SELECTIVE PROTECTION AND DE-PROTECTION OF PHENOLIC HYDROXY GROUPS OF NARINGENIN

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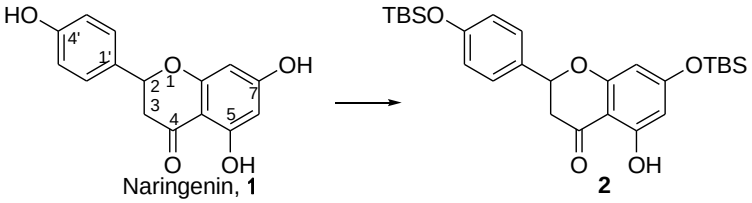
Experimental

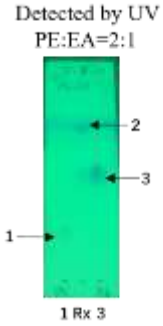
^{1}H and ^{13}C NMR spectra were recorded on a Bruker AV-400 spectrometer at 400 and 100 MHz, respectively, in Chloroform-*d* or DMSO-d_6 as indicated. Coupling constants (*J*) are expressed in hertz (Hz). Chemical shifts (δ) of NMR are reported in parts per million (ppm) units relative to the solvent. High resolution mass spectra (HRMS) data were recorded on Thermo QExactive Focus with Orbitrap analyzer. Unless otherwise noted, materials were obtained from commercial suppliers and used without further purification. Melting points were measured using an YRT-3 melting point apparatus (Shanghai, China) and were uncorrected. All solvents were purified by distillation before use. Chemicals were obtained from commercial sources and were used without further purification.

General synthetic procedure for 2 and 3 (entries 3-6, 8-10, and 12-14, Table 1): 0.5 g (1.84 mmol) naringenin (racemic, **1**) was dissolved in DCM as indicated in **Table 1**, the predetermined quantities of a base and TBSCl were added subsequently. The reaction temperature was set up in **Table 1**. The reaction progress was monitored by TLC. After the reaction was finished, the reaction was diluted by ethyl acetate (EA) and treated with sat. $NaHCO_3$ solution. The organic phase was washed by brine and then dried over anhydrous Na_2SO_4. After filtered and evaporated, the residue was silica gel column chromatography to afford **2** or **3**.

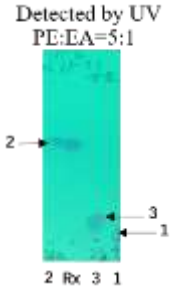
*(+/-)-4',7-bis(t-Butyldimethylsilyloxy)-5-hydroxy-naringenin (**2**) from naringenin (racemic, **1**)*



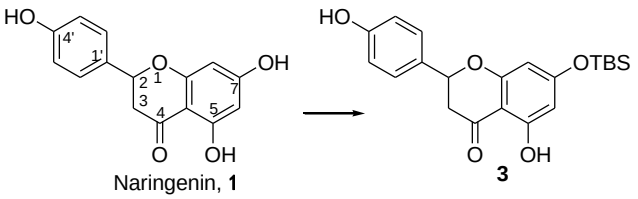
Entry 7 (Table 1): 1.0 g (3.7 mmol) of racemic naringenin (**1**) was dissolved in DCM (20 mL) and then 2.1 mL (22.0 mmol) of TEA and 1.33 g (8.9 mmol) of TBSCl were successively added to the solution at rt. The reaction was stirred at rt for 6 h and by monitored by thin layer chromatography (TLC). After the workup, 1.6 g (87% yield) of compound **2** was received: white solid; mp 107.2-107.5 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 11.99 (s, 1H), 7.37 – 7.32 (m, 2H), 6.94 – 6.88 (m, 2H), 6.08 – 5.97 (m, 2H), 5.37 (dd, *J* = 13.3, 2.9 Hz), 3.12 (dd, *J* = 17.2, 13.3 Hz), 2.80 (dd, *J* = 17.2, 3.0 Hz), 1.02 (s, 9H), 0.99 (s, 9H), 0.27 (s, 6H), 0.24 (s, 6H); ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.06 (s, 1H), 7.48 – 7.40 (m, 2H), 6.94 – 6.88 (m, 2H), 6.04 – 5.94 (m, 2H), 5.57 (dd, *J* = 13.1, 2.9 Hz, 1H), 3.39 (d, *J* = 13.8 Hz, 1H), 2.76 (dd, *J* = 17.1, 3.0 Hz, 1H), 0.97 (s, 9H), 0.94 (s, 9H), 0.24 (s, 6H), 0.21 (s, 6H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 196.27, 164.98, 163.98, 162.92, 156.29, 131.05, 127.68 (2C), 120.40 (2C), 103.65, 101.27, 99.90, 79.04, 43.38, 25.68 (3C), 25.51 (3C), 18.22 (2C), -4.33 (2C), -4.38 (2C); HRMS (ESI) *m*/*z* 501.2489 $[M+H]^+$, calculated for $C_{27}H_{40}O_5Si_2$, 501.2487.



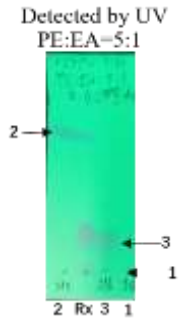
Entry 8 (Table 1): 0.5 g (1.84 mmol) naringenin (racemic, **1**) was dissolved in DCM (5 mL), and then 750 mg (11.0 mmol) imidazole and 664 mg (4.41 mmol) TBSCl were added. The reaction was complete in 4 h at rt and the workup was conducted as above to afford 874 mg of compound **2** in 95% yield.



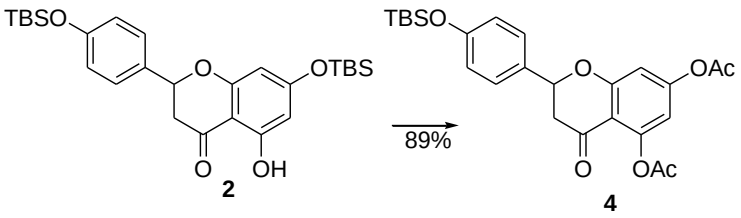
(+/-)-7-(t-Butyldimethylsilyloxy)-5-hydroxy-naringenin (**3**) *from naringenin (racemic, **1**)*



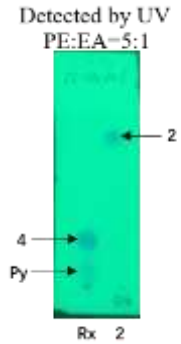
Entry 11 (Table 1): To the solution of 1.0 g (3.7 mmol) of naringenin (**1**) dissolved in DCM (20 mL) at rt, 1.1 mL (11.0 mmol) of TEA was added, and then 665 mg (4.4 mmol) of TBSCl was added subsequently. The reaction was stirred at rt for 3 h until the starting material of **1** disappeared by the TLC indication. The reaction was diluted by EA and then washed by sat. $NaHCO_3$ solution and brine. The organic phase was dried over anhydrous Na_2SO_4 before filtered and distilled off the volatiles. The residue was silica gel column chromatographed to afford 1.2 g (89% yield) of compound **3**: white solid; mp 57.2-57.8 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.06 (s, 1H), 9.62 (s, 1H), 7.34 (d, J = 8.2 Hz, 2H), 6.80 (d, J = 8.2 Hz, 2H), 5.97 (s, 2H), 5.50 (dd, J = 13.0, 2.9 Hz, 1H), 3.42–3.36 (m, 1H), 2.72 (dd, J = 17.2, 2.9 Hz, 1H), 0.94 (s, 9H), 0.24 (s, 6H); HRMS (ESI) m/z 387.1620 $[M+H]^+$, calculated for $C_{21}H_{26}O_5Si$, 387.1622. ^{1}H NMR data are identical to the reported data in the reference.[34]



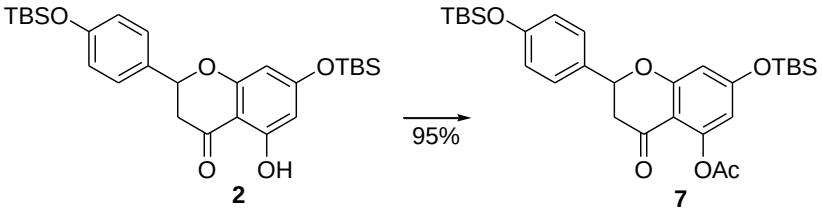
*(+/-)-4'-(t-Butyldimethylsilyloxy)-5,7-diacetyloxy-naringenin (**4**) from **2***



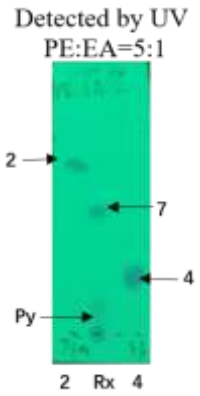
Entry 1 (Table 2): To the ice-water bath cooled solution of 500 mg (1.0 mmol) of compound **2** dissolved in 6 mL of pyridine, 0.47 mL (5.0 mmol) of acetyl anhydrous was added dropwise and then slowly warmed to the ambient temperature. The reaction was stirred at the same temperature for 24 h before the reaction was complete. Treated with EA and successively washed by sat. $NaHCO_3$ solution and brine, the organic phase was dried over anhydrous Na_2SO_4. After filtered and distilled off in vacuum the solvents, silica gel column chromatography gave 420 mg (89% yield) of compound **4**: white solid; mp 54.0-54.6 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.34 – 7.27 (m, 2H), 6.93 – 6.85 (m, 2H), 6.77 (d, J = 2.3 Hz, 1H), 6.52 (d, J = 2.3 Hz, 1H), 5.42 (dd, J = 13.7, 2.7 Hz, 1H), 3.06 (dd, J = 16.7, 13.7 Hz, 1H), 2.74 (dd, J = 16.7, 2.7 Hz, 1H), 2.38 (s, 3H), 2.29 (s, 3H), 0.99 (s, 9H), 0.21 (s, 6H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 189.47, 169.30, 168.00, 163.42, 156.36, 155.86, 151.22, 130.64, 127.67 (2C), 120.38 (2C), 111.76, 110.41, 109.14, 79.45, 45.01, 25.66 (3C), 21.19, 21.08, 18.22, -4.38 (2C). HRMS (ESI) *m/z* 471.1835 $[M+H]^+$, calculated for $C_{25}H_{30}O_7Si$, 471.1835.



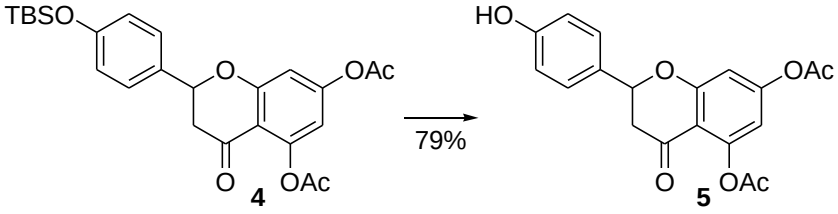
(+/-)-4',7-Bis(t-butyldimethylsilyloxy)-5-acetyloxy-naringenin (7) from ***2***



Entry 3 (Table 2): 500 mg (1.0 mmol) compound **2** was dissolved in 6.0 mL DCM and then cooled in ice-water bath. To the cooled solution, 0.52 mL (5.0 mmol) pyridine and then 0.28 mL (4.0 mmol) AcCl were added dropwise. After addition, the reaction mixture was kept in ice-cooled bath for 5 min before moved to rt. The reaction was finished in 18 h by TLC indication, after that the reaction was diluted by EA, then the organic phase was washed by sat. $NaHCO_3$ solution and brine subsequently. The organic phase was dried over anhydrous Na_2SO_4, after filtered and distilled off the volatiles in vacuum, purification by silica gel column chromatography gave 515 mg (95% yield) of compound **7**: white solid; mp 51.8-52.2 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.33 (d, J = 8.4 Hz, 2H), 6.91 (d, J = 8.4 Hz, 2H), 6.42 – 6.35 (m, 1H), 6.23 (d, J = 2.4 Hz, 1H), 5.40 (dd, J = 13.6, 2.7 Hz, 1H), 3.05 (dd, J = 16.8, 13.7 Hz, 1H), 2.70 (dd, J = 16.8, 2.7 Hz, 1H), 2.41 (s, 3H), 1.03 – 1.01 (m, 9H), 1.00 – 0.97 (m, 9H), 0.29 – 0.26 (m, 6H), 0.25 – 0.22 (m, 6H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 189.27, 169.49, 164.11, 162.36, 156.29, 151.85, 131.12, 127.71 (2C), 120.36 (2C), 109.56, 108.58, 106.16, 79.32, 45.04, 25.68 (3C), 25.48 (3C), 21.16, 18.22, 18.17, -4.39 (4C); HRMS (ESI) *m/z* 565.2415 $[M+Na]^+$; calculated for $C_{29}H_{42}O_6NaSi_2$, 565.2412.

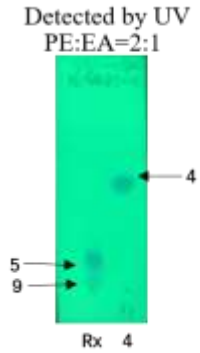


(+/-)-5,7-Diacetyloxy-naringenin (**5**) *from compound* ***4***

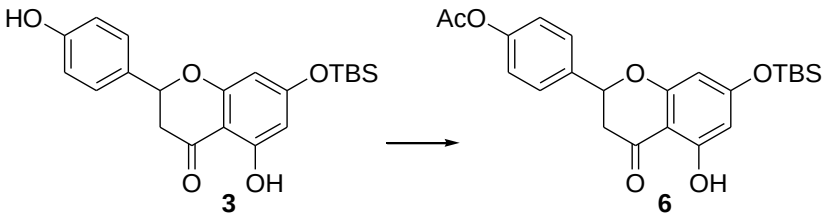


200 mg (0.43 mmol) of compound **4** was dissolved in THF (5 mL) and then cooled in ice-water bath before 40 mg (0.51 mmol) of KHF_2 was added dropwise. After the addition, the reaction was moved to rt for 30 min for the completion of the reaction. Diluted with EA and successively washed by sat. $NaHCO_3$ solution

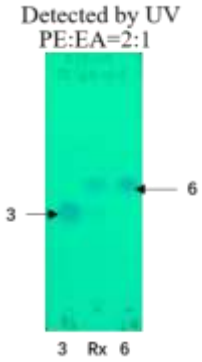
and brine, the organic phase was dried over anhydrous Na_2SO_4. Filtered, rotavapored and dried, the residue was purified by silica gel chromatography to afford 120 mg (79% yield) of compound **5**: white solid; mp 104.2-104.9 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.68 (s, 1H), 7.40 (d, J = 8.3 Hz, 2H), 6.89 (d, J = 2.2 Hz, 1H), 6.85 (d, J = 8.1 Hz, 2H), 6.73 (d, J = 2.2 Hz, 1H), 5.60 (dd, J = 13.2, 2.7 Hz, 1H), 3.33 (dd, J = 16.6, 13.2 Hz, 1H), 2.71 (dd, J = 16.6, 2.8 Hz, 1H), 2.35 (s, 3H), 2.33 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 190.06, 169.12, 168.79, 163.42, 158.38, 156.11, 151.19, 128.98, 115.67, 111.97, 111.07, 109.68, 79.41, 44.27, 21.36, 21.28. ^{1}H NMR and ^{13}C NMR data are identical to reported data in the reference.[25]



