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Furoplocamioids A−C, Novel Polyhalogenated Furanoid Monoterpenes from *Plocamium cartilagineum*

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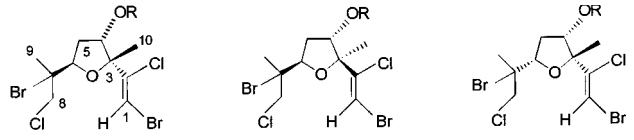
Three new tetrahydrofuran derivatives, marine monoterpenes, with an unusual chlorobromo vinyl functional group, have been isolated from the red alga *Plocamium cartilagineum*. The structure and relative stereochemistry of these compounds were determined on the basis of spectroscopic evidence and molecular mechanics (MM2) calculations. These compounds are related to pantofuranoids isolated from the antarctic *Pantoneura plocamioides*, which strongly suggests a close relationship between these species.

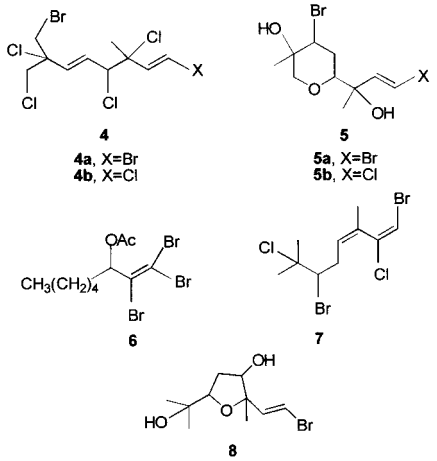
Algae of the genus *Plocamium*, particularly *P. cartilagineum*, have proved to be a rich source of acyclic and carbocyclic polyhalogenated monoterpenes,[1,2] and, incredibly, after 25 years of natural products research the genus still continues to provide metabolites with novel features.

Previously, we found[3,4] that *Pantoneura plocamioides* Kylin, an alga endemic to the Antarctic that belongs to the Delesseriaceae family (order Ceramiales), was the source of novel oxane derivatized monoterpenes (tetrahydropyran and tetrahydrofuran skeletons) with a high degree of oxygenation, and recently we described[5] some related tetrahydropyran monoterpenes from *Plocamium cartilagineum*. In this work we report on the first tetrahydrofuran derivatives furoplocamioids A−C, **1a**−**3a**, found in a *Plocamium* species. These compounds contain a chlorobromo vinyl system which is unusual within the marine monoterpene family.



1a, R= H
1b, R= Ac
2a, R= H
2b, R= Ac
3a, R= H
3b, R= Ac

It is well known that monoterpenoids with a terminal bromovinylic (e.g., **4a**, **5a**) or chlorovinylic system (e.g., **4b, 5b**) are very common in algae of the genera *Plocamium*,[6] *Chondrococcus*,[7] *Octhodes*,[8] *Gelidium*,[9] *Microcladia*,[10] and mollusks such as *Aplysia*.[11] Also marine acetogenin metabolites with a tribromo-substituted vinylic system (e.g., **6**) have been found in *Delisea fimbriata*[12] and in other species of the genera *Bonnemaisonia*[13−15] and *Ptilonia*[16] belonging to the Bonnemaisoneaceae family. However,



4
4a, X=Br
4b, X=Cl
5
5a, X=Br
5b, X=Cl
6
7
8

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Table 1. ^{1}H, ^{13}C, and HMBC Data of Compounds **1a**−**3a** and **1b**−**3b** [500 MHz, δ ppm, (J) Hz, $CDCl_3$]

