# *vic*-Iodothiocyanates and Iodoisothiocyanates. Part 2.[1,2] New Syntheses of Thiazolidin-2-ones and 2-Amino-2-thiazolines

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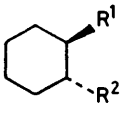
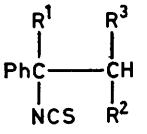
Convenient one-step syntheses of thiazolidin-2-ones and 2-amino-2-thiazolines from *vic*-iodoisothiocyanates are reported.

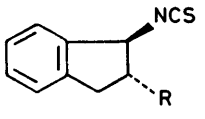
In the preceding paper [1] we reported methods for the preparation of *vic*-iodothiocyanates and *vic*-iodoisothiocyanates from alkenes in high yield, and for isomerization of the former into the latter. One-step methods for conversion of the *vic*-iodoisothiocyanates into thiazolidin-2-ones and 2-amino-2-thiazoline derivatives are reported in the present paper.



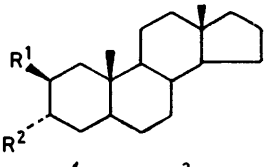
(1) $R^1$ = I, $R^2$ = NCS
(2) $R^1$ = I, $R^2$ = NHC(:S)OMe
(3) $R^1$ = I, $R^2$ = SCN
(4) $R^1$ = H, $R^2$ = NCS



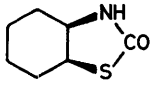
(5) $R^1$ = $R^2$ = H, $R^3$ = I
(6) $R^1$ = H, $R^2$ = Me, $R^3$ = I
(7) $R^1$ = Me, $R^2$ = H, $R^3$ = I
(8) $R^1$ = $R^2$ = $R^3$ = H
(9) $R^1$ = $R^3$ = H, $R^2$ = Me
(10) $R^1$ = Me, $R^2$ = $R^3$ = H



(11) R = I
(12) R = H



(13) $R^1$ = NCS, $R^2$ = I
(14) $R^1$ = I, $R^2$ = NCS
(15) $R^1$ = SCN, $R^2$ = I
(16) $R^1$ = I, $R^2$ = SCN
(17) $R^1$ = NCS, $R^2$ = H
(18) $R^1$ = H, $R^2$ = NCS



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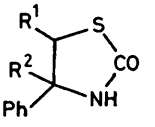
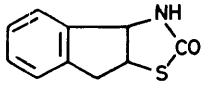


(20) $R^1$ = $R^2$ = H
(21) $R^1$ = Me, $R^2$ = H
(22) $R^1$ = H, $R^2$ = Me



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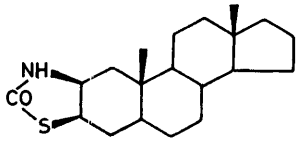

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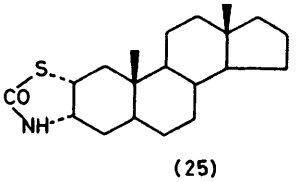

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Unlike thiazolidin-4-ones,[3] few methods are available for the synthesis of thiazolidin-2-ones,[4] and the parent unsubstituted heterocycle has been prepared only recently.[5] In the present approach the *vic*-iodoisothiocyanates were heated under reflux in the dark with anhydrous methanol in tetrachloroethylene without isolation of the intermediate *vic*-methyl *N*-(*trans*-2-iodoalkyl)-thioxocarbamate (Scheme 1; *cf.* ref. 6). All the iodoisothiocyanates examined (Table 1) gave moderate yields of thiazolidin-2-ones, except that derived from 2-phenylpropene in which the isothiocyanato-group is both benzylic and tertiary. Negligible yields were obtained when reactions were carried out at 20 °C and, in the case of *trans*-1-iodo-2-isothiocyanatocyclohexane (1), only a low yield of the unstable thioxocarbamate (2) was obtained. Unlike the cyclization of iodoisocyanates,[6] no catalysis occurred on addition of lithium methoxide. Treatment of the isomeric iodothiocyanate (3) by the above method gave no detectable thiazolidin-2-one while addition of lithium methoxide to this reaction resulted in decomposition and the formation of a complex mixture.

Literature methods for the preparation of 2-amino-2-thiazoline derivatives mainly involve the formation and cyclization of thiourea derivatives.[7] We have found that treatment of *vic*-iodoisothiocyanates with aniline in anhydrous ether at 20 °C in the dark affords moderate to high yields of 2-phenylamino-2-thiazolines (Table 1). The *vic*-iodoisothiocyanates derived from 2-phenylpropene and 5α-androst-2-ene reacted more slowly than those of the other alkenes, possibly as a result of steric hindrance at the isothiocyanato-carbon. The method appears to have general application since reaction of the iodoisothiocyanates (1) and (5) with alkylamines afforded 2-alkylamino-2-thiazolines (Table 2). The ease of formation of products, which presumably arise as indicated (Scheme 2), correlated well with the nucleophilicities of the amines. Reaction of the iodoisothiocyanate (1) with an excess of anhydrous ammonia at *ca.* −33 °C gave a *vic*-iodothiourea which readily cyclized at 20 °C (even more readily in refluxing chloroform) to give the 2-thiazolinylammonium iodide (30). A similar preparation of 2-amino-2-oxazolines has been observed for the reaction of *vic*-iodoisocyanates with ammonia.[8]

