Tetrahedron Letters No. 51, pp 4753-4756, 1976. Pergamon Press. Printed in Great Britian.

THERMAL REACTIONS OF 1,2,4-TRIAZEPINES

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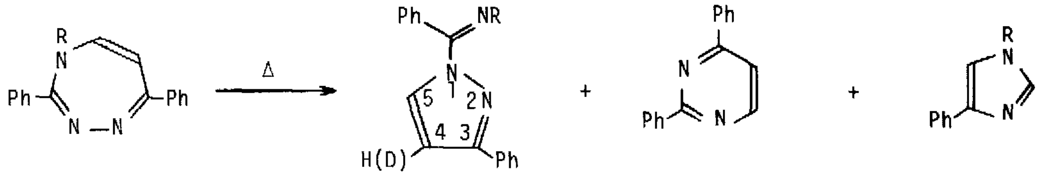
(Received in Japan 14 October 1976; received in UK for publication 2 November 1976)

In spite of recent advance in the thermal rearrangements of heteropines such as oxepins,[1] azepines,[1] oxazepines,[2] and diazepines,[3] little is known on the thermal behaviours of triazepines.[4] We have recently reported a new photochemical method for the preparation of hitherto unknown 4-alkyl-1,2,4(4 H)-triazepine system.[5] We now wish to report the thermally induced ring contraction of the 1,2,4-triazepines.

When a dry diglyme solution of 4-benzyl-3,7-diphenyl-1,2,4(4 H)-triazepine (Ia)[5] was heated under reflux for 3 hr, three major products IIa, III, and IVa were isolated in yields as shown in Table 1 together with minor amounts of products including benzonitrile. 2,4-Diphenylpyrimidine (III)[6] and 1-benzyl-4-phenylimidazole (IVa)[7] were identical with authentic samples, and the structure of IIa was assigned on the basis of spectral data (Table 2) and by converting it to 3-phenylpyrazole V[8] and N-benzylbenzamide with aqueous HCl. Thermal decomposition of Ia in dry xylene gave essentially the same result. However, when the thermal reaction was carried out in wet solvents, the yield of II increased significantly. Thus, thermolysis of Ia in diglyme containing D_2O gave IIa as a major product along with minor amounts of III and IVa (Table 1). Deuterium (0.44 D) from D_2O was incorporated exclusively into the 4-position of IIa during the reaction.[9] Analogous results were obtained in the thermolysis of Ib, where the formation of III was not observed (Table 1).



Ia, $R=CH_2Ph$
b, $R=C_6H_{11}$

IIa, b

III

IVa, b

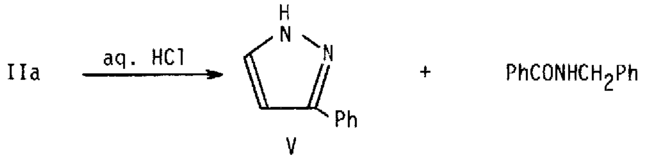


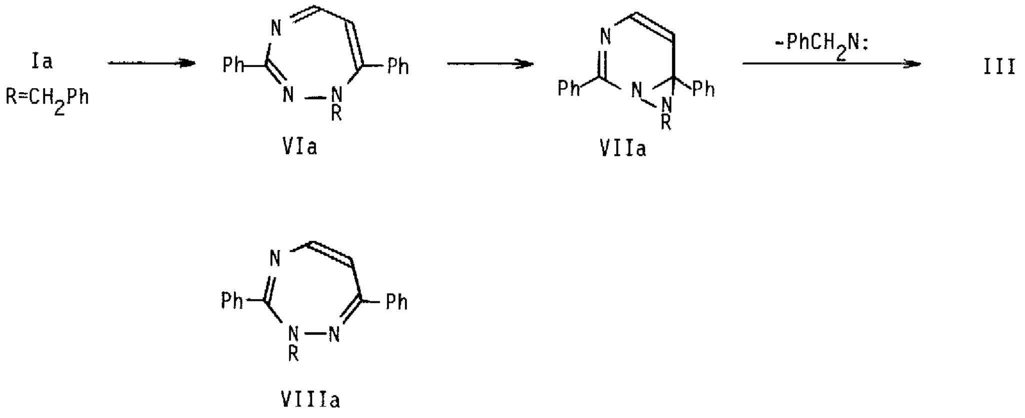
Table 1. Product Distributions (%) from the Thermolysis of I

	Solvent	Products (Isolated Yield)		
		II	III	IV
Ia	Diglyme	4	64	8
Ia	Diglyme + D_2O	42(0.44 D)	14	6
Ib	Diglyme	15	--	28[a]
Ib	Diglyme + D_2O	71(0.45 D)	--	9