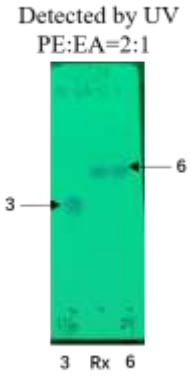
*(+/-)-7-(t-Butyldimethylsilyloxy)-4'-acetyloxy-naringenin (**6**) from **3***



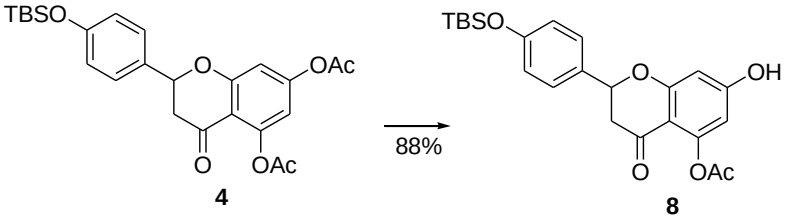
Entry 1 (Table 3): To the solution of 100 mg (0.26 mmol) of compound **3** in DCM (4 mL) at 0 °C, TEA (72 µL, 0.52 mmol) was added. At 0 °C, the 1st portion of acetyl chloride (9.2 µL, 0.13 mmol) was added and the reaction was stirred for 30 min before the 2nd portion of acetyl chloride (9.2 µL, 0.13 mmol) was added. The reaction continued to stir at 0 °C until the disappearance of **3** before was diluted with EA and washed with sat. $NaHCO_3$ solution and brine. The organic phase was dried over anhydrous Na_2SO_4 and filtered and rotavapored to give the residue. Purification of the residue by silica gel chromatography provided 82 mg (74% yield) of compound **6**: white solid; mp 115.4-115.9 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 11.95 (s, 1H), 7.55 – 7.46 (m, 2H), 7.22 – 7.15 (m, 2H), 6.08 – 5.98 (m, 2H), 5.44 (dd, J = 13.1, 3.0 Hz, 1H), 3.09 (dd, J = 17.2, 13.1 Hz, 1H), 2.84 (dd, J = 17.1, 3.1 Hz, 1H), 2.34 (s, 3H), 0.99 (s, 9H), 0.27 (s, 6H); ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.05 (s, 1H), 7.62 – 7.57 (m, 2H), 7.23 – 7.18 (m, 2H), 6.02 (d, J = 2.2 Hz, 1H), 5.99 (d, J = 2.2 Hz, 1H), 5.66 (dd, J = 13.0, 2.9 Hz, 1H), 3.41 (d, J = 13.5 Hz, 1H), 2.83 (dd, J = 17.0, 3.0 Hz, 1H), 2.51 (q, J = 1.9 Hz, 3H), 0.94 (s, 9H), 0.25 (s, 6H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.73, 169.37, 165.07, 163.99, 162.64, 150.93, 136.01, 127.39, 122.09, 103.62, 101.40, 99.91, 78.58, 43.47, 25.51, 21.15, 18.22, -4.32, -4.35; HRMS (ESI) m/z 429.1727 $[M+H]^+$, calculated for $C_{23}H_{28}O_6Si$, 429.1728.



Entry 2 (Table 3): At 0 °C, 100 mg (0.26 mmol) compound **3** was dissolved in 4 mL DCM and then about 42 μL (0.52 mmol) pyridine was added dropwise to the solution. After the addition of 24 μL (0.26 mmol) Ac_2O, the reaction was moved to rt for 3 h until **3** was consumed completely. Workup as above to afford 105 mg (95% yield) compound **6**.



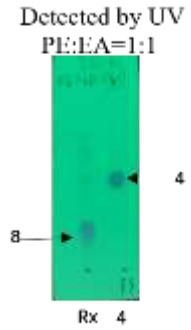
(+/-)-4'-(t-Butyldimethylsilyloxy)-5-acetyloxy-naringenin ***8*** *from* ***4***



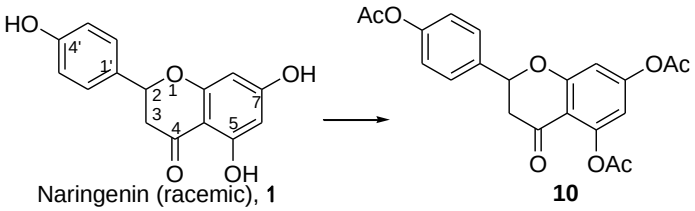
4 **8**

150 mg (0.32 mmol) compound **4** was dissolved in 4 ml tetrahydrofuran (THF) and 2 mL methanol. The solution was treated with 44 mg (0.64 mmol) imidazole at rt and the reaction was monitored by TLC and finished in 1 h. The reaction was quenched by addition of sat. $NaHCO_3$ solution and extracted with EA, and then the organic phase was washed by sat. $NaHCO_3$ solution and brine before dried over anhydrous Na_2SO_4. Filtered and evaporated in vacuum, the residue was silica gel column chromatographed to yield 120 mg (88% yield) compound **8**: white solid; mp 123.2-123.7 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.94 (s, 1H), 7.51 – 7.28 (m, 2H), 6.99 – 6.81 (m, 2H), 6.31 (d, J = 2.3 Hz, 1H), 6.19 (d, J = 2.3 Hz, 1H), 5.47 (dd, J = 13.1, 2.8 Hz, 1H), 3.10 (dd, J = 16.7, 13.1 Hz, 1H), 2.59 (dd, J = 16.6, 2.9 Hz, 1H), 2.26 (s, 3H), 0.97 (s, 9H), 0.21 (s, 6H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 188.85, 169.11, 164.51, 164.21, 155.85, 152.22, 132.10, 128.80 (2C), 120.26 (2C), 107.12, 105.47, 101.36, 78.80, 44.42, 26.03, 21.37 (3C), 18.42, -4.07 (2C); HRMS

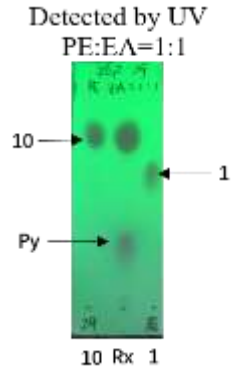
(ESI) *m/z* 451.1545 [M+Na]+, calculated for $C_{23}H_{28}O_6NaSi$, 451.1547.



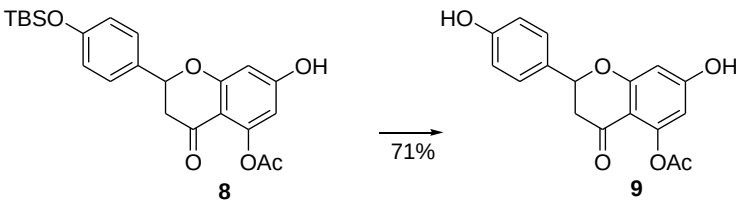
*(+/-)-4',5,7-Triacetyloxy naringenin **10** from naringenin (racemic, **1**)*



Full acetylation of naringenin (racemic, **1**) was conducted according to the references [23-26] to afford compound **10**: ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 (m, 2H), 7.17 (m, 2H), 6.80 (t, J = 1.8 Hz, 1H), 6.58 – 6.53 (m, 1H), 5.50 (dd, J = 13.6, 2.7 Hz, 1H), 3.05 (m, 1H), 2.79 (m, 1H), 2.40 (d, J = 1.4 Hz, 3H), 2.33 (d, J = 1.4 Hz, 3H), 2.31 (d, J = 1.5 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 188.94, 169.33, 169.25, 167.99, 163.17, 155.98, 151.28, 151.01, 135.64, 127.39 (2C), 122.11 (2C), 111.79, 110.65, 109.12, 79.04, 45.12, 21.15, 21.11, 21.04.

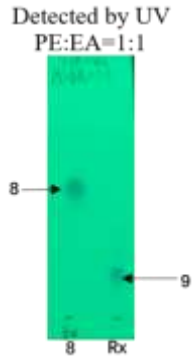


*(+/-)-5-Acetyloxy-naringenin **9** from compound **8***

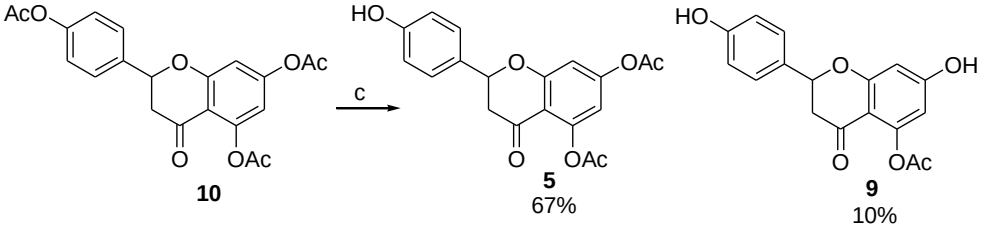


To the ice-cooled solution of 100 mg (0.23 mmol) dissolved in 2.0 mL acetonitrile, 35 mg (0.23 mmol) CsF was added in portion and then the reaction was moved to rt until compound **9** was completely consumed.

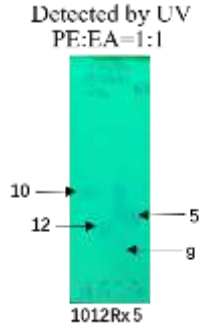
Diluted with EA and treated with sat. $NaHCO_3$ solution, the organic phase was washed with sat. $NaHCO_3$ solution and brine. After dried over anhydrous Na_2SO_4, filtered and distilled off solvents, the residue was purified by silica gel column chromatography to afford 52 mg (71% yield) **9**: white solid; mp 67.2-67.8 ℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.94 (s, 1H), 9.61 (s, 1H), 7.37 – 7.28 (m, 2H), 6.84 – 6.74 (m, 2H), 6.29 (d, J = 2.3 Hz, 1H), 6.18 (d, J = 2.3 Hz, 1H), 5.41 (dd, J = 13.0, 2.8 Hz, 1H), 3.10 (dd, J = 16.7, 13.0 Hz, 1H), 2.55 (dd, J = 16.6, 2.9 Hz, 1H), 2.26 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 189.09, 169.16, 164.47, 164.27, 158.20, 152.20, 129.40, 128.83 (2C), 115.62 (2C), 107.09, 105.37, 101.34, 79.04, 44.36, 21.38; HRMS (ESI) m/z 337.0680 $[M+Na]^+$, calculated for $C_{17}H_{14}O_6Na$, 337.0683.



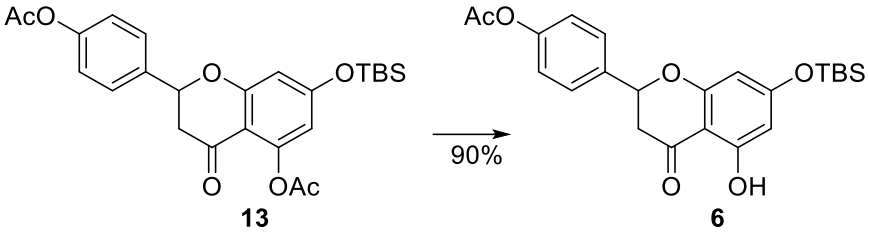
*(+/-)-5,7-Diacetyloxy-naringenin (**5**) and (+/-)-5-acetyloxy-naringenin **9** from compound **10***



500 mg (1.3 mmol) of compound **10** was dissolved in THF (10 mL) and acetic acid (5 mL) at rt and then 215 mg (1.13 mmol) of $TsOH·H_2O$ was added. The reaction was stirred at rt for 10 h and quenched by EA and sat. $NaHCO_3$ solution when TLC monitoring indicated that about higher than 50% of **10** was reacted. The organic phase was washed with sat. $NaHCO_3$ solution and brine, dried over anhydrous Na_2SO_4 before rotavapored in vacuum. The residue was purified by silica gel column chromatography to recover about 200 mg (40%) of **10** and get 180 mg (40% yield based on total **10** and 67% yield based on reacted **10**) of compound **5** and 40 mg (9.1% yield based on total **10** and 10% yield based on reacted **10**) of compound **9**.

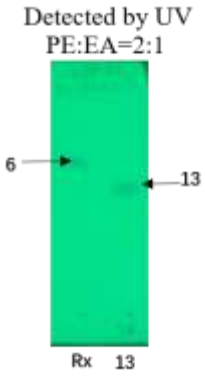


(+/-)-7-(t-Butyldimethylsilyloxy)-4'-acetyloxy-naringenin (**6**) *from* ***13***

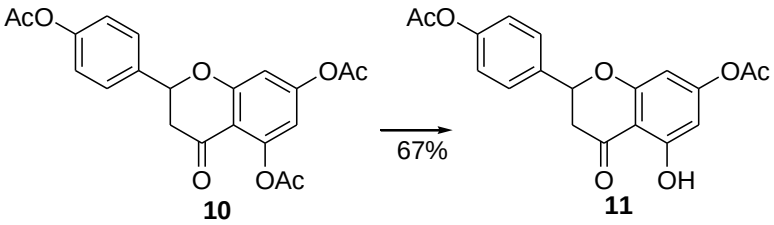


13 **6**

1.0 g (2.1 mmol) of Compound **13** was treated with TFA (30 mL) at rt and heated at 40 ºC for 1 h for the completion of the reaction by TLC monitoring. Cooled to rt and then diluted with EA, washed with brine three times, sat. $NaHCO_3$ solution twice, the organic phase was dried over anhydrous Na_2SO_4. Purification of compound **6** as above.

