SPIRAMINES A, B, C, AND D, NEW DITERPENE ALKALOIDS FROM *SPIRAEA JAPONICA* VAR. *ACUMINATA* FRANCH

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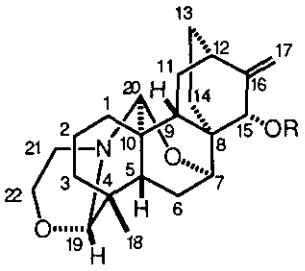
Abstract - New atisine-type alkaloids, spiramines A, B, C, and D were isolated from Spiraea japonica and their structures were elucidated by chemical and spectroscopic means.

The plant of Spiraea japonica var. acuminata was used as the folk medicine (Chinese name chui huo tong) in China.[1] From the dried roots of this plant collected in Kunming, Yunnan province of China, we isolated fifteen new atisine-type alkaloids and a new atisane-type diterpene. Here we report the structures of main alkaloids, spiramines A (**1**), B (**2**), C (**3**), and D (**4**).[2]

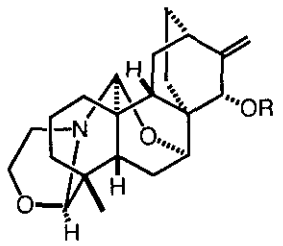
The high resolution mass spectrum and elemental analysis indicated a molecular formula of $C_{24}H_{33}NO_4$ for spiramine A (**1**). The basic skeleton of spiramine A (**1**) was established by comparing its ^{13}C-nmr shift values with literature data of atisine-type alkaloids.[3] The other spectroscopic analysis exhibited the presence of following groups; an exo methylene group [^1H-nmr (C_6D_6) δ 5.04, 5.30 (each 1H, br.s); ir (KBr) ν 3060, 1640, 895 cm^{-1}], a secondary acetoxy group [δ 1.65 (3H, s), 5.46 (1H, br.s); ν 1708, 1230 cm^{-1}]. The presence of an oxazolidine ring and an ether linkage between C-7 and C-20 in spiramine A (**1**) was also approved by the signals of ^1H-nmr [δ 3.87 (1H, s, H-19), 3.01, 3.24 (2H, m, H_2-21), 3.37, 3.81 (2H, m, H_2-22), 4.47 (1H, d, J = 2 Hz, H-20), 3.54 (1H, d, J = 5 Hz, H-7)]. Reduction of spiramine A (**1**) with sodium borohydride afforded a triol **5**, which confirmed that the two oxygen atoms exist as a part of two carbinolamine ether (N-C-O-C) linkages in spiramine A (**1**) similar to that in spiradine G (**6**).[4] On irradiation at δ 5.46, both of the signals at δ 5.04 and 5.30 were changed to the doublets with J = 2 Hz, demonstrating the location of the secondary

acetoxy group on C-15. Triol **5** was not identical with dihydroajaconine (**7**).[5] ^{13}C-nmr shift values of triol **5** and dihydroajaconine (**7**) were very close each other except for *C-7 and C-15. The downfield shifts of* C-7 (11 ppm) and C-15 (6 ppm) in triol **5** indicated 1,3-diaxial-like interaction between 7-H and 15-H.[6] Since 7-β and 15-β hydrogens in triol **5** have the 1,3-diaxial-like interaction, 15-acetoxy group in spiramine A (**1**) should be of the α-configuration.

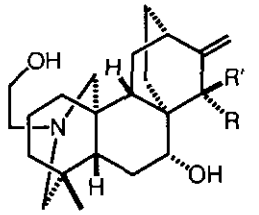
Hydrolysis of spiramine A (**1**) with potassium hydroxide in methanol afforded an approximately 2:1 mixture of spiramine C (**3**) and spiramine D (**4**). Oxidation of spiramine C (**3**) with manganese dioxide gave α,β-unsaturated ketones **8** and **9**. The former was reduced with sodium borohydride in methanol to give a triol, which was identified with dihydroajaconine (**7**) by ir, ^{1}H-nmr, ^{13}C-nmr data and optical rotation $[\alpha]_D^{19}$ -36.6° (c 1.2, EtOH); lit.[5] $[\alpha]_D^{24}$ -35.5° (c 1.0, EtOH). This chemical conversion confirmed the absolute strucutre **1** for spiramine A except for the stereochemistry at C-19.



