Electronic Supplementary Information

Construction of the Tetracyclic Core of the Lycopodium Alkaloid Annotinolide C

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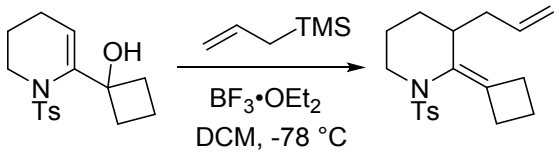
1. General Information

Unless otherwise stated, all reactions were carried out under dry argon atmosphere with dry solvents in dry glassware. Dry THF was refluxed with Sodium Sand, dry DCM was refluxed with CaH_2 and other extra dry solvent was bought. All reactions were monitored by thin layer chromatography of silica gel prefabricated plate, visualized with UV light and the products were purified by column chromatography with silica gel (200~300 mesh). Petroleum ether and ethyl acetate were used as eluent. And ^{1}H NMR and ^{13}C NMR spectra data were obtained on 400 MHz or 600 MHz NMR spectrometers. High-resolution mass spectral analysis (HRMS) data were detected on a Bruker APEXII mass spectrometer. The X-ray single-crystal determination was performed on an Agilent SuperNova Eos diffractometer.

2. Experimental details for compounds

2.1. Synthesis of compound 7



6 **7**

Compound 7: Compound **6**[1] (900 mg, 2.9 mmol) was dissolved in dry DCM (300 mL). Allyltrimethylsilane (930 μL, 5.8 mmol) was added to the solution under argon atmosphere at room temperature (20 °C). Then the mixture was stirred at -78 °C. Boron trifluoride etherate (1.2 mL, 8.7 mmol) was added dropwisely into the solution at -78 °C. The reaction was allowed to rise to room temperature (20 °C) slowly. Finally, the reaction was quenched with saturated $NaHCO_3$ (100 mL). The reaction was extracted with DCM (3 × 80 mL). The combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/30 to 1/15) to give product **7** (730 mg, 75%) as a colorless oil.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.4 Hz, 2H), 7.27 (d, *J* = 8.4 Hz, 2H), 5.82-5.77 (m, 1H), 5.02-4.98 (m, 2H), 3.61-3.59 (m, 1H), 3.13-3.11 (m, 1H), 2.89-2.85 (m, 1H), 2.85-2.77 (m, 1H), 2.71-2.68 (m, 1H), 2.60-2.57 (m, 1H), 2.41 (s, 3H), 2.31-2.27 (m, 2H), 1.99-1.94 (m, 1H), 1.92-1.88 (m, 2H), 1.66-1.55 (m, 3H), 1.34-1.31 (m, 1H).

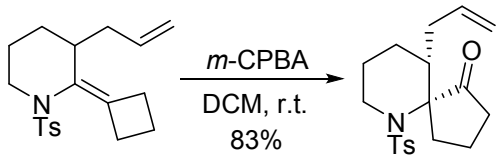
^{13}C NMR (150 MHz, $CDCl_3$) δ 142.83, 138.69, 138.34, 137.40, 129.33, 128.70, 127.32, 115.73, 48.45, 36.03, 30.40, 29.36, 29.32, 21.45, 20.59, 16.54.

IR (neat): νmax= 3071, 2930, 2861, 1737, 1639, 1598, 1446, 1154, 1091, 914, 815, 547 cm^{-1}

HRMS ESI Calcd for $C_{19}H_{25}NO_2SNa$ $[M+Na]^+$: 354.1498, Found: 354.1507

MS (EI) m/z (%): 331 (53), 319 (31), 290 (76), 267(31), 252 (27), 239 (21), 224 (34), 198 (34), 176 (18), 148 (28), 120 (28).

2.2. Synthesis of compound 5



7 **5**

Compound 5: The diolefin (300 mg, 0.9 mmol) was dissolved in DCM (300 mL) at room temperature (20 °C). Then the mixture was added 75% *m*-CPBA (320 mg, 1.35 mmol). After the solution was stirred at room temperature (20 °C) for 3 hours, it was quenched with saturated $Na_2S_2O_3$ (50 mL) and $NaHCO_3$ (50 mL). The reaction was extracted with DCM (3 × 80 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/20 to 1/10) to give product **5** (261 mg, 83%) as a colorless oil.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.4 Hz, 2H), 7.29 (d, *J* = 8.4

Hz, 2H), 5.60-5.58 (m, 1H), 4.98-4.95 (m, 2H), 3.27-3.24 (m, 1H), 3.14-3.09 (m, 1H), 2.71-2.65 (m, 1H), 2.53-2.49 (m, 2H), 2.42 (s, 3H), 2.36-2.28 (m, 2H), 2.16-2.15 (m, 1H), 2.03-2.00 (m, 1H), 1.82-1.78 (m, 1H), 1.76-1.72 (m, 2H), 1.66-1.55 (m, 2H), 1.44-1.43 (m, 1H).

