Supporting Information

1,1′-Carbonyldiimidazole-mediated transformation of allomaltol containing hydrazides to substituted 3-acetyltetronic acids

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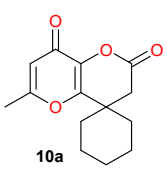
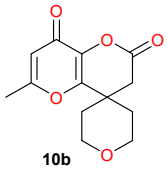
Table of content

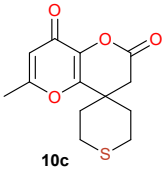
1. General information

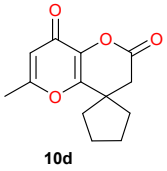
Unless otherwise stated, all starting chemicals were commercially available and were used as received. Compounds **10** and **15** were prepared according to a procedure described previously.[1] NMR spectra were recorded with Bruker AM 300 (300 MHz), Bruker DRX 500 (500 MHz) and Bruker AV 600 (600 MHz) spectrometers in DMSO-d_6. Chemical shifts (ppm) are given relative to solvent signals (DMSO-d_6: 2.50 ppm (^{1}H NMR) and 39.52 ppm (^{13}C NMR)). High-resolution mass spectra (HRMS) were obtained on a Bruker micrOTOF II instrument using electrospray ionization (ESI). The melting points were determined on a Kofler hot stage. Magnetic stirrer IKA C-MAG HS 7 was used for the reactions that require heating.

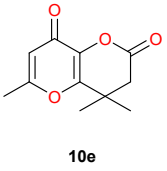
Compounds **10**:



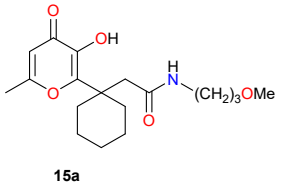


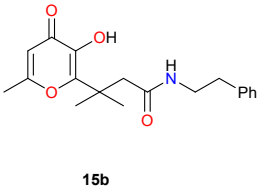


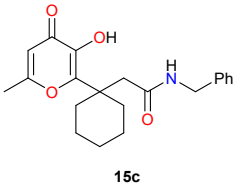


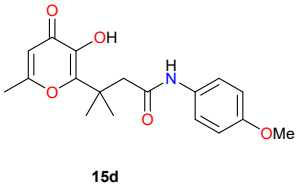


Compounds **15**:

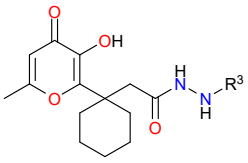




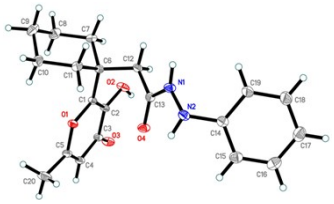




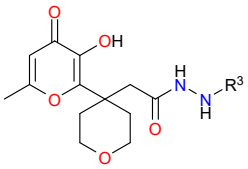
Synthesized compounds **7**:



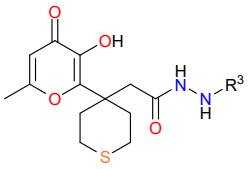
R^3 = Ph (**7a**), 73%
3,5-$(CH_3)_2C_6H_3$ (**7b**), 71%
4-BrC_6H_4 (**7c**), 76%
4-FC_6H_4 (**7d**), 67%
2-$CH_3C_6H_4$ (**7e**), 65%
2,4-$(F)_2C_6H_3$ (**7f**), 62%
t-Bu (**7g**), 53%



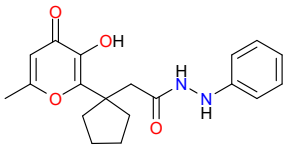
7a (CCDC 2270304)



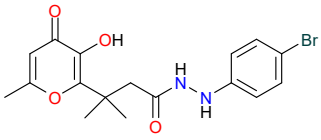
R^3 = Ph (**7h**), 78%
4-BrC_6H_4 (**7i**), 82%
4-FC_6H_4 (**7j**), 73%



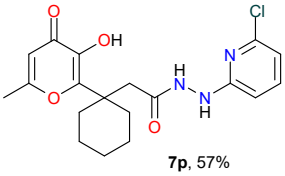
R^3 = Ph (**7k**), 79%
4-$CH_3CH_2C_6H_4$ (**7l**), 76%
4-BrC_6H_4 (**7m**), 84%



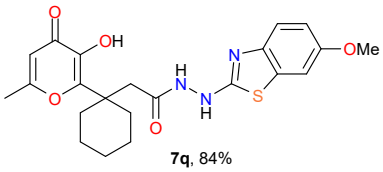
7n, 59%



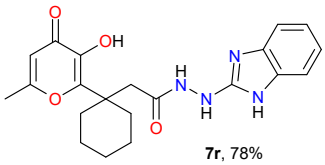
7o, 64%



7p, 57%

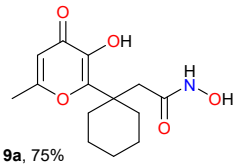


7q, 84%

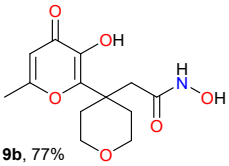


7r, 78%

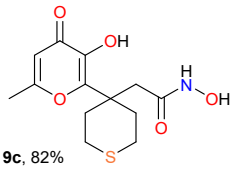
Synthesized compounds **9**:



9a, 75%



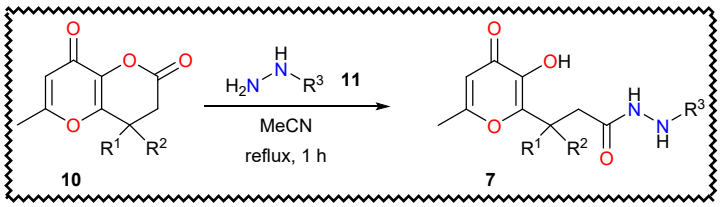
9b, 77%



9c, 82%

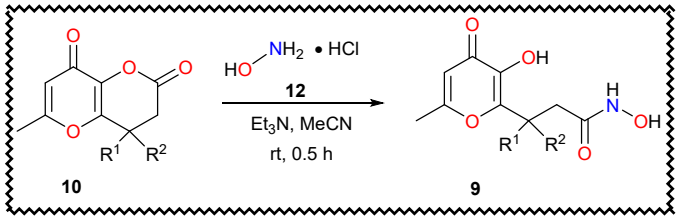
2. Experimental procedure

General experimental procedure for the synthesis of hydrazides 7



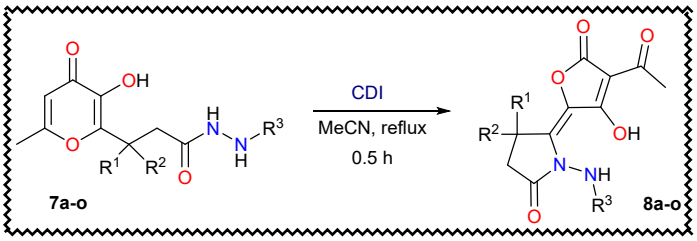
A mixture of lactone **10** (1 mmol) and the corresponding hydrazine **11** (1.1 mmol) (or hydrazine hydrochloride (1.1 mmol) and Et_3N (1.1 mmol, 0.11 g)) was refluxed in acetonitrile (5 ml) for 1 h. The resulting mixture was evaporated in vacuum and obtained residue was recrystallized from EtOH. The precipitate formed was filtered and washed with EtOH (3 × 5 ml).

General experimental procedure for the synthesis of compounds 9.



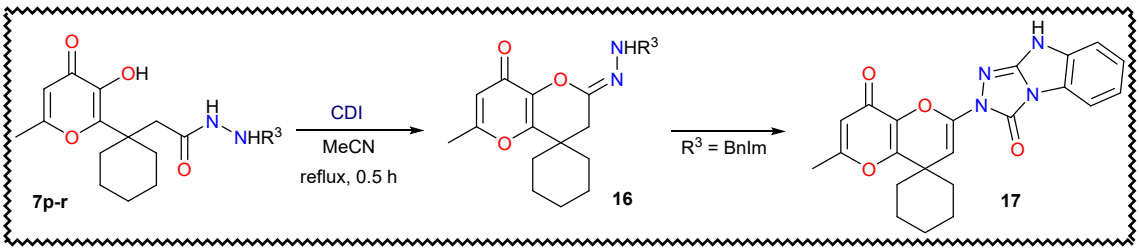
A mixture of lactone **10** (1 mmol), hydroxylamine hydrochloride **12** (0.08 g, 1.1 mmol) and Et_3N (1.1 mmol, 0.11 g) was stirred at room temperature in acetonitrile (5 ml) for 0.5 h. The resulting precipitate was filtered and washed with MeCN (3 × 5 ml).

General experimental procedure for the synthesis of 3-acetyltetronic acids 8



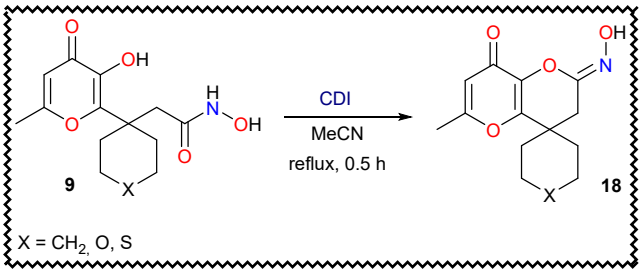
A mixture of corresponding hydrazide **7a**-**o** (1 mmol) and 1,1-carbonyldiimidazole (0.49 g, 3 mmol) was refluxed in acetonitrile (7 ml) for 0.5 h. The resulting solution was evaporated in vacuum and obtained residue was dissolved in EtOH (5 ml) and $HCl_{conc.}$ (0.7 g) was added. The precipitate formed was filtered and washed with EtOH (3 × 5 ml).

Experimental procedure for the synthesis of compounds 16,17



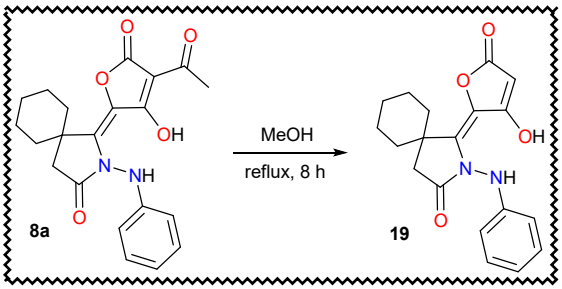
A mixture of corresponding hydrazide **7p**-**r** (1 mmol) and 1,1-carbonyldiimidazole (0.49 g, 3 mmol) was refluxed in acetonitrile (7 ml) for 0.5 h. The resulting solution was evaporated in vacuum and obtained residue was recrystallized from *i*-PrOH. The resulting precipitate was filtered and washed with *i*-PrOH (3 × 5 ml).

Experimental procedure for the synthesis of compounds 18



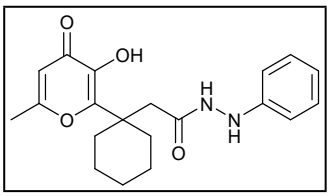
A mixture of corresponding hydroxamic acid (1 mmol) and 1,1-carbonyldiimidazole (0.49 g, 3 mmol) was refluxed in acetonitrile (7 ml) for 0.5 h. The resulting solution was evaporated in vacuum and H_2O (10 ml) was added. The obtained mixture was refluxed 1 h. The resulting precipitate was filtered and washed with H_2O (3 × 5 ml).

Experimental procedure for the synthesis of tetronic acid 19



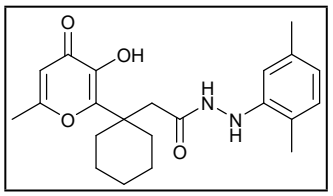
3-Acyltetronic acid **8a** (0.38 g, 1 mmol) in MeOH (5 ml) was refluxed for 8 h. After evaporation of the solvent in vacuum the target product **19** was obtained in pure form.

3. Characterization data for starting compounds 7 and 9



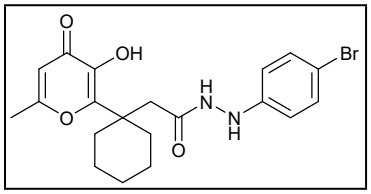
*2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)-N'-phenylacetohydrazide (**7a**)*

white powder; yield 73% (0.26 g); mp 212-214 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.51 (d, J = 2.9 Hz, 1H), 8.42 (br. s, 1H), 7.57 (d, J = 2.9 Hz, 1H), 7.13 – 7.02 (m, 2H), 6.70 – 6.57 (m, 3H), 6.21 (s, 1H), 2.59 (s, 2H), 2.44 – 2.30 (m, 2H), 2.19 (s, 3H), 1.66 – 1.43 (m, 5H), 1.42 – 1.21 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.81, 169.36, 164.14, 152.73, 149.37, 141.87, 128.57, 118.30, 112.03, 110.06, 41.72, 41.38, 33.19, 25.42, 22.51, 19.22. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{25}N_2O_4$: 357.1809; Found: 357.1793.



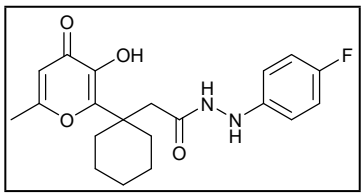
*N'-(2,5-dimethylphenyl)-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetohydrazide (**7b**)*

white powder; yield 71% (0.27 g); mp 204-206 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.49 (d, J = 3.1 Hz, 1H), 8.41 (br. s, 1H), 7.40 (d, J = 3.0 Hz, 1H), 6.31 (s, 1H), 6.26 (s, 2H), 6.19 (s, 1H), 2.59 (s, 2H), 2.40 – 2.29 (m, 2H), 2.18 (s, 3H), 2.13 (s, 6H), 1.66 – 1.43 (m, 5H), 1.40 – 1.26 (m, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173.8, 169.3, 164.1, 152.9, 149.4, 141.8, 137.5, 120.2, 110.1, 41.7, 33.0, 25.4, 22.5, 21.1, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{22}H_{29}N_2O_4$: 385.2122; Found: 385.2110.



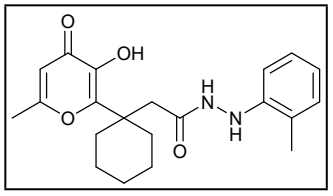
*N'-(4-bromophenyl)-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetohydrazide (**7c**)*

yellowish powder; yield 76% (0.33 g); mp 231-233 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.56 (d, J = 2.7 Hz, 1H), 8.44 (br. s, 1H), 7.80 (d, J = 2.6 Hz, 1H), 7.22 (d, J = 8.7 Hz, 2H), 6.55 (d, J = 8.8 Hz, 2H), 6.22 (s, 1H), 2.58 (s, 2H), 2.42 – 2.27 (m, 2H), 2.20 (s, 3H), 1.65 – 1.44 (m, 5H), 1.42 – 1.27 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.82, 169.43, 164.17, 152.65, 148.75, 141.90, 131.18, 113.99, 110.05, 109.03, 41.73, 41.40, 33.26, 25.40, 22.50, 19.23. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{24}BrN_2O_4$: 435.0914; Found: 435.0911.



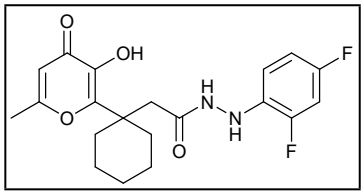
*N'-(4-fluorophenyl)-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetohydrazide (**7d**)*

white powder; yield 67% (0.25 g); mp 208-210 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.54 (d, J = 3.1 Hz, 1H), 8.44 (br.s, 1H), 7.57 (d, J = 3.1 Hz, 1H), 6.99 – 6.87 (m, 2H), 6.67 – 6.54 (m, 2H), 6.21 (s, 1H), 2.58 (s, 2H), 2.42 – 2.30 (m, 2H), 2.19 (s, 3H), 1.65 – 1.43 (m, 5H), 1.40 – 1.26 (m, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173.8, 169.4, 164.2, 155.7 (d, J = 233.2 Hz), 152.7, 145.9, 141.9, 115.0 (d, J = 22.2 Hz), 113.2 (d, J = 7.6 Hz), 110.1, 41.7, 41.4, 33.2, 25.4, 22.5, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{24}FN_2O_4$: 375.1715; Found: 375.1720.



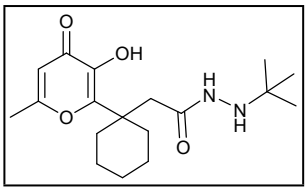
*2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)-N'-(o-tolyl)acetohydrazide (**7e**)*

white powder; yield 65% (0.24 g); mp 181-183 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.56 (s, 1H), 8.46 (s, 1H), 7.01 – 6.89 (m, 3H), 6.66 – 6.58 (m, 1H), 6.49 (d, J = 8.0 Hz, 1H), 6.21 (s, 1H), 2.64 (s, 2H), 2.40 – 2.30 (m, 2H), 2.18 (s, 3H), 2.09 (s, 3H), 1.63 – 1.46 (m, 5H), 1.39 – 1.27 (m, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173.79, 169.32, 164.10, 152.88, 146.67, 141.82, 129.83, 126.29, 121.64, 118.44, 110.74, 110.09, 41.61, 41.18, 33.14, 25.42, 22.49, 19.24, 17.18. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{21}H_{27}N_2O_4$: 371.1965; Found: 371.1955.



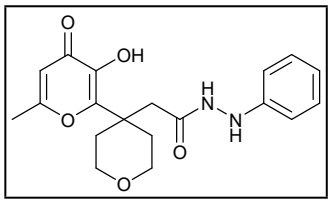
*N'-(2,4-difluorophenyl)-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetohydrazide (**7f**)*

white powder; yield 62% (0.24 g); mp 190-192 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.62 (d, J = 2.7 Hz, 1H), 8.46 (br.s, 1H), 7.43 (s, 1H), 7.16 – 7.02 (m, 1H), 6.89 – 6.77 (m, 1H), 6.67 – 6.53 (m, 1H), 6.21 (s, 1H), 2.59 (s, 2H), 2.41 – 2.25 (m, 2H), 2.19 (s, 3H), 1.68 – 1.43 (m, 5H), 1.41 – 1.23 (m, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173.81, 169.58, 164.16, 154.62 (dd, J = 236.1, 11.0 Hz), 152.68, 149.37 (dd, J = 242.7, 12.1 Hz), 141.88, 133.70 (dd, J = 11.4, 2.2 Hz), 113.89 (dd, J = 9.1, 4.8 Hz), 110.62 (dd, J = 21.6, 3.4 Hz), 110.07, 103.55 (dd, J = 27.0, 22.3 Hz), 41.69, 41.34, 33.22, 25.39, 22.49, 19.21. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{23}F_2N_2O_4$: 393.1620; Found: 393.1619.



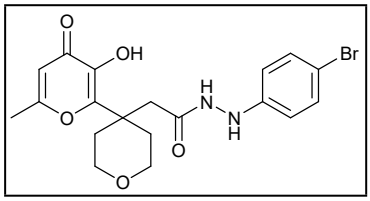
*N'-(tert-butyl)-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetohydrazide (**7g**)*

white powder; yield 53% (0.18 g); mp 190-192 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.04 (s, 1H), 8.36 (br.s, 1H), 6.20 (s, 1H), 4.53 (br.s, 1H), 2.48 (s, 2H), 2.41 – 2.29 (m, 2H), 2.20 (s, 3H), 1.63 – 1.40 (m, 5H), 1.37 – 1.21 (m, 3H), 0.92 (s, 9H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.8, 168.0, 164.0, 152.6, 141.9, 110.0, 53.9, 41.9, 41.8, 33.2, 27.1, 25.4, 22.5, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{18}H_{29}N_2O_4$: 337.2122; Found: 337.2121.



*2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-pyran-4-yl)-N'-phenylacetohydrazide (**7h**)*

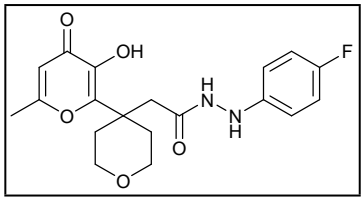
white powder; yield 78% (0.28 g); mp 171-173 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.57 (s, 1H), 8.66 (br. s, 1H), 7.61 (s, 1H), 7.12 – 7.02 (m, 2H), 6.70 – 6.64 (m, 1H), 6.59 (d, J = 7.9 Hz, 2H), 6.24 (s, 1H), 3.82 – 3.73 (m, 2H), 3.42 (d, J = 10.7 Hz, 2H), 2.65 (s, 2H), 2.39 (d, J = 13.7 Hz, 2H), 2.19 (s, 3H), 1.81 – 1.66 (m, 2H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 173.83, 169.00, 164.34, 151.24, 149.24, 142.14, 128.56, 118.30, 111.99, 110.23, 64.01, 41.37, 39.56, 33.48, 19.19. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{23}N_2O_5$: 359.1601; Found: 359.1587.



*N'-(4-bromophenyl)-2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-pyran-4-yl)acetohydrazide (**7i**)*

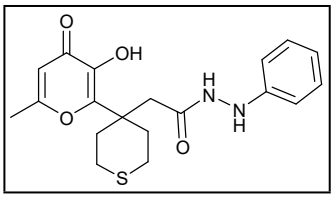
white powder; yield 82% (0.36 g); mp 204-206 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.61 (s, 1H), 8.68 (s, 1H), 7.82 (s, 1H), 7.22 (d, J = 8.4 Hz, 2H), 6.53 (d, J = 8.4 Hz, 2H), 6.25 (s, 1H), 3.75 (d, J = 12.0 Hz, 2H), 3.41 (d, J = 10.8 Hz, 2H), 2.64 (s, 2H), 2.38 (d, J = 13.8 Hz, 2H), 2.20 (s, 3H), 1.77 – 1.64 (m, 2H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 173.86, 169.08, 164.40, 151.17, 148.64, 142.18, 131.18, 113.96, 110.23,

109.05, 64.02, 41.43, 39.60, 33.57, 19.20. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{22}BrN_2O_5$: 439.0687; Found: 439.0677.



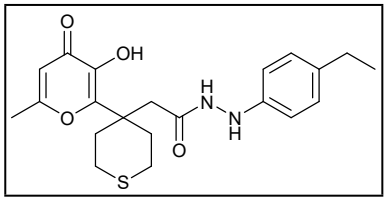
*N'-(4-fluorophenyl)-2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-pyran-4-yl)acetohydrazide (**7j**)*

white powder; yield 73% (0.27 g); mp 192-194 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.59 (s, 1H), 8.67 (s, 1H), 7.59 (s, 1H), 6.98 – 6.87 (m, 2H), 6.65 – 6.53 (m, 2H), 6.24 (s, 1H), 3.83 – 3.70 (m, 2H), 3.41 (d, *J* = 11.0 Hz, 2H), 2.64 (s, 2H), 2.38 (d, *J* = 13.8 Hz, 2H), 2.19 (s, 3H), 1.76 – 1.63 (m, 2H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 173.86, 169.06, 164.37, 155.70 (d, *J* = 232.8 Hz), 151.21, 145.81, 142.17, 114.98 (d, *J* = 22.2 Hz), 113.18 (d, *J* = 7.8 Hz), 110.23, 64.02, 41.43, 39.60, 33.53, 19.19. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{22}FN_2O_5$: 377.1507; Found: 377.1505.



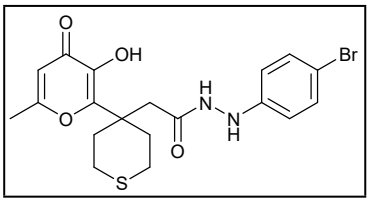
*2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-thiopyran-4-yl)-N'-phenylacetohydrazide(**7k**)*

white powder; yield 79% (0.3 g); mp 211-213 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.57 (d, *J* = 3.0 Hz, 1H), 8.63 (br.s, 1H), 7.60 (d, *J* = 2.9 Hz, 1H), 7.14 – 7.04 (m, 2H), 6.67 (d, *J* = 7.3 Hz, 1H), 6.61 (d, *J* = 8.0 Hz, 2H), 6.23 (s, 1H), 2.69 – 2.61 (m, 8H), 2.20 (s, 3H), 1.94 – 1.80 (m, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.8, 168.9, 164.5, 151.1, 149.3, 142.1, 128.6, 118.3, 112.0, 110.2, 41.5, 41.1, 34.2, 24.0, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{23}N_2O_4S$: 375.1373; Found: 375.1381.



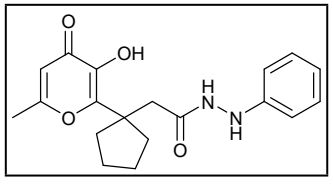
*N'-(4-ethylphenyl)-2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-thiopyran-4-yl)acetohydrazide (**7l**)*

yellowish powder; yield 76% (0.31 g); mp 225-227 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.55 (d, *J* = 3.3 Hz, 1H), 8.62 (br.s, 1H), 7.44 (d, *J* = 3.2 Hz, 1H), 6.93 (d, *J* = 7.9 Hz, 2H), 6.54 (d, *J* = 8.0 Hz, 2H), 6.23 (s, 1H), 2.75 – 2.54 (m, 8H), 2.47 – 2.40 (m, 2H), 2.20 (s, 3H), 1.94 – 1.75 (m, 2H), 1.11 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173.9, 168.9, 164.5, 151.2, 147.2, 142.1, 133.7, 127.8, 112.3, 110.2, 41.5, 41.1, 34.2, 27.4, 24.0, 19.2, 16.0. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{21}H_{27}N_2O_4S$: 403.1686; Found: 403.1684.



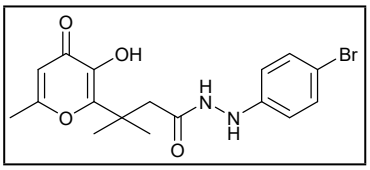
*N'-(4-bromophenyl)-2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-thiopyran-4-yl)acetohydrazide (**7m**)*

white powder; yield 84% (0.38 g); mp 222-224 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.62 (d, *J* = 2.7 Hz, 1H), 8.65 (br.s, 1H), 7.82 (d, *J* = 2.7 Hz, 1H), 7.23 (d, *J* = 8.3 Hz, 2H), 6.55 (d, *J* = 8.5 Hz, 2H), 6.24 (s, 1H), 2.74 – 2.56 (m, 8H), 2.21 (s, 3H), 1.92 – 1.81 (m, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.8, 169.0, 164.5, 151.1, 148.6, 142.1, 131.2, 114.0, 110.2, 109.1, 41.5, 41.1, 34.3, 24.0, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{22}BrN_2O_4S$: 453.0478; Found: 453.0467.



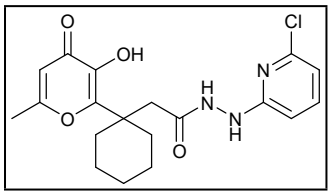
*2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclopentyl)-N'-phenylacetohydrazide (**7n**)*

white powder; yield 59% (0.2 g); mp 212-214 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.51 (d, J = 2.8 Hz, 1H), 8.43 (br.s, 1H), 7.58 (d, J = 2.8 Hz, 1H), 7.14 – 7.03 (m, 2H), 6.71 – 6.56 (m, 3H), 6.18 (s, 1H), 2.67 (s, 2H), 2.27 – 2.12 (m, 5H), 1.88 – 1.52 (m, 6H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.7, 169.9, 163.7, 153.9, 149.4, 141.1, 128.5, 118.3, 112.0, 110.3, 48.5, 39.9, 35.5, 23.2, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{23}N_2O_4$: 343.1652; Found: 343.1650.



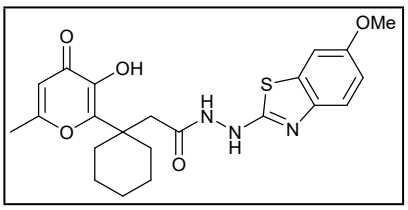
*N'-(4-bromophenyl)-3-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)-3-methylbutanehydrazide (**7o**)*

white powder; yield 64% (0.25 g); mp 190-192 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.60 (s, 1H), 8.48 (br. s, 1H), 7.85 (s, 1H), 7.23 (d, J = 8.3 Hz, 2H), 6.57 (d, J = 8.4 Hz, 2H), 6.20 (s, 1H), 2.65 (s, 2H), 2.21 (s, 3H), 1.38 (s, 6H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173. 8, 169.9, 163.8, 154.0, 148.8, 141.1, 131.2, 114.0, 110.2, 109.0, 42.3, 37.6, 25.6, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{17}H_{20}BrN_2O_4$: 395.0601; Found: 395.0605.



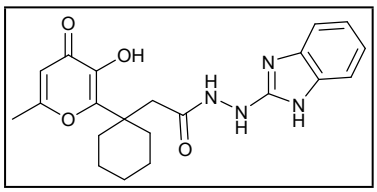
*N'-(6-chloropyridin-2-yl)-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetohydrazide (**7p**)*

White powder; yield 57% (0.22 g); mp 180-182 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.71 (s, 1H), 8.59 (s, 1H), 8.45 (s, 1H), 7.56 – 7.44 (m, 1H), 6.69 (d, J = 7.5 Hz, 1H), 6.37 (d, J = 8.2 Hz, 1H), 6.20 (s, 1H), 2.58 (s, 2H), 2.44 – 2.32 (m, 2H), 2.19 (s, 3H), 1.65 – 1.45 (m, 5H), 1.37 – 1.21 (m, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173.8, 169.4, 164.2, 160.1, 152.7, 148.2, 141.9, 140.4, 113.0, 110.1, 104.5, 41.8, 41.4, 33.1, 25.4, 22.6, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{23}ClN_3O_4$: 392.1372; Found: 392.1365.



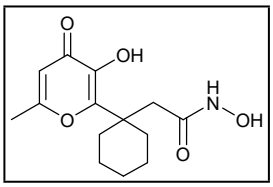
*2-(1-(4-hydroxy-6-methyl-4H-pyran-2-yl)cyclohexyl)-N'-(6-methoxybenzo[d]thiazol-2-yl)acetohydrazide (**7q**)*

grey powder; yield 84% (0.37 g); mp 216-218 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.16 (s, 1H), 9.52 (br. s, 1H), 8.50 (br. s, 1H), 7.40 – 7.30 (m, 2H), 6.87 (dd, J = 8.8, 2.7 Hz, 1H), 6.21 (s, 1H), 3.75 (s, 3H), 2.61 (s, 2H), 2.43 – 2.31 (m, 2H), 2.20 (s, 3H), 1.68 – 1.42 (m, 5H), 1.41 – 1.26 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.9, 169.9, 169.0, 164.2, 154.8, 152.6, 146.5, 141.9, 131.4, 119.3, 113.5, 110.2, 105.5, 55.6, 41.7, 41.0, 33.0, 25.4, 22.5, 19.3. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{22}H_{26}N_3O_5S$: 444.1588; Found: 444.1581.



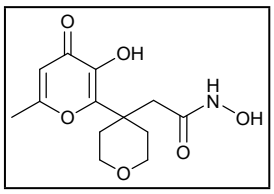
*N'-(1H-benzo[d]imidazol-2-yl)-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetohydrazide (7**r**)*

white powder; yield 78% (0.31 g); mp 165-167 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 11.05 (br.s, 1H), 9.80 (s, 1H), 8.85 – 8.29 (m, 2H), 7.24 – 7.13 (m, 2H), 6.97 – 6.84 (m, 2H), 6.19 (s, 1H), 2.62 (s, 2H), 2.38 (d, J = 12.4 Hz, 2H), 2.21 (s, 3H), 1.65 – 1.45 (m, 5H), 1.41 – 1.20 (m, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 173.85, 169.95, 164.10, 155.93, 152.98, 141.81, 110.13, 41.63, 32.98, 25.42, 22.54, 19.21. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{21}H_{25}N_4O_4$: 397.1870; Found: 397.1867.



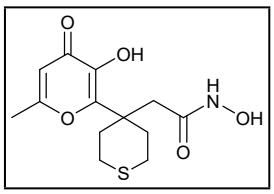
*N-hydroxy-2-(1-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)cyclohexyl)acetamide (**9a**)*

White powder; yield 75% (0.21 g); mp 187-189 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.29 (s, 1H), 8.63 (br.s, 1H), 8.40 (br.s, 1H), 6.21 (s, 1H), 2.39 – 2.26 (m, 4H), 2.22 (s, 3H), 1.58 – 1.19 (m, 8H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.8, 166.4, 164.1, 152.7, 141.8, 110.0, 41.7, 40.6, 33.0, 25.4, 22.5, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{14}H_{20}NO_5$: 282.1336; Found: 282.1334.



*N-hydroxy-2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-pyran-4-yl)acetamide (**9b**)*

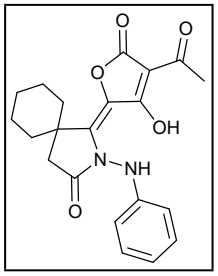
White powder; yield 77% (0.22 g); mp 202-204 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.33 (s, 1H), 8.77 – 8.46 (m, 2H), 6.23 (s, 1H), 3.81 – 3.65 (m, 2H), 3.44 – 3.34 (m, 2H), 2.40 (s, 2H), 2.38 – 2.27 (m, 2H), 2.23 (s, 3H), 1.75 – 1.58 (m, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.9, 166.0, 164.4, 151.3, 142.1, 110.2, 64.1, 40.4, 33.2, 19.2. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{13}H_{18}NO_6$: 284.1129; Found: 284.1132.



*N-hydroxy-2-(4-(3-hydroxy-6-methyl-4-oxo-4H-pyran-2-yl)tetrahydro-2H-thiopyran-4-yl)acetamide (**9c**)*

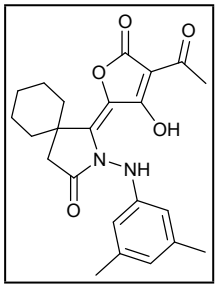
White powder; yield 82% (0.25 g); mp 179-181 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.35 (s, 1H), 8.80 – 8.44 (m, 2H), 6.23 (s, 1H), 2.71 – 2.53 (m, 6H), 2.34 (s, 2H), 2.24 (s, 3H), 1.86 – 1.71 (m, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 173.9, 165.8, 164.5, 151.1, 142.2, 110.2, 41.2, 40.9, 34.1, 24.1, 19.3. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{13}H_{18}NO_5S$: 300.0900; Found: 300.0907.

4. Characterization data for 3-acetyltetronic acids 8 and intermediates 14



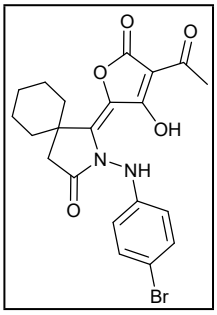
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-(phenylamino)-2-azaspiro[4.5]decan-3-one (**8a**)*

Yellowish powder; yield 64% (0.24 g); mp 204-206 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.32 – 7.18 (m, 2H), 6.99 – 6.87 (m, 1H), 6.75 (d, J = 7.9 Hz, 2H), 4.68 - 4.41 (m, 2H in H_2O), 2.74 (s, 2H), 2.25 (s, 3H), 2.22 – 2.07 (m, 2H), 1.74 – 1.58 (m, 5H), 1.50 – 1.31 (m, 2H), 1.31 – 1.14 (m, 1H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.7, 175.6, 171.6, 166.3, 144.8, 142.6, 129.3, 125.7, 122.4, 114.5, 98.2, 41.7, 38.2, 32.6, 28.2, 24.7, 21.6. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{21}H_{23}N_2O_5$: 383.1601; Found: 383.1605.



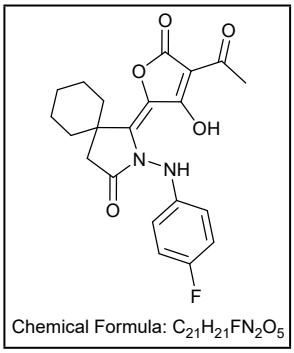
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((3,5-dimethylphenyl)amino)-2-azaspiro[4.5]decan-3-one (**8b**)*

White powder; yield 53% (0.22 g); mp 206-208 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 6.59 (s, 1H), 6.36 (s, 2H), 4.28 - 4.06 (m, 2H in H_2O), 2.74 (s, 2H), 2.24 (s, 3H), 2.18 (s, 7H), 1.73 – 1.58 (m, 5H), 1.53 – 1.30 (m, 3H), 1.31 – 1.13 (m, 1H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.6, 174.7, 171.5, 166.3, 144.5, 143.0, 138.6, 125.3, 124.5, 112.4, 98.4, 41.7, 40.4, 38.2, 32.7, 28.6, 24.7, 21.6, 21.1. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{23}H_{27}N_2O_5$: 411.1912; Found: 411.1914.



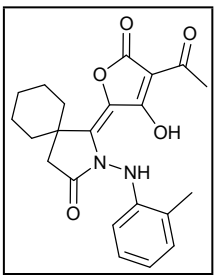
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((4-bromophenyl)amino)-2-azaspiro[4.5]decan-3-one (**8c**)*

Yellowish powder; yield 65% (0.3 g); mp 195-197 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.96 – 7.67 (m, 2H), 7.37 (d, J = 8.5 Hz, 2H), 6.65 (d, J = 8.3 Hz, 2H), 2.72 (s, 2H), 2.26 (s, 3H), 2.18 – 2.03 (m, 2H), 1.76 – 1.56 (m, 5H), 1.49 – 1.13 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.8, 177.5, 171.5, 166.7, 145.2, 140.8, 131.8, 128.3, 116.0, 112.7, 97.7, 41.4, 38.2, 32.4, 27.8, 24.7, 21.6. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{21}H_{22}BrN_2O_5$: 461.0707; Found: 461.0689.



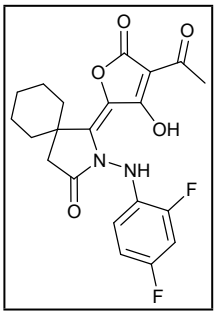
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((4-fluorophenyl)amino)-2-azaspiro[4.5]decan-3-one (**8d**)*

White powder; yield 68% (0.27 g); mp 196-198 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.14 – 7.05 (m, 2H), 6.92 – 6.73 (m, 4H), 2.73 (s, 2H), 2.26 (s, 3H), 2.19 – 2.07 (m, 2H), 1.71 – 1.55 (m, 5H), 1.45 – 1.17 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.5, 176.3, 171.6, 166.6, 157.7 (d, J = 237.7 Hz), 141.6 (d, J = 2.1 Hz), 141.4, 126.2, 116.0, 115.9 (d, J = 29.9 Hz), 98.0, 41.5, 38.2, 32.5, 28.3, 24.7, 21.6. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{21}H_{22}FN_2O_5$: 401.1507; Found: 401.1513.



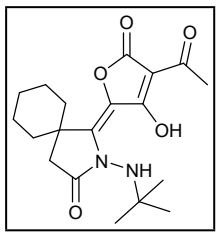
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-(o-tolylamino)-2-azaspiro[4.5]decan-3-one (**8e**)*

Yellowish powder; yield 47% (0.19 g); mp 135-137 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.17 – 7.01 (m, 2H), 6.87 – 6.75 (m, 1H), 6.40 (d, J = 8.0 Hz, 1H), 4.70 – 4.41 (m, 2H in H_2O), 2.75 (s, 2H), 2.28 (s, 3H), 2.24 (s, 3H), 2.21 – 2.13 (m, 2H), 1.72 – 1.60 (m, 4H), 1.52 – 1.13 (m, 4H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.6, 177.0, 171.3, 166.6, 142.5, 141.9, 130.8, 126.7, 126.3, 124.4, 121.2, 111.6, 97.8, 41.4, 38.3, 32.8, 28.0, 24.7, 21.7, 17.0. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{22}H_{25}N_2O_5$: 397.1758; Found: 397.1762.



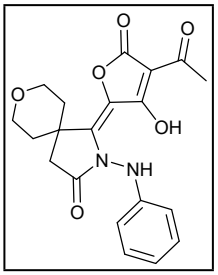
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((2,4-difluorophenyl)amino)-2-azaspiro[4.5]decan-3-one (**8f**)*

White powder; yield 74% (0.31 g); mp 201-203 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.27 – 7.18 (m, 1H), 7.07 – 6.86 (m, 3H), 6.70 – 6.55 (m, 1H), 2.72 (s, 2H), 2.25 (s, 3H), 2.22 – 2.06 (m, 2H), 1.74 – 1.57 (m, 5H), 1.48 – 1.31 (m, 2H), 1.29 – 1.15 (m, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 190.8, 178.2, 171.4, 166.7, 156.1 (dd, J = 239.0, 11.1 Hz), 150.99 (dd, J = 245.6, 12.2 Hz), 140.45, 130.12 (d, J = 10.4 Hz), 127.0, 115.1 (dd, J = 9.2, 3.4 Hz), 111.0 (dd, J = 22.3, 3.1 Hz), 104.4 (dd, J = 27.0, 22.5 Hz), 97.4, 41.3, 38.2, 32.5, 27.5, 24.7, 21.6. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{21}H_{21}F_2N_2O_5$: 419.1410; Found: 419.1413.



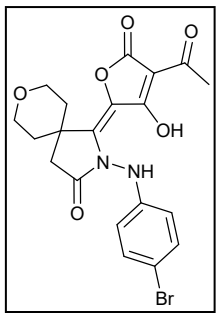
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-(tert-butylamino)-2-azaspiro[4.5]decan-3-one (**8g**)*

White powder; yield 41% (0.15 g); mp 238-240 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 3.57 – 3.21 (m, 2H in H_2O), 2.92 – 2.62 (m, 2H), 2.27 (s, 3H), 2.17 – 1.95 (m, 2H), 1.76 – 1.56 (m, 5H), 1.50 – 1.28 (m, 3H), 1.17 (s, 9H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 190.3, 174.1, 171.5, 166.2, 142.9, 125.0, 98.7, 61.4, 41.8, 37.8, 29.8, 28.7, 25.8, 24.6, 21.5. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{27}N_2O_5$: 363.1914; Found: 363.1908.



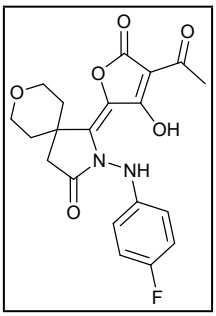
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-(phenylamino)-8-oxa-2-azaspiro[4.5]decan-3-one (**8h**)*

White powder; yield 66% (0.25 g); mp 209-211 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.31 – 7.19 (m, 2H), 6.99 – 6.87 (m, 1H), 6.73 (d, J = 7.9 Hz, 2H), 6.42 – 6.11 (m, 2H in H_2O), 3.93 – 3.77 (m, 2H), 3.57 – 3.39 (m, 2H), 2.90 (s, 2H), 2.46 – 2.37 (m, 2H), 2.25 (s, 3H), 1.55 (d, J = 12.9 Hz, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.4, 176.7, 171.2, 166.8, 145.3, 139.5, 129.2, 126.6, 121.8, 114.2, 97.7, 63.3, 39.0, 37.8, 32.6, 28.3. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{21}N_2O_6$: 385.1394; Found: 385.1380.



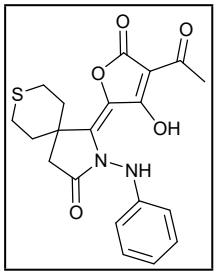
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((4-bromophenyl)amino)-8-oxa-2-azaspiro[4.5]decan-3-one (**8i**)*

White powder; yield 71% (0.34 g); mp 207-209 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.34 (d, J = 8.2 Hz, 2H), 6.62 (d, J = 8.3 Hz, 2H), 4.54 – 4.07 (m, 2H in H_2O), 3.91 – 3.77 (m, 2H), 3.55 – 3.38 (m, 2H), 2.86 (s, 2H), 2.44 – 2.31 (m, 2H), 2.23 (s, 3H), 1.53 (d, J = 12.9 Hz, 2H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 190.6, 178.4, 171.2, 167.3, 145.5, 137.8, 131.7, 127.6, 115.8, 112.4, 97.3, 63.3, 38.8, 37.9, 32.6, 28.2. HRMS (ESI-TOF) *m/z*: $[M+Na]^+$ Calcld for $C_{20}H_{19}BrN_2O_6Na$: 485.0319; Found: 485.0339.



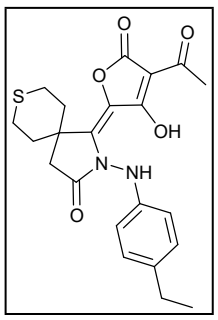
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((4-fluorophenyl)amino)-8-oxa-2-azaspiro[4.5]decan-3-one (**8j**)*

Orange powder; yield 62% (0.25 g); mp 186-188 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.10 – 6.98 (m, 2H), 6.77 – 6.67 (m, 2H), 4.42 – 4.05 (m, 2H in H_2O), 3.86 – 3.77 (m, 2H), 3.50 – 3.40 (m, 2H), 2.86 (s, 2H), 2.39 (d, J = 14.0 Hz, 2H), 2.24 (s, 3H), 1.53 (d, J = 13.0 Hz, 2H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 190.4, 177.5, 171.3, 167.1, 157.5 (d, J = 236.6 Hz), 142.0, 138.5, 127.2 (d, J = 6.5 Hz), 115.8 (d, J = 16.8 Hz), 115.6, 97.5, 63.3, 38.9, 37.8, 32.6, 28.4. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{20}FN_2O_6$: 403.1300; Found: 403.1307.



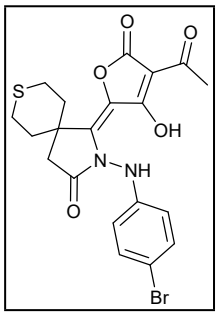
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-(phenylamino)-8-thia-2-azaspiro[4.5]decan-3-one (**8k**)*

Yellowish powder; yield 71% (0.28 g); mp 212-214 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.28 – 7.17 (m, 2H), 6.96 – 6.85 (m, 1H), 6.70 (d, J = 7.9 Hz, 2H), 4.22 - 3.94 (m, 2H in H_2O), 2.84 (d, J = 13.5 Hz, 2H), 2.77 (s, 2H), 2.49 – 2.36 (m, 4H), 2.23 (s, 3H), 1.92 (d, J = 13.6 Hz, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.4, 177.4, 171.1, 167.1, 145.6, 139.3, 129.2, 127.1, 121.6, 114.1, 97.6, 40.6, 37.1, 33.0, 28.5, 23.4. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{21}N_2O_5S$: 401.1166; Found: 401.1173.



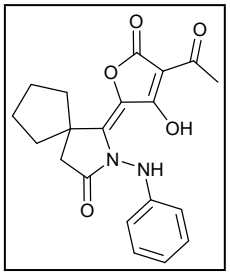
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((4-ethylphenyl)amino)-8-thia-2-azaspiro[4.5]decan-3-one (**8l**)*

Yellowish powder; yield 62% (0.27 g); mp 203-205 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.08 (d, J = 7.9 Hz, 2H), 6.94 – 6.80 (m, 2H), 6.70 (d, J = 7.9 Hz, 2H), 2.89 – 2.71 (m, 4H), 2.61 – 2.53 (m, 2H), 2.49 – 2.35 (m, 4H), 2.25 (s, 3H), 1.92 (d, J = 10.9 Hz, 2H), 1.11 (t, J = 7.6 Hz, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.5, 176.1, 171.1, 166.7, 142.8, 140.5, 137.7, 128.5, 126.3, 114.7, 98.0, 40.8, 37.0, 33.0, 28.5, 27.4, 23.3, 15.7. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{22}H_{25}N_2O_5S$: 429.1479; Found: 429.1467.



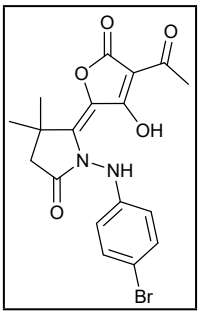
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-((4-bromophenyl)amino)-8-thia-2-azaspiro[4.5]decan-3-one (**8m**)*

Yellowish powder; yield 76% (0.36 g); mp 208-210 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.34 (d, J = 8.4 Hz, 2H), 6.61 (d, J = 8.4 Hz, 2H), 4.29 - 3.92 (m, 2H in H_2O), 2.82 (d, J = 12.8 Hz, 2H), 2.75 (s, 2H), 2.49 – 2.33 (m, 4H), 2.23 (s, 3H), 1.90 (d, J = 12.9 Hz, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 190.6, 178.5, 171.1, 167.3, 145.6, 138.4, 131.8, 127.6, 115.9, 112.4, 109.6, 97.3, 37.1, 33.0, 28.2, 23.4. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{20}BrN_2O_5S$: 479.0267; Found: 479.0271.



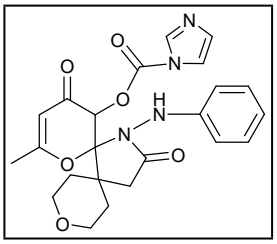
*(E)-1-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-(phenylamino)-2-azaspiro[4.4]nonan-3-one (**8n**)*

Yellowish powder; yield 54% (0.2 g); mp 192-194 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.29 – 7.19 (m, 2H), 6.98 – 6.89 (m, 1H), 6.74 (d, J = 7.9 Hz, 2H), 4.97 – 4.54 (m, 2H in H_2O), 2.70 (s, 2H), 2.38 – 2.14 (m, 5H), 1.89 – 1.62 (m, 6H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 190.7, 176.1, 171.6, 166.7, 145.2, 140.6, 129.2, 125.8, 121.9, 114.1, 98.1, 46.8, 43.2, 37.9, 28.2, 24.3. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{20}H_{21}N_2O_5$: 369.1445; Found: 369.1437.



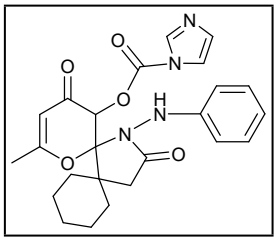
*(E)-5-(4-acetyl-3-hydroxy-5-oxofuran-2(5H)-ylidene)-1-((4-bromophenyl)amino)-4,4-dimethylpyrrolidin-2-one (**8o**)*

Yellowish powder; yield 60% (0.25 g); mp 177-179 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.38 (d, J = 8.2 Hz, 2H), 6.66 (d, J = 8.5 Hz, 2H), 6.63 – 6.54 (m, 2H), 2.64 (s, 2H), 2.25 (s, 3H), 1.43 (s, 6H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 190.7, 177.5, 171.3, 166.9, 145.4, 140.2, 131.7, 126.8, 116.0, 112.6, 97.7, 43.2, 36.7, 28.0, 26.4. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{18}H_{18}BrN_2O_5$: 421.0377; Found: 421.0394.



*2-methyl-4,14-dioxo-15-(phenylamino)-1,10-dioxa-15-azadispiro[5.0.57.36]pentadec-2-en-5-yl 1H-imidazole-1-carboxylate (**14a**)*

White powder; yield 59% (0.27 g); mp 168-170 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.40 (d, J = 12.6 Hz, 2H), 7.74 (s, 1H), 7.23 – 7.11 (m, 3H), 6.85 – 6.71 (m, 3H), 6.09 (s, 1H), 5.27 (s, 1H), 3.89 (dd, J = 11.8, 4.6 Hz, 1H), 3.81 – 3.71 (m, 1H), 3.61 – 3.49 (m, 1H), 3.45 – 3.37 (m, 1H), 2.80 (d, J = 17.1 Hz, 1H), 2.61 (d, J = 17.2 Hz, 1H), 2.32 – 2.18 (m, 1H), 1.96 – 1.88 (m, 1H), 1.85 (s, 3H), 1.68 (d, J = 13.6 Hz, 1H), 1.37 (d, J = 12.5 Hz, 1H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 184.03, 171.26, 170.56, 147.20, 147.06, 138.11, 130.46, 128.63, 120.04, 118.11, 113.16, 101.06, 99.32, 71.61, 63.33, 63.25, 41.48, 36.36, 31.72, 31.19, 20.33. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{23}H_{25}N_4O_6$: 453.1769; Found: 453.1761.

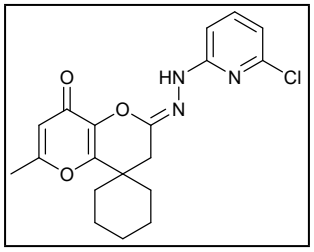


*2-methyl-4,14-dioxo-15-(phenylamino)-1-oxa-15-azadispiro[5.0.57.36]pentadec-2-en-5-yl 1H-imidazole-1-carboxylate (**14b**)*

White powder; yield 43% (0.19 g); mp 171-173 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.43 (s, 1H), 8.34 (s, 1H), 7.74 (s, 1H), 7.25 – 7.12 (m, 3H), 6.85 – 6.71 (m, 3H), 6.02 (s, 1H), 5.26 (s, 1H), 2.65 (d, J = 17.0 Hz, 1H), 2.42 (d, J = 17.1 Hz, 1H), 1.90 – 1.30 (m, 12H), 1.21 – 1.08 (m, 1H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 184.07, 171.55, 170.65, 147.35, 147.07, 138.09, 130.52, 128.62, 120.01, 118.07,

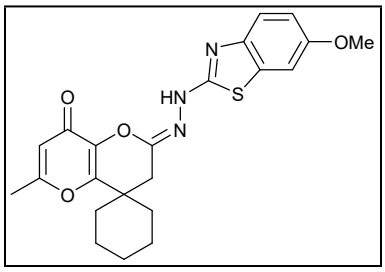
113.16, 100.97, 99.90, 71.87, 43.33, 37.08, 31.44, 31.02, 25.01, 22.09, 21.83, 20.37. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{24}H_{27}N_4O_5$: 451.1976; Found: 451.1975.

5. Characterization data for compounds 16-19



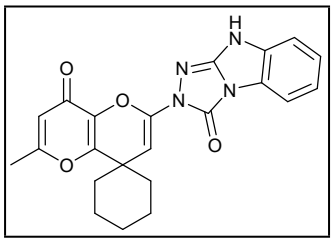
*(Z)-2'-(2-(6-chloropyridin-2-yl)hydrazineylidene)-6'-methyl-2',3'-dihydro-8'H-spiro[cyclohexane-1,4'-pyrano[3,2-b]pyran]-8'-one (**16a**)*

Yellowish powder; yield 62% (0.23 g); mp 246-248 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.23 (s, 1H), 7.71 – 7.56 (m, 1H), 6.99 (d, J = 8.3 Hz, 1H), 6.79 (d, J = 7.6 Hz, 1H) , 6.32 (s, 1H), 2.85 (s, 2H), 2.31 (s, 3H), 1.88 – 1.73 (m, 2H), 1.71 – 1.41 (m, 7H), 1.38 – 1.21 (m, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 170.2, 164.7, 156.8, 155.8, 148.2, 141.1, 141.0, 136.8, 113.8, 113.5, 104.9, 36.7, 33.0, 31.9, 24.8, 20.5, 19.90. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{21}ClN_3O_3$: 374.1266; Found: 374.1252.



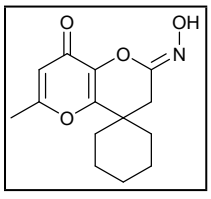
*(Z)-2'-(2-(6-methoxybenzo[d]thiazol-2-yl)hydrazineylidene)-6'-methyl-2',3'-dihydro-8'H-spiro[cyclohexane-1,4'-pyrano[3,2-b]pyran]-8'-one (**16b**)*

Pale brown powder; yield 79% (0.34 g); mp 252-254 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 11.17 (br.s, 1H), 7.35 (s, 1H), 7.26 (d, J = 9.0 Hz, 1H), 6.86 (d, J = 8.3 Hz, 1H), 6.31 (s, 1H), 3.75 (s, 3H), 2.85 (s, 2H), 2.31 (s, 3H), 1.90 – 1.75 (m, 2H), 1.63 – 1.47 (m, 7H), 1.40 – 1.27 (m, 1H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 170.4, 165.3, 164.8, 156.1, 154.6, 143.3, 137.1, 117.2, 113.6, 113.4, 106.1, 55.6, 36.6, 33.2, 31.9, 24.9, 20.6, 19.1. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{22}H_{24}N_3O_4S$: 426.1482; Found: 426.1475.



*2-(6'-methyl-8'-oxo-8'H-spiro[cyclohexane-1,4'-pyrano[3,2-b]pyran]-2'-yl)-2,9-dihydro-3H-benzo[4,5]imidazo[2,1-c][1,2,4]triazol-3-one (**17**)*

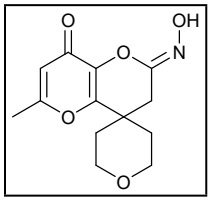
White powder; yield 44% (0.18 g); mp 263-265 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 11.67 (br.s, 1H), 7.62 (d, J = 7.9 Hz, 1H), 7.38 – 7.13 (m, 3H), 6.28 (s, 1H), 5.78 (s, 1H), 2.31 (s, 3H), 2.05 – 1.92 (m, 2H), 1.85 – 1.55 (m, 7H), 1.41 – 1.21 (m, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 170.1, 165.4, 152.9, 147.8, 145.8, 138.0, 136.8, 136.4, 125.3, 123.5, 121.0, 113.3, 111.4, 111.3, 100.0, 37.4, 36.2, 24.8, 20.1, 19.1. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{22}H_{21}N_4O_4$: 405.1557; Found: 405.1558.



*(Z)-2'-(hydroxyimino)-6'-methyl-2',3'-dihydro-8'H-spiro[cyclohexane-1,4'-pyrano[3,2-b]pyran]-8'-one (**18a**)*

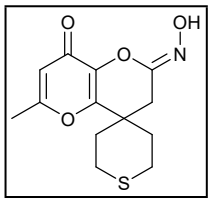
White powder; yield 51% (0.13 g); mp 178-180 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.14 (s, 1H), 6.25 (s, 1H), 2.66 (s, 2H), 2.28 (s, 3H), 1.85 – 1.73 (m, 2H), 1.67 – 1.44 (m, 7H), 1.34 – 1.21 (m, 1H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 170.4, 164.4, 155.6,

146.1, 136.9, 113.4, 36.2, 31.8, 31.4, 24.8, 20.4, 18.9. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{14}H_{18}NO_4$: 264.1230; Found: 264.1231.



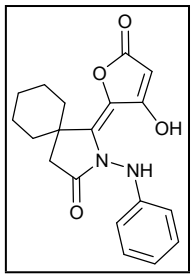
*(Z)-2'-(hydroxyimino)-6'-methyl-2,2',3,3',5,6-hexahydro-8'H-spiro[pyran-4,4'-pyrano[3,2-b]pyran]-8'-one (**18b**)*

White powder; yield 57% (0.15 g); mp 122-124 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.21 (s, 1H), 6.27 (s, 1H), 3.84 – 3.56 (m, 4H), 2.79 (s, 2H), 2.30 (s, 3H), 2.07 – 1.88 (m, 2H), 1.47 (d, J = 13.6 Hz, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 170.4, 164.6, 154.4, 145.7, 137.2, 113.5, 62.2, 34.1, 31.9, 31.6, 18.9. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{13}H_{16}NO_5$: 266.1023; Found: 266.1021.



*(Z)-2-(hydroxyimino)-6-methyl-2,2',3,3',5',6'-hexahydro-8H-spiro[pyrano[3,2-b]pyran-4,4'-thiopyran]-8-one (**18c**)*

White powder; yield 61% (0.17 g); mp 206-208 °C. ^{1}H NMR (600 MHz, DMSO-d_6) δ 10.37 (s, 1H), 6.25 (s, 1H), 3.01 (s, 2H), 2.88 – 2.78 (m, 2H), 2.60 (d, J = 14.6 Hz, 2H), 2.30 (s, 3H), 2.15 – 2.04 (m, 2H), 1.79 (d, J = 13.7 Hz, 2H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 170.6, 164.7, 156.0, 153.7, 137.6, 113.2, 35.2, 33.2, 25.2, 22.5, 19.0. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{13}H_{16}NO_4S$: 282.0795; Found: 282.0790.



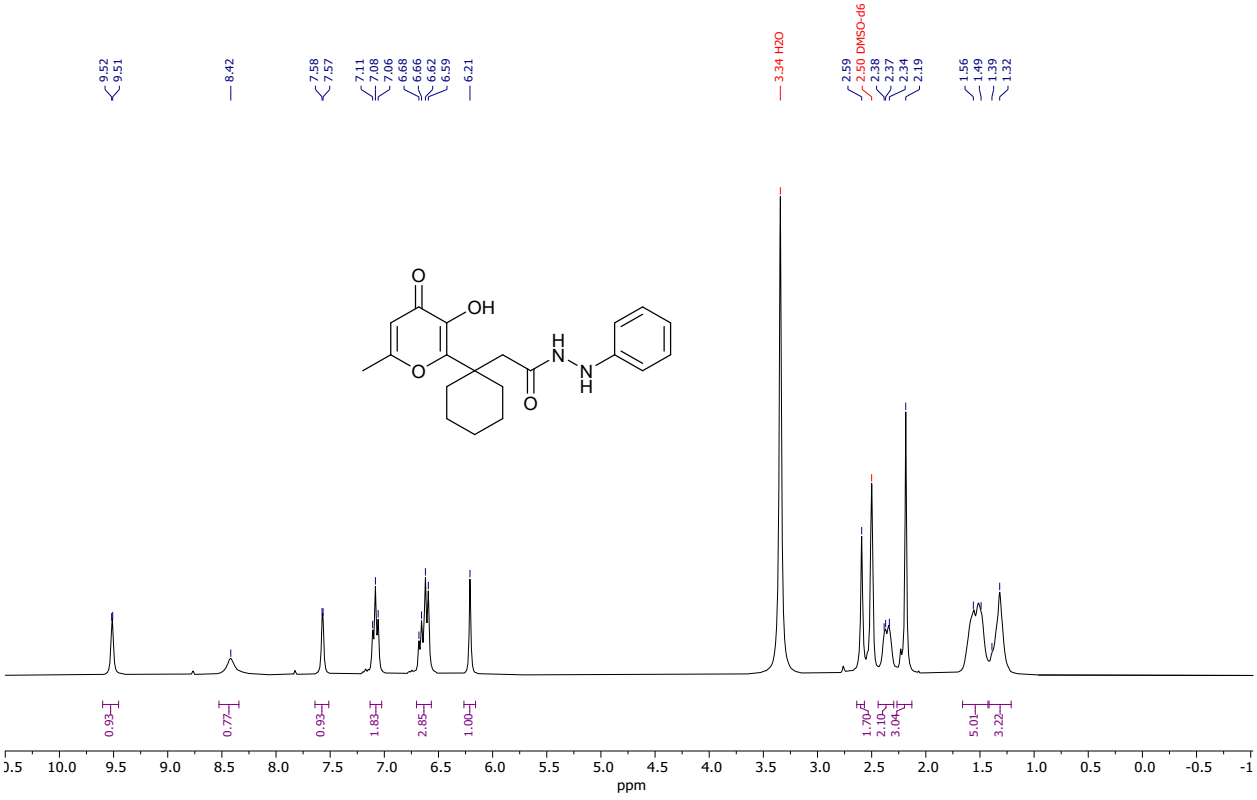
*(E)-1-(3-hydroxy-5-oxofuran-2(5H)-ylidene)-2-(phenylamino)-2-azaspiro[4.5]decan-3-one (**19**)*

Orange powder; yield 95% (0.32 g); mp 205-207 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.40 – 7.28 (m, 2H), 7.13 – 7.03 (m, 1H), 6.94 (d, J = 7.9 Hz, 2H), 5.12 (s, 1H), 3.69 – 3.19 (m, 2H in H_2O), 2.76 (s, 2H), 2.34 – 2.18 (m, 2H), 1.77 – 1.62 (m, 5H), 1.45 – 1.18 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 171.5, 168.2, 167.5, 143.6, 140.4, 129.6, 125.1, 123.8, 115.4, 88.1, 41.7, 37.9, 33.2, 24.6, 21.6. HRMS (ESI-TOF) *m/z*: $[M+H]^+$ Calcld for $C_{19}H_{21}N_2O_4$: 341.1496; Found: 341.1501.

