Organotelluriums. Part 21.† Amidotellurinylation of Olefins and a Novel One-Pot Synthesis of 4,5-Dihydro-oxazoles from Olefins

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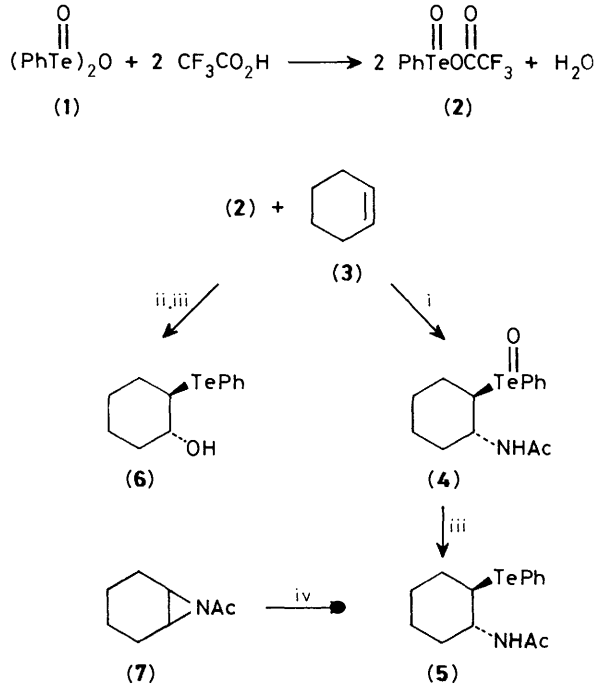
Benezenetellurinyl trifluoroacetate in the presence of boron trifluoride–diethyl ether effects ready amidotellurinylation of olefins in acetonitrile at room temperature. The resulting β-acetamidoalkyl phenyl telluroxides further suffer an *in situ* intramolecular substitution at 75 °C to give 4,5-dihydro-oxazoles in high yields. These reactions are highly regio- and stereo-selective.

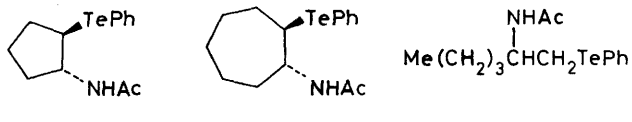
Benzenetellurinyl reagents in combination with an alcohol or carbamate as a nucleophile were found to effect ready oxytellurinylation[1] or aminotellurinylation[2] of olefins. Furthermore, at elevated temperature the latter reaction resulted in the one-pot formation of oxazolidin-2-ones by way of pyrolysis of the β-phenyltellurinyl carbamates produced *in situ*.[3] The phenyltellurinyl group acts not only as an efficient electrophile but also as a good nucleofuge; this versatility bodes well for its synthetic application. Toshimitsu *et al.* reported that benzeneselenenyl reagents underwent amidoselenation of olefins in acetonitrile (here acting both as a solvent and as a nucleophile),[4] a reaction reminiscent of the Ritter amide synthesis.[5] This prompted us to examine the amidotellurinylation of olefins as an approach to functionalized organotelluriums. The successful amidotellurinylation of olefins was accomplished using a combination reagent of benzenetellurinyl trifluoroacetate (2) and a nitrile; the one-pot synthesis of 4,5-dihydro-oxazoles was also induced by way of an intramolecular cyclization similar to that observed in the formation of oxazolidin-2-ones.[3] In this paper we report the details of these novel reactions.[6]

Results and Discussion

Amidotellurinylation.—Benzenetellurinyl trifluoroacetate (2) was readily generated from the reaction of benzenetellurinic anhydride (1) with trifluoroacetic acid in acetonitrile; because of its hygroscopicity, it was used as an effective tellurinylating agent without isolation.[3] In a typical amidotellurinylation reaction, cyclohexene (3) (1 equiv.) and boron trifluoride–diethyl ether (1.4 equiv.) were added to a solution of (2) (1.2 equiv.) in acetonitrile, and the resulting mixture was stirred at room temperature for 12 h to give *trans*-2-acetamidocyclohexyl phenyl telluroxide (4). The telluroxide (4) was very difficult to purify, but on reduction with hydrazine hydrate in ethanol gave the telluride (5) in 76% yield (Scheme 1). Boron trifluoride was required to promote the amidotellurinylation; in its absence no reaction occurred at room temperature, and on heating to reflux oxytellurinylation occurred with water formed as the by-product in the generation of (2), leading, after reduction with hydrazine hydrate, to 2-hydroxycyclohexyl phenyl telluride (6)[7] in 48% yield. A catalytic amount of trifluoroacetic acid was also neccessary to promote the amidotellurinylation because use of (2), alternatively generated from (1) with trifluoroacetic anhydride, gave compound (5) in only 29% yield, while the yield was improved to 83% by addition of a small amount of trifluoroacetic acid to the reaction mixture. The *trans* stereochemistry of adduct (5) was confirmed by direct comparison with an authentic sample, derived from the ring opening of 7-acetyl-7-azabicyclo[4.1.0]heptane (7) with sodium benzenetellurolate.