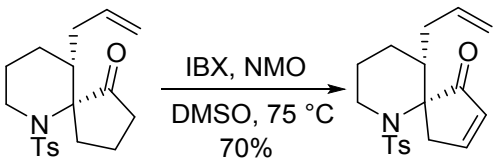
^{13}C NMR (150 MHz, $CDCl_3$) δ 214.33, 143.23, 137.65, 136.74, 129.28, 127.74, 116.28, 69.02, 43.86, 37.73, 36.61, 34.78, 31.78, 21.59, 21.50, 18.90, 17.82.

IR (neat): νmax= 3399, 3068, 2953, 2870, 1744, 1458, 1326, 1155, 1094, 996, 817, 685 cm^{-1}

HRMS ESI Calcd for $C_{19}H_{25}NO_3SNa$ $[M+Na]^+$:370.1447, Found: 370.1452.

MS (EI) m/z (%): 347 (75), 319 (15), 291 (36), 226 (41), 212 (74), 192 (100), 164 (28), 136 (15), 91 (15).

2.3. Synthesis of compound 8



5 **8**

Compound 8: Compound **5** (265 mg, 0.8 mmol) was dissolved in dry DMSO (10 mL) at room temperature (20 °C) , and then IBX (2-iodoxybenzoic acid) (2.14 g, 8 mmol) and NMO (4-methylmorpholine N-oxide) (900 mg, 8 mmol) were added into the solution. The resulting

solution was heated to 75 °C and stirred for 12 h. After the reaction was cooled down to room temperature (20 °C), it was quenched with saturated $Na_2S_2O_3$ (80 mL). The reaction was extracted with EtOAc (3 × 80 mL). The combined organic layer was washed with water and brine for several times, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/20 to 1/8) to give product **8** (186 mg, 70%) as a colorless oil.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.4 Hz, 2H), 7.56-7.54 (m, 1H), 7.30 (d, *J* = 8.4 Hz, 2H), 6.23-6.22 (m, 1H), 5.60-5.30 (m, 1H), 4.99-4.95 (m, 2H), 3.42-3.34 (m, 2H), 3.29-3.27 (m, 1H), 2.89-2.85 (m, 1H), 2.42 (s, 3H), 2.24-2.21 (m, 1H), 1.84-1.77 (m, 2H), 1.73-1.65 (m, 1H), 1.64-1.57 (m, 2H), 1.49-1.47 (m, 1H).

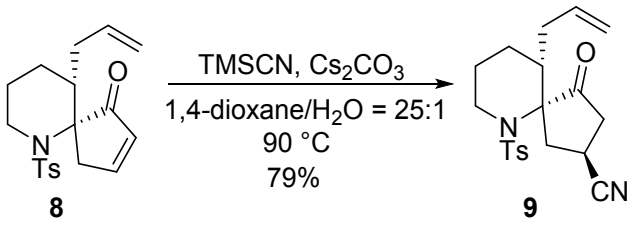
^{13}C NMR (150 MHz, $CDCl_3$) δ 205.48, 159.01, 143.36, 137.41, 136.33, 132.98, 129.31, 127.84, 116.68, 66.70, 43.73, 43.10, 41.76, 32.94, 21.62, 21.21, 20.36.

IR (neat): νmax= 3048, 3070, 2944, 2870, 2368, 1716, 1596, 1325, 1159, 1093, 817, 670, 606, 547 cm^{-1}.

HRMS ESI Calcd for $C_{19}H_{23}NO_3SNa$ $[M+Na]^+$: 368.1691; Found: 368.1698.

MS (EI) m/z (%): 345 (67), 304 (35), 276 (36), 190 (6), 162 (41), 149 (6), 135 (12), 121 (50), 91 (13).

2.4. Synthesis of compound 9



8 9

Compound 9: Compound **8** (44 mg, 0.13 mmol) was dissolved in dry 1,4-dioxane (2 mL) at room temperature (20 °C). And then, distilled water (80 μL), TMSCN (48 μL, 0.36 mmol) and the Cs_2CO_3 (10 mg, 0.03 mmol) were added into the solution. The resulting solution was heated to 90 °C and stirred for 2 h. After the reaction was cooled down to room temperature (20 °C), it was quenched with H_2O (5 mL). The reaction was extracted with EtOAc (3 × 10 mL). The combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether = 1/15 to 1/5) to give product **9** (38 mg, 79%) as a white solid. m.p. = 164.6 °C-165.8 °C.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.4 Hz, 2H), 7.32 (d, *J* = 8.4 Hz, 2H), 5.58-5.51 (m, 1H), 5.01-4.96 (m, 2H), 3.30-3.28 (m, 1H), 3.10-2.99 (m, 4H), , 2.84-2.82 (m, 1H), 2.75-2.73 (m, 1H), 2.43 (s, 3H), 2.26-2.23 (m, 1H), 2.05-2.02 (m, 1H), 1.81-1.78 (m, 1H), 1.65-1.62 (m, 2H), 1.59-1.49 (m, 2H).

