

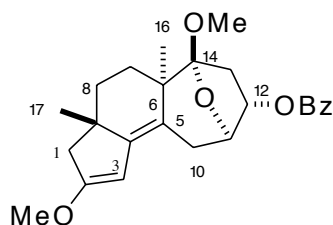
SUPPORTING INFORMATION

A GENERAL APPROACH TO CYATHIN DITERPENES. TOTAL SYNTHESIS OF ALLOCYATHIN B₃

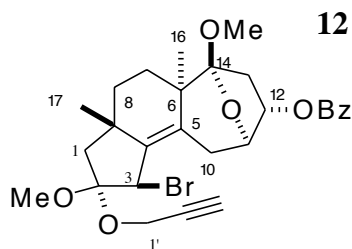
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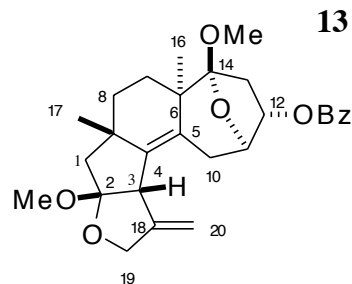
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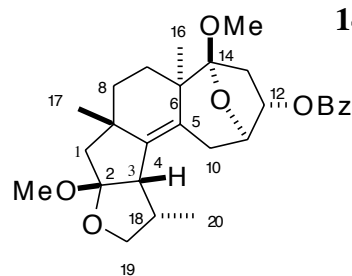
11 ^1H NMR (300 MHz, C_6D_6) δ : 8.24 (2H, m, Ar-H), 7.10 (3H, m, Ar-H), 5.23 (1H, dd, $J = 2, 7.5$ Hz, HC-12), 5.01 (1H, br s, HC-3), 4.60 (1H, d, $J = 4.5$ Hz, HC-11), 3.48 (3H, s, $\text{H}_3\text{COC-14}$), 3.28 (3H, s, $\text{H}_3\text{COC-2}$), 2.54 (1H, dd, $J = 4.5, 14$ Hz, HC-10), 2.51 (1H, dd, $J = 7.5, 14.5$ Hz, HC-13), 2.38 (1H, d, $J = 14.5$ Hz, HC-1), 2.15 (1H, d, $J = 14$ Hz, HC-10), 2.14 (1H, dd, $J = 2, 14.5$ Hz, HC-13), 2.13 (1H, d, $J = 14.5$ Hz, HC-1), 1.55 (3H, s, $\text{H}_3\text{C-17}$), 1.24 (3H, s, $\text{H}_3\text{C-16}$). ^{13}C NMR (75 MHz, C_6D_6) δ : 165.9, 144.3, 132.7, 130.7, 129.6 ($\times 2$, Ph), 128.3 ($\times 2$, Ph), 119.6, 111.8, 96.2, 79.8, 78.7, 56.2, 49.1, 47.6, 45.1, 40.4, 32.8, 30.7, 30.0, 28.2, 28.1, 19.9. LRMS (EI), m/z (relative intensity): 410 ($[\text{M}]^+$, 24), 305 (13), 289 (66), 249 (10), 221 (43), 105 (66), 100 (26), 99 (100).



12 ^1H NMR (300 MHz, C_6D_6) δ : 8.22 (2H, m, Ar-H), 7.14 (3H, m, Ar-H), 5.43 (1H, dd, $J = 2, 7$ Hz, HC-12), 4.85 (1H, s, HC-3), 4.53 (1H, br d, $J = 5$ Hz, HC-11), 3.99 (2H, d, $J = 1.5$ Hz, $\text{H}_2\text{C-1}'$), 3.40 (3H, s, $\text{H}_3\text{COC-14}$), 3.11 (3H, s, $\text{H}_3\text{COC-2}$), 2.41 (1H, br d, $J = 14$ Hz, HC-10), 2.32 (1H, dd, $J = 7, 15$ Hz, HC-13), 2.19 (1H, dd, $J = 5, 14$ Hz, HC-10), 2.11 (1H, d, $J = 14$ Hz, HC-1), 2.04 (2H, m, HC-13, HC-1), 1.44 (3H, s, $\text{H}_3\text{CC-17}$), 1.42 (3H, d, $\text{H}_3\text{CC-16}$).

