

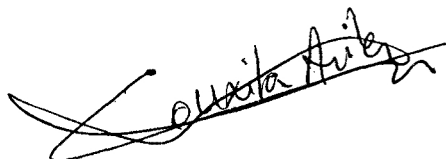
DEPARTAMENTO DE BIOLOGIA ANIMAL
FACULTAD DE BIOLOGIA
UNIVERSIDAD DE BARCELONA

**SUSTANCIAS NATURALES DE MOLUSCOS OPISTHOBANQUIOS:
ESTUDIO DE SU ESTRUCTURA, ORIGEN Y FUNCION
EN ECOSISTEMAS BENTONICOS.**

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Memoria redactada por Conxita
Avila Escartín, para optar al grado
de Doctor en Ciencias Biológicas
por la Universidad de Barcelona.



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10. ANEXOS

ANEXO 10.I. Datos espectrales de las sustancias de mayor interés.

Longifolina: (3-methyl-2-[(2'E)-3'-methyl-4'-(4"-methyl-2"-furyl)-2'-butenyl] furano; C₁₅ H₁₈ O₂ EIMS *m/z*: 230 (M⁺); ¹H-NMR (C₆D₆): 1.60 (3H, s, CH₃-3'); 1.78 (3H, s, CH₃-4"); 1.81 (3H, s, CH₃-3); 3.16 (2H, s, H-4'); 3.22 (2H, d, J = 7.0 Hz, H-1'); 5.46 (1H, t, J = 7.0 Hz, H-2'); 5.77 (1H, bs, H-3"); 6.00 (1H, d, J = 1.5 Hz, H-4); 6.92 (1H, bs, H-5"); 7.07 (1H, d, J = 1.5 Hz, H-5). ¹³C-NMR (C₆D₆): 9.7 (CH₃-4" y CH₃-3); 15.8 (CH₃-3'); 25.5 (C-1'); 38.6 (C-4'); 109.2 (C-3"); 113.0 (C-4); 113.7 (C-4"); 120.5 (C-3); 122.8 (C-2'); 133.2 (C-3'); 138.0 (C-5"); 140.1 (C-5); 149.8 (C-2); 154.3 (C-2").

El espectro ¹H-NMR en C₆D₆ se expone en el apartado correspondiente. La numeración coincide con Guella *et al.*, (1985b). Las asignaciones, ya expuestas en el mencionado trabajo, se han confirmado mediante experimentos 2D-NMR: ¹H-¹H COSY, ¹H-¹³C HETCOR.

Nakafurano-9: [α]_D = - 107.5 (c=0,2 CHCl₃); C₁₅ H₁₈ O₂ EIMS *m/z* (%): 216 (M⁺,100), 201 (55), 175 (35). ¹H-NMR (CDCl₃): 1.08 (3H, s, H-15's); 1.37 (1H, ddd, J = 4.1, 13.3 y 13.3 Hz, H-5a); 1.57 (3H, s, H-13's or H-14's); 1.59 (3H, s, H-14's o H-13's); 1.72 (1H, ddd, J = 2.7, 2.7 y 13.0 Hz, H-12a), 1.79 (1H, ddd, J = 1.8, 4.3 y 13.0 Hz, H-12b); 1.92 (1H, bddd, J = 4.1, 4.1 y 13.3 Hz, H-5b); 1.95 (1H, bd, J = 15.5 Hz H-9a); 2.25 (1H, ddd, J = 4.1, 13.3 y 16.0 Hz, H-4a); 2.33 (1H, ddd, J = 4.1, 4.1 y 16.0 Hz, H-4b); 2.37 (1H, bdd, J = 5.2 y 15.5, H-9b); 3,17 (1H, m, H-10); 6.06 (1H, d, J = 1.7 Hz, H-2); 7.12 (1H, d, J = 1.7 Hz, H-1). ¹³C-NMR (CDCl₃): 13.2 (C-14); 19.8 (C-13); 23.0 (C-4); 30.7 (C-15); 31.8 (C-10); 37.6 (C-6); 38.2 (C-9); 38.6 (C-5); 41.3 (C-12); 113.1 (C-2); 118.3 (C-3); 126.3 (C-7 or C-8); 129.5 (C-8 or C-7); 138.4 (C-1); 156.2 (C-11).

