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Diterpenoids. XXVII.[1] Synthesis of 11-Methoxy-diterpenoids. (2). Synthesis of 11-Methoxy-dehydroabietic Acid Derivatives

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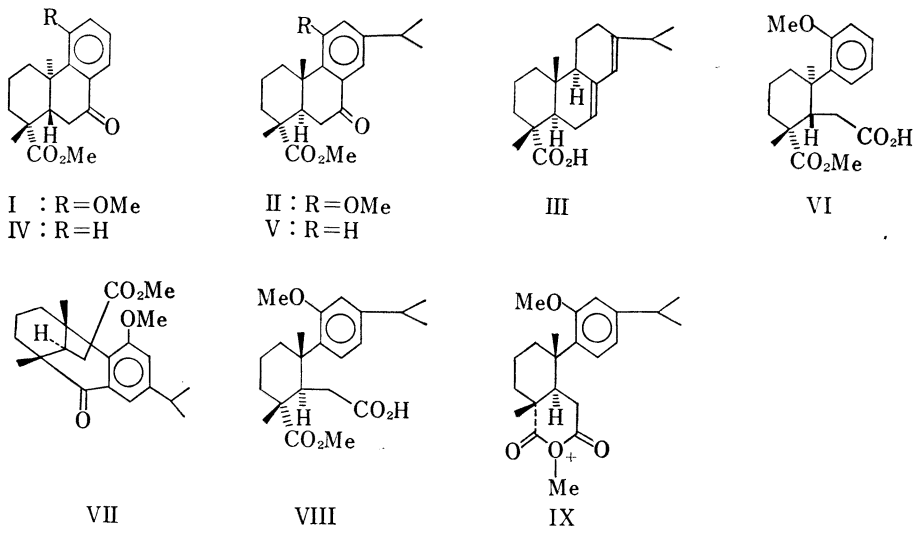
7-Oxo-dehydroabietamide (XI) derived from *l*-abietic acid (III) was converted to methoxycyano acid (XVI) *via* cyano lactone (XIII) and the intramolecular cyclization of XVI gave the expected 11-methoxy-7-oxo-dehydroabietonitrile (XVII). The cyclized compound (XVII) was converted to some 11-methoxy-dehydroabietic acid derivatives, which could be regarded as potential intermediates for synthesis of natural products having 11-hydroxyabietane skeleton.

11-Methoxy compounds (I and II) can be regarded as potential intermediates for the synthesis of the interesting natural products (*e.g.* tumor-inhibitor taxodione[3,4] and fish-killing callicarpone[5]). So, a synthetic attempt of I and II was made by the chemical conversion of *l*-abietic acid (III).



I : R=OMe
IV : R=H

II : R=OMe
V : R=H

III

VI

VII

VIII

IX

Chart 1

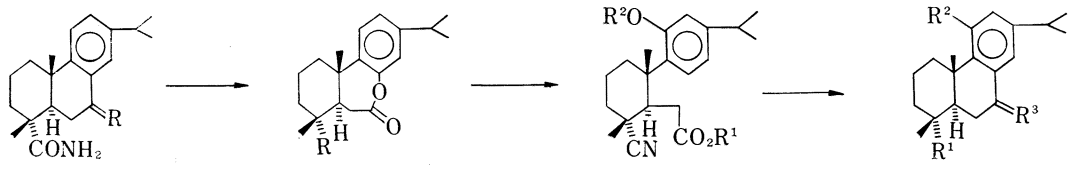
In previous paper,[1] the conversion was carried out by the oxidative B-ring cleavage (Baeyer–Villiger oxidation) and successive recyclization of 7-oxo ester(IV and V). As the