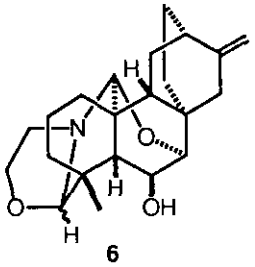
1 : R = Ac
3 : R = H



2 : R = Ac
4 : R = H



5 : R' = H, R = OH
7 : R' = OH, R = H



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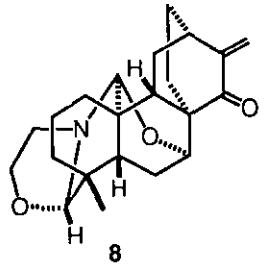

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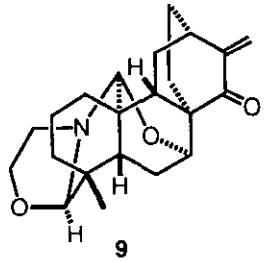

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Three-dimensional single-crystal X-ray analysis provided the total structure for spiramine A (**1**) including the *S*-configuration at C-19 in oxazolidine ring (Figure 1). The C-C single bond distances are varied from 1.509(7) to 1.568(5) Å, whereas the bond angles around the C(sp^2) atoms are varied from 104.2(3) to 116.3(3)°. The large bond distortion was observed around the *C(5)-C(10) bond fusing the four six-membered* rings. The bond distances of 1.510(5) Å for C(5)-C(10) and 1.568(5) Å for C(5)-C(6) are

significantly deviated from the usual C-C single bond distance (1.54 Å). The bond angles of 104.2(3)° for C(5)-C(10)-C(20) and 116.3(3)° for C(4)-C(5)-C(6) are also significantly deviated from the normal tetrahedral angle (109.5°). The shortest C-C bond was found in the oxazolidine ring. The five-membered ring has a distorted half-chair conformation with the C_2-axis bisecting the N-C(19) bond. The nitrogen atom has a pyramidal sp^3 configuration with the normal N-C distances. The molecules are packed in the crystal with the usual van der Waals contacts.

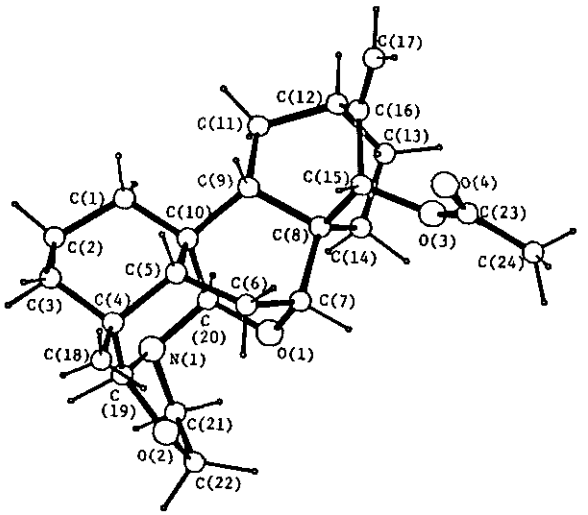

Figure 1 Crystal structure of **1**, showing the atom-labeling scheme.

The spectroscopic data of spiramine B (**2**) indicated the same basic skeleton and functional groups as spiramine A (**1**) except for the configuration at C-19 in the oxazolidine ring. Hydrolys of spiramine B (**2**) also gave a 2:1 mixture of spiramine C (**3**) and spiramine D (**4**). Reduction of spiramine B (**2**) with sodium borohydride gave a triol **5**. Spiramine B (**2**) was epimerized in methanol to give a mixture of spiramine A (**1**) and B (**2**). Thus, spiramine B (**2**) was confirmed to be the C-19 epimer of spiramine A (**1**). A close inspection of ^{13}C-nmr chemical shifts (Table 1) for the carbons of the oxazolidine ring in spiramines clearly reveals that the stereochemistries at C-19 in spiramine C (**3**) and D (**4**) correspond to those of spiramines A (**1**) and B (**2**), respectively. This suggested the structures **3** for spiramine C and **4** for spiramine D.