La numeración es acorde con Schulte *et al.*, (1980). Las asignaciones se han comprobado mediante experimentos de desacoplamiento ^1H - ^1H , ^1H - ^1H COSY y ^1H - ^{13}C HETCOR. La comparación con los datos de NMR previos ha revelado algunas diferencias menores, en particular para las resonancias del ^{13}C -NMR asignadas a los metilos.

iso-Tavacfurano: (3-methyl-2-[(3'E)-3'-methyl-4'-(4"-methyl-2"-furyl)-3'-butenyl] furano $\text{C}_{15}\text{H}_{18}\text{O}_2$ EIMS m/z : 230 (M^+); ^1H -NMR (C_6D_6): 1.77 (6H, s, CH_3 -3 or CH_3 -4"); 1.78 (3H, s, CH_3 -4" or CH_3 -3); 1.88 (3H, s, CH_3 -3'); 2.34 (2H, t, $J = 7.5$ Hz, H-2"); 2.60 (2H, t, $J = 7.5$ Hz, H-1'); 5.95 (1H, bs, H-3"); 5.98 (1H, d, $J = 1.5$ Hz, H-4); 6.11 (1H, bs, H-4'); 6.91 (1H, bs, H-5"); 7.08 (1H, d, $J = 1.5$ Hz, H-5).

La numeración y asignaciones son acordes con las de Guella *et al.* (1985b).

Tavacfurano: ópticamente inactivo; UV (Diethyl ether)= 285 nm ($\epsilon=7100$), 274 nm ($\epsilon=10800$), 220 nm ($\epsilon=7300$); $\text{C}_{15}\text{H}_{18}\text{O}_2$; EIMS m/z : 230 (M^+); ^1H -NMR (C_6D_6): 1.63 (3H, bs); 1.78 (3H, s); 1.83 (3H, s); 2.76 (4H, m); 5.99 (1H, bs); 6.01 (1H, d, $J = 1.5$ Hz); 6.08 (1H, bs); 6.90 (1H, bs); 7.09 (1H, d, $J = 1.5$ Hz).

Las asignaciones coinciden con las de Guella *et al.*, (1985).

Dendrolasina: ópticamente inactivo; UV (Diethyl ether) 273 nm ($\epsilon=6480$); $\text{C}_{15}\text{H}_{22}\text{O}$; EIMS m/z (%): 218 (5), 203 (15), 81 (90), 69 (100); ^1H -NMR (C_6D_6) δ 1.52 (3H, s), 1.55 (3H, s), 1.67 (3H, s), 2.06 (2H, t, $J = 7.3$ Hz), 2.14 (2H, t, $J = 7.3$ Hz), 2.18 (2H, q, $J = 7.3$ Hz), 5.21 (2H, m), 6.08 (1H, s), 7.07 (1H, s), 7.12 (1H, s); ^{13}C -NMR (C_6D_6) δ : 16.1 (q), 17.8 (q), 25.4 (t), 25.8 (q), 27.1 (t), 28.9 (t), 40.1 (t), 111.3 (d),

124.4 (d), 124.8 (d), 125.2 (s), 131.2 (s), 135.6 (s), 139.2 (d), 142.8 (d).

Agassizina: UV (Diethyl ether) 223 nm ($\epsilon=9430$), 258 nm ($\epsilon=3510$); $C_{15}H_{18}O$; EIMS m/z (%): 214 (); 1H -NMR (C_6D_6) δ 0.71 (3H, s); 0.81 (3H, s), 1.63 (2H, m), 2.26 (1H, m), 2.45 (1H, m), 2.59 (1H, m), 3.25 (1H, m), 3.27 (1H, m), 3.46 (1H, bd, $J=16$ Hz), 5.40 (1H, bd), 5.50 (1H, bd, $J=5$ Hz), 5.74 (1H, m), 5.98 (1H, d, $J=1.5$ Hz), 7.05 (1H, d, $J=1.5$ Hz).

