Ring Expansion Reaction of 1,2-Dihydroquinolines to 1-Benzazepines. 2

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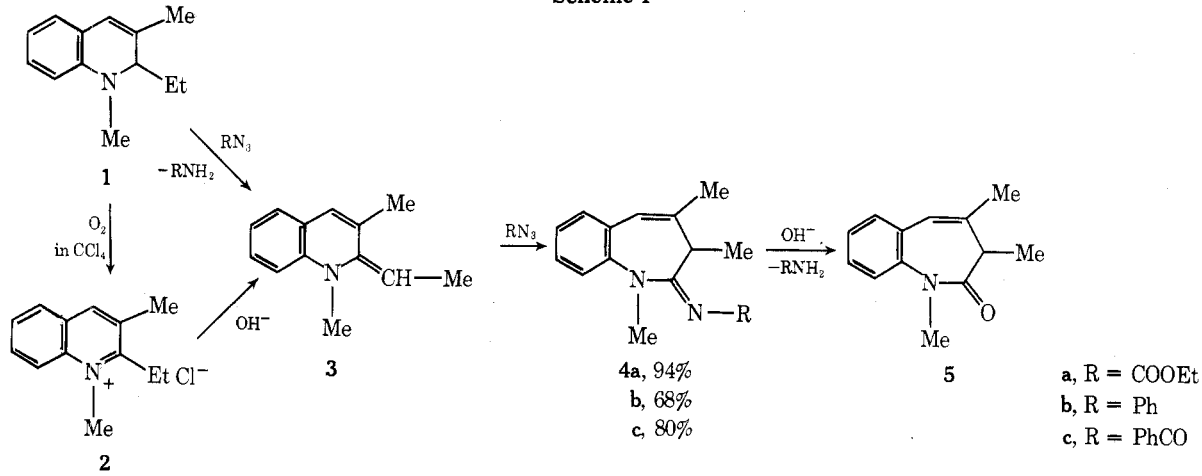
Received April 26, 1976

In a previous paper,[1] we reported a convenient synthetic method for the preparation of 1-benzazepines from 1,2-dihydroquinolines by the use of ethyl azidoformate. It was also revealed that the reaction proceeded by way of the intermediate 1,3-dialkyl-2-alkylidene-1,2-dihydroquinolines which were easily prepared by the treatment of 1,2,3-trialkylquinolinium chlorides with alkali. Successful employment of phenyl and benzoyl azides in the same ring expansion reaction is described in this paper with some mechanistic considerations.

When a mixture of 1,3-dimethyl-2-ethylidene-1,2-dihydroquinoline (**3**) with phenyl or benzoyl azide was heated at 110–120 °C, 1,3,4-trimethyl-2-phenylimino- (or benzoylimino-) 2,3-dihydro-1*H*-1-benzazepine (**4b** or **4c**) was produced in a good yield. Alkaline hydrolysis of **4b** or **4c** gave a high yield of 1,3,4-trimethyl-2-oxo-2,3-dihydro-1*H*-1-benzazepine (**5**) with elimination of aniline or benzamide. The yields are shown in Scheme I together with that previously reported for the case of ethyl azidoformate.[1]

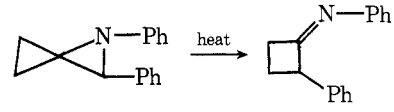
Scheme I



Compound **4b** was also obtained in 40% yield by the reaction of 1,3-dimethyl-2-ethyl-1,2-dihydroquinoline (**1**) with an excess of phenyl azide. However, a similar treatment of **1** with benzoyl azide gave no **4c** but phenyl isocyanate which is a thermal decomposition product of the azide.[2] This result would be attributable to the different thermal stabilities of azides employed.[2]