Epimerization and isomerization of oxazolidine ring of atisine-type alkaloids are well known and have been studied extensively.[7] Although the existence of epimeric mixtures at C-20 in the atisine series and C-19 in the isoatisine series has been demonstrated by ^{1}H-nmr and ^{13}C-nmr studies[8,9] no epimeric pairs have ever been isolated in pure form. It is the first time that each epimer at C-19 in the isoatisine series was isolated. The rate of epimerization of spiramines is slower than atisine. Spiramine A (**1**) gave a 3:1 mixture of spiramine A (**1**) and B (**2**) after 1 day at room temperature in CD_3OD, while almost unchanged after two days in $CDCl_3$. On chromatography with silica gel or alumina, epimerization takes place rather quickly.

Thus, spiramine A (**1**) afforded a mixture of spiramine A (**1**) and B (**2**) in an approximate ratio of 5:3 on the silica gel column and of 4:1 with alumina after 2 h.

EXPERIMENTAL

All melting points were determined on a Yanagimoto micro melting point apparatus and are uncorrected. ^{1}H-Nmr spectra and double irradiation spectra were recorded on a JOEL JMN-GX 400 spectrometer. ^{13}C-Nmr and HETCOR spectra were recorded on a VARIAN VXR-200 spectrometer and assignments are given in Table I. Optical rotations were measured with a JASCO DIP-181 polarimeter. Ir spectra were measured with a JASCO IR-180 spectrophotometer. Ms spectra were measured with a JEOL JMS-DX 300 mass spectrometer.

Extraction of Spiramines

Dried roots (15.5 kg) of Spiraea japonica var. acuminata, collected in Kunming, Yunnan province of China in November, 1985, were extracted with 90% EtOH (10 l) for 10 days at room temperature (3 times). Removing solvent afforded 800g of residue which was dissolved in 2000 ml of 2% HCl solution and filtered. HCl solution was made basic (pH 9 - 10) with NH_4OH and extracted with $CHCl_3$ (600 ml x 10). Evaporation of $CHCl_3$ gave 96g of a basic fraction which was chromatographed on an alumina column. Elution with light petroleum ether and acetone (50:1) afforded 47g of fraction A and 40.5g fraction B.

Spiramine (A) (**1**) and B (**2**)

A slight modification of dry-column flash chromatography[10] was used. Kieselgel 60H (Merck) (8g) was packed under reduced pressure in a glass filter 3 cm in diameter and 4.3 cm in height. A 460 mg of fraction A in CH_2Cl_2 (1 ml) was adsorbed and elution with *n*-hexane-ether (3:1) afforded spiramine A (**1**, 211mg, needles): mp 137.5-139 °C (from *n*-hexane); $[\alpha]_D^{25}$ -103.1° (c 0.9, benzene); ir (KBr) ν 3060, 1640, 895, 1707, 1230, 1010 cm^{-1}; ms m/z 399.239 (95, M^+), 382 (20), 356 (20), 328 (20), 239 (38); Anal. Calcd for $C_{24}H_{33}NO_4$: C, 72.18; H, 8.27; N, 3.51. Found. C, 72.44; H, 8.32; N, 3.56; ^{1}H-nmr (C_6D_6) δ 5.46 (1H, brs, H-15), 5.30, 5.04 (each 1H, brs, H_2-17), 4.47 (1H, d, *J* = 2 Hz, H-20), 3.87 (1H, s, H-19), 3.54 (1H, d, *J* = 5 Hz, H-7), 3.81, 3.37 (each 1H, m, H_2-22), 3.24, 3.01 (each 1H, m, H_2-21), 2.63 (1H, ddd, *J* = 5, 15, 4 Hz, H-6β), 2.23 (1H, m, H-12), 1.80 (1H, dd, *J* = 13, 15 Hz, H-6α), 1.65 (3H, s, -$COCH_3$), 1.18 (3H, s, H_3-18), 0.62 (1H, ddd, *J* = 13, 2, 4 Hz, H-5), a mixture of spiramine A (**1**) and B (**2**) (144 mg), and spiramine B (**2**, 56 mg, needles): mp 129-131 °C (from *n*-hexane); $[\alpha]_D^{25}$ -159.5° (c 0.9, benzene); ir (KBr) ν 3075, 1650, 895, 1712, 1230, 1010 cm^{-1}; ms m/z 399.242 (35, M^+), 382 (20), 356 (20), 239 (100); Anal. Calcd for $C_{24}H_{33}NO_4$: C, 72.18; H, 8.27; N, 3.51. Found. C, 72.41; H, 8.39; N,

