Supporting Information
for
Magnetic metal-organic framework as a highly active heterogeneous catalyst for one-pot synthesis of 2-substituted alkyl and aryl(indolyl)kojic acid derivatives

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2-((1H-Indol-3-yl)(phenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4a)

Brown solid; IR (KBr): 3387, 3269, 2924, 2850, 1655, 1621, 1456, 1228, 738 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.06\) (s, 1 H), 9.15 (s, 1 H), 7.23-7.37 (m, 8 H), 7.07 (t, \(J = 7.5\) Hz, 1 H), 6.93 (t, \(J = 7.5\) Hz, 1 H), 6.31 (s, 1 H), 5.98 (s, 1 H), 5.66 (s, 1 H), 4.25 (d, \(J = 5.0\) Hz, 2 H). \(^1^3\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.1, 167.6, 151.5, 141.4, 141.0, 136.6, 128.9, 128.7, 127.2, 126.2, 124.5, 121.7, 119.1, 118.9, 113.3, 112.1, 109.5, 60.0. ESI-MS: m/z = 348.3 (M+1)\(^+\).

2-((1H-Indol-3-yl)(2-methoxyphenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4b)

Brown solid; IR (KBr): 3436, 2919, 1658, 1624, 1460, 1252, 1094, 756 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 10.96\) (s, 1 H), 8.88 (s, 1 H), 7.35 (d, \(J = 8.0\) Hz, 1 H), 7.28 (t, \(J = 7.0\) Hz, 2 H), 7.23 (t, \(J = 7.5\) Hz, 1 H), 7.00-7.07 (m, 3 H), 6.92 (t, \(J = 7.5\) Hz, 1 H), 6.86 (t, \(J = 7.5\) Hz, 1 H), 6.34 (s, 1 H), 6.30 (s, 1 H), 5.63 (s, 1 H), 4.22 (s, 2 H), 3.79 (s, 3 H). \(^1^3\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.1, 167.5, 156.9, 151.5, 141.4, 136.7, 129.9, 128.7, 128.5, 126.9, 124.3, 121.6, 120.8, 119.1, 118.7, 113.9, 112.0, 111.5, 109.4, 60.1, 56.2, 33.3. ESI-MS: m/z = 378.3 (M+1)\(^+\).

2-((1H-Indol-3-yl)(3-methoxyphenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4c)

Brown solid; IR (KBr): 3409, 2926, 2838, 1618, 1453, 1239, 1047, 749 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.05\) (s, 1 H), 9.15 (s, 1 H), 7.36 (t, \(J = 8.5\) Hz, 1 H), 7.23 (d, \(J = 7.5\) Hz, 2 H), 7.07 (d, \(J = 7.5\) Hz, 2 H), 6.89-6.95 (m, 3 H), 6.81 (d, \(J = 8.5\) Hz, 1 H), 6.31 (s, 1 H), 5.94 (s, 1 H), 5.66 (s, 1 H), 4.25 (s, 2 H), 3.69 (s, 3 H). \(^1^3\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.1, 167.5, 159.7, 151.4, 142.5, 141.4, 136.6, 129.9, 126.9, 124.5, 121.7, 121.0, 119.2, 118.9, 114.7, 113.2, 112.3, 112.1, 109.5, 60.1, 55.4. ESI-MS: m/z = 378.3 (M+1)\(^+\).

2-((1H-Indol-3-yl)(4-methoxyphenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4d)

Brown solid; IR (KBr): 3409, 2926, 1611, 1460, 1245, 1178,
1027, 792 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.03\) (s, 1 H), 9.09 (s, 1 H), 7.36 (d, \(J = 8.5\) Hz, 1 H), 7.31 (d, \(J = 8.0\) Hz, 1 H), 7.27 (d, \(J = 8.5\) Hz, 2 H), 7.20 (s, 1 H), 7.06 (t, \(J = 7.5\) Hz, 1 H), 6.92 (t, \(J = 7.5\) Hz, 1 H), 6.86 (d, \(J = 8.0\) Hz, 2 H), 6.30 (s, 1 H), 5.91 (s, 1 H), 5.65 (s, 1 H), 4.24 (s, 2 H), 3.71 (s, 3 H). \(^{13}\)C NMR (125MHz, DMSO-\(d_6\)): \(\delta = 174.2, 167.6, 158.5, 151.8, 141.2, 136.7, 132.9, 129.7, 126.8, 124.3, 121.7, 119.1, 119.0, 114.3, 113.7, 112.0, 109.4, 60.0, 55.5, 21.2, 14.6. ESI-MS: m/z = 378.3 (M+1).  

