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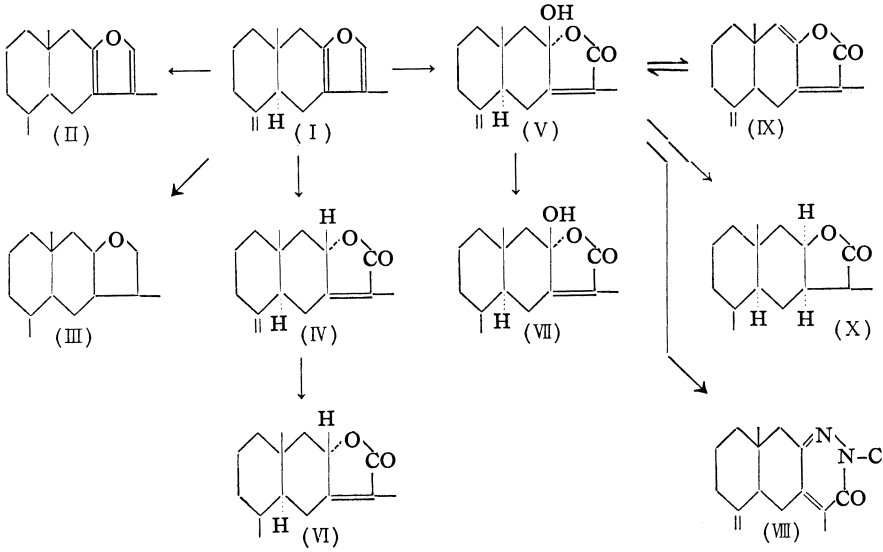
Structure and Autoxidation of Atractylon

The crystalline sesquiterpenoid, atractylon, was first isolated from the crude drug "Sō-jutsu"[1] and later from *Atractylodes japonica* Koidzumi[2] and its related plant.[3] The present comunication contains evidence which permits the assignment of expression (I) to atractylon and expressions (IV) and (V) to its autoxidation products.

Atractylon (I), $C_{15}H_{20}O$, m.p. 38°, $[\alpha]_D$ +40.0°,[*1] had infrared spectrum which exhibited no band associated with hydroxyl or carbonyl grouping but a band at 1134 cm^{-1} assigned to ether mode. The presence of the furan system in (I) was indicated from the positive color reactions for furan ring such as vanillin-HCl, pine stick, Ehrlich, Liebermann-Burchard reactions and from ultraviolet spectrum (λ_{max}^{EtOH} 220 mμ) as well as from the formation of maleic anhydride adduct, $C_{19}H_{22}O_4$, m.p. 118°. The third ethylenic bond as in exocyclic was revealed by infrared absorption (bands at 3077, 1639, 886 cm^{-1}) and by ozonolysis to give formaldehyde. Catalytic hydrogenation of (I) over PtO_2 in MeOH resulted in the saturation of the exocyclic double bond to afford the dihydroderivative (II), $C_{15}H_{22}O$, b.p$_3$ 101°, $[\alpha]_D$ −44.0°. The retention of the furan system in (II) was indicated by the coloration given with reagents described above and by UV: λ_{max}^{EtOH} 221 mμ. On catalytic hydrogenation in AcOEt using Pd-C, (I) took up three moles of H_2 with the formation of a saturated oxide (III), $C_{15}H_{26}O$, b.p$_6$ 120~122°, $[\alpha]_D$ -51.4°, which was identified (IR spectra) with octahydrodesoxylinderene.[4] In agreement with the proposed structure, nuclear magnetic resonance spectrum of (I), measured at 40 Mc. in CCl_4 vs. H_2O as external reference, showed the following peaks: singlet (3*H*) at +160 c.p.s., doublet (3*H*) at +114 c.p.s. (J 1 c.p.s.), doublet (2*H*) at +1 c.p.s. (J 5 c.p.s) with additional fine splitting, unresolved band (1*H*) at −87 c.p.s.



[*1] All analytical values are in good agreement with the molecular formula shown. $[\alpha]_D$s refer to $CHCl_3$ solutions.

1) S. Takagi, G. Hongo: Yakugaku Zasshi, **44**, 539 (1924).

2) I. Yosioka, H. Hikino, Y. Hikino: unpublished data.

3) I. Yosioka, S. Takahashi, H. Hikino, Y. Sasaki: Yakugaku Zasshi, **80**, 1564 (1960).

4) H. Kondo, K. Takeda: *Ibid.*, **59**, 504 (1939).

(I) suffered remarkably rapid autoxidation on standing in air to give two crystalline products, (IV), $C_{15}H_{20}O_2$, m.p. 125°, $[\alpha]_D$ +266.1°, and (V), $C_{15}H_{20}O_3$, m.p. 197~197.5°, $[\alpha]_D$ +281.4°. The presence of a α,β-butenolide system in both (IV) and (V), was confirmed by the spectral properties in ultraviolet (λ_{max}^{EtOH} 220 mμ) and infrared region (bands at 1733, 1672 and 1736, 1695 cm^{-1}, respectively). (IV) and (V) showed also infrared bands at 900 and 897 cm^{-1} (vinylidene) and yielded formaldehyde on ozonolysis. On hydrogenation with Pd-C in AcOMe, (IV) and (V) gave dihydro-derivatives, (VI), $C_{15}H_{22}O_2$, m.p. 114~115°, $[\alpha]_D$ +130.8°, and (VII), $C_{15}H_{22}O_3$, m.p. 178~179.5°, $[\alpha]_D$ +299.0°, respectively, which retained the spectral properties due to α,β-butenolide but disclosed no $>C{=}CH_2$ absorption. That the last oxygen in (V) was the hydroxyl group situated as hemiketal lactone form in the α,β-butenolide system was established from the following observations: (V), UV: $\lambda_{max}^{NaOH-EtOH}$ 264 mμ, IR: ν^{Nujol} 3333 cm^{-1}, exhibited the weakly acidic properties, reacted with phenylhydrazine to give a product (VIII), $C_{21}H_{24}ON_2$, m.p. 210~212°, and was easily dehydrated to afford an anhydroderivative (IX), $C_{15}H_{18}O_2$, m.p. 106~108°, UV: λ_{max}^{EtOH} 275 mμ, from which (V) was regenerated by dissolution in alkali followed by acidification. Hydrogenation of (V) over PtO_2 in AcOH in the presence of HCl led to a saturated lactone (X), $C_{15}H_{24}O_2$, m.p. 141~143°, $[\alpha]_D$ +15.2°, which was identified (m.p., mixed m.p. and IR spectra) with tetrahydroalantolactone. It is very probable that (IV) is the desoxy-compound of (V). (VI) was proved to be identical (m.p., mixed m.p. and IR spectra) with the butenolide[5] derived from alantolactone. Although the autoxidation process from (I) to (V) has a few examples,[6] that from (I) to (IV) seems to have no precedence.

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5) H. Matsumura, I. Iwai, E. Ohki: *Ibid,*. **74**, 1029 (1954).

6) G.O. Schenck: Ber., **77**, 661 (1944); Angew. Chem., **60A**, 224 (1948); R.B. Woodward, R.H. Eastman: J. Am. Chem. Soc., **72**, 399 (1950); A. Melera, K. Schaffner, D. Arigoni, O. Jeger: Helv. Chim. Acta, **40**, 1420 (1957).