3.56; ^{1}H-nmr (C_6D_6) δ 5.46 (1H, brs, H-15), 5.30, 5.04 (each 1H, brs, H_2-17), 4.69 (1H, d, J = 2 Hz, H-20), 4.27 (1H, s, H-19), 3.73, 3.65 (each 1H, m, H_2-22), 3.61 (1H, d, J = 5 Hz, H-7), 3.02, 2.70 (each 1H, m, H_2-21), 2.59 (1H, m, H-20), 1.85 (2H, m, H_2-6), 1.66 (3H, s, -$OCOCH_3$), 0.97 (3H, s, H_3-18), 0.75 (1H, ddd, J = 13, 2, 4 Hz, H-5).

Table I. ^{13}C Chemical Shifts[a] for Spiramines and Their Derivatives

carbon	A (1)[b,c]	A(1)	B(2)	C(3)	D(4)[c]	5	7
1(t)	40.9	41.0	33.9	40.8	34.2	39.8	39.8
2(t)	23.3	22.9	22.9	23.0	23.0	23.1	23.1
3(t)	29.9	29.8	29.8	29.9	30.0	41.1	41.1
4(s)	35.6[d]	35.4[d]	35.4[d]	35.4[d]	35.6[d]	33.5	33.4
5(d)	45.2	45.2	47.4	45.5	47.3	47.9	47.9
6(t)	25.2	25.2	25.3	25.2	25.5	15.3	20.7
7(d)	69.3	69.2	69.7	69.0	69.6	81.2	70.2
8(s)	40.9	40.8	41.0	41.5	41.9	41.4	42.6
9(d)	42.7	43.0	43.9	43.1	44.3	46.9	39.5
10(s)	34.3[d]	34.2[d]	34.9[d]	34.1[d]	34.2[d]	38.2	38.0
11(t)	23.6	23.5	23.1	23.5	23.1	26.9	28.2
12(d)	37.2	36.7	36.4	37.0	37.6	35.9	36.2
13(t)	21.1[e]	21.1[e]	21.2[e]	19.9[e]	23.1[e]	25.9	26.5
14(t)	20.9[e]	20.9[e]	20.8[e]	20.4[e]	20.4[e]	25.5	25.4
15(d)	74.2	74.2	74.3	74.3	74.5	77.8	71.8
16(s)	151.0	150.1	150.1	155.3	156.2	155.5	155.7
17(t)	114.1	114.2	114.3	112.0	111.6	109.0	109.9
18(q)	26.3	26.0	25.9	26.4	26.9	26.5	26.5
19(d)	95.3	95.2	91.3	95.3	91.5	60.7(t)	60.2(t)
20(d)	85.9	85.8	83.5	85.9	83.6	53.4(t)	53.9(t)
21(t)	51.3	51.0	45.7	51.0	45.7	58.0	58.0
22(t)	63.4	63.1	64.9	63.1	64.9	60.7	60.7
$\underline{O}\underline{C}OCH_3$	170.5	170.9	171.1				
$OCO\underline{C}H_3$	20.7	20.4	20.8				

[a]Determined in $CDCl_3$ unless otherwise stated. [b]Assigned by 200 MHz HETCOR experiment. [c]In C_6D_6. [d,e]These assignments may be interchanged in any vertical column.

Spiramine C (3) and D (4)

Fraction B (360 mg) was separated by the similar way as above. Elution with *n*-hexane-ether (2:1) gave spiramine C (**3**, 105 mg, needles): mp 167-169 °C (from ether); $[\alpha]_D^{25}$ -149.9° (c 1.0, benzene); ir (KBr) ν 3450, 1650, 890, 1040 cm^{-1}; Anal. Calcd for $C_{22}H_{31}NO_3$: C, 73.95; H, 8. 68; N, 3.92. Found. C, 73.74; H, 8.76; N, 3.78; ^{1}H-nmr (C_6D_6) δ 4.93, 4.90 (each 1H, brs, H_2-17), 4.49 (1H, d, J = 2 Hz, H-20), 3.88 (1H, s, H-19), 3.80 (1H, d, J = 5 Hz, H-7), 3.83, 3.36 (each 1H, m, H_2-22), 3.79 (1H, brs, H-15), 3.25, 3.00 (each 1H, m H_2-21), 2.62 (1H, ddd, J = 5, 15, 4Hz, H-6β), 2.22 (1H, m, H-12), 1.52 (1H, m, H-6α), 1.22 (3H, s, H_3-18), 0.67 (1H, m, H-5). Further elution with *n*-hexane-ether (1:2) afforded

