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THERMAL REARRANGEMENT OF 2-PHENYL-1,3-OXAZEPINE INTO N-FORMYL-2-PHENYLPYRROLE[1]

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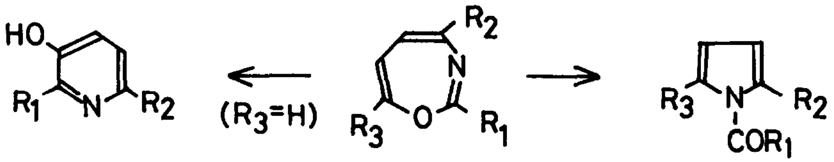
1,3-Oxazepines have been known to rearrange thermally to 3-hydroxypyridine or pyrrole derivatives, in which the order of the C_2-C_7 framework in the 1,3-oxazepine system does not alter as schematically shown below.[2,3] We wish to report a new deep seated thermal rearrangement of 2-phenyl-1,3-oxazepine (I)[4] leading to N-formyl-2-phenylpyrrole (II). The rearrangement is of significance, since a transposition of the C_2-C_7 of I is involved. To our knowledge, this is the first example of the thermally induced transposition reaction of heteropines, while the transposition of five membered heterocycles has been well known.[5]



When a dry benzene solution of I was pyrolyzed by passing it through a quartz column containing Pyrex helices at 450° and 550°C, several phenylpyrrole derivatives II-VI were formed in addition to the hydroxypyridine derivative (VII)[3] in yields as presented in Table 1. The phenylpyrrole derivatives II, III, and VI were identified by comparison with authentic samples,[6] and the structures IV and V[7] were assigned on the basis of the following facts. IV: mp 137°; ν_{co} 1642 cm^{-1}; δ(in C_6D_6) 6.96 (1H; q., J=1.5 Hz, J=3.0 Hz), 7.32 (1H; q.), 7.06~7.63 (5H; Ph), 9.81 (1H; s., $C\underline{H}O$), 11.00 (1H; br., $N\underline{H}$). V: mp 176°; ν_{co} 1640 cm^{-1}; δ(in acetone-d_6) 6.65 (1H; t., J=3.0 Hz), 6.92 (1H; t., J=3.0 Hz), 7 35~7.70

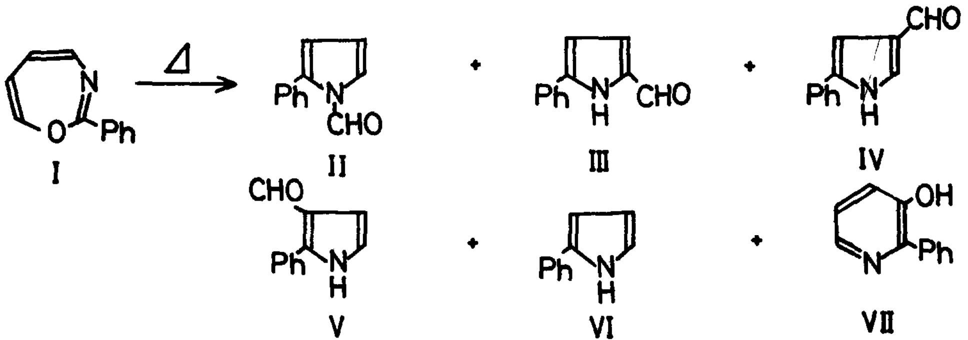


Table 1.

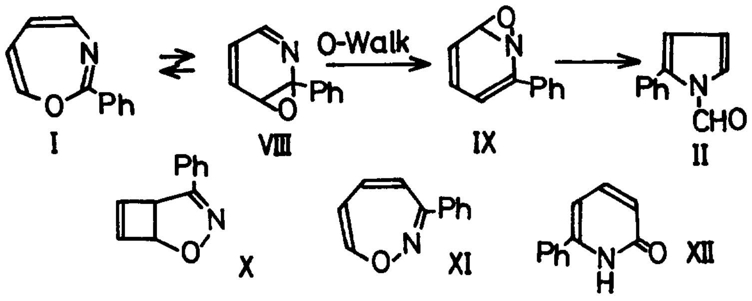
Temp.	Reactants	Products (isolated yields in %)						
		II	III	IV	V	VI	VII	XII
450°C	I	14	11	11	5	29	23	0
	X	14	13	16	3	32	0	7
	XV	23	30	11	4	17	0	0
550°C	I	0	6	4	1	34	16	0
	X	0	11	3	2	50	0	7

(5H; Ph), 9.86 (1H; d., J=0.7 Hz), 11.00 (1H; br., $W_{1/2} \approx 3$ Hz, N$\underline{H}$). The position of the phenyl group in V was confirmed by the fact that V was derived from II by pyrolysis as well as by photolysis.