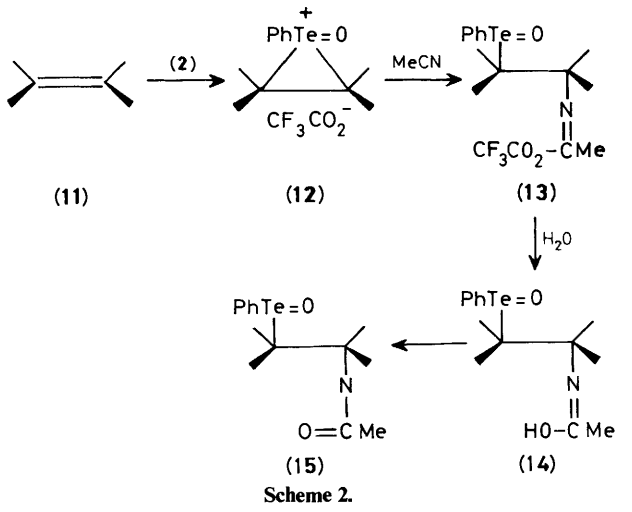


Scheme 1. *Reagents:* i, CH_3CN, BF_3-OEt_2; ii, H_2O; iii, NH_2NH_2-H_2O; iv, PhTeNa

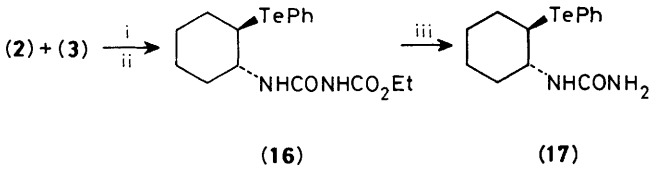


Cyclopentene and cycloheptene were similarly subjected to the amidotellurinylation reaction to give the corresponding tellurides (8) and (9) in 89% and 92% yields, respectively. When this reaction was applied to 1-hexene, a Markovnikov-type adduct (10) was obtained in 95% yield. These results suggest that, as shown in Scheme 2, the reaction proceeds by rear-side attack of the nitrogen atom of acetonitrile on the epitelluronium ion (12) to give the intermediate (13), followed by hydrolysis to the iminol (14) and then tautomerization to the more stable amide (15).

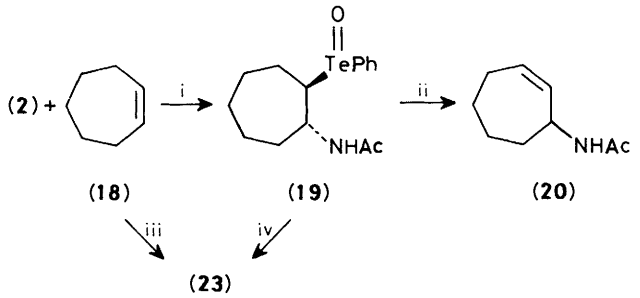
† Part 20: N. X. Hu, Y. Aso, T. Otsubo, and F. Ogura, *J. Org. Chem.*, 1989, **54**, in press.



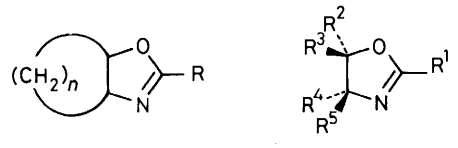
Scheme 2.



Scheme 3. *Reagents:* i, $NCNHCO_2Et$, $BF_3{\cdot}OEt_2$, $(CH_2Cl)_2$; ii, $NH_2NH_2{\cdot}H_2O$, EtOH; iii, KOH, EtOH



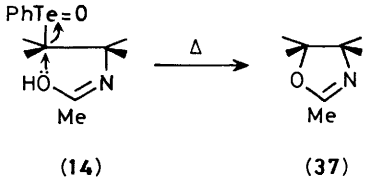
Scheme 4. *Reagents and conditions:* i, $BF_3{\cdot}OEt_2$, CH_3CN, room temperature; ii, aq. NaOH, room temperature; iii, $BF_3{\cdot}OEt_2$, CH_3CN, 75 °C; iv, Et_3N, THF, 30 °C



(**21**) R = Me, n = 3
(**22**) R = Me, n = 4
(**23**) R = Me, n = 5
(**24**) R = Me, n = 6
(**25**) R = Et, n = 3
(**26**) R = Ph, n = 3
(**27**) R = Ph, n = 4
(**28**) R = $NHCO_2Et$, n = 3
(**29**) R = $NHCO_2Et$, n = 4
(**30**) R = $NHCO_2Et$, n = 5
(**31**) R^1 = Me, R^2 = R^3 = R^4 = H, R^5 = Bu
(**32**) R^1 = Me, R^2 = R^4 = H, R^3 = R^5 = Pr
(**33**) R^1 = Me, R^2 = R^5 = H, R^3 = R^4 = Pr
(**34**) R^1 = Me, R^2 = R^5 = H, R^3 = Me, R^4 = Ph
(**35**) R^1 = $NHCO_2Et$, R^2 = R^4 = H, R^3 = R^5 = Pr
(**36**) R^1 = $NHCO_2Et$, R^2 = R^5 = H, R^3 = R^4 = Pr

In order to extend the scope of amidotellurinylation, the synthesis of a urea derivative bearing a phenyltelluro group was attempted with cyanamide as a nucleophile, but unfortunately the polymerization of cyanamide itself under the reaction conditions allowed no amidotellurinylation. This difficulty was circumvented by protection of the amine group of cyanamide. Thus cyclohexene was treated with (**2**) (1.2 equiv.), *N*-(ethoxycarbonyl)cyanamide[8] (3 equiv.), and boron trifluoride–diethyl ether (1.4 equiv.) in 1,2-dichloroethane at 50 °C, followed by hydrazine hydrate, leading to the formation of (**16**) in 73% yield (Scheme 3). The subsequent hydrolysis of the adduct (**16**) under reflux in a 1.5M ethanolic solution of potassium hydroxide gave the urea derivative (**17**) in 85% yield.