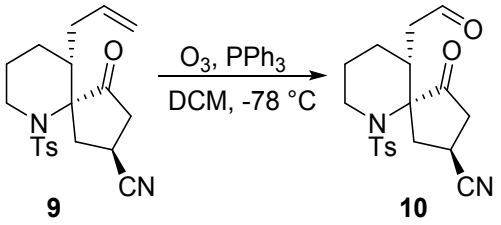
^{13}C NMR (150 MHz, $CDCl_3$) δ 207.49, 143.80, 136.88, 135.80, 129.44, 127.69, 120.12, 116.95, 68.37, 44.33, 39.19, 38.17, 36.79, 31.37, 21.85, 21.53, 21.20, 18.41.

IR (neat): νmax= 3339, 3170, 2949, 2369, 1746, 1459, 1328, 1157, 1097, 784, 669, 557 cm^{-1}

HRMS ESI Calcd for $C_{20}H_{24}N_2O_3SNa$ $[M+Na]^+$: 395.1400; Found: 395.1407.

MS (EI) m/z (%): 372 (87), 344 (25), 291 (25), 276 (25), 226 (26), 217 (85), 212 (26), 189 (25), 147 (42), 136 (25), 91 (25).

2.5. Synthesis of compound 10



9 **10**

Compound 10: compound **9** (181 mg, 0.49 mmol) was dissolved in dry DCM (20 mL) at room temperature (20 °C). Then the mixture was cooled down to -78 °C, and ozone was bubbled through the reaction mixture for 10 minutes. PPh_3 (638 mg, 2.5 mmol) was added into the solution and the mixture was allowed to rise to room temperature (20 °C) slowly. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/20 to 1/2) to give product **10** as a white solid. m.p. = 153.7 °C-155.3 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.57 (s, 1H), 7.82 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.0 Hz, 2H), 3.42-3.35 (dd, *J* = 8.4 Hz, 1H), 3.28-3.24 (m, 2H), 3.06-2.93 (m, 3H), 2.78-2.68 (m, 3H), 2.44 (s, 3H), 2.07 (dd, *J* = 1.6 Hz, 1H), 1.82-1.78(m, 1H), 1.63-1.59(m, 2H), 1.54-1.43 (m, 1H).

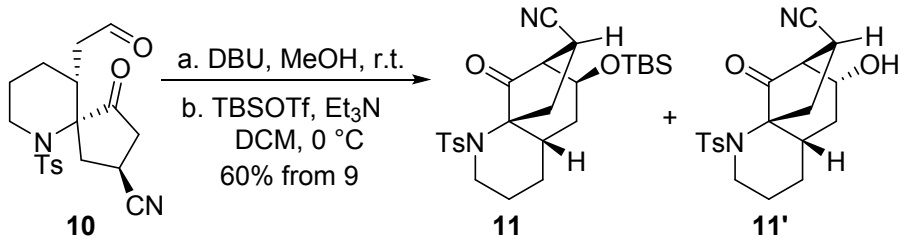
^{13}C NMR (100 MHz, $CDCl_3$) δ 209.29, 200.19, 144.01, 136.42, 129.48, 127.78, 120.09, 67.33, 44.80, 44.06, 38.91, 37.55, 29.54, 26.59, 21.54, 21.14, 19.66.

IR (neat): νmax= 2949, 2872, 2369, 2245, 1749, 1721, 1597, 1448, 1323, 1154, 1115, 1091, 922, 669, 557 cm^{-1}

HRMS ESI Calcd for $C_{19}H_{22}N_2O_4SNa$ $[M+Na]^+$: 397.1192; Found: 397.1193.

MS (EI) m/z (%): 374 (100), 346 (34), 317 (65), 293 (34), 244 (34), 219 (100), 200 (34), 186 (34), 110 (35), 91 (34).

2.6. Synthesis of compound 11



Compound 11: The above product **10** was dissolved in dry MeOH (5 mL) at room temperature (20 °C), then DBU (80 μL, 0.53 mmol) was added into the solution. After the mixture was stirred at room temperature (20 °C)

for 1 h, the reaction was quenched with saturated NH_4Cl. The reaction was extracted with EtOAc (3 × 10 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was went straight to the next step. The crude product was dissolved in dry DCM (5 mL) at 0 °C. Finally, Et_3N (350 μL, 2.53 mmol) and TBSOTf (350 μL, 1.53 mmol) were added in order at 0 °C. After the mixture was stirred for 10 minutes at 0 °C, the reaction was quenched with saturated $NaHCO_3$. The reaction was extracted with DCM (3 × 5 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/40 to 1/20) to give product **11** (144 mg, 60% from **9**) as a white solid. m.p. = 107.5 °C - 108.9 °C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.4 Hz, 2H), 7.30 (d, *J* = 8.4 Hz, 2H), 4.13-4.11 (m, 1H), 4.10-3.94 (m, 1H), 3.92-3.87 (m, 1H), 3.20-3.16 (m, 1H), 2.82-2.81 (m, 1H), 2.70-2.61 (m, 2H), 2.41 (s, 3H), 1.75-1.73 (m, 1H), 1.72-1.66 (m, 6H), 0.86 (s, 9H), 0.05 (s, 6H).

