Aziridination of Cyclohex-2-enols and 3-Substituted Cyclohexenes: Comparison with Epoxidation

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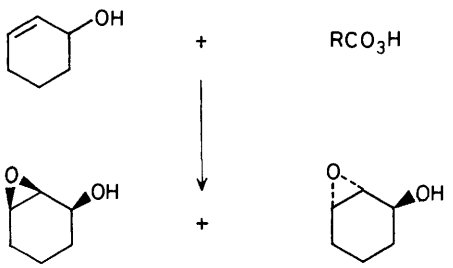
Aziridination of cyclohex-2-enol, 3-methylcyclohex-2-enol, and 3-phenylcyclohex-2-enol with 3-acetoxyamino-2-ethylquinazolin-4(3*H*)-one (**4**) proceeds with high stereoselectivity *syn* to the hydroxy group to give compounds (**7**), (**19**), and (**21**), respectively in good yields. These results are analogous to the epoxidations of these alkenes using peracids. Aziridinations of cyclohex-2-enyl acetate or cyclohex-2-enyl methyl ether proceed stereospecifically *anti* to the acetoxy or methoxy group to give (**11**) and (**17**), respectively, but in low yield. These results are in contrast to the epoxidations of these alkenes using peracids.

The configurations assigned to these products are supported by an analysis of the n.m.r. spectra of 2-substituted 7-azabicyclo[4.1.0]heptanes.

Peracid epoxidation of cyclohex-2-enol was first shown by Henbest *et al.* to proceed with high *syn*-stereoselectivity giving a 9:1 ratio of the two alcohols (**1**) and (**2**).[1] This *syn*-directing effect of the allylic hydroxy group, which has been found to be general for a variety of allylic alcohols, is thought to be the result of hydrogen bonding between the hydrogen of the allylic hydroxy group and one of the oxygens of the peracid in the transition state (**5**) for epoxidation.[2]



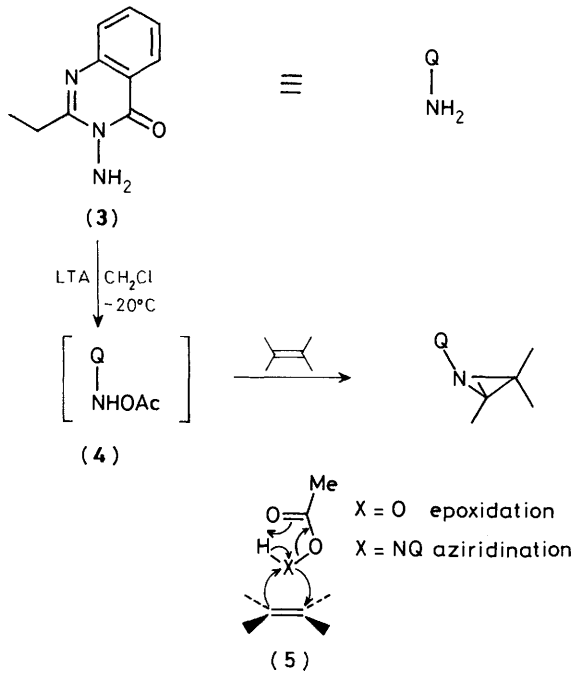
(**1**) (**2**)

Oxidation of the *N*-aminoquinazolone (**3**) with lead tetra-acetate (LTA) at −20 °C in dichloromethane gives a solution of the 3-acetoxyaminoquinazolone (**4**) which is stable at this temperature:[3] (**4**) brings about the aziridination of alkenes by a mechanism which may be analogous to the Bartlett mechanism (**5**) by which epoxidation of alkenes using peracids is thought to proceed.

In view of this possible analogy, it was of interest to examine whether aziridination of alkenes would respond stereochemically to the presence of an allylic hydroxy group in the same way as epoxidation using peracids and in this paper we report the reaction of (**4**) with a number of cyclohex-2-enols and their derivatives.[4]

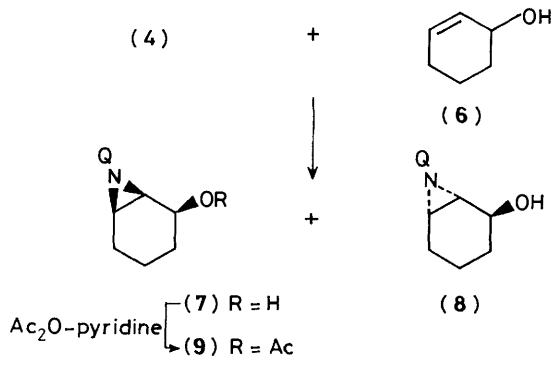
Aziridination using the acetoxyaminoquinazolone (**4**) was routinely carried out by addition of 3 equiv. of the alkene to preformed (**4**) at −20 °C and then allowing the solution to warm to ambient temperature. The excess alkene was removed by chromatography on silica gel and the more polar aziridines eluted subsequently. Using this method, the aziridine (**7**), m.p. 99—102 °C was obtained in 77% yield from cyclohex-2-enol (**6**).

