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Oxidation of Selenoureas in Protic Medium. The Selenoanalogue to Hugershoff's Base

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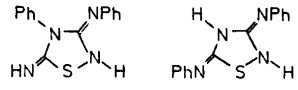
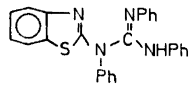
Three substituted selenoureas have been oxidised in protic medium. The reaction products were substituted benzoselenazolylguanidines in the case of *N*-methyl-*N'*-phenyl- and *N*,*N'*-diphenylselenourea. As by-products a cyclic trimer and a cyclic dimer of the corresponding carbodiimides are formed, respectively. For phenylselenourea the only product is an open chain dimer of phenylcarbodiimide.

Oxidation of substituted thioureas in protic media results in the formation of heterocyclic bases.[1] Depending upon the substitution of the thiourea three different types of heterocycles namely Hector's (I), Dost's (II), and Hugershoff's (III) bases [1,2] are formed. In order to investigate whether the seleno analogue heterocyclic bases are formed upon oxidation of substituted selenoureas, the oxidation of phenyl-, *N*-phenyl-*N'*-methyl- and *N*,*N'*-diphenylselenourea have been carried out.



I II



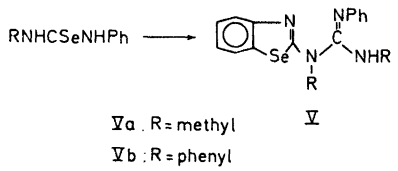
III

Substituted selenoureas have not previously been subjected to oxidation in protic media. Unsubstituted selenourea is analogous to thiourea, known to form formamidine diselenide.[3] In aprotic medium arylselenoureas form the well known aminobenzoselenazoles.[4]

The oxidations were carried out at room temperature with hydrogen peroxide in ethanol or water-ethanol mixtures with hydrochloric acid as a catalyst. Oxidation of phenylselenourea was expected to give a Hector type (I) heterocycle, but a non-selenium containing compound corresponding to a phenylcarbodiimide dimer was formed. No conclusive evidence for its structure has been established, but structure IV is favoured for IV' because of a very intense infrared absorption band at 2235 cm^{-1} wich is close to the cyanide region (2260 – 2240 cm^{-1})[5] but considerably higher than the carbodiimide region (2155 – 2130 cm^{-1}).[5]

IV IV'

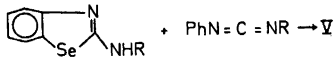
Oxidation of *N*-methyl-*N'*-phenylselenourea and *N*,*N'*-diphenylselenourea were expected to give the Dost (II) and Hugershoff (III) type compounds, respectively,[2] but in both cases Hugershoff type heterocycles were formed (Scheme 1).



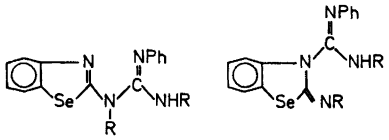
Va : R = methyl
Vb : R = phenyl

Scheme 1.

The compounds Va and Vb were characterised by elemental analysis, IR and NMR spectra. As chemical evidence for the structure V, synthesis from the aminobenzoselenazole and carbodiimide were carried out.



This synthetic pathway does not *a priori* determine the structure unambiguously, since it is know that aminobenzoselenazoles upon methylation methylate on the endocyclic nitrogen atom.[4] In order to discriminate between the two possible structures V and V′ the ^{13}C NMR spectra of Va and Vb were obtained and compared with ^{13}C NMR spectra of the model compounds 2-methylaminobenzoselenazole and 3-methyl-2-iminobenzoselenazoline.

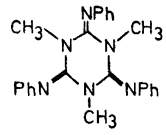


V V′

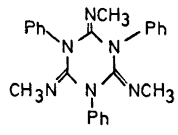
The ^{13}C NMR spectrum of 3-methyl-2-iminobenzoselenazoline shows a very characteristic high-field resonance at 110.5 ppm for one carbon in the benzoselenazoline ring system, a feature which is also observed for the benzothiazolines.[2] The analogue of this ^{13}C resonance is not seen in the spectra of 2-methylaminobenzoselenazole, Va or Vb, where the highest-field aromatic carbon signals are at 121.7, 120.2 and 119.6 ppm, respectively.

On this basis the structure V is favoured over V′ for the oxidation products of *N*-methyl-*N*′-phenyl- and *N*,*N*′-diphenylselenourea.

Besides these benzoselenazolylguanidines Va and Vb non-selenium containing heterocyclic substances are formed as by-products upon oxidation of the selenoureas. In the case of *N*-methyl-*N*′-phenylselenourea a cyclic trimer of methylphenylcarbodiimide is formed. A symmetrical 2,4,6-triiminohexahydro-1,3,5-triazine VI or VI′ is the only possibility for the structure because the ^1H NMR spectrum shows only one CH_3 signal.