Las asignaciones coinciden con Hochlowski *et al.* (1982).

ent-Furodysinina: $[\alpha]_D=-43.7^\circ$ ($c=0.3$ $CHCl_3$); UV ($CHCl_3$) 214 nm ($\epsilon=8700$); $C_{15}H_{20}O$; EIMS m/z (%): 216 (15), 122 (100), 107 (15); 1H -NMR (C_6D_6) δ 1.12 (3H, s, CH_3 -13 or CH_3 -14), 1.14 (3H, s, CH_3 -14 ó CH_3 -13), 1.17 (1H, m, H-10a), 1.44 (1H, ddd, $J=3, 3, y 13$ Hz, H-11), 1.54 (1H, m, H-10b), 1.55 (3H, bs, CH_3 -15), 1.79 (1H, bdd, $J=6.8$ y 17.4 Hz, H-9a), 1.85 (1H, m, H-9b), 2.36 (1H, dd, $J=10.5$ y 16.4, H-5a), 2.54 (1H, m, H-6), 2.70 (1H, dd, $J=6.9$ y 16.4 Hz, H-5b), 5.46 (1H, bd, $J=6.9$ Hz, H-7), 6.13 (1H, bs, H-2), 7.11 (1H, s, H-1). ^{13}C -NMR (C_6D_6) δ 19.6 (C-10), 23.2 (C-15), 26.4 (C-13 ó C-14), 28.0 (C-5), 31.6 (C-6), 31.8 (C-9), 33.0 (C-14 ó C-13), 44.9 (C-11), 108.3 (C-2), 124.9 (C-8), 126.6 (C-7), 133.1 (C-3), 140.9 (C-1), 147.6 (C-4).

Las asignaciones han sido confirmadas mediante experimentos de desacoplamiento 1H - 1H , 1H - 1H COSY and 1H - ^{13}C HETCOR; son acordes con Guella *et al.* (1985).

iso-Nakafurano-9: $[\alpha]_D=+6^\circ$ ($c=0.3$ $CHCl_3$); UV ($CHCl_3$) = 214 nm ($\epsilon=4240$); $C_{15}H_{20}O$; EIMS m/z : 216 (M^+ , 80), 201 (40), 147 (100), 84 (85); 1H -NMR (C_6D_6) δ 0.72 (3H, s, CH_3 -15), 0.92 (3H, d, $J=7.2$, CH_3 -14), 1.37 (1H, m, H-5), 1.44 (1H, dd, $J=5.1$ y 14.6 Hz, H-12), 1.47 (1H, bd, $J=$

14.6 Hz, H-12), 1.83 (1H, ddd, J=3.5, 9.8 y 16.5 Hz, H-5), 1.95 (1H, q, J=7.2 Hz, H-7), 2.30 (2H, m, H-4 y H-9), 2.40 (1H, bd, J= 14.5 Hz, H-9), 2.43 (1H, ddd, J= 3.5, 8.6 y 15.7 Hz, H-4), 3.11 (1H, bm, H-10), 4.59 (1H, bs, J= 2 Hz, H-13a), 4.66 (1H, bs, J= 2 Hz, H-13b), 5.97 (1H, bs, J=1.3, H-2), 7.03 (1H, bs, J=1.3 Hz, H-1).

La numeración y asignaciones son acordes con Tanis y Herrinton (1985). Se han comprobado mediante desacoplamientos ^1H - ^1H COSY y ^1H - ^1H .