2-((1H-Indol-3-yl)(p-tolyl)methyl)-3-hydroxy-6-(hydroxymethyl)-\(4H\)-pyran-4-one (4e)  
Brown solid; IR (KBr): 3400, 2924, 2856, 1650, 1620, 1456, 1227, 1076, 995, 738 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.04\) (s, 1 H), 9.11 (s, 1 H), 7.23-7.38 (m, 5 H), 7.05-7.11 (m, 3 H), 6.92 (t, \(J = 7.5\) Hz, 1 H), 6.31 (s, 1 H), 5.94 (s, 1 H), 5.66 (s, 1 H), 4.25 (s, 2 H), 2.25 (s, 3 H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.1, 167.6, 151.7, 141.3, 138.0, 136.7, 136.2, 129.5, 128.6, 126.9, 124.4, 121.7, 119.1, 119.0, 113.5, 112.0, 109.5, 60.1, 21.1. ESI-MS: m/z = 362.3 (M+1).  

3-Hydroxy-6-(hydroxymethyl)-2-((3-hydroxyphenyl)(1H-indol-3-yl)methyl)-\(4H\)-pyran-4-one (4f)  
Brown solid; IR (KBr): 3409, 2926, 2851, 1618, 1453, 1232, 1198, 736 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.05\) (s, 1 H), 9.12 (s, 1 H), 6.60-7.38 (m, 9 H), 6.31 (s, 1 H), 5.89 (s, 1 H), 5.66 (t, \(J = 6.0\)Hz, 1 H), 4.25 (d, \(J = 5.5\)Hz, 2 H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.2, 167.6, 157.8, 151.6, 142.4, 141.4, 136.6, 129.8, 126.9, 124.5, 121.7, 119.2, 119.1, 119.0, 115.5, 114.2, 113.1, 112.0, 109.4, 60.0. ESI-MS: m/z = 364.3 (M+1).  

2-((2-Fluorophenyl)(1H-indol-3-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-\(4H\)-pyran-4-one (4g)  
Brown solid; IR (KBr): 3395, 2926, 2858, 1645, 1611, 1466, 1212, 1087, 997, 742 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.09\) (s, 1 H), 9.16 (s, 1 H), 7.18-7.42 (m, 6 H), 7.13 (t, \(J = 7.5\) Hz, 1 H), 7.08 (t, \(J = 7.5\) Hz, 1 H), 6.95 (t, \(J = 7.5\) Hz, 1 H), 6.32 (s, 1 H), 6.24 (s, 1 H), 5.66 (t, \(J = 6.0\) Hz, 1 H), 4.24 (d, \(J = 5.5\) Hz, 2 H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.1, 167.7, 160.2\) (d, \(J_{\text{FC}} = 243.3\) Hz),
150.2, 141.5, 136.7, 130.9, 129.4 (d, $^3J_{FC} = 8.2\text{Hz}$), 127.5 (d, $^3J_{FC} = 13.8\text{Hz}$), 126.6, 124.9 (d, $^4J_{FC} = 2.8\text{Hz}$), 124.6, 121.8, 119.3, 118.4, 115.7 (d, $^2J_{FC} = 21.9\text{Hz}$), 112.3 (d, $^2J_{FC} = 26.6\text{Hz}$), 109.6, 60.0, 33.0. ESI-MS: m/z = 366.3 (M+1)$^+$. 

**2-((4-Chlorophenyl)(1H-indol-3-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4h)**

Brown solid; IR (KBr): 3409, 2926, 1617, 1460, 1225, 1094, 1018, 742 cm$^{-1}$. $^1$H NMR (500 MHz, DMSO-d$_6$): $\delta$ = 11.11 (s, 1 H), 9.23 (s, 1 H), 7.33-7.40 (m, 7 H), 7.27 (s, 1 H), 7.09 (t, $J = 7.5$ Hz, 1 H), 6.94 (t, $J = 7.5$ Hz, 1 H), 6.34 (s, 1 H), 6.00 (s, 1 H), 4.27 (s, 2 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.2, 167.8, 151.0, 141.5, 140.0, 136.7, 131.9, 131.6, 130.5, 129.2, 128.9, 126.7, 124.6, 121.8, 119.3, 119.0, 112.9, 112.1, 109.5, 60.0, 31.1. ESI-MS: m/z = 382.3 (M+1)$^+$. 

