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NEW HALOGENATED MONOTERPENES FROM DESMIA (CHONDROCOCCUS) HORNEMANNI

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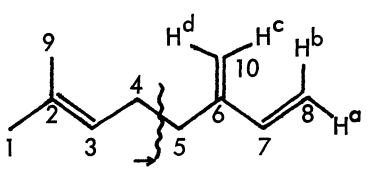
Constituents of fragrant subtidal red algae on Amami Island coasts were investigated, and the structures of several halogenated monoterpene compounds (II-XII) have been established.

Halogenated monoterpene compounds [1] (II-XII), have been found from red algae, Desmia hornemanni Mertens [Chondrococcus hornemanni (Mertens) Schmitz] (Japanese name "hosobanaminohana") together with myrcene (I) and methyl palmitate. In this paper we wish to report the structure elucidation of the isolated compounds (II-IX) and also structure estimation of a few minor components (X-XII).

The fresh red algae (500 g), have been extracted with methanol (1.5 l) for three days at room temperature. The extract was concentrated in vacuo and then extracted with hexane. After evaporation of the solvent the residue was separated into the two fractions eluted successively by hexane (1020 mg) and benzene (290 mg) through a column of silica gel (20 g). The fraction eluted by hexane had characteristic odor of the red algae and concerned to this communication. Separation of each constituent was carried out by preparative gas chromatography (carbowax-20M, 120°, 160-200°C). MS and NMR spectra of the related compounds are listed for comparison (Table 1 and 2). The contents were calculated from the gas chromatogrammn (HB 2000, 0.25mm X 45 m, 150°C /1.7 Kg/cm^2).

Compound II, a major fragrant oil (75.4% of the volatile oil), M^+, m/e 170 and 172 ($C_{10}H_{15}Cl$), λ_{max} 228 nm (ϵ, 10,250 in hexane), was easy to polymerize in the air. Dehalogenation of II with $NaBH_4$ in methanol gave myrcene (I) in 40% yield after 8 hrs reflux, which was identified by comparison of the physical data with those of the authentic sample. IR, UV, NMR, and MS spectra of II exhibited the presence of an isopropylidene group, and a conjugated system consisting of two terminal methylenes, wherein no signal of AMX spin system indicated that a vinyl proton at C^7 in the structure I was substituted by a chlorine. Indeed, protons close to chlorine absorbed at lower field (the differences were 0.59 ppm at $C^8\underline{H}^a$ and 0.41 ppm at $C^{10}\underline{H}^c$) than those of myrcene. Thus, the chloride II must be 7-chloromyrcene.



m/e 69 (I)

IR spectrum of III showed a striking resemblance to that of II. The MS spectrum of III was also similar to that of II except the fragments of M^+ (m/e 214, 216) and M-43 (m/e 171, 173) depending on the difference of halogen atoms (Br and Cl). NMR spectrum of III indicated the bromine substituent taking the place of chlorine in II.

The electronegative substituent well accounts for lower field chemical shifts of the protons at $C^{8}\underline{H}_2$ (5.85, 5.59 ppm) and $C^{10}\underline{H}_2$ (5.48, 5.12 ppm). From the above data III should be 7-bromomyrcene.

Compounds IV and V exhibited a quite similar fragmentation containing bromine ($C_{10}H_{15}Br$, M^+ m/e 214, 216 : M-43, m/e 171, 173), and hence should be geometrical isomers with each other. Compound V was dehalogenated by $NaBH_4$ as stated above and gave myrcene. NMR spectra with AMX spin systems at $C^{7}\underline{H}$ (6.24 ppm in IV and 6.74 ppm in V), and strongly deshielding protons (6.21 ppm in IV and 6.05 ppm in V) suggested that IV and V were substituted by bromine at $C^{10}\underline{H}^{d}$ or at $C^{10}\underline{H}^{c}$ respectively. The proton attached to the carbon bearing a bromine in V exhibited about 10% of NOE caused by irradiation of methylene protons (2.20 ppm). Therefore, V must be (E)-10-bromomyrcene, and IV should be (Z)-10-bromomyrcene.

