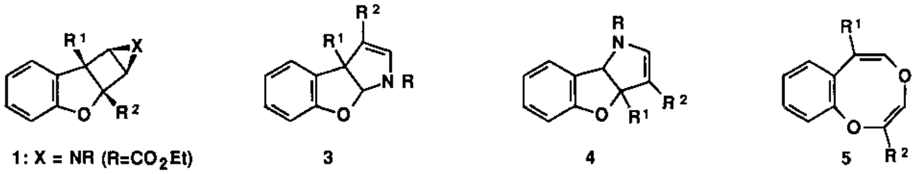
THERMOLYSIS OF 8-AZA- AND 8-OXABENZO[C]TRICYCLO[5.1.0.0^{2,6}]OCTANES: FORMATION OF 3-BENZAZOCINES AND 3-BENZOXOCINS

Jyoji Kurita, Toshiko Aruga, and Takashi Tsuchiya*

Faculty of Pharmaceutical Sciences, Hokuriku University,
Kanagawa-machi, Kanazawa 920-11, Japan

Abstract ―― Flash vacuum pyrolysis of 8-aza- (10) and 8-oxabenzo[c]-tricyclo[5.1.0.0^{2,6}]octanes (11) resulted in ring-expansion to give the novel 3-benzazocines (14) and 3-benzoxocins (16), respectively. In the case of 11, several kinds of rearrangement products were also obtained.

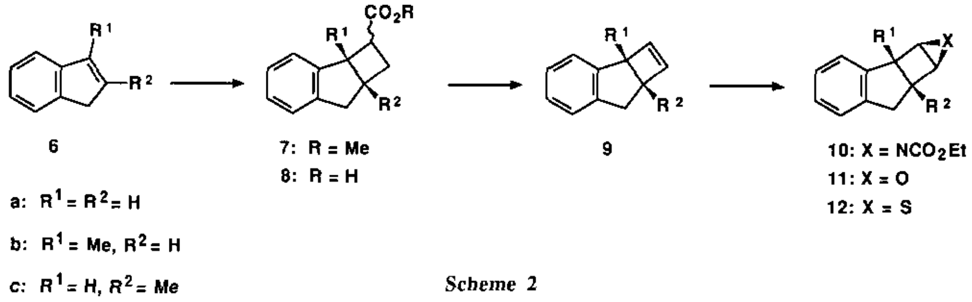
The ring-opening reactions of highly strained bicyclopentane ring systems[1] and their hetero analogues[2-5] have recently been the object of extensive study. We have reported that the thermolysis of the oxazabenzotricyclo-octanes (1) in xylene at 160 °C resulted in rearrangement to give two kinds of benzofuropyrroles (3) and (4),[4] whereas the flash vacuum pyrolysis (f.v.p.) of the dioxa derivatives (2) resulted in ring-expansion to form the novel 1,4-benzodioxocins (5),[5] although even when the compounds (2) were heated in solvents at 250 °C, no reaction occurred, (Scheme 1). These results prompted us to examine the thermal behavior of the title benzotricyclo-octanes having no oxygen atom in the five-membered ring, and we report here that the f.v.p. of them gave 3,6-dihydro-3-benzazocines and 6H-3-benzoxocins, which are new eight-membered heterocyclic rings, although the synthesis of eight-membered heterocyclic ring systems has recently been widely investigated.[6]