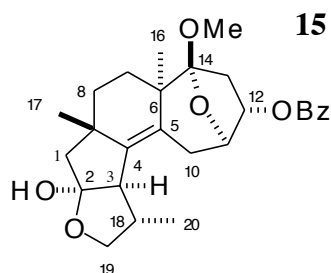


13 ^1H NMR (300 MHz, CDCl_3) δ : 8.03 (2H, m, Ar-H), 7.57 (1H, m, Ar-H), 7.45 (2H, m, Ar-H), 5.27 (1H, br s, HC-20), 5.20 (1H, br s, HC-20), 5.05 (1H, dd, $J = 2, 7.5$ Hz, HC-12), 4.37 (1H, br d, $J = 5$ Hz, HC-11), 4.34 (1H, br d, $J = 11.5$ Hz, HC-19), 4.28 (1H, br d, $J = 11.5$ Hz, HC-19), 3.76 (1H, br s, HC-3), 3.40 (3H, s, $\text{H}_3\text{COC-14}$), 3.29 (3H, s, $\text{H}_3\text{COC-2}$), 2.90 (1H, dd, $J = 1, 15$ Hz, HC-10), 2.36 (2H, m, HC-10, HC-13), 2.03 (2H, m, HC-1, HC-13), 1.83 (1H, d, $J = 13.5$ Hz, HC-1), 1.67-1.47 (4H, m, $\text{H}_2\text{C-7}$, $\text{H}_2\text{C-8}$), 1.18 (3H, s, $\text{H}_3\text{C-17}$), 1.15 (3H, s, $\text{H}_3\text{C-16}$). ^{13}C NMR (75 MHz, C_6D_6) δ : 166.5 (s, C=O), 148.9 (s, C-18), 140.5 (s, C-5), 132.8 (d, Ph), 130.9 (s, C-4), 130.6 (s, Ph), 129.6 (d $\times 2$, Ph), 128.3 (d $\times 2$, Ph), 117.6 (s, C-2), 111.0 (s, C-14), 110.3 (t, C-20), 78.9 (d, C-12), 78.3 (d, C-11), 71.0 (t, C-19), 56.0 (d, C-3), 50.4 (q, $\text{CH}_3\text{OC-2}$), 49.6 (q, $\text{CH}_3\text{OC-14}$), 49.0 (t, C-1), 45.9 (s, C-6), 43.0 (s, C-9), 33.0 (t, C-13), 32.6 (t, C-8), 29.4 (t, C-7), 28.3 (t, C-10), 27.8 (q, C-17), 20.1 (q, C-16). LRMS (EI), m/z (relative intensity): 466 ($[\text{M}]^+$, 57), 435 (84), 313 (18), 231 (34), 197 (23), 171 (42), 157 (51), 105 (100).