	1a			**2a**			**3a**		
no.	H	C	HMBC	H	C	HMBC	H	C	HMBC
1	6.96 s	106.1	C_2, C_3	6.79 s	104.6	C_2, C_3, Me-10	7.08 s	106.2	C_2
2		138.3			141.1			141.0	
3		91.5			89.8			89.5	
4	4.30 d (4.6)	76.8		4.53 dddd (4.5, 7, 7, 9)	75.5	C_2, C_6	4.49 dd (3.6, 7.0)	75.7	
5	H-5α: 2.04 dd (4.7, 13) H-5β: 2.31 ddd (4.4, 11.4, 13)	36.6	C_3, C_4, C_6, C_7	H-5α: 2.40 td (7.2, 13.8) H-5β: 2.0 dddd (4.5, (2.6, 7.5, 13.8)	36.6	C_3, C_4, C_7	H-5α: 1.95 ddd (2.6, 9.8, 13.0) H-5β: 2.26 ddd (1.7, 7.0, 13.0)	36.5	C_6, C_7
6	4.32 dd (4.9, 11.1)	80.7	C_7, C_8	4.00 t (7.5)	77.5	C_5, C_7, C_8, C_9	4.18 dd (6.1, 10.2)	78.6	C_7, C_9
7		69.6			70.0			69.5	
8	4.19 and 3.84 d (10.7)	51.1	C_6, C_7, Me-9	4.25 and 3.84 d (10.7)	50.6	C_6, C_7, Me-9	4.18 and 3.84 d(10.7)	50.9	C_6, C_7, Me-9
9	1.71 s	25.6	C_6, C_7, C_8	1.72 s	25.6	C_6, C_7, C_8	1.72 s	25.9	C_6, C_7, C_8
10	1.49 s	25.2	C_2, C_3, C_4	1.46 s	20.7	C_2, C_3, C_4	1.46 s	19.8	C_2, C_3, C_4
O*H*	2.05 d (4.7)			2.24 d (9.0)			1.53 (bs)		

	1b			**2b**			**3b**		
no.	H	C	HMBC	H	C	HMBC	H	C	HMBC
1	6.88 s	105.0	C_2, C_3	6.86 s	105.2	C_2, C_3	7.18	107.5	C_2, C_3
2		138.6			140.7			139.7	
3		89.5			88.1			88.7	
4	5.34 d (4.8)	77.6	C_3, C_6, C_{10}, C=O	5.45 dd (5.6, 7.5)	76.3	C_2, C_6, C=O	5.49 dd (1.9, 6.1)	76.4	C_2, C_6, C=O
5	H-5α: 1.99 dd (4.9, 13.4) H-5β: 2.42 ddd (4.9, 10.7, 13.4)	35.6	C_3, C_4, C_6, C_7	H-5α: 2.0 ddd (5.6, 8.8, 13.6) H-5β: 2.52 dt (6.5, 13.6)	35.2	C_3, C_4, C_7	H-5α: 1.90 ddd (1.9, 5.0, 13.4) H-5β: 2.33 ddd) (6.1, 10.1, 13.3)	35.2	C_3, C_4, C_6, C_7
6	4.20 dd (4.9, 10.6)	80.6	C_7, C_8, C_9	4.00 dd (6.8, 8.8)	77.9	C_5, C_7, C_8	4.14 dd (5.0, 10.1)	79.4	C_7
7		68.8			68.1			68.4	
8	4.21 and 3.83 d (10.7)	51.0	C_6, C_7, Me-9	4.22 and 3.82 d (10.7)	50.7	C_6, C_7, Me-9	4.19, 3.86 d (10.7)	51.0	C_6, C_7, C_9
9	1.70 s	25.6	C_6, C_7, C_8	1.69 s	25.7	C_6, C_7, C_8	1.72 s	26.0	C_6, C_7, C_8
10	1.53 s	25.5	C_2, C_3, C_4	1.46 s	21.3	C_2, C_3, C_4	1.44 s	20.8	C_3, C_4
11		169.6			169.8			169.4	
12	2.04 s	20.9		2.08 s	20.8		2.11	20.7	

until now only one compound, **7**, with a similar chlorobromo vinyl system has been isolated[17] from *P. cartilagineum* collected in New Zealand waters. Thus, these findings enhance the number of new algal polyhalogenated monoterpene metabolites possessing this halovinyl feature and have allowed us to propose a way to determine the regiochemistry of the 1,2-dihalovinyl system (chlorine and bromine substituents) on the basis of the ^{13}C chemical shift of the disubstituted vinyl carbon.

Results and Discussion

Compounds **1a**−**3a** were isolated as a mixture, homogeneous by TLC, from the fraction of the crude extract of *Plocamium cartilagineum* Dixon (Plocamiaceae, order Gigartinales) eluted with hexanes−EtOAc (95:5) using chromatography on a Si gel column. The compounds were separated as their acetate derivatives **1b**−**3b** by recycling-HPLC (RHPLC) after acetylation of the mixture of the alcohols with acetic anhydride and pyridine. The acetates **1b**−**3b** were saponified by using potassium carbonate in methanol, affording the respective alcohols **1a**−**3a**, which were also purified by RHPLC.