spiramine D (**4**, 70 mg, needles): mp 160-162 °C (from ether); $[\alpha]_D^{25}$ -169.0° (c 0.7, benzene); ir (KBr) ν 3450, 1630, 890, 1050 cm^{-1}; Anal. Calcd for $C_{22}H_{31}NO_3$: C 73.95; H, 8.68; N, 3.92. Found. C, 73.63; H, 8.78; N, 3.69; ^{1}H-nmr (C_6D_6) δ 4.94, 4.91 (each 1H. brs, H_2-17), 4.72 (1H, d, *J* = 2 Hz, H-20), 4.29 (1H, s, H-19), 3.86 (1H, d, *J* = 5 Hz, H-7), 3.79 (1H, br.s, H-15), 3.74, 3.66 (each 1H, m, H_2-22), 3.04, 2.71 (each 1H, m, H_2-21), 2.61 (1H, m, H-12), 1.84 (1H, ddd, J = 5, 15, 4 Hz, H-6β), 1.52 (1H, m, H-6α), 0.99 (3H, s, H_3-18), 0.77 (1H, m, H-5).

Hydrolysis of Spiramine A (**1**)

Spiramine A (**1**) (50 mg) was dissolved in 15 ml of 2% KOH-MeOH and left overnight at room temperature. The mixture was evaporated *in vacuo*, taken up to water and extracted with benzene. Evaporation of benzene gave 41 mg of an approximately 2:1 mixture of spiramine C (**3**) and D (**4**). Hydrolysis of spiramine B (**2**) by the same procedure as above gave the similar results.

Reduction of Spiramine A (**1**)

To a solution of 100 mg of spiramine A (**1**) in 10 ml of MeOH was added 150 mg of sodium borohydride and allowed to stand for 5 h at room temperature. Removal of the solvent was followed by the partition between H_2O and $CHCl_3$. Organic layer was washed with H_2O, dried over Na_2SO_4, and evaporated *in vacuo* to give 89 mg of triol **5**: *amorphous*; *ir* (KBr) ν *3450, 3550, 1640 cm*$^{-1}$; *ms m/z 361.260* (8, M^+), 346 (8), 330 (100); ^{1}H-nmr ($CDCl_3$) δ 5.04, 5.02 (each 1H, brs, H_2-17), 3.91 (1H, brs, H-15), 3.70 (1H, dd, *J* = 5, 12 Hz, H-7), 3.63 (2H, t, *J* = 6 Hz, H_2-22), 2.78 (1H, d, *J* = 11 Hz, H-19β), 2.61 (1H, dd, *J* = 11, 2 Hz, H-19α), 2.50 (1H, d, *J* = 11 Hz, H-20β), 2.20 (1H, dd, *J* = 11, 2 Hz, H-20α), 2.45 (2H, m, H_2-21), 2.35 (1H, m, H-12), 1.17 (1H, dd, *J* = 3, 13 Hz, H-5), 0.80 (3H, s, H_3-18).

Oxidation of Spiramine C (**3**) with MnO_2

To a solution of 260 mg of spiramine C (**3**) in 10 ml of acetone was added 1.25g of active MnO_2[11] and the mixture was stirred for 3 days at room temperature. The mixture was filtered and acetone was removed. The residue was subjected to the SiO_2 flash column (eluted with *n*-hexane-ether 1:1) to give 120 mg of dehydrospiramine C (**8**, needles): mp 172-174 °C (from *n*-hexane-ether); ir (KBr) ν 1700, 1620 cm^{-1}; ms m/z 355.212 (40, M^+). 327 (55), 284 (50); ^{1}H-nmr ($CDCl_3$) δ 5.91, 5.21 (each 1H, d, *J* = 1.5 Hz, H_2-17), 4.67 (1H, d, *J* = 1 Hz, H-20), 3.90 (1H, s, H-19), 3.84 (1H, d, *J* = 5 Hz, H-7), 1.09 (3H, s, H_3-18) and 80 mg of dehydrospiramine D (**9**, needles): mp 155-157 °C (from *n*-hexane-ether); ir (KBr) ν 1700, 1620 cm^{-1}; ms m/z 355.213 (80, M^+), 338(20), 327 (100), 284 (80); ^{1}H-nmr ($CDCl_3$) δ 5.93, 5.23 (each 1H, d, *J* = 1.5 Hz, H_2-17), 4.90 (1H, d, *J* = 1 Hz, H-20), 4.21 (1H, s, H-19), 3.83 (1H, d, *J* = 5 Hz, H-7), 3.94 (2H, t, *J* = 7 Hz, H_2-22), 3.05 (2H, t, *J* = 7 Hz, H_2-21), 0.92 (3H, s, H_3-18).