1) Part XXVI: Y. Ohtsuka and A. Tahara, *Chem. Pharm. Bull.* (Tokyo), **21**, 643 (1973).
All melting points were measured on a micro hot-stage and are uncorrected. Nuclear magnetic resonance (NMR) spectra were measured at 60 MHz in $CDCl_3$ (5—10% solution) *vs.* Me_4Si as internal reference. Retention time (t_R) of gas–liquid chromatography were detected by using of the column (1.5% OV-17 on Shimalite W (80—100 mesh), 4 mm × 2.0 m) and carrier N_2 gas.
2) Location: *Wako-shi, Saitama-ken*; *a*) To whom inquiries regarding this report should be addressed.
3) S.M. Kupchan, A. Karim, and C. Marcks, *J. Am. Chem. Soc.*, **90**, 5923 (1968).
4) K. Mori and M. Matsui, *Tetrahedron*, **26**, 3467 (1970); T. Matsumoto, Y. Tachibana, J. Uchida, and K. Fukui, *Bull. Chem. Soc. Japan*, **44**, 2766 (1971).
5) K. Kawazu, M. Inaba, and T. Mitsui, *Agr. Biol. Chem.* (Japan), **31**, 494 (1967).

results, IV of podocarpic acid type was converted to the expected 11-methoxy-7-oxo ester (I) *via* half ester (VI), but V of dehydroabietic acid type was only derived to the undesirable compound (VII) of bicyclo[3,3,1]nonane type *via* half ester (VIII). The latter observation (V→VII) have been reported by Fukui and co-workers, independently.[6]

In the latter case (V→VII), methoxy migration to 6-carboxyl group from 4-methoxycarbonyl group is occurred *via* oxonium intermediate (IX) and the resulting 4-carboxyl group is cyclized to C-aromatic ring to give VII. Thus, it was considered that an analogous derivative (*e.g.* XVI) having 4-modified function would be prevented from the undesirable cyclization and be cyclized to the expected 11-methoxy compound (XVII) as in the case of VI. The result will be reported herein.

7-Oxodehydroabietamide (XI), mp 195—196°, $\nu_{max}^{CHCl_3}$ 3500, 3430, 1667 cm^{-1}, prepared (CrO_3–AcOH aq., room temp.) from dehydroabietamide (X),[7] was readily oxidized (CF_3CO_3H–Na_2HPO_4–CH_2Cl_2, 5—7°) to give lactone (XII), $\nu_{max}^{CCl_4}$ 3540, 3430, 1760, 1675 cm^{-1}. The 4-carbamoyl group of XII was modified to cyano group (XIII), bp 163—164° (bath temp.) /10^{-3} mmHg, ν_{max}^{film} 2225, 1760 cm^{-1}, by dehydration (PCl_5–CCl_4, reflux). All of these structures (XI, XII and XIII) were ascertained by their above infrared (IR) spectral data.



X : R=H_2
XI: R=O
XII : R=$CONH_2$
XIII: R=CN
XIV: R^1=Me,R^2=H
XV : R^1=R^2=Me
XVI: R^1=H,R^2=Me
XVII : R^1=CN,R^2=OMe,R^3=O
XVIII: R^1=CN,R^2=OMe,R^3=H_2
XIX : R^1=CO_2Me,R^2=OMe,R^3=$\langle^{H}_{OH}$
XX : R^1=CO_2Me,R^2=OMe,R^3=H_2
XXI : R^1=CH_2OH,R^2=OMe,R^3=H_2
XXII : R^1=CN,R^2=H,R^3=O
XXIII: R^1=CN,R^2=H,R^3=H_2
XXIV: R^1=CO_2Me,R^2=H,R^3=H_2
XXV : R^1=CH_2OH,R^2=H,R^3=H_2

Chart 2

Methanolysis (MeOH– conc. HCl aq., reflux) and successive methylation (CH_2N_2–MeOH, room temp. or Me_2SO_4–K_2CO_3–acetone, reflux) of XIII gave methoxy cyano ester (XV), bp 136—138° (bath temp.)/10^{-3} mmHg, ν_{max}^{film} 2225, 1737 cm^{-1}, *via* hydroxy cyano ester (XIV), mp 146.5—147.5°, ν_{max}^{KBr} 3360, 2225, 1714 cm^{-1}. The resulting ester (XV) was hydrolyzed (10% KOH aq. -MeOH, reflux) to yield methoxy cyano acid (XVI), bp 183—185° (bath temp.)/10^{-3} mmHg, ν_{max}^{film} 2230, 1710 cm^{-1}. Their structures (XIV, XV and XVI) were justified by NMR-doublet splitting due to 6-methylene protons (XIV: δ 2.38, J=6.0 Hz; XV: δ 2.30, J=6.5 Hz; XVI: δ 2.28, J=6.0 Hz).