Furoplocamioid A, **1a**, is a colorless oil. The EIMS spectrum showed peaks at *m*/*z* 394/396/398/400, with relative intensities suggestive of two bromine atoms and two chlorine atoms, which correspond to the empirical formula $C_{10}H_{14}O_2Br_2Cl_2$ [M^+] (HRMS). An absorbance for a hydroxyl group was observed at 3450 cm^{-1} in the IR spectrum.

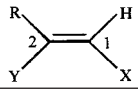
The ^{13}C NMR spectrum of **1a** (Table 1) showed signals for 10 carbons. Multiplicities of the carbon signals were determined from the DEPT spectra: two methyls, two methylenes (one bearing chlorine), three methines (one olefinic, and two bearing oxygen), and three nonprotonated carbons.

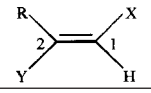
The ^{1}H NMR spectrum of **1a** (Table 1) showed signals corresponding to one olefinic proton at δ 6.96 (1H, s) and two doublets at δ 4.30 (1H, d, J 4.6 Hz) and 4.32 (1H, dd, J 4.9, 11.1 Hz) attributed to methine protons geminal to oxygen. A methylene multiplet appeared at δ 2.31 (1H, ddd, J 4.4, 11.4, 13.0 Hz) and 2.04 (1H, dd, J 4.7, 13.0 Hz), while two doublets corresponding to the protons of the chloromethylene group were observed at δ 4.19 and 3.84 (1H, d, J 10.7 Hz) each. The signals upfield at δ 1.49 (3H, s) and 1.71 (3H, s) correspond to methyl groups geminal to oxygen and halogen, respectively. The presence of only two methyl groups suggested that the third methyl group, corresponding to a monoterpene skeleton, was oxidized.

Chemical shift arguments and ^{1}H−^{1}H COSY correlations supported by MS data allowed the assignment of fragments **a**−**c** as shown in Figure 1. The differentiated chemical shift as well as the values of the respective coupling constants of the methine and methylene protons suggested that the fragments should form part of a ring. This, along with the olefinic unsaturation, is in keeping with the two degrees of unsaturation required by the molecular formula.

^{1}H−^{1}H COSY NMR spectroscopy shows coupling between the protons bearing oxygen (δ 4.30 and 4.32) and

Table 2. ^1H, ^{13}C Chemical Shifts for cis (c) and trans (t) 1,2-Dihaloalkenes in $CDCl_3$, δ ppm





alk.	X	Y	C_1	C_2	H_1	R	alk.	X	Y	C_1	C_2	H_1
Ic	Cl	Br	116.3	130.7	6.35	$CH_3(CH_2)_3$	**It**	Cl	Br	115.6	127.2	6.23
IIc	Br	Br	105.4	134.1	6.58	$CH_3(CH_2)_3$	**IIt**	Br	Br	102.1	127.0	6.33
IIIc	Cl	Br	116.3	130.7	6.27	$CH_3(CH_2)_5$	**IIIt**	Cl	Br	114.8	127.0	6.17
						$CH_3(CH_2)_3$	**IVt**	Cl	Cl	114.3	137.5	6.10
						$CH_3(CH_2)_3$	**Vt**	Br	Cl	101.6	137.8	6.16
						$C_8H_{12}BrCl$	**7**	Br	Cl	100.2	136.0	6.28
IVc	Cl	Br	119.5	136.3	6.65	$(Me_2)COMe$						
Vc	Br	Cl			6.44	$(Me_2)COMe$						
VIc	Cl	Cl	116.5	141.3	6.24	$(Me_2)COMe$						
VIIc	Br	Cl			6.50	$MeCH{=}CH_2$						

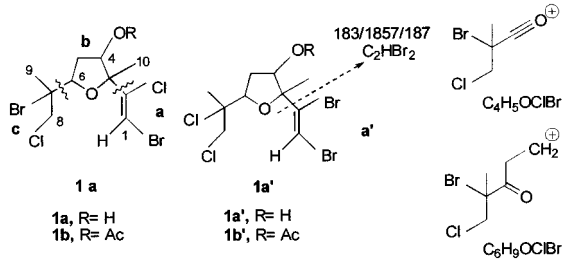


Figure 1. Significant fragments of furoplocamioids A−C and their acetate derivatives.