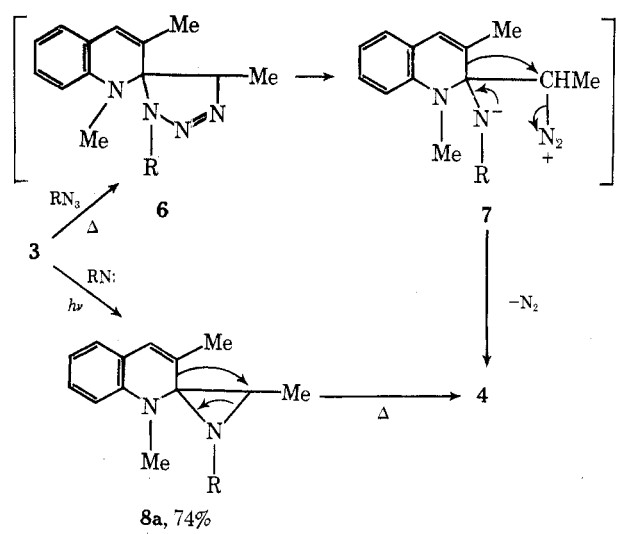
The half-life of the unimolecular decomposition of ethyl azidoformate to ethoxycarbonyl nitrene may be estimated to be 1–2 h at 120 °C based on Breslow's work.[3] The thermal reaction of **3** with azide may proceed either via a 1,3-dipolar addition process giving the triazoline **6** or via a cycloaddition process of a nitrene to give the aziridine **8** (Scheme II). Uv irradiation of a mixture of **3** and an azide at low temperature was expected to direct the reaction exclusively into the nitrene pathway.

A solution of **3** and an azide (ethyl azidoformate, phenyl azide, or benzoyl azide) in petroleum ether was thus irradiated with a high-pressure mercury lamp at 0–10 °C to give a yellow oil (**8a**, **8b**, or **8c**), which could be distilled between 120 and 150 °C under reduced pressure without appreciable decomposition. The empirical formulas of these oils agreed with the compositions of the corresponding compounds **4a**, **4b**, and **4c**. When **8a–c** were heated at 180 °C for 1 h, excellent yields of **4a–c** were obtained. These results together with the spectral data suggest that compounds **8** have the structures of 1,3-dimethyl-1,2-dihydroquinoline-2-spiro-2′-(1′-substituted 3′-methyl)aziridines. A similar thermal rearrangement of 1,2-diphenylazaspiro[2.2]pentane has been reported by Crandall et al.[4]



Because the aziridines **8** are stable at 120 °C, they are not intermediates in the thermal reaction of **3** with the azides. The azide addition via **6** and **7** may therefore be a more reasonable mechanism for the thermal reaction.

Scheme II



Experimental Section

NMR spectra were recorded using a JNM-MH-100 (JEOL) spectrometer with Me_4Si as internal standard. Ir spectra were taken on a IRA-2 (JASCO) spectrometer. Fractional distillation was accomplished by a Büchi GKR-5 Kugelrohr distillation apparatus. All procedures were carried out under a nitrogen atmosphere.

1,3,4-Trimethyl-2-phenylimino-2,3-dihydro-1*H*-1-benzazepine (4b). To a solution of 1,3-dimethyl-2-ethylquinolinium chloride[5] (**2**, 1.50 g, 6.8 mmol) in 10 ml of water was added 10 ml of 20% potassium hydroxide at 0–5 °C. 1,3-Dimethyl-2-ethylidene-1,2-dihydroquinoline

(3) was liberated immediately as a yellow oil, which was extracted with 40 ml of ligroin (bp 110–120 °C). To the boiling ligroin solution was added dropwise 1.61 g (13.5 mmol) of phenyl azide and the mixture was refluxed for 3 h. Fractional distillation of the reaction mixture gave 1.28 g (68%) of **4b:** bp 152–156 °C (0.03 mm); NMR ($CDCl_3$) δ 0.76 (d, 3, J = 7.5 Hz, C-3 CH_3), 1.78 (s, 3, C-4 CH_3), 3.49 (s, 3, NCH_3), 3.49 (q, 1, J = 7.5 Hz, C-3 H), 6.31 (s, 1, C-5 H), and 6.63–7.30 (m, 9, aromatic H).

Anal. Calcd for $C_{19}H_{20}N_2$: C, 82.57; H, 7.29; N, 10.14. Found: C, 82.38; H, 7.30; N, 10.31.

1,3,4-Trimethyl-2-benzoylimino-2,3-dihydro-1*H*-1-benzazepine (4c). In a similar manner as described above for **4b, 3** prepared from **2** (1.00 g, 4.5 mmol) was treated with benzoyl azide (1.29 g, 8.8 mmol) to give 1.10 g (80%) of **4c:** bp 158–162 °C (0.03 mm); NMR ($CDCl_3$) δ 0.81 (d, 3, J = 7.0 Hz, C-3 CH_3), 1.98 (s, 3, C-4 CH_3), 3.52 (s, 3, NCH_3), 3.82 (q, 1, J = 7.0 Hz, C-3 H), 6.38 (s, 1, C-5 H), and 6.80–8.20 (m, 9, aromatic H).