The reactions of *vic*-iodoisothiocyanates with aniline are noteworthy since Hassner and co-workers [6] have

TABLE 1

Thiazolidin-2-ones and 2-phenylaminothiazolines

| Iodoisothiocyanate | Thiazolidin-2-one | Reaction time/h | Yield (%) * | 2-Phenylamino-2-thiazoline | Reaction time/h | Yield (%) |
|---|---|---|---|---|---|---|
| (1) | (19) | 70 | 59 | (26) | 72 | 84 |
| (5) | (20) | 48 | 83 | (32) | 22 | 59 |
| (6) | (21) | 49 | 77 | (33) | 22 | 67 |
| (7) | (22) | 220 | 21 | (34) | 168 | 62 |
| (11) | (23) | 50 | 72 | (37) | 24 | 83 |
| (13, 14) | (24, 25) | 136 | 64 | (38, 39) | 94 | 57 |
| 7 : 1 † | 6.3 : 1 | | | 6 : 1 | | |

* After p.l.c. and/or crystallisation. † A mixture which was inseparable after multiple p.l.c. (hexane–chloroform, 2 : 1).

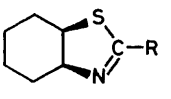
reported that treatment of *vic*-iodoisocyanates with aniline gives only phenylureas. Formation of the 2-amino-2-thiazolines in the present case probably results from the greater nucleophilicity of the sulphur atom in the intermediate thioureas.

TABLE 2

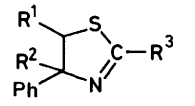
2-Alkylamino-2-thiazoline derivatives

| Iodoisothiocyanate | Amine | Reaction time/h | Product | Yield (%) |
|---|---|---|---|---|
| (1) | n-pentyl | 5 | (27) | 94 |
| (1) | di-n-butyl | 1 | (28) | 78 |
| (1) | di-isobutyl | 1 | (29) | 89 |
| (5) | n-pentyl | 7 | (35) | 56 |
| (5) | di-n-butyl | 2 | (36) | 53 |

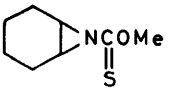
Further reactions of *vic*-iodothiocyanates and iodoisothiocyanates were also examined. Hinshaw [9] has recently synthesized thiirans (episulphides) by treatment of the products (assumed to be *trans*-iodothiocyanates) from the action of iodine and thiocyanogen on cyclic alkenes with methanolic potassium hydroxide *in situ* at room temperature. Similar results were obtained in the present work when the iodothiocyanates (3) and (15), (16) were treated in the same manner and when compound (3) was treated with methanolic potassium carbonate. The thiiran (40) was also formed, albeit more slowly but in quantitative yield, when the iodothiocyanate (3) was treated with potassium t-butoxide, a result in keeping with the weaker nucleophilicity and higher basicity of the latter reagent. Treatment of the iodoisothiocyanate (1) with methanolic potassium hydroxide gave low yields of unstable compounds, identified from spectral data as methyl *N*-(*trans*-2-iodocyclohexyl)-thioxocarbamate (2) together with some of the isomeric methyl *N*-(*trans*-2-iodocyclohexyl)thiolcarbamate (2), and the aziridine (31). The iodothioxocarbamate is less stable than the corresponding iodocarbamate which is formed in high yield from the action of an alcohol with the *vic*-iodoisocyanate.[6,11]



(26) R = NHPh
(27) R = NH[$CH_2$]$_4$Me
(28) R = $NBu^n_2$
(29) R = $NBu^i_2$
(30) R = $^+NH_3I^-$



(32) $R^1$ = $R^2$ = H, $R^3$ = NHPh
(33) $R^1$ = Me, $R^2$ = H, $R^3$ = NHPh
(34) $R^1$ = H, $R^2$ = Me, $R^3$ = NHPh
(35) $R^1$ = $R^2$ = H, $R^3$ = NH[$CH_2$]$_4$Me
(36) $R^1$ = $R^2$ = H, $R^3$ = $NBu^n_2$



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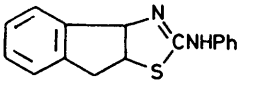

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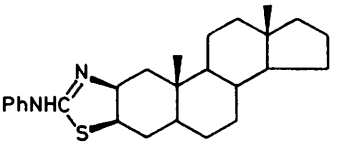

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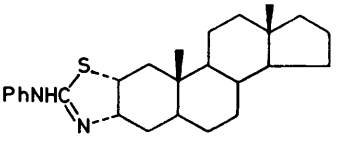
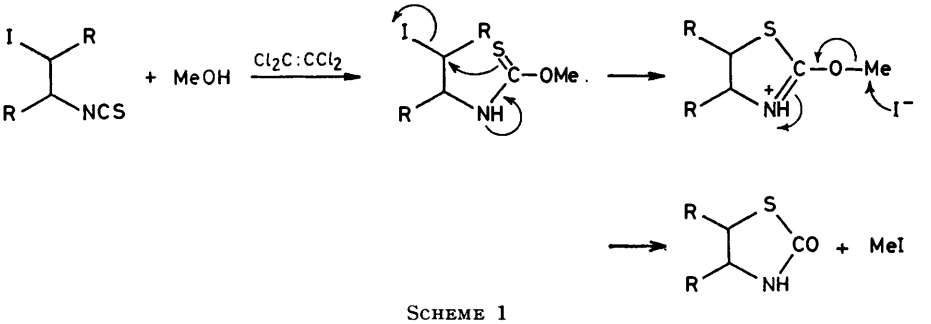