The *syn*-relationship between the aziridine ring and hydroxy



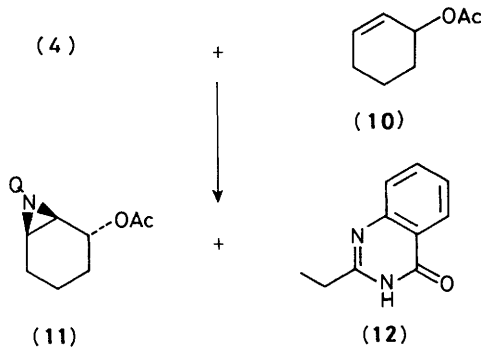
(**3**) (**4**) (**5**)

group in (**7**) was proved by n.m.r. spectroscopy (see below) and by relating the derived acetate (**9**) m.p. 93—95 °C to that obtained by aziridination of cyclohex-2-enyl acetate (**10**). In this case, aziridination proceeded in poor yield (7%) and the product (**11**), m.p. 120—123 °C was clearly different from (**9**).

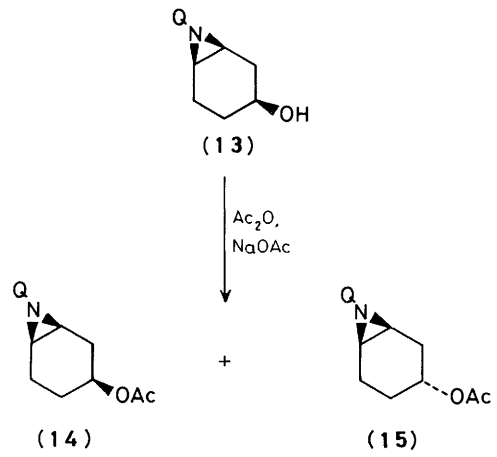


The major product from this latter aziridination and others which proceed in poor yield is the de-aminated quinazolone (**12**).

Acetylation of the crude aziridination product of alcohol (**6**) with pyridine and acetic anhydride and examination of the crude product by n.m.r. shows that a small amount (5%) of the epimeric acetate (**11**) is present. This might be taken to indicate that the stereoselectivity of the aziridination is 95:5 assuming that acetylation of both alcohols (**7**) and (**8**) is equally efficient and proceeds in each case without change in configuration at the hydroxy-bearing carbon [or at the acetoxy-bearing carbon in the product (**9**)].



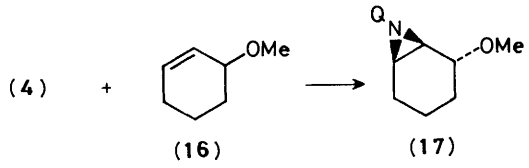
We have found that acetylation of the isomeric alcohol (**13**) (albeit under different acetylation conditions) gives a 3:1 mixture of epimeric acetates (**14**) and (**15**).[5] However, acetylation of a pure sample of the alcohol (**7**) and examination



of the crude product by n.m.r. showed no trace of the epimeric acetate (**11**) and hence the 95:5 ratio above does represent the stereoselectivity of the aziridination.

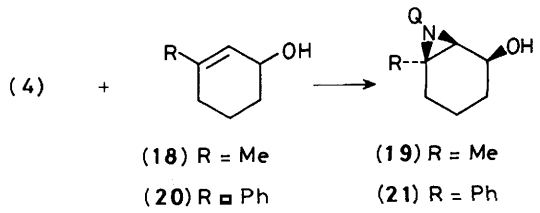
Interestingly, although the yield in aziridination of cyclohexenyl acetate (**10**) is poor, the reaction proceeds stereospecifically and none of the epimeric acetate (**9**) is detectable in the crude reaction product. This same stereospecificity is not found in the expoxidation of (**10**) which was shown by Henbest *et al.*[6] (using peroxybenzoic acid) to give the *syn*- and *anti*-epoxides in a 6:4 ratio.

We have shown previously[7] that otherwise unreactive alkenes can be aziridinated by a mixture of *N*-aminoquinazolone (**3**) and LTA in the presence of trifluoroacetic acid (3 mol equiv.) in dichloromethane. Under these conditions, aziridination of (**10**) proceeds in much better yield (66%) but with almost complete loss of stereospecificity [ratio (**11**):(**9**), 1.2:1].



