N-(3,4-Dihydro-4-oxoquinazolin-3-yl)pyridinium Imides: Aziridinating Agents for Alkenes: Measurement of Rotational Barriers around each N–N Bond in an N–N–N System

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Pyridinium imides **3–5** and **8** are obtained as crystalline solids from the reaction of 3-acetoxyaminoquinazolinones **2** and **10** with the corresponding pyridines; barriers to rotation around each of the N–N bonds in **3** have been measured by NMR spectroscopy, and the imides **3–5** react both with styrene and with diethyl fumarate to give the corresponding aziridines.

Oxidation of 3-aminoquinazolinones, *e.g.* **1**, with lead tetraacetate in dichloromethane gives the 3-acetoxyaminoquinazolinone **2** which is stable in solution at −20 °C.[1] Addition of pyridine (10 mol equiv.) gives the pyridinium imide **3** as a pale yellow crystalline solid, mp 134–136 °C (decomp.). Similarly, the pyridinium imides **4** (53%) and **5** (55%) were obtained from reaction of **2** with 2-methylpyridine and 3-methylpyridine, respectively.† These imides are not stable to silica chromatography and were purified by crystallisation after removal of the bulk of the pyridine.

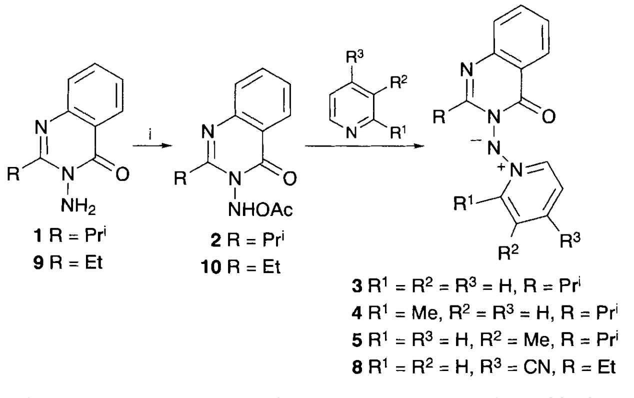
In the NMR spectra of the imides **3** and **5**, broadened signals are observed at room temperature for the methyl groups in the quinazolinone 2-isopropyl substituent and from the two *ortho*-protons on the pyridinium ring.

Examination of a number of NMR spectra of **3** at 400 MHz between −95 °C and ambient temperature reveals the involvement of *two* dynamic processes in the broadening of the signals from the two types of proton referred to above. In anticipation of what follows, the preferred stereostructure proposed for this imide ($\mathbf{3'} \rightleftharpoons \mathbf{3''}$) is that shown in Fig. 1.

In the NMR spectrum of **3** at −40 °C, the broadened isopropyl methyl signals have separated and sharpened: from their separation and coalescence temperature, a barrier $\Delta G^{\ddagger}$ = 60 kJ mol^{-1} was calculated. This barrier is assigned to that for rotation around the N_{α}–N_{β} bond in Fig. 1. ($\mathbf{3'} \rightleftharpoons \mathbf{3''}$).

The signals from the *ortho*-protons of the pyridinium ring in **3** are separated at −90 °C (CD_2Cl_2 solution) although not sharpened fully. From their separation and coalescence temperature, a barrier $\Delta G^{\ddagger}$ = 48 kJ mol^{-1} was calculated and this is assigned to that for rotation around the N_{β}–N_{γ} bond in Fig. 1.

Interconversion of the magnetic environments of the two *ortho*-protons of the pyridinium ring in **3** would result from direct *inversion via* **6** at the divalent nitrogen N_{β} in **3′** (Fig. 1) in which the three nitrogens are linear. However, the lower energy barrier measured above is *not* that associated with this inversion at N_{β} since such a process ($\mathbf{3'} \rightleftharpoons \mathbf{3''}$) would, at the same time, also interconvert the magnetic environments of the isopropyl methyl groups. This inversion at N_{β} *via* **6** *could* account for the higher energy barrier referred to above; however, this transition state requires a higher energy sp-hybridisation for N_{β} and unfavourable interaction between lone pairs contained in p-orbitals on N_{α} and N_{β}.‡ Rotation around this N_{α}–N_{β} bond, on the other hand, can proceed *via* **7** (Fig. 1) having sp^3 hybridisation for N_{β} and less unfavourable interactions between lone pairs on N_{α} and N_{β}.



