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Aromatic Substitution in Dehydroabietane Derivatives. —Syntheses of the Phenolic Dehydroabietane Series—

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In order to investigate the relationship between the position of the hydroxy group on the aromatic C-ring of dehydroabietane and the cleavage pattern upon ozonolysis, phenolic dehydroabietane derivatives having a hydroxyl group on every possible position (11-, 12-, 13-, and 14-positions) were synthesized from dehydroabietic acid (**2**).

Friedel–Crafts acetylation of dehydroabietane (**7**) derived from **2** gave the 12-acetyl compound (**8**), which was converted to the 12-hydroxy compound (ferruginol, **10**) and 11,12-dihydroxy dehydroabietane (**14**). On the other hand, nitration of 7-oxo dehydroabietane (**25**) afforded a mixture of the 14-nitro-7-oxo compound (**26**) and the 13-nitro-7-oxo compound (**27**) in *ca.* 1: 1 ratio. The former (**26**) was converted into 14-hydroxy dehydroabietane (**32**) and the latter (**27**) was led to both the 13-hydroxy compound (**37**) and the 13,14-dihydroxy compound (**47**).

Keywords——diterpene; phenol; catechol; nitration; Friedel–Crafts acetylation

As part of our work on the utilization of pine rosin,[1] we intended to convert *l*-abietic acid (**1**), the main component of rosin, into biologically active sesquiterpenes. In order to achieve this, it was necessary to study the cleavage of the aromatic C-ring of dehydroabietic acid (**2**),

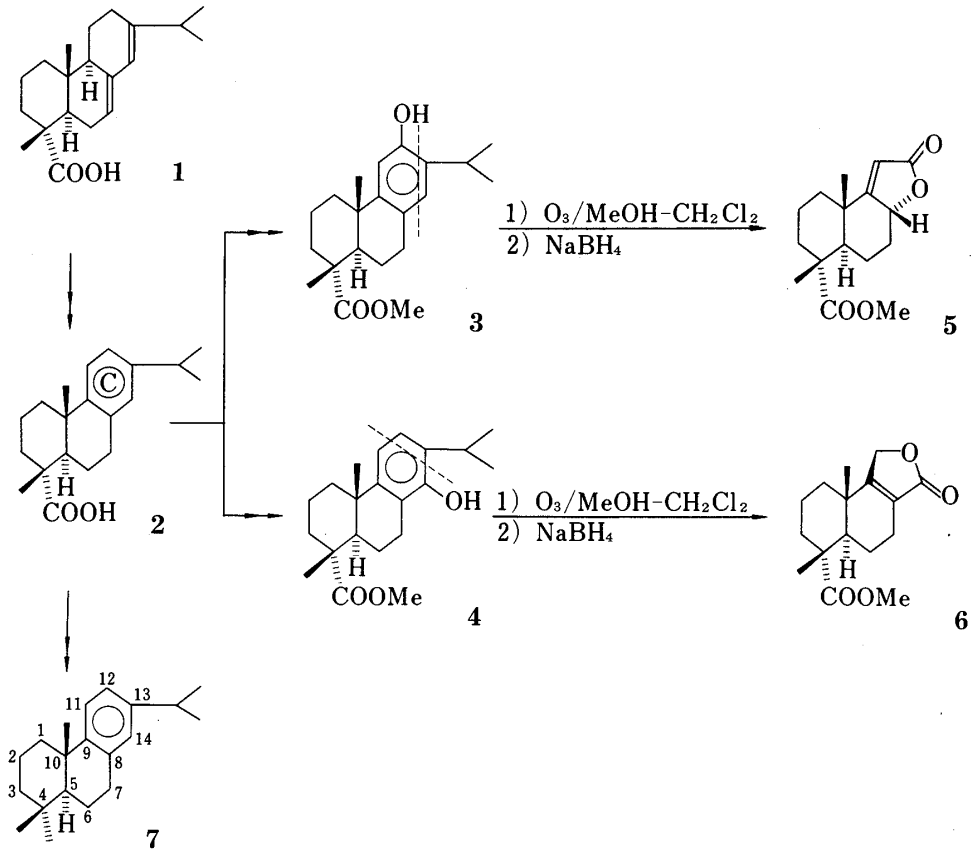

Chart 1

which is easily obtained from **1**. We have already reported that ozonolysis of the phenolic dehydroabietic acid derivatives **3** and **4** results in selective cleavage of the aromatic C-ring of **2**, producing **5** and **6**, respectively.[2]

The relationship between the position of the hydroxyl group on the aromatic C-ring and the cleavage pattern of ozonolysis was then investigated. In this work, we examined the introduction of a hydroxyl group at every possible position (11-, 12-, 13-, and 14-positions) of the aromatic C-ring of dehydroabietane (**7**)[3] derived from **2**.

1) Synthesis of the 12-Hydroxy Compound, Ferruginol (10), and the 11,12-Dihydroxy Compound (14)

The Friedel–Crafts acetylation of dehydroabietane (**7**) with AcCl and $AlCl_3$ in nitrobenzene gave the 12-acetyl compound (**8**) in 63% yield. The Baeyer–Villiger oxidation of **8** with 40% peracetic acid in CH_2Cl_2 afforded the 12-acetoxy compound (**9**) in quantitative yield, and this was hydrolyzed with conc. H_2SO_4 in MeOH to give ferruginol (**10**)[4] also in quantitative yield.

Next, synthesis of the 11,12-dihydroxy derivative (**14**) was carried out in place of the 11-hydroxy compound (**11**) because the synthesis of the latter was expected to be quite difficult. Nitration[5] of **10** gave the crude 12-hydroxy-11-nitro compound (**12**), which, without further

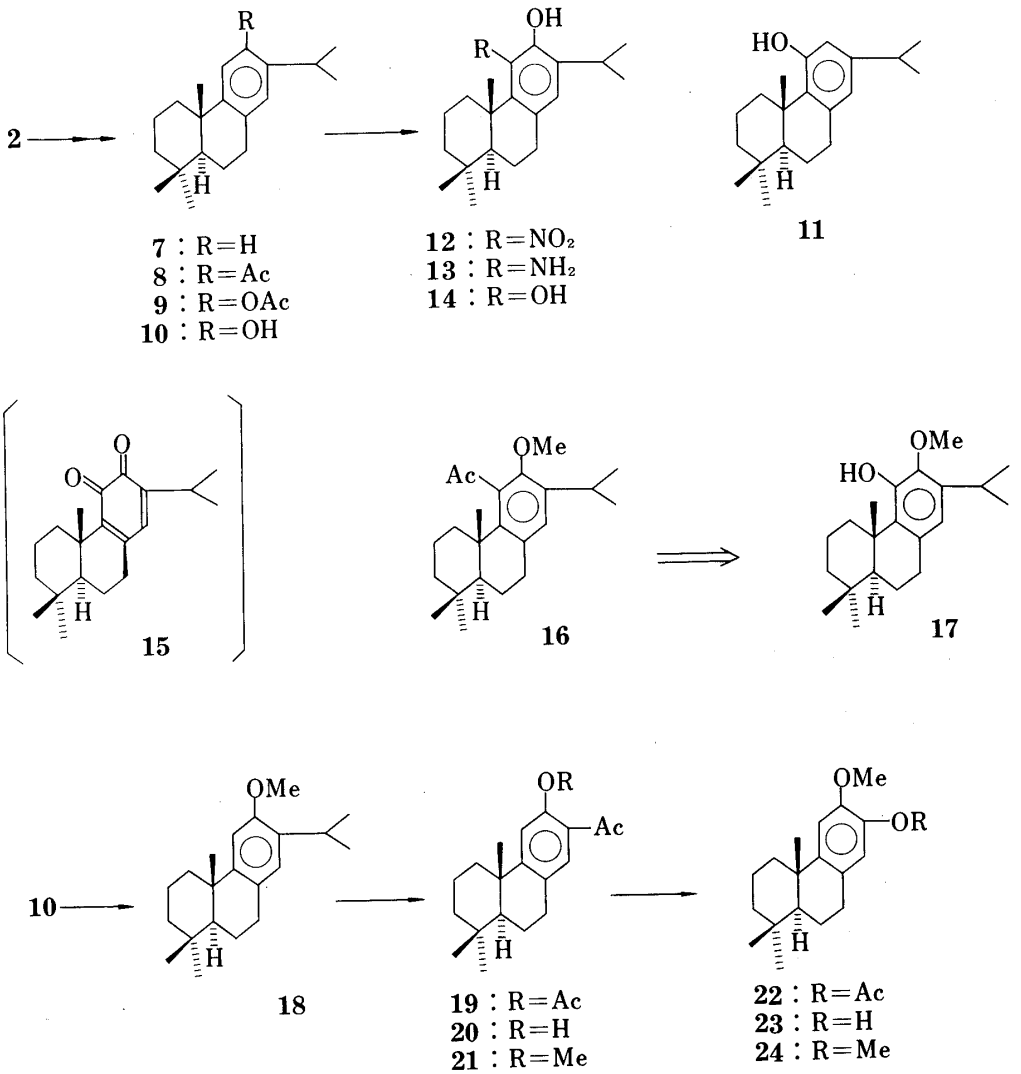

Chart 2

purification, was hydrogenated (H_2/PtO_2) to afford the amino phenol (**13**). Oxidation of **13** with $FeCl_3$ followed by catalytic hydrogenation (H_2/10% Pd–C) of the crude product[6] gave the desired 11,12-dihydroxy compound (**14**) in 37% overall yield from **10**.