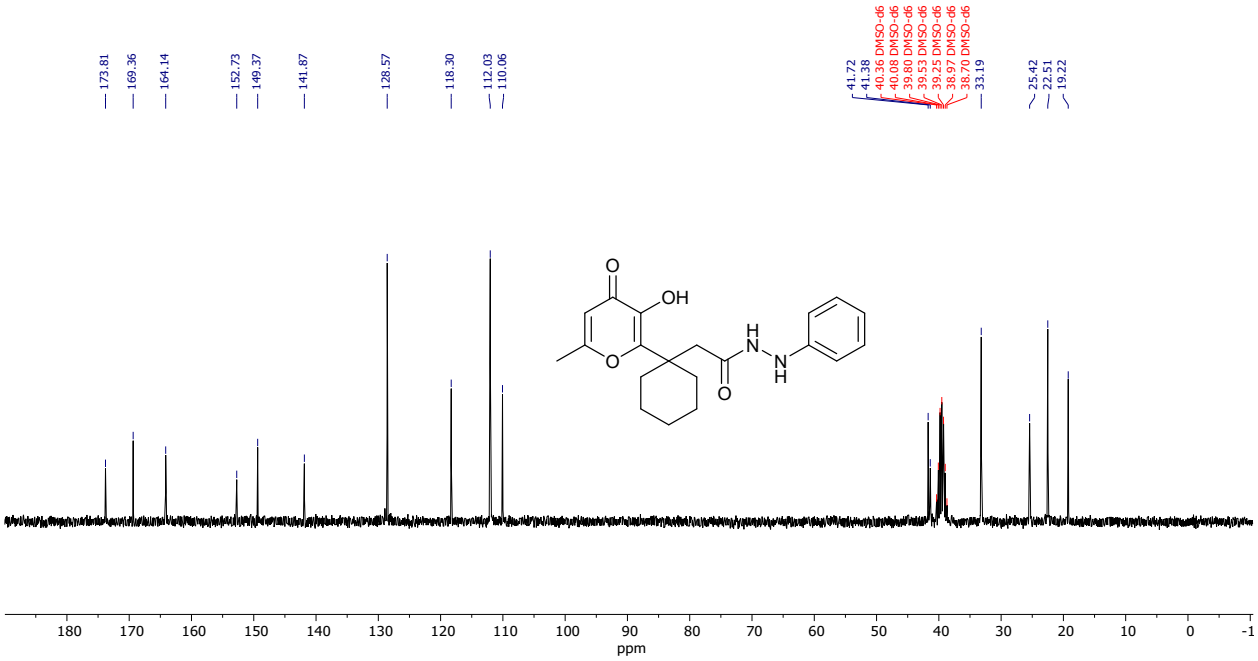
6. Copies of ^{1}H and ^{13}C NMR spectra

6.1 Starting compounds 7 and 9

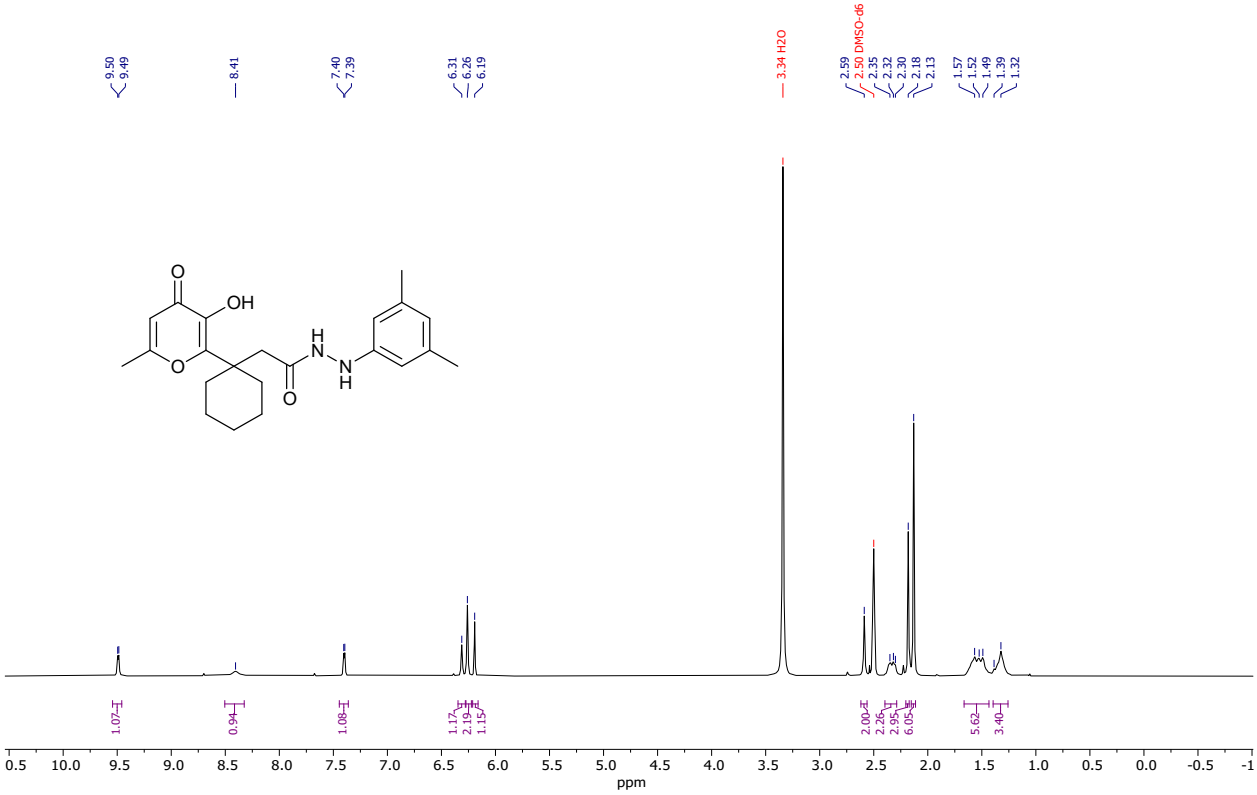
^{1}H NMR spectrum (300 MHz) of **7a** in DMSO-d_6



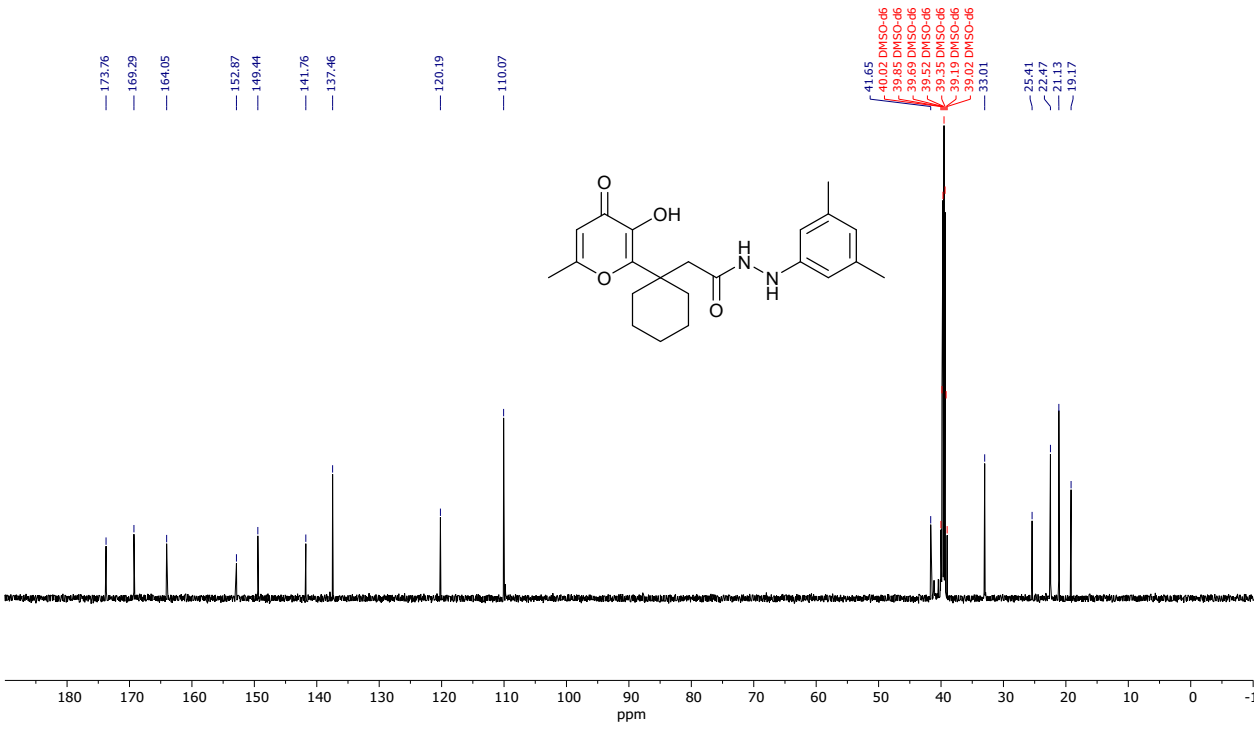
^{13}C {^{1}H} NMR spectrum (75 MHz) of **7a** in DMSO-d_6


173.81
169.36
164.14
152.73
149.37
141.87
128.57
118.30
112.03
110.06
41.72
41.38
40.36 DMSO-d6
40.08 DMSO-d6
39.80 DMSO-d6
39.53 DMSO-d6
39.25 DMSO-d6
38.97 DMSO-d6
38.70 DMSO-d6
33.19
25.42
22.51
19.22
O
OH
O
H
N
N
H
O
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-1
ppm

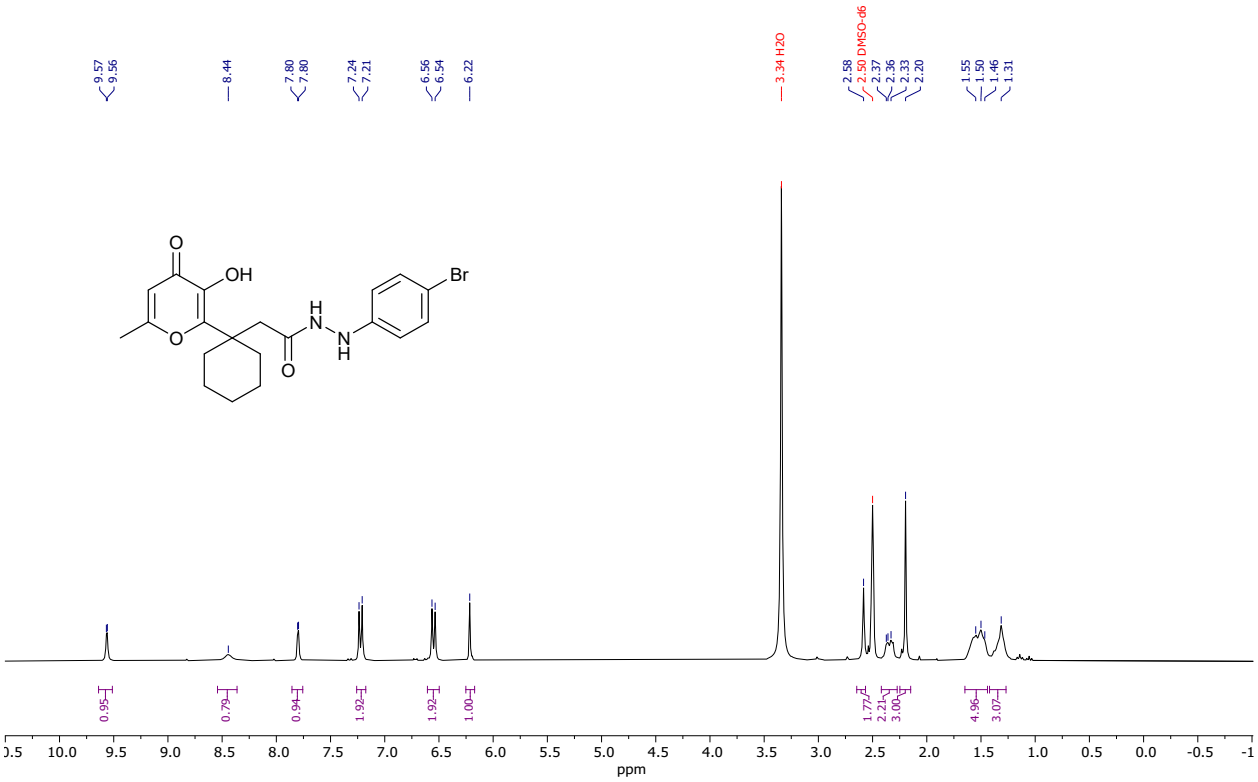
^{1}H NMR spectrum (300 MHz) of **7b** in DMSO-d_6



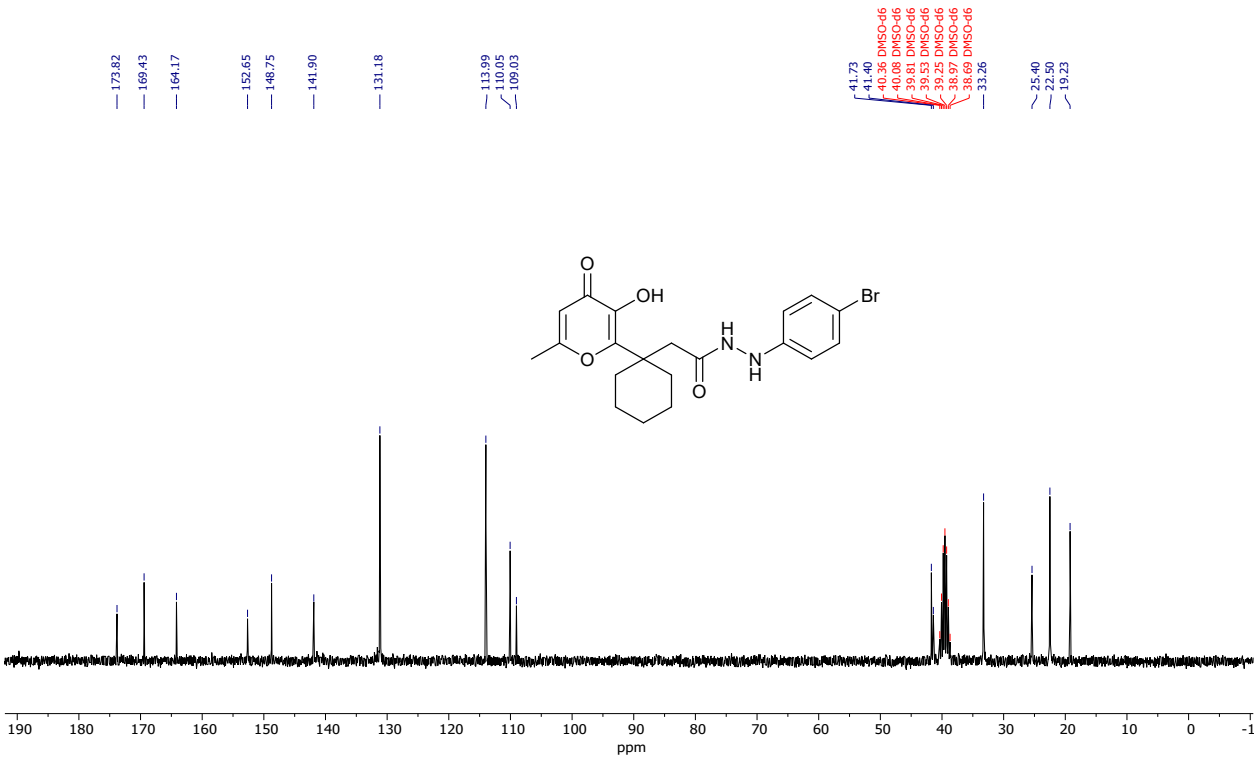
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7b** in DMSO-d_6



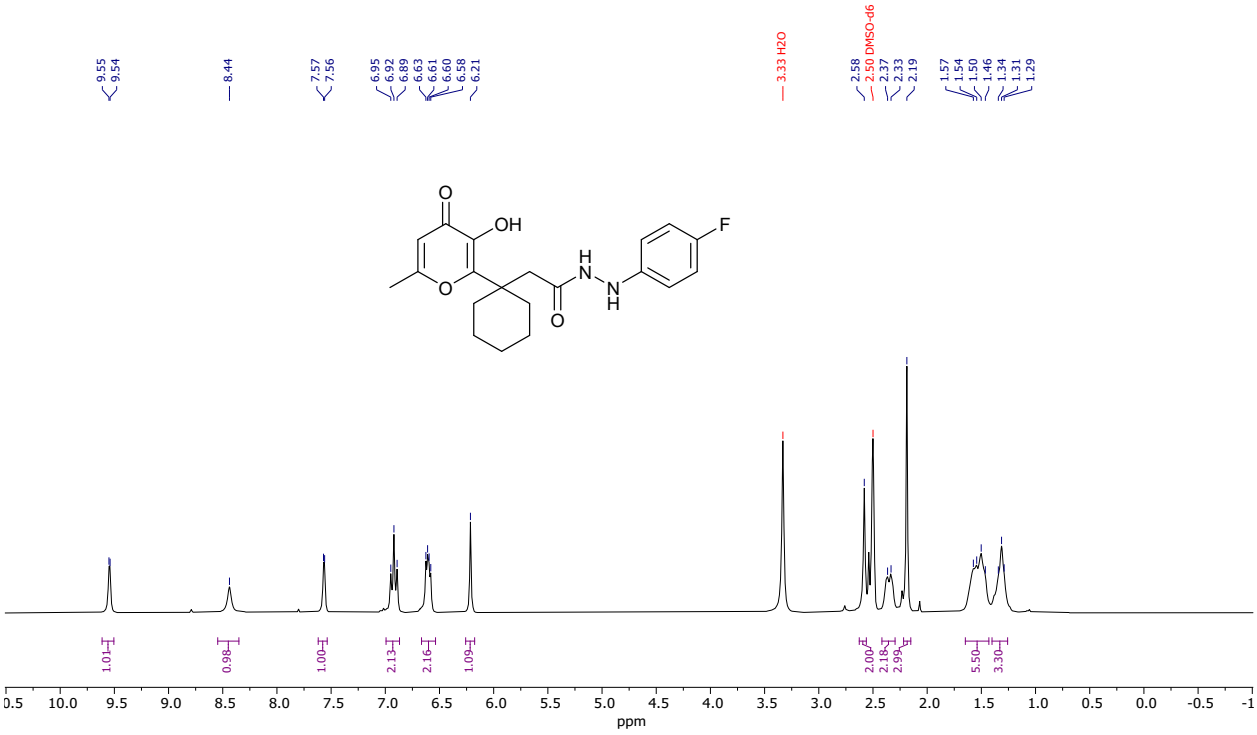
^{1}H NMR spectrum (300 MHz) of **7c** in DMSO-d_6



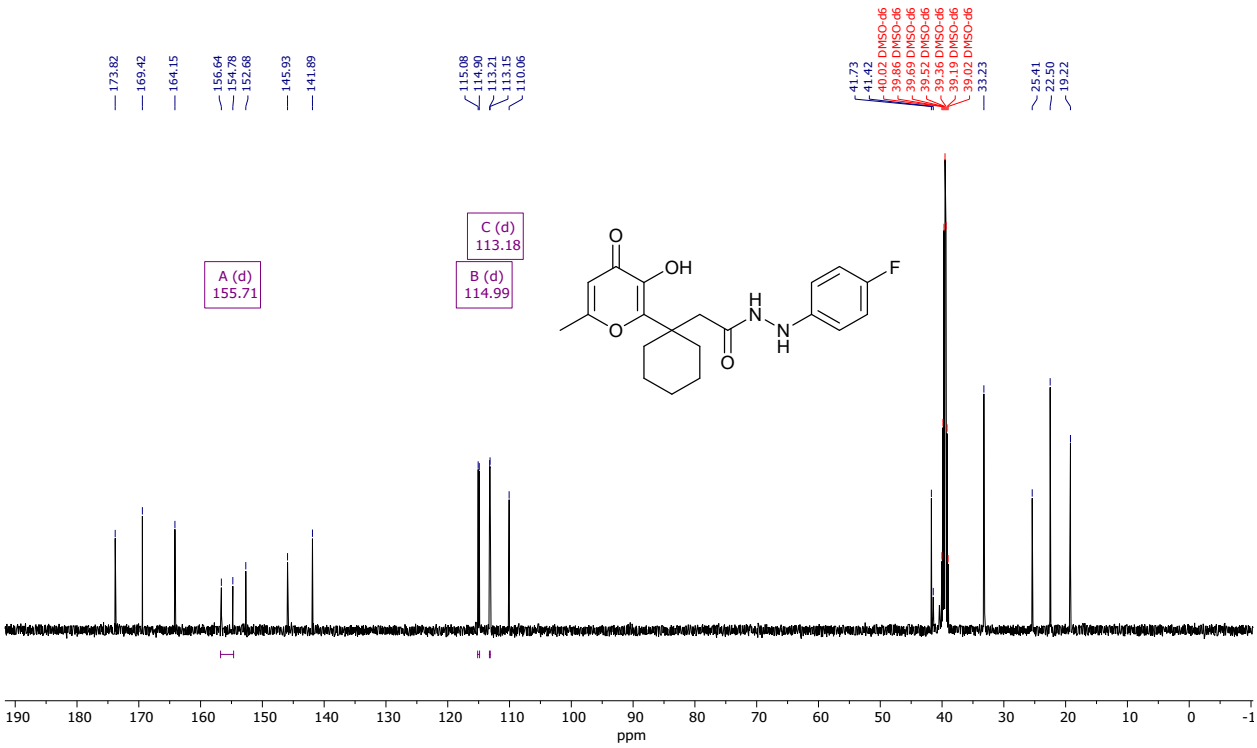
^{13}C {^{1}H} NMR spectrum (75 MHz) of **7c** in DMSO-d_6



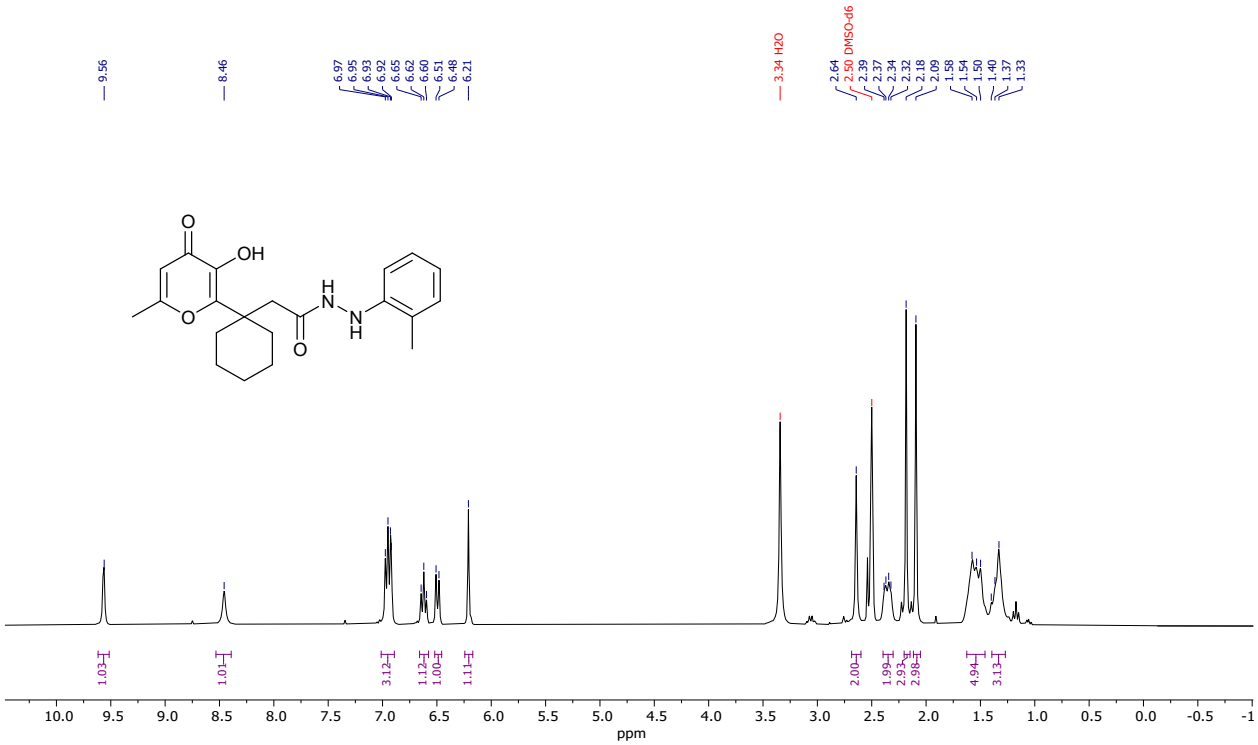
^{1}H NMR spectrum (300 MHz) of **7d** in DMSO-d_6



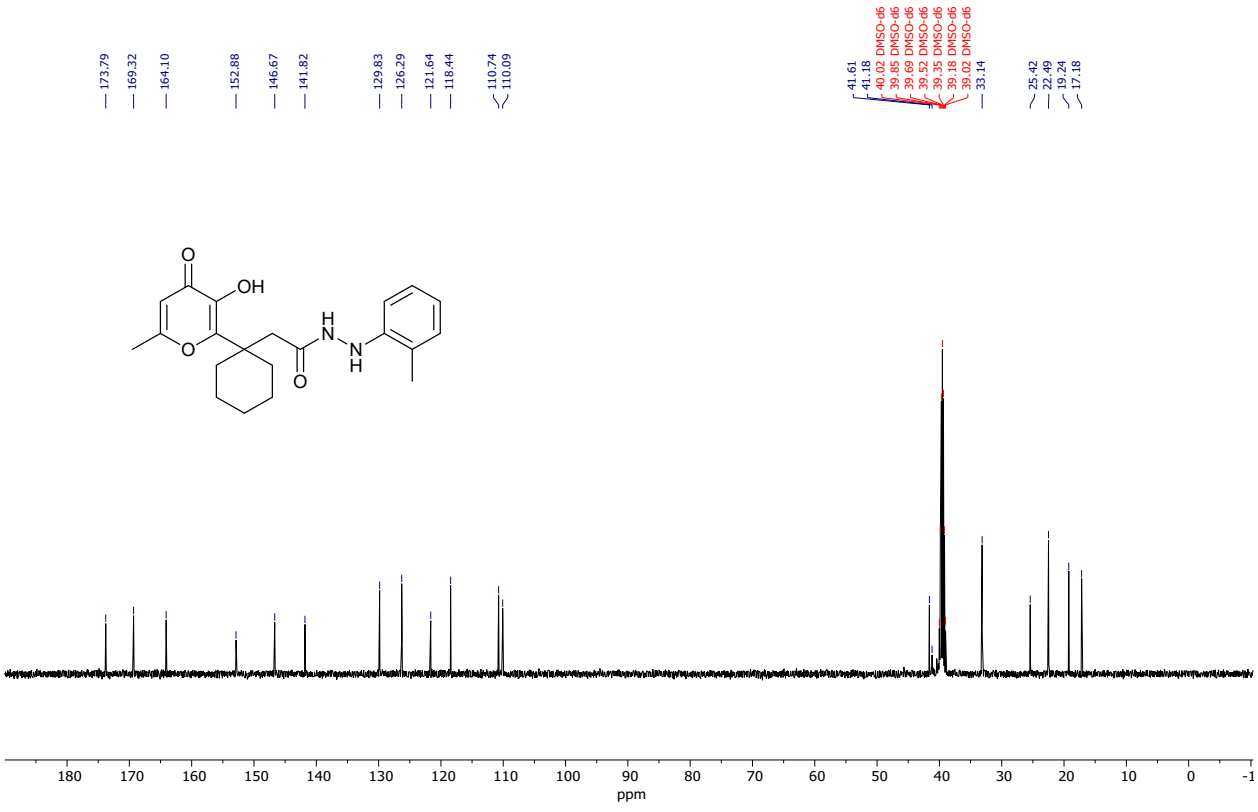
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7d** in DMSO-d_6



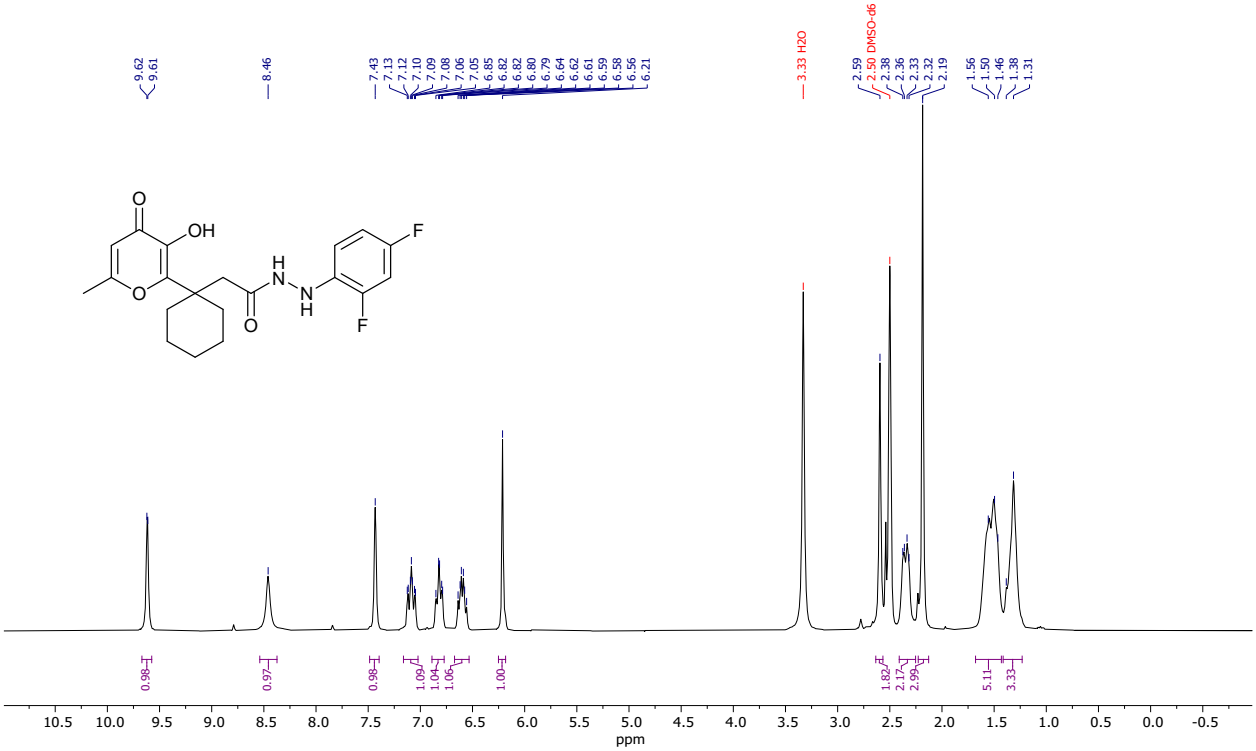
^{1}H NMR spectrum (300 MHz) of **7e** in DMSO-d_6



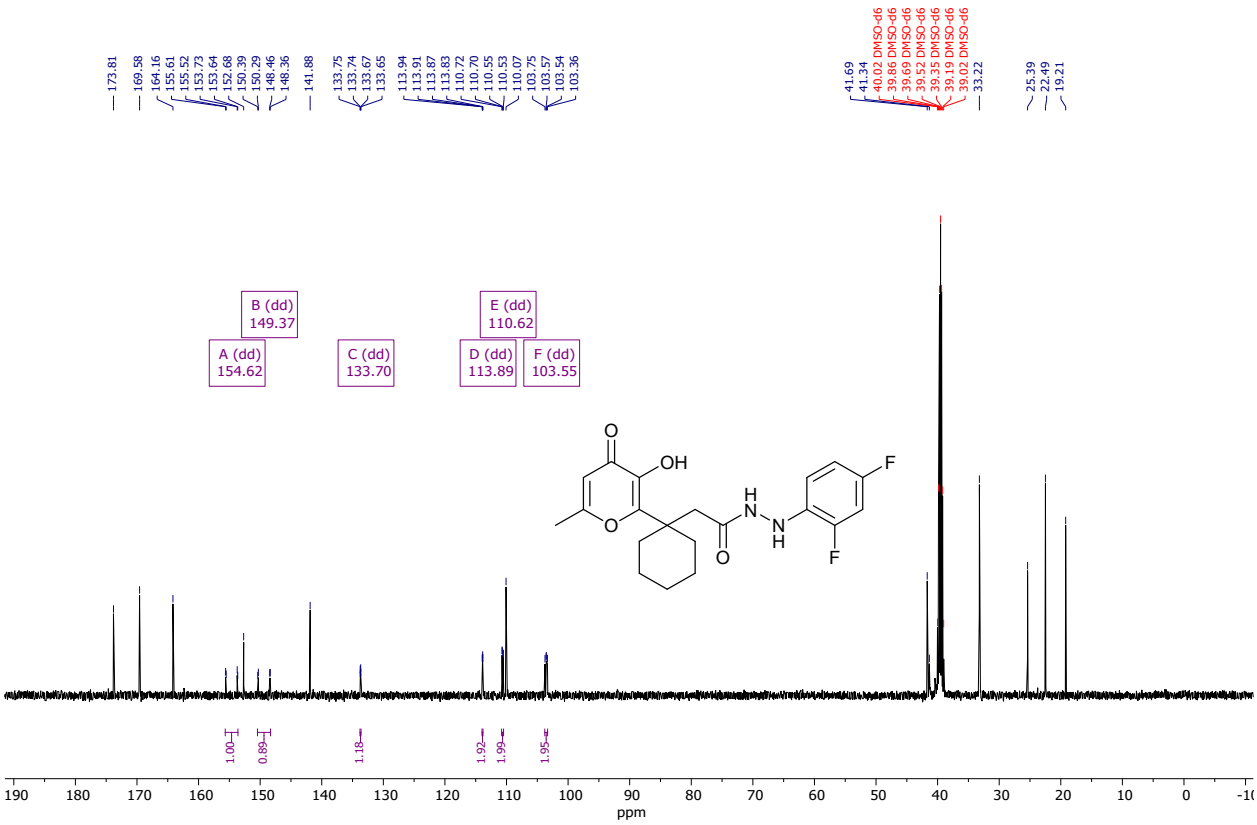
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7e** in DMSO-d_6



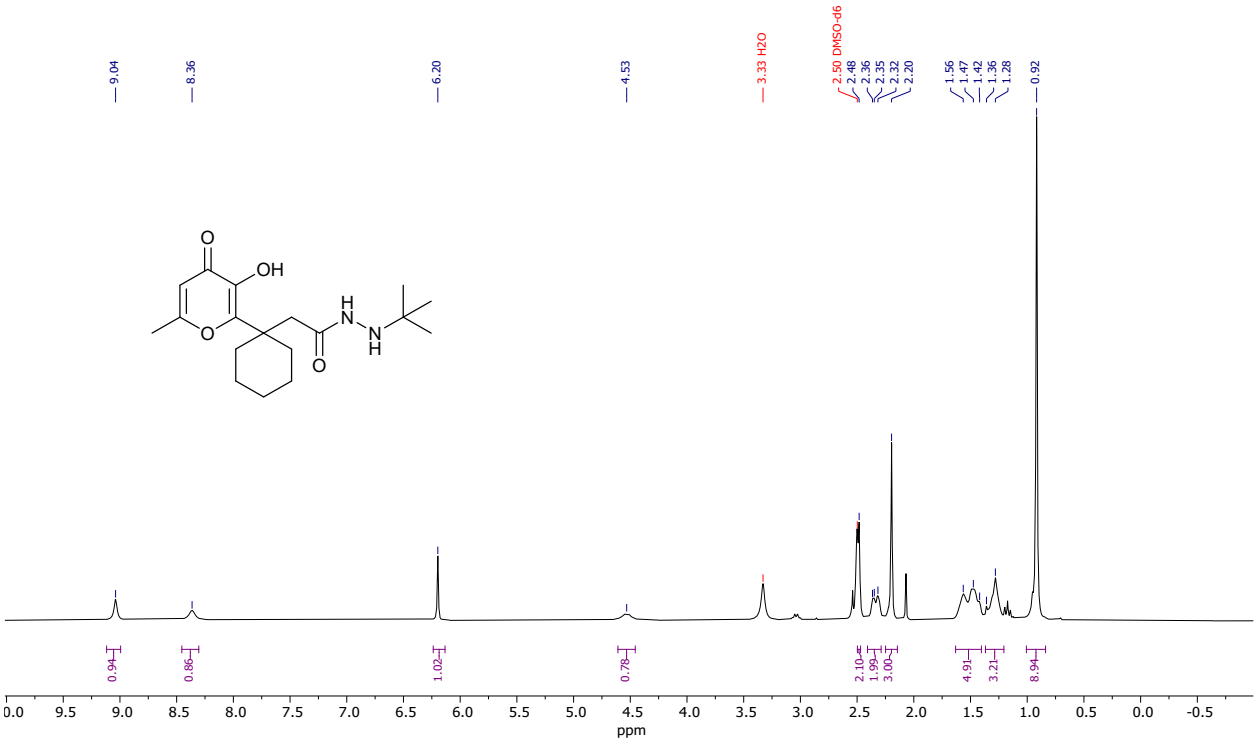
^{1}H NMR spectrum (300 MHz) of **7f** in DMSO-d_6



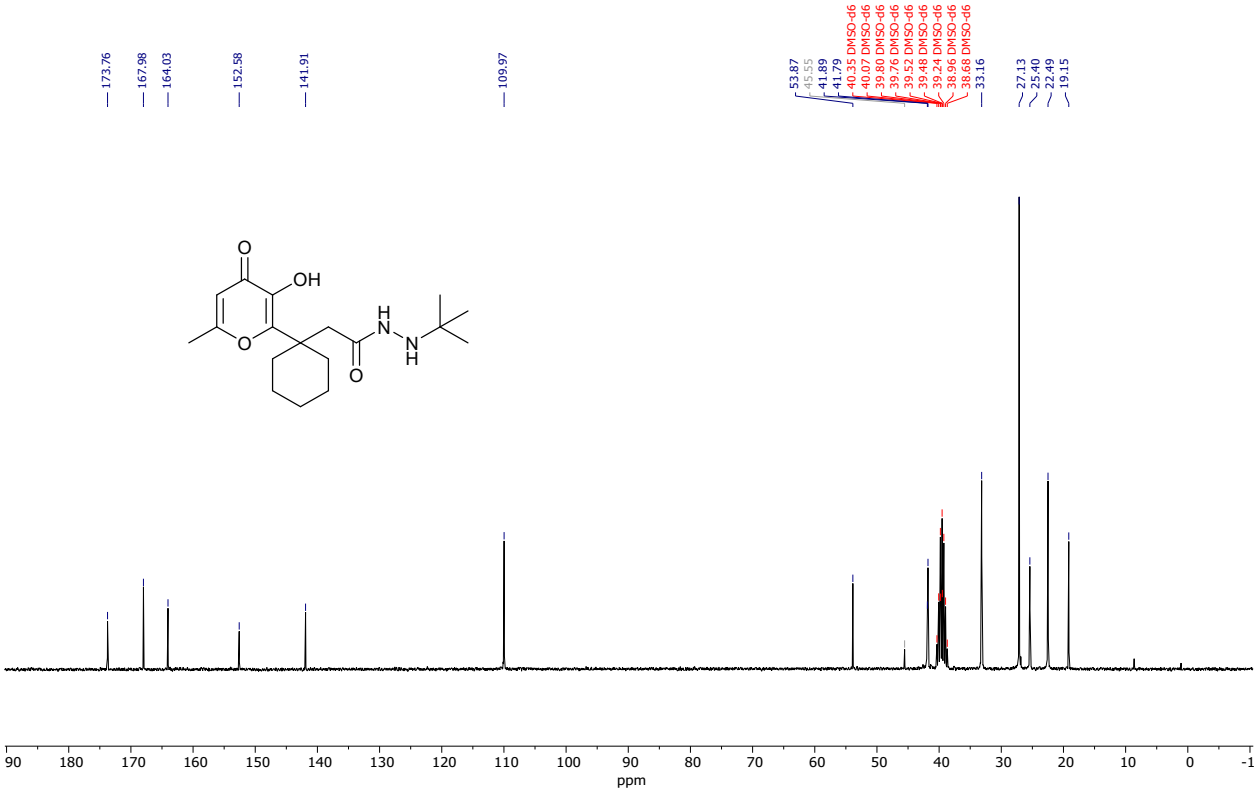
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7f** in DMSO-d_6


173.81
169.58
164.16
155.61
155.52
153.73
153.64
152.68
150.39
150.29
148.46
148.36
141.88
133.75
133.74
133.67
133.65
113.94
113.91
113.87
113.83
110.72
110.70
110.55
110.53
110.07
103.75
103.57
103.54
103.36
41.69
41.34
40.02 DMSO-d6
39.86 DMSO-d6
39.69 DMSO-d6
39.52 DMSO-d6
39.35 DMSO-d6
39.19 DMSO-d6
39.02 DMSO-d6
33.22
25.39
22.49
19.21
B (dd)
149.37
A (dd)
154.62
C (dd)
133.70
E (dd)
110.62
D (dd)
113.89
F (dd)
103.55
O
OH
O
H
N
N
H
O
F
F
1.00
0.89
1.18
1.92
1.99
1.95
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
ppm

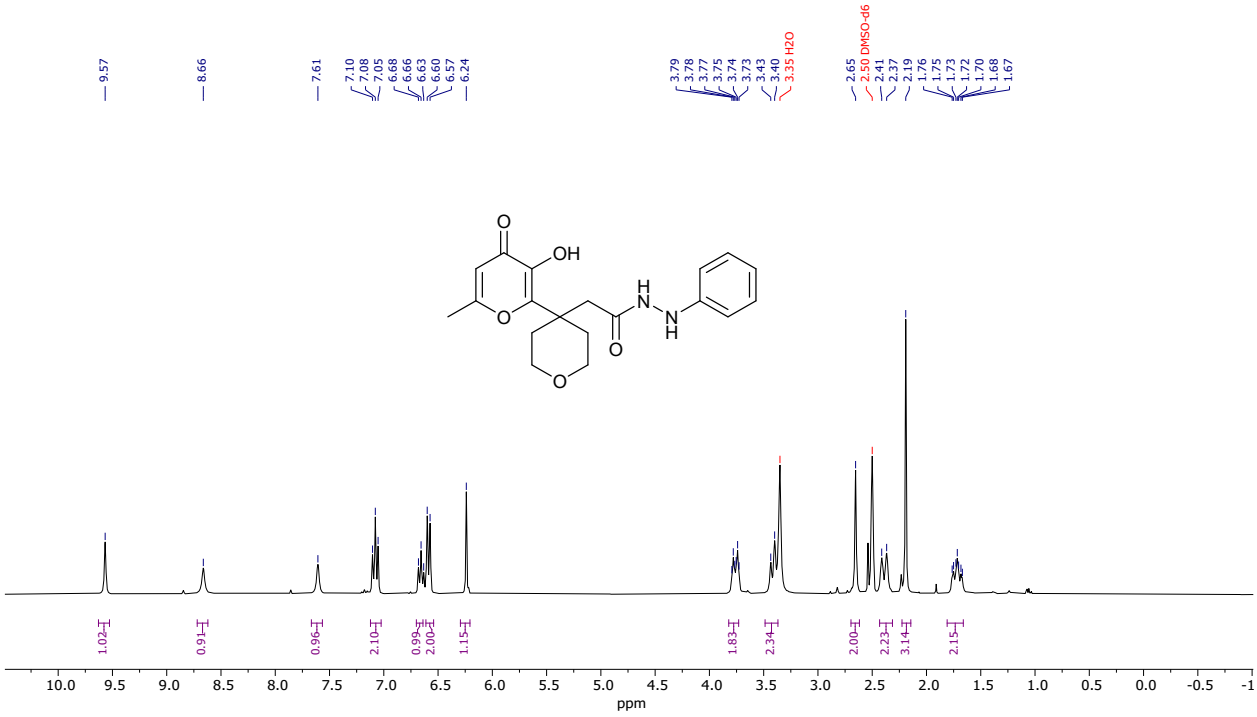
^{1}H NMR spectrum (300 MHz) of **7g** in DMSO-d_6



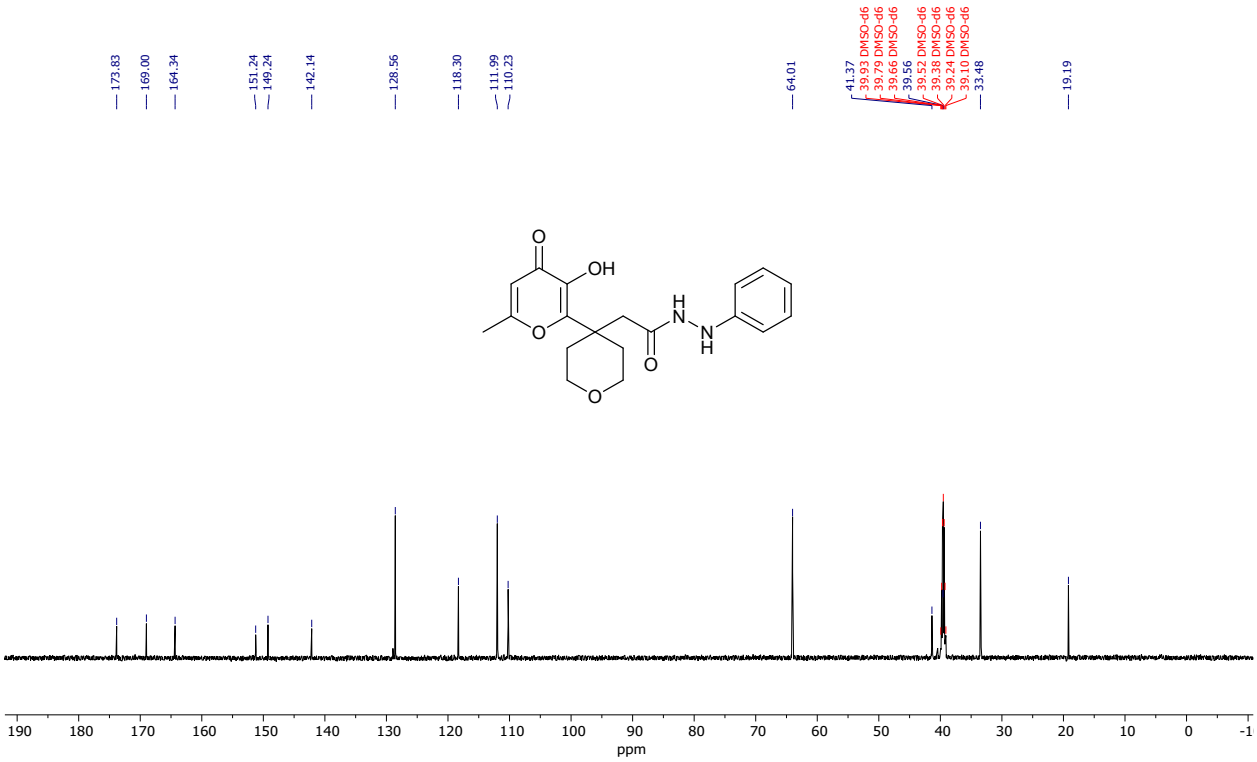
^{13}C {^{1}H} NMR spectrum (75 MHz) of **7g** in DMSO-d_6



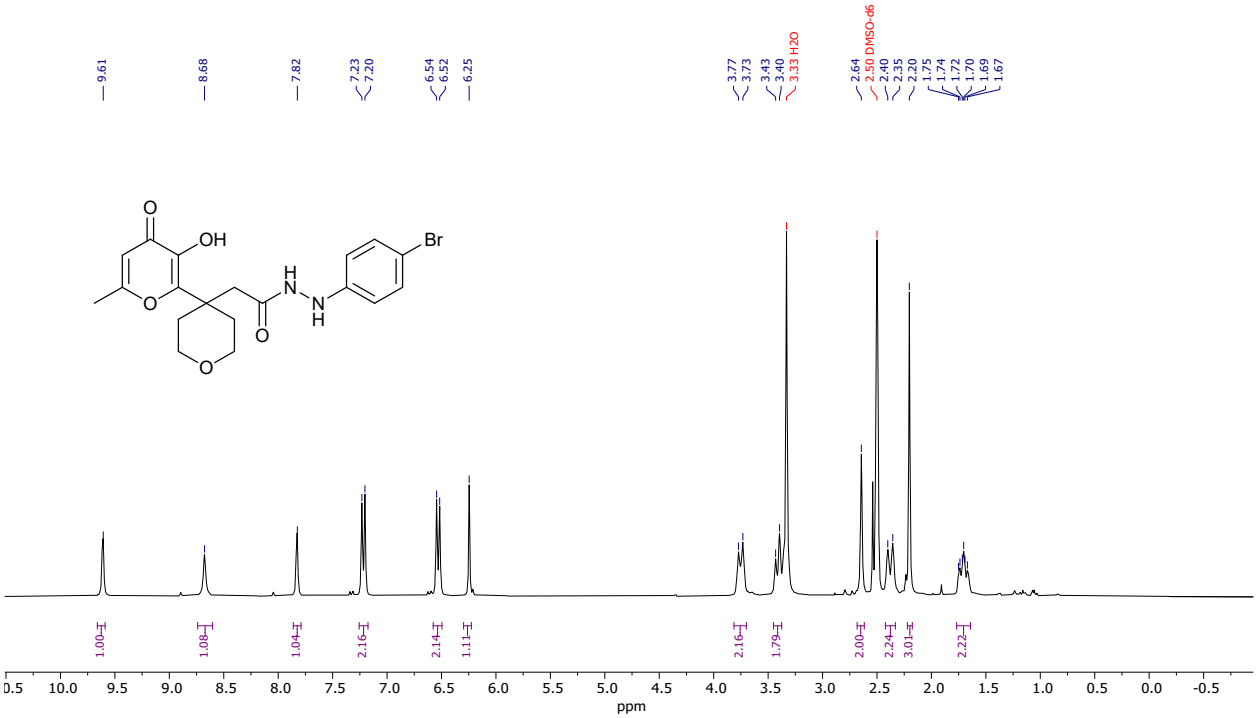
^{1}H NMR spectrum (300 MHz) of **7h** in DMSO-d_6



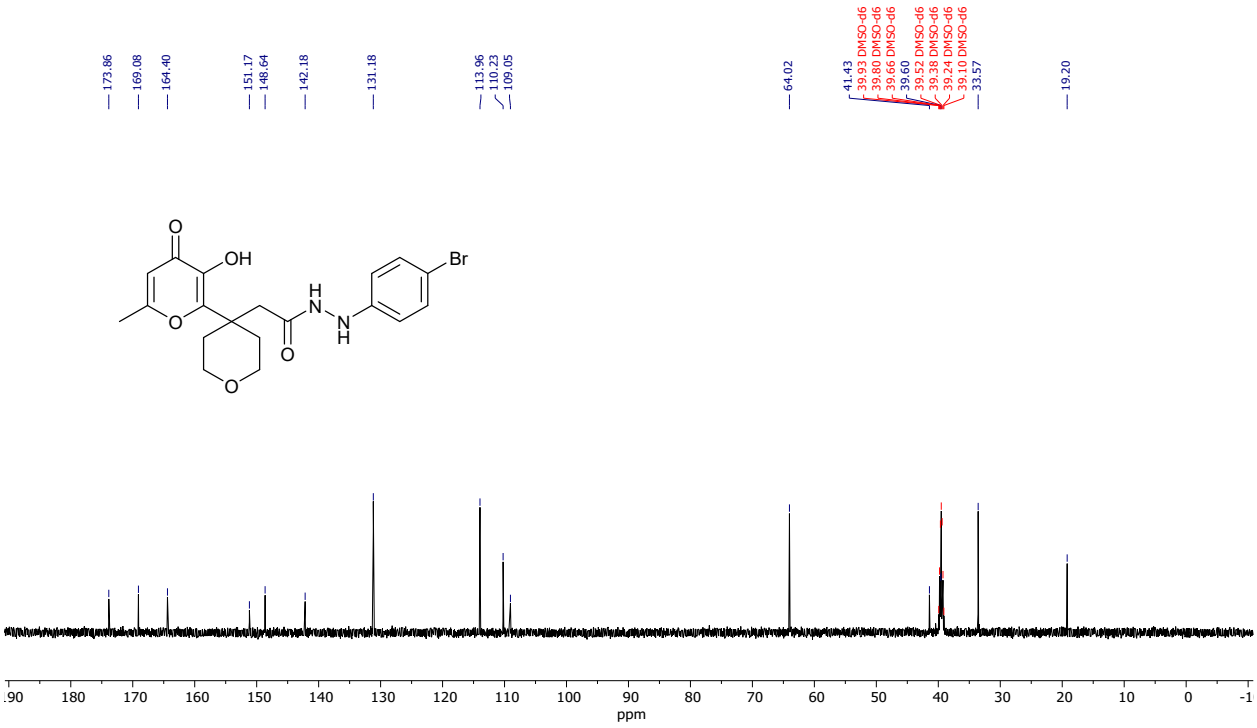
^{13}C {^{1}H} NMR spectrum (151 MHz) of **7h** in DMSO-d_6



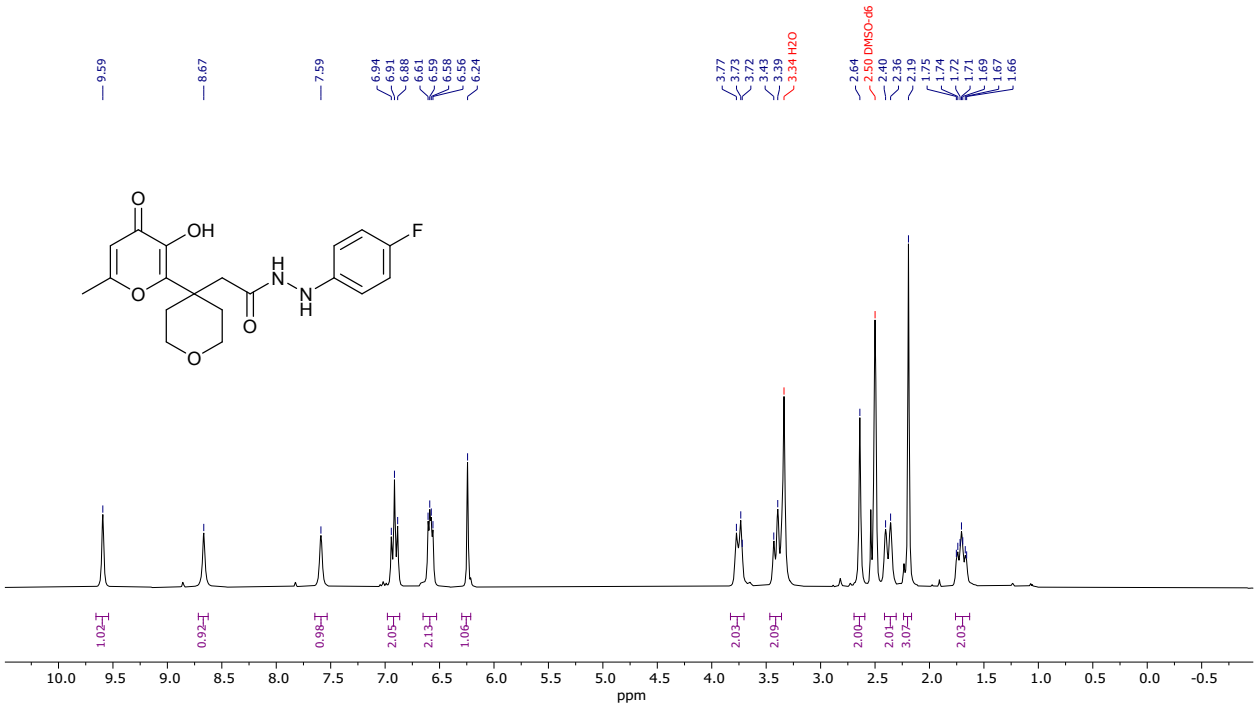
^{1}H NMR spectrum (300 MHz) of **7i** in DMSO-d_6



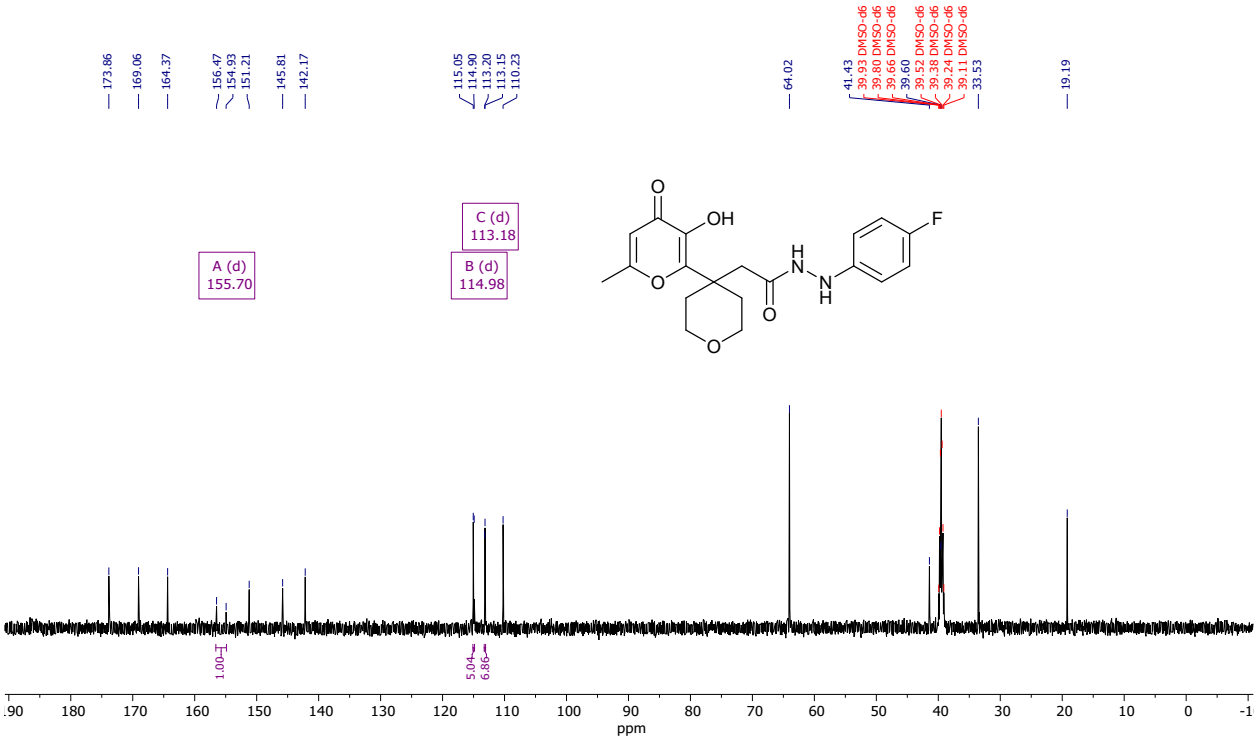
^{13}C {^{1}H} NMR spectrum (151 MHz) of **7i** in DMSO-d_6



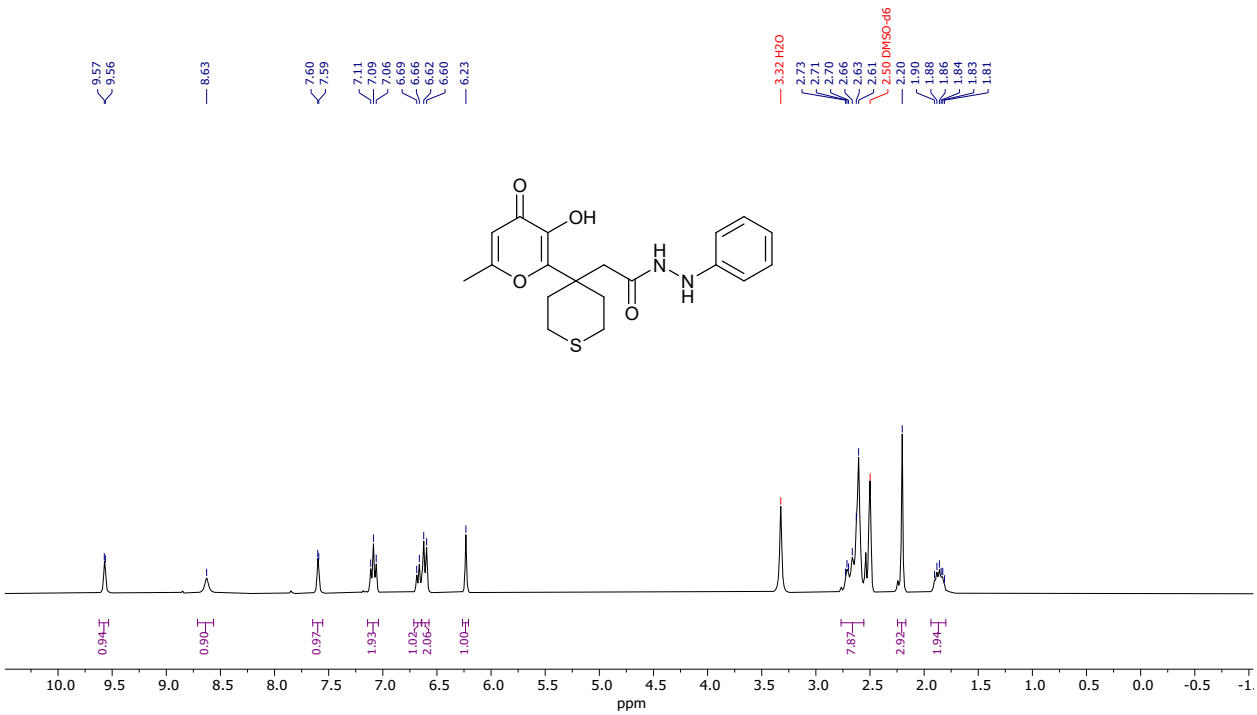
^{1}H NMR spectrum (300 MHz) of **7j** in DMSO-d_6



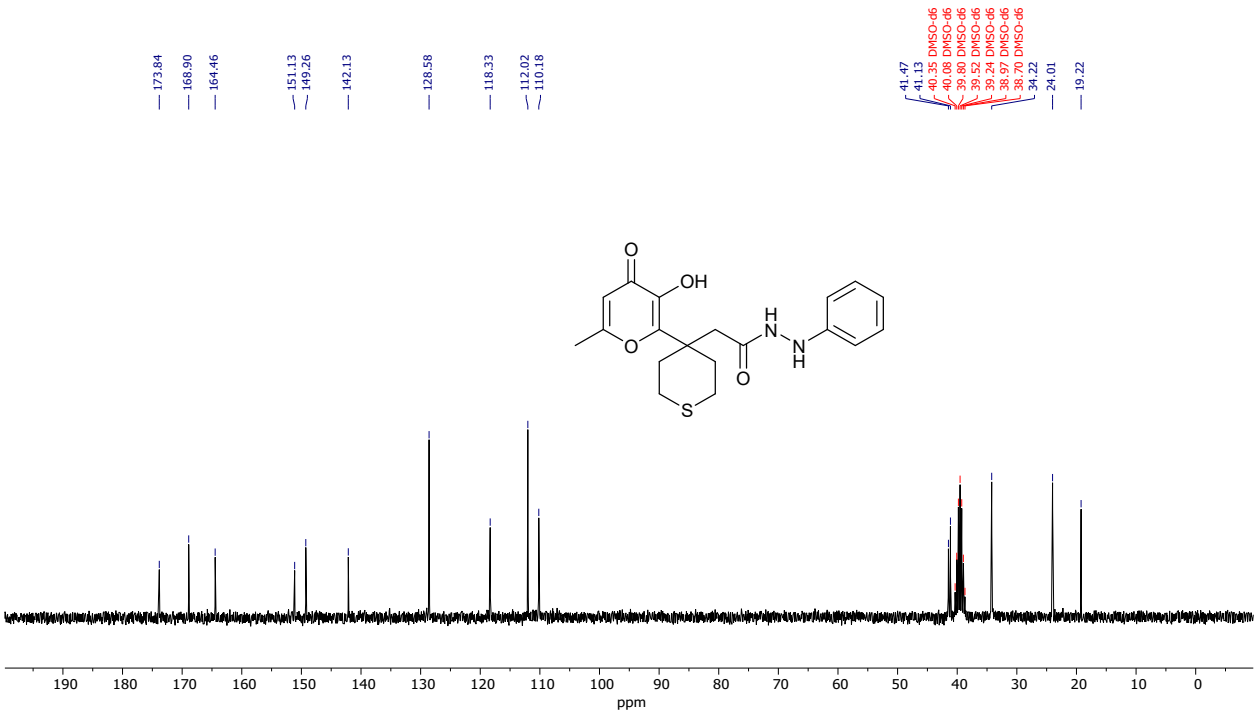
^{13}C {^{1}H} NMR spectrum (151 MHz) of **7j** in DMSO-d_6



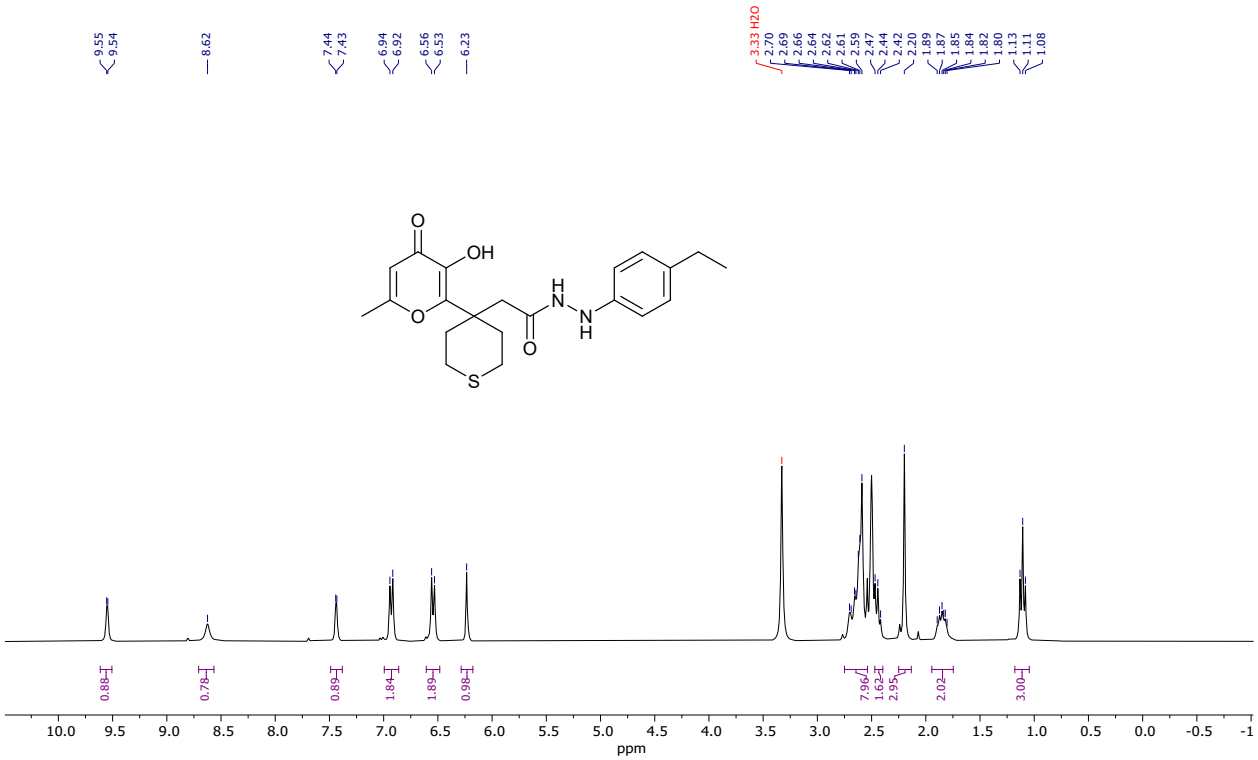
^{1}H NMR spectrum (300 MHz) of **7k** in DMSO-d_6



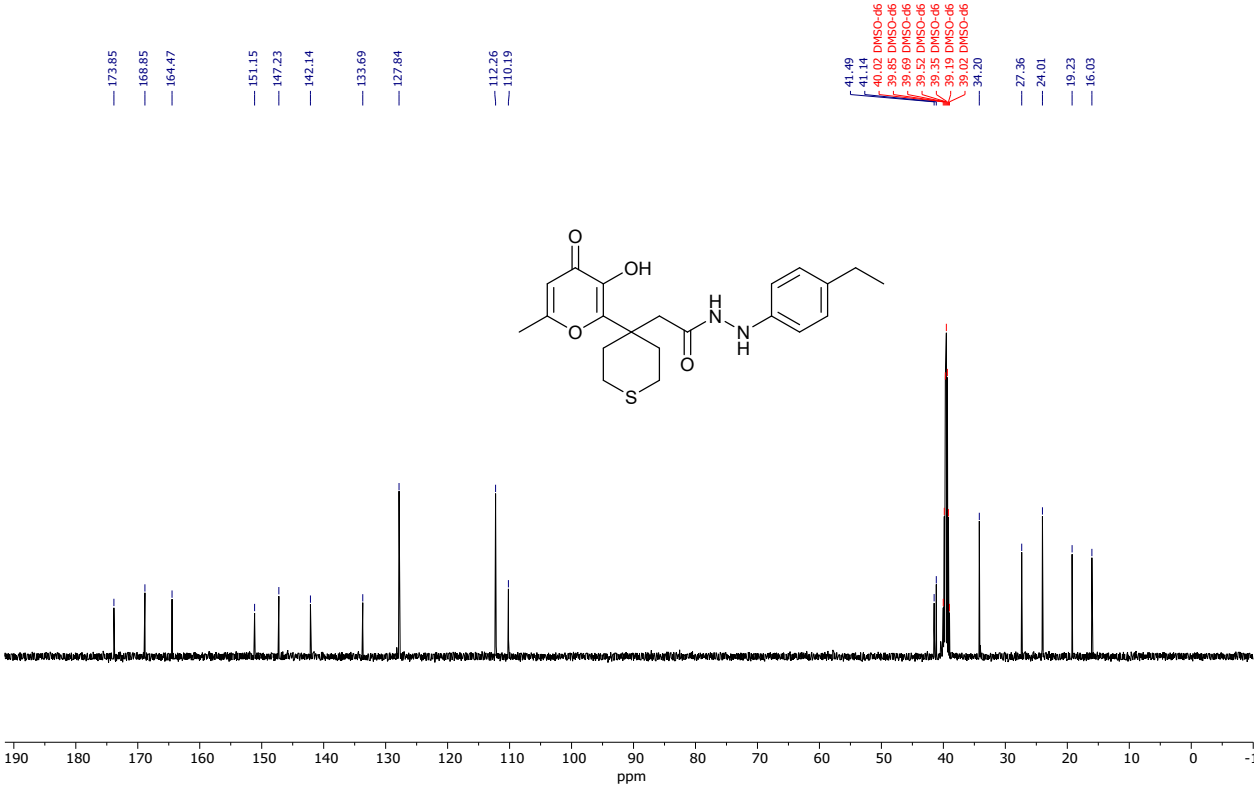
^{13}C {^{1}H} NMR spectrum (75 MHz) of **7k** in DMSO-d_6



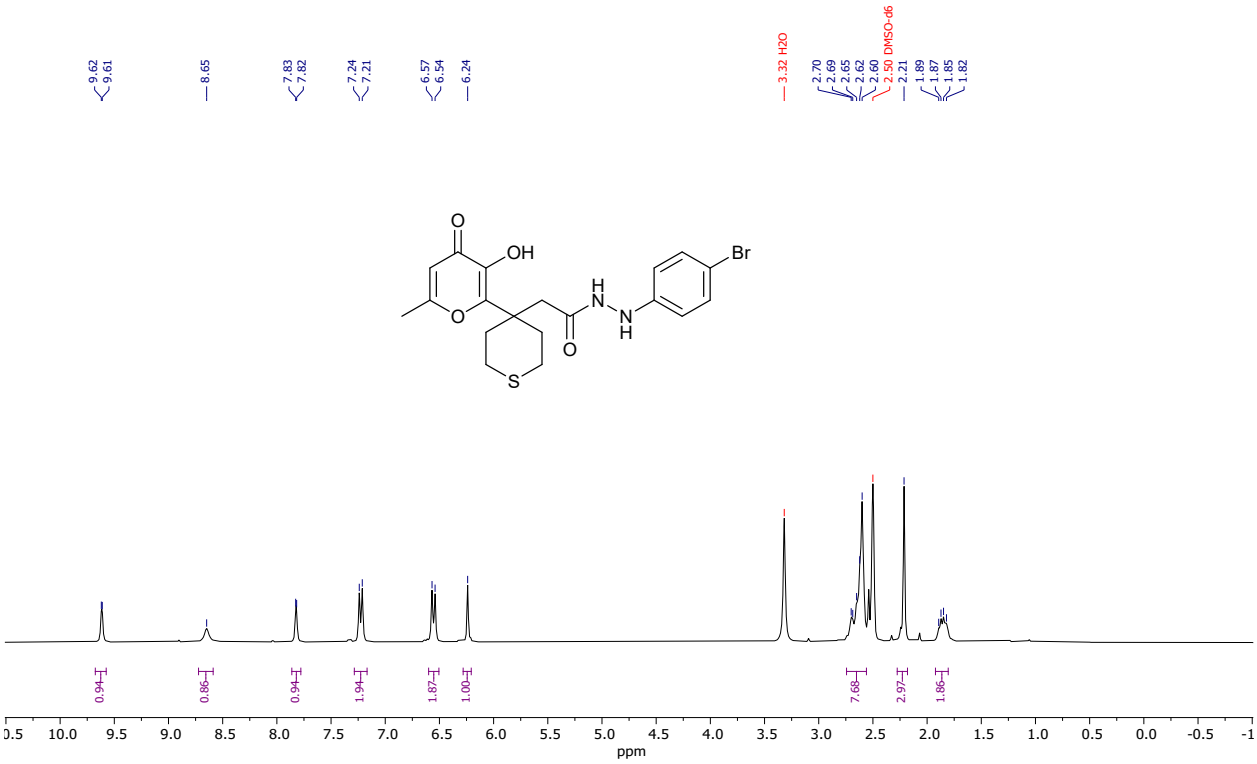
^{1}H NMR spectrum (300 MHz) of **7l** in DMSO-d_6



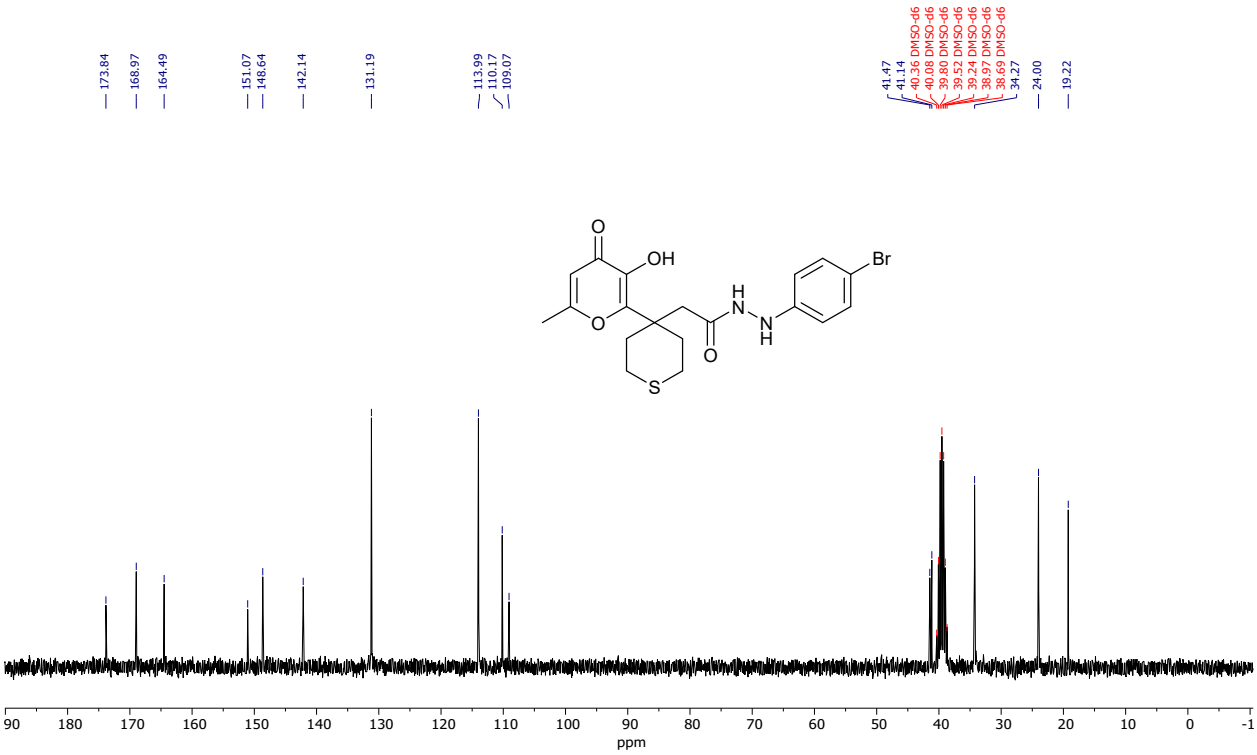
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7l** in DMSO-d_6



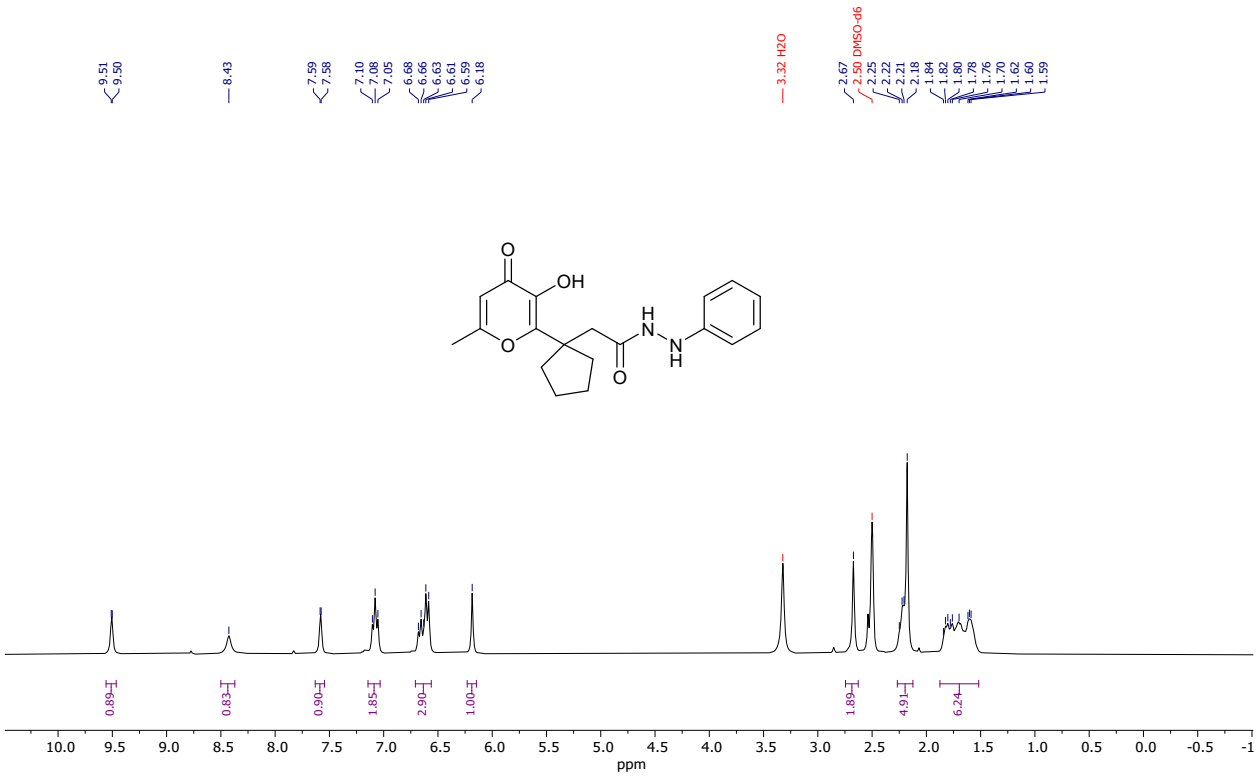
^{1}H NMR spectrum (300 MHz) of **7m** in DMSO-d_6



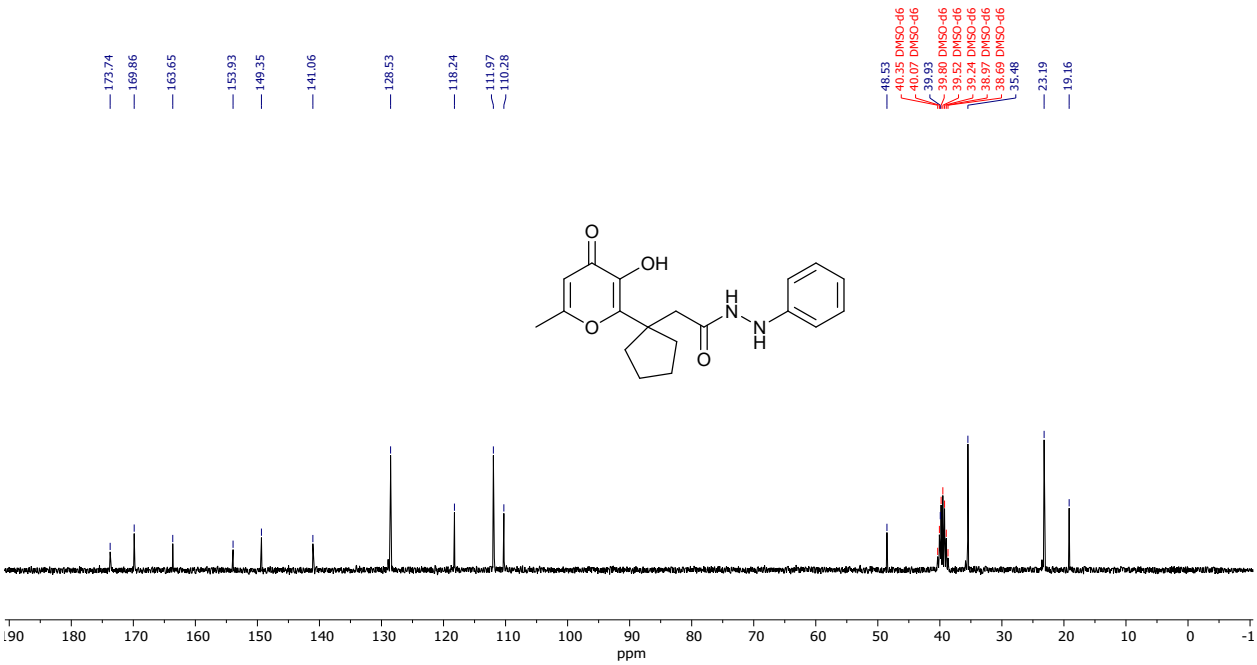
^{13}C {^{1}H} NMR spectrum (75 MHz) of **7m** in DMSO-d_6



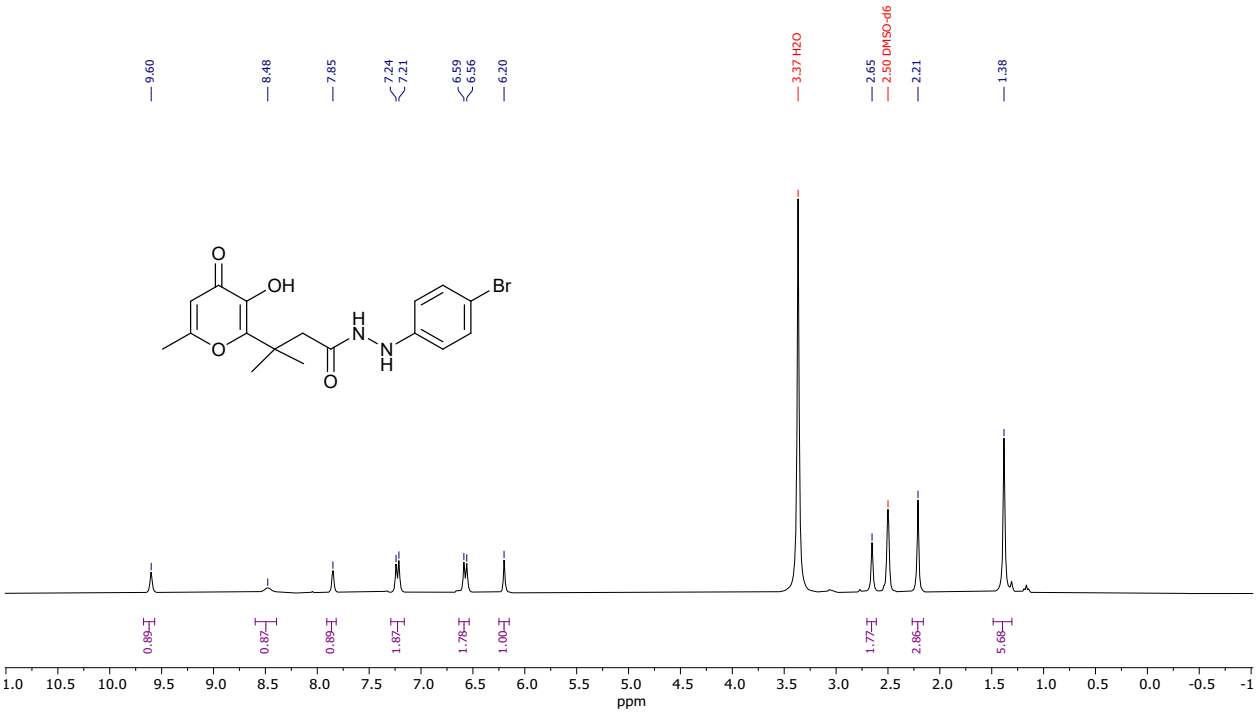
^{1}H NMR spectrum (300 MHz) of **7n** in DMSO-d_6