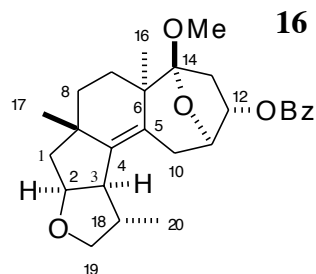


14 ^1H NMR (300 MHz, CDCl_3) δ : 8.04 (2H, m, Ar-H), 7.58 (1H, m, Ar-H), 7.46 (2H, m, Ar-H), 4.96 (1H, dd, $J = 2, 7.5$ Hz, HC-12), 4.42 (1H, br d, $J = 4.5$ Hz, HC-11), 4.11 (1H, dd, $J = 4, 8.5$ Hz, $\text{H}_2\text{C-19}$), 3.73 (1H, d, $J = 8.5$ Hz, $\text{H}_2\text{C-19}$), 3.43 (3H, s, $\text{H}_3\text{COC-14}$), 3.32 (3H, s, $\text{H}_3\text{COC-2}$), 3.30 (1H, m, HC-3), 2.56 (1H, ddd, $J = 2, 4.5, 14$ Hz, HC-10), 2.40 (1H, m, HC-18), 2.38 (1H, dd, $J = 7.5, 14.5$ Hz, HC-13), 2.24 (1H, dd, $J = 1, 13$ Hz, HC-1), 2.06 (2H, m, HC-13, HC-10), 1.80-1.46 (4H, m, $\text{H}_2\text{C-7}$, $\text{H}_2\text{C-8}$), 1.32 (1H, d, $J = 13$ Hz, HC-1), 1.23 (3H, s, $\text{H}_3\text{C-16}$ or 17), 1.22 (3H, s, $\text{H}_3\text{C-16}$ or 17),

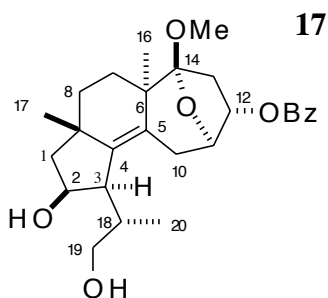
0.83 (3H, d, $J = 7$ Hz, H₃C-20). **¹³C NMR** (75 MHz, C₆D₆) δ : 165.9, 141.6, 132.7, 130.6, 129.6 ($\times 2$, Ph), 128.6, 128.3 ($\times 2$, Ph), 117.8, 111.5, 79.2, 78.4, 77.2, 57.0, 49.6, 49.0, 47.3, 45.7, 44.9, 37.1, 32.6, 32.0, 31.4, 27.6, 26.7, 20.3, 15.0. **LRMS** (EI), m/z (relative intensity): 468 ([M]⁺, 20), 427 (100), 436 (52), 331 (18), 315 (47), 213 (18), 157 (14), 105 (54).



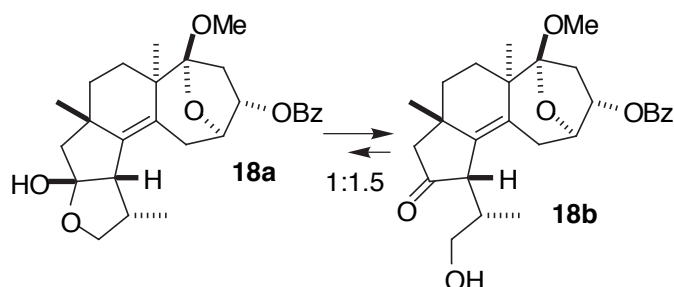
¹H NMR (300 MHz, CDCl₃) δ : 8.04 (2H, m, Ar-H), 7.56 (1H, m, Ar-H), 7.45 (2H, m, Ar-H), 4.95 (1H, dd, $J = 2, 7.5$ Hz, HC-12), 4.46 (1H, br d, $J = 4$ Hz, HC-11), 4.19 (1H, br dd, $J = 8, 8.5$ Hz, HC-19), 3.73 (1H, dd, $J = 8.5, 10.5$ Hz, HC-19), 3.43 (3H, s, OCH₃), 2.68 (1H, br d, $J = 7$ Hz, HC-3), 2.53 (1H, dd, $J = 4, 14$ Hz, HC-10), 2.32 (1H, m, HC-18), 2.27 (1H, dd, $J = 7, 14.5$ Hz, HC-13), 2.23 (1H, dd, $J = 1.5, 14$ Hz, HC-10), 2.12 (1H, d, $J = 12.5$ Hz, HC-1), 2.06 (1H, br d, $J = 14.5$ Hz, HC-13), 1.63 (1H, d, $J = 12.5$ Hz, HC-1), 1.32 (3H, d, $J = 6.5$ Hz, H₃C-20), 1.24 (3H, s, H₃C-17), 1.19 (3H, s, H₃C-16). **¹³C NMR** (75 MHz, CDCl₃) δ : 166.4 (s, C=O), 144.0 (s, C-5), 133.1 (d, Ph), 130.1 (s, Ph), 129.6 (d $\times 2$, Ph), 128.8 (s, C-4), 128.4 (d $\times 2$, Ph), 116.6 (s, C-2), 111.8 (s, C-14), 79.5 (d, C-12), 78.0 (d, C-11), 75.4 (t, C-19), 60.5 (d, C-3), 53.1 (t, C-1), 49.6 (q, OCH₃), 45.4 (s, C-6), 44.2 (d, C-18), 42.8 (s, C-9), 34.2 (t, C-13), 32.2 (t, C-8), 30.5 (t, C-7), 27.5 (t, C-10), 26.3 (q, C-17), 19.0 (q, C-20), 17.4 (q, C-16). **LRMS** (EI), m/z (relative intensity): 454 ([M]⁺, 9), 436 (20), 395 (6), 332 (8), 315 (12), 199 (11), 105 (48), 69 (100). **HRMS** m/z calcd. for C₂₇H₃₄O₆: 454.2355; found: 454.2353 (EI).