Since the yield of **14** was not satisfactory, another route for the preparation of 11,12-dihydroxy derivatives was then sought. In order to obtain the 11-acetyl-12-methoxy compound (**16**), which could easily be converted to the desired 11-hydroxy compound (**17**), Friedel–Crafts acetylation of O-methyl ferruginol (**18**)[4] derived from **10** was investigated. Treatment of **18** with AcCl and $AlCl_3$ in CH_2Cl_2 gave, however, the 13-acetyl compounds (**19**; 30% yield, **20**; 30% yield, **21**; 10% yield), with deisopropylation in every case.[7] The structures of these unexpected compounds were determined by nuclear magnetic resonance (NMR) analysis of the aromatic substitution pattern and by means of the following chemical correlations. Hydrolysis of the 12-acetoxy-13-acetyl compound (**19**) gave the 13-acetyl-12-hydroxy compound (**20**), which was converted to the 13-acetyl-12-methoxy compound (**21**) by treatment with Me_2SO_4. The Baeyer–Villiger oxidation of **21** with 40% peracetic acid in CH_2Cl_2 afforded the 13-acetoxy-12-methoxy compound (**22**), which was finally led to the 12,13-dimethoxy compound (**24**) by way of the 13-hydroxy-12-methoxy compound (**23**). The physical data of **24** thus obtained were identical with those of an authentic sample of **24**, the preparation of which will be described later in this paper.

2) Synthesis of the 14-Hydroxy Compound (32) and the 13-Hydroxy Compound (37)

The known 7-ketone (**25**)[3] derived from **7** was nitrated[8] with fum. HNO_3 (d=1.52)–conc. H_2SO_4 (20:1) to give a mixture of the 14-nitro-7-oxo compound (**26**) and the 13-nitro-7-oxo

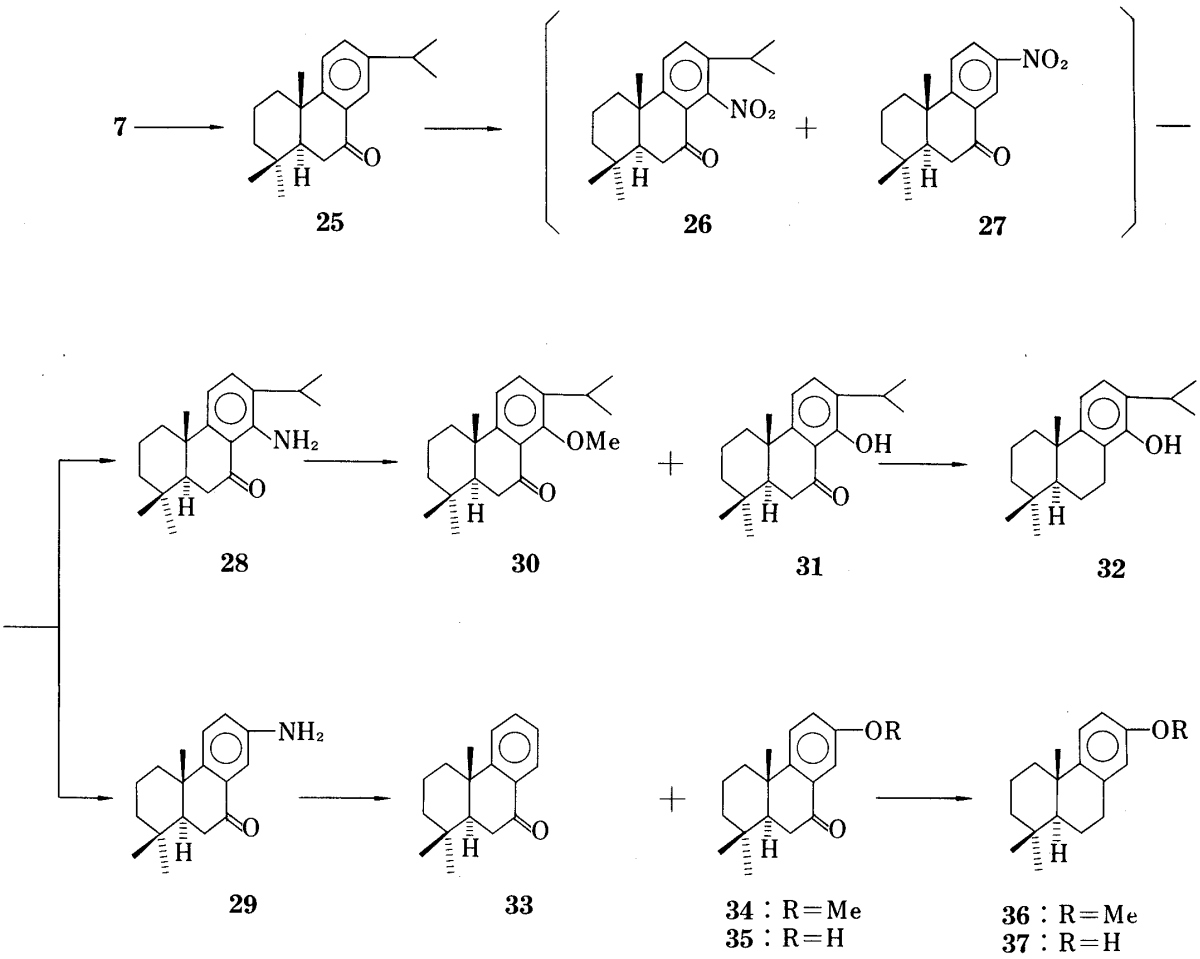

Chart 3

compound (**27**) in *ca.* 1: 1 ratio, which were subjected to further reaction without separation. This mixture was reduced with Sn–HCl and the products were separated by SiO_2 column chromatography to afford the corresponding 14-amino-7-oxo compound (**28**; 30% overall yield from **25**) and the 13-amino-7-oxo compound (**29**; 35% overall yield from **25**). The amine

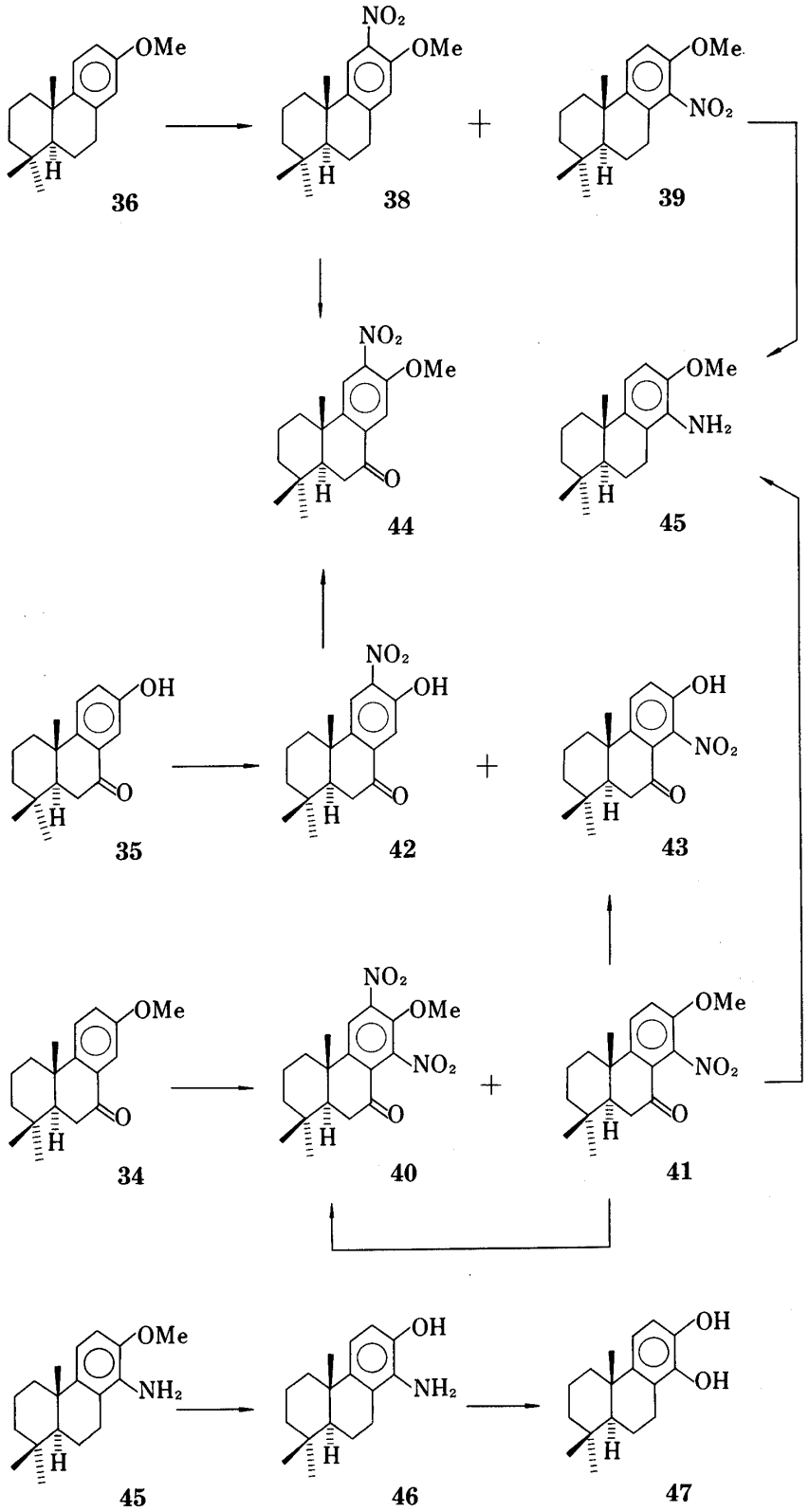

Chart 4

(**28**) was treated with $NaNO_2$ in MeOH in the presence of conc. H_2SO_4 and the resulting mixture was subjected to column chromatography (SiO_2) to give the 14-methoxy-7-oxo compound (**30**; 62% yield) and the 14-hydroxy-7-oxo compound (**31**; 20% yield). The phenol (**31**) was also obtained by treatment of **30** with HI–HBr. Reduction of **31** with $NaBH_4$ followed by hydrogenolysis with 10% Pd–C afforded the desired 14-hydroxy compound (**32**) in 92% yield.

