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THE RUTHENIUM TETROXIDE OXIDATION OF STEROIDAL CONJUGATED HOMOANNULAR DIENES

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During our investigations on synthesis of heterocyclic steroids the problem of degradation of conjugated homoannular dienes by oxidative cleavage of olefinic bonds arose. Ruthenium tetroxide was found to be a good oxidant for degradation of steroidal conjugated ketones and aromatic steroids 1,2). The aim of the present work was to investigate an application of this oxidant for the cleavage of conjugated dienes.

When cholesta-2,4-diene (1) was treated with RuO_4 3), the known hydroxylactone 2a 4)(70% yield) and α-epoxy-ketol 3 (m.p. 156-157°C, $[\alpha]_D^{24}$ +37.5°, 5% yield) were obtained. The structure of 3 was established by its analytical and spectral data (Table 1). The assignment of the α-configuration of the epoxide ring and C-5 hydroxyl group was based on the concept of preferred attack from an α-side of the molecule 5). It was supported by the values of chemical shifts of protons 18-H and 19-H of angular methyl groups 6).

In the case of 3β-acetoxycholesta-5,7-diene (4) the oxidation reaction yielded four products: α-epoxy-ketol 5a (m.p. 151-152°C, $[\alpha]_D^{24}$ -15.2°, 70% yield), a known ketol 6 (m.p. 238-239°C, $[\alpha]_D^{24}$ +16.9°, 15% yield) 7), diol 7 (m.p. 188--190°C, $[\alpha]_D^{24}$ +3.4°, 2% yield) and oxa-lactone 8 (m.p. 148-150°C, $[\alpha]_D^{25}$ -5.9°, 1% yield).

Structures of compounds 5a, 7 and 8 followed from their analytical and spectral data (Table 1) as well as their further chemical transformations.

In the ^{1}H-NMR spectrum of 5a a multiplet corresponding to 3α-H indicated the trans fusion of A and B rings and therefore the axial orientation of C-5 hydroxyl group. Signals of 18-H and 19-H protons suggested α-configuration of