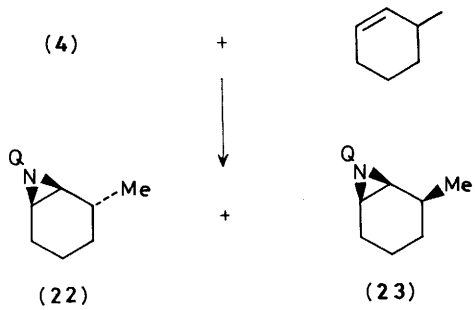
Aziridination of cyclohex-2-enyl methyl ether (**16**) was also examined since the effects of the methoxy group on the double bond were expected to be similar to those of the hydroxy group although the hydrogen bonding capability is absent. The yield of aziridine (**17**) (m.p. 107 °C) in this case was still low (19%) but, as in the aziridination of (**10**), the reaction appeared to proceed in a highly stereoselective *anti* fashion. The directing effects of allylic oxygen-bound substituents on the facial selectivity of the alkene have been noted in a number of other (electrophilic) reactions.[8]

It seems likely, therefore, that shorn of its hydrogen bonding ability, the hydroxy group would similarly possess an *anti*-directing (and deactivating) effect on the aziridination.



Aziridination of 3-methylcyclohex-2-enol (**18**) was also carried out. The aziridine (**19**) (m.p. 125—126 °C) was isolated in 71% yield: the presence of the methyl group on the aziridine ring in this compound facilitated interpretation of its n.m.r. spectrum (see below). Likewise aziridination of 3-phenylcyclohex-2-enol (**20**) was accomplished in good yield giving (**21**).

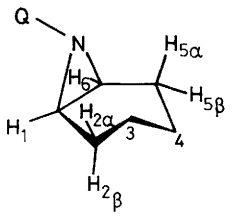
For comparison purposes in n.m.r. analysis of these 7-azabicyclo[4.1.0]heptanes we also aziridinated 3-methylcyclohexene with *N*-acetoxyaminoquinazolone (**4**). Both aziridine stereoisomers (**22**) and (**23**) were formed (in a ratio 5:1) and were separated by silica gel chromatography. The *cis*-isomer (**23**) was isolated as a colourless oil (4%) and the major *trans*-isomer as a solid, m.p. 75—76 °C, in 14% yield. Assignments of configuration in these and other compounds above follow from their n.m.r. spectra (see below).



N.m.r. Spectra of 2-Substituted 7-Azabicyclo[4.1.0]-*heptanes.*— From the n.m.r. spectra of a number of examples of this bicyclic ring system (**24**) we have examined, all of which bear a single substituent on the four carbon bridge, a number of conclusions can be drawn:[9] (*a*) $J_{1,2\alpha}$ and $J_{6,5\alpha}$ are small, typically <1— 1.5 Hz; (*b*) $J_{1,2\beta}$ is 4—5 Hz and only marginally smaller than $J_{6,5\beta}$ at 5—7.5 Hz.

Together (*a*) and (*b*) make assignment of configuration at C-2

in the foregoing aziridines straightforward provided that $J_{1,2\beta}$ or $J_{1,2\alpha}$ can be measured. Fortunately, the only other aziridine ring coupling $J_{1,6}$ has, reliably, a value of 7.5—8 Hz: even if $J_{1,2\beta}$ or $J_{1,2\alpha}$ cannot be directly determined from the multiplicity of the 1-H signal, it may be possible to do so from analysis of the signal from the 2α or 2β-H.



(24)

Using the above values for $J_{1,2\beta}$ or $J_{1,2\alpha}$ it is clear that (7), (9), (19), (21), and (3) with $J_{1,2\beta}$ values of 4, 4, 4.4, 5, and 3.9 Hz, respectively, have their 2-substituents *cis* to the aziridine ring whereas (11), (17), and (22) with $J_{1,2}$ values of ~1, 0.8, and <1 Hz, respectively, have these substituents *trans* to the aziridine ring. These conclusions are in accord with the expectation that the 6-membered rings have half-chair conformations, since the 1,2β and 6,5β dihedral angles are less than 30° in both half chair conformations whereas the 1,2α and 6,5α dihedral angles are close to 90°.

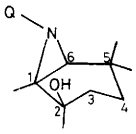
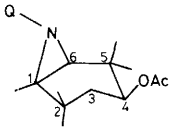
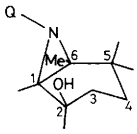
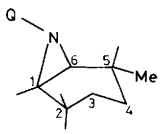
The best evidence available for the expected half-chair conformation for the 6-membered rings in these compounds comes from the n.m.r. spectra of the aziridines (7) and (19) in which enough coupling constants between protons on this ring are measurable to allow comparison with the n.m.r. spectra of aziridines (14) and (22) to be made. The n.m.r. spectra of these latter compounds show clearly, from their axial–axial (pseudo-axial) coupling constants of $J_{2\beta,3\alpha}$ 10—12.8 Hz, $J_{3\alpha,4\beta}$ 11.5—11.8 Hz, and $J_{4\beta,5\alpha}$ 10.2—10.5 Hz together with the values of their 1-H and 6-H coupling constants, that they must have half-chair conformations and the similarities between the respective coupling constants in (14) and (22) to those in (7) and (19) suggest that the latter contain half-chair conformations for their 6-membered rings also (see Table).

