Absolute Stereostructures of Polypodane-Type Triterpenes, Myrrhanol A and Myrrhanone A, from Guggul-Gum Resin (the Resin of *Balsamodendron mukul*)

Hisashi MATSUDA,[a] Toshio MORIKAWA,[a] Shin ANDO,[a] Hideo OOMINAMI,[a] Toshiyuki MURAKAMI,[a] Ikuko KIMURA,[b] and Masayuki YOSHIKAWA*,[a]

[a] *Kyoto Pharmaceutical University; Misasagi, Yamashina-ku, Kyoto 607–8412, Japan: and* [b] *Department of Clinical Pharmacology, Graduate School of Clinical Pharmaceutical Sciences, Toyama Medical and Pharmaceutical University; 2630 Sugitani, Toyama 930–0194, Japan.* Received May 24, 2004; accepted July 2, 2004

Two new polypodane-type triterpenes, myrrhanol A and myrrhanone A, were isolated from the 50% aqueous methanolic extract of guggul-gum resin [the resin of *Balsamodendron* (=*Commiphora*) *mukul* HOOK.]. The structures of the new constituents, including their absolute configurations, were determined on the basis of chemical and physicochemical evidence.

Key words *Balsamodendron mukul*; myrrhanol; myrrhanone; polypodane-type triterpene; guggul-gum; Ayurvedic traditional medicine

Guggul-gum resin [the resin of *Balsamodendron* (=*Commiphora*) *mukul* HOOK. (Burseraceae)] is produced by drying the milky-white sap of the tree (15—20 years old) for one year. This natural medicine is prescribed in the form of direct mixtures with powders or extracts of other natural medicines for use as anti-obesity, antiinflammatory, antibacterial, anticoagulant, and anti-atherosclerosis agents in Ayurvedic folk medicine in India. Previously, the antiinflammatory activity of guggul has been reported,[1—3] and guggulsterone, a constituent of guggul, activates lipolytic enzymes, inhibits hepatic cholesterol biosynthesis, and reduces the total serum lipid and total serum cholesterol levels.[4,5] A similar natural medicine, myrrh [the resin of *Balsamodendron* (or *Commiphora*) *myrrha* NEES] was used by the Egyptians for embalming, and by the Jews as an anointing oil. The sesquiterpene constituents isolated from myrrh, furanoeudesma-1,3-diene and curzarene, have analgesic effects that are blocked by naloxone, explaining the use of myrrh as a painkiller in ancient times.[6] However, because of its toxicity, myrrh is not used in medicines today, except as a mouthwash in India.

In the course of our characterization studies on traditional Ayurvedic medicines,[7—26] we found that the 50% aqueous methanolic extract of guggul (the resin of *B. mukul*) showed an anti-inflammatory effect on adjuvant-induced air pouch granuloma in mice. From the extract, two new polypodane-type triterpenes, myrrhanol A (**1**) and myrrhanone A (**2**), were isolated as the active components.[7] Furthermore, the methanolic extract of this natural medicine was found to exhibit an inhibitory effect on nitric oxide production in lipopolysaccharide-activated mouse peritoneal macrophages. From the methanolic extract, we isolated three polypodane-type triterpenes named myrrhanol B (**3**), myrrhanones B (**4**), and A acetate, and an octanordammarane-type triterpene termed epimansumbinol, together with 17 known constituents.[8] This paper presents a full account of the isolation and characterization of myrrhanol A (**1**) and myrrhanone A (**2**).

The 50% aqueous methanolic extract (5.68% from natural medicine) of the resin of guggul-gum was partitioned in an ethyl acetate (EtOAc) and water mixture to furnish the EtOAc- and H_2O-soluble fractions. The EtOAc-soluble fraction was subjected to normal and reversed phase silica gel column chromatographies, and finally HPLC, to give two new polypodane-type triterpenes, myrrhanol A[7] (**1**, 0.036%) and myrrhanone A[7] (**2**, 0.026%), together with four polypodane-type triterpenes, myrrhanol B[8] (**3**, 0.0025%), myrrhanone B[8] (**4**, 0.013%), (8*R*)-3β,8-dihydroxypolypoda-13*E*,17*E*,21-triene[8] (**5**, 0.0084%), and (8*R*)-3-oxo-8-hydroxypolypoda-13*E*,17*E*,21-triene[8] (**6**, 0.0037%) and a lignan, (+)-diayangambin[8] (**7**, 0.0007%).