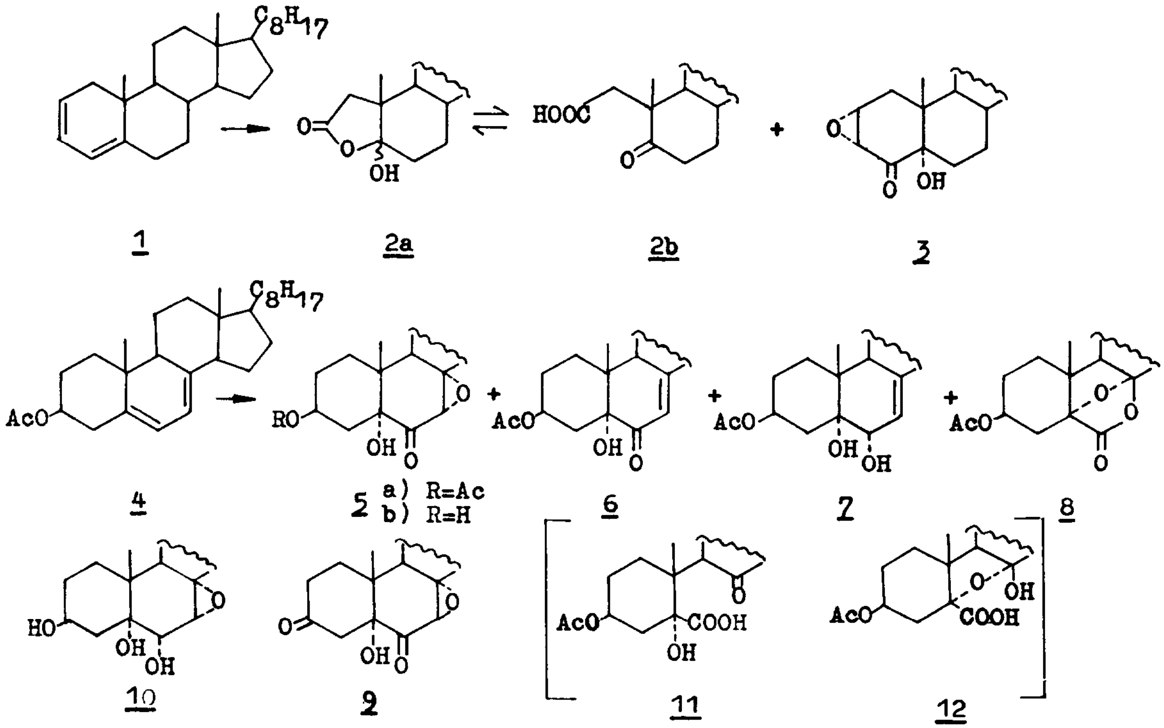


TABLE 1

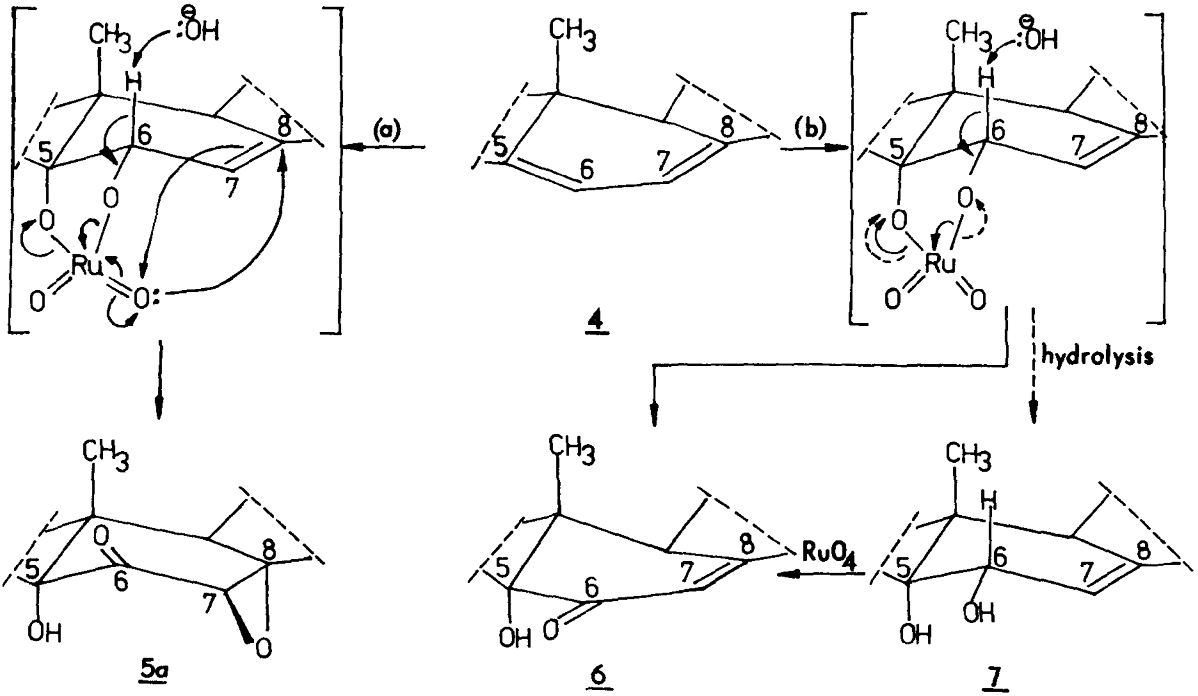
Comp. No	IR ν_{max}^{KBr} (cm^{-1})	^{1}H-NMR (δ) (CDCl$_3$)						
		3α-H	5α-OH	7β-H	18-H (s)	19-H (s)	3β-OAc (s)	Others signals
3	3495,1715,890		2.84		0.64	0.89		3.40 (d, 3β-H, J=3.2 Hz), 3.22 (d, 2β-H, J=3.2 Hz)
5a	3445,1730,1715, 1265,1045,900	4.96 m, $\frac{W}{2}$=23Hz	4.72 (s)	3.56 (s)	0.73	0.89	1.98	
7	3550,1735,1250,	5.05 m, $\frac{W}{2}$=23Hz	2.30		0.55	0.84	2.02	3.92 (m, 6β-H, $\frac{W}{2}$=7.5 Hz), 5.00 (m, 7-H, $\frac{W}{2}$= 7.5 Hz)
8	1800,1725,1260, 1150,1010,980	4.98 m, $\frac{W}{2}$=23Hz			1.02	1.04	2.10	2.68 (q, 4α-H J=12.5 and 3 Hz)
9	3440,1720,1240		4.70 d, J=3Hz	3.65 (s)	0.77	1.11		2.89 (q, 4α-H J=15 and 3 Hz)