(39)

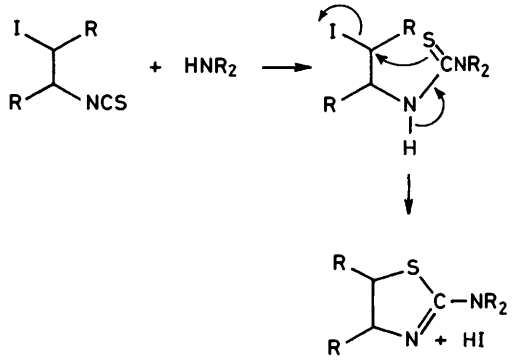
Reduction of alkyl iodides with tri-n-butyltin hydride [12] affords alkanes in high yield.[13] Treatment of the *vic*-iodoisothiocyanates used in the present study with tri-n-butyltin hydride effected selective reduction to



SCHEME 1

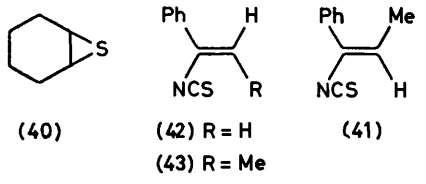
formed by Newman–Kwart thermal or acid-catalysed thioxo–thiolo rearrangement [10] of the thioxocarbamate

the corresponding isothiocyanates in high yields (Table 3). Under the same conditions the *vic*-iodothiocyanates



Scheme 2

underwent elimination (*cf. vic*-dihalides [13]). Treatment of either the *vic*-iodothiocyanato- or *vic*-iodoisothiocyanato-derivatives of arylethenes and arylpropenes



(40) (42) R = H (43) R = Me (41)

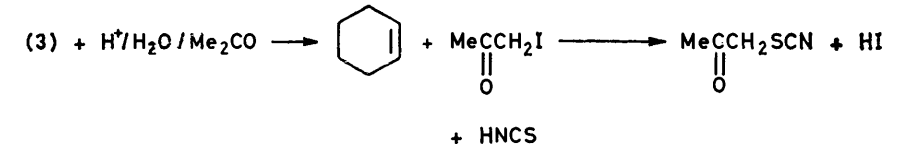
with potassium t-butoxide resulted in elimination to give vinyl thiocyanates and vinyl isothiocyanates,

Table 3

Reduction products of iodoisothiocyanates

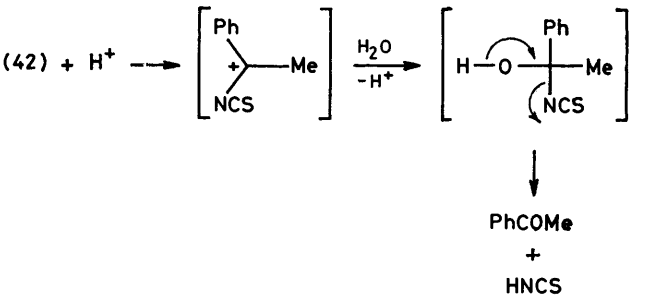
| Iodoisothiocyanate | Reaction time/h | Isothiocyanate | Yield (%) |
|---|---|---|---|
| (1) | 4 | (4) | 81 |
| (5) | 4 | (8) | 72 |
| (6) | 7 | (9) | 74 |
| (7) | 6 | (10) | 79 |
| (11) | 3 | (12) | 76 |
| (13), (14) | 4 | (17), (18) | 74 |

respectively, in moderate yields (50—66%). The initial product from the iodoisothiocyanate (6) was entirely



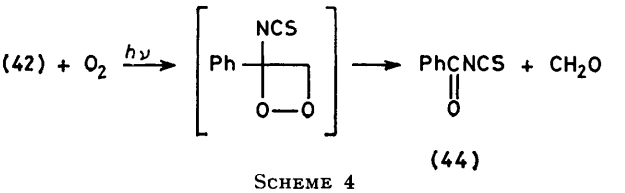
Scheme 5

the *E*-isomer (41) which partially isomerised to the *Z*-isomer (43) during purification by p.l.c.; almost complete isomerisation occurred on standing at 20 °C for 24 h. All the elimination products, but particularly the vinyl isothiocyanates, were unstable, undergoing conversion to a ketone, presumably *via* an acid-induced hydrolytic pathway (Scheme 3). The vinyl isothiocyanates (41), (42), and (43) also underwent another decomposition on standing to give benzoyl isothiocyanate (44).[14] The latter compound is thought to arise *via* an intermediate 1,2-dioxetan (Scheme 4) produced by the action of singlet oxygen on the activated double bond in the presence of light (*cf.* ref. 15).



Scheme 3

Treatment of the *vic*-iodothiocyanate (3) with hydrochloric acid in aqueous acetone at 20 °C for 24 h gave α-thiocyanatoacetone (43%) and α-iodoacetone (trace). The products are presumably formed (Scheme 5) by an



(44)

Scheme 4

acid-catalysed reversal of the iodothiocyanation of alkenes [1] followed by attack of cationic iodine on the enol form of acetone (*cf.* ref. 16). Treatment of the iodoisothiocyanate (1) with aqueous acid under the same conditions gave no observable reaction (*cf.* refs. 6 and 17).

