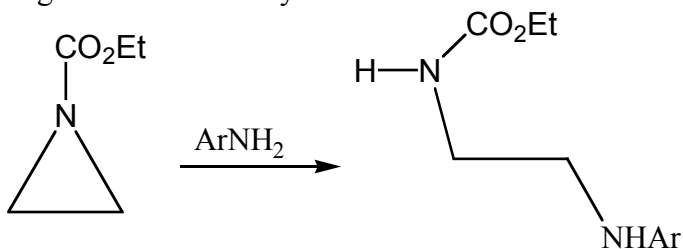


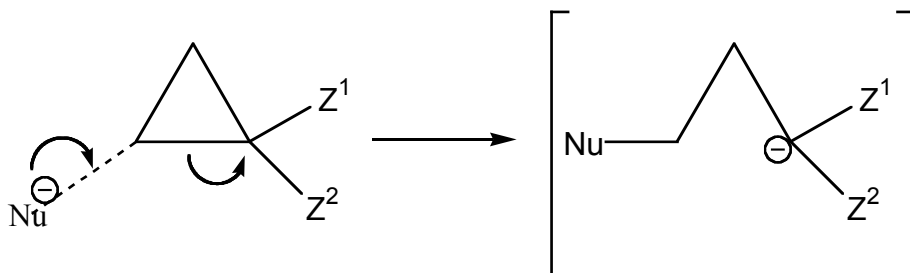
Alicyclic and Heterocyclic Chemistry. Lecture 7

Nucleophilic Ring Opening, contd.

Aziridines: They are much less reactive than the corresponding oxiranes and, indeed, those aziridines which do undergo direct nucleophilic attack bear strongly electron withdrawing groups (RCO, RSO₂, CN, Ar etc) on the nitrogen probably because the intermediate nitrogen anion is thereby stabilized.



Cyclopropanes: Cyclopropanes only suffer nucleophilic attack if there are TWO electron-withdrawing substituents on the SAME carbon in the ring which stabilize the resultant carbanion:

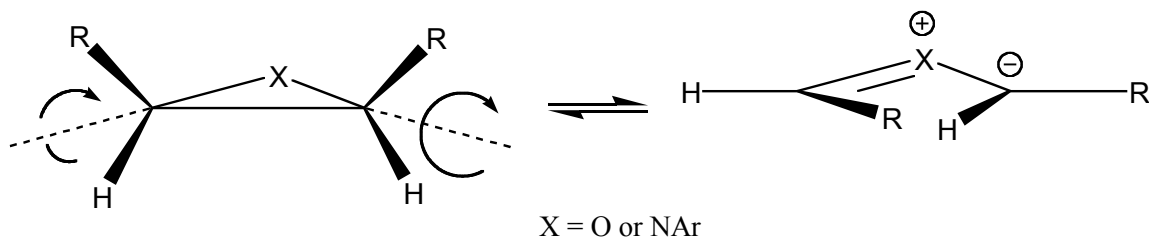


Z¹, Z² = any combination of COR, CO₂R, CN, NO₂, P⁺Ph₃, SO₂R etc

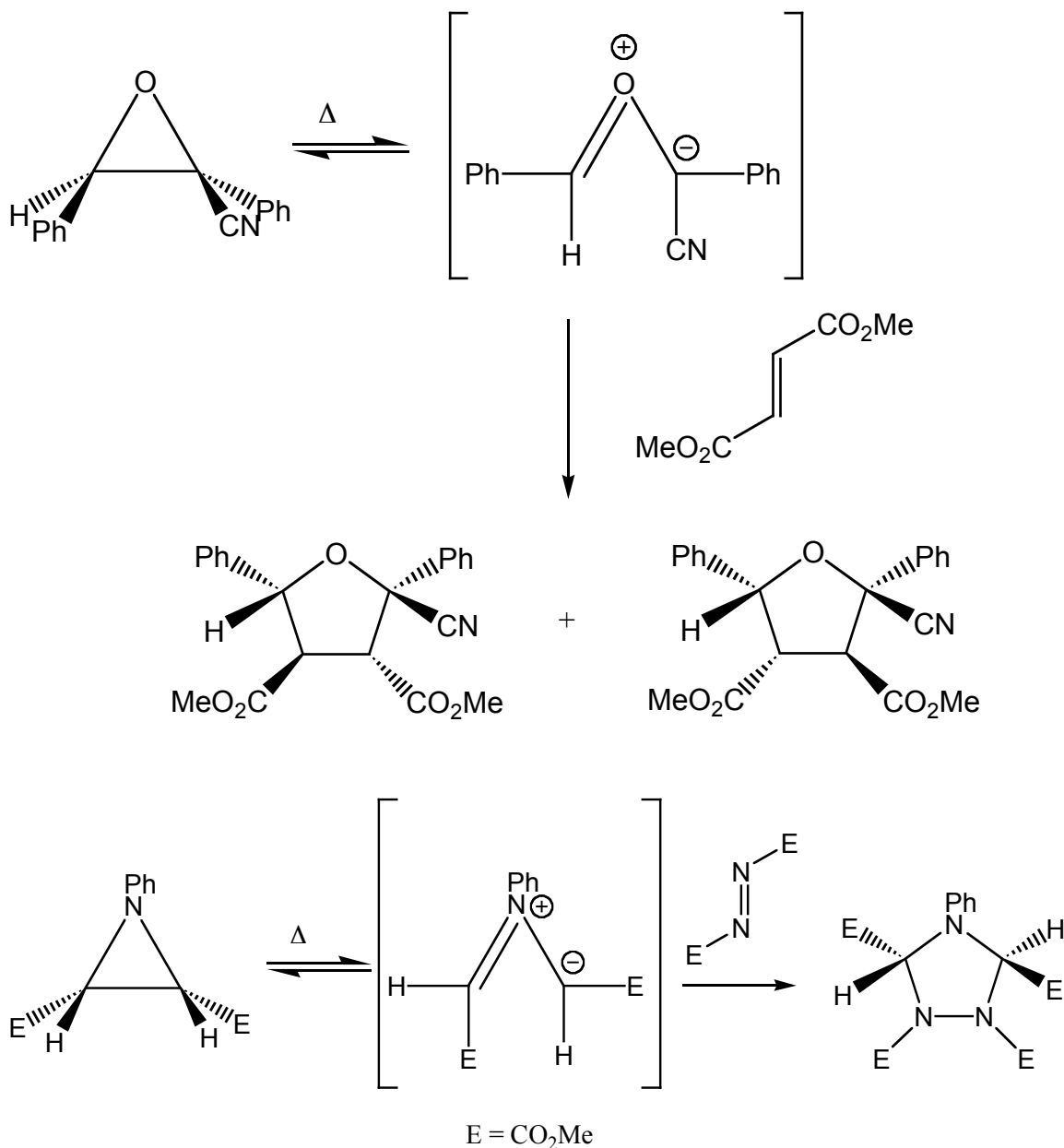
The reaction is analogous to the Michael addition of alkenes and again reflects the π-like character of the ring bonds.

Electrocyclic Ring Opening

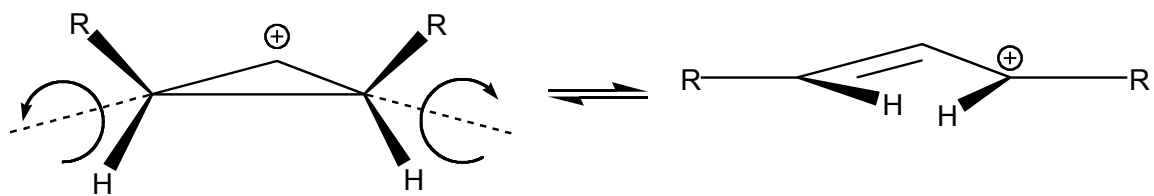
Both oxiranes and N-aryl-aziridines undergo a stereospecific, electrocyclic ring opening on heating. There are four electrons (one lone pair and one σ-pair) involved in the process so the movement of the substituents is conrotatory:



The intermediate carbonyl ylides (from epoxides) or azomethine ylides (from aziridines) may be trapped suprafacially in a 1,3-dipolar sense by double bonds:

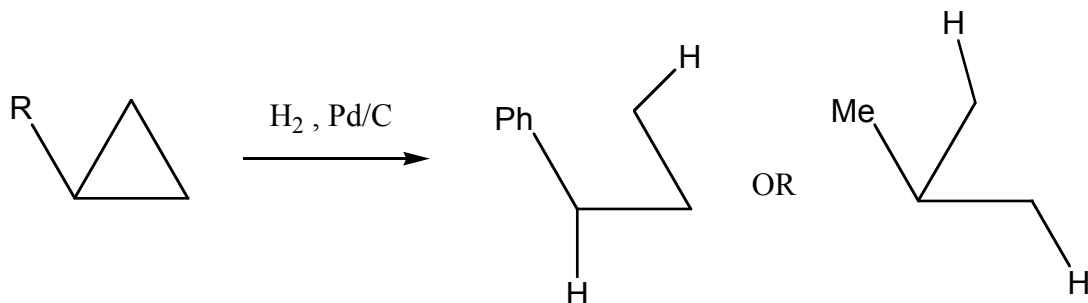


A very similar thing happens if we try to make the cyclopropyl cation but here the electrocycloisation involves only two σ -electrons and so proceeds in a disrotatory manner to give an allyl cation:



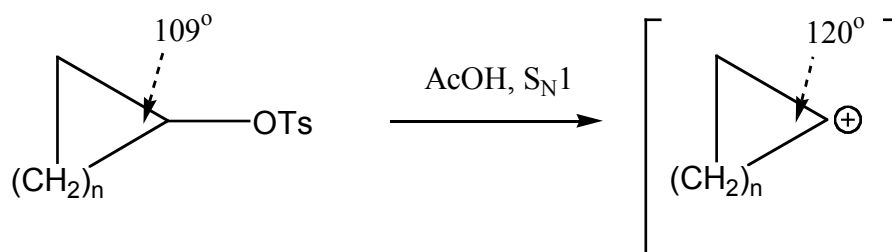
Catalytic Hydrogenation of Cyclopropanes

Cyclopropanes may be hydrogenated under catalytic conditions just like alkenes. The nature of the product depends upon the substituents, with aryl groups favouring cleavage of the adjacent (benzylic) bond and alkyl groups favouring the opposing (less hindered) one:



Consequences of Reactions in which increasing Angle Strain occurs

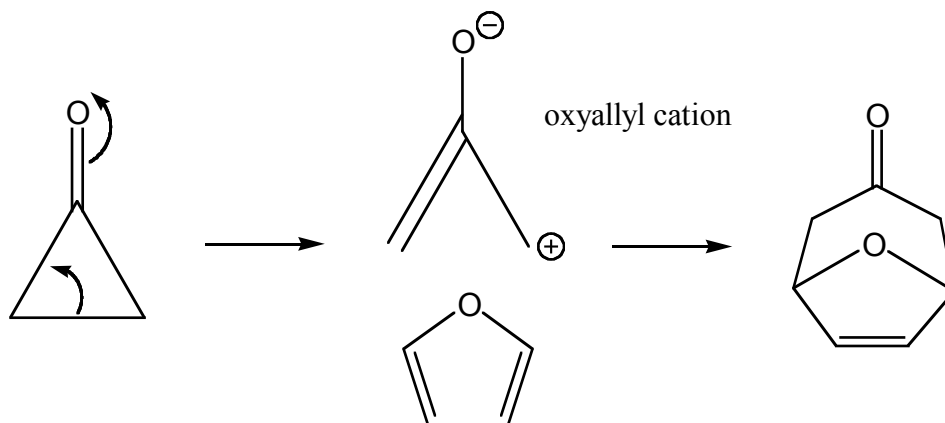
a) Formation of the Cyclopropyl Cation: Any reaction or process which converts one of the carbons in a cyclopropane ring from sp^3 to sp^2 hybridisation will obviously be resisted since sp^2 hybridised carbons have bond angles of 120° and hence an increase in angle strain will result from such a process. For this reason the formation of the cyclopropyl cation is a slow process compared to that for cyclohexyl cation in which angle strain is not significant:



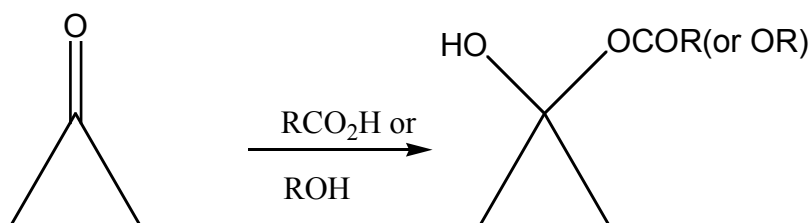
n	relative rate
4 (cyclohexyl)	1
1 (cyclopropyl)	2×10^{-5}

