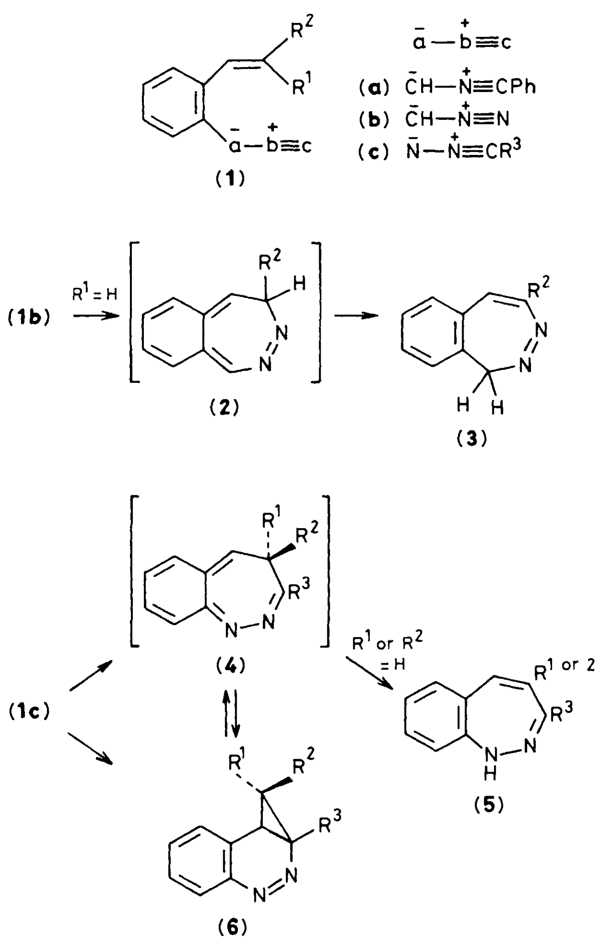
Reactions of Diene-conjugated 1,3-Dipolar Intermediates: the Formation of Cycloprop[*c*]isoquinolines from Benzonitrile *o*-Alkenylbenzyl Ylides and their Rearrangements to 2-Benzazepines

Keith R. Motion, Ian R. Robertson, and John T. Sharp*

Department of Chemistry, University of Edinburgh, West Mains Road, Edinburgh EH9 3JJ, Scotland, U.K.

The α,β:γ,δ-unsaturated nitrile ylides (**9**), when generated by the 1,3-dehydrochlorination of the benzimidoyl chlorides (**8**) at room temperature, react by a stereospecific 1,1-cycloaddition to give the cycloprop[*c*]isoquinolines (**10**); the latter undergo two types of thermal rearrangement giving the 1*H*-2-benzazepines (**14**) when R^1 or R^2 = H, and the 5*H*-2-benzazepines (**17**) when R^1 = Ph and R^2 = Ph or Me.