Reduction of Dehydrospiramine C (8)

To a solution of 80 mg of dehydrospiramine C (**8**) in 10 ml of MeOH was added 150 mg of sodium borohydride. The mixture was stirred for 6.5 h at room temperature. After the solvent was removed, the residue was partitioned between H_2O and CH_2Cl_2. The organic layer was washed with water, dried over Na_2SO_4, and evaporated in vacuo to give 81 mg of residue. This residue was subjected to preparative tlc (Kieselgel 60 F_{254}, developed with Et_2NH:$CHCl_3$:ether = 1:5:5) to give 51 mg of triol, $[\alpha]_D^{19}$ -36.6° (c 1.2, EtOH), which was identified with dihydroajaconine (**7**) by ^{13}C-nmr and ^{1}H-nmr.

X-Ray Analysis of Spiramine A (1)

Crystal data: $C_{24}H_{33}NO_4$, M. W. = 399.5, orthorhombic, $P2_12_12_1$, a = 10.341(3), b = 12.718(7), c = 16.043(4) Å, V = 2109.9 Å^3, z = 4, D_m = 1.258 g cm^{-3}. The crystal with

Table II. Atomic Coordinates and Isotropically Equivalent Thermal Parameters with Their Standard Deviations in Parentheses for Non-hydrogen Atoms of Spiramine A (**1**)

Atom	x	y	z	B_{eq}(Å^2)
C(1)	-0.1843(4)	0.3427(4)	0.1470(3)	6.07(20)
C(2)	-0.3137(5)	0.3435(4)	0.1955(3)	7.21(24)
C(3)	-0.3667(4)	0.4556(5)	0.2041(3)	7.24(23)
C(4)	-0.2699(4)	0.5372(3)	0.2335(2)	4.97(16)
C(5)	-0.1589(3)	0.5390(3)	0.1696(2)	4.42(14)
C(6)	-0.0537(4)	0.6264(3)	0.1821(2)	4.76(17)
C(7)	0.0760(4)	0.5754(3)	0.2005(2)	4.23(13)
C(8)	0.1290(3)	0.5079(3)	0.1297(2)	4.38(12)
C(9)	0.0143(4)	0.4392(3)	0.1002(2)	4.61(16)
C(10)	-0.0930(4)	0.4331(3)	0.1683(2)	4.48(13)
C(11)	0.0688(5)	0.3390(3)	0.0585(3)	6.34(22)
C(12)	0.1999(5)	0.3741(4)	0.0189(3)	6.58(24)
C(13)	0.3025(4)	0.3770(4)	0.0871(3)	6.87(23)
C(14)	0.2437(4)	0.4388(3)	0.1617(2)	5.30(19)
C(15)	0.1723(3)	0.5642(3)	0.0511(2)	4.72(14)
C(16)	0.1898(4)	0.4819(4)	-0.0162(3)	5.83(21)
C(17)	0.1935(5)	0.5063(5)	-0.0963(3)	7.72(26)
C(18)	-0.3367(4)	0.6460(4)	0.2393(3)	6.86(25)
C(19)	-0.2234(4)	0.5049(4)	0.3193(2)	5.12(19)
C(20)	-0.0316(4)	0.4232(3)	0.2558(2)	4.53(13)
C(21)	-0.0723(4)	0.4313(4)	0.4051(2)	6.05(20)
C(22)	-0.0808(5)	0.5470(4)	0.4252(2)	6.34(19)
C(23)	0.3146(3)	0.7135(4)	0.0343(2)	5.20(18)
C(24)	0.4275(5)	0.7649(4)	0.0704(3)	6.86(23)
N(1)	-0.1288(3)	0.4207(3)	0.3207(2)	4.96(12)
O(1)	0.0587(2)	0.5068(2)	0.2706(1)	4.41(11)
O(2)	-0.1648(3)	0.5911(2)	0.3645(2)	5.75(12)
O(3)	0.2921(3)	0.6196(2)	0.0707(2)	5.73(12)
O(4)	0.2469(3)	0.7490(3)	-0.0203(2)	6.34(12)