Anal. Calcd for $C_{20}H_{20}N_2O$: C, 78.92; H, 6.62; N, 9.20. Found: C, 78.63; H, 6.73; N, 9.25.

Hydrolysis of 4b or 4c. A solution of **4b** (550 mg, 2.0 mmol) in 5% potassium hydroxide in 50% ethanol (20 ml) was refluxed for 12 h. After removal of the ethanol, the aqueous solution was extracted with chloroform. The extract was washed with water, dried, and concentrated. Fractional distillation of the residue gave 65 mg (35%) of aniline and 362 mg (90%) of **5,** bp 105–109 °C (0.03 mm) [lit.[1] bp 103–105 °C (0.025 mm)].

In a similar manner, **4c** (257 mg, 0.84 mmol) gave 49 mg (48%) of benzamide and 158 mg (93%) of **5.**

1,3-Dimethyl-1,2-dihydroquinoline-2-spiro-2′-(1′-ethoxycarbonyl-3′-methyl)aziridine (8a). Ethyl azidoformate 0.96 g, 9.0 mmol) was added to a solution of **3** [prepared from 1.00 g (4.5 mmol) of **2**] in 40 ml of petroleum ether. The mixture was irradiated with a high-pressure mercury lamp (100 W) at 0–10 °C for 6 h. The solvent was removed under reduced pressure. Distillation of the residue gave 832 mg (74%) of **8a:** bp 118–125 °C (0.03 mm); ir (neat) 1708 cm^{-1}; NMR ($CDCl_3$) δ 0.86 (d, 3, J = 7.5 Hz, C-3′ CH_3), 1.37 (t, 3, J = 7.0 Hz, ethoxy CH_3), 2.16 (s, 3, C-3 CH_3), 3.14 (s, 3, NCH_3), 4.07 (q, 1, J = 7.5 Hz, C-3′ H), 4.32 (q, 2, J = 7.0 Hz, ethoxy CH_2), and 6.83–7.40 (m, 5, C-4 and aromatic H).

Anal. Calcd for $C_{16}H_{20}N_2O_2$: C, 70.56; H, 7.40; N, 10.29. Found: C, 70.32; H, 7.41; N, 10.34.

1,3-Dimethyl-1,2-dihydroquinoline-2-spiro-2′-(1′-phenyl-3′-methyl)aziridine (8b). In a similar manner as described for **8a,** a solution of **3** [prepared from 1.00 g (4.5 mmol) of **2**] and phenyl azide (1.08 g, 8.4 mmol) in petroleum ether was treated giving 772 mg (62%) of **8b:** bp 125–132 °C (0.03 mm); NMR ($CDCl_3$) δ 1.36 (d, 3, J = 7.5 Hz, C-3′ CH_3), 1.72 (s, 3, C-3 CH_3), 2.36 (s, 3, NCH_3), 4.28 (q, 1, J = 7. Hz, C-3′ H), and 6.40–7.48 (m, 10, C-4 and aromatic H).

Anal. Calcd for $C_{19}H_{20}N_2$: C, 82.57; H, 7.29; N, 10.14. Found: C, 82.43; H, 7.29; N, 10.28.

1,3-Dimethyl-1,2-dihydroquinoline-2-spiro-2′-(1′-benzoyl-3′-methyl)aziridine (8c). In a similar manner as described above for **8a,** treatment of **3** [prepared from 1.00 g (4.5 mmol) of **2**] with benzoyl azide (1.33 g, 8.4 mmol) gave 821 mg (60%) of **8c:** bp 143–149 °C (0.04 mm); ir (neat) 1660 cm^{-1}; NMR ($CDCl_3$) δ 0.82 (d, 3, J = 7.5 Hz, C-3′ CH_3), 2.23 (s, 3, C-3 CH_3), 2.98 (s, 3, NCH_3), 4.03 (q, 1, J = 7.5 Hz C-3′ H), and 6.73–8.05 (m, 10, C-4 and aromatic H).

Anal. Calcd for $C_{20}H_{20}N_2O$: C, 78.92; H, 6.62; N, 9.20. Found: C, 78.74; H, 6.64; N, 9.23.

Thermal Rearrangement of 8a, 8b, and 8c to 4a, 4b, and 4c. Five hundred milligrams of **8a, 8b,** or **8c** was sealed in a glass tube under reduced pressure and heated at 180 °C for 1 h. Distillation of the reactant gave 450 mg (90%) of **4a** [bp 138–142 °C (0.07 mm), lit.[1] bp 130–132 °C (0.03 mm)], 490 mg (98%) of **4b,** or 457 mg (91%) of **4c.** They were identified by spectroscopic comparisons with authentic samples obtained by the thermal reaction of **3** with ethyl azidoformate,[1] phenyl azide, or benzoyl azide, respectively.