On the other hand, treatment of the 13-amino-7-oxo compound (**29**) with $NaNO_2$ in the same way as for **28** afforded the deamino 7-oxo compound (**33**; 22% yield), the 13-methoxy-7-oxo compound (**34**; 28% yield), and the 13-hydroxy-7-oxo compound (**35**; 14% yield). Demethylation of **34** with HI–HBr also gave **35**. Catalytic hydrogenolysis of **34** and **35** in the presence of 60% $HClO_4$ afforded quantitatively the 13-methoxy compound (**36**) and the 13-hydroxy compound (**37**).

3) Synthesis of the 13,14-Dihydroxy Compound (47)

In order to obtain the 13,14-disubstituted compound, nitration and Friedel–Crafts acetylation of the 13-substituted compounds (**34**, **35**, and **36**) were carried out.

Nitration of **36** with fum. HNO_3 (d=1.52) in Ac_2O afforded the 12-nitro compound (**38**; 48% yield) and the 14-nitro compound (**39**; 35% yield). On the other hand, nitration of the 13-methoxy-7-oxo compound (**34**) gave the 12,14-dinitro compound (**40**) and the desired 14-nitro compound (**41**). In this case, the product distribution in the nitration reaction was found to be subtly affected by the density of nitric acid, as shown in Table I.

Table I

Density of HNO_3	Products (%)		
	40	**41**	**34** (S.M.)
d=1.52	35		
d=1.45	41	28	
d=1.43		84	
d=1.415		33	65
d=1.38			Quantitative

It is noteworthy that when nitric acid of d=1.43 was used, the desired 14-nitro compound (**41**) was exclusively obtained in 84% yield from **34**. On the other hand, in the nitration of the 13-hydroxy-7-oxo compound (**35**) using the same nitric acid of d=1.43, an inseparable mixture was obtained. When nitric acid of d=1.415 was used, the 12-nitro compound (**42**; 18% yield) and the 14-nitro compound (**43**; 46% yield) were obtained, as shown in Table II.

Table II

Density of HNO_3	Products (%)		
	42	**43**	**35** (S.M.)
d=1.43	Many products		
d=1.415	18	46	15
d=1.38			Quantitative

The structures of the above nitration products (**38**, **39**, **40**, **41**, **42**, and **43**) were determined both by NMR analysis of the substitution pattern (*ortho*- and *para*-pattern) in the aromatic C-ring and by chemical correlations. Oxidation of **38** afforded the corresponding 7-oxo compound (**44**), whose physical data were identical with those of the methylation product of **42**.

The compound (**41**) was chemically correlated with the above-mentioned **40** or **43** by nitration or demethylation, respectively. Reduction of **39** with Sn–HCl in MeOH gave the 14-amino-13-methoxy compound (**45**), whose physical data were identical with those of the product derived from **41** by successive reduction with Sn–HCl, $NaBH_4$, and H_2/Pd–C. The amino anisole (**45**) thus obtained was treated with Me_3SiI[9] in sulfolane to give the amino phenol (**46**), which, without further purification, was converted to the desired 13,14-dihydroxy compound (**47**; 96% yield) by applying Stubenrauch's technique.[10]

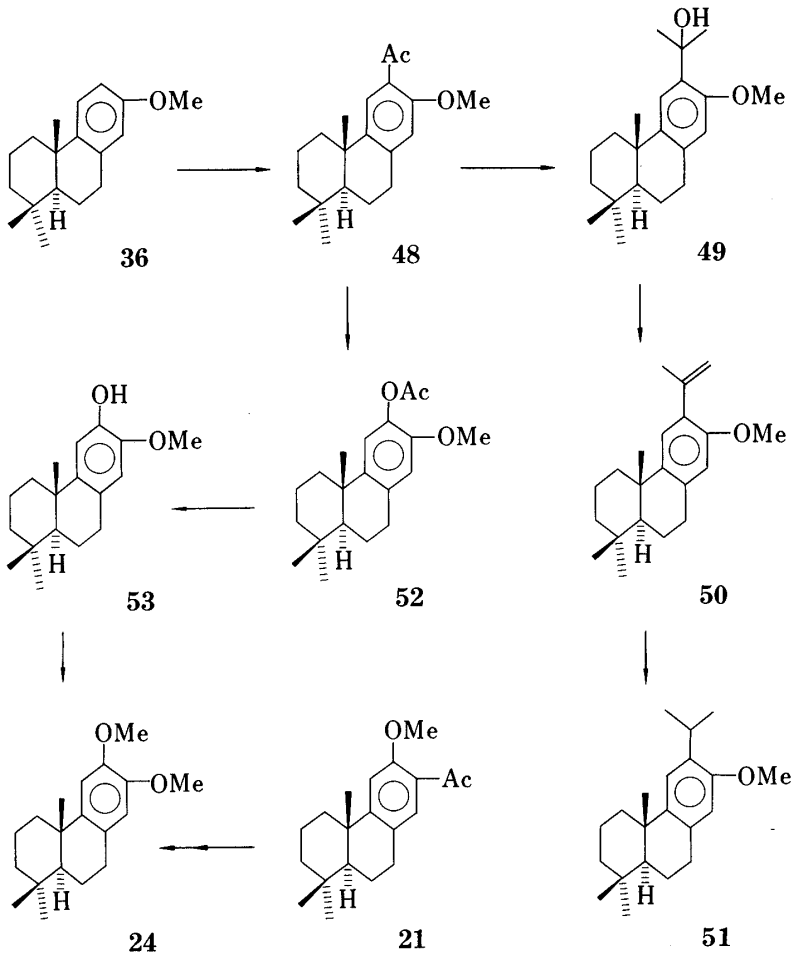

Chart 5

Although positional selectivity was not observed in the nitration of the 13-methoxy compound (**36**), the Friedel–Crafts reaction of **36** with AcCl and $AlCl_3$ in nitrobenzene was found to give selectively the 12-acetylated product (**48**; 71% yield). The structure of **48** was determined by analysis of the NMR spectra. Finally. **48** was converted to O-methyl sempervirol (**51**). Methylation with MeLi, dehydration with $SOCl_2$ in pyridine and catalytic hydrogenation of **48** gave **51**. The spectral data of the synthetic **51** were identical with those of an authentic sample (**51**) derived from dehydroabietic acid (**2**) by Matsumoto.[7]

Now, **48** was found to possess an acetyl group at the 12-position as well as the methoxyl group at the 13-position. Therefore, **48** was converted into the 12,13-dimethoxy compound (**24**) (Baeyer–Villiger oxidation, hydrolysis and methylation with Me_2SO_4) to confirm the presence of an acetyl group at the 13-position of **21**, since **21** had already been correlated with **24** as mentioned above.

Thus, we succeeded in the synthesis of all the possible phenolic dehydroabietane derivatives (**10**, **14**, **32**, **37**, and **47**) having hydroxyl groups at the 11-, 12-, 13-, and 14-positions. The

ozonolysis of these phenolic dehydroabietane derivatives will be described in the following paper.

Experimental

All melting points were measured on a Kofler micro melting point apparatus and are uncorrected. Infrared (IR) spectra (CCl_4) were measured on a JASCO A-3 spectrophotometer. NMR spectra were measured on a JEOL MH-60 spectrometer and spectra were taken as 5—10% (w/v) solutions in $CDCl_3$ with Me_4Si as an internal reference. Gas chromatography–mass spectroscopy (GC–MS) spectra were measured on a Hitachi RMU-6M mass spectrometer and high-resolution mass spectra were taken with a JMS-01SG spectrometer. Gas-liquid chromatography (GLC) was carried out on a column (2 m×4 mm) of 1.5% OV-17 on Shimalite W (80—100 mesh).

Friedel-Crafts Acetylation of Dehydroabietane (**7**)——A solution of **7** (30 g), acetyl chloride (15 ml) and aluminum chloride (30 g) in nitrobenzene (200 ml) was stirred for 24 hr at room temperature. The reaction mixture was extracted with ether after H_2O had been added and the extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product, which was subjected to steam-distillation until no nitrobenzene could be detected. The reaction mixture gave an oil (34.2 g) after the usual treatment, and this was recrystallized from MeOH to give 12-acetyldehydroabietane as colorless needles (**8**) (21.9 g, 63% yield), mp 101—102°. *Anal.* Calcd for $C_{22}H_{32}O$: C, 84.56; H, 10.32. Found: C, 84.45; H, 10.33. IR ν_{max}^{KBr} cm^{-1}: 1680. NMR δ: 0.95 (6H, s, 4-*gem* Me), 1.17 (3H, s, 10-Me), 1.17, 1.20 (each 3H, d, J=7.2 Hz, isopropyl Me), 2.55 (3H, s, 12-Ac), 7.08 (1H, s, 14-H), 7.46 (1H, s, 11-H).