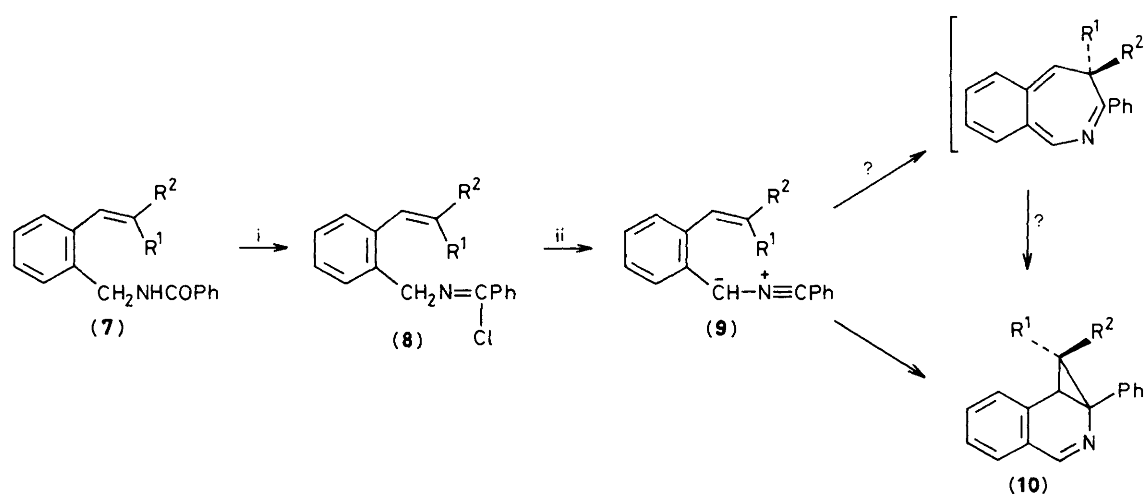
This communication is concerned with the reactions of the diene-conjugated nitrile ylides (**1a**). The objective was to compare their reactions with those of the analogous diazo-compounds (**1b**) and nitrile imines (**1c**). Recent work has shown that both (**1b**) and (**1c**) cyclise to give seven-membered heterocyclic systems, (**3**) and (**5**) respectively, but *via* reaction paths which show interesting and not fully understood differences. The diazo-compounds (**1b**; R^1 = H) apparently cyclise directly *via* 1,7-electrocyclisation to give (**2**) which rearrange to give (**3**) by [1,5] sigmatropic hydrogen shifts.[1–3] This cyclisation is however blocked when $R^1 \neq$ H; *e.g.* the diazo-compounds (**1b**; R^1 = Me or Ph, R^2 = H) react only *via* loss of nitrogen to give carbene-derived products.[3] The nitrile imines (**1c**; R^1 or R^2 = H) undergo a formally similar conversion at 80 °C to give the 1,2-benzodiazepine system (**5**), but when neither R^1 nor R^2 = H give instead the tricyclic system (**6**).[4,5] Subsequent work however has shown that at room temperature the nitrile imines give only (**6**) in a highly stereoselective reaction, irrespective of whether R^1 or R^2 = H.[6] It is not yet clear whether these cyclopropacinno-



lines (6) are formed directly in a one-step stereospecific 1,1-cycloaddition process or *via* (4) in a two-step mechanism in which the ring contraction of (4) to give (6) must be much faster than its rate of ring inversion.

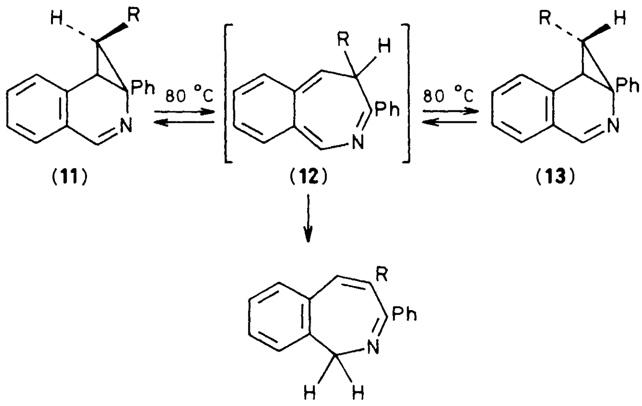
One example of the analogous nitrile ylide system (**1a**; $R^1 = R^2 = H$) has been studied by Padwa. This system was generated by the photolysis of an azirine and gave (**10**, $R^1 = R^2 = H$).[7] Since nitrile ylides generated by this method have been shown to give non-stereospecific 1,1-cycloadditions in related non-conjugated systems,[7–9] our intention was to use a non-photochemical method to generate a range of intermediates of type (**9**) to find out: (i) if this process is stereospecific like the nitrile imine cyclisation, (ii) if the reaction with the double bond is blocked when $R^1 \neq H$ as it is in the diazo-compound reaction, and (iii) if compounds of type (**10**) would undergo thermal ring expansion and so provide a synthetic route to fully unsaturated 2-benzazepine systems.