iso-Dehidro-dendrolasina: ópticamente inactiva; UV (Diethyl ether) 230 nm ($\epsilon=9430$), 224 nm ($\epsilon=3510$); $\text{C}_{15}\text{H}_{20}\text{O}$; EIMS m/z : (%): 216 (5), 201 (20), 93 (100), 81 (90) ^1H -NMR (C_6D_6) δ 1.50 (3H, s, CH_3 -15), 1.76 (3H, s, CH_3 -14), 2.17 (2H, t, J= 7.4 Hz, H-6), 2.31 (2H, t, J= 7.5 Hz, H-5), 2.70 (2H, d, J= 7.0, H-9), 4.89 (1H, bs, H-13a), 4.94 (1H, bs, H-13b), 5.22 (1H, bt, J= 7.0 Hz, H-7), 5.65 (1H, dt, J= 15.5, 7.0 and 7.0 Hz, H-10), 6.07 (1H, bs, H-3), 6.19 (1H, d, J= 15.5 Hz, H-11), 7.05 (1H, s H-4), 7.12 (1H, s, H-1). ^{13}C -NMR (C_6D_6) δ : 16.2 (q, C-15), 18.8 (q, C-14), 25.2 (t, C-5), 28.9 (t, C-6), 43.3 (t, C-9), 111.2 (d, C-3), 115 (t, C-13), 125.2 (s, C-2), 134.6 (s, C-8), 139.2 (d, C-1), 142.2 (s, C-12), 142.8 (d, C-4).

Chelonaplysina-C: $[\alpha]_{25\text{D}}-55.0^\circ$ (c 0.24, CHCl_3); mp (n-hexane/ethyl ether) 180° - 182° ; ir (CHCl_3) n_{max} 1755 cm^{-1} ; ^1H y ^{13}C -NMR (CDCl_3) posición carbono (d ^{13}C ; d ^1H): 1 ó 3 (39.7; 1.18, 1.71), 2 (20.1; 1.52, 1.67), 3 ó 1 (41.4; 1.08, 1.46), 4 (33.3), 5 (58.8; 1.30), 6 (20.5; 1.42, 1.65), 7 (24.9, 1.73), 8 (140.3), 9 (56.0; 2.15), 10 (43.4), 11 (166.7), 12 (32.5; 2.62, 3.14), 13 (38.2; 2.81), 14 (46.9; 3.20), 15 (100.6; 5.88), 16 (101.2; 6.26), 17 (116.3; 5.16, 5.24), 18 (20.6; 0.87), 19 (33.1; 0.86), 20 (13.8; 0.71), COCH_3 (169.4), COCH_3 (21.1; 2.11); ^1H -NMR (C_6D_6) d 6.12

(s, H-16), 5.79 (d J=3.4, H-15), 4.93 (bs, H-17b), 4.74 (d J=2.2, H-17a), 3.08 (m, H-14), 2.68 (dd J=19.2, 6.3, H-12b), 2.03 (m, H-13), 2.00 (d J=19.2, H-12a), 1.96 (bt J=9.5, H-9), 1.51 (3H singlet, CH₃CO), 0.80, 0.78, 0.50 (3H singlets, CH₃-18, CH₃-19 y CH₃-20); ¹³C-NMR (C₆D₆) δ 168.4, 165.5, 141.1, 116.0, 101.3, 100.5, 58.5, 56.1, 47.4, 43.4, 41.5, 39.7, 38.5, 33.2, 32.8, 25.1, 20.7, 20.4, 20.3, 20.0, 13.9; nOed's (CDCl₃) irradiado (observado) H-9 (H-15 y H-5), H-13 (H-16, H-17a, H-12b y H-14), H-14 [superpuesto con H-12b] (H-15, H-17a, H-13 y H-12a), H-15 (H-14 y H-9), H-16 (H-12a y H-13), H-17a (H-17b, H-12b y H-13), H-17b (H-17a, H-7 y CH₃-20); nOed's (C₆D₆) irradiado (observado) H-14 (H-15 y H-13), H-12b (H-12a y H-17a); eims m/z (rel. int.): 376 (2), 361 (4), 316 (15), 301 (10), 283 (7), 192 (20), 137 (75), 123 (100); hreims m/z 376.2269, C₂₂H₃₂O₅ son 376.2250.