Preparation of 12-Hydroxydehydroabietane (**Ferruginol**, **10**)——i) A solution of **8** (15.6 g) and 40% peracetic acid (90 ml) in CH_2Cl_2 (60 ml) was stirred for 72 hr at room temperature. The reaction mixture was extracted with ether after H_2O had been added and the extract was washed with sat. $NaHCO_3$ aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave a homogeneous oil (**9**), which was used for the next reaction without further purification. **9**: IR ν_{max} cm^{-1}: 1765. NMR δ: 0.94 (3H, s, 4-*gem* Me), 1.17 (3H, s, 10-Me), 1.18 (6H, d, J=7.2 Hz, isopropyl Me), 2.26 (3H, s, 12-OAc), 6.88, 7.00 (each 1H, s, 11-, 14-H).

ii) The crude oil (**9**) was hydrolyzed in conc. H_2SO_4 (0.2 ml)–MeOH (200 ml) under reflux for 1.5 hr with stirring. The residue obtained by the removal of MeOH was extracted with ether and the extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent afforded an oil (16.2 g), which was chromatographed on silica gel (100 g) to give ferruginol as a homogeneous oil (**10**) (14.3 g, quantitative yield from **8**) from the petr. ether–benzene (2: 1—1: 1) eluate. *Anal.* GC–MS Calcd for $C_{20}H_{30}O$ (M^+, *m/e*): 286. Found: 286. IR ν_{max} cm^{-1}: 3640. NMR δ: 0.90 (6H, s, 4-*gem* Me), 1.10 (3H, s, 10-Me), 1.18 (6H, d, J=7.2 Hz, isopropyl Me), 5.48 (1H, br s, 12-OH), 6.54, 6.75 (each 1H, s, 11-, 14-H).

Synthesis of 11,12-Dihydroxydehydroabietane (**14**)——i) Ferruginol (**10**) (5.186 g) in Ac_2O (50 ml) was nitrated with a solution of 25 ml of conc. HNO_3 (d=1.38)–Ac_2O (1: 10) under stirring at 0—4° for 30 min. The mixture was poured into ice-water, then extracted with ether. The extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oil (**12**) (6.119 g), which was used for the next reaction without further purification.

ii) A mixture of the crude nitro phenol (**12**) (6.119 g) and PtO_2 (740 mg) in *iso*-PrOH (100 ml) was stirred for 24 hr at room temperature under a hydrogen atmosphere. The filtrate of the reaction mixture was concentrated under reduced pressure to give a crude amino phenol (**13**) (6.587 g).

iii) A solution of $FeCl_3 \cdot 6H_2O$ (9.6 g) in 0.5 N HCl aq. (250 ml) was added to a solution of **13** (6.587 g) in MeOH (320 ml) and the mixture was stirred for 1 hr at room temperature. After dilution with H_2O, the mixture was extracted with $CHCl_3$ and the extract was washed with sat. NaCl aq. then dried over Na_2SO_4. Removal of the solvent gave a crude oily product (6.266 g).

iv) A mixture of the above product (6.266 g) and 10% Pd–C (2 g) in AcOH (50 ml) was stirred for 12 hr at room temperature under a hydrogen atmosphere. The filtrate of the reaction mixture was evaporated to dryness under reduced pressure to give a residue, which was extracted with ether after H_2O had been added. The extract was washed with sat. Na_2CO_3 aq. and sat. NaCl, then dried over Na_2SO_4. Removal of the solvent gave an oil (5.455 g), which was chromatographed on silica gel (100 g) to give 11,12-dihydroxydehydroabietane as a homogeneous oil (**14**) (2.019 g, 37% overall yield from **10**) from the petr. ether–ether (9: 1—4: 1) eluate. *Anal.* high-resolution mass spectrum. Calcd for $C_{20}H_{30}O_2$: 302.224. Found: 302.223. IR ν_{max} cm^{-1}: 3560, 3640. NMR δ: 0.96 (6H, s, 4-*gem* Me), 1.19, 1.22 (each 3H, d, J=7.2 Hz, isopropyl Me), 5.46, 5.89 (each 1H, br s, 11-, 12-OH), 6.55 (1H, s, 14-H).

Friedel-Crafts Reaction of O-Methylferruginol (**18**)——A solution of **18** (1.502 g), acetyl chloride (0.71 ml) and aluminum chloride (1.33 g) in CH_2Cl_2 (10 ml) was stirred for 16 hr at room temperature. The reaction mixture was extracted with ether after H_2O had been added and the extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product, which was chromatographed on silica gel (80 g) to provide three fractions upon *n*-hexane–ethyl acetate (10: 1—5: 1) elution. The first fraction (429 mg, 30% yield) was recrystallized from MeOH to give 13-acetyl-12-hydroxy-

13-deisopropyldehydroabietane (**20**) as colorless needles, mp 124—125°. *Anal.* Calcd for $C_{19}H_{26}O_2$: C, 79.68; H, 9.15. Found: C, 79.68; H, 9.13. IR ν_{max} cm^{-1}: 1664. NMR δ: 0.93 (6H, s, 4-gem Me), 1.17 (3H, s, 10-Me), 2.54 (3H, s, 13-Ac), 6.84 (1H, s, 11-H), 7.38 (1H, s, 14-H). The second fraction (153 mg, 10% yield) was recrystallized from *n*-hexane to give 13-acetyl-12-methoxy-13-deisopropyldehydroabietane (**21**) as colorless prisms, mp 78—81°. *Anal.* Calcd for $C_{20}H_{28}O_2$: C, 79.95; H, 9.39. Found: C, 79.84; H, 9.31. IR ν_{max} cm^{-1}: 1680. NMR δ: 0.98 (6H, s, 4-*gem* Me), 1.23 (3H, s, 10-Me), 2.60 (3H, s, 13-Ac), 3.89 (3H, s, 12-OMe), 6.84 (1H, s, 11-H), 7.45 (1H, s, 14-H). The third fraction (488 mg, 30% yield) was recrystallized from *n*-hexane to give 13-acetyl-12-acetoxy-13-deisopropyldehydroabietane (**19**) as pale yellow prisms, mp 110—110.5°. *Anal.* Calcd for $C_{21}H_{28}O_3$: C, 76.79; H, 8.59. Found: C, 76.82; H, 8.61. IR ν_{max} cm^{-1}: 1765, 1695, 1205. NMR δ: 0.95 (6H, s, 4-*gem* Me), 1.19 (3H, s, 10-Me), 2.31 (3H, s, 12-OAc), 2.49 (3H, s, 13-Ac), 6.95 (1H, s, 11-H), 7.49 (1H, s, 14-H).

Hydrolysis of 13-Acetyl-12-acetoxy-13-deisopropyldehydroabietane (19)——A solution of **19** (129 mg), conc. H_2SO_4 (1 drop) and H_2O (0.1 ml) in MeOH (20 ml) was stirred for 3 hr at reflux. The residue obtained on removal of MeOH was extracted with ether and the extract was washed with sat. $NaHCO_3$ aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product (97 mg), which was recrystallized from MeOH to give colorless prisms (**20**) (61 mg). Physical data (IR, NMR, and GLC) for these crystals (**20**) were identical with those of the previous authentic sample (**20**).

Methylation of 13-Acetyl-12-hydroxy-13-deisopropyldehydroabietane (20)——A mixture of **20** (166 mg), Me_2SO_4 (1 ml) and K_2CO_3 (2 g) in acetone (30 ml) was stirred for 12 hr under reflux. The filtrate of the reaction mixture was evaporated to dryness under reduced pressure to give a residue, which was extracted with ether after H_2O had been added. The extract was washed with sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product (201 mg). A part of the above oil was recrystallized from *n*-hexane to afford colorless prisms (**21**), whose physical data (IR, NMR, and GLC) were identical with those of the previous authentic sample (**21**).

Conversion of 13-Acetyl-12-methoxy-13-deisopropyldehydroabietane (21) to 12,13-Dimethoxy-13-deisopropyldehydroabietane (24)——i) A mixture of crude **21** (759 mg) and 40% peracetic acid (7 ml) in CH_2Cl_2 (4 ml) was stirred for 60 hr at room temperature. The reaction mixture was treated as in the case of the Baeyer–Villiger oxidation of **8** to give oily product (517 mg), which was chromatographed on silica gel (30 g) to give 13-acetoxy-12-methoxy-13-deisopropyldehydroabietane (**22**) ss a homogeneous oil (250 mg) from the *n*-hexane–ethyl acetate (9: 1) eluate. IR ν_{max} cm^{-1}: 1765, 1200. NMR δ: 0.93 (6H, s, 4-*gem* Me), 1.20 (3H, s, 10-Me), 2.29 (3H, s, 13-OAc), 3.78 (3H, s, 12-OMe), 6.69, 6.84 (each 1H, s, 11-, 14-H).

ii) A mixture of **22** (250 mg), conc. H_2SO_4 (1 drop) and H_2O (0.1 ml) in MeOH (10 ml) was stirred for 1 hr under reflux. The reaction mixture was treated as in the case of the hydrolysis of **19** to give 13-hydroxy-12-methoxy-13-deisopropyldehydroabietane (**23**) as an oily material (174 mg). IR ν_{max} cm^{-1}: 3550. NMR δ: 0.94 (6H, s, 4-*gem* Me), 1.19 (3H, s, 10-Me), 3.84 (3H, s, 12-OMe), 5.57 (1H, br s, 13-OH), 6.63, 6.79 (each 1H, s, 11-, 14-H).

iv) A mixture of **23** (174 mg), Me_2SO_4 (1 ml) and K_2CO_3 (2 g) in acetone (30 ml) was stirred for 12 hr under reflux. The reaction mixture was treated as in the case of the methylation of **20** to give an oily product (218 mg), which was chromatographed on silica gel (30 g) to give 12,13-dimethoxy-13-deisopropyldehydroabietane (**24**) as a homogeneous oil (125 mg). The physical data (IR, NMR, and GLC) of the above sample (**24**) were identical with those of the authentic sample (**24**) as described later in this paper.