In the subject of B-ring reformation, methoxy cyano acid (XVI) was cyclized (($(CF_3CO)_2O$–CF_3CO_2H, room temp.) to give 11-methoxy-7-oxo nitrile (XVII), bp 156—158° (bath temp.)/ 3×10^{-3} mmHg, ν_{max}^{film} 2230, 1690 cm^{-1}, which had the aimed structure. The cyclized nitrile (XVII) was hydrogenolyzed (H_2, 15% Pd–C–AcOH–conc.H_2SO_4, room temp.) to give methoxy nitrile (XVIII), bp 128—130° (bath temp.)/10^{-3} mmHg, $\nu_{max}^{CCl_4}$ 2235 cm^{-1}, and, on the other way, XVII was hydrolyzed (50% KOH aq. -diethylene glycol, reflux) and successively met hylated

6) T. Matsumoto, S. Imai, M. Aizawa, H. Kitagawa, and K. Fukui, *Chem. Letters* (Japan), **1972**, 581.
7) K. Kanno, *Nippon Kagaku Zasshi*, **82**, 113 (1961).

(CH_2N_2) to give 11-methoxy-7-oxo ester (II),[8] mp 167—169°, $\nu_{max}^{CCl_4}$ 1727, 1690 cm^{-1}, accompanied with 7-hydroxy ester (XIX), $\nu_{max}^{CCl_4}$ 3620, 1727 cm^{-1}, (*ca.* 7:3 ratio). The latter ester (XIX) was assumed to be 7-epimeric mixture by reason that the methyl signal of the methoxycarbonyl group appeared as two peaks (δ 3.66 and 3.68, ratio of peak height *ca.* 1:1). However, the epimeric component could not be distinguished by comparison of chemical shifts of the other methyl groups and of gas-chromatographic retention time (t_R=4.18 min: 230°). The epimeric mixture was readily oxidized (Jones reagent[9] -acetone, room temp.) to give the former product (II).

Hydrogenolysis (H_2, 15% Pd-C–AcOEt–$HClO_4$ aq., room temp.) of II gave methyl 11-methoxy-dehydroaboetate (XX), bp 115—116° (bath temp.)/5×10^{-3} mmHg, ν_{max}^{film} 1726cm^{-1}, which was further reduced ($LiAlH_4$–ether, reflux) to give 11-methoxy alcohol (XXI), mp 86—88°, $\nu_{max}^{CCl_4}$ 3650 cm^{-1}.

The structures of the cyclized products (XVII and its derivatives (XVIII, II, XX and XXI)) were confirmed by the following NMR analyses. At first, 11-methoxy position was clearly proved by the coupling constant due to the aromatic 14-proton. The signal of 14-proton (δ 7.63, J=2.0 Hz (*meta* coupling)) in XVII is obviously observed in a lower magnetic field than that of the other aromatic proton (δ 6.97) by the effect of 7-oxo group and it shows the figure of 1,2,3,5-tetrasubstituted benzene type. Thus, the methoxy group is located at 11-position.

Further structural evidence of 11-methoxy compounds was adduced by NMR-comparison between methoxy compounds (XVII, XVIII, II, XX and XXI) and the corresponding demethoxy standards (XXII,[10] XXIII,[11] V, XXIV and XXV[12]) (see Table I). It is reported[13] that the 10-methyl group of abietane series having a 11-methoxy group is suffered by paramagnetic effect (*ca.* 0.1—0.2 ppm) by the 11-methoxy group. In our case, NMR signals due to 4-methyl groups were not shifted, but those due to 10-methyl groups (XVII: δ 1.36; XVIII: δ 1.23; II: δ 1.39 or 1.33; XX: δ 1.30 or 1.27; XXI: δ 1.33) were shifted *ca.* 0.15—0.05 ppm to lower magnetic field than those of the corresponding demethoxy standards (XXII: δ 1.24; XXIII: δ 1.17; V: δ 1.24; XXIV: δ 1.22; XXV: δ 1.22), respectively. The above NMR data are consistent with the conclusion that these compounds (XVII, XVIII, II, XX and XXI) have 11-methoxy group of abietane skeleton.

