

1 **Identification of Phenanthroindolizines and Phenanthroquinolizidines as Novel Potent**
2 **Anti-Coronaviral Agents for Porcine Enteropathogenic Coronavirus Transmissible**
3 **Gastroenteritis Virus and Human Severe Acute Respiratory Syndrome Coronavirus**

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14 **Supplementary data**

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16 **(I) Physical properties of synthesized tylophorine compounds**

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18 **Tylophorine (1a)&(1a')**

19 White crystals; mp 240-241 °C(**1a**), mp 254-255 °C(decompose) (**1a'**); $[\alpha]_D^{25} = \pm 0$ (c 0.205,

20 CHCl₃) (**1a**), $[\alpha]_D^{25} = -16.1$ (c 0.1, CHCl₃) (**1a'**); IR (KBr) cm⁻¹: 1616, 1512 and 1468

21 (aromatic C=C); CI MS *m/z* 394 (M + H)⁺; ¹H-NMR (400 MHz, CDCl₃): 1.78 (1H, m),
22 1.93 (1H, m), 2.04 (1H, m), 2.24 (1H, m), 2.47 (1H, d, *J*=9.0 Hz), 2.50 (1H, m), 2.92 (1H,
23 dd, *J*=15.6 Hz, *J*=10.8 Hz), 3.38 (1H, dd, *J*=15.6 Hz, *J*=2.4 Hz), 3.47 (1H, t, *J*=9.0 Hz),
24 3.67 (1H, d, *J*=14.6 Hz), 4.05 (6H, s), 4.12 (6H, s), 4.63 (1H, d, *J*=14.6 Hz), 7.16 (1H, s),
25 7.32 (1H, s), 7.82 (1H, s), 7.83 (1H, s).

26
27 **4-methoxytylophorine (2,3,4,6,7-Pentamethoxy-9,10,11,12,12a,13-hexahydro-9a-aza**
28 **-cyclopenta[*b*]triphenylene) (1b)**

29 Light yellow needles; mp 182-183 °C; IR (KBr) cm⁻¹: 1604, 1504 and 1466 (aromatic C=C);

30 EI-MS *m/z* (rel. int.): 423 [M]⁺ (28) and 354 (100); HR-EI-MS *m/z*: 423.2055 (calcd for

31 C₂₅H₂₉NO₅, 423.2046). ¹H NMR(600 MHz, CDCl₃): 1.77 (1 H, m), 1.93 (1 H, m), 2.04 (1
32 H, m), 2.25 (1 H, m), 2.47 (1 H, m), 2.90 (1 H, dd, *J*=15 Hz, *J*=10.8 Hz), 3.32 (1 H, d, *J*
33 =15 Hz), 3.48 (1 H, t, *J*=8.4 Hz), 3.67 (1 H, d, *J*=14.7 Hz), 3.99 (3 H, s), 4.04 (3 H, s),
34 4.05 (3 H, s), 4.06 (3 H, s), 4.09 (3 H, s), 4.62 (1 H, d, *J*=14.7 Hz), 7.17 (1 H, s), 7.20 (1 H,
35 s), 9.20 (1 H, s); ¹³C-NMR (150 MHz, CDCl₃): 21.6, 31.2, 34.2, 54.2, 55.2, 55.7, 55.8, 60.2,
36 60.5, 61.3, 100.5, 102.5, 108.0, 117.9, 123.5, 124.9, 126.2, 127.6, 128.8, 142.0, 147.9,

1 151.6.