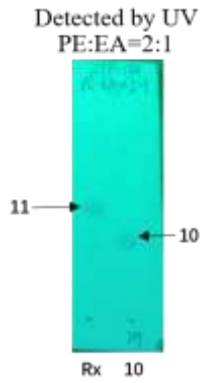


(+/-)-4',7-diacetyloxy-naringenin (***11***) *from* ***10***

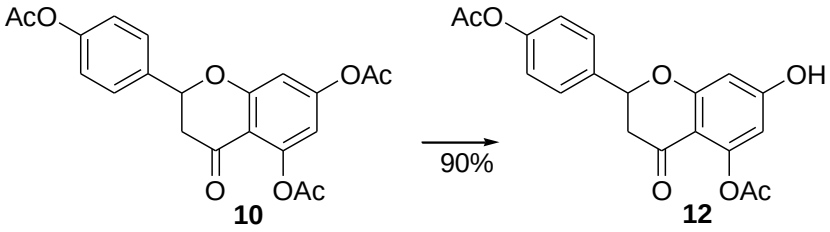


10 **11**

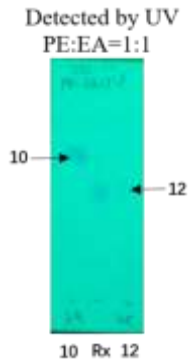
2.0 g (5.0 mmol) of triacetyloxylated naringenin **10** was dissolved in DCE (20 mL) and then TFA (20 mL) was added. The reaction was heated at 40 ºC for 6 h until starting material **10** disappeared. Cooled to rt and diluted with EA before washed with water twice, the organic phase was washed with sat. $NaHCO_3$ solution and brine before dried over anhydrous Na_2SO_4. Filtered and distilled off in vacuum, the residue was purified by silica gel column chromatography to give 1.2 g (67% yield) of compound **11**: white solid; mp 144.4-145.2 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.93 (s, 1H), 7.61 – 7.53 (m, 2H), 7.24 – 7.17 (m, 2H), 6.40 – 6.34 (m, 2H), 5.73 (dd, J = 13.1, 2.9 Hz, 1H), 3.49 – 3.42 (m, 1H), 2.90 (dd, J = 17.2, 3.0 Hz, 1H), 2.28 (s, 3H), 2.26 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 198.25, 169.69, 168.74, 162.70, 162.53, 158.52, 151.18, 136.23, 128.54, 122.55, 106.35, 103.41, 102.25, 78.76, 42.77, 21.39, 21.32; HRMS (ESI) m/z 357.0970 $[M+H]^+$, calculated for $C_{19}H_{16}O_7$, 357.0969. ^{1}H NMR and ^{13}C NMR data are identical to reported data in the reference.[35]



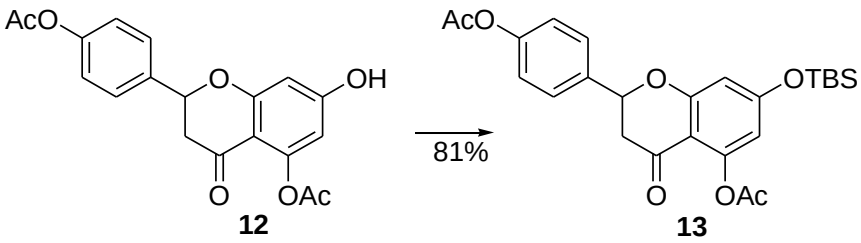
*(+/-)-4',5-diacetyloxy-naringenin (**12**) from **10***



To the solution of 5.0 g (12.6 mmol) of triacetyloxylated naringenin **10** in THF (50 mL) and methanol (25 mL), 1.7 g (25.2 mmol) of imidazole was added. The reaction was heated at 40 ºC and complete in 1 h by TLC monitoring. Cooled to rt before quenched by the mixture of EA and sat. $NaHCO_3$ solution, the organic phase was washed with sat. $NaHCO_3$ solution and brine, and then dried over anhydrous Na_2SO_4. Filtered and evaporated in vacuum, the residue was silica gel column chromatographed to afford 3.8 g (90% yield) of compound **12**: white solid; mp 173.2-173.9 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.96 (s, 1H), 7.57 (d, J = 8.2 Hz, 2H), 7.18 (d, J = 8.2 Hz, 2H), 6.32 (d, J = 2.3 Hz, 1H), 6.20 (d, J = 2.4 Hz, 1H), 5.57 (dd, J = 13.1, 2.8 Hz, 1H), 3.12 (dd, J = 16.6, 13.0 Hz, 1H), 2.64 (dd, J = 16.6, 2.9 Hz, 1H), 2.27 (d, J = 9.0 Hz, 6H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 188.61, 169.68, 169.13, 164.59, 164.06, 152.24, 151.03, 136.71, 128.43(2C), 122.44 (2C), 107.14, 105.59, 101.41, 78.55, 44.40, 21.37, 21.30. ^{1}H NMR data are identical to reported data in the reference.[25,26]

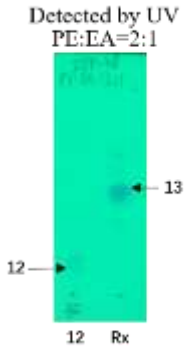


*(+/-)-7-(t-Butyldimethylsilyloxy)-4',5-diacetyloxy-naringenin (**13**) from **12***

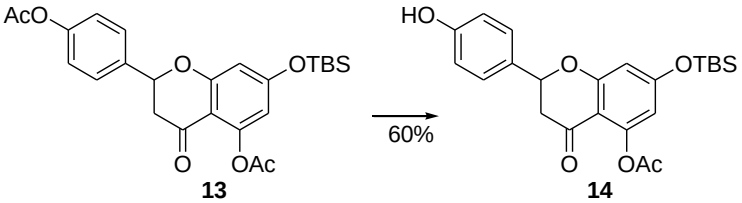


12 **13**

3.0 g (8.4 mmol) of Compound **12** was dissolved in DCM (20 mL) and then 690 mg (10.1 mmol) and 1.53 g (10.0 mmol) of TBSCl were added subsequently at rt. The reaction was stirred at rt for 6 h until compound **12** disappeared. Treated with EA and sat. $NaHCO_3$ solution, the organic phase was washed with sat. $NaHCO_3$ solution and brine, and then dried over anhydrous Na_2SO_4. Filtered and evaporated in vacuum, silica gel column chromatography of the residue to afford 3.2 g (81% yield) of compound **13**: white solid; mp 107.2-107.6 ºC; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.51 – 7.42 (m, 2H), 7.20 – 7.11 (m, 2H), 6.37 (d, J = 2.4 Hz, 1H), 6.21 (d, J = 2.4 Hz, 1H), 5.44 (dd, J = 13.6, 2.7 Hz, 1H), 2.99 (dd, J = 16.7, 13.5 Hz, 1H), 2.71 (dd, J = 16.7, 2.8 Hz, 1H), 2.38 (s, 3H), 2.32 (s, 3H), 0.97 (s, 9H), 0.25 (s, 6H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 188.73, 169.45, 169.30, 163.84, 162.46, 151.88, 150.94, 136.06, 127.41 (2C), 122.06 (2C), 109.71, 108.58, 106.14, 78.90, 45.14, 25.48 (3C), 21.13, 21.11, 18.17, -4.38 (2C); HRMS (ESI) *m/z* 471.1836 $[M+H]^+$, calculated for $C_{25}H_{30}O_7Si$, 471.1834. ^{1}H NMR data are identical to reported data in the reference.[36]



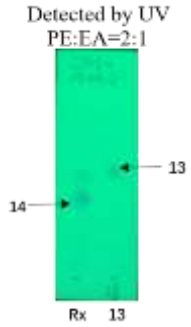
*(+/-)-7-(t-Butyldimethylsilyloxy)-4',5-diacetyloxy-naringenin (**14**) from **13***



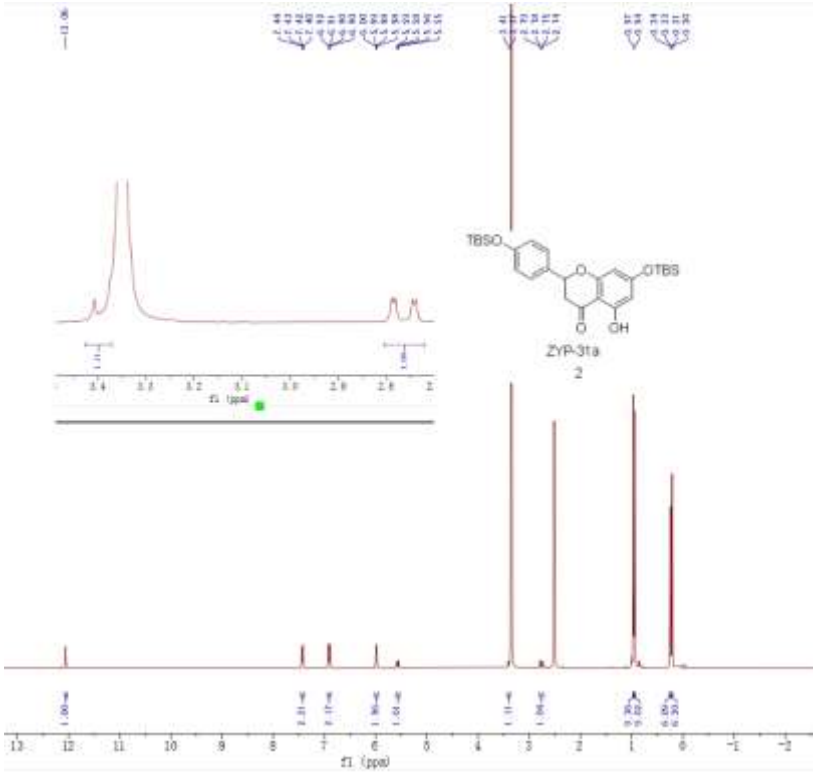
13 **14**

The solution of 1.0 g (2.1 mmol) of compound **13** in methanol (30 mL) was treated with 750 mg (4.2 mmol) of $TsOH{\cdot}H_2O$ at rt for about 6 h. After the reaction was complete, diluted with EA and sat. NaHCO3 solution, the organic phase was washed with sat. $NaHCO_3$ solution and brine, followed by dried over anhydrous Na_2SO_4. Filtered and distilled to dryness, purification of the residue by silica gel column chromatography afford 540 mg (60% yield) of compound **14**: white solid; mp 165.2-165.4 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.62 (s, 1H), 7.38 – 7.30 (m, 2H), 6.85 – 6.74 (m, 2H), 6.40 (d, J = 2.4 Hz, 1H), 6.29 (dd, J = 6.9, 2.3 Hz, 1H), 5.53 –5.42 (m, 1H), 3.19 (dd, J = 16.6, 13.2 Hz, 1H), 2.58 (dd, J = 16.6, 2.8 Hz, 1H),

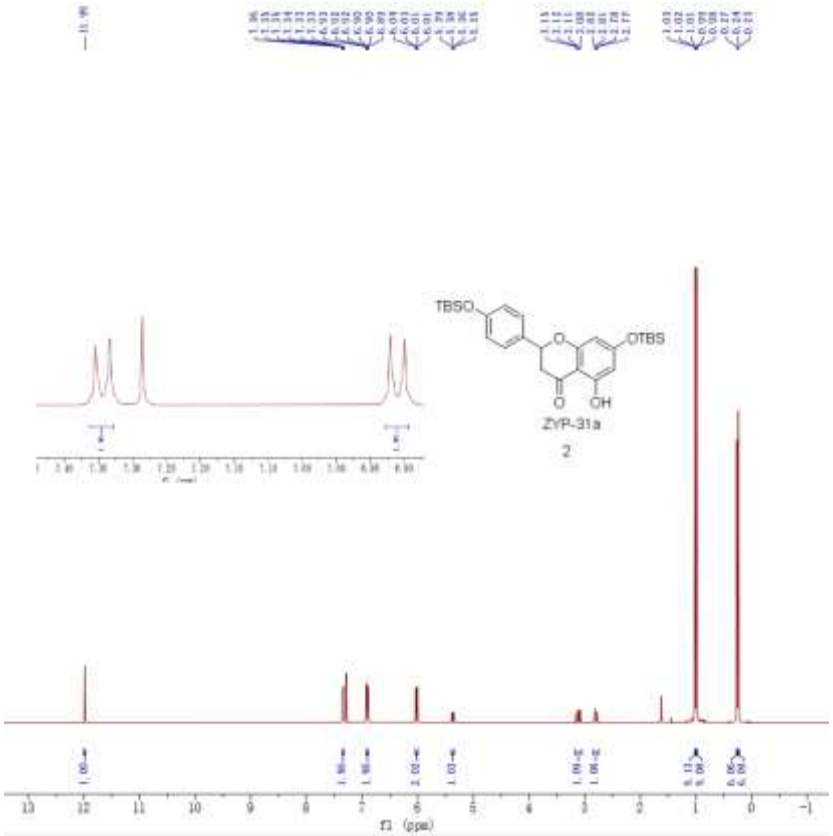
2.26 (d, J = 4.8 Hz, 3H), 0.94 (s, 9H), 0.24 (s, 6H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 189.96, 170.08, 164.25, 162.65, 156.67, 151.75, 130.09, 127.99, 115.72, 109.59, 108.45, 106.26, 79.21, 44.80, 25.47, 21.22, 18.18, -4.39; HRMS (ESI) m/z 429.1728 $[M+H]^+$, calculated for $C_{23}H_{28}O_6Si$, 429.1728.



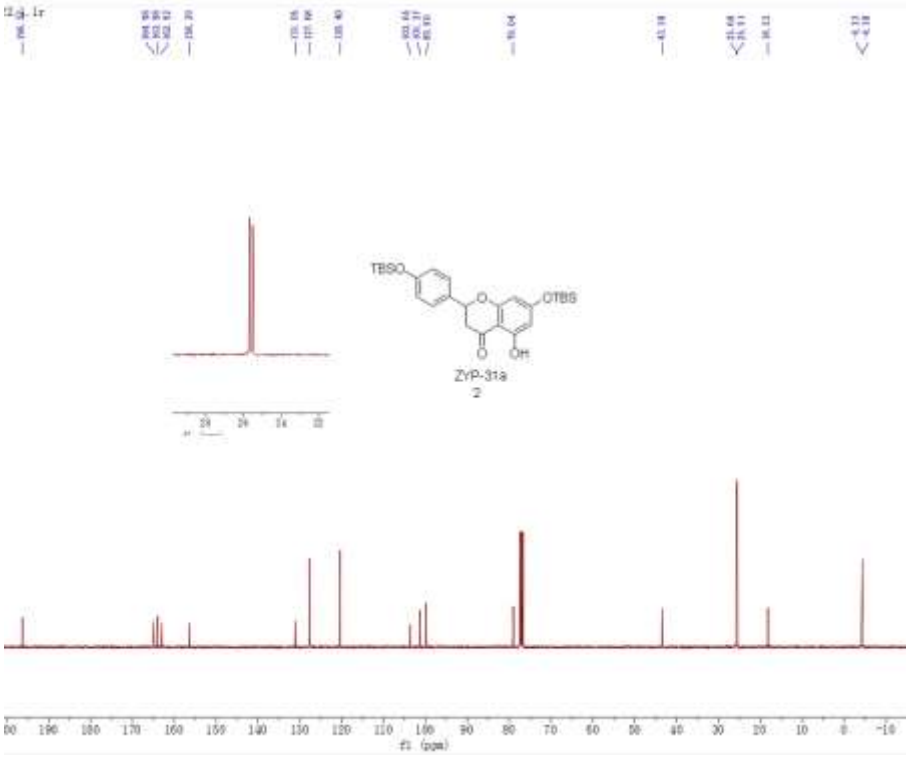
^{1}H NMR analysis of **2** (DMSO-d_6)