## EXPERIMENTAL

General experimental details are given in the preceding paper.

*General Procedure for Formation of Thiazolidin-2-ones.*—Anhydrous methanol (1 ml) was added to a solution of the *vic*-iodoisothiocyanate (*ca.* 0.5 mmol, except where stated) in tetrachloroethylene (2 ml) and the mixture heated under reflux in the dark under anhydrous conditions. Solvent was removed *in vacuo* with gentle warming and the product was purified by p.l.c. ($CHCl_3$) and/or recrystallization.

The i.r. spectra of those thiazolidin-2-ones which were reasonably soluble in carbon tetrachloride showed two distinct carbonyl stretching frequencies ($\nu_{max.}$ 1 700 and 1 680 $cm^{-1}$) (*cf.* ref. 5*b*). In chloroform, in which solubilities were higher, resolution was lower and the peak at 1 700 $cm^{-1}$ appeared as a shoulder. All compounds also showed NH stretching peaks at *ca.* 3 410 and 3 200 (br) $cm^{-1}$.

cis-*Perhydrobenzothiazol-2-one* (19) formed plates, m.p. 51—52° (from ether–pentane) (Found: C, 53.5; H, 7.0;

N, 8.85. $C_7H_{11}NOS$ requires C, 53.5; H, 7.1; N, 8.9%), δ 3.77 (d, *J* 5.4 Hz, CHS), 3.91 (d, *J* 5.4 Hz, CHN), and 6.57 (br s, 3-H), *m/e* 157 ($M^{+\cdot}$). 4-*Phenylthiazolidin*-2-*one* (20) formed pale yellow needles, m.p. 139—140.5° (from dichloromethane) (Found: C, 60.05; H, 5.1; N, 7.9. $C_9H_9NOS$ requires C, 60.3; H, 5.1; N, 7.8%), δ 3.29 (q, *J* 11, 8.5 Hz, CHS), 3.68 (q, *J* 11, 8 Hz, CHS), 4.99 (q, *J* 8.5, 8 Hz, CHN), and 7.38 (s, ArH), *m/e* 179 ($M^{+\cdot}$). 5-*Methyl*-4-*phenylthiazolidin*-2-*one* (21) formed needles, m.p. 120—120.5° (from carbon tetrachloride) (Found: C, 62.0; H, 5.7; N, 7.45. $C_{10}H_{11}NOS$ requires C, 62.1; H, 5.75; N, 7.25%), δ 1.42 (d, *J* 6.5 Hz, Me), 3.73 (m, CHS), 4.45 (d, *J* 8 Hz, CHN), 6.62 (br s, NH), and 7.37 (s, ArH), *m/e* 193 ($M^{+\cdot}$). 4-*Methyl*-4-*phenylthiazolidin*-2-*one* (22) formed pale yellow needles, m.p. 79—79.5° (from ether–pentane) (Found: C, 62.15; H, 5.85; N, 7.3. $C_{10}H_{11}NOS$ requires C, 62.2; H, 5.8; N, 7.3%), δ 1.80 (s, Me), 3.50 (s, $CH_2S$), 6.75 (br s, NH), and 7.40 (s, ArH), *m/e* 193 ($M^{+\cdot}$). cis-8,8a-Dihydro-3*a*H-*indeno*[1,2-d]*thiazol*-2(3H)-*one* (23) formed pale yellow needles, m.p. 155—158° (decomp.) (from dichloromethane) (Found: C, 62.65; H, 4.9; N, 7.1. $C_{10}H_9NOS$ requires C, 62.8; H, 4.8; N, 7.3%), δ 3.15 (dd, *J* 17.5, 4 Hz, CH), 3.54 (dd, *J* 17.5, 7 Hz, CH), 4.62 (m, CHS), 5.19 (dd, *J* 7.5, 2 Hz, CHN), 7.27 (s, ArH), and 7.65 (br s, NH), *m/e* 191 ($M^{+\cdot}$).

2,3-*Dihydro*-5α-*androst*-2-*enothiazol*-2′(3′H)-*ones* (24) *and* (25). A 7 : 1 mixture of the iodoisothiocyanates (13) and (14) (0.15 mmol) gave (i) 2α,3α-*dihydro*-5α-*androst*-2-*eno*[2,3-d]*thiazol*-2′(3′H)-*one* as needles, m.p. 197—199° (from ether) (Found: C, 71.8; H, 9.6; N, 4.0. $C_{20}H_{31}NOS$ requires C, 72.0; H, 9.4; N, 4.2%), δ 0.69 (s, 18-$H_3$), 1.00 (s, 19-$H_3$), 3.40 (m, $W_{1/2}$ 24 Hz, CHS), 4.09 (m, $W_{1/2}$ 8.5 Hz, CHN), and 6.65 (br s, NH), *m/e* 333 ($M^{+\cdot}$), and (ii) 2β,3β-*dihydro*-5α-*androst*-2-*eno*[3,2-d]*thiazol*-2′(3′H)-*one* as needles, subliming at 310—320° (from chloroform) (Found: C. 71.8; H, 9.4; N, 4.0. $C_{20}H_{31}NOS$ requires C, 72.0; H, 9.4; N, 4.2%), δ 0.70 (s, 18-$H_3$), 0.80 (s, 19-$H_3$), 3.49 (m, $W_{1/2}$ 19.5 Hz, CHS), 4.08 (m, $W_{1/2}$ 10 Hz, CHN), and 5.44 (br s, NH), *m/e* 333 ($M^{+\cdot}$).