Preparation of 14-Amino-7-oxodehydroabietane (28) and 13-Amino-7-oxo-13-deisopropyldehydroabietane (29)——i) 7-Oxodehydroabietane (**25**) (5 g) was added to a solution of fum. HNO_3 (d=1.52) (20 ml)–conc. H_2SO_4 (1 ml) under ice–salt cooling. The reaction mixture was stirred for 30 min, then poured into ice-water and extracted with ether. The extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave crude crystals (**26** and **27**) (6.025 g), which were used for the next reaction without further purification.

ii) A mixture (6.025 g) of 14-nitro-7-oxodehydroabietane (**26**) and 13-nitro-7-oxo-13-deisopropyldehydroabietane (**27**) was refluxed in conc. HCl aq. (40 ml)–MeOH (40 ml) with Sn dust (8 g) for 12 hr under stirring. Excess solvent was evaporated off under reduced pressure, and the residue was extracted with ether after 20% NaOH aq. had been added. The extract was washed with sat. NaCl aq. then dried over Na_2SO_4. An oil (4.889 g) obtained by the removal of the solvent was chromatographed on silica gel (100 g) to provide two fractions. The first fraction was eluted with petr. ether–ether (19: 1—9: 1) to give 14-amino-7-oxodehydroabietane (**28**) as a homogeneous oil (1.554 g, 30% yield from **25**). *Anal.* high-resolution mass spectrum. Calcd for $C_{20}H_{29}ON$ (M^+, m/e): 299.225. Found: 299.224. IR ν_{max} cm^{-1}: 3310, 3525, 1640. NMR δ: 0.91, 0.97 (each 3H, s, 4-*gem* Me), 1.18 (3H, s, 10-Me), 1.21, 1.24 (each 3H, d, J=7.2 Hz, isopropyl Me), 6.58, 7.22 (each 1H, d, J=7.2 Hz; 11-, 12-H). The second fraction was eluted with petr. ether–ether (1: 1) to afford 13-amino-7-oxo-13-deisopropyldehydroabietane (**29**) as a homogeneous oil (1.592 g, 35% yield from **25**). *Anal.* high-resolution mass spectrum. Calcd for $C_{17}H_{23}ON$ (M^+, m/e): 257.178. Found: 257.176. IR ν_{max} cm^{-1}: 3500, 3420, 1680. NMR δ: 0.86, 0.94 (each 3H, s, 4-*gem* Me), 1.14 (3H, s, 10-Me), 4.04 (2H, s, 13-NH_2), 6.86 (1H, dd, J=2, 8.4 Hz, 12-H), 7.17 (1H, d, J=8.4 Hz, 11-H), 7.37 (1H, d, J=2 Hz, 14-H).

Preparation of 14-Methoxy-7-oxodehydroabietane (30) and 14-Hydroxy-7-oxodehydroabietane (31)——

A solution of 14-amino-7-oxodehydroabietane (**28**) (8.705 g) and conc. H_2SO_4 (70 ml) in MeOH (1400 ml) was treated with $NaNO_2$ (10 g) under ice cooling (0—5°) and the mixture was stirred for 2 hr at room temperature. Urea (10 g) was added, and the reaction mixture was stirred for 30 min more, then evaporated to dryness on a steam bath. The residue was extracted with benzene. The benzene extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product (8.882 g), which was chromatographed on silica gel (200 g) to provide two fractions. The first fraction was eluted with benzene–petr. ether (1: 3) to give 14-hydroxy-7-oxodehydroabietane (**31**) as a homogeneous oil (1.770 g, 20% yield). *Anal.* high-resolution mass spectrum. Calcd for $C_{20}H_{28}O_2$ (M^+, *m/e*): 300.209. Found: 300.208. IR ν_{max} cm^{-1}: 1630. NMR δ: 0.92, 0.98 (each 3H, s, 4-*gem* Me), 1.19 (3H, s, 10-Me), 1.20 (6H, d, J=7.2 Hz, isopropyl Me), 6.73, 7.33 (each 1H, d, J=8.4 Hz, 11-, 12-H). The second fraction was eluted with petr. ether–ether (9: 1) to give 14-methoxy-7-oxodehydroabietane (**30**) as a homogeneous oil (5.624 g, 62% yield). *Anal.* Calcd for $C_{21}H_{30}O_2$ (M^+, *m/e*): 314.225. Found: 314.223. IR ν_{max} cm^{-1}: 1686. NMR δ: 0.91, 1.00 (each 3H, s, 4-*gem* Me), 1.17 (3H, s, 10-Me), 1.17, 1.21 (each 3H, d, J=7.2 Hz, isopropyl Me), 3.80 (3H, s, 14-OMe), 7.07, 7.40 (each 1H, d, J=8.4 Hz, 11-, 12-H).

Direct Synthesis of 14-Hydroxy-7-oxodehydroabietane (31) from 28——14-Amino-7-oxodehydroabietane (**28**) (15.023 g) was treated with a solution of $NaNO_2$ (8.667 g) and conc. H_2SO_4 (125 ml) in MeOH (2500 ml) to give a crude reaction mixture by the same procedure as in the previously described diazotization. A mixture of the reaction product (14.5 g), 48% HBr aq. (50 ml) and HI aq. (5 ml) in AcOH (50 ml) was refluxed with stirring for 1 hr under a nitrogen atmosphere. The reaction mixture was extracted with ether after H_2O had been added, and the extract was washed with sat. Na_2CO_3 aq. and NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product, which was chromatographed on silica gel (120 g) to afford 14-hydroxy-7-oxodehydroabietane (**31**) as a homogeneous oil (8.319 g, 55% yield from **28**) from the petr. ether–benzene (3: 1) eluate. Its physical data (NMR and GLC) were identical with those of the previous authentic sample (**31**).

Preparation of 14-Hydroxydehydroabietane (32)——A solution of 14-hydroxy-7-oxodehydroabietane (**31**) (8.319 g) in EtOH (100 ml) was reduced with $NaBH_4$ (5 g) under stirring for 3 hr at 0—5°. The reaction mixture was extracted with ether after acidification with 10% HCl aq. and the ether extract was washed with sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product, which was catalytically hydrogenolyzed in AcOH (100 ml)–conc. H_2SO_4 (5 drops) in the presence of 10% Pd–C (2 g) under a hydrogen atmosphere (3—4 kg/cm^2). The filtrate was concentrated, and H_2O was added to the residue. The solution was extracted with ether and the extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product (7.728 g), which was chromatographed on silica gel (100 g) to afford 14-hydroxy-dehydroabietane (**32**) as a homogeneous oil (7.259 g, 92% yield) from the petr. ether–benzene (9: 1—4: 1) eluate. *Anal.* high resolution mass spectrum. Calcd for $C_{20}H_{30}O$ (M^+, *m/e*): 286.230. Found: 286.232. IR ν_{max} cm^{-1}: 3640. NMR δ: 0.97 (6H, s, 4-*gem* Me), 1.20 (3H, s, 10-Me), 1.24 (6H, d, J=7.2 Hz, isopropyl Me), 5.10 (1H, br s, 14-OH), 6.99, 7.22 (each 1H, d, J=8.4 Hz, 11-, 12-H).

Preparation of 13-Methoxy-7-oxo-13-deisopropyldehydroabietane (34) and 13-Hydroxy-7-oxo-13-deisopropyldehydroabietane (35)——A solution of 13-amino-7-oxo-13-deisopropyldehydroabietane (**29**) (7.762 g) and conc. H_2SO_4 (40 ml) in MeOH (800 ml) was treated with $NaNO_2$ (5.203 g) under ice cooling (0—5°) and the whole was stirred for 2 hr at room temperature. Urea (5 g) was added, and the reaction mixture was stirred for 30 min more. The reaction mixture was treated as in the case of the diazotization of **28** to give a crude oily product (7 g). The diazotization reaction was then carried out as before but on a ten times larger scale. Finally, the diazotization product (66.95 g) was obtained from 75.346 g of **29**, and chromatographed on silica gel (600 g) to provide three fractions. The first fraction was eluted with petr. ether–ether (19: 1) to give 7-oxo-13-deisopropyldehydroabietane (**33**) as a homogeneous oil (15.3 g, 22% yield). *Anal.* GC–MS. Calcd for $C_{17}H_{22}O$ (M^+, *m/e*): 242. Found: 242. IR ν_{max} cm^{-1}: 1681. NMR δ: 0.95, 1.02 (each 3H, s, 4-*gem* Me), 1.25 (3H, s, 10-Me), 7.20—7.70 (3H, m, 11-, 12-, 13-H), 8.00 (1H, d, J=8 Hz, 14-H). The second fraction was eluted with petr. ether–ether (19: 1) to give 13-methoxy-7-oxo-13-deisopropyldehydroabietane (**34**) as a homogeneous oil (22.696 g, 28% yield). A part of **34** was converted into the corresponding 2,4-dinitrophenylhydrazone (mp 216.5—217°). *Anal.* Calcd for $C_{24}H_{28}O_5N_4$: C, 63.70; H, 6.24; N, 12.38. Found: C, 63.51; H, 6.17; N, 12.47. **34**: *Anal.* high-resolution mass spectrum. Calcd for $C_{18}H_{24}O_2$ (M^+, *m/e*): 272. Found: 272. IR ν_{max} cm^{-1}: 1683. NMR δ: 0.92, 0.99 (each 3H, s, 4-*gem* Me), 1.20 (3H, s, 10-Me), 3.81 (3H, s, 13-OMe), 7.02 (1H, dd, J=2.4, 8.4 Hz, 12-H), 7.28 (1H, d, J=8.4 Hz, 11-H), 7.47 (1H, d, J=2.4 Hz, 14-H). The third fraction was eluted with petr. ether–ether (3: 1—2: 1) to give 13-hydroxy-7-oxo-13-deisopropyldehydroabietane (**35**) as crystals (10.508 g, 14% yield), which were recrystallized from *n*-hexane–ethyl acetate to give pale yellow prisms (**35**), mp 199.5—200°. *Anal.* Calcd for $C_{17}H_{22}O_2$: C, 79.03; H, 8.58. Found: C, 79.13; H, 8.55. IR ν_{max} cm^{-1}: 3600, 1675. NMR δ: 0.93, 1.00 (each 3H, s, 4-*gem* Me), 1.21 (3H, s, 10-Me), 7.09 (1H, dd, J=2.4, 9.0 Hz, 12-H), 7.29 (1H, d, J=9.0 Hz, 11-H), 7.55 (1H, br s, 13-OH), 7.65 (1H, d, J=2.4 Hz, 14-H).