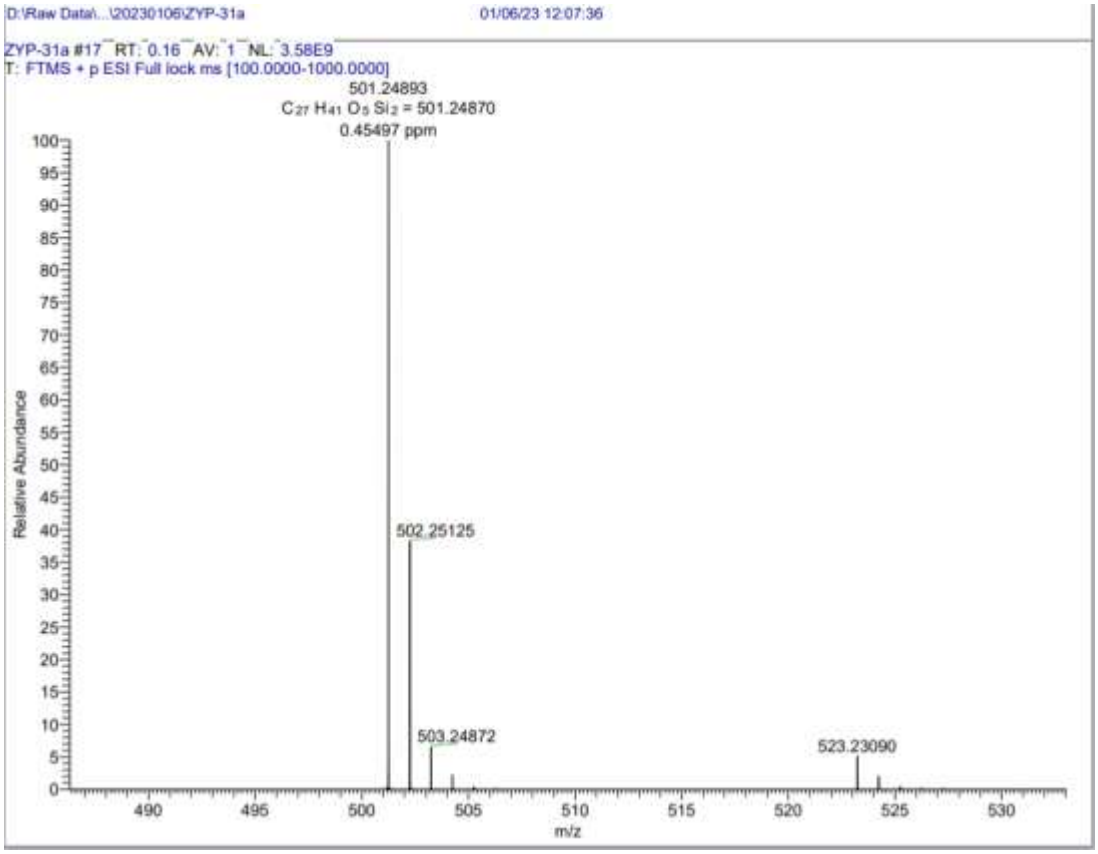
^{1}H NMR analysis of **2** (Chloroform-*d*)



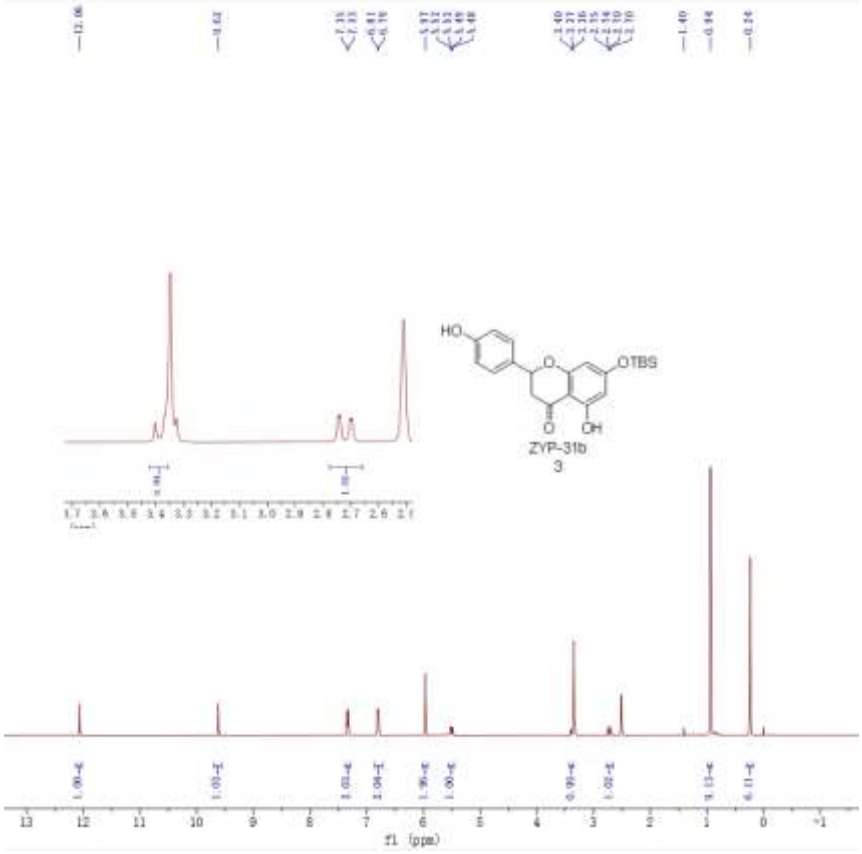
^{13}C NMR analysis of **2** (DMSO-d_6)



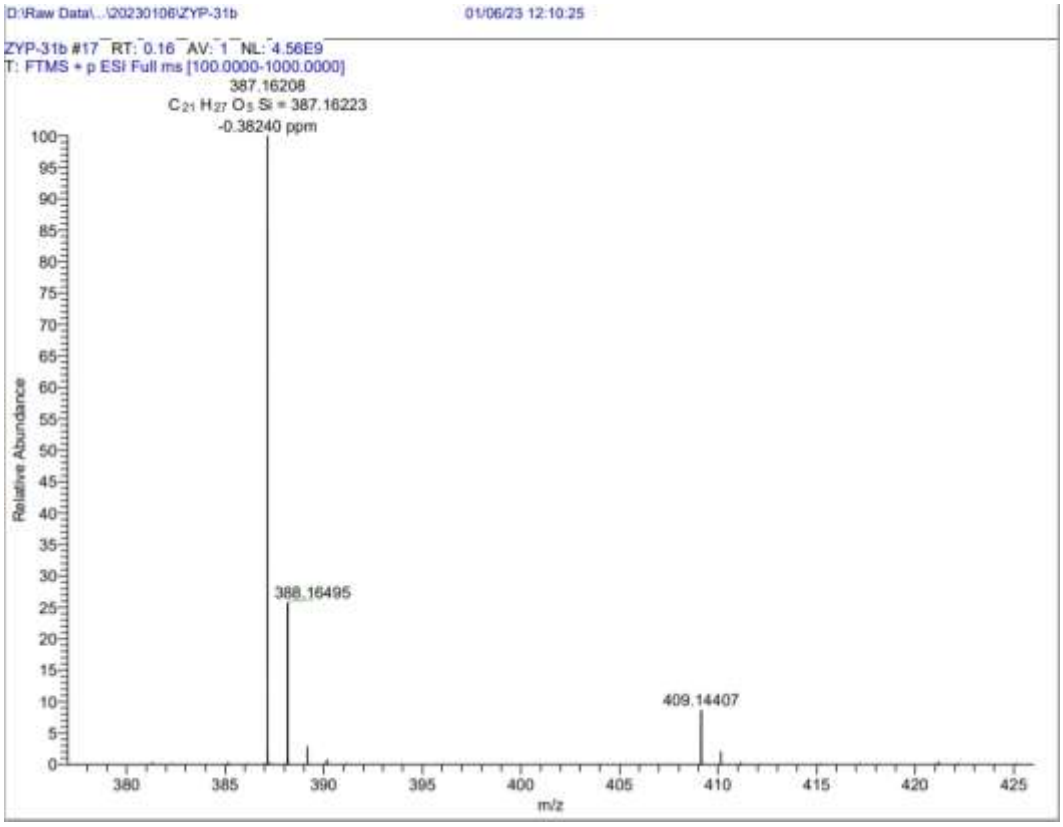
HRMS analysis of **2**



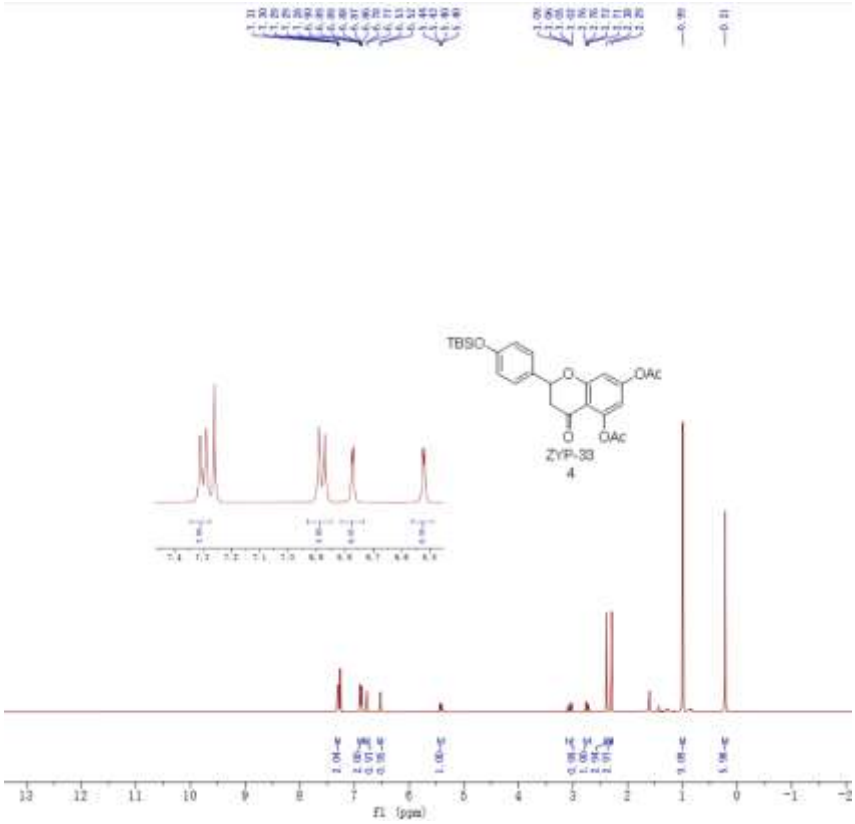
^{1}H NMR analysis of **3** (DMSO-d_6)



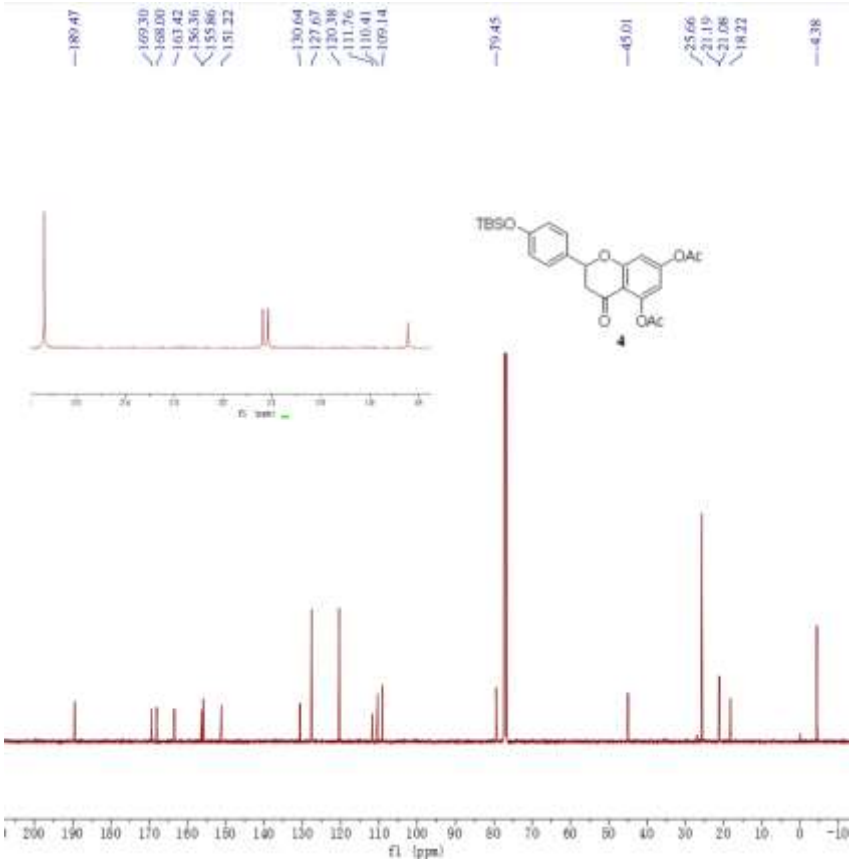
HRMS analysis of **3**



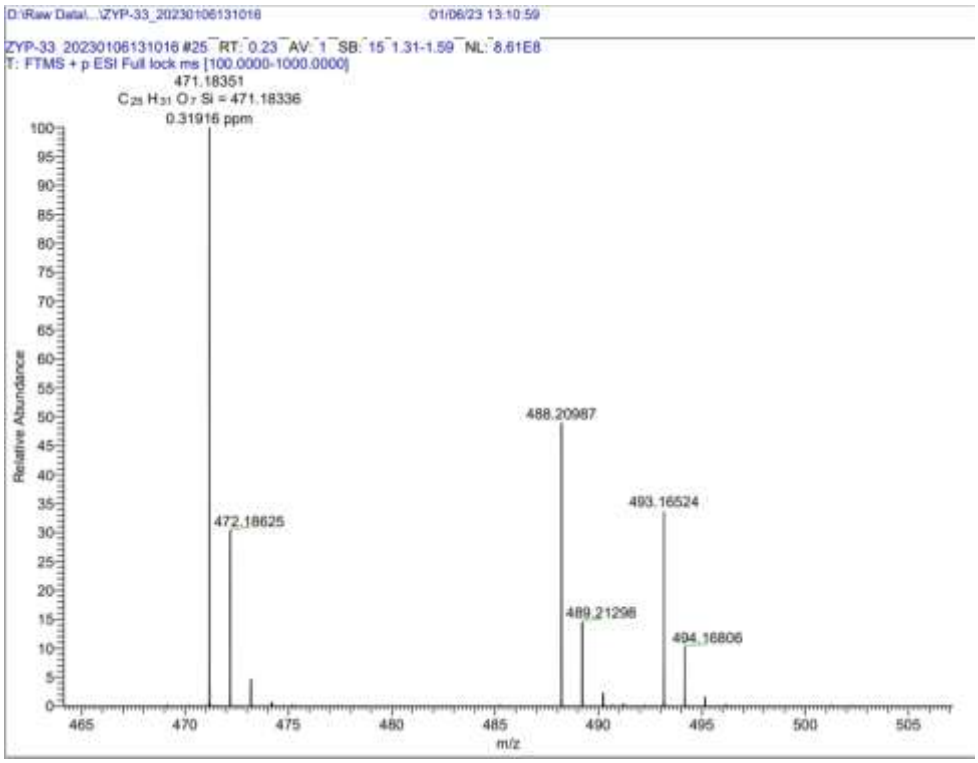
^{1}H NMR analysis of **4** (Chloroform-*d*)