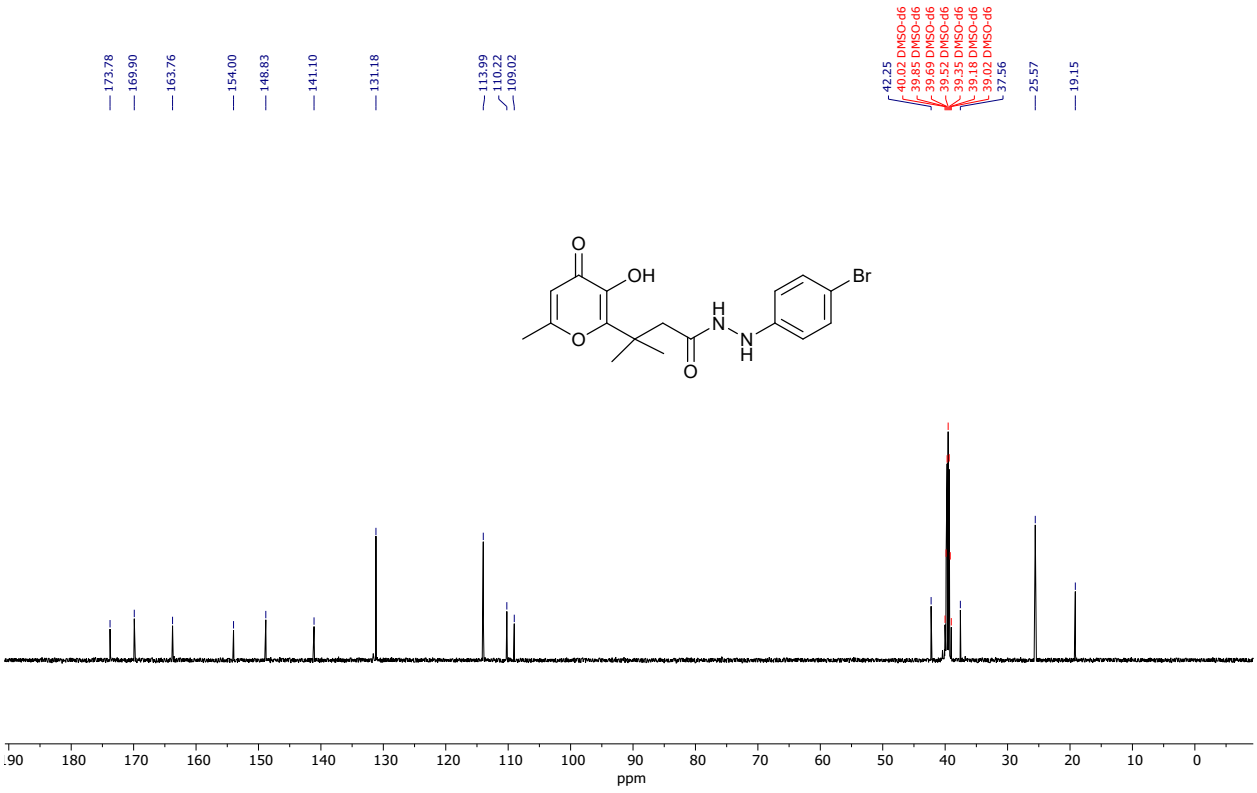
^{13}C {^{1}H} NMR spectrum (75 MHz) of **7n** in DMSO-d_6



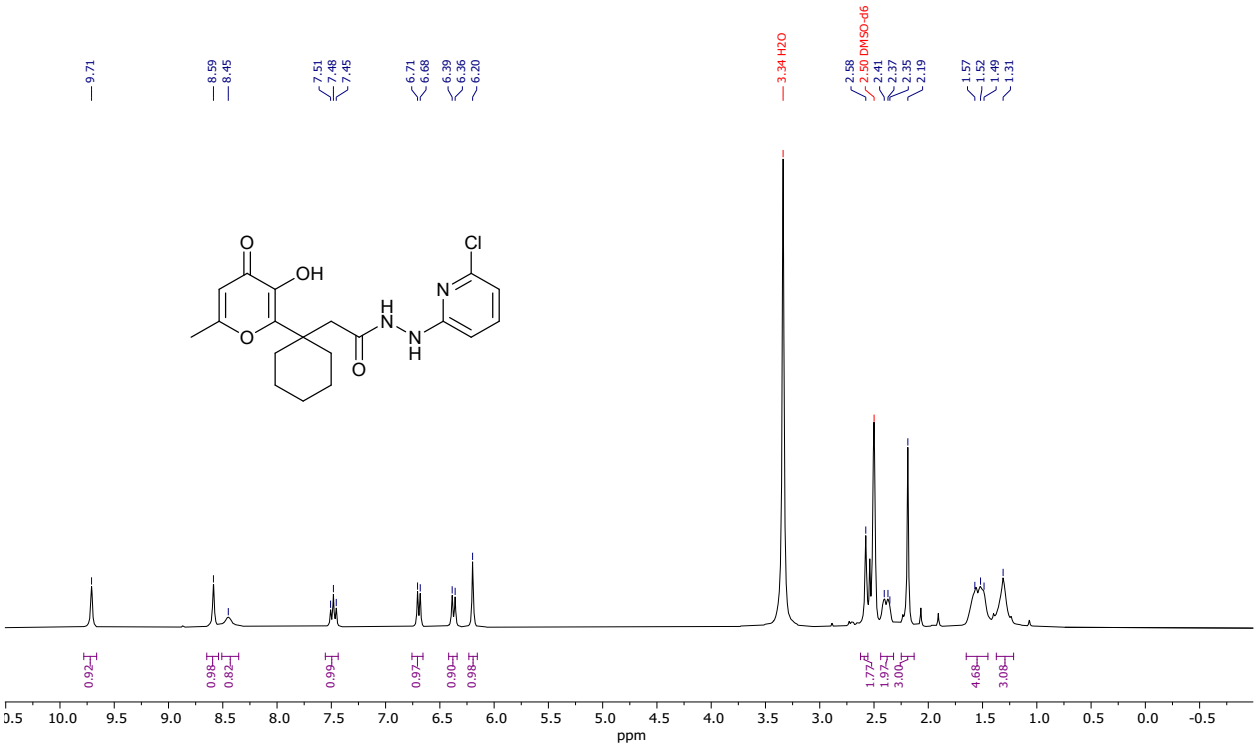
^{1}H NMR spectrum (300 MHz) of **7o** in DMSO-d_6



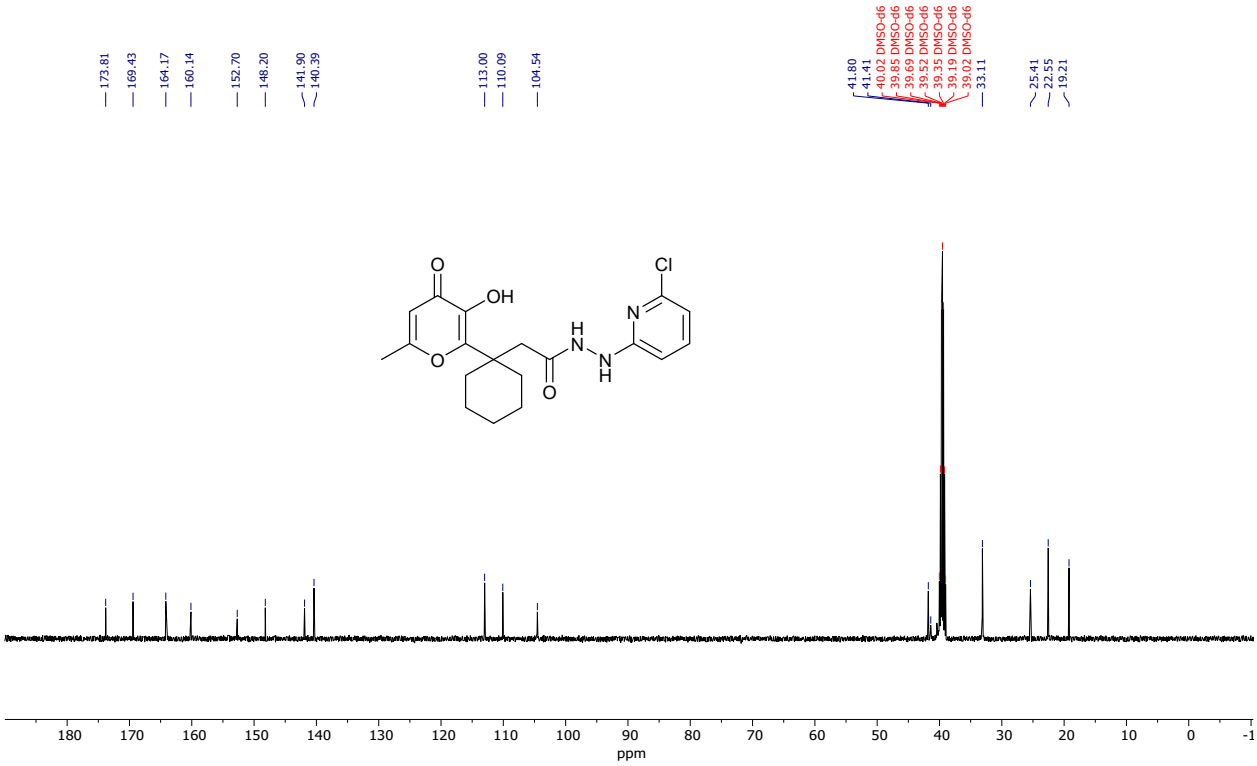
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7o** in DMSO-d_6



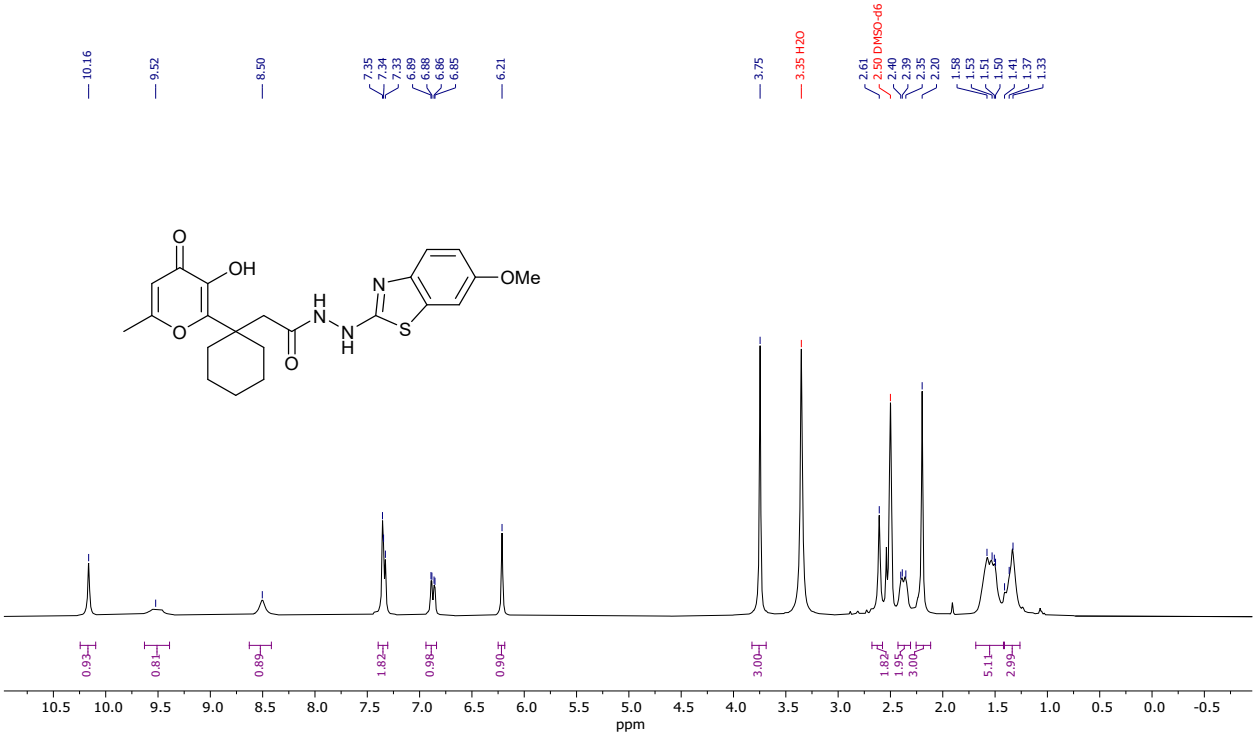
^{1}H NMR spectrum (300 MHz) of **7p** in DMSO-d_6



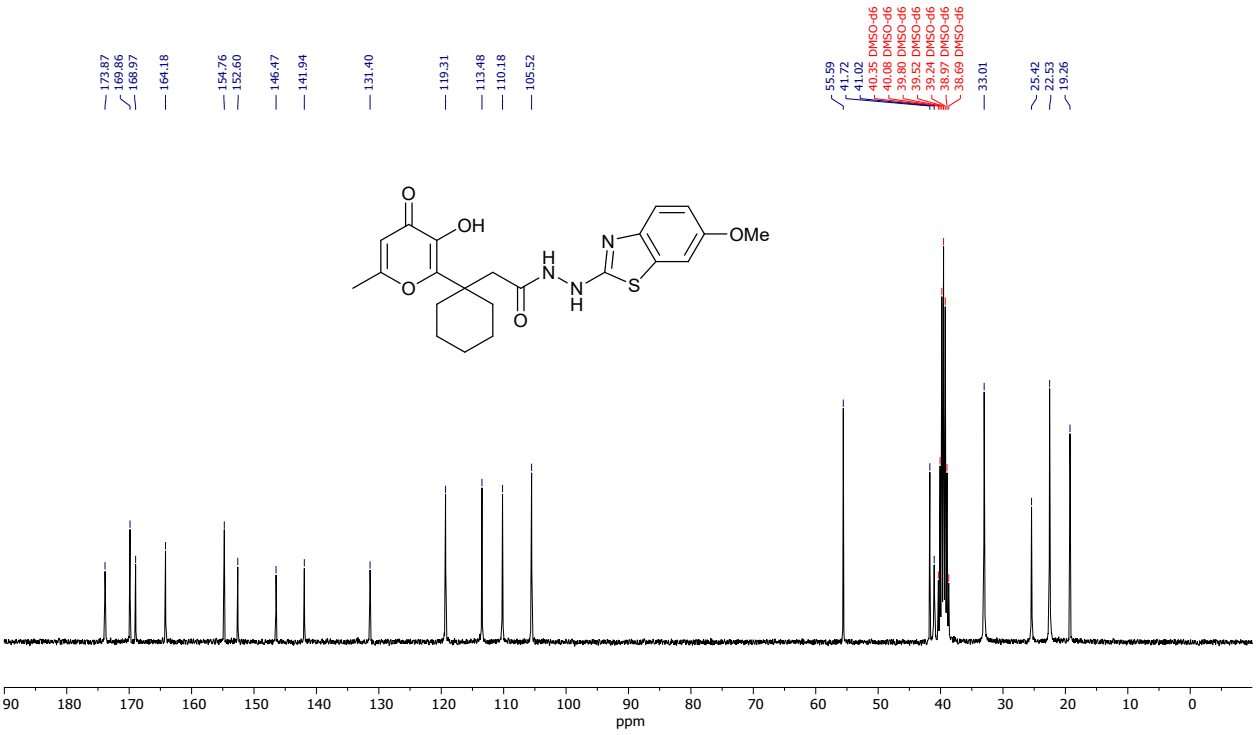
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7p** in DMSO-d_6



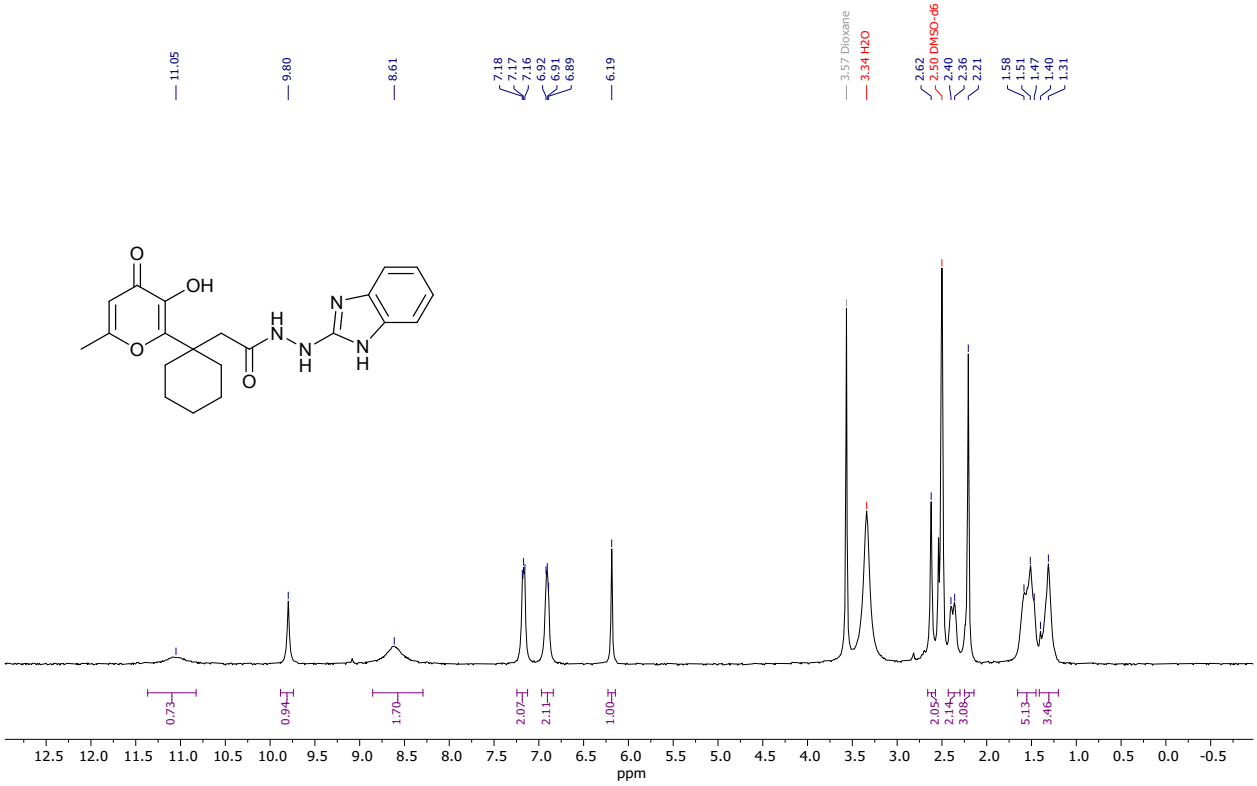
^{1}H NMR spectrum (300 MHz) of **7q** in DMSO-d_6



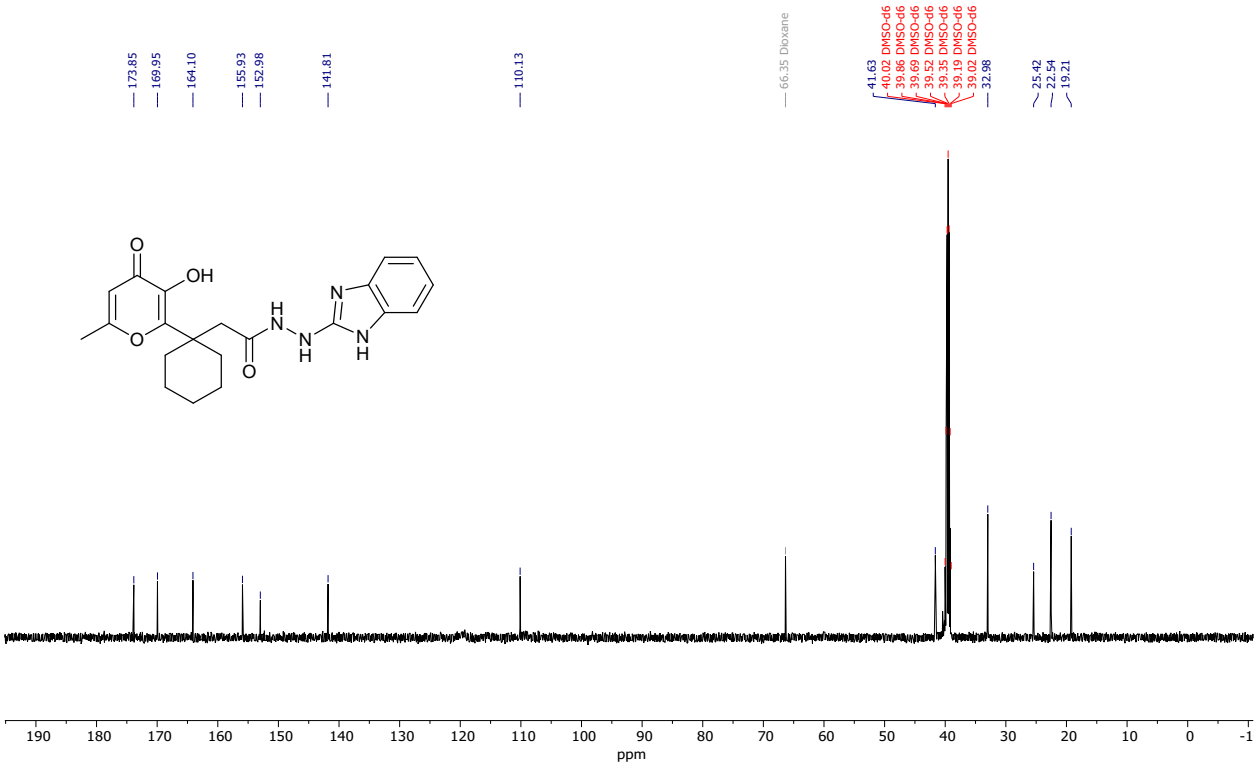
^{13}C {^{1}H} NMR spectrum (75 MHz) of **7q** in DMSO-d_6



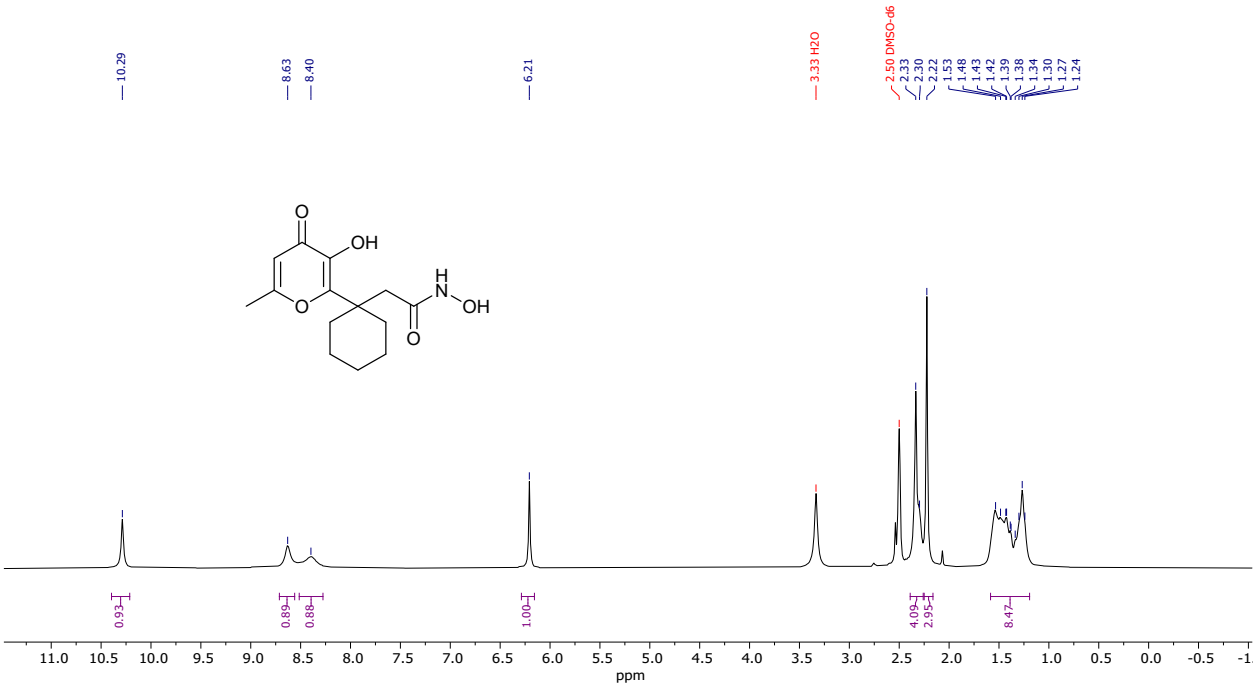
^{1}H NMR spectrum (300 MHz) of **7r** in DMSO-d_6



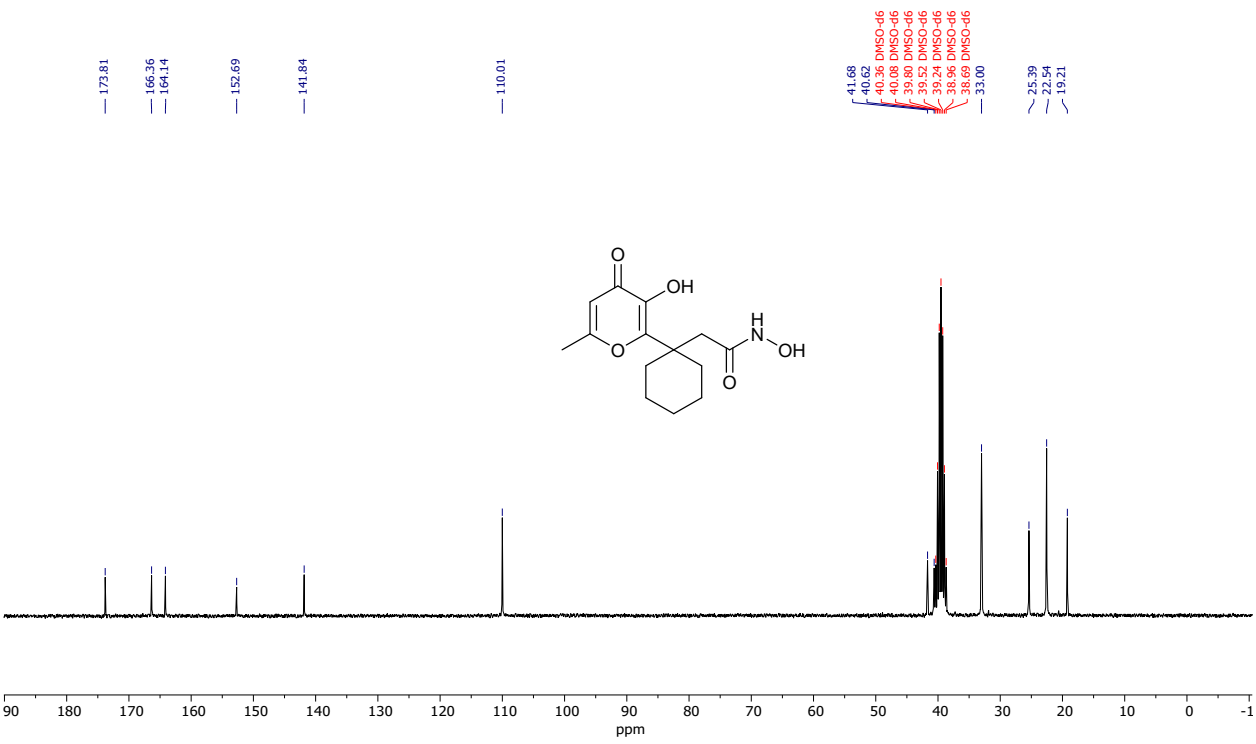
^{13}C {^{1}H} NMR spectrum (126 MHz) of **7r** in DMSO-d_6



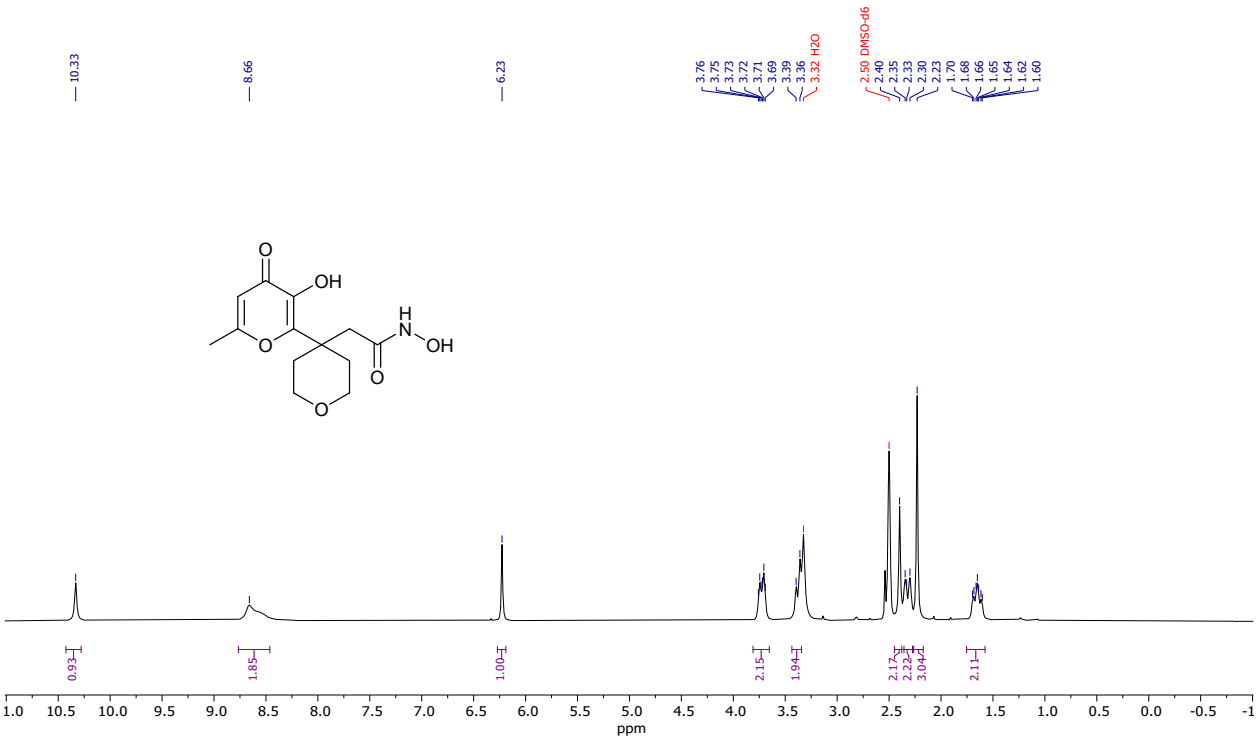
^{1}H NMR spectrum (300 MHz) of **9a** in DMSO-d_6



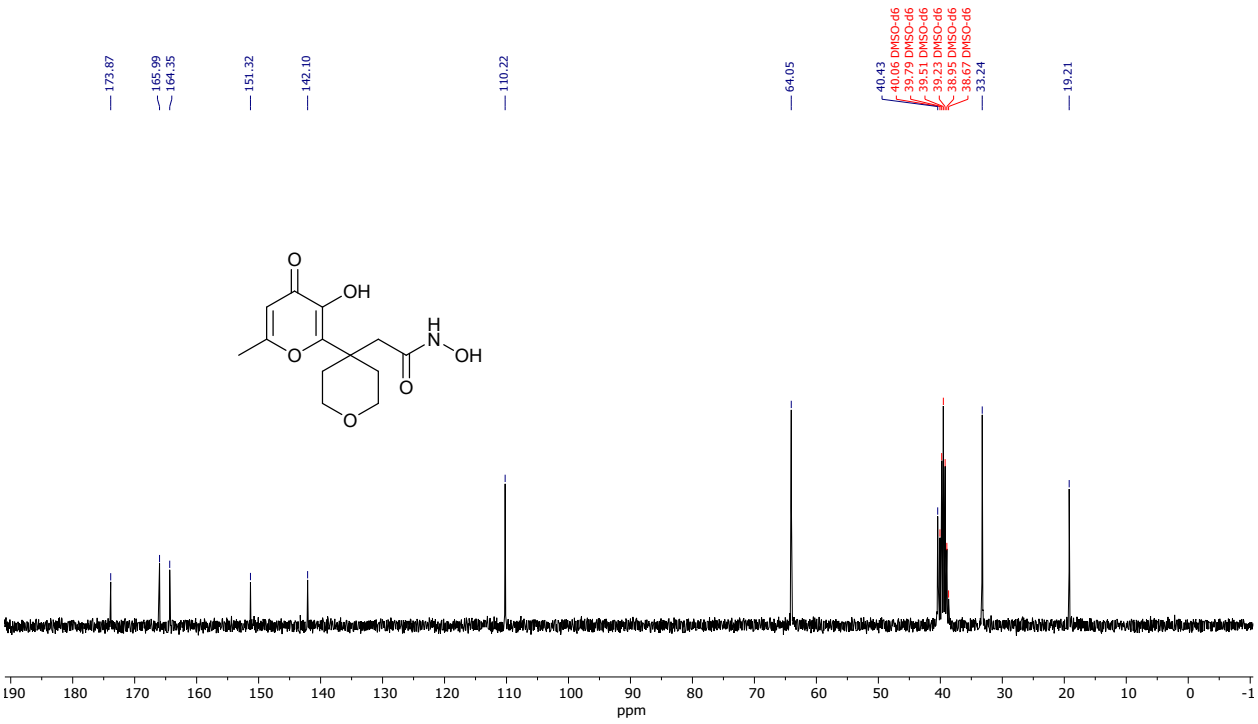
^{13}C {^{1}H} NMR spectrum (75 MHz) of **9a** in DMSO-d_6



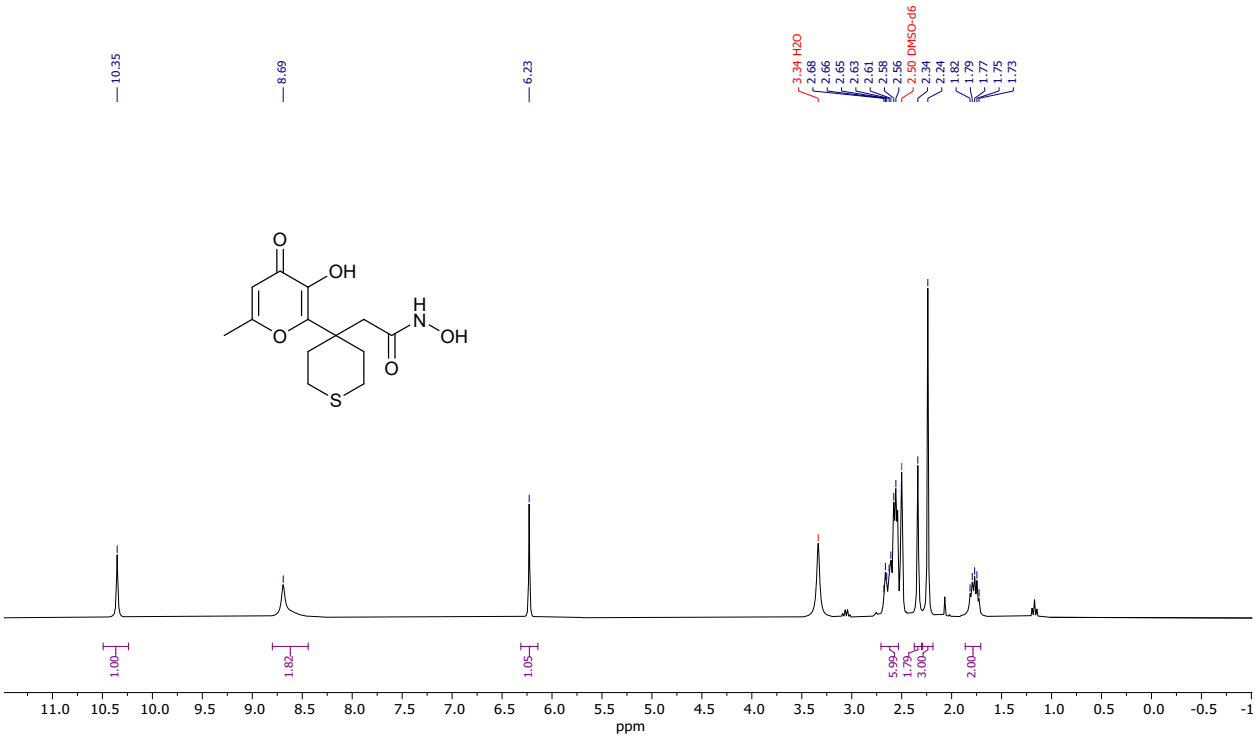
^{1}H NMR spectrum (300 MHz) of **9b** in DMSO-d_6



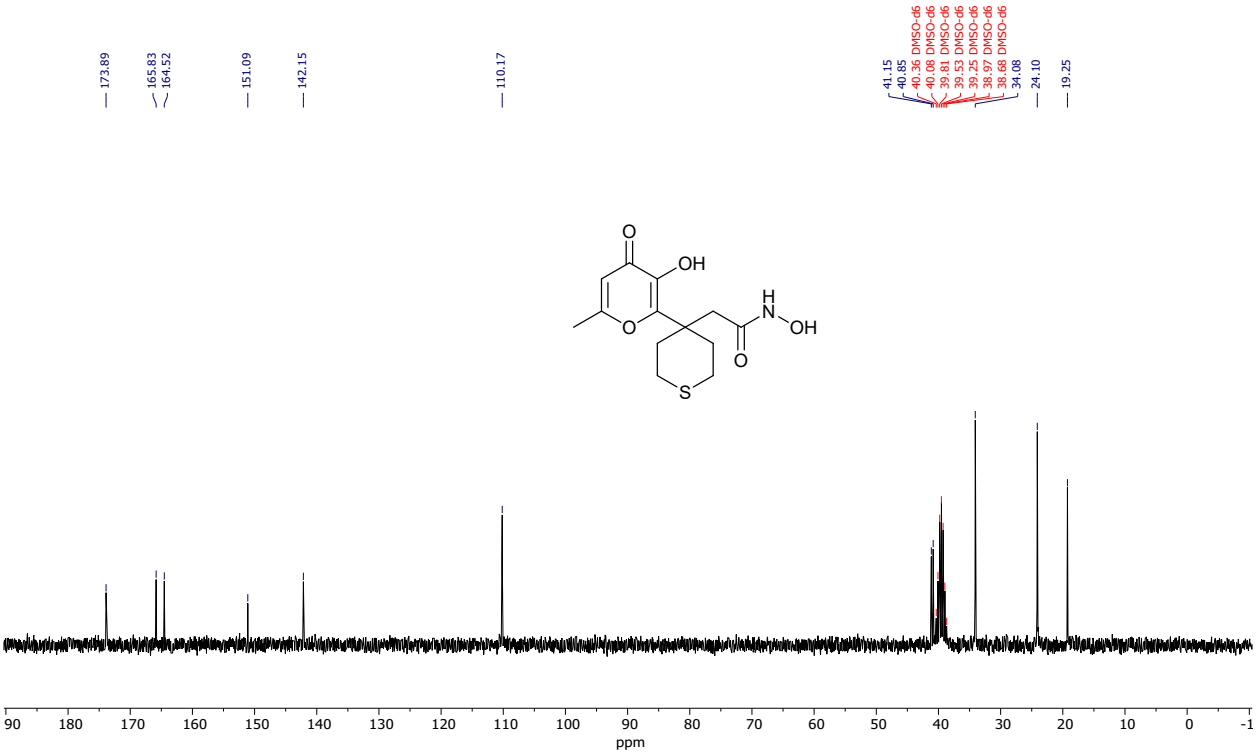
^{13}C {^{1}H} NMR spectrum (75 MHz) of **9b** in DMSO-d_6



^{1}H NMR spectrum (300 MHz) of **9c** in DMSO-d_6

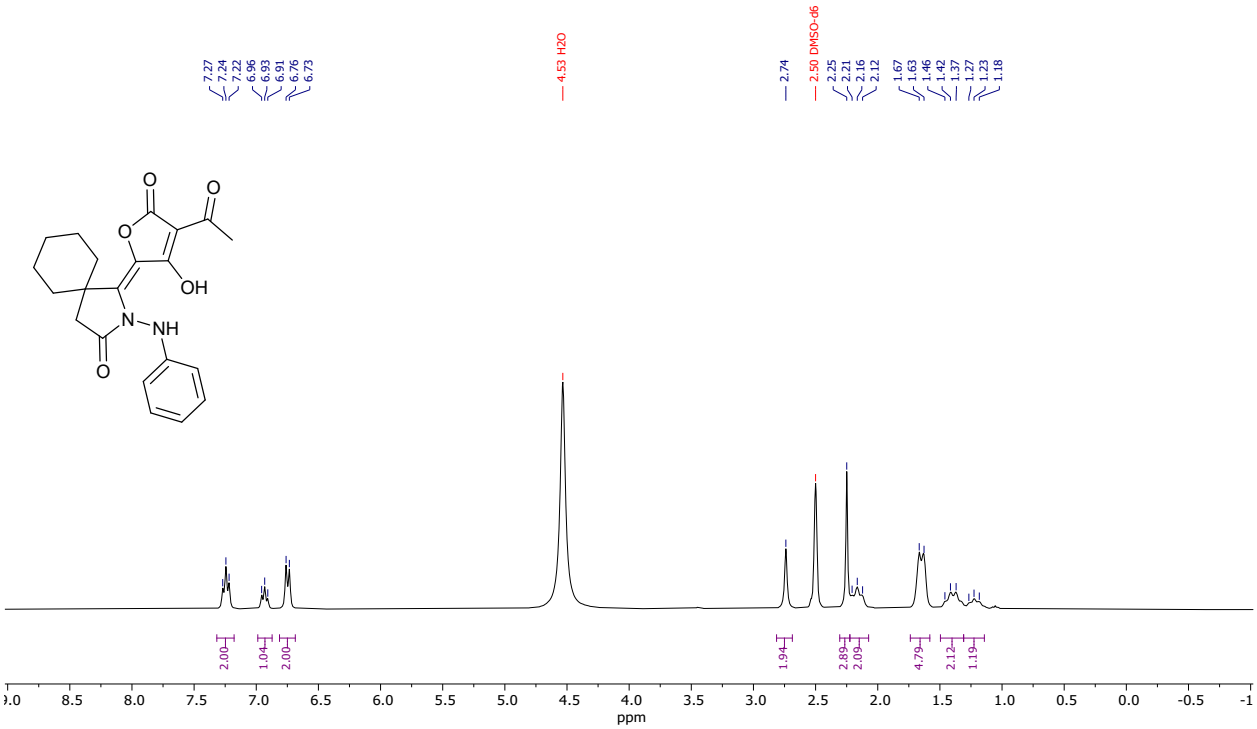


^{13}C {^{1}H} NMR spectrum (75 MHz) of **9c** in DMSO-d_6

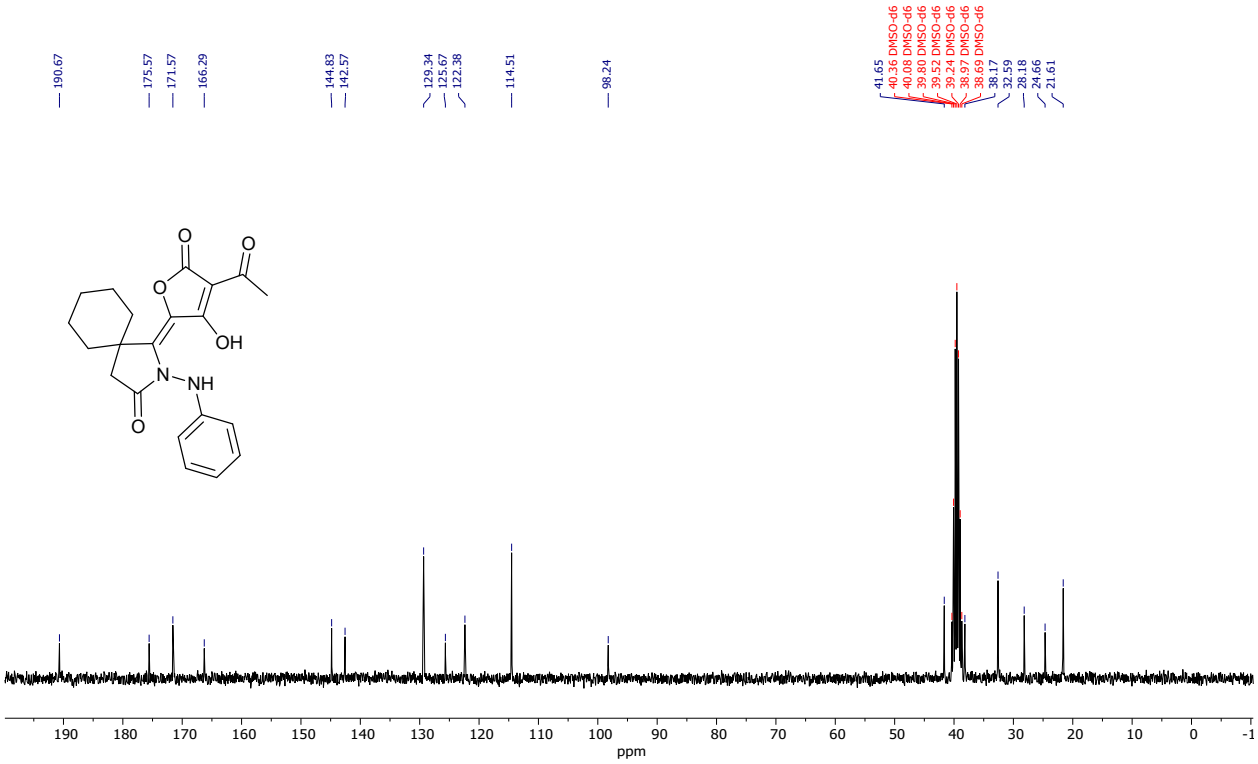


6.2 3-Acetyltetronic acids 8

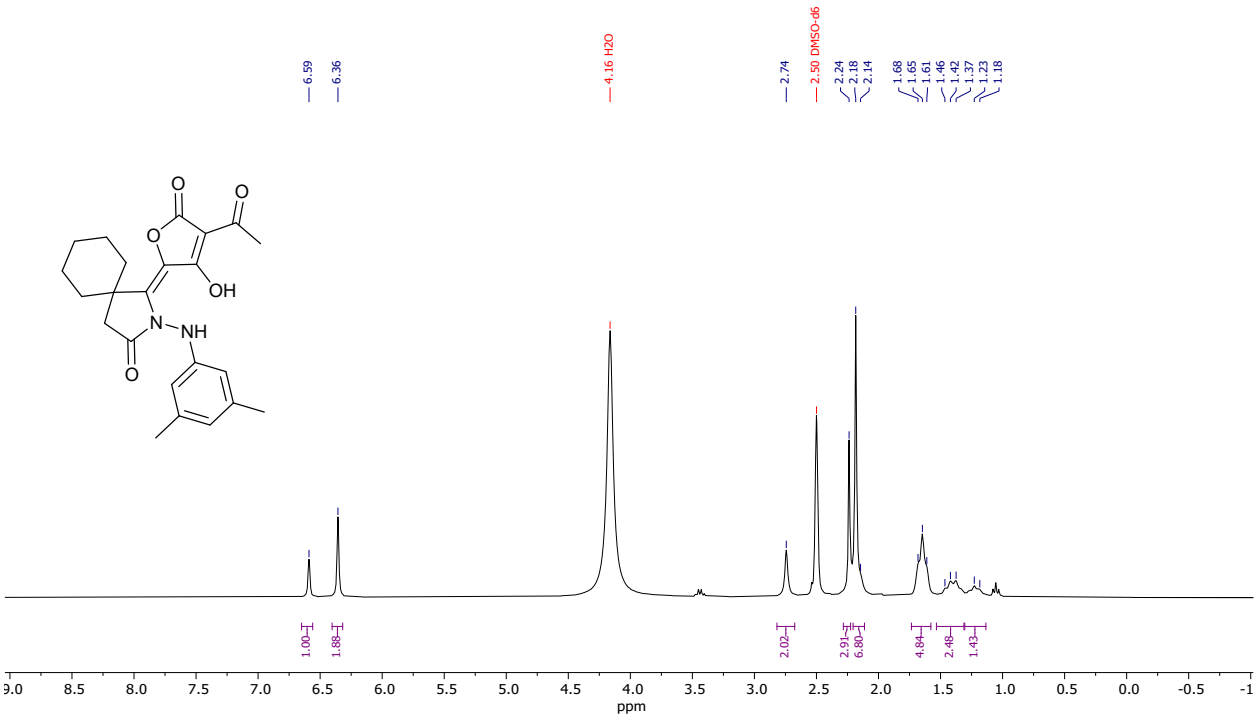
^{1}H NMR spectrum (300 MHz) of **8a** in DMSO-d_6



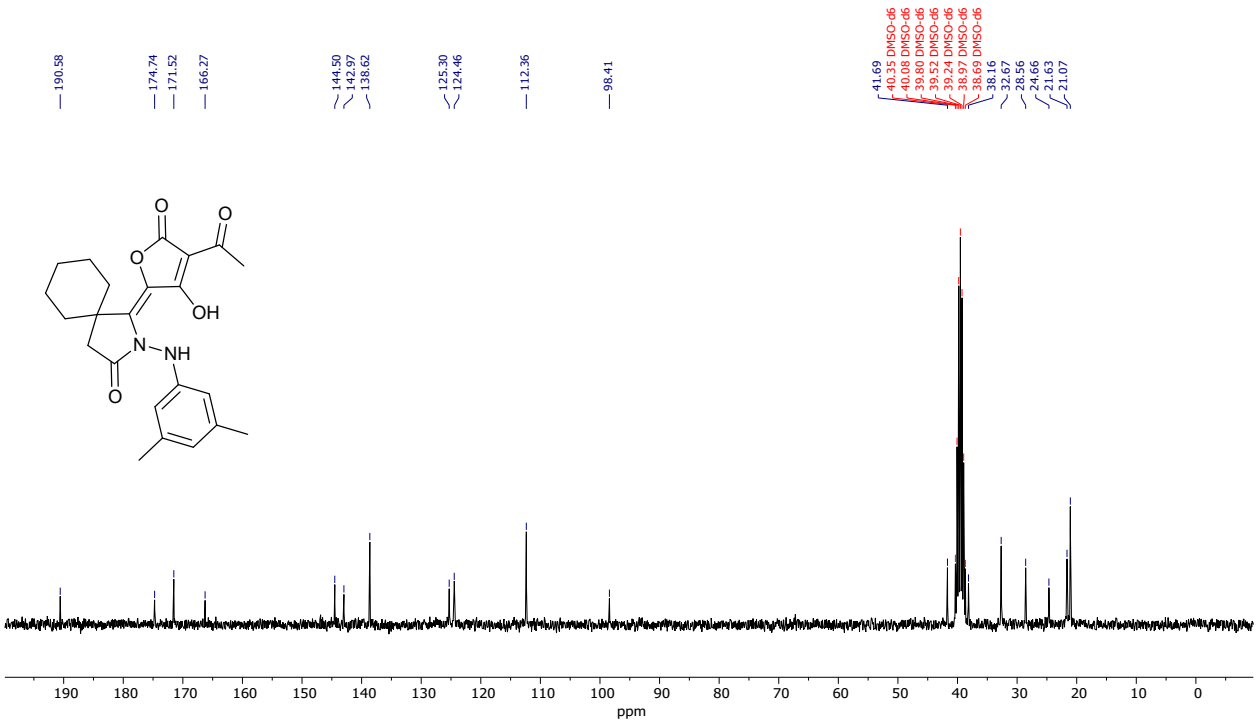
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8a** in DMSO-d_6


190.67
175.57
171.57
166.29
144.83
142.57
129.34
125.67
122.38
114.51
98.24
41.65
40.36 DMSO-d6
40.08 DMSO-d6
39.80 DMSO-d6
39.52 DMSO-d6
39.24 DMSO-d6
38.97 DMSO-d6
38.69 DMSO-d6
38.17
32.59
28.18
24.66
21.61
O
O
O
OH
N
NH
O
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-1
ppm

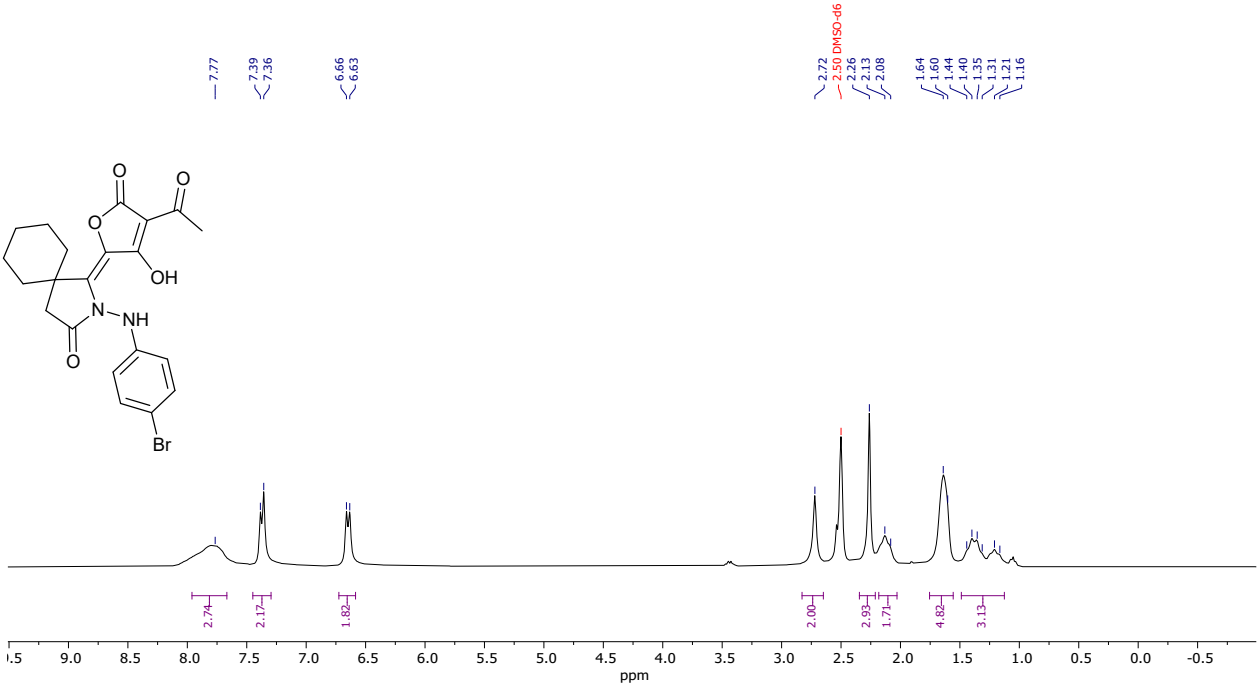
^{1}H NMR spectrum (300 MHz) of **8b** in DMSO-d_6



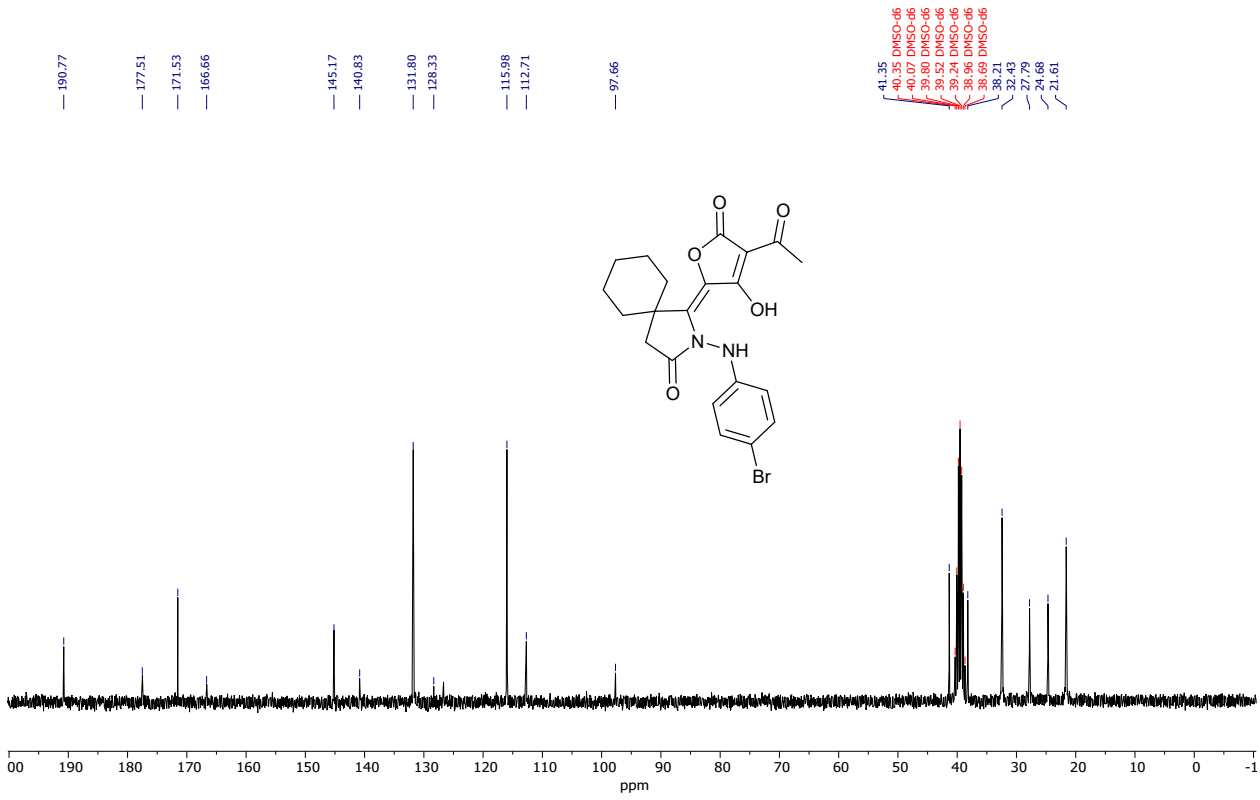
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8b** in DMSO-d_6



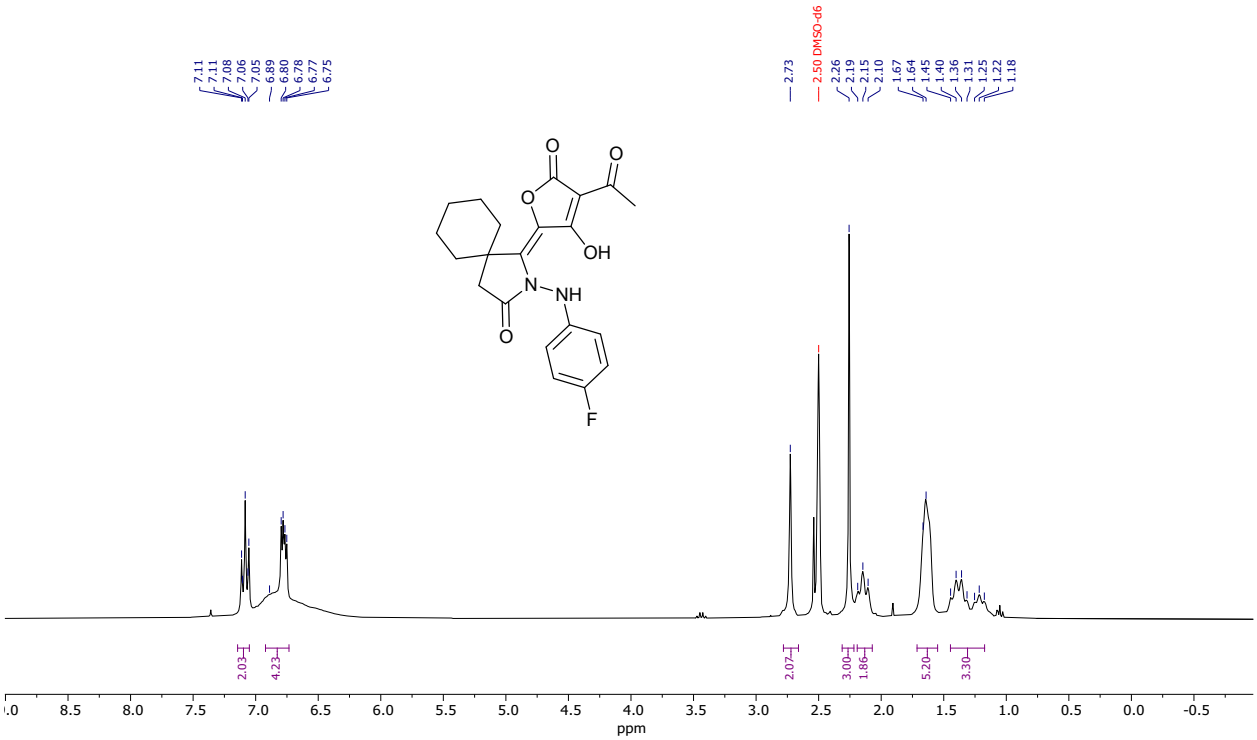
^{1}H NMR spectrum (300 MHz) of **8c** in DMSO-d_6



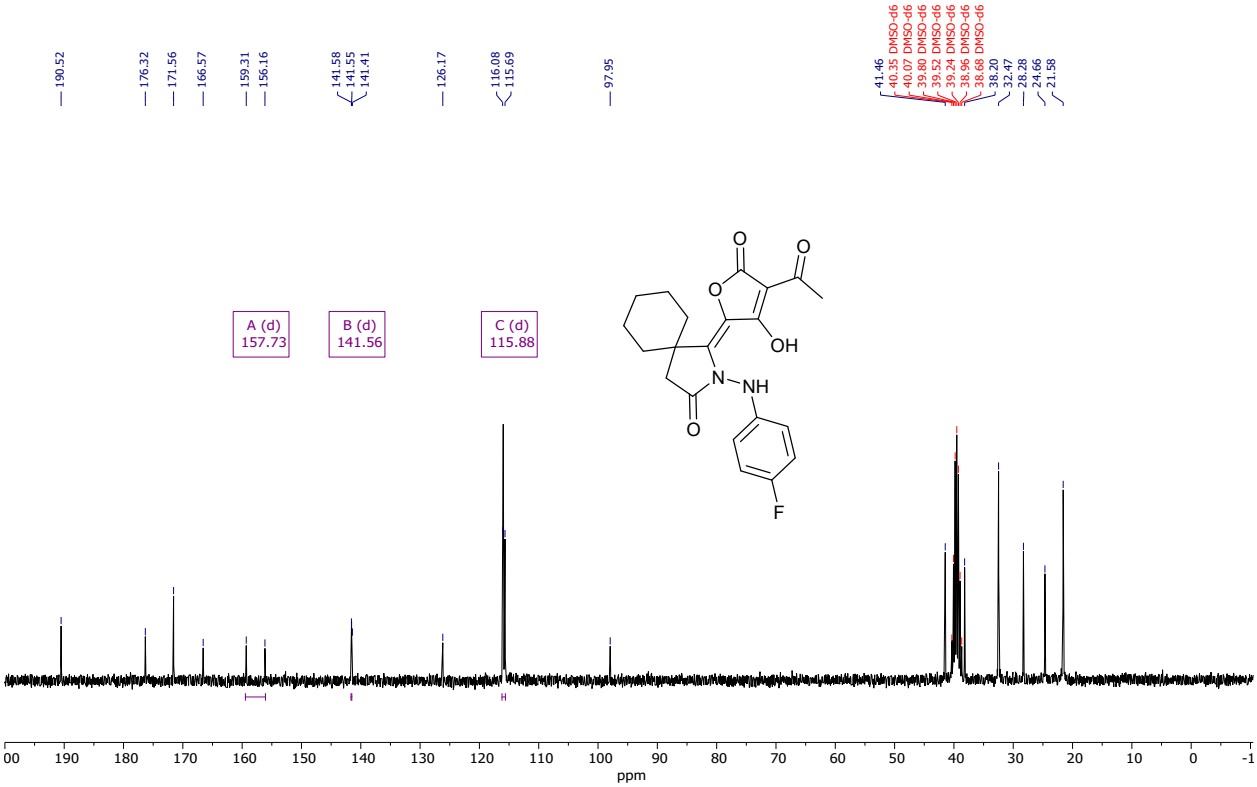
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8c** in DMSO-d_6



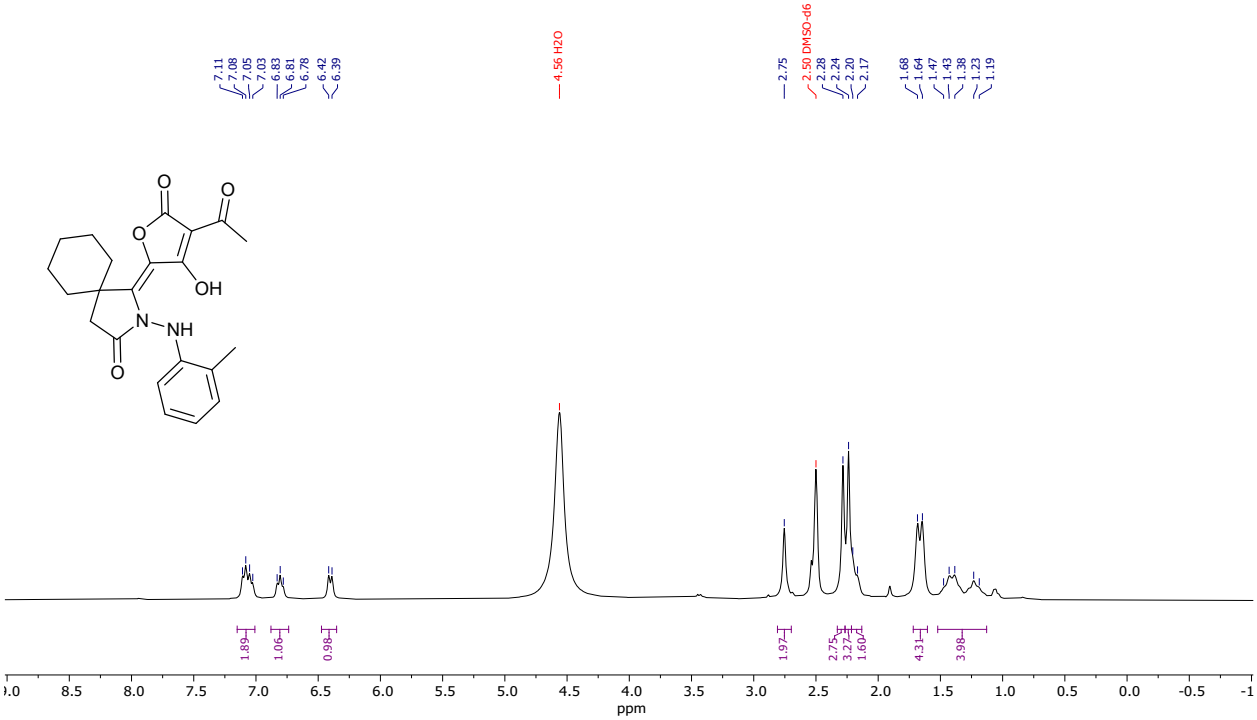
^{1}H NMR spectrum (300 MHz) of **8d** in DMSO-d_6



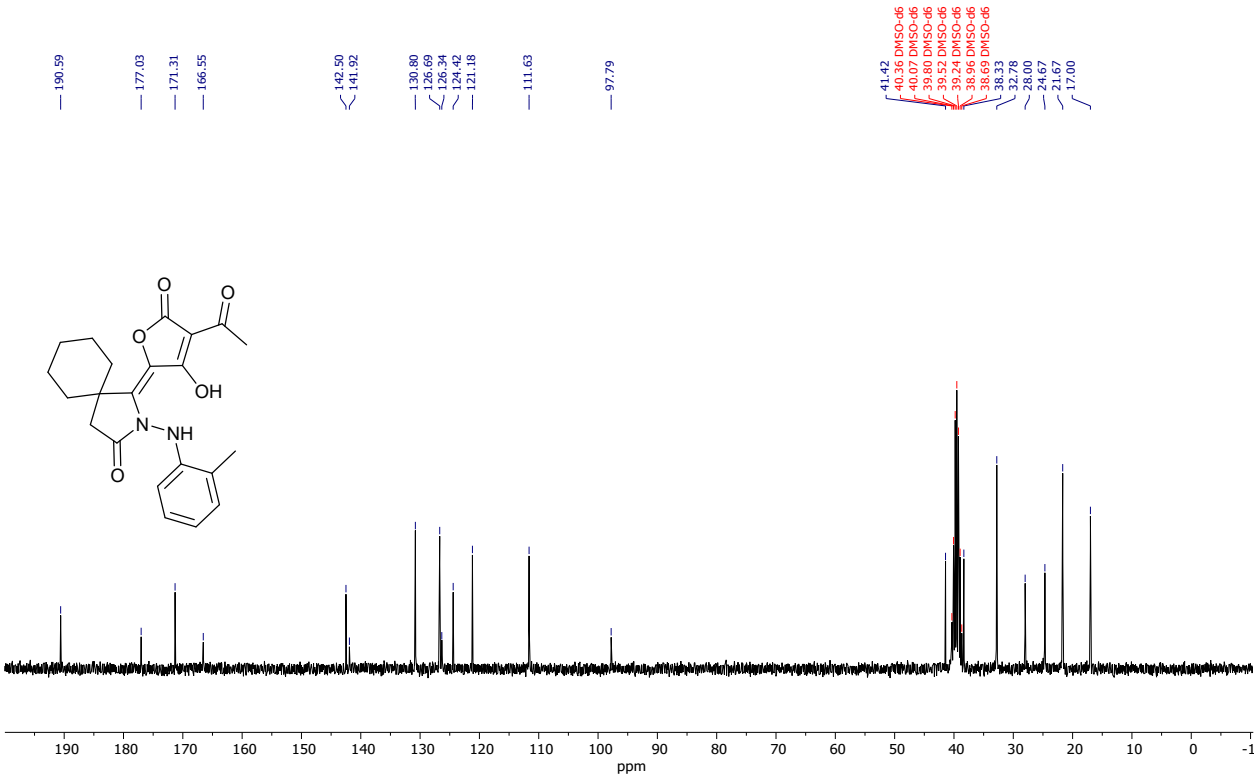
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8d** in DMSO-d_6



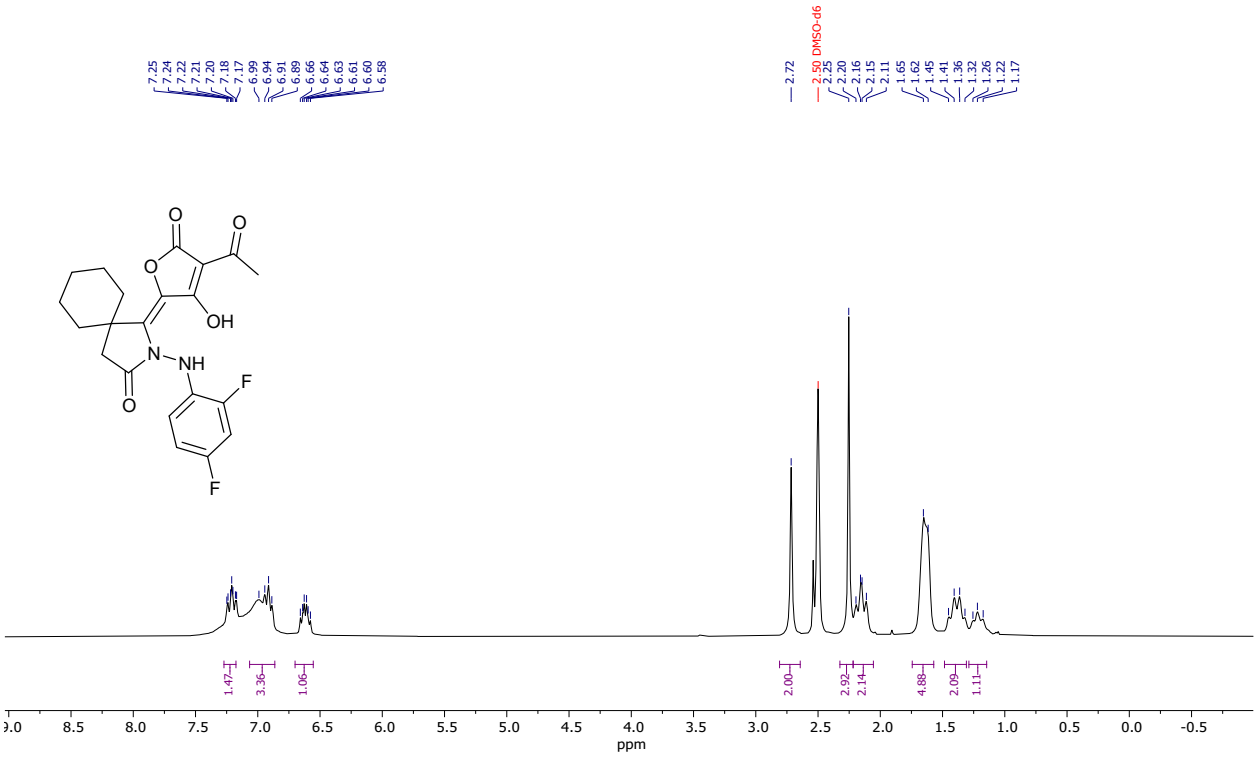
^{1}H NMR spectrum (300 MHz) of **8e** in DMSO-d_6