*General Procedure for Formation of* 2-*Amino*-2-*thiazolines*.—A solution of the appropriate iodoisothiocyanate (*ca.* 0.23 mmol, except where stated) in ether (3 ml) was stirred with the amine (*ca.* 2 mol. equiv.) at 20 °C. The ether was removed and the residue was purified by p.l.c. ($CHCl_3$) and/or recrystallization, $\nu_{max.}$ 3 400 (m), 3 100br (m), 1 640 (s), and 1 595 $cm^{-1}$ (s).

2-*Phenylamino*-cis-3a,4,5,6,7,7a-*hexahydrobenzothiazole* (26) was formed from the iodoisothiocyanate (0.31 mmol) and was obtained as needles, m.p. 133—134° with sintering at 120° (from ether) (Found: C, 67.2; H, 6.5; N, 12.2. $C_{13}H_{16}N_2S$ requires C, 67.2; H, 6.95; N, 12.1%), δ 3.63, 3.83 (2 overlapping m, CHS and CHN), 6.68 (s, NH), and 7.15 (m, ArH), *m/e* 232 ($M^{+\cdot}$). 4-*Phenyl*-2-*phenylamino*-2-*thiazoline* (32) formed needles, 153.5—154° (from ether) (Found: C, 70.8; H, 5.6; N, 10.65. $C_{15}H_{14}N_2S$ requires C, 70.8; H, 5.6; N, 11.0%), δ 3.07 (dd, *J* 11, 8.5 Hz, CHS), 3.50 (dd, *J* 11, 7 Hz, CHS), 5.01 (dd, *J* 8.5, 7 Hz, CHN), 6.50 (br s, NH), and 6.95—7.36 (m, ArH), *m/e* 254 ($M^{+\cdot}$). 5-*Methyl*-4-*phenyl*-2-*phenylamino*-2-*thiazoline* (33) formed pale yellow plates, m.p. 155—156.5° (from ether) (Found: C, 71.7; H, 6.0; N, 10.1. $C_{16}H_{16}N_2S$ requires C, 71.6; H, 6.0; N, 10.4%), δ 1.35 (d, *J* 6.5 Hz, Me), 3.62 (d × q, *J* 8.5, 6.5 Hz, CHS), 4.50 (d, *J* 8.5 Hz, CHN), 7.04 (m, anilino-ArH), and 7.37 (s, ArH), *m/e* 268 ($M^{+\cdot}$). 4-*Methyl*-4-*phenyl*-2-*phenylamino*-2-*thiazoline* (34) formed pale yellow needles, m.p. 80—81° with sintering at 72° (from ether—pentane) (Found: C, 71.7; H, 6.35; N, 10.0. $C_{16}H_{16}N_2S$ requires C, 71.6; H, 6.0; N, 10.4%), δ 1.65 (s, Me), 3.39 (s, $CH_2S$), 6.54 (br s, NH), and 6.97—7.62 (m, ArH), *m/e* 268 ($M^{+\cdot}$). 2-*Phenylamino*-cis-3,3a,8,8a-*tetrahydro*-2H-*indeno*[1,2-d]*thiazole* (37) crystallized from chloroform, acetone, and then methanol as pale orange needles, m.p. 197—198° (Found: C, 72.15; H, 5.25; N, 10.6. $C_{16}H_{14}N_2S$ requires C, 72.1; H, 5.3; N, 10.5%), δ 3.14 (dd, *J* 17.5, 4 Hz, CH), 3.52 (dd, *J* 17.5, 6 Hz, CH), 4.63 (m, CHS), 4.67 (d, *J* 7.5 Hz, CHN), 5.27 (br s, NH), and 7.27 (m, ArH), *m/e* 266 ($M^{+\cdot}$).

2′-*Phenylamino*-2,3-*dihydro*-5α-*androst*-2-*enothiazoles* (38) *and* (39). A 7 : 1 mixture of the iodoisothiocyanates (13) and (14) (0.11 mmol) gave (i) 2′-*phenylamino*-2α,3α-*dihydro*-5α-*androst*-2-*eno*[2,3-d]*thiazole* (38) as needles, m.p. 235—236° (from ether) (Found: C, 76.65; H, 8.85; N, 6.55. $C_{26}H_{36}N_2S$ requires C, 76.4; H, 8.9; N, 6.9%), δ 0.67 (s, 18-$H_3$), 0.97 (s, 19-$H_3$), 3.38 (m, $W_{1/2}$ 24 Hz, CHS), 4.02 (m, $W_{1/2}$ 12 Hz, CHN), 5.30 (br s, NH), and 7.19 (m, ArH), *m/e* 408 ($M^{+\cdot}$), and (ii) 2′-phenylamino-2β,3β-dihydro-5α-androst-2-eno[3,2-*d*]thiazole (39) as needles, m.p. 178° with sintering at 163° (from ether), δ 0.65 (s, 18-$H_3$), 0.74 (s, 19-$H_3$), 3.32 (m, $W_{1/2}$ 25 Hz, CHS), 3.89 (m, $W_{1/2}$ 12 Hz, CHN), 5.80 (br s, NH), and 7.03 (m, ArH), *m/e* 408 ($M^{+\cdot}$).