Hydrogenolysis of 13-Methoxy-7-oxo-13-deisopropyldehydroabietane (34)——13-Methoxy-7-oxo-13-deisopropyldehydroabietane (**34**) (485 mg) was hydrogenolyzed in ethyl acetate (20 ml)–60% $HClO_4$ (5 drops) with 10% Pd–C (300 mg) under a hydrogen atmosphere. The catalyst was filtered off, and the filtrate was

concentrated, then diluted with H_2O and extracted with ether. The extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave crystals, which were recrystallized from MeOH to give 13-methoxy-13-deisopropyldehydroabietane (**36**) as colorless plates (450 mg, 98% yield), mp 84—86.5°. *Anal.* Calcd for $C_{18}H_{26}O$: C, 83.66; H, 10.14. Found: C, 83.61; H, 10.18. NMR δ: 0.92 (6H, s, 4-*gem* Me), 1.14 (3H, s, 10-Me), 3.60 (3H, s, 13-OMe), 6.48 (1H, d, $J=2$ Hz, 14-H), 6.57 (1H, dd, $J=2$, 8.4 Hz, 12-H), 7.05 (1H, d, $J=8.4$ Hz, 11-H).

Hydrogenolysis of 13-Hydroxy-7-oxo-13-deisopropyldehydroabietane (**35**)——13-Hydroxy-7-oxo-13-deisopropyldehydroabietane (**35**) (2.592 g) was hydrogenolyzed in ethyl acetate (50 ml)–60% $HClO_4$ (10 drops) with 10% Pd–C (1.5 g) under a hydrogen atmosphere. The reaction mixture was treated as in the case of the hydrogenolysis of **34** to afford a homogeneous oil (**37**) (2.449 g, quantitative yield). A part of the above oily product was recrystallized from *n*-hexane to give 13-hydroxy-13-deisopropyldehydroabietane (**37**) as colorless needles, mp 127—127.5°. *Anal.* Calcd for $C_{17}H_{24}O$: C, 83.55; H, 9.90. Found: C, 83.66; H, 9.78. IR ν_{max} cm^{-1}: 3600. NMR δ: 0.93 (6H, s, 4-*gem* Me), 1.15 (3H, s, 10-Me), 4.72 (1H, br s, 13-OH), 6.47—6.73 (2H, m, 12-, 14-H), 7.10 (1H, d, $J=8$ Hz, 11-H).

Nitration of 13-Methoxy-13-deisopropyldehydroabietane (**36**)——13-Methoxy-13-deisopropyldehydroabietane (**36**) (470 mg) in Ac_2O (5 ml) was nitrated with fum. HNO_3 ($d=1.52$)–Ac_2O (1: 10) (3 ml) under stirring at 0—4° for 30 min. The reaction mixture was treated as in the case of the nitration of **10** to give crude crystals, which were recrystallized from MeOH to give pale yellow plates (**38**) (101 mg). The mother liquor was chromatographed on silica gel (80 g) to provide two fractions by *n*-hexane–ethyl acetate (19: 1) elution. The first fraction was recrystallized from MeOH to give 13-methoxy-14-nitro-13-deisopropyldehydroabietane (**39**) as pale yellow plates, (194 mg, 35% yield), mp 153—155°. *Anal.* Calcd for $C_{18}H_{25}NO_3$: C, 71.25; H, 8.31; N, 4.62. Found: C, 71.21; H, 8.33; N, 4.60. IR ν_{max} cm^{-1}: 1525, 1375. NMR δ: 0.94 (6H, s, 4-*gem* Me), 1.18 (3H, s, 10-Me), 3.84 (3H, s, 13-OMe), 6.85, 7.35 (each 1H, d, $J=8$ Hz, 11-, 12-H). The second fraction was recrystallized from MeOH to give 13-methoxy-12-nitro-13-deisopropyldehydroabietane (**38**) as pale yellow plates (162 mg, total 263 mg, 48% yield), mp 170—171°. *Anal.* Calcd for $C_{18}H_{25}NO_3$: C, 71.25; H, 8.31; N, 4.62. Found: C, 71.18; H, 8.34; N, 4.60. IR ν_{max} cm^{-1}: 1515, 1355. NMR δ: 0.90, 0.93 (each 3H, s, 4-*gem* Me), 1.14 (3H, s, 10-Me), 3.88 (3H, s, 13-OMe), 6.72 (1H, s, 14-H), 7.78 (1H, s, 11-H).

Nitration of 13-Methoxy-7-oxo-13-deisopropyldehydroabietane (**34**)——i) Nitration of **34** (444 mg) with fum. HNO_3 ($d=1.52$) (5 ml)–conc. H_2SO_4 (0.25 ml) under ice cooling for 30 min gave 12,14-dinitro-13-methoxy-7-oxo-13-deisopropyldehydroabietane (**40**) (208 mg, 35% yield) on treatment as in the case of the nitration of **36**; the product was recrystallized from MeOH to give pale yellow plates, mp 165—165.5°. *Anal.* Calcd for $C_{18}H_{22}N_2O_6$: C, 59.66; H, 6.12; N, 7.73. Found: C, 59.54; H, 6.16; N, 7.68. IR ν_{max} cm^{-1}: 1707. NMR δ: 0.98, 1.02 (each 3H, s, 4-*gem* Me), 1.28 (3H, s, 10-Me), 3.98 (3H, s, 13-OMe), 8.00 (1H, s, 11-H).

ii) Nitration of **34** (417 mg) with fum. HNO_3 ($d=1.45$) (5 ml)–conc. H_2SO_4 (0.25 ml) under ice cooling for 30 min gave crude crystals on treatment as in the case of the nitration of **36**. The crude crystals were chromatographed on silica gel (30 g) to provide two fractions. The first fraction (**40**) (255 mg, 41% yield) was eluted with *n*-hexane–ethyl acetate (9: 1), and the product was recrystallized from MeOH to afford 12,14-dinitro-13-methoxy-7-oxo-13-deisopropyldehydroabietane (**40**) as pale yellow plates (225 mg). Its physical data (NMR) were identical with those of the previous authentic sample (**40**). The second fraction (**41**) (176 mg, 28% yield) was eluted with *n*-hexane–ethyl acetate (4: 1). It was recrystallized from ethyl acetate to give 13-methoxy-14-nitro-7-oxo-13-deisopropyldehydroabietane (**41**) as colorless prisms (136 mg), mp 234—235.5°. *Anal.* Calcd for $C_{18}H_{23}NO_4$: C, 68.12; H, 7.31; N, 4.41. Found: C, 67.78; H, 7.25; N, 4.53. IR ν_{max} cm^{-1}: 1685, 1525, 1370. NMR δ: 0.95, 1.01 (each 3H, s, 4-*gem* Me), 1.23 (3H, s, 10-Me), 3.90 (3H, s, 13-OMe), 7.23, 7.51 (each 1H, d, $J=9$ Hz, 11-, 12-H).

iii) Nitration of **34** (492 mg) with conc. HNO_3 ($d=1.43$) (5 ml)–conc. H_2SO_4 (0.25 ml) under ice cooling for 30 min gave crude crystals on treatment as in the case of the nitration of **36**. The crude crystals were recrystallized from ethyl acetate to afford 13-methoxy-14-nitro-7-oxo-13-deisopropyldehydroabietane (**41**) as colorless prisms (480 mg, 84% yield), whose NMR spectra were identical with those of the previous authentic sample (**41**).

iv) Nitration of **34** (500 mg) with conc. HNO_3 ($d=1.415$) (5 ml)–conc. H_2SO_4 (0.25 ml) under ice cooling for 30 min gave a crude oil on treatment as in the case of the nitration of **36**. The crude oily product was recrystallized from ethyl acetate to give 13-methoxy-14-nitro-7-oxo-13-deisopropyldehydroabietane (**41**) as colorless prisms (195 mg, 33% yield), whose NMR spectra were identical with those of the previous authentic sample (**41**). The mother liquor (326 mg, 65% recovery) was found to contain the starting material (**34**) by GLC analysis.

v) Nitration of **34** (417 mg) with conc. HNO_3 ($d=1.38$) (5 ml)-conc. H_2SO_4 (0.25 ml) under ice cooling for 30 min gave the starting material (**34**) quantitatively (GLC analysis).

