# Intramolecular Reactions of *N*-Nitrenes: Description of the Transition State Geometry for Addition to Alkenes

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Oxidation of the *N*-aminoquinazolones (**10**) and (**11**) generates the corresponding *N*-nitrenes which add intramolecularly to both double bonds. Although nitrene addition is stereospecifically *cis*, both faces of each double bond are attacked and consequently stereoisomers are formed. From the different selectivity of the *N*-nitrenes for the two double bonds in (**10**) and (**11**) [or (**29**)] by comparison with (**15**) and (**24**), respectively, and from a consideration of the stereoisomer ratios, it is concluded that concerted addition of the *N*-nitrene to the double bonds in (**10**) and (**11**) obtains *via* a transition-state geometry resembling that shown in (**34**).

The preferred transition state geometry (TSG) of any reaction is that which both accommodates stereoelectronic factors and minimises strain elements. Pericyclic reactions are no exception to this generalisation with the stereoelectronic factor in this case being efficient overlap of orbitals of appropriate symmetry. For the case of concerted cycloadditions, Woodward Hoffmann rules, or extensions of them, have successfully accounted for the stereochemical features of $\pi 4s + \pi 2s$,[1] $\pi 6s + \pi 4s$,[2] and $\pi 2a + \pi 2s$ (ketene cycloadditions),[3] as consequences of their particular TSGs.

Experimental evidence for the $\pi 2s + \pi 2a$ cycloaddition geometry of singlet carbenes to alkenes, with the carbene acting antarafacially, (I), as predicted by Frontier Orbital Theory[4] has not been forthcoming and theoretical calculations have predicted a tilting of the carbene, (II), leading to a TSG which is closer to that of the product cyclopropane.[5,6]

(I)

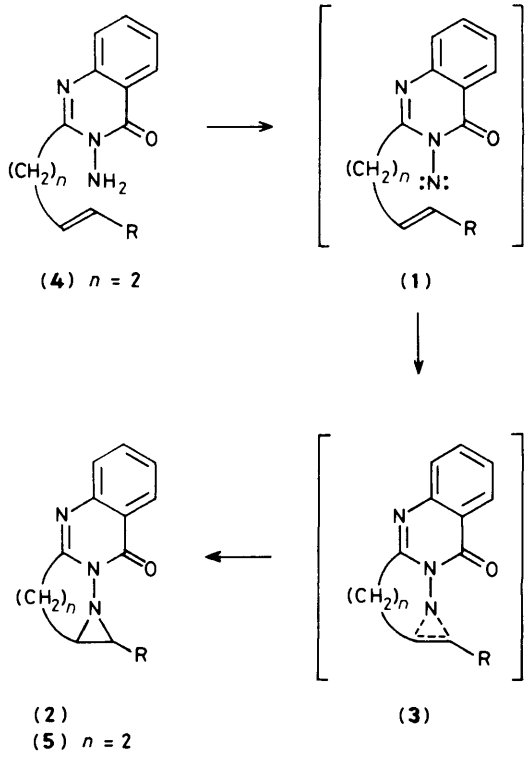
(II)

We have been interested in the related problem of the mode of singlet nitrene addition to alkenes and, in particular, the possibility of deducing the preferred TSG using *experimental* methods.

It seemed clear to us at the outset that the only means of exercising any control over the configuration of the nitrene and alkene in the transition state for their reaction was by carrying out the latter intramolecularly. The degree of control exercised in the cycloaddition is, of course, crucial: without any definable constraint on the TSG there can be no means of describing the latter. On the other hand, the constraint applied to the interacting components may, of itself, help to determine or even dictate, the preferred TSG in this intramolecular reaction: this latter TSG would not necessarily be identical to that which would result from an untrammelled approach of the same components in an intermolecular reaction.

We elected to study intramolecular additions of *N*-nitrenes to alkenes in the system (**1**) to give aziridines (**2**) where the control referred to above is variation of the length of the alkyl chain in the transition state (**3**).

The limitations on the TSG of (**3**) imposed by the chain are, of course, not only a function of the value of *n* but are also

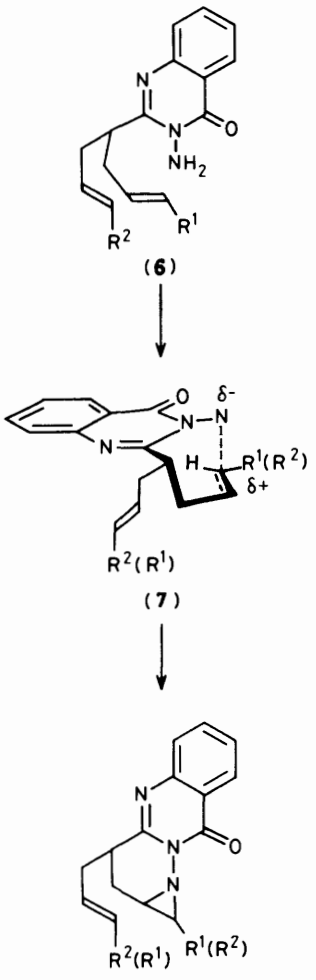


(**4**) *n* = 2 (**1**) (**2**) (**5**) *n* = 2 (**3**)

determined by the usual minimisation of angle, torsional, and other strain factors within this chain. At small values of *n* in (**3**), the available geometries by which the nitrene and alkene could react are clearly fewer and (with the aid of models) more definable: at larger values of *n*, the conformational freedom of the chain allows for any TSG but definition of the actual TSG becomes correspondingly more ambiguous.†

Our preliminary investigations[7] involved the generation of *N*-nitrenes from oxidation of (**4**), *i.e.* with *n* = 2 in (**1**). Although the aziridines (**5**) were obtained in good yield by intramolecular trapping of the nitrene, competition experiments involving

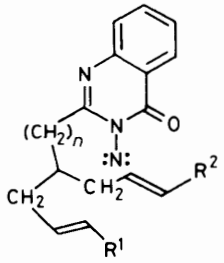
† One can conceive of different connectivities between the nitrene and the alkene which would allow for easier definition of the TSG for the reaction between them but inevitably these would involve less flexibility than is available in a chain and consequently more limitation in the choice of TSG which could be exercised.



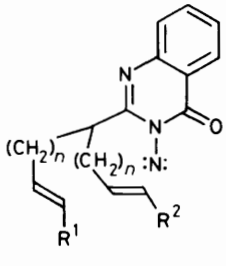
Scheme 1.

generation of these nitrenes in the presence of two different alkenes from *e.g.* (**6**), suggested that the addition was non-concerted with a transition state (**7**) having some dipolar character (Scheme 1).

These results suggested that in (**1**; $n = 2$) the transition state for *concerted* nitrene addition was not geometrically accessible. Moreover, they also suggested a possible *criterion* which could be used to determine the preferred TSG for such a concerted addition assuming that the latter was lower than any other [*e.g.* (**7**)] in energy. This criterion would be a change in the selectivity of the *N*-nitrene for the two double bonds to one which reflected the reactivity of the latter in a concerted cycloaddition. Our strategy, therefore, was to identify the value of *n* in a system such as (**8**) or (**9**) for the non-concerted to concerted changeover and



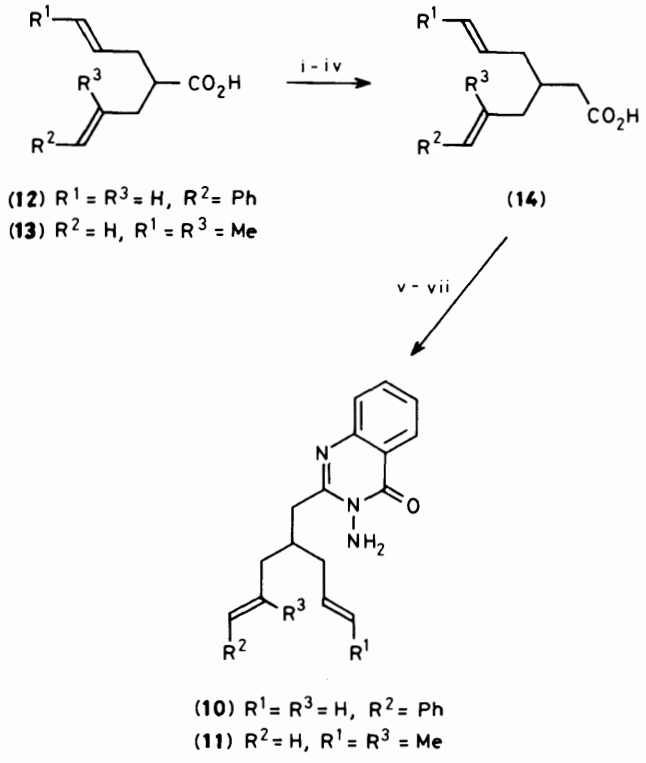
(**8**)



(**9**)

to correlate this (with the help of molecular models) with a TSG made available as a result of the $n - 1 \rightarrow n$ increment.

Synthesis of the *N*-aminoquinazolones (**10**) and (**11**) was carried out by chain extension of the previously used[7] carboxylic acids (**12**) and (**13**) and then by formation of the quinazolones in the usual way (Scheme 2).



**Scheme 2.** *Reagent:* i, $LiAlH_4$; ii, TosCl–pyridine; iii, KCN–DMSO; iv, $KOH–H_2O$; v, $(COCl)_2$ on Na salt; vi, methyl anthranilate; vii, $NH_2NH_2$–EtOH, 130 °C (sealed tube).

The choice of substituents on the double bonds in (**10**) was made on the assumption that concerted addition of the nitrene to the latter might be particularly sensitive to these different substituents. Moreover, in the n.m.r. spectra of (**10**) and (**11**) and their intramolecular aziridination products (see below), the two double bonds have signals from their olefinic protons at sufficiently different chemical shifts to enable the selectivity of the nitrene for the individual double bonds to be easily measured by integration.

Although (**10**) and (**11**) were isolated as oils their structures were confirmed by their spectroscopic properties. The preparation of the *N*-aminoquinazolones (**10**) and (**11**) (and those reported subsequently in this paper) from the corresponding acids by the route shown (Scheme 2) gives these products essentially pure but the products were routinely chromatographed over alumina and, in particular, the 1:1 ratio of the component alkenes was confirmed by n.m.r. before oxidation was carried out.

*Oxidation of Compound* (**10**).—Oxidation of (**10**) was carried out as previously described[8] by slow addition of dichloromethane solutions of (**10**) and lead tetra-acetate contained in different separating funnels to a stirred dichloromethane solution. Under these conditions, formation of aziridines is quantitative (from n.m.r.) and, in particular, there is no deamination of the *N*-aminoquinazolone, a side reaction which intrudes when oxidation is carried out under other conditions.