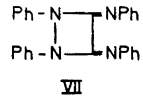
VI



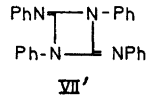
VI′

On basis of the spectroscopic evidence it is not possible to discriminate between VI and VI′.

In the case of *N*,*N*′-diphenylselenourea a cyclic dimer of diphenylcarbodiimide is formed. This has been previously isolated by Huisgen [6] without any structure elucidation. The structure must be VII or VII′, but on the basis of spectroscopic data obtained here, discrimination between the two isomers VII and VII′ was impossible.



VII



VII′

EXPERIMENTAL

IR-spectra were recorded on a Perkin-Elmer model 225 grating spectrograph, ^1H NMR spectra on a Varian A 60 or a JEOL JNM-MH-60/II instrument (chemical shifts are given in ppm relative to TMS as internal reference). ^{13}C NMR spectra were recorded on a Bruker WH 90 instrument. The mass spectra were obtained on an AEI-MS 902 mass spectrometer, operating at 70 eV. Elemental analyses were carried out by the microanalysis department of Chemical Laboratory II, University of Copenhagen, The H. C. Ørsted Institute, and melting points (uncorrected) were determined on a Büchi melting point apparatus.

Synthesis of the selenoureas

Phenyl-, *N*-methyl-*N*′-phenyl- and *N*,*N*′-diphenylselenourea were synthesised according to the procedure described by Sonoda *et al.*[7] Phenyl isocyanide was refluxed with equivalent amounts of selenium and the amine in tetrahydrofurane. The selenoureas were obtained in good yield even when undistilled phenyl isocyanide prepared in accordance with Bulka and co-workers [8] was used.

Oxidation of phenylselenourea

N-Cyano-N,N′-diphenylguanidine (IV). A solution of hydrogen peroxide (0.02 mol, 2.07 ml 30 %) in water was added dropwise to a stirred solution of phenylselenourea (0.2 mol) in ethanol

(50 ml) and four drops of conc. hydrochloric acid. After stirring for 1 h the precipitated selenium (1.51 g (0.019 mol) after drying) was removed by filtration. 200 ml of crushed ice was added to the filtrate. The precipitate was filtered off and recrystallized from ethanol. Yield 1.36 g (57 %) of shining colourless plates m.p. 103–105 °C. (Found: C 71.05; H 5.30; N 24.00. Calc. for $C_7H_6N_2$: C 71.16; H 5.12; N 23.72). ^{1}H NMR ($CDCl_3$): δ 4.55 (1 H, broad), 6.81–7.71 (5 H, m). IR (KBr): cm^{-1} 3420 (m), 3310 (m), 2235 (s), 1690 (s), 1650 (s), 1490 (s), 1365 (s). MS: 236 (M^+).

Oxidation of *N*-methyl-*N'*-phenylselenourea

N-(2-Benzoselenazolyl)-N,N'-dimethyl-N''-phenylguanidine (Va). To a stirred solution of *N*-methyl-*N'*-phenylselenourea (0.02 mol) in ethanol (30 ml) and four drops of conc. hydrochloric acid, a solution of hydrogen peroxide (0.02 mol, 2.07 ml 30 %) in water (20 ml) was added dropwise. The reaction mixture was stirred for 1 h and the precipitate was removed by filtration. 200 ml of crushed ice and 1 M sodium hydroxide were added to the filtrate until pH 10–11. The precipitate was filtered and purified by preparative thin layer technique (PLC) on silica gel plates with chloroform as eluent. Yield 2.64 g (77 %) of a light yellow amorphous compound. (Found: C 56.15; H 5.09; N 15.90. Calc. for $C_{16}H_{16}N_4Se$: C 55.98; H 4.70; N 16.32) ^{1}H NMR ($CDCl_3$): δ 2.63 (3 H, s), 3.47 (3 H, s), 3.90 (1 H, broad), 6.73–7.77(9 H, m). IR (KBr): cm^{-1} 3395 (m) 1335(s), 1585(s), 1495(s). ^{13}C NMR ($CDCl_3$): δ 164.0, 151.9, 151.6, 146.9; 135.8, 129.2, 125.8, 123.7, 122.8, 122.7, 121.1, 121.7, 37.0, 31.5.

Trimer of methylphenylcarbodiimide (VI *or* VI'). Extraction of the precipitated selenium with boiling petrolether and crystallisation resulted in 0.40 g (15 %) of colourless crystals, m.p. 120–124 °C. (Found: C 72.56; H 6.12; N 21.04. Calc. for $C_8H_8N_2$: C 72.70; H 6.10; N 21.20). ^{1}H NMR ($CDCl_3$): δ 2.92 (3 H, s), 6.67–7.33 (5 H, m). IR (KBr): cm^{-1} 1620 (s), 1580 (s), 1465 (s), 1450 (s), 1430 (s), 1395 (s). MS: 396 (M^+).