¹H NMR (300 MHz, CDCl₃) δ : 8.04 (2H, m, Ar-H), 7.58 (1H, m, Ar-H), 7.45 (2H, m, Ar-H), 4.99 (1H, dd, $J = 2, 7.5$ Hz, HC-12), 4.50 (1H, br dd, $J = 7, 7$ Hz, HC-2), 4.47 (1H, m, HC-11), 4.16 (1H, br dd, $J = 7, 9$ Hz, HC-19), 3.44 (3H, s, OCH₃), 3.21 (1H, dd, $J = 9, 10$ Hz, HC-19), 2.76 (1H, br dd, $J = 7, 7$ Hz, HC-3), 2.53 (1H, dd, $J = 4.5, 14$ Hz, HC-10), 2.34 (1H, dd, $J = 1.5, 14$ Hz, HC-10), 2.32-2.20 (1H, m, HC-18), 2.31 (1H, dd, $J = 7.5, 14.5$ Hz, HC-13), 2.06 (1H, br d, $J = 14.5$ Hz, HC-13), 1.98 (1H, d, $J = 13.5$ Hz, HC-1), 1.70-1.25 (5H, m), 1.28 (3H, d, $J = 7$ Hz, H₃C-20), 1.27 (3H, s, H₃C-17), 1.16 (3H, s, H₃C-16). **LRMS** (EI), m/z (relative intensity): 438 ([M]⁺, 33), 396 (39), 333 (19), 316 (34), 301 (18), 159 (20), 145 (21), 105 (100).

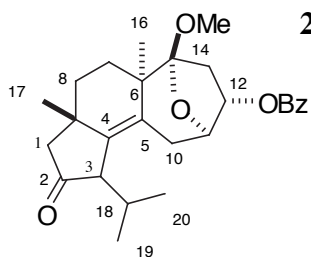


¹H NMR (300 MHz, CDCl₃) δ : 8.03 (2H, m, Ar-H), 7.47 (1H, m, Ar-H), 7.45 (2H, m, Ar-H), 5.14 (1H, dd, $J = 1.5, 7.5$ Hz, HC-12), 4.43 (1H, br d, $J = 4.5$ Hz, HC-11), 4.20 (1H, ddd, $J = 7, 7.5, 8$ Hz, HC-2), 3.78 (1H, dd, $J = 4, 10.5$ Hz, HC-19), 3.57 (1H, dd, $J = 8, 10.5$ Hz, HC-19), 3.43 (3H, s, H₃CO), 2.68 (1H, br dd, $J = 7.5, 8$ Hz, HC-3), 2.50 (1H, dd, $J = 4.5, 14.5$ Hz, HC-10), 2.34 (1H, m, HC-18), 2.30 (1H, dd, $J = 7.5, 14.5$ Hz, HC-13), 2.22 (1H, dd, $J = 1.5, 14.5$ Hz, HC-10), 2.04 (1H, br d, $J = 14.5$ Hz, HC-13), 2.00 (variable, 2H, br s, HO), 1.88 (1H, dd, $J = 8, 13$ Hz, HC-1), 1.74 (1H, dd, $J = 7.5, 13$ Hz, HC-1), 1.60-1.45 (4H, m, H₂C-7, H₂C-8), 1.24 (3H, s, H₃C-17), 1.17 (3H, s, H₃C-16), 1.08 (3H, d, $J = 7$ Hz, H₃C-20). **LRMS** (CI, NH₃), m/z (relative intensity): 455 ([M-1]⁺, 30), 439 (69), 438 (33), 437 (100), 412 (30), 397 (31), 136 (28), 105 (38).