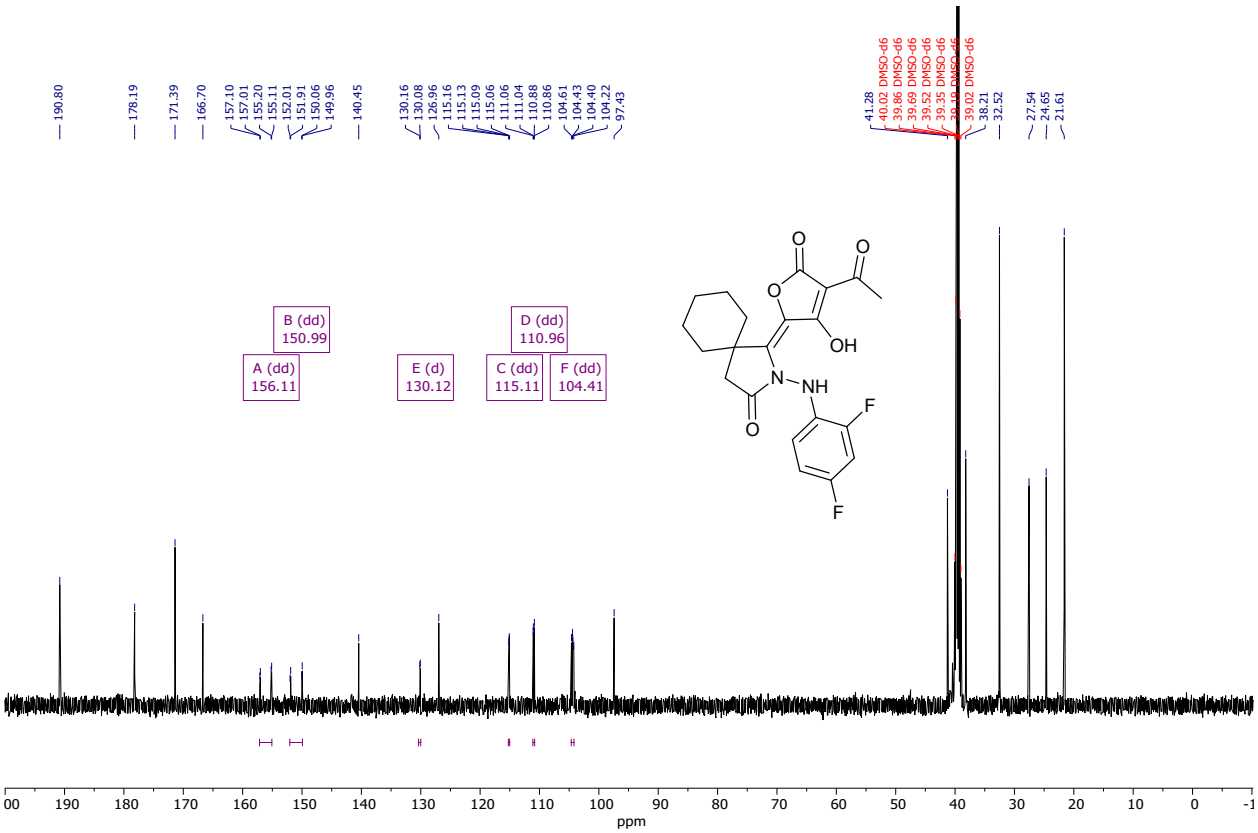
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8e** in DMSO-d_6



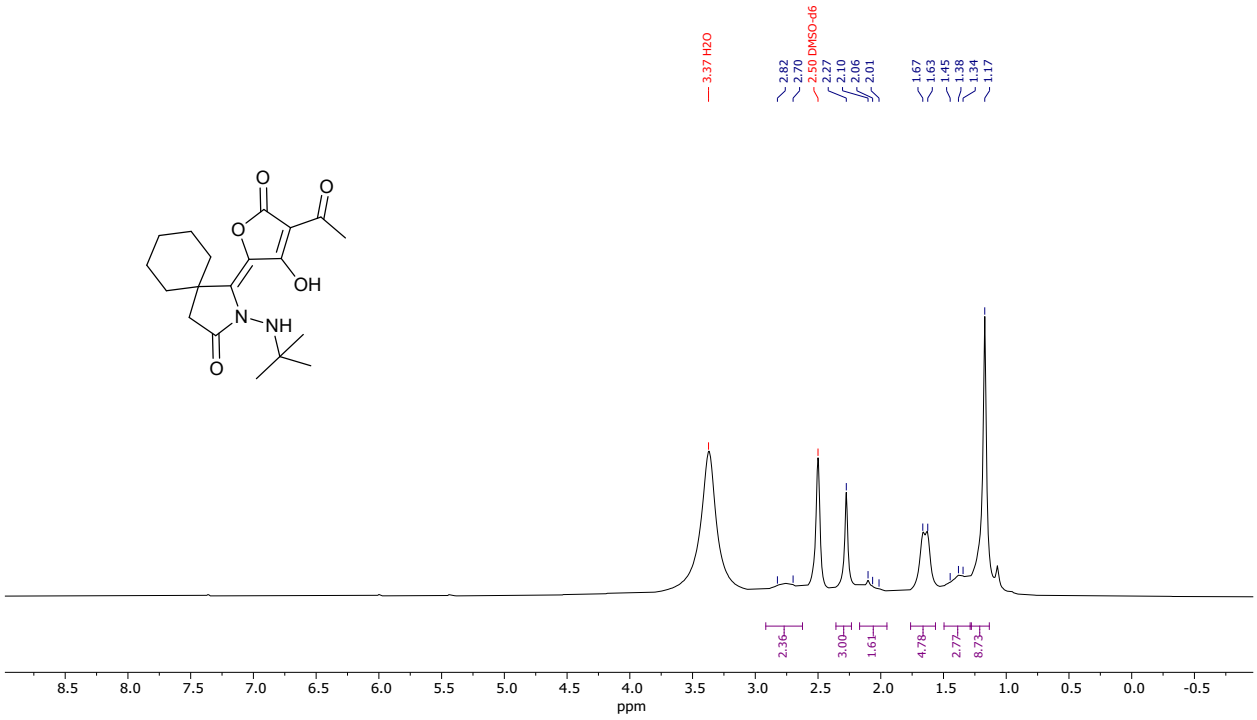
^{1}H NMR spectrum (300 MHz) of **8f** in DMSO-d_6



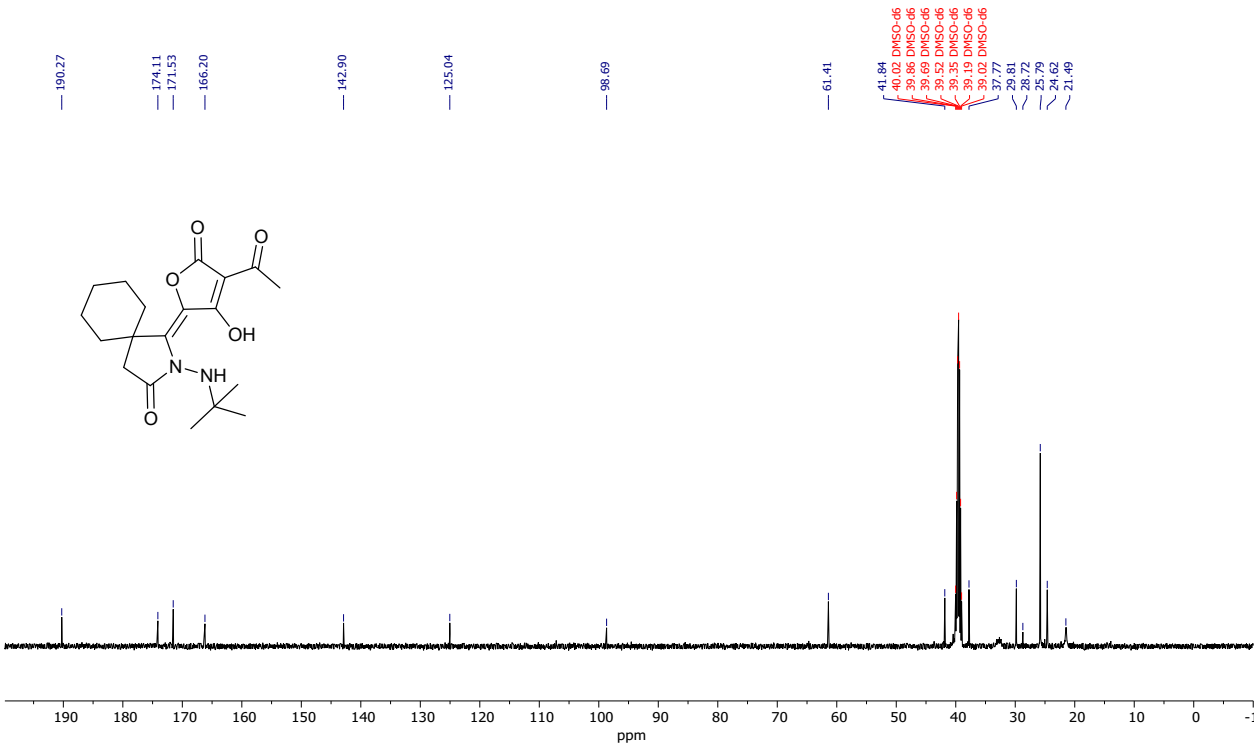
^{13}C {^{1}H} NMR spectrum (126 MHz) of **8f** in DMSO-d_6


190.80
178.19
171.39
166.70
157.10
157.01
155.20
155.11
152.01
151.91
150.06
149.96
140.45
130.16
130.08
126.96
115.16
115.13
115.09
115.06
111.06
111.04
110.88
110.86
104.61
104.43
104.40
104.22
97.43
41.28
40.02 DMSO-d6
39.86 DMSO-d6
39.69 DMSO-d6
39.52 DMSO-d6
39.35 DMSO-d6
39.19 DMSO-d6
39.02 DMSO-d6
38.21
32.52
27.54
24.65
21.61
B (dd)
150.99
A (dd)
156.11
E (d)
130.12
D (dd)
110.96
C (dd)
115.11
F (dd)
104.41
O
O
O
OH
N
NH
O
F
F
ppm

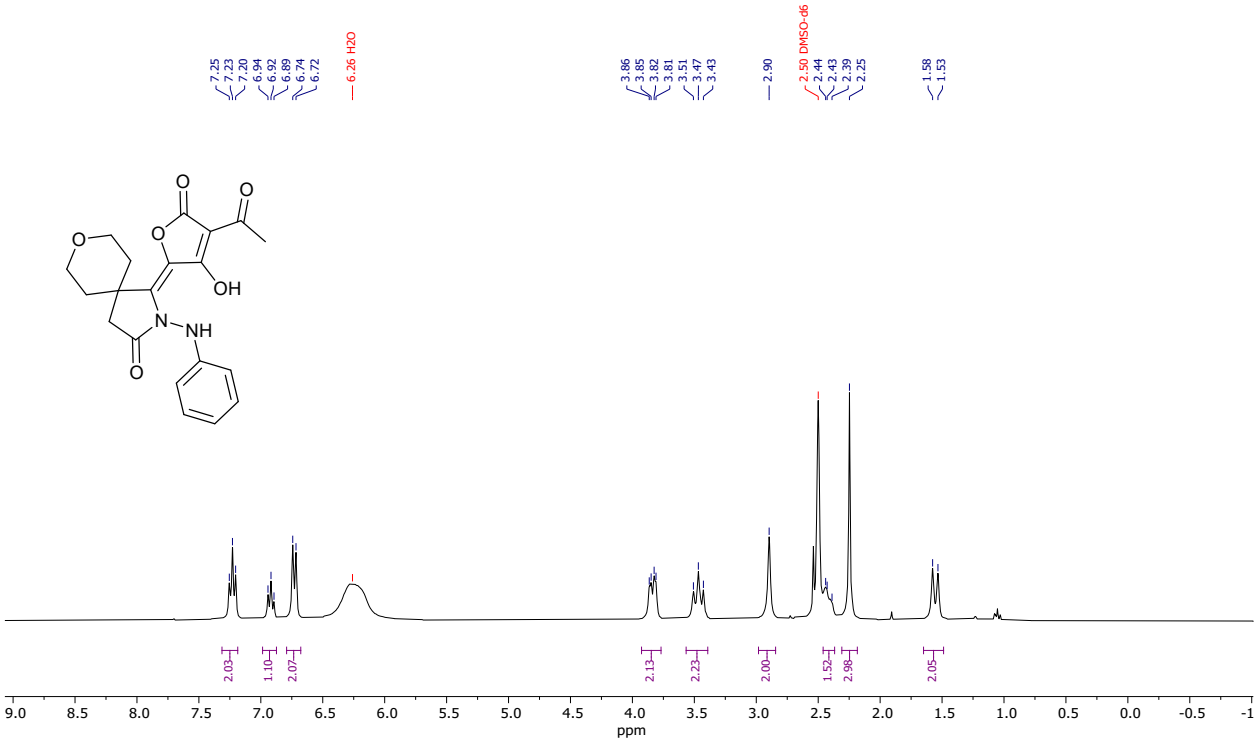
^{1}H NMR spectrum (300 MHz) of **8g** in DMSO-d_6



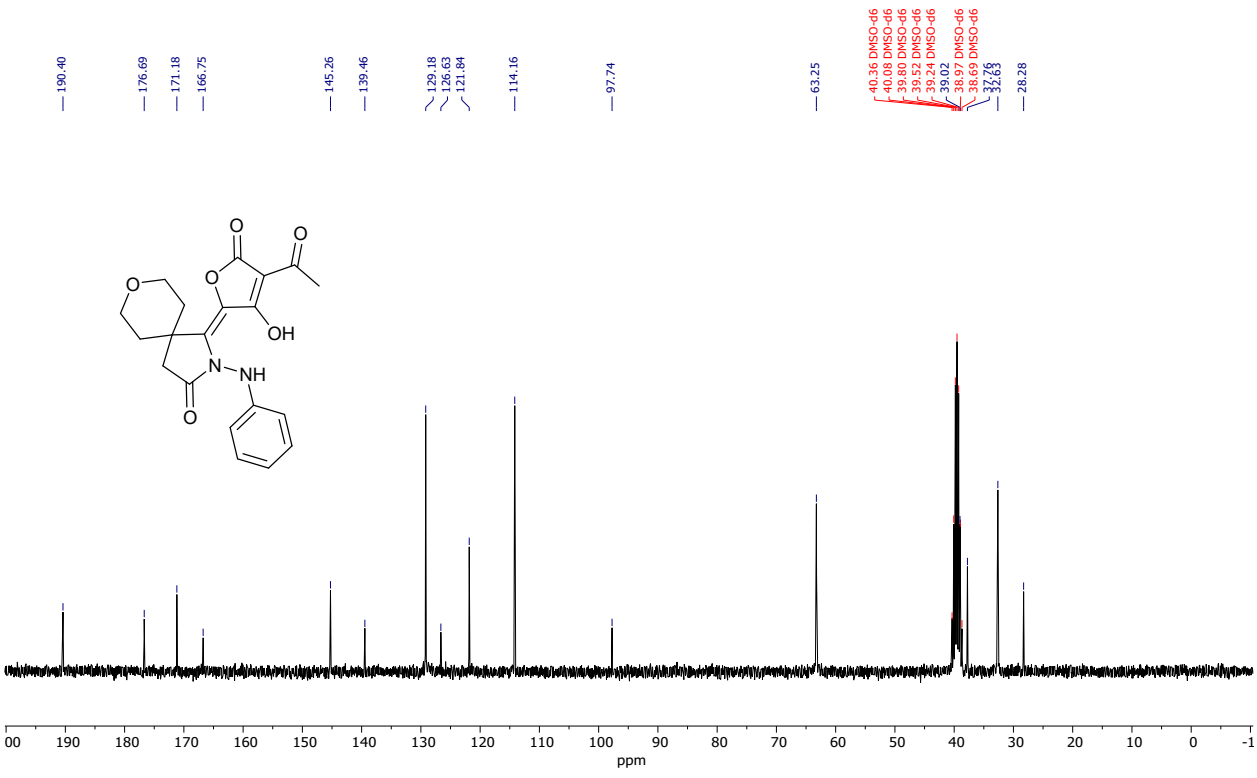
^{13}C {^{1}H} NMR spectrum (126 MHz) of **8g** in DMSO-d_6



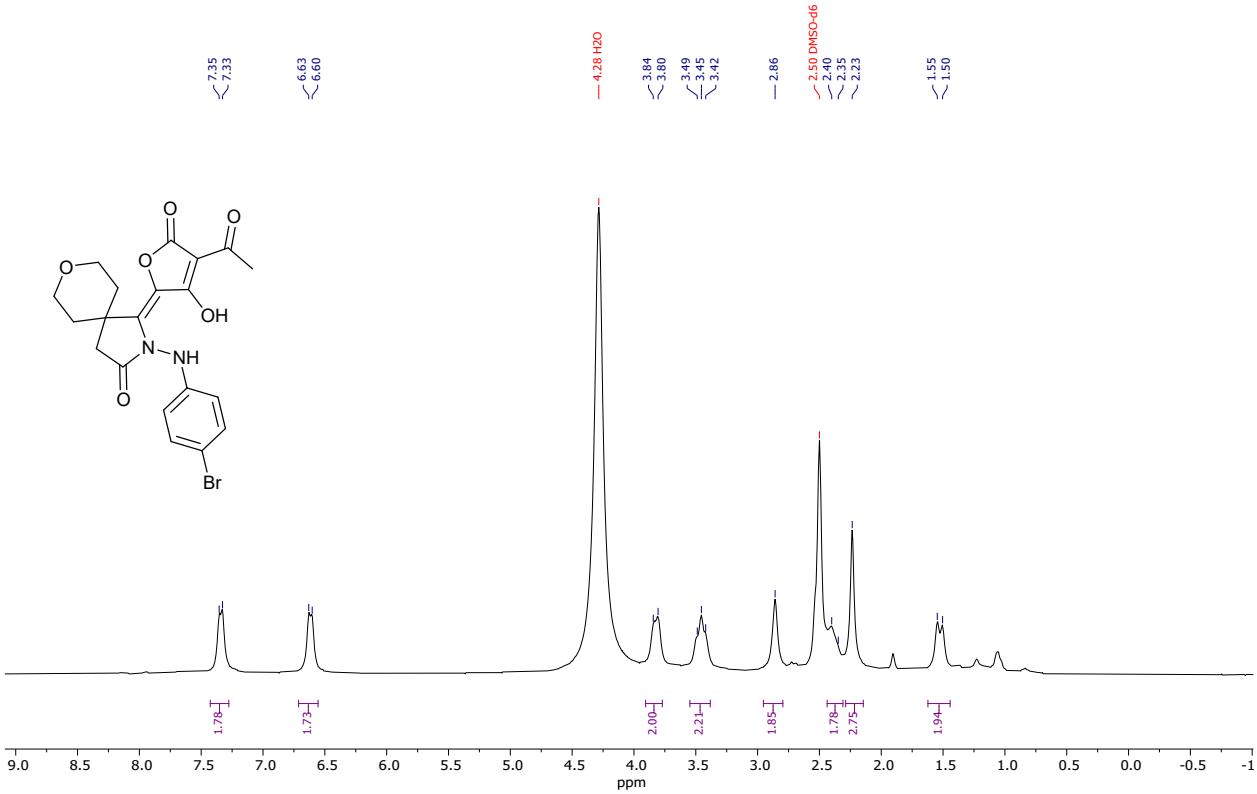
^{1}H NMR spectrum (300 MHz) of **8h** in DMSO-d_6



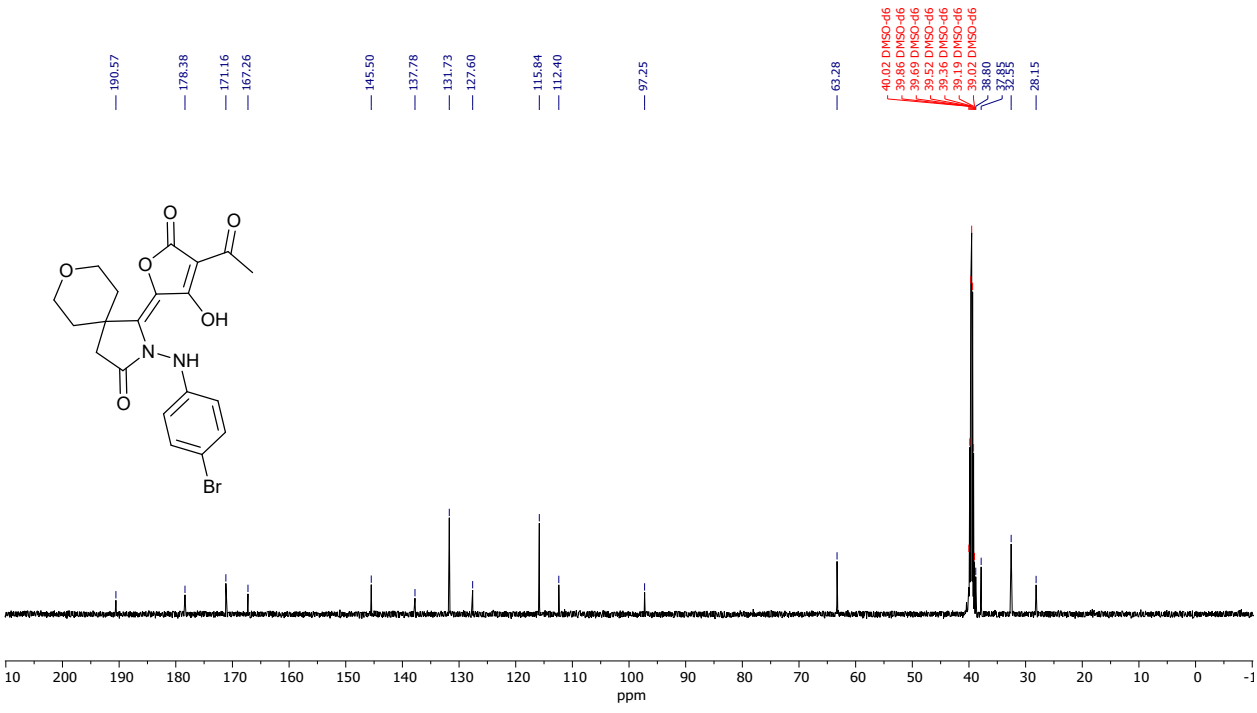
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8h** in DMSO-d_6



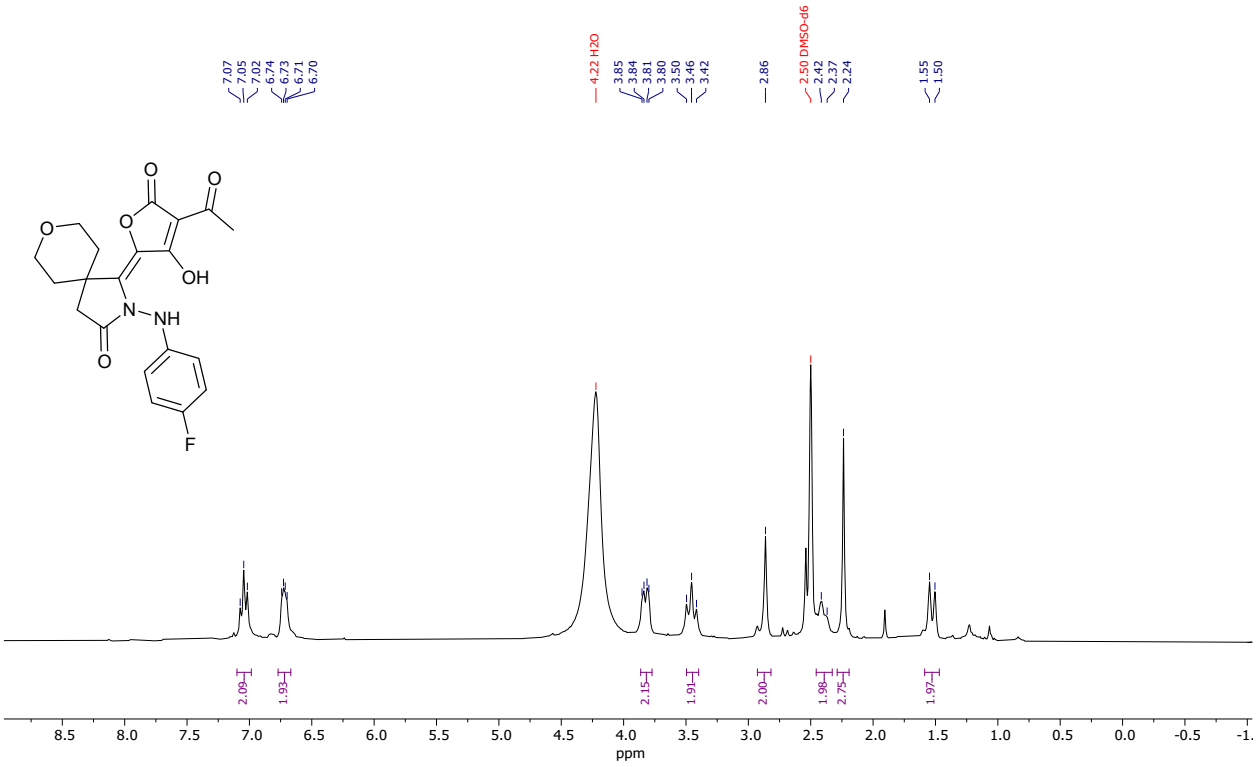
^{1}H NMR spectrum (300 MHz) of **8i** in DMSO-d_6



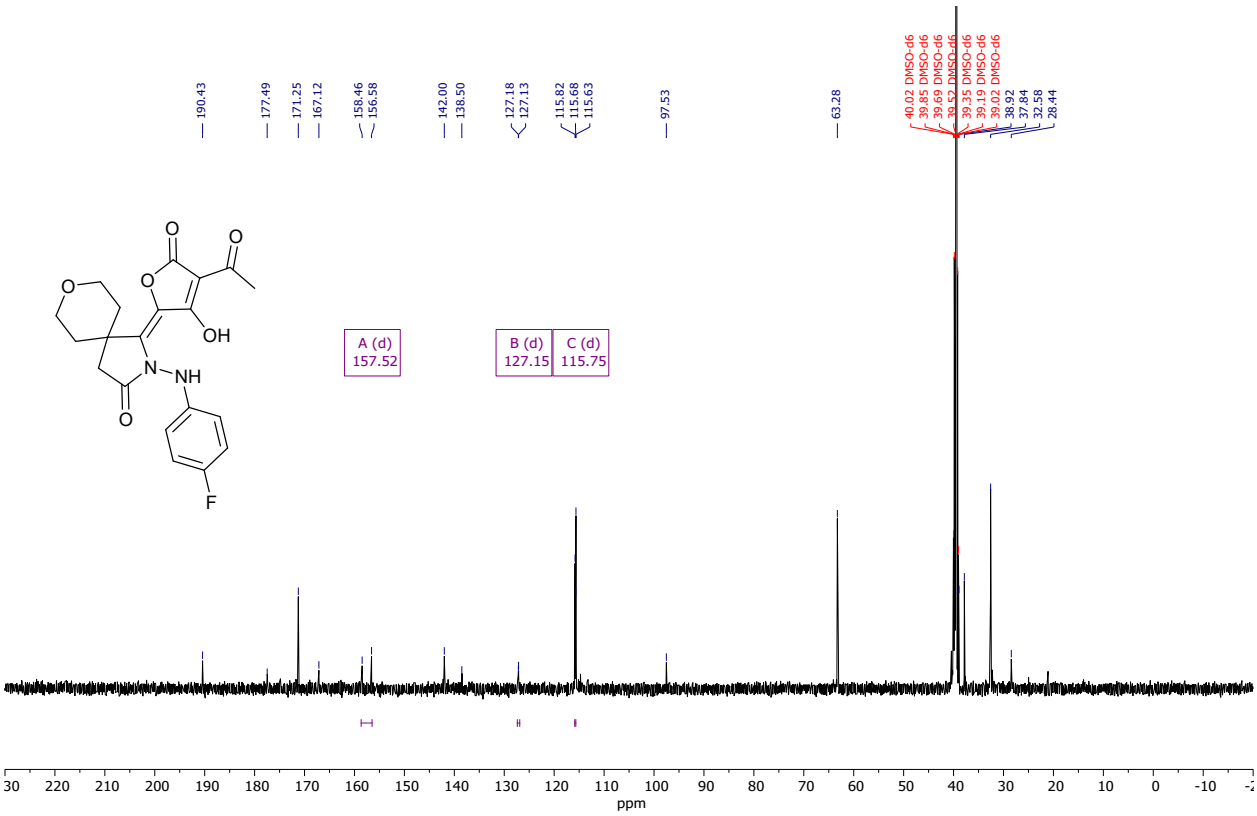
^{13}C {^{1}H} NMR spectrum (126 MHz) of **8i** in DMSO-d_6



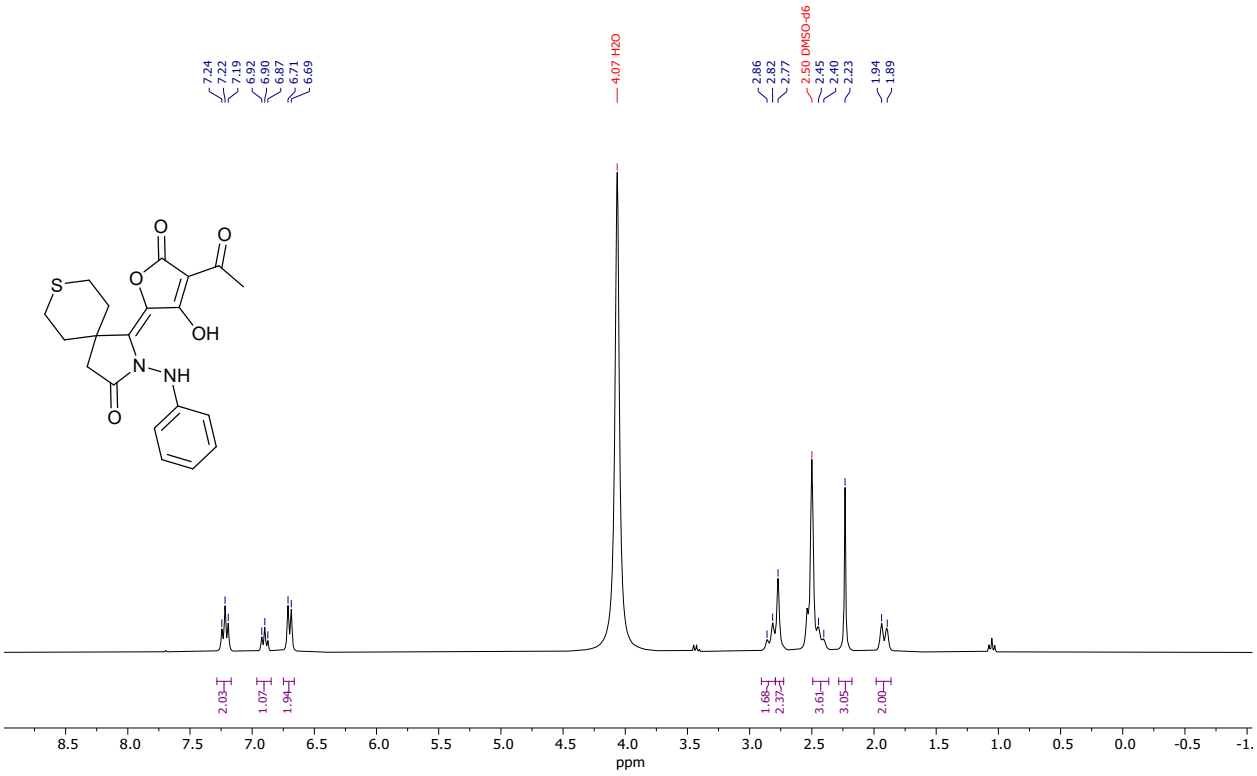
^{1}H NMR spectrum (300 MHz) of **8j** in DMSO-d_6



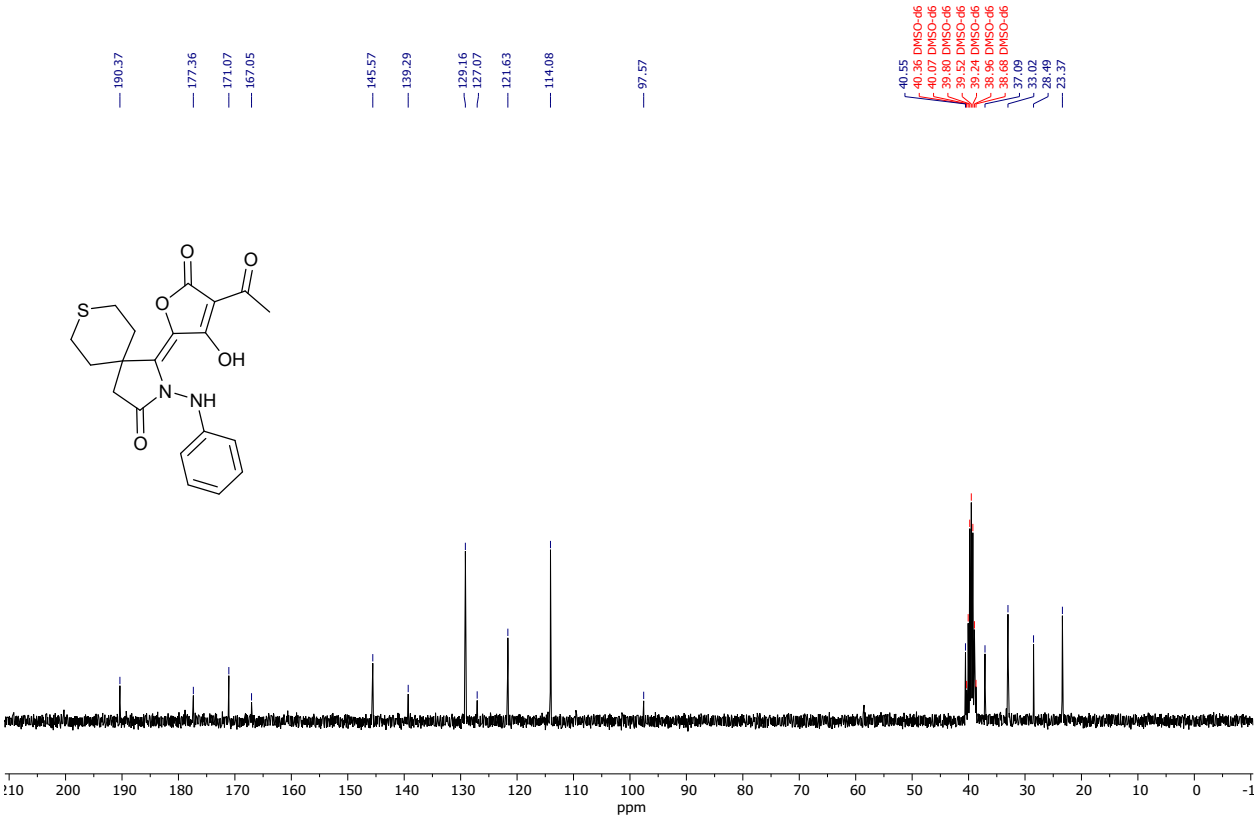
^{13}C {^{1}H} NMR spectrum (126 MHz) of **8j** in DMSO-d_6


190.43
177.49
171.25
167.12
158.46
156.58
142.00
138.50
127.18
127.13
115.82
115.68
115.63
97.53
63.28
40.02 DMSO-d6
39.85 DMSO-d6
39.69 DMSO-d6
39.52 DMSO-d6
39.35 DMSO-d6
39.19 DMSO-d6
39.02 DMSO-d6
38.92
37.84
32.58
28.44
A (d)
157.52
B (d)
127.15
C (d)
115.75
O
O
O
OH
N
NH
O
F
ppm

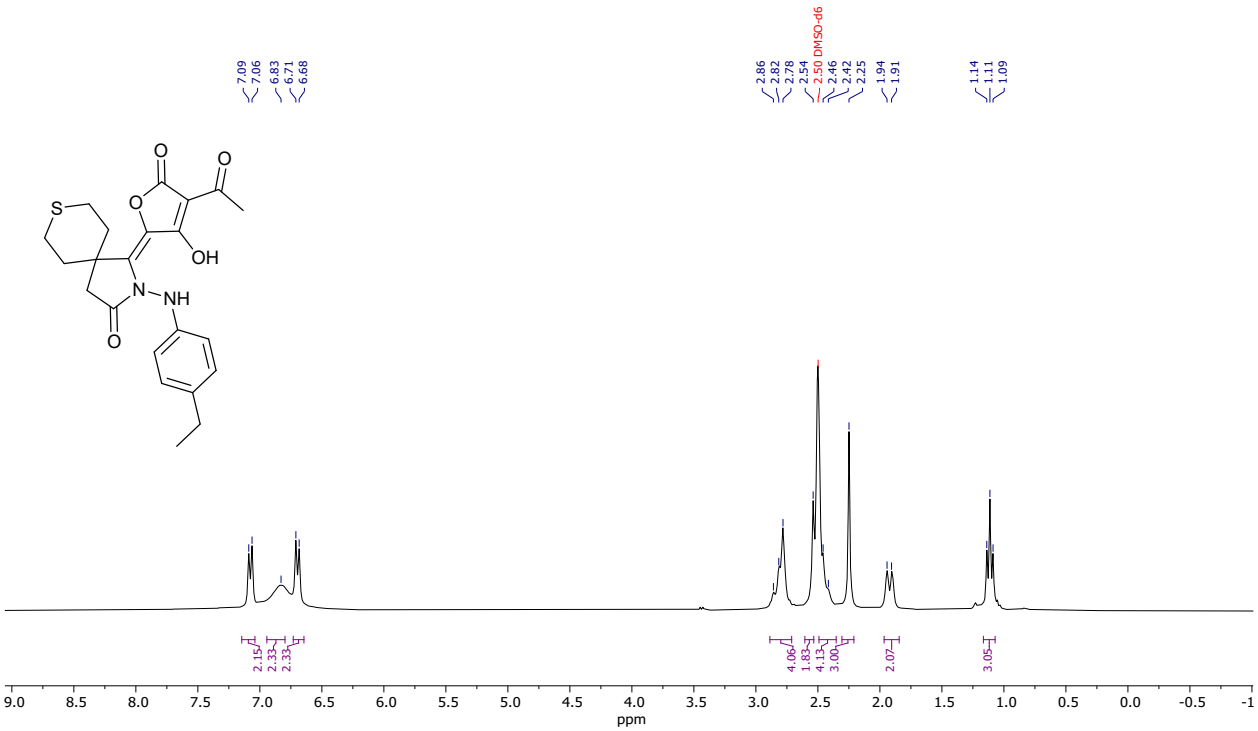
^{1}H NMR spectrum (300 MHz) of **8k** in DMSO-d_6



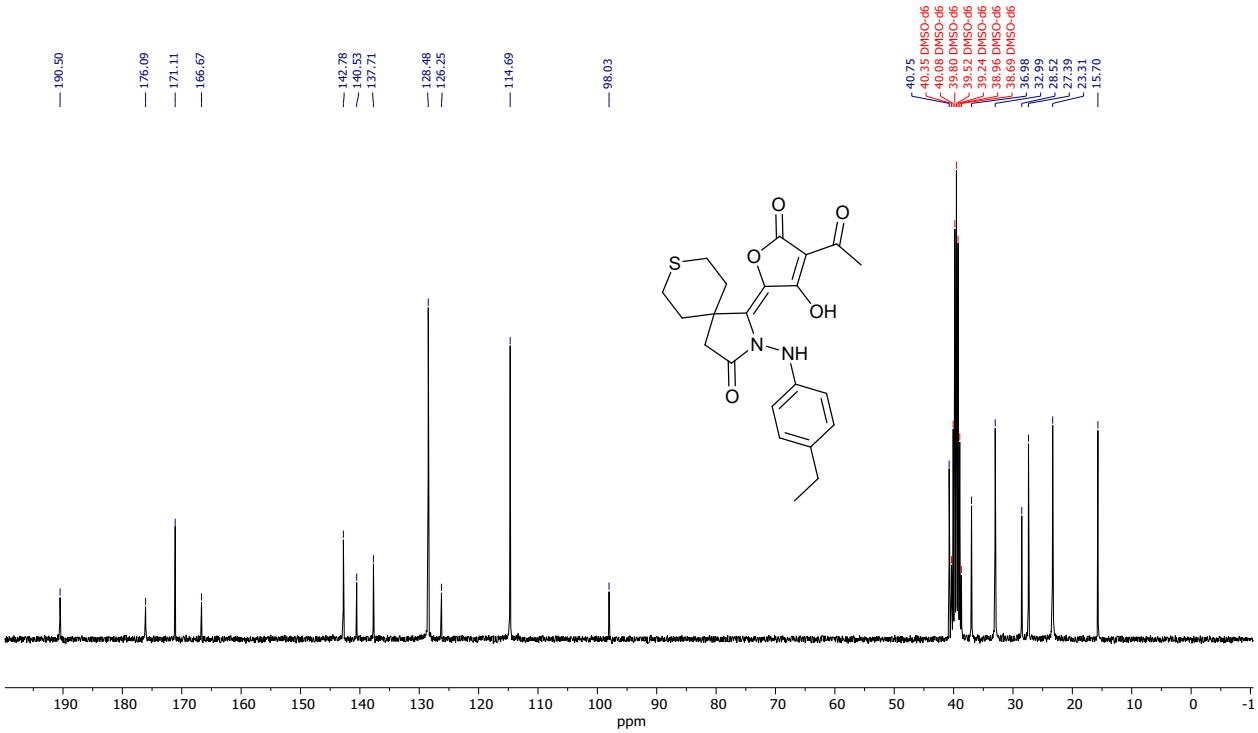
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8k** in DMSO-d_6



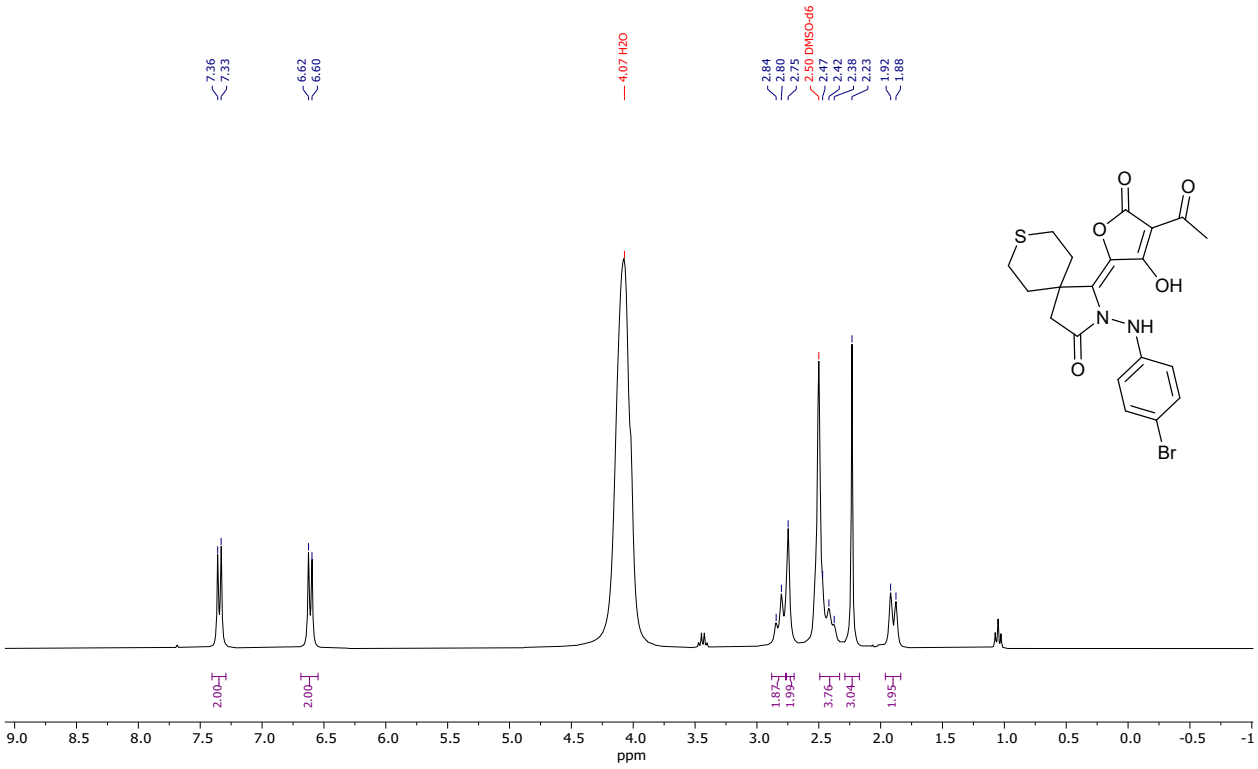
^{1}H NMR spectrum (300 MHz) of **8l** in DMSO-d_6



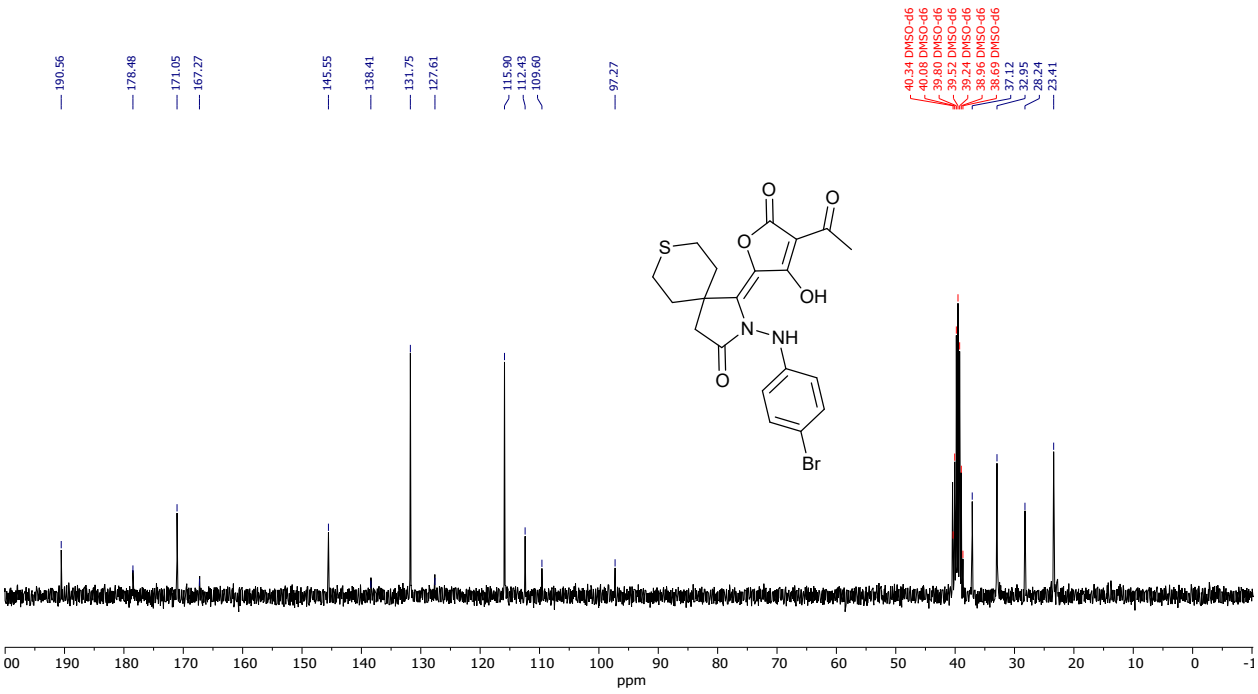
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8l** in DMSO-d_6



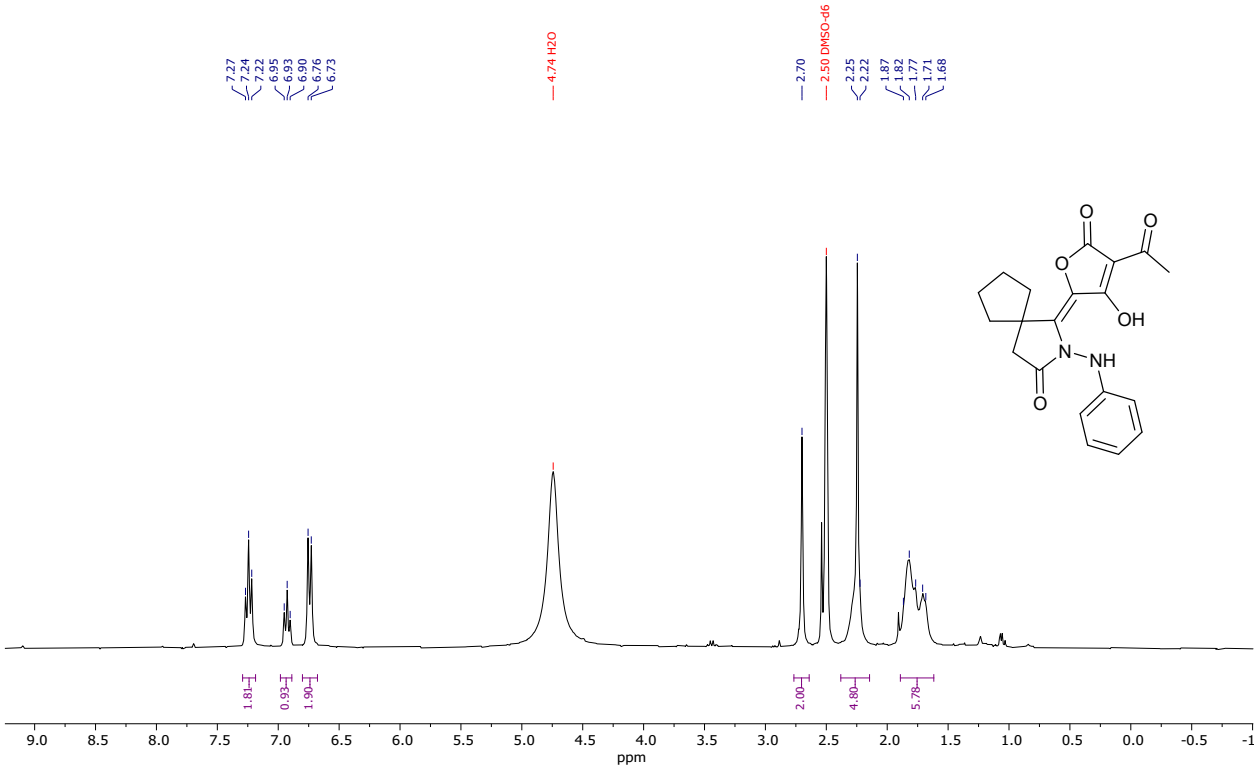
^{1}H NMR spectrum (300 MHz) of **8m** in DMSO-d_6



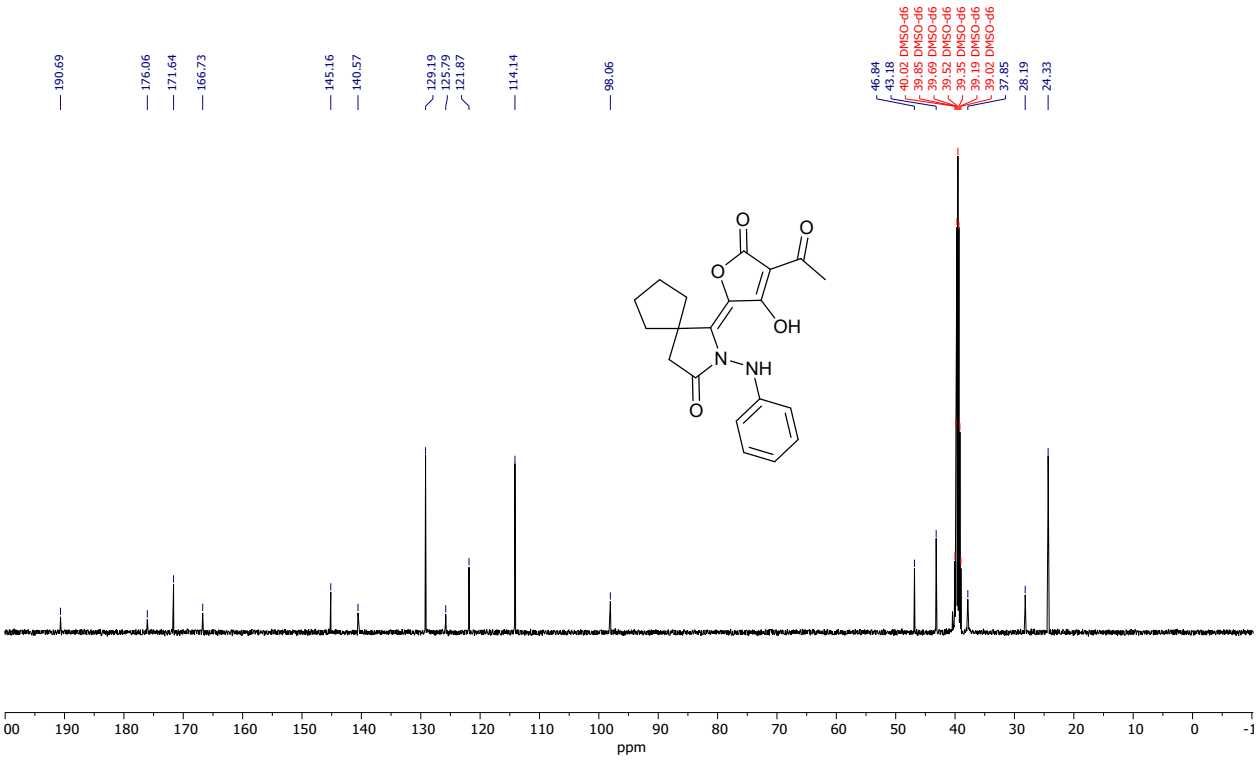
^{13}C {^{1}H} NMR spectrum (75 MHz) of **8m** in DMSO-d_6



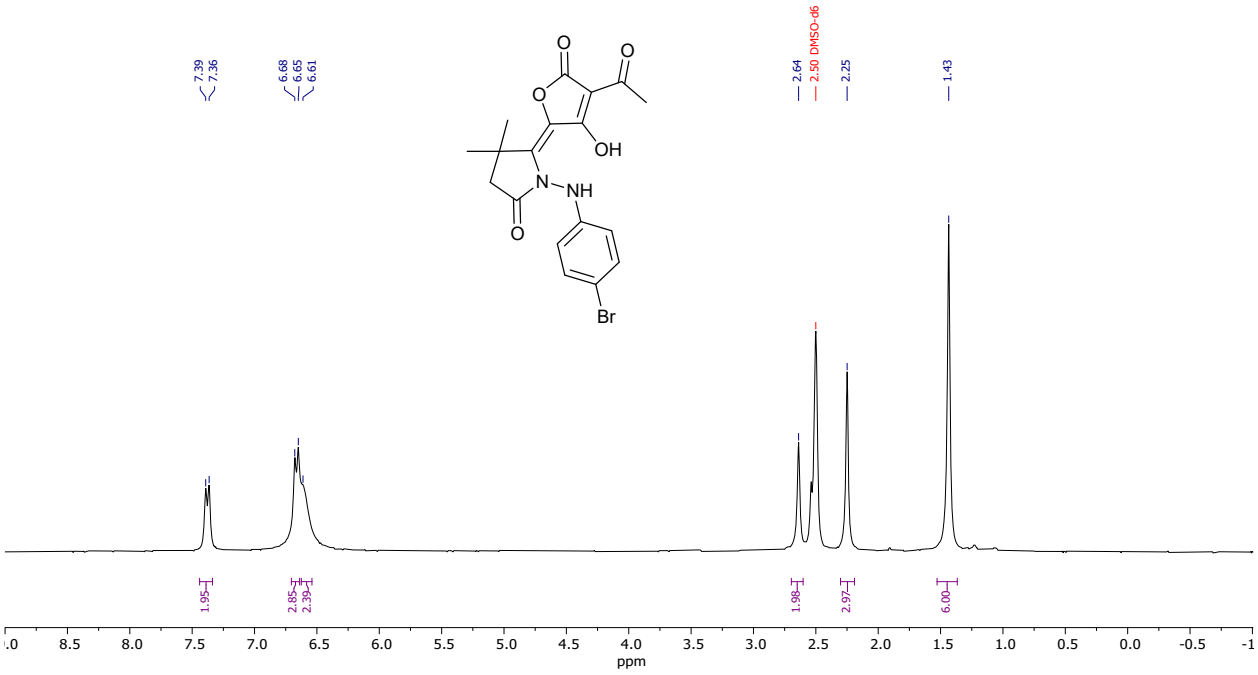
^{1}H NMR spectrum (300 MHz) of **8n** in DMSO-d_6



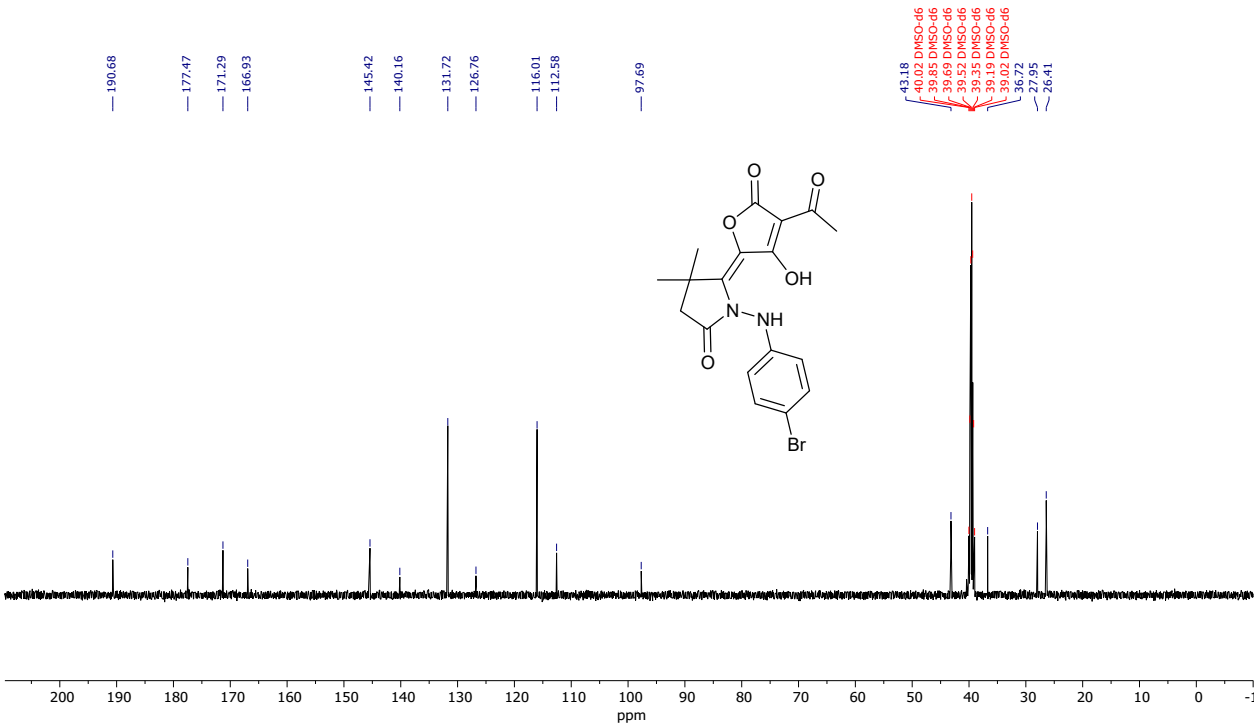
^{13}C {^{1}H} NMR spectrum (126 MHz) of **8n** in DMSO-d_6



^{1}H NMR spectrum (300 MHz) of **8o** in DMSO-d_6

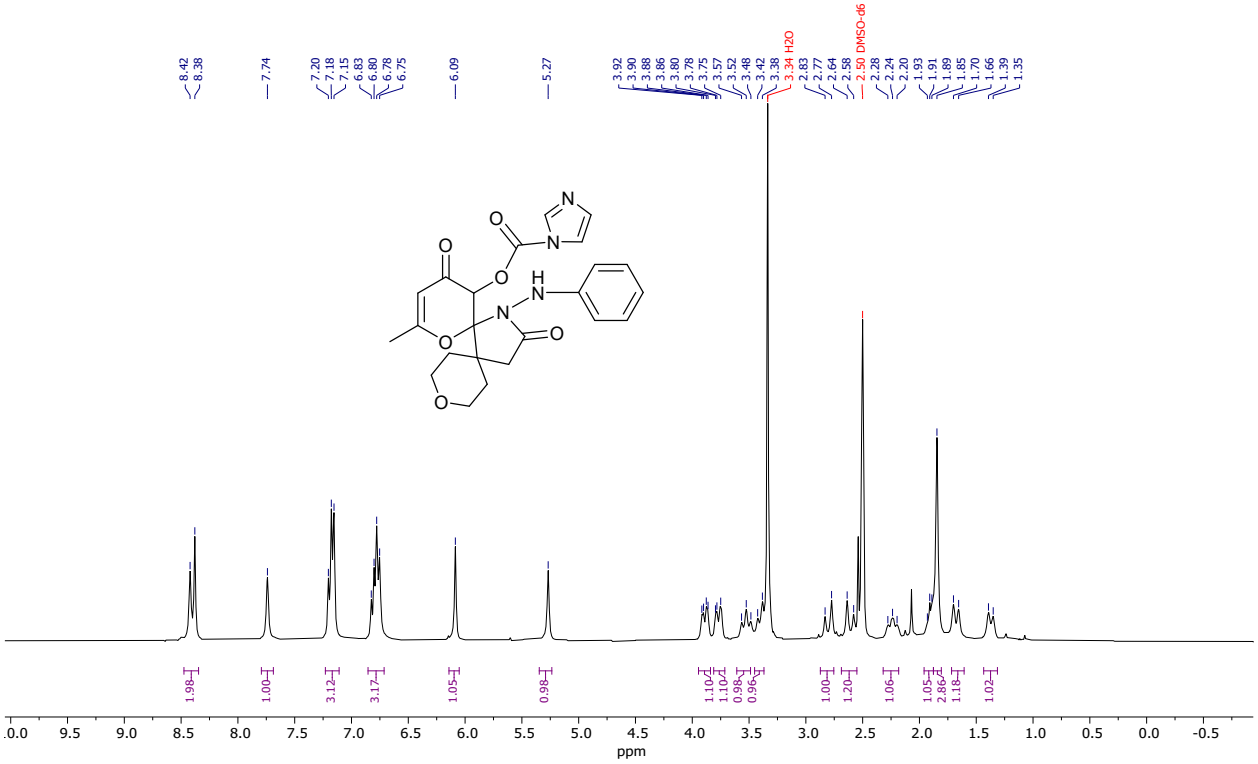


^{13}C {^{1}H} NMR spectrum (126 MHz) of **8o** in DMSO-d_6

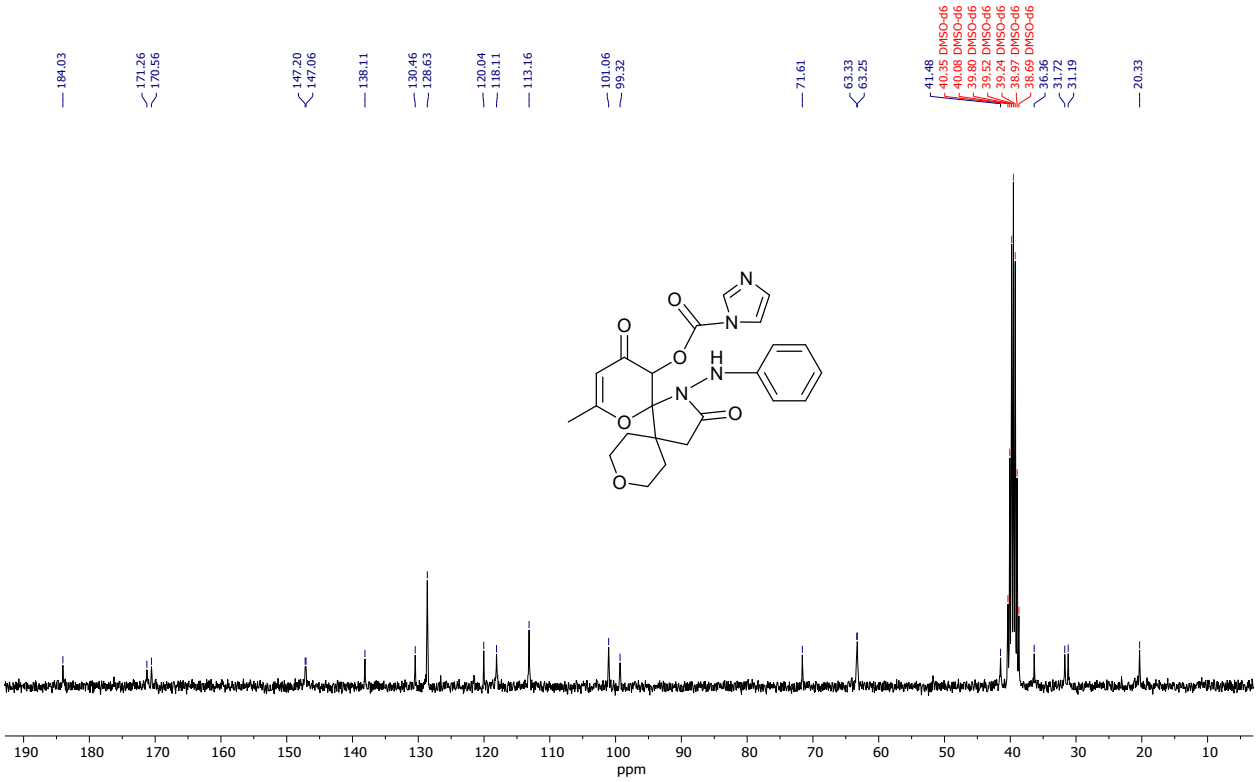


6.3 Intermediates 14

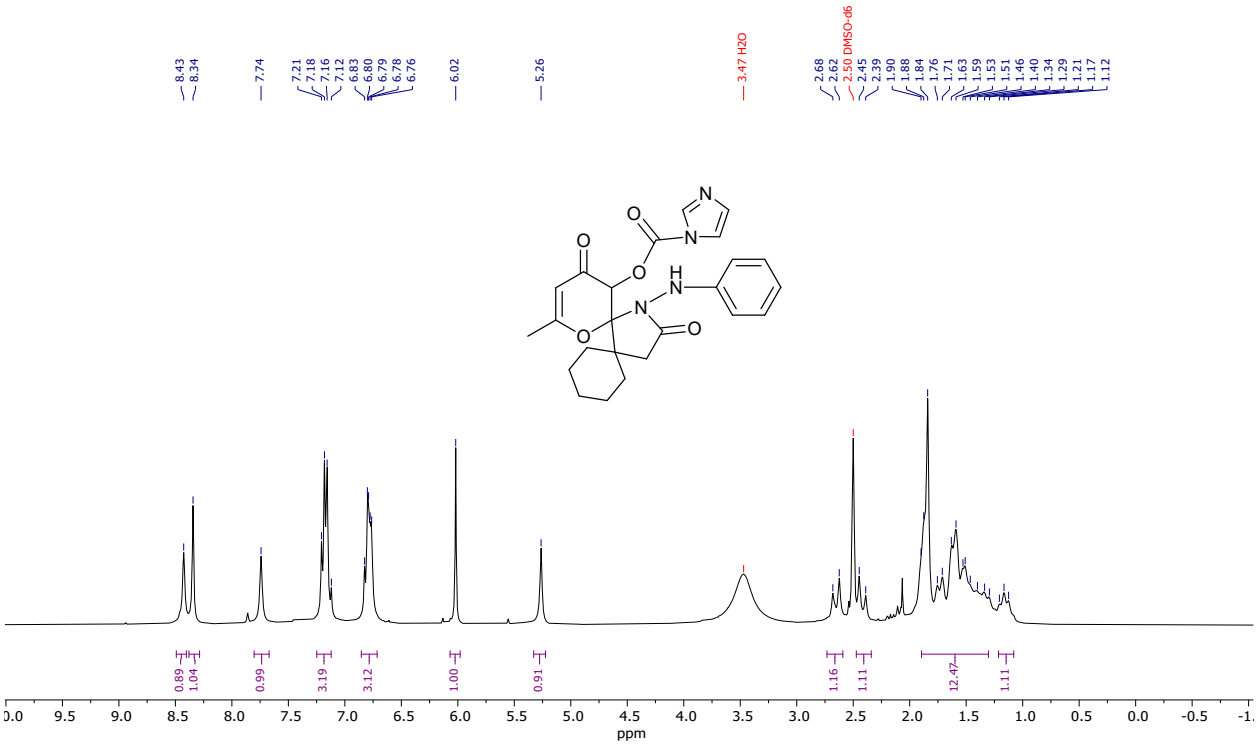
^{1}H NMR spectrum (300 MHz) of **14a** in DMSO-d_6



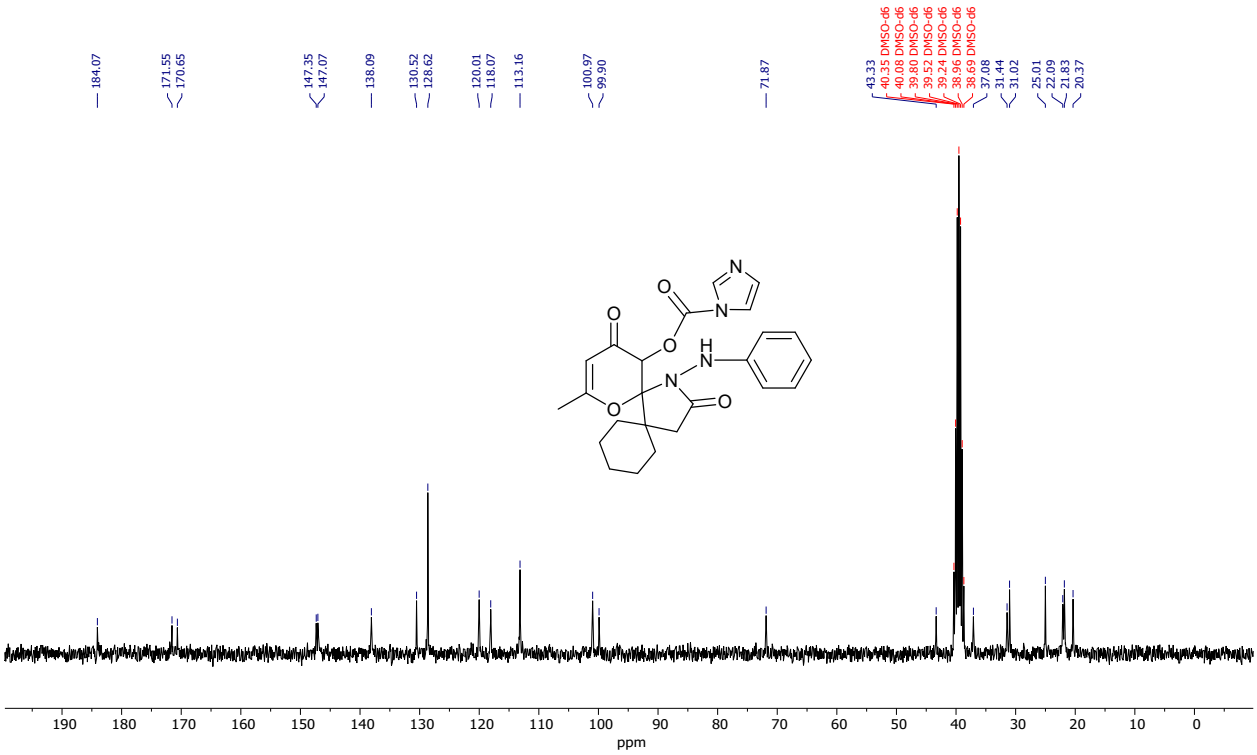
^{13}C {^{1}H} NMR spectrum (75 MHz) of **14a** in DMSO-d_6


184.03
171.26
170.56
147.20
147.06
138.11
130.46
128.63
120.04
118.11
113.16
101.06
99.32
71.61
63.33
63.25
41.48
40.35 DMSO-d6
40.08 DMSO-d6
39.80 DMSO-d6
39.52 DMSO-d6
39.24 DMSO-d6
38.97 DMSO-d6
38.69 DMSO-d6
36.36
31.72
31.19
20.33
O
N
O
O
H
N
N
O
O
O
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