**2-((4-Bromophenyl)(1H-indol-3-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4i)**

Brown solid; IR (KBr): 3415, 2975, 2926, 1624, 1460, 1232, 1198, 1067, 1004, 749 cm$^{-1}$. $^1$H NMR (500 MHz, DMSO-d$_6$): $\delta$ = 11.11 (s, 1 H), 9.24 (s, 1 H), 7.50 (d, $J = 8.5$ Hz, 2 H), 7.40 (d, $J = 8.5$ Hz, 1 H), 7.31-7.35 (m, 3 H), 7.28 (s, 1 H), 7.08 (t, $J = 7.5$ Hz, 1 H), 6.95 (t, $J = 7.5$ Hz, 1 H), 6.35 (s, 1 H), 5.99 (s, 1 H), 4.27 (s, 2 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.2, 167.7, 150.9, 141.5, 140.4, 136.7, 131.8, 130.9, 126.7, 124.6, 121.8, 120.4, 119.3, 118.9, 112.8, 112.1, 109.5, 60.1. ESI-MS: m/z = 426.2 (M+1)$^+$. 

**2-((1H-Indol-3-yl)(2-nitrophenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4j)**

Brown solid; IR (KBr): 3415, 2975, 2926, 1667, 1617, 1527, 1356, 1225, 1087, 741 cm$^{-1}$. $^1$H NMR (500 MHz, DMSO-d$_6$): $\delta$ = 11.13 (s, 1 H), 9.21 (s, 1 H), 7.90 (d, $J = 7.5$ Hz, 1 H), 6.94-7.64 (m, 8 H), 6.47 (s, 1 H), 6.32 (s, 1 H), 5.63 (s, 1 H), 4.19 (s, 2 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.2, 167.7, 149.8, 149.1, 142.1, 136.7, 133.7, 133.3, 131.4, 128.9, 126.6, 125.1, 124.6, 121.9, 119.5, 118.4, 112.2, 109.6, 59.9, 35.8, 31.2. ESI-MS: m/z = 393.3 (M+1)$^+$. 

**2-((1H-Indol-3-yl)(3-nitrophenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4k)**

Brown solid; IR (KBr): 3415, 2975, 2926, 1667, 1617, 1527, 1356, 1225, 1087, 741 cm$^{-1}$. $^1$H NMR (500 MHz, DMSO-d$_6$): $\delta$ = 11.13 (s, 1 H), 9.21 (s, 1 H), 7.90 (d, $J = 7.5$ Hz, 1 H), 6.94-7.64 (m, 8 H), 6.47 (s, 1 H), 6.32 (s, 1 H), 5.63 (s, 1 H), 4.19 (s, 2 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.2, 167.7, 149.8, 149.1, 142.1, 136.7, 133.7, 133.3, 131.4, 128.9, 126.6, 125.1, 124.6, 121.9, 119.5, 118.4, 112.2, 109.6, 59.9, 35.8, 31.2. ESI-MS: m/z = 393.3 (M+1)$^+$. 

S4
2-((1H-Indol-3-yl)(4-nitrophenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4l)

Brown solid; IR (KBr): 3409, 2970, 2920, 1643, 1498, 1406, 1225, 749 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-d\(_6\)): \(\delta = 11.20\) (s, 1 H), 9.37 (s, 1 H), 6.94-8.18 (m, 9 H), 6.37 (s, 1 H), 6.19 (s, 1 H), 5.71 (s, 1 H), 4.28 (s, 2 H). \(^1\)C NMR (125 MHz, DMSO-d\(_6\)): \(\delta = 174.2, 167.8, 150.3, 148.4, 143.2, 141.8, 136.8, 135.4, 130.5, 126.6, 124.9, 123.2, 122.4, 122.0, 119.4, 118.9, 112.3, 112.2, 109.6, 60.0, 31.2. ESI-MS: m/z = 393.3 (M+1)+.