The data in the Table also suggest that the hydroxy groups in (7) and (19) and the methyl group in (22) occupy pseudo-equatorial positions.

Conclusion.—The analogy between aziridination of alkenes using *N*-acetoxyaminoquinazolone (4) and their epoxidation using peracids is strengthened by the *syn*-selectivity exhibited in both reactions using cyclohex-2-enols. However, aziridination of cyclohexenes substituted in the allylic position with acetoxy or methoxy is highly *anti*-stereoselective whereas epoxidation of these double bonds is not.

If the yields in these *anti*-aziridinations of 1-substituted cyclohex-2-enes can be improved whilst maintaining the high stereoselectivity, then efficient aziridination on *either* face of

Table. Selected values of coupling constants in aziridines (7), (14), (19), and (20) in Hz[a]

	$J_{1,2\alpha}$	$J_{1,2\beta}$	$J_{2\alpha,3\alpha}$	$J_{2\beta,3\alpha}$	$J_{2\beta,3\beta}$	$J_{4\beta,5\alpha}$	$J_{5\alpha,6}$	$J_{5\beta,6}$
 (7)	—	4.0	—	9[b]	6	—	1.5	6
 (14)	1.2	3.6	4.6	12.8[b]	5.2	10.2	1	7.4
 (19)	—	4.4	—	7.8[b]	5.4	10	—	—
 (20)	1	4	4.7	10[b]	4.6	10.5	1	—

[a] (14) and (20) have been renumbered to allow this comparison to be made with all half chairs having the same conformational presentation to the viewer. [b] The spread of values of this coupling constant is in part the result of differing substituent electronegativity. See Jackmann, L. M. and Sternhell, S. 'Applications of Nuclear Magnetic Spectroscopy in Organic Chemistry,' Pergamon Press, Oxford, 1969, 2nd edn., p. 283.

the allylic double bond will be feasible by manipulation of the oxygen substituent: a versatility not shared by peracid epoxidation.

Experimental

Unless otherwise indicated n.m.r. spectra were run at 300 MHz in deuteriochloroform solution with tetramethylsilane as internal standard using a Bruker AM300 spectrometer and i.r. spectra were run as Nujol mulls. Cyclohex-2-enol and 3-methylcyclohexenes were purchased from Aldrich and used as received. Chromatography was performed according to the method of Still.[10] For other experimental details, see ref. 3.

General Procedure for Aziridination using 3-*Acetoxyamino*-2-*ethylquinazolin*-4(3H)-*one* (**4**).—A solution of (**4**) was obtained by oxidation of 3-amino-2-ethylquinazolin-4(3*H*)-one (**3**) (1 mol equiv.) with LTA (1.05 mol equiv.) in dry dichloromethane [1 ml/100 mg of (**3**)] as described previously.[3] The alkene (3 mol equiv.) was added and the solution allowed to warm to ambient temperature. The insoluble lead di-acetate was separated and washed with dichloromethane and the combined dichloromethane solutions washed successively with aqueous sodium hydrogen carbonate and water, dried, and the solvent removed under reduced pressure.

(*a*) *Using cyclohex*-2-*enol* (**6**). The above procedure was followed using (**3**) (0.5 g), LTA (1.23 g), dichloromethane (5 ml), and (**6**) (0.77 g). Chromatography of the crude reaction product over silica with ethyl acetate–light petroleum (1:1) as eluant gave 7-(2-*ethyl*-3,4-*dihydro*-4-*oxoquinazolin*-3-*yl*)-2α-*hydroxy*-7-*azabicyclo*[4.1.0]*heptane* (**7**) as colourless crystals (from ethanol) m.p. 99—102 °C (Found: C, 67.3; H, 6.8; N, 14.7. $C_{16}H_{19}N_3O_2$ requires C, 67.35; H, 6.7; N, 14.7%); $\nu_{max.}$ 3 480s, 1 655s, and 1 595s cm^{-1}; δ_H 8.17 (ddd, *J* 8.2, 1.5, and 0.7 Hz, Q 5-H), 7.7 (ddd, *J* 8.1, 7.5, and 1.5 Hz, Q 7-H), 7.63 (ddd, *J* 8.1, 1.4, and 0.7 Hz, Q 8-H), 7.41 (ddd, *J* 8.2, 7.5, and 1.4 Hz, Q 6-H), 5.21 (d, exch. D_2O, *J* 4 Hz, OH), 4.19 (dddd, *J* 9, 6, 4.5, and 4 Hz, C*H*OH), 3.18 (dd, *J* 7.5 and 4.0 Hz, 1-H), 3.09 (dq, *J* 18 and 7.5 Hz, HC*H*Me), 2.91 (dq, *J* 18 and 7.5 Hz, *H*CHMe), 2.77 (ddd, *J* 7.5, 6, and 1.5 Hz, 6-H), 1.45 (t, *J* 7.5 Hz, CH_2*Me*), and 2.15—1.15 (6 H, m, aliphatic); *m*/*z* 285 (M^+, 45%), 226 (18), 200 (41), 189 (11), 175 (44), 174 (100), 173 (75), 146 (11), 131 (30), 130 (31), 119 (24), 112 (13), and 103 (15).