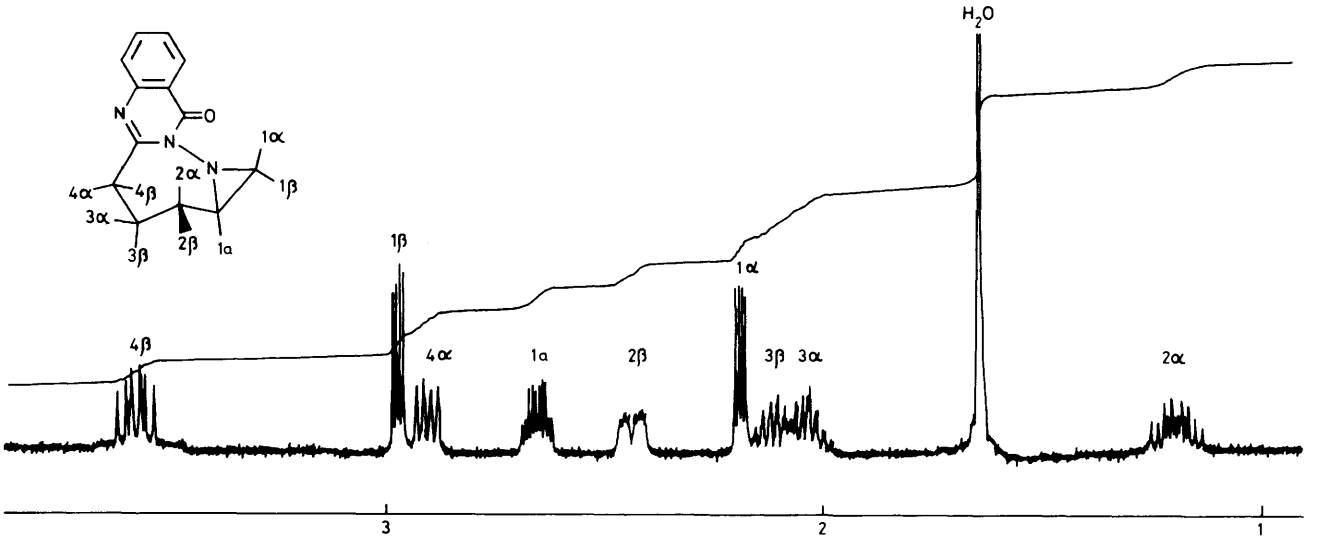
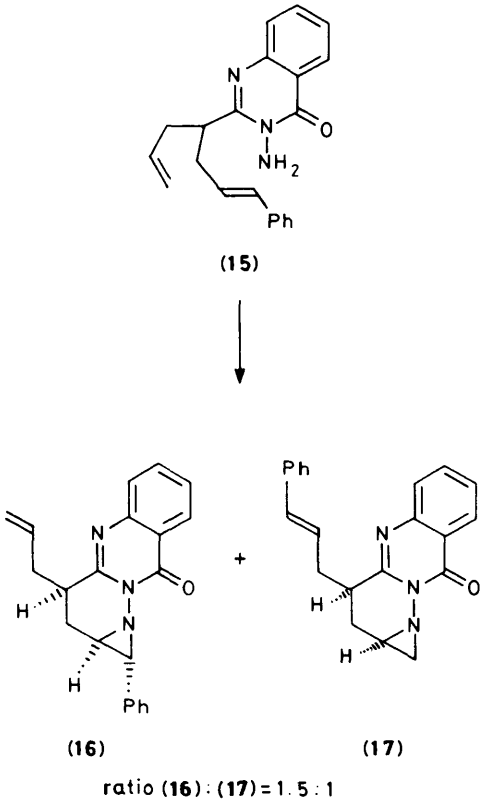



**Figure.** Part of the 400 MHz spectrum of (**20**) in $CDCl_3$: the material crystallises as a hydrate.

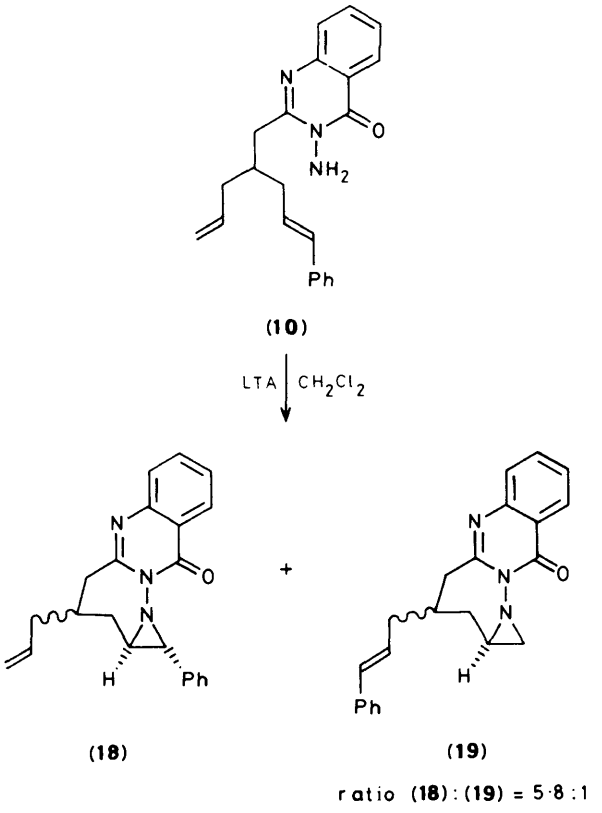
The ratio of aziridines formed was determined both from the ratio of the corresponding residual olefinic protons and from appropriate proton signals in the two aziridines in the 400 MHz spectra of the crude reaction products.

Previously, we had shown that oxidation of (**15**) yielded two aziridines (**16**) and (**17**) in a ratio of 1.5:1 with attack on the phenyl-substituted double bond favoured. Each aziridine was formed as a single stereoisomer with the relative configurations as shown (Scheme 3).

The corresponding ratio of aziridines (**18**) and (**19**) produced from oxidation of (**10**) was 5.8:1.* It was clear from examination of the n.m.r. spectra both of the total reaction product and also




**Scheme 3.**



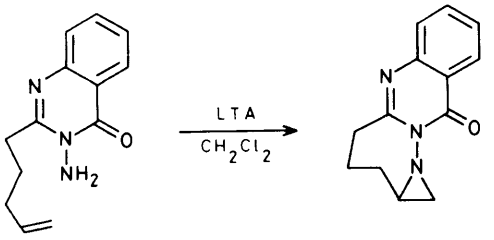

**Scheme 4.**

of the chromatographically separated aziridines that, unlike (**16**) and (**17**) above, both (**18**) and (**19**) were produced as mixtures of stereoisomers although addition to the phenyl substituted double bond was stereospecifically *cis* in (**18**) (Scheme 4).

Interpretation of the n.m.r. spectra of (**18**), (**19**) and other

* Unfortunately in our previous communication of this work (*J. Chem. Soc., Chem. Commun.*, 1985, 1218) this figure was given as 8.5:1.

compounds containing the same skeleton reported in this paper, was considerably facilitated by the presence of only a single conformation for the seven-membered ring. The 400 MHz n.m.r. spectrum of (**20**), the unsubstituted ring system contained in (**18**) and (**19**), is shown in the Figure. This aziridine was obtained in good yield by oxidation of the corresponding *N*-aminoquinazolone (**21**).




(**21**) (**20**)

Assignments of signals in this spectrum are unambiguous from consideration of multiplicity and chemical shift and the conformation of the ring deduced from the best fit of coupling constants is that shown. With the vicinal and geminal coupling constants from (**20**) in hand and after separation of the two stereoisomers of (**19**) both from (**18**) and also in the case of (**19**), from each other by chromatography over alumina, assignments of relative configurations to the individual stereoisomers of (**18**) and (**19**) was straightforward and confirmed in most cases by COSY spectra correlations.

With the assignments of the signals from stereoisomers of (**18**) and (**19**) available, the relative proportions both of (**18**) and (**19**) and their individual stereoisomers in the crude reaction mixture were measured by integration of appropriate and respective peaks in the n.m.r. spectrum of this mixture and the results are summarised in Scheme 5.

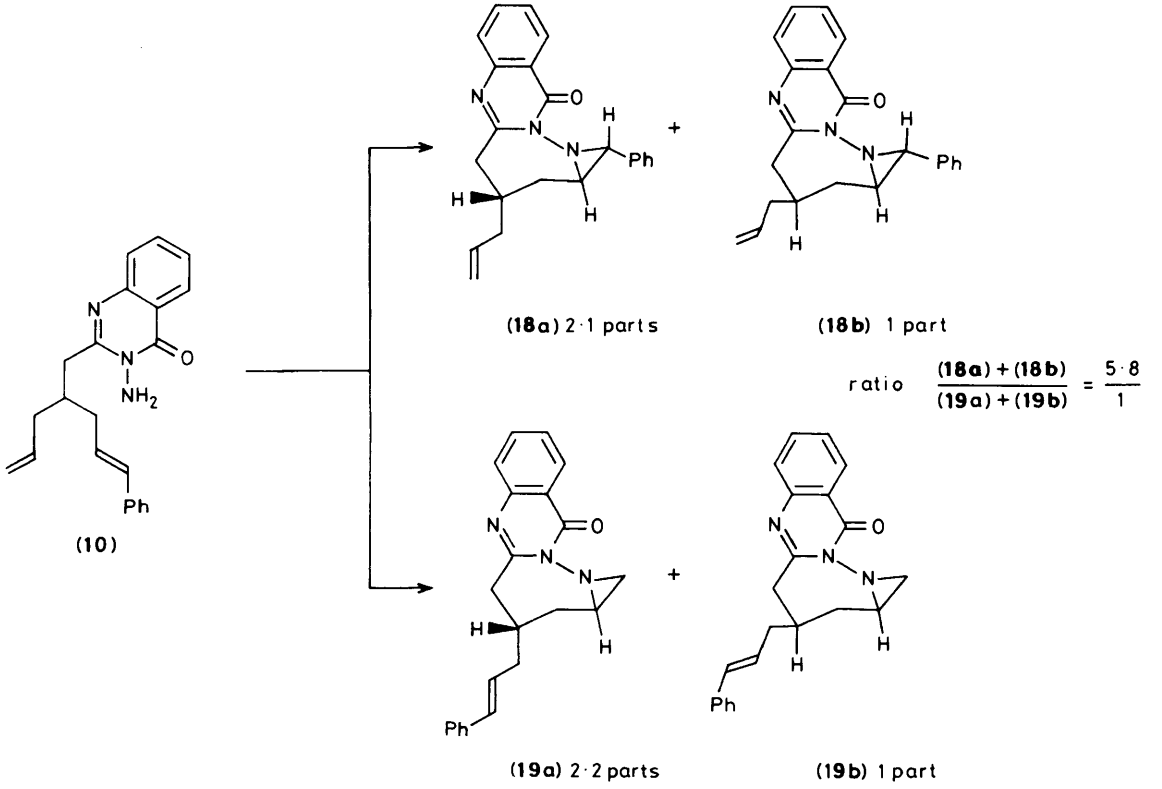
*Oxidation of Compound* (**11**).—In our previous work[7] it was found that in oxidation of the *N*-aminoquinazolone (**22**), the only product identified was the aziridine (**23**) (64% isolated) resulting from addition of the nitrene to the β-methyl substituted double bond and in agreement with a mechanism which involves the generation of some carbonium ion character at this position (*cf.* Scheme 1) in the transition state.