4-((3-Hydroxy-6-(hydroxymethyl)-4-oxo-4H-pyran-2-yl)(1H-indol-3-yl)methyl)benzonitrile (4m)

Brown solid; IR (KBr): 3366, 3251, 2926, 2858, 1645, 1611, 1460, 1205, 749 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-d\(_6\)): \(\delta = 11.06\) (s, 1 H), 9.29 (s, 1 H), 7.77 (d, \(J = 8.0\) Hz, 2 H), 7.52 (d, \(J = 8.0\) Hz, 2 H), 7.37 (d, \(J = 8.0\) Hz, 1 H), 7.32 (d, \(J = 8.0\) Hz, 1 H), 7.28 (s, 1 H), 7.08 (s, 2 H), 6.93 (t, \(J = 7.5\) Hz, 1 H), 6.32 (s, 1 H), 6.06 (s, 1 H), 5.65 (s, 1 H), 4.24 (s, 2 H). \(^1\)C NMR (125 MHz, DMSO-d\(_6\)): \(\delta = 174.1, 167.8, 150.2, 146.7, 141.8, 136.7, 132.9, 129.7, 126.6, 124.8, 121.9, 119.4, 119.3, 118.9, 112.3, 112.2, 110.1, 109.6, 60.0, 6.99. ESI-MS: m/z = 373.3 (M+1)+.
11.10 (s, 1 H), 9.38 (s, 1 H), 6.69-8.29 (m, 13 H), 6.30 (s, 1 H), 5.60 (s, 1 H), 4.12-4.22 (m, 2 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.1, 167.7, 151.3, 141.2, 136.8, 136.4, 133.9, 131.6, 129.3, 128.0, 127.0, 126.9, 126.8, 126.2, 126.0, 125.1, 123.4, 121.8, 119.3, 118.6, 113.3, 112.2, 109.6, 60.0, 36.6. ESI-MS: m/z = 398.3 (M+1)$^+$. 

2-((1H-Indol-3-yl)(4-methylcyclopenta-1,3-dien-1-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4o) 

Brown solid; IR (KBr): 3409, 2919, 1624, 1453, 1260, 1186, 1134, 1094, 1061, 742 cm$^{-1}$. $^1$H NMR (500 MHz, DMSO-d$_6$): $\delta$ = 11.08 (s, 1 H), 9.23 (s, 1 H), 6.99-7.52 (m, 5 H), 6.31 (s, 1 H), 6.11 (s, 1 H), 6.00 (s, 1 H), 5.95 (s, 1 H), 5.66 (s, 1 H), 4.22-4.30 (m, 2 H), 2.21 (s, 3 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.2, 167.5, 151.4, 149.6, 141.4, 136.6, 126.6, 124.5, 121.7, 119.2, 118.9, 112.1, 111.4, 109.5, 108.5, 107.0, 60.0, 34.7, 13.8. ESI-MS: m/z = 352.3 (M+1)$^+$. 

2-((1H-Indol-3-yl(thiophen-2-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4p) 

Brown solid; IR (KBr): 3389, 2990, 1630, 1466, 1224, 860, 753 cm$^{-1}$. $^1$H NMR (500 MHz, DMSO-d$_6$): $\delta$ = 11.09 (s, 1 H), 9.29 (s, 1 H), 7.47 (d, $J$ = 8.0 Hz, 1 H), 7.37-7.40 (m, 2 H), 7.29 (s, 1 H), 6.96-7.10 (m, 4 H), 6.32 (s, 1 H), 6.23 (s, 1 H), 5.67 (s, 1 H), 4.28 (s, 2 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.2, 167.7, 150.5, 143.8, 140.9, 136.6, 127.2, 126.5, 126.2, 125.5, 124.4, 121.8, 119.3, 118.9, 113.6, 112.1, 109.5, 60.0, 35.7. ESI-MS: m/z = 354.3 (M+1)$^+$. 

2-((1H-Indol-3-yl)(1H-indol-5-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one(4q) 

Brown solid; IR (KBr): 3409, 2926, 2851, 1624, 1453, 1262, 1205, 749 cm$^{-1}$. $^1$H NMR (500 MHz, DMSO-d$_6$): $\delta$ = 10.97 (s, 2 H), 9.12 (s, 1 H), 7.51 (d, $J$ = 8.0 Hz, 2 H), 7.36 (d, $J$ = 8.0 Hz, 2 H), 7.23 (s, 2 H), 7.06 (t, $J$ = 7.5 Hz, 2 H), 6.95 (t, $J$ = 7.5 Hz, 2 H), 6.29 (s, 1 H), 6.22 (s, 1 H), 5.65 (s, 1 H), 4.25 (s, 2 H). $^{13}$C NMR (125 MHz, DMSO-d$_6$): $\delta$ = 174.2, 167.5, 152.3, 140.6, 136.7, 126.9, 124.3, 121.6, 119.0, 113.9, 112.0, 109.4, 60.2, 60.1, 32.0. ESI-MS: m/z = 387.3 (M+1)$^+$. 