the methylene protons at δ 2.31 and 2.04, establishing the connectivity of the H-4−H-6 fragment **b**. The signal at δ 4.30 assigned to the proton geminal to the alcohol shifted to δ 5.34 (1H, d, J 4.8 Hz) after acetylation. HMQC and HMBC data were used to confirm the fragments **a**−**c** and establish the connectivity between them. The linkage C-2/C-3 was secured by the correlation between H-1 and C-2, C-3; C-3/C-4 was determined by the correlation between H-4 and C-3, the C-10 methyl group in the acetate (**1b)**, and also by the correlation H-5 with C-3, C-4, and C-6 in the alcohol (**1a**). The C-8/C-7/C-9 linkage was confirmed by the correlation of the C-9 methyl group with C-7 and C-8 in **1a** and **1b**, and the correlation of C-7, C-8, C-9 with H-6 in **1b** suggested the overall structure **1**, with the requisite two degrees of unsaturation.

Because the molecular formula of furoplocamioid A contains two bromine and two chlorine atoms, either **1a** or **1a′** may represent the substitution pattern of the halogens. However, a careful analysis of the MS spectrum of furoplocamioid A and its acetate derivative enabled us to discriminate between them. The EIMS spectrum of furoplocamioid A showed a base peak at *m*/*z* 183/185/187 compatible, at first glance, with fragment **a′** (C_2HBr_2) of **1a′**; however, HRMS indicates that these masses correspond to a base peak with the formula C_4H_5OClBr. Moreover, the EIMS of the acetate derivative **1b** showed fragments at *m*/*z* 183/185/187 for C_4H_5OClBr (HRMS) and at *m*/*z* 211/213/215 (base peak) consistent with a fragment C_6H_9OClBr (HRMS). Thus, bromine and chlorine atoms must be contiguous.

Carbon-13 NMR spectroscopy played an important role in the assignment of the regiochemistry. The probable regiochemistry for C-1 and C-2 followed from the known substituent effects[18] for bromine and chlorine on their chemical shifts. Both bromine and chlorine markedly deshield the α- and β-carbons, but although the α effect of chlorine shows the largest deshielding effect, the β effect is nearly the same[19] for each halogen. Therefore, in the same way that the ^{13}C chemical shift differences of the 1-halovinyl moiety of some naturally occurring monoterpenes[4,18] (e.g., **4a**, **5a** or **4b**, **5b**) are large enough to distinguish C-1 chlorovinyl (δ_C ∼120 ppm) from C-1 bromovinyl (δ_C ∼106 ppm), 1,2-dihalovinyl-substituted compounds show similar substantial and regular halogen-dependent ^{13}C chemical shift differences, as can be seen from the ^{13}C chemical shifts of some 1,2-dihalohexenes[20,21] (Table 2). The table shows that ^{13}C chemical shift differences on the order of 10 ppm can be observed between C-1 chorovinyl and C-1 bromovinyl derivatives (entries **Ic**, **IIc**) and 15 ppm (entries **It**, **7**), allowing us to assume that the α effect determines the chemical shift of C-1 independent of the cis/trans orientation of the halogen on C-2.

From the chemical shift of the halogen-bearing carbon of the vinyl halide group at 106.1 ppm for compound **1a**, this halogen atom was bromine. The halogen-bearing carbon atom of a vinyl chloride would resonate at about 115 ppm (Table 2). Therefore, Br is on C-1 and Cl is on C-2. This correlates well with the observed values for the C-1, C-2 chemical shift for the model[22] compounds **IVc**, **VIIc** that have 1,2-dihalovinyl units in similar structural environments as proposed for **1a**.

The influence is known of both the effects of polar substituents and the stereochemistry of the vicinal group in the olefinic carbon shielding. Table 2, entries **Ic**−**IIIc**, shows that both the C-1 carbon and H-1 protons are deshielded in cis versus trans double bond geometry. Thus, the deshielded C-1 and H-1 chemical shifts (106.1 and 6.96 ppm, respectively) of compound **1a** compared with the relative carbon and proton chemical shifts (100.2, 6.28 ppm) of the trans bromochloro vinyl system of the natural[17] compound **7** and the proton chemical shifts for the model compounds **IVc**−**VIc** (Table 2) suggest a *Z* geometry for the olefinic system of **1a**.

On the other hand, it was deduced from the carbon chemical shift of the sp^3 halogen-bearing carbon at 51.1 ppm that this halogen atom was chlorine[5,23] (a bromomethylene would resonate[23,24] at about 41 ppm). All these data support the structure **1a** for furoplocamioid A.