Absolute Stereostructures of Myrrhanol A (1) and Myrrhanone A (2) Myrrhanol A (**1**) was isolated as a colorless oil with positive optical rotation ($[\alpha]_D^{27}$ +12.2°). In the positive-ion fast atom bombardment (FAB)-MS of **1**, a quasi-molecular ion peak was observed at *m/z* 483 $(M+Na)^+$, and the molecular formula $C_{30}H_{52}O_3$ was determined by high-resolution MS measurement. The IR spectrum of **1** showed absorption bands at 3432 and 1670 cm^{-1}, suggestive of hydroxyl and olefin functions. The ^{1}H-NMR ($CDCl_3$) and ^{13}C-NMR (Table 1) spectra of **1**, which were assigned by various NMR experiments,[27] showed a presence of seven tertiary methyls [δ 0.75, 0.79, 0.98, 1.13, 1.65 (s, 24, 25, 23, 26, 29-H_3), 1.60 (s, 27, 28-H_3)], a methine bearing an oxygen function [δ 3.21 (dd, *J*=4.9, 11.6 Hz, 3-H)], a methylene bearing an oxygen function [δ 3.96 (s, 30-H_2)], and three trisubstituted olefins [δ 5.12 (dd, *J*=5.8, 6.7 Hz, 17-H), 5.16, 5.38 (dd-like, 13, 21-H)], together with a quaternary carbon bearing an oxygen function (δ_C 73.9, C-8). The planar structure of **1** was constructed on the basis of ^{1}H–^{1}H correlation spectroscopy (^{1}H–^{1}H COSY) and heteronuclear multiple bond correlation (HMBC) experiments, as shown in Fig. 1. Thus, the ^{1}H–^{1}H COSY experiment indicated the presence of partial structures in bold lines (from C-1–C-3, from C-5–C-7, from C-9–C-11–C-13, and so on). In the HMBC experiment of **1**, long-range correlations were observed between the following protons and carbons: 21-H and 30-C; 23-H_3 and 3, 4, 5, 24-C; 24-H_3 and 3, 4, 5, 23-C; 25-H_3 and 1, 5, 9, 10-C; 26-H_3 and 7, 8, 9-C; 27-H_3 and 13, 14, 15-C; 28-H_3 and 17, 18, 19-C; 29-H_3 and 21, 22, 30-C; 30-H_2 and 21-C, so that the connectivities of all carbons in **1** were identified. Furthermore, the relative stereostructure of **1** was characterized by a