S6
2-(Cyclohexyl(1H-indol-3-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4r)

Brown solid; IR (KBr): 3429, 2924, 1624, 1453, 1258, 1087, 1024, 809, 746 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 10.96\) (s, 1 H), 8.73 (s, 1 H), 7.62 (d, \(J = 7.5\) Hz, 1 H), 7.32 (d, \(J = 8.0\) Hz, 1 H), 7.29 (s, 1 H), 7.05 (t, \(J = 7.5\) Hz, 1 H), 6.97 (t, \(J = 7.5\) Hz, 1 H), 6.22 (s, 1 H), 4.25-4.36 (m, 4 H), 2.17-2.21 (m, 1H), 1.58-1.81 (m, 10H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 177.1, 173.8, 167.3, 152.6, 141.6, 136.4, 127.5, 123.7, 121.4, 119.2, 119.0, 113.1, 111.9, 109.1, 60.1, 31.6, 31.5, 29.1, 26.5, 26.0, 25.4. ESI-MS: m/z = 354.4 (M+1)\(^+\).

2-(3-(4-(tert-Butyl)phenyl)-1-(1H-indol-3-yl)-2-methylpropyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4s)

Brown solid; IR (KBr): 3366, 2230, 1718, 1687, 1598, 1541, 1441, 710 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 10.99\) (s, 1 H), 8.82 (s, 1 H), 6.67 (d, \(J = 8.0\) Hz, 1 H), 7.31-7.34 (m, 2 H), 7.26 (d, \(J = 8.5\) Hz, 2 H), 7.04-7.09 (m, 3H), 6.99 (t, \(J = 7.5\) Hz, 1 H), 6.21 (s, 1 H), 5.69 (s, 1 H), 4.32-4.37 (m, 3 H), 2.67 (d, \(J = 10.5\) Hz, 2 H), 2.27-2.32(m, 1H), 1.24 (s, 9H), 0.71 (d, \(J = 6.0\) Hz, 3 H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 173.9, 167.1, 152.5, 148.4, 141.6, 138.1, 136.4, 129.1, 129.0, 127.3, 125.3, 123.8, 121.5, 119.3, 119.0, 113.5, 112.0, 109.2, 60.2, 41.5, 41.1, 37.7, 34.5, 31.7, 18.4. ESI-MS: m/z = 446.4 (M+1)\(^+\).

3-Hydroxy-6-(hydroxymethyl)-2-((4-methoxy-1H-indol-3-yl)(phenyl)methyl)-4H-pyran-4-one(4t)

Brown solid; IR (KBr): 3409, 2925, 2850, 1710, 1618, 1460, 1203, 740 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.00\) (s, 1 H), 8.89 (s, 1 H), 6.93-7.30 (m, 8 H), 6.41 (t, \(J = 8.0\) Hz, 2 H), 6.30 (s, 1 H), 5.68 (s, 1H), 4.23-4.32 (m, 2 H), 3.69 (s, 3 H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.2, 167.3, 154.5, 152.5, 142.5, 141.1, 137.9, 128.8, 128.6, 126.8, 123.0, 122.6, 116.9, 113.7, 109.5, 105.4, 99.7, 60.1, 55.4, 21.2, 14.6. ESI-MS: m/z = 378.3 (M+1)\(^+\).

3-Hydroxy-6-(hydroxymethyl)-2-((4-methyl-1H-indol-3-yl)(phenyl)methyl)-4H-pyran-4-one(4u)

Brown solid; IR (KBr): 3409, 2926, 1735, 1645, 1618, 1460,
1198, 736 cm⁻¹. ¹H NMR (500 MHz, DMSO-d₆): δ = 11.08 (s, 1 H), 9.12 (s, 1 H), 7.17-7.32 (m, 8 H), 6.94 (t, J = 7.5 Hz, 1 H), 6.67 (d, J = 7.0 Hz, 1 H), 6.32 (d, J = 7.5 Hz, 2 H), 4.17-4.28 (m, 2 H), 2.44 (s, 3 H). ¹³C NMR (125 MHz, DMSO-d₆): δ = 174.2, 167.5, 152.4, 142.3, 141.0, 136.9, 129.5, 128.9, 128.7, 127.1, 125.5, 125.0, 121.7, 121.1, 113.6, 110.2, 109.6, 60.1, 20.4. ESI-MS: m/z = 362.3 (M+1)⁺.