Thus we see that the cyclopropyl cation is unique in two regards, it is formed very slowly and, once formed, it undergoes electrocyclic ring opening to the allyl cation.

b) Cyclopropanones: Cyclopropanones, which cannot avoid having an sp^2 hybridised carbon in the ring, are very reactive. If they are prepared in the absence of a hydroxylic solvent they undergo an electrocyclic ring opening exactly analogous to that of the cyclopropyl cation. The resultant zwitterion can be trapped by dienes:

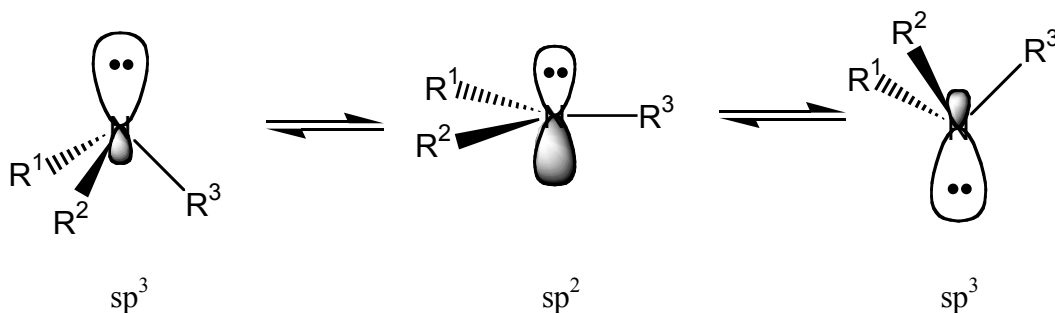


In the presence of hydroxylic solvents cyclopropanones form hemiketals thereby removing the sp^2 centre:

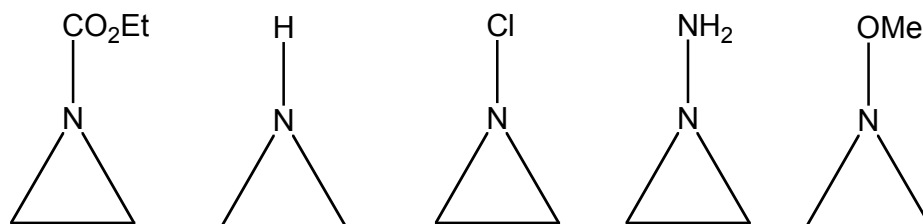


In contrast, for simple ketones this addition is an equilibrium lying well on the side of the ketone. Again, therefore, we see the occurrence of abnormal reactivity brought about by ring strain.

c) Nitrogen Inversion in Aziridines: The process of nitrogen inversion in amines involves an intermediate in which there has been a change of hybridization at the nitrogen atom:

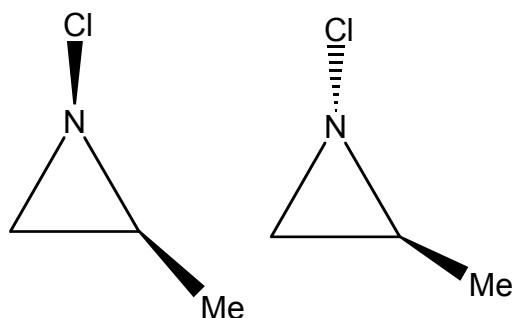


For simple amines this process is very rapid ($\Delta G^\ddagger \sim 25$ kJ/mol) but in aziridines the activation energy for inversion depends upon the nature of the substituent on nitrogen. For substituents which can conjugate with the lone pair the rate is still high but for other groups the inversion is substantially slower because of the increased angle strain in the sp^2 hybridised intermediate:



ΔG^\ddagger (kJ/mol):	30	72	88	92	92
Temp. ($^\circ\text{C}$)	-138	68	120	150	150

Indeed the chloro- and alkoxy-aziridines isomers (so-called invertomers) can be isolated separately, for example the following chloro compounds were separated by glc (at 25°C) and their individual ^1H NMR spectra recorded:



Thus, again, the effect of extra ring strain provides us with unusual behaviour.