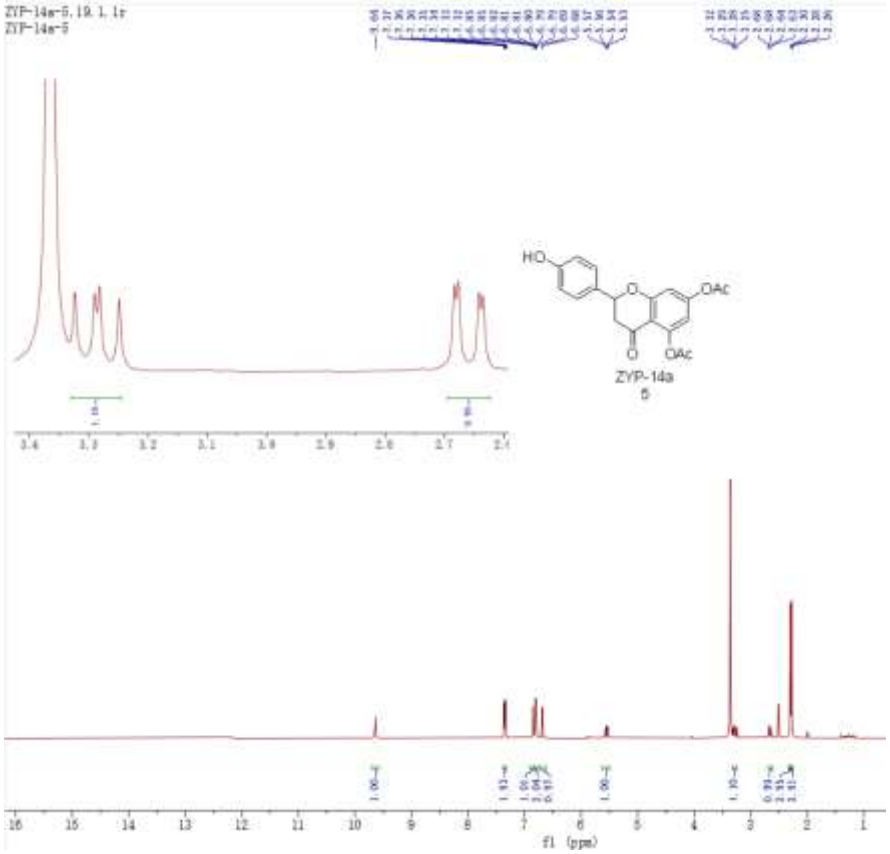
^{13}C NMR analysis of **4** (Chloroform-*d*)



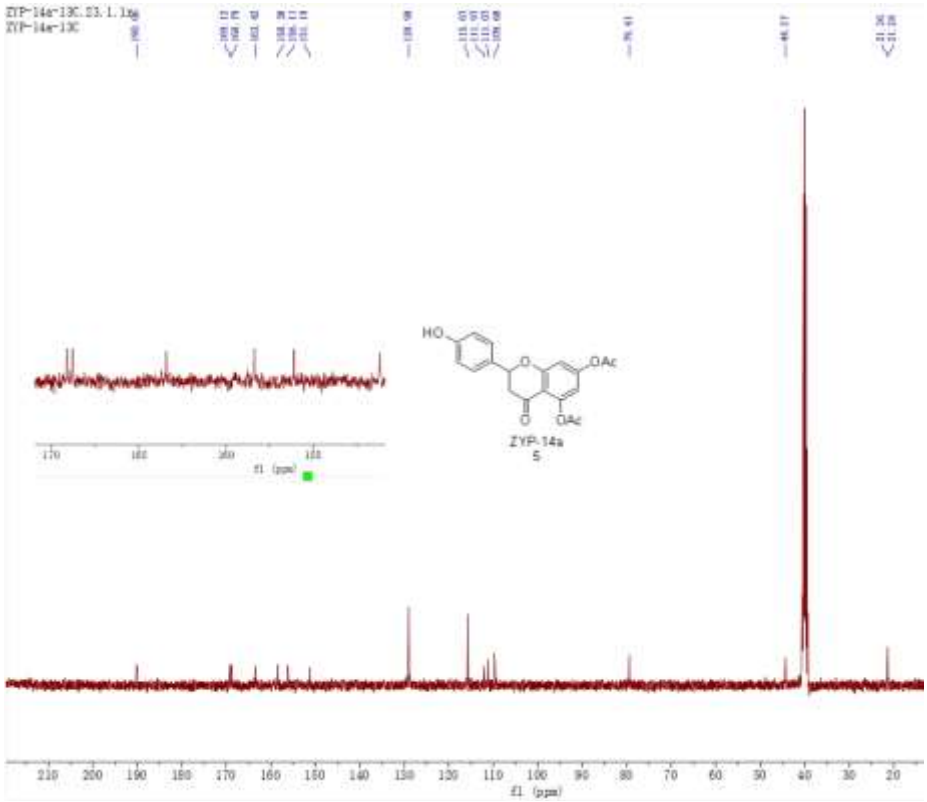
HRMS analysis of **4**



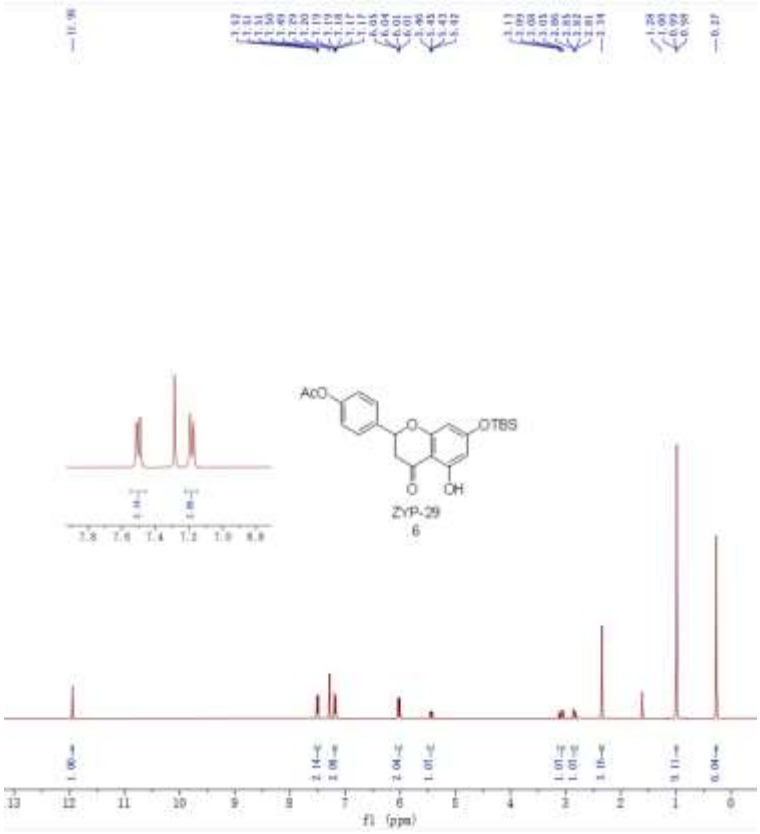
^{1}H NMR analysis of **5** (DMSO-d_6)



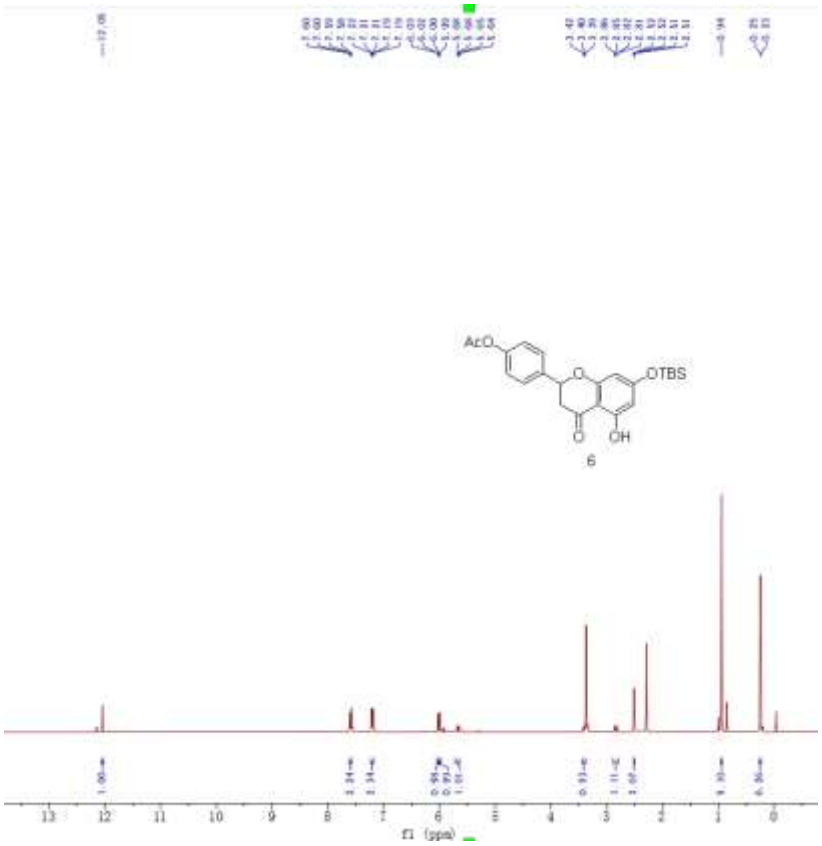
^{13}C NMR analysis of **5** (DMSO-d_6)



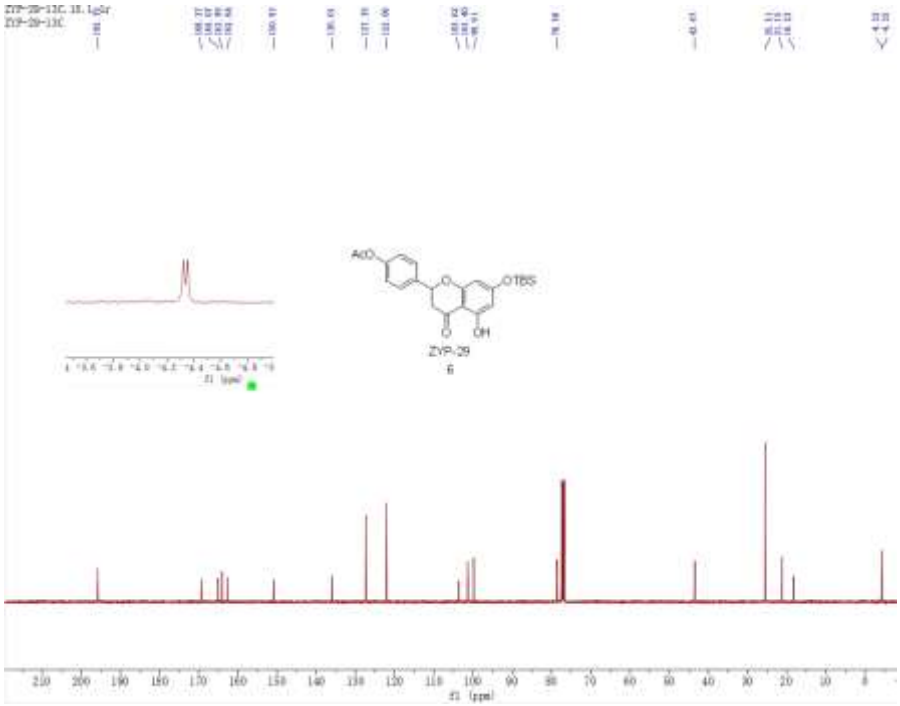
^{1}H NMR analysis of **6** (Chloroform-*d*)



^{1}H NMR analysis of **6** (DMSO-d_6)

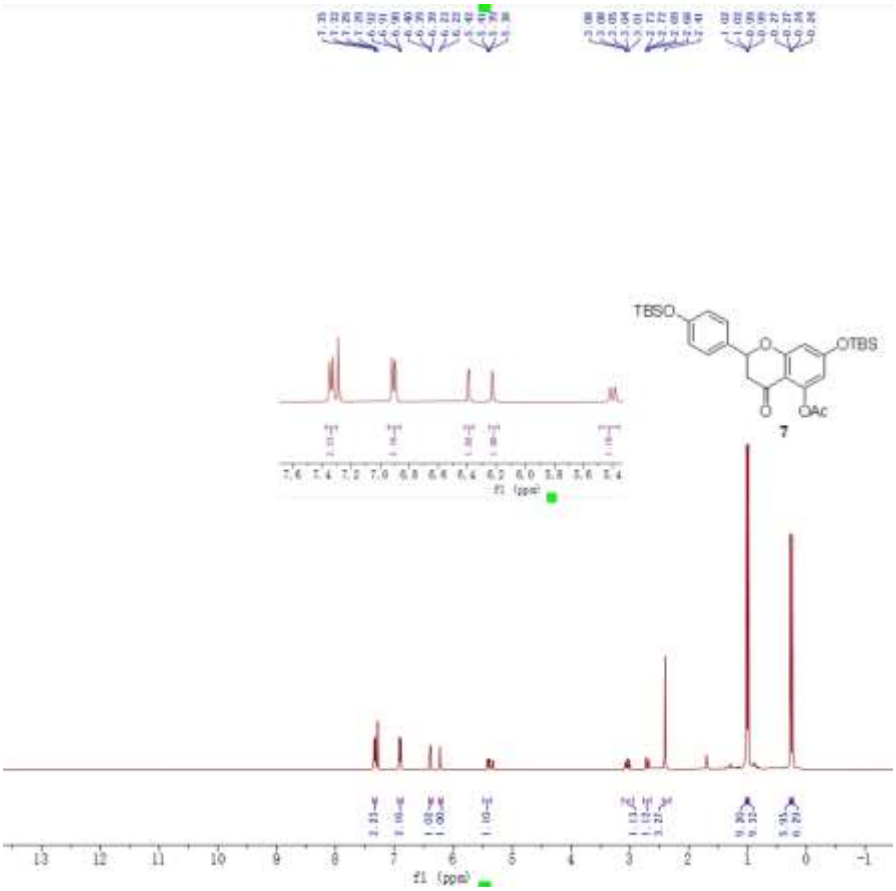


^{13}C NMR analysis of **6** (Chloroform-*d*)