Addition of the *N*-nitrene to the β-methyl substituted double bond is also the major reaction pathway in oxidation of (**24**) but some addition to the α-methyl substituted double bond is also observed [ratio (**25**):(**26**) = 5.3:1]. As in the cases of the aziridines (**16**), (**17**), and (**23**), both (**25**) and (**26**) were produced as single stereoisomers whose configuration at the side-chain-bearing carbon was deduced from the vicinal coupling constants of the proton at this position with the adjacent (ring) methylene protons as previously described.

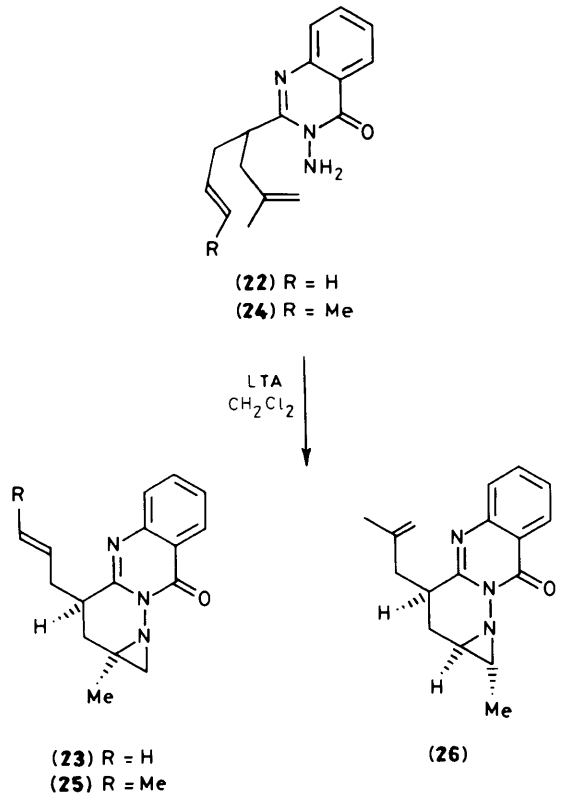
The *N*-aminoquinazolone (**11**) (Scheme 2) was oxidised using the same conditions described for (**10**) and gave the aziridine isomer and stereoisomer distribution shown in Scheme 6.

Assignments and integration of appropriate resonances in the n.m.r. spectrum of the crude reaction product from (**11**) were facilitated when chromatography over alumina separated the stereoisomers (**27a**) and (**27b**) from each other and from (**28a**) and (**28b**). Moreover the aziridine (**28b**) was separated from the minor amount of its stereoisomer (**28a**) by crystallisation: signals from the latter were recognisable in the n.m.r. spectrum of the mixture of these stereoisomers (and in that of the crude oxidation product).

At first sight it would appear that the *N*-nitrene derived by oxidation of (**11**) has a very different selectivity for reaction with




**Scheme 5.**




the two double bounds by comparison with the *N*-nitrene derived from its lower homologue (**24**). However, implicit in the use of these *N*-aminoquinazolones bearing bifurcated chains in position 2 as probes for the reactivity of the derived *N*-nitrenes with double bonds is the assumption that this reactivity is not controlled by conformational factors. If some (unspecified) conformational preference resulted in one double bond being more accessible to the nitrene than the other then clearly this would invalidate any conclusions drawn as to their relative affinity for the nitrene.

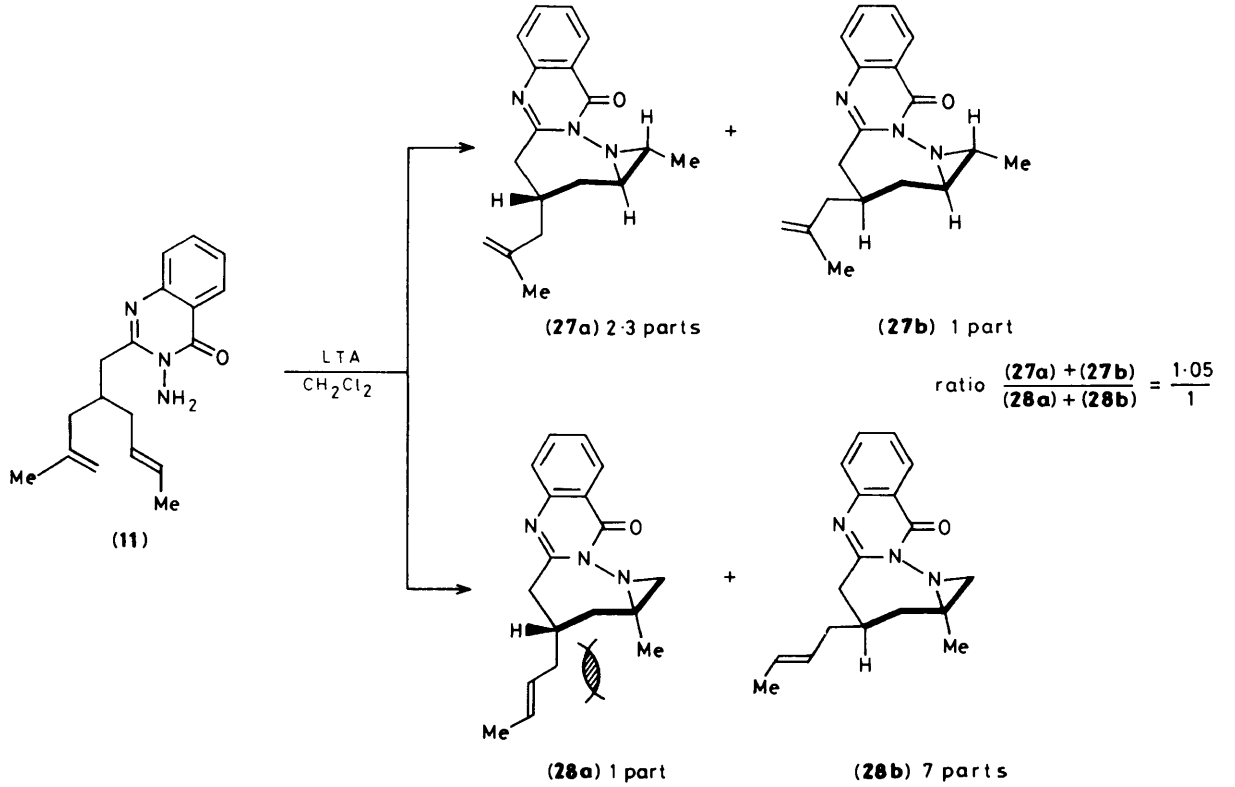
Evidence that the above assumption is justified comes from the identity of the stereoisomer ratios in Schemes 5 and 6 for (**18a**):(**18b**), (**19a**):(**19b**), and (**27a**):(**27b**). This identity of ratios we believe is good evidence that neither of the double bonds involved in oxidation of (**10**) enjoys a conformation-derived advantage in trapping the corresponding *N*-nitrene and that the ratio of attack on the two faces of each double bond in (**10**) and on the two faces of the α-methyl substituted double bond in (**11**) is controlled by the same conformational factors in each case.

However, we suspected that addition to the α-methyl substituted double bond in (**11**) might be adversely affected by conformational factors (see below) and to test this point we synthesized the analogous α-branched *N*-aminoquinazolone (**29**) by the route outlined in Scheme 7.

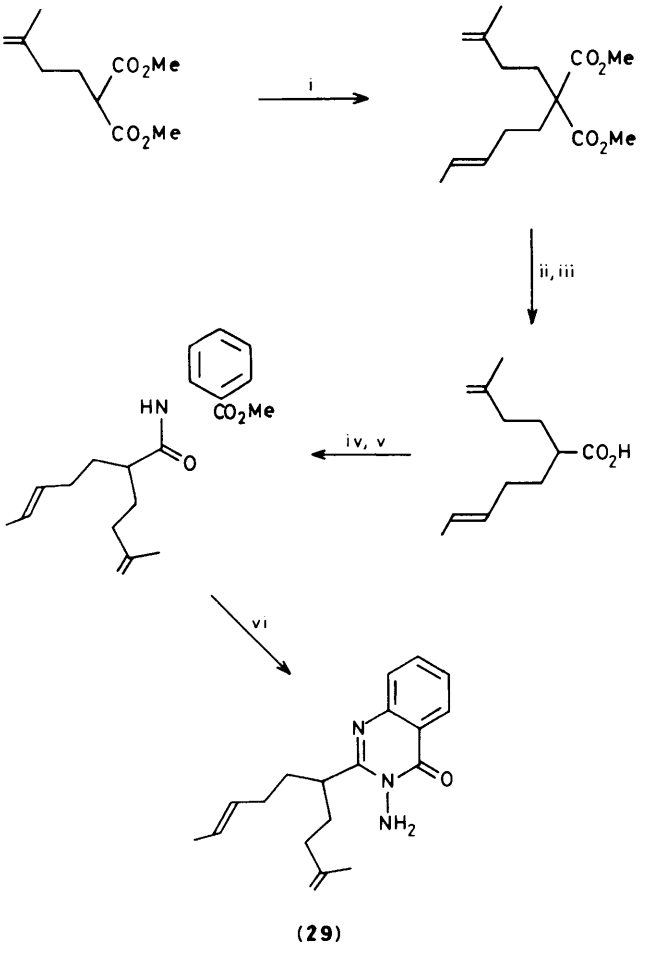
Oxidation of (**29**) was carried out as previously described for (**10**) and (**11**) and gave two aziridines (**30**) and (**31**), each as a single stereoisomer, in the ratio 3:1, respectively.

It does appear that the ratio (**30**):(**31**) gives a better measure of the relative affinity of these two double bonds for the nitrene than does the ratio of addition to the same double bonds in oxidation of (**11**) (see below).

*Mechanism of Addition of* N-*Nitrenes to the Double Bonds in Compounds* (**10**), (**11**), and (**29**).—Inclusion of an additional methylene group in the bifurcated chain of (**15**) to give the *N*-aminoquinazolone (**10**) results in a gross change in the selectivity of the derived nitrene for the two different double bonds [from 1.5:1 for (**15**) to 5.8:1 for (**10**)]. The corresponding change in the selectivity of the nitrene derived from *N*-

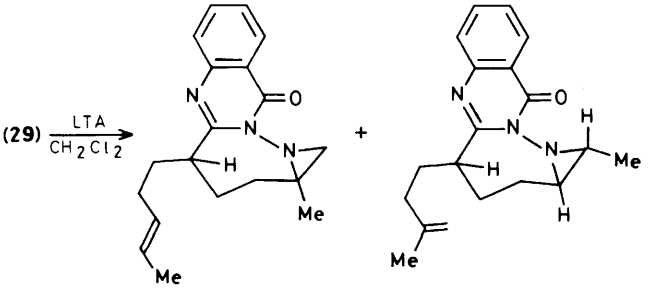



Scheme 6.