^{1}H NMR spectrum (300 MHz) of **14b** in DMSO-$d_{6/}$

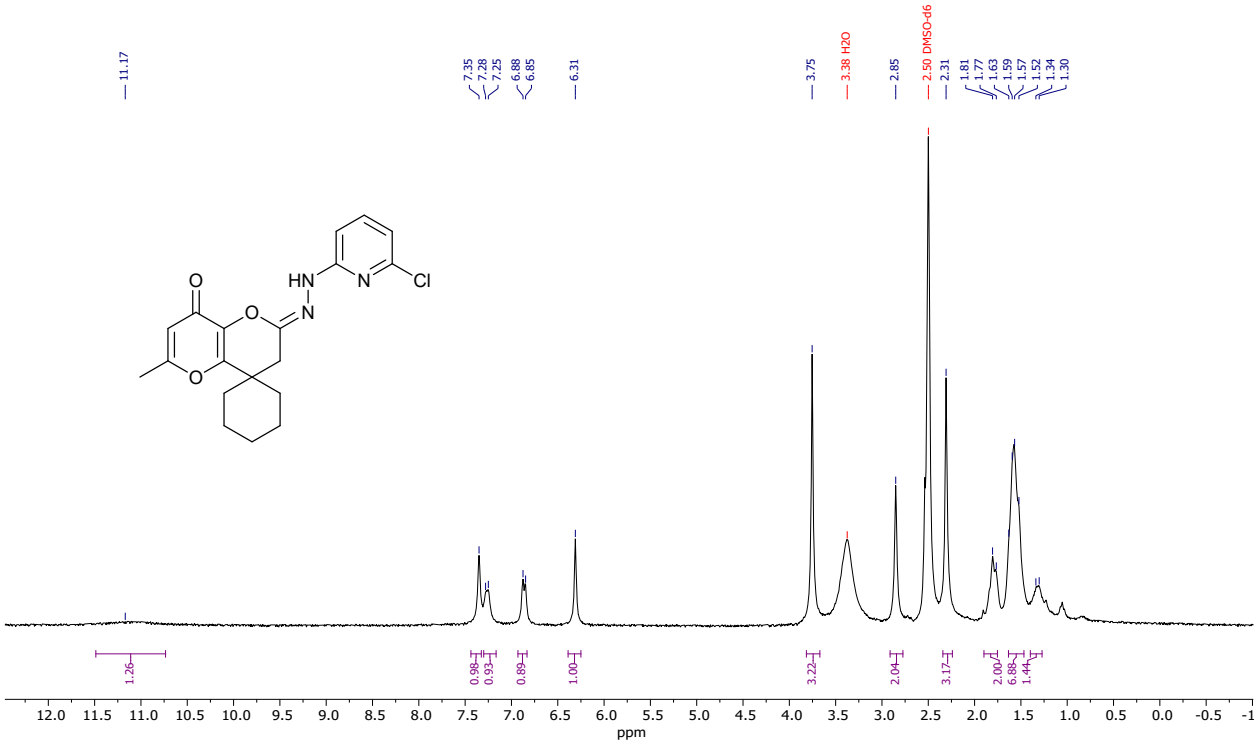


^{13}C {^{1}H} NMR spectrum (75 MHz) of **14b** in DMSO-d_6

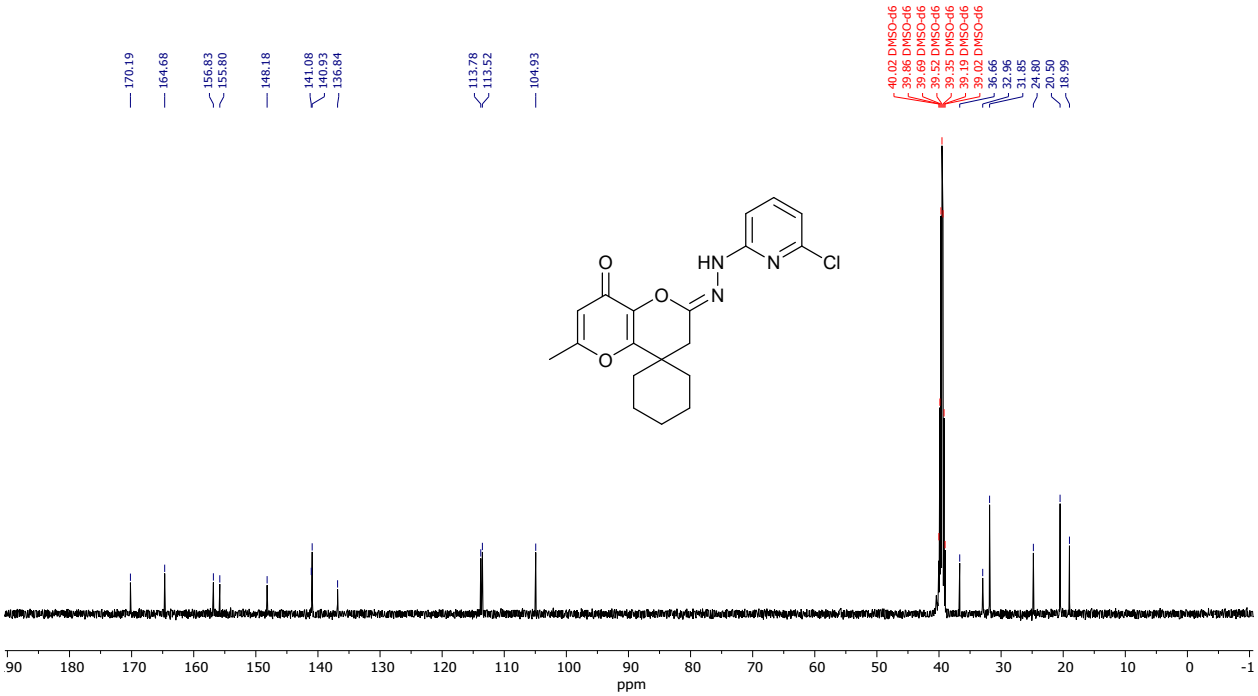


6.4 Compounds 16-19

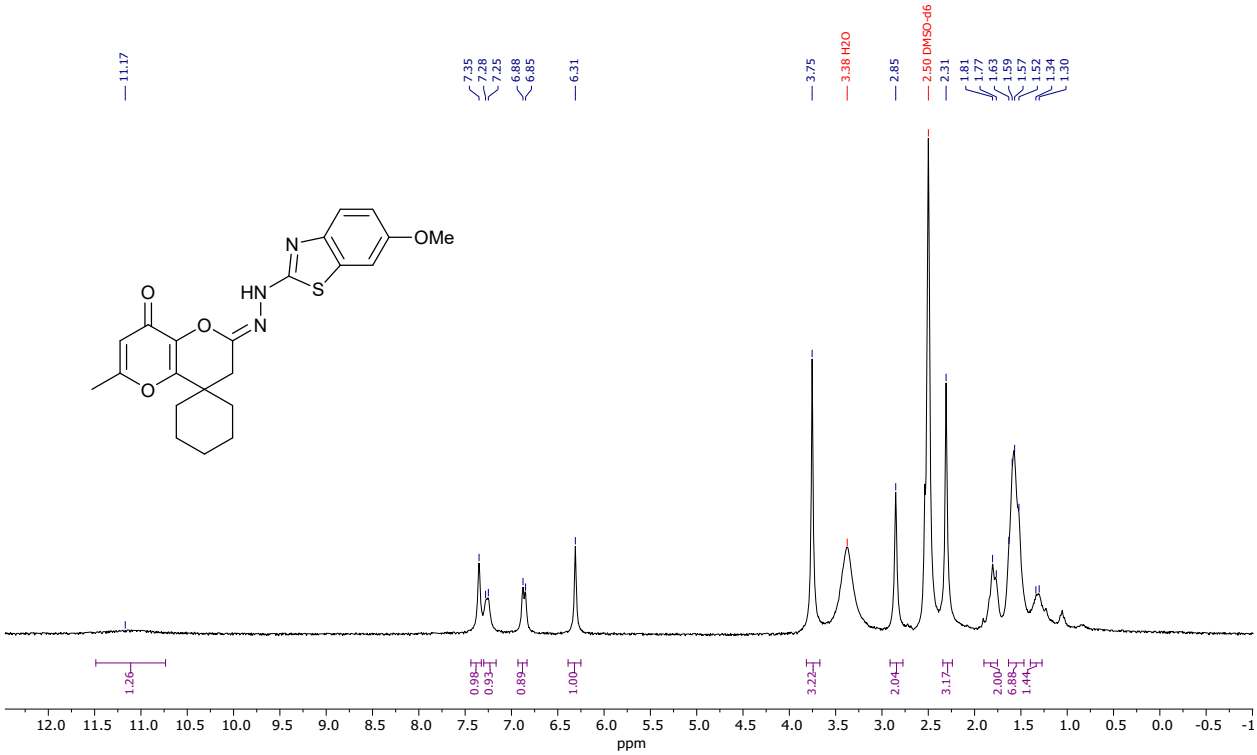
^{1}H NMR spectrum (300 MHz) of **16a** in DMSO-d_6



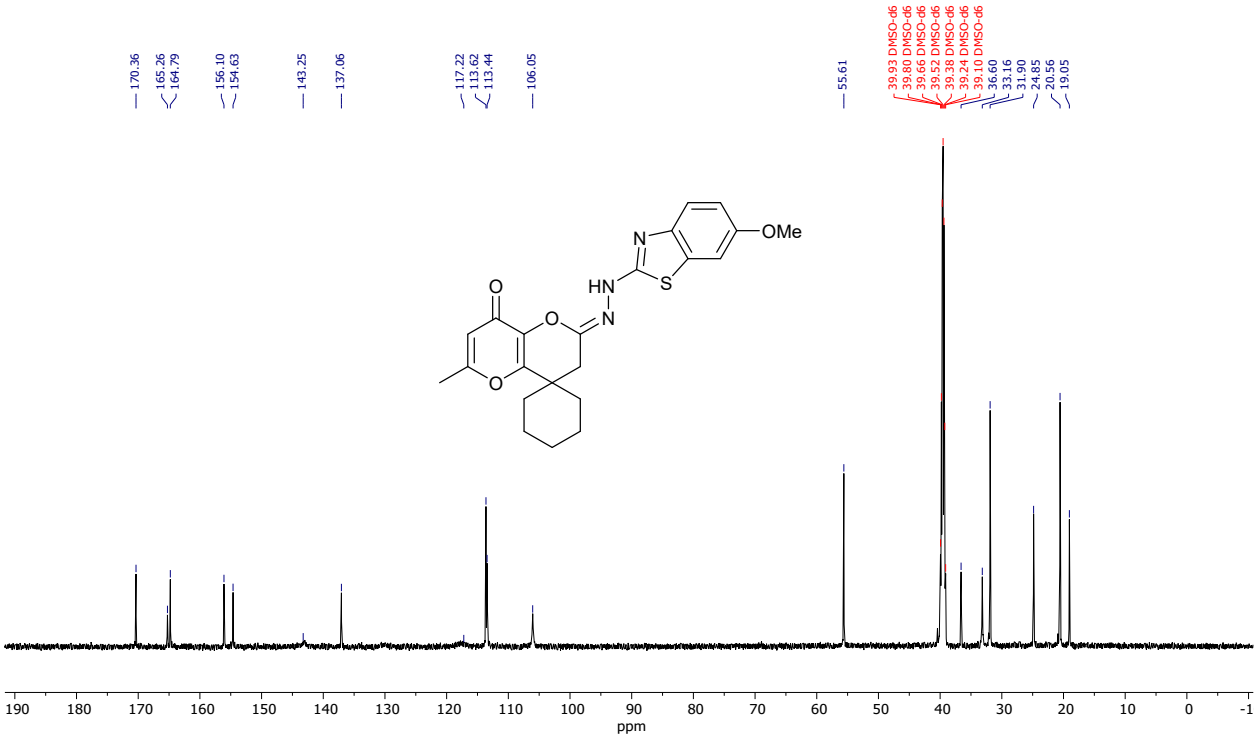
^{13}C {^{1}H} NMR spectrum (126 MHz) of **16a** in DMSO-d_6



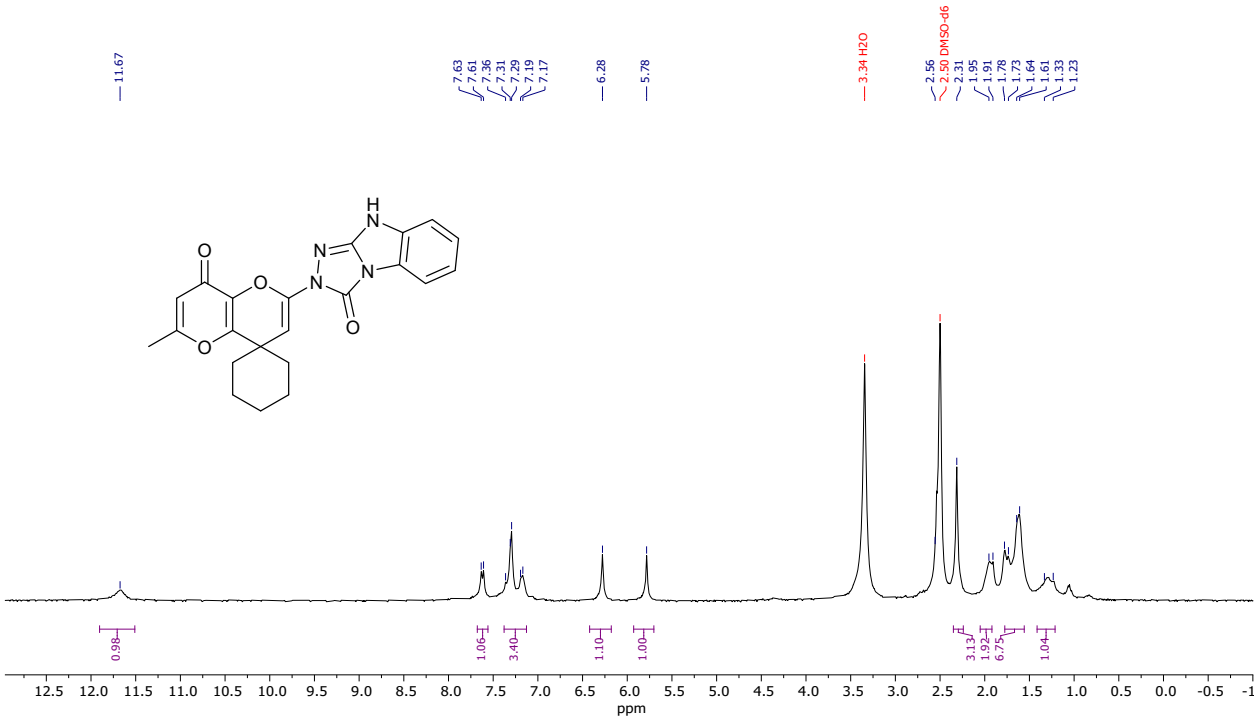
^{1}H NMR spectrum (300 MHz) of **16b** in DMSO-d_6



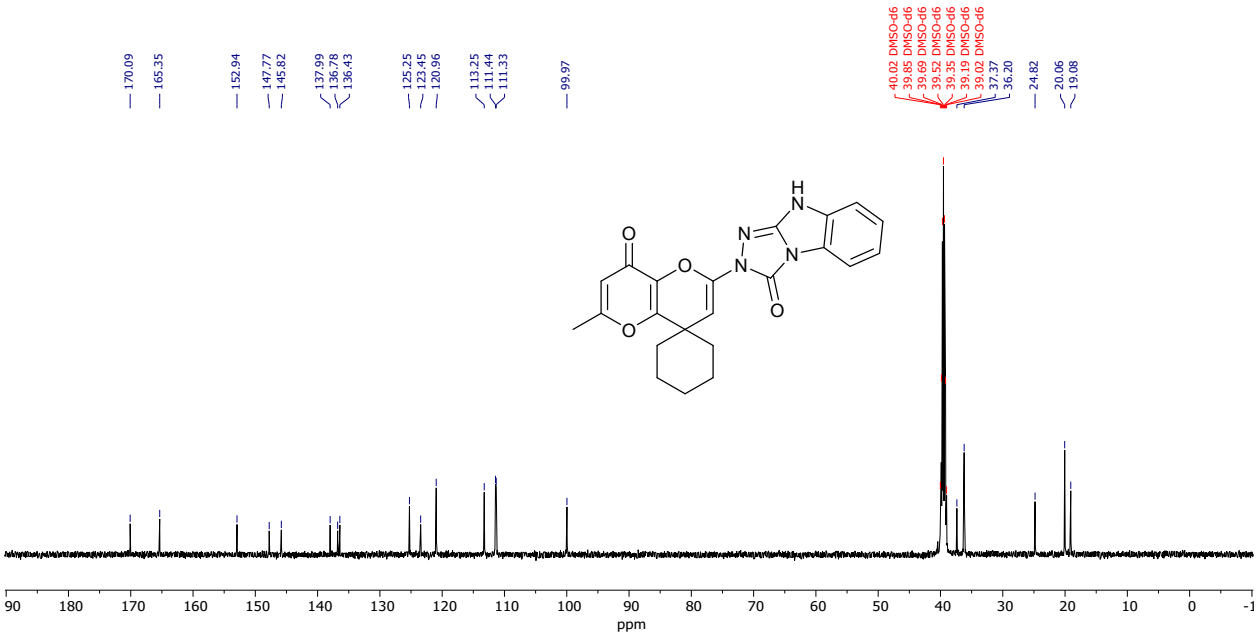
^{13}C {^{1}H} NMR spectrum (151 MHz) of **16b** in DMSO-d_6


170.36
165.26
164.79
156.10
154.63
143.25
137.06
117.22
113.62
113.44
106.05
55.61
39.93 DMSO-d6
39.80 DMSO-d6
39.66 DMSO-d6
39.52 DMSO-d6
39.38 DMSO-d6
39.24 DMSO-d6
39.10 DMSO-d6
36.60
33.16
31.90
24.85
20.56
19.05
OMe
N
S
HN
N
O
O
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
ppm

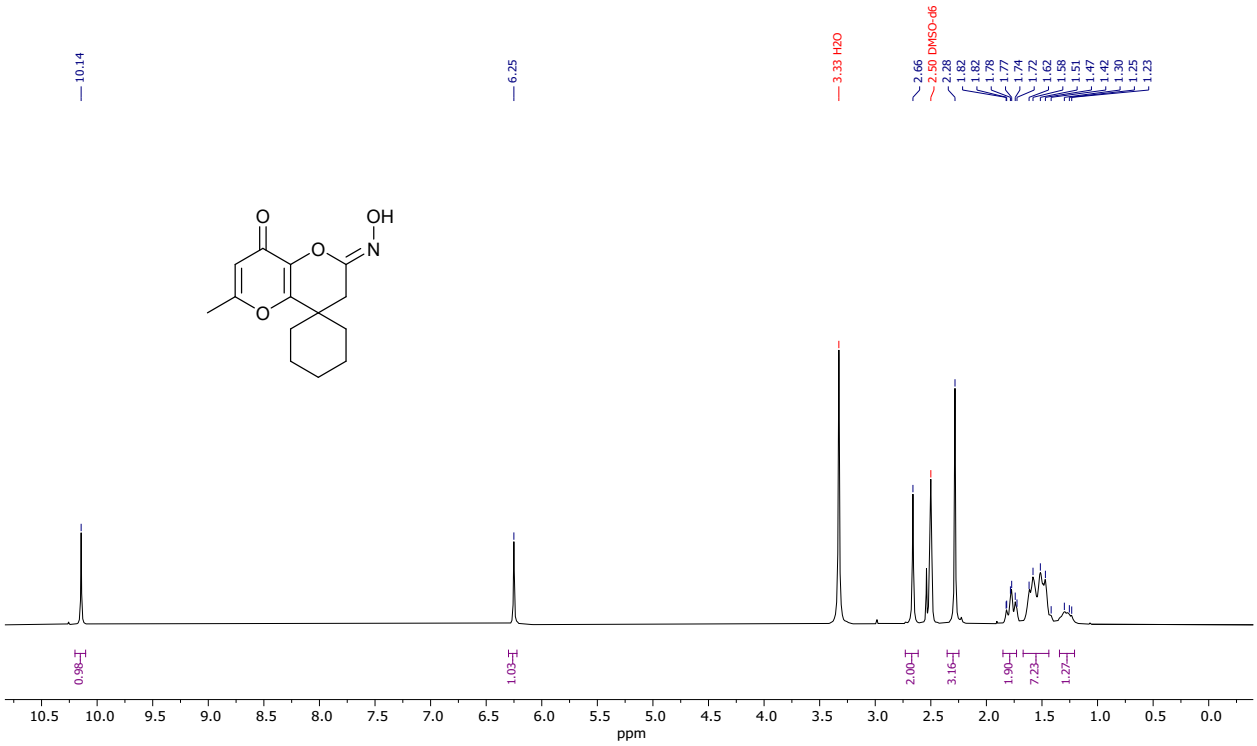
^{1}H NMR spectrum (300 MHz) of **17** in DMSO-d_6



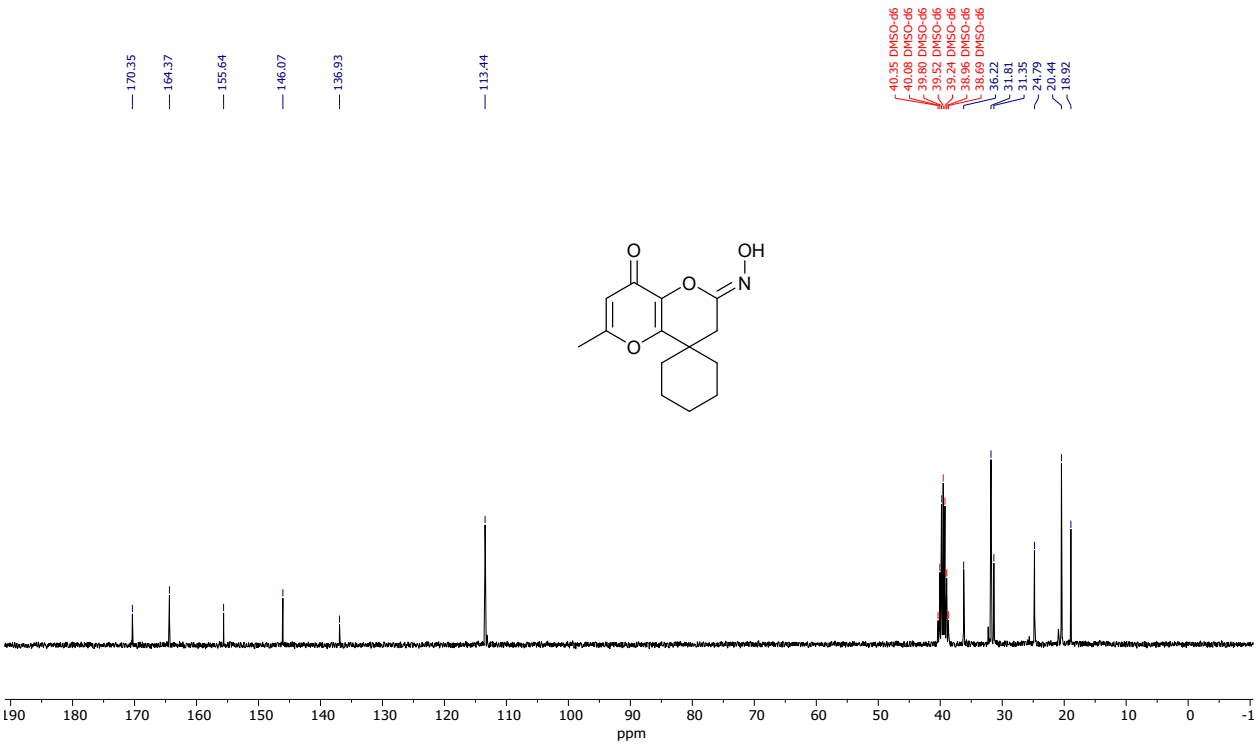
^{13}C {^{1}H} NMR spectrum (126 MHz) of **17** in DMSO-d_6



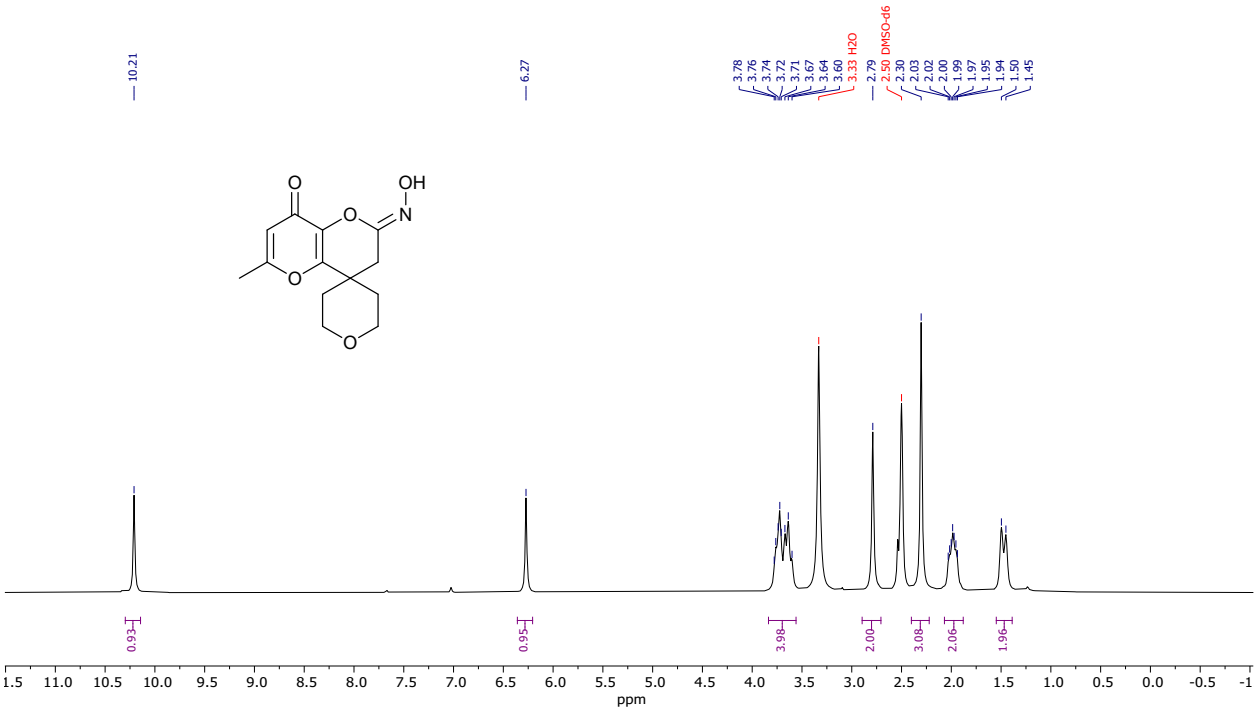
^{1}H NMR spectrum (300 MHz) of **18a** in DMSO-d_6



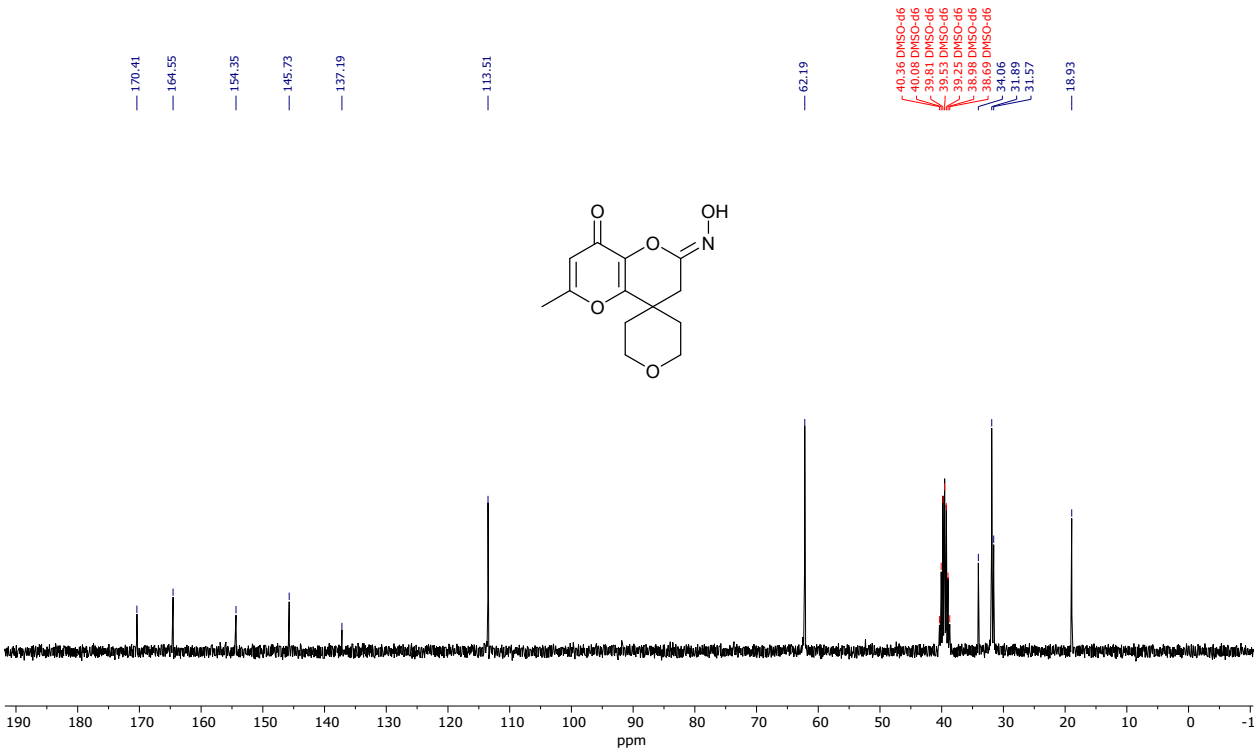
^{13}C {^{1}H} NMR spectrum (75 MHz) of **18a** in DMSO-d_6



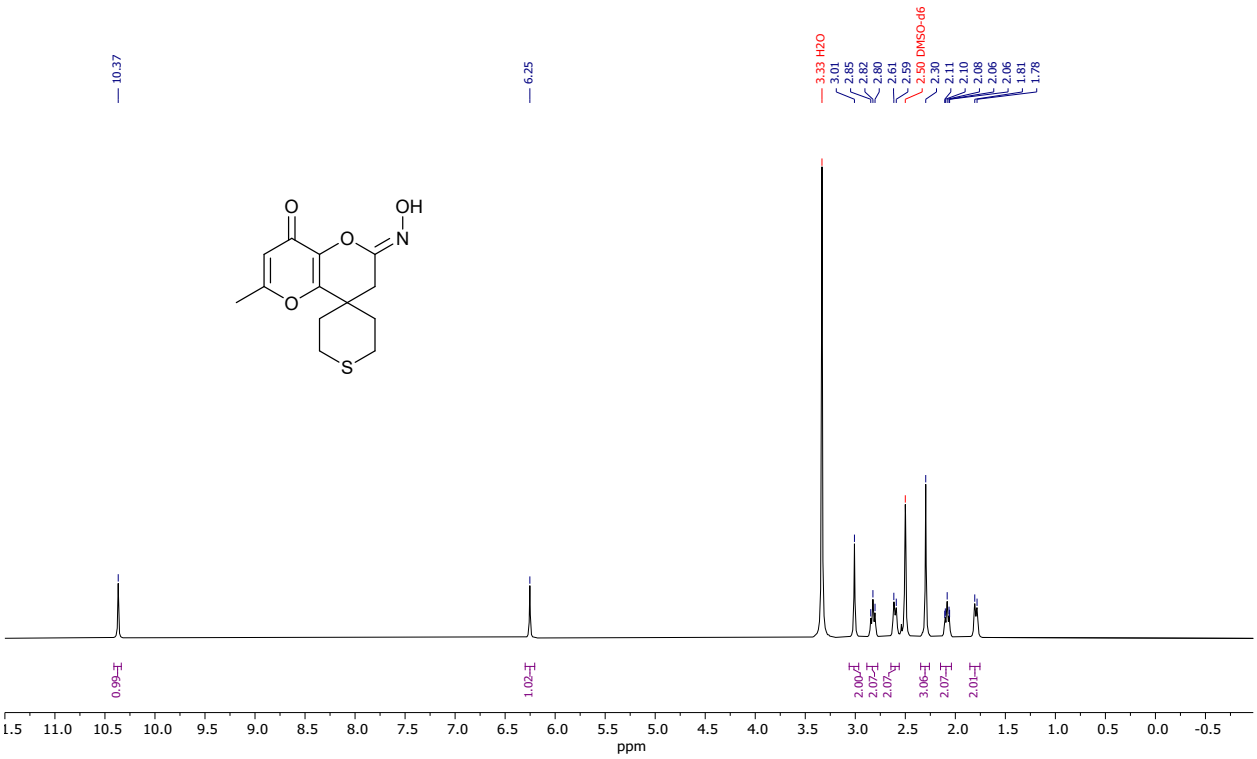
^{1}H NMR spectrum (300 MHz) of **18b** in DMSO-d_6



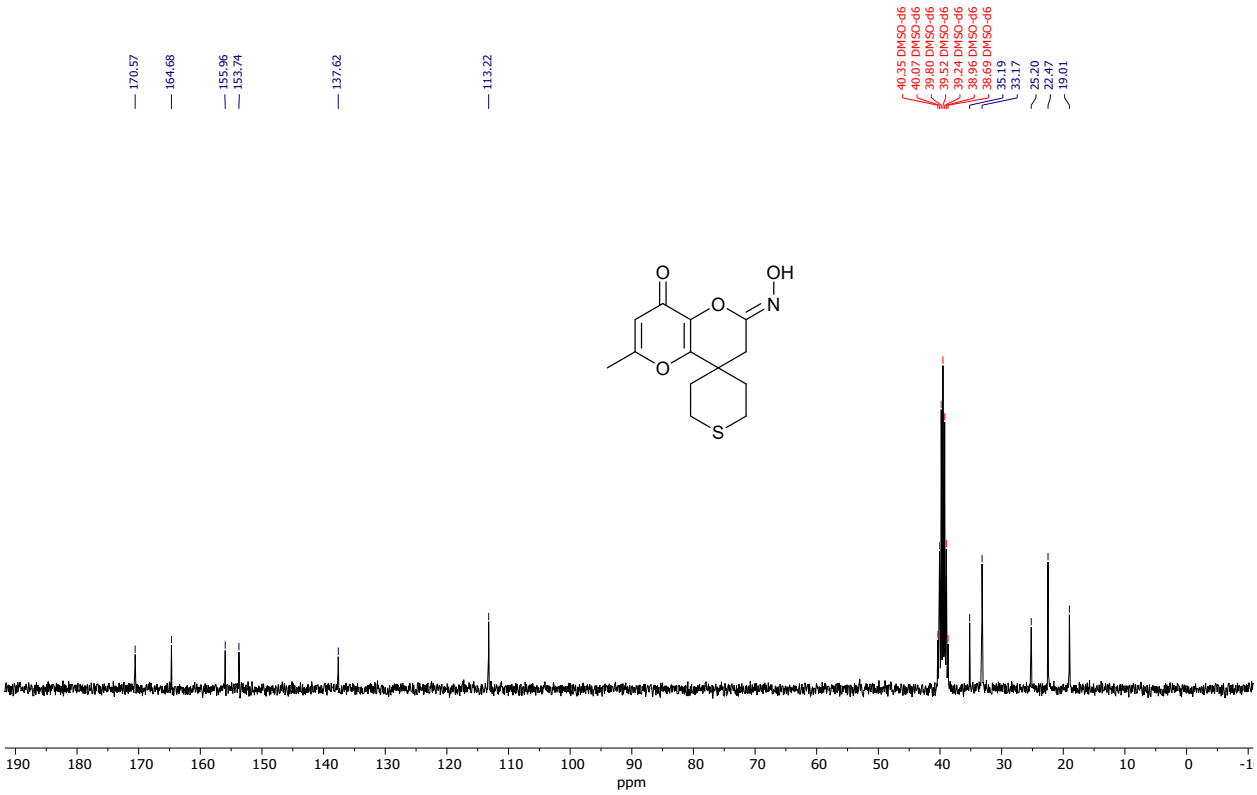
^{13}C {^{1}H} NMR spectrum (75 MHz) of **18b** in DMSO-d_6



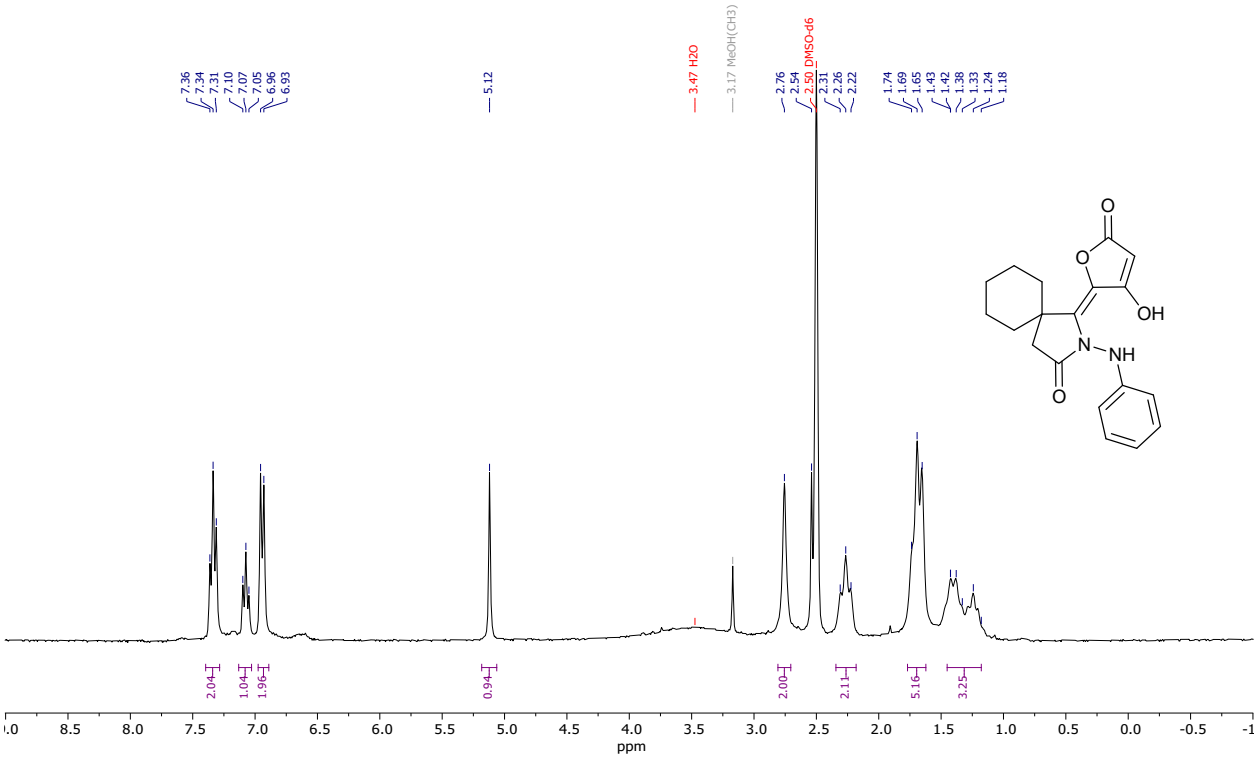
^{1}H NMR spectrum (600 MHz) of **18c** in DMSO-d_6



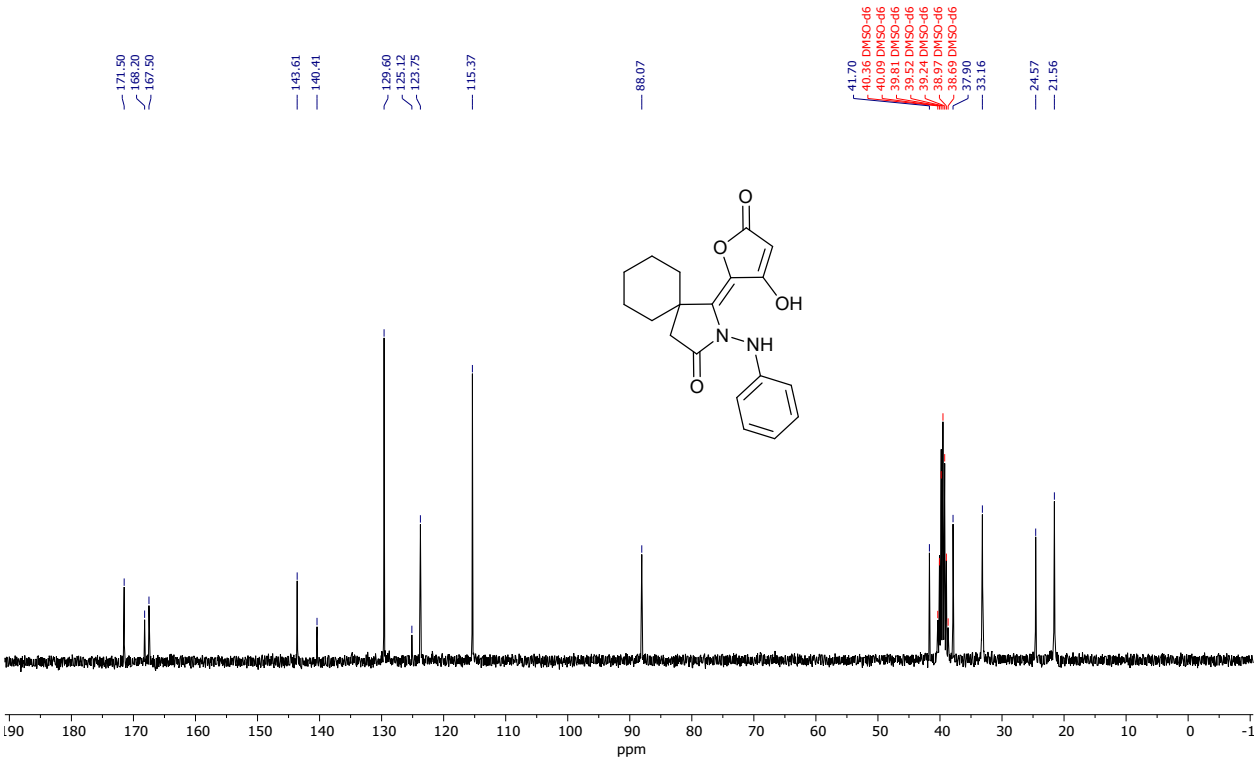
^{13}C {^{1}H} NMR spectrum (75 MHz) of **18c** in DMSO-d_6



^{1}H NMR spectrum (300 MHz) of **19** in DMSO-d_6

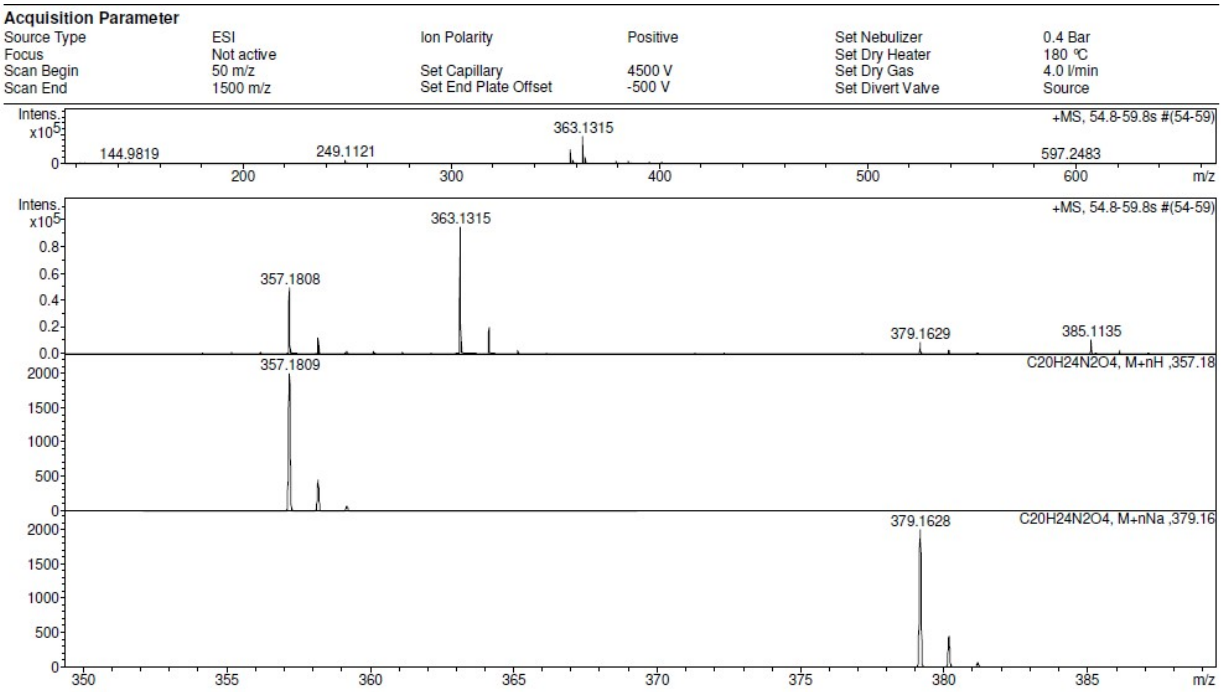


^{13}C {^{1}H} NMR spectrum (75 MHz) of **19** in DMSO-d_6

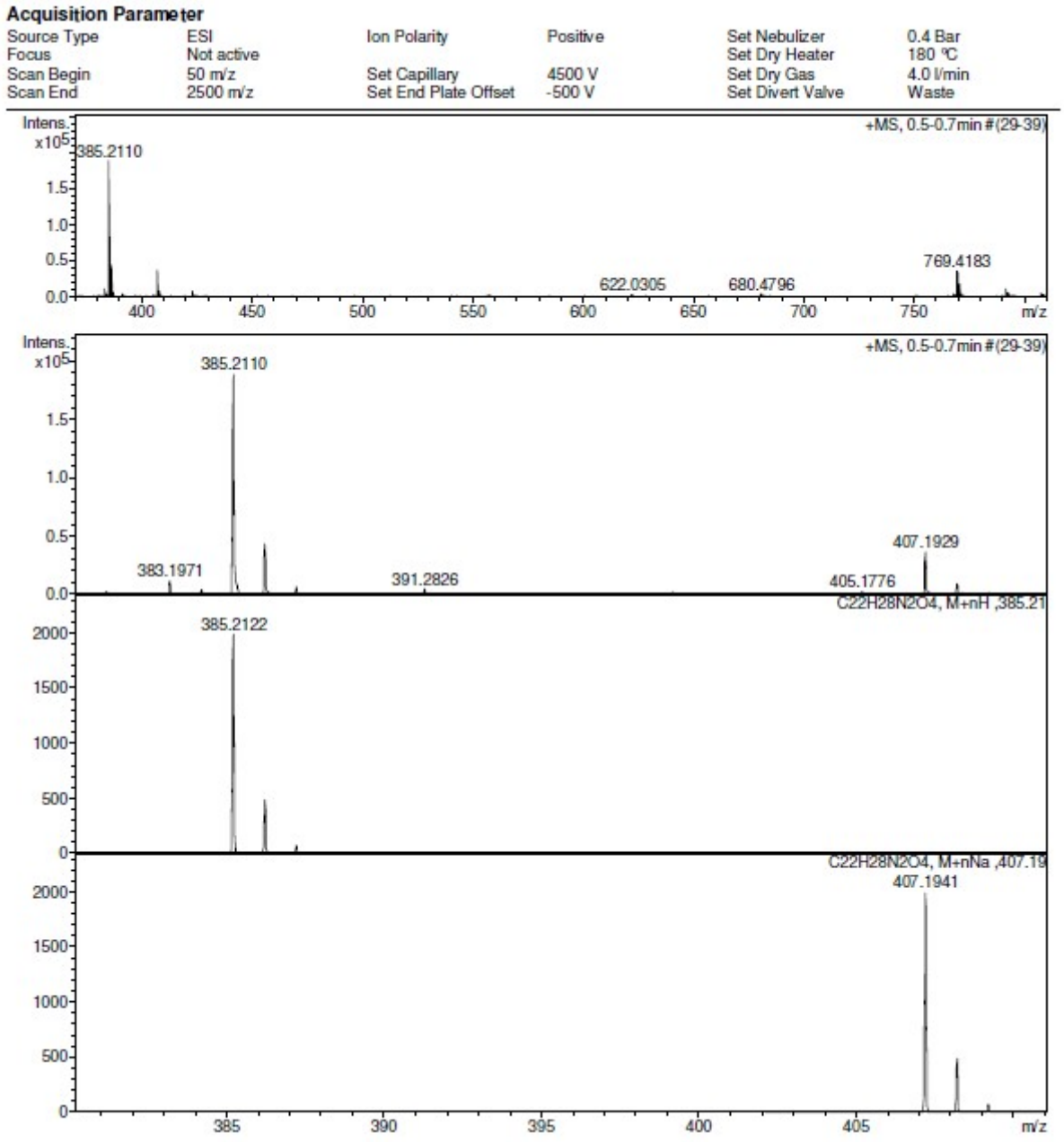


7. Copies of HRMS for all compounds

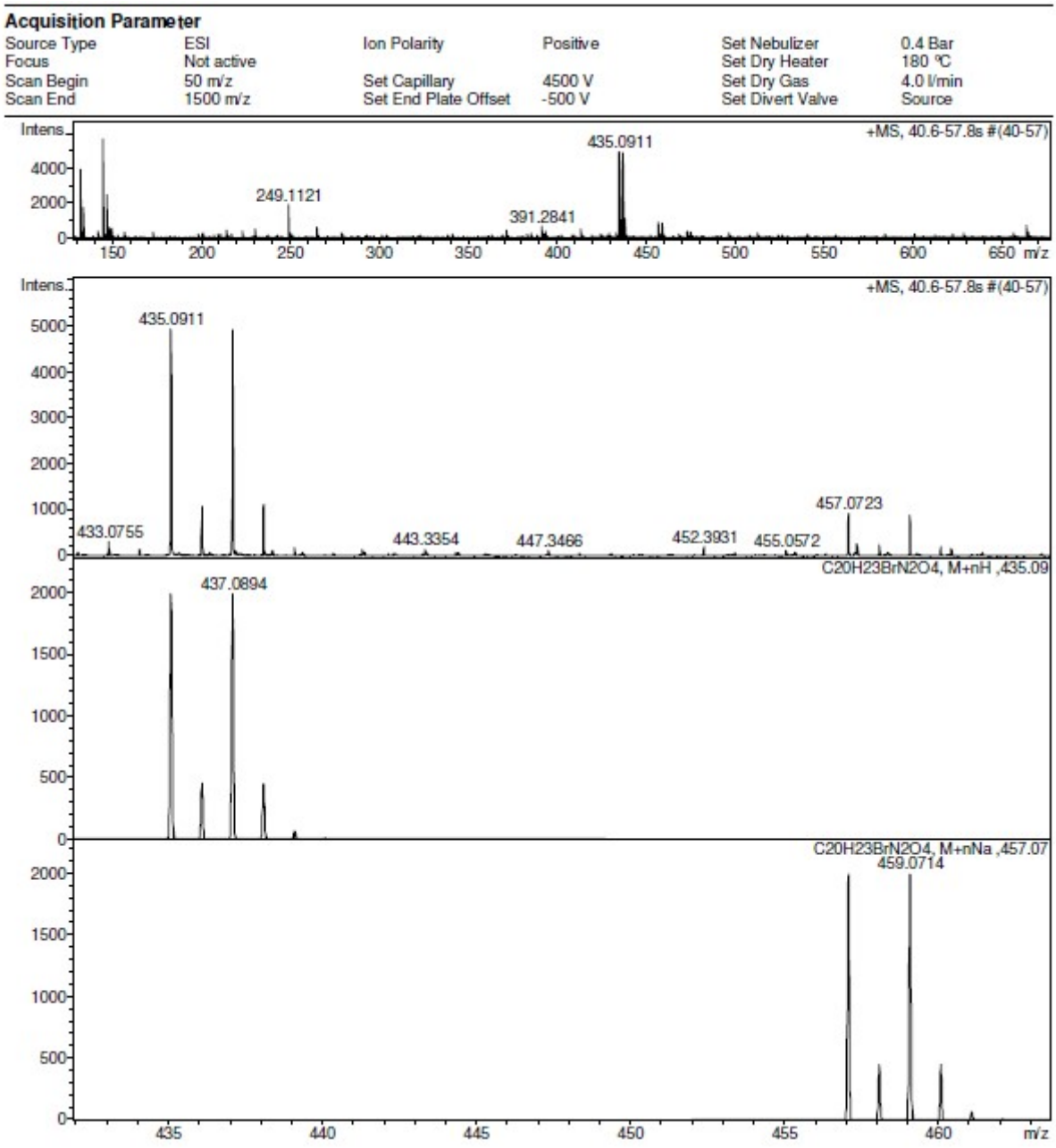
HRMS for compound **7a**



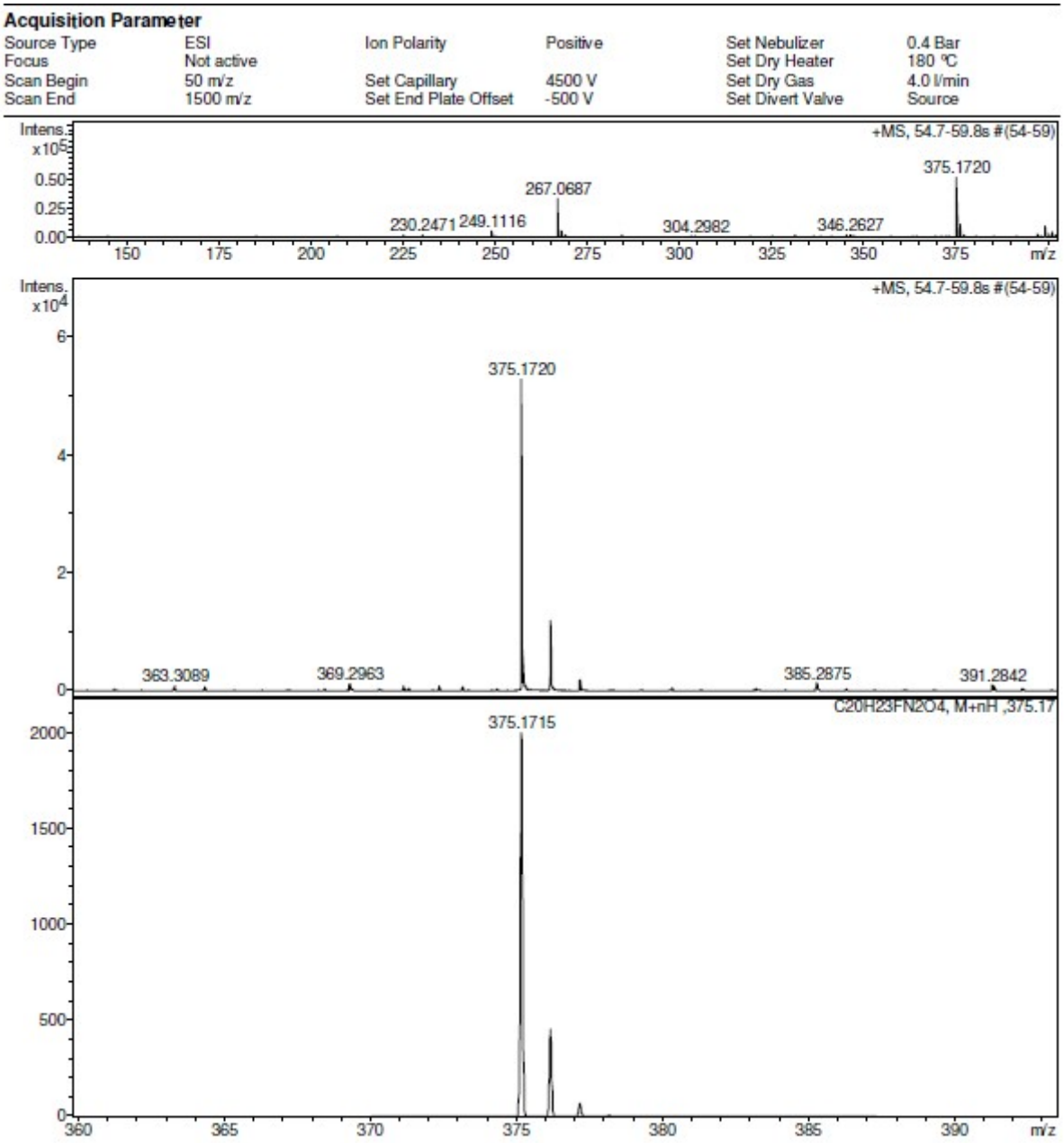
HRMS for compound **7b**



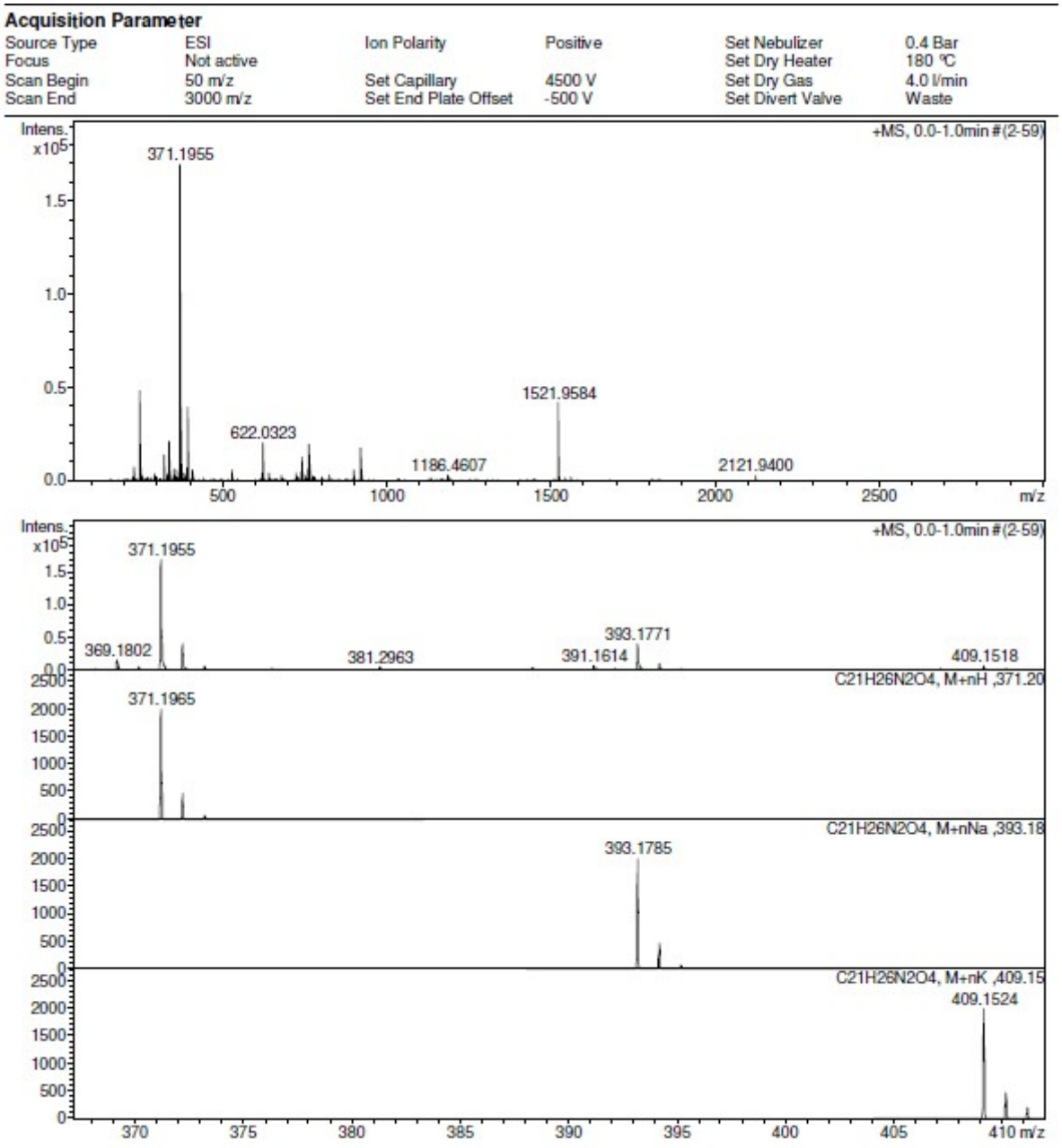
HRMS for compound **7c**



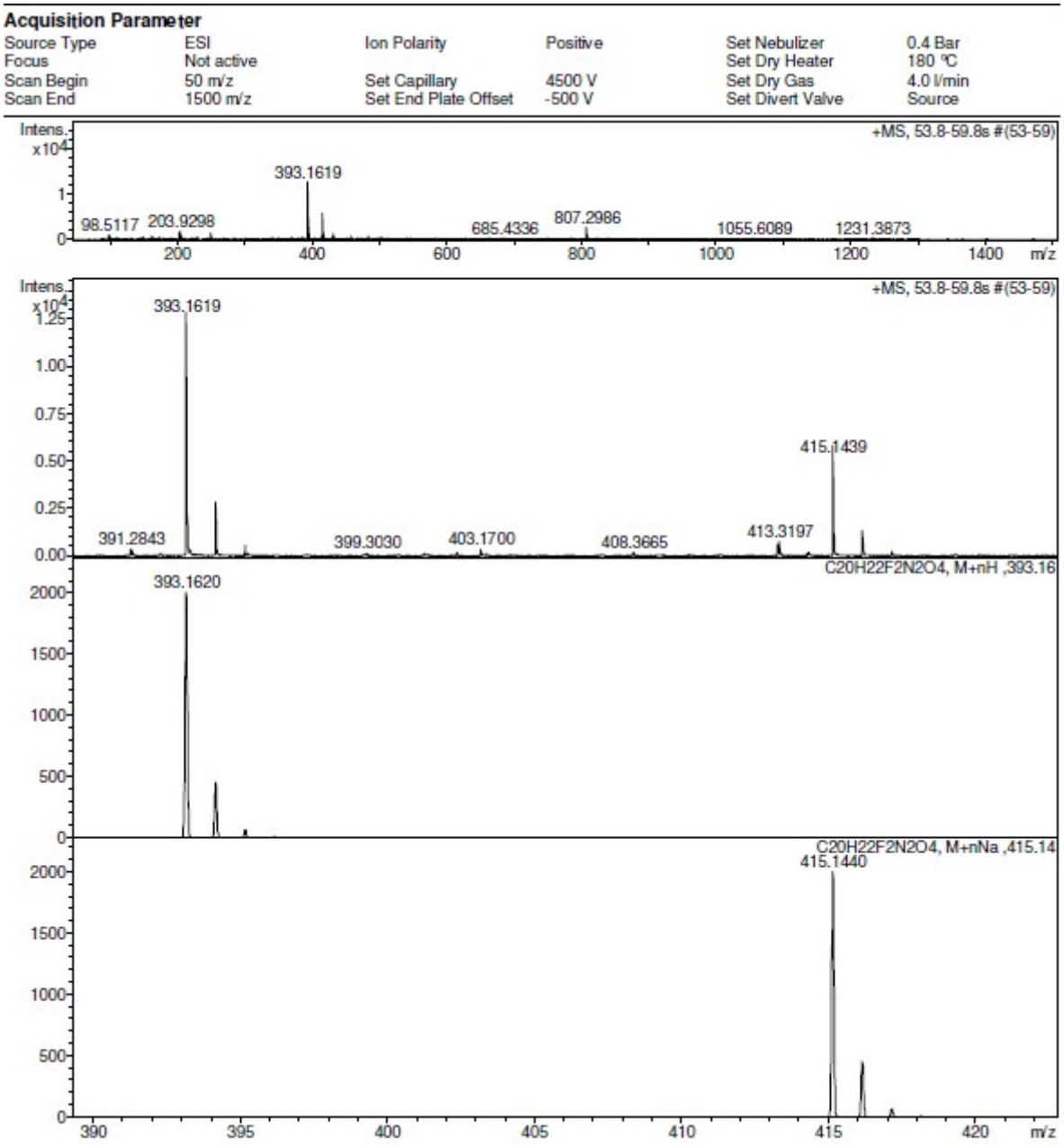
HRMS for compound **7d**



HRMS for compound **7e**



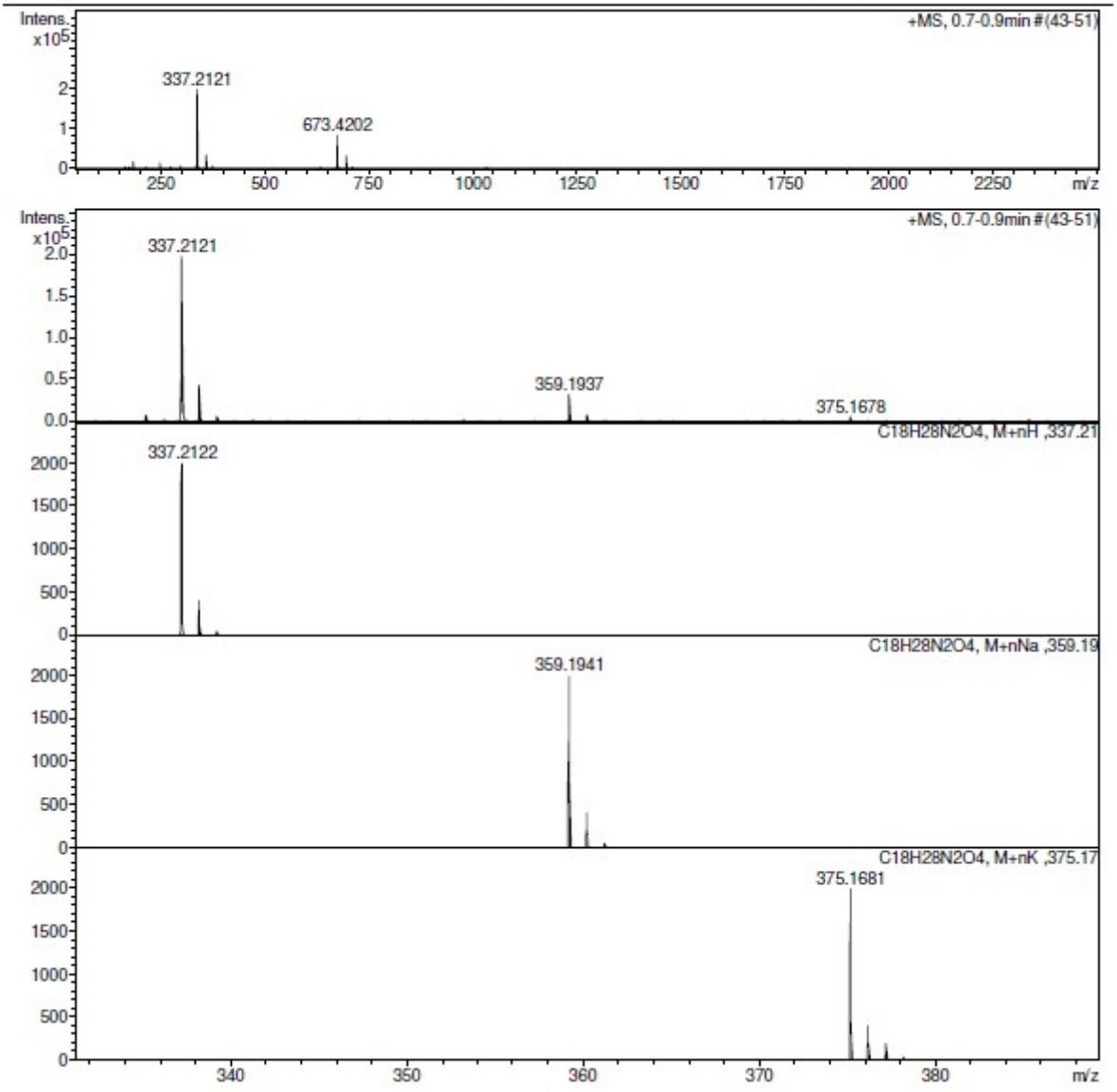
HRMS for compound **7f**



HRMS for compound **7g**

Acquisition Parameter

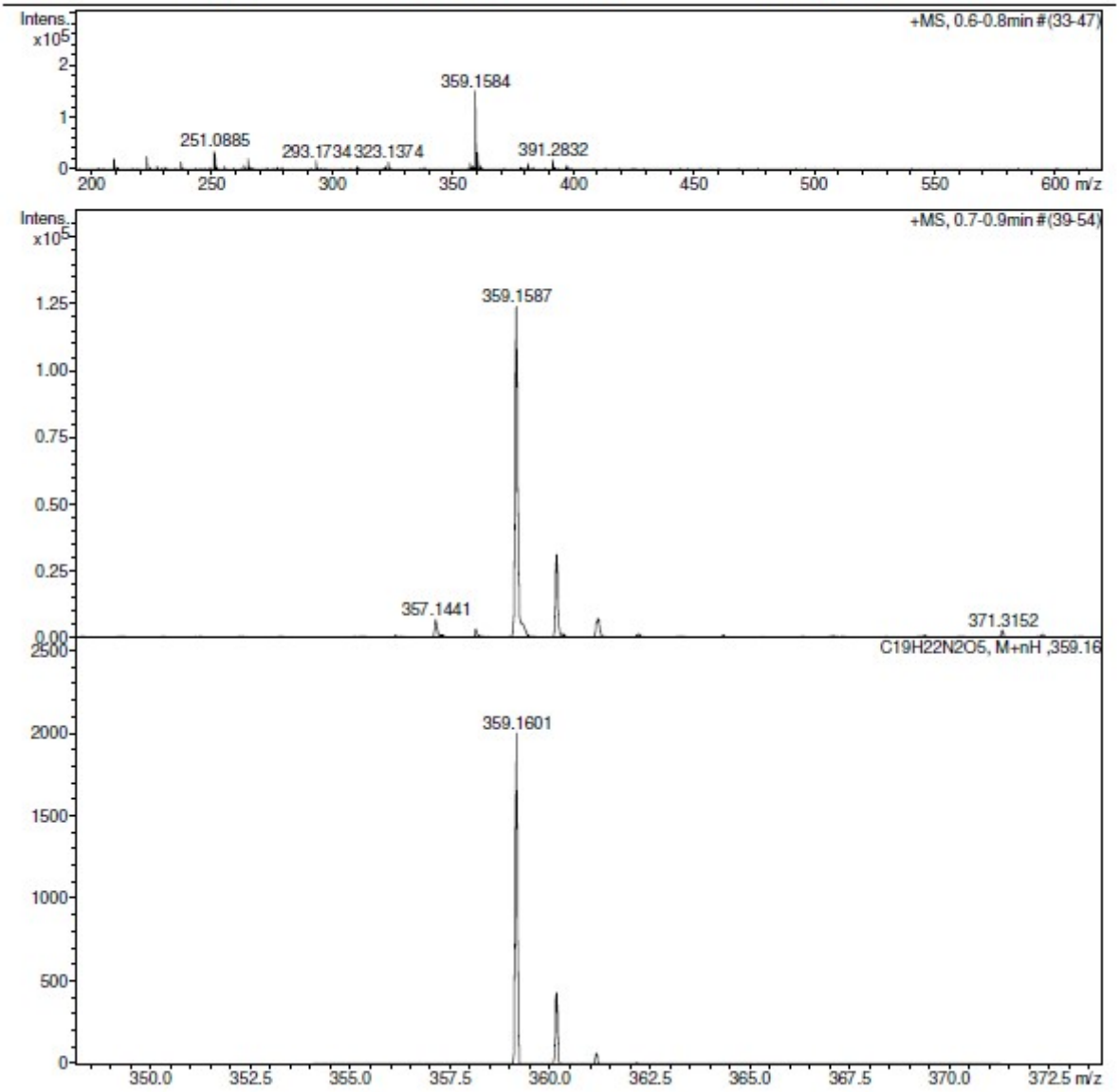
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	0.4 Bar
Focus	Not active			Set Dry Heater	180 °C
Scan Begin	50 m/z	Set Capillary	4500 V	Set Dry Gas	4.0 l/min
Scan End	2500 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Waste



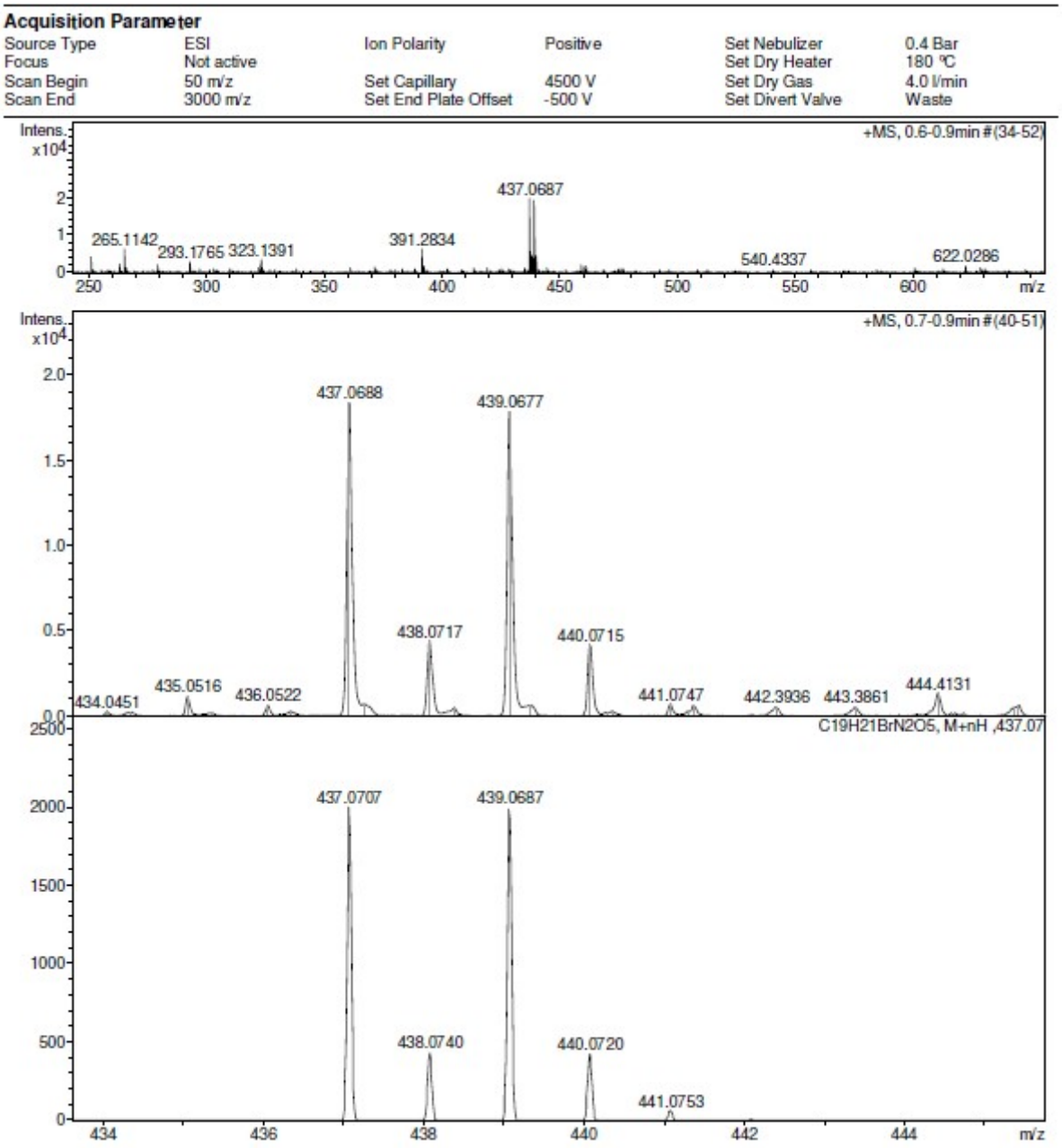
HRMS for compound **7h**

Acquisition Parameter

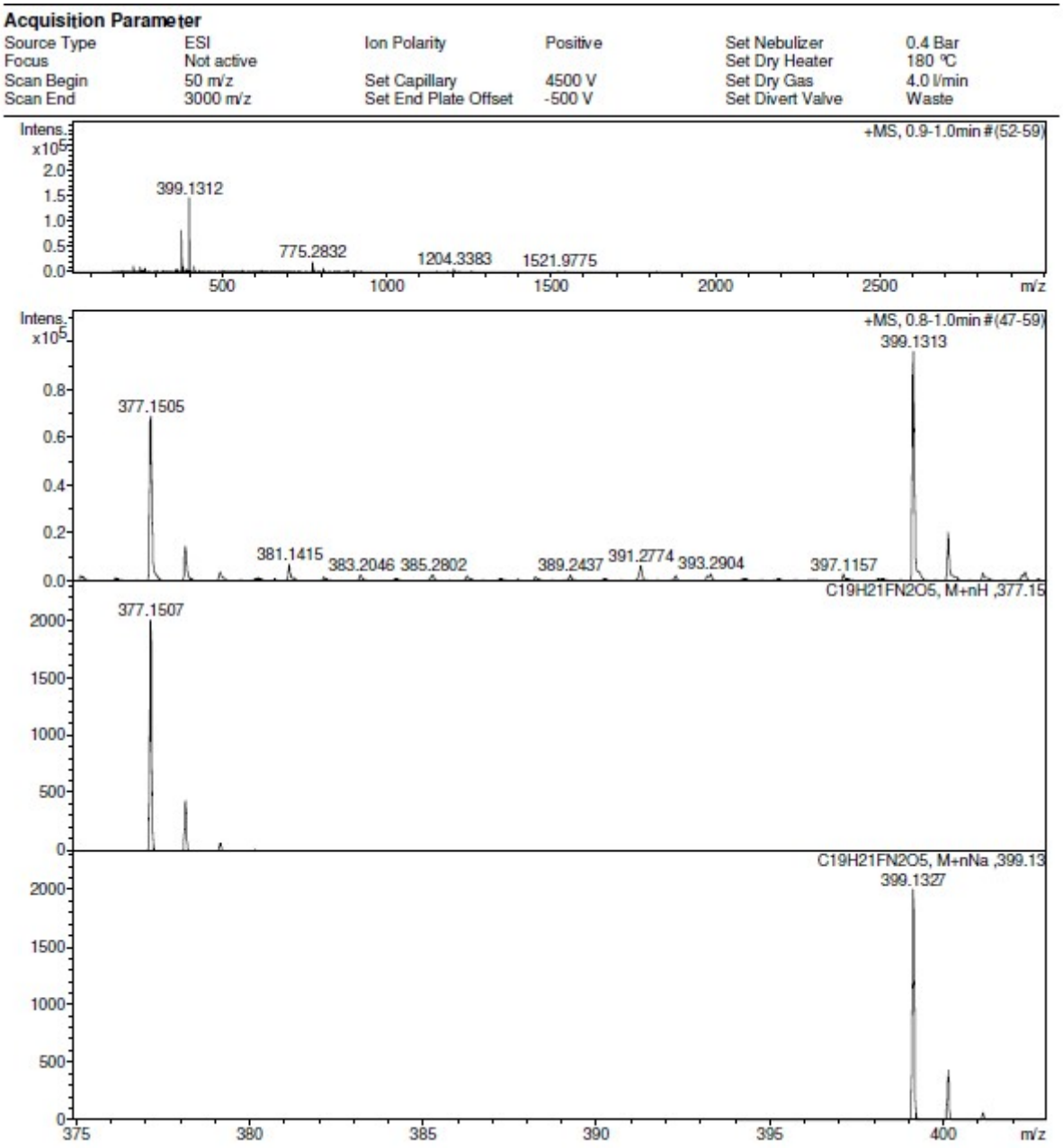
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	0.4 Bar
Focus	Not active			Set Dry Heater	180 °C
Scan Begin	50 m/z	Set Capillary	4500 V	Set Dry Gas	4.0 l/min
Scan End	3000 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Waste