The spectroscopic similarity between compounds **1a**−**3a** and their acetates **1b**−**3b** (Table 1) indicated that all three compounds possess the same halogen regiochemistry and double bond geometry and suggested that they were diasteroisomeric at C-3, C-4, and/or C-6. The relative stereochemistry of the chiral centers was determined by a combination of molecular mechanics calculations, a study of the coupling constants, and 2D-NOESY experiments.

Molecular mechanics (MM2) calculations[25] were carried out on the acetate derivatives of the all possible relative configurations of the furoplocamioids. The calculated ^3J coupling constants between the H-4 and H-6 protons and the vicinal pair of methylene protons for the relative

Table 3. Calculated and Measured *J* Values (Hz)

	calculated *J* values		measured *J* values		
rel config	H-4	H-6	H-4	H-6	comp
A: 3R, 4S, 6R	1.6, 4.5	4.2, 11.6	0.0, 4.8	4.9, 10.6	**1b**
B: 3S, 4S, 6R	7.3, 8.8	6.2, 9.2	5.6, 7.5	6.8, 8.8	**2b**
C: 3R, 4S, 6S	1.1, 7.2	6.2, 9.2	1.9, 6.1	5.0, 10.1	**3b**
D: 3S, 4S, 6S	7.0, 10.1	4.3, 11.6			

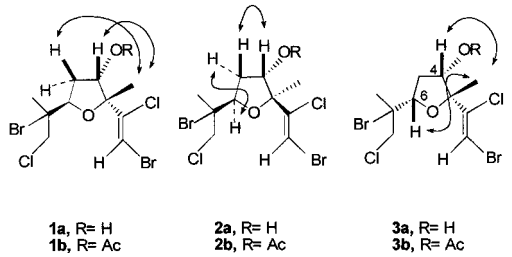


Figure 2. Selected NOE for furoplocamioids A−C.

configurations **A**−**D** are shown in Table 3. These calculated values[25] of ^3J are to be compared with the measured values for the acetates **1b**−**3b**.

It will be seen that there is a very good correspondence between the calculated and observed coupling constants with the exception of **D**, which was ruled out as a possible configuration for any of the furoplocamioids. A comparison of the ^3J values for the H-4 and H-6 protons of **2b** (Table 1b) with those of the corresponding protons in **A**−**C** (Table 2) suggested that **B** is the more plausible configuration for **2b**. However, it was not clear whether configuration **A** or **C** would correspond to **1b** or **3b** because of the ^3J similarities of the respective H-4 and H-6 protons. In addition, although most of the NOE correlations observed in the NOESY experiments were equivocal, clear NOE effects between H-4 and H-6 with Me-10 in **3b** and **3a** were observed, Figure 2. On the basis of the above data and the NOE observed between H-4 and Me-10 in both **1b** and **1a** we assigned configuration **C** to **3b** and configuration **A** to **1b**. The configuration **B** for **2b** was also reinforced by the fact that H-4 and H-6 gave the strongest NOE with different protons of the methylene. Thus, we propose for furoplocamioids **A**−**C** the stereochemistry shown in **1a**−**3a**, respectively.

Once again, the close structural relationship between **1a**−**3a** and pantoisofuranoids **8** isolated[4] from the antarctic *Pantoneura plocamioides* is quite surprising because *Plocamium cartilagineum* and *Pantoneura plocamioides* belong to different orders, Gigartinales and Ceramiales, respectively, pointing to the fact that *Plocamium cartilagineum* and *Pantoneura plocamioides* are similar at the biochemical level or that a taxonomic revision is required.

Experimental Section

General Experimental Procedures. Optical rotations were measured on a Perkin-Elmer model 241 polarimeter using a Na lamp at 25 °C. IR spectra were obtained with a Perkin-Elmer 1650/FTIR spectrometer in $CHCl_3$ solutions. EIMS and HRMS spectra were taken on a Micromass Autospec spectrometer. ^{1}H NMR and ^{13}C NMR, HMQC, HMBC, NOESY, and ^{1}H−^{1}H COSY spectra were measured employing a Bruker AMX 500 instrument operating at 500 MHz for ^{1}H NMR and at 125 MHz for ^{13}C NMR, using TMS as internal standard. Two-dimensional spectra were obtained with the standard Bruker software. RHPLC separations were performed with a Japan Analytical LC-908. The gel filtration column (Sephadex LH-20) used hexane−MeOH−$CHCl_3$ (2:1:1 or 7:1:1) as solvent. Merck Si gels 7734 and 7729 were used in column chromatography. The spray reagent for TLC was H_2SO_4−H_2O−AcOH (1:4:20).