Synthesis of 4,5-*Dihydro-oxazoles.*—The synthesis of 3-amido olefins by the telluroxide elimination[9] of the intermediate β-amidotelluroxides demonstrates the utility of the present amidotellurinylation in organic synthesis. Thus the β-amidotelluroxide (**19**), derived by amidotellurinylation of cycloheptene, was treated with sodium hydroxide in aqueous THF at room temperature for 3 h, causing ready elimination of benzenetellurenic acid to form 3-acetamidocycloheptene (**20**) in 76% yield (Scheme 4). On the other hand, when (**19**) was treated with triethylamine in THF at 30 °C for 4 h, an apparent intramolecular substitution of the phenyltellurinyl group by the oxygen of the β-amido group occurred to form 2-methyl-3a,5,6,7,8,8a-hexahydro-4*H*-cycloheptoxazole (**23**) in 82% yield. Furthermore, (**23**) was found to be almost quantitatively formed directly from the amidotellurinylation of cycloheptene at elevated temperature (75 °C) for 3 h. A variety of examples of this one-pot synthesis are summarized in the Table. The reaction generally proceeds in high yield for cyclic olefins, though cyclo-octene was converted into (**24**) in only 29% yield, probably due to steric hindrance (Run 4). The reaction of 1-hexene produced 4-butyl-4,5-dihydro-2-methyloxazole (**31**) in 96% yield (Run 11). This high regioselectivity is quite consistent with the Markovnikov addition observed in the preceding amidotellurinylation. In addition, the reaction shows high stereoselectivity (Runs 12—14). The stereospecific formations of the isomeric 4,5-dihydro-2-methyl-4,5-dipropyloxazoles from *cis*- and *trans*-oct-4-enes give accurate information on the stereochemical course of the reaction. By examination of their ^1H n.m.r. spectra, the product obtained from *cis*-oct-4-ene was characterized as the *cis*-isomer (**32**) and the product from *trans*-4-octene as the *trans*-isomer (**33**). From this result, together with the *trans* addition for the initial amidotellurinylation of olefins discussed above, we propose that the reaction mechanism involves an intramolecular nucleophilic substitution in the iminol (**14**) with inversion of configuration at the carbon bearing the phenyltellurinyl group, leading to the



Scheme 5.

formation of the 4,5-dihydro-oxazole (**37**) as shown in Scheme 5. Thus the transformation of olefin into 4,5-dihydro-oxazole is, as a whole, *cis* stereoselective.

The reaction proceeded equally well in other nitrile solvents. As shown in the Table, use of propionitrile led to the formation of the 2-ethyltetrahydrocyclopentoxazole (**25**) (Run 5) and use of benzonitrile to the 2-phenylcyclopent- and benzo-oxazoles (**26**) and (**27**) (Runs 6 and 7). However, the lower nucleophilicity

Table. One-pot formation of 4,5-dihydro-oxazoles from alkenes induced by benzenetellurinyl trifluoroacetate (**2**)

Run	Substrate	Nucleophile	Temp. (°C)	Time (h)	Product	Yield (%)
1	Cyclopentene	MeCN	75	3	(**21**)	95
2	Cyclohexene	MeCN	75	8	(**22**)	80
3	Cycloheptene	MeCN	75	3	(**23**)	97
4	Cyclo-octene	MeCN	75	3	(**24**)	29
5	Cyclopentene	EtCN	75	3	(**25**)	96
6	Cyclopentene	PhCN	75	3	(**26**)	46
			65	12		87
7	Cyclohexene	PhCN	75	3	(**27**)	34
			65	12		53
8	Cyclopentene	$NCNHCO_2Et$	75	3	(**28**)	95
9	Cyclohexene	$NCNHCO_2Et$	75	12	(**29**)	60
10	Cycloheptene	$NCNHCO_2Et$	75	3	(**30**)	91
11	Hex-1-ene	MeCN	75	3	(**31**)	96
12	*cis*-Oct-4-ene	MeCN	75	3	(**32**)	83
13	*trans*-Oct-4-ene	MeCN	75	3	(**33**)	33
			65	8		56
14	*trans*-β-Methylstyrene	MeCN	75	3	(**34**)	71
15	*cis*-Oct-4-ene	$NCNHCO_2Et$	75	3	(**35**)	89
16	*trans*-Oct-4-ene	$NCNHCO_2Et$	75	3	(**36**)	93

of benzonitrile resulted in a considerable lowering of the yield. This is probably due to competitive side reactions, which are markedly suppressed by use of a lower reaction temperature (65 °C) and a longer reaction time.

2-Amino-4,5-dihydro-oxazole derivatives are of particular interest in therapeutic applications.[10] A similar treatment of olefins with (**2**) at 75 °C in 1,2-dichloroethane containing boron trifluoride–diethyl ether (1.4 equiv.) and *N*-(ethoxycarbonyl)-cyanamide (3 equiv.) for 3 h led to the straightforward formation of 2-(ethoxycarbonylamino)-4,5-dihydro-oxazoles in high yield. Typical examples are summarized in the Table (Runs 8—10, 15, and 16). High stereoselectivity holds in this case.

Conclusion.—The present amidotellurinylation of olefins by the benzenetellurinyl reagent (**2**) gives a novel method for introduction of both phenyltelluro and amido groups into organic substrates. In addition, this reaction in combination with the subsequent intramolecular substitution constitutes a new approach to 4,5-dihydro-oxazoles. 4,5-Dihydro-oxazoles possess various industrial applications[10] and are of synthetic utility as useful intermediates.[11] Many methods for the synthesis of 4,5-dihydro-oxazoles have been reported, including the condensation of β-amino alcohols and carboxylic acids, the intramolecular cyclization of β-substituted *N*-alkylamides, and the addition of aliphatic epoxides to nitriles.[10] These methods, however, may often suffer from difficult access to the starting materials and severe reaction conditions. In contrast, the present reaction provides a simple one-pot synthesis of 4,5-dihydro-oxazoles from easily available olefins and proceeds under very mild conditions with high regio- and stereoselectivity.