1: X = NR (R=CO_2Et)
2: X = O
3
4
5

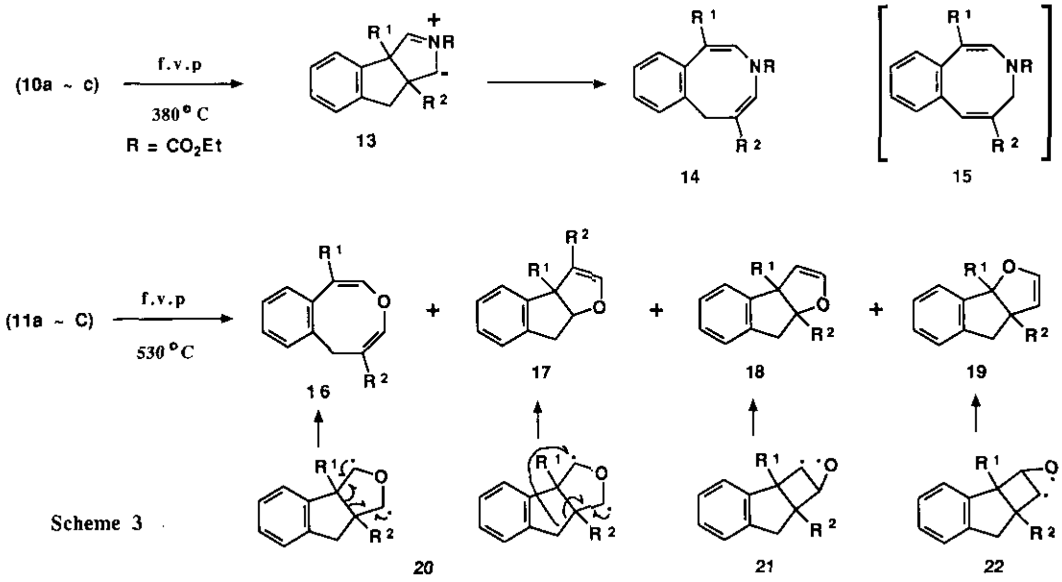
Scheme 1

The synthetic route to the starting benzotricyclo-octanes (10)-(12) used in the present thermolysis is shown in Scheme 2. The methoxycarbonylbenzobicycloheptanes (7a-c), prepared from indenes (6) by photocycloaddition with methyl acrylate, were hydrolyzed to the acids (8), which were oxidatively decarboxylated by treatment with lead tetra-acetate to give the bicycloheptenes (9). The benzotricyclo *compounds (10, 11, and 12) were prepared from 9 by treatment with ethoxycarbonyl-*nitrene,[7] m-chloroperbenzoic acid, and succimide-N-sulfenyl chloride followed by LiAlH$_4$,[8] respectively.[9]



Scheme 2

Although heating the aziridine compounds (10a-c) in dichlorobenzene at 180 °C gave complex mixtures and no characterizable products, f.v.p. of them at 380 °C (3 x 10^{-5} mmHg) gave the expected 3-benzazocines (14)[10] in 60-80% yields as the sole products, probably via the ionic intermediates (13) formed by initial C-C bond fission in the aziridine ring by analogy with the thermolysis of 1.[4]



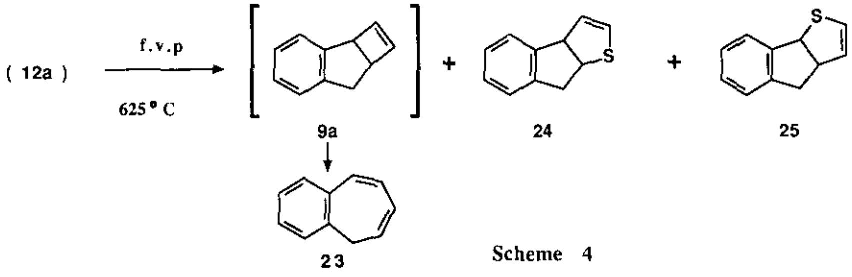
Scheme 3

The structures of the novel 3,6-dihydro-3-benzazocines (14) were characterized by elemental and spectroscopic analyses. For example, in the ^{1}H-nmr spectrum of 14a,[10] signals due to the four heterocyclic ring protons lie in the olefinic range (δ 5.5-6.7) as two pairs of doublets and one of them is further coupled with a methylene signal at δ 3.66. The ^{13}C-nmr spectrum of 14a shows a signal due to the ring methylene carbon at δ 33.36 (t). These spectroscopic data are consistent with the proposed 3,6-dihydro structures (14) for the products and rule out the 3,4-dihydro structures (15).

As compared with the case of the aziridine compounds (10), higher temperatures were needed for the thermolysis of the oxirane compounds (11). F.v.p. of 11a-c at 530 °C also gave the novel 6H-3-benzoxocins (16)[11] in 10-15% yields, but in the case, several kinds of rearrangement products such as indenofurans (17)-(19) were formed in 50-60% yields[12] together with 16. In contrast with the case of the aziridines (10), the thermolysis of the oxiranes (11) may proceed via homolytic bond fission only at a high temperature to give the biradical intermediates (20-22) shown in Scheme 3.[13] The ring-expansion products (16) and the rearrangement products (17) may be derived from 20 formed by C-C bond fission and the biradicals (21) and (22) formed by C-O bond fission might afford the other rearrangement products (18) and (19), respectively.

In addition, heating the thiirane compound (12a) in xylene at 160 °C resulted only in desulfurization to give the cyclobutaindene (9a) in 60-70% yield, whereas f.v.p. of 12a at 625 °C gave 5H-benzocycloheptene (23: 14%) and two rearrangement products (24: 26%) and (25: 11%), but no ring-expansion product. The former product (23) may be derived from initially formed 9a.