2-*n*-*Pentylamino*-cis-3a,4,5,6,7,7a-*hexahydrobenzothiazole* (27) formed needles, m.p. 64—65° (from ether) (Found: C, 63.9; H, 9.75; N, 12.1. $C_{12}H_{22}N_2S$ requires C, 63.7; H, 9.8; N, 12.4%), δ 0.90 (t, *J* 5.5 Hz, Me), 1.34 (m, $CH_2$), 3.22 (t, *J* 6.5 Hz, $CH_2N$), 3.50—4.12 (overlapping m, CHS and CHN), and 4.35 (br s, NH), *m/e* 226 ($M^{+\cdot}$).

2-*Di*-*n*-*butylamino*-cis-3a,4,5,6,7,7a-*hexahydrobenzothiazole* (28) was a viscous oil, b.p. 98—102° at 0.02 mmHg (Found: C, 67.2; H, 10.6; N, 10.2. $C_{15}H_{28}N_2S$ requires C, 67.1; H, 10.5; N, 10.4%), δ 0.65—2.05 (m. Me and $CH_2$), 3.31 (t, *J* 7 Hz, 2 × $CH_2N$), and 3.49—4.10 (overlapping m, CHS and CHN), *m/e* 268 ($M^{+\cdot}$). 2-*Di*-*t*-*butylamino*-cis-3a,4,5,6,7,7a-*hexahydrobenzothiazole* (29) was a viscous oil, b.p. 84—88° at 0.05 mmHg, δ 0.90 (d, *J* 7 Hz, Me), 1.15—2.35 (m, $CH_2$ and CH), 3.03 (dd, *J* 14.5, 7 Hz, $CH_2N$), 3.32 (dd, *J* 14.5, 7.5 Hz, $CH_2N$), and 3.60—4.12 (overlapping m, CHS and CHN), *m/e* 268 ($M^{+\cdot}$). 2-*n*-*Pentylamino*-4-*phenyl*-2-*thiazoline* (35) formed needles, m.p. 80.5—81.5° (from ether–pentane) (Found: C, 67.55; H, 7.95; N, 11.15. $C_{14}H_{20}N_2S$ requires C, 67.7; H, 8.1; N, 11.3%), δ 0.89 (t, *J* 5.5 Hz, Me), 2.98—3.43 (m, CHS and CHN), 3.65 (dd, *J* 10.5, 7.5 Hz, CHS), 4.05 (br s, NH), 5.30 (t, *J* 7.5 Hz, CHN), and 7.34 (s, ArH), *m/e* 248 ($M^{+\cdot}$). 2-*Di*-*n*-*butylamino*-4-*phenyl*-2-*thiazoline* (36) was a pale yellow viscous oil, b.p. 96—100° at 0.01 mmHg (Found: C, 70.65; H, 9.0; N, 9.4. $C_{17}H_{26}N_2S$ requires C, 70.3; H, 9.0; N, 9.65%), δ 0.68—1.93 (m, Me and $CH_2$), 3.07 (dd, *J* 10.5, 7.5 Hz, CHS), 3.37 (t, *J* 7.5 Hz, 2 × $CH_2N$), 3.64 (dd, *J* 10.5, 7.5 Hz, CHS), 5.33 (t, *J* 7.5 Hz, CHN), and 7.30 (s, ArH), *m/e* 290 ($M^{+\cdot}$).

2-*Ammonio*-cis-3a,4,5,6,7,7a-*hexahydrobenzothiazole Iodide* (30).—Anhydrous ammonia was bubbled through a solution of the iodoisothiocyanate (1) (0.15 g, 0.57 mmol) in ether (5 ml) at −33 °C for 3 h. The mixture was warmed to 20 °C and ether was removed *in vacuo* to give an unstable *vic*-iodothiourea intermediate as a pale yellow solid which was dissolved in chloroform (5 ml) and heated under reflux for 2 h. Removal of solvent gave 2-*ammonio*-cis-, 3a,4,5,6,7,7a-*hexahydrobenzothiazole iodide* (0.11 g, 68%), m.p. 175—176° (from ether) (Found: C, 29.8; H,

4.85; I, 44.2; N, 9.8. $C_7H_{13}IN_2S$ requires C, 29.6; H, (4.6; I, 44.65; N, 9.9%), δ ($CDCl_3$ + DMSO) 1.25—2.46 (m, $CH_2$), 3.93—4.40 (overlapping m, CHS and CHN), and 7.00 (br s, NH), *m/e* 156 ($M^{+\cdot}$ — HI) (no $M^{+\cdot}$).

1,2-*Epithiocyclohexane* (40).—A solution of the iodothiocyanate (3) (0.38 g, 1.43 mmol) in ether (1 ml) was stirred with 2% methanolic potassium hydroxide (4.8 ml, 1.72 mmol) at 20 °C for 2 h. Work-up with ether gave 1,2-epithiocyclohexane (0.13 g, 78%) as a yellow liquid, δ 0.80—1.80 (m, 4- and 5-$CH_2$), 1.90—2.40 (m, 3- and 6-$H_2$), and 3.10 (m, CHS), *m/e* 114 ($M^{+\cdot}$).