2

3 **7-methoxycryptopleurine (2,3,6,7-Tetramethoxy-10,11,12,13,13a,14-hexahydro-9H-9^a**
4 **-azabenzob[b]triphenylene)(1c)**

5 Yellow needles; mp 226-228 °C; IR (KBr) cm⁻¹: 1615, 1512 and 1470 (aromatic C=C); CI
6 MS *m/z* 408 (M + H)⁺; ¹H-NMR (400 MHz, CDCl₃): 1.50 (2H, m), 1.80 (2H, m), 1.89 (1H,
7 m), 2.06 (1H, m), 2.32 (1H, m), 2.39 (1H, m), 2.90 (1H, dd, *J*=16.4 Hz, *J*=11.0 Hz), 3.12
8 (1H, dd, *J*=16.4 Hz, *J*=3.0 Hz), 3.30 (1H, br d, *J*=11.0 Hz), 3.61 (1H, br d, *J*=15.4 Hz),
9 4.05 (3H, s), 4.06 (3H, s), 4.11 (6H, s), 4.37 (1H, br d, *J*=15.4 Hz), 7.13 (1H, s), 7.26 (1H,
10 s), 7.81 (1H, s), 7.82 (1H, s).

11

12 **Deoxypergularinine (1d)**

13 White needles ; mp 193-195 °C(decompose); IR (KBr) cm⁻¹: 1616, 1510 and 1469 (aromatic
14 C=C); EI-MS *m/z* (rel. int.): 363 [M]⁺ (25) and 264 (100); HR-EI-MS *m/z*: 363.1823 (calcd
15 for C₂₃H₂₅NO₃, 363.1834). ¹H NMR(600 MHz, CDCl₃): 1.77 (1 H, m), 1.92 (1 H, m), 2.03
16 (1 H, m), 2.24 (1 H, m), 2.46 (1 H, m), 2.47 (1 H, d, *J*=8.4 Hz), 2.94 (1 H, dd, *J*=15.6 Hz,
17 *J*=10.8 Hz), 3.43 (1 H, dd, *J*=15.6 Hz, *J*=1.8 Hz) 3.47(1 H, t, *J*=8.4 Hz), 3.65 (1 H, d, *J*
18 =14.4 Hz), 4.02 (3 H, s), 4.06 (3 H, s), 4.10 (3 H, s), 4.64 (1 H, d, *J*=14.4 Hz), 7.16 (1 H, s),
19 7.22 (1 H, dd, *J*=9.6 Hz, *J*=3.0 Hz), 7.89 (1 H, d, *J*=3.0 Hz), 7.92 (1 H, s), 7.95 (1 H, d, *J*
20 =9.6 Hz). ¹³C-NMR (150 MHz, CDCl₃): 21.6, 30.9, 31.2, 33.6, 54.0, 55.1, 55.5, 55.9, 56.0,
21 60.2, 103.1, 103.9, 104.5, 114.7, 123.3, 125.0, 125.1, 125.3, 125.5, 125.6, 130.3, 148.2,
22 149.4, 157.5.

23

24 **2,3,4,6,7-Pentamethoxy-10,11,12,13,13a,14-hexahydro-9H-9^a-aza-benzob[b]triphenylen**
25 **e (1i)**

26 White needles; mp 147-148 °C; IR (KBr) cm⁻¹: 1604, 1505 and 1466 (aromatic C=C);
27 EI-MS *m/z* (rel. int.): 437 [M]⁺ (28) and 354 (100); HR-EI-MS *m/z*: 437.2206 (calcd for
28 C₂₆H₃₁NO₅, 437.2202). ¹H NMR(600 MHz, CDCl₃): 1.44 (1 H, m), 1.54 (1 H, m), 1.80 (2
29 H, m), 1.89 (1 H, d, *J*=12.6 Hz), 2.04 (1 H, d, *J*=12.0 Hz), 2.31 (1 H, td, *J*=11.4 Hz, *J*
30 =3.0 Hz), 2.39 (1 H, br t), 2.89 (1 H, dd, *J*=16.2 Hz, *J*=10.8 Hz), 3.08 (1 H, dd, *J*=16.2
31 Hz, *J*=3.0 Hz), 3.30 (1 H, d, *J*=11.4 Hz), 3.62 (1 H, d, *J*=15.6 Hz), 3.98 (3 H, s), 4.03 (3
32 H, s), 4.04 (3 H, s), 4.05 (3 H, s), 4.08 (3 H, s), 4.37 (1 H, d, *J*=15.0 Hz), 7.14 (2 H, s),
33 9.20 (1 H, s). ¹³C-NMR (150 MHz, CDCl₃): 24.3, 25.9, 33.7, 35.2, 55.7, 55.8, 55.9, 56.3,
34 56.4, 57.5, 60.5, 61.3, 100.4, 102.4, 108.1, 117.8, 123.4, 124.5, 125.1, 126.6, 128.2, 142.0,
35 147.8, 147.9, 151.6.