Experimental

General.—Melting points were determined with a Yanaco micro melting point determination apparatus and are uncorrected. I.r. spectra were recorded with a Hitachi 260-30 spectrometer. ^1H N.m.r. spectra were recorded on a JEOL JNM-PMX 60 spectrometer in deuteriochloroform using tetramethylsilane as internal standard. ^{13}C N.m.r. spectra were measured with a JEOL FX-90A spectrometer in deuteriochloroform. Mass spectra were taken on a Shimadzu GCMS-QP 1000 spectrometer, and peaks involving a typical isotopic pattern of tellurium are reported on the basis of its isotope mass number 130. All reactions were carried out under a nitrogen atmosphere. All chemicals and solvents were of reagent grade.

General Procedure for Amidotellurinylation.—trans-2-*Acetamidocyclohexyl phenyl telluride* (**5**). Benzenetellurinyl trifluoroacetate (**2**) was generated *in situ* by treatment of benzenetellurinic anhydride (**1**)[12] (0.27 g, 0.59 mmol) with trifluoroacetic acid (0.159 g, 1.4 mmol) in acetonitrile (6 ml) at room temperature for 10 min. To this solution were successively added cyclohexene (**3**) (0.082 g, 1.0 mmol) and boron trifluoride–diethyl ether (0.2 g, 1.4 mmol), and the resulting mixture was stirred at room temperature for 12 h. Evaporation of solvent under reduced pressure left a yellow oil containing (**4**), which was reduced with hydrazine hydrate (0.1 g, 2 mmol) in ethanol (6 ml) at room temperature for 15 min. The product mixture was poured into water and extracted with dichloromethane (2 × 20 ml). The organic layer was washed with brine, dried ($MgSO_4$), and evaporated to give a residue. This was chromatographed on silica gel with ethyl acetate–hexane (3:2) as eluant to give (**5**) (0.262 g, 76%). Recrystallization from hexane–chloroform (5:1) gave white *needles*, m.p. 146—146.5 °C (Found: C, 48.55; H, 5.4; N, 4.0. $C_{14}H_{19}NOTe$ requires C, 48.74; H, 5.56; N, 4.06%); $\nu_{max.}$(KBr disc) 3 300 (NH), 1 640, and 1 535 cm^{-1} (NHC=O); δ_H(60 MHz) 0.9—2.3 (8 H, m, CH_2), 1.92 (3 H, s, Me), 3.0—3.5 (1 H, m, CHTe), 3.5—4.1 (1 H, m, CHN), 5.95 (1 H, br d, *J* 8 Hz, NH), 7.0—7.3 (3 H, m, ArH), and 7.6—7.9 (2 H, m, ArH); *m/z* 347 (M^+, 8%), 207 ($PhTe^+$, 7), 140 (M^+ − PhTe, 67), 98 (100), 81 (60), 77 (31), 60 (82), 56 (33), and 43 (83).

trans-2-*Acetamidocyclopentyl phenyl telluride* (**8**). White *needles* from hexane–chloroform (10:1), m.p. 77.8—78.2 °C (Found: C, 47.2; H, 5.2; N, 4.15. $C_{13}H_{17}NOTe$ requires C, 47.18; H, 5.19; N, 4.23%); $\nu_{max.}$(KBr disc) 3 325 (NH), 1 640, and 1 530 cm^{-1} (NHC=O); δ_H(60 MHz) 1.2—2.3 (6 H, m, CH_2), 1.85 (3 H, s, Me), 3.34 (1 H, q, *J* 8 Hz, CHTe), 4.17 (1 H, quin, *J* 8 Hz, CHN), 6.30 (1 H, br d, *J* 8 Hz, NH), 7.0—7.3 (3 H, m, ArH), and 7.6—7.9 (2 H, m, ArH); *m/z* 333 (M^+, 5%), 207 ($PhTe^+$, 8), 126 (M^+ − PhTe, 49), 84 (67), 77 (38), 67 (54), 60 (74), 56 (25), 51 (32), and 43 (100).

trans-2-*Acetamidocycloheptyl phenyl telluride* (**9**). White *needles* from hexane–chloroform (5:1), m.p. 108—109 °C (Found: C, 50.1; H, 5.65; N, 3.8. $C_{15}H_{21}NOTe$ requires C, 50.19; H, 5.91; N, 3.82%); $\nu_{max.}$(KBr disc) 3 310 (NH), 1 640, and 1 535 cm^{-1} (NHC=O); δ_H(60 MHz) 1.2—2.2 (10 H, m, CH_2), 1.87 (3 H, s, Me), 3.3—3.7 (1 H, m, CHTe), 3.9—4.3 (1 H, m, CHN), 6.46 (1 H, br d, *J* 8 Hz, NH), 7.0—7.3 (3 H, m, ArH), and 7.6—7.9 (2 H,

m, ArH); *m/z* 361 (M^+, 5%), 207 ($PhTe^+$, 7), 154 (M^+ − PhTe, 31), 112 (45), 95 (28), 77 (37), 67 (19), 60 (37), 56 (27), 55 (19), 51 (28), and 43 (100).

2-*Acetamido*-1-(*phenyltelluro*)*hexane* (**10**). White *crystals* from hexane–chloroform, m.p. 70—71.5 °C (Found: C, 48.4; H, 6.05; N, 3.95. $C_{14}H_{21}NOTe$ requires C, 48.46; H, 6.11; N, 4.04%); $\nu_{max.}$(KBr disc) 3 320 (NH), 1 645, 1 575, and 1 545 cm^{-1} (NHC=O); δ_H(60 MHz) 0.83 (3 H, br t, Me), 1.0—1.7 (6 H, m, CH_2), 1.78 (3 H, s, Me), 3.08 (2 H, d, *J* 5 Hz, CH_2Te), 3.8—4.3 (1 H, m, CHN), 5.96 (1 H, br d, *J* 8 Hz, NH), 7.0—7.3 (3 H, m, ArH), and 7.5—7.8 (2 H, m, ArH); *m/z* 349 (M^+, 4%), 207 ($PhTe^+$, 11), 142 (M^+ − PhTe, 100), 100 (49), 86 (25), 77 (37), and 55 (26).

