Generation and reaction of carbenes from α-oxacyclo-*N*-aziridinyl imines—a new method for ring expansion of cyclic ethers

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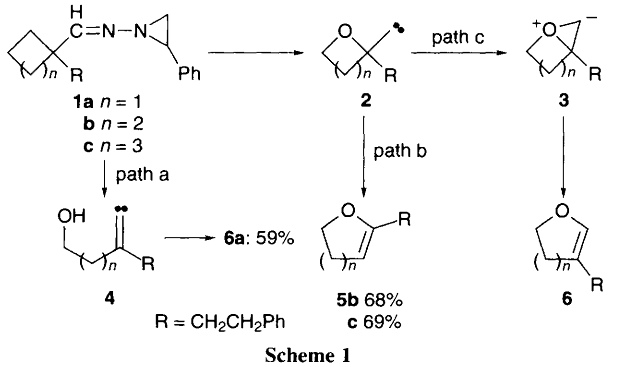
α-Oxetanyl-*N*-aziridinyl imines undergo ring expansion on heating to afford dihydrofurans *via* alkylidenecarbenes, whereas heating α-tetrahydrofuranyl and α-tetrahydropyranyl *N*-aziridinyl imines affords the ring expanded cyclic enol ethers *via* alkyl carbenes.

Since Eschenmoser reported that *N*-aziridinyl imines of α,β-epoxy ketones underwent thermal fragmentation,[1] *N*- aziridinyl imines have been utilized as precursors of both diazoalkanes[2] and carbenes.[3] In connection with our interest in the synthetic utility of *N*-aziridinyl imines,[4] we recently reported that the thermal reaction of α,β-epoxy-*N*-aziridinyl imines in refluxing toluene generates (β-hydroxyalkylidene)carbenes, which underwent 1,5-C–H insertion and 1,5-O–Si insertion to afford cyclopentenols[5] and dihydrofurans.[6] As an extension to this work, we were interested in the generation and reaction of carbenes from α-oxacyclo-*N*-aziridinyl imines.

The reaction of oxetanes with alkoxycarbonylcarbenes has been previously studied and the reaction was known to proceed *via* competitive C–H insertion and oxonium ylide formation.[7] However, with tetrahydrofuran, carbenes reacted to give only C–H insertion products.[8] We turned our attention to the question of whether (i) α-oxacyclo-*N*-aziridinyl imines would generate alkylcarbenes **2** or alkylidenecarbenes **4** (path a) and (ii) alkylcarbene intermediates would involve C–C insertion to afford **5** (path b) or oxonium ylide formation to afford **6** (path c), Scheme 1.

When the thermal reaction of **1b** was carried out in refluxing toluene for 5 h, we were somewhat surprised to find that the expected **6b** was not obtained. Compound **5b** was instead isolated in 68% yield. Apparently, the reaction did not proceed *via* the oxonium ylide **3b** or alkylidenecarbene **4b** from the structure of the product **5b**. Thus, the most reasonable explanation for the formation of **5b** would involve the direct insertion of alkylcarbene **2b** into C–C bond.[9] The same result was also obtained with α-tetrahydropyranyl-*N*-aziridinyl imine **1c**. For the thermal reaction of bicyclic ether **7**, in the carbene intermediate **8**, migration of bond *a* would be expected to afford **9**. Alternatively, migration of bond *b* is unlikely due to the formation of the bridged product **10**, eqn. (1). Thus, the thermal reaction of **7** in refluxing toluene for 7 h afforded **9** in 72% yield. Further examples are shown in Table 1.



Scheme 1

We next examined the thermal reaction of α-oxetanyl-*N*-aziridinyl imines. When the thermal reaction of **1a** was carried out in refluxing toluene for 8 h, **6a** was isolated in 59% yield, indicating that the reaction did not undergo C–C insertion *via*

