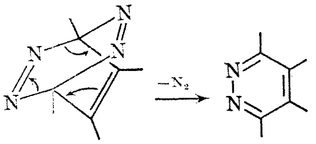
Thermal Elimination Reactions of Nitrogen and Sulphur Heterocycles

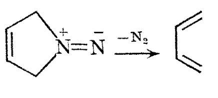
By R. GRIGG,* R. HAYES, and J. L. JACKSON
(*University of Nottingham, Nottingham* NG7 2RD)

Summary Eliminations of hydrogen cyanide and nitriles in retro-diene and retro-homocycloadditions are reported and attention drawn to combined electrocyclic–cheletropic processes occurring in nitrogen- and sulphur-containing heterocycles.

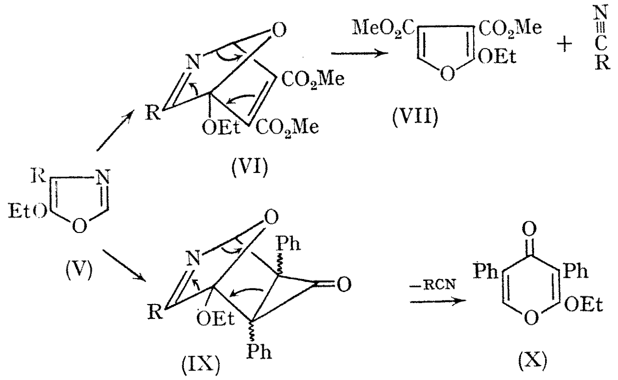
THERMAL elimination reactions in heterocyclic compounds involving loss of inorganic molecules such as nitrogen, carbon dioxide, carbon monoxide, sulphur, "sulphur monoxide", and sulphur dioxide are well known.[1] These reactions may be concerted or may involve stepwise elimination of the inorganic fragment. The reactions considered here are the concerted eliminations in which orbital symmetry requirements[2] control the stereochemistry of the processes. These reactions are classified as retro-cycloadditions, [*e.g.* the retro-diene reaction, (I) → (II)],[3] in which the two σ-bonds broken in the reaction are attached to different atoms of the eliminated fragment or cheletropic processes[4] [*e.g.* (III) → (IV)][5] in which the two σ-bonds are attached to the same atom.



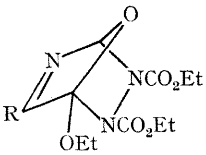
(I) (II)



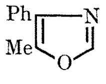
(III) (IV)



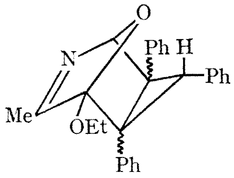
(V) (VI) (VII) (IX) (X)



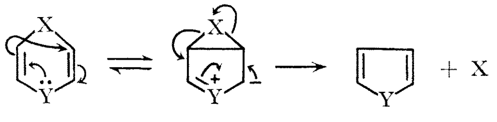
(XI)



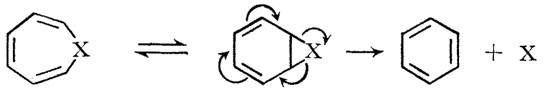
(VIII)



(XII)



(XIII) (XIV)



(XV)

We now report what appear to be the first examples of elimination of hydrogen cyanide and nitriles in retro-cycloaddition reactions. The reaction of the oxazoles (V; R = H or Me) with dimethyl acetylenedicarboxylate in cold ether led directly to the furan (VII), 51—53%, and the appropriate nitrile. The adduct (VI) could not be isolated; adducts from ethylenic dienophiles have, however, been isolated.[6] The less reactive oxazole (VIII) reacted with the acetylenic ester in boiling toluene to give the expected furan (69%) and benzonitrile. A similar elimination of nitrile but involving a retro-homo-cycloaddition reaction occurred when the oxazoles (V; R = H or Me) were heated in boiling toluene with diphenylcyclopropenone. Once again the intermediate adduct (IX) could not be isolated but instead the pyrone (X) and appropriate nitrile were obtained directly. Stable adducts (XI; R = H or Me) were isolated from the oxazoles (V; R = H or Me) and diethyl azodicarboxylate in good yield (65—66%) whereas only (V;

R = Me) gave an adduct (XII), 60—63% with triphenylcyclopropene.