7-Deacetoxy-olepupuana: δ¹H-NMR (CDCl₃), 6.31 (1H, d, J= 2 Hz, H-11); 6.05 (1H, bt, J=2 Hz, H-12); 2.47 (1H, ddd, J= 13.8, 5.2, 1.7, H-7 eq.); 2.28 (1H, bs, H-9); 2.08 (3H, s, CH₃CO); 2.00 (1H, dddd, J= 13.8, 13.8, 5.7, 1.8, 2 Hz, H-7ax.); 1.71 (1-H, bdd, J= 13.1, 5.7 Hz, H-6eq.); 1.26 (1H, m, H-6ax.); 1.00 (1H, dd, J= 12.5, 2.5, H-5); 0.89 (3H, s); 0.83 (3H, s); 0.81 (3H, s), otras resonancias entre δ 1.70 y δ1.00; δ¹H-NMR (C₆D₆): 6.70 (1H, d, J=2 Hz); 5.91 (1H, bt, J=2 Hz); 2.24 (1H, bs); 2.17 (1H, bdd, J= 4, 13.5 Hz); 1.67 (3H, s, CH₃CO); 0.76 (3H, s); 0.69 (3H, s); 0.68 (3H, s), otras resonancias entre δ 1.80 y δ 0.80; EIMS, m/z (%): 278 (M⁺, 5); 218 (30); 203 (50); 59 (100).

Mediante termolisis (en la placa TLC) la 7-deacetoxy-olepupuana se transforma fácilmente en euryfurano.

ANEXO 10.II. Datos de los ejemplares del apartado 5.17.

| ESPECIE y SECCIONES | n | PESO SECO | EXTRACTOS(*) |
|------------------------------------|-----|-----------|--------------|
| <i>Gastropteron meckeli</i> | 4 | 321 mg | 429 mg (1) |
| | 25 | 1120 mg | 752 mg (1) |
| | | | 202 mg (2) |
| borde parápodos | 1 | 5.9 mg | 0.9 mg (1) |
| resto parápodos | 1 | 31 mg | 5.2 mg (1) |
| glándula digestiva | 1 | 27.3 mg | 13.6 mg (1) |
| resto de vísceras | 1 | 14.6 mg | 3.0 mg (1) |
| vísceras | 10 | 140.1 mg | 31.4 mg (1) |
| parte externa | 10 | 236.5 mg | 119.4 mg (1) |
| <i>Philinopsis depicta</i> | | | |
| parte externa | 1 | 309 mg | 298 mg (1) |
| digestivo anterior | 1 | 960 mg | 223 mg (1) |
| glánd. hermafrodita | 1 | 55 mg | 5 mg (1) |
| glándula digestiva | 1 | 317 mg | 82 mg (1) |
| otras vísceras | 1 | 50 mg | 6 mg (1) |
| puesta | 1 | 290 mg | 170 mg (1) |
| puestas | 24 | 3604 mg | 35 mg (2) |
| secreción mucosa | 1 | -- | 423 mg (1) |
| <i>Haminoea</i> sp | | | |
| puestas | 100 | -- | 76 mg (2) |
| <i>Elysia viridis</i> | 50 | -- | 200 mg (2) |
| | | | 65 mg (3) |
| vísceras | 3 | 1.5 mg | 0.2 mg (1) |
| parte externa | 3 | 8.4 mg | 0.6 mg (1) |
| <i>Elysia timida</i> | 3 | 10.2 mg | 17.2 mg (1) |
| <i>Thuridilla hopei</i> | 5 | 104 mg | 40 mg (1) |
| | 27 | 100 mg | 25 mg (2) |
| | 1 | 2 mg | 1 mg (1) |
| | 1 | 3.5 mg | 1 mg (1) |
| | 2 | 0.5 mg | 3.2 mg (1) |
| puestas | 2 | 7 mg | 55 mg (1) |
| <i>Pleurobranchus membranaceus</i> | | | |
| secreción mucosa | 1 | -- | 64 mg (1) |
| <i>Berthella aurantiaca</i> | | | |
| vísceras | 1 | 123.2 mg | 37.9 mg (1) |
| parte externa | 1 | 98.0 mg | 8.2 mg (1) |
| puesta | 1 | 1.7 mg | 1.3 mg (1) |
| secreción mucosa | 1 | -- | 0.8 mg (2) |