(*b*) *Using cyclohex*-2-*enyl acetate* (**10**). The above procedure was followed using (**3**) (0.3 g), LTA (0.74 g), and (**10**) (0.66 g) in dichloromethane (3 ml). The crude oxidation product was triturated with cold diethyl ether and the insoluble 2-ethylquinazolin-4(3*H*)-one separated. Evaporation of the ether and chromatography of the residue over silica with ethyl acetate–light petroleum (1:2) as eluant afforded 2β-*acetoxy*-7-(2-*ethyl*-3,4-*dihydro*-4-*oxoquinazolin*-3-*yl*)-7-*azabicyclo*[4.1.0]-*heptane* (**11**) as colourless crystals (7%), m.p. 120—123 °C (from ethanol) (Found: M^+, 327.1586. $C_{18}H_{21}N_3O_3$ requires M^+, 327.1582); $\nu_{max.}$ 1 725s, 1 675s, and 1 595s cm^{-1}; δ_H 8.16 (ddd, *J* 8.1, 1.5, and 0.6 Hz, Q 5-H), 7.68 (ddd, *J* 8.2, 7.6, and 1.5 Hz, Q 7-H), 7.61 (ddd, *J* 8.2, 1.5, and 0.6 Hz, Q 8-H), 7.4 (ddd, *J* 8.1, 7.6, and 1.5 Hz, Q 6-H), 5.43 (br dd, *J* ~ 4 and 4 Hz, C*H*OAc), 3.05 (q, *J* 7 Hz, CH_2Me obscuring 6-H), 2.93 (d, *J* 7.5 Hz, 1-H), 2.11 (s, OCOMe), 2.35—1.25 (6 H, m, aliphatic), and 1.43 (t, *J* 7 Hz, CH_2*Me*); *m*/*z* 327 (M^+, 35%), 284 (12), 268 (100), 239 (15), 226 (30), 213 (10), 200 (32), 189 (20), 175 (40), 174 (30), 173 (45), 157 (12), 138 (15), 130 (50), 119 (20), 112 (17), and 103 (23).

(*c*) *Using cyclohex*-2-*enyl methyl ether*. The above procedure was followed using (**3**) (0.3 g), LTA (0.739 g), and (**16**) (0.533 g) in dichloromethane (3 ml). Chromatography of the crude oxidation product over silica with ethyl acetate–light petroleum (1:2) as eluant gave 7-(2-*ethyl*-3,4-*dihydro*-4-*oxoquinazolin*-3-*yl*)-2β-*methoxy*-7-*azabicyclo*[4.1.0]*heptane* (**17**) as colourless crystals (19%) (from ethanol), m.p. 107—109 °C (Found: C, 68.1; H, 7.1; N, 14.05. $C_{17}H_{21}N_3O_2$ requires C, 68.2; H, 7.05; N, 14.05%); $\nu_{max.}$ 1 670s and 1 597s cm^{-1}; δ_H (400 MHz) 8.18 (ddd, *J* 8, 1.4, and 0.6 Hz, Q 5-H), 7.67 (ddd, *J* 8.1, 7.35, and 1.4 Hz, Q 7-H), 7.62 (ddd, *J* 8.1, 1.3, and 0.6 Hz, Q 8-H), 7.39 (ddd, *J* 8.1, 7.4, and 1.3 Hz, Q 6-H), 3.94 (dd, *J* ~ 7.6 and 5.4 Hz, C*H*OMe), 3.57 (s, OMe), 3.04 (dq, *J* 16 and 7.5 Hz, *H*CHMe), 2.95 (dq, *J* 16 and 7.5 Hz, HC*H*Me), 2.89 (dd, *J* 7.8 and 0.8 Hz, 1-H), 2.78 (ddd, *J* 7.8, 4.7, and 1.2 Hz, 6-H), 2.77 (ddd, *J* 14, 6, and 5 Hz, 5α-H), 1.95—1.25 (5 H, m, aliphatic), and 1.43 (t, *J* 7.5 Hz, CH_2*Me*); *m*/*z* 299 (M^+, 25%), 284 (24), 228 (20), 226 (11), 200 (100), 175 (66), 174 (84), 173 (87), 158 (11), 157 (14), 146 (15), 132 (15), 131 (40), 130 (57), 126 (53), 119 (27), 112 (11), 111 (75), 110 (17), 104 (11), and 103 (26).