(29)

**Scheme 7.** *Reagents:* i, $MeCH{=}CH(CH_2)_2OTos$, NaOMe–DMSO; ii, NaOH–$H_2O$; iii, heat, 130—150 °C; iv, $(COCl)_2$ on $Na^+$ salt; v, methyl anthranilate; vi, $NH_2NH_2$–EtOH (sealed tube).

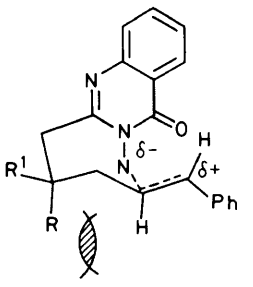



(30) 3 parts (31) 1 part

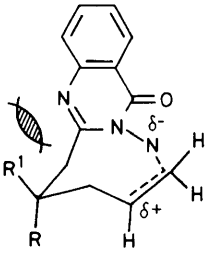
aminoquinazolone (**29**) by comparison with that from (**24**) is less [5.3:1 for (**24**) to 3:1 for (**29**)].

We suggest that these changes in ratios above, are the result of a change in mechanism from one involving non-concerted nitrene addition (Scheme 1) to one which is concerted. The nitrene-alkene reaction in the latter case is then a concerted cycloaddition in which HOMO-alkene/LUMO-nitrene is presumably the dominant pair of interacting frontier orbitals and the (methylene) styrenoid double bond in (**10**) would be expected to react faster in such a cycloaddition.

An alternative explanation for these changes in ratios would retain both a transition state having dipolar character and also attack *via* a seven-membered ring (**32**) (as in Scheme 1) for the particular case of addition to the phenyl-substituted double bond. The corresponding addition to the unsubstituted double bond would presumably require an eight-membered transition state (**33**) to generate the more stable (partial) secondary carbonium ion, and the accelerated rate of addition in (**32**) would be the result both of benzylic stabilisation of the carbonium ion and the favourable entropy factor in formation of a seven- rather than an eight-membered transition state.




(**32**) R, $R^1$ = H, $CH_2CH{=}CH_2$



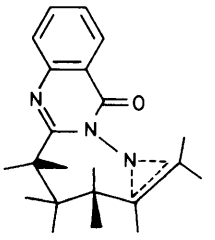

(**33**) R, $R^1$ = H, $CH_2CH{=}CHPh$

A result which militates against this alternative explanation is again the identity of the stereoisomer ratios in Scheme 5. Although the additional carbon atom in the side chain of (**10**) allows some increased flexibility in attack of the nitrene on either double bond by comparison with (**15**), an examination of Dreiding models suggests that the chain is still sufficiently tight for identifiably different conformations to be necessary for attack on the α- and β-carbon atoms of the alkenes as shown in (**32**) and (**33**) with the significant differences in eclipsing or steric strain elements shown. The assumption is made here (as in Scheme 1) that the nitrene is sp-hybridised and attack on the double bond at either α- or β-positions is the result of overlap of the p-orbital at that position with the empty p-orbital on the nitrene.

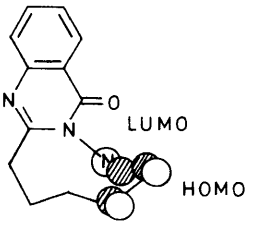
It would be expected, therefore, that attack on α- and β-positions *via* (**33**) and (**32**) would be accompanied by a significant change in stereoisomer ratio: specifically reaction *via* (**32**) would be expected to result in more of the stereoisomer with R = H. Identical stereoisomer ratios, however, would be expected if attack of the nitrene on both double bonds in (**10**) and on the α-methyl-substituted double bond in (**11**) took place *via* a geometry intermediate between (**32**) and (**33**).

The transition state geometry which, from examination of molecular models, has become accessible to the derived nitrene as a result of the change from (**15**) to (**10**) and from which, we suggest, concerted addition to the alkene double bond occurs is shown in (**34**).

This conformation is intermediate between those leading to (**32**) and (**33**) and leads directly to what we have deduced to be



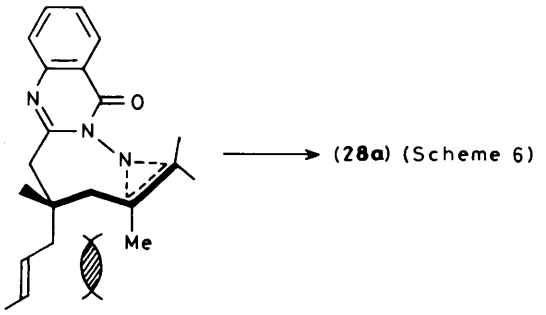

(**34**)




(**111**)

the most stable conformation of the seven-membered ring formed. A frontier orbital description of the nitrene-alkene interaction in (**34**), (III), has the nitrene LUMO (the empty p-orbital) ideally disposed to overlap with the HOMO of the alkene (the nitrene HOMO is the filled p-orbital which is correctly aligned for overlap with the alkene LUMO).

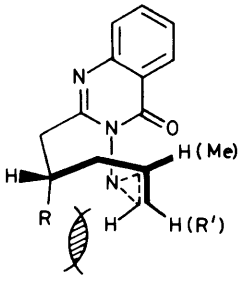
Support for this TSG (**34**) is the 'abnormal' ratio of stereoisomeric aziridines formed in addition of the nitrene to the β-methyl-substituted double bond in (**11**) since addition to one face of this double bond will be discriminated against by a '1,3-diaxial' methyl-alkenylmethylene interaction (**35**). The transition state energy leading to (**28a**) (Scheme 6) would thereby be



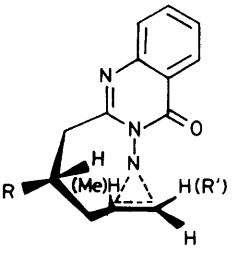

(**35**)

raised, accounting for the minor amounts of this stereoisomer formed in the reaction.

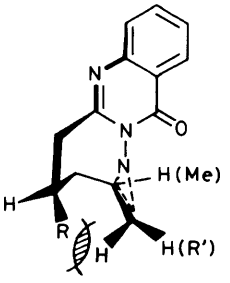
There are at least three readily identifiable transition state geometries (**36**)—(**38**) which, from examination of Dreiding models, have also become accessible to the nitrenes derived from (**10**) and (**11**) as a result of the additional carbon atom in the chain.



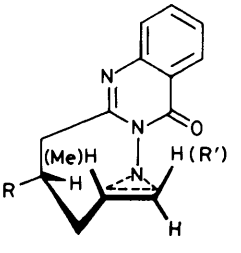
(**36**)



(**37**)



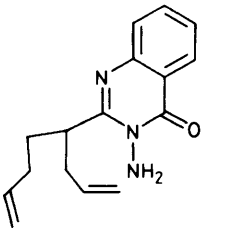
(**38**)



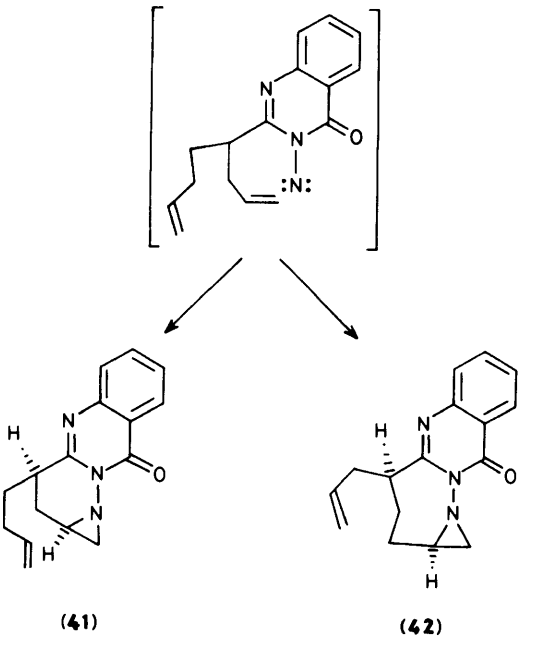
(**39**)

All of these alternatives can be excluded because none of them satisfactorily accounts for the gross change in the stereoisomer ratio in addition of the nitrene to the β-methyl substituted double bond in (**11**), by comparison with addition to the α-methyl substituted double bond (Scheme 6). Moreover, in the cases of (**36**) and (**38**) with the side chain R as shown, the severe non-bonded interactions likely to be present would mean that, at the very least, the resulting stereoisomer would be the minor one and not, as is the case, the major one. Transition-state geometry (**39**) is of interest since it resembles (**34**) in that the same orbital overlap is possible [*cf.* (III)]. However, models suggest that it is considerably more strained than (**34**) (as well as being ruled out for the reasons given above).

In an attempt to provide evidence for the proposed change in mechanism from non-concerted to concerted referred to earlier, we synthesized compound (**40**) and examined the response of the selectivity of its derived nitrene for the two double bonds to solvent changes.



(**40**)



(**41**) (**42**)

Synthesis of (**40**) was carried out by successive alkylation of dimethyl malonate with 4-tosyloxybutene and allyl chloride and the quinazolone elaborated in the usual way (*cf.* Scheme 7).

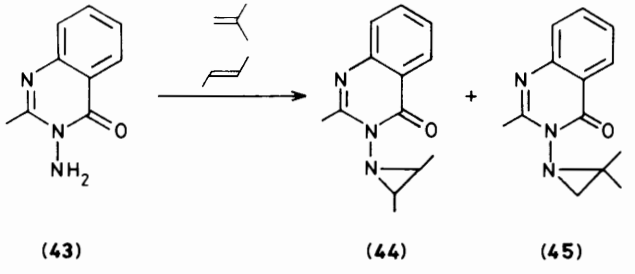
When oxidation of (**40**) was carried out in dichloromethane, the major product is the aziridine (**41**) [ratio (**41**):(**42**) = 3.4:1]. If addition to form (**41**) involves a transition state having dipolar character whereas addition to form (**42**) is the result of a concerted addition involving, presumably, a transition state having less charge separation, then a change from a more polar to a less polar solvent would be expected to favour the formation of (**42**) relative to (**41**).