MS spectra of VI and VII were comparable to those of IV and V in the resemblance of each pair and, consequently, should be geometrical isomers. And their MS spectra indicated that they were composed of $C_{10}H_{14}BrCl$ (M^+ m/e 248, 250, 252 : M-Br, m/e 169, 171 : M-Br-Cl-H, m/e 133). Though dehalogenation of them were unsuccessful under the above described conditions, the base peak m/e 69 suggested for them to have an acyclic skeleton. Missing of AMX spin systems in their NMR spectra, and strongly deshielding protons (6.84 ppm in VI and 6.10 ppm in VII) suggested the orientation of their halogen substituents. From the comparison of their chemical shifts at $C^{8}\underline{H}_2$ (5.59, 5.42 ppm in VI and 5.52, 5.32 ppm in VII) with those of the compounds II and III, it is clear that C^{7} protons are replaced by chlorines respectively. Therefore, VI must be (Z)-10-bromo-7-chloromyrcene, and VII should be (E)-10-bromo-7-chloromyrcene. VIII was found to be a trihalogenated compound even though difficult to find its molecular ions M^+ at m/e 326, 328, 330, and 332 ($C_{10}H_{13}Br_2Cl$). M-Br-43+H at m/e 205, 207, 209 : M-2Br-43+2H at m/e 127 : base peak at m/e 67, and b.p.+Cl+H at m/e 103, 105 were characteristic fragments. Base peak (m/e 67), and peaks with chlorine (m/e 103, 105) suggested chlorine substitution at C^{3}. This could be also accounted for by disappearence of a vinyl proton corresponding to $C^{3}\underline{H}$ in its NMR spectrum. From the comparison of NMR spectra of VIII and VI two bromine substituents in VIII should be at $C^{7}\underline{H}$ and $C^{10}\underline{H}^{d}$. And it should be 3-chloro-7, (Z)-10-dibromomyrcene.

MS spectrum of IX exhibited M^+ at m/e 326, 328, 330, 332 ($C_{10}H_{13}Br_2Cl$), M-Br-43+H at m/e 205, 207, 209, M-2Br at m/e 168, 170, base peak at m/e 67, and b.p.+Br+H at m/e 147, 149. Base peak (m/e 67), and the peaks with bromine (m/e 147, 149) indicated bromine substitution at C^{3} which was supported by its NMR spectrum in a similar manner as VIII. Though locations of the remaining halogen atoms in IX were difficult to determine, a bromine at C^{7} and a chlorine at C^{10} would be most likely presumed, by comparison of the chemical shifts at lower field between IX and VIII. Thus, IX would be (Z)-10-chloro-3,7-dibromomyrcene.

Though a minor compound X (0.56 %) did not show M^+ peak, fragments of M-Br (m/e 169, 171), M-Br-43+H (m/e 127, 129), M-Br-Cl-H (m/e 133), base peak (m/e 67), and b.p.+Br+H (m/e 147, 149) suggested the structure as 3-bromo-7-chloromyrcene from analogy with the fragmentation of other related compounds.

XI (0.24 %) was estimated as 7-bromo-(Z) or (E)-10-chloromyrcene in a similar manner as above. Its characteristic fragments were as follows ; M-43 (m/e 205, 207), M-Br (m/e 169, 171), M-Br-43+H (m/e 127, 129) and base peak (m/e 69).

MS spectrum of XII (1.13 %) suggested the molecular formula as $C_{10}H_{15}Br$ M^+ m/e 214 (8 %), 216 (6 %); M-Br, 135 (75 %) ; M-Br-H at 134 (51 %) ; and base peak 119 (100 %). From the base peak (m/e 119) XII was estimated to have a cyclic skeleton and differ from the other acyclic components. Further study is in progress.

REFERENCES

1) D.J. Faulkner and M.O. Stallard, Tetrahedron Letters, 1171 (1973); D.J. Faulkner, M.O. Stallard, J. Fayos and J. Clardy, J. Am. Chem. Soc., 95, 3414 (1973).