the epoxide ring. In the case of β-epoxide these protons would be strongly deshielded 8). Hydrolysis of 5a with methanolic aqueous KOH yielded keto-epoxy-diol 5b (m.p. 138-140°C, $[\alpha]_D^{24}$ -23.7°), which on oxidation with Sarett's reagent afforded epoxy-dione 9 (m.p. 173-174°C, $[\alpha]_D^{24}$ -23.3°) identical in all respects with the product obtained from oxidation of epoxy-triol 10 9). This proved the configuration and position of hydroxyl group and epoxide ring in compound 5 to be the same as in epoxy-triol 10.

The sample of diol 7 was identical with the product obtained from hydroxylation of diene 4 with OsO_4.

Oxa-lactone 8 was also obtained by treatment of ketol 6 directly with RuO_4. It suggested that in reaction of diene 4 with RuO_4 compound 8 could arise *via* intermediates 11 and 12. The proposed mechanism of formation of compound 8 supported α-configuration of oxygen bridge between C-5 and C-8.

Formation of epoxy-ketol 5a from diene 4 could be explained by mechanism presented below. The reaction probably goes in two steps as in the case of $KMnO_4$ oxidation of dienes 10). It is evident that the mechanism of oxidation of diene 1 to epoxy-ketol 3 should be the same.



On the basis of the results presented in this communication it is possible to draw a conclusion that hindered homoannular dienes (e.g. diene 4) are resistant to cleavage with RuO_4. In the contrary, unhindered dienes (e.g. diene 1) are degraded as conjugated ketones and aromatic compounds.

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REFERENCES AND NOTES

1. D. M. Piatak, G. Herbst, J. Wicha and E. Caspi, J. Org. Chem., 34, 116 (1969)
2. D. M. Piatak, H. B. Bhat and E. Caspi, ibid. 34, 112 (1969).
3. The ruthenium tetroxide was initially generated in situ from ruthenium dioxide and sodium periodate and was regenerated throughout the reaction by the addition of a sodium periodate solution.
4. R. J. Conca and W. Bergman, J. Org. Chem., 18, 1104 (1953). Hydroxy-lactone 2a is a tautomer of seco-keto-acid 2b.
5. D. N. Kirk and M. P. Hartshorn, Steroids Reactions Mechanism, Elsevier Publishing Company, Amsterdam/London/New York 1968, p. 70.
6. N. S. Bhacca and D. H. Williams, Applications of NMR Spectroscopy in Organic Chemistry, Holden-Day, San Francisco 1966, p. 14-24.
7. E. Harvey and K. Bloch, Chem. Ind., 1961, 595.
8. N. S. Bhacca and D. H. Williams, Applications of NMR Spectroscopy in Organic Chemistry, Holden-Day, San Francisco 1966, p. 101.
9. W. J. Rodewald and Zb. Bończa-Tomaszewski, Polish J. Chem. (1979), in press.
10. H. Z. Sable, K. A. Powell, H. Katchian, C. B. Niewochner, S. B. Kadlec, Tetrahedron, 26, 1509 (1970).

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