Table I. Chemical Shifts of 11-Methoxy- and The Corresponding Demethoxy-compounds

	7-Oxo-nitriles		Nitriles		7-Oxo-esters		Esters		Alcohols	
	XVII	XXII	XVIII	XXIII	II	V	XX	XXIV	XXI	XXV
10-Me	1.36	1.24	1.23	1.17	1.39	1.24	1.30	1.22	1.33	1.22
4-Me	1.47	1.48	1.40	1.41	1.33	1.33	1.27	1.28	0.88	0.88

In conclusion, the aimed 11-methoxy-dehydroabietic acid derivatives (XVII, XVIII, II, XX and XXI) were synthesized by use of 4-modified acid (XVI). It is properly considered that the other derivatives having 4-function modified from 4-methoxycarbonyl group are

8) Fukui and co-workers[6] reported that this compound (II) was obtained from half acid (VIII) in only 4% yield by succissive treatment with PCl_5 and $SnCl_4$ in benzene. NMR spectrum of the compound is almost the same as ours, but the melting point (114—115°) is different.

9) A. Bowers, T.G. Halsall, E.R.H. Jones, and A.J. Lemin, *J. Chem. Soc.*, **1953**, 2548.

10) This compound (XXII) was prepared by oxidation (CrO_3–AcOH aq., room temp.) of XXIII[11] as described in experimental.

11) E. Wenkert and B.G. Jackson, *J. Am. Chem. Soc.*, **80**, 211 (1958).

12) L.F. Fieser and W.P. Campbell, *J. Am. Chem. Soc.*, **61**, 2528 (1939).

13) C.H. Brieskorn, A. Fuchs, J.B-son Bredenberg, J.D. McChesney, and E. Wenkert, *J. Org. Chem.*, **29**, 2293 (1964).

cyclized as was expected. The 11-methoxy compounds obtained (*e.g*, II) are suitable for synthesis of taxodione and the others, and the conversion is now attempted.

Experimental

Oxidation of Dehydroabietamide (X) to 7-Oxo-dehydroabietamide (XI)——A solution of CrO_3 (11.0 g) in 80% AcOH aq. (250 ml) was dropwise added to a solution of dehydroabietamide (X) (10.0 g) in AcOH (500 ml) at room temperature with stirring and the mixture was continued to stir for 24 hr at room temperature. The mixture was stirred for 1 hr more at room temperature after an addition of MeOH (100 ml), and was evaporated under reduced pressure. The ether extract of the resulting residue was washed with sat. Na_2CO_3 aq., sat. NaCl aq. and dried over Na_2SO_4. The solvent was removed to give crystals which were recrystallized from $CHCl_3$–petr. ether to a pale blue powder (XI) (9.07 g). The powder was pure enough for the further experiment and was recrystallized from $CHCl_3$–petr. ether to give colorless fine prisms, mp 195—196°. *Anal.* Calcd. for $C_{20}H_{27}O_2N$: C, 76.64; H, 8.68; N, 4.47. Found: C, 76.15; H, 8.46; N, 4.20. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3500, 3430, 1667. NMR δ: 1.23 (d, 6H, J=6.5 Hz; -CH($C\underline{H}_3$)$_2$), 1.25 (s, 3H; 4-CH_3), 1.35 (s, 3H; 10-CH_3), 5.82 (br, 2H; $CONH_2$), 7.86 (d, 1H, J=2.0 Hz; 14-H). t_R=12.0 min (230°).

Oxidation and Successive Dehydration of 7-Oxo-dehydroabietamide (XI) to Cyano Lactone (XIII) *via* Lactone (XII)——A peracid solution prepared from $(CF_3CO)_2O$ (14.1 ml)–90% H_2O_2 (11.1 ml)–CH_2Cl_2 (111 ml) by usual method,[1] was dropwise added to a mixture of oxo amide (XI) (4.50 g) and Na_2HPO_4 (15.0 g) in CH_2Cl_2 (111 ml) at 5—7° with vigorous stirring. The mixture was continued to stir for 30 min at 5—7° and, then, diluted with cold water. The organic layer was washed with sat. Na_2CO_3 aq., sat. NaCl aq. and dried over Na_2SO_4. The solvent was evaporated to give a pale yellow powder (XII) (3.47 g), and it was used to the next experiment without further purification. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3540, 3430, 1760, 1675. NMR δ: 1.22 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.47 (s, 3H,) 1.50 (s, 3H), 6.11 (br, 2H; $CONH_2$).