Plant Material. *Plocamium cartilagineum* was collected off the Chilean coast (V Región) using SCuba diving. Voucher specimens have been deposited at the Museo de Historia Natural, Santiago de Chile (no. R23Pl35PLc-2).

Extraction and Isolation of Monoterpenoids 1a−3a. Air-dried *P. cartilagineum* (628 g, dry wt) was extracted with EtOAc−CH_2Cl_2−hexane (1:1:1) at room temperature. The extract was concentrated to give a dark green residue (41 g) and chromatographed by flash chromatography on Si gel. The fraction eluted with hexanes−EtOAc (95:5) (1.5 g) was further separated by filtration chromatography to give a fraction (210 mg) which was chromatographed on a Si gel column to obtain a mixture (43 mg) of monoterpenes **1a**−**3a**, homogeneous by TLC.

Acetylation of Monoterpenoids 1a−3a. A solution of a mixture of compounds **1a**−**3a** (40 mg) in dry C_5H_5N (0.5 mL) was treated with Ac_2O (1 mL) and stirred at room temperature for 2 h and then poured into 10% aqueous HCl and extracted with $CHCl_3$. The organic layer was washed with H_2O and brine, dried (Na_2SO_4), and concentrated. The residue of acetates **1b**−**3b** was separated using recycling-HPLC (Jaigelsil column 20 × 250 mm) eluted with $CHCl_3$, affording **1b** (10.2 mg), **2b** (8.8 mg), and **3b** (11.5 mg).

Saponification of Acetates 1b−3b. Each of the acetates **1b**−**3b** was saponified using an excess of potassium carbonate in methanol to give the respective alcohols **1a**−**3a**.

Furoplocamioid A (1a): colorless oil; $[\alpha]^{25}_D$ −47 (*c*, 0.3, $CHCl_3$); IR ν_{max} 3450 cm^{-1}; ^{1}H and ^{13}C NMR see Table 1; EIMS *m*/*z* 394/396/398/400 [M^+] (<3), 379/381/383/385 [M − Me]$^+$ (1, 4, 3, 1), 359/361/363/365 [M − Cl]$^+$ (34, 79, 56, 11), 315/317/319 [M − Br]$^+$ (20, 31, 14), 211/213/215 [C_6H_9OClBr] (14, 18, 4), 183/185/187 [C_4H_5OClBr] (83, 100, 26), 129 (60); 69 (91); EIHRMS [M]$^+$ 399.8663 (calcd for $C_{10}H_{14}O_2{}^{81}Br^{81}Br^{35}Cl^{37}Cl$, 399.8667); [M − Cl]$^+$ 360.8880 (calcd for $C_{10}H_{12}O_2{}^{81}Br^{81}Br^{35}Cl$, 360.8851); [M − Br]$^+$ 318.9415 (calcd for $C_{10}H_{14}O_2{}^{79}Br^{37}Cl^{37}Cl$, 318.9495); 212.9443 (calcd for $C_6H_9O^{79}Br^{37}Cl$, 212.9495); [base peak] 184.9120 (calcd for $C_4H_5O^{79}Br^{37}Cl$, 184.9182).

Acetate 1b: colorless oil; IR ν_{max} 1745 cm^{-1}; ^{1}H and ^{13}C NMR see Table 1; EIMS *m*/*z* 421/423/425/427 [M − Me]$^+$ (3, 8, 7, 2), 401/403/405/407 [M − Cl]$^+$ (7, 16, 12, 2), 357/359/361 [M − Br]$^+$ (9, 14, 7), 297/299/301 (43, 74, 32), 211/213/215 [C_6H_9OclBr] (80, 100, 24), 183/185/187 [C_4H_5OclBr] (19, 25, 6); EIHRMS [M − Me]$^+$ 426.8590 (calcd for $C_{11}H_{13}O_3{}^{81}Br^{81}Br^{35}Cl^{37}Cl$, 426.8538).