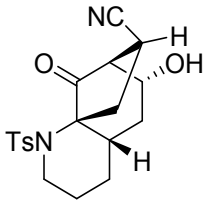
^{13}C NMR (100 MHz, $CDCl_3$) δ 205.36, 143.51, 139.24, 129.87, 126.57, 121.03, 69.95, 67.70, 57.19, 44.44, 43.08, 34.80, 33.83, 28.44, 25.52, 21.52, 18.61, 17.90, -4.89, -4.92.

IR (neat): νmax= 3376, 2928, 2856, 2241, 1759, 1463, 1323, 1252, 1152,

1091, 838, 775, 666 cm^{-1}

HRMS ESI Calcd for $C_{25}H_{36}N_2O_4SSiNa$ $[M+Na]^+$: 511.2057; Found: 511.2059.

MS (EI) m/z (%): 488 (100), 403 (15), 350 (8), 333 (100), 305 (33), 276 (12), 247 (37), 213 (32), 173 (11), 120 (25), 91 (6).



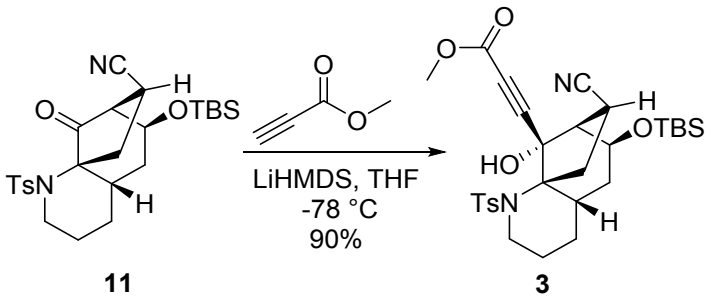
11'

^{1}H NMR (600 MHz, DMSO-d^6) δ 7.66 (d, *J* = 8.4 Hz, 2H), 7.40 (d, *J* = 8.4 Hz, 2H), 5.38 (s, 1H), 4.21 (s, 1H), 3.84-3.82 (m, 1H), 3.67-3.65 (m, 1H), 3.33-3.28 (m, 3H), 2.71-2.68 (m, 1H), 2.38 (s, 3H), 1.80-1.77 (m, 1H), 1.64-1.61 (m, 1H), 1.54-1.51 (m, 1H), 1.41-1.39 (m, 2H), 1.24-1.16 (m, 1H).

^{13}C NMR (150 MHz, DMSO-d^6) δ 207.90, 142.99, 139.76, 129.87, 126.20, 121.76, 75.14, 67.70, 54.92, 54.05, 49.06, 44.16, 32.23, 31.16, 28.12, 25.01, 20.95, 20.70.

MS (EI) m/z (%): 374 (100), 346 (18), 317 (98), 298 (15), 276 (34), 251 (36), 229 (20), 201 (20), 191 (9), 147 (29), 91 (6).

2.7. Synthesis of compound 3



11 **3**

Compound 3: Methyl propiolate (41 μL, 0.46 mmol) was dissolved in dry THF, and then the mixture was cooled to -78 °C. LiHMDS (350 μL, 1mol/L in THF, 0.46 mmol) was added into the mixture at -78 °C. After the reaction was stirred at -78 °C for 45 minutes, the solution of compound **11** (144 mg, 0.42 mmol) in dry THF was added into the mixture at -78 °C. Finally, the reaction was allowed to rise to room temperature (20 °C) slowly. The reaction was quenched with saturated NH_4Cl, and extracted with EtOAc (3 × 10 mL). The combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/20 to 1/10) to give product **3** (166 mg, 90%) as a yellow oil.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.4 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 4.43-4.40 (m, 1H), 4.05-3.98 (m, 2H), 3.76 (s, 3H), 3.06-3.04 (m, 2H), 2.54-2.49 (m, 3H), 2.39 (s, 3H), 2.37-2.20 (m, 2H), 1.69-1.61 (m, 5H), 0.86 (s, 9H), 0.05 (s, 6H).