Scheme 1 *Reagents and conditions*: i, $Pb(OAc)_4$, CH_2Cl_2, −20 °C

Support for this interpretation comes from the NMR spectra at various temperatures of the pyridinium imide **8**, prepared from 4-cyanopyridine and the 3-acetoxyaminoquinazolinone **10** derived from **9**. From the separation and coalescence of the *ortho*-protons on the cyanopyridine ring, the barrier for N_{β}–N_{γ} rotation in **8** is higher ($\Delta G^{\ddagger}$ = 62 kJ mol^{-1}) than that in **3**, corresponding to greater resonance delocalisation with the pyridine ring and hence more double bond character in this N_{β}–N_{γ} bond. The barrier to rotation around the N_{α}–N_{β} is also raised (ΔG > 77 kJ mol^{-1})§ which is consistent with a rotation around this bond which is coupled with the rotation around the N_{β}–N_{γ} bond, *i.e.* the transition state for the N_{α}–N_{β} rotation has an orientation around the N_{β}–N_{γ} bond as illustrated in **7**.

These imides **3–5** function as aziridinating agents: heating **3** with styrene (3 mol equiv.) at 135 °C gave aziridine **11** (44%) identical with a sample prepared by aziridination of styrene using **2**. Likewise, aziridination of diethyl fumarate (3 mol equiv.) using **5** at 145 °C gave aziridine **12** (33%); the same aziridine **12** was obtained in 56% yield by heating the 2-methylpyridine-derived imide **4** in diethyl fumarate at 150 °C.¶ Aziridine **12** (81%) was also prepared by aziridination of diethyl fumarate using **2**.

Oxidation of **1** in the presence of 3,5-lutidine gave an oily impure product which could not be purified. However, if the oil obtained on work-up was heated directly with diethyl fumarate

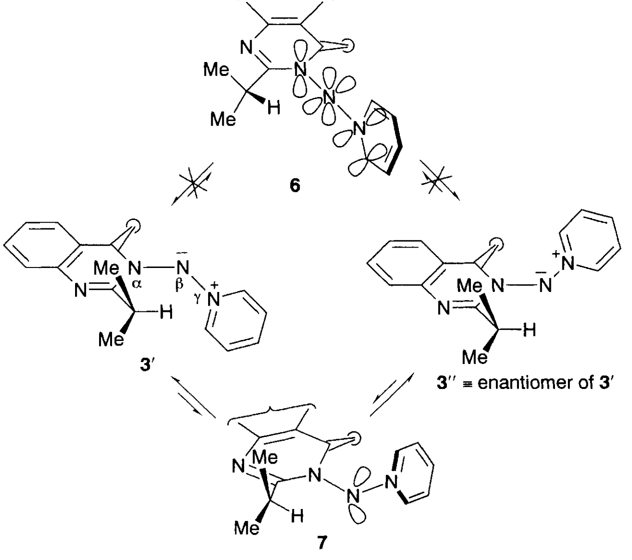
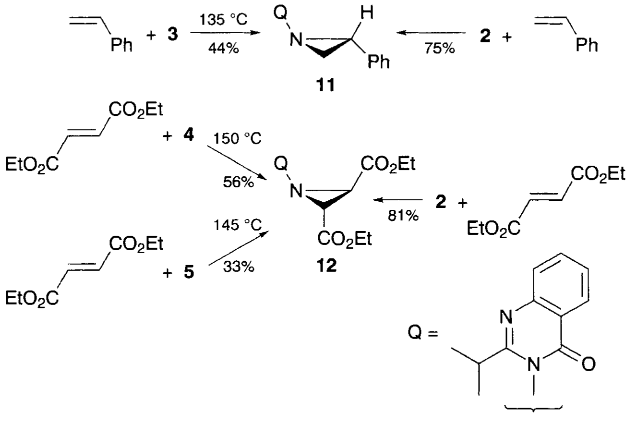


Fig. 1

at 145 °C, aziridine **12** was isolated (30%) after chromatography.

A large number of pyridinium imides are known,[2] the majority having the additional substituent on the divalent nitrogen as CO_2R, COR, SO_2Ar or Ar. Barriers to rotation around the N–N bond in these compounds have not been reported; the symmetry likely to be present in many of them means that the two *ortho*-protons of the pyridinium ring are magnetically equivalent. Some of these pyridinium imides act as nitrene precursors and on photolysis bring about the aziridination of alkenes.[2]



Scheme 2

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Footnotes

† All new compounds have been fully characterised.

‡ Some alleviation of the lone-pair interaction in **6** is possible by inversion *via* a rotamer around the N_α–N_β bond in which these lone pairs are not eclipsed.

§ The increase in this higher barrier is difficult to account for in terms of inversion at N_β *via* a transition state analogous to **6**.

¶ The cyano-substituted imide **8** was unreactive towards either styrene or diethyl fumarate even at higher temperatures.

References

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