Reaction of 1,3-Dimethyl-2-ethyl-1,2-dihydroquinoline[5] (1) with Phenyl Azide or Benzoyl Azide. Phenyl azide (4.76 g, 40 mmol) was added dropwise to a boiling solution of **1** (1.87 g, 10 mmol) in 20 ml of ligroin (bp 110–120 °C). The mixture was heated at reflux for 6 h. Fractional distillation of the reaction mixture was repeated to give 1.11 g (40%) of **4b,** which was identified with an authentic sample prepared by the thermal reaction of **3** with phenyl azide.

A similar treatment of **1** (1.87 g, 10 mmol) with benzoyl azide (5.88 g, 40 mmol) gave 3.82 g (80%) of phenyl isocyanate and 1.83 g (98%) of **1.**

Registry No.—**1,** 51904-95-1; **2,** 55539-76-9; **3,** 57091-72-2; **4b,** 59181-48-5; **4c,** 59183-03-5; **5,** 57091-65-3; **8a,** 59181-49-6; **8b,** 59813-04-6; **8c,** 59181-51-0; phenyl azide, 622-37-7; benzoyl azide, 582-61-6; ethyl azidoformate, 817-87-8.

References and Notes

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(3) D. S. Breslow, T. J. Prosser, A. F. Marcantonio, and C. A. Genge, *J. Am. Chem. Soc.,* **89,** 2384 (1967).
(4) J. K. Crandall and W. W. Conover, *J. Chem. Soc., Chem. Commun.,* 33 (1973).
(5) Y. Sato, H. Kojima, and H. Shirai, *Tetrahedron,* **30,** 2695 (1974).

A General Method for the Synthesis of Reactive α,β-Unsaturated Diazomethyl Ketones: Allenyl Diazomethyl Ketone and Vinyl Diazomethyl Ketone[1]

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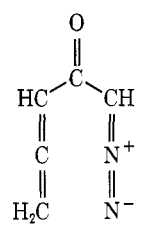
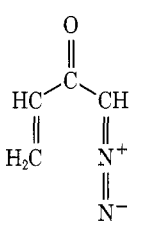
Received March 29, 1976

In the course of our photochemical studies, we required two unknown α,β-unsaturated diazomethyl ketones, allenyl diazomethyl ketone (**1**) and vinyl diazomethyl ketone (**2**).



1



2

Synthesis of α,β-unsaturated diazomethyl ketones poses special problems. The Arndt–Eistert reaction of diazomethane with α,β-unsaturated acid chlorides does not compete effectively with the cycloaddition of diazomethane to the conjugated double bond.[2,3] The normal Arndt–Eistert reaction prevails only in a few highly substituted α,β-unsaturated acid chlorides.[3–6] Alternative procedures based on diazo transfer,[2,7] tosylhydrazone anion decomposition,[8] and the modified Forster[9] reaction have been developed for certain α,β-unsaturated diazo ketones. We wish to describe a facile method for the conversion of α,β-unsaturated carboxylic acids to the corresponding α,β-unsaturated diazomethyl ketones which is applicable to the synthesis of even the most reactive α,β-unsaturated diazomethyl ketones. The method uses a protected double bond in the Arndt–Eistert reaction and takes advantage of the stability of diazomethyl ketones in base in the regeneration of the double bond.

Addition of hydrogen bromide to 2,3-butadienoic acid (**3**)[10] gives 3-bromo-3-butenoic acid (**4**). Successive treatment of **4** with oxalyl chloride and diazomethane gives **5** which on treatment with DBN (1,5-diazabicyclo[4.3.0]non-5-ene)[11] in ether at −20 °C gives allenyl diazomethyl ketone (**1**). The maximum yield of allenyl diazomethyl ketone (**1**) was obtained when **5** was treated with 1 equiv of DBN in ether at −20 °C followed by warming to room temperature over 20 min. Use of potassium *tert*-butoxide in ether gave a lower yield of **1.**

A similar sequence starting from 3-bromopropionic acid (**6a**) gives vinyl diazomethyl ketone (**2**) via **7a.** Vinyl diazomethyl ketone proved to be very reactive at room temperature. It forms a glassy solid in 30 min at room temperature even in