Oxidation of *N,N'*-diphenylselenourea

N-(2-Benzoselenazolyl)-N,N',N''-triphenylguanidine (Vb). A solution of hydrogen peroxide (0.01 mol, 1.04 ml 30 %) in water (10 ml), was added dropwise to a stirred suspension of *N,N'*-diphenylselenourea (0.01 mol) in an ethanol-water mixture (50 ml:20 ml) with four drops of conc. hydrochloric acid. The reaction mixture was stirred for 2 h and the precipitated selenium was removed by filtration. 200 ml of crushed ice and conc. ammonia was added to the filtrate until pH 10–11. The mixture was stirred for an hour, the precipitate was filtered off and recrystallized from ethanol. Yield 1.20 g (51 %) of colourless crystals, m.p. 156–157 °C. (Found: C 67.10; H 4.43; N 11.76. Calc. for $C_{26}H_{20}N_4Se$: C 66.87; H 4.28; N 12.00). ^{1}H NMR ($CDCl_3$): δ 6.67–7.73. IR (KBr): cm^{-1} 3400 (m), 1650 (s), 1585 (s), 1495 (s), 1480 (s), 1435 (s), 1315 (s). ^{13}C NMR ($CDCl_3$): δ 151.8, 146,3, 140.3, 129.5, 129.1, 128.8, 127.8, 126.2, 125.8, 124.9, 124.2, 123.6, 123.3, 122.5, 121.9, 121.2, 120.5, 120.2.

Dimer of diphenylcarbodiimide (VII *or* VII'). The precipitated selenium from the oxidation of *N,N'*-diphenylselenourea was extrated with boiling toluene. Evaporation of the extract to dryness yielded 0.70 g (36 %) of colourless crystals, m.p. 163–165 °C. (Found: C 80.55; H 5.33: N 14.05. Calc. for $C_{13}H_{10}N_2$: C 80.39; H 5.19; N 14.42). ^{1}H NMR ($CDCl_3$): δ 6.58–7.37. IR (KBr): cm^{-1} 1700 (s), 1680 (s), 1590 (s), 1485 (s), 1360 (s). MS: 388 (M^+).

N-(2-Benzoselenazolyl)-N,N'-dimethyl-N''-phenylguanidine. A mixture of 2-methylaminobenzoselenazole (0.005 mol) and *N*-methyl-*N'*-phenylthiourea (0.005 mol) was refluxed in 30 ml dry benzene together with 5 g lead oxide (PbO) for 1 h. The precipitated lead sulfide was removed by filtration. The filtrate was evaporated to dryness under reduced pressure. *N*-(2-Benzoselenazolyl)-*N,N'*-dimethyl-*N''*-phenylguanidine was purified by PLC and shown to have a superimposable IR spectrum upon Va arising from oxidation of *N*-methyl-*N'*-phenylselenourea.

N-(2-Benzoselenazolyl)-N,N',N''-triphenylguanidine was prepared in a similar way to *N*-(2-benzoselenazolyl)-*N,N'*-dimethyl-*N''*-phenylguanidine from phenylaminobenzoselenazole and *N,N'*-diphenylthiourea. The compound was purified by recrystallization from ethanol and shown to have a superimposable IR-spectrum upon Vb arising from oxidation of *N,N'*-diphenylselenourea.

2-Methylaminobenzoselenazole was prepared in accordance with a previously published procedure.[4] ^{13}C NMR ($CDCl_3$): δ 206.0; 170.1; 154.1; 132.8; 126.3; 124.2; 123.9; 121.3; 119.6; 32.9.

3-Methyl-2-iminobenzoselenazoline was prepared in accordance with a previously published procedure.[4] ^{13}C NMR ($CDCl_3$): δ 160.0; 142.5; 126.6; 125.0; 121.9; 121.3; 110.5; 29.9.

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REFERENCES

1. Kurzer, F. *Advan. Heterocycl. Chem. 5* (1965) 119.
2. Christophersen, C., Ottersen, T., Seff, K. and Treppendahl, S. *J. Amer. Chem. Soc. To be published.*
3. Chiesi, A., Grossoni, G., Nardelli, M. and Vidoni, M. E. *Chem. Commun.* (1969) 404.

4. Hasan, H. and Haunter, R. F. *J. Chem. Soc.* (1935) 1762.
5. Bellamy, L. J. *The Infra-Red Spectra of Complex Molecules*, Methuen, London 1966, p. 263.
6. Huisgen, R., Grasberg, R., Kunz, R., Wallbillich, G. and Adenhaar, E. *Chem. Ber. 98* (1965) 2174.
7. Sonoda, N., Yamamoto, G. and Tsutsumi, S. *Bull. Chem. Soc. Jap. 45* (1972) 2937.
8. Bulka, E., Ahlers, K. D. and Tucek, E. *Chem. Ber. 100* (1967) 1376.

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