(*d*) *Using* 3-*methylcyclohex*-2-*enol* (**18**). The above procedure was followed using (**3**) (0.4 g), LTA (0.986 g) and (**18**) (0.71 g) in dichloromethane (4 ml). Chromatography of the crude reaction product over silica with ethyl acetate–light petroleum (1:1) as eluant gave 7-(2-*ethyl*-3,4-*dihydro*-4-*oxoquinazolin*-3-*yl*)-5α-*hydroxy*-1-*methyl*-7-*azabicyclo*[4.1.0]*heptane* (**19**) as colourless crystals (71%) (from di-isopropyl ether), m.p. 125—126 °C (Found: C, 68.3; H, 7.0; N, 14.0. $C_{17}H_{21}N_3O_2$ requires C, 68.2; H, 7.05; N, 14.05%); $\nu_{max.}$ 3 450br s, 1 655s, and 1 595s cm^{-1}; δ_H(400 MHz) 8.13 (ddd, *J* 8 and 1.4 Hz, Q 5-H), 7.68 (ddd, *J* 8.1, 7.4, and 1.4 Hz, Q 7-H), 7.62 (ddd, *J* 8.1 and 1.3 Hz, Q 8-H), 7.4 (ddd, *J* 8, 7.4, and 1.3 Hz, Q 6-H), 4.97 (d, exch. D_2O, *J* 3 Hz, OH), 4.2 (dddd, *J* 7.6, 5.6, 4.4, and 3 Hz, C*H*OH), 3.06 (d, *J* 4.4 Hz, 6-H), 3.05 (dq, *J* 16 and 7.5 Hz, *H*CHMe), 2.78 (dq, *J* 16 and 7.5 Hz, HC*H*Me), 2.05 (ddd, *J* 14, 10 and 5 Hz, 2α-H), 1.8—1.2 (5 H, m, aliphatic), 1.39 (t, *J* 7.5 Hz, CH_2*Me*), and 1.19 (s, Me); *m*/*z* 299 (M^+, 17), 242 (11), 200 (90), 190 (17), 189 (100), 188 (16), 175 (75), 174 (84), 173 (99), 172 (10), 160 (27), 158 (15), 146 (15), 145 (11), 144 (14), 132 (20), 131 (19), 130 (42), 127 (35), 119 (78), 117 (12), and 103 (18).

(*e*) *Using* 3-*phenylcyclohex*-2-*enol* (**20**). Sodium borohydride (0.968 g) was added in small portions to a solution of 3-phenylcyclohex-2-enone (10.2 g) in methanol (5 ml) at room temperature and the reaction monitored by t.l.c. After disappearance of the starting material (6 h), water (100 ml) was added and the mixture extracted twice with diethyl ether. The combined extracts were dried and the solvent removed under reduced pressure. 3-Phenylcyclohex-2-enol (11.9 g, 87%) was obtained as colourless crystals, m.p. 59—62 °C (from light petroleum) (lit.[11] m.p. 60—61 °C). The above aziridination procedure was followed using (**3**) (0.3 g), LTA (0.739 g), and (**20**) (0.828 g) in dichloromethane (3 ml). Chromatography of the crude oxidation product over silica with ethyl acetate–light petroleum (1:2) as eluant gave 7-(2-*ethyl*-3,4-*dihydro*-4-*oxoquinazolin*-3-*yl*)-5α-*hydroxy*-1-*phenyl*-7-*azabicyclo*[4.1.0]-*heptane* (**21**) as colourless crystals (74%) (from ethanol), m.p. 171—174 °C (Found: C, 73.45; H, 6.5; N, 11.65. $C_{22}H_{23}N_3O_2$ requires C, 73.1; H, 6.4; N, 11.6%); $\nu_{max.}$ 3 420m, 1 645s, and 1 590s cm^{-1}; δ_H 8.2 (ddd, *J* 7.9, and 1.3 Hz, Q 5-H), 7.65 (ddd, *J*, 8.0, 7.3, and 1.3 Hz, Q 7-H), 7.45 (dd, *J* 8.0 and 1.3 Hz, Q 8-H), 7.42 (ddd, *J* 7.9, 7.3, and 1.3 Hz, Q 6-H), 7.25—7.05 (m, 5 × Ar*H*), 5.01 (d, exch. D_2O, *J* 2.5 Hz, OH), 4.45 (dddd, *J* 5.6, 5.5, 5, and 2.5 Hz, C*H*OH), 4.34 (d, *J* 5 Hz, 6-H), 2.87 (dq, *J* 16.5 and 7.5 Hz, *H*CHMe), 2.71 (ddd, *J* 14.1, 7.5 and 5.1 Hz, 2α- or 2β-H), 2.40 (m, 1 H), 2.34 (dq, *J* 16.5 and 7.5 Hz, HC*H*Me), 1.93 (m, 1 H), 1.78 (m, 1 H), 1.68 (m, 1 H), 1.5 (m, 1 H), and 1.14 (t, *J* 7.5 Hz, CH_2*Me*); *m*/*z* 361 (M^+, 8%), 200 (100), 189 (12), 188 (22), 175 (30), 174 (38), 173 (37), 130 (21), 119 (14), and 103 (11).