The ratios of (**41**):(**42**) measured from the crude reaction products by n.m.r. from oxidations of (**40**) carried out in benzene, dichloromethane, and acetonitrile are shown in the Table. Clearly the expected solvent effect is present though it is

not a large one. Whether a larger solvent effect would be expected is difficult to say since the amount of dipolar character developed at the transition state in formation of (**41**) is not known and good analogies for the solvent effects to be expected in generation of such species (*i.e.* where the partial dipoles are almost within bonding distance) have not been found.

| Solvent | Ratio (**41**):(**42**) |
|---|---|
| $C_6H_6$ | 2.8:1 |
| $CH_2Cl_2$ | 3.4:1 |
| MeCN | 4.7:1 |

If addition to both double bonds in (**8**) is concerted with $n = 1$, then no further change in the nitrene selectivity would be expected with $n = 2$. However, in the *intra*molecular reactions reported in this paper, only terminal *trans*-substituted or β-methyl substituted double bonds have been used, specifically to eliminate any secondary interaction of the above double bond substituents with the quinazolone ring. This secondary interaction is known to be important in *inter*molecular reactions and presumably accounts for the selectivity of the *N*-nitrene derived from oxidation of 1-amino-2-methylquinazoline (**43**) for (*E*)-butene to give the aziridine (**44**) (Scheme 8) [ratio (**44**):(**45**) = 7.4:1]. This result is to be



(**43**) (**44**) (**45**)

**Scheme 8.**

contrasted with the corresponding ratio of 1:3 for the nitrene addition to the two analogously substituted double bonds in (**29**). It is possible that in (**8**; $n = 2$), there will be accessible conformations which allow this secondary interaction to operate [*cf.* (**39**)] and consequently the nitrene selectivity may be significantly affected by this additional factor.

## Experimental

For descriptions of instrumentation and general experimental details see refs. 7 and 8. N.m.r. spectra refer to 90 MHz unless otherwise indicated. 300 MHz Spectra were obtained using a JEOL EM 300 spectrometer. 3-Methylbut-3-en-1-ol and but-3-en-1-ol (Aldrich) were used as received, converted into their respective toluene-*p*-sulphonates using the method of Brandsma,[9] and used directly in the alkylations below.

*Dimethyl Monosubstituted Propane-1,3-dioates.*—These compounds were obtained by addition of dimethyl propanedioate (1.1 mol equiv.) to a solution of sodium methoxide (1.1 mol equiv.) in methanol followed by dropwise addition of the alkylating agent (1.05 mol equiv.) with stirring. When allyl chloride, methylallyl chloride, cinnamyl bromide, or but-2-enyl bromide was used as the alkylating agent, the mixture was stirred at room temperature overnight. With other alkylating agents, the solution was heated under reflux for 1—2 days. After cooling and separation of the sodium chloride or tosylate, the methanol was evaporated under reduced pressure, the residue dissolved in ether, and the ether solution washed twice with water, dried, and evaporated. Distillation gave the required propanedioates as colourless liquids. Dimethyl 2-(3-methylbut-3-enyl)propane-1,3-dioate, prepared by this method from 3-methylbut-3-en-1-ol toluene-*p*-sulphonate (35% yield), had b.p. 85—90 °C/0.15 mmHg. Dimethyl 2-but-3-enylpropane-1,3-dioate was obtained similarly but dimethyl sulphoxide was used as the solvent and alkylation using sodium methoxide and but-3-en-1-ol toluene-*p*-sulphonate carried out by heating the solution at 90—100 °C (oil-bath temp.) for 2 days. After cooling, the solution was poured into water, extracted twice with ether and the combined ether extracts worked up as described above to give a colourless oil (33%), b.p. 82—85 °C/0.4 mmHg.

*Dimethyl Disubstituted Propane-1,3-dioates.*—Dimethyl 2-[(*E*)-but-2-enyl]-2-(2-methylprop-2-enyl)propane-1,3-dioate [for (**24**)] was obtained from dimethyl but-2-enylpropane-1,3-dioate (1 mol equiv.) and 3-chloro-2-methylpropene (1.1 mol equiv.) using sodium methoxide (1.05 mol equiv.) in methanol as described above. The product was obtained as a colourless oil (29%), b.p. 104—110 °C/1.5 mmHg; δ 5.40 (m, C*H*=C*H*Me), 4.77 (m, CMe=C$H_2$), 3.66 (s, 2 × $CO_2$Me), 2.65 (s, –$CH_2$-CMe=$CH_2$), 2.57 (d, *J* 7 Hz, $CH_2$CH=CHMe), and 1.62 (m, C*Me*=$CH_2$, –CH=CH*Me*). Dimethyl 2-but-3-enyl-2-prop-2-enylpropane-1,3-dioate [for (**40**)] was prepared similarly from the foregoing dimethyl 2-but-3-enylpropane-1,3-dioate and allyl chloride. The oil obtained was distilled, b.p. 87—91 °C/0.4 mmHg, to give the diester (**29**); δ 5.65 (m, 2 × C*H*=$CH_2$), 5.00 (m, 2 × CH=C$H_2$), 3.68 (s, 2 × $CO_2$Me), 2.62 (d, *J* 7 Hz, $CH_2$CH=$CH_2$), and 1.98 (m, $CH_2CH_2$CH=$CH_2$). Dimethyl 2-(3-methylbut-3-enyl)-2-(*E*)-pent-3-enylpropane-1,3-dioate [for (**29**)] was prepared from dimethyl 2-(3-methylbut-3-enyl)-propane-1,3-dioate (prepared as above), and (*E*)-pent-3-enyl toluene-*p*-sulphonate by using sodium methoxide in dimethyl sulphoxide and heating at 55 °C (bath temp.) overnight. After the work-up described above, distillation gave the propane-1,3-dioate as a colourless oil, b.p. 140—150 °C/5 × $10^{-6}$ mmHg (25%); δ 5.40 (m, C*H*=C*H*Me), 4.67 (m, CMe=C$H_2$), 3.66 (s, 2 × $CO_2$Me), 1.90 (m, 2 × $CH_2CH_2$), 1.69 (s, C*Me*=$CH_2$), and 1.61 (d, *J* 4 Hz, CH=CH*Me*).

*Demethoxycarbonylation and Hydrolysis of Disubstituted Propane-1,3-dioates.*—The disubstituted propane-1,3-dioate (1 mol equiv.), sodium chloride (2.4 mol equiv.), and water (3—6 mol equiv.) were heated in dimethyl sulphoxide in an oil-bath at 185 °C overnight.[10] The solution was cooled, poured into water, and extracted twice with ether; the combined ether extracts were then washed twice with water, dried, and evaporated and the residual ester distilled under reduced pressure. The following were obtained in this way: methyl 2-(2-methylprop-2-enyl)-(*E*)-hex-4-enoate as a liquid, b.p. 54—66 °C/0.35 mmHg (69%); δ 5.28 (m, C*H*=C*H*Me), 4.60 (m, CMe=C$H_2$), 3.52 (s, $CO_2$Me), 2.46 (m, CH), 2.16 (m, 2 × $CH_2$), 1.64 (s, C*Me*=$CH_2$), and 1.58 (d, *J* 4 Hz, CH=CH*Me*); methyl 2-(3-methylbut-3-enyl)-(*E*)-hept-5-enoate as a liquid (83%) (not distilled); δ 5.36 (m, CH=C*H*Me), 4.64 (m, CMe=C$H_2$), 3.62 (s, $CO_2$Me), and 2.39—1.50 (m, CH, 2 × $CH_2CH_2$, 2 × Me); methyl 2-(prop-2-enyl)hex-5-enoate as a liquid (77%) (not distilled); δ 5.70 (m, 2 × C*H*=$CH_2$) 4.97 (m, 2 × CH=$CH_2$), 3.62 (s, $CO_2$Me), and 2.46—1.52 (m, 7 H).

Hydrolysis of the esters above was carried out by heating under reflux with sodium hydroxide (2M) containing ethanol in the usual way to give the following acids: 2-(2-methylprop-2-enyl)-(*E*)-hex-4-enoic acid as an oil (95%); δ 11.24 (br s, $CO_2$H), 5.42 (m, C*H*=C*H*Me), 4.73 (m, CMe=C$H_2$), 2.57 (m, CH), 2.22 (m, 2 × $CH_2$), 1.72 (s, C*Me*=$CH_2$), and 1.63 (d, *J* 4 Hz, CH=CH*Me*); 2-(3-methylbut-3-enyl)-(*E*)-hept 5-enoic acid as an oil (90%); δ 9.75 (br s, $CO_2$H), 5.38 (m, C*H*=C*H*Me), 4.64 (m, CMe=C$H_2$), and 2.40—1.52 (m, 15 H); 2-(prop-2-enyl)hex-5-

enoic acid as an oil (96%), δ 10.54 (br s, $CO_2H$), 5.78 (m, 2 × C*H*=$CH_2$), 5.04 (m, 2 × CH=C*H*$_2$), and 2.57—1.51 (m, 7 H).

*Chain Extension of Compounds* (**12**) *and* (**13**).—The acid (**12**), prepared as described previously,[7] was chain extended by the following sequence. (i) Reduction with lithium aluminium hydride in ether to the corresponding alcohol, b.p. 145—148 °C/0.35 mmHg; δ 7.21 (s, 5 × ArH), 6.48—5.86 (m, C*H*=C*H*Ph, C*H*=$CH_2$), 5.00 (m, CH=C*H*$_2$), 3.53 (d, *J* 5 Hz, C*H*$_2$OH), 2.16 (m, 2 × $CH_2$), and 1.73 (m, C*H*, O*H*); $\nu_{max.}$ 3 400s $cm^{-1}$. (ii) Conversion of the latter into a toluene-*p*-sulphonate. (iii) Reaction of the latter with potassium cyanide in dimethyl sulphoxide to form the nitrile (93%), b.p. 148—155 °C/0.35 mmHg; δ 7.21 (s, 5 × ArH), 6.50—5.48 (m, C*H*=C*H*Ph, C*H*=$CH_2$), 5.06 (m, CH=C*H*$_2$), 2.24 (m, 3 × $CH_2$), and 1.90 (m, CH); $\nu_{max.}$ 2 250w $cm^{-1}$. (iv) Hydrolysis of this nitrile by heating in aqueous alcoholic potassium hydroxide to the homologenated acid using methods previously described.[8] 3-Prop-2-enyl-6-phenylhex-5-enoic acid (**14**; $R^1$ = $R^3$ = H, $R^2$ = Ph) was obtained as an oil (49%); δ 10.12 (br s, $CO_2H$), 7.21 (s, 5 × ArH), 6.45—5.48 (m, C*H*=C*H*Ph, C*H*=$CH_2$), 5.03 (m, CH=C*H*$_2$), and 2.20 (m, CH, 3 × $CH_2$); $\nu_{max.}$ 3 000br and 1 705s $cm^{-1}$. Similarly, the acid (**13**) was converted into the corresponding alcohol (96%); δ 5.45 (m, C*H*=C*H*Me), 4.72 (m, CMe=C*H*$_2$), 3.50 (d, *J* 5 Hz, C*H*$_2$OH), 2.2 (br s, OH), 2.0 (m, CH, 2 × $CH_2$), 1.71 (s, C*Me*=$CH_2$), and 1.64 (d, *J* 6 Hz, CH=CH*Me*), and then *via* the toluene-*p*-sulphonate into the corresponding nitrile (90%); δ 5.39 (m, C*H*=C*H*Me), 4.75 (m, CMe=C*H*$_2$), 2.27 (d, *J* 5 Hz, C*H*$_2$CN), 2.05 (m, 2 × $CH_2$), and 1.64 (m, C*Me*=$CH_2$, CH=CH*Me*). Hydrolysis of this nitrile gave 3-(2-methylprop-2-enyl)-(*E*)-hept-5-enoic acid (**14**; $R^2$ = H, $R^1$ = $R^3$ = Me) as an oil (66%); δ 11.43 (br s, $CO_2H$), 5.40 (m, C*H*=C*H*Me), 4.79 (m, CMe=C*H*$_2$), 2.29—1.98 (m, CH, 3 × $CH_2$), 1.71 (s, C*Me*=$CH_2$), and 1.64 (d, *J* 5 Hz, CH=CH*Me*).