Preparation of an Authentic Sample of trans-2-*Acetamidocyclohexyl Phenyl Telluride* (**5**).—To a solution of 7-azabicyclo-[4.1.0]heptane[13] (0.85 g, 8.75 mmol) in diethyl ether (25 ml) were successively added triethylamine (1.33 g, 13.1 mmol) and acetyl chloride (1.03 g, 13.1 mmol) with ice-bath cooling. The resulting white suspension was stirred at 0 °C for 12 h, and then the white solid was filtered off and thoroughly washed with ether. The filtrate and washings were combined, washed with saturated aqueous $NaHCO_3$, and dried ($MgSO_4$). After evaporation of the solvent, the residue was chromatographed on silica gel with ethyl acetate–hexane (1:1) as eluant and then distilled by a Kugelrohr apparatus (75 °C at 0.8 mmHg) to give *cis*-7-acetyl-7-azabicyclo[4.1.0]heptane (**7**) (0.51 g, 42%) as a colourless *oil* (Found: C, 68.75; H, 9.3; N, 10.0. $C_8H_{13}NO$ requires C, 69.01; H, 9.43; N, 10.06%); $\nu_{max.}$(neat film) 1 695 cm^{-1} (C=O); δ_H(60 MHz) 1.2—1.6 (4 H, m, CH_2), 1.7—2.0 (4 H, m, CH_2), 2.07 (3 H, s, CH_3), and 2.6 (2 H, m, CH).

Sodium borohydride (0.05 g, 1.32 mmol) was added in one portion to a suspension of diphenyl ditelluride (0.25 g, 0.61 mmol) in ethanol (6 ml) at room temperature. Into the colourless solution was then added a solution of (**7**) (0.153 g, 1.1 mmol) in ethanol, and the resulting mixture was stirred at room temperature for 3 h, poured into aqueous HCl (0.2M; 30 ml) and extracted with dichloromethane (2 × 20 ml). The extract was washed with saturated aqueous $NaHCO_3$ and dried ($MgSO_4$). After evaporation, the residue was subjected to column chromatography (silica gel) with ethyl acetate–hexane (3:1) as eluant to give (**5**) (0.219 g, 58%) as white crystals. Its m.p. and spectral data were identical with those of the sample obtained by amidotellurinylation of cyclohexene.

N-(*Ethoxycarbonyl*)-N′-[trans-2-(*phenyltelluro*)*cyclohexyl*]-*urea* (**16**).—Cyclohexene (0.082 g, 1 mmol) was treated with (**2**) (1.2 mmol), *N*-(ethoxycarbonyl)cyanamide (0.342 g, 3 mmol), and boron trifluoride–diethyl ether (0.20 g, 1.4 mmol) in 1,2-dichloroethane (6 ml) at 50 °C, as generally described for amidotellurinylation. Isolation by column chromatography on silica gel with hexane–ethyl acetate (3:2) as eluant followed by recrystallization from hexane–methanol gave (**16**) as white *crystals* (0.305 g, 73%), m.p. 121—122.5 °C (Found: C, 45.75; H, 5.15; N, 6.5. $C_{16}H_{22}N_2O_3Te$ requires C, 45.97; H, 5.32; N, 6.70%); $\nu_{max.}$(KBr disc) 3 325 (NH), 1 720 (CO_2), 1 690, and 1 540 cm^{-1} (NHC=O); δ_H(60 MHz) 1.0—2.4 (8 H, m, CH_2), 1.26 (3 H, t, *J* 7 Hz, Me), 3.1—3.6 (1 H, m, CHTe), 3.6—4.1 (1 H, m, CHN), 4.15 (2 H, q, *J* 7 Hz, CH_2), 7.1—7.3 (3 H, m, ArH), 7.7—7.9 (2 H, m, ArH), 8.00 (1 H, br s, NH), and 8.25 (1 H, br s, NH).

N-[2-(*Phenyltelluro*)*cyclohexyl*]*urea* (**17**).—*N*-(Ethoxycarbonyl)-*N*′-[*trans*-2-(phenyltelluro)cyclohexyl]urea (**16**) (0.455 g, 1.09 mmol) was added in one portion to a solution of 1.5M potassium hydroxide in ethanol (8 ml). The mixture was stirred under reflux for 3 h and poured into water. The resulting solid was filtered, dried *in vacuo*, and recrystallized from ethanol to give (**17**) as white fine *needles* (0.32 g, 85%), m.p. 166—166.5 °C (Found: C, 45.15; H, 5.05; N, 8.15. $C_{13}H_{18}N_2OTe$ requires C, 45.13; H, 5.26; N, 8.10%); $\nu_{max.}$(KBr disc) 3 440, 3 350, and 3 205 (NH), 1 660, 1 590, and 1 550 cm^{-1} (NHC-ONH_2); δ_H(60 MHz, [$^2H_6$]-DMSO) 0.9—2.1 (8 H, m, CH_2), 3.2—3.7 (2 H, m, CHTe and CHN), 5.33 (2 H, br s, NH), 6.10 (1 H, br s, NH), 7.1—7.3 (3 H, m, ArH), and 7.6—7.8 (2 H, m, ArH); *m/z* 348 (M^+, 7%), 207 ($PhTe^+$, 15), 141 (M^+ − PhTe, 79), 98 (100), 81 (90), 77 (74), 69 (21), 61 (89), 56 (71), and 51 (41).