Table III. Bond Distances (Å) and Bond Angles (°) with Their Standard Deviations in Parentheses for Spiramine A (**1**)

Bond distance

C(1) - C(2)	1.548(7)	C(8) - C(9)	1.547(5)	C(16) - C(17)	1.323(7)
C(1) - C(10)	1.526(6)	C(8) - C(14)	1.563(5)	C(19) - N(1)	1.451(6)
C(2) - C(3)	1.534(8)	C(8) - C(15)	1.518(5)	C(19) - O(2)	1.447(5)
C(3) - C(4)	1.517(7)	C(9) - C(10)	1.559(5)	C(20) - N(1)	1.448(5)
C(4) - C(5)	1.539(5)	C(9) - C(11)	1.546(6)	C(20) - O(1)	1.435(5)
C(4) - C(18)	1.549(6)	C(10) - C(20)	1.546(5)	C(21) - C(22)	1.509(7)
C(4) - C(19)	1.515(5)	C(11) - C(12)	1.562(7)	C(21) - N(1)	1.481(5)
C(5) - C(6)	1.568(5)	C(12) - C(13)	1.525(7)	C(22) - O(2)	1.420(5)
C(5) - C(10)	1.510(5)	C(12) - C(16)	1.486(7)	C(23) - C(24)	1.458(6)
C(6) - C(7)	1.519(6)	C(13) - C(14)	1.556(6)	C(23) - O(3)	1.350(5)
C(7) - C(8)	1.526(5)	C(15) - C(16)	1.515(6)	C(23) - O(4)	1.209(5)
C(7) - O(1)	1.435(4)	C(15) - O(3)	1.459(4)		

Bond angle

C(2) - C(1) - C(10)	114.7(4)	C(9) - C(8) - C(15)	103.8(3)	C(12) - C(16) - C(15)	112.1(4)
C(1) - C(2) - C(3)	111.1(4)	C(14) - C(8) - C(15)	108.3(3)	C(12) - C(16) - C(17)	125.6(5)
C(2) - C(3) - C(4)	115.3(4)	C(8) - C(9) - C(10)	111.1(3)	C(15) - C(16) - C(17)	122.3(5)
C(3) - C(4) - C(5)	107.2(3)	C(8) - C(9) - C(11)	108.6(3)	C(4) - C(19) - N(1)	115.4(3)
C(3) - C(4) - C(18)	109.6(4)	C(10) - C(9) - C(11)	121.5(3)	C(4) - C(19) - O(2)	112.5(4)
C(3) - C(4) - C(19)	107.8(4)	C(1) - C(10) - C(5)	113.3(3)	N(1) - C(19) - O(2)	105.6(3)
C(5) - C(4) - C(18)	111.1(3)	C(1) - C(10) - C(9)	108.7(3)	C(10) - C(20) - N(1)	111.7(3)
C(5) - C(4) - C(19)	111.9(3)	C(1) - C(10) - C(20)	113.3(3)	C(10) - C(20) - O(1)	110.9(3)
C(18) - C(4) - C(19)	109.2(3)	C(5) - C(10) - C(9)	106.7(3)	N(1) - C(20) - O(1)	110.4(3)
C(4) - C(5) - C(6)	116.3(3)	C(5) - C(10) - C(20)	104.2(3)	C(22) - C(21) - N(1)	105.1(3)
C(4) - C(5) - C(10)	109.4(3)	C(9) - C(10) - C(20)	110.4(3)	C(21) - C(22) - O(2)	105.9(3)
C(6) - C(5) - C(10)	108.7(3)	C(9) - C(11) - C(12)	104.9(3)	C(24) - C(23) - O(3)	111.3(3)
C(5) - C(6) - C(7)	109.6(3)	C(11) - C(12) - C(13)	108.6(4)	C(24) - C(23) - O(4)	125.7(5)
C(6) - C(7) - C(8)	114.4(3)	C(11) - C(12) - C(16)	110.9(4)	O(3) - C(23) - O(4)	123.0(4)
C(6) - C(7) - O(1)	107.6(3)	C(13) - C(12) - C(16)	107.4(4)	C(19) - N(1) - C(20)	116.2(3)
C(8) - C(7) - O(1)	106.6(3)	C(12) - C(13) - C(14)	107.0(4)	C(19) - N(1) - C(21)	102.3(3)
C(7) - C(8) - C(9)	105.7(3)	C(8) - C(14) - C(13)	109.1(3)	C(20) - N(1) - C(21)	112.4(3)
C(7) - C(8) - C(14)	110.2(3)	C(8) - C(15) - C(16)	107.5(3)	C(7) - O(1) - C(20)	113.7(2)
C(7) - C(8) - C(15)	117.3(3)	C(8) - C(15) - O(3)	107.4(3)		
C(9) - C(8) - C(14)	111.4(3)	C(16) - C(15) - O(3)	112.7(3)		