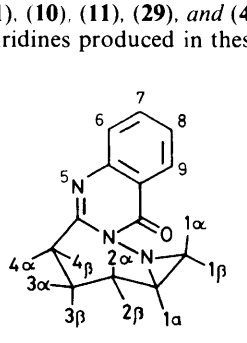
*Methyl* N-*Substituted Anthranilates*.—Hex-5-enoic acid was converted into its acid chloride with thionyl chloride and then treated with methyl anthranilate in ether as described previously to give methyl *N*-hex-5-enoylanthranilate as a colourless oil; δ ($CCl_4$) 10.95 (br s, NH), 8.67 (dd, *J* 8 and 1 Hz, 3-H), 7.96 (dd, *J* 8 and 2 Hz, 6-H), 7.53 (ddd, *J* 8, 8, and 2 Hz, 4-H), 7.03 (ddd, *J* 8, 8, and 1 Hz, 5-H), 5.8 (m, C*H*=$CH_2$), 5.0 (m, CH=C*H*$_2$), 3.78 (s, $CO_2$Me), and 2.6—1.8 (m, C*H*$_2$C*H*$_2$C*H*$_2$).

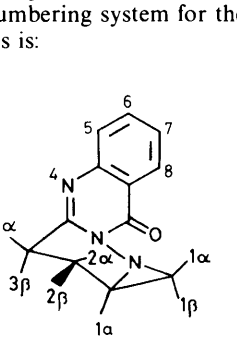
The sodium salts of the acids prepared above were treated with oxalyl chloride to give their acid chlorides as described previously[11] and these were then allowed to react with methyl anthranilate. The following anthranilates were prepared in this way and obtained as colourless oils; methyl *N*-[2-(2-methylprop-2-enyl)-(*E*)-hex-4-enoyl]anthranilate (71%); δ 10.89 (br s, NH), 8.58 (dd, *J* 8 and 1 Hz, 3-H), 7.87 (dd, *J* 8 and 2 Hz, 6-H), 7.39 (ddd, *J* 8, 8, and 2 Hz, 4-H), 6.91 (ddd, *J* 8, 8, and 1 Hz, 5-H), 5.39 (m, C*H*=C*H*Me), 4.64 (s, CMe=C*H*$_2$), 3.8 (s, $CO_2$Me), 2.48—2.10 (m, CH, 2 × $CH_2$), 1.66 (s, C*Me*=$CH_2$), and 1.50 (d, *J* 5 Hz, CH=CH*Me*); methyl *N*-[3-(2-methylprop-2-enyl)-(*E*)-hept-5-enoyl]anthranilate (67%); δ 10.96 (br s, NH), 8.69 (dd, *J* 8 and 1 Hz, 3-H), 7.94 (dd, *J* 8 and 2 Hz, 6-H), 7.48 (ddd, *J* 8, 8, and 2 Hz, 4-H), 7.00 (ddd, *J* 8, 8, and 1 Hz, 5-H), 5.40 (m, C*H*=C*H*Me), 4.73 (m, CMe=C*H*$_2$), 3.88 (s, $CO_2$Me), 2.36—1.98 (m, CH, 3 × $CH_2$), 1.72 (s, C*Me*=$CH_2$), and 1.60 (d, *J* 3 Hz, CH=CH*Me*); methyl *N*-(3-prop-2-enyl-6-phenylhex-5-enoyl)-anthranilate (80%); δ 11.0 (br s, NH), 8.66 (dd, *J* 8 and 1 Hz, 3-H), 7.93 (dd, *J* 8 and 2 Hz, 6-H), 7.45 (ddd, *J* 8, 8, and 2 Hz, 4-H), 6.98 (ddd, *J* 8, 8, and 1 Hz, 5-H), 6.66—5.60 (m, C*H*=C*H*Ph, C*H*=$CH_2$), 5.03 (m, CH=C*H*$_2$), 3.83 (s, $CO_2$Me), and 2.30 (m, CH, 3 × $CH_2$); methyl *N*-[2-(3-methylbut-3-enyl)-(*E*)-hept-5-enoyl]anthranilate (96%), δ 10.9 (br s, NH), 8.74 (dd, *J* 8 and 1 Hz, 3-H), 7.95 (dd, *J* 8 and 2 Hz, 6-H), 7.48 (ddd, *J* 8, 8, and 2 Hz, 4-H), 7.02 (ddd, *J* 8, 8, and 1 Hz, 5-H), 5.38 (m, C*H*=C*H*Me), 4.66 (m, CMe=C*H*$_2$), 3.89 (s, $CO_2$Me), and 2.47—1.53 (m, CH, and 2 × C*H*$_2$C*H*$_2$); methyl *N*-(2-prop-2-enylhex-5-enoyl)-anthranilate (55%); δ 11.09 (br s, NH), 8.74 (dd, *J* 8 and 1 Hz, 3-H), 7.98 (dd, *J* 8 and 2 Hz, 6-H), 7.50 (ddd, *J* 8, 8, and 2 Hz, 4-H), 7.02 (ddd, *J* 8, 8, and 1 Hz, 5-H), 5.82 (m, 2 × C*H*=$CH_2$), 5.04 (m, 2 × CH=C*H*$_2$), 3.89 (s, $CO_2$Me), and 2.60—1.60 (m, 11 H).

2-*Substituted* 3-*Aminoquinazolin*-4(3H)-*ones*.—Methyl *N*-(hex-5-enoyl)anthranilate was heated with hydrazine in ethanol as described previously to give 3-*Amino*-2-*pent*-4-*enylquinazolin*-4(3H)-*one* (**21**) as colourless plates (80%), m.p. 76—77 °C (from ethanol) (Found: C, 67.95; H, 6.6, N, 18.3 $C_{13}H_{15}N_3O$ requires C, 68.1; H, 6.6; N, 18.35%); δ (60 MHz) 8.20 (dd, *J* 8 and 2 Hz, quinaz. H *ortho* to C=O), 7.8—7.2 (m, 3 × quinaz. H), 6.3—5.6 (m, C*H*=$CH_2$), 5.2 (m, CH=C*H*$_2$), 4.88 (s, $NH_2$), 2.97 [t (further split), *J* 8 Hz, C*H*$_2$-quinaz.], and 2.5—1.6 (m, C*H*$_2$-C*H*$_2$CH=$CH_2$); $\nu_{max.}$ 3 290w, 3 195w, and 1 665s $cm^{-1}$. Other 2-substituted 3-aminoquinazolin-4(3*H*)-ones were obtained by heating the corresponding anthranilate with hydrazine and ethanol in a Carius tube with exclusion of oxygen as previously described.[7]

3-*Amino*-2-(2-*methylhepta*-1,6-*dien*-4-*yl*)*quinazolin*-4(3H)-*one* (**24**) was obtained as a colourless solid (90%), m.p. 67—69 °C (from light petroleum) (Found: C, 72.0; H, 7.5; N, 14.9. $C_{17}H_{21}N_3O$ requires C, 72.0; H, 7.5; N, 14.8%); δ 8.15 (d, *J* 8 Hz, 5-H), 7.68—7.20 (m, 6-, 7-, and 8-H), 5.30 (m, C*H*=C*H*Me), 4.81 (br s, CMe=C*H*$_2$), 4.62 (br s, $NH_2$), 3.94 (quintet, *J* 8 Hz, CH), 2.74—2.13 (m, 2 × $CH_2$), 1.71 (s, CMe=$CH_2$), and 1.53 (d, *J* 4 Hz, CH=CH*Me*). The following were obtained as colourless oils after purification by chromatography over alumina and eluting with light petroleum–ethyl acetate (4:1): 3-amino-2-[2-(2-methylprop-2-enyl)hex-4-enyl]quinazolin-4(3*H*)-one (**11**); δ 8.15 (d, *J* 8 Hz, 5-H), 7.70—7.17 (m, 6-, 7-, and 8-H), 5.39 (m, C*H*=C*H*Me), 4.84 (br s, CMe=C*H*$_2$), 4.62 (br s, $NH_2$), 2.94 (d, *J* 6 Hz, $CH_2$-quinaz.), 2.50 (m, CH), 2.11 (m, 2 × $CH_2$), 1.70 (s, C*Me*=$CH_2$), and 1.58 (m, CH=CH*Me*); 3-amino-2-(2-prop-2-enyl)-5-phenylpent-4-enyl)quinazolin-4(3*H*)-one (**10**) as a colourless oil (41%); δ 8.12 (d, *J* 8 Hz, 5-H), 7.67—7.11 (m, 8 × ArH), 6.40—5.60 (m, C*H*=C*H*Ph, C*H*=$CH_2$), 5.00 (m, CH=C*H*$_2$), 4.78 (br s, $NH_2$), 3.01 (d, *J* 6 Hz, C*H*$_2$ quinaz.), and 2.50—2.10 (m, CH, 2 × $CH_2$); 3-amino-2-(2-methyldeca-1,8-dien-5-yl)quinazolin-4(3*H*)-one (**29**) as a colourless oil (47%); δ 8.2 (d, *J* 8 Hz, 5-H), 7.68—7.27 (m, 6-, 7-, and 8-H), 5.36 (m, C*H*=C*H*Me), 4.84 (br s, $NH_2$), 4.60 (br s, CMe=C*H*$_2$), 3.71 (m, CH), 2.17—1.82 (m, 2 × C*H*$_2$C*H*$_2$), 1.68 (s, C*Me*=$CH_2$), and 1.56 (m, CH=CH*Me*); 3-amino-2-octa-1,7-dien-4-ylquinazolin-4(3*H*)-one (**40**) as a colourless oil (56%); δ 8.16 (d, *J* 8 Hz, 5-H), 7.70—7.25 (m, 6-, 7-, and 8-H), 5.74 (m, 2 × CH=$CH_2$), 4.9 (m, 2 × CH=C*H*$_2$), 3.80 (quint. *J* 7 Hz, CH), and 2.62—1.70 (m, 3 × $CH_2$). Since distillation (at $10^{-5}$—$10^{-6}$ mmHg) of the above quinazolones was accompanied in each case by partial decomposition, they were used directly in the oxidations below after purification by chromatography.