The properties of several heterocine monoanions, which are 10π-electron systems, have been reported.[6,14] However, attempts to convert 14 and 16 into their monoanions by removal of a proton have been unsuccessful.



Scheme 4

REFERENCES AND NOTES

1. K. U. Ingold and J. C. Walton, Acc. Chem. Res., 1968, 19, 72.
2. R. A. Aitken, J. I. G. Cadgan, I. Gosney, B. J. Hamill, and L. M. McLaughlin, J. CHem. Soc., Chem. Commun., 1982, 1164; H. D. Martin, H. Höchstetter, and S. Steigel, Tetrahedron Lett., 1984, 25, 297.
3. J. Kurita, K. Iwata, H. Sakai, and T. Tsuchiya, Chem. Pharm. Bull., 1985, 33, 4572; J. Kurita, K. Iwata, and T. Tsuchiya, ibid., 1987, 35, 3166; J. Kurita, H. Sakai, and T. Tsuchiya, J. Chem. Soc., Chem. Commun., 1985, 1769; idem, Heterocycles, 1987, 26, 2861; idem, Chem. Pharm. Bull., 1988, 36, 2887; J. Kurita, T. Yoneda, N. Kakusawa, and T. Tsuchiya, Heterocycles, 1987, 26, 3085.
4. J. Kurita, H. Sakai, S. Yamada, and T. Tsuchiya, J. Chem. Soc., Chem. Commun., 1987, 285.
5. J. Kurita, S. Yamada, H. Sakai, and T. Tsuchiya, J. Chem. Soc., Chem. Commun., 1985, 1254.
6. J. A. Moore and F. A. L. Anet, 'Comprehensive Heterocyclic Chemistry,' Vol. 7, eds. by A. R. Katritzky and C. W. Rees, Pergamon Press, Oxford, 1984, pp. 653-707.
7. W. Lwowski and T. J. Maricich, J. Am. Chem. Soc., 1965, 87, 3630.
8. M. U. Bombala and S. V. Ley, J. Chem. Soc., Perkin Trans. 1, 1979, 3013.
9. In the ^{1}H-nmr spectrum of 11b, a nuclear Overhauser effect enhancement (15-20%) was observed only between the methyl (R^1) signal and a proton (R^2) signal; indicating that 11b is the anti-sterostructure shown in Scheme 2, and consequently, all of the tricyclic compounds are considered to be similar stereostructures.
10. 14a: viscous oil; ir (neat) 1730 (C=O) cm^{-1}; ^{1}H-nmr (CDCl$_3$) δ 1.30 and 4.24 (3H, t, and 2H, q, J=7 Hz, CO$_2$Et), 3.66 (2H, d, J=8 Hz, 6-H$_2$), 5.52 (1H, d, J=11 Hz, 1-H), 5.72 (1H, dt, J=8 and 8 Hz, 5-H), 6.16 (1H, d, J=8 Hz, 4-H), 6.74 (1H, d, J=11 Hz, 2-H), 7.1-7.3 (4H, m, Ph-H); ^{13}C-nmr (8-membered ring carbons) δ 33.36 (t, 6-C), 112.30 (d, 5-C), 126.01 (d, 4-C), 126.95 (d, 2-C), 128.07 (d, 1-C), 135.83 (s, 6a-C), 139.13 (s, 10a-C); 14b: mp 49-51 °C; 14c: viscous oil.
11. 16a: viscous oil; ^{1}H-nmr (CDCl$_3$) δ 3.58 (2H, dd, J=8 and 1 Hz, 6-H$_2$), 5.44 (1H, d, J=8 Hz, 1-H), 5.46 (1H, m, 5-H), 6.14 (1H, d, J=8 Hz, 2-H), 6.20 (1H, dd, J= 6 and 1 Hz, 4-H), 7.06 (4H, s, Ph-H); ^{13}C-nmr (8-membered ring carbons): δ 31.59 (t, 6-C), 110.98 (d, 5-C), 118.75 (d, 1-C), 135.2 (s, 6a-C), 139.59 (s, 10a-C), 142.28 and 143.36 (each d, 2- and 4-C); 16b: viscous oil; 16c: viscous oil.
12. Yields and ratios of these rearrangement products were dependent on the methyl group and experimental conditions; details will be published in a full paper.
13. Such difference in thermolysis between aziridine and oxirane rings has been widely observed.[2-5]
14. M. Fletschinger, B. Zipperer, H. Fritz, and H. Prinzbach, Tetrahedron Lett., 1987, 28, 2517.

Received, 13th August, 1990