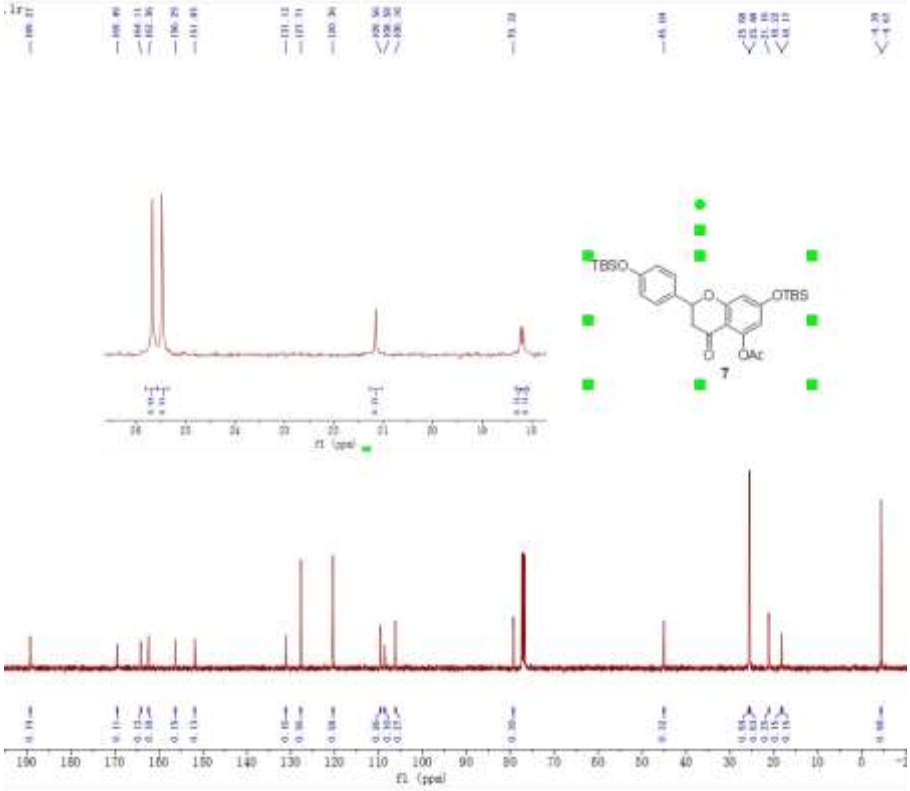


HRMS analysis of **6**

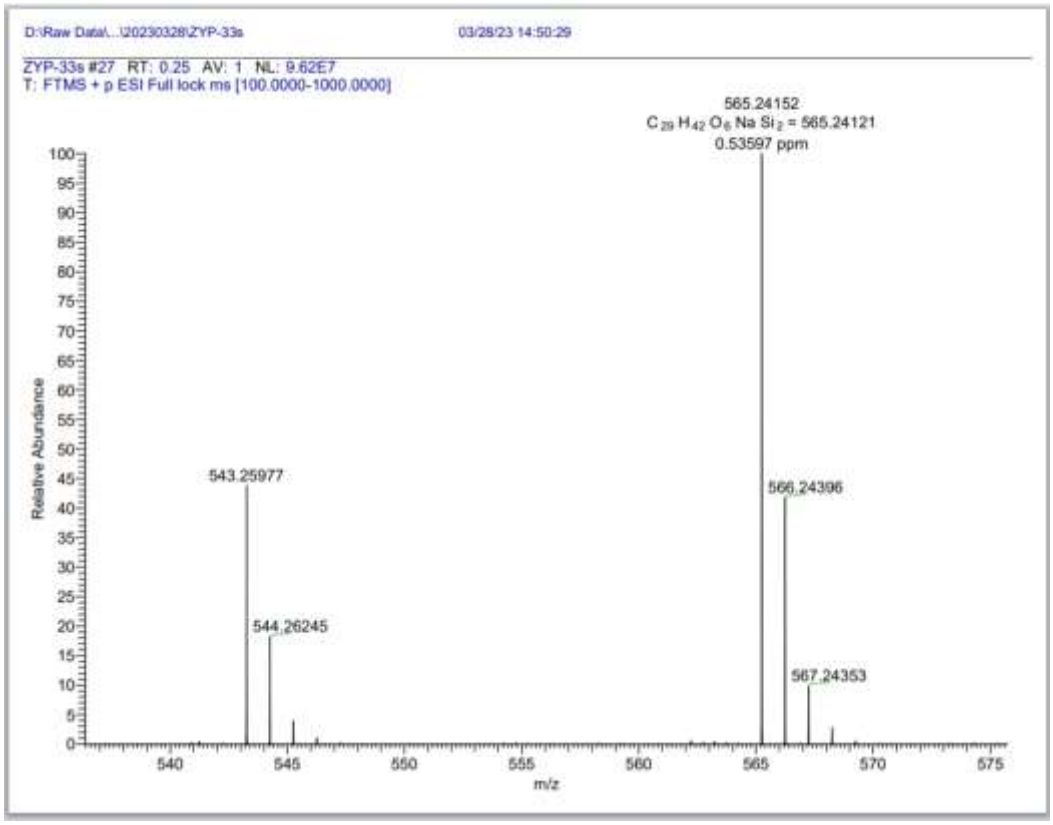
^{1}H NMR analysis of **7** (Chloroform-*d*)



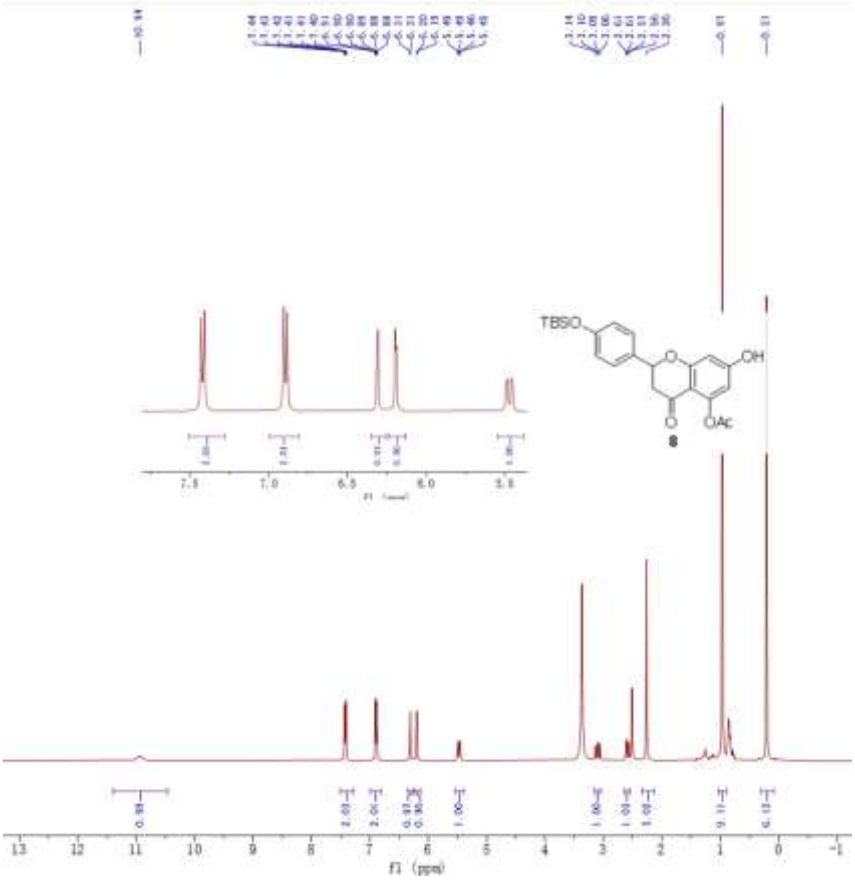
^{13}C NMR analysis of **7** (Chloroform-*d*)



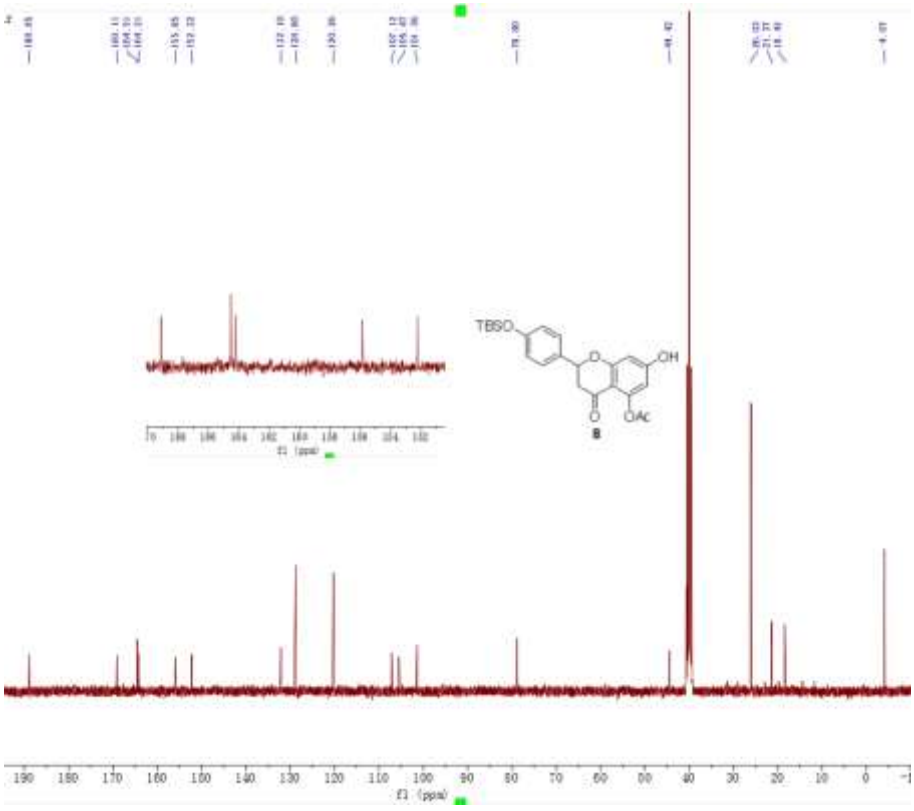
HRMS analysis of **7**



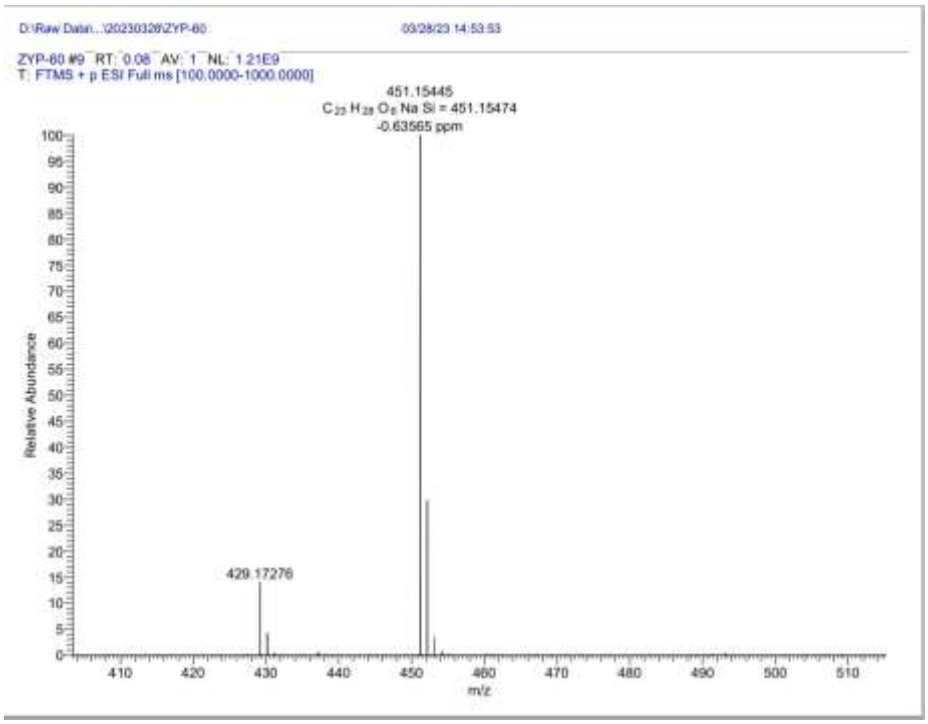
^{1}H NMR analysis of **8** (DMSO-d_6)



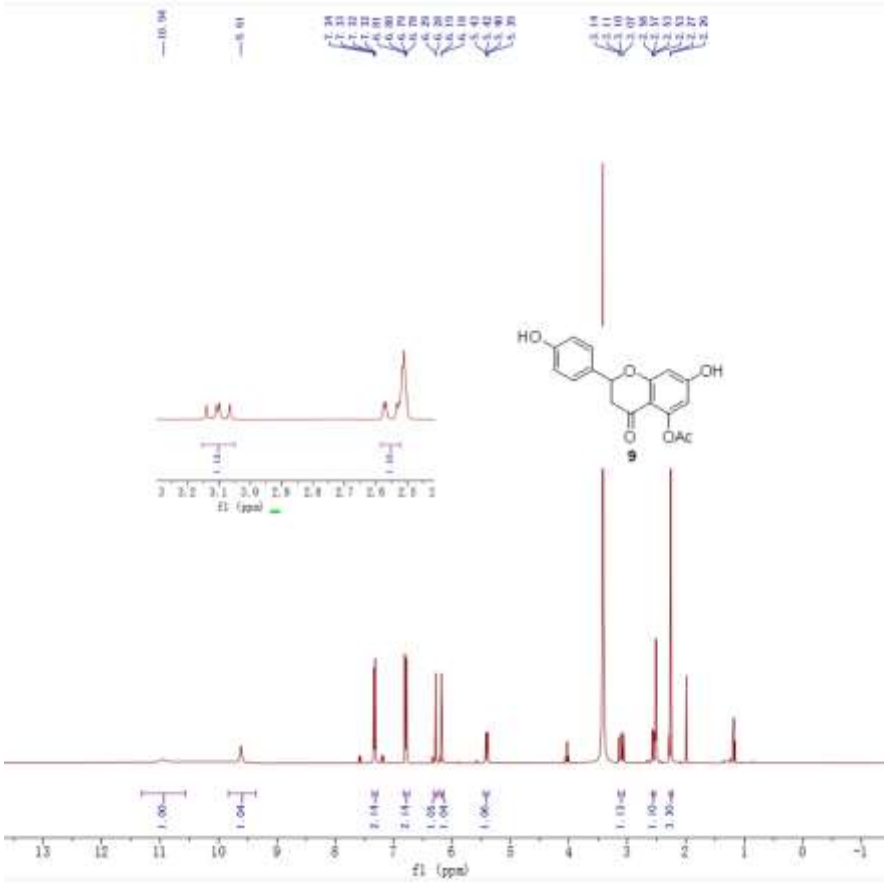
^{13}C NMR analysis of **8** (DMSO-d_6)