2-((6-Fluoro-1H-indol-3-yl)(phenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4v)

Brown solid; IR (KBr): 3348, 2926, 2851, 1631, 1453, 1198, 1142, 1101, 799, 709 cm⁻¹. ¹H NMR (500 MHz, DMSO-d₆): δ = 11.13 (s, 1 H), 9.18 (s, 1 H), 7.13-7.36 (m, 8 H), 6.80 (t, J = 8.5 Hz, 1 H), 6.31 (s, 1 H), 5.96 (s, 1 H), 5.66 (s, 1H), 4.24 (s, 2 H).

¹³C NMR (125 MHz, DMSO-d₆): δ = 174.1, 167.7, 159.3 (d, ¹J_FC = 233.1 Hz), 151.2, 141.5, 140.8, 136.5 (d, ²J_FC = 12.6Hz), 128.9, 128.6, 127.3, 125.2, 123.7, 120.0 (d, ²J_FC = 10.3Hz) 113.6, 109.5, 107.8, 107.6, 98.1, 97.9, 60.0. ESI-MS: m/z = 366.3 (M+1)⁺.

2-((5-Chloro-1H-indol-3-yl)(phenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4w)

Brown solid; IR (KBr): 3409, 2919, 2851, 1708, 1624, 1453, 1205, 1087, 695 cm⁻¹. ¹H NMR (500 MHz, DMSO-d₆): δ = 11.28 (s, 1 H), 9.20 (s, 1 H), 7.06-7.40 (m, 9 H), 6.31 (s, 1 H), 5.95 (s, 1 H), 5.66 (t, J = 6.5 Hz, 1 H), 4.25 (d, J = 5.5Hz, 2 H).

¹³C NMR (125 MHz, DMSO-d₆): δ = 174.1, 167.7, 151.1, 141.5, 140.6, 135.2, 133.3, 129.7, 129.0, 128.6, 127.9, 127.3, 126.4, 123.8, 121.7, 118.2, 113.7, 113.3, 109.5, 60.0. ESI-MS: m/z = 382.3 (M+1)⁺.

2-((6-Chloro-1H-indol-3-yl)(phenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4x)

Brown solid; IR (KBr): 3422, 2919, 2845, 1618, 1460, 1205, 698 cm⁻¹. ¹H NMR (500 MHz, DMSO-d₆): δ = 11.21 (s, 1 H), 9.19 (s, 1 H), 7.24-7.41 (m, 8 H), 6.95 (d, J = 8.0Hz, 1 H), 6.31 (s, 1 H), 5.96 (s, 1 H), 5.66 (s, 1H), 4.24 (s, 2 H). ¹³C NMR (125 MHz, DMSO-d₆): δ = 174.1, 167.7, 151.1, 141.5, 140.7, 137.1, 129.0, 128.6, 127.3, 126.5, 125.7, 125.6, 120.4, 119.5, 113.7, 111.7, 109.5, 60.0. ESI-MS: m/z = 382.3 (M+1)⁺.
2-((5-Bromo-1H-indol-3-yl)(phenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4y)

Brown solid; IR (KBr): 3422, 2919, 2845, 1618, 1460, 1198, 1081, 695 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-d\(_6\)): \(\delta = 11.30\) (s, 1 H), 9.20 (s, 1 H), 7.47 (s, 1 H), 7.30-7.36 (m, 6 H), 7.25 (t, \(J = 7.0\)Hz, 1 H), 7.18 (d, \(J = 8.5\)Hz, 1 H), 6.31 (s, 1 H), 5.95 (s, 1 H), 5.66 (s, 1 H), 4.25 (s, 2 H). \(^1^3\)C NMR (125 MHz, DMSO-d\(_6\)): \(\delta = 174.1, 167.7, 151.1, 141.5, 140.6, 135.4, 133.3, 129.7, 129.0, 128.6, 127.3, 126.3, 124.2, 121.2, 114.2, 113.1, 111.8, 109.5, 60.0. ESI-MS: \(m/z = 427.3\) (M\(^{+}\))