Treatment of the iodoisothiocyanate (1) (0.13 g, 0.50 mmol) with potassium t-butoxide (67 mg, 0.60 mmol) in anhydrous ether (3 ml) for 19 h gave the thiiran (40) (57 mg, 100%).

2β,3β-*Epithio-5α-androstane*.—A 7 : 1 mixture of the iodothiocyanates (15) and (16) (0.14 g, 0.32 mmol) in ether (1 ml) was stirred with 2% methanolic potassium hydroxide (1.1 ml, 0.39 mmol) at 20 °C for 2 h. Work-up and p.l.c. gave a 6.8 : 1 mixture of 2β,3β-epithio-5α-androstane and 2α,3α-epithio-5α-androstane (45 mg, 48%) which after crystallization from ether afforded 2β,3β-*epithio-5α-androstane* as needles, m.p. 123—125° (Found: C, 78.8; H, 10.55; S, 10.7. $C_{19}H_{30}S$ requires C, 78.5; H, 10.4; S, 11.0%), δ 0.66 (s, 18-$H_3$), 0.88 (s, 19-$H_3$), 2.41 (d, $J_{gem}$ 15 Hz, 1β-H), and 3.05 (m, $W_{1/2}$ 7.5 Hz, CHS), *m/e* 290 ($M^{+\cdot}$). 2α,3α-Epithio-5α-androstane had δ 0.66 (s, 18-$H_3$), 0.78 (s, 19-$H_3$), 2.31 (d, $J_{gem}$ 15 Hz, 1α-H), and 2.85 (m, $W_{1/2}$ 8 Hz, CHS).

*Methyl* N-(trans-2-*Iodocyclohexyl*)*thioxocarbamate* (2).—A solution of the iodoisothiocyanate (1) was treated with methanolic potassium hydroxide as above. Work-up gave (i) methyl *N*-(*trans*-2-iodocyclohexyl)thioxocarbamate as an unstable oil, $\nu_{max.}$ 3 400, 3 250br (NH), and 1 440 $cm^{-1}$ (NCS), δ 4.00 (br m, CHI, CHN, and Me), *m/e* 299 ($M^{+\cdot}$) and 172 ($M^{+\cdot}$ — $I^{\cdot}$), together with some methyl *N*-(*trans*-2-iodocyclohexyl)thiolcarbamate, $\nu_{max.}$ 1 665 $cm^{-1}$, and (ii) *methyl 7-azabicyclo*[4.1.0]*heptane-7-thioxocarboxylate* (31), b.p. 65° at 0.25 mmHg (Found: C, 56.3; H, 8.15; N, 8.2. $C_8H_{13}NOS$ requires C, 56.1; H, 7.65; N, 8.2%), δ 1.39 (m, 3- and 4-$H_2$), 1.89 (m, 2- and 5-$H_2$), 2.71 (m, 1- and 6-H), and 4.00 (s, OMe), *m/e* 171 ($M^{+\cdot}$).

*General Procedure for Reduction of Iodoisothiocyanates by Tri-n-butyltin Hydride*.—In a three-necked flask equipped with a condenser and protected from air and moisture, tri-n-butyltin hydride (*ca.* 1.2 mol. equiv.) was introduced to a solution of the iodoisothiocyanate in anhydrous ether (3 ml) by a syringe through a rubber septum. The mixture was heated under reflux under nitrogen with a trace of α-azoisobutyronitrile until reaction was complete, and the mixture was then concentrated and purified by p.l.c. The i.r. spectra of the products showed a strong band in the region 2 070—2 110 $cm^{-1}$ (NCS). *Isothiocyanatocyclohexane* (4) was an oil, b.p. 51—55° at 0.12 mmHg (Found: C, 59.6; H, 7.5; N, 9.9. $C_7H_{11}NS$ requires C, 59.5; H, 7.8; N, 9.9%), δ 1.1—2.3 (m, $CH_2$) and 3.69 (m, $W_{1/2}$ 15 Hz, CHN), *m/e* 141 ($M^{+\cdot}$). 1-*Isothiocyanato*-1-*phenylethane* (8) was an oil, b.p. 65° at 0.05 mmHg (Found: C, 66.0; H, 5.5; N, 8.4. $C_9H_9NS$ requires C, 66.3; H, 5.5; N, 8.6%), δ 1.69 (d, *J* 7 Hz, Me), 4.85 (q, *J* 7 Hz, CHN), and 7.33 (s, ArH), *m/e* 163 ($M^{+\cdot}$). 1-*Isothiocyanato*-1-*phenylpropane* (9) was a pale yellow oil, b.p. 81—85° at 0.05 mmHg (Found: C, 67.5; H, 6.2; N, 7.8. $C_{10}H_{11}NS$ requires C, 67.75; H, 6.2; N, 7.9%), δ 1.00 (t, *J* 6.5 Hz, Me), 1.91 (m, $CH_2$), 4.65 (t, *J* 7 Hz, CHN), and 7.33 (s, ArH), *m/e* 177 ($M^{+\cdot}$). 2-*Isothiocyanato*-2-*phenylpropane* (10) was an oil, b.p. 85° at 0.15 mmHg (Found: C, 67.7; H, 6.1; N, 7.9. $C_{10}H_{11}NS$ requires C, 67.8; H, 6.2; N, 7.9%), δ 1.78 (s, 2 × Me), and 7.38 (m, ArH), *m/e* 177 ($M^{+\cdot}$). 1-*Isothiocyanatoindane* (12) was a pale yellow oil, b.p. 108—113° at 0.1 mmHg (Found: C, 68.8; H, 5.15; N, 8.2. $C_{10}H_9NS$ requires C, 68.5; H, 5.1; N, 8.0%), δ 2.34 (m, 2-$H_2$), 2.98 (m, 3-$H_2$), 5.15 (t, $J_{obs}$ 6.5 Hz, CHN), and 7.25 (m, ArH), *m/e* 175 ($M^{+\cdot}$).

