Manipulated Thermal Rearrangement of *N*-t-Alkyl-2,2-dichlorocyclopropylimines to *N*-Alkyl-chloropyrroles

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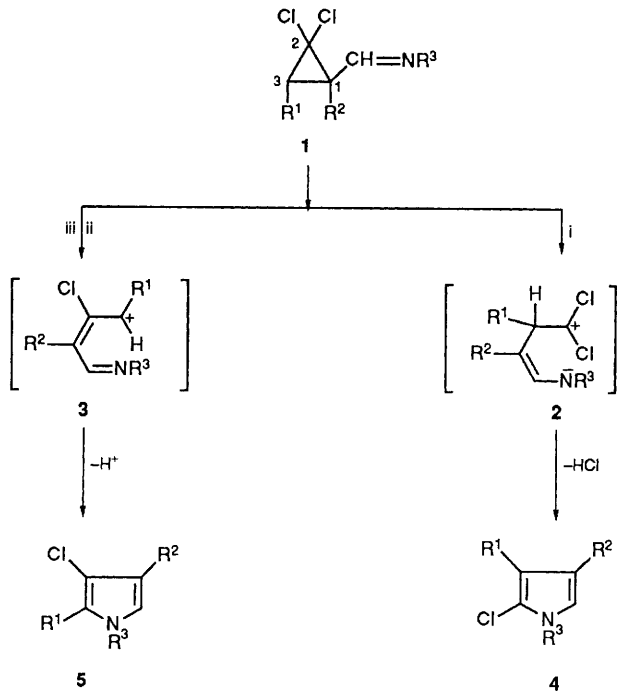
Thermolysis of *N*-t-butyl- and *N*-cumyl-2,2-dichlorocyclopropylimines gives selectively 3-chloropyrroles in polar solvents and 2-chloro derivatives with added base.

Acid-catalysed thermolysis of cyclopropylimine, regardless of *N*-alkyl or aryl group, generally affords dihydropyrrole and has been widely applied to the synthesis of alkaloids.[1] However, we recently showed that *N*-benzyl-2,2-dichlorocyclopropylimines rearrange not to the five-membered ring but to 2-phenylpyridines.[2] We have extended the study on the thermal behaviour of halo-substituted cyclopropylimine to find that *N*-t-alkyl-2,2-dichlorocyclopropane derivatives were transformed directly to two isomeric chloropyrroles and interestingly the course of ring cleavage to each isomer can be manipulated by solvents and additives.

1-[(Cumylimino)methyl]-2,2-dichloro-1-phenylcyclopropane **1a** was heated at 220 °C in benzene in an autoclave for 8 h to afford 2-chloro- and 3-chloro-1-cumyl-4-phenylpyrroles **4a**–**5a** in 0.8 and 60.9% yields, respectively (see Scheme 1).†‡ In pyrolysis of the 1-methyl- and 1-methyl-3-phenyl analogues **1b**–**1c**, 3-chloro-1-cumyl-4-phenylpyrrole **5b** and 3-chloro-1-cumyl-4-methyl-2-phenylpyrrole **5c** were obtained in 45 and 31% yields, respectively and the formation of the 2-chloro-isomers was not observed. Similarly, the Schiff bases of t-butylamine **1d**–**1e** were pyrolysed only to the 3-chloro derivatives **5d** and **5e** in 28 and 33% yields, respectively. The thermolysis of the imine prepared from aniline **1f** produced 3-chloro-1,4-diphenylpyrrole **5f** only in 1.4% yield. The dichlorocyclopropylimines, as distinct from cyclopropylimines, were not affected by ammonium chloride or HBr additives in ring opening. The cyclopropylimine rearrangement is driven by C=N π-bond abstraction by Lewis acid followed by either the counter ion or internal trapping of the cation. However, in the case of the dichlorocyclopropylimine, the leaving chloride ion is responsible for triggering the cyclopropane-ring cleavage with the 1,3-bond fission and the resultant allyl cation **3** is trapped by the imino group followed by dehydrochlorination to the 3-chloropyrrole **5**. The carbonium ion participation in the rearrangement was warranted by enhancement of the pyrrole formation in a polar solvent such as *N*-methylpyrrolidone (NMP). In NMP the thermolysis of **1a**, **1b** and **1d** produced selectively **5a**, **5b** and **5d** without the isomers in improved isolated yields of 90, 72 and 75%, respectively, and a drastic yield increase to as high as 81% was realized in the case of **1f**.

The formation of 2-chloropyrroles **4** involving the less stable dichlorocarbonium ion **2** or the radical with the cyclopropane 1,2-bond fission is apparently unfavoured. Interestingly, the addition of Lewis bases proved to provoke the thermal ring opening toward the 1,2-bond cleavage. Thus, when **1a** was heated in the refluxing phenetole in the presence of 6 mol CaO or K_2CO_3, 2-chloropyrrole **4a** in 76 and 71% yields, respectively and 3-chloro isomer **5a** formed only in 1% yield in the former oxide. Among the bases studied diisopropylamine guided this reaction path most effectively, as seen with **4a** which was selectively obtained in 87.5% yield. The base-catalysed formation of the 2-chloropyrroles is contrasted to the well-documented results that cyclopropyl-*p*-toluenesulphonate and other substrates are extremely resistant to nucleophilic attack.[3] For the novel cyclopropylimine rearrangement we tentatively assume that the nitrogen atom of the imino group, electron donated by the catalytic base, attacks the most electron-deficient dichloromethynyl carbon with 1,2-bond rupture of the cyclopropane ring (**2** in Scheme 1).



a: R^1 = H, R^2 = Ph, R^3 = $C(CH_3)_2Ph$
b: R^1 = H, R^2 = Me, R^3 = $C(CH_3)_2Ph$
c: R^1 = Ph, R^2 = Me, R^3 = $C(CH_3)_2Ph$
d: R^1 = H, R=2 = Ph, R^3 = Bu^t
e: R^1 = Ph, R^2 = Me, R^3 = Bu^t
f: R^1 = H, R^2 = R^3 = Ph

Scheme 1 *Reagents and conditions*: i, 1,3-bond fission; ii, Cl^-; iii, 3-bond fission

† Analytical (combustion and/or high resolution mass spectrometric) data were obtained for all products. The configurations of the pyrroles were determined on the basis of the NMR spectra; the pyrrole hydrogen adjacent to the nitrogen atom and/or the substituting benzene ring is shifted downfield and the coupling constant of J_{2-5} is greater than that of J_{2-4}.[4] The ^1H NMR data of the pyrrole ring of the compounds; [δ($CDCl_3$, 270 MHz)] **2a**: 6.42 (d, *J* 2.2 Hz, 3-H), 7.29 (d, *J* 2.2 Hz, 5-H); **3a**: 6.76 (d, *J* 2.7 Hz, 2-H), 6.84 (d, *J* 2.7 Hz, 5-H); **3b**: 6.32 (d, *J* 2.93 Hz, 5-H), 6.65 (d, *J* 2.93 Hz, 2-H); **3c**: 6.86 (s, 5-H); **3d**: 6.84 (d, *J* 2.9 Hz, 2-H), 6.90 (d, *J* 2.9 Hz, 5-H); **3e**: 6.65 (s, 5-H); **3f**: 7.12 (d, *J* 2.6 Hz, 2-H), 7.15 (d, *J* 2.6 Hz, 5-H).

‡ Isolated yields based on the Schiff bases.

The study of the extension of the first example of the controlled thermal rearrangement of cyclopropylimine by media to the analogous vinylcyclopropane system is underway.

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