Phosphorus pentachloride (1.00 g) was added to a solution of lactone (XII) (1.070 g) in CCl_4 (50 ml) and, then, it was refluxed for 15 hr. The solvent was evaporated and the resulting residue was diluted with cold water. The ether extract was washed with sat. Na_2CO_3 aq., sat. NaCl aq., and dried over Na_2SO_4. The solvent was removed to give a pale yellow powder (780 mg), which was purified by chromatography on silica gel (40 g) in petr. ether–ether (4: 1) elution to give a colorless oil (XIII) (522 mg), bp 163—164° (bath temp.)/10^{-3} mmHg. *Anal.* Calcd. for $C_{20}H_{25}O_2N$: C, 77.13; H, 8.09; N, 4.50. Found: C, 76.87; H, 8.01; N, 4.57. IR ν_{max}^{film} cm^{-1}: 2225, 1760. NMR δ: 1.24 (d, 6H, J=6.5 Hz; -CH($C\underline{H}_3$)$_2$), 1.47 (s, 3H, 10-CH_3), 1.61 (s, 3H; 4-CH_3). t_R=6.70 min (240°).

Methanolysis of Cyano Lactone (XIII) to Hydroxy Cyano Ester (XIV)——A mixture of lactone (XIII) (800 mg) in MeOH (80 ml)–conc. HCl aq. (1.5 ml) was refluxed for 10 min. The solvent was removed under reduced pressure and the resulting residue was extracted with ether. The extract was washed with sat. Na_2CO_3 aq., sat. NaCl aq. and dried over Na_2SO_4. The solvent was evaporated to give crystals (XIV) (837 mg), which were chromatographed on silica gel (40 g) in petr. ether–ether (4: 1) elution to give crystals (773 mg). They were recrystallized from MeOH–H_2O to give colorless needles (XIV) (591 mg), mp 146.5—147.5°. *Anal.* Calcd. for $C_{21}H_{29}O_3N$: C, 73.43; H, 8.51; N, 4.08. Found: C, 73.68; H, 8.50; N, 4.15. IR ν_{max}^{KBr} cm^{-1}: 3360, 2225, 1714. NMR δ: 1.17 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.36 (s, 3H; 10-CH_3), 1.45 (s, 3H; 4-CH_3), 2.38 (d, 2H, J=6.0 Hz; -CH-$C\underline{H}_2$-CO_2CH_3), 3.30 (s, 3H; CO_2CH_3), 4.16 (t, 1H, J=6.0 Hz; -$C\underline{H}$-$CH_2CO_2CH_3$). t_R=6.70 min (240°).

Methylation of Hydroxy Cyano Ester (XIV) to Methoxy Cyano Ester (XV)——i) Methylation with CH_2N_2–MeOH: Hydroxy cyano ester (XIV) (400 mg) in MeOH (20 ml) was methylated as usual with CH_2N_2-ether. The solvent was removed under reduced pressure and the resulting oil was purified by chromatography on silica gel (20 g) to give a colorless oil (XV) (355 mg) in petr. ether–ether (9: 1) elution and crystals (50 mg) in petr. ether–ether (4: 1) elution. The latter crystals (50 mg) were identified with the starting hydroxy cyano ester (XIV) by comparison of IR spectrum (CCl_4) and t_R. The former oil (XV) was distilled at 136—138° (bath temp.)/10^{-3} mmHg for an analytical sample. *Anal.* Calcd. for $C_{22}H_{31}O_3N$: C, 73.91; H, 8.74; N, 3.92. Found: C, 74.00; H, 8.76; N, 4.22. IR ν_{max}^{film} cm^{-1}: 2225, 1737. NMR δ: 1.23 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.32 (s, 3H; 10-CH_3), 1.43 (s, 3H; 4-CH_3), 2.30 (d, 2H, J=6.5 Hz; -$C\underline{H}$-$C\underline{H}_2$-CO_2CH_3), 3.32 (s, 3H; CO_2CH_3), 3.93 (s, 3H; OCH_3). t_R=3.80 min (240°).

