Tetrahedron Letters No.39, pp. 3357-3360, 1969. Pergamon Press. Printed in Great Britain.

THERMAL REARRANGEMENT OF SHIROMODIOL-MONOACETATE[*]

Kojiro Wada, Yuji Enomoto, and
Katsura Munakata

Laboratory of Pesticide Chemistry,
Faculty of Agriculture, Nagoya University
Nagoya, Japan

(Received in Japan 28 June 1969; received in UK for publication 18 July 1969)

We have recently reported the structures of two new sesquiterpenoids having insect antifeeding activity, shiromodiol-diacetate (I) and -monoacetate (II), which were isolated from the leaves of <u>Parabenzoin trilobum</u> Nakai.1), 2) In the course of the isolation of shiromodiol-monoacetate (II), we found that II was readily decomposed by vaccum distillation. There are many reports on the thermal rearrangements of germacrane sesquiterpenoids containing two double bonds on ten-membered ring3), 4), however no reports on that of germacrane sesquiterpenoids containing a double bond and an epoxide ring. Thus, we decided to elucidate the thermal rearrangement of Shiromodiol-monoacetate (II).

We wish to describe here work has led to the structures of the thermally rearranged products of II. Distillation of II gave the distillate (bp. 130-160°C at 5 mmHg). The distillate chromatographed over silicic acid using benzene-ethyl acetate as eluent, gave three crystalline products which we named A, B and C respectively.

<u>A(III)</u>, $C_{17}H_{28}O_4$ (elementary analysis and mass) has mp. 89-90°C, ν_{max}^{KBr} ; 3580, 1730, 1695, 1240 cm^{-1}, λ_{max}^{MeOH} ; 275 mμ (ϵ =70), nmr5) ; 0.67 (2H, m, protons on a cyclopropane ring), 0.91 (3H, d, J=7) and 0.96 (3H, d, J=7) ($-CH(CH_3)_2$), 1.10 (3H, s, $\succ\!\!-CH_3$), 2.00 (3H, s, $-COCH_3$), 2.48 (2H, t, J=5, $-CH_2-\underline{CH}_2-CO$), 4.37 (1H, t, J=3, $-C\underline{H}-OH$), and 4.9 (1H, dt, J=6.3, 6.3, 8.8, $-C\underline{H}-OAc$). Reduction of A with sodium borohydride gave dihydro A (IV), $C_{17}H_{30}O_4$6) ($M^{\pm}18$, 280)7), $\nu_{max}^{CCl_4}$; 3500, 1740, 1240 cm^{-1}, UV; no absorption, nmr5) ; 0.68 (2H, m, protons on a cyclopropane ring), 0.91 (3H, d, J=6.8) and 0.97 (3H, d, J=6.8) ($-CH(CH_3)_2$), 1.10 (3H, s, $\succ\!\!-CH_3$), 1.19 (3H, d, J=7, $-CH-\underline{CH}_3$), 2.00 (3H, s, $-COCH_3$), 3.8 (1H, m, $-C\underline{H}-OH$), 4.38 (1H, t, J=3, $-C\underline{H}-OH$), and 4.99 (1H, dt, J=6.3, 6.3, 8.8, $-C\underline{H}-OAc$). The nmr spectrum indicates the disappearance of an acetyl methyl

---

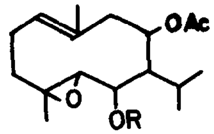
[*] This investigation was supported by a grant from the Ministry of Education of Japan.

group and two protons adjacent to carbonyl group, and the formation of a secondary methyl group and a proton adjacent to a hydroxyl group. Irradiation at the AcO-C<u>H</u> frequency reduced the signals at 1.6 (1H, q, J=6.3, 15) and 2.20 (1H, q, J=6.3, 15) to AB quartet (J=15). These findings suggest that A has the side chain ($-CH_2-CH_2-COCH_3$) and the partial structure (-CH-CH (OAc)-CH_2-C-). On alkaline hydrolysis, A gave deacetyl A(V), $C_{15}H_{26}O_3$ (M^+, 254). In the nmr of V, the protons on the cyclopropane ring appeared at 0.60 (1H, q, J=3.3, 5.0) and 0.85 (1H, m). Irradiation at the signal (4.41, 1H, t, J=3.3) of the proton adjacent to the hydroxy group which presented also in A collapsed the signal of 0.60 ppm to a doublet, clearly indicating that A has the partial structure $(\text{-C}\underset{\text{CH}}{\triangledown}\text{CH-CH(OH)-CH-})$. Oxidation of A (III) with chromic acid-pyridine complex gave two products, Oxo-A(VI), $C_{17}H_{26}O_4$ (M^+, 294), $\nu_{max}^{CHCl_3}$; 1740, 1715, 1670 cm^{-1}, λ_{max}^{MeOH} ; 207 mμ (ε =7600), and α,β-unsaturated ketone (VII), $C_{15}H_{22}O_2$ (M^+, 234), $\nu_{max}^{CHCl_3}$; 1710, 1645 cm^{-1}, λ_{max}^{MeOH} ; 225 mμ (ε =9200) and 315 mμ (ε =140). The ultraviolet spectrum of VI shows that the newly formed ketone conjugates with a cyclopropane ring$^{8)}$. Treatment of VI with 10 % sodium hydroxide gave readily VII having an α,β-unsaturated ketone chromophore, indicating that VI possesses β-acetoxyketone group. These fact suggests the that A has the partial structure $(\text{C}\underset{\text{CH}}{\triangledown}\text{CH-CH(OH)-CH-CH(OAc)-CH}_2\text{-C-})$. From the above mentioned data as well as the structure of shiromodiol-monoacetate, the structure (III) was assigned to A.