0.4x0.4x0.5 mm was mounted on a Rigaku AFC-5RU diffractometer using graphite-monochromated Cu-K_α radiation and 1719 unique reflections with $Fo>3\sigma(Fo)$ were collected with $\theta < 60$ ($0\leq h\leq 11$, $0\leq k\leq 14$, $0\leq 1\leq 18$), using θ-2θ scans at speeds of 4° min^{-1}. No significant intensity fluctuation during data collection was observed from the three standard reflections. The data were corrected for Lorentz and polarization factors, but not for absorption effects. The structure was solved by direct methods using MULTAN78,[12] and refined to R = 0.056, R_w = 0.083 by blockdiagonal least-squares including anisotropic non-H atoms and isotropic H atoms. All the H atoms were located from a ΔF map. The parameter shifts at the last least-squares cycle were less than 0.7σ. The atomic scattering factors used were from International Tables for

X-ray Crystallography. All computations were performed on a FACOM M780 in the Data Processing Center of Kyoto University, using the program system KPPXRAY.[13] The final atomic coordinates and isotropically equivalent thermal parameters for the non-H atoms were listed in Table II. The bond distances and bond angles are given in Table III. Tables of the anisotropic thermal parameters for the non-H atoms and the atomic parameters for the H atoms, and a list of the observed and calculated structure factors are available on request.

ACKNOWLEDGMENT

We are grateful to Prof. Feng Guo-Mei of Kunming Institute of Botany, Academia Sinica, for identifying the plant materials.

REFERENCES

1. "Zhong Yao Da Ci Dian", ed by Jiangshu new medical College, Shanghai people's publishing House, 1971,p1117.
2. X. Hao, M. Node, T. Taga, Y. Miwa, J. Zhou, S. Chen, and K. Fuji, Chem. Pharm. Bull., 1987, **35**, 1670.
3. N. W. Mody and S. W. Pelletier, Tetrahedron, 1978, **34**, 2421.
4. M. Toda and Y. Hirata, Tetrahedron Lett., 1968, 5565.
5. S. W. Pelletier, R. S. Sawhney, and N. V. Mody, Heterocycles, 1978, **9**, 1241.
6. H. Beierbeck and J. K. Saunders, Can. J. Chem., 1976, **54**, 2985.
7. S. W. Pelletier and N. V. Mody, "The Alkaloids", Vol 18, ed. by R. G. A. Rodrigo, Academic Press, New York, 1981, p99.
8. S. W. Pelletier, N. V. Mody, H. K. Desai, J. Finer-Moore, J. Nowacki, and B. S. Joshi, J. Org. Chem., 1983, **48**, 1787.
9. F. Sun, X. Liang and D. Yu, Heterocycles, 1987, **26**, 19.
10. L. M. Harwood, Aldrichimica Acta, 1985, **18**, 25.
11. Preparation of active MnO_2 see: S. Ball, T. W. Goodwin, and R. A. Morton, Biochem. J., 1948, 516.
12 P. Main, S. E. Hull, L. Lessinger, G. Germain, J.-P. Declecq, and M. M. Woolfwon, MULTAN78: "A System of Computer Program for the Automatic Solution of Crystal Structures from X-Ray Diffraction Data", Univs. of York, England, and Louvain, Bergium, 1978.
13 T. Taga, T. Higashi, and H. Iizuka, KPPXRAY; "Kyoto Program Package for X-Ray Crystal Structure Analysis", Kyoto Univ., 1985.

Received, 4th September, 1989