Furoplocamioid B (2a): colorless oil; $[\alpha]^{25}_D$ −110 (*c*, 0.36, $CHCl_3$); IR ν_{max} 3450 cm^{-1}; ^{1}H and ^{13}C NMR see Table 1; EIMS *m*/*z* 379/381/383/385 [M − Me]$^+$ (1, 2, 2, 1), 359/361/363/365 [M − Cl]$^+$ (35, 77, 57, 11), 315/317/319 [M − Br]$^+$ (14, 20, 9), 183/185/187 [C_4H_5OclBr] (74, 100, 25), 129 (41), 69 (70); EIHRMS [M − Me]$^+$ 380.8469 (calcd for $C_9H_{11}O_2{}^{81}Br^{81}Br^{35}Cl^{37}Cl$, 380.8473); [M − Cl]$^+$ 362.8969 (calcd for $C_{10}H_{14}O_2{}^{79}Br^{81}Br^{37}Cl$, 362.8999); [M − Br]$^+$ 316.9510 (calcd for $C_{10}H_{14}O_2{}^{79}Br^{35}Cl^{37}Cl$, 316.9524); [base peak] 184.9176 (calcd for $C_4H_5O^{81}Br^{35}Cl$, 184.9191).

Acetate 2b: colorless oil; IR ν_{max} 1745 cm^{-1}; ^{1}H and ^{13}C NMR see Table 1b; EIMS *m*/*z* 421/423/425/427 [M − Me]$^+$ (3, 7, 7, 2), 401/403/405/407 [M − Cl]$^+$ (5, 14, 11, 2), 357/359/361 [M − Br]$^+$ (9, 14, 6), 297/299/301 (43, 74, 30), 211/213/215 [C_6H_9OClBr] (78, 100, 25), 183/185/187 [C_4H_5OClBr] (16, 23, 5); EIHRMS [M − Me]$^+$ 426.8590 (calcd for $C_{11}H_{13}O_3{}^{81}Br^{81}Br^{35}Cl^{37}Cl$, 426.8538).

Furoplocamioid C (3a): colorless oil; $[\alpha]^{25}_D$ −81 (*c*, 0.2, $CHCl_3$); IR ν_{max} 3450 cm^{-1}; ^{1}H and ^{13}C NMR see Table 1; EIMS *m*/*z* 379/381/383/385 [M − Me]$^+$ (1, 2, 2, 1), 359/361/363/365 [M − Cl]$^+$ (27, 68, 48, 8), 315/317/319 [M − Br]$^+$ (16, 26, 12), 183/185/187 [C_4H_5OClBr] (82, 100, 24), 129 (54), 69 (80); EIHRMS [M]$^+$ 397.8600 (calcd for $C_{10}H_{14}O_2{}^{79}Br^{79}Br^{37}Cl^{37}Cl$, 397.8678); [M − Cl]$^+$ 364.8919 (calcd for $C_{10}H_{14}O_2{}^{81}Br^{81}Br^{37}Cl$, 364.8978); [M − Br]$^+$ 318.9417 (calcd for $C_{10}H_{14}O_2{}^{79}Br^{37}Cl^{37}Cl$, 318.9495); [base peak] 184.9119 (calcd for $C_4H_5O^{79}Br^{37}Cl$, 184.9182).

Acetate 3b: colorless oil; IR ν_{max} 1745 cm^{-1}; ^{1}H and ^{13}C NMR see Table 1b; EIMS *m*/*z* 421/423/425/427 $[M - Me]^+$ (1, 2, 2, 1), 401/403/405/407 $[M - Cl]^+$ (3, 6, 4, 1), 357/359/361 $[M - Br]^+$ (8, 13, 6), 297/299/301 (9, 17, 8), 211/213/215 [C_6H_9OClBr] (78, 100, 25), 183/185/187 [C_4H_5OClBr] (10, 13, 3); EIHRMS $[M]^+$ 439.8763 (calcd for $C_{12}H_{16}O_3{}^{79}Br^{37}Cl^{37}Cl$, 439.8784); $[(M - Me)]^+$ 426.8560 (calcd for $C_{11}H_{13}O_3{}^{79}Br^{81}Br^{35}Cl^{37}Cl$, 426.8558); $[(M - Cl)]^+$ 402.9118 (calcd for $C_{12}H_{16}O_3{}^{79}Br^{79}Br^{37}Cl$, 402.9125); [base peak] 212.9501 (calcd for $C_6H_9O^{81}Br^{35}Cl$, 212.9504).

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