It was found that the required nitrile ylides (**9a**—**h**) could be generated by reaction of the benzimidoyl chlorides (**8**) with potassium t-butoxide at room temperature. On addition of the base an intense transient red colour was generated, and after work-up and flash chromatography the cycloprop[*c*]isoquinolines (**10**) were isolated, Scheme 1. It can be seen from these results that the reaction of the nitrile ylide with the double bond is not inhibited by the presence of R^1 groups other than hydrogen and that the 1,1-cycloaddition is stereospecific under these reaction conditions. The stereospecificity is shown clearly by the observation that the separated *E* and *Z* isomers of the amide, (**7a**) and (**7b**), gave, respectively, only the *exo* and *endo* isomers (**10a**) and (**10b**) together with some unreacted starting material. In two other cases (**7c/d**) and (**7e/f**) it was not possible to separate the *E* and *Z* isomers at any stage but it was shown by n.m.r. spectroscopy (using the nuclear Overhauser effect to identify the *E* and *Z* isomers) that the *exo/endo* ratios in (**10**) were, within experimental



	(7)		(10) (% yield)		
(**a**)	$R^1 = H, R^2 = Ph$	(**a**)	$R^1 = H, R^2 = Ph$	(85)	
(**b**)	$R^1 = Ph, R^2 = H$	(**b**)	$R^1 = Ph, R^2 = H$	(73)	
(**c**)/(**d**)	R^1, R^2 = Me and H	(**c**)	$R^1 = H, R^2 = Me$	(72)	(**d**:**c** = 69:31)
	(*Z*:*E* = 68:32)	(**d**)	$R^1 = Me, R^2 = H$		
(**e**)/(**f**)	R^1, R^2 = Me and Ph	(**e**)	$R^1 = Me, R^2 = Ph$	(56)	(**f**:**e** = 60:40)
	(*Z*:*E* = 63:37)	(**f**)	$R^1 = Ph, R^2 = Me$		
(**g**)	$R^1 = R^2 = Me$	(**g**)	$R^1 = R^2 = Me$	(79)	
(**h**)	$R^1 = R^2 = Ph$	(**h**)	$R^1 = R^2 = Ph$	(91)	

Scheme 1. *Reagents:* i, PCl_5; ii, $KOBu^t$ in tetrahydrofuran.



(11) (12) (13) (14)

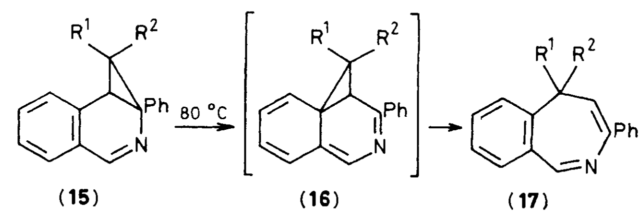
Scheme 2

	% Yield
R = Ph	70
R = Me	92

error, the same as the *E*/*Z* ratios of the amide mixtures used.† These results therefore closely parallel the reactions of the analogous nitrile imines (**1c**).

Investigation of the thermal rearrangement of the cycloprop[*c*]isoquinolines (**10**) has revealed two distinct reaction paths. In cases where either R^1 or R^2 = H heating causes the interconversion of the *endo* and *exo* isomers, (**11**) and (**13**), Scheme 2, and the eventual formation of the 1*H*-2-benzazepine system (**14**) in high yield. When neither R^1 nor R^2 was hydrogen the rearrangement was slower and followed an alternative path, Scheme 3, to give 5*H*-2-benzazepines (**17**). The structure of (**17a**) was confirmed by *X*-ray crystallography.[10]

† The *exo* and *endo* isomers of (**10**) were separated and characterised in all cases.



(15) (16) (17)

Scheme 3

		% Yield
(**a**)	R^1, R^2 = Me/Ph	51
(**b**)	$R^1 = R^2$ = Ph	74

Work on the kinetics of some of these reactions is in progress and discussion of the mechanisms of the formation and rearrangement of the cycloprop[*c*]isoquinolines (**10**) will be deferred until the full paper.

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