3-*Acetamidocycloheptene* (**20**).—To *trans*-2-acetamidocycloheptyl phenyl telluroxide (**19**) in THF (5 ml) [generated from cycloheptene (**18**) (0.105 g, 1.09 mmol) and (**2**) (1.2 mmol) as described above] was added aqueous NaOH solution (0.5M; 5 ml). The mixture was stirred at room temperature for 3 h, poured into water, and extracted with chloroform (20 ml × 2). The organic layer was dried ($MgSO_4$) and evaporated under reduced pressure. The residue was subjected to column chromatography on silica gel, with hexane–ethyl acetate (1:1) as eluant, to give 3-acetamidocycloheptene (**20**) (0.127 g, 76%) as colourless crystals, m.p. 74—75 °C (lit.,[4] 74—75 °C); $\nu_{max.}$(KBr disc) 3 310 (NH), 1 640, and 1 555 cm^{-1} (NHC=O and C=C); δ_H(60 MHz) 1.1—2.3 (8 H, m, CH_2), 1.95 (3 H, s, Me), 4.3—4.8 (1 H, m, CHN), 5.3—5.9 (2 H, m, =CH), and 6.0 (1 H, br s, NH).

General Procedure for the Synthesis of 2-*Methyl*-, 2-*Ethyl*-, *and* 2-*Phenyl*-4,5-*dihydro-oxazoles*.—cis-3a,5,6,7,8,8a-*Hexahydro*-2-*methyl*-4H-*cycloheptoxazole* (**23**). Benzenetellurinyl trifluoroacetate (**2**) was generated *in situ* by treatment of benzenetellurinic anhydride (0.27 g, 0.59 mmol) with trifluoroacetic acid (0.159 g, 1.4 mmol) in acetonitrile (6 ml) at room temperature for 10 min. Into the solution were successively added cycloheptene (0.096 g, 1 mmol) and boron trifluoride–diethyl etherate (0.27 g, 1.4 mmol). The resulting mixture was heated at 75 °C for 3 h, and gradually turned black-red. It was cooled to room temperature, poured into chloroform (25 ml), and then extracted with 0.5M HCl (25 ml × 2). The aqueous extract was made alkaline by addition of NaOH pellets with ice cooling, and again extracted with ether (25 ml × 2). The combined organic extracts were dried (K_2CO_3) and evaporated to give (**23**) (0.149 g, 97%) as a colourless *oil*, b.p. 130 °C at 42 mmHg; $\nu_{max.}$(neat film) 1 679 cm^{-1} (C=N); δ_H(60 MHz) 1.2—2.2 (10 H, m, CH_2), 1.93 (3 H, s, Me), 4.0—4.3 (1 H, m, CHN), and 4.4—4.8 (1 H, m, CHO); δ_C(22.5 MHz) 14.0, 24.7, 26.1, 30.5, 30.8, 31.2, 69.5, 82.9, and 162.8. An analytical sample was characterized as the *picrate salt*, yellow needles from ethanol, m.p. 150—152 °C (Found: C, 47.1; H, 4.65; N, 14.65. $C_{15}H_{18}N_4O_8$ requires C, 47.11; H, 4.75; N, 14.66%).

cis-3a,5,6,6a-*Tetrahydro*-2-*methyl*-4H-*cyclopentoxazole* (**21**). Colourless *oil*; $\nu_{max.}$(neat film) 1 670 cm^{-1} (C=N); δ_H(60 MHz) 1.3—2.0 (6 H, m, CH_2), 1.91 (3 H, s, Me), 4.3—4.6 (1 H, m, CHN), and 4.7—5.0 (1 H, m, CHO); *picrate salt*, m.p. 150—152 °C (Found: C, 44.05; H, 3.9; N, 15.8. $C_{13}H_{14}N_4O_8$ requires C, 44.07; H, 3.99; N, 15.82%).

cis-3a,4,5,6,7,7a-*Hexahydro*-2-*methylbenzoxazole* (**22**). Colourless *oil*; $\nu_{max.}$(neat film) 1 662 cm^{-1} (C=N); δ_H(60 MHz) 1.2—2.1 (8 H, m, CH_2), 1.95 (3 H, s, Me), 3.7—4.1 (1 H, m, CHN), and 4.3—4.6 (1 H, m, CHO); *picrate salt*, m.p. 157—159 °C (Found: C, 45.6; H, 4.25; N, 15.1. $C_{14}H_{16}N_4O_8$ requires C, 45.65; H, 4.39; N, 15.21%).

cis-3a,4,5,6,7,8,9,9a-*Octahydro*-2-*methylcyclo-octoxazole* (**24**). Colourless *oil*; $\nu_{max.}$(neat film) 1 680 cm^{-1} (C=N); δ_H(60 MHz) 1.0—2.2 (12 H, m, CH_2), 1.90 (3 H, s, Me), 3.7—4.0 (1 H, m, CHN), and 4.1—4.5 (1 H, m, CHO); *picrate salt*, m.p. 157—158 °C (decomp.) (Found: C, 48.4; H, 5.0; N, 14.1. $C_{16}H_{20}N_4O_8$ requires C, 48.48; H, 5.10; N, 14.14%).

cis-2-*Ethyl*-3a,5,6,6a-*tetrahydro*-4H-*cyclopentoxazole* (**25**). Colourless *oil*; $\nu_{max.}$(neat film) 1 675 cm^{-1} (C=N); δ_H(60 MHz)

1.14 (3 H, t, *J* 7 Hz, Me), 1.3—2.1 (6 H, m, CH_2), 2.23 (2 H, q, *J* 7 Hz, CH_2Me), 4.3—4.6 (1 H, m, CHN), and 4.7—4.9 (1 H, m, CHO); *picrate salt*, m.p. 154—155 °C (Found: C, 45.65; H, 4.25; N, 151.15. $C_{14}H_{16}N_4O_8$ requires C, 45.65; H, 4.39; N, 15.21%).