¹H NMR (500 MHz, CDCl₃) δ (18a[†], 18b^{*}): 8.02 (2H, m, Ph), 7.56 (1H, m, Ph), 7.43 (2H, m, Ph), 4.97* (dd, *J* = 1.5, 7.5 Hz) and 4.96[†] (dd, *J* = 1.5, 7 Hz) (1H, , HC-12), 4.43* (br d, *J* = 4.5 Hz) and 4.40[†] (br d, *J* = 4.5 Hz) (1H, , HC-11), 4.19[†] (dd, *J* = 3.5, 8.5 Hz) and 3.64* (m) (1H, , HC-19), 3.74[†] (d, *J* = 8.5 Hz) and

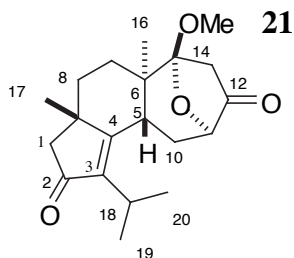
3.57* (m) (1H, , HC-19), 3.41 (3H, s, H₃CO), 3.36* (br s) and 3.29[†] (d, *J* = 7 Hz) (1H, , HC-3), 2.70-1.45 (11H, m), 1.29[†] (s) and 1.26* (s) (3H, , H₃C-6), 1.19[†] (s) and 1.06* (s) (3H, , H₃C-9), 0.80[†] (d, *J* = 7 m Hz) and 0.68* (d, *J* = 7 Hz) (3H, , H₃C-20). **¹³C NMR** (125 MHz, CDCl₃) δ (18a[†], 18b^{*}): 219.0*, 166.4[†], 166.2*, 142.1[†], 139.9*, 133.22*, 133.17[†], 130.6*, 129.92[†], 129.83*, 129.55* (×2), 129.53[†] (×2), 128.8[†], 128.43* (×2), 128.41[†] (×2), 114.8[†], 111.5[†], 110.9*, 79.1[†], 78.5*, 78.1[†], 77.8*, 77.2[†], 65.7*, 57.1[†], 56.6*, 54.7[†], 50.0*, 49.55[†], 49.51*, 45.7*, 45.4[†], 45.1[†], 39.4*, 37.6[†], 35.9*, 32.5*, 32.4[†], 31.9[†], 31.42[†], 31.47*, 31.2*, 28.3*, 27.4[†], 27.2[†], 27.1*, 20.5*, 20.0[†], 14.9[†], 12.2*. **LRMS** (FAB), *m/z* (relative intensity): 455 ([M+1]⁺, 70), 437 (100), 395 (15), 315 (17), 105 (81). **HRMS** *m/z* calcd. for C₂₇H₃₄O₆: 455.2434 (M+H); found: 455.2435 (FAB).