(*f*) *Using* 3-*methylcyclohex*-1-*ene*. 3-Amino-2-ethylquinazolin-4(3*H*)-one (**3**) (0.5 g) and LTA (1.23 g) in finely divided solid form were added consecutively and continuously in very small quantities over 15 min to a stirred solution of 3-methylcyclohex-1-ene (0.76 g) in dry dichloromethane (5 ml) at room temperature. After stirring for an additional 15 min the

solution was worked up as described in the general procedure above. Chromatography of the crude reaction product over silica with ethyl acetate–light petroleum (1:4) as eluant, gave 7-(3,4-dihydro-2-ethyl-4-oxoquinazolin-3-yl)-2α-methyl-7-azabicyclo[4.1.0]heptane (**23**) as a colourless oil (4%); $\nu_{max.}$ 1 665s and 1 585s cm^{-1}; δ_H(400 MHz) 8.15 (dd, *J* 8.0 and 1.5 Hz, Q 5-H), 7.65 (ddd, *J* 8.2, 6.9, and 1.5 Hz, Q 7-H), 7.59 (dd, *J* 8.2 and 1.3 Hz, Q 8-H), 7.37 (ddd, *J* 8.0, 6.9, and 1.3 Hz, Q 6-H), 3.38 (dd, *J* 8.0 and 3.9 Hz, 1-H), 3.12 (dq, *J* 16.4 and 7.4 Hz, *H*CHMe), 2.96 (dq, *J* 16.4 and 7.4 Hz, HC*H*Me), 2.62 (ddd, *J* 8, 6.7, and 1.3 Hz, 6-H), 2.14—2.04 (m, 5β-H), 2.04—1.96 (m, 2β-H), 1.95 (dddd, *J* 15, 11, 5.6 and 1.3 Hz, 5α-H), 1.56 (m, 3β-H), 1.43 (t, *J* 7.4 Hz, CH_2*Me* obscuring 4α-H or 4β-H), 1.41 (d, *J* 6.8 Hz, CH*Me*), and 1.30—1.05 (m, 4α-H or 4β-H; and 3α-H); *m/z* 283 (M^+, 30%), 240 (15), 226 (20), 200 (52), 175 (30), 174 (52), 173 (58), 131 (37), 130 (56), 119 (17), 110 (100), and 103 (25). Nuclear Overhauser effects were observed as follows: 3.38 (1-H) with 2.62 (6-H, 4.3%) and 2.04—1.96 (2β-H, 5.5%); 2.62 (6-H) with 3.38 (1-H, 4.8%), 3.12 (*H*CHMe, 1.2%), 2.96 (HC*H*Me, 2.5%), 2.14—2.04 (5β-H, 4.3%), and 1.95 (5α-H, 1.2%); 1.1 (3α-H) with 1.95 (5α-H, 1.9%), 1.5 (3β-H, 6.5%), and 1.41 (CH*Me*, 11%).