ii) Methylation with Me_2SO_4–K_2CO_3: A mixture of hydroxy cyano ester (XIV) (515 mg), K_2CO_3 (10 g) and Me_2SO_4 (1.0 ml) in acetone (50 ml) was refluxed for 5 hr with stirring and refluxed for 19 hr more after an addition of Me_2SO_4 (1.0 ml). The reaction mixture was filtered. The filtrate was evaporated, diluted with H_2O and extracted with ether. The ether extract was washed with sat. NaCl aq. and dried over Na_2SO_4. The solvent was removed to give a pale yellow oil (506 mg) and it was chromatographed on silica gel (30 g) in petr. ether–ether (4: 1) elution to give a colorless oil (431 mg), which was identified with methoxy cyano ester (XV) by comparison of IR spectrum and t_R.

Hydrolysis of Methoxy Cyano Ester (XV) to Methoxy Cyano Acid (XVI)——A mixture of methoxy cyano ester (XV) (775 mg) in 10% KOH aq. (30 ml)–MeOH (30 ml) was refluxed for 60 min with stirring and, then, the solvent was removed to the half volume under reduced pressure. The resulting mixture was washed with

ether and acidified with dil. HCl aq. The ether extract was washed with sat. NaCl aq. and dried over Na_2SO_4. The solvent was evaporated to give a colorless oil (XVI) (684 mg), which was pure enough for the further experiment. A part of an oil (120 mg) was chromatographed on silicic acid–Celite (1: 1) (10 g) in petr. ether–ether (4: 1) elution to give a colorless oil (XVI) (108 mg), bp 183—185° (bath temp.)/10^{-3} mmHg. *Anal.* Calcd. for $C_{21}H_{29}O_3N$: C, 73.43; H, 8.51; N, 4.08. Found: C, 73.14; H, 8.49; N, 4.08. IR ν_{max}^{film} cm^{-1}: 2225, 1710. NMR δ: 1.18 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.29 (s, 3H; 10-CH_3), 1.40 (s, 3H; 4-CH_3), 2.28 (d, 2H, J=6.0 Hz; -CH-$C\underline{H}_2$-CO_2H), 3.87 (s, 3H; OCH_3), *ca.* 8.16 (br, CO_2H).

Cyclization of Methoxy Cyano Acid (XVI) to 11-Methoxy-7-oxo-dehydroabietonitrile (XVII)——A solution of methoxy cyano acid (XVI) (440 mg) in $(CF_3CO)_2O$ (3.6 ml)–CF_3CO_2H (1.8 ml) was left standing for 3 hr at room temperature. The reaction mixture was poured into ice and extracted with ether. The ether extract was washed 10% KOH aq., then, sat. NaCl aq., and was dried over Na_2SO_4 (neutral part). The alkaline layer was acidified and extracted with ether. The extract was washed with sat. NaCl aq. and dried over Na_2SO_4 (acidic part). Both solvents were evaporated respectively to give a colorless oil (349 mg) as the neutral part and a pale yellow powder (57 mg) as the acidic part. The latter acidic powder (57 mg) was identified with the starting methoxy cyano acid (XVI) by comparison of IR spectrum (CCl_4). The former neutral oil (349 mg), whose gas chromatogram showed it was almost single product (t_R=8.20 min: 240°), was chromatographed on silica gel (30 g) in petr. ether–ether (4: 1) elution to give a colorless oil (XVII) (280 mg), bp 156—158° (bath temp.)/3×10^{-3} mmHg. *Anal.* Calcd. for $C_{21}H_{27}O_2N$: C, 77.50; H, 8.36; N, 4.30. Found: C, 77.21; H, 8.24; N, 4.41. IR ν_{max}^{film} cm^{-1}: 2230, 1690, 1608. NMR δ: 1.25 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.36 (s, 3H; 10-CH_3), 1.47 (s, 3H; 4-CH_3), 3.85 (s, 3H; 11-OCH_3), 6.97 (d, 1H, J=2.0 Hz; 12-H), 7.63 (d, 1H, J=2.0 Hz: 14-H). t_R=8.20 min (240°).

