Notes

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Studies on the Constituents of *Chloranthus* spp. II.[1] The Sesquiterpenes from *Chloranthus serratus*

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(—)-Dihydropyrocurzerenone (I), mp 65—66°, $C_{15}H_{18}O$, $[\alpha]_D^{17}$ —28° was isolated from *Chloranthus serratus* ROEM. et SCHULT. (Japanese name, "Futarishizuka"). Also, pyrocurzerenone (II) was identified by gas chromatography–mass spectrometry (GC–MS) and by a comparison in gas chromatography with an authentic specimen of pyrocurzerenone. Three additional sesquiterpenes were detected by GC–MS.

As a result of our continuing studies on Chloranthaceae plants, (—)-dihydropyrocurzerenone (I), mp 65—66°, $C_{15}H_{18}O$, $[\alpha]_D^{17}$ —28°, was isolated from *Chloranthus serratus* ROEM. et SCHULT. (Japanese name, "Futarishizuka"). Also, pyrocurzerenone (II) and others (III—V) were expected as the sesquiterpenic constituents of this plant by an application of gas chromatography–mass spectrometry. Among them, II was confirmed by a comparison of gas chromatography using an authentic specimen of pyrocurzerenone. These results provide a good construction to the report on (—)-α-copaene and humulene as the constituents of *C. spicatus*.[3]

(—)-Dihydropyrocurzerenone (I) was obtained as colorless needles after repeated alumina chromatography of the ethyl acetate extract prepared from the methanolic extract of the roots of *C. serratus*. In its nuclear magnetic resonance (NMR) spectrum, a quartet (1H, J=1.5 Hz) at 7.10 ppm is assigned to a hydrogen on the α position of a furan ring and a doublet (3H, J=1.5 Hz) at 2.28 ppm is assigned to a methyl group on the β position of the furan ring. Also, a doublet (3H, J=7 Hz) at 1.05 ppm, ascribed to a secondary methyl group, and two singlets (3H and 1H) at 2.18 ppm and 6.92 ppm, to a methyl group and a hydrogen on an aromatic ring, are recognized. In the mass spectrum, the peak at m/e 214 suggests the molecular formula $C_{15}H_{18}O$ and a predominant peak at m/e 172 is explained reasonably as a fragment ion shown in Chart 1. These properties and a general biogenesis of sesquiterpenes lead us the molecular structure I for the compound (I). This structure has been proposed for dihydropyrocurzerenone, a hydrogenation product of pyrocurzerenone, which is obtained in pyrolysis of curzerenone.[4] After a comparison of thin-layer chromatography (TLC) and NMR spectra, the isolated compound (I) was concluded as dihydropyrocurzerenone, but the synthesized compound is a racemate, while the natural product showed $[\alpha]_D^{17}$ —28°. This is the first case of the isolation of (—)-dihydropyrocurzerenone from the natural source.

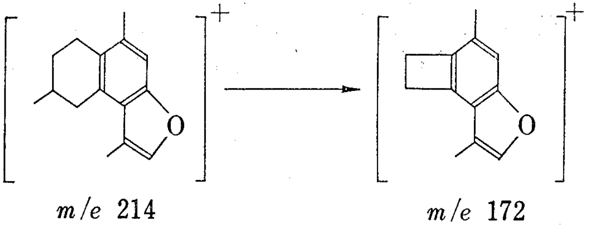

Chart 1

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[1] Part I: T. Takemoto, M. Uchida, K. Koike, Y. Hoshina, and G. Kusano, *Chem. Pharm. Bull.* (Tokyo), 23, 1161 (1975).
[2] Location: *Aobayama, Sendai.*
[3] P. de Mayo, R.E. Williams, G. Buchi, and S.H. Feairheller, *Tetrahedron*, 21, 619 (1965).
[4] H. Hikino, K. Agatsuma, C. Konno, and T. Takemoto, *Tetrahedron Letters*, 42, 4417 (1968).

After the isolation of (—)-dihydropyrocurzerenone, the mother solution of the recrystallization and the other eluates in the alumina chromatography were examined by gas chromatography–mass spectrometry (GC–MS). The experiment was undertaken with the fractions themselves and ones treated with trimethylsilyl chloride, and the results are summarized in Table I and II.

TABLE I. Gas Chromatogram of Sesquiterpenes of of *C. serratus*

Peak No.	Compound	Retention time (min)
1	dihydropyrocurzerenone (I)	6.7
2	pyrocurzerenone (II)	7.5
3	III	7.7(8.7)
4	IV	10.3
5	V	12.7(12.9)

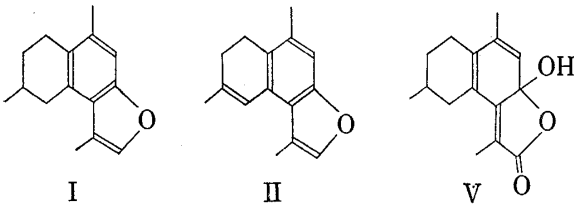
absorbent: 1% OV-1, 2m. oven temp.: 170°
( ): trimethylsilyl derivative