Table 1 MS spectral data of the compounds (I-XI) taken by GC-MS

No.	Compound (m/e (%))	M^+	M-43	M-X	M-Br-43+H	Base Peak	Key Peak
I	Myrcene $C_{10}H_{16}$	136 (1)	93 (82)			41 (100) 69 (84)	
II	7-chloro- $C_{10}H_{15}Cl$	170 (4) 172 (2)	127 (82) 129 (25)	135 (6) (X=Cl)		69 (100)	
III	7-bromo- $C_{10}H_{15}Br$	214 (2.4) 216 (2)	171 (57) 173 (48)	135 (9) (X=Br)		69 (100)	
IV	(Z)-10-bromo- $C_{10}H_{15}Br$	214 (1.6) 216 (1.6)	171 (12) 173 (12)	135 (22) (X=Br)	93 (26)	69 (100)	
V	(E)-10-bromo- $C_{10}H_{15}Br$	214 (1) 216 (0.8)	171 (10) 173 (10)	135 (36) (X=Br)	93 (66)	69 (100)	
VI	(Z)-10-bromo- 7-chloro- $C_{10}H_{14}BrCl$	248 (t) 250 (t) 252 (t)	205 (16) 207 (19) 209 (6)	169 (10) 171 (4) (X=Br)	127 (8) 129 (2)	69 (100)	133 (3) (M-Br-Cl-H)
VII	(E)-10-bromo- 7-chloro- $C_{10}H_{14}BrCl$	248 (0.4) 250 (0.4) 252 (-)	205 (12) 207 (19) 209 (4)	169 (14) 171 (4) (X=Br)	127 (15) 129 (6)	69 (100)	133 (4) (M-Br-Cl-H)
VIII	3-chloro- 7,(Z)-10- dibromo- $C_{10}H_{13}Br_2Cl$	[326 (t) 328 (t) 330 (t) 332 (t)]			205 (70) 207 (65) 209 (20) 127^* (35) 129^* (16)	67 (100)	167 (8) 169 (2) (M-2Br-H) 103 (100) 105 (30) (B.P.+Cl+H)
IX	(Z)-10-chloro- 3,7-dibromo- $C_{10}H_{13}Br_2Cl$	326 (1) 328 (2) 330 (1) 332 (t)		247 (18) 249 (24) 251 (6) (X=Br)	205 (10) 207 (12) 209 (3)	67 (100)	168 (70) 170 (22) (M-2Br) 147 (35) 149 (35) (B.P.+Br+H)
X	[3-bromo- 7-chloro-] $C_{10}H_{14}BrCl$	[248 (t) 250 (t)]		169 (46) 171 (12) (X=Br)	127 (66) 129 (27)	67 (100)	133 (22) (M-Br-Cl-H) 147 (18) 149 (21) (B.P.+Br+H)
XI	[7-bromo- 10-chloro-] $C_{10}H_{14}BrCl$	[248 (t) 250 (t)]	205 (25) 207 (40)	169 (20) 171 (10) (X=Br)	127 (20) 129 (8)	69 (100)	

Estimated compounds are written in [ ] . * (+2H, 2Br)

Table 2 NMR spectral data of the compounds (I-IX)

No.	Compound (δ, Hz in CCl_4)	% on GLC	$C^1\underline{H}_3$, $C^9\underline{H}_3$	$C^3\underline{H}$	$C^4\underline{H}_2$, $C^5\underline{H}_2$	$C^7\underline{H}$	$C^8\underline{H}^a$	$C^8\underline{H}^b$	$C^{10}\underline{H}^c$	$C^{10}\underline{H}^d$
I	Myrcene	0.14	1.56 s, 1.63 s	5.0 b	2.11 b	6.30 d.d, J=18, J=10	4.94 d.d, J=10, J=1.5	5.13 d.d, J=18, J=1.5	4.91 b	
II	7-chloro-	75.4	1.56 s, 1.64 s	5.0 b	2.21 b	Cl	5.53 b	5.38 d, J=1.0	5.32 d, J=1.0	5.08 b
III	7-bromo-	1.84	1.59 s, 1.67 s	5.0 b	2.26 b	Br	5.85 d, J=1.0	5.59 d, J=1.0	5.48 d, J=1.0	5.12 d, J=1.0
IV	(Z)-10-bromo-	3.56	1.57 s, 1.64 s	5.0 b	2.25 m	6.24 d.d, J=17, J=10	5.06 d.d, J=10, J=1.0	5.24 d.d, J=17.5, J=1.0	6.21 s	Br
V	(E)-10-bromo-	7.60	1.53 s, 1.64 s	5.0 b	2.20 b	6.74 d.d, J=18, J=10	5.23 d.d, J=10, J=1.0	5.35 d.d, J=18, J=1.0	Br	6.05 d, J=1.0
VI	(Z)-10-bromo-7-chloro-	0.68	1.63 s, 1.69 s	5.1 b	2.45 m	Cl	5.59 d, J=1.5	5.42 d, J=1.5	6.84 s	Br
VII	(E)-10-bromo-7-chloro-	3.51	1.55 s, 1.63 s	5.0 b	2.18 b	Cl	5.52 d, J=1.5	5.32 d, J=1.5	Br	6.10 d, J=1.0
VIII	3-chloro-7, (Z)-10-dibromo-	0.76	1.84 b	Cl	2.65 m	Br	5.67 d, J=1.5	5.50 d, J=1.5	6.95 s	Br
IX	(Z)-10-chloro-3,7-dibromo-	1.57	1.82 b	Br	2.69 m	Br (Cl)	5.68 d, J=1.5	5.50 d, J=1.5	6.94 s	Cl (Br)

s : singlet, b : broad peak, d : doublet, d.d : doublet of doublets Hitachi R-20B , 60 M Hz

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