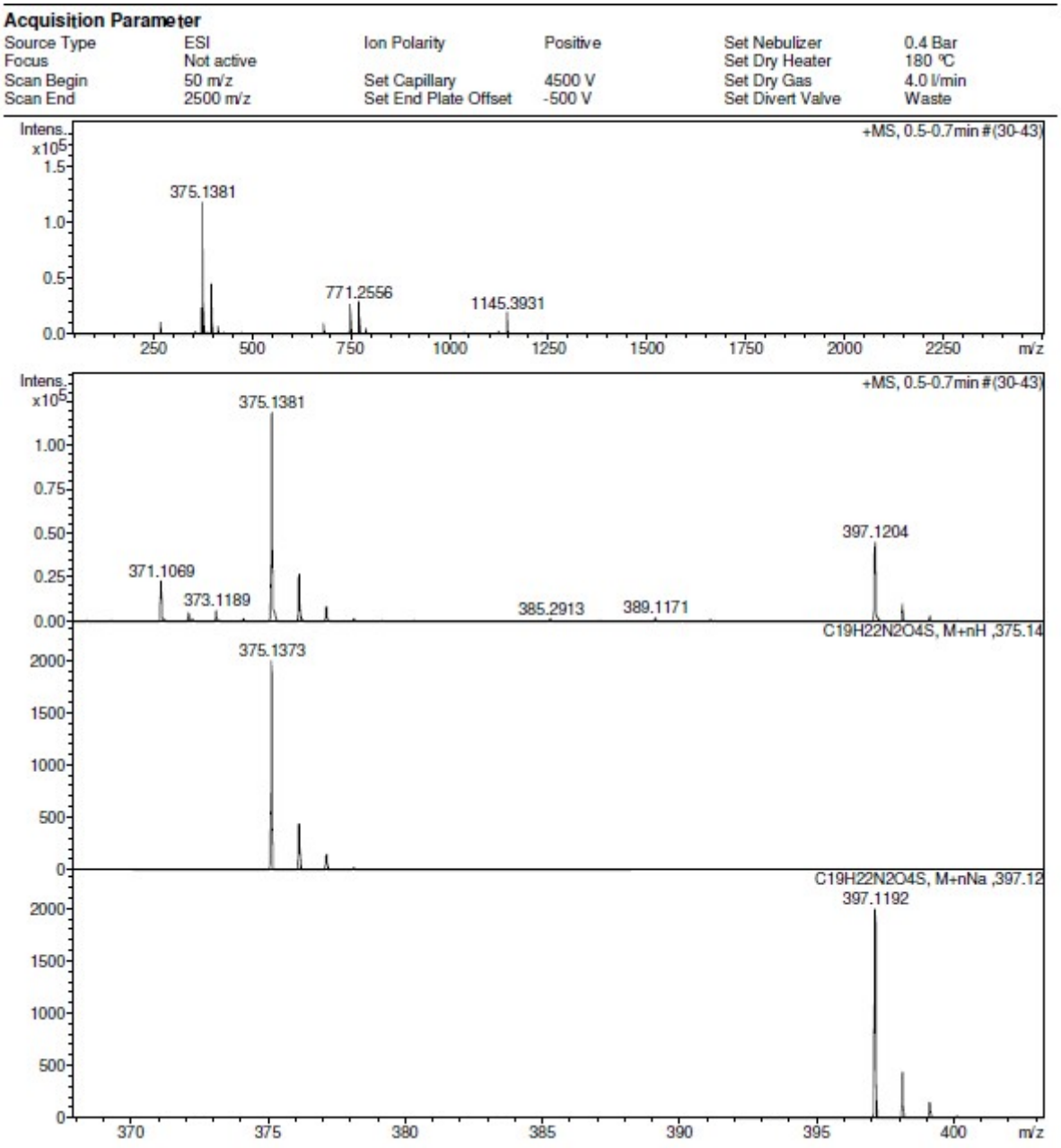
HRMS for compound **7i**



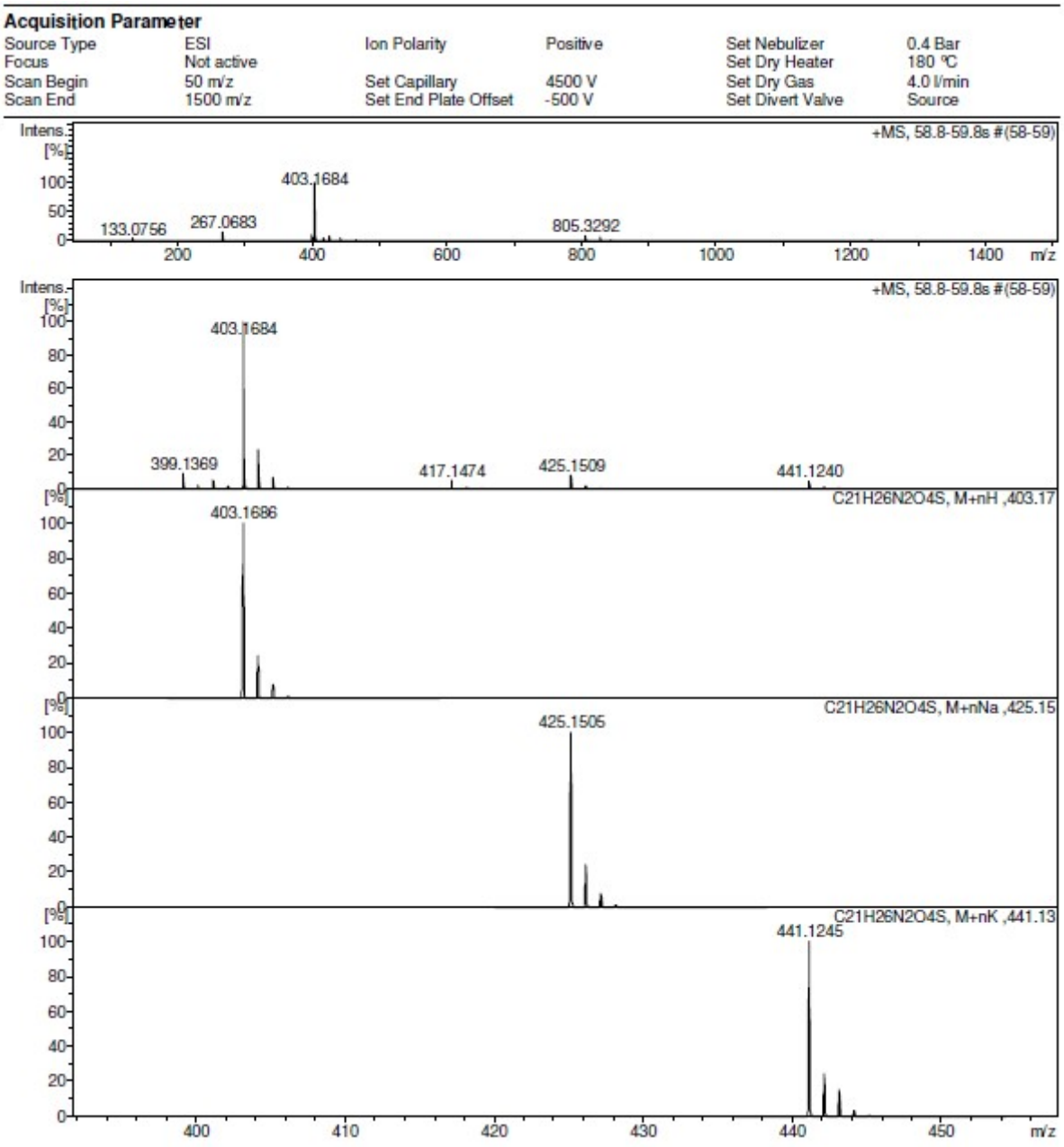
HRMS for compound **7j**



HRMS for compound **7k**



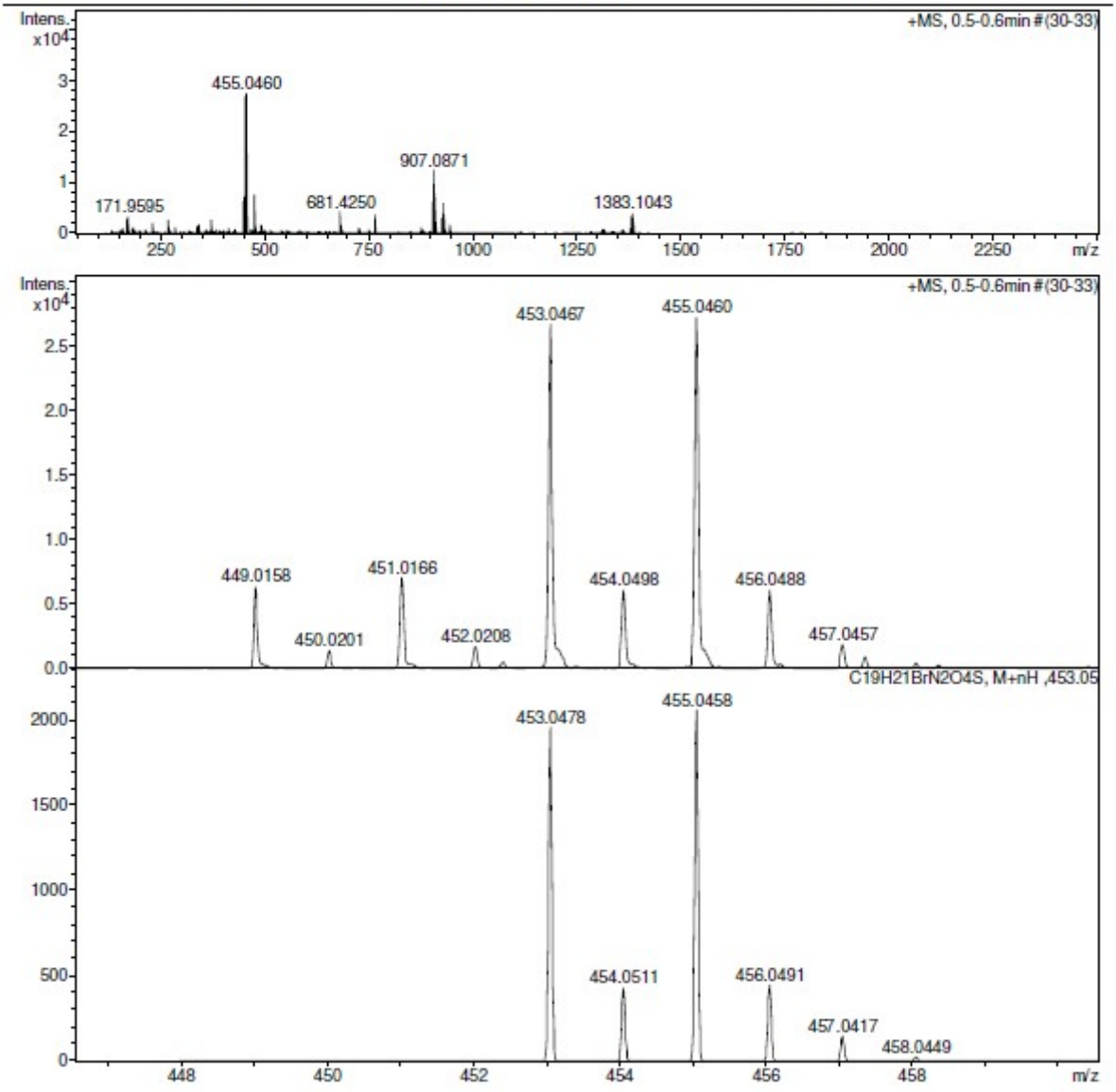
HRMS for compound **7l**



HRMS for compound **7m**

Acquisition Parameter

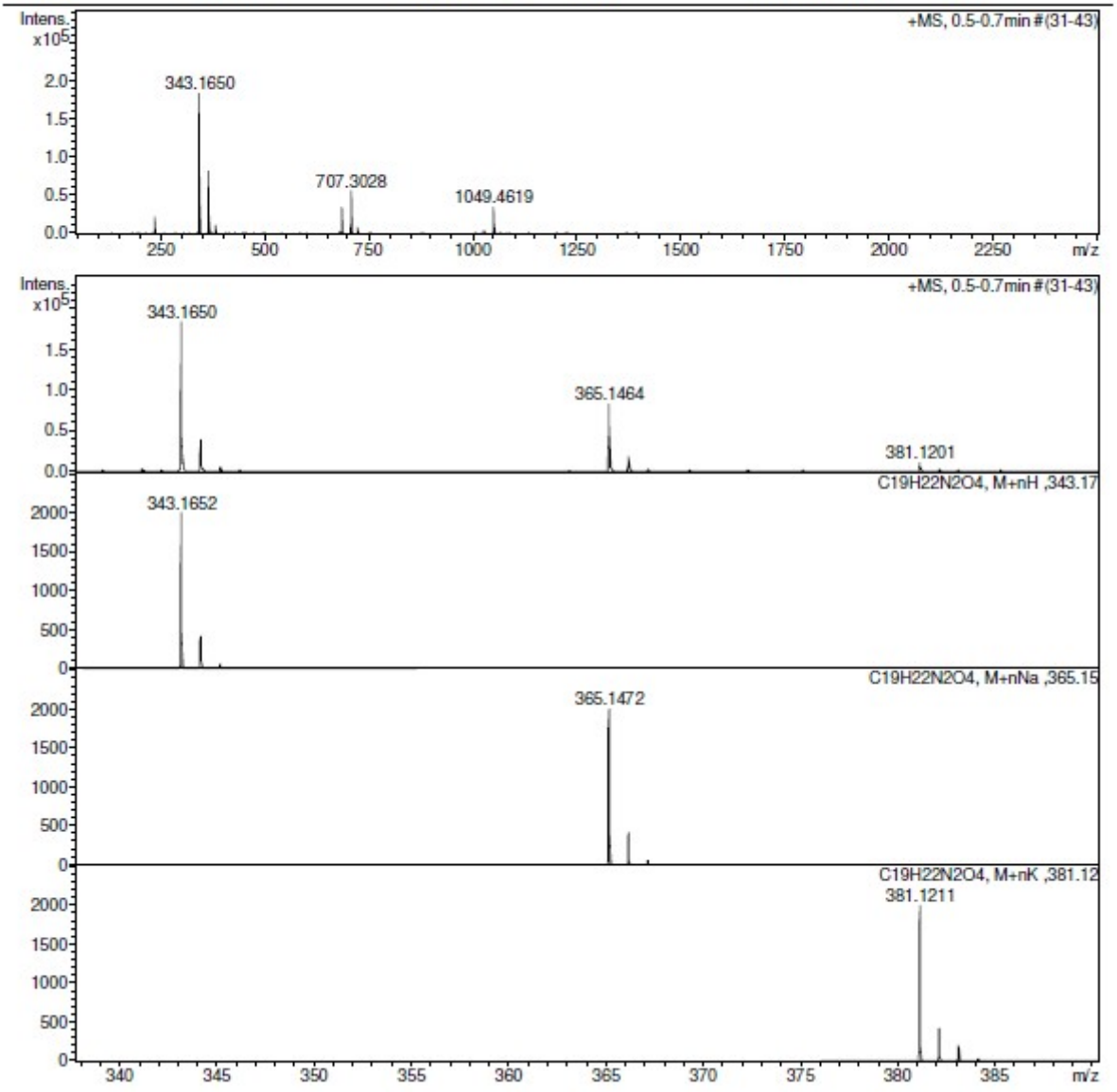
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	0.4 Bar
Focus	Not active			Set Dry Heater	180 °C
Scan Begin	50 m/z	Set Capillary	4500 V	Set Dry Gas	4.0 l/min
Scan End	2500 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Waste



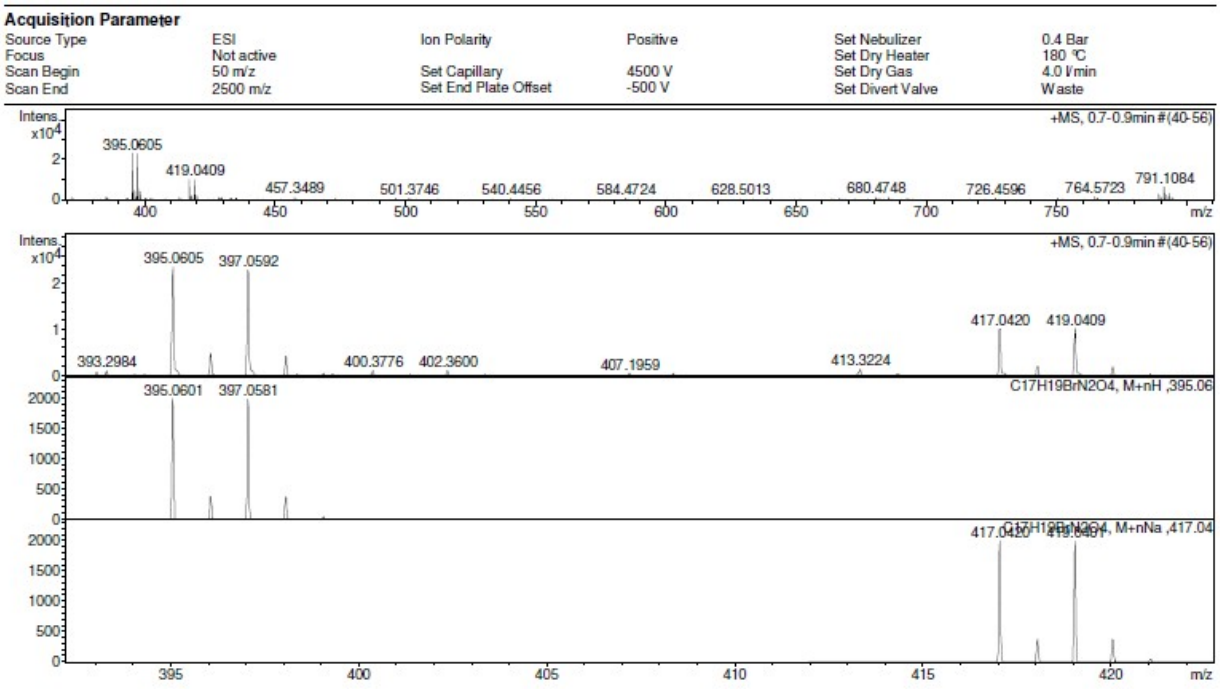
HRMS for compound **7n**

Acquisition Parameter

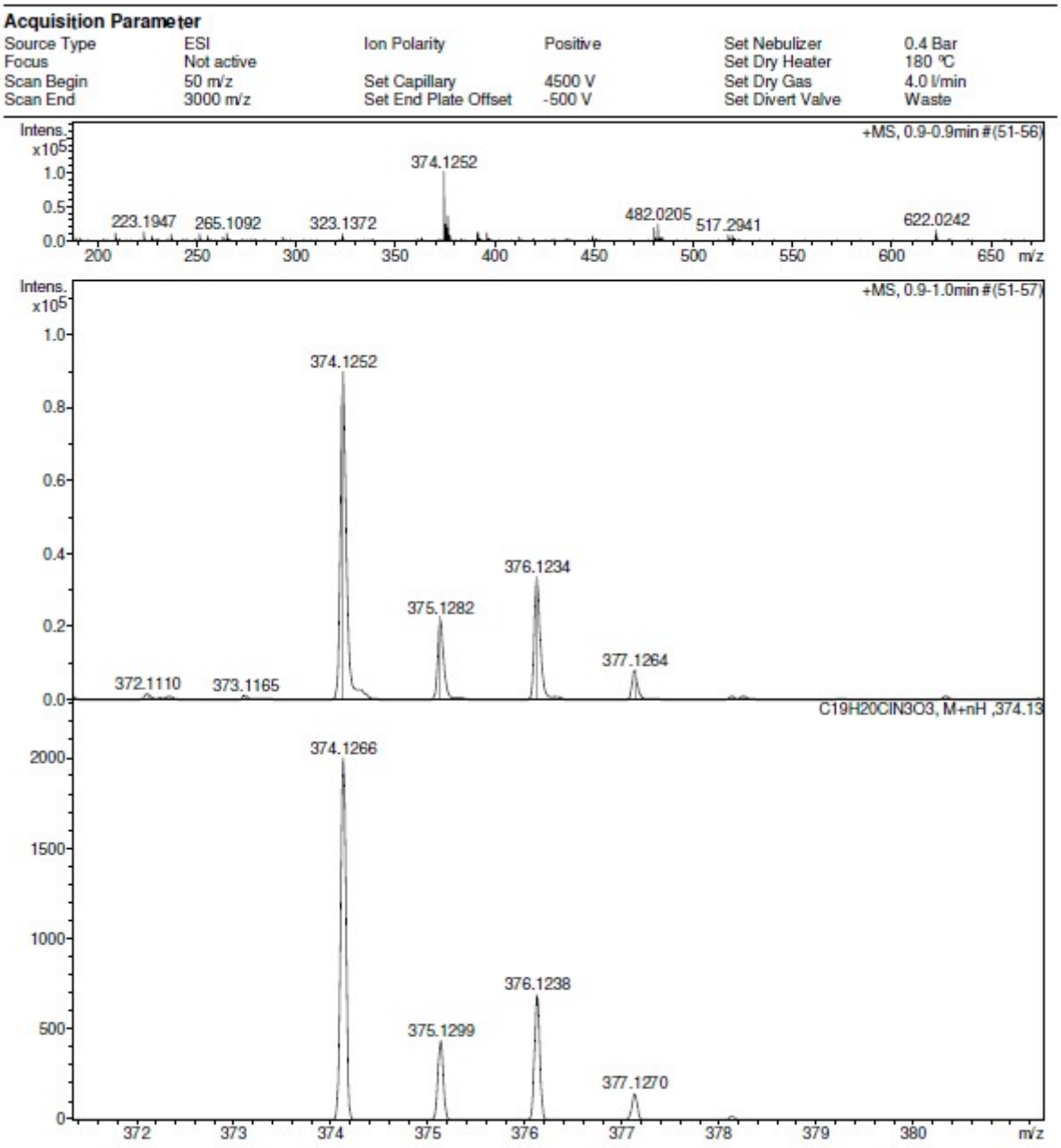
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	0.4 Bar
Focus	Not active			Set Dry Heater	180 °C
Scan Begin	50 m/z	Set Capillary	4500 V	Set Dry Gas	4.0 l/min
Scan End	2500 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Waste



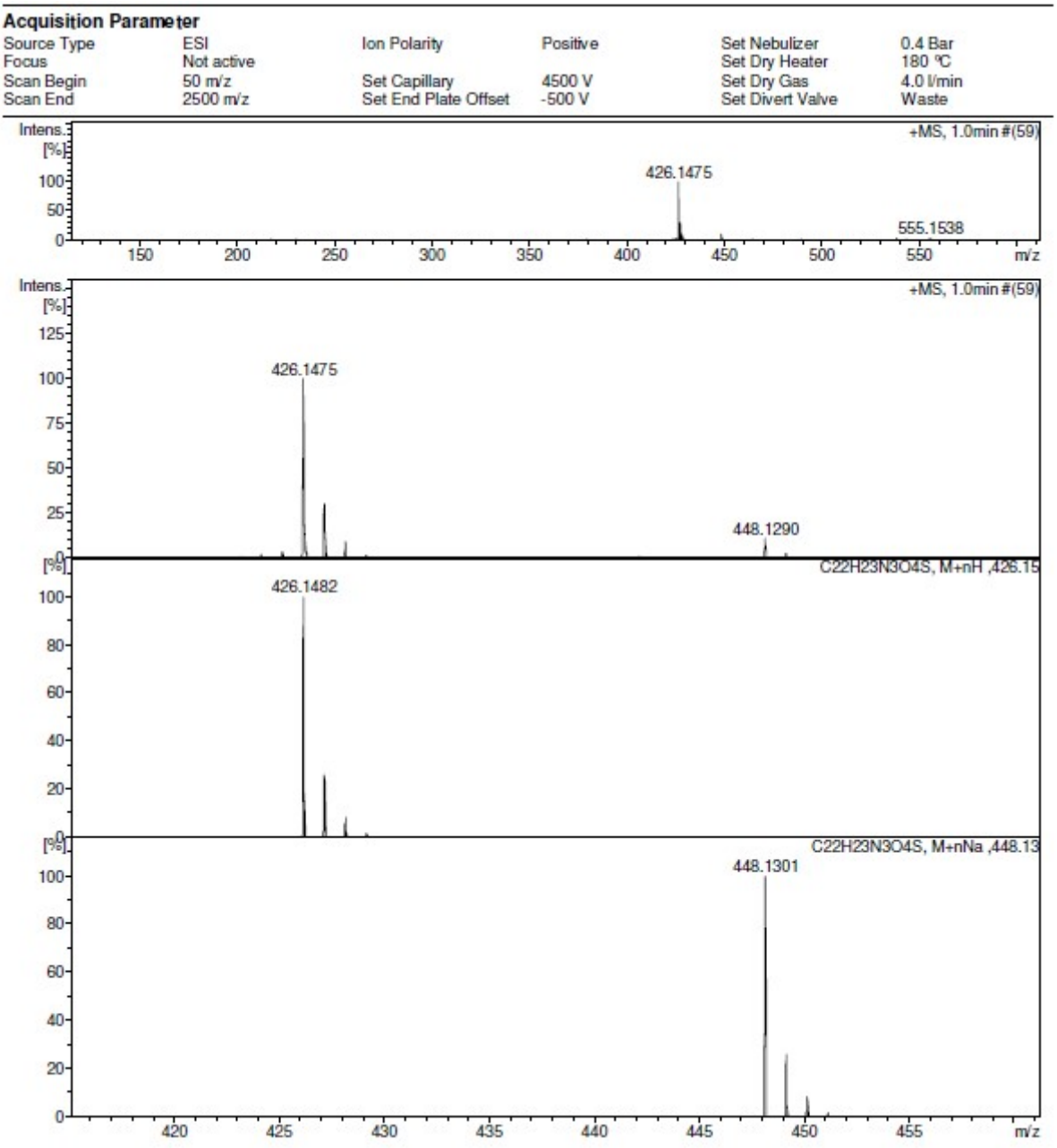
HRMS for compound **7o**



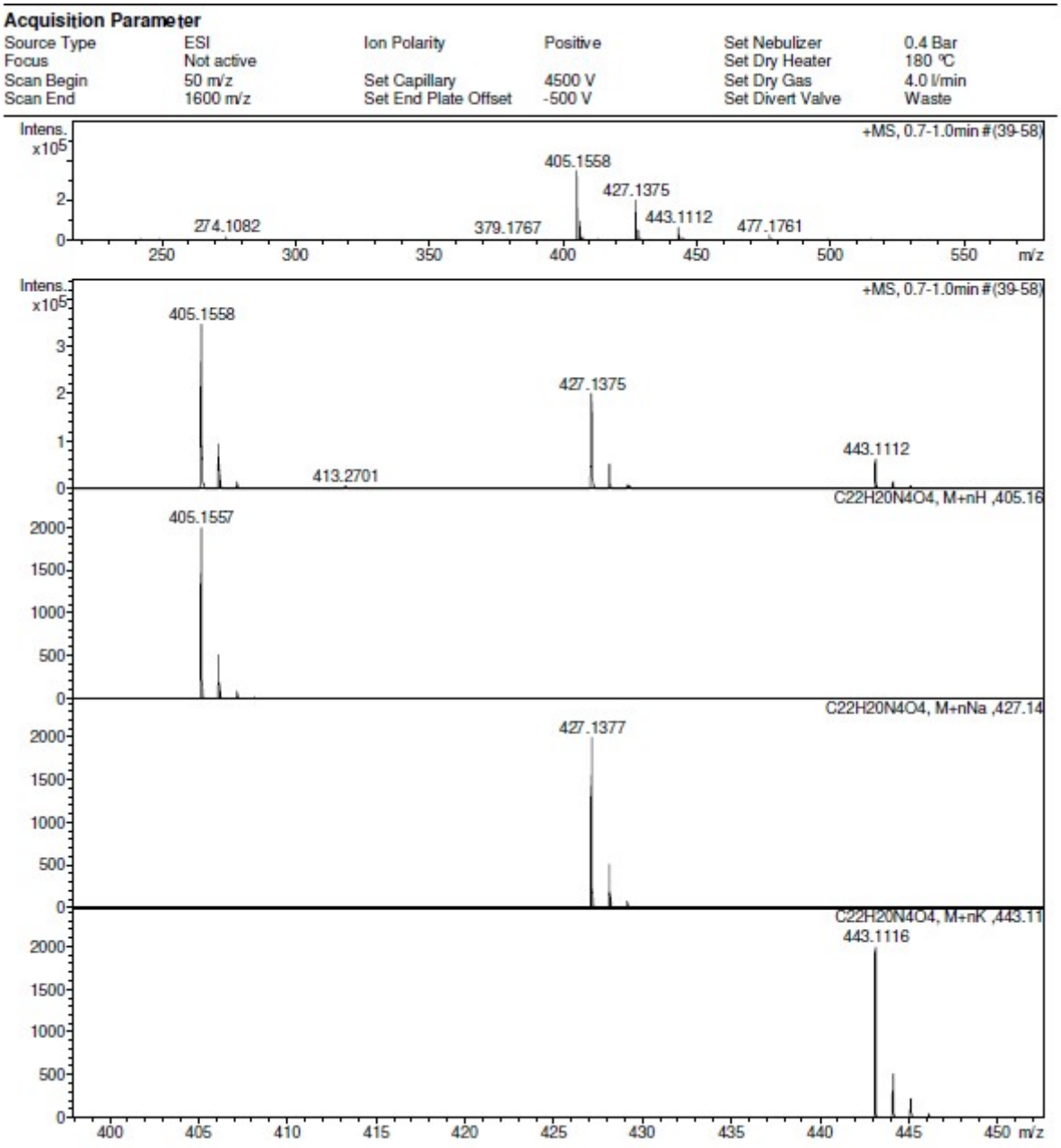
HRMS for compound **7p**



HRMS for compound **7q**



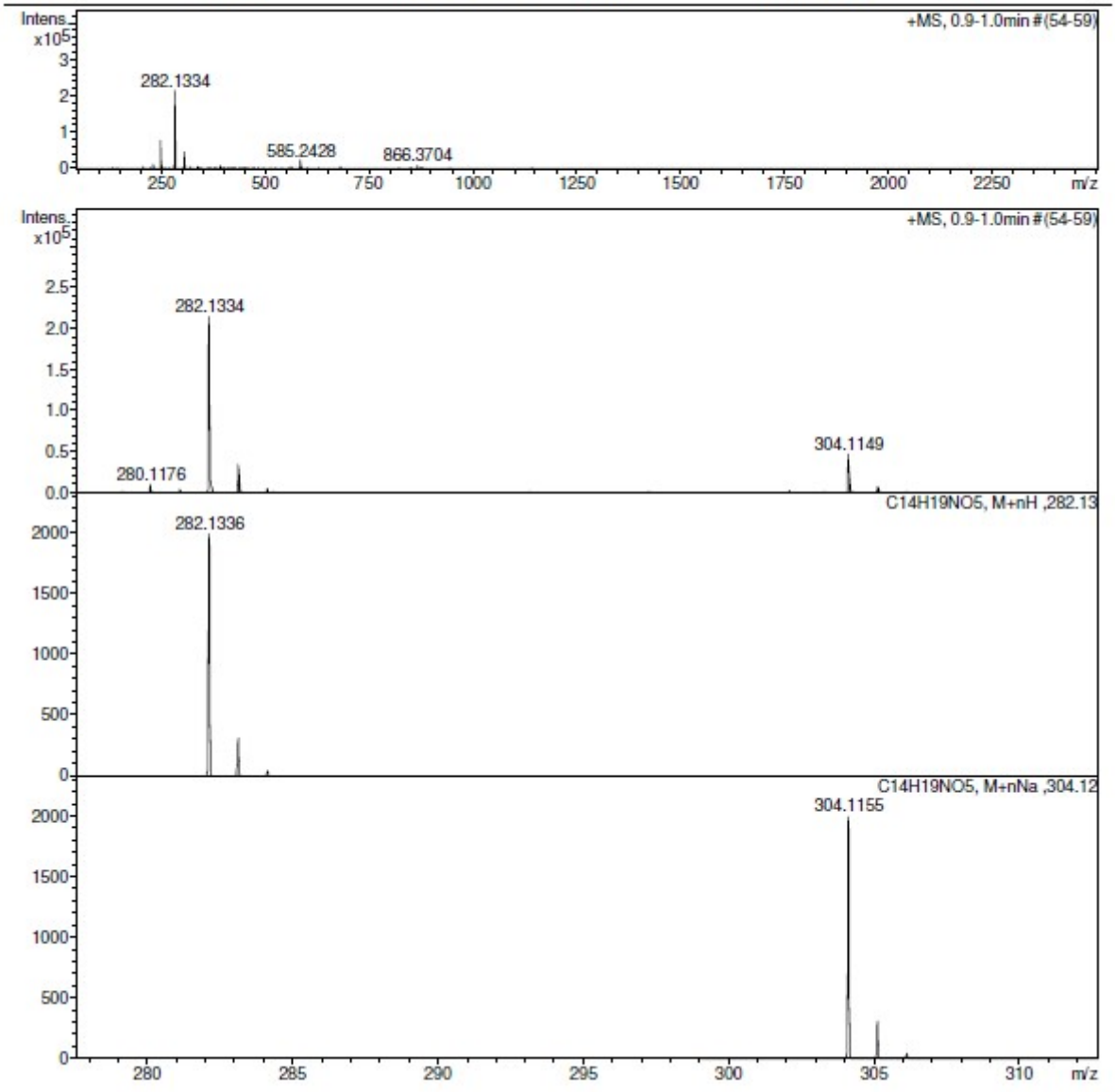
HRMS for compound 7**r**



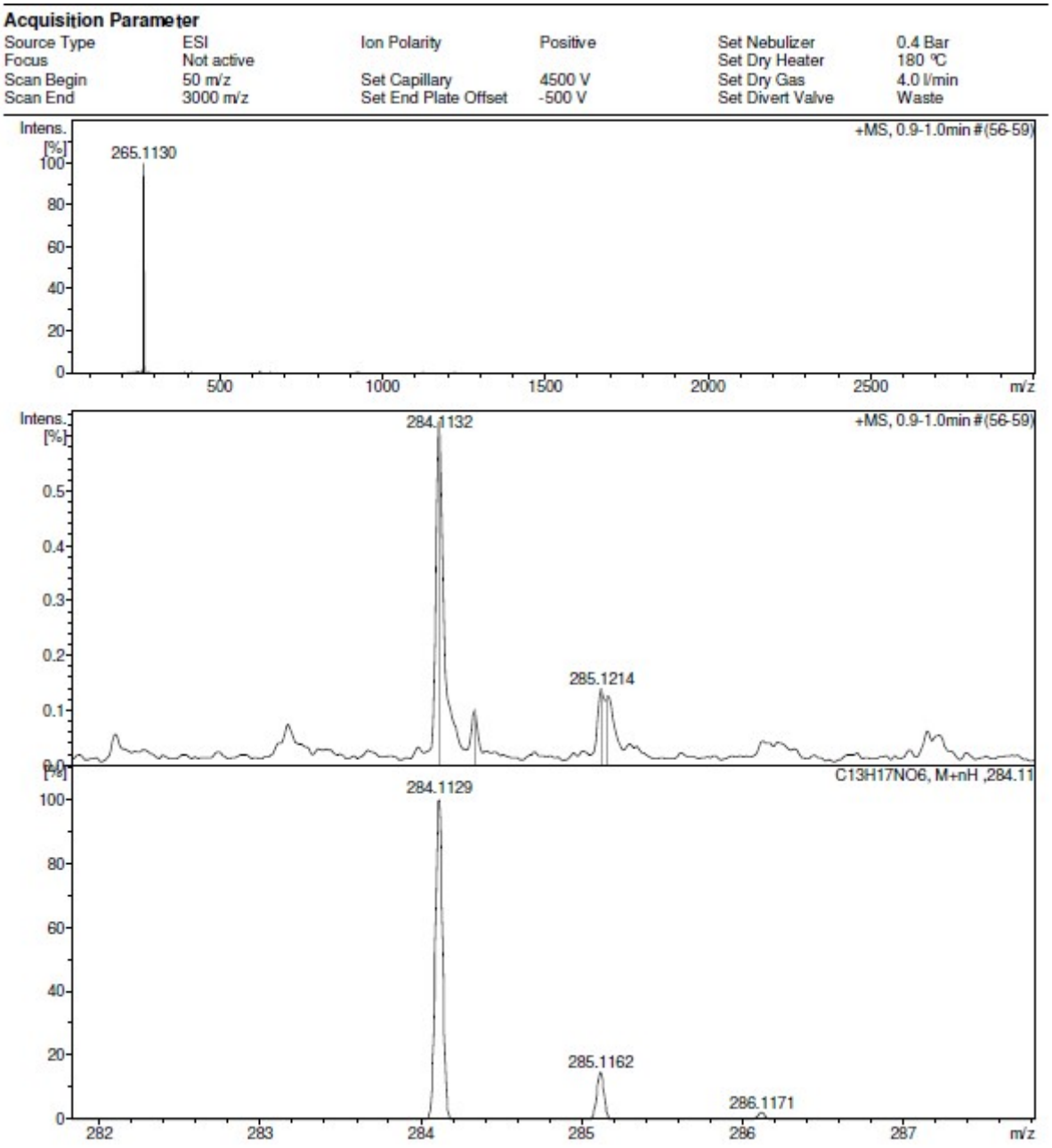
HRMS for compound **9a**

Acquisition Parameter

Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	0.4 Bar
Focus	Not active			Set Dry Heater	180 °C
Scan Begin	50 m/z	Set Capillary	4500 V	Set Dry Gas	4.0 l/min
Scan End	2500 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Waste



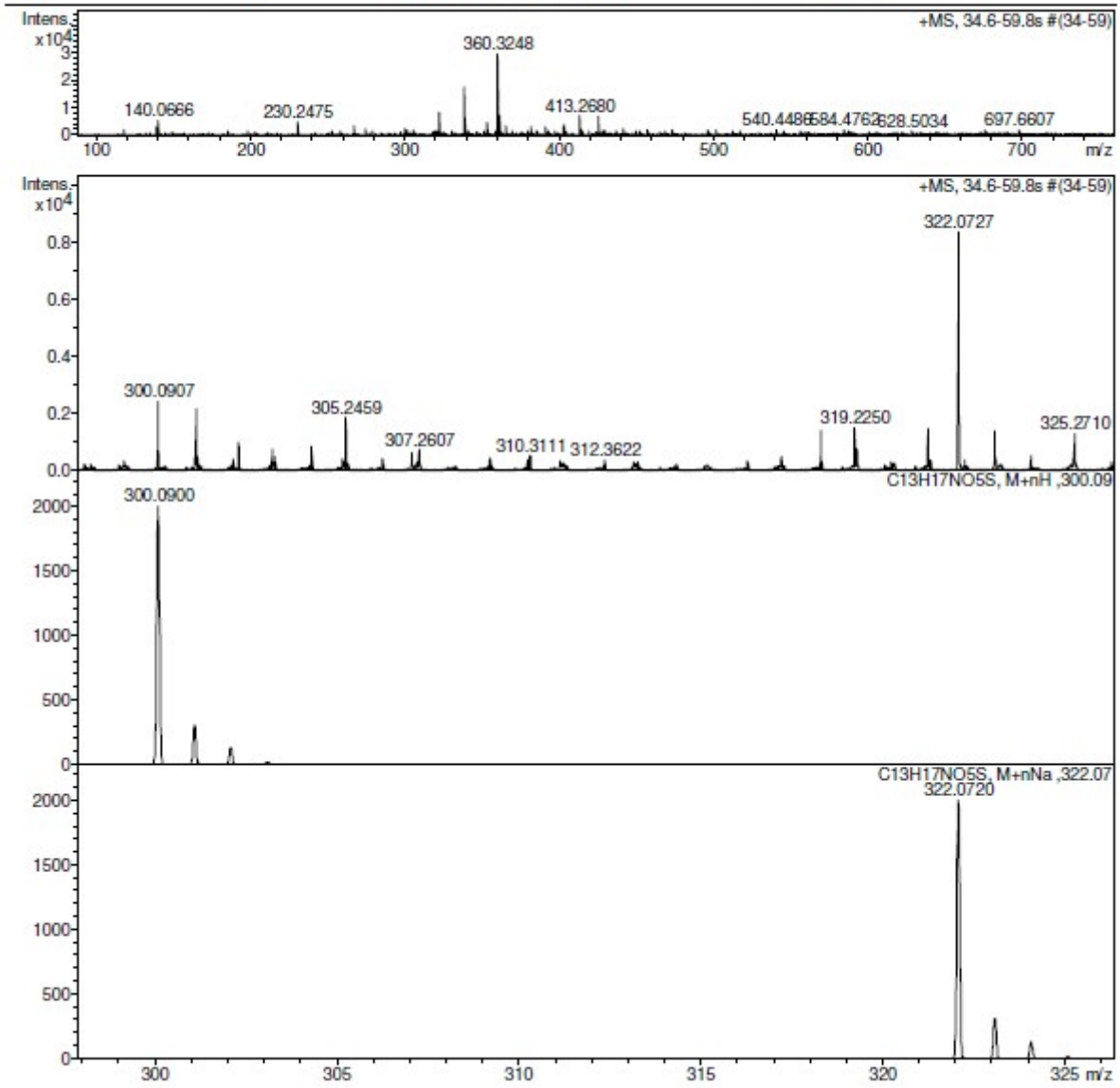
HRMS for compound **9b**



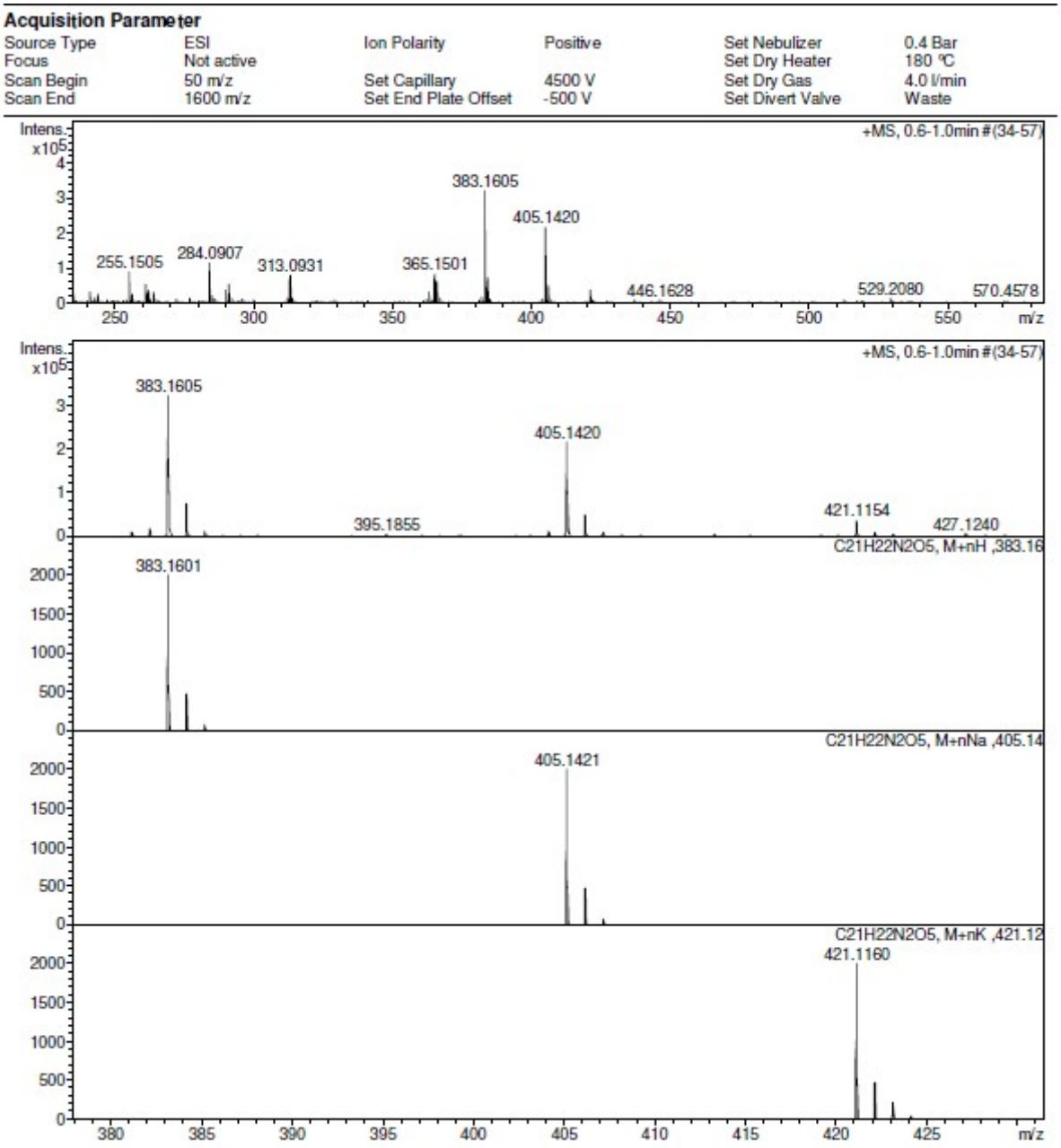
HRMS for compound **9c**

Acquisition Parameter

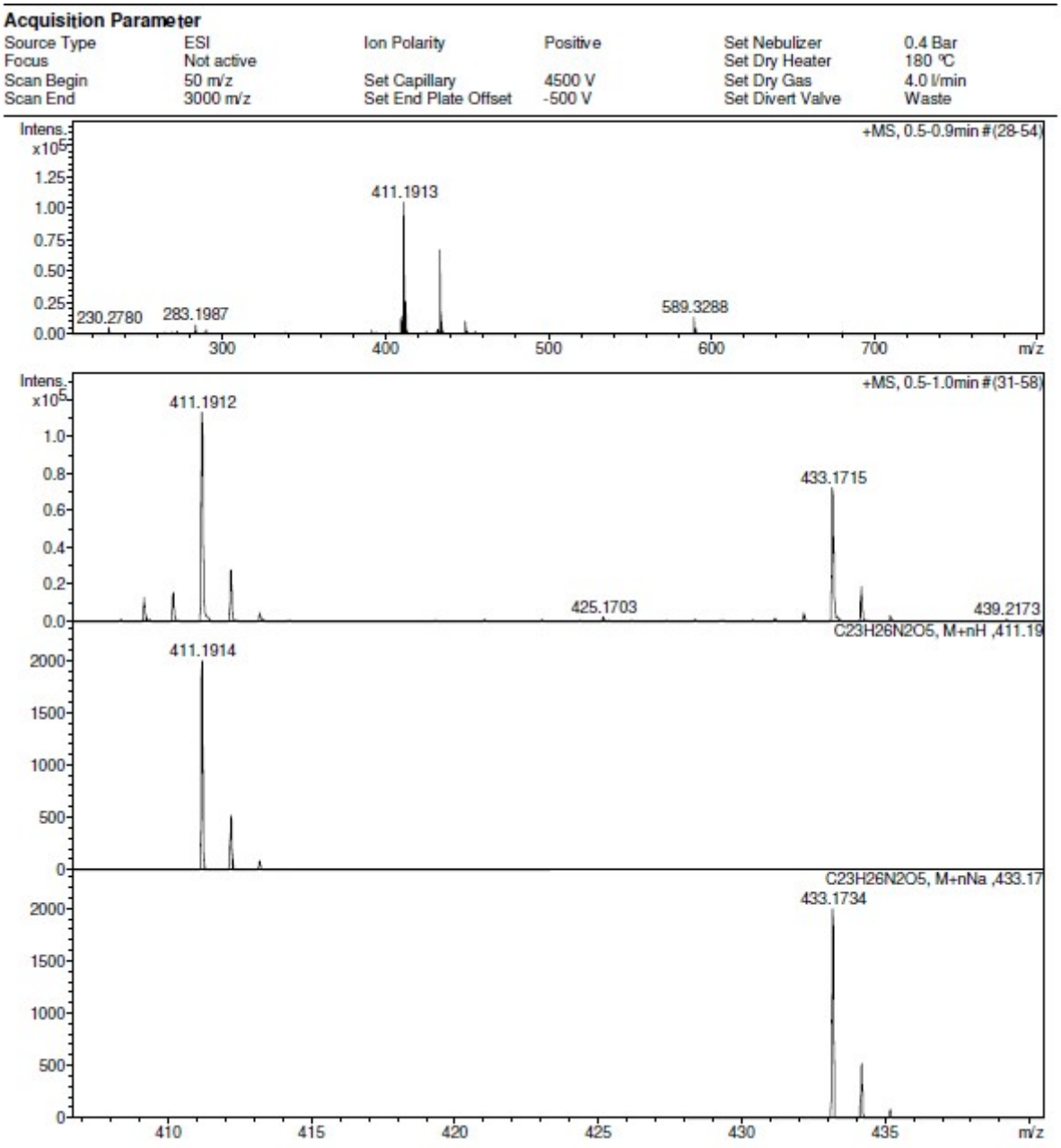
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	0.4 Bar
Focus	Not active			Set Dry Heater	180 °C
Scan Begin	50 m/z	Set Capillary	4500 V	Set Dry Gas	4.0 l/min
Scan End	1500 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Source



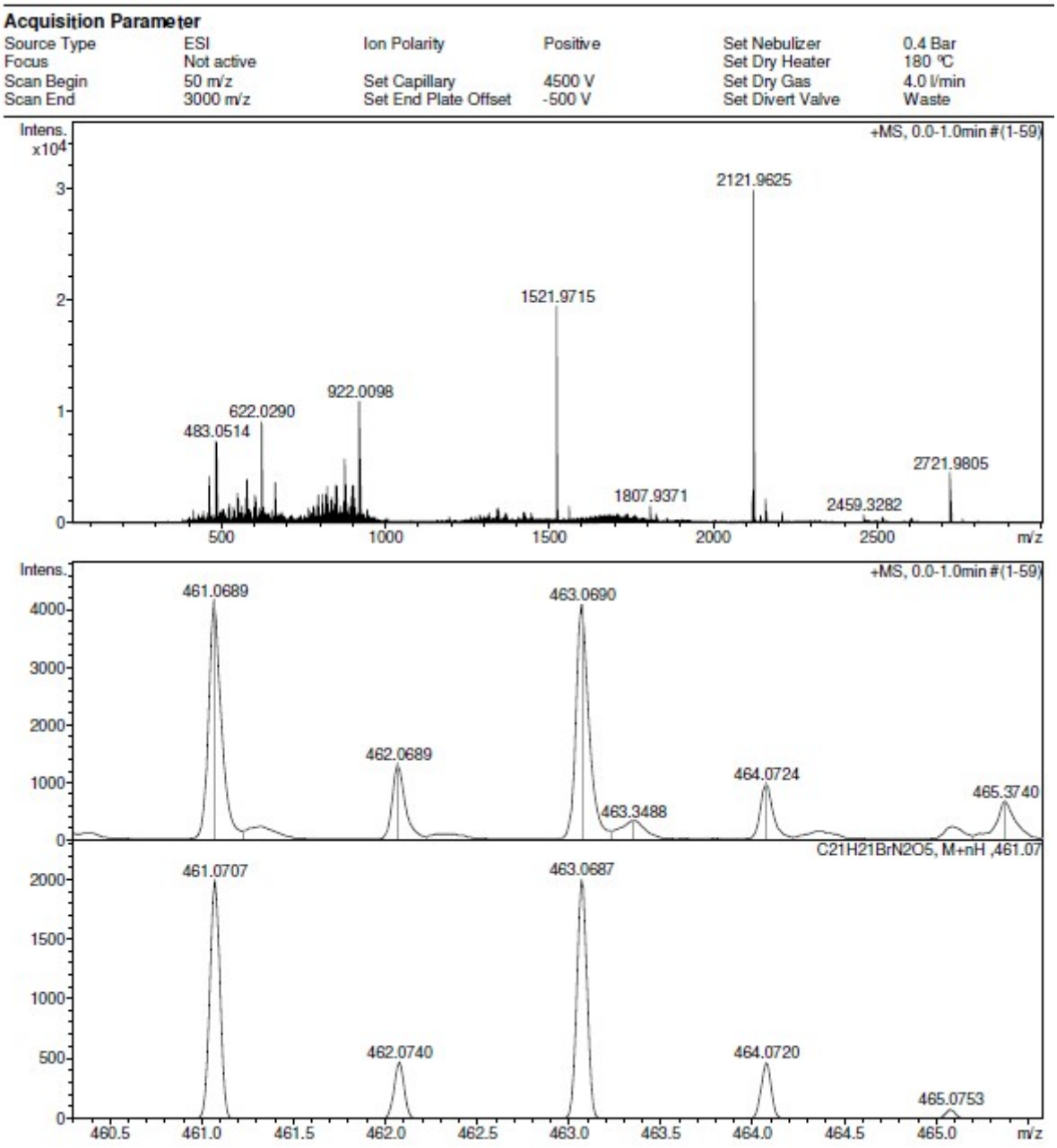
HRMS for compound **8a**



HRMS for compound **8b**



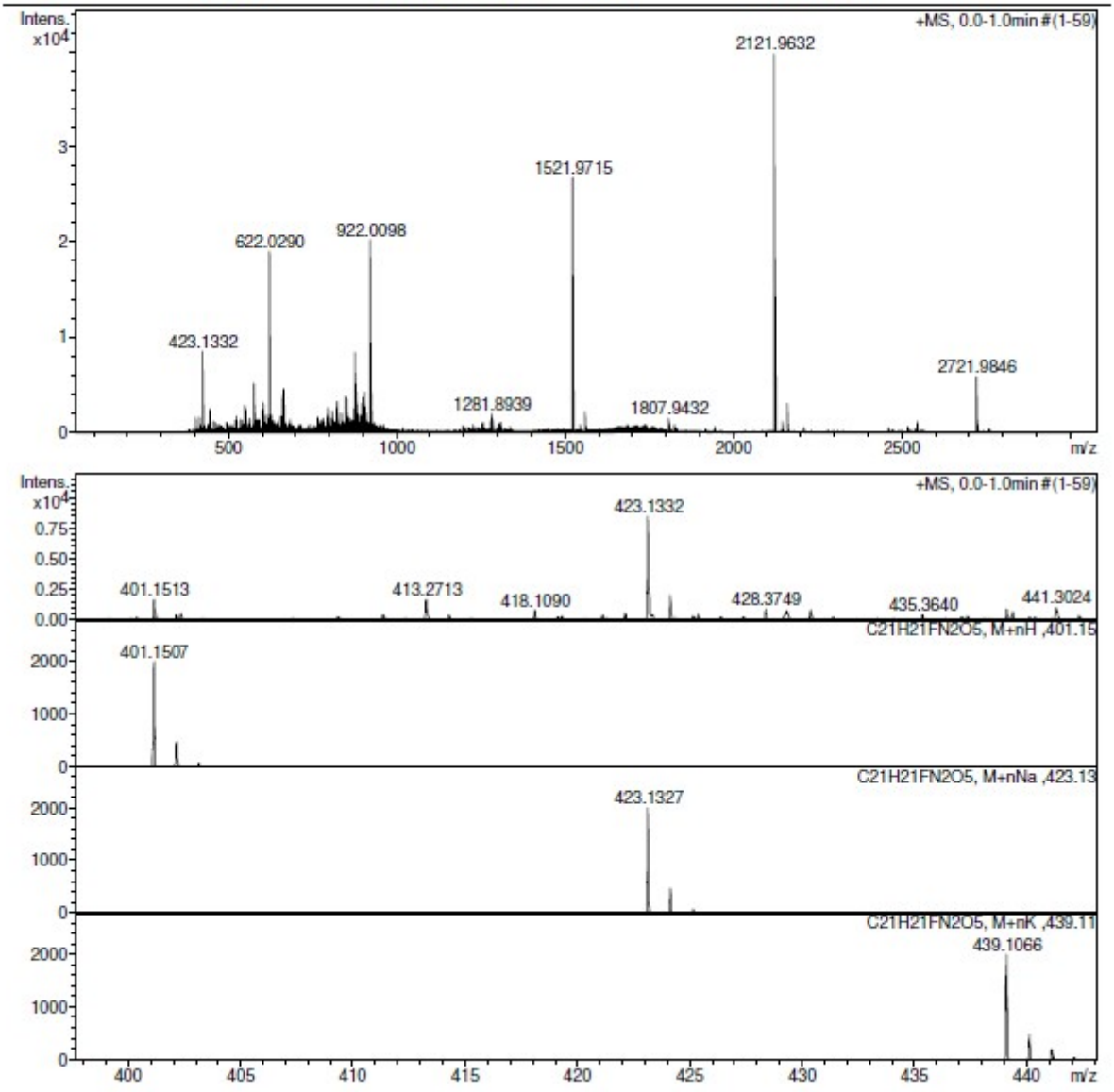
HRMS for compound **8c**



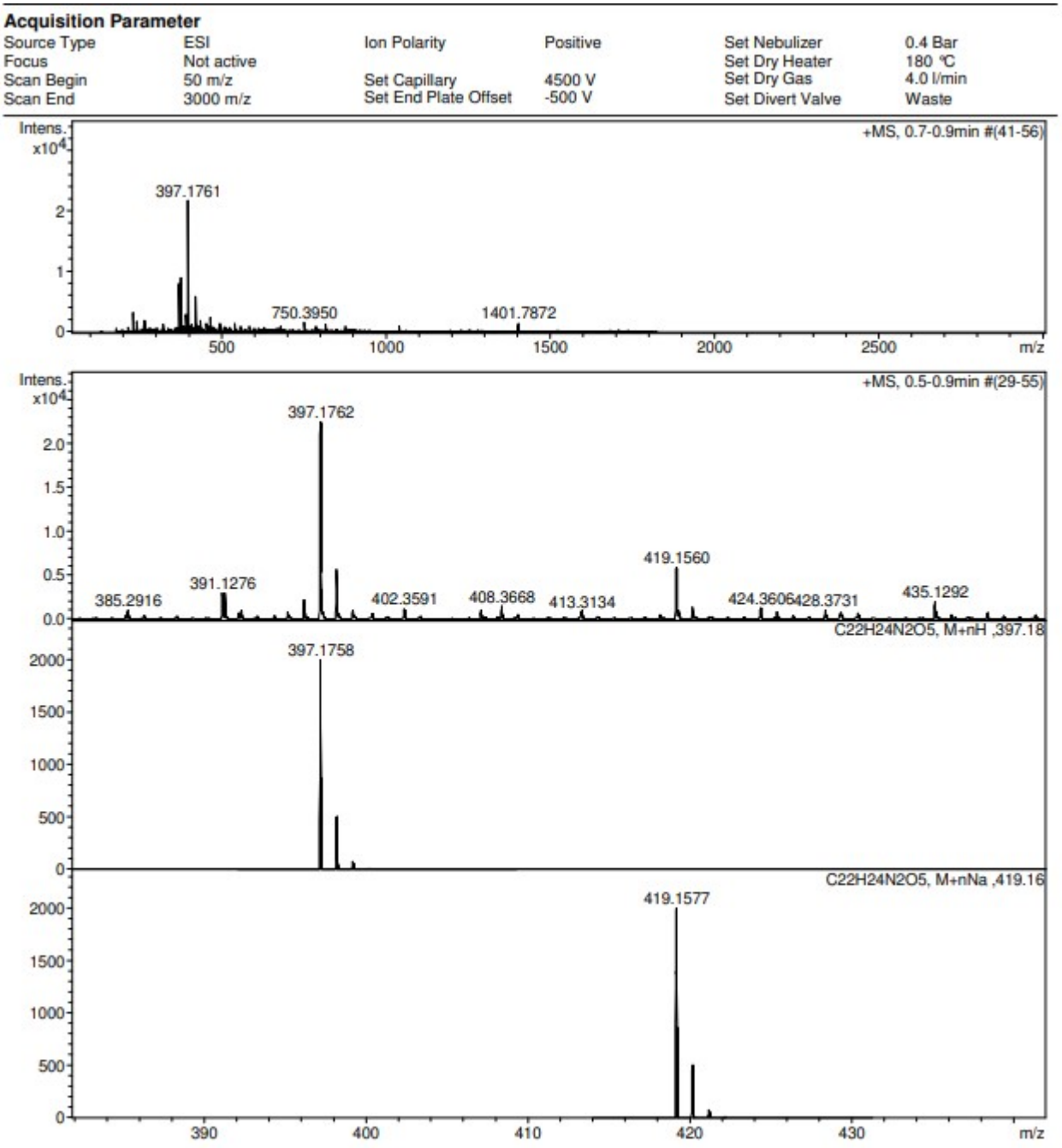
HRMS for compound **8d**

Acquisition Parameter

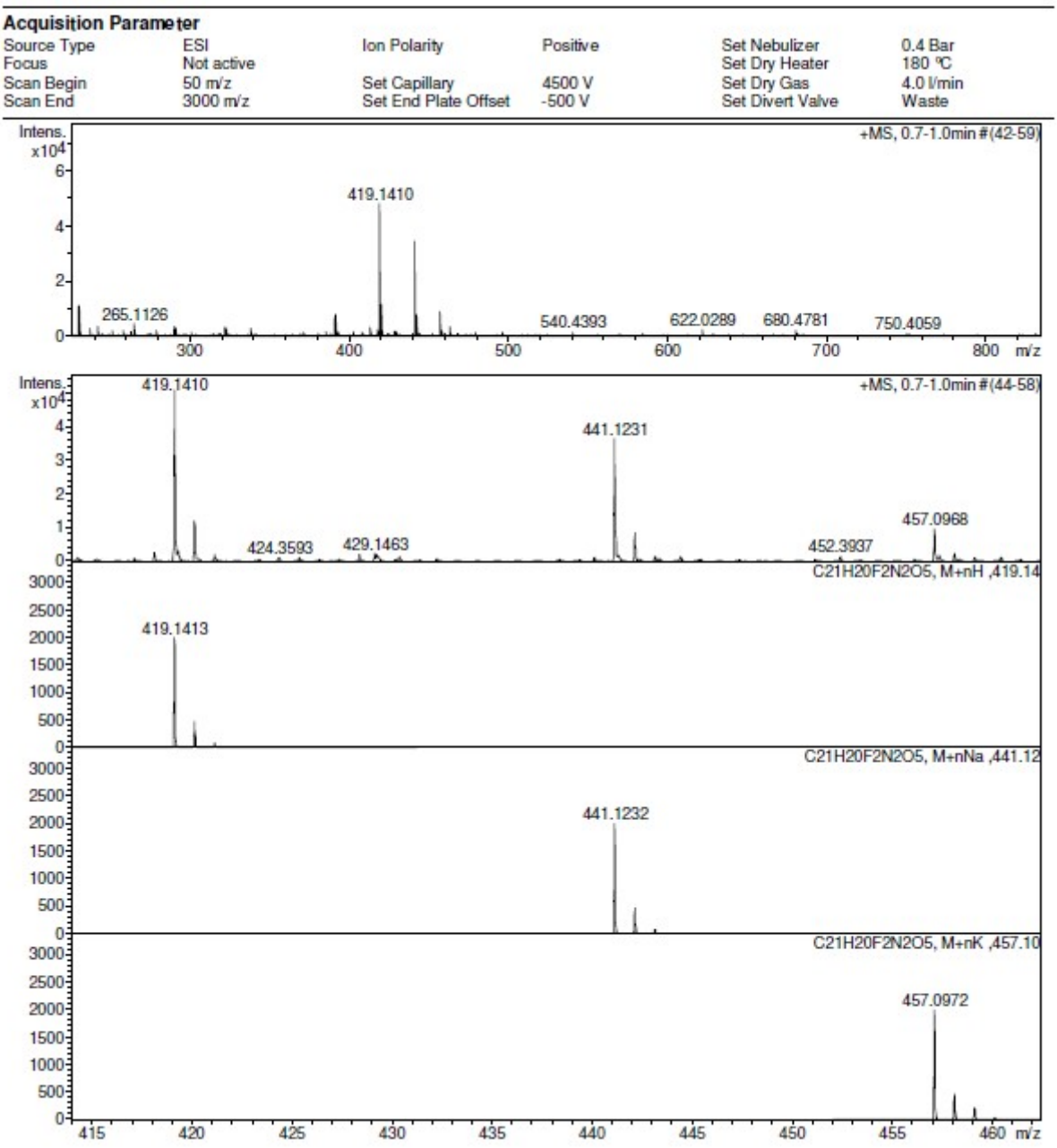
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	0.4 Bar
Focus	Not active			Set Dry Heater	180 °C
Scan Begin	50 m/z	Set Capillary	4500 V	Set Dry Gas	4.0 l/min
Scan End	3000 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Waste