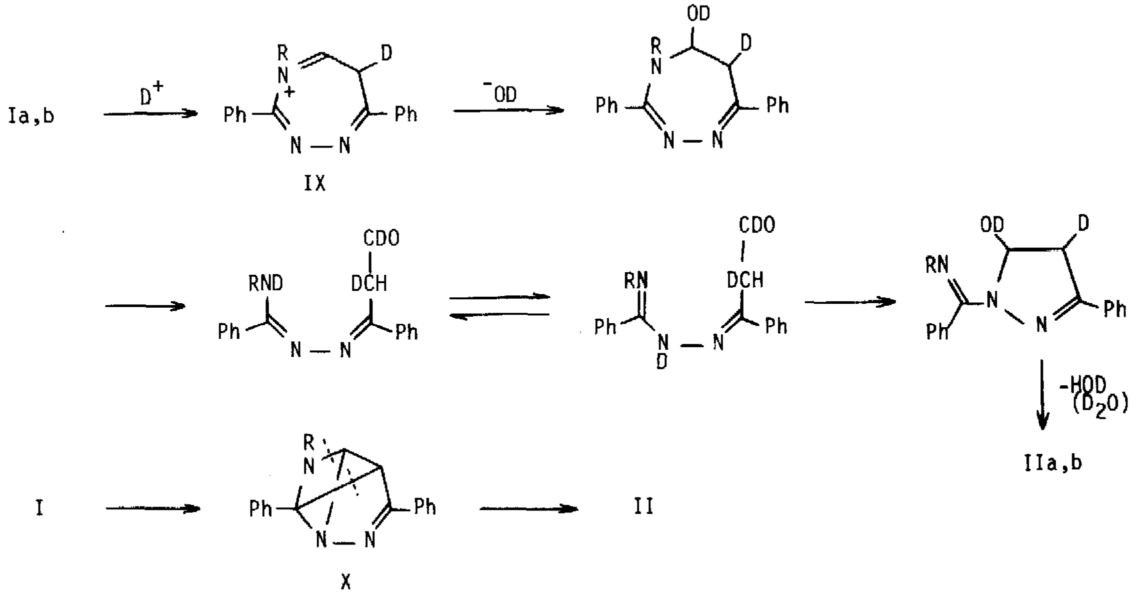
[a] Unreacted Ib was recovered in 27% yield.

The formation of the pyrimidine III can be rationalyzed in terms of a thermally allowed [1,5] benzyl shift of Ia to give VIa.[10] Thermal decomposition of VIa may lead to III <u>via</u> an equilibration to triazanorcaradiene VIIa followed by loss of :NCH_2Ph (Scheme 1). Analogous thermal reactions have been reported with 2H-1,2,4-triazepines.[4b] The rearrangement of I into II apparently involves the addition of water to I, being deferent from the usual ring contraction of heteropines to five-membered ring compounds, where valence bond isomerization and/or [1,3] shift of the hetero group are commonly involved.[1,2b,3d,4] The experimental result using D_2O is compatible with the mechanism shown in Scheme 2, eliminating an alternative mechanism involving a cross-linked intermediate X[4c]. The first step involves a protonation at the 6-position of I giving IX.[12]

Scheme 1



Scheme 2



The formation of IV and benzonitrile is not so straightforward, but may be accounted for as being derived from the bicyclic isomer XI. The triazepine I undergoes a thermal valence isomerization to give triazanorcaradiene XII, which is, in tern, converted to XIII by walk rearrangement.[13] Thermal decomposition of XIII to give IV and benzonitrile <u>via</u> XI are well established.[4a,5,15] Note that photolysis of XIII and I gives I and XIV, respectively (Scheme 3).[5]

Scheme 3

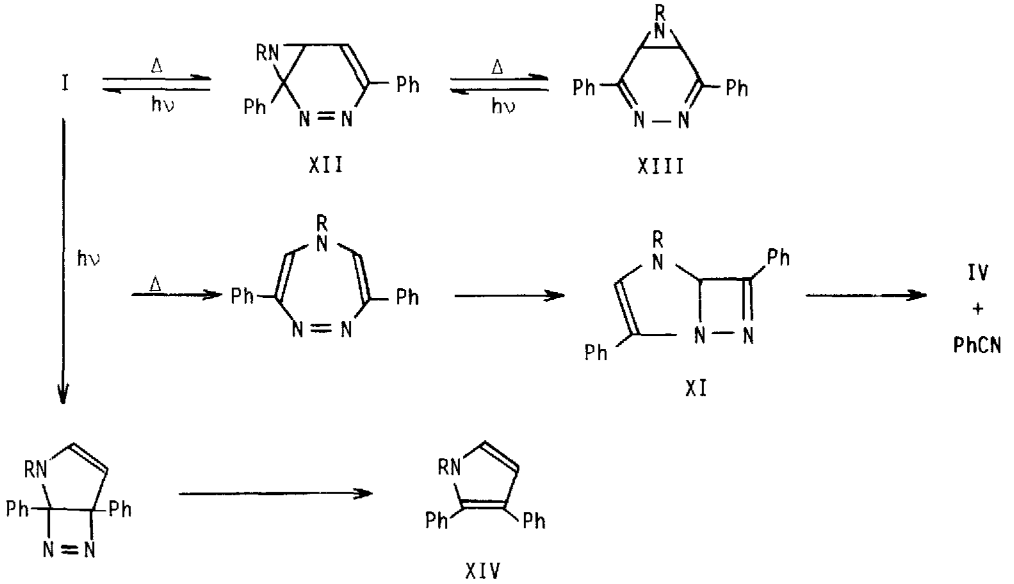


Table 2. Spectral Data[a]