Nitration of 13-Hydroxy-7-oxo-13-deisopropyldehydroabietane (**35**)——i) Nitration of **35** (300 mg) with conc. HNO_3 ($d=1.43$) (5 ml)–conc. H_2SO_4 (0.25 ml) under ice cooling for 30 min gave an inseparable mixture.

ii) 13-Hydroxy-7-oxo-13-deisopropyldehydroabietane (**35**) (501 mg) was nitrated with conc. HNO_3 ($d=1.415$) (5 ml)–conc. H_2SO_4 (0.25 ml) as in the case of the nitration of **36**. The ether extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product

(125 mg), which was recrystallized from *n*-hexane–ethyl acetate to give the starting material (**35**) (47 mg). The mother liquor was chromatographed on silica gel (18 g) to provide two fractions. The first fraction was eluted with *n*-hexane–ethyl acetate (19: 1) to give crystals (**42**) (17.5 mg). The second fractions, eluted with *n*-hexane–ethyl acetate (9: 1), gave the starting material (**35**) (29 mg, total 76 mg, 15% recovery). On the other hand, the aqueous layer (alkali layer) was extracted with $CHCl_3$ after acidification with 10% HCl aq. The extract (acidic part) was washed with sat. NaCl aq. then dried over Na_2SO_4. Removal of the solvent gave crystals (486.5 mg), which were recrystallized from *n*-hexane–ethyl acetate to afford pale yellow prisms (**43**) (183.5 mg). The mother liquor was chromatographed on silica gel (25 g) to provide two fractions. The first fraction (**42**) (87.5 mg, total 105 mg, 18% yield) was eluted with *n*-hexane–ethyl acetate (19: 1). The product was recrystallized from *n*-hexane to give 13-hydroxy-12-nitro-7-oxo-13-deisopropyldehydroabietane (**42**) as yellow crystals, mp 119—120°. *Anal.* Calcd for $C_{17}H_{21}NO_4$: C, 67.31; H, 6.98; N, 4.62. Found: C, 67.21; H, 6.98; N, 4.62. IR ν_{max} cm^{-1}: 3290, 1698. NMR δ: 0.97, 1.03 (each 3H, s, 4-*gem* Me), 1.27 (3H, s, 10-Me), 7.70 (1H, s, 14-H), 8.08 (1H, s, 11-H). The second fraction (**43**) (86.5 mg, total 270 mg, 46% yield) was eluted with *n*-hexane–ethyl acetate (4: 1). The product was recrystallized from *n*-hexane–ethyl acetate to give 13-hydroxy-14-nitro-7-oxo-13-deisopropyldehydroabietane (**43**) as pale yellow prisms, mp 206.5—208°. *Anal.* for $C_{17}H_{21}NO_4$: C, 67.31; H, 6.98; N, 4.62. Found: C, 67.23; H, 6.95; N, 4.62. IR ν_{max} cm^{-1}: 3220, 1695. NMR δ: 0.96, 1.00 (each 3H, s, 4-*gem* Me), 1.13 (3H, s, 10-Me), 7.21, 7.47 (each 1H, d, J=8.4 Hz, 11-, 12-H).

iii) Nitration of **35** (300.5 mg) with conc. HNO_3 (d=1.38) (2 ml)–conc. H_2SO_4 (0.1 ml) under ice cooling for 30 min gave the starting material (**35**) quantitatively as judged by thin-layer chromatography (TLC).

Oxidation of 13-Methoxy-12-nitro-13-deisopropyldehydroabietane (**38**)——The 12-nitro compound (**38**) (61 mg) in AcOH (7 ml) was oxidized with CrO_3 (140 mg) in 80% AcOH aq. (3.6 ml) under stirring for 12 hr at 60°. The reaction mixture was concentrated under reduced pressure after MeOH (1 ml) had been added, and the resulting residue was extracted with ether. The extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave crystals, which were recrystallized from *n*-hexane–ethyl acetate to afford 13-methoxy-12-nitro-7-oxo-13-deisopropyldehydroabietane (**44**) as pale yellow prisms (28.5 mg), mp 243—245.5°. *Anal.* Calcd for $C_{18}H_{23}NO_4$: C, 68.12; H, 7.31; N, 4.41. Found: C, 67.94; H, 7.26; N, 4.37. IR ν_{max} cm^{-1}: 1690. NMR δ: 0.97, 1.02 (each 3H, s, 4-*gem* Me), 1.27 (3H, s, 10-Me), 3.97 (3H, s, 13-OMe), 7.67, 7.75 (each 1H, s, 11-, 14-H).

Methylation of 13-Hydroxy-12-nitro-7-oxo-13-deisopropyldehydroabietane (**42**)——A mixture of **42** (319 mg), Me_2SO_4 (2 ml) and K_2CO_3 (2 g) in acetone (20 ml) was stirred for 12 hr under reflux. The reaction mixture was treated as in the case of the methylation of **20** to give crystals. These were recrystallized from *n*-hexane–ethyl acetate to afford 13-methoxy-12-nitro-7-oxo-13-deisopropyldehydroabietane (**44**) as pale yellow prisms (128 mg), whose physical data (IR and NMR) were identical with those of the previous authentic sample (**44**).

Nitration and Demethylation of 13-Methoxy-14-nitro-7-oxo-13-deisopropyldehydroabietane (**41**)——i) Nitration of **41** (51 mg) with fum. HNO_3 (d=1.52)–conc. H_2SO_4 (0.1 ml) under ice cooling for 30 min gave crystals on treatment as in the case of the nitration of **34**. The product was chromatographed on silica gel (18 g) to give crystals from the *n*-hexane–ethyl acetate (9: 1) eluate. The product was recrystallized from MeOH to give 12,14-dinitro-13-methoxy-7-oxo-13-deisopropyldehydroabietane (**40**) as pale yellow plates (21 mg). Its physical data (IR, NMR, and TLC) were identical with those of the previous authentic sample (**40**).

ii) A mixture of **40** (200 mg), 47% HBr aq. (10 ml) and HI aq. (d=1.7) (1 ml) in AcOH (40 ml) was refluxed for 12 hr with stirring under a nitrogen atmosphere. The reaction mixture was treated as in the case of the nitration of **35** to give two parts. The product from the neutral part (ether extract) was recrystallized from *n*-hexane–ethyl acetate to give colorless prisms (**41**) (48 mg), whose NMR spectra were identical with those of the starting material (**41**). The product obtained from the acidic part ($CHCl_3$ part) was recrystallized from *n*-hexane–ethyl acetate to give 13-hydroxy-14-nitro-7-oxo-13-deisopropyldehydroabietane (**43**) as pale yellow prisms (50 mg), whose NMR spectra were identical with those of the previous authentic sample (**43**).

Reduction of 13-Methoxy-14-nitro-13-deisopropyldehydroabietane (**39**)——A mixture of **39** (100 mg), Sn dust (300 mg) and conc. HCl aq. (2 ml) in MeOH (15 ml) was refluxed with stirring for 12 hr. The reaction mixture was treated as in the case of the reduction of a mixture of **26** and **27** to give an oily product (94.5 mg), which was chromatographed on silica gel (15 g) from the *n*-hexane–ethyl acetate (9: 1—4: 1) eluate. The product was crystallized from *n*-hexane to give 14-amino-13-methoxy-13-deisopropyldehydroabietane (**45**) as colorless plates, mp 83—84°. *Anal.* Calcd for $C_{18}H_{27}NO$: C, 79.07; H, 9.95; N, 5.12. Found: C, 79.19; H, 9.93; N, 5.15. IR ν_{max} cm^{-1}: 3490, 3400. NMR δ: 0.96 (6H, s, 4-*gem* Me), 1.19 (3H, s, 10-Me), 3.66 (2H, br s, 14-NH_2), 3.83 (3H, s, 13-OMe), 6.72 (2H, s, 11-, 12-H).

Conversion of 13-Methoxy-14-nitro-7-oxo-13-deisopropyldehydroabietane (**41**) **to 14-Amino-13-methoxy-13-deisopropyldehydroabietane** (**45**)——i) A mixture of **41** (7.37 g), Sn dust (10 g) and conc. HCl aq. (50 ml) in MeOH (100 ml) was refluxed with stirring for 12 hr. The reaction mixture was treated as in the case of the reduction of **39** to give 14-amino-13-methoxy-7-oxo-13-deisopropyldehydroabietane as a homogeneous oil (5.18 g). *Anal.* high-resolution mass spectrum. Calcd for $C_{18}H_{25}NO_2$ (M^+, m/e): 287.1885. Found:

287.1881. IR ν_{max} cm^{-1}: 3510, 3340, 1642. NMR δ: 0.87, 0.95 (each 3H, s, 4-*gem* Me), 1.23 (3H, s, 10-Me), 3.74 (3H, s, 13-OMe), 6.37, 6.71 (each 1H, d, J=8.4 Hz, 11-, 12-H), 6.81 (2H, br s, 14-NH_2).

ii) A solution of the above oil (5.18 g) in EtOH (100 ml) was reduced with $NaBH_4$ (8 g) under stirring for 12 hr at 0—5°. The reaction mixture was extracted with ether after H_2O had been added, and the ether extract was washed with sat. NaCl aq. then dried over Na_2SO_4. Removal of the solvent gave crystals (4.80 g), which were catalytically hydrogenolyzed in ethyl acetate (30 ml)–conc. H_2SO_4 (10 drops) in the presence of 10% Pd–C (2 g) under a hydrogen atmosphere (3—4 kg/cm^2). The reaction mixture was treated as in the case of the reduction of **31** to give an oily product (4.77 g), which was chromatographed on silica gel (150 g) to give 14-amino-13-methoxy-13-deisopropyldehydroabietane (**45**) as a homogeneous oil (2.649 g, 42% overall yield from **41**) from the *n*-hexane–ethyl acetate (9: 1) eluate. A part of the above oil (**45**) was crystallized from *n*-hexane to afford colorless plates (**45**), whose physical data (IR, NMR, TLC, and GLC) were identical with those of the previous authentic sample (**45**).