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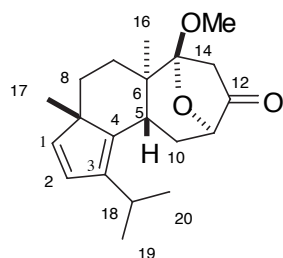
¹H NMR (500 MHz, CDCl₃) δ: 8.06 (2H, m, Ph), 7.61 (1H, m, Ph), 7.48 (2H, m, Ph), 5.02 (1H, br d, *J* = 7.5 Hz, HC-12), 4.46 (1H, br d, *J* = 5 Hz, HC-11), 3.46 (3H, s, H₃CO), 2.91 (1H, br s, HC-3), 2.69 (1H, ddd, *J* = 2.5, 5, 14.5 Hz, HC-10), 2.41 (1H, dd, *J* = 7.5, 15 Hz, HC-13), 2.31 (1H, m, HC-18), 2.17 (2H, ap s, HC-1), 2.14 (1H, br d, *J* = 15 Hz, HC-13), 2.11 (1H, br d, *J* = 14.5 Hz, HC-10), 1.81-1.59 (4H, m, H₂C-7, H₂C-8), 1.29 (3H, s, *J* = 7 Hz, H₃C), 1.13 (3H, d, H₃CC-18), 1.07 (3H, s, *J* = 7 Hz, H₃C), 0.77

(3H, d, H₃CC-18). **¹³C NMR** (125 MHz, CDCl₃) δ: 217.8, 166.8, 133.7, 130.8, 130.3, 130.0 (×2), 128.9 (×2), 111.3, 79.1, 78.4, 56.8, 54.6, 50.0, 45.6, 39.5, 32.8, 32.0, 31.5, 29.6, 28.8, 27.6, 21.1, 20.9, 18.0. **LRMS** (EI), *m/z* (relative intensity): 438 ([M]⁺, 19), 395 (100), 316 (16), 273 (26), 216 (19), 199 (36), 105 (93), 77 (25). **HRMS** *m/z* calcd. for C₂₇H₃₄O₅: 438.2406; found: 438.2410 (EI).

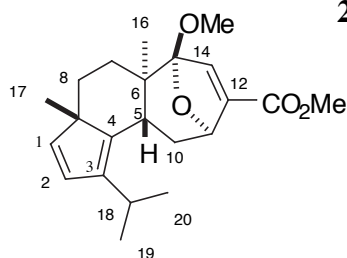


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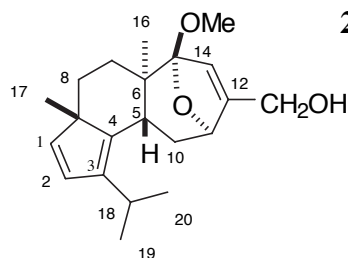
¹H NMR (300 MHz, CDCl₃) δ: 4.32 (1H, br s, HC-11), 3.39 (3H, s, H₃CO), 2.91 (1H, sept, *J* = 7 Hz, HC-18), 2.79-2.72 (2H, m, HC-13, HC-15), 2.53 (1H, d, *J* = 18.5 Hz, HC-13), 2.44 (1H, ddd, *J* = 4, 13, 13 Hz, HC-10), 2.20 (1H, d, *J* = 18.5 Hz, HC-1), 2.12 (1H, d, *J* = 18.5 Hz, HC-1), 1.94 (1H, ddd, *J* = 2.5, 4, 13 Hz, HC-10), 1.78 (1H, m, HC-7 or HC-8), 1.55 (3H, m, HC-7, HC-8), 1.20 (3H, d, *J* = 7 Hz, H₃C-19), 1.17 (3H, s, H₃C-17), 1.16 (3H, d, *J* = 7 Hz, H₃C-20), 1.06 (3H, s, H₃C-16).



