BULLETIN OF THE CHEMICAL SOCIETY OF JAPAN, VOL. 51 (12), 3663—3664 (1978)

Oxidation of Thujopsene with Metal Acetate in Acetic Acid

Haruo SEKIZAKI,* Masaaki ITO, and Shoji INOUE**

Chemistry Laboratory, Department of General Education, Higashi Nippon Gakuen University, Onbetsu-cho, Hokkaido 088-01

***Faculty of Pharmacy, Meijo University, Tenpaku-ku, Nagoya 468*

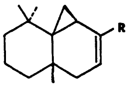
(Received June 23, 1978)

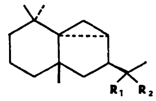
Synopsis. Thujopsene has been oxidized with lead tetraacetate, cobalt triacetate and manganese triacetate, to different kinds of products being 4β-acetyl-6β,10,10-trimethyltricyclo[4.4.0.$0^{1,3}$]decane (**3**) and its diacetate; 2β-acetoxymethyl-2α,4aβ,8,8-tetramethyl-2,3,4,4a,5,6,7,8-octahydronaphthalene (**7**) and widdryl acetate; **3**, **7**, and widdrol, respectively.

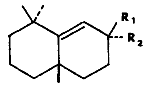
In the oxidation of thujopsene (**1**) with metal acetates[1—3] much attention has been focused on the acetate of Pb(IV), Co(III), and Mn(III). The reactions with metal acetates are summarized in Table 1.

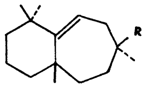
Results and Discussion

*Oxidation of **1** with Lead Tetraacetate.* Thujopsene (**1**) was oxidized with lead tetraacetate in acetic acid at 30 °C for 3 h. Workup and purification gave a stereospecifically ring-contracted ketone (**3**) in 60—65% yield, and the diacetate (**6**) in 16—20% yield. The structure of **3** was identical with that already reported by Nagahama *et al.*[3] The configuration of the acetyl group of **3**[2] was determined and the structure of **6** deduced from the spectral data. The IR absorptions of **6** at 1753 cm^{-1} show the presence of an acetyl group and the presence of a methyl and two acetyl groups is indicated by the NMR signals at 1.91 and 2.06. Hydrolysis of **6** gave **3** in quantitative yield. Thus the minor product (**6**) on this reaction was identified as the stereospecifically ring-contracted diacetate.









1: R=CH_3
2: R=CH_2OAc
4: R=CHO

3: R_1=R_2=O
6: R_1=R_2=OAc

5: R_1=CH_3, R_2=CH_2OAc
7: R_1=CH_2OAc, R_2=CH_3
10: R_1=CH_2OH, R_2=CH_3

8: R=OAc
9: R=OH

*Oxidation of **1** with Cobalt Triacetate.* Onopchenko *et al.*[4] have reported that the preparation of cobalt triacetate and oxidation of cyclohexene with cobalt triacetate gave the 3-cyclohexenyl acetate in high yield. However, a similar reaction with **1** shows different results. After stirring the acetic acid solution of **1** and cobalt triacetate for 45 h, the usual workup yielded no oxidation product and gave the acid-catalyzed isomerization-acetoxylation products **7** and **8** in poor yields. Compound **7** was purified by column chromatography and the structure of **7** confirmed by comparing the IR and NMR spectra of an authentic sample.[5] The configuration of the acetoxymethyl group in **7** was the reverse of the acetate (**5**) prepared by the mercury diacetate oxidation.[1] The structure of the product **8** was determined from following chemical evidence. Hydrolysis of a mixture of **7** and **8** with ethanolic KOH at room temperature for 1 h afforded alcohols **9** and **10**, the spectral data of which were identical with authentic specimens.[6,7] These results indicate that product **8** is widdryl acetate.

*Oxidation of **1** with Manganese Triacetate.* The acetic acid solution of **1** and manganese triacetate was stirred at 80 °C for 54 h. The usual workup and purification gave the acetate (**7**), widdrol (**9**) and the ring-contracted ketone (**3**) in 13.8, 10.3, and 4.3% yields, respectively. The same reaction on general olefins (*e.g.* α-methylstyrene, octene-1 *etc.*) affords the corresponding γ-lactone.[8]

Experimental

The melting points were determined on a Yanagimoto micro melting point apparatus and are uncorrected. The NMR spectra were recorded on a JEOL PMX-60 spectrometer at 60 MHz, using Me_4Si as an internal standard. The IR spectra were determined on a Shimadzu IR-400 spectrometer.

*Oxidation of Thujopsene (**1**) with Lead Tetraacetate.* To the stirred solution of **1** (5.1 g, 25 mmol) in acetic acid (20 ml), kept at 5 °C, was added solid lead tetraacetate (9.0 g, 20 mmol) in portions for 30 min. The mixture was stirred for 3 h at 30 °C, then poured into ice-water and extracted with

TABLE 1. OXIDATION PRODUCTS OF THUJOPSENE WITH METAL ACETATES IN ACETIC ACID

Reagent	Reaction temp (°C)	Product No.							
		2	3	4	5	6	7	8	9
$Pb(OAc)_4$	30	—	60—65	—	—	16—20	—	—	—
$Hg(OAc)_2$[1]	70	14.4	—	11.1	5.4	—	—	—	—
$Tl(OAc)_3$[2]	room	76	10	—	—	—	—	—	—
	50	8	72	—	—	—	—	—	—
$Co(OAc)_3$	80	—	—	—	—	—	7.9	2.4	—
$Mn(OAc)_3$	80	—	4.3	—	—	—	14	—	10