Demethylation of 14-Amino-13-methoxy-13-deisopropyldehydroabietane (45)——A mixture of **45** (2.076 g) and trimethylsilyl iodide (2.0 g) in sulfolane (2 ml) was stirred for 3.5 hr at 50°under a nitrogen atmosphere. The reaction mixture was extracted with $CHCl_3$ after MeOH and H_2O had been added, and the extract was washed with sat. $Na_2S_2O_3$ aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave an oily product (2.899 g), which was chromatographed on silica gel (60 g) to give 14-amino-13-hydroxy-13-deisopropyldehydroabietane (**46**) as crystals (590 mg, 30% yield) from the *n*-hexane–ethyl acetate (4: 1) eluate. This product was recrystallized from CCl_4 to give colorless plates (**46**) (426.5 mg), mp 179—181°. *Anal.* Calcd for $C_{17}H_{25}NO$: C, 78.71; H, 9.72; N, 5.40. Found: C, 78.18; H, 9.52; N, 5.36. IR ν_{max} cm^{-1}: 3625, 3400, 3330. NMR δ: 0.94 (6H, s, 4-*gem* Me), 1.17 (3H, s, 10-Me), 4.15 (3H, br s, 14-NH_2, 13-OH), 6.62 (2H, s, 11-, 12-H).

Preparation of 13,14-Dihydroxy-13-deisopropyldehydroabietane (47)——A solution of **46** (368 mg) in AcOH (90 ml) was added to a solution of $NaIO_4$ (3 g) in 0.1 N HCl aq. (210 ml) over a period of 3 min at room temperature. After being stirred for 5 min, the reaction mixture was extracted with $CHCl_3$. The $CHCl_3$ extract was washed with sat. NaCl aq. and treated with a solution of KI (0.9 g) in AcOH (60 ml) with shaking for 2 min. The $CHCl_3$ layer was also washed with 5% $NaHSO_3$ aq. and sat. NaCl aq., then dried over Na_2SO_4. Removal of the solvent gave crystals (375.5 mg), which were recrystallized from *n*-hexane to give 13,14-dihydroxy-13-deisopropyldehydroabietane (**47**) as colorless needles (353.5 mg, 96% yield), mp 146.5—147.5°. *Anal.* Calcd for $C_{17}H_{24}O_2$: C, 78.42; H, 9.29. Found: C, 78.59; H, 9.44. IR ν_{max} cm^{-1}: 3610, 3560. NMR δ: 0.95 (6H, s, 4-*gem* Me), 1.17 (3H, s, 10-Me), 5.03 (2H, br s, $W_{h/2}$=11 Hz, 13-, 14-OH), 6.73 (2H, s, 11-, 12-H).

Friedel-Crafts Acetylation of 13-Methoxy-13-deisopropyldehydroabietane (36)——A solution of **36** (450 mg), acetyl chloride (0.25 ml) and aluminum chloride (0.5 g) in nitrobenzene (6 ml) was stirred for 24 hr at room temperature. The reaction mixture was treated as in the case of the acetylation of **7** to give an oily product (558 mg), which was subjected to chromatography on silica gel (30 g) to afford a homogeneous oil (**48**) (373 mg, 71% yield) from the petr. ether–ether (19: 1—9: 1) eluate. It was crystallized from *n*-hexane to give 12-acetyl-13-methoxy-13-deisopropyldehydroabietane (**48**) as colorless needles, mp 104—105.5°. *Anal.* Calcd for $C_{20}H_{28}O_2$: C, 79.95; H, 9.39. Found: C, 80.00; H, 9.38. IR ν_{max}^{KBr} cm^{-1}: 1673. NMR δ: 0.94 (6H, s, 4-*gem* Me), 1.14 (3H, s, 10-Me), 2.58 (3H, s, 12-Ac), 3.86 (3H, s, 13-OMe), 6.61 (1H, s, 14-H), 7.68 (1H, s, 11-H).

Conversion of 12-Acetyl-13-methoxy-13-deisopropyldehydroabietane (48) to O-Methylsempervirol (51)——i) A solution of **48** (355 mg) in ether (10 ml) was added to a solution of MeLi [prepared from Li metal (0.403 g) and methyl iodide (4 ml)] in ether (40 ml) under a nitrogen atmosphere at 0°. The reaction mixture was stirred for 2 hr then extracted with ether after H_2O had been added. The extract was washed with sat. NaCl aq. then dried over Na_2SO_4. Removal of the solvent gave an oily product (397 mg), which was subjected to chromatography on silica gel (30 g) to give a homogeneous oil (**49**) (322 mg, 86% yield) from the petr. ether–ether (4: 1) eluate. IR ν_{max} cm^{-1}: 3570. NMR δ: 0.91 (6H, s, 4-*gem* Me), 1.14 (3H, s, 10-Me), 1.57 (6H, s, 12-C(OH)Me_2), 3.84 (3H, s, 13-OMe), 6.54, 7.17 (each 1H, s, 11-, 14-H).

ii) A mixture of **49** (97 mg) and $SOCl_2$ (0.2 ml) in pyridine (2 ml) was stirred for 2 hr at 0°. The reaction mixture was extracted with $CHCl_3$ after acidification with 10% HCl aq. The extract was washed with sat. Na_2CO_3 aq. and sat. NaCl aq. then dried over Na_2SO_4. Removal of the solvent gave an oily product (112 mg), which was chromatographed on silica gel (40 g) to give a homogeneous oil (**50**) (62 mg, 68% yield) from the petr. ether–ether (3: 1—2: 1) eluate. NMR δ: 0.94 (6H, s, 4-*gem* Me), 1.16 (3H, s, 10-Me), 2.06 (3H, br s, 12-isopropenyl Me), 3.72 (3H, s, 13-OMe), 4.86—5.08 (2H, m, *exo*-methylene), 6.43, 6.97 (each 1H, s, 11-, 14-H).

iii) A mixture of **50** (104 mg) and 10% Pd–C (127 mg) in MeOH (5 ml) was stirred under a hydrogen atmosphere at room temperature. The filtrate was evaporated to dryness and the residue (110 mg) was chromatographed on silica gel (25 g) to give O-methylsempervirol (**51**) as a homogeneous oil (100 mg, 96% yield) from the petr. ether–benzene (4: 1) eluate. Its physical data (IR and NMR) were identical with those of an authentic sample (**51**) prepared by Matsumoto and co-workers.[7] IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1610, 1570, 1495, 894, 850. NMR (CCl_4) δ: 0.90, 0.93 (each 3H, s, 4-*gem* Me), 1.14 (6H, d, J=7.2 Hz, isopropyl Me), 1.13 (3H, s, 10-Me), 3.15 (1H, m, isopropyl methine), 3.70 (3H, s, 13-OMe), 6.27, 6.89 (each 1H, s, 11-, 14-H).

Conversion of 12-Acetyl-13-methoxy-13-deisopropyldehydroabietane (48) to 12,13-Dimethoxy-13-deisopropyldehydroabietane (24)——i) A solution of **48** (2.852 g) and 40% peracetic acid (17 ml) in CH_2Cl_2 (12 ml) was stirred for 42 hr at room temperature. The reaction mixture was treated as in the case of the Baeyer–Villiger oxidation of **21** to give 12-acetoxy-13-methoxy-13-deisopropyldehydroabietane (**52**) as a crude oil (2.75 g). IR ν_{max} cm^{-1}: 1768, 1200.

ii) A mixture of **52** (2.75 g), conc. H_2SO_4 (5 drops) and H_2O (1.3 ml) in MeOH (260 ml) was stirred for 2 hr under reflux. The reaction mixture was treated as in the case of the hydrolysis of **22** to give 12-hydroxy-13-methoxy-13-deisopropyldehydroabietane (**53**) as a crude oil (2.366 g). IR ν_{max} cm^{-1}: 3580.

iii) A mixture of **53** (2.366 g), Me_2SO_4 (2 ml) and K_2CO_3 (30 g) in acetone (200 ml) was stirred for 14 hr under reflux. The reaction mixture was treated as in the case of the methylation of **23** to give a crude oil (2.383 g), which was chromatographed on silica gel (100 g) to give 12,13-dimethoxy-13-deisopropyldehydroabietane (**24**) as a homogeneous oil (1.034 g) from the petr. ether–ether (9: 1) eluate. Its physical data (IR and NMR) were identical with those of the previously described sample (**24**) in this paper. *Anal.* high-resolution mass spectrum. Calcd for $C_{19}H_{28}O_2$ (M^+, *m/e*): 288.2089. Found: 288.2091. NMR δ: 0.95 (6H, s, 4-*gem* Me), 1.20 (3H, s, 10-Me), 3.83 (6H, s, 12-, 13-OMe), 6.53, 6.78 (each 1H, s, 11-, 14-H).

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