Recent publications[7] have provided evidence for a preferred geometry in the retro-homo-Diels–Alder reaction in which the cyclopropane ring and the departing molecule are *trans* so that in the transition state there is maximum orbital overlap of the bonds undergoing fission. In our examples the *endo*-isomer[8] would have the cyclopropanone ring and the departing fragment *cis*, whereas the *exo*-isomer has the more favourable geometry for the retro-homo-Diels–Alder reaction. Whether the transient nature of the intermediate (IX) is due to formation of the *exo*-adduct or whether the presence of the more strained cyclopropanone ring accelerates fragmentation of the *endo*-isomer is not known. However, pyrolysis of the adduct (XII) affords the oxazole (V; R = Me) and not acetonitrile. The stereochemistry of (XII) is being studied.

We have recently reported[9] a reaction in which we suggested a $(4n + 2)$ electrocyclic process was followed by a cheletropic loss of sulphur. This combination of a thermal electrocyclic process followed by a cheletropic loss of an inorganic fragment is one which occurs widely in heterocyclic chemistry but has been hitherto unrecognised except perhaps in the thiepin case. We wish to draw attention to the operation of these processes in 6π-electron systems. The general scheme (XIII) → (XIV) and (XV) → (XVI) for thermal, as opposed to photochemical, processes requires a $(4n + 2)$ disrotatory electrocyclic process leading to a *cis*-fused three-membered ring since a $4n$ controtatory closure would generate a *trans*-fused three-membered ring. Consideration of orbital symmetry requirements provides a rationale for the mechanism of extrusion of sulphur from dithiins (XIII; X = Y = S) suggested by Parham and Traynelis[10] and the carbanion analogue of this extrusion occurs in the transformation of thiadiazines into pyrazoles.[11] The operation of these processes in seven-membered rings (XVI) → (XVII) provides a orbital symmetry allowed pathway for the loss of sulphur from benzothiepins[12a] and dibenzothiazepines[13] and sulphur dioxide from benzothiepin dioxide.[12b] The extrusion of species other than sulphur and its oxides and the replacement of sp^2 carbon by nitrogen is largely unexplored although a combined electrocyclic-cheletropic process involving extrusion of carbon monoxide from a diazatropone has recently been suggested.[14]

(*Received, August* 12*th*, 1969; *Com.* 1241.)

---

[1] B. P. Stark and A. J. Duke, "Extrusion Reactions," Pergamon, Oxford, 1967.

[2] R. Hoffmann and R. B. Woodward, *Accounts Chem. Res.*, 1968, **1**, 17.

[3] R. A. Carboni and R. V. Lindsey, *J. Amer. Chem. Soc.*, 1959, **81**, 4342.

[4] R. B. Woodward, Symposium on Orbital Symmetry Correlations in Organic Chemistry, Cambridge, 1969.

[5] D. M. Lemal and S. D. McGregor, *J. Amer. Chem. Soc.*, 1966, **88**, 1335.

[6] T. Naito, K. Ueno, M. Sano, Y. Omura, I. Itoh, and F. Ishikawa, *Tetrahedron Letters*, 1968, 5767.

[7] B. Halton, M. A. Battiste, R. Rehberg, C. L. Deyrup, and M. E. Brennan, *J. Amer. Chem. Soc.*, 1967, **89**, 5964; J. A. Berson and S. S. Olin, *J. Amer. Chem. Soc.*, 1969, **91**, 777.

[8] K. Alder and G. Stein, *Angew. Chem.*, 1937, **50**, 510; R. Hoffmann and R. B. Woodward, *J. Amer. Chem. Soc.*, 1965, **87**, 4388.

[9] M. J. Broadhurst, R. Grigg, and A. W. Johnson, *Chem. Comm.*, 1969, 23.

[10] W. E. Parham and V. J. Traynelis, *J. Amer. Chem. Soc.*, 1954, **76**, 4960.

[11] H. Beyer, E. Bulka, and F.-W. Beckhaus, *Chem. Ber.*, 1959, **92**, 2593.

[12] (a) W. E. Parham and D. G. Weetman, *J. Org. Chem.*, 1969, **34**, 56; (b) W. E. Truce and F. J. Lotspeich, *J. Amer. Chem. Soc.*, 1956, **78**, 848.

[13] R. H. B. Galt, J. D. Loudon, and A. D. B. Sloan, *J. Chem. Soc.*, 1958, 1588.

[14] C. W. Rees and M. Yelland, *Chem. Comm.*, 1969, 377.