- 22** $^1\text{H NMR}$ (300 MHz, CDCl_3) δ : 6.29 (1H, d, $J = 5.5$ Hz, HC-1 or HC-2), 6.23 (1H, d, $J = 5.5$ Hz, HC-1 or HC-2), 4.30 (1H, br s, HC-11), 3.38 (1H, s, H_3CO), 2.89 (1H, sept, $J = 7$ Hz, HC-18), 2.72 (1H, d, $J = 18.5$ Hz, HC-13), 2.57 (1H, d, $J = 18.5$ Hz, HC-13), 2.49 (1H, dd, $J = 2.5, 13.5$ Hz, HC-5), 2.39 (1H, ddd, $J = 3.5, 12, 13.5$ Hz, HC-10), 1.93 (1H, ddd, $J = 2.5, 2.5, 12$ Hz, HC-10), 1.68 (1H, ddd, $J = 3, 3, 13$ Hz, HC-7 or HC-8), 1.50–1.17 (3H, m, HC-7, HC-8), 1.09 (3H, d, $J = 7$ Hz, H_3CC -18), 1.03 (3H, d, $J = 7$ Hz, H_3CC -18), 0.95 (3H, s, H_3C -17), 0.88 (3H, s, H_3C -16).



- 23** $^1\text{H NMR}$ (300 MHz, CDCl_3) δ : 7.13 (1H, s, HC-13), 6.30 (1H, d, $J = 5.5$ Hz, HC-1), 6.21 (1H, d, $J = 5.5$ Hz, HC-2), 5.08 (1H, dd, $J = 2, 3$ Hz, HC-11), 3.81 (3H, s, H_3COC -15), 3.34 (3H, s, H_3COC -14), 2.96 (1H, sept, $J = 7$ Hz, HC-18), 2.45–2.35 (2H, m, HC-5, HC-10), 1.70–1.20 (5H, m, HC-10, H_2C -8, H_2C -7), 1.10 (3H, d, $J = 7$ Hz, H_3CC -18), 1.03 (3H, d, $J = 7$ Hz, H_3CC -18), 0.92 (3H, s, H_3C -16 or -17), 0.81 (3H, s, H_3C -17 or -16).



- 24** $^1\text{H NMR}$ (500 MHz, CDCl_3) δ : 6.29 (1H, d, $J = 5.5$ Hz, HC-1), 6.20 (1H, d, $J = 5.5$ Hz, HC-2), 6.10 (1H, dd, $J = 1.5, 2$ Hz, HC-13), 4.80 (1H, dd, $J = 2, 3$ Hz, HC-11), 4.37 (1H, br d, $J = 15$ Hz, HC-15), 4.32 (1H, br d, $J = 15$ Hz, HC-15), 3.31 (3H, s, H_3CO), 2.95 (1H, sept, $J = 7$ Hz, HC-18), 2.52 (1H, dd, $J = 4, 13$ Hz, HC-5), 2.38 (1H, ddd, $J = 3, 13, 13$ Hz, HC-10), 1.70–1.40 (5H, m, HC-10, H_2C -8, H_2C -7), 1.09 (3H, d, $J = 7$ Hz, H_3CC -18), 1.03 (3H, d, $J = 7$ Hz, H_3CC -18), 0.92 (3H, s, H_3C -16 or -17), 0.79 (3H, s, H_3C -17 or -16). $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ : 148.3 (s, C-12), 144.5 (d, C-1), 142.7 (s, C-3), 141.1 (s, C-4), 128.0 (d, C-2), 124.3 (d, C-13), 114.6 (s, C-14), 78.5 (s, C-11), 59.3 (t, C-15), 54.3 (s, C-9), 51.1 (q, OCH_3), 44.7 (s, C-6), 39.5 (d, C-5), 31.5 (t, C-8), 29.2 (t, C-7), 26.0 (t, C-10), 25.9 (d, C-18), 22.9 (q, C-19), 22.8 (q, C-20), 20.9 (q, C-17), 12.0 (q, C-16). **LRMS** (EI), m/z (relative intensity): 330 ($[\text{M}]^+$, 35), 312 (29), 299 (12), 297 (22), 187 (49), 173 (28), 141 (100). **HRMS** m/z calcd. for $\text{C}_{21}\text{H}_{30}\text{O}_3$: 330.2195; found: 330.2195 (EI). **UV**: λ_{max} 255 nm ($\text{CH}_3\text{CN}/\text{H}_2\text{O}$).