* To whom correspondence should be addressed. e-mail: shoyaku@mb.kyoto-phu.ac.jp

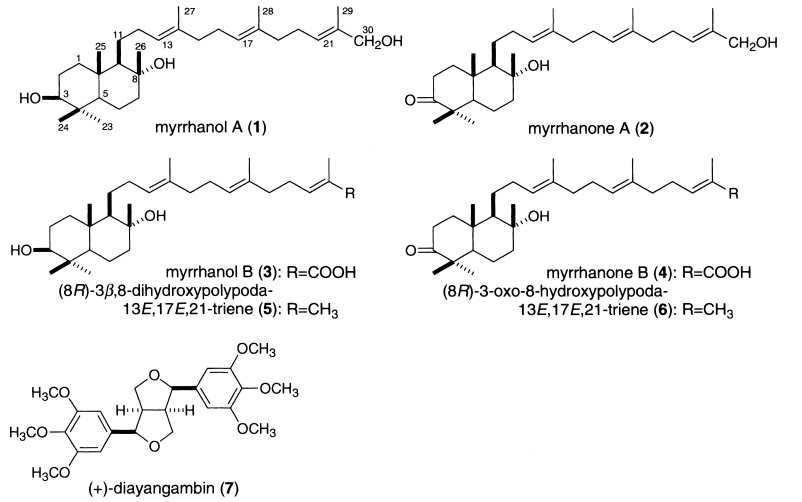

Chart 1

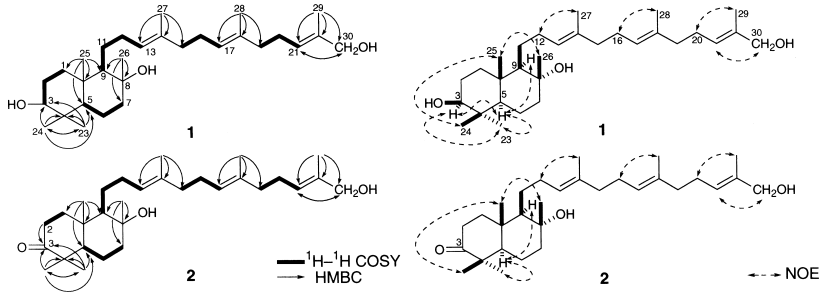

Fig. 1. ^{1}H–^{1}H COSY, HMBC, and NOESY Experiments of **1** and **2**

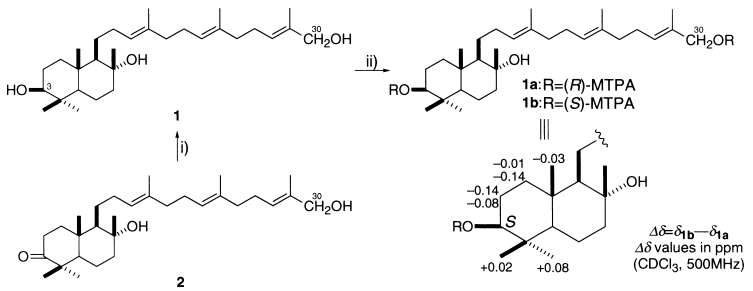

Fig. 2

nuclear Overhauser enhancement spectroscopy (NOESY) experiment, which showed NOE correlations between the following protons: 3-H and 5-H, 23-H_3; 5-H and 9-H; 12-H_2 and 27-H_3; 16-H_2 and 28-H_3; 20-H_2 and 29-H_3; 21-H and 30-H_2; 24-H_3 and 25-H_3; 25-H_3 and 26-H_3 (Fig. 1).

Next, the absolute configuration of **1** was determined by application of modified Mosher's method.[28] Namely, **1** was treated with (*R*)- and (*S*)-α-methoxy-α-trifluoromethylphenylacetic acid (MTPA) in the presence of 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (EDC·HCl) and 4-dimethylaminopyridine (4-DMAP) to give the 3,30-di-(*R*)-MTPA ester (**1a**) and the 3,30-di-(*S*)-MTPA ester (**1b**), respectively. As shown in Fig. 2, the proton signals attached at the 1, 2, and 25-positions in **1b** were observed at higher fields compared to those of **1a** ($\Delta\delta$: negative), while the signal due to the 23 and 24-positions in **1b** were observed at lower fields as compared to those of **1a** ($\Delta\delta$: positive). On the basis of this evidence, the absolute stereostructure of myrrhanol A was determined to be (3*S*,5*R*,8*R*,9*R*,10*S*)-3,8,30-trihydroxypolypoda-13*E*,17*E*,21*E*-triene (**1**).[29]

Myrrhanone A (**2**) was also obtained as a colorless oil with positive optical rotation ($[\alpha]_D^{28}$ +11.9°), and its IR spectrum showed absorption bands due to hydroxyl, carbonyl, and olefin functions at 3453, 1709, and 1650 cm^{-1}. In the positive-ion FAB-MS of **2**, a quasimolecular ion peak was observed at *m*/*z* 481 $(M+Na)^+$, and the molecular formula $C_{30}H_{50}O_3$ was determined by high-resolution MS measurement. The proton and carbon signals in the ^{1}H-NMR ($CDCl_3$) and ^{13}C-NMR (Table 1) spectra[27] of **2** showed signals assignable to seven tertiary methyls [δ 0.95, 1.02, 1.09, 1.19, 1.65 (3H each, all s, 25, 24, 23, 26, 29-H_3), 1.60 (6H, s, 27, 28-H_3)], a methylene bearing an oxygen function [δ 3.96 (2H, s, 30-H_2)], and three trisubstituted olefins [δ 5.12, 5.16, 5.39 (1H each, all dd-like, 17, 13, 21-H)] together with a quater-

Table 1. ^{13}C-NMR Data of Myrrhanol A (**1**) and Myrrhanone A (**2**)