*Oxidation of* 2-*Substituted*-3-*Aminoquinazolin*-4(3H)-*ones* (**21**), (**10**), (**11**), (**29**), *and* (**40**).—The numbering system for the aziridines produced in these oxidations is:



Lead tetra-acetate (LTA) (1.04 g) was added in small portions over 10 min to a rapidly stirred solution of compound (**21**) (540 mg) in dry dichloromethane (50 ml). The mixture was stirred for an additional 10 min. after which the insoluble lead diacetate was separated and the solution washed with aqueous sodium hydrogen carbonate and water, dried, and evaporated. Crystallisation of the residual oil was induced by addition of water and trituration. The *aziridine* (**20**) (440 mg) was obtained as a colourless solid hydrate m.p. 105—107 °C (from ethanol–water) (Found: C, 63.55; H, 6.05; N, 17.05. $C_{13}H_{13}N_3O{\cdot}H_2O$ requires C, 63.65; H, 6.15; N, 17.15%); δ (400 MHz) 8.25 (dd, *J* 8 and 1.5 Hz, 9-H), 7.70 (ddd, *J* 8, 7, and 1.5 Hz, 7-H), 7.62 (dd, *J* 8 and 1.3 Hz, 6-H), 7.44 (ddd, *J* 8, 7, and 1.3 Hz, 8-H), 3.57 (ddd, *J* 13, 12, and 8 Hz, 4β-H), 2.97 (dd, *J* 6.1 and 3.3 Hz, 1β-H), 2.90 (ddd, *J* 13, 6.7, and 1.6 Hz, 4α-H), 2.65 (dddd, *J* 12, 6.1, 6.1, and 3.2 Hz, 1a-H), 2.43 (dddd, *J* 15.2, *ca.* 6, 3.2, and 1.3 Hz, 2β-H), 2.18 (dd, *J* 6.1 and 3.3 Hz, 1α-H), 2.11 (ddddd, *J ca.* 14, 12.3, *ca* 8, *ca.* 6, and 1.6 Hz, 3β-H), 2.02 (ddddd, *J ca.* 14, 12, 6.7, 6.4, and 1.3 Hz, 3α-H), 1.19 (dddd, *J* 15.2, 12.3, 12.0, and 6.4 Hz, 2α-H). Oxidation of the other *N*-aminoquinazolones (**24**), (**10**), (**11**), (**29**) and (**40**) was carried out with lead tetra-acetate in dry dichloromethane using the high dilution conditions previously described.[8] In every case, only the aziridines which were subsequently isolated were present, from n.m.r. examination of the crude reaction mixtures, in yields >90%.

Oxidation of compound (**24**) in dry dichloromethane in this way gave the aziridines (**25**) and (**26**). Chromatography on alumina with light petroleum–ethyl acetate (2:1) as eluant gave the aziridine (**26**), m.p. 97—100 °C (from ethanol); δ (400 MHz) 8.21 (dd, *J* 8 and 1.3 Hz, 8-H), 7.64 (ddd, *J* 8.1, 6.8, and 1.3 Hz, 6-H), 7.58 (dd, *J* 8.1 and 1.1 Hz, 5-H), 7.37 (ddd, *J* 8, 6.8, and 1.1 Hz, 7-H), 4.80 (m, $CMe{=}CH_2$), 3.18 (dd, *J* 14.4 and 3.1 Hz, $CHHCMe{=}CH_2$), 3.03 (dddd, *J* 12.6, 10.7, 3.6, and 3.1 Hz, 3β-H), 2.71 (ddd, *J* 13.3, 8, and 3.6 Hz, 2β-H), 2.63 (ddd, *J* 8.3, 8, and 5.3 Hz, 1a-H), 2.05 (dd, *J* 14.4 and 10.7 Hz, $CHHCMe{=}CH_2$), 2.0 (dq, *J* 5.6 and 5.3 Hz, 1α-H), 1.78 (s, $CMe{=}CH_2$), 1.50 (d, *J* 5.6 Hz, Me), and 1.1 (ddd, *J* 13, 12.6, and 8.3 Hz, 2α-H). Further elution gave *aziridine* (**25**), m.p. 159—164 °C (from ether–chloroform) (Found: C, 72.6; H, 6.9; N, 14.9. $C_{17}H_{19}N_3O$ requires C, 72.6; N, 6.8; N, 14.8%); δ (400 MHz), 8.30 (dd, *J* 8 and 1.5 Hz, 8-H), 7.70 (ddd, *J* 8.2, 6.6, and 1.5 Hz, 6-H), 7.66 (dd, *J* 8.2 and 1.5 Hz, 5-H), 7.43 (ddd, *J* 8, 6.6, and 1.5 Hz, 8-H), 5.60 (m, $CH{=}CHMe$), 3.05 (m, $CHHCH{=}CHMe$), 2.89 (dddd, *J* 12.8, 8.6, 4.1, and 3.9 Hz, 3β-H), 2.81 (d, *J* 2.2 Hz, 1β-H), 2.41 (dd, *J* 13.3 and 3.9 Hz, 2β-H), 2.31 (m, $CHHCH{=}CHMe$), 1.97 (d, *J* 2.2 Hz, 1α-H), 1.72 (d, *J* 4.5 Hz, $CH{=}CHMe$), 1.47 (s, Me), and 1.33 (dd, *J* 13.3 and 12.8 Hz, 2α-H). The ratio of (**25**):(**26**) obtained was 5.3:1 (from the ratio of respective olefinic proton, $CHHC{=}C$, methyl, and 2α-H signals).

Oxidation of (**10**) (100 mg) using the same method gave a mixture of the aziridines (**18a**), (**18b**) and (**19a**), (**19b**). Chromatography on alumina and elution with light petroleum–ethyl acetate (3:1) gave a mixture of (**18a**) and (**18b**) (53 mg). The aziridine (**18a**) (viscous oil) has *inter alia* δ (400 MHz) 3.37 (d, *J* 5.4 Hz, 1α-H), 3.26 (dd, *J* 12.8 and 11.4 Hz, 4β-H), and 1.51 (ddd, *J* 15.2, 12.2, and 6.3 Hz, 2α-H). The aziridine (**18b**) (viscous oil) has *inter alia* δ 3.74 (dd, *J* 13.2 and 7.2 Hz, 4α-H), 3.38 (d, *J* 5.4 Hz, 1α-H), and 1.04 (ddd, *J* 15.2, 12, and 12 Hz, 2α-H). From the ratio of the peak areas at 3.26 and 3.74 (4β-H and 4α-H, respectively) the ratio of (**18a**):(**18b**) was 2.1:1.

Further elution with ethyl acetate gave (**19a**) and (**19b**) (31 mg). Re-chromatography on alumina and elution with light petroleum–ethyl acetate (1:1) gave the aziridine (**19a**) as an oil (16 mg); δ (400 MHz) 8.24 (dd, *J* 8 and 1.3 Hz, 9-H), 7.69 (ddd, *J* 7.9, 7, and 1.3 Hz, 7-H), 7.60 (dd, *J* 7.9 and 1.4 Hz, 6-H), 7.43 (ddd, *J* 8, 7, and 1.4 Hz, 8-H), 6.50 (d, *J* 15.7 Hz, $CH{=}CHPh$), 6.23 (dt, *J* 15.7 and 7.3 Hz, $CH{=}CHPh$), 3.26 (dd, *J* 12.1 and 12.1 Hz, 4β-H), 2.98 (dd, *J* 6.1 and 3.2 Hz, 1β-H), 2.95 (dd, *J* 12.1 and 6 Hz, 4α-H), 2.75 (dddd, *J* 12.2, 6.1, 6.1, and 3 Hz, 1a-H), 2.50 (m, $CH_2CH{=}CHPh$), 2.33 (m, 2β-, 3α-H), 2.16 (dd, *J* 6.1 and 3.2 Hz, 1α-H), and 1.31 (ddd, *J* 15.4, 12.2, and 6.5 Hz, 2α-H). (These assignments were consistent with a COSY projection.) Further elution gave aziridine (**19b**) (1.5 mg) as an oil. In the mixture of (**19a**) and (**19b**), signals from (**19b**) are visible at 3.66 (dd, *J* 13.1 and 7.3 Hz, 4β-H) and 2.11 (dd, *J* 7.4 and 3.3 Hz, 1α-H). From the ratio of peak areas at 2.11 and 2.10 (1α-H) and 3.66 and 3.26 (4β-H) the ratio of (**19a**):(**19b**) was 2.2:1. The ratio of (**19a**) + (**19b**) to (**18a**) + (**18b**) was found to be 5.8:1 from the peak areas of olefin proton signals at δ 6.5 and 6.23 to those at 5.75 and 5.10 in the n.m.r. spectrum of the total reaction product.

Oxidation of (**11**) (500 mg) by the same method and chromatography on alumina eluting with light petroleum–ethyl acetate (2:1) gave the aziridine (**27a**) as an oil (53 mg), δ (400 MHz) 8.24 (dd, *J* 8 and 1.4 Hz, 9-H), 7.69 (ddd, *J* 8.2, 6.9 and 1.4 Hz, 7-H), 7.62 (dd, *J* 8.2 and 1.1 Hz, 6-H), 7.44 (ddd, *J* 8, 6.9, and 1.1 Hz, 8-H), 4.85 (m, $CMe{=}CH_2$), 3.17 (dd, *J* 12.5 and 10.9 Hz, 4β-H), 2.86 (dd, *J* 12.5 and 4.7 Hz, 4α-H), 2.50 (ddd, *J* 12.2, 5.5, and 3.1 Hz, 1a-H), 2.30 (m, 1α-, 2β-, 3α-H, $CH_2CMe{=}CH_2$), 1.76 (s, $CMe{=}CH_2$), 1.58 (d, *J* 5.7 Hz, azir. Me), and 1.26 (ddd, *J* 14.4, 12.2, and 6.1 Hz, 2α-H). Further elution gave mixed fractions of (**27a**) and (**27b**) and then the aziridine (**27b**) as an oil (12 mg); δ (400 MHz) 8.24 (dd, *J* 8 and 1.5 Hz, 9-H), 7.70 (ddd, *J* 8.2, 6.8 and 1.5 Hz, 7-H), 7.65 (dd, *J* 8.2 and 1.5 Hz, 6-H), 7.44 (ddd, *J* 8, 6.8, and 1.5 Hz, 8-H), 4.85 (m, $CMe{=}CH_2$), 3.67 (dd, *J* 13.1 and 7.3 Hz, 4β-H), 2.79 (dd, *J* 13.1 and 1.5 Hz, 4α-H), 2.48 (ddd, *J* 11.9, 5.8, and 2.8 Hz, 1α-H), 2.40 (m, 2β- and 3β-H), 2.33 (dq, *J* 5.8 and 5.7 Hz, 1α-H), 2.25 (dd, *J* 13.9 and 7.6 Hz, $CHHCMe{=}CH_2$), 2.01 (dd, *J* 13.9 and 7 Hz, $CHHCMe{=}CH_2$), 1.76 (s, $CMe{=}CH_2$), 1.57 (d, *J* 5.7 Hz, azir. Me), and 0.8 (ddd, *J* 16.4, 13, and 11.9 Hz, 2α-H). From the ratio of peak areas at δ 3.17 and 3.67 (4β-H), the ratio of (**27a**):(**27b**) was 2.3:1.