Hydrogenolysis of 11-Methoxy-7-oxo-dehydroabietonitrile (XVII) to 11-Methoxy-dehydroabietonitrile (XVIII)——A solution of methoxy oxo nitrile (XVII) (280 mg) in conc. H_2SO_4 (5 drops)–AcOH (70 ml) was stirred in the presence of 15% Pd-C (560 mg) under an atmospheric hydrogen pressure at room temperature. After hydrogen absorption was ceased, the catalyst was filtered off and the filtrate was evaporated under reduced pressure. The ether extract of the resulting residue was washed with sat. Na_2CO_3 aq., sat. NaCl aq. and dried over Na_2SO_4. The solvent was evaporated to give an oil (209 mg) and it was chromatographed on silica gel (20 g) in petr. ether–ether (19: 1) elution to give a colorless oil (XVIII) (199 mg), bp 128—130° (bath temp.)/10^{-3} mmHg. *Anal.* Calcd. for $C_{21}H_{29}ON$: C, 80.98; H, 9.39; N, 4.50. Found: C, 81.03; H, 9.27; N, 4.39. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 2235. NMR δ: 1.23 (d, 6H, J=6.5 Hz; -CH($C\underline{H}_3$)$_2$), 1.28 (s, 3H; 10-CH_3), 1.40 (s, 3H; 4-CH_3), 3.78 (s, 3H; 11-OCH_3), 6.57 (s, 2H; 12- and 14-H). t_R=6.90 min (220°).

Hydrolysis and Successive Methylation of 11-Methoxy-7-oxo-dehydroabietonitrile (XVII) to Methyl 11-Methoxy-7-oxo-dehydroabietate (II) and Methyl 7-Hydroxy-11-methoxy-dehydroabietate (XIX)——A mixture of methoxy oxo nitrile (XVII) (170 mg) and KOH (8.0 g) in diethylene glycol (15 ml)–H_2O (8.0 ml) was refluxed for 12 hr with stirring and, then, acidified with dil. HCl aq. The ether extract was washed with H_2O and extracted with 10% KOH aq. The alkaline extract was acidified and extracted with ether. The ether extract was washed with sat. NaCl aq. and dried over Na_2SO_4. The solvent was evaporated to give a powder, which was methylated as usual with CH_2N_2–ether to yield a pale yellow oil (118 mg). The oil was purified by chromatography on silica gel (15 g) to give colorless crystals (II) (71 mg) in petr. ether–ether (9: 1) elution and a colorless oil (XIX: epimeric mixture at C-7) (33 mg) in petr. ether–ether (4: 1) elution.

A part (32 mg) of the former crystals (II) was recrystallized from petr. ether–ether to give colorless prisms (26 mg), mp 167—168°. *Anal.* Calcd. for $C_{22}H_{30}O_4$: C, 73.71; H, 8.44. Found: C, 73.42; H, 8.76. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1727, 1690. NMR δ: 1.25 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.33 (s, 3H; 4- or 10-CH_3), 1.39 (s, 3H; 10- or 4-CH_3), 3.66 (s, 3H; 4-CO_2CH_3), 3.84 (s, 3H; 11-OCH_3), 6.95 (d, 1H, J=2.0 Hz; 12-H), 7.59 (d, 1H, J=2.0 Hz; 14-H). t_R=6.10 min (230°).

The latter oil (assumed to be 7-epimeric mixture), IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3620, 1727; NMR δ: 1.23 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.29 (s, 3H; 4-CH_3), 1.35 (s, 3H; 10-CH_3), 3.66 and 3.68 (s, 3H; 4-CO_2CH_3), 3.79 (s, 3H; 11-OCH_3), 4.5—5.0 (m, 1H; -C$\underline{H}$-OH), 6.66 (br, 1H), 6.85 and 7.07 (br, 1H); t_R=4.18 min (230°), was oxidized to 11-methoxy-7-oxo ester (II) by the following manner.