36

1 **Boehmeriasin A (1j)**

2 White needles; mp 203-204°C; IR (KBr) cm^{-1} : 1612, 1511 and 1468 (aromatic C=C);

3 EI-MS m/z (rel. int.): 377 [M]⁺ (28) and 294 (100); HR-EI-MS m/z : 377.1987 (calcd for

4 $\text{C}_{24}\text{H}_{27}\text{NO}_3$, 377.1991). ¹H NMR(600 MHz, CDCl_3): 1.45 (1 H, m), 1.53 (1 H, m), 1.79 (2H,
5 m), 1.88 (1 H, d, $J=12.0$ Hz), 2.03(1 H, d, $J=12.0$ Hz), 2.32 (1 H, td, $J=11.4$ Hz, $J=3.0$
6 Hz), 2.39 (1 H, br t), 2.94 (1 H, dd, $J=16.2$ Hz, $J=10.2$ Hz), 3.19 (1 H, dd, $J=16.2$ Hz, J
7 =3.0 Hz), 3.29 (1 H, d, $J=10.8$ Hz), 3.60 (1 H, d, $J=15.0$ Hz), 4.01 (3 H, s), 4.05 (3 H, s),
8 4.10 (3 H, s), 4.35 (1 H, d, $J=15.0$ Hz), 7.14 (1 H, s), 7.21 (1 H, dd, $J=9.9$ Hz, $J=2.4$ Hz),
9 7.89 (1 H, d, $J=2.4$ Hz), 7.91 (1 H, d, $J=9.9$ Hz), 7.92 (1 H, s). ¹³C-NMR (150 MHz,
10 CDCl_3): 24.3, 25.9, 33.7, 34.7, 55.5, 55.9, 56.0, 56.1, 56.3, 57.5, 103.0, 104.0, 104.6, 114.7,
11 123.2, 124.2, 124.9, 125.0, 125.2, 125.9, 130.2, 148.1, 149.4, 157.5.

12

13 **Tylophorin-9-one (2a)**

14 CI MS m/z 408 (M + H)⁺; ¹H NMR(300 MHz, CDCl_3): 1.94 (2H, m), 2.16 (1H, m), 2.44
15 (1H, m), 2.93 (1 H, dd, $J=15.6$ Hz, $J=13.2$ Hz), 3.58 (1H, dd, $J=15.6$ Hz, $J=4.2$ Hz), 3.87
16 (3H, m), 4.05 (3H, s), 4.08 (3H, s), 4.11 (3H, s), 4.14 (3H, s), 7.32 (1H, s), 7.77 (1H, s),
17 7.80 (1H, s), 9.02 (1H, s).

18

19 **2,3,4,6,7-Pentamethoxy-9,10,11,12,12a,13-hexahydro-9a-aza-cyclopenta[b]triphenylen**
20 **-9-one (2b)**

21 CI MS m/z 438 (M + H)⁺; ¹H NMR(400 MHz, CDCl_3): 1.95 (2 H, m), 2.17 (1 H, m), 2.45
22 (1 H, m), 2.94 (1 H, dd, $J=15.6$ Hz, $J=13.2$ Hz), 3.56 (1 H, dd, $J=15.6$ Hz, $J=4.0$ Hz),
23 3.87 (3 H, m), 3.93 (3 H, s), 4.04 (3 H, s), 4.08 (9 H, s), 7.24 (1 H, s), 8.91 (1 H, s), 9.13 (1
24 H, s).