<u>B(VIII)</u>, $C_{17}H_{28}O_4$ (elementary analysis and mass) has mp. 115-118°C, ν_{max}^{KBr} ; 3440, 1740, 1235 cm^{-1}, nmr$^{5)}$; 1.00 (3H, d, J=7.5) and 1.07 (3H, d, J=7.5) ($-CH(CH_3)_2$), 1.21 (3H, s, $-O-C-CH_3$), 1.63 (3H, s, $C=C-CH_3$), 2.03 (3H, s, $-CO-CH_3$), 4.27 (1H, q, J=2.0, 5.0, -C<u>H</u>-OH) and 5.13 (1H, dt, J=3.3, 3.3, 7.5, -C<u>H</u>-OAc). B was identified as cycloshiromodiol-8-acetate (VIII)$^{9)}$ from the spectral data.

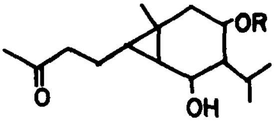
<u>C(IX)</u> $C_{17}H_{28}O_4$ (elementary analysis and mass) has mp. 94-97°C, ν_{max}^{KBr} ; 3440, 1735, 1235 cm^{-1}, nmr$^{5)}$; 0.96 (6H, d, J=6.5, $-CH(CH_3)_2$), 1.2 (3H, s, $-O-C-CH_3$), 4.04 (1H, d, J=4.0, -C<u>H</u>-OH) and 5.00 (1H, m, -C<u>H</u>-OAc). C was assumed to be a steresisomer of B since the spectral data of C was almost identical with those of B, and C also gave a 1,4,7-trisubstituted azulene$^{1)}$ on dehydrogenation.

The thermal rearrangement of shiromodiol-monoacetate may rationalized if it be assumed that a homolytic cleavage of the epoxide ring followed by trans annular cyclization takes place to give a biradical (a), which further undergoes cleavage of C4-C5 bond or removal of hydrogen radical from C-1 to give A or B and C, respectively. It is interesting fact that a germacrane sesquiterpenoid, shiromodiol-monoacetate was thermally transformed to A having the same skeletal



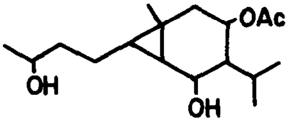
(I) R = Ac

(II) R = H

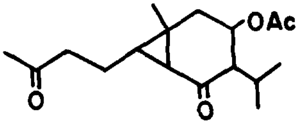


(III) R = Ac

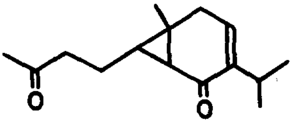
(V) R = H



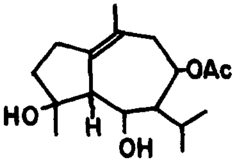
(IV)



(VI)

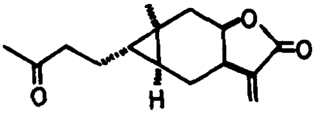


(VII)



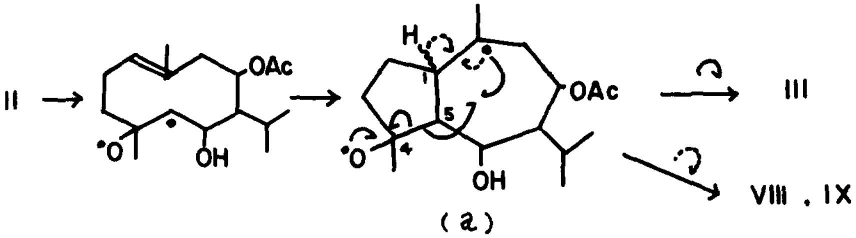
(VIII) , (IX)

Stereoisomers at C-5



(X) Carabrone

Possible Mechanism of the Thermal Rearrangement of II



structure as carabrone (X),10) which was biogenetically considered to be formed from a guaiane type precursor.

Footnotes and References

1) K. Wada, Y. Enomoto, K. Matsui, and K. Munakata, Tetrahedron Letters, No. 45, 4673 (1968).

2) K. Wada and K. Munakata, Tetrahedron Letters, No. 45, 4677 (1968).

3) Molecular Rearrangements (Edited by P. de Mayo) Part II, p. 794. Interscience Publishers (1964).

4) H. Hikino, K. Agatsuma, C. Konno, and T. Takemoto, Tetrahedron Letters, No. 42 4417 (1968).

5) Nmr spectra were measured in $CDCl_3$ at 100 Mc., shifts are expressed as δ values (p.p.m.) from tetramethylsilane as internal standard.

6) The homogeneity of the derivatives of A was characterised by tlc as well as mass and nmr spectroscopy.

7) The molecular weight was supported by the fact that IV was oxidized to oxo-A (MW. 294).

8) W. G. Dauben and G.H. Berezin, J. Amer. Chem. Soc., **89**, 3449 (1967).

9) Shiromodiol-monoacetate was readily transformed to VIII by BF_3-treatment2).

10) H. Minato, S. Nosaka, and I. Horibe, J. Chem. Soc., 5503 (1964).