^{13}C NMR (150 MHz, $CDCl_3$) δ 153.19, 142.85, 140.34, 129.50, 126.77, 122.07, 85.49, 81.31, 79.38, 68.41, 63.54, 56.48, 53.01, 45.01, 40.60,

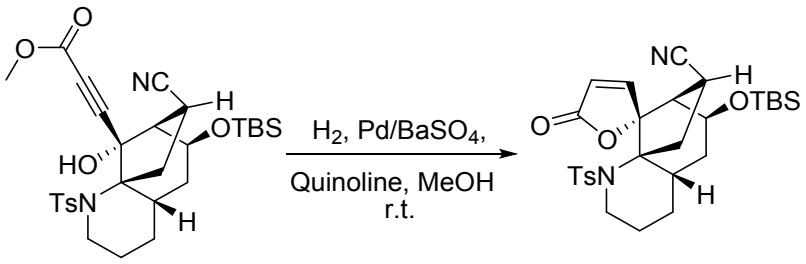
37.81, 34.59, 28.53, 25.67, 25.49, 21.57, 20.42, 17.91, -4.70, -4.85.

IR (neat): νmax= 3410, 2954, 2930, 2857, 2241, 1718, 1598, 1463, 1253, 1153, 1091, 1076, 989, 863, 834 cm^{-1}

HRMS ESI Calcd for $C_{29}H_{40}N_2O_6SSiNa$ $[M+Na]^+$: 595.2269; Found: 595.2268.

MS (EI) m/z (%): 572 (100), 515 (100), 417 (18), 350 (93), 285 (40), 253 (100), 173 (69), 155 (22), 91 (5).

2.8. Synthesis of compound 12



3 **12**

Compound 12: compound **3** (166 mg, 0.3 mmol) was dissolved in dry MeOH, and then quinoline (35 μL, 0.3 mmol) and 10% $Pd/BaSO_4$ (26mg, 0.03 mmol) were added into the solution. The reaction was stirred at hydrogen atmosphere at room temperature (20 °C) for 5 h. Finally, the mixture was filtered through diatomite. The filtrate was concentrated under vacuum, and the crude product was purified by column chromatography (EtOAc: petroleum ether =1/30 to 1/10) to give product **12** as a white solid. CCDC 2043936. m.p.= 197 °C-198 °C. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via

www.ccdc.cam.ac.uk/data_request/cif

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.4 Hz, 2H), 7.41 (d, *J* = 5.4 Hz, 1H), 7.32 (d, *J* = 8.4 Hz, 2H), 6.18 (d, *J* = 5.4 Hz, 1H), 4.38-4.35 (m, 1H), 4.14-4.11 (m, 1H), 3.14 (dd, *J* = 6 Hz, 1H), 2.96 (dd, *J* = 6 Hz, 1H), 2.88 (td, *J* = 2.4 Hz,1H), 2.54-2.50 (m, 1H), 2.45 (s, 3H), 2.37-2.34 (m, 1H), 2.14-2.13 (m, 1H), 2.05-2.03 (m, 1H), 1.74-1.58 (m, 4H), 1.43-1.42 (m, 1H), 0.84 (s, 9H), 0.04 (s, 3H), 0.02 (s, 3H).

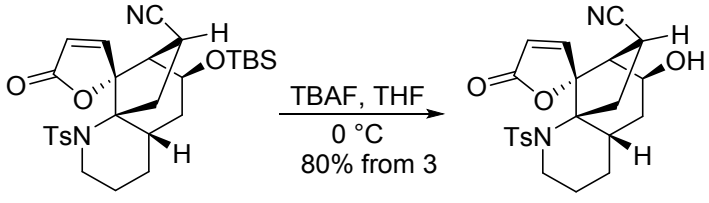
^{13}C NMR (150 MHz, $CDCl_3$) δ 170.49, 156.70, 143.76, 140.27, 129.84, 126.55, 122.30, 121.29, 97.43, 66.47, 64.80, 54.63, 44.30, 42.07, 37.31, 34.78, 28.36, 25.58, 25.28, 21.53, 20.07, 17.81, -4.71, -4.88.

IR (neat): νmax= 3394, 2953, 2930, 2889, 2857, 1775, 1738, 1462, 1331, 1252, 1153, 1094, 1066, 986, 854, 666 cm^{-1}

HRMS ESI Calcd for $C_{28}H_{38}N_2O_5SSiNa$ $[M+Na]^+$: 565.2163; Found: 565.2172.

MS (EI) m/z (%): 542 (31), 485 (57), 442 (100), 419 (12), 387 (15), 350 (47), 287 (16), 255 (18), 198 (81), 173 (42), 155 (22), 91 (12).