25

26 **2,3,6,7 -Tetramethoxy-**

27 **10,11,12,13,13a,14-hexahydro-9a-azabenzob[b]triphenylen-9-one (2c)**

28 CI MS m/z 422 (M + H)⁺; ¹H NMR(300 MHz, CDCl_3): 1.61 (3H,m), 1.93 (2H, m), 2.02
29 (1H, m), 2.90 (1H, td, $J=13.7$ Hz, $J=2.4$ Hz), 3.04 (1H, dd, J 16.2 and 11.1), 3.46 (1H, dd,
30 J 16.2 and 4.8), 3.61 (1H, m), 4.07 (3H, s), 4.10 (3H, s), 4.12 (3H, s), 4.14 (3H, s), 4.72
31 (1H, brd, $J=13.7$ Hz), 7.34 (1H, s), 7.78 (1H, s), 7.82 (1H, s), 9.38 (1H, s).

32

33 **3,6,7-Trimethoxy-11,12,12a,13-tetrahydro-10H-9a-aza-cyclopenta[b]triphenylen-9-one**
34 **(2d)**

35 CI MS m/z 378 (M + H)⁺; ¹H NMR(400 MHz, CDCl_3): 1.92 (2 H, m), 2.16 (1 H, m), 2.43
36 (1 H, m), 2.95 (1 H, dd, $J=15.6$ Hz, $J=13.6$ Hz), 3.68 (1 H, dd, $J=15.6$ Hz, $J=4.0$ Hz),
37 3.79 (1 H, m), 3.90 (2 H, m), 4.05 (3 H, s), 4.09 (3 H, s), 4.11 (3 H, s), 7.24 (1 H, dd, $J=9.2$
38 Hz, $J=2.4$ Hz), 7.87 (1 H, s), 7.90 (1 H, d, $J=2.4$ Hz), 8.02 (1 H, d, $J=9.2$ Hz), 9.03 (1 H,
39 s).

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2 **Dehydro- tylophorine (3a)**

3 ESI MS m/z 390 (M)⁺; IR (KBr) cm^{-1} :1707、 1519 and 1433 (aromatic C=C); ¹H NMR(400

4 MHz, DMSO- d_6): 2.55 (2H, m), 3.55 (2H, t, $J=7.6$ Hz), 4.06 (6H, s), 4.07 (3H, s), 4.09
5 (3H, s), 4.98 (2H, t, $J=7.6$ Hz), 7.81 (1H, s), 7.82 (1H, s), 8.13(1H, s), 8.18 (1H, s), 9.24
6 (1H, s), 10.65 (1H, s).

7

8 **2,3,6,7-Tetramethoxy-10,11,12,13-tetrahydro-9a-azoniabenzob[*b*]triphenylene (3c)**

9 ESI MS m/z 404 (M)⁺; IR (KBr) cm^{-1} :1612、 1511 and 1467 (aromatic C=C); ¹H NMR(400

10 MHz, DMSO- d_6): 2.04 (2H, quintet, $J=6.8$ Hz), 2.19 (2H, quintet, $J=6.8$ Hz), 3.38 (2H, t,
11 $J=6.8$ Hz), 4.08 (6H, s), 4.10 (3H, s), 4.14 (3H, s), 4.82 (2H, t, $JJ=6.4$ Hz), 8.04 (2H, s),
12 8.25 (2H, m), 9.17 (1H, s), 10.26 (1H, s).

13

14 **Tylophorine *N*-Oxide (4a)**

15 White crystal; mp 230 °C(decompose); ESI MS m/z 410 (M + H)⁺; ¹H-NMR (300 MHz,

16 CDCl_3) : 2.19 (1H, m), 2.26 (2H, m), 2.49 (1H, m), 2.68 (1H, d, $J=7.2$ Hz), 3.13 (1H, m),
17 3.37 (1H, m), 3.62 (1H, dd, $J=10.8$ Hz, $J=8.7$ Hz), 3.94 (3H, s), 4.01 (3H, s), 4.06 (3H, s),
18 4.08 (3H, s), 4.21 (1H, d, $J=8.4$ Hz), 4.67 (1H, d, $J=15.0$ Hz), 5.43 (1H, d, $J=15.0$ Hz), 6.85
19 (1H, s), 7.15 (1H, s), 7.70 (1H, s), 7.72(1H, s).