	1	**2**
C-1	37.9	38.3
C-2	27.0	33.9
C-3	78.6	217.0
C-4	38.8	47.4
C-5	55.0	55.1
C-6	20.2	21.3
C-7	44.3	43.7
C-8	73.9	73.6
C-9	61.1	60.3
C-10	38.8	38.5
C-11	25.5	25.8
C-12	31.3	31.2
C-13	125.1	124.8
C-14	135.0	135.1
C-15	39.6	39.6
C-16	26.5	26.5
C-17	124.5	124.4
C-18	134.6	134.6
C-19	39.3	39.3
C-20	26.1	26.1
C-21	125.7	125.7
C-22	134.7	134.6
C-23	28.1	26.3
C-24	15.4	21.3
C-25	15.5	14.8
C-26	23.7	23.5
C-27	16.2	16.2
C-28	16.0	16.0
C-29	13.7	13.7
C-30	68.6	68.6

125 MHz, $CDCl_3$.

nary carbon bearing an oxygen function (δ_C 73.6, C-8) and carbonyl carbon (δ_C 217.0, C-3), which were found to be superimposable on those of **1**, except for the signal due to the carbonyl group. In the HMBC experiment of **2**, long-range correlations were observed between the 23,24-methyl protons and 3-carbonyl carbon (Fig. 1). In addition, reduction of **2** with sodium borohydride ($NaBH_4$) yielded **1**, so that the absolute stereostructure of myrrhanone A was determined to be (5*R*,8*R*,9*R*,10*S*)-3-oxo-8,30-dihydroxypolypoda-13*E*,17*E*,21*E*-triene (**2**).[29]

Experimental

The following instruments were used to obtain physical data: specific rotations, Horiba SEPA-300 digital polarimeter (l=5 cm); UV spectra, Shimadzu UV-1600 spectrometer; IR spectra, Shimadzu FTIR-8100 spectrometer; EI-MS and high-resolution MS, JEOL JMS-GCMATE mass spectrometer; FAB-MS and high-resolution MS, JEOL JMS-SX 102A mass spectrometer; ^{1}H-NMR spectra, JNM-LA500 (500 MHz) spectrometer; ^{13}C-NMR spectra, JNM-LA500 (125 MHz) spectrometer with tetramethylsilane as an internal standard; and HPLC detector, Shimadzu RID-6A refractive index detector.

The following experimental conditions were used for chromatography: ordinary-phase silica gel column chromatography, Silica gel BW-200 (Fuji Silysia Chemical, Ltd., 150—350 mesh); reverse-phase silica gel column chromatography, Chromatorex ODS DM1020T (Fuji Silysia Chemical, Ltd., 100—200 mesh); TLC, precoated TLC plates with Silica gel 60F_{254} (Merck, 0.25 mm) (ordinary phase) and Silica gel RP-18 F_{254S} (Merck, 0.25 mm) (reverse phase); reverse-phase HPTLC, precoated TLC plates with Silica gel RP-18 WF_{254S} (Merck, 0.25 mm); and detection was achieved by spraying with 1% $Ce(SO_4)_2$–10% aqueous H_2SO_4, followed by heating.

Extraction and Isolation The resin of *B. mukul* [1.85 kg, collected in Rajastan, India and purchased from Sharangdhar Pharmaceuticals PTV, Ltd. (Pune, India)] was finely minced and extracted three times with 50% aqueous methanol under reflux for 3 h. Evaporation of the solvent under reduced pressure provided the 50% aqueous methanolic extract (105 g, 5.68%). The aqueous methanolic extract (96.8 g) was partitioned in an EtOAc–H_2O (1 : 1, v/v) mixture. Removal of the solvent from the EtOAc- and H_2O-soluble fractions under reduced pressure yielded an EtOAc-soluble fraction (34.0 g, 2.00%) and H_2O-soluble fraction (62.8 g, 3.68%), respectively.