Further elution gave the *aziridine* (**28b**) (55 mg) as colourless crystals, m.p. 161—165 °C (from ethanol) (Found: C, 72.9; H, 7.3; N, 14.0. $C_{18}H_{21}N_3O$ requires C, 73.2; H, 7.2; N, 14.2%); δ (400 MHz) 8.25 (dd, *J* 8 and 1.5 Hz, 9-H), 7.70 (ddd, *J* 8.2, 6.7, and 1.5 Hz, 7-H), 7.65 (dd, *J* 8.2 and 1.5 Hz, 6-H), 7.44 (dd, *J* 8, 6.7, and 1.5 Hz, 8-H), 5.50 (m, $-CH{=}CHMe$), 3.41 (dd *J* 13 and 6.8 Hz, 4β-H), 2.83, (dd, *J* 13 and 1 Hz, 4α-H), 2.79 (d, *J* 3 Hz, 1β-H), 2.20 (m, 2β-H,3β-H, $CHHCH{=}CHMe$), 2.19 (d, *J* 3 Hz, 1α-H), 1.95 (ddd, *J* 13, 8.2, and 8.2 Hz, $CHHCH{=}CHMe$), 1.69 (dd, *J* 6.2 and 1.3 Hz, $CH{=}CHMe$), 1.42 (s, azir. Me), and 0.82 (dd, *J* 16.2 and 13.1 Hz, 2α-H).

Examination of the mother-liquor after crystallisation of (**28b**) by n.m.r. revealed the presence of (**28a**) with an aziridine ring methyl signal at δ 1.50. From the peak areas of signals at δ 1.42 and 1.50 (azir. ring methyl), the ratio of (**28b**):(**28a**) was estimated to be *ca* 7:1. The ratio of (**27a**) + (**27b**):(**28b**) + (**28a**) was measured from integration of the respective olefinic and aziridine ring methyl signals in the n.m.r. spectrum of the crude reaction product and found to be 1.05 (±0.05):1.

Oxidation of (**29**) (210 mg) by the same method and chromatography of the product on alumina, eluting with light petroleum–ethyl acetate (4:1) gave aziridine (30) as colourless crystals (62 mg) (from light petroleum), m.p. 104.5—106 °C (Found: $M^+$, 309.1820; $C_{19}H_{23}N_3O$ requires *M*, 309.1841); δ (400 MHz) 8.17 (dd, *J* 8.1 and 1.5 Hz, 9-H), 7.61 (ddd, *J* 8.2, 6.6, and 1.5 Hz, 7-H), 7.58 (dd, *J* 8.2 and 1.6 Hz, 6-H), 7.36 (ddd, *J* 8.1, 6.6, and 1.6 Hz, 8-H), 4.64 (m, $CMe{=}CH_2$), 3.49 (dddd, *J* 12, 7.9, 6.3, and 6.3 Hz, 4β-H), 2.38 (ddd, *J* 11.9, 5.5, and 3.1 Hz, 1a-H), 2.26 (m, 3 H), 1.98 (m, 3 H), 1.69 (m, 4 H), 1.50 (m, 4 H), and 1.1 (m, 1 H). Further elution gave the aziridine (**31**) as an oil (193 mg); δ (400 MHz) 8.17 (dd, *J* 8.2 and 1.5 Hz, 9-H), 7.61 (ddd, *J* 8.2, 6.5, and 1.5 Hz, 7-H), 7.57 (dd, *J* 8.2 and 1.7 Hz, 6-H), 7.35 (ddd, *J* 8.2, 6.5, and 1.7 Hz, 8-H), 5.40 (m, $CH{=}CHMe$), 3.24 (dddd, *J* 11.8, 6.6, 6.6, and 6.6 Hz, 4β-H), 2.72 (d, *J* 3.1 Hz, 1β-H), 2.1 (m, 6 H), 1.70 (m, 1 H), 1.57 (dd, *J* 3.7 and 0.9 Hz,

CH=CH*Me*), 1.40 (m, 1 H), 1.32 (s, Me), and 1.09 (ddd, *J* 14.2, 12.0, and 6.3 Hz, 2α-H). From comparison of the peak areas of the respective olefinic and 4β-H signals together with those from 1a-H (**30**) and 1β-H (**31**), the ratio of (**31**), the ratio of (**31**):(**30**) was found to be 3 (±0.3):1.

Oxidation of (**40**) (100 mg) under the same conditions and crystallisation from ethanol gave the *aziridine* (**41**) (60 mg), m.p. 144—145 °C (Found: C, 71.5; H, 6.45; H, 15.8. $C_{16}H_{17}N_3O$ requires C, 71.9; H, 6.4; N, 15.75%); δ (400 MHz) 8.27 (dd, *J* 8 and 1.5 Hz 8-H), 7.69 (ddd, *J* 8, 7.5, and 1 Hz, 6-H), 7.64 (dd, *J* 8 and 1.0 Hz, 7-H), 7.42 (ddd, *J* 8.0, 7.5, and 1.0 Hz, 7-H) 5.90 (dddd, *J* 17.3, 10.2, 6.6, and 6.6 Hz, C*H*=$CH_2$), 5.10 (dd, *J* 17.3 and 1.3 Hz, $\overset{H}{H}\!>\!C\!=\!C\!<^{H}$), 5.05 (dd, *J* 10.2 and 1.3 Hz, $\overset{H}{H}\!>\!C\!=\!C\!<^{H}$), 2.95 (dddd, *J* 12.9, 6.9, 5.4, and 3.9 Hz, 3β-H), 2.90 (dd, *J* 6.0 and 1.8 Hz, 1β-H), 2.90 (ddd, *J* 8.5, 7.5, 6.0, and 5.4 Hz, 1a-H), 2.75 (ddd, *J* 13.4, 7.5, and 3.9 Hz, 2β-H), 2.50 (dddd, *J* 13.7, 7.2, 7.2, and 6.9 Hz, C*H*HC$H_2$CH=$CH_2$), 2.40, 2.33 (2 × dddd both *J* 14.6, 8.3, 7.2, and 6.6 Hz, C$H_2$CH=$CH_2$), 1.85 (dd, *J* 5.4 and 1.8 Hz, 1α-H), 1.62 (dddd, *J* 13.7, 8.3, 8.3, and 5.4 Hz, CH*H*C$H_2$CH=$CH_2$), and 1.3 (ddd, *J* 13.4, 12.9, and 8.5 Hz, 2α-H). The mother-liquor after removal of (**41**) above was evaporated and the residue chromatographed over alumina. Elution with light petroleum–ethyl acetate gave the aziridine (**42**) (10 mg) as a colourless solid (from light petroleum), m.p. 51—55 °C (Found: $M^+$, 267.1385. $C_{16}H_{17}N_3O$ requires $M^+$, 267.1371); δ (400 MHz) 8.23 (dd, *J* 8 and 1 Hz, 9-H), 7.42 (ddd, *J* 8, 7, and 1 Hz, 8-H), 5.90 (dddd, *J* 17, 10, 7.9, and 6.0 Hz, C*H*=$CH_2$), 5.15 (dd, *J* 17.0 and 2.0 Hz, $\overset{H}{H}\!>\!C\!=\!C\!<^{H}$), 5.05 (dd, *J* 10 and 2 Hz, $\overset{H}{H}\!>\!C\!=\!C\!<^{H}$), 3.65 (dddd, *J* 13.6, 6.9, 6.9, and 6.6 Hz, 3β-H), 2.96 (dd, *J* 5.9 and 3.3 Hz, 1α-H), 2.88 (ddd, *J* 14.4, 6.9, and 6.0 Hz, C*H*HCH=$CH_2$), 2.65 (dddd, *J* 12, 6.2, 5.9, and 3.0 Hz, 1a-H), 2.45 (ddd, *J* 14.4, 7.9, and 6.9 Hz, CH*H*CH=$CH_2$), 2.38 (ddd, *J* 14.6, 5.9, and 3.0 Hz, 2β-H), 2.22 (dddd, *J* 13.6, 12.0, 6.1, and 5.9 Hz, 3β-H), 2.15 (dd, *J* 6.2 and 3.3 Hz, 1β-H), 1.57 (ddd, *J* 12, 12, and 6.6 Hz, 3α-H), 1.12 (dddd, *J* 14.6, 12, 12, and 6.1 Hz, 2α-H). From comparison of the peak areas of signals at 1.85 [1α-H in (**41**)] and 3.65 [3β-H in (**42**)] in the crude reaction mixture, the ratio of aziridines (**41**):(**42**) was found to be 3.4:1. This ratio (from an oxidation carried out in dichloromethane) was found to be dependent on the solvent in which the oxidation was carried out; analogous oxidations of the quinazolone (**40**) in dry benzene and in dry acetonitrile gave ratios of (**41**):(**42**) of 2.8:1 and 4.7:1, respectively.

*Oxidation of 3-Amino-2-methylquinazolin-4(3H)-one in the Presence of 2-Methylpropene and* (E)*-Butene.*—(*E*)-But-2-ene (0.49 g) and 2-methylpropene (6.39 g) were condensed into ice-cold dichloromethane (15 ml). To this magnetically stirred solution, small portions of LTA (0.75 g total) and the aminoquinazolone (**43**) (0.25 g total) were added alternately in equivalent amounts over 15 min. After the mixture had been stirred for a further 30 min at 0 °C, the precipitated lead salts were separated and the solution washed with aqueous sodium hydrogen carbonate, dried, and evaporated. Examination of the 300 MHz n.m.r. spectrum of this total oxidation product showed the presence of aziridines (**45**) and (**44**) in a 1.76:1 ratio from the ratio of the respective aziridine ring methyl signals. Taking into account the molar ratios of the two alkenes used, the double bond of (*E*)-but-2-ene is 7.6 times more reactive than that of 2-methylpropene. An authentic sample of aziridine (**45**) was obtained by oxidation of (**43**) in the presence of only 2-methylpropene as above. The product was purified by chromatography on alumina, eluting with light petroleum–ethyl acetate (5:2) followed by distillation to give the *aziridine* (**45**) (40%), b.p. 130 °C/0.3 mmHg (Found: C, 68.1; H, 6.6; N, 18.2. $C_{13}H_{15}N_3O$ requires C, 68.1; H, 6.6; N, 18.3%); δ (90 MHz) 8.17 (d, *J* 8 Hz, quinaz. H *ortho* to C=O), 7.70—7.28 (m, 3 × quinaz. H), 2.75 (m, 2 × azir. ring H), 2.71 (s, quinaz. Me), 1.52 (s, Me), and 1.22 (s, Me); $\nu_{max.}$ 1 678s $cm^{-1}$.

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