2-((6-Bromo-1H-indol-3-yl)(phenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4z)

Brown solid; IR (KBr): 3415, 2926, 2858, 1618, 1453, 1198, 702 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-d\(_6\)): \(\delta = 11.22\) (s, 1 H), 9.20 (s, 1 H), 7.56 (s, 1 H), 7.23-7.35 (m, 8 H), 7.06-7.08 (m, 1 H), 6.32 (s, 1 H), 5.96 (s, 1 H), 4.24 (s, 2 H). \(^1^3\)C NMR (125 MHz, DMSO-d\(_6\)): \(\delta = 174.1, 167.7, 151.1, 141.5, 140.7, 137.6, 129.7, 129.0, 128.6, 127.3, 125.9, 125.7, 122.1, 120.8, 114.6, 114.5, 113.7, 109.5, 60.0. ESI-MS: \(m/z = 427.3\) (M\(^{+}\))

2-((5-Bromo-1H-indol-3-yl)(4-methoxyphenyl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one (4aa)

Brown solid; IR (KBr): 3422, 2919, 2845, 1618, 1460, 1198, 1081, 695 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-d\(_6\)): \(\delta = 11.28\) (s, 1 H), 9.15 (s, 1 H), 7.46 (s, 1 H), 7.23-7.35 (m, 8 H), 7.06-7.08 (m, 1 H), 6.32 (s, 1 H), 5.96 (s, 1 H), 4.24 (s, 2 H). \(^1^3\)C NMR (125 MHz, DMSO-d\(_6\)): \(\delta = 174.1, 167.7, 151.4, 141.2, 135.4, 132.5, 129.7, 128.6, 126.1, 124.2, 121.2, 114.3, 114.1, 113.5, 111.7, 109.4, 60.2, 60.0, 55.5. ESI-MS: \(m/z = 456.3\) (M\(^{+}\))

3-Hydroxy-6-(hydroxymethyl)-2-((1-methyl-1H-indol-3-yl)(phenyl)methyl)-4H-pyran-4-one (4ab)

Brown solid; IR (KBr): 3422, 2919, 2854, 1622, 1573, 1452, 1202, 867, 732 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-d\(_6\)): \(\delta = 9.14\) (s, 1 H), 7.41 (d, \(J = 8.5\)Hz, 1 H), 7.29-7.37 (m, 5 H), 7.24 (t, \(J = 7.5\)Hz, 2 H),
7.14 (t, J = 7.5 Hz, 1 H), 6.97 (t, J = 7.5 Hz, 1 H), 6.31 (s, 1 H), 5.97 (s, 1 H), 5.64 (s, 1 H),
4.26 (s, 2 H), 3.76 (s, 3 H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.1, 167.8, 151.2, 141.4,
140.8, 137.1, 128.9, 128.8, 128.7, 127.3, 127.2, 121.8, 119.3, 119.1, 112.6, 110.3, 109.4, 60.0,
32.9. ESI-MS: m/z = 362.3 (M+1)+.

4-((3-Hydroxy-6-(hydroxymethyl)-4-oxo-4\(^H\)-pyran-2-yl)(1\(^H\)-indol-3-yl)methyl)benzaldehyde (4ac)

Red solid; IR (KBr): 3417, 2930, 1712, 1630, 1459, 1258, 1254, 1218, 1193, 1109, 753 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.18\) (s, 1 H), 9.96 (s, 1 H), 7.85 (d, J = 7.5 Hz, 1 H), 7.56 (d, J = 8.0
Hz, 1 H), 7.38 (d, J = 8.0 Hz, 1 H), 7.32 (d, J = 8.0 Hz, 1 H), 7.29 (s, 1 H), 7.07 (t, J = 7.5 Hz, 1 H), 6.93 (t, J = 7.5 Hz, 1 H), 6.32 (s 1 H), 6.09 (s, 1 H), 4.25(s, 2H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 193.1, 174.2, 172.7,
167.8, 150.6, 147.9, 141.9, 141.8, 136.7, 135.4, 130.2, 129.4, 126.7, 124.7, 121.8, 119.3,
118.9, 112.5, 112.2, 109.6, 60.3, 60.0, 29.5. ESI-MS: m/z = 376.4 (M+1)+.