Normal-phase silica gel column chromatography [BW-200 (Fuji Silysia Chemical, Ltd., 1 kg), *n*-hexane–EtOAc (3 : 1→1 : 1, v/v)→$CHCl_3$–MeOH (10 : 1, v/v)→MeOH] of the EtOAc-soluble extract (29.0 g) gave nine fractions [Fr. 1 (1.51 g), 2 (1.13 g), 3 (5.22 g), 4 (4.50 g), 5 (3.60 g), 6 (3.20 g), 7 (4.80 g), 8 (3.80 g), 9 (1.24 g)]. Fraction 2 (1.10 g) was purified by reversed-phase silica gel column chromatography [30 g, MeOH–H_2O (80 : 20→90 : 10, v/v)→MeOH] and HPLC [MeOH–H_2O (90 : 10, v/v)] to give (8*R*)-3β,8-dihydroxypolypoda-13*E*,17*E*,21-triene (**5**, 118 mg, 0.0084%) and (8*R*)-3-oxo-8-hydroxypolypoda-13*E*,17*E*,21-triene (**6**, 52 mg, 0.0037%). Fraction 4 (1.00 g) was purified by HPLC [MeOH–H_2O (90 : 10, v/v)] to give myrrhanone A (**2**, 84 mg, 0.026%). Fraction 5 (3.60 g) was separated by reversed-phase silica gel column chromatography [100 g, MeOH–H_2O (70 : 30→80 : 20, v/v)→MeOH] and HPLC [MeOH–H_2O (85 : 15, v/v)] to give myrrhanol A (**1**, 523 mg, 0.036%). Fraction 6 (3.20 g) was separated by reversed-phase silica gel column chromatography [100 g, MeOH–H_2O (90 : 10, v/v)→MeOH] and HPLC [MeOH–H_2O (75 : 25, v/v)] to give myrrhanol B (**3**, 36 mg, 0.0025%), myrrhanone B (**4**, 187 mg, 0.013%), and (+)-diayangambin (**7**, 10 mg, 0.0007%). The known compounds (**3**—**7**) were identified by comparison of their physical data ($[\alpha]_D$, IR, ^{1}H-NMR, ^{13}C-NMR) with those of authentic samples.[8]

Myrrhanol A (**1**): Colorless oil, $[\alpha]_D^{27}$ +12.2° (c=1.00, MeOH). High-resolution positive-ion FAB-MS: Calcd for $C_{30}H_{52}O_3Na$ $(M+Na)^+$: 483.3814. Found: 483.3830. IR (KBr): 3432, 2936, 1670, 1461, 1387, 1087 cm^{-1}. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 0.75, 0.79, 0.98, 1.13, 1.65 (3H each, all s, 24, 25, 23, 26, 29-H_3), 0.88 (1H, dd, J=2.1, 9.5 Hz, 5-H), 1.02 (1H, dd, J=3.9, 3.9 Hz, 9-H), 1.13, 1.70 (1H each, both m, 1-H_2), 1.27, 1.45 (1H each, both m, 11-H_2), 1.32, 1.65 (1H each, both m, 6-H_2), 1.32, 1.87 (1H each, both m, 7-H_2), 1.60 (6H, s, 27, 28-H_3), 2.00 (4H, m, 15, 19-H_2), 2.08 (4H, m, 12, 16-H_2), 2.12 (2H, m, 20-H_2), 3.21 (1H, dd, J=4.9, 11.6 Hz, 3-H), 3.96 (2H, s, 30-H_2), 5.12 (1H, dd, J=5.8, 6.7 Hz, 17-H), 5.16, 5.38 (1H each, both dd-like, 13, 21-H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ_C: given in Table 1. Positive-ion FAB-MS: m/z 483 $(M+Na)^+$.

Myrrhanone A (**2**): Colorless oil, $[\alpha]_D^{28}$ +11.9° (c=1.00, MeOH). High-resolution positive-ion FAB-MS: Calcd for $C_{30}H_{50}O_3Na$ $(M+Na)^+$: 481.3658. Found: 481.3669. IR (KBr): 3453, 2930, 1709, 1650, 1456, 1385, 1080 cm^{-1}. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 0.95, 1.02, 1.09, 1.19, 1.65 (3H each, all s, 25, 24, 23, 26, 29-H_3), 1.13 (1H, dd, J=4.0, 4.0 Hz, 9-H), 1.30, 1.52 (1H each, both m, 11-H_2), 1.37, 1.60 (1H each, both m, 6-H_2), 1.46 (1H, m, 5-H), 1.46, 1.90 (1H each, both m, 7-H_2), 1.52, 1.90 (1H each, both m, 1-H_2), 1.60 (6H, s, 27, 28-H_3), 2.00 (4H, m, 15, 19-H_2), 2.10 (6H, m, 12, 16, 20-H_2), 2.40, 2.60 (1H each, both m, 2-H_2), 3.96 (2H, s, 30-H_2), 5.12, 5.16, 5.39 (1H each, all dd-like, 17, 13, 21-H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ_C: given in Table 1. Positive-ion FAB-MS: m/z 481 $(M+Na)^+$.