	^{1}H-nmr ($CDCl_3$) δ (ppm)	λ_{max}^{EtOH} (nm)(ε)	mass spectrum
IIa, mp 89°	4.62 (s, 2 H); 6.67 (d, 1 H, J=2.6 Hz); 7.20-7.75 (m, 15 H); 8.31 (d, 1 H, J=2.6 Hz)	292 (11000) 281 (15000) 275 (16500)	337 (M^+) 232 211 193
IIb, mp 119°	1.0-2.0 (br, 10 H); 3.1-3.4 (m, 1 H) 6.68 (d, 1 H, J=2.5 Hz); 7.20-7.85 (m, 10 H); 8.27 (d, 1 H, J=2.5 Hz)	292 (7500) 280 (13500) 275 (15000)	329 (M^+) 233 186
IVb, mp 98°	1.0-2.3 (br. 10 H), 3.6-4.1 (m, 1 H), 7.1-7.4 (m, 5 H), 7.52 (d, 1 H, J=1.0 Hz) 7.60-7.85 (m, 2 H)	255 (21000)	226 (M^+)

[a] Satisfactory elemental analyses were obtained for the compounds.

REFERENCES AND NOTES

(1) L. A. Paquette, "Nonbenzenoid Aromatics", vol. I, J. P. Sydner Ed., Academic Press, New York, N. Y., 1969, p. 250.
(2) (a) G. G. Spence, E. C. Taylor, and O. Buchardt, Chem. Rev., **70**, 231 (1970).
(b) T. Tezuka, O. Seshimoto, and T. Mukai, Tetrahedron Lett., 1067 (1975).
(3) (a) N. Nastasi and J. Streith, Bull. Soc. Chim. Fr., 635 (1973). (b) T. Sasaki, K. Kanematsu, A. Kakehi, I. Ichikawa, and K. Hayakawa, J. Org. Chem., **35**, 426 (1970). (c) G. Kiel, J. Streith, and G. Taurand, Tetrahedron, **30**, 2851 (1974), and references therein. (d) C. D. Anderson, J. T. Scharp, E. Stefaniuk, and R. S. Strathdee, Tetrahedron Lett., 305 (1976).
(4) (a) G. C. Johnson and R. H. Levin, Tetrahedron Lett., 2303 (1974); (b) D. J. Anderson and A. Hassner, Chem. Commun., 45, (1974); (c) V. Nail, J. Heterocycl. Chem., 183 (1975).
(5) I. Saito, A. Yazaki, and T. Matsuura, Tetrahedron Lett., 2459 (1976).
(6) R. M. Wagner and C. Jutz, Chem. Ber., **104** 2975 (1971).
(7) H. W. Heine and J. Irving, Tetrahedron Lett., 4767 (1967).
(8) A. Dornow and W. Bartsch, Liebigs Ann. Chem., **602**, 23 (1957).
(9) The 4-proton of IIa is found at δ 6.67 whereas the 5-proton was considerably deshielded (δ 8.31). The content of deuterium in II was analyzed by mass spectrometry.
(10) An alternative pathway involving VIII$_a$ formed by [1,3] benzyl shift from Ia is also possible, since thermally induced [1,3] benzyl shift in directions (N→C and C→N) with inversion of configration is well established.[11] The observation that III was not formed from Ib may be attributable to inability of migration of the cyclohexyl group.
(11) J. W. Lown, M. Humayoun Akhtar, and W. M. Dadson, J. Org. Chem., **40**, 3363 (1975), and references therein.
(12) D. J. Harris, M. T. Thomas, V. Sniekus, and E. Klingsberg, Can. J. Chem., **52**, 2805 (1974).
(13) Analogy for this process is found in the thermal rearrangement of 4,4-dimethyl-3,7-diphenyl-1,2-diazepine to 7,7-dimethyl-2,5-diphenyl-3,4-diazanorcaradiene.[14]
(14) H. E. Zimmerman and W. Eberbach, J. Am. Chem. Soc., **95**, 3970 (1973).
(15) A. B. Turner, H. W. Heine, J. Irving, and J. B. Bush, Jr., J. Am. Chem. Soc., **87**, 1050 (1965).