ether. The ether solution was washed with aqueous $NaHCO_3$ solution, water, dried (Na_2SO_4), and evaporated to give an oily residue (7.3 g). The products were separated by column chromatography using silica gel. Elution with benzene gave **3** (3.6 g) as a colorless liquid and **6** (914 mg) as colorless crystals. The pure sample of **3** was obtained by distillation under reduced pressure. **3**: Bp 117—119 °C/5 mmHg. NMR ($CDCl_3$) δ 0.75 (s, 3, CH_3), 1.05 (s, 3, CH_3), 1.10 (s, 3, CH_3), 2.20 (s, 3, Ac), and 3.07 (t, 1, J=10.0 and 4.0 Hz); 2,4-dinitrophenylhydrazone: mp 168—169 °C (lit,[3] mp 170—170.5 °C). The pure sample of **6** was obtained by recrystallization from hexane. **6**: Mp 67—71 °C. IR (KBr) 3075, 3045 (cyclopropyl) and 1753 cm^{-1} (OAc); NMR ($CDCl_3$) δ 0.57 (s, 3, CH_3), 1.00 (s, 3, CH_3), 1.03 (s, 3, CH_3), 1.90 (s, 3, CH_3), 2.03 (s, 6, OAc), 3.17 (t, 1, J=10.0 and 4.0 Hz).

Hydrolysis of ***6****.* The compound (**6**) (322 mg, 1 mmol) was hydrolyzed in ethanol (3 ml) with 5% HCl (1 ml) for 1 h at 50 °C. After the usual workup a crude product (**3**) (217 mg) was obtained.

Oxidation of Thujopsene (1) with Cobalt Triacetate. A mixed solution of cobalt triacetate[4] (prepared from $Co(OAc)_2\cdot 4H_2O$ (25 g)) and **1** (20.4 g, 0.1 mol) was heated to 80 °C. Reaction was continued for 45 h, then the solution was poured into ice-water and extracted with benzene. The benzene solution was washed with aqueous $NaHCO_3$ solution, water, dried (Na_2SO_4) and evaporated to give an oily residue (22.7 g). The products were separated by column chromatography using silica gel. Elution with benzene gave **7** (1.25 g) as a colorless liquid and a mixture of **7** and **8** (1.45 g). **7**: IR (neat) 1743 cm^{-1} (OAc); NMR ($CDCl_3$) δ 0.93 (s, 3, CH_3), 1.05 (s, 6, $2CH_3$), 1.17 (s, 3, CH_3), 2.03 (s, 3, OAc), 3.81 (m, 2, $-\underline{CH_2}OAc$), and 5.10 (s, 1, olefinic). Accordingly, compound (**8**) could not be isolated by repeated column chromatography, a mixture of **7** and **8** was used for the following reaction.

Hydrolysis of Mixture of 7 and 8. To the stirred solution of the mixture of **7** and **8** (1.45 g) in ethanol (15 ml), kept at 10 °C, powdered KOH (56 mg, 10 mmol) was added. The solution was stirred for 1 h at room temperature, then the the solvent was evaporated under reduced pressure and the residue diluted by water and extracted with ether. The ether solution was washed with water, dried (Na_2SO_4), and evaporated to give an oily residue (1.17 g). The products were separated by column chromatography using silica gel. Elution with benzene and ether (5: 1) gave **10** (532 mg), colorless crystals. **10**: mp 70—72 °C (lit,[6] 71—72 °C); IR (KBr) 3230 cm^{-1} (-OH); NMR ($CDCl_3$) δ 0.92 (s, 3, CH_3), 1.07 (s, 3, CH_3), 1.10 (s, 3, CH_3), 3.27 (s, 2, $-\underline{CH_2}OAc$), 5.05 (s, 1, olefinic), and **9** (528 mg), colorless crystals. **9**: mp 83—85 °C (lit,[7] 86—87 °C); IR (KBr) 3255 cm^{-1} (-OH); NMR ($CDCl_3$) δ 1.10 (s, 6, $2CH_3$), 1.23 (s, 6, $2CH_3$), 5.52 (dd, 1, J=9.0 and 6.0 Hz, olefinic).

Oxidation of Thujopsene (1) with Manganese Triacetate. To a stirred solution of **1** (5.10 g, 25 mmol) in acetic acid (50 ml) was added solid manganase triacetate (13.6 g, 30 mmol) in portions for 10 min. The mixture was stirred for 54 h at 80 °C, then poured into ice-water and extracted with ether. The extract was washed with aqueous $NaHCO_3$ solution, water, dried (Na_2SO_4), and evaporated to give an oily residue (6.5 g). The products were separated by column chromatography using silica gel. Elution with benzene gave **7** (903 mg), **9** (549 mg), and **3** (344 mg).

The authors are grateful to Takasago Perfumery Co., Ltd. for providing the crude sample of thujopsene.

References

1) M. Ito, K. Abe, and H. Takeshita, *Bull. Chem. Soc. Jpn.*, **45**, 1913 (1972).

2) H. Sekizaki, M. Ito, and S. Inoue, *Bull. Chem. Soc. Jpn.*, **51**, 2439 (1978).

3) S. Nagahama, H. Kobayashi, and S. Akiyoshi, *Bull. Chem. Soc. Jpn.*, **32**, 366 (1959).

4) A. Onopchenko and J. G. D. Schuly, *J. Org. Chem.*, **40**, 3338 (1975).

5) K. Abe and M. Ito, *Bull. Chem. Soc. Jpn.*, **51**, 319 (1978).

6) W. G. Dauben and L. E. Friedrich, *Tetrahedron Lett.*, **1967**, 1735.

7) W. G. Dauben and L. E. Friedrich, *Tetrahedron Lett.*, **1964**, 2675.

8) E. I. Heiba, R. M. Dessan, and W. J. Koehl, *J. Am. Chem. Soc.*, **90**, 5905 (1968).