2.9. Synthesis of compound 13



12 **13**

Compound 13: The crude product **12** was dissolved in dry THF (8 mL) at 0 °C. TBAF (0.6 mL, 1 mol/L in THF, 0.6 mmol) in THF was added into the mixture. After the reaction was stirred for 5 minutes, it was quenched with H_2O (10 mL). The reaction was extracted with EtOAc (3 × 10 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/15 to 1/2) to give the product **13** (102 mg, 80% from **3**) as a white solid. m.p.= 182.4 °C-184 °C.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.60 (d, *J* = 7.8 Hz, 2H), 7.43 (d, *J* = 6.0 Hz, 1H), 7.33 (d, *J* = 7.8 Hz, 2H), 6.19 (d, *J* = 6.0 Hz, 1H), 4.50-4.48 (m, 1H), 4.14-4.11 (m, 1H), 3.13 (dd, *J* = 5.4 Hz, 1H), 2.98 (dd, *J* = 5.4, 1H), 2.90-2.85 (m, 1H), 2.56-2.52 (m, 1H), 2.45 (s, 3H), 2.36-2.27 (m, 2H), 2.11-2.05 (m, 1H), 1.88-1.81 (m, 2H), 1.75-1.62 (m, 4H).

^{13}C NMR (150 MHz, $CDCl_3$) δ 170.54, 156.81, 143.88, 140.21, 129.91, 126.56, 122.20, 121.38, 97.37, 66.49, 64.18, 54.02, 44.35, 42.04, 37.32, 33.39, 28.32, 25.28, 21.57, 20.21.

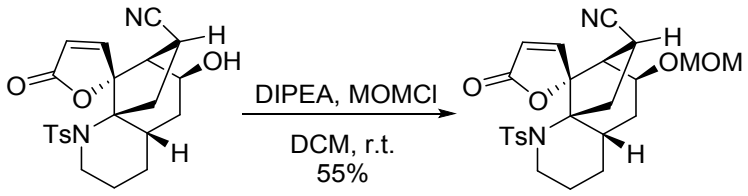
IR (neat): νmax= 3501, 2937, 2241, 1770, 1737, 1598, 1306, 1245, 1152, 1056, 986, 816, 669 cm^{-1}

HRMS ESI Calcd for $C_{22}H_{24}N_2O_5SNa$ $[M+Na]^+$: 451.1298, Found: 451.1307.

MS (EI) m/z (%): 428 (24), 290 (66), 288 (50), 273 (17), 255 (51), 245

(60), 229 (53), 155 (49), 91 (8).

2.10. Synthesis of compound 14



13 **14**

Compound 14: Compound **13** (41 mg, 0.1 mmol) was dissolved in dry DCM (3 mL), and then DIPEA (200 μL, 1.21 mmol) and MOMCl (60 μL, 0.8 mmol) were added into the solution at room temperature (20 °C). After the mixture was stirred at the room temperature (20 °C) for 24 h, it was quenched with saturated $NaHCO_3$ (5 mL). The reaction was extracted with DCM (3 × 8 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/20 to 1/5) to give the product **14** (26 mg, 55% from 13) as a white solid. m.p.= 197.5 °C-199.2 °C.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.4 Hz, 2H), 7.40 (d, *J* = 6.0 Hz, 1H), 7.33 (d, *J* = 8.4 Hz, 2H), 6.19 (d, *J* = 6.0 Hz, 1H), 4.61 (dd, *J* = 7.2Hz, 2H), 4.26-4.23 (m, 1H), 4.14-4.11 (m, 1H), 3.32 (s, 3H), 3.04 (dd, *J* = 6 Hz, 1H), 2.95-2.90 (m, 1H), 2.88-2.86 (m, 1H), 2.86-2.54 (m, 1H), 2.48-2.47 (m, 1H), 2.45 (s, 3H), 2.39-2.36 (m, 1H), 2.12-2.08 (m, 1H),

1.88-1.85 (m, 1H), 1.76-1.66 (m, 3H), 1.63-1.57 (m, 1H).

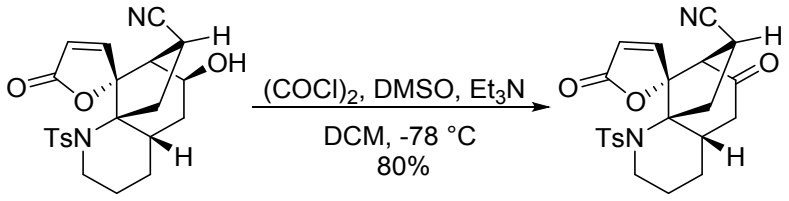
^{13}C NMR (150 MHz, $CDCl_3$) δ 170.42, 156.57, 143.83, 140.28, 129.89, 126.55, 122.09, 121.47, 97.15, 96.02, 70.98, 66.53, 55.65, 52.07, 44.34, 41.98, 37.33, 31.97, 28.33, 25.29, 21.57, 20.60.

IR (neat): νmax= 3392, 2942, 2241, 1771, 1451, 1329, 1308, 1152, 1039, 987, 910, 816, 737, 669 cm^{-1}

HRMS ESI Calcd for $C_{24}H_{28}N_2O_6SNa$ $[M+Na]^+$: 495.1560, Found: 495.1560.

MS (EI) m/z (%): 472 (24), 410 (100), 317 (15), 285 (24), 255 (21), 155 (21), 133 (30), 91 (5).