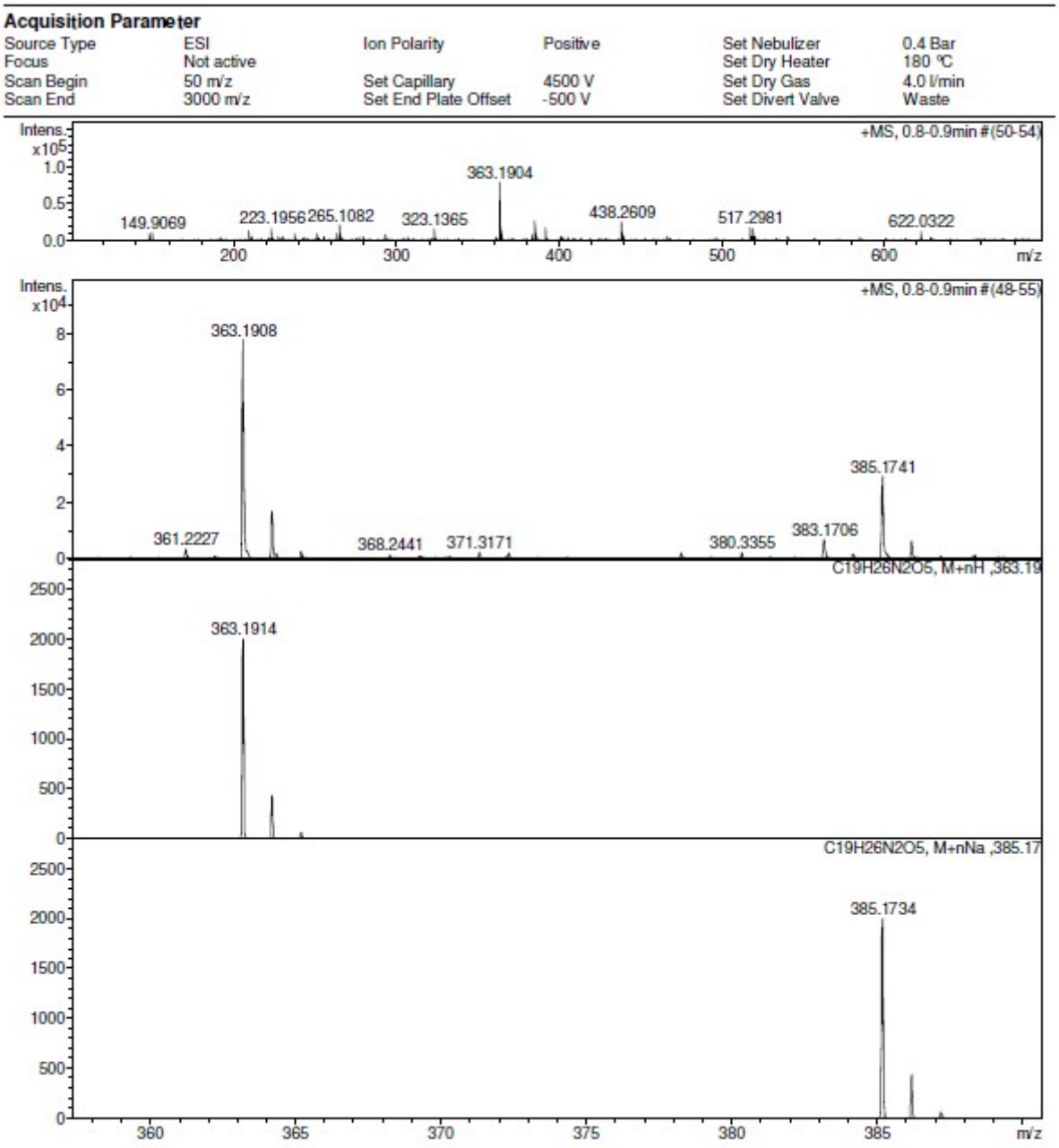
HRMS for compound **8e**



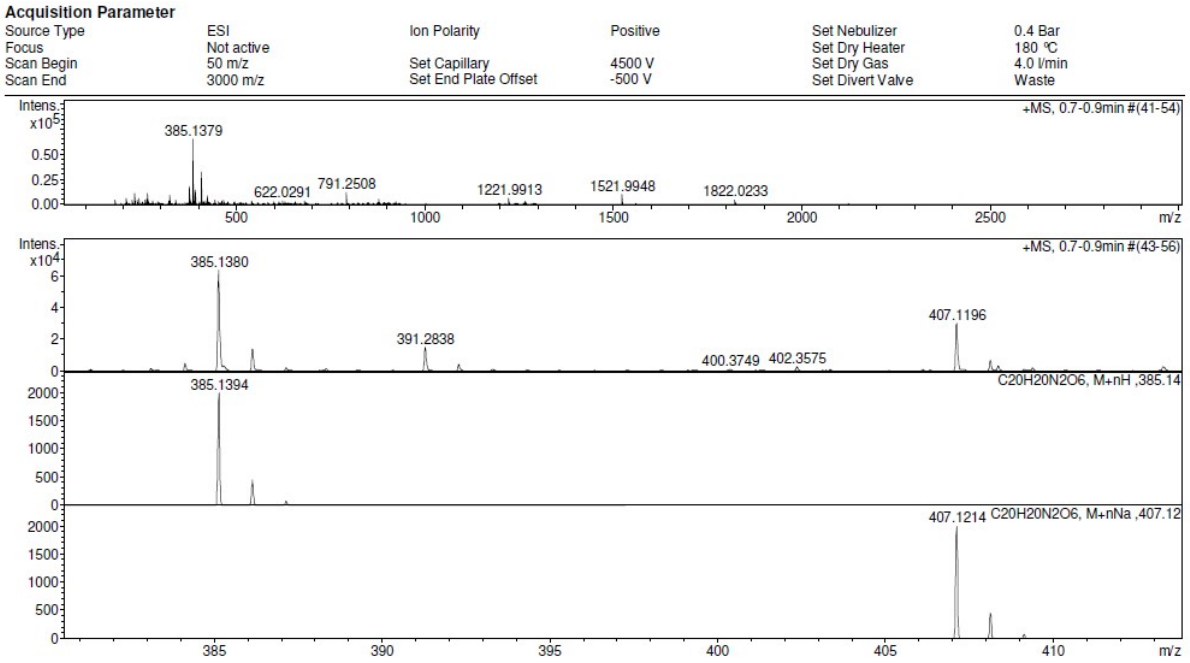
HRMS for compound **8f**



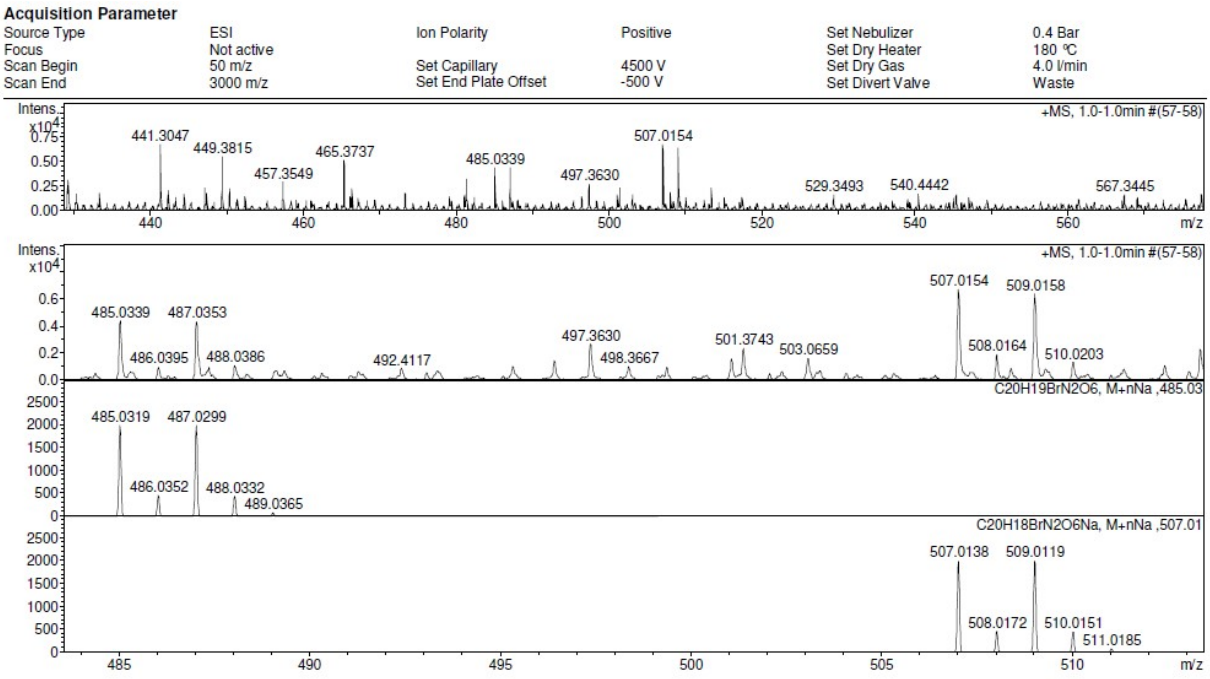
HRMS for compound **8g**



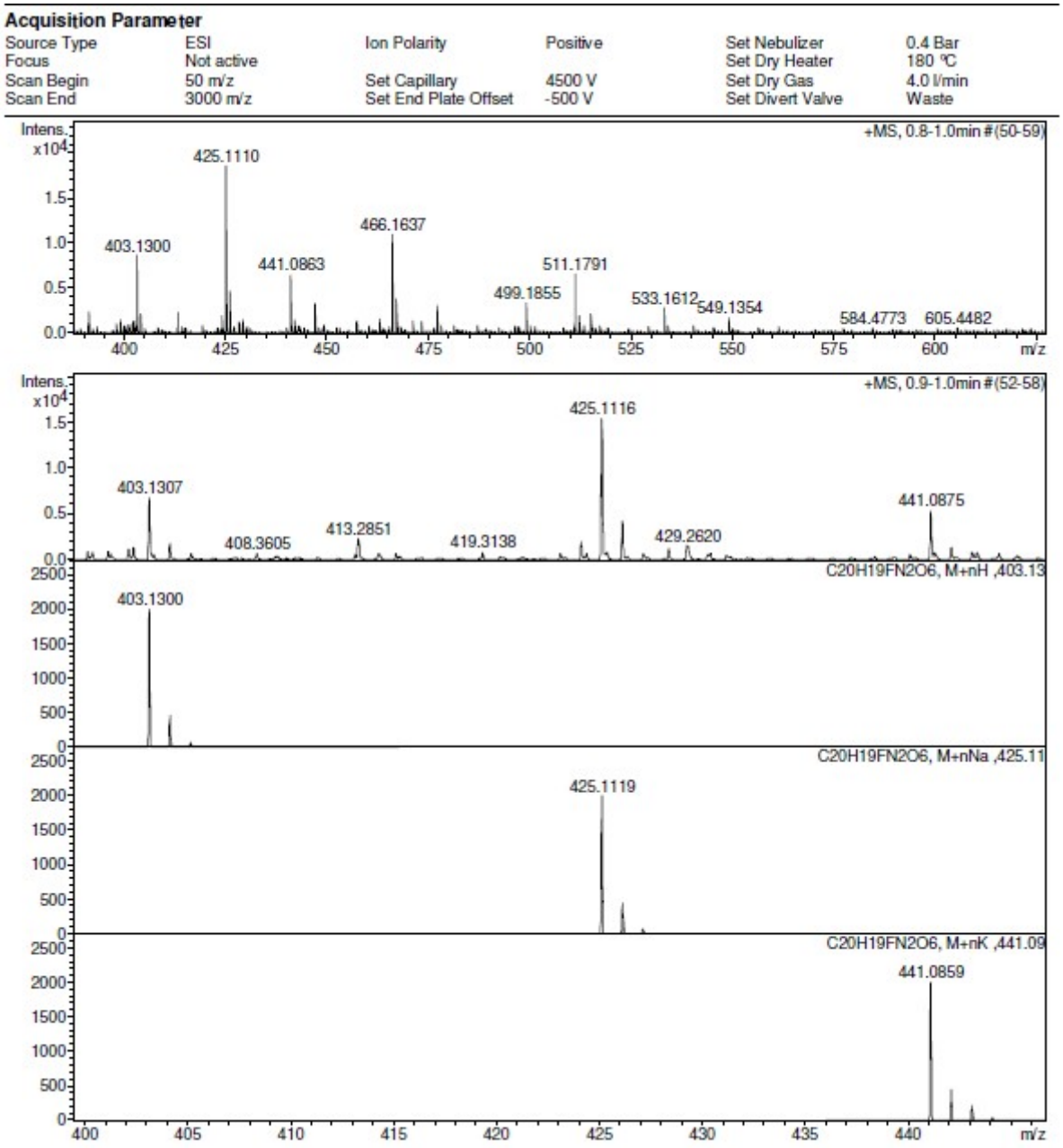
HRMS for compound **8h**



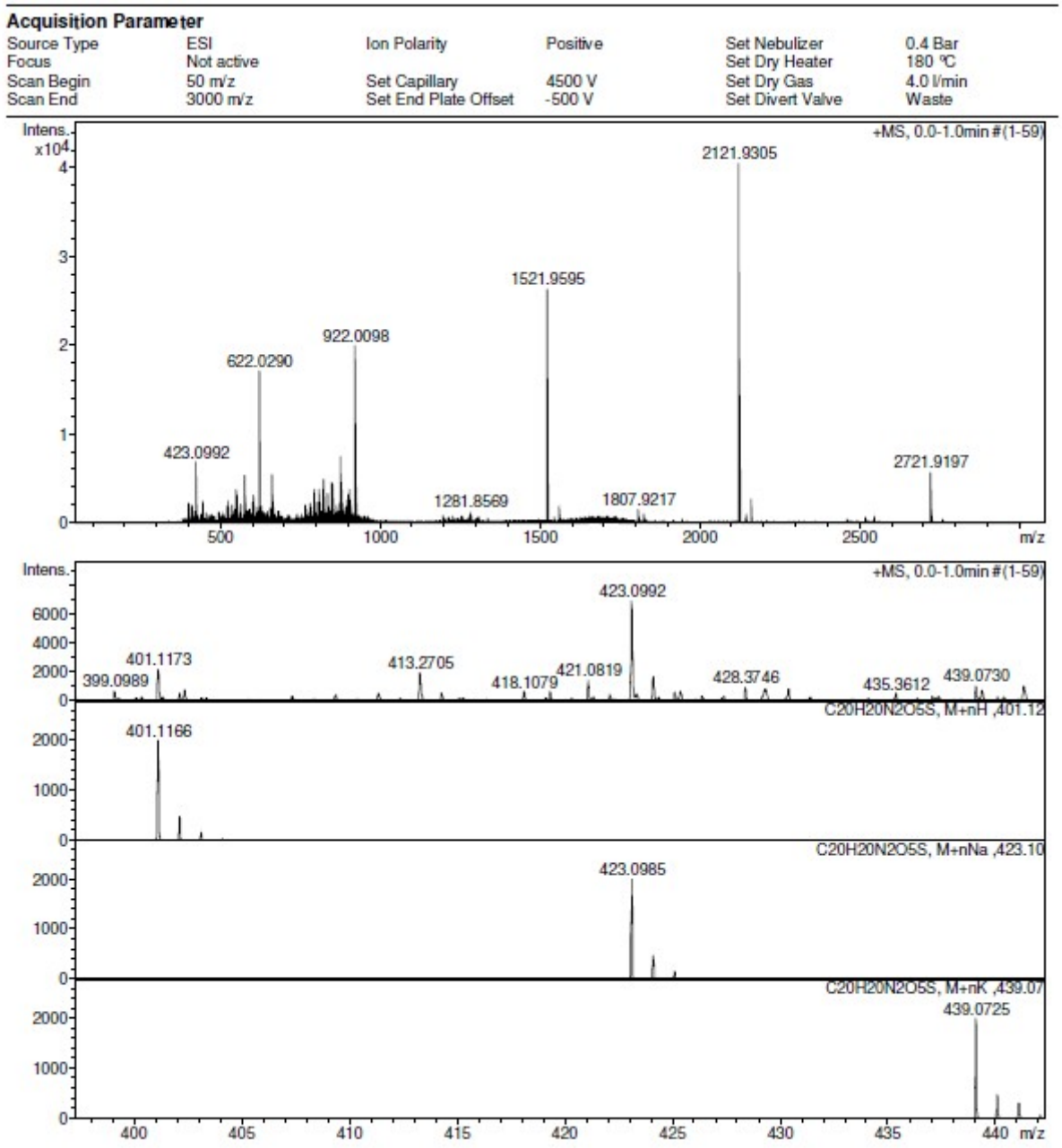
HRMS for compound **8i**



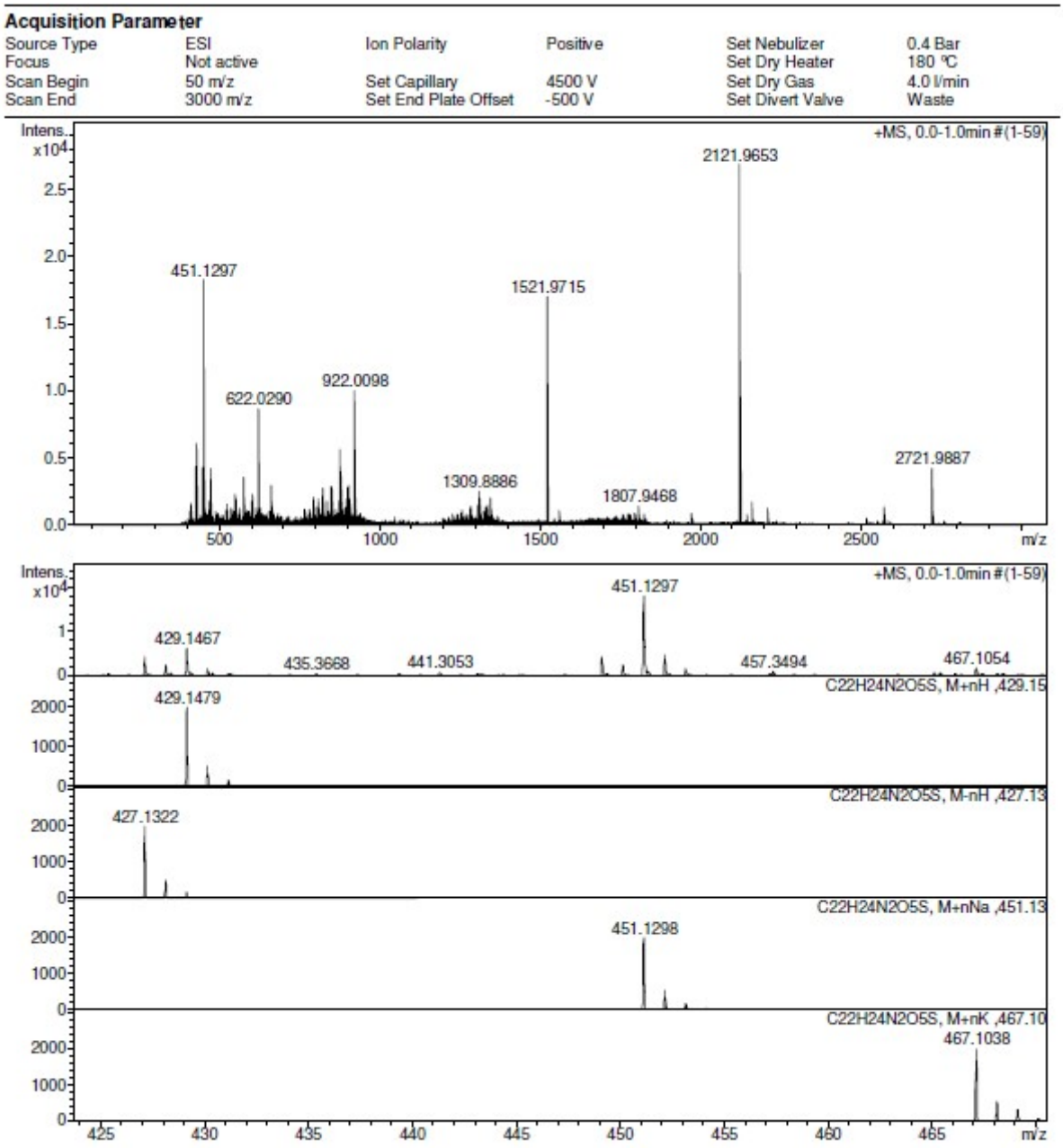
HRMS for compound **8j**



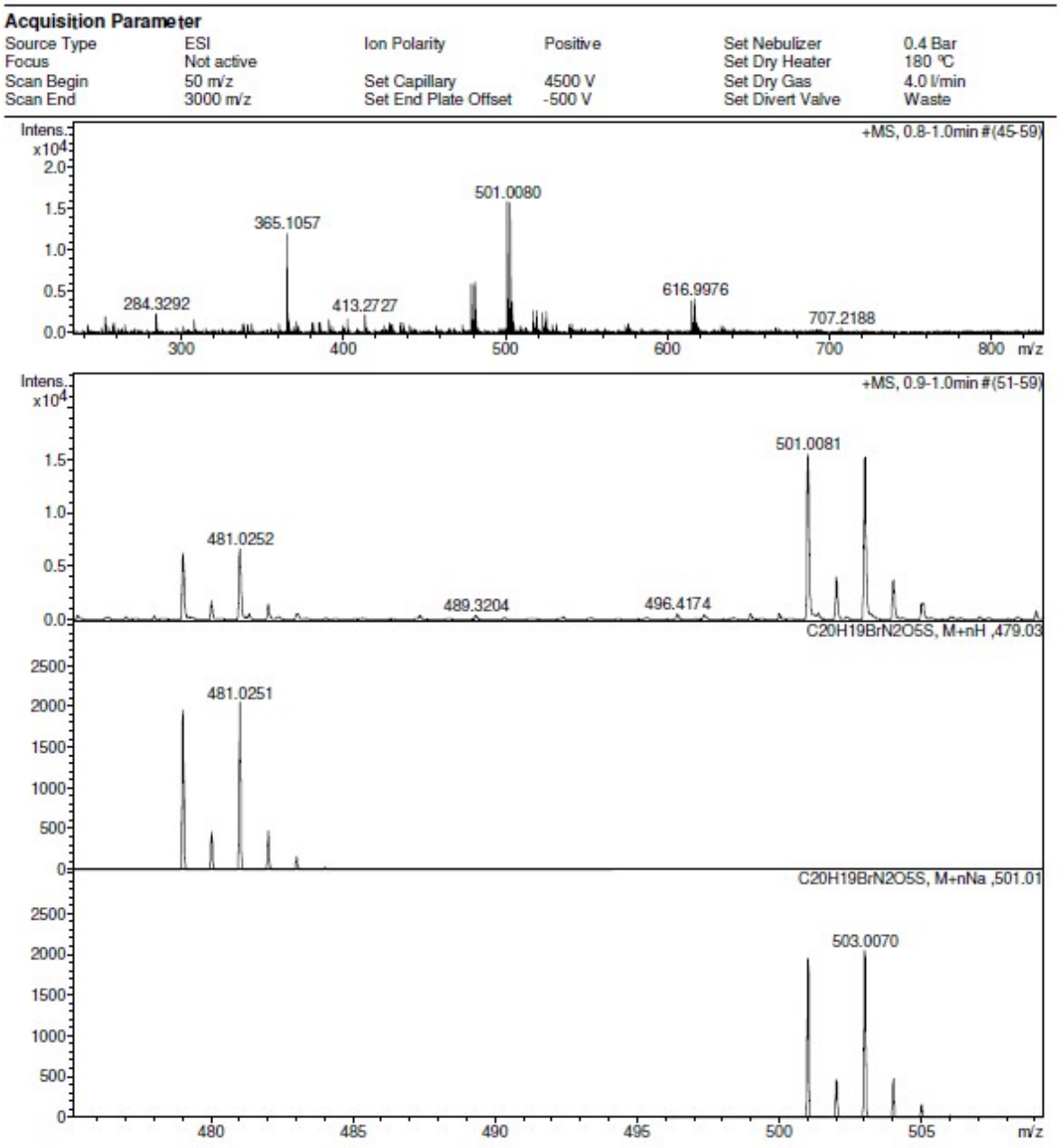
HRMS for compound **8k**



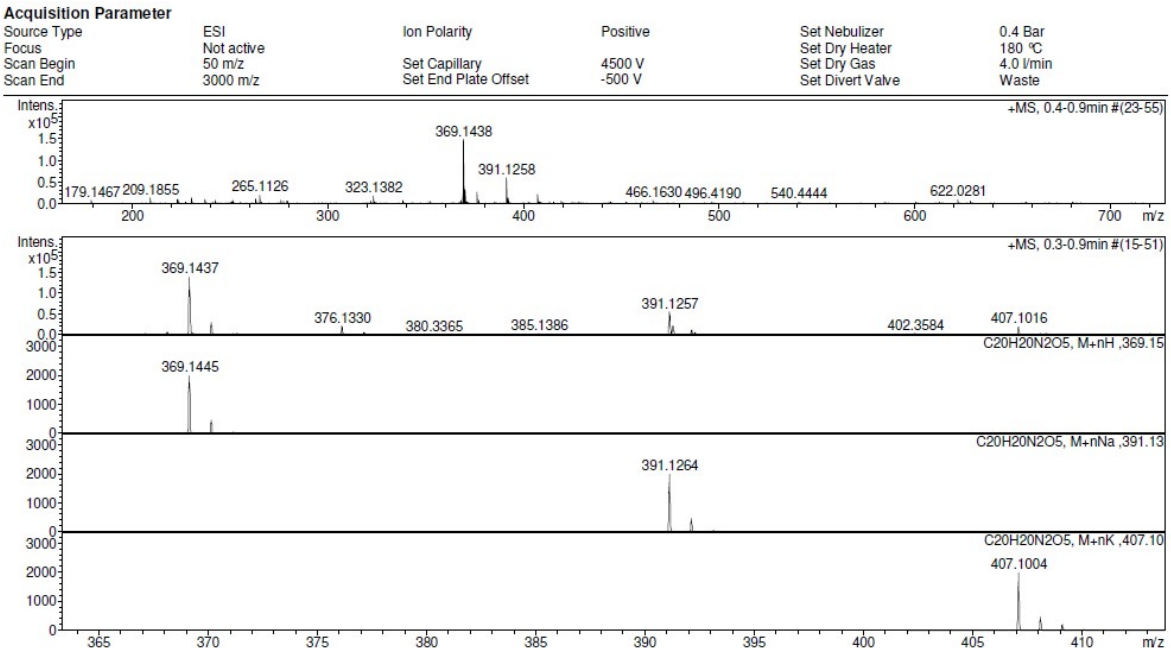
HRMS for compound **8l**



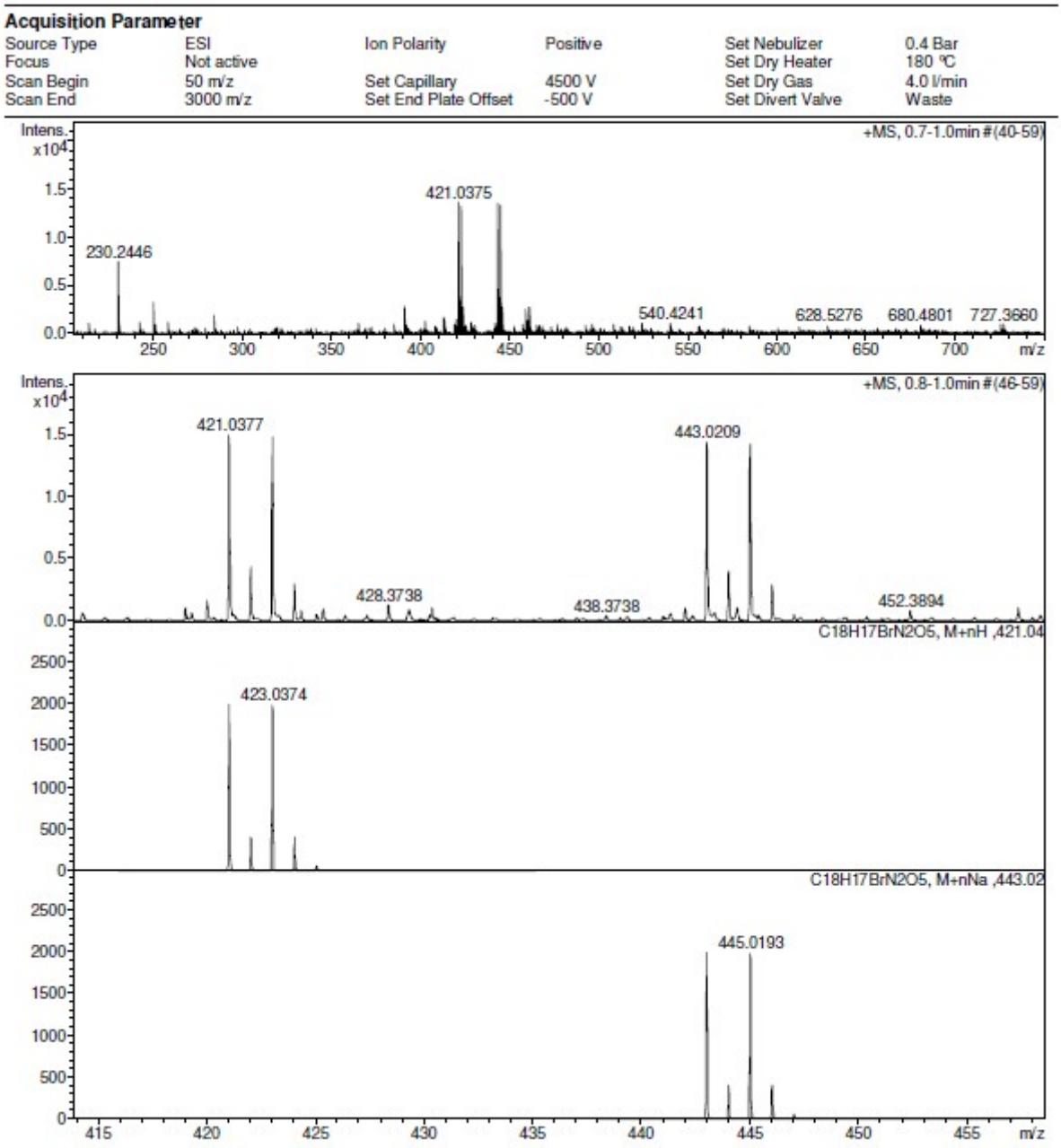
HRMS for compound **8m**



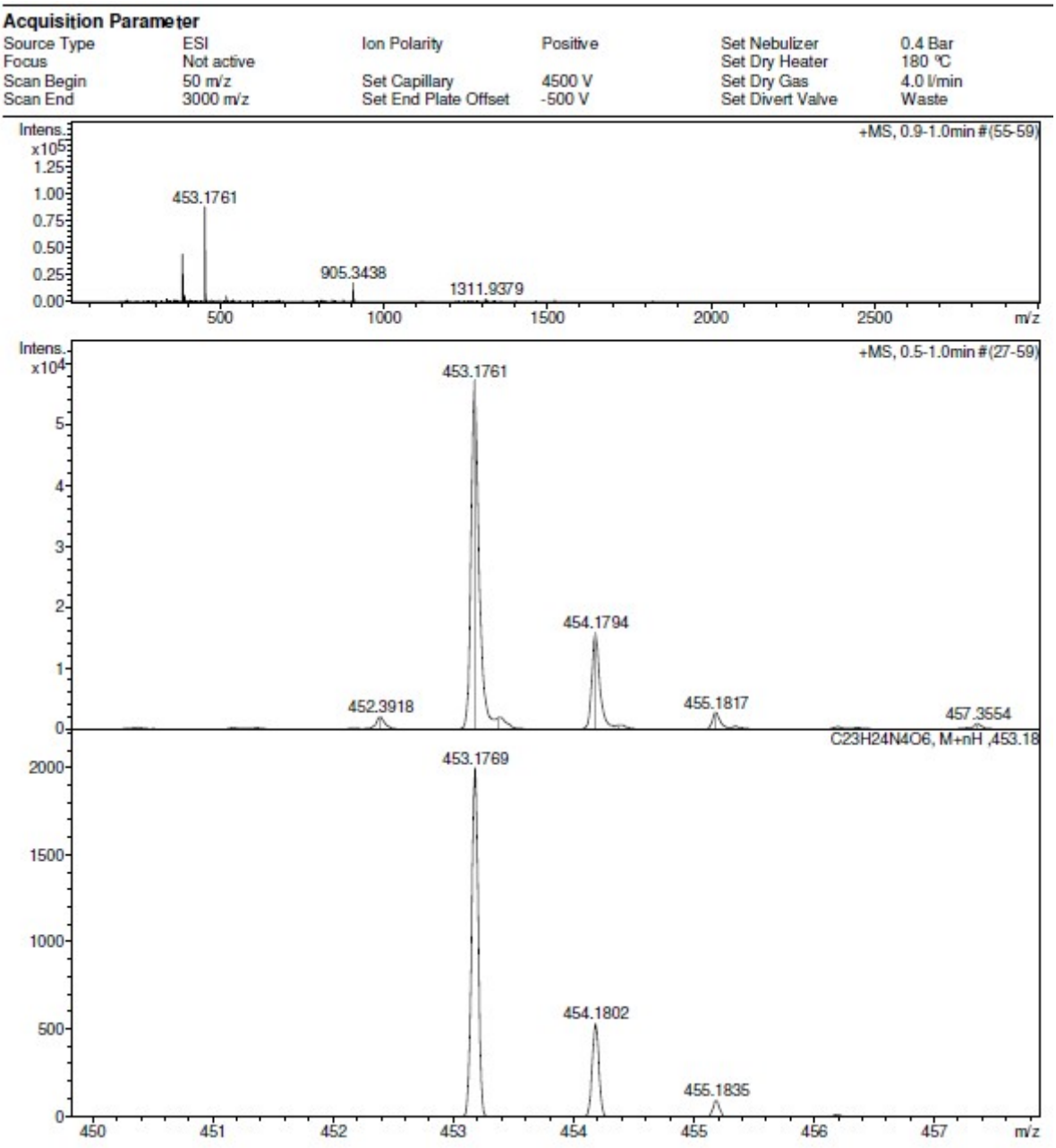
HRMS for compound **8n**



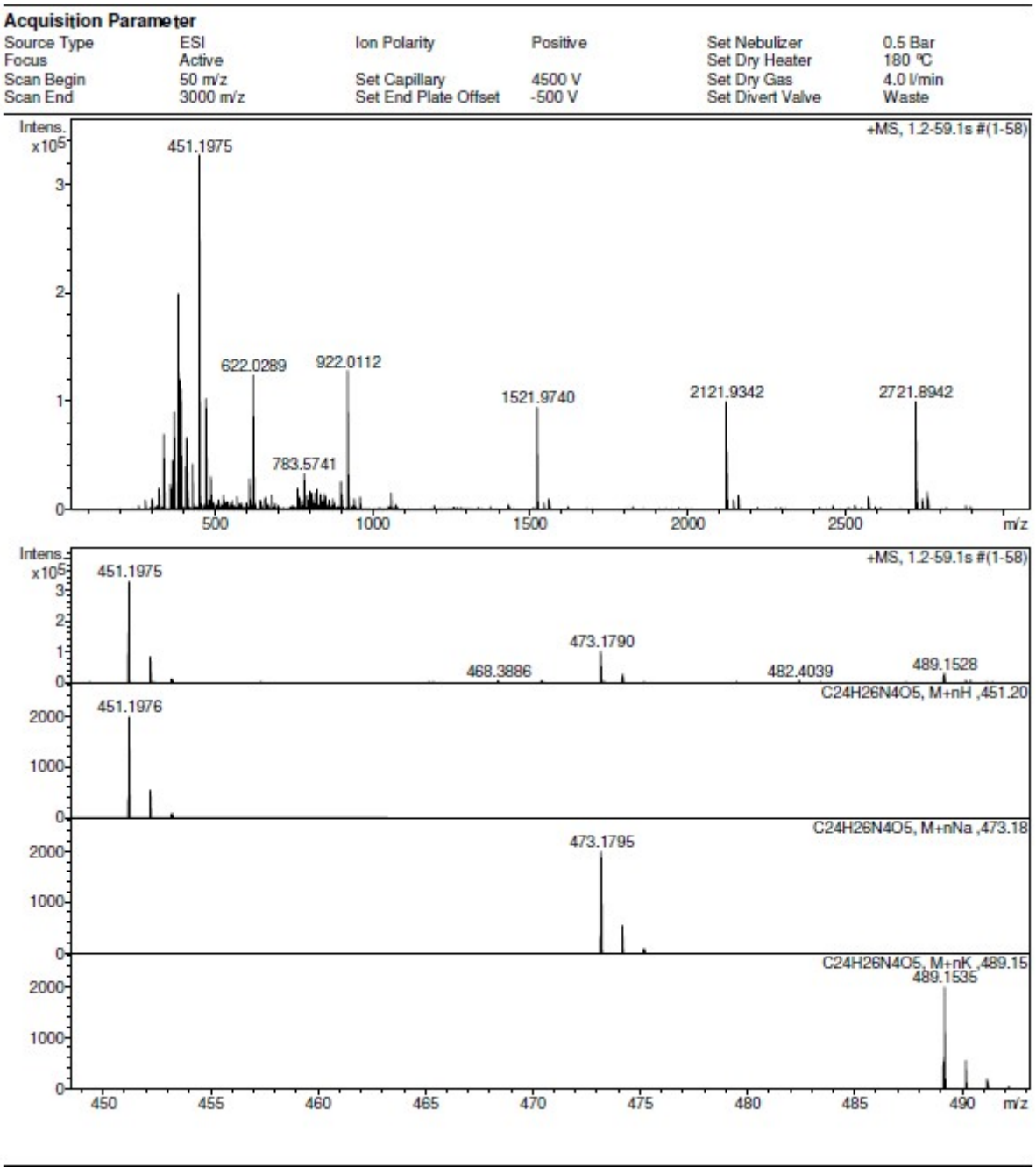
HRMS for compound **8o**



HRMS for compound **14a**



HRMS for compound **14b**

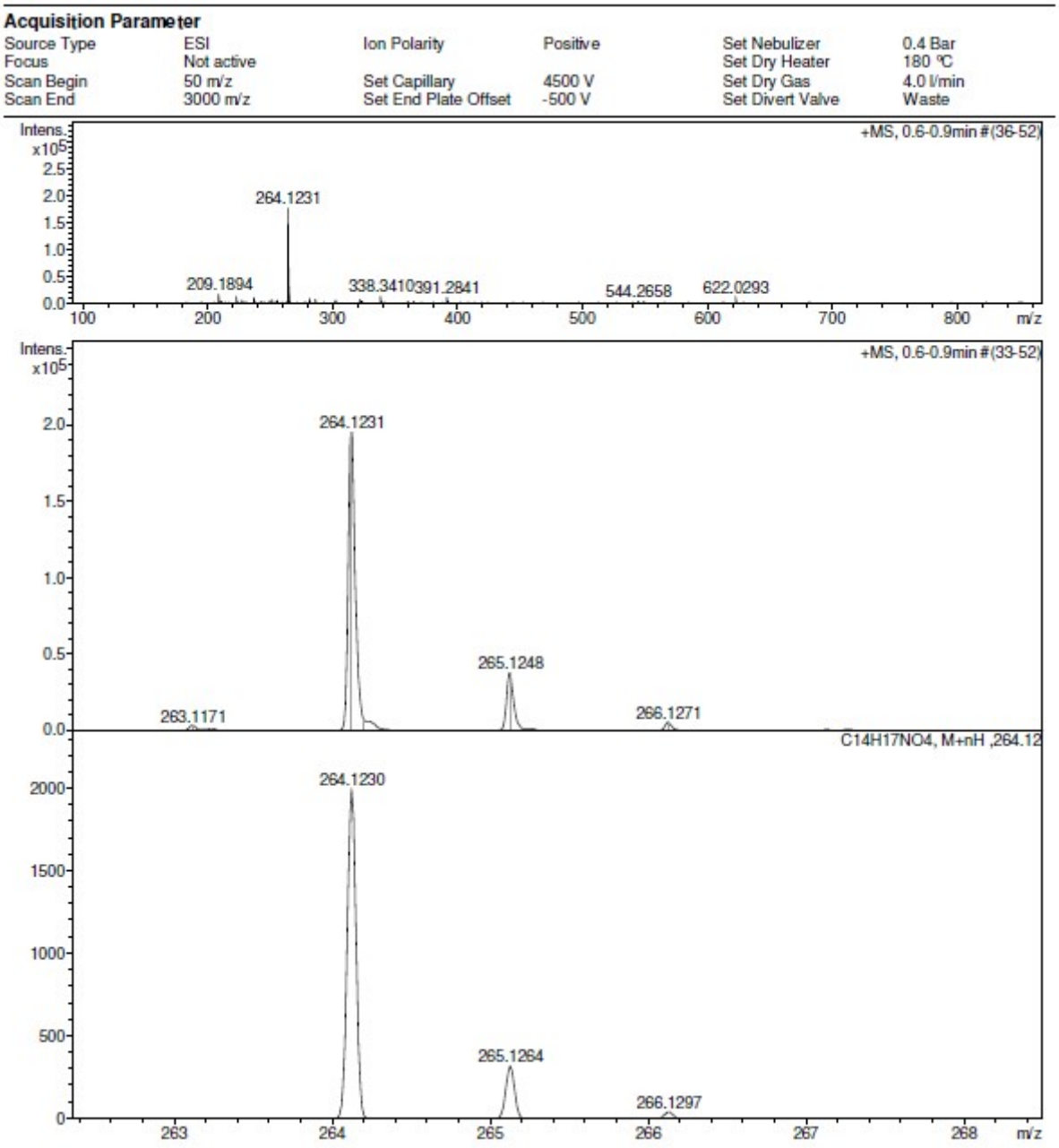


HRMS for compound **16a**

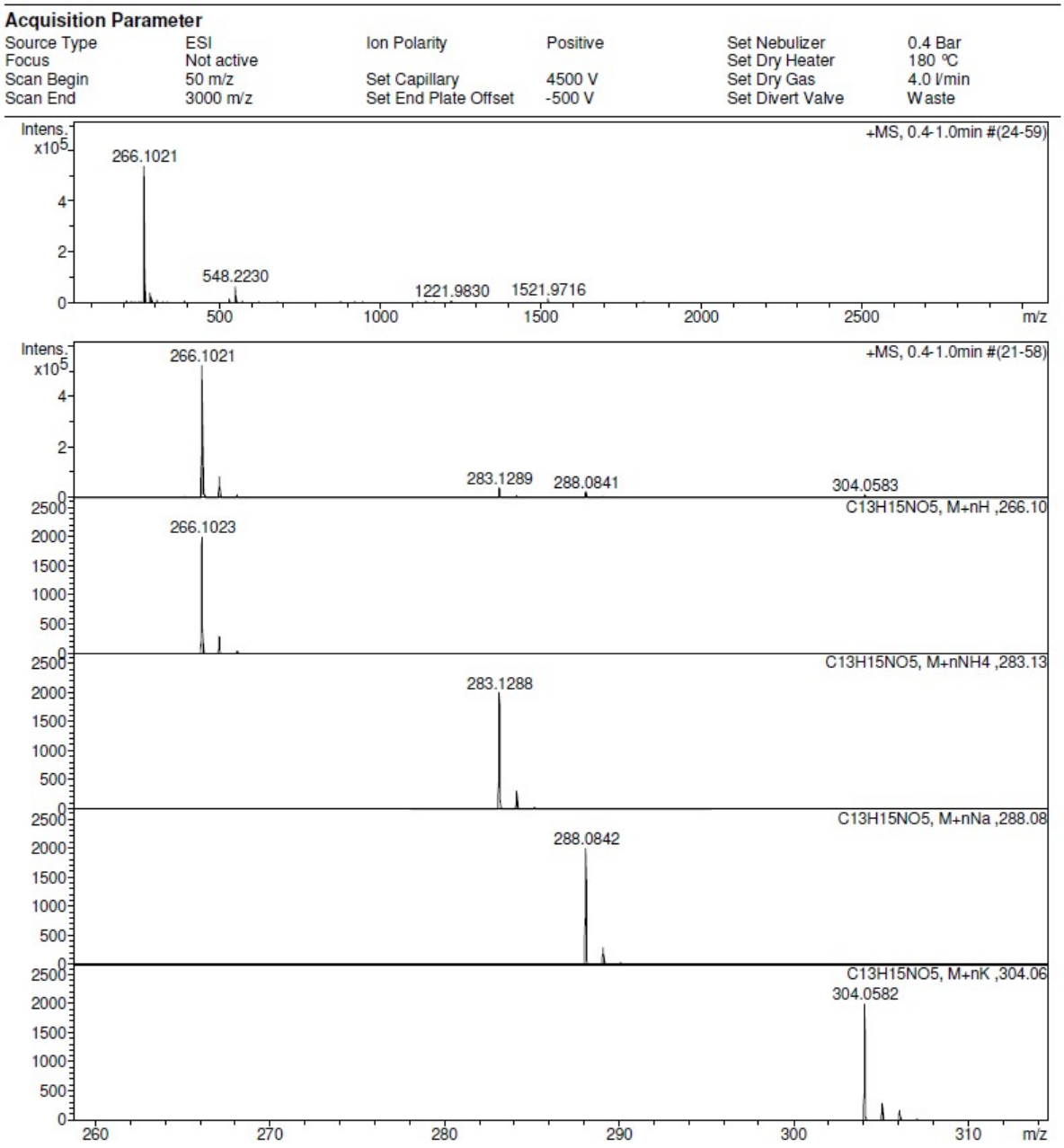
HRMS for compound **16b**

HRMS for compound **17**

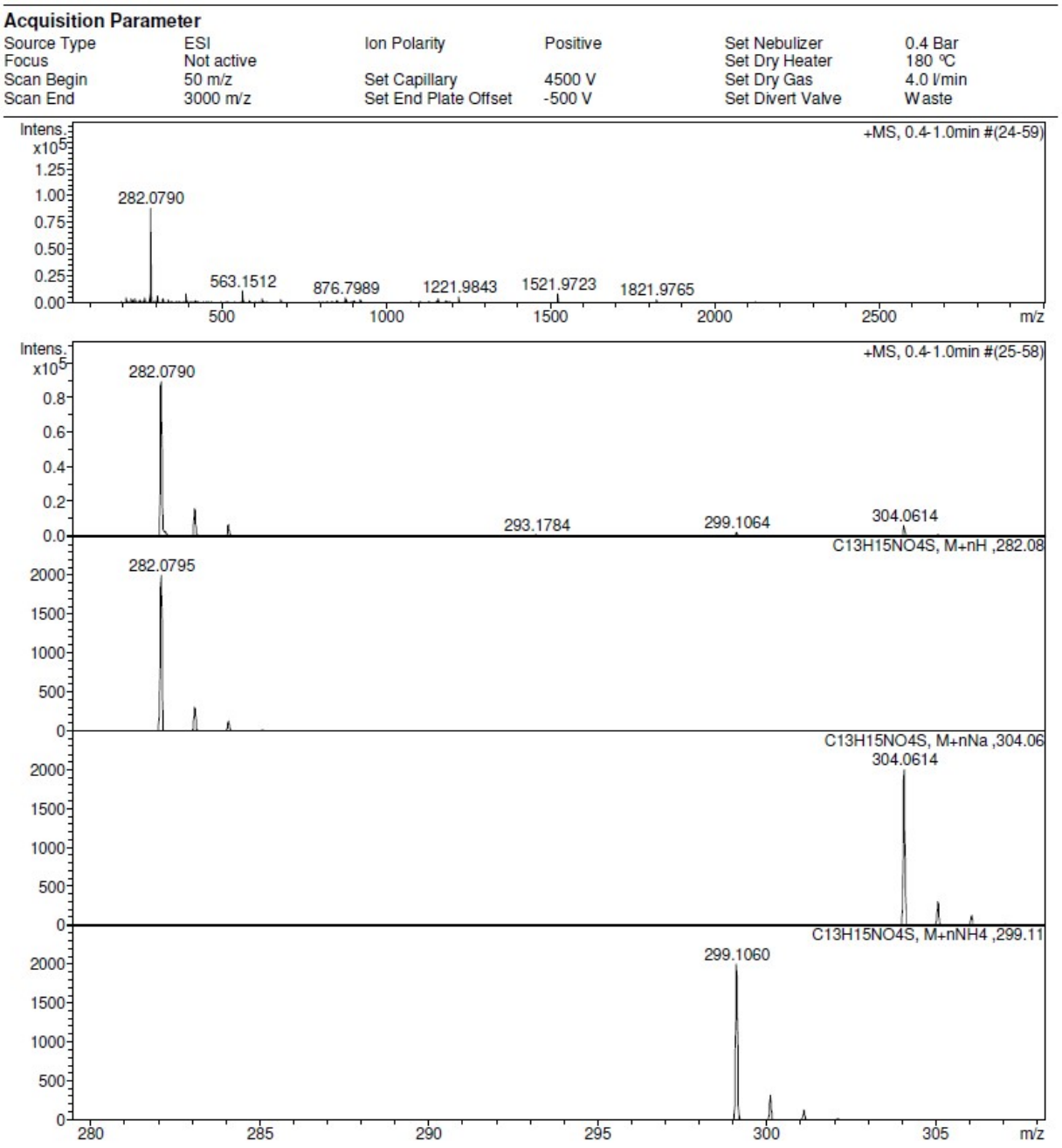
HRMS for compound **18a**



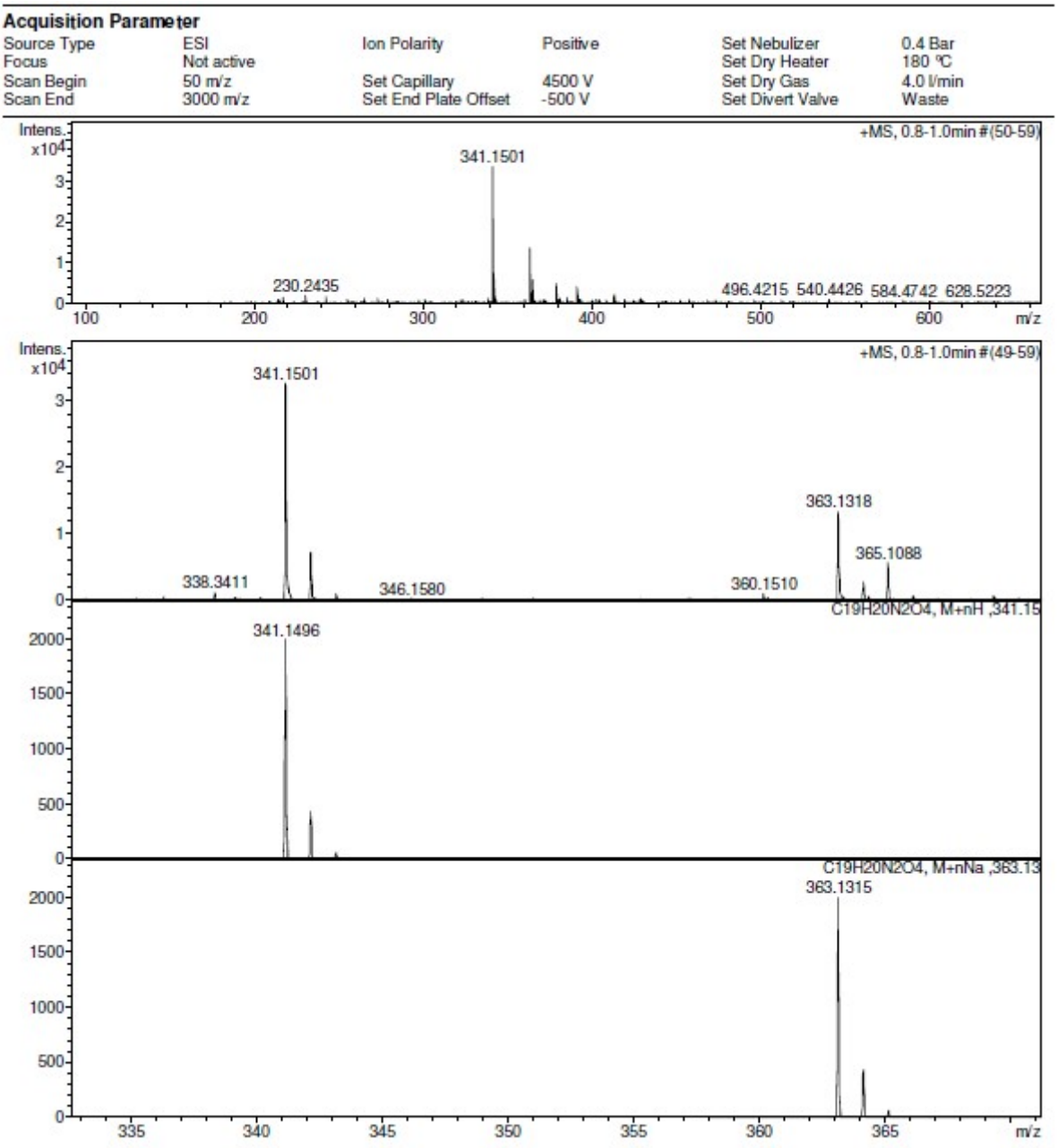
HRMS for compound **18b**



HRMS for compound **18c**



HRMS for compound **19**



8. X-ray crystallographic data and refinement details

8.1 Compound 7a

X-ray diffraction data were collected at 100K on a Bruker Quest D8 diffractometer equipped with a Photon-III area-detector (graphite monochromator, shutterless φ- and ω-scan technique), using Mo K_α-radiation. The intensity data were integrated by the SAINT program[2] and were corrected for absorption and decay using SADABS.[3] The structure was solved by direct methods using SHELXT[4] and refined on F^2 using SHELXL-2018.[5] All non-hydrogen atoms were refined with individual anisotropic displacement parameters. Locations of atoms H1, H2 and H3 were found from the electron density-difference map; these hydrogen atoms were refined with individual isotropic displacement parameters. All other hydrogen atoms were placed in ideal calculated positions and refined as riding atoms with relative isotropic displacement parameters. The SHELXTL program suite[1] was used for molecular graphics.

Table S1. Crystal data and structure refinement for **7a**

Identification code	**7a**	
Empirical formula	C20 H24 N2 O4	
Formula weight	356.41	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 9.1768(3) Å	a= 90°.
	b = 9.4700(3) Å	b= 90°.
	c = 21.5491(8) Å	g = 90°.
Volume	1872.71(11) $Å^3$	
Z	4	
Density (calculated)	1.264 g/cm^3	
Absorption coefficient	0.088 mm^{-1}	
F(000)	760	
Crystal size	0.867 x 0.80 x 0.302 mm^3	
Theta range for data collection	2.349 to 33.738°.	

Index ranges	-13<=h<=14, -14<=k<=14, -33<=l<=33
Reflections collected	54599
Independent reflections	7492 [R(int) = 0.0316]
Observed reflections	7058
Completeness to theta = 25.242°	99.9 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7467 and 0.6797
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	7492 / 0 / 248
Goodness-of-fit on F^2	1.062
Final R indices [I>2sigma(I)]	R1 = 0.0332, wR2 = 0.0860
R indices (all data)	R1 = 0.0367, wR2 = 0.0889
Absolute structure parameter	-0.11(15)
Largest diff. peak and hole	0.327 and -0.235 e.Å^{-3}
CCDC	2270304

Table S2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for **7a**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	4854(1)	3652(1)	3653(1)	14(1)
O(2)	5520(1)	35(1)	3228(1)	20(1)
O(3)	8085(1)	1319(1)	2906(1)	19(1)
O(4)	3096(1)	3175(1)	2513(1)	18(1)
N(1)	704(1)	2592(1)	2516(1)	16(1)
N(2)	353(1)	3677(1)	2092(1)	16(1)
C(1)	4645(1)	2234(1)	3575(1)	12(1)
C(2)	5723(1)	1436(1)	3318(1)	13(1)
C(3)	7080(1)	2075(1)	3127(1)	13(1)
C(4)	7186(1)	3573(1)	3199(1)	15(1)
C(5)	6079(1)	4303(1)	3462(1)	16(1)
C(6)	3137(1)	1731(1)	3763(1)	12(1)
C(7)	3220(1)	443(1)	4207(1)	16(1)
C(8)	3801(1)	821(2)	4850(1)	22(1)
C(9)	2889(1)	1982(2)	5153(1)	24(1)
C(10)	2828(1)	3280(1)	4735(1)	20(1)
C(11)	2251(1)	2901(1)	4088(1)	16(1)
C(12)	2323(1)	1251(1)	3170(1)	14(1)
C(13)	2086(1)	2425(1)	2706(1)	13(1)
C(14)	37(1)	3204(1)	1484(1)	16(1)
C(15)	675(1)	3851(1)	971(1)	21(1)
C(16)	266(2)	3452(2)	373(1)	25(1)
C(17)	-788(2)	2416(1)	282(1)	26(1)
C(18)	-1422(2)	1776(1)	793(1)	29(1)
C(19)	-1016(2)	2154(1)	1393(1)	24(1)
C(20)	6039(2)	5849(1)	3585(1)	30(1)

Table S3. Bond lengths [Å] and angles [°] for **7a**.

O(1)-C(5)	1.3462(13)	C(12)-H(12A)	0.9900
O(1)-C(1)	1.3665(12)	C(12)-H(12B)	0.9900
O(2)-C(2)	1.3531(13)	C(14)-C(15)	1.3927(16)
O(2)-H(3)	0.84(2)	C(14)-C(19)	1.4010(16)
O(3)-C(3)	1.2613(13)	C(15)-C(16)	1.3933(18)
O(4)-C(13)	1.2397(13)	C(15)-H(15)	0.9500
N(1)-C(13)	1.3420(13)	C(16)-C(17)	1.391(2)
N(1)-N(2)	1.4115(13)	C(16)-H(16)	0.9500
N(1)-H(1)	0.88(2)	C(17)-C(18)	1.386(2)
N(2)-C(14)	1.4163(15)	C(17)-H(17)	0.9500
N(2)-H(2)	0.87(2)	C(18)-C(19)	1.3912(18)
C(1)-C(2)	1.3630(14)	C(18)-H(18)	0.9500
C(1)-C(6)	1.5191(14)	C(19)-H(19)	0.9500
C(2)-C(3)	1.4447(14)	C(20)-H(20A)	0.9800
C(3)-C(4)	1.4301(15)	C(20)-H(20B)	0.9800
C(4)-C(5)	1.3533(15)	C(20)-H(20C)	0.9800
C(4)-H(4)	0.9500	C(5)-O(1)-C(1)	121.95(9)
C(5)-C(20)	1.4888(17)	C(2)-O(2)-H(3)	111.8(13)
C(6)-C(11)	1.5428(15)	C(13)-N(1)-N(2)	119.94(9)
C(6)-C(12)	1.5487(15)	C(13)-N(1)-H(1)	122.8(15)
C(6)-C(7)	1.5516(15)	N(2)-N(1)-H(1)	116.7(15)
C(7)-C(8)	1.5274(17)	N(1)-N(2)-C(14)	114.54(9)
C(7)-H(7A)	0.9900	N(1)-N(2)-H(2)	109.7(13)
C(7)-H(7B)	0.9900	C(14)-N(2)-H(2)	111.8(13)
C(8)-C(9)	1.5282(19)	C(2)-C(1)-O(1)	119.58(9)
C(8)-H(8A)	0.9900	C(2)-C(1)-C(6)	126.54(9)
C(8)-H(8B)	0.9900	O(1)-C(1)-C(6)	113.79(8)
C(9)-C(10)	1.5251(18)	O(2)-C(2)-C(1)	120.15(9)
C(9)-H(9A)	0.9900	O(2)-C(2)-C(3)	119.26(9)
C(9)-H(9B)	0.9900	C(1)-C(2)-C(3)	120.58(9)
C(10)-C(11)	1.5341(16)	O(3)-C(3)-C(4)	123.68(10)
C(10)-H(10A)	0.9900	O(3)-C(3)-C(2)	120.00(10)
C(10)-H(10B)	0.9900	C(4)-C(3)-C(2)	116.31(9)
C(11)-H(11A)	0.9900	C(5)-C(4)-C(3)	120.08(9)
C(11)-H(11B)	0.9900	C(5)-C(4)-H(4)	120.0
C(12)-C(13)	1.5108(15)	C(3)-C(4)-H(4)	120.0

O(1)-C(5)-C(4)	121.41(10)	C(10)-C(11)-H(11B)	108.9
O(1)-C(5)-C(20)	112.06(10)	C(6)-C(11)-H(11B)	108.9
C(4)-C(5)-C(20)	126.53(10)	H(11A)-C(11)-H(11B)	107.7
C(1)-C(6)-C(11)	112.06(8)	C(13)-C(12)-C(6)	113.56(9)
C(1)-C(6)-C(12)	108.15(8)	C(13)-C(12)-H(12A)	108.9
C(11)-C(6)-C(12)	109.37(8)	C(6)-C(12)-H(12A)	108.9
C(1)-C(6)-C(7)	111.47(8)	C(13)-C(12)-H(12B)	108.9
C(11)-C(6)-C(7)	108.11(8)	C(6)-C(12)-H(12B)	108.9
C(12)-C(6)-C(7)	107.58(8)	H(12A)-C(12)-H(12B)	107.7
C(8)-C(7)-C(6)	113.10(9)	O(4)-C(13)-N(1)	122.47(10)
C(8)-C(7)-H(7A)	109.0	O(4)-C(13)-C(12)	122.39(9)
C(6)-C(7)-H(7A)	109.0	N(1)-C(13)-C(12)	115.14(9)
C(8)-C(7)-H(7B)	109.0	C(15)-C(14)-C(19)	119.43(11)
C(6)-C(7)-H(7B)	109.0	C(15)-C(14)-N(2)	120.69(10)
H(7A)-C(7)-H(7B)	107.8	C(19)-C(14)-N(2)	119.67(10)
C(7)-C(8)-C(9)	111.42(10)	C(14)-C(15)-C(16)	120.08(12)
C(7)-C(8)-H(8A)	109.3	C(14)-C(15)-H(15)	120.0
C(9)-C(8)-H(8A)	109.3	C(16)-C(15)-H(15)	120.0
C(7)-C(8)-H(8B)	109.3	C(17)-C(16)-C(15)	120.57(12)
C(9)-C(8)-H(8B)	109.3	C(17)-C(16)-H(16)	119.7
H(8A)-C(8)-H(8B)	108.0	C(15)-C(16)-H(16)	119.7
C(10)-C(9)-C(8)	110.35(9)	C(18)-C(17)-C(16)	119.23(12)
C(10)-C(9)-H(9A)	109.6	C(18)-C(17)-H(17)	120.4
C(8)-C(9)-H(9A)	109.6	C(16)-C(17)-H(17)	120.4
C(10)-C(9)-H(9B)	109.6	C(17)-C(18)-C(19)	120.86(13)
C(8)-C(9)-H(9B)	109.6	C(17)-C(18)-H(18)	119.6
H(9A)-C(9)-H(9B)	108.1	C(19)-C(18)-H(18)	119.6
C(9)-C(10)-C(11)	111.14(10)	C(18)-C(19)-C(14)	119.82(12)
C(9)-C(10)-H(10A)	109.4	C(18)-C(19)-H(19)	120.1
C(11)-C(10)-H(10A)	109.4	C(14)-C(19)-H(19)	120.1
C(9)-C(10)-H(10B)	109.4	C(5)-C(20)-H(20A)	109.5
C(11)-C(10)-H(10B)	109.4	C(5)-C(20)-H(20B)	109.5
H(10A)-C(10)-H(10B)	108.0	H(20A)-C(20)-H(20B)	109.5
C(10)-C(11)-C(6)	113.51(9)	C(5)-C(20)-H(20C)	109.5
C(10)-C(11)-H(11A)	108.9	H(20A)-C(20)-H(20C)	109.5
C(6)-C(11)-H(11A)	108.9	H(20B)-C(20)-H(20C)	109.5

Table S4. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for **7a**. The anisotropic displacement factor exponent takes the form: $-2p^2[\ h^2\ a^{*2}U^{11} + ...\ + 2\ h\ k\ a^*\ b^*\ U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	15(1)	10(1)	17(1)	-1(1)	4(1)	-2(1)
O(2)	16(1)	11(1)	34(1)	-5(1)	11(1)	-1(1)
O(3)	11(1)	17(1)	30(1)	3(1)	6(1)	2(1)
O(4)	11(1)	22(1)	21(1)	6(1)	0(1)	-4(1)
N(1)	10(1)	19(1)	19(1)	5(1)	-1(1)	-2(1)
N(2)	14(1)	14(1)	20(1)	3(1)	-3(1)	-2(1)
C(1)	10(1)	11(1)	14(1)	0(1)	1(1)	-1(1)
C(2)	10(1)	11(1)	18(1)	0(1)	2(1)	-1(1)
C(3)	10(1)	14(1)	16(1)	2(1)	1(1)	0(1)
C(4)	13(1)	15(1)	17(1)	2(1)	2(1)	-3(1)
C(5)	18(1)	13(1)	16(1)	1(1)	4(1)	-4(1)
C(6)	10(1)	12(1)	15(1)	1(1)	1(1)	0(1)
C(7)	14(1)	16(1)	19(1)	5(1)	2(1)	0(1)
C(8)	20(1)	28(1)	18(1)	6(1)	-1(1)	3(1)
C(9)	23(1)	32(1)	16(1)	2(1)	4(1)	1(1)
C(10)	18(1)	23(1)	17(1)	-3(1)	4(1)	1(1)
C(11)	12(1)	17(1)	18(1)	0(1)	3(1)	3(1)
C(12)	12(1)	14(1)	16(1)	2(1)	-1(1)	-3(1)
C(13)	11(1)	15(1)	14(1)	0(1)	0(1)	0(1)
C(14)	14(1)	13(1)	20(1)	2(1)	-2(1)	1(1)
C(15)	16(1)	22(1)	23(1)	2(1)	3(1)	-1(1)
C(16)	27(1)	26(1)	20(1)	3(1)	4(1)	3(1)
C(17)	40(1)	19(1)	21(1)	-2(1)	-4(1)	3(1)
C(18)	42(1)	18(1)	25(1)	2(1)	-10(1)	-8(1)
C(19)	31(1)	18(1)	22(1)	4(1)	-6(1)	-9(1)
C(20)	38(1)	13(1)	38(1)	-4(1)	18(1)	-7(1)

Table S5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **7a**.

	x	y	z	U(eq)
H(3)	6180(20)	-320(20)	3003(9)	26(5)
H(1)	-30(30)	2130(20)	2684(11)	45(6)
H(2)	1030(20)	4310(20)	2095(9)	25(4)
H(4)	8034	4056	3062	18
H(7A)	2235	29	4251	19
H(7B)	3860	-284	4020	19
H(8A)	4823	1143	4814	26
H(8B)	3787	-31	5116	26
H(9A)	1889	1629	5228	28
H(9B)	3322	2241	5558	28
H(10A)	3816	3690	4697	24
H(10B)	2186	4000	4926	24
H(11A)	2265	3759	3826	19
H(11B)	1225	2589	4126	19
H(12A)	2889	488	2968	17
H(12B)	1365	856	3290	17
H(15)	1390	4564	1028	25
H(16)	711	3891	25	30
H(17)	-1069	2152	-126	32
H(18)	-2144	1069	734	34
H(19)	-1452	1701	1740	28
H(20A)	6991	6263	3488	45
H(20B)	5810	6014	4023	45
H(20C)	5290	6289	3325	45

Table S6. Torsion angles [°] for **7a**.

C(13)-N(1)-N(2)-C(14)	107.03(12)	C(12)-C(6)-C(7)-C(8)	-171.63(9)
C(5)-O(1)-C(1)-C(2)	2.40(15)	C(6)-C(7)-C(8)-C(9)	56.52(13)
C(5)-O(1)-C(1)-C(6)	-174.27(9)	C(7)-C(8)-C(9)-C(10)	-56.12(14)
O(1)-C(1)-C(2)-O(2)	-178.84(10)	C(8)-C(9)-C(10)-C(11)	55.68(13)
C(6)-C(1)-C(2)-O(2)	-2.64(16)	C(9)-C(10)-C(11)-C(6)	-56.31(12)
O(1)-C(1)-C(2)-C(3)	0.03(15)	C(1)-C(6)-C(11)-C(10)	-69.65(11)
C(6)-C(1)-C(2)-C(3)	176.23(10)	C(12)-C(6)-C(11)-C(10)	170.44(9)
O(2)-C(2)-C(3)-O(3)	-3.19(16)	C(7)-C(6)-C(11)-C(10)	53.58(11)
C(1)-C(2)-C(3)-O(3)	177.93(10)	C(1)-C(6)-C(12)-C(13)	-62.63(11)
O(2)-C(2)-C(3)-C(4)	176.17(10)	C(11)-C(6)-C(12)-C(13)	59.65(11)
C(1)-C(2)-C(3)-C(4)	-2.71(15)	C(7)-C(6)-C(12)-C(13)	176.84(8)
O(3)-C(3)-C(4)-C(5)	-177.49(11)	N(2)-N(1)-C(13)-O(4)	-1.65(17)
C(2)-C(3)-C(4)-C(5)	3.17(15)	N(2)-N(1)-C(13)-C(12)	178.71(9)
C(1)-O(1)-C(5)-C(4)	-1.94(16)	C(6)-C(12)-C(13)-O(4)	53.05(14)
C(1)-O(1)-C(5)-C(20)	178.75(11)	C(6)-C(12)-C(13)-N(1)	-127.31(10)
C(3)-C(4)-C(5)-O(1)	-0.97(17)	N(1)-N(2)-C(14)-C(15)	-132.17(11)
C(3)-C(4)-C(5)-C(20)	178.23(13)	N(1)-N(2)-C(14)-C(19)	53.11(14)
C(2)-C(1)-C(6)-C(11)	175.39(10)	C(19)-C(14)-C(15)-C(16)	-0.03(18)
O(1)-C(1)-C(6)-C(11)	-8.21(12)	N(2)-C(14)-C(15)-C(16)	-174.76(11)
C(2)-C(1)-C(6)-C(12)	-63.99(13)	C(14)-C(15)-C(16)-C(17)	0.51(19)
O(1)-C(1)-C(6)-C(12)	112.40(10)	C(15)-C(16)-C(17)-C(18)	-0.4(2)
C(2)-C(1)-C(6)-C(7)	54.07(14)	C(16)-C(17)-C(18)-C(19)	-0.1(2)
O(1)-C(1)-C(6)-C(7)	-129.53(9)	C(17)-C(18)-C(19)-C(14)	0.6(2)
C(1)-C(6)-C(7)-C(8)	69.97(11)	C(15)-C(14)-C(19)-C(18)	-0.5(2)
C(11)-C(6)-C(7)-C(8)	-53.62(11)	N(2)-C(14)-C(19)-C(18)	174.27(12)

Table S7. Hydrogen bonds for **7a** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1)...O(3)#1	0.88(2)	1.95(2)	2.8168(12)	167(2)
N(2)-H(2)...O(3)#2	0.87(2)	2.07(2)	2.8834(13)	157.0(17)

Symmetry transformations used to generate equivalent atoms:
#1 x-1,y,z #2 -x+1,y+1/2,-z+1/2

8.2 Compound 8a

X-ray diffraction data were collected at 100K on a four-circle Rigaku Synergy S diffractometer equipped with a HyPix6000HE area-detector (kappa geometry, shutterless ω-scan technique), using graphite monochromatized Cu K_α-radiation. The intensity data were integrated and corrected for absorption and decay by the CrysAlisPro program.[6] The structure was solved by direct methods using SHELXT[4] and refined on F^2 using SHELXL-2018[5] in the OLEX2 program.[7] All non-hydrogen atoms were refined with individual anisotropic displacement parameters. Locations of amino and hydroxy hydrogen atoms (H2 and H4) were found from the electron density-difference map; these hydrogen atoms were refined with individual isotropic displacement parameters. All other hydrogen atoms were placed in ideal calculated positions and refined as riding atoms with relative isotropic displacement parameters.

Table S8. Crystal data and structure refinement for **8a**.

Identification code	**8a**	
Empirical formula	C21 H22 N2 O5	
Formula weight	382.40	
Temperature	99.99(10) K	
Wavelength	1.54184 Å	
Crystal system	Monoclinic	
Space group	$P2_1/c$	
Unit cell dimensions	a = 11.69260(10) Å	a= 90°.
	b = 11.74390(10) Å	b= 97.3170(10)°.
	c = 13.59140(10) Å	g = 90°.
Volume	1851.13(3) $Å^3$	
Z	4	
Density (calculated)	1.372 Mg/m^3	
Absorption coefficient	0.814 mm^{-1}	
F(000)	808	
Crystal size	0.5 x 0.3 x 0.2 mm^3	
Theta range for data collection	3.811 to 77.762°.	
Index ranges	-13<=h<=14, -14<=k<=14, -17<=l<=17	
Reflections collected	22156	
Independent reflections	3929 [R(int) = 0.0539]	
Completeness to theta = 67.684°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	1.00000 and 0.78483	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3929 / 0 / 262	
Goodness-of-fit on F^2	1.031	
Final R indices [I>2sigma(I)]	R1 = 0.0390, wR2 = 0.1034	
R indices (all data)	R1 = 0.0406, wR2 = 0.1050	
Largest diff. peak and hole	0.266 and -0.206 $e.Å^{-3}$	
CCDC	2270314	

Table S9. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$ x 10^3) for **8a**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	9267(1)	6382(1)	4555(1)	23(1)
O(2)	5296(1)	3371(1)	3835(1)	20(1)
O(3)	3590(1)	2530(1)	3409(1)	24(1)
O(4)	5765(1)	5195(1)	1834(1)	22(1)
O(5)	2732(1)	3087(1)	1358(1)	29(1)
N(1)	7694(1)	5391(1)	3813(1)	18(1)
N(2)	7689(1)	5896(1)	2873(1)	18(1)
C(1)	8500(1)	5709(1)	4618(1)	19(1)
C(2)	8199(1)	5065(1)	5499(1)	23(1)
C(3)	7280(1)	4177(1)	5099(1)	19(1)
C(4)	6887(1)	4602(1)	4044(1)	17(1)
C(5)	7832(1)	2991(1)	5004(1)	22(1)
C(6)	8260(1)	2467(1)	6014(1)	29(1)
C(7)	7305(1)	2445(1)	6683(1)	31(1)
C(8)	6798(1)	3627(1)	6798(1)	25(1)
C(9)	6325(1)	4112(1)	5779(1)	20(1)
C(10)	5959(1)	4208(1)	3442(1)	18(1)
C(11)	4323(1)	3155(1)	3165(1)	19(1)
C(12)	4411(1)	3808(1)	2272(1)	19(1)
C(13)	5401(1)	4460(1)	2449(1)	18(1)
C(14)	3540(1)	3757(1)	1395(1)	21(1)
C(15)	3654(1)	4533(1)	537(1)	30(1)
C(16)	8690(1)	5650(1)	2384(1)	19(1)
C(17)	9387(1)	4709(1)	2616(1)	21(1)
C(18)	10301(1)	4498(1)	2073(1)	25(1)
C(19)	10510(1)	5215(1)	1310(1)	28(1)
C(20)	9803(1)	6155(1)	1079(1)	28(1)
C(21)	8893(1)	6376(1)	1614(1)	23(1)

Table S10. Bond lengths [Å] and angles [°] for **8a**.

O(1)-C(1)	1.2069(15)	C(12)-C(13)	1.3833(16)
O(2)-C(10)	1.4001(14)	C(12)-C(14)	1.4670(15)
O(2)-C(11)	1.3869(13)	C(14)-C(15)	1.4988(17)
O(3)-C(11)	1.2067(15)	C(15)-H(15A)	0.9800
O(4)-H(4)	0.97(2)	C(15)-H(15B)	0.9800
O(4)-C(13)	1.3095(14)	C(15)-H(15C)	0.9800
O(5)-C(14)	1.2257(15)	C(16)-C(17)	1.3862(17)
N(1)-N(2)	1.4081(13)	C(16)-C(21)	1.3934(17)
N(1)-C(1)	1.4003(14)	C(17)-H(17)	0.9500
N(1)-C(4)	1.3865(15)	C(17)-C(18)	1.3957(18)
N(2)-H(2)	0.888(19)	C(18)-H(18)	0.9500
N(2)-C(16)	1.4467(15)	C(18)-C(19)	1.382(2)
C(1)-C(2)	1.4969(16)	C(19)-H(19)	0.9500
C(2)-H(2B)	0.9900	C(19)-C(20)	1.390(2)
C(2)-H(2C)	0.9900	C(20)-H(20)	0.9500
C(2)-C(3)	1.5447(16)	C(20)-C(21)	1.3881(18)
C(3)-C(4)	1.5324(15)	C(21)-H(21)	0.9500
C(3)-C(5)	1.5476(16)	C(11)-O(2)-C(10)	109.00(9)
C(3)-C(9)	1.5396(16)	C(13)-O(4)-H(4)	108.4(12)
C(4)-C(10)	1.3545(16)	C(1)-N(1)-N(2)	121.37(9)
C(5)-H(5A)	0.9900	C(4)-N(1)-N(2)	124.27(9)
C(5)-H(5B)	0.9900	C(4)-N(1)-C(1)	114.27(9)
C(5)-C(6)	1.5289(16)	N(1)-N(2)-H(2)	108.1(11)
C(6)-H(6A)	0.9900	N(1)-N(2)-C(16)	115.03(9)
C(6)-H(6B)	0.9900	C(16)-N(2)-H(2)	111.8(11)
C(6)-C(7)	1.5276(18)	O(1)-C(1)-N(1)	123.54(11)
C(7)-H(7A)	0.9900	O(1)-C(1)-C(2)	129.80(10)
C(7)-H(7B)	0.9900	N(1)-C(1)-C(2)	106.66(9)
C(7)-C(8)	1.5247(19)	C(1)-C(2)-H(2B)	110.4
C(8)-H(8A)	0.9900	C(1)-C(2)-H(2C)	110.4
C(8)-H(8B)	0.9900	C(1)-C(2)-C(3)	106.44(9)
C(8)-C(9)	1.5343(16)	H(2B)-C(2)-H(2C)	108.6
C(9)-H(9A)	0.9900	C(3)-C(2)-H(2B)	110.4
C(9)-H(9B)	0.9900	C(3)-C(2)-H(2C)	110.4
C(10)-C(13)	1.4528(15)	C(2)-C(3)-C(5)	110.98(9)
C(11)-C(12)	1.4500(16)	C(4)-C(3)-C(2)	102.83(9)

C(4)-C(3)-C(5)	107.09(9)	C(4)-C(10)-O(2)	116.67(10)
C(4)-C(3)-C(9)	115.04(9)	C(4)-C(10)-C(13)	136.27(11)
C(9)-C(3)-C(2)	110.32(9)	O(2)-C(11)-C(12)	108.27(9)
C(9)-C(3)-C(5)	110.34(9)	O(3)-C(11)-O(2)	118.86(10)
N(1)-C(4)-C(3)	107.32(9)	O(3)-C(11)-C(12)	132.84(10)
C(10)-C(4)-N(1)	127.36(10)	C(11)-C(12)-C(14)	122.90(10)
C(10)-C(4)-C(3)	125.18(10)	C(13)-C(12)-C(11)	107.12(10)
C(3)-C(5)-H(5A)	109.1	C(13)-C(12)-C(14)	129.95(11)
C(3)-C(5)-H(5B)	109.1	O(4)-C(13)-C(10)	125.65(10)
H(5A)-C(5)-H(5B)	107.9	O(4)-C(13)-C(12)	125.95(10)
C(6)-C(5)-C(3)	112.30(10)	C(12)-C(13)-C(10)	108.40(10)
C(6)-C(5)-H(5A)	109.1	O(5)-C(14)-C(12)	120.72(11)
C(6)-C(5)-H(5B)	109.1	O(5)-C(14)-C(15)	120.16(10)
C(5)-C(6)-H(6A)	109.4	C(12)-C(14)-C(15)	119.13(10)
C(5)-C(6)-H(6B)	109.4	C(14)-C(15)-H(15A)	109.5
H(6A)-C(6)-H(6B)	108.0	C(14)-C(15)-H(15B)	109.5
C(7)-C(6)-C(5)	111.17(10)	C(14)-C(15)-H(15C)	109.5
C(7)-C(6)-H(6A)	109.4	H(15A)-C(15)-H(15B)	109.5
C(7)-C(6)-H(6B)	109.4	H(15A)-C(15)-H(15C)	109.5
C(6)-C(7)-H(7A)	109.3	H(15B)-C(15)-H(15C)	109.5
C(6)-C(7)-H(7B)	109.3	C(17)-C(16)-N(2)	122.76(10)
H(7A)-C(7)-H(7B)	108.0	C(17)-C(16)-C(21)	120.52(11)
C(8)-C(7)-C(6)	111.59(11)	C(21)-C(16)-N(2)	116.62(10)
C(8)-C(7)-H(7A)	109.3	C(16)-C(17)-H(17)	120.4
C(8)-C(7)-H(7B)	109.3	C(16)-C(17)-C(18)	119.25(11)
C(7)-C(8)-H(8A)	109.6	C(18)-C(17)-H(17)	120.4
C(7)-C(8)-H(8B)	109.6	C(17)-C(18)-H(18)	119.7
C(7)-C(8)-C(9)	110.28(10)	C(19)-C(18)-C(17)	120.60(12)
H(8A)-C(8)-H(8B)	108.1	C(19)-C(18)-H(18)	119.7
C(9)-C(8)-H(8A)	109.6	C(18)-C(19)-H(19)	120.1
C(9)-C(8)-H(8B)	109.6	C(18)-C(19)-C(20)	119.79(12)
C(3)-C(9)-H(9A)	109.5	C(20)-C(19)-H(19)	120.1
C(3)-C(9)-H(9B)	109.5	C(19)-C(20)-H(20)	119.9
C(8)-C(9)-C(3)	110.73(9)	C(21)-C(20)-C(19)	120.22(12)
C(8)-C(9)-H(9A)	109.5	C(21)-C(20)-H(20)	119.9
C(8)-C(9)-H(9B)	109.5	C(16)-C(21)-H(21)	120.2
H(9A)-C(9)-H(9B)	108.1	C(20)-C(21)-C(16)	119.61(12)
O(2)-C(10)-C(13)	107.00(9)	C(20)-C(21)-H(21)	120.2

Symmetry transformations used to generate equivalent atoms:

Table S11. Anisotropic displacement parameters ($Å^2$ x 10^3) for **8a**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2} U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	21(1)	24(1)	23(1)	-1(1)	0(1)	-5(1)
O(2)	21(1)	21(1)	16(1)	1(1)	-1(1)	-5(1)
O(3)	25(1)	24(1)	21(1)	-1(1)	1(1)	-8(1)
O(4)	21(1)	26(1)	18(1)	4(1)	-2(1)	-5(1)
O(5)	27(1)	32(1)	26(1)	5(1)	-7(1)	-10(1)
N(1)	18(1)	20(1)	14(1)	2(1)	-1(1)	-2(1)
N(2)	19(1)	19(1)	15(1)	3(1)	1(1)	0(1)
C(1)	18(1)	21(1)	17(1)	-2(1)	-1(1)	1(1)
C(2)	22(1)	29(1)	16(1)	1(1)	-2(1)	-4(1)
C(3)	18(1)	21(1)	15(1)	1(1)	-1(1)	0(1)
C(4)	18(1)	16(1)	16(1)	0(1)	2(1)	2(1)
C(5)	24(1)	23(1)	21(1)	4(1)	4(1)	4(1)
C(6)	28(1)	32(1)	26(1)	12(1)	5(1)	8(1)
C(7)	32(1)	34(1)	26(1)	13(1)	6(1)	4(1)
C(8)	25(1)	34(1)	16(1)	3(1)	2(1)	-1(1)
C(9)	20(1)	25(1)	16(1)	-1(1)	1(1)	1(1)
C(10)	19(1)	17(1)	16(1)	1(1)	2(1)	0(1)
C(11)	20(1)	20(1)	17(1)	-4(1)	-1(1)	-1(1)
C(12)	19(1)	20(1)	17(1)	-1(1)	1(1)	-1(1)
C(13)	18(1)	19(1)	15(1)	-1(1)	1(1)	1(1)
C(14)	20(1)	23(1)	19(1)	-1(1)	-1(1)	-1(1)
C(15)	27(1)	39(1)	20(1)	6(1)	-5(1)	-9(1)
C(16)	17(1)	22(1)	16(1)	-3(1)	-1(1)	-3(1)
C(17)	22(1)	23(1)	16(1)	-1(1)	-2(1)	-1(1)

C(18)	23(1)	30(1)	21(1)	-7(1)	-4(1)	4(1)
C(19)	21(1)	42(1)	21(1)	-7(1)	2(1)	0(1)
C(20)	26(1)	37(1)	21(1)	2(1)	3(1)	-5(1)
C(21)	22(1)	25(1)	22(1)	2(1)	1(1)	-1(1)

Table S12. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$ x 10^3) for **8a**.

	x	y	z	U(eq)
H(4)	6483(18)	5519(17)	2144(16)	49(5)
H(2)	7584(15)	6640(16)	2937(13)	33(4)
H(2B)	7887	5587	5971	27
H(2C)	8890	4681	5845	27
H(5A)	7257	2476	4639	27
H(5B)	8488	3063	4614	27
H(6A)	8532	1681	5920	35
H(6B)	8920	2916	6338	35
H(7A)	6686	1922	6398	37
H(7B)	7621	2150	7345	37
H(8A)	7402	4139	7126	30
H(8B)	6170	3580	7221	30
H(9A)	6008	4883	5862	25
H(9B)	5691	3622	5468	25
H(15A)	4310	4291	206	45
H(15B)	3778	5315	778	45
H(15C)	2947	4499	66	45
H(17)	9245	4213	3139	25
H(18)	10783	3855	2229	30
H(19)	11135	5067	945	34
H(20)	9944	6647	552	33
H(21)	8411	7019	1456	28

Table S13. Torsion angles [°] for **8a**.