cis-3a,5,6,6a-*Tetrahydro*-2-*phenyl*-4H-*cyclopentoxazole* (**26**). Colourless *oil*; $\nu_{max.}$(neat film) 1 645 cm^{-1} (C=N); δ_H(60 MHz) 1.4—2.3 (6 H, m, CH_2), 4.5—4.8 (1 H, m, CHN), 4.9—5.2 (1 H, m, CHO), 7.3—7.5 (3 H, m, ArH), and 7.8—8.0 (2 H, m, ArH); *picrate salt*, m.p. 155—157 °C (Found: C, 51.9; H, 3.8; N, 13.35. $C_{18}H_{16}N_4O_8$ requires C, 51.92; H, 3.88; N, 13.46%).

cis-3a,4,5,6,7,7a-*Hexahydro*-2-*phenylbenzoxazole* (**27**). Colourless crystals from hexane, m.p. 47—48 °C (lit.,[14] m.p. 45—46 °C); $\nu_{max.}$(neat film) 1 640 cm^{-1} (C=N); δ_H(60 MHz) 1.2—2.1 (8 H, m, CH_2), 3.9—4.3 (1 H, m, CHN), 4.5—4.8 (1 H, m, CHO), 7.2—7.5 (3 H, m, ArH), and 7.8—8.0 (2 H, m, ArH); picrate salt, m.p. 156—157.5 °C (lit.,[14] m.p. 155—156 °C).

4-*Butyl*-4,5-*dihydro*-2-*methyloxazole* (**31**). Colourless *oil*; $\nu_{max.}$(neat film) 1 672 cm^{-1} (C=N); δ_H(60 MHz) 0.89 (6 H, br t, Me), 1.0—1.7 (6 H, m, CH_2), 1.93 (3 H, s, Me), and 3.7—4.4 (3 H, m, CHN and CH_2O); δ_C(22.5 MHz) 13.68, 13.83, 22.55, 28.01, 35.62, 66.29, 74.48, and 164.19; *picrate salt*, m.p. 113—115 °C (Found: C, 45.2; H, 4.85; N, 14.65. $C_{14}H_{18}N_4O_8$ requires C, 45.40; H, 4.91; N, 15.13%).

cis-4,5-*Dihydro*-2-*methyl*-4,5-*dipropyloxazole* (**32**). Colourless *oil*; $\nu_{max.}$(neat film) 1 670 cm^{-1} (C=N); δ_H(60 MHz) 0.94 (6 H, br t, Me), 1.1— 1.7 (8 H, m, CH_2), 1.91 (3 H, s, Me), 3.88 (1 H, m, CHN; doublet, *J* 9 Hz on irradiation at δ 1.53), and 4.43 (1 H, m, CHO; doublet, *J* 9 Hz on irradiation at δ 1.53); *picrate salt*; m.p. 124.5—126 °C (Found: C, 48.25; H, 5.35; N, 14.0. $C_{16}H_{22}N_4O_8$ requires C, 48.23; H, 5.58; N, 14.07%). The *cis* configuration was assigned because the chemical shifts and coupling constants of the two methine protons were almost the same as those of the corresponding protons reported for *cis*-4,5-diethyl-4,5-dihydro-2-methyloxazole[15] (δ 3.90 and 4.42, *J* 9.0 Hz).

trans-4,5-*Dihydro*-2-*methyl*-4,5-*dipropyloxazole* (**33**). Colourless *oil*; $\nu_{max.}$(neat film) 1 670 cm^{-1} (C=N); δ_H(60 MHz) 0.92 (6 H, br, Me), 1.1—1.7 (8 H, m, CH_2), 1.92 (3 H, s, Me), 3.53 (1 H, q, *J* 6 Hz, CHN; doublet, *J* 6 Hz on irradiation at δ 1.53), and 4.02 (1 H, q, *J* 6 Hz, CHO; doublet, *J* 6.0 Hz, irradiation at δ 1.53); *picrate salt*, m.p. 96—97 °C (Found: C, 48.15; H, 5.55; N, 14.05. $C_{16}H_{22}N_4O_8$ requires C, 48.23; H, 5.58; N, 14.07%). The *trans* configuration was assigned because the chemical shifts and coupling constants of the two methine protons were almost the same as those reported for *trans*-4,5-diethyl-4,5-dihydro-2-methyloxazole[15] (δ 3.54 and 4.02, *J* 6.0 Hz).

trans-4,5-*Dihydro*-2,5-*dimethyl*-4-*phenyloxazole* (**34**). Colourless *oil*; $\nu_{max.}$(neat film) 1 670 cm^{-1} (C=N); δ_H(60 MHz) 1.43 (3 H, d, *J* 6 Hz, Me), 2.05 (3 H, s, Me), 4.2—5.0 (2 H, m, CHN and CHO), and 7.20 (5 H, br s, Ph); *picrate salt*, m.p. 139—141 °C (Found: C, 50.4; H, 4.0; N, 13.7. $C_{17}H_{16}N_4O_8$ requires C, 50.49; H, 4.00; N, 13.86%).

Synthesis of cis-3a,5,6,7,8,8a-*Hexahydro*-2-*methyl*-4H-*cycloheptoxazole* (**23**) *from* trans-2-*Acetamidocycloheptyl Phenyl Telluroxide* (**19**).—To a solution of (**19**) in THF (5 ml), prepared by reaction of cycloheptene (0.096 g, 1 mmol) and (**2**) (1.2 mmol), was added triethylamine (0.51 g, 5 mmol) and the solution was stirred at 30 °C for 4 h. The solution was worked up as described above to give the same compound (**23**) (0.126 g, 82%) as a colourless oil.