2.11. Synthesis of compound 16



13 16

Compound 16: A dry round bottom flask was added into dry DCM (0.3 mL), next $(COCl)_2$ (10 µL, 0.12 mmol) was added. The mixture was cooled to -78 °C. And DMSO (15 µL, 0.21 mmol) in DCM (0.3 mL) was added into the mixture at -78 °C. After the reaction stirred for 10 minutes, compound **13** (26 mg, 0.061 mmol) dissolved in DCM (0.3 mL) was added into the solution at -78 °C. The reaction was stirred for another 20 minutes at -78 °C. Finally, Et_3N (38 µL, 0.28 mmol) was added into the mixture,

and then the reaction was allowed to rise to room temperature (20 °C) slowly. The reaction was quenched with saturated $NaHCO_3$ (5 mL). The reaction was extracted with DCM (3 × 8 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/15 to 1/3) to give the product **16** (21 mg, 80%) as a white solid. m.p.= 275.5 °C-277 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.4 Hz, 2H), 7.38-7.35 (m, 3H), 6.26 (d, *J* = 5.6 Hz, 1H), 4.19-4.16 (m, 1H), 3.13 (dd, *J* = 5.2, 1H), 3.02-2.95 (m, 1H), 2.91-2.83 (m, 3H), 2.74 (brs, 1H), 2.47 (s, 3H), 2.43-2.31 (m, 3H), 1.78-1.68 (m, 3H).

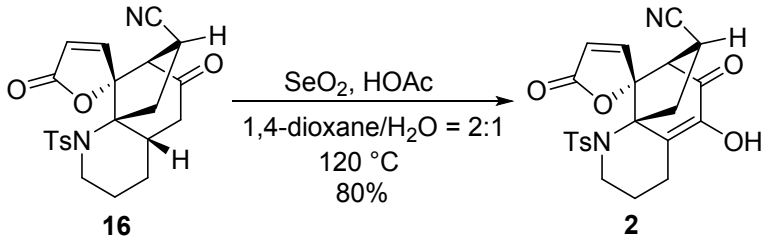
^{13}C NMR (100 MHz, $CDCl_3$) δ 200.63, 169.04, 153.73, 144.24, 140.12, 130.09, 126.53, 122.60, 119.76, 98.11, 66.26, 59.72, 44.29, 41.83, 40.73, 38.04, 28.90, 24.71, 23.71, 21.61.

IR (neat): νmax= 3396, 3099, 2923, 2854, 1816, 1767, 1721, 1594, 1431, 1350, 1304, 1141, 983, 908, 781 cm^{-1}

HRMS ESI Calcd for $C_{22}H_{22}N_2O_5SNa$ $[M+Na]^+$: 449.1142, Found: 449.1139.

MS (EI) m/z (%): 426 (30), 288 (25), 271 (6), 243 (25), 224 (51), 155 (29), 133 (14), 91 (4).

2.12. Synthesis of compound 2



Compound 2: Compound **16** (47 mg, 0.11 mmol) was dissolved in 1,4-dioxane (1 mL), and then distilled water (500 μL), SeO_2 (25 mg, 0.22 mmol) and HOAc (20 μL, 0.35 mmol) were added into the solution. The resulting solution was heated to 120 °C and stirred for 12 h. After the reaction was cooled down to room temperature (20 °C), the reaction was quenched with saturated $Na_2S_2O_3$. The reaction was extracted with EtOAc (3 × 10 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum, the crude product was purified by column chromatography (EtOAc: petroleum ether =1/10 to 1/1) to give the product **2** (40 mg, 80%) as a white solid. m.p. = 126.8 °C - 127.5 °C

^{1}H NMR (400 MHz, CD_2Cl_2) δ 7.73 (d, *J* = 8.4 Hz, 2H), 7.68 (d, *J* = 5.6 Hz, 1H), 7.37 (d, *J* = 8.4 Hz, 2H), 6.33 (d, *J* = 5.6 Hz, 1H), 5.88 (brs, 1H), 4.05 (dd, *J* = 8 Hz, 1H), 3.87 (dd, *J* = 6.4, 1H), 3.32-3.30 (m, 1H), 3.23 (brs, 1H), 2.95-2.93 (m, 2H), 2.45 (s, 3H), 1.92-1.87 (m, 1H), 1.72-1.56

(m, 3H).

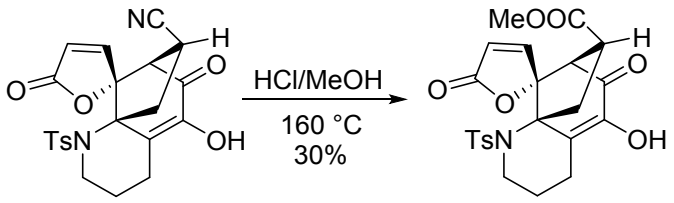
^{13}C NMR (100 MHz, CD_2Cl_2) δ 188.54, 169.94, 153.15, 145.00, 142.60, 138.86, 132.00, 130.50, 127.25, 123.55, 119.71, 98.75, 71.22, 44.66, 32.63, 25.01, 22.28, 21.71, 18.59.