Further elution with ethyl acetate–light petroleum (1:4) gave 7-(2-*ethyl*-3,4-*dihydro*-4-*oxoquinazolin*-3-*yl*)-2β-*methyl*-7-*azabicyclo*[4.1.0]*heptane* (**22**) (14%) as colourless crystals, m.p. 75—76 °C (from light petroleum) (Found: C, 72.05; H, 7.5; N, 14.8. $C_{17}H_{21}N_3O$ requires C, 72.05; H, 7.5; N, 14.85%) $\nu_{max.}$ 1 660s and 1 585s cm^{-1}; δ_H(400 MHz) 8.15 (dd, *J* 8.0 and 1.3 Hz, Q 5-H), 7.67 (ddd, *J* 8.0, 6.9, and 1.3 Hz, Q 7-H), 7.57 (d, *J* 8.0 Hz, Q 8-H), 7.36 (ddd, *J* 8.0, 6.9, and 1.2 Hz, Q 6-H), 2.99 (dq, *J* 11.3 and 7.3 Hz, *H*CHMe), 2.94 (dq, *J* 11.3 and 7.3 Hz, *H*CHMe), 2.76 (dd, *J* 7.9 and 4.0 Hz, 6-H), 2.38 (ddd, *J* 14, 4.8, and 4.7 Hz, 5α-H), 2.37 (d, *J* 7.9 Hz, 1-H), 2.3—2.21 (m, 2α-H), 1.75 (dddd, *J* 15, 10, 4.6, and 4.0 Hz, 5β-H), 1.64 (dddd, *J* 13, 6, 6, and 2.4 Hz, 3α-H), 1.48 (m, 4β-H), 1.41 (t, *J* 7.3 Hz, CH_2*Me*), 1.34 (m, 4α-H), 1.18 (d, *J* 7.3 Hz, CH*Me*), and 0.85 (dddd, *J* 13, 11.5, 10.5, and 2.8 Hz, 3β-H). Nuclear Overhauser effects were observed as follows: 2.97 (*H*CHMe and HC*H*Me) with 2.7 (6-H, 1.4%), 2.38 (1-H and 5α-H, 3.3%), 2.3—2.21 (2α-H, 2.3%) and 1.41 (CH_2*Me*, 4.9%); 2.76 (6-H) with 2.97 (*H*CHMe and HC*H*Me, 1.6%), 2.38 (5α-H, 6.2%), and 1.75 (5β-H, 3.7%); 1.18 (CH*Me*) with 2.37 (1-H, 2.6%), 2.3—2.21 (2α-H, 2.6%), and 0.85 (3β-H, 1.2%); 0.85 (3β-H) with 2.3—2.21 (2α-H, 1.5%), 1.75 (5β-H, 1.7%), 1.48 (4β-H, 3.4%), and 1.18 (CH*Me*, 2.7%).

Aziridination of Cyclohex-2-enyl Acetate (**10**) *with* (**4**) *in the Presence of Trifluoroacetic Acid.*—The alkene (**10**) (1.11 g), dissolved in dichloromethane (5 ml) containing TFA (0.9 g) was treated with (**3**) (0.5 g) and LTA (1.23 g) as previously described.[12] Chromatography of the crude oxidation product, which from n.m.r. comprised a 1.2:1 ratio of aziridines (**11**) and (**9**), on silica with ethyl acetate–light petroleum (1:1) as eluant gave a mixture of these aziridines (66%) as a crystalline solid.

Acetylation of Aziridine (**7**).—The aziridine (**7**) (0.26 g) was dissolved in pyridine (0.43 g) containing acetic anhydride (0.19 g) and set aside overnight at room temperature. After addition of water, the reaction mixture was extracted with dichloromethane, and the dichloromethane extract washed successively with hydrochloric acid (2M) and saturated aqueous sodium hydrogen carbonate, dried, and evaporated to give 2α-*acetoxy*-7-(2-*ethyl*-3,4-*dihydro*-4-*oxoquinazolin*-3-*yl*)-7-*azabicyclo*-[4.1.0]*heptane* (**9**) as colourless crystals (83%) (from ethanol), m.p. 93—95 °C (Found: C, 65.0; H, 6.95; N, 12.0. $C_{18}H_{21}N_3O_3 \cdot 0.5C_2H_5OH$ requires C, 65.1; H, 6.9; N, 12.0%); $\nu_{max.}$ 3 470m, 1 735s, 1 710s, and 1 670s cm^{-1}; δ_H 8.15 (ddd, *J* 8.1 and 1.5 Hz, Q 5-H), 7.66 (ddd, *J* 8.2, 7.5, and 1.5 Hz, Q 7-H), 7.59 (ddd, *J* 8.2 and 1.6 Hz, Q 8-H), 7.38 (ddd, *J* 8.1, 7.5, and 1.6 Hz, Q 6-H), 5.18 (m, C*H*OAc), 3.71 (m, OCH_2Me), 3.52 (dd, *J* 7.5 and 4 Hz, 1-H), 3.08 (q, *J* 7 Hz, CH_2Me obscuring 3-H), 2.23 (s, OCOMe), 2.2—1.25 (6 H, m, aliphatic), 1.43 (t, *J* 7 Hz, CH_2*Me*), and 1.23 (t, *J* 7 Hz, OCH_2*Me*) (the signals at 3.71 and 1.23 are from the ethanol solvate); *m/z* 327 (M^+, 45%), 284 (18), 268 (52), 267 (39), 239 (27), 226 (26), 201 (16), 200 (52), 175 (57), 174 (100), 173 (69), 154 (23), 146 (11), 131 (48), 130 (41), 119 (20), 112 (55), and 103 (18).

Stereoselectivity in Aziridination of (**6**).—Aziridination of cyclohex-2-enol (**6**) by oxidative (LTA) addition of (**3**) was carried out as described above and the crude reaction mixture directly acetylated using pyridine and acetic anhydride as described above. Examination of the crude product from this acetylation by n.m.r. showed the ratio of aziridines (**9**):(**11**) was 20:1 from integration of signals at δ 5.18 [from (**9**)] and 5.43 [from (**11**)].

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