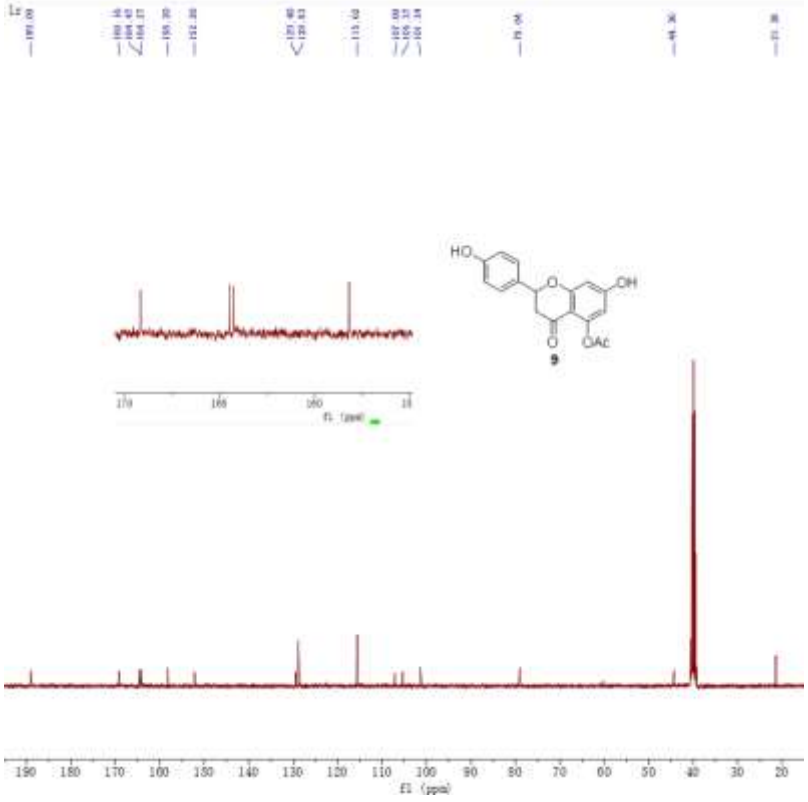
HRMS analysis of **8**



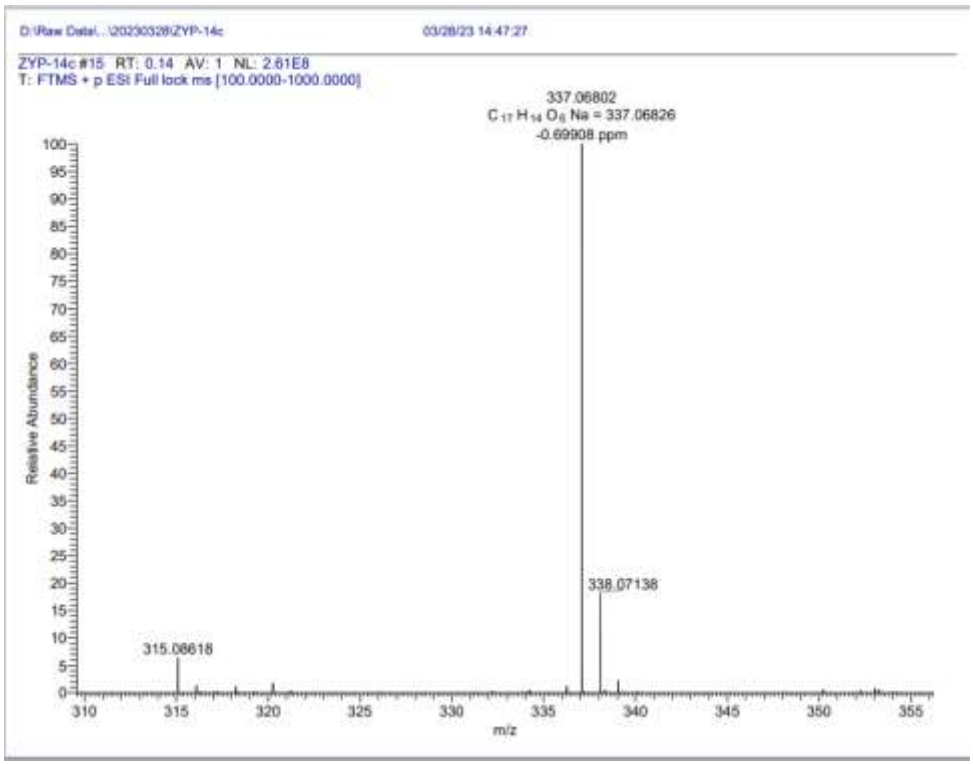
^{1}H NMR analysis of **9** (DMSO-d_6)



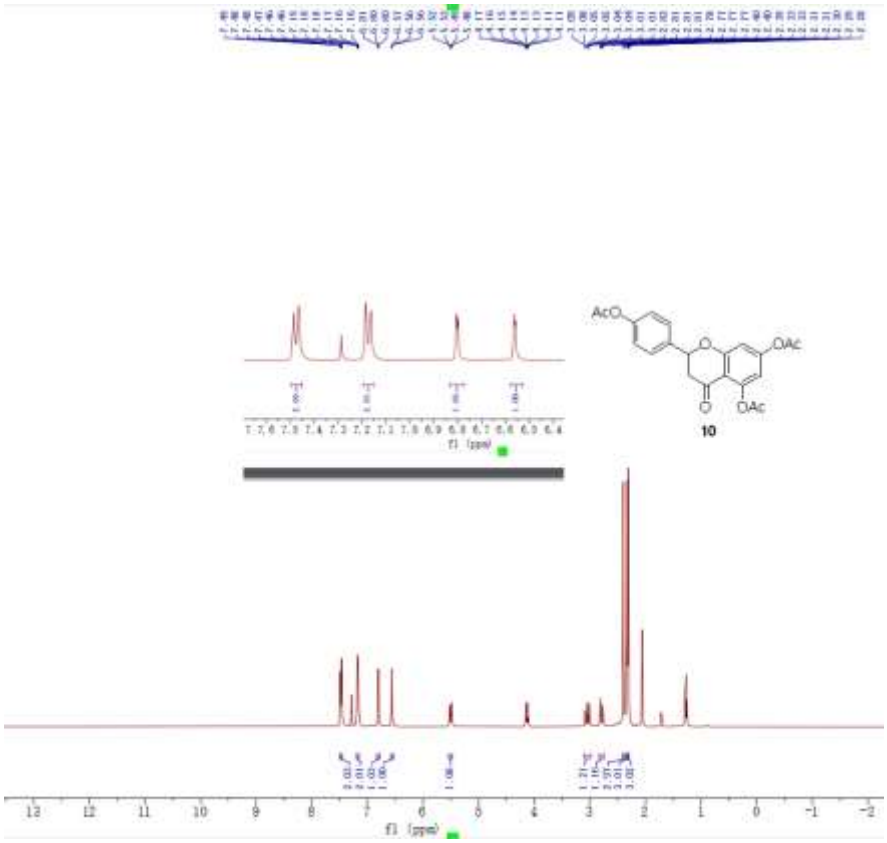
^{13}C NMR analysis of **9** (DMSO-d_6)



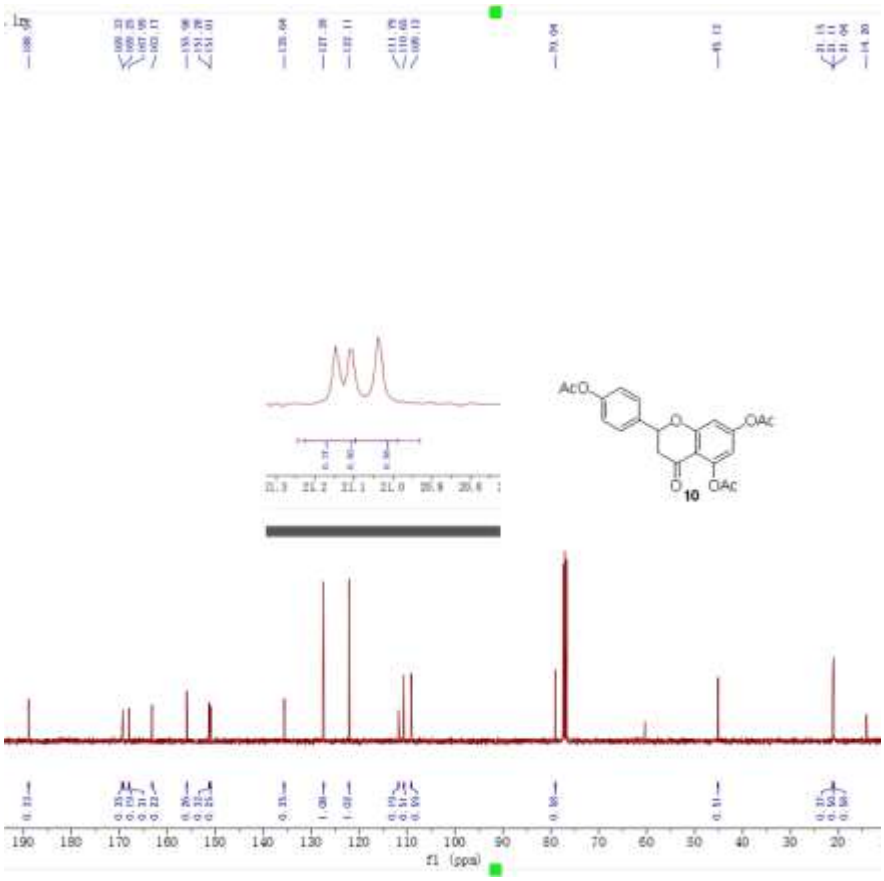
HRMS analysis of **9**



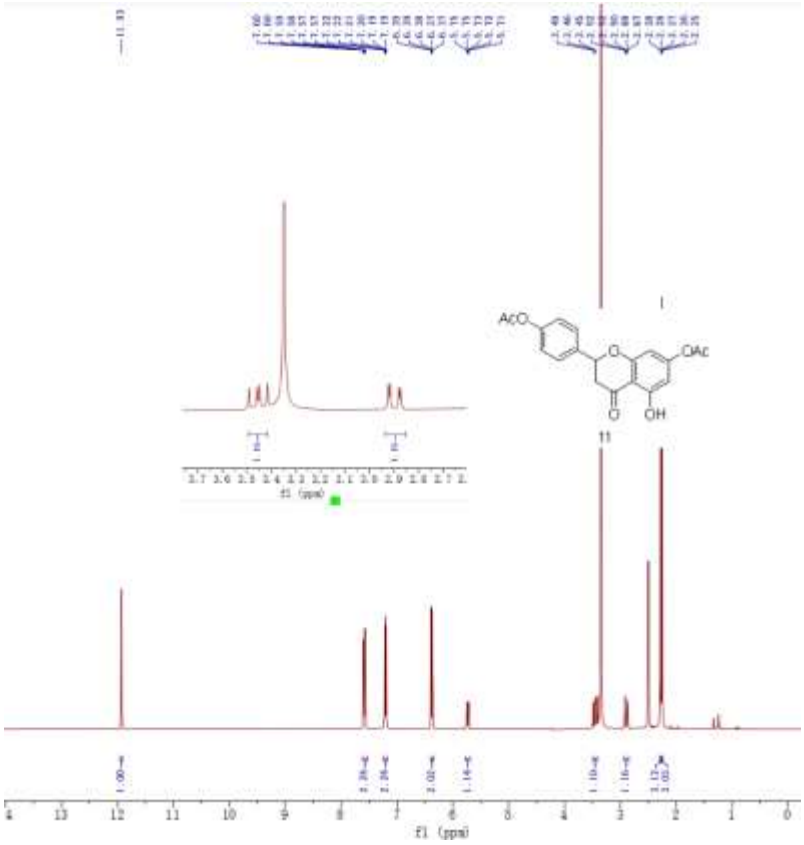
^{1}H NMR analysis of **10** (Chloroform-*d*)



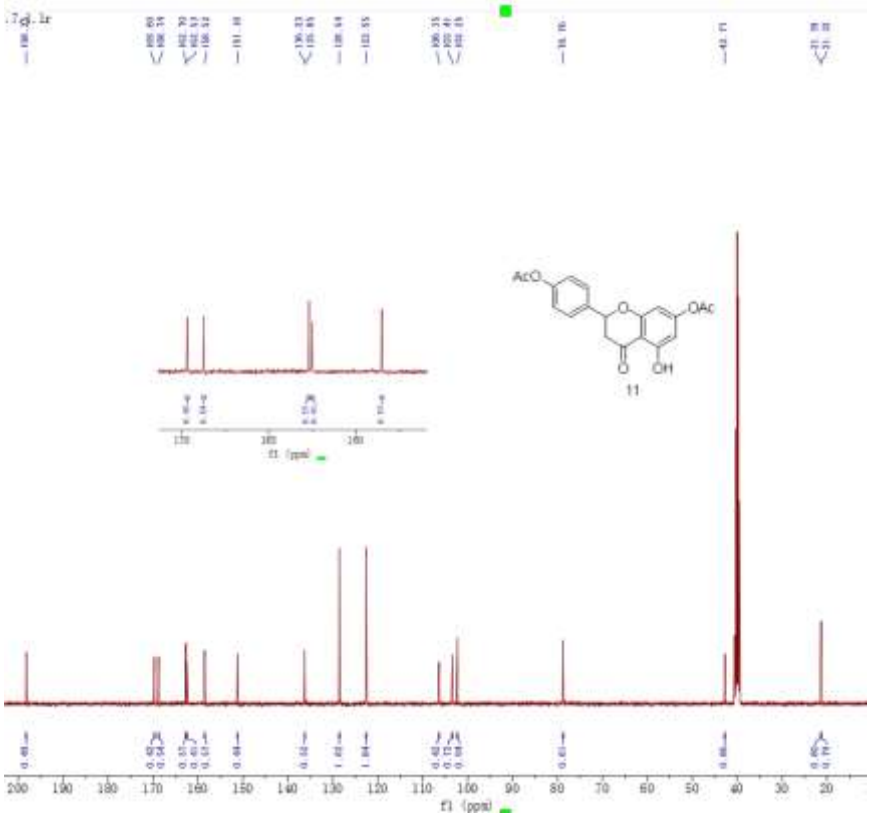
^{13}C NMR analysis of **10** (Chloroform-*d*)



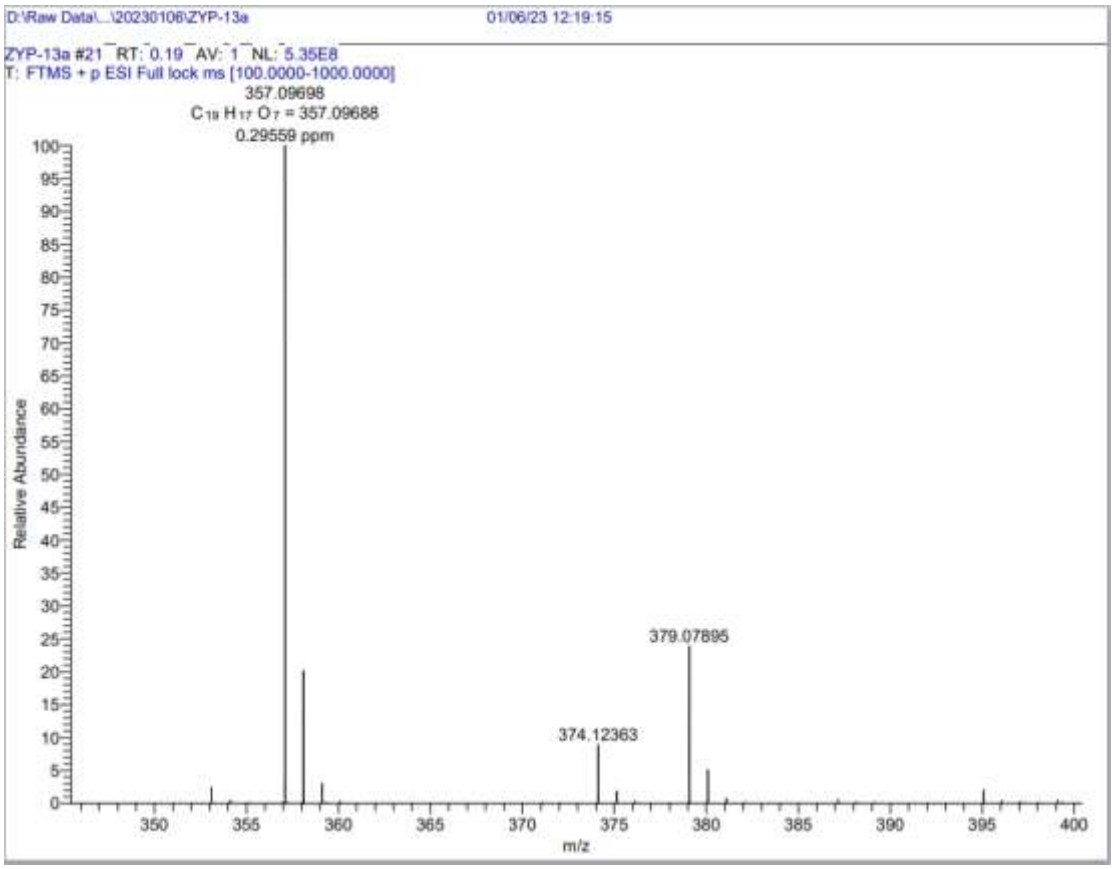
^{1}H NMR analysis of **11** (DMSO-d_6)