2β-*Isothiocyanato-5α-androstane* (17).—A 7 : 1 mixture of the iodoisothiocyanates (13) and (14) gave a *ca.* 6 : 1 mixture of 2β-isothiocyanato-5α-androstane and 3α-isothiocyanato-5α-androstane. Recrystallization from pentane gave 2β-*isothiocyanato-5α-androstane* as needles, m.p. 93.5—94.5° (Found: C, 75.9; H, 9.9; N, 4.6. $C_{20}H_{31}NS$ requires C, 75.6; H, 9.9; N, 4.4%), δ 0.70 (s, 18-$H_3$), 1.07 (s, 19-$H_3$), and 4.19 (m, $W_{1/2}$ 9.5 Hz, CHN), *m/e* 317 ($M^{+\cdot}$). 3α-Isothiocyanato-5α-androstane had δ 0.67 (s, 18-$H_3$), 0.77 (s, 19-$H_3$), and 4.00 (m, CHN).

1-*Phenyl*-1-*thiocyanatoethene* (42).—Potassium t-butoxide (62 mg, 0.56 mmol) was added to a cold (0 °C) solution of 1-iodo-2-phenyl-2-thiocyanatoethane [1] (0.13 g, 0.46 mmol) in anhydrous ether (3 ml) and the mixture was stirred at 20 °C for 72 h. Work-up with ether and p.l.c. gave 1-phenyl-1-thiocyanatoethene as a pale yellow oil (37 mg, 50%), b.p. 78—82° at 0.07 mmHg, $\nu_{max.}$ 2 160 $cm^{-1}$ (SCN), δ 5.79 (s, $CH_2$) and 7.42 (m, ArH), *m/e* 161 ($M^{+\cdot}$).

*E- and Z-1-Phenyl-1-isothiocyanatopropenes* (41) *and* (43).—A mixture of the iodoisothiocyanate (6) (0.11 g, 0.36 mmol) and potassium t-butoxide (49 mg, 0.44 mmol) in anhydrous ether (3 ml) was stirred at 20 °C for 2 h. Work-up and p.l.c. gave a *ca.* 1 : 1 mixture of *E*- and *Z*-1-phenyl-1-isothiocyanatopropenes (42 mg, 66%) as an oil, $\nu_{max.}$ 2 080 $cm^{-1}$ (NCS), δ 1.79 [d, *J* 7.5 Hz, Me of (41)], 1.99 [d, *J* 7 Hz, Me of (43)], 5.82 (q, *J* 7.5 Hz, CH of (41)], 5.99 [q, *J* 7 Hz, CH of (43)], and 7.33 (br s, ArH), *m/e* 175 ($M^{+\cdot}$).

After 1 day at 20 °C the isomer (41) isomerized to (43) in >90% yield. The mixture also formed benzoyl isothiocyanate (44) which was purified by p.l.c. to give a pale yellow oil (23%), b.p. 65—70° at 0.4 mmHg, identical (i.r. and mass spectra) with an authentic sample.[13]

1-*Isothiocyanato*-1-*phenylethene*.—The iodoisothiocyanate (5) (0.10 g, 0.36 mmol) was treated with potassium t-butoxide (49 mg, 0.44 mmol) as above for 2 h. Work-up and p.l.c. gave acetophenone (6 mg, 14%) and 1-isothiocyanato-1-phenylethene as an orange oil (32 mg, 54%), $\nu_{max.}$ 2 080 $cm^{-1}$ (NCS), δ 5.32 (br s, CH *trans* to Ph), 5.54 (br s, CH *cis* to Ph), and 7.47 (m, ArH), *m/e* 161 ($M^{+\cdot}$).

After 2 days at 20 °C the compound was converted (69%) to benzoyl isothiocyanate.

α-*Thiocyanatoacetone*.—The iodothiocyanate (3) (0.14 g) was treated with concentrated hydrochloric acid (2 drops) in acetone (2 ml) and water (1 ml) at 20 °C for 24 h. Work-up and p.l.c. gave α-thiocyanatoacetone (27 mg, 43%), $\nu_{max.}$ 2 155 (SCN) and 1 720 $cm^{-1}$ (CO), δ 2.37 (s, Me) and 4.03 (s, $CH_2$), *m/e* 115 ($M^{+\cdot}$), 72 ($M^{+\cdot}$ — $MeCO^{\cdot}$), and 43 ($MeCO^{+}$). The mass spectrum showed the presence of a trace of α-iodoacetone, *m/e* 184 ($M^{+\cdot}$).

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