2-((4-(Di(1\(^H\)-indol-3-yl)methyl)phenyl)(1\(^H\)-indol-3-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4\(^H\)-pyran-4-one (5)

Red solid; IR (KBr): 3423, 2924, 1718, 1624, 1453, 746 cm\(^{-1}\). \(^1\)H NMR (500 MHz, DMSO-\(d_6\)): \(\delta = 11.01\) (s, 1 H), 10.79 (s, 2 H), 9.08 (s, 1 H), 7.24-7.36 (m, 11 H), 7.16 (s, 1 H), 7.05 (t,
J = 7.5 Hz, 1 H), 7.01 (t, J = 7.5 Hz, 2 H), 6.91 (t, J = 7.0 Hz, 1 H), 6.83 (t, J = 7.5 Hz, 3 H), 6.28 (s 1 H), 5.93 (s, 1 H), 5.79(s, 1H), 5.60 (s, 1H), 4.21 (s, 2 H). \(^{13}\)C NMR (125 MHz, DMSO-\(d_6\)): \(\delta = 174.1, 167.6, 143.9, 141.4, 138.3, 137.1, 128.8,
128.4, 127.1, 126.9, 124.4, 124.0, 121.7, 121.3, 119.5, 119.1, 118.6, 118.5, 118.4, 113.7,
112.0, 111.9, 109.4, 60.0, 29.5, 22.6. ESI-MS: m/z = 592.4 (M+1)+.
$^1$H NMR and $^{13}$C NMR of compound 4a
$^1$H NMR and $^{13}$C NMR of compound 4b
$^1$H NMR and $^{13}$C NMR of compound 4c
$^1$H NMR and $^{13}$C NMR of compound 4d
$^1$H NMR and $^{13}$C NMR of compound 4e
$^1$H NMR and $^{13}$C NMR of compound 4f
$^1$H NMR and $^{13}$C NMR of compound 4g
$^1$H NMR and $^{13}$C NMR of compound 4h
$^1$H NMR and $^{13}$C NMR of compound 4i
$^1$H NMR and $^{13}$C NMR of compound 4j
$^1$H NMR and $^{13}$C NMR of compound 4k
$^1$H NMR and $^{13}$C NMR of compound 41
$^1$H NMR and $^{13}$C NMR of compound 4m
$^1$H NMR and $^{13}$C NMR of compound 4n
$^1$H NMR and $^{13}$C NMR of compound 4o
$^1$H NMR and $^{13}$C NMR of compound 4p
$^1$H NMR and $^{13}$C NMR of compound 4q
\(^1\)H NMR and \(^{13}\)C NMR of compound 4r
$^1$H NMR and $^{13}$C NMR of compound 4t
$^1$H NMR and $^{13}$C NMR of compound 4u
$^1$H NMR and $^{13}$C NMR of compound 4v
$^1$H NMR and $^{13}$C NMR of compound 4w
$^1$H NMR and $^{13}$C NMR of compound $4x$
$^1$H NMR and $^{13}$C NMR of compound 4y
$^1$H NMR and $^{13}$C NMR of compound 4z
$^1$H NMR and $^{13}$C NMR of compound 4aa
$^1$H NMR and $^{13}$C NMR of compound 4ab
$^{1}H$ NMR and $^{13}C$ NMR of compound 4ac
$^1$H NMR and $^{13}$C NMR of compound 5
ESI-MS of compound 4a

ESI-MS of compound 4b
ESI-MS of compound 4e

ESI-MS of compound 4f
ESI-MS of compound 4g

[Graph showing mass spectrum]

ESI-MS of compound 4h

[Graph showing mass spectrum]
ESI-MS of compound 4i

ESI-MS of compound 4j
ESI-MS of compound 4k

ESI-MS of compound 4l
ESI-MS of compound 4m

ESI-MS of compound 4n

S47
ESI-MS of compound 4o

ESI-MS of compound 4p
ESI-MS of compound 4q

ESI-MS of compound 4r
ESI-MS of compound 4s

ESI-MS of compound 4t
ESI-MS of compound 4u

ESI-MS of compound 4v
ESI-MS of compound 4w

ESI-MS of compound 4x
ESI-MS of compound 4y

ESI-MS of compound 4z
ESI-MS of compound 4aa

ESI-MS of compound 4ab
ESI-MS of compound 4ac

ESI-MS of compound 5