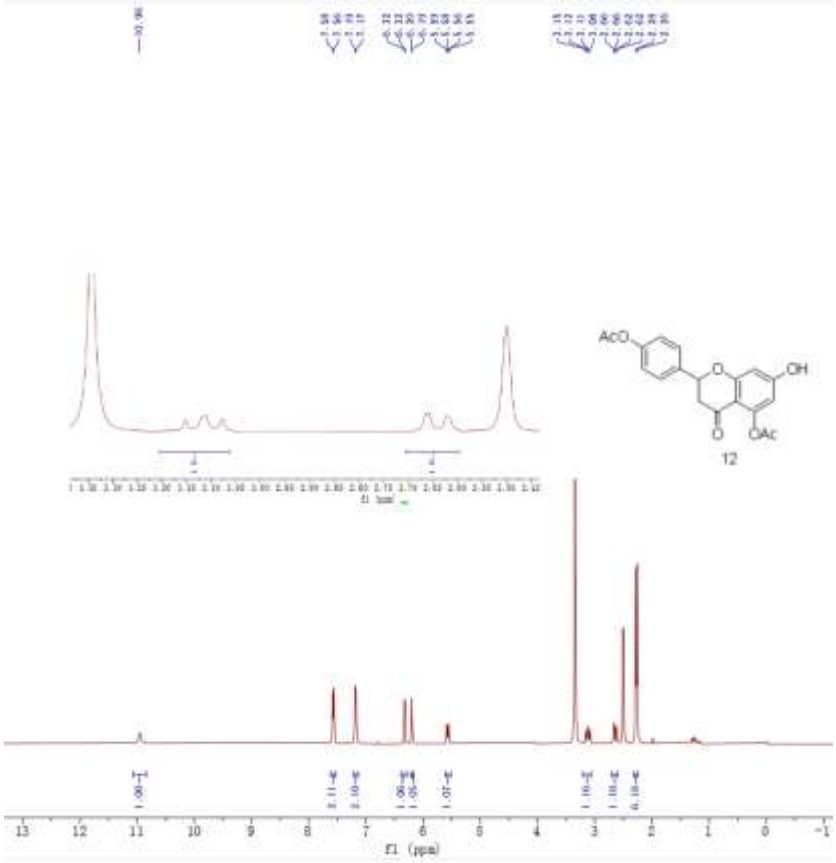
^{13}C NMR analysis of **11** (DMSO-d_6)



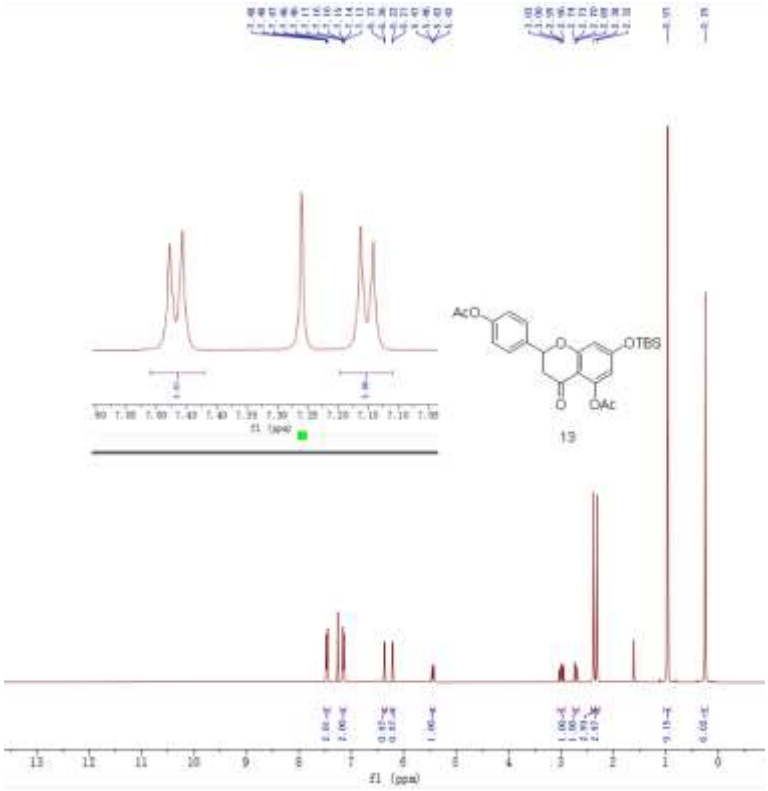
HRMS analysis of **11**



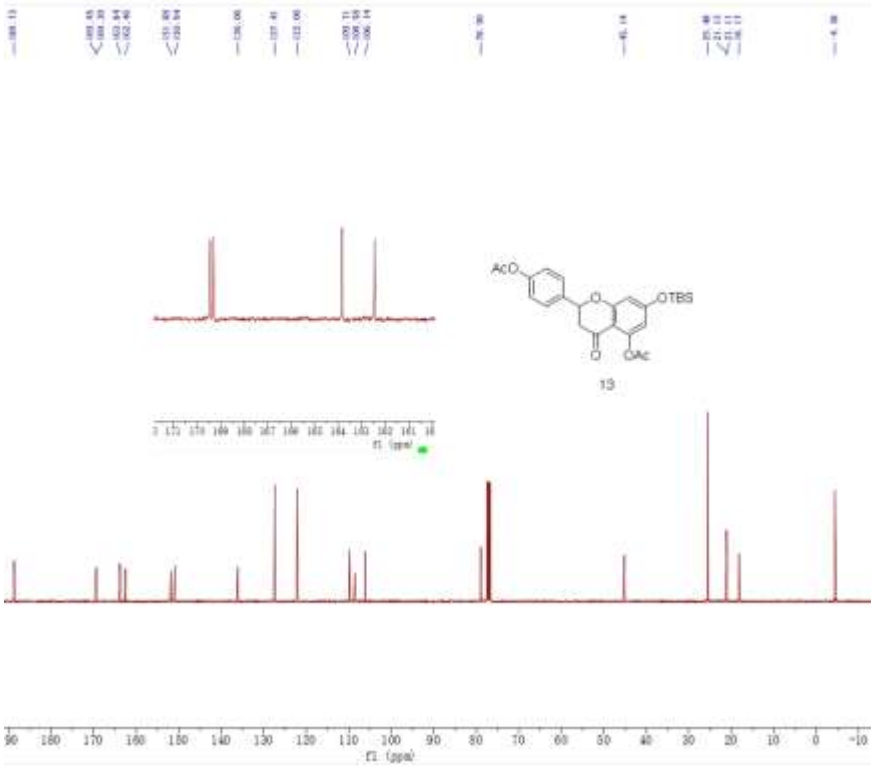
^{1}H NMR analysis of **12** (DMSO-d_6)



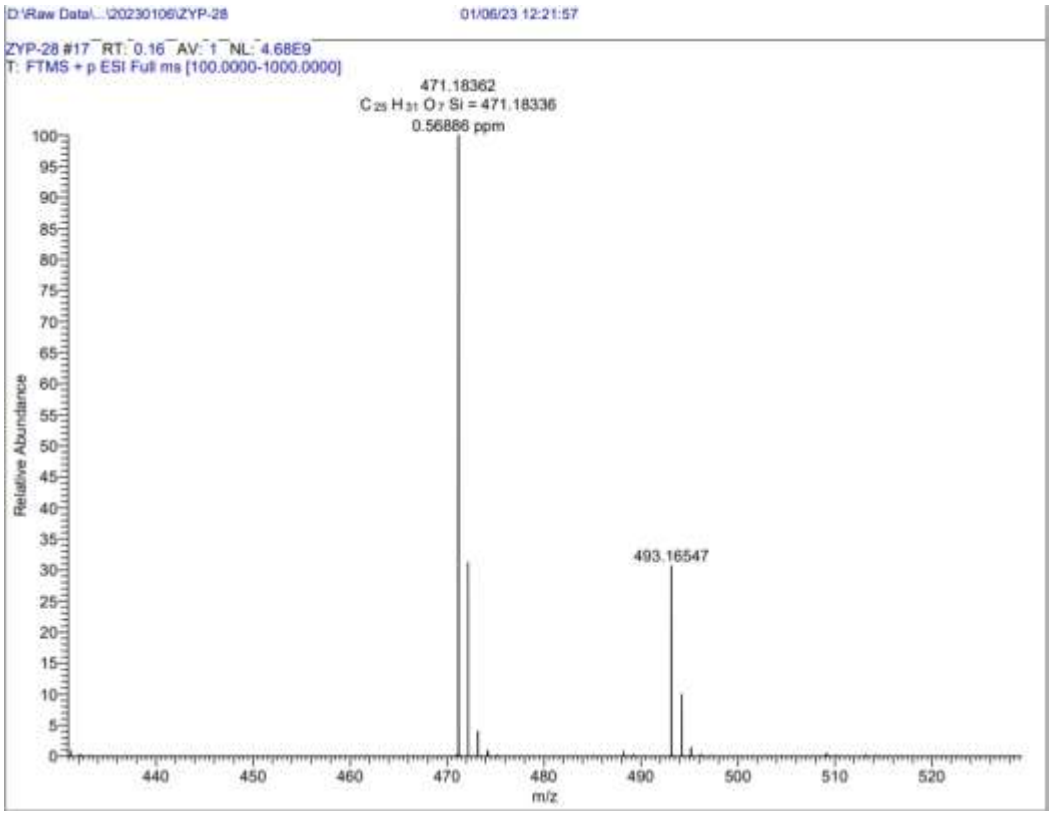
^{1}H NMR analysis of **13** (Chloroform-*d*)



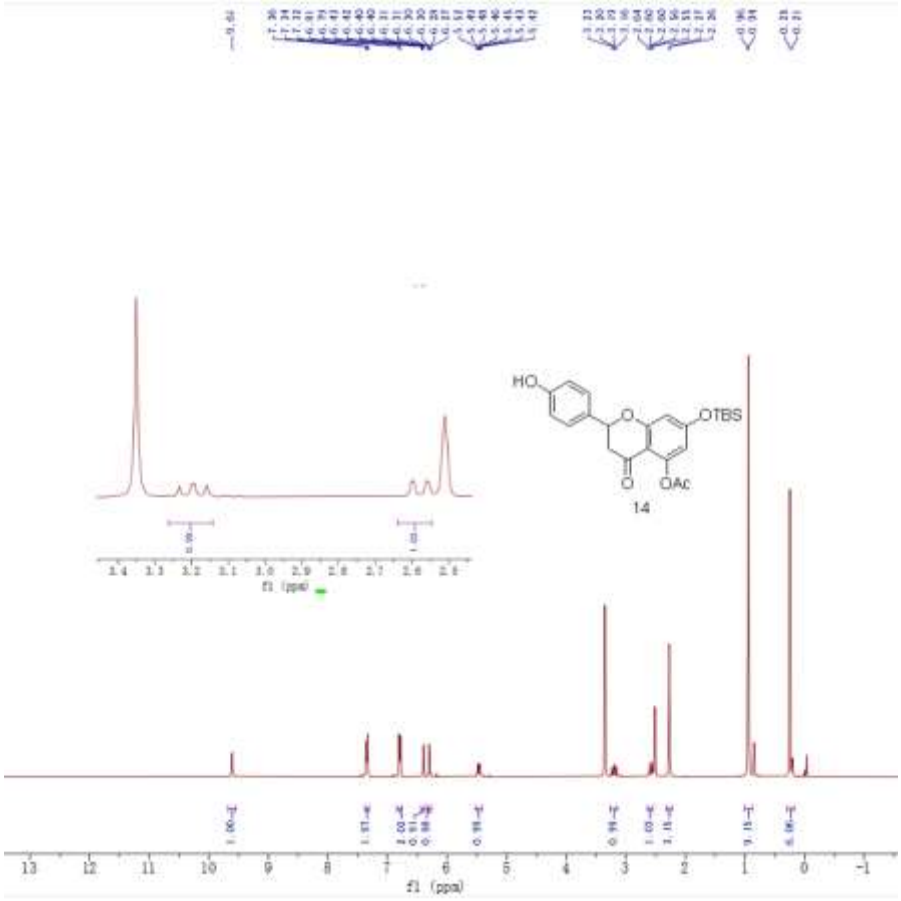
^{13}C NMR analysis of **13** (Chloroform-*d*)



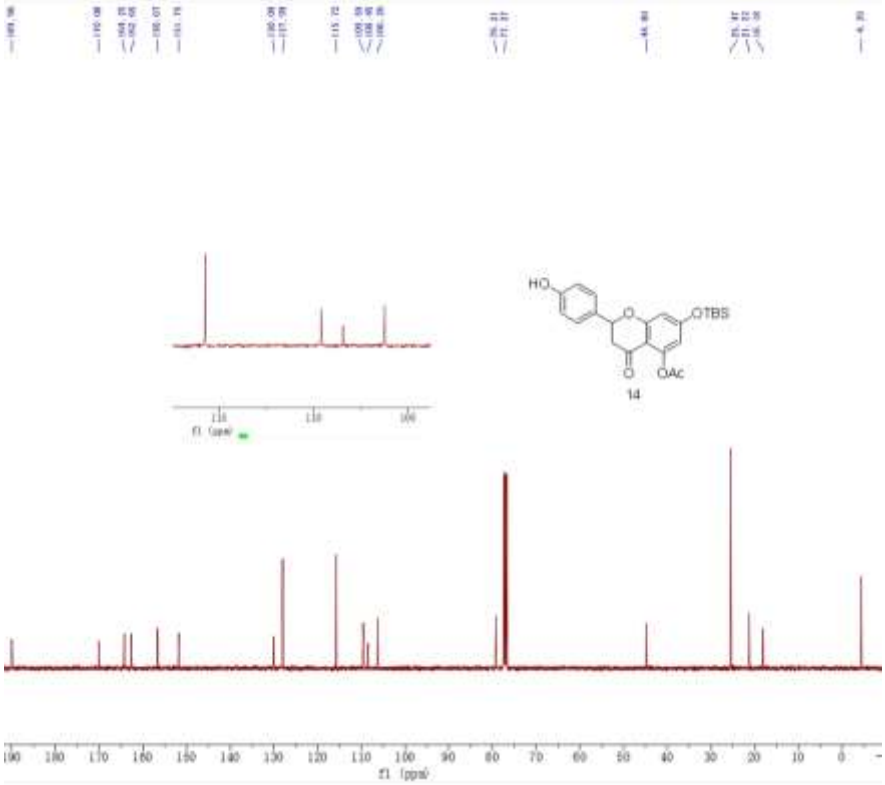
HRMS analysis of **13**



^{1}H NMR analysis of **14** (DMSO-d_6)



^{13}C NMR analysis of **14** (Chloroform-*d*)



HRMS analysis of **14**