| | | | |
|-----------------------------------|----|----------|--|
| <i>Pleurobranchaea meckeli</i> | | | |
| glándula digestiva | 1 | 45.5 mg | 7.1 mg (1) |
| resto de vísceras | 1 | 68.1 mg | 7.8 mg (1) |
| parte externa | 1 | 218.2 mg | 12.4 mg (1) |
| glándula digestiva | 1 | 137.7 mg | 144.5 mg (1) |
| resto de vísceras | 1 | 557.4 mg | 83.7 mg (1) |
| parte externa | 1 | 724.7 mg | 9.3 mg (1) |
| <i>Trapania maculata</i> | | | |
| | 1 | 12 mg | 1 mg (1) |
| <i>Limacia clavigera</i> | | | |
| | 20 | 115 mg | 14 mg (1) |
| <i>Polycera quadrilineata</i> | | | |
| | 40 | -- | 18 mg (2) |
| protuberancias | 10 | 5 mg | 6 mg (1, #) |
| resto parte externa | 10 | 31 mg | 31 mg (1, #) |
| vísceras | 10 | 24 mg | 61 mg (1, #) |
| <i>Archidoris tuberculata</i> | | | |
| vísceras | 3 | 3.02 g | 8 mg (2) 25 mg (3) |
| parte externa | 3 | 3428 mg | 4 mg (2) 7 mg (3) |
| vísceras | 2 | 136 mg | 7 mg (2) 45 mg (3) |
| parte externa | 2 | 727 mg | 6 mg (2) 5 mg (3) |
| <i>Austrodoris kerguelenensis</i> | | | |
| vísceras | 1 | 308 mg | 125.8 mg (1) |
| parte externa | 1 | 628.6 mg | 265.7 mg (1) 17 mg (2) 35 mg (3) |
| <i>Discodoris rosi</i> | | | |
| | 22 | 282 mg | 25 mg (1) |
| <i>Platydoris argo</i> | | | |
| borde del manto | 1 | 126 mg | 15 mg (1) |
| borde del pie | 1 | 26 mg | 3.5 mg (1) |
| resto parte externa | 1 | 108 mg | 2.5 mg (1) |
| glándula digestiva | 1 | 20 mg | 3.5 mg (1) |
| puesta | 1 | 53 mg | 4 mg (1) |
| puesta | 1 | 98 mg | 19 mg (1) |
| vísceras | 1 | 45.3 mg | 30.8 mg (1) |
| parte externa | 1 | 477.9 mg | 17 mg (1) |
| vísceras | 1 | 146.7 mg | 33.8 mg (1) |
| parte externa | 1 | 1416 mg | 28.8 mg (1) |
| <i>Dendrodoris languida</i> | | | |
| borde del manto | 1 | 35.6 mg | 8.0 mg (1) |
| resto parte externa | 1 | 42.1 mg | 5.3 mg (1) |
| glándula digestiva | 1 | 8.3 mg | 2.9 mg (1) |
| glánd. hermafrodita | 1 | 2.8 mg | 1.5 mg (1) |
| resto de vísceras | 1 | 15.7 mg | 4.4 mg (1) |
| secreción mucosa | 1 | -- | 9.9 mg (1) |

| | | | |
|---------------------------------|----|----------|-------------|
| <i>Dendrodoris subpellucida</i> | 1 | 32.9 mg | 2.1 mg (1) |
| <i>Tritonia nilsodhneri</i> | 20 | 28 mg | 31 mg (1) |
| puestas | 13 | 7.1 mg | 12.9 mg (1) |
| <i>Marionia blainvillea</i> | | | |
| vísceras | 3 | 147.4 mg | 60 mg (1) |
| parte externa | 3 | 84.3 mg | 30 mg (1) |
| <i>Tethys fimbria</i> | | | |
| parte externa | 3 | 8 g | 210 mg (1) |

n= número de ejemplares.

(*)= tipo de extracto: 1= acetónico, 2= etéreo, 3= butanólico.

(#)= con elevado contenido en sales debido al Cl_2Mg .