Preparation of the (*R*)-MTPA Ester (1a) and the (*S*)-MTPA Ester (1b) from Myrrhanol A (1) A solution of **1** (2.0 mg) in CH_2Cl_2 (1.0 ml) was treated with (*R*)-MTPA (10.0 mg) in the presence of EDC·HCl (10.0 mg) and 4-DMAP (5.0 mg), and the mixture was heated under reflux for 2 h. The reaction mixture was poured into ice-water, and the whole was extracted with EtOAc. The EtOAc extract was successively washed with 5% aqueous HCl, aqueous saturated $NaHCO_3$, and brine, then dried over $MgSO_4$ and filtered. Removal of the solvent from the filtrate under reduced pressure furnished a residue, which was purified by a normal-phase silica gel column [1.0 g, *n*-hexane–EtOAc (4 : 1)] to give **1a** (1.1 mg, 38%) and **1** (0.5 mg). Through a similar procedure, **1b** (1.0 mg, 37%) and **1** (0.6 mg) were prepared from **1** (2.0 mg) by the use of (*S*)-MTPA (10.0 mg), EDC·HCl (10.0 mg), and 4-DMAP (5.0 mg).

1a: Colorless oil. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 0.78, 0.82, 0.83, 1.13, 1.59 (3H each, all s, 24, 25, 23, 26, 29-H_3), 1.61 (6H, s, 27, 28-H_3), 1.25, 1.79 (1H each, both m, 1-H_2), 1.79, 1.88 (1H each, both m, 2-H_2), 3.56 (6H, s, OMe×2), 4.66, 4.71 (2H, ABq, J=13.1 Hz, 30-H_2), 4.73 (1H, dd-like, 3-H), 5.11, 5.16, 5.51 (1H each, both dd-like, 17, 13, 21-H), 7.39—7.55 (10H, m, Ph-H). Positive-ion FAB-MS: m/z 915 $(M+Na)^+$.

1b: Colorless oil. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 0.79, 0.80, 0.91, 1.13, 1.59 (3H each, all s, 25, 24, 23, 26, 29-H_3), 1.24, 1.65 (1H each, both m, 1-H_2), 1.61 (6H, s, 27, 28-H_3), 1.65, 1.80 (1H each, both m, 2-H_2), 3.56 (6H, s, OMe×2), 4.46, 4.71 (2H, ABq, J=13.1 Hz, 30-H_2), 4.73 (1H, dd-like, 3-H), 5.11, 5.16, 5.51 (1H each, both dd-like, 17, 13, 21-H), 7.38—7.51 (10H, m, Ph-H). Positive-ion FAB-MS: m/z 915 $(M+Na)^+$.

$NaBH_4$ Reduction of Myrrhanone A (2) A solution of **2** (10.0 mg) was

added to MeOH (2.0 ml) treated with $NaBH_4$ (4.0 mg each), and the whole mixture was stirred at room temperature (25 °C) for 1 h. The reaction mixture was poured into acetone. Removal of the solvent under reduced pressure gave a product, which was purified by normal-phase silica-gel column chromatography [1.0 g, *n*-hexane–EtOAc (1 : 1)] to give myrrhanol A (**1**, 7.5 mg, 75%).

