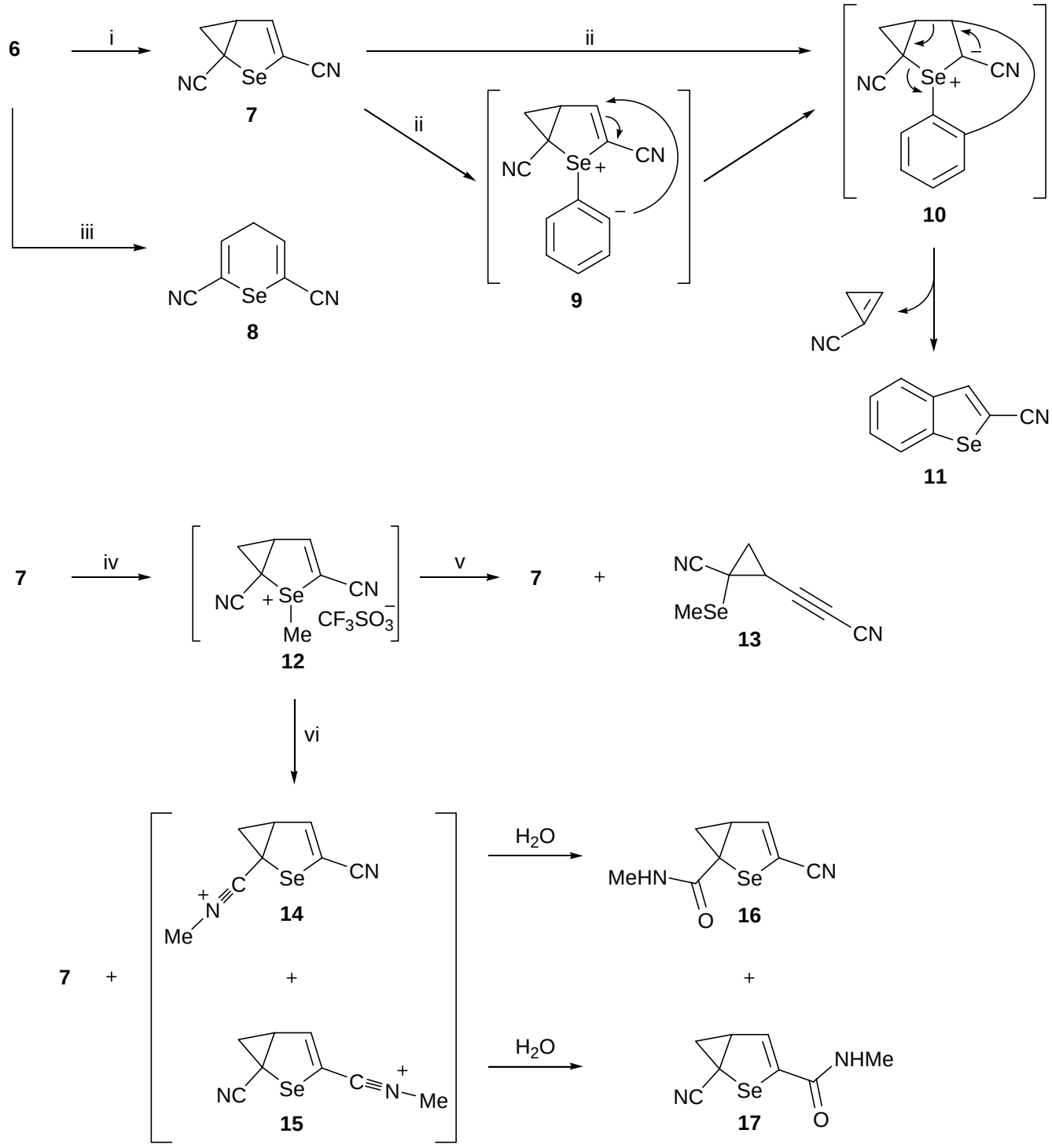


Scheme 1 *Reagents and conditions*: i, Br_2 (2 equiv.), cat. PBr_3, neat, 150 °C, 0.5 h, 74%; ii, Na_2Se (1 equiv.), EtOH, reflux, 0.5 h; iii, MCPBA (1.1 equiv.), CH_2Cl_2, reflux, 3 h; iv, PPSE, toluene, reflux, 1 week, 80%; v, NBS (2 equiv), CH_2Cl_2, 0 °C, 0.5 h, 91%.