TABLE II. Mass Fragmentations of I—V

Compound	Fragment ion peak (*m/e*)	mol. formula
Dihydropyrocurzerenone (I)	214(100), 199(28), 172(93)	$C_{15}H_{18}O$
Pyrocurzerenone (II)	212(100), 197(82), 183(39), 69(38)	$C_{15}H_{16}O$
III	218(56), 203(100),	$C_{15}H_{22}O$
III[a]	290(22), 275(100), 73(22)	$C_{15}H_{21}OSi(CH_3)_3$
IV	230(100), 202(49), 187(38), 173(35)	$C_{15}H_{18}O_2$
V	246(38), 218(54), 203(100)	$C_{15}H_{18}O_3$
V[a]	318(19), 290(24), 275(100)	$C_{15}H_{17}O_3Si(CH_3)_3$

a) trimethylsilyl derivative
( ): relative intensity

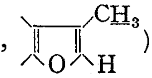
A peak of t_R 7.5 min in the gas chromatography provided the mass spectrum of *m/e* 212 (M^+), 197 (M^+–15), 183 and 69, suggesting pyrocurzerenone (II), that was confirmed later by a gas chromatographic comparison using an authentic specimen. Another peak of t_R 7.7 min in GC corresponding to the mass spectrum of *m/e* 218 (M^+) and 203 (M^+–15), moved to the peak of t_R 8.7 min in GC giving the MS of *m/e* 290 (M^+) and 275 (M^+–15) after a treatment with trimethylsilyl chloride. This suggests an existence of the third compound (III), a sesquiterpenic alcohol, the molecular formula of which is $C_{15}H_{22}O$. Although many possible structures are expected for III, it is most attractive to think that this compound might be a precursor of dihydropyrocurzerenone (I). Another peak of t_R 10.3 min in GC produced the mass spectrum of *m/e* 230 (M^+), 202, 187 and 173. Because this peak showed no change of the retention time after a treatment with trimethylsilyl chloride, two oxygen atoms of the molecular formula $C_{15}H_{18}O_2$ of the fourth compound (IV) are expected to be etheric or lactonic. The last peak of t_R 12.7 min gave the mass spectrum of *m/e* 246 (M^+), 218 and 203, the treatment with trimethylsilyl chloride produced the peak of t_R 12.9 min and *m/e* 318, 290 and 275. This result suggests the molecular formula $C_{15}H_{18}O_3$ for the fifth compound (V), which is expected an auto-oxidized compound of I, and the molecular structure (V) is proposed.

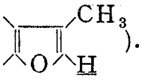


I II V

Chart 2

Experimental[5]

Isolation of Dihydropyrocurzerenone (I)——The dried roots (6.7 kg) of *C. serratus* were extracted with hot MeOH. The MeOH extract was condensed to 2 liters, and extracted with AcOEt. The last extract was chromatographed on alumina to prepare many eluates. Among them, the petr. benzine eluate provided colorless needles of dihydropyrocurzerenone (I) 20 mg, after recrystallization from petr. benzine. mp 65—66°. Vanillin–HCl reaction (+). $Rf=0.33$ on TLC (solvent: petr. benzine). $[\alpha]_D^{17}$ $-28°$ ($c=0.84$, $CHCl_3$). Mass Spectrum m/e (relative intensity): 214 (100), 199 (28), 172 (93). IR ν_{max}^{KBr} cm^{-1}: 1610 (aromatic ring), 1100 (ether). NMR (CCl_4) ppm: 1.05 (3H, d, $J=7$ Hz, $>CH-C\underline{H}_3$), 2.18 (3H, s, $Ar-CH_3$), 2.28 (3H, d, $J=1.5$ Hz, 

), 6.92 (1H, s, aromatic proton), 7.10 (1H, q, $J=1.5$ Hz, 

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Gas Chromatography–Mass Spectrometric Analysis——The petr. benzine eluates gained from alumina chromatography of the AcOEt extract of this plant, were analysed with combination of gas chromatograph and mass spectrometer. The results are summarized in Table I and II.

Identification of Pyrocurzerenone (II)——The peak at the retention time (t_R) 4.9 min was compared with an authentic sample of pyrocurzerenone by GLC (1% OV-1, 2m, 190°).

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5) Melting point was not corrected. NMR spectra were measured with JNM-PS 100 spectrometer using tetramethylsilane as an internal standard. GC–MS spectra were taken with LKB-9000s GC–MS spectrometer and gas chromatography was with JEOL JGC-20K gas chromatograph. IR spectrum was recorded on Shimazu IR-27G spectrometer. Optical activity was determined with Hitachi polarimeter. Thin-layer chromatography was done on Kieselgel GF 254 nach Stahl, and column chromatography was done using Sumitomo activated alumina.

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Reaction of Aromatic N-Oxides with Dipolarophiles. II.[1] Reaction of β-Alkylpyridine N-Oxides with Phenyl Isocyanate[2]

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The reaction of β-alkylpyridine N-oxides (I) with phenyl isocyanate (II) in dimethylformamide at 110° gave the cycloadducts (III and IV), although it was noticed that the reaction of pyridine N-oxide with II directly affords α-anilinopyridine. The duration at elevated temperature resulted in an increased yield of the anilino derivatives, while the cycloadducts tended to decrease. The effect by using various sorts of solvents demonstrated that dimethylformamide and dimethylsulfoxide are suitable for the formation of cycloadducts.

The previous papers from our laboratory[1,4] described that 3-picoline N-oxide (Ia) reacted with phenyl isocyanate (II) at 110° in dimethylformamide (DMF) to afford primary cycloadducts, IIIa and IVa, in 34 and 24% yields, respectively. Under this condition, an excess

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1) Part I: T. Hisano, S. Yoshikawa, and K. Muraoka, *Chem. Pharm. Bull.* (Tokyo), 22, 1611 (1974).
2) A part of this work was presented at the Kyushu Local Meeting of the Pharmaceutical Society of Japan, December 1973.
3) Location: *Oe-honmachi, Kumamoto.*
4) T. Hisano, S. Yoshikawa, and K. Muraoka, *Organic Preparations and Procedures International*, 5, 95 (1973).