References and Notes

1) Sharma J. N., Sharma J. N., *Arzneim.-Forsch.*, **27**, 1455—1457 (1977).
2) Arora R. B., Taneja V., Sharma R. C., Gupta S. K., *Indian J. Med. Res.*, **60**, 929—931 (1972).
3) Duwiejua M., Zeitlin I. J., Waterman P. G., Chapman J., Mhango G. J., Provan G. J., *Planta Med.*, **59**, 12—16 (1993).
4) Chander R., Khanna A. K., Kapoor N. K., *Phytother. Res.*, **10**, 508—511 (1996).
5) Beg M., Singhal K. C., Afzaal S., *Indian J. Physiol. Pharmacol.*, **40**, 237—240 (1996).
6) Dolara P., Luceri C., Ghelardini C., Monserrat C., Aiolli S., Luceri F., Lodovici M., Menichetti S., Romanelli M. N., *Nature* (London), **379**, 29 (1996).
7) Kimura I., Yoshikawa M., Kobayashi S., Sugihara Y., Suzuki M., Oominami H., Murakami T., Matsuda H., Doiphode V. V., *Bioorg. Med. Chem. Lett.*, **11**, 985—989 (2001).
8) Matsuda H., Morikawa T., Ando S., Oominami H., Murakami T., Kimura I., Yoshikawa M., *Bioorg. Med. Chem.*, **12**, 3037—3046 (2004).
9) Murakami N., Murakami T., Kadoya M., Matsuda H., Yamahara J., Yoshikawa M., *Chem. Pharm. Bull.*, **44**, 469—471 (1996).
10) Yoshikawa M., Murakami T., Komatsu H., Murakami N., Yamahara J., Matsuda H., *Chem. Pharm. Bull.*, **45**, 81—87 (1997).
11) Yoshikawa M., Murakami T., Kadoya M., Li Y., Murakami N., Yamahara J., Matsuda H., *Chem. Pharm. Bull.*, **45**, 1671—1676 (1997).
12) Yoshikawa M., Murakami T., Matsuda H., *Chem. Pharm. Bull.*, **45**, 2034—2038 (1997).
13) Yoshikawa M., Murakami T., Shimada H., Matsuda H., Yamahara J., Tanabe G., Muraoka O., *Tetrahedron Lett.*, **38**, 8367—8370 (1997).
14) Yoshikawa M., Murakami T., Komatsu H., Yamahara J., Matsuda H., *Heterocycles*, **47**, 397—405 (1998).
15) Yoshikawa M., Murakami T., Yashiro K., Matsuda H., *Chem. Pharm. Bull.*, **46**, 1339—1340 (1998).
16) Matsuda H., Murakami T., Yashiro K., Yamahara J., Yoshikawa M., *Chem. Pharm. Bull.*, **47**, 1725—1729 (1999).
17) Murakami T., Nakamura J., Matsuda H., Yoshikawa M., *Chem. Pharm. Bull.*, **47**, 1759—1764 (1999).
18) Murakami T., Nakamura J., Kageura T., Matsuda H., Yoshikawa M., *Chem. Pharm. Bull.*, **48**, 1720—1725 (2000).
19) Yoshikawa M., Nishida N., Shimoda H., Takada M., Kawahara Y., Matsuda H., *Yakugaku Zasshi*, **121**, 371—378 (2001).
20) Matsuda H., Murakami T., Kishi A., Yoshikawa M., *Bioorg. Med. Chem.*, **9**, 1499—1507 (2001).
21) Matsuda H., Morikawa T., Ueda H., Yoshikawa M., *Heterocycles*, **55**, 1499—1504 (2001).
22) Matsuda H., Morikawa T., Ueda H., Yoshikawa M., *Chem. Pharm. Bull.*, **49**, 1368—1371 (2001).
23) Muraoka O., Ying S., Yoshiaki K., Matsuura Y., Yamada E., Minematsu T., Tanabe G., Matsuda H., Yoshikawa M., *Chem. Pharm. Bull.*, **49**, 1503—1505 (2001).
24) Yoshikawa M., Ninomiya K., Shimoda H., Nishida N., Matsuda H., *Biol. Pharm. Bull.*, **25**, 72—76 (2002).
25) Yoshikawa M., Morikawa T., Matsuda H., Tanage G., Muraoka O., *Bioorg. Med. Chem.*, **10**, 1547—1554 (2002).
26) Yoshikawa M., Shimoda H., Nishida N., Takada M., Matsuda H., *J. Nutr.*, **132**, 1819—1824 (2002).
27) The ^{1}H- and ^{13}C-NMR spectra of **1** and **2** were assigned with the aid of distortionless enhancement by polarization transfer (DEPT), homo- and heterocorrelation spectroscopy (^{1}H–^{1}H, ^{13}C–^{1}H COSY), and HMBC experiments.
28) Ohtani I., Kusumi T., Kashman Y., Kakisawa H., *J. Am. Chem. Soc.*, **113**, 4092—4096 (1991).
29) This study was reported in a preliminary communication[7)] and the absolute configuration of the 5-positions in myrrhanol A (**1**) and myrrhanone A (**2**) were wrongly reported as *S*. We devised here the 5*S* configurations of **1** and **2** to the 5*R* configurations, respectively.