Bromide (**6**) was treated with triethylamine to afford selenabicyclo[3.1.0]hexene (**7**)[9] in 77% yield *via* γ-elimination reaction, but not selenine (**8**) *via* β-elimination. This reaction mode was governed by the difference of the acidity of hydrogens at 3- and 4-positions of **6**. When the bromine group of **6** is located in the axial position, one of hydrogens at the 3-position (3-H) and that at the 4-position (4-H) are antiperiplanar against the bromine. However, triethylamine deprotonates 4-H rather than 3-H because 4-H is more acidic than 3-H. When bromide (**6**) was treated with silver tetrafluoroborate (under the E1 reaction conditions), compound (**7**) was not obtained, but a small amount of 4*H*-selenine (**8**) was formed.

Next, we examined the conversion of **7** into novel compounds. Although selenabicyclohexene (**7**) has a vinylcyclopropane moiety cyclized between the selenenyl and the vinyl groups, **7** did not react with *p*-toluenesulfonic acid in refluxing benzene.[10] The reaction of **7** with benzyne, generated from iodinane and tetra-*n*-butylammonium fluoride,[11] gave benzo[*b*]selenophene (**11**) in 35% yield with recovery of **7** (54%). Benzyne reacts with the selenium atom to form betain (**9**), whose anionic site causes the Michael addition to the α,β-unsaturated nitrile moiety. Alternatively, benzyne would undergo the [4+2] cycloaddition with **7** to give **10**. The resulting cyclic selenonium ylide (**10**) liberates cyanocyclopropene to give benzoselenophene (**11**). Selenonium salt (**12**) was prepared by methylation of **7** with methyl trifluoromethanesulfonate and submitted to PTLC on silica gel to give ethynylcyclopropane (**13**) in 27% yield together with **7** (42%). Treatment of **12** with triethylamine gave amides (**16**) and (**17**) in 7 and 8% yields, respectively, and **7** (37%). 2-Carboxamide (**17**) showed an NOE enhancement between a proton of the amide group (N-H) and an

olefinic proton at the 3-position and was assigned as a 3-caboxamide derivative. The amides (**16**) and (**17**) are formed *via* the Ritter reaction, *i.e.*, *via* the mutual methylation of **12** followed by hydrolysis of the resulting nitrilonium ions (**14**) and (**15**), respectively.



Scheme 2 *Reagents and conditions*: i, Et_3N (4.4 equiv.), CH_2Cl_2, rt, 2 h, 77%; ii, *o*-$TMSC_6H_4I(OTf)Ph$ (1 equiv.), $^nBu_4NF$ (1.2 equiv.), CH_2Cl_2, 0 °C–rt, 1 day, 35%; iii, $AgBF_4$ (2 equiv.), MeCN, 5 min, then H_2O, 13%; iv, TfOMe (7 equiv.), CH_2Cl_2, rt, 72 h; v, PTLC; vi, Et_3N (2.5 equiv.), MeCN, rt, overnight.

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9 **1.3-Dicyano-2-selenabicyclo[3.1.0]hex-3-ene** (**7**); colorless plates (from ether−hexane), mp 58–59 °C; IR (film; cm^{-1}) 2220 (CN); ^1H NMR (400 MHz; $CDCl_3$) δ: 1.24 (1 H, t, *J*=6 Hz, 5-H), 2.11 (1 H, dd, *J*=6 and 10 Hz, 5-H), 3.07 (1 H, ddd, *J*=3, 6 and 10 Hz, 4-H), 6.87 (1 H, d, *J*=3 Hz); ^{13}C NMR (100 MHz; $CDCl_3$) δ: 14.7 (s), 19.2 (t), 39.3 (d), 106.2 (s), 112.9 (s), 117.8 (s), 141.4 (d); ^{77}Se NMR (76 MHz; $CDCl_3$) δ: 644; *m/z* (EI): 196 (M^+, 55%), 83 (100). *Anal.* Calcd for $C_7H_4N_2Se$: C, 43.10; H, 2.07; N, 14.36. Found: C, 43.15; H, 2.17; N, 14.40.

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