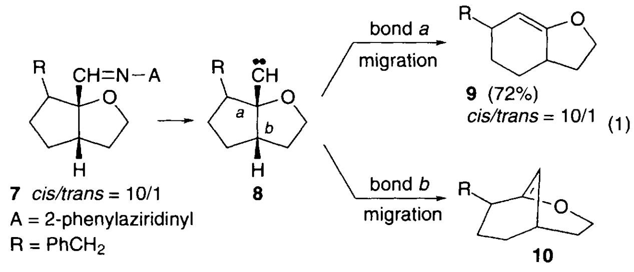
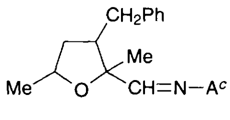
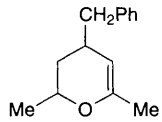
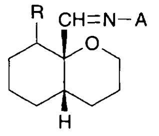
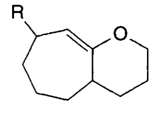
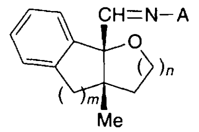
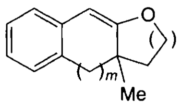
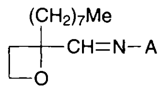
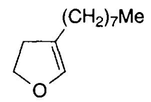
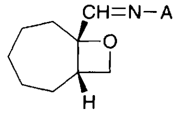
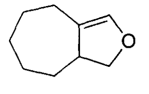
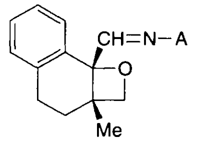
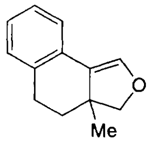


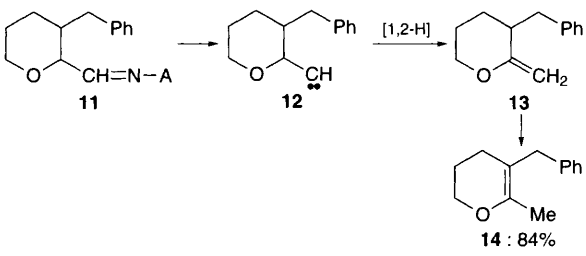
Table 1 Ring expansion of cyclic ethers

Entry	Substrate[a]	*t*/h	Product (%)[b]	
1	 CH2Ph, Me, Me, CH=N–A[c] *cis/trans* = 1/2	5	 CH2Ph, Me, Me *cis/trans* = 1/2	(60)
2	 R, CH=N–A, H *cis/trans* = 1/8 R = PhCH2	8	 R *cis/trans* = 1/8	(62)
3	 CH=N–A, Me *m* = 1, *n* = 2	5	 Me *m* = 1, *n* = 2	(85)
4	*m* = 2, *n* = 1	5	*m* = 2, *n* = 1	(91)
5	 (CH2)7Me, CH=N–A		 (CH2)7Me	(59)
6	 CH=N–A, H	8		(58)
7	 CH=N–A, Me	5	 Me	(69)

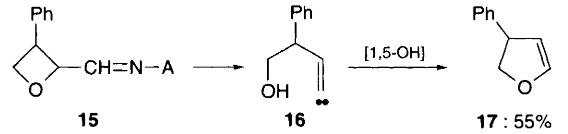
[a] All substrates are a mixture of *syn*- and *anti*- isomers. [b] The yield refers to the isolated yield. [c] A = 2-phenylaziridinyl.

alkylcarbene **2a**. Since the thermal reaction of **1b** and **1c** did not involve the formation of oxonium ylides **3b** and **3c**, the reaction seems to proceed *via* alkylidenecarbene **4a**, indicating the dependence of the mode of the reaction on the ring size of cyclic ethers. Our previous results on the thermal reaction of α,β-epoxy-*N*-aziridinyl imines also support the intermediacy of **4a**.[5] For most of the cases observed, the reaction was complete within 8 h in refluxing toluene affording dihydrofurans as shown in Table 1. The reaction was also successful with bicyclic oxetanes.

To study the relative ease of the two processes, 1,2-H migration and direct ring expansion into the C–C bond in alkylcarbenes, we examined the thermal reaction of **11**, eqn. (2). The thermal reaction of **11** in refluxing toluene for 8 h gave only pyran **14** in 84% yield as a result of selective 1,2-H migration in the alkyl carbene **12** and the following isomerization of the double bond. However, it is noteworthy that the 1,5-OH insertion in alkylidenecarbenes proceeded exclusively without 1,2-H migration. Thus, the thermal reaction of **15** in refluxing toluene for 8 h afforded **17** in 55% yield, eqn. (3).



(2)



(3)

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