IR (neat): νmax= 3389, 2958, 2926, 2854, 2245, 1774, 1697, 1458, 1382, 1262, 1089, 972, 924, 899, 737 cm^{-1}

HRMS ESI Calcd for $C_{22}H_{20}N_2O_6SNa$ $[M+Na]^+$: 463.0934, Found: 463.0931.

MS (EI) m/z (%): 440 (50), 317 (23), 285 (52), 239 (97), 232 (42), 155 (20), 133(22), 91(4).

2.13. Synthesis of compound 20



2 **20**

Compound 20: Compound **2** (18 mg) in MeOH was added into a dry high pressure seal tube, and then 4 mol/L HCl in MeOH (3 mL) was added into the solution. The resulting solution was heated to 160 °C and stirred for 24 hours. After the reaction was cooled down to room temperature (20 °C), the reaction was quenched with saturated $NaHCO_3$. The reaction was extracted with EtOAc (3 × 10 mL), and the combined organic layer was washed with brine, dried over Na_2SO_4. After concentrated under vacuum,

the crude product was purified by preparative liquid chromatograph to give the product **20** (5.6 mg, 30%) as a white solid. m.p. = 182.3 °C-183.0 °C.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.4 Hz, 2H), 7.57 (d, *J* = 5.4 Hz, 1H), 7.33 (d, *J* = 8.4 Hz, 2H), 6.17 (d, *J* = 5.4 Hz, 1H), 5.81 (brs, 1H), 4.06 (dd, *J* = 8.4, 1H), 3.80 (s, 3H), 3.78-3.77 (m, 1H), 3.35-3.34 (m, 1H), 3.21 (brs, 1H), 2.77-2.75 (m, 1H), 2.45 (s, 3H), 2.34-2.33 (m, 1H), 2.01 (brs, 1H), 2.00-1.92 (m, 1H), 1.72-1.59 (m, 2H).

^{13}C NMR (150 MHz, $CDCl_3$) δ 190.14, 172.59, 170.46, 154.47, 144.02, 142.02, 138.81, 130.69, 129.85, 127.03, 121.88, 99.18, 71.21, 53.34, 53.16, 44.31, 39.89, 31.12, 22.09, 21.56, 18.22.

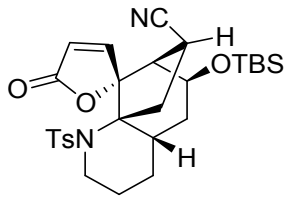
IR (neat): νmax= 3402, 2956, 2367, 1774, 1736, 1690, 1589, 1381, 1181, 1092, 1000, 736 cm^{-1}

HRMS ESI Calcd for $C_{23}H_{23}NO_8SNa$ $[M+Na]^+$: 496.1037, Found: 496.1035.

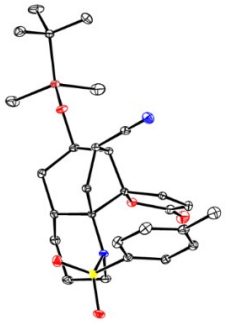
MS (EI) m/z (%): 473 (49), 318 (33), 290 (30), 262 (63), 230 (55), 202 (42), 155 (52), 148 (30), 133 (14), 91 (5).

3.X-ray Crystallographic Data

X-Ray data for 12: (CCDC 2043936)



12



Crystal data and structure refinement for guox_0106.

Identification code	guox_0106
Empirical formula	$C_{28}H_{38}N_2O_5SSi$
Formula weight	542.75
Temperature/K	293.23(10)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	15.0653(3)
b/Å	14.8904(2)
c/Å	14.5281(3)
α/°	90
β/°	118.494(3)
γ/°	90

Volume/Å^3	2864.30(12)
Z	4
ρ_{calc}g/cm^3	1.259
μ/mm^{-1}	1.724
F(000)	1160.0
Crystal size/mm^3	0.18 × 0.15 × 0.12
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	8.938 to 133.196
Index ranges	-17 ≤ h ≤ 17, -13 ≤ k ≤ 17, -16 ≤ l ≤ 17
Reflections collected	11338
Independent reflections	5041 [R_{int} = 0.0232, R_{sigma} = 0.0264]
Data/restraints/parameters	5041/0/340
Goodness-of-fit on F^2	1.047
Final R indexes [I>=2σ (I)]	R_1 = 0.0402, wR_2 = 0.1047
Final R indexes [all data]	R_1 = 0.0445, wR_2 = 0.1086
Largest diff. peak/hole / e Å^{-3}	0.21/-0.46

4. References and notes:

[1] *J. Org. Chem*. **2004**, *69*, 5676-5683

5. Copies of the spectrum of corresponding compounds