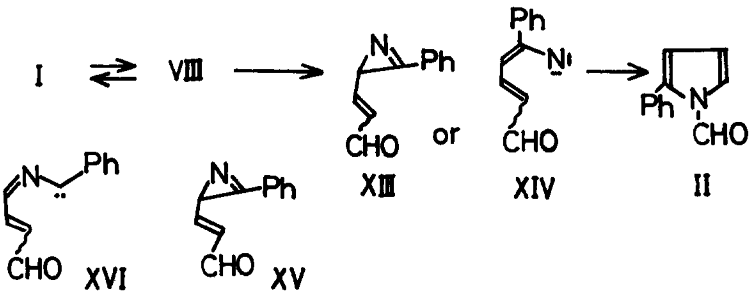
The N-formylpyrrole II was converted to III-VI in 17, 16, 5, and 36% yields respectively when pyrolyzed at 450°C,[6] indicating that the primary products of the pyrolysis of I were II and VII. The formation of III-V from II may be in analogy to that of acylpyrroles from a N-acylpyrrole by thermal and photochemical reactions.[8] Though the formation of VII is readily accounted for as being derived from norcaradiene isomer (VIII),[3] the mechanistic interpretation for the formation of II from I is not so straightforward. There may be two pathways A and B to derive II from I.

The path A is based on consecutive oxygen migration. The norcaradiene isomer VIII is converted to oxide (IX), a norcaradiene valence isomer of 1,2-oxazepine (XI), by successive oxygen migrations, which then rearranges to II.

Path A



Path B



The rearrangement of IX to II has been reported.[2,6] It has also been reported that IX rearranges to the pyridone XII at the same time.[6] In fact, the reinvestigation of the pyrolysis of X, a precursor of IX or XI under the pyrolytic conditions,[6] revealed that XII was formed (from IX) in 7% yield together with II (Table 1). Therefore, it is expected that the pyridone XII would be formed from I in addition to the pyrroles, if the oxide IX is an intermediate of the rearrangement of I to II (path A). Careful examination of the reaction mixtures demonstrated that the pyridone XII was not formed from I (Table 1). Therefore, we suppose the path A not to be the case. In addition, it is not conceivable that the oxygen migrates successively over such a wide range of a molecule as shown in VIII to IX by the thermal reactions.[2,9]

In contrast to the path A, the path B assumes azirine (XIII)[10] as a key intermediate of the rearrangement, from which II is derived probably through nitrene intermediate (XIV). One of the key steps of this mechanistic pathway is whether or not the azirine XIII is transformed to II. Padwa et al. have recently reported that azirine (XV) affords III when heated at 150°C.[11] In order to clearify this point, the azirine XV was prepared, and the pyrolysis was undertaken. When XV was pyrolyzed at 450°C, the N-formylpyrrole II was formed in addition to III-VI in yields as presented in Table 1. This fact implies that XIII formed from I may readily be transformed to II under the pyrolytic conditions employed. Therefore, it seems that there is no doubt about the last step (from XIII to II) of the path B.

However, there is still some difficulty in the path B, as to how the azirine XIII is derived from I. We consider, though it is tentative, that XIII arises from carbene (XVI) which is derived from VIII by the double cleavage of the C_1-C_6 and C_1-O bonds. The formation of XIII from XVI, and XVI from VIII may be in analogy to that of an azirine from iminocarbene,[12] and carbenes from oxiranes[13] respectively. All the evidence provided by this study seems to support the path B, but details of the mechanism must be awaited for further studies being in progress.

REFERENCES AND NOTES

1. Organic Thermal Reaction XXX.
2. G.G. Spence, E.C. Taylor, and O. Buchardt, Chem. Rev., 70, 231 (1970); C. Kaneko and S. Yamada, Rept. Res. Inst. Dental Mat. Tokyo Medico Dental Univ., 2, 804 (1966).
3. T. Tezuka, O. Seshimoto, and T. Mukai, J.C.S. Chem. Commun., 373 (1974).
4. T. Mukai and H. Sukawa, Tetrahedron Lett., 1835 (1973).
5. E.F. Ullman, Accounts Chem. Research, 1, 353 (1968).
6. H. Sukawa, O. Seshimoto, T. Tezuka, and T. Mukai, J.C.S. Chem. Commun., 696 (1974).
7 The authours thank Professor J. Streith for donation of 2-formyl-3-phenylpyrrole as well as for helpful discussions of the reactions, and also thank Professor A. Padwa for the identification of V.[11]
8. J.M. Patterson and D.M. Bruser, Tetrahedron Lett., 2959 (1973).
9. D M. Jerina, H. Yagi, and J.W Daly, Heterocycles, 1, 267 (1973); C. Kaneko, S Yamada and M. Ishikawa, Tetrahedron Lett., 2329 (1970).
10 The stereochemistry of the aldehyde group in XIII can not be defined; XIII may be a mixture of stereoisomers of cis-and trans- (XV) aldehydes.
11 A. Padwa, J. Smolanoff, and A. Tremper, Tetrahedron Lett., 29 (1974).
12. L.A. Wendling and R.G. Bergman, J. Amer. Chem. Soc., 96, 308 (1974).
13. W J. Lin, ibid., 87, 3665 (1965).