A part (20 mg) of the latter oil (XIX) was treated with Jones reagent (0.06 ml) in acetone (1 ml) for 30 min at room temperature. The reaction mixture was diluted with H_2O and extracted with ether. The ether extract was washed with sat. NaCl aq. and was dried over Na_2SO_4. The solvent was evaporated to give a colorless oil (18.5 mg) and it was identified with 11-methoxy-7-oxo ester (II) by comparison of IR spectrum (CCl_4) and t_R.

Hydrogenolysis of Methyl 11-Methoxy-7-oxo-dehydroabietate (II) to Methyl 11-Methoxy-dehydroabietate (XX)——A solution of methoxy oxo ester (II) (71 mg) in AcOEt (15 ml)–70% $HClO_4$ aq. (1 drop) was stirred for 18 hr in the presence of 15% Pd-C (100 mg) under an atmospheric hydrogen pressure at room temperature. The catalyst was filtered off and the filtrate was washed with sat. NaCl aq. and dried over Na_2SO_4. The solvent was evaporated to give a colorless oil (77 mg) and it was chromatographed on neutral Al_2O_3 (15 g) in petr. ether–ether (19: 1) elution to give a colorless oil (XX) (64 mg), bp 115—116° (bath temp.)/5×10^{-3} mmHg. *Anal.* Calcd. for $C_{22}H_{32}O_3$: C, 76.70; H, 9.36. Found: C, 76.91; H, 9.42. IR ν_{max}^{film} cm^{-1}: 1726. NMR δ: 1.21 (d, 6H, J=7.0 Hz; -CH($C\underline{H}_3$)$_2$), 1.27 (s, 3H; 4- or 10-CH_3), 1.30 (s, 3H; 10- or 4-CH_3), 3.65 (s, 3H; 4-CO_2CH_3), 3.78 (s, 3H; 11-OCH_3), 6.54 (s, 2H; 12- and 14-H). t_R=3.15 min (240°).

Reduction of Methyl 11-Methoxy-dehydroabietate (XX) to 11-Methoxy-dehydroabietanol (XXI)——A mixture of methoxy ester (XX) (63 mg) and $LiAlH_4$ (50 mg) in ether (10 ml) was refluxed for 5 hr with stirring and dil. HCl aq. was added to the reaction mixture. The organic layer was washed with sat. NaCl aq. and dried over Na_2SO_4. The solvent was evaporated to give a colorless oil (55 mg) and it was chromatographed on silica gel (10 g) in petr. ether–ether (9: 1) elution to give colorless crystals (XXI) (53 mg), which were recrystallized from petr. ether–ether to colorless fine needles (20 mg), mp 86—88°. *Anal.* Calcd. for $C_{21}H_{32}O_2$: C, 79.70; H, 10.19. Found: C, 80.07; H, 10.63. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3650. NMR δ: 0.88 (s, 3H; 4-CH_3), 1.22 (d, 6H, J=7.0 Hz; -CH(CH_3)$_2$), 1.33 (s, 3H; 10-CH_3), 3.15 (d, 1H, J=10.5 Hz; CH_2OH), 3.48 (d, 1H, J=10.5 Hz; CH_2OH), 3.78 (s, 3H; 11-OCH_3), 6.63 (s, 2H; 12- and 14-H).

Oxidation of Dehydroabietonitrile (XXIII) to 7-Oxo-dehydroabietonitrile (XXII)——Nitrile (XXIII) (150 mg) in AcOH (10.5 ml) was treated with CrO_3 (210 mg)–80% AcOH aq. (5.25 ml) as in the case of amide (X). The resulting oil (127 mg) was chromatographed on silica gel (15 g) in petr. ether–ether (4: 1) elution to give a colorless oil (XXII) (74 mg), bp 109—110° (bath temp.)/10^{-3} mmHg. *Anal.* Calcd. for $C_{20}H_{25}ON$: C, 81.31; H, 8.35; N, 4.74. Found: C, 80.91; H, 8.26; N, 4.79. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 2230, 1685. NMR δ: 1.24 (d, 6H, J=6.5 Hz; -CH(CH_3)$_2$), 1.24 (s, 3H; 10-CH_3), 1.48 (s, 3H; 4-CH_3), 7.93 (d, 1H, J=2.0 Hz; 14-H). t_R=3.50 min (250°).

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