20

21 **7-Methoxycryptopleurine *N*-Oxide (2,3,6,7-Tetramethoxy-9,10,11,12,13,14-hexahydro**
22 **-9aH-13a-aza-benzo[*b*]triphenylene *N*-oxide) (4b)**

23 White crystal; mp 209 °C(decompose); ESI MS m/z 424 (M + H)⁺; ¹H-NMR (300 MHz,

24 CDCl_3) : 1.46 (1H, br d, $J=12.6$ Hz), 1.69 (2H, m), 1.87(1H, br d, $J=13.2$ Hz), 2.11 (1H, m),
25 2.44 (1H, m), 2.78(1H, br d, $J=13.2$ Hz), 3.21 (2H, m), 3.36 (1H, t, $J=12.6$ Hz), 3.90 (3H,
26 s), 3.98 (3H, s), 4.04 (1H, m), 4.09 (3H, s), 4.11 (3H, s), 4.64 (1H, d, $J=15.0$ Hz), 4.98 (1H,
27 d, $J=15.0$ Hz), 6.79 (1H, s), 7.03 (1H, s), 7.67 (1H, s), 7.69(1H, s).

28

29

30 **(II) Physical properties of isolated tylophorine compounds**

31

32 **Tylophorine (1a')**-refer to **1a** described above.

33

34 **Tylophorinine (1e)**

35 White crystals; mp 228-229°C; $[\alpha]_D^{25} = -9.7$ (c 0.215, CHCl_3); IR (KBr) cm^{-1} :

1 3182(OH), 1617, 1512 and 1469 (aromatic C=C); ¹H NMR(600 MHz, CDCl₃): 1.91 (2 H,
2 m), 2.02 (1 H, m), 2.26 (1 H, m), 2.40 (2 H, m), 3.12 (1 H, t, *J*=14.2 Hz), 3.32 (1 H, t, *J*
3 =7.8 Hz), 3.55 (1 H, m), 3.85 (3 H, s), 4.05 (3 H, s), 4.10 (3 H, s), 4.96 (1 H, br), 6.32 (1
4 H, d, *J*=22.8 Hz), 7.26 (1 H, dd, *J*=9.0 Hz, *J*=2.4 Hz), 7.62 (1 H, d, *J*=10.2 Hz), 7.76 (1
5 H, d, *J*=2.4 Hz), 8.41 (1 H, dd, *J*=9.0 Hz, *J*=4.2 Hz). ¹³C-NMR (150 MHz, CDCl₃): 21.9,
6 23.9, 53.4, 55.4, 55.5, 55.6, 55.7, 64.5, 65.3, 102.8, 103.0, 104.2, 114.8, 123.7, 124.2, 125.3,
7 128.9, 130.6, 148.5, 148.7, 157.5.

8

9 **Acetyl-tylophorinine (1f)**

10 White crystals; mp 196-198°C; [α]_D²⁵ = - 11.8 (c 0.215, CHCl₃); IR (KBr) cm⁻¹:

11 1728(C=O), 1617, 1515 and 1471 (aromatic C=C); CI MS m/z 362 (M-CH₃COOH+ H)⁺ ;

12 ¹H NMR(400 MHz, CDCl₃): 1.67 (1 H, m), 2.02 (2 H, m), 2.06 (1 H, m), 2.15 (3 H, S), 2.46

13 (1 H, d, *J*=8.8 Hz), 2.72 (1 H, t), 3.53 (1 H, t), 3.64 (1 H, d, *J*=15.4 Hz), 4.01 (3 H, S), 4.06 (3 H, S),

14 4.12 (3 H, S), 4.78 (1 H, d, *J*=15.4 Hz), 6.71 (1 H, d, *J*=2.4 Hz), 7.22 (1 H, dd, *J*=8.8 Hz, *J*=2.4 Hz),

15 7.87 (1 H, d, *J*=9.2 Hz), 7.91 (1 H, d, *J*=2.8 Hz), 7.92 (1 H, S).