General Procedure for the Synthesis of 2-(*Ethoxycarbonylamino*)-4,5-*dihydro-oxazoles*.—cis-2-(*Ethoxycarbonylamino*)-3a,5,6,7,8,8a-*hexahydro*-4H-*cycloheptazole* (**30**). Into a solution of (**2**) in 1,2-dichloroethane (6 ml), generated from the treatment of benzenetellurinic anhydride (0.27 g, 0.59 mmol) with trifluoroacetic acid (0.159 g, 1.4 mmol), was successively added cycloheptene (**18**) (0.096 g, 1 mmol), *N*-(ethoxycarbonyl)cyanamide (0.342 g, 3 mmol), and boron trifluoride–diethyl ether (0.27 g, 1.4 mmol). The resulting solution was stirred at 75 °C for 3 h, cooled to room temperature, then made alkaline with 10% aqueous sodium hydroxide (30 ml) and extracted with dichloromethane (2 × 20 ml). The organic layer was washed with brine, dried ($MgSO_4$), and evaporated under reduced pressure to give a black-red residue. This was subjected to column chromatography on silica gel with hexane–ethyl acetate (3:2) as eluant to give (**30**) (0.206 g, 91%) as white *crystals*, m.p. 80—81 °C (hexane) (Found: C, 58.15; H, 7.9; N, 12.25. $C_{11}H_{18}N_2O_3$ requires C, 58.38; H, 8.03; N, 12.38%); $\nu_{max.}$(KBr disc) 3 350 (NH), 1 665, and 1 610 cm^{-1} ($NHCO_2$ and C=N); δ_H(60 MHz) 1.26 (3 H, t, *J* 7 Hz, Me), 1.0—2.2 (10 H, m, CH_2), 3.9—4.4 (1 H, m, CHN), 4.06 (2 H, q, *J* 7 Hz, CH_2Me), 4.6—5.1 (1 H, m, OCH), and 8.3 (1 H, br s, NH); δ_C(22.5 MHz) 14.04, 23.09, 24.61, 29.70, 30.02, 30.84, 58.03, 60.74, 80.73, 163.99, and 165.78; *m/z* 226 (M^+, 7%), 181 (30), 154 (98), 95 (95), 82 (32), 70 (53), 55 (60), and 41 (100).

cis-2-(*Ethoxycarbonylamino*)-3a,5,6,6a-*tetrahydro*-4H-*cyclopentoxazole* (**28**). Colourless *crystals* from hexane, m.p. 51—52 °C (Found: C, 54.5; H, 7.1; N, 14.1. $C_9H_{14}N_2O_3$ requires C, 54.52; H, 7.13; N, 14.13%); $\nu_{max.}$(KBr disc) 3 360 (NH), 1 660, and 1 620 cm^{-1} ($NHCO_2$ and C=N); δ_H(60 MHz) 1.23 (3 H, t, *J* 7 Hz, Me), 1.4—2.2 (6 H, m, CH_2), 4.03 (2 H, q, *J* 7 Hz, CH_2Me), 4.3—4.6 (1 H, m, CHN), 5.0—5.3 (1 H, m, CHO), and 8.3 (1 H, br s, NH); *m/z* 198 (M^+, 6%), 153 (99), 126 (78), 97 (35), and 67 (100).

cis-2-(*Ethoxycarbonylamino*)-3a,4,5,6,7,7a-*hexahydrobenzoxazole* (**29**). Colourless *crystals* from hexane, m.p. 34—35 °C (Found: C, 56.4; H, 7.55; N, 13.0. $C_{10}H_{16}N_2O_3$ requires C, 56.58; H, 7.61; N, 13.20%); $\nu_{max.}$(KBr disc) 3 350 (NH), 1 660, and 1 610 cm^{-1} ($NHCO_2$ and C=N); δ_H(60 MHz) 1.21 (3 H, t, *J* 6.2 Hz, Me), 1.2—2.2 (8 H, m, CH_2), 3.8—4.2 (1 H, m, CHN), 4.05 (2 H, q, *J* 6.2 Hz, CH_2Me), 4.5—4.8 (1 H, m, CHO), and 7.2 (1 H, br s, NH).

cis-2-(*Ethoxycarbonylamino*)-4,5-*dihydro*-4,5-*dipropyloxazole* (**35**). Colourless *crystals* from hexane, m.p. 46—47 °C (Found: C, 59.45; H, 9.0; N, 11.55. $C_{12}H_{22}N_2O_3$ requires C, 59.47; H, 9.17; N, 11.56%); $\nu_{max.}$(KBr disc) 3 350 (NH), 1 660, and 1 610 cm^{-1} ($NHCO_2$ and C=N); δ_H(60 MHz) 0.98 (6 H, br t, Me), 1.26 (3 H, t, *J* 7 Hz, Me), 1.3—1.8 (8 H, m, CH_2), 3.8—4.3 (1 H, m, CHN), 4.08 (2 H, q, *J* 7 Hz, CH_2Me), 4.4—4.8 (1 H, m, CHO), and 7.5 (1 H, br s, NH).

trans-2-(*Ethoxycarbonylamino*)-4,5-*dihydro*-4,5-*dipropyloxazole* (**36**). Colourless *oil* (Found: C, 59.45; H, 9.0; N, 11.55. $C_{12}H_{22}N_2O_3$ requires C, 59.47; H, 9.17; N, 11.56%); $\nu_{max.}$(neat film) 3 355 (NH), 1 665, and 1 620 cm^{-1} ($NHCO_2$ and C=N); δ_H(60 MHz) 0.97 (6 H, br t, Me), 1.26 (3 H, t, *J* 7 Hz, Me), 1.2—1.8 (8 H, m, CH_2), 3.59 (1 H, q, *J* 6 Hz, CHN), 4.08 (2 H, q, *J* 7 Hz, CH_2Me), 4.0—4.3 (1 H, m, CHO), and 8.4 (1 H, br s, NH).

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