O(1)-C(1)-C(2)-C(3)	-170.04(12)	C(4)-N(1)-C(1)-C(2)	-0.37(13)
O(2)-C(10)-C(13)-O(4)	-179.49(10)	C(4)-C(3)-C(5)-C(6)	-179.79(10)
O(2)-C(10)-C(13)-C(12)	1.69(12)	C(4)-C(3)-C(9)-C(8)	177.39(10)
O(2)-C(11)-C(12)-C(13)	-3.71(13)	C(4)-C(10)-C(13)-O(4)	3.3(2)
O(2)-C(11)-C(12)-C(14)	178.29(10)	C(4)-C(10)-C(13)-C(12)	-175.50(13)
O(3)-C(11)-C(12)-C(13)	174.22(13)	C(5)-C(3)-C(4)-N(1)	-102.12(10)
O(3)-C(11)-C(12)-C(14)	-3.8(2)	C(5)-C(3)-C(4)-C(10)	73.91(14)
N(1)-N(2)-C(16)-C(17)	22.07(15)	C(5)-C(3)-C(9)-C(8)	56.12(13)
N(1)-N(2)-C(16)-C(21)	-161.52(10)	C(5)-C(6)-C(7)-C(8)	-55.23(16)
N(1)-C(1)-C(2)-C(3)	10.09(13)	C(6)-C(7)-C(8)-C(9)	57.84(14)
N(1)-C(4)-C(10)-O(2)	177.26(10)	C(7)-C(8)-C(9)-C(3)	-58.38(13)
N(1)-C(4)-C(10)-C(13)	-5.7(2)	C(9)-C(3)-C(4)-N(1)	134.85(10)
N(2)-N(1)-C(1)-O(1)	-3.73(17)	C(9)-C(3)-C(4)-C(10)	-49.12(15)
N(2)-N(1)-C(1)-C(2)	176.15(10)	C(9)-C(3)-C(5)-C(6)	-53.90(13)
N(2)-N(1)-C(4)-C(3)	173.96(9)	C(10)-O(2)-C(11)-O(3)	-173.44(10)
N(2)-N(1)-C(4)-C(10)	-1.96(18)	C(10)-O(2)-C(11)-C(12)	4.83(12)
N(2)-C(16)-C(17)-C(18)	176.57(10)	C(11)-O(2)-C(10)-C(4)	173.78(10)
N(2)-C(16)-C(21)-C(20)	-176.65(11)	C(11)-O(2)-C(10)-C(13)	-4.05(12)
C(1)-N(1)-N(2)-C(16)	66.28(13)	C(11)-C(12)-C(13)-O(4)	-177.62(11)
C(1)-N(1)-C(4)-C(3)	-9.64(13)	C(11)-C(12)-C(13)-C(10)	1.19(13)
C(1)-N(1)-C(4)-C(10)	174.44(11)	C(11)-C(12)-C(14)-O(5)	-5.28(18)
C(1)-C(2)-C(3)-C(4)	-14.98(12)	C(11)-C(12)-C(14)-C(15)	175.07(11)
C(1)-C(2)-C(3)-C(5)	99.23(11)	C(13)-C(12)-C(14)-O(5)	177.20(12)
C(1)-C(2)-C(3)-C(9)	-138.15(10)	C(13)-C(12)-C(14)-C(15)	-2.4(2)
C(2)-C(3)-C(4)-N(1)	14.89(12)	C(14)-C(12)-C(13)-O(4)	0.2(2)
C(2)-C(3)-C(4)-C(10)	-169.08(11)	C(14)-C(12)-C(13)-C(10)	179.01(12)
C(2)-C(3)-C(5)-C(6)	68.70(13)	C(16)-C(17)-C(18)-C(19)	-0.13(18)
C(2)-C(3)-C(9)-C(8)	-66.86(13)	C(17)-C(16)-C(21)-C(20)	-0.16(17)
C(3)-C(4)-C(10)-O(2)	2.03(17)	C(17)-C(18)-C(19)-C(20)	-0.19(18)
C(3)-C(4)-C(10)-C(13)	179.03(12)	C(18)-C(19)-C(20)-C(21)	0.33(19)
C(3)-C(5)-C(6)-C(7)	53.32(15)	C(19)-C(20)-C(21)-C(16)	-0.16(19)
C(4)-N(1)-N(2)-C(16)	-117.56(11)	C(21)-C(16)-C(17)-C(18)	0.30(17)
C(4)-N(1)-C(1)-O(1)	179.75(11)		

Symmetry transformations used to generate equivalent atoms:

Table S14. Hydrogen bonds for **8a** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(4)-H(4)...N(1)	0.97(2)	2.52(2)	3.2909(12)	136.4(16)
O(4)-H(4)...N(2)	0.97(2)	1.68(2)	2.6317(13)	168.1(19)
N(2)-H(2)...O(3)#1	0.888(19)	2.384(18)	2.8794(13)	115.5(14)
N(2)-H(2)...O(5)#1	0.888(19)	2.009(19)	2.8441(14)	156.2(16)

Symmetry transformations used to generate equivalent atoms:
#1 -x+1,y+1/2,-z+1/2

8.3 Compound 16b

X-ray diffraction data were collected at 100K on a four-circle Rigaku Synergy S diffractometer equipped with a HyPix6000HE area-detector (kappa geometry, shutterless ω-scan technique), using monochromatized Cu K_α-radiation. The intensity data were integrated and corrected for absorption and decay by the CrysAlisPro program.[6] The structure was solved by direct methods using SHELXT[4] and refined on F^2 using SHELXL-2018[5] in the OLEX2 program.[7] All non-hydrogen atoms were refined with individual anisotropic displacement parameters. Locations of amino and hydroxy hydrogen atoms (H2, and H5) were found from the electron density-difference map; these hydrogen atoms were refined with individual isotropic displacement parameters. All other hydrogen atoms were placed in ideal calculated positions and refined as riding atoms with relative isotropic displacement parameters.

Table S15. Crystal data and structure refinement for **16b**.

Identification code	**16b**	
Empirical formula	C24 H29 N3 O5 S	
Formula weight	471.56	
Temperature	99.97(10) K	
Wavelength	1.54184 Å	
Crystal system	Triclinic	
Space group	$P\bar{1}$	
Unit cell dimensions	a = 10.03440(10) Å	α= 70.4960(10)°.
	b = 10.70520(10) Å	β= 89.3540(10)°.
	c = 11.26660(10) Å	γ = 79.0940(10)°.
Volume	1118.45(2) $Å^3$	
Z	2	
Density (calculated)	1.400 g/cm^3	
Absorption coefficient	1.643 mm^{-1}	
F(000)	500	
Crystal size	0.2 x 0.12 x 0.06 mm^3	
Theta range for data collection	4.169 to 77.920°.	
Index ranges	-10<=h<=12, -13<=k<=13, -14<=l<=14	
Reflections collected	34127	
Independent reflections	4730 [R(int) = 0.0412]	
Observed reflections	4689	
Completeness to theta = 67.684°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	1.00000 and 0.74689	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	4730 / 3 / 318	
Goodness-of-fit on F^2	1.048	
Final R indices [I>2sigma(I)]	R1 = 0.0333, wR2 = 0.0897	
R indices (all data)	R1 = 0.0335, wR2 = 0.0899	
Extinction coefficient	0.0016(3)	
Largest diff. peak and hole	0.500 and -0.289 e. $Å^{-3}$	
CCDC	2270302	

Table S16. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for **16b**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	5056(1)	7940(1)	1878(1)	16(1)
O(1A)	8484(15)	11211(16)	1130(12)	16(2)
O(1B)	8335(17)	11411(17)	1114(14)	16(2)
O(2)	2248(1)	4836(1)	4582(1)	16(1)
O(3)	435(1)	2171(1)	4665(1)	14(1)
O(4)	1420(1)	4130(1)	6969(1)	18(1)
N(1)	4907(1)	8269(1)	4090(1)	16(1)
N(2)	3682(1)	6690(1)	3846(1)	17(1)
N(3)	3203(1)	6239(1)	2950(1)	15(1)
C(1)	4490(1)	7619(1)	3423(1)	15(1)
C(2)	5768(1)	9089(1)	3385(1)	15(1)
C(3)	5982(1)	9042(1)	2168(1)	15(1)
C(4)	6826(1)	9786(1)	1351(1)	16(1)
C(5)	7488(1)	10585(1)	1796(1)	16(1)
C(6)	7265(1)	10681(1)	2993(1)	16(1)
C(7)	6407(1)	9948(1)	3786(1)	16(1)
C(8A)	8616(14)	11275(13)	-138(11)	29(1)
C(8B)	8336(15)	11600(14)	-188(12)	29(1)
C(9)	2488(1)	5331(1)	3324(1)	14(1)
C(10)	1796(1)	4893(1)	2405(1)	14(1)
C(11)	1626(1)	3402(1)	2906(1)	13(1)
C(12)	546(1)	3210(1)	2052(1)	16(1)
C(13)	1058(1)	3332(1)	741(1)	19(1)
C(14)	2376(1)	2319(1)	816(1)	23(1)
C(15)	3471(1)	2496(1)	1646(1)	21(1)
C(16)	2972(1)	2396(1)	2958(1)	17(1)
C(17)	1177(1)	3157(1)	4231(1)	13(1)
C(18)	1502(1)	3826(1)	4978(1)	14(1)
C(19)	1119(1)	3521(1)	6275(1)	14(1)
C(20)	331(1)	2472(1)	6654(1)	16(1)
C(21)	5(1)	1858(1)	5862(1)	15(1)
C(22)	-842(1)	804(1)	6147(1)	19(1)
O(5)	2621(1)	6405(1)	6253(1)	18(1)

C(23)	3812(1)	5979(1)	7079(1)	22(1)
C(24)	3484(2)	5547(1)	8451(1)	29(1)

Table S17. Bond lengths [Å] and angles [°] for **16b**.

S(1)-C(1)	1.7665(11)	C(8B)-H(8D)	0.9800
S(1)-C(3)	1.7435(11)	C(8B)-H(8E)	0.9800
O(1A)-C(5)	1.383(9)	C(8B)-H(8F)	0.9800
O(1A)-C(8A)	1.413(9)	C(9)-C(10)	1.4955(15)
O(1B)-C(5)	1.382(10)	C(10)-H(10A)	0.9900
O(1B)-C(8B)	1.413(11)	C(10)-H(10B)	0.9900
O(2)-C(9)	1.3732(13)	C(10)-C(11)	1.5480(14)
O(2)-C(18)	1.3801(13)	C(11)-C(12)	1.5424(15)
O(3)-C(17)	1.3614(13)	C(11)-C(16)	1.5486(15)
O(3)-C(21)	1.3622(13)	C(11)-C(17)	1.5069(15)
O(4)-C(19)	1.2438(14)	C(12)-H(12A)	0.9900
N(1)-C(1)	1.3010(15)	C(12)-H(12B)	0.9900
N(1)-C(2)	1.3974(14)	C(12)-C(13)	1.5306(15)
N(2)-H(1)	0.896(19)	C(13)-H(13A)	0.9900
N(2)-N(3)	1.3808(13)	C(13)-H(13B)	0.9900
N(2)-C(1)	1.3605(15)	C(13)-C(14)	1.5268(18)
N(3)-C(9)	1.2737(15)	C(14)-H(14A)	0.9900
C(2)-C(3)	1.4016(16)	C(14)-H(14B)	0.9900
C(2)-C(7)	1.4033(16)	C(14)-C(15)	1.5275(18)
C(3)-C(4)	1.3955(16)	C(15)-H(15A)	0.9900
C(4)-H(4)	0.9500	C(15)-H(15B)	0.9900
C(4)-C(5)	1.3903(16)	C(15)-C(16)	1.5313(16)
C(5)-C(6)	1.3994(16)	C(16)-H(16A)	0.9900
C(6)-H(6)	0.9500	C(16)-H(16B)	0.9900
C(6)-C(7)	1.3870(16)	C(17)-C(18)	1.3504(16)
C(7)-H(7)	0.9500	C(18)-C(19)	1.4513(15)
C(8A)-H(8K)	0.9800	C(19)-C(20)	1.4402(15)
C(8A)-H(8L)	0.9800	C(20)-H(20)	0.9500
C(8A)-H(8M)	0.9800	C(20)-C(21)	1.3473(16)

C(21)-C(22)	1.4876(15)	C(4)-C(5)-C(6)	121.03(11)
C(22)-H(22A)	0.9800	C(5)-C(6)-H(6)	119.6
C(22)-H(22B)	0.9800	C(7)-C(6)-C(5)	120.88(10)
C(22)-H(22C)	0.9800	C(7)-C(6)-H(6)	119.6
O(5)-H(2)	0.85(2)	C(2)-C(7)-H(7)	120.3
O(5)-C(23)	1.4281(15)	C(6)-C(7)-C(2)	119.46(10)
C(23)-H(23A)	0.9900	C(6)-C(7)-H(7)	120.3
C(23)-H(23B)	0.9900	O(1A)-C(8A)-H(8K)	109.5
C(23)-C(24)	1.5105(18)	O(1A)-C(8A)-H(8L)	109.5
C(24)-H(24A)	0.9800	O(1A)-C(8A)-H(8M)	109.5
C(24)-H(24B)	0.9800	H(8K)-C(8A)-H(8L)	109.5
C(24)-H(24C)	0.9800	H(8K)-C(8A)-H(8M)	109.5
C(3)-S(1)-C(1)	87.94(5)	H(8L)-C(8A)-H(8M)	109.5
C(5)-O(1A)-C(8A)	118.2(11)	O(1B)-C(8B)-H(8D)	109.5
C(5)-O(1B)-C(8B)	115.5(13)	O(1B)-C(8B)-H(8E)	109.5
C(9)-O(2)-C(18)	118.57(9)	O(1B)-C(8B)-H(8F)	109.5
C(17)-O(3)-C(21)	119.86(9)	H(8D)-C(8B)-H(8E)	109.5
C(1)-N(1)-C(2)	109.20(10)	H(8D)-C(8B)-H(8F)	109.5
N(3)-N(2)-H(1)	122.8(12)	H(8E)-C(8B)-H(8F)	109.5
C(1)-N(2)-H(1)	119.5(12)	O(2)-C(9)-C(10)	119.41(9)
C(1)-N(2)-N(3)	115.80(9)	N(3)-C(9)-O(2)	119.22(10)
C(9)-N(3)-N(2)	117.41(10)	N(3)-C(9)-C(10)	121.11(10)
N(1)-C(1)-S(1)	117.20(9)	C(9)-C(10)-H(10A)	108.6
N(1)-C(1)-N(2)	124.46(10)	C(9)-C(10)-H(10B)	108.6
N(2)-C(1)-S(1)	118.32(8)	C(9)-C(10)-C(11)	114.73(9)
N(1)-C(2)-C(3)	115.86(10)	H(10A)-C(10)-H(10B)	107.6
N(1)-C(2)-C(7)	125.79(10)	C(11)-C(10)-H(10A)	108.6
C(3)-C(2)-C(7)	118.35(10)	C(11)-C(10)-H(10B)	108.6
C(2)-C(3)-S(1)	109.79(8)	C(10)-C(11)-C(16)	112.63(9)
C(4)-C(3)-S(1)	127.24(9)	C(12)-C(11)-C(10)	108.90(9)
C(4)-C(3)-C(2)	122.97(10)	C(12)-C(11)-C(16)	109.69(9)
C(3)-C(4)-H(4)	121.4	C(17)-C(11)-C(10)	105.70(9)
C(5)-C(4)-C(3)	117.24(10)	C(17)-C(11)-C(12)	111.58(9)
C(5)-C(4)-H(4)	121.4	C(17)-C(11)-C(16)	108.32(9)
O(1A)-C(5)-C(4)	121.6(7)	C(11)-C(12)-H(12A)	109.3
O(1A)-C(5)-C(6)	117.1(7)	C(11)-C(12)-H(12B)	109.3
O(1B)-C(5)-C(4)	125.4(7)	H(12A)-C(12)-H(12B)	108.0
O(1B)-C(5)-C(6)	113.5(7)	C(13)-C(12)-C(11)	111.39(9)

C(13)-C(12)-H(12A)	109.3	C(17)-C(18)-O(2)	122.92(10)
C(13)-C(12)-H(12B)	109.3	C(17)-C(18)-C(19)	122.64(10)
C(12)-C(13)-H(13A)	109.3	O(4)-C(19)-C(18)	122.95(10)
C(12)-C(13)-H(13B)	109.3	O(4)-C(19)-C(20)	124.07(10)
H(13A)-C(13)-H(13B)	108.0	C(20)-C(19)-C(18)	112.96(10)
C(14)-C(13)-C(12)	111.54(10)	C(19)-C(20)-H(20)	119.0
C(14)-C(13)-H(13A)	109.3	C(21)-C(20)-C(19)	122.09(10)
C(14)-C(13)-H(13B)	109.3	C(21)-C(20)-H(20)	119.0
C(13)-C(14)-H(14A)	109.5	O(3)-C(21)-C(22)	112.18(10)
C(13)-C(14)-H(14B)	109.5	C(20)-C(21)-O(3)	121.69(10)
C(13)-C(14)-C(15)	110.87(10)	C(20)-C(21)-C(22)	126.12(10)
H(14A)-C(14)-H(14B)	108.1	C(21)-C(22)-H(22A)	109.5
C(15)-C(14)-H(14A)	109.5	C(21)-C(22)-H(22B)	109.5
C(15)-C(14)-H(14B)	109.5	C(21)-C(22)-H(22C)	109.5
C(14)-C(15)-H(15A)	109.4	H(22A)-C(22)-H(22B)	109.5
C(14)-C(15)-H(15B)	109.4	H(22A)-C(22)-H(22C)	109.5
C(14)-C(15)-C(16)	111.17(10)	H(22B)-C(22)-H(22C)	109.5
H(15A)-C(15)-H(15B)	108.0	C(23)-O(5)-H(2)	108.2(13)
C(16)-C(15)-H(15A)	109.4	O(5)-C(23)-H(23A)	109.1
C(16)-C(15)-H(15B)	109.4	O(5)-C(23)-H(23B)	109.1
C(11)-C(16)-H(16A)	109.1	O(5)-C(23)-C(24)	112.29(10)
C(11)-C(16)-H(16B)	109.1	H(23A)-C(23)-H(23B)	107.9
C(15)-C(16)-C(11)	112.59(9)	C(24)-C(23)-H(23A)	109.1
C(15)-C(16)-H(16A)	109.1	C(24)-C(23)-H(23B)	109.1
C(15)-C(16)-H(16B)	109.1	C(23)-C(24)-H(24A)	109.5
H(16A)-C(16)-H(16B)	107.8	C(23)-C(24)-H(24B)	109.5
O(3)-C(17)-C(11)	115.55(9)	C(23)-C(24)-H(24C)	109.5
C(18)-C(17)-O(3)	120.70(10)	H(24A)-C(24)-H(24B)	109.5
C(18)-C(17)-C(11)	123.73(10)	H(24A)-C(24)-H(24C)	109.5
O(2)-C(18)-C(19)	114.43(9)	H(24B)-C(24)-H(24C)	109.5

Table S18. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for **16b**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2 a^{*2} U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
S(1)	21(1)	17(1)	14(1)	-7(1)	4(1)	-11(1)
O(1A)	21(3)	15(4)	16(1)	-6(2)	4(1)	-9(3)
O(1B)	21(3)	15(4)	16(1)	-6(2)	4(1)	-9(3)
O(2)	22(1)	16(1)	12(1)	-5(1)	3(1)	-10(1)
O(3)	19(1)	13(1)	13(1)	-4(1)	4(1)	-7(1)
O(4)	23(1)	20(1)	15(1)	-8(1)	3(1)	-9(1)
N(1)	20(1)	16(1)	14(1)	-6(1)	3(1)	-7(1)
N(2)	23(1)	19(1)	14(1)	-8(1)	5(1)	-11(1)
N(3)	18(1)	14(1)	15(1)	-6(1)	2(1)	-6(1)
C(1)	17(1)	14(1)	14(1)	-4(1)	2(1)	-5(1)
C(2)	17(1)	12(1)	14(1)	-3(1)	1(1)	-4(1)
C(3)	17(1)	12(1)	15(1)	-5(1)	0(1)	-4(1)
C(4)	20(1)	16(1)	13(1)	-5(1)	2(1)	-6(1)
C(5)	18(1)	14(1)	16(1)	-3(1)	1(1)	-6(1)
C(6)	20(1)	14(1)	17(1)	-6(1)	-1(1)	-6(1)
C(7)	20(1)	15(1)	13(1)	-5(1)	0(1)	-5(1)
C(8A)	39(4)	38(4)	18(1)	-9(2)	8(2)	-27(3)
C(8B)	39(4)	38(4)	18(1)	-9(2)	8(2)	-27(3)
C(9)	16(1)	13(1)	12(1)	-4(1)	3(1)	-4(1)
C(10)	18(1)	13(1)	12(1)	-4(1)	2(1)	-6(1)
C(11)	17(1)	12(1)	12(1)	-4(1)	2(1)	-6(1)
C(12)	18(1)	18(1)	14(1)	-5(1)	1(1)	-9(1)
C(13)	26(1)	21(1)	13(1)	-6(1)	1(1)	-11(1)
C(14)	36(1)	18(1)	18(1)	-9(1)	8(1)	-9(1)
C(15)	23(1)	18(1)	18(1)	-5(1)	6(1)	0(1)
C(16)	18(1)	15(1)	16(1)	-4(1)	2(1)	-3(1)
C(17)	14(1)	11(1)	14(1)	-2(1)	1(1)	-5(1)
C(18)	15(1)	12(1)	13(1)	-2(1)	2(1)	-6(1)
C(19)	16(1)	14(1)	14(1)	-4(1)	1(1)	-2(1)
C(20)	19(1)	14(1)	12(1)	-3(1)	4(1)	-5(1)
C(21)	18(1)	13(1)	13(1)	-2(1)	4(1)	-3(1)
C(22)	26(1)	17(1)	17(1)	-6(1)	6(1)	-10(1)

O(5)	22(1)	19(1)	16(1)	-6(1)	2(1)	-9(1)
C(23)	17(1)	20(1)	27(1)	-4(1)	0(1)	-5(1)
C(24)	35(1)	28(1)	21(1)	-1(1)	-7(1)	-12(1)

Table S19. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for **16b**.

	x	y	z	U(eq)
H(1)	3326(19)	6567(19)	4599(18)	35(5)
H(4)	6943	9748	525	19
H(6)	7707	11255	3267	20
H(7)	6253	10028	4594	19
H(8K)	7728	11649	-599	44
H(8L)	8950	10365	-166	44
H(8M)	9260	11856	-528	44
H(8D)	7435	12075	-587	44
H(8E)	8559	10718	-305	44
H(8F)	9016	12137	-576	44
H(10A)	2324	5033	1640	17
H(10B)	886	5481	2152	17
H(12A)	313	2309	2448	20
H(12B)	-290	3901	1970	20
H(13A)	355	3173	229	23
H(13B)	1214	4260	317	23
H(14A)	2701	2452	-42	27
H(14B)	2203	1389	1168	27
H(15A)	3720	3388	1240	25
H(15B)	4293	1790	1728	25
H(16A)	3679	2577	3449	20
H(16B)	2837	1464	3401	20
H(20)	32	2206	7488	19
H(22A)	-1633	1120	5546	29
H(22B)	-1150	629	7006	29
H(22C)	-302	-30	6078	29

H(2)	2200(20)	5750(20)	6422(18)	39(5)
H(23A)	4310	6731	6898	27
H(23B)	4414	5215	6915	27
H(24A)	2918	6311	8627	43
H(24B)	4329	5247	8982	43
H(24C)	2992	4801	8636	43

Table S20. Torsion angles [°] for **16b**.

S(1)-C(3)-C(4)-C(5)	-178.77(9)	C(3)-S(1)-C(1)-N(1)	1.28(10)
O(1A)-C(5)-C(6)-C(7)	-172.1(8)	C(3)-S(1)-C(1)-N(2)	-177.07(10)
O(1B)-C(5)-C(6)-C(7)	178.1(9)	C(3)-C(2)-C(7)-C(6)	-2.44(16)
O(2)-C(9)-C(10)-C(11)	-36.40(14)	C(3)-C(4)-C(5)-O(1A)	171.0(8)
O(2)-C(18)-C(19)-O(4)	0.94(16)	C(3)-C(4)-C(5)-O(1B)	-178.4(10)
O(2)-C(18)-C(19)-C(20)	179.43(9)	C(3)-C(4)-C(5)-C(6)	-2.76(17)
O(3)-C(17)-C(18)-O(2)	-179.78(9)	C(4)-C(5)-C(6)-C(7)	1.93(18)
O(3)-C(17)-C(18)-C(19)	1.51(17)	C(5)-C(6)-C(7)-C(2)	0.77(17)
O(4)-C(19)-C(20)-C(21)	178.62(11)	C(7)-C(2)-C(3)-S(1)	-178.61(8)
N(1)-C(2)-C(3)-S(1)	0.62(13)	C(7)-C(2)-C(3)-C(4)	1.57(17)
N(1)-C(2)-C(3)-C(4)	-179.20(10)	C(8A)-O(1A)-C(5)-C(4)	13.8(16)
N(1)-C(2)-C(7)-C(6)	178.41(10)	C(8A)-O(1A)-C(5)-C(6)	-172.3(9)
N(2)-N(3)-C(9)-O(2)	-0.99(15)	C(8B)-O(1B)-C(5)-C(4)	10.5(18)
N(2)-N(3)-C(9)-C(10)	173.04(10)	C(8B)-O(1B)-C(5)-C(6)	-165.5(10)
N(3)-N(2)-C(1)-S(1)	-9.94(14)	C(9)-O(2)-C(18)-C(17)	10.57(16)
N(3)-N(2)-C(1)-N(1)	171.84(10)	C(9)-O(2)-C(18)-C(19)	-170.63(9)
N(3)-C(9)-C(10)-C(11)	149.59(10)	C(9)-C(10)-C(11)-C(12)	162.95(9)
C(1)-S(1)-C(3)-C(2)	-0.97(8)	C(9)-C(10)-C(11)-C(16)	-75.14(12)
C(1)-S(1)-C(3)-C(4)	178.84(11)	C(9)-C(10)-C(11)-C(17)	42.95(12)
C(1)-N(1)-C(2)-C(3)	0.30(14)	C(10)-C(11)-C(12)-C(13)	68.90(12)
C(1)-N(1)-C(2)-C(7)	179.46(11)	C(10)-C(11)-C(16)-C(15)	-67.26(12)
C(1)-N(2)-N(3)-C(9)	177.32(10)	C(10)-C(11)-C(17)-O(3)	153.43(9)
C(2)-N(1)-C(1)-S(1)	-1.12(13)	C(10)-C(11)-C(17)-C(18)	-28.36(14)
C(2)-N(1)-C(1)-N(2)	177.11(10)	C(11)-C(12)-C(13)-C(14)	57.05(12)
C(2)-C(3)-C(4)-C(5)	1.02(17)	C(11)-C(17)-C(18)-O(2)	2.09(17)

C(11)-C(17)-C(18)-C(19)	-176.61(10)	C(17)-C(11)-C(12)-C(13)	-174.80(9)
C(12)-C(11)-C(16)-C(15)	54.20(12)	C(17)-C(11)-C(16)-C(15)	176.20(9)
C(12)-C(11)-C(17)-O(3)	35.20(13)	C(17)-C(18)-C(19)-O(4)	179.75(11)
C(12)-C(11)-C(17)-C(18)	-146.59(11)	C(17)-C(18)-C(19)-C(20)	-1.77(15)
C(12)-C(13)-C(14)-C(15)	-56.67(13)	C(18)-O(2)-C(9)-N(3)	-178.28(10)
C(13)-C(14)-C(15)-C(16)	55.21(13)	C(18)-O(2)-C(9)-C(10)	7.59(14)
C(14)-C(15)-C(16)-C(11)	-54.92(13)	C(18)-C(19)-C(20)-C(21)	0.16(16)
C(16)-C(11)-C(12)-C(13)	-54.77(12)	C(19)-C(20)-C(21)-O(3)	1.74(17)
C(16)-C(11)-C(17)-O(3)	-85.64(11)	C(19)-C(20)-C(21)-C(22)	-177.64(11)
C(16)-C(11)-C(17)-C(18)	92.58(13)	C(21)-O(3)-C(17)-C(11)	178.74(9)
C(17)-O(3)-C(21)-C(20)	-2.10(16)	C(21)-O(3)-C(17)-C(18)	0.47(15)
C(17)-O(3)-C(21)-C(22)	177.36(9)		

Table S21. Hydrogen bonds for **16b** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(2)-H(1)...O(5)	0.896(19)	1.95(2)	2.8441(13)	175.6(18)
O(5)-H(2)...O(4)	0.85(2)	1.95(2)	2.7956(12)	172.8(19)

8.4 Compound 17

X-ray diffraction data were collected at 100K on a four-circle Rigaku Synergy S diffractometer equipped with a HyPix6000HE area-detector (kappa geometry, shutterless ω-scan technique), using graphite monochromatized Cu K_α-radiation. The intensity data were integrated and corrected for absorption and decay by the CrysAlisPro program.[6] The structure was solved by direct methods using SHELXT[4] and refined on F^2 using SHELXL-2018[5] in the OLEX2 program.[7] All non-hydrogen atoms were refined with individual anisotropic displacement parameters. The locations of hydrogen atoms H1, H20A and H20B were found from the electron density-difference map; these hydrogen atoms were refined with individual isotropic displacement parameters. All other hydrogen atoms were placed in ideal calculated positions and refined as riding atoms with relative isotropic displacement parameters. The Mercury program suite[8] was used for molecular graphics.

Table S22. Crystal data and structure refinement for **17**.

Identification code	**17**	
Empirical formula	C22 H22 N4 O5	
Formula weight	422.43	
Temperature	100.0(2) K	
Wavelength	1.54184 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	a = 8.26940(12) Å	a= 66.2311(15)°.
	b = 11.01204(19) Å	b= 74.6710(13)°.
	c = 12.41759(17) Å	g = 76.7962(14)°.
Volume	988.49(3) $Å^3$	
Z	2	
Density (calculated)	1.419 g/cm^3	
Absorption coefficient	0.851 mm^{-1}	
F(000)	444	
Crystal size	0.22 x 0.11 x 0.02 mm^3	
Theta range for data collection	3.965 to 77.859°.	
Index ranges	-10<=h<=10, -13<=k<=13, -15<=l<=15	
Reflections collected	47219	
Independent reflections	4157 [R(int) = 0.0306]	

Observed reflections	3886
Completeness to theta = 67.684°	99.8 %
Absorption correction	Gaussian
Max. and min. transmission	1.000 and 0.499
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4157 / 0 / 293
Goodness-of-fit on F^2	1.035
Final R indices [I>2sigma(I)]	R1 = 0.0354, wR2 = 0.0922
R indices (all data)	R1 = 0.0373, wR2 = 0.0935
Largest diff. peak and hole	0.267 and -0.244 e.Å^{-3}
CCDC	2270301

Table S23. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **17**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(5)	2834(1)	4578(1)	3800(1)	28(1)
O(14)	7595(1)	5767(1)	1601(1)	23(1)
O(16)	10314(1)	6911(1)	-4(1)	30(1)
O(19)	11115(1)	3160(1)	2471(1)	23(1)
N(1)	2062(1)	8880(1)	1186(1)	24(1)
N(3)	4722(1)	7344(1)	1536(1)	24(1)
N(4)	4790(1)	6006(1)	2389(1)	23(1)
N(6)	2140(1)	6781(1)	2511(1)	21(1)
C(2)	3095(1)	7736(1)	1670(1)	22(1)
C(5)	3212(1)	5632(1)	3014(1)	22(1)
C(7)	418(1)	7331(1)	2625(1)	22(1)
C(8)	-1022(2)	6821(1)	3368(1)	26(1)
C(9)	-2541(2)	7677(1)	3223(1)	30(1)
C(10)	-2581(2)	8981(1)	2376(1)	29(1)
C(11)	-1114(2)	9502(1)	1651(1)	27(1)
C(12)	402(2)	8651(1)	1783(1)	23(1)

C(13)	6352(1)	5185(1)	2528(1)	21(1)
C(15)	9204(1)	5073(1)	1650(1)	21(1)
C(16)	10553(2)	5761(1)	745(1)	24(1)
C(17)	12196(2)	4968(1)	808(1)	27(1)
C(18)	12428(2)	3728(1)	1638(1)	26(1)
C(20)	9517(1)	3838(1)	2476(1)	21(1)
C(21)	8216(1)	3072(1)	3459(1)	20(1)
C(22)	6564(1)	4011(1)	3413(1)	24(1)
C(23)	8062(2)	1813(1)	3242(1)	23(1)
C(24)	6815(2)	957(1)	4258(1)	26(1)
C(25)	7348(2)	519(1)	5463(1)	25(1)
C(26)	7560(1)	1717(1)	5714(1)	23(1)
C(27)	8746(1)	2622(1)	4686(1)	21(1)
C(28)	14053(2)	2821(1)	1790(1)	32(1)
O(20)	7325(1)	8587(1)	-346(1)	30(1)

Table S24. Bond lengths [Å] and angles [°] for **17**.

O(5)-C(5)	1.2203(14)	C(7)-C(12)	1.4067(15)
O(14)-C(13)	1.3681(13)	C(8)-H(8)	0.9500
O(14)-C(15)	1.3780(13)	C(8)-C(9)	1.3932(17)
O(16)-C(16)	1.2420(14)	C(9)-H(9)	0.9500
O(19)-C(18)	1.3549(13)	C(9)-C(10)	1.3959(18)
O(19)-C(20)	1.3606(13)	C(10)-H(10)	0.9500
N(1)-H(1)	0.933(18)	C(10)-C(11)	1.3914(18)
N(1)-C(2)	1.3590(14)	C(11)-H(11)	0.9500
N(1)-C(12)	1.4026(15)	C(11)-C(12)	1.3870(16)
N(3)-N(4)	1.4256(12)	C(13)-C(22)	1.3279(15)
N(3)-C(2)	1.3030(15)	C(15)-C(16)	1.4557(15)
N(4)-C(5)	1.3880(14)	C(15)-C(20)	1.3505(15)
N(4)-C(13)	1.4053(14)	C(16)-C(17)	1.4397(17)
N(6)-C(2)	1.3702(14)	C(17)-H(17)	0.9500
N(6)-C(5)	1.3856(14)	C(17)-C(18)	1.3465(17)
N(6)-C(7)	1.4086(14)	C(18)-C(28)	1.4861(17)
C(7)-C(8)	1.3753(16)	C(20)-C(21)	1.5000(15)

C(21)-C(22)	1.5118(15)	O(5)-C(5)-N(4)	130.16(10)
C(21)-C(23)	1.5537(14)	O(5)-C(5)-N(6)	128.13(11)
C(21)-C(27)	1.5505(14)	N(6)-C(5)-N(4)	101.71(9)
C(22)-H(22)	0.9500	C(8)-C(7)-N(6)	132.39(10)
C(23)-H(23A)	0.9900	C(8)-C(7)-C(12)	123.08(11)
C(23)-H(23B)	0.9900	C(12)-C(7)-N(6)	104.51(9)
C(23)-C(24)	1.5298(15)	C(7)-C(8)-H(8)	121.9
C(24)-H(24A)	0.9900	C(7)-C(8)-C(9)	116.21(11)
C(24)-H(24B)	0.9900	C(9)-C(8)-H(8)	121.9
C(24)-C(25)	1.5277(16)	C(8)-C(9)-H(9)	119.3
C(25)-H(25A)	0.9900	C(8)-C(9)-C(10)	121.39(11)
C(25)-H(25B)	0.9900	C(10)-C(9)-H(9)	119.3
C(25)-C(26)	1.5276(15)	C(9)-C(10)-H(10)	119.0
C(26)-H(26A)	0.9900	C(11)-C(10)-C(9)	122.01(11)
C(26)-H(26B)	0.9900	C(11)-C(10)-H(10)	119.0
C(26)-C(27)	1.5307(15)	C(10)-C(11)-H(11)	121.6
C(27)-H(27A)	0.9900	C(12)-C(11)-C(10)	116.90(11)
C(27)-H(27B)	0.9900	C(12)-C(11)-H(11)	121.6
C(28)-H(28A)	0.9800	N(1)-C(12)-C(7)	109.58(10)
C(28)-H(28B)	0.9800	C(11)-C(12)-N(1)	130.05(10)
C(28)-H(28C)	0.9800	C(11)-C(12)-C(7)	120.38(11)
O(20)-H(20A)	0.93(2)	O(14)-C(13)-N(4)	109.57(9)
O(20)-H(20B)	0.88(2)	C(22)-C(13)-O(14)	125.80(10)
C(13)-O(14)-C(15)	115.26(8)	C(22)-C(13)-N(4)	124.61(10)
C(18)-O(19)-C(20)	120.11(9)	O(14)-C(15)-C(16)	115.42(9)
C(2)-N(1)-H(1)	124.0(11)	C(20)-C(15)-O(14)	122.62(10)
C(2)-N(1)-C(12)	106.84(9)	C(20)-C(15)-C(16)	121.96(10)
C(12)-N(1)-H(1)	125.6(11)	O(16)-C(16)-C(15)	123.55(11)
C(2)-N(3)-N(4)	101.36(9)	O(16)-C(16)-C(17)	123.49(11)
C(5)-N(4)-N(3)	113.79(9)	C(17)-C(16)-C(15)	112.97(10)
C(5)-N(4)-C(13)	125.69(9)	C(16)-C(17)-H(17)	118.8
C(13)-N(4)-N(3)	120.51(9)	C(18)-C(17)-C(16)	122.46(11)
C(2)-N(6)-C(5)	108.90(9)	C(18)-C(17)-H(17)	118.8
C(2)-N(6)-C(7)	109.41(9)	O(19)-C(18)-C(28)	111.39(10)
C(5)-N(6)-C(7)	141.49(10)	C(17)-C(18)-O(19)	121.37(11)
N(1)-C(2)-N(6)	109.59(10)	C(17)-C(18)-C(28)	127.24(11)
N(3)-C(2)-N(1)	136.18(11)	O(19)-C(20)-C(21)	113.30(9)
N(3)-C(2)-N(6)	114.22(10)	C(15)-C(20)-O(19)	121.10(10)

C(15)-C(20)-C(21)	125.59(10)	C(24)-C(25)-C(26)	111.64(9)
C(20)-C(21)-C(22)	106.40(9)	H(25A)-C(25)-H(25B)	108.0
C(20)-C(21)-C(23)	109.73(9)	C(26)-C(25)-H(25A)	109.3
C(20)-C(21)-C(27)	109.90(9)	C(26)-C(25)-H(25B)	109.3
C(22)-C(21)-C(23)	110.50(9)	C(25)-C(26)-H(26A)	109.1
C(22)-C(21)-C(27)	111.30(9)	C(25)-C(26)-H(26B)	109.1
C(27)-C(21)-C(23)	108.99(8)	C(25)-C(26)-C(27)	112.46(9)
C(13)-C(22)-C(21)	123.42(10)	H(26A)-C(26)-H(26B)	107.8
C(13)-C(22)-H(22)	118.3	C(27)-C(26)-H(26A)	109.1
C(21)-C(22)-H(22)	118.3	C(27)-C(26)-H(26B)	109.1
C(21)-C(23)-H(23A)	109.3	C(21)-C(27)-H(27A)	109.1
C(21)-C(23)-H(23B)	109.3	C(21)-C(27)-H(27B)	109.1
H(23A)-C(23)-H(23B)	107.9	C(26)-C(27)-C(21)	112.42(9)
C(24)-C(23)-C(21)	111.73(9)	C(26)-C(27)-H(27A)	109.1
C(24)-C(23)-H(23A)	109.3	C(26)-C(27)-H(27B)	109.1
C(24)-C(23)-H(23B)	109.3	H(27A)-C(27)-H(27B)	107.9
C(23)-C(24)-H(24A)	109.5	C(18)-C(28)-H(28A)	109.5
C(23)-C(24)-H(24B)	109.5	C(18)-C(28)-H(28B)	109.5
H(24A)-C(24)-H(24B)	108.1	C(18)-C(28)-H(28C)	109.5
C(25)-C(24)-C(23)	110.88(9)	H(28A)-C(28)-H(28B)	109.5
C(25)-C(24)-H(24A)	109.5	H(28A)-C(28)-H(28C)	109.5
C(25)-C(24)-H(24B)	109.5	H(28B)-C(28)-H(28C)	109.5
C(24)-C(25)-H(25A)	109.3	H(20A)-O(20)-H(20B)	103.5(17)
C(24)-C(25)-H(25B)	109.3		

Table S25. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for **17**. The anisotropic displacement factor exponent takes the form: $-2p^2[\ h^2\ a^{*2}U^{11} + ...\ + 2\ h\ k\ a^*\ b^*\ U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(5)	26(1)	20(1)	30(1)	-1(1)	-3(1)	-6(1)
O(14)	24(1)	21(1)	20(1)	-2(1)	-2(1)	-5(1)
O(16)	34(1)	23(1)	24(1)	-1(1)	-1(1)	-9(1)
O(19)	20(1)	24(1)	22(1)	-5(1)	-2(1)	-7(1)
N(1)	27(1)	20(1)	23(1)	-2(1)	-7(1)	-4(1)

N(3)	27(1)	18(1)	21(1)	1(1)	-6(1)	-5(1)
N(4)	23(1)	18(1)	21(1)	0(1)	-5(1)	-5(1)
N(6)	23(1)	19(1)	21(1)	-4(1)	-5(1)	-5(1)
C(2)	26(1)	20(1)	18(1)	-3(1)	-6(1)	-6(1)
C(5)	24(1)	20(1)	22(1)	-6(1)	-5(1)	-5(1)
C(7)	24(1)	22(1)	23(1)	-9(1)	-8(1)	-3(1)
C(8)	28(1)	24(1)	27(1)	-9(1)	-6(1)	-6(1)
C(9)	26(1)	34(1)	33(1)	-15(1)	-5(1)	-7(1)
C(10)	27(1)	32(1)	32(1)	-14(1)	-11(1)	1(1)
C(11)	32(1)	25(1)	25(1)	-9(1)	-11(1)	-1(1)
C(12)	27(1)	23(1)	20(1)	-8(1)	-7(1)	-5(1)
C(13)	22(1)	22(1)	20(1)	-6(1)	-3(1)	-6(1)
C(15)	23(1)	22(1)	20(1)	-7(1)	-4(1)	-6(1)
C(16)	30(1)	23(1)	19(1)	-6(1)	-3(1)	-10(1)
C(17)	24(1)	30(1)	24(1)	-6(1)	-1(1)	-12(1)
C(18)	23(1)	30(1)	24(1)	-8(1)	-2(1)	-11(1)
C(20)	22(1)	22(1)	20(1)	-8(1)	-4(1)	-6(1)
C(21)	22(1)	19(1)	18(1)	-4(1)	-4(1)	-6(1)
C(22)	22(1)	23(1)	21(1)	-3(1)	-3(1)	-5(1)
C(23)	27(1)	23(1)	21(1)	-7(1)	-4(1)	-9(1)
C(24)	30(1)	25(1)	25(1)	-7(1)	-5(1)	-12(1)
C(25)	27(1)	21(1)	23(1)	-3(1)	-4(1)	-8(1)
C(26)	25(1)	23(1)	18(1)	-4(1)	-5(1)	-5(1)
C(27)	24(1)	21(1)	20(1)	-6(1)	-5(1)	-6(1)
C(28)	22(1)	36(1)	32(1)	-5(1)	-3(1)	-8(1)
O(20)	34(1)	22(1)	27(1)	-1(1)	-4(1)	-8(1)

Table S26. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **17**.

	x	y	z	U(eq)
H(1)	2420(20)	9718(18)	764(16)	46(5)
H(8)	-983	5935	3947	31
H(9)	-3571	7367	3711	36
H(10)	-3643	9530	2293	35
H(11)	-1148	10397	1091	32
H(17)	13151	5333	243	32
H(22)	5629	3747	4051	29
H(23A)	7678	2097	2475	28
H(23B)	9189	1267	3174	28
H(24A)	5669	1479	4290	31
H(24B)	6769	156	4098	31
H(25A)	8431	-93	5462	30
H(25B)	6482	20	6111	30
H(26A)	8016	1387	6458	27
H(26B)	6437	2248	5845	27
H(27A)	9912	2135	4640	25
H(27B)	8750	3424	4858	25
H(28A)	14296	2652	2573	48
H(28B)	14968	3240	1154	48
H(28C)	13966	1971	1744	48
H(20A)	8320(30)	8010(20)	-198(18)	64(6)
H(20B)	6560(30)	8208(19)	279(18)	55(5)

Table S27. Torsion angles [°] for **17**.

O(14)-C(13)-C(22)-C(21)	-6.06(18)	C(7)-N(6)-C(5)-N(4)	-175.01(13)
O(14)-C(15)-C(16)-O(16)	2.32(16)	C(7)-C(8)-C(9)-C(10)	-0.54(17)
O(14)-C(15)-C(16)-C(17)	-177.58(9)	C(8)-C(7)-C(12)-N(1)	178.60(10)
O(14)-C(15)-C(20)-O(19)	177.50(9)	C(8)-C(7)-C(12)-C(11)	-1.37(17)
O(14)-C(15)-C(20)-C(21)	-2.06(17)	C(8)-C(9)-C(10)-C(11)	-1.19(19)
O(16)-C(16)-C(17)-C(18)	179.19(11)	C(9)-C(10)-C(11)-C(12)	1.63(17)
O(19)-C(20)-C(21)-C(22)	174.50(8)	C(10)-C(11)-C(12)-N(1)	179.64(11)
O(19)-C(20)-C(21)-C(23)	-65.94(11)	C(10)-C(11)-C(12)-C(7)	-0.40(16)
O(19)-C(20)-C(21)-C(27)	53.89(12)	C(12)-N(1)-C(2)-N(3)	-176.85(13)
N(3)-N(4)-C(5)-O(5)	-179.25(11)	C(12)-N(1)-C(2)-N(6)	2.59(12)
N(3)-N(4)-C(5)-N(6)	0.84(12)	C(12)-C(7)-C(8)-C(9)	1.80(17)
N(3)-N(4)-C(13)-O(14)	-12.23(14)	C(13)-O(14)-C(15)-C(16)	-173.21(9)
N(3)-N(4)-C(13)-C(22)	169.16(11)	C(13)-O(14)-C(15)-C(20)	7.00(15)
N(4)-N(3)-C(2)-N(1)	179.12(13)	C(13)-N(4)-C(5)-O(5)	1.66(19)
N(4)-N(3)-C(2)-N(6)	-0.30(12)	C(13)-N(4)-C(5)-N(6)	-178.26(10)
N(4)-C(13)-C(22)-C(21)	172.32(10)	C(15)-O(14)-C(13)-N(4)	178.37(8)
N(6)-C(7)-C(8)-C(9)	179.90(11)	C(15)-O(14)-C(13)-C(22)	-3.04(16)
N(6)-C(7)-C(12)-N(1)	0.05(12)	C(15)-C(16)-C(17)-C(18)	-0.91(16)
N(6)-C(7)-C(12)-C(11)	-179.92(10)	C(15)-C(20)-C(21)-C(22)	-5.91(15)
C(2)-N(1)-C(12)-C(7)	-1.62(12)	C(15)-C(20)-C(21)-C(23)	113.65(12)
C(2)-N(1)-C(12)-C(11)	178.35(11)	C(15)-C(20)-C(21)-C(27)	-126.52(11)
C(2)-N(3)-N(4)-C(5)	-0.36(12)	C(16)-C(15)-C(20)-O(19)	-2.27(16)
C(2)-N(3)-N(4)-C(13)	178.78(9)	C(16)-C(15)-C(20)-C(21)	178.16(10)
C(2)-N(6)-C(5)-O(5)	179.12(11)	C(16)-C(17)-C(18)-O(19)	-0.38(18)
C(2)-N(6)-C(5)-N(4)	-0.97(11)	C(16)-C(17)-C(18)-C(28)	179.97(11)
C(2)-N(6)-C(7)-C(8)	-176.81(12)	C(18)-O(19)-C(20)-C(15)	0.85(15)
C(2)-N(6)-C(7)-C(12)	1.54(12)	C(18)-O(19)-C(20)-C(21)	-179.54(9)
C(5)-N(4)-C(13)-O(14)	166.81(10)	C(20)-O(19)-C(18)-C(17)	0.49(16)
C(5)-N(4)-C(13)-C(22)	-11.80(18)	C(20)-O(19)-C(18)-C(28)	-179.81(9)
C(5)-N(6)-C(2)-N(1)	-178.71(9)	C(20)-C(15)-C(16)-O(16)	-177.88(11)
C(5)-N(6)-C(2)-N(3)	0.86(13)	C(20)-C(15)-C(16)-C(17)	2.21(15)
C(5)-N(6)-C(7)-C(8)	-2.8(2)	C(20)-C(21)-C(22)-C(13)	9.70(15)
C(5)-N(6)-C(7)-C(12)	175.57(13)	C(20)-C(21)-C(23)-C(24)	177.01(9)
C(7)-N(6)-C(2)-N(1)	-2.64(12)	C(20)-C(21)-C(27)-C(26)	-174.33(9)
C(7)-N(6)-C(2)-N(3)	176.94(9)	C(21)-C(23)-C(24)-C(25)	-57.90(13)
C(7)-N(6)-C(5)-O(5)	5.1(2)	C(22)-C(21)-C(23)-C(24)	-65.97(11)

C(22)-C(21)-C(27)-C(26)	68.06(11)	C(24)-C(25)-C(26)-C(27)	-53.09(13)
C(23)-C(21)-C(22)-C(13)	-109.36(12)	C(25)-C(26)-C(27)-C(21)	53.30(12)
C(23)-C(21)-C(27)-C(26)	-54.05(12)	C(27)-C(21)-C(22)-C(13)	129.41(11)
C(23)-C(24)-C(25)-C(26)	55.15(13)	C(27)-C(21)-C(23)-C(24)	56.62(12)

Table S28. Hydrogen bonds for **17** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1)...O(20)#1	0.933(18)	1.771(18)	2.6741(13)	162.0(16)
C(22)-H(22)...O(5)	0.95	2.34	2.9520(14)	122.0
C(28)-H(28C)...O(20)#2	0.98	2.58	3.3228(16)	132.4

Symmetry transformations used to generate equivalent atoms:
#1 -x+1,-y+2,-z #2 -x+2,-y+1,-z

8.5 Compound 18b

X-ray diffraction data were collected at 100K on a four-circle Rigaku Synergy S diffractometer equipped with a HyPix6000HE area-detector (kappa geometry, shutterless ω-scan technique), using monochromatized Cu K_α-radiation. The intensity data were integrated and corrected for absorption and decay by the CrysAlisPro program.[6] The structure was solved by direct methods using SHELXT[4] and refined on F^2 using SHELXL-2018[5] in the OLEX2 program.[7] All non-hydrogen atoms were refined with individual anisotropic displacement parameters. Locations of amino hydrogen atoms (H5D, H5K) were found from the electron density-difference map; these hydrogen atoms were refined with individual isotropic displacement parameters. All other hydrogen atoms were placed in ideal calculated positions and refined as riding atoms with relative isotropic displacement parameters.

Table S29. Crystal data and structure refinement for **18b**.

Identification code	**18b**	
Empirical formula	C19 H23 N5 O5	
Formula weight	401.42	
Temperature	100.00(10) K	
Wavelength	1.54184 Å	
Crystal system	Monoclinic	
Space group	I 1 2/a 1	
Unit cell dimensions	a = 19.5566(2) Å	a= 90°.
	b = 9.65170(10) Å	b= 95.9400(10)°.
	c = 21.0321(2) Å	g = 90°.
Volume	3948.59(7) $Å^3$	
Z	8	
Density (calculated)	1.351 g/cm^3	
Absorption coefficient	0.832 mm^{-1}	
F(000)	1696	
Crystal size	0.14 x 0.13 x 0.08 mm^3	
Theta range for data collection	4.227 to 77.853°.	
Index ranges	-24<=h<=24, -11<=k<=11, -26<=l<=23	
Reflections collected	26476	
Independent reflections	4156 [R(int) = 0.0258]	
Observed reflections	4091	
Completeness to theta = 67.684°	99.9 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	1.00000 and 0.89830	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	4156 / 32 / 306	
Goodness-of-fit on F^2	1.285	
Final R indices [I>2sigma(I)]	R1 = 0.0562, wR2 = 0.1258	
R indices (all data)	R1 = 0.0567, wR2 = 0.1260	
Largest diff. peak and hole	0.233 and -0.270 $e.Å^{-3}$	
CCDC	2270307	

Table S30. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for **18b**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	5687(1)	4668(2)	4300(1)	27(1)
O(2)	8023(1)	5096(1)	4104(1)	20(1)
O(3)	9195(1)	1908(2)	3557(1)	31(1)
O(4)	7790(1)	1715(2)	3351(1)	27(1)
O(5)	7150(1)	-337(2)	2791(1)	27(1)
O(5A)	6337(3)	509(6)	2636(3)	27(1)
N(1)	6743(2)	863(3)	2815(1)	24(1)
N(1A)	7016(4)	495(8)	2911(4)	24(1)
C(1)	6949(1)	3940(2)	3756(1)	21(1)
C(2)	6649(1)	5412(2)	3737(1)	26(1)
C(3)	5873(1)	5379(3)	3747(1)	31(1)
C(4)	5905(1)	3257(2)	4305(1)	24(1)
C(5)	6681(1)	3153(2)	4323(1)	21(1)
C(6)	7718(1)	3943(2)	3830(1)	19(1)
C(7)	8725(1)	5178(2)	4188(1)	21(1)
C(8)	9120(1)	4133(2)	4018(1)	24(1)
C(9)	8840(1)	2890(2)	3722(1)	23(1)
C(10)	8097(1)	2885(2)	3633(1)	21(1)
C(11)	7108(1)	1817(2)	3098(1)	28(1)
C(12)	6758(1)	3182(3)	3118(1)	28(1)
C(13)	8963(1)	6534(2)	4464(1)	26(1)
N(2)	3711(4)	2748(7)	2733(3)	28(1)
N(3)	4127(8)	753(13)	3102(9)	26(2)
C(14)	4412(5)	2724(8)	2696(4)	30(2)
C(15)	4667(6)	1466(13)	2895(10)	30(2)
C(16)	3561(6)	1530(13)	2962(9)	29(1)
N(2A)	3958(6)	2855(10)	2662(5)	28(1)
N(3A)	4199(11)	730(19)	3001(13)	26(2)
C(14A)	4647(6)	2560(12)	2628(6)	30(2)
C(15A)	4818(9)	1290(20)	2884(15)	30(2)
C(16A)	3711(8)	1720(19)	2907(12)	29(1)
N(4)	4269(7)	164(9)	5106(5)	26(1)
N(5)	3163(9)	456(18)	5186(11)	26(1)

C(17)	3522(17)	910(60)	5744(17)	29(2)
C(18)	4201(17)	710(50)	5700(11)	33(1)
C(19)	3641(8)	50(30)	4808(7)	23(2)
N(4A)	3258(10)	387(18)	5187(12)	26(1)
N(5A)	4394(7)	350(9)	5246(5)	26(1)
C(17A)	4208(17)	830(50)	5820(11)	33(1)
C(18A)	3513(17)	830(60)	5786(17)	29(2)
C(19A)	3809(7)	80(30)	4888(8)	23(2)

Table S31. Bond lengths [Å] and angles [°] for **18b**.

O(1)-C(3)	1.429(3)	C(4)-C(5)	1.517(3)
O(1)-C(4)	1.427(3)	C(5)-H(5B)	0.9900
O(2)-C(6)	1.361(2)	C(5)-H(5C)	0.9900
O(2)-C(7)	1.368(2)	C(6)-C(10)	1.351(3)
O(3)-C(9)	1.246(3)	C(7)-C(8)	1.341(3)
O(4)-C(10)	1.384(2)	C(7)-C(13)	1.487(3)
O(4)-C(11)	1.388(3)	C(8)-H(8)	0.9500
O(5)-H(5)	0.8400	C(8)-C(9)	1.435(3)
O(5)-N(1)	1.410(3)	C(9)-C(10)	1.446(3)
O(5A)-H(5A)	0.8400	C(11)-C(12)	1.486(3)
O(5A)-N(1A)	1.392(8)	C(12)-H(12A)	0.9900
N(1)-C(11)	1.274(3)	C(12)-H(12B)	0.9900
N(1A)-C(11)	1.342(8)	C(13)-H(13A)	0.9800
C(1)-C(2)	1.536(3)	C(13)-H(13B)	0.9800
C(1)-C(5)	1.549(3)	C(13)-H(13C)	0.9800
C(1)-C(6)	1.497(3)	N(2)-C(14)	1.381(6)
C(1)-C(12)	1.541(3)	N(2)-C(16)	1.315(8)
C(2)-H(2A)	0.9900	N(3)-H(3)	0.8800
C(2)-H(2B)	0.9900	N(3)-C(15)	1.369(8)
C(2)-C(3)	1.521(3)	N(3)-C(16)	1.345(9)
C(3)-H(3A)	0.9900	C(14)-H(14)	0.9500
C(3)-H(3B)	0.9900	C(14)-C(15)	1.361(7)
C(4)-H(4A)	0.9900	C(15)-H(15)	0.9500
C(4)-H(4B)	0.9900	C(16)-H(16)	0.9500

N(2A)-C(14A)	1.386(8)	C(6)-C(1)-C(12)	103.98(16)
N(2A)-C(16A)	1.324(11)	C(12)-C(1)-C(5)	111.54(17)
N(3A)-H(3E)	0.8800	C(1)-C(2)-H(2A)	109.4
N(3A)-C(15A)	1.372(11)	C(1)-C(2)-H(2B)	109.4
N(3A)-C(16A)	1.352(12)	H(2A)-C(2)-H(2B)	108.0
C(14A)-H(14A)	0.9500	C(3)-C(2)-C(1)	111.01(18)
C(14A)-C(15A)	1.364(11)	C(3)-C(2)-H(2A)	109.4
C(15A)-H(15A)	0.9500	C(3)-C(2)-H(2B)	109.4
C(16A)-H(16A)	0.9500	O(1)-C(3)-C(2)	111.09(17)
N(4)-C(18)	1.376(11)	O(1)-C(3)-H(3A)	109.4
N(4)-C(19)	1.324(10)	O(1)-C(3)-H(3B)	109.4
N(5)-H(5D)	0.80(5)	C(2)-C(3)-H(3A)	109.4
N(5)-C(17)	1.375(13)	C(2)-C(3)-H(3B)	109.4
N(5)-C(19)	1.347(10)	H(3A)-C(3)-H(3B)	108.0
C(17)-H(17)	0.9500	O(1)-C(4)-H(4A)	109.4
C(17)-C(18)	1.352(10)	O(1)-C(4)-H(4B)	109.4
C(18)-H(18)	0.9500	O(1)-C(4)-C(5)	111.08(17)
C(19)-H(19)	0.9500	H(4A)-C(4)-H(4B)	108.0
N(4A)-C(18A)	1.375(12)	C(5)-C(4)-H(4A)	109.4
N(4A)-C(19A)	1.337(11)	C(5)-C(4)-H(4B)	109.4
N(5A)-H(5K)	0.98(7)	C(1)-C(5)-H(5B)	109.3
N(5A)-C(17A)	1.378(13)	C(1)-C(5)-H(5C)	109.3
N(5A)-C(19A)	1.329(10)	C(4)-C(5)-C(1)	111.47(17)
C(17A)-H(17A)	0.9500	C(4)-C(5)-H(5B)	109.3
C(17A)-C(18A)	1.353(10)	C(4)-C(5)-H(5C)	109.3
C(18A)-H(18A)	0.9500	H(5B)-C(5)-H(5C)	108.0
C(19A)-H(19A)	0.9500	O(2)-C(6)-C(1)	115.91(17)
C(4)-O(1)-C(3)	111.32(17)	C(10)-C(6)-O(2)	121.20(18)
C(6)-O(2)-C(7)	119.42(16)	C(10)-C(6)-C(1)	122.88(18)
C(10)-O(4)-C(11)	117.61(17)	O(2)-C(7)-C(13)	111.76(18)
N(1)-O(5)-H(5)	109.5	C(8)-C(7)-O(2)	121.37(19)
N(1A)-O(5A)-H(5A)	109.5	C(8)-C(7)-C(13)	126.8(2)
C(11)-N(1)-O(5)	108.7(3)	C(7)-C(8)-H(8)	118.7
C(11)-N(1A)-O(5A)	101.9(6)	C(7)-C(8)-C(9)	122.6(2)
C(2)-C(1)-C(5)	108.40(17)	C(9)-C(8)-H(8)	118.7
C(2)-C(1)-C(12)	110.99(17)	O(3)-C(9)-C(8)	123.9(2)
C(6)-C(1)-C(2)	112.15(17)	O(3)-C(9)-C(10)	122.9(2)
C(6)-C(1)-C(5)	109.78(16)	C(8)-C(9)-C(10)	113.13(18)

O(4)-C(10)-C(9)	116.33(18)	C(16A)-N(3A)-C(15A)	108.5(11)
C(6)-C(10)-O(4)	121.45(19)	N(2A)-C(14A)-H(14A)	124.3
C(6)-C(10)-C(9)	122.20(19)	C(15A)-C(14A)-N(2A)	111.3(9)
O(4)-C(11)-C(12)	118.63(18)	C(15A)-C(14A)-H(14A)	124.3
N(1)-C(11)-O(4)	126.7(2)	N(3A)-C(15A)-H(15A)	128.0
N(1)-C(11)-C(12)	114.6(2)	C(14A)-C(15A)-N(3A)	104.0(10)
N(1A)-C(11)-O(4)	98.0(4)	C(14A)-C(15A)-H(15A)	128.0
N(1A)-C(11)-C(12)	143.4(4)	N(2A)-C(16A)-N(3A)	111.1(10)
C(1)-C(12)-H(12A)	109.2	N(2A)-C(16A)-H(16A)	124.4
C(1)-C(12)-H(12B)	109.2	N(3A)-C(16A)-H(16A)	124.4
C(11)-C(12)-C(1)	111.97(18)	C(19)-N(4)-C(18)	106.8(12)
C(11)-C(12)-H(12A)	109.2	C(17)-N(5)-H(5D)	131(4)
C(11)-C(12)-H(12B)	109.2	C(19)-N(5)-H(5D)	123(4)
H(12A)-C(12)-H(12B)	107.9	C(19)-N(5)-C(17)	105.7(16)
C(7)-C(13)-H(13A)	109.5	N(5)-C(17)-H(17)	125.8
C(7)-C(13)-H(13B)	109.5	C(18)-C(17)-N(5)	108(2)
C(7)-C(13)-H(13C)	109.5	C(18)-C(17)-H(17)	125.8
H(13A)-C(13)-H(13B)	109.5	N(4)-C(18)-H(18)	126.2
H(13A)-C(13)-H(13C)	109.5	C(17)-C(18)-N(4)	107.6(19)
H(13B)-C(13)-H(13C)	109.5	C(17)-C(18)-H(18)	126.2
C(16)-N(2)-C(14)	105.5(6)	N(4)-C(19)-N(5)	111.3(7)
C(15)-N(3)-H(3)	126.4	N(4)-C(19)-H(19)	124.3
C(16)-N(3)-H(3)	126.4	N(5)-C(19)-H(19)	124.3
C(16)-N(3)-C(15)	107.1(7)	C(19A)-N(4A)-C(18A)	105.6(16)
N(2)-C(14)-H(14)	125.3	C(17A)-N(5A)-H(5K)	127(5)
C(15)-C(14)-N(2)	109.4(6)	C(19A)-N(5A)-H(5K)	127(5)
C(15)-C(14)-H(14)	125.3	C(19A)-N(5A)-C(17A)	105.9(12)
N(3)-C(15)-H(15)	127.0	N(5A)-C(17A)-H(17A)	126.0
C(14)-C(15)-N(3)	106.1(7)	C(18A)-C(17A)-N(5A)	107.9(19)
C(14)-C(15)-H(15)	127.0	C(18A)-C(17A)-H(17A)	126.0
N(2)-C(16)-N(3)	111.6(7)	N(4A)-C(18A)-H(18A)	125.8
N(2)-C(16)-H(16)	124.2	C(17A)-C(18A)-N(4A)	108(2)
N(3)-C(16)-H(16)	124.2	C(17A)-C(18A)-H(18A)	125.8
C(16A)-N(2A)-C(14A)	104.3(9)	N(4A)-C(19A)-H(19A)	123.9
C(15A)-N(3A)-H(3E)	125.8	N(5A)-C(19A)-N(4A)	112.1(7)
C(16A)-N(3A)-H(3E)	125.8	N(5A)-C(19A)-H(19A)	123.9

Symmetry transformations used to generate equivalent atoms:

Table S32. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for **18b**. The anisotropic displacement factor exponent takes the form: $-2p^2[\ h^2\ a^{*2}U^{11} + ...\ + 2\ h\ k\ a^*\ b^*\ U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	24(1)	29(1)	29(1)	5(1)	4(1)	3(1)
O(2)	22(1)	17(1)	21(1)	-3(1)	2(1)	-1(1)
O(3)	34(1)	23(1)	37(1)	-2(1)	7(1)	7(1)
O(4)	37(1)	18(1)	26(1)	-7(1)	6(1)	-5(1)
O(5)	30(1)	20(1)	29(1)	-7(1)	0(1)	-4(1)
O(5A)	30(1)	20(1)	29(1)	-7(1)	0(1)	-4(1)
N(1)	27(2)	23(2)	21(1)	-3(1)	3(1)	-4(1)
N(1A)	27(2)	23(2)	21(1)	-3(1)	3(1)	-4(1)
C(1)	21(1)	23(1)	18(1)	-1(1)	1(1)	-1(1)
C(2)	27(1)	24(1)	28(1)	7(1)	3(1)	1(1)
C(3)	27(1)	33(1)	31(1)	11(1)	2(1)	4(1)
C(4)	25(1)	25(1)	23(1)	1(1)	3(1)	-2(1)
C(5)	25(1)	19(1)	19(1)	0(1)	2(1)	0(1)
C(6)	24(1)	18(1)	15(1)	-1(1)	2(1)	-1(1)
C(7)	21(1)	22(1)	20(1)	-1(1)	1(1)	-3(1)
C(8)	24(1)	24(1)	25(1)	0(1)	4(1)	-1(1)
C(9)	28(1)	21(1)	22(1)	2(1)	6(1)	3(1)
C(10)	29(1)	16(1)	18(1)	-2(1)	4(1)	-3(1)
C(11)	34(1)	32(1)	18(1)	-7(1)	6(1)	-14(1)
C(12)	27(1)	38(1)	18(1)	-4(1)	2(1)	-6(1)
C(13)	30(1)	21(1)	28(1)	-4(1)	3(1)	-4(1)
N(2)	28(4)	26(2)	29(2)	2(1)	-2(2)	-1(3)
N(3)	41(3)	21(1)	15(6)	-1(2)	-2(3)	4(1)
C(14)	35(6)	23(2)	32(3)	-1(2)	1(3)	2(3)
C(15)	23(5)	28(3)	37(2)	0(3)	-12(4)	4(3)
C(16)	32(5)	29(3)	25(3)	0(2)	-3(4)	2(3)
N(2A)	28(4)	26(2)	29(2)	2(1)	-2(2)	-1(3)
N(3A)	41(3)	21(1)	15(6)	-1(2)	-2(3)	4(1)
C(14A)	35(6)	23(2)	32(3)	-1(2)	1(3)	2(3)
C(15A)	23(5)	28(3)	37(2)	0(3)	-12(4)	4(3)
C(16A)	32(5)	29(3)	25(3)	0(2)	-3(4)	2(3)
N(4)	19(4)	22(1)	37(1)	3(1)	3(2)	3(1)

N(5)	19(4)	22(1)	37(1)	3(1)	3(2)	3(1)
C(17)	38(1)	22(5)	28(3)	5(4)	8(2)	2(2)
C(18)	37(2)	31(7)	31(7)	6(6)	0(5)	5(2)
C(19)	18(5)	21(1)	29(3)	3(3)	0(4)	3(5)
N(4A)	19(4)	22(1)	37(1)	3(1)	3(2)	3(1)
N(5A)	19(4)	22(1)	37(1)	3(1)	3(2)	3(1)
C(17A)	37(2)	31(7)	31(7)	6(6)	0(5)	5(2)
C(18A)	38(1)	22(5)	28(3)	5(4)	8(2)	2(2)
C(19A)	18(5)	21(1)	29(3)	3(3)	0(4)	3(5)

Table S33. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for **18b**.

	x	y	z	U(eq)
H(5)	6907	-989	2627	40
H(5A)	6217	-299	2526	40
H(2A)	6860	5944	4109	31
H(2B)	6764	5887	3344	31
H(3A)	5695	6339	3745	37
H(3B)	5660	4908	3357	37
H(4A)	5688	2783	3917	29
H(4B)	5753	2783	4683	29
H(5B)	6815	2166	4305	25
H(5C)	6896	3545	4730	25
H(8)	9605	4220	4098	29
H(12A)	6254	3041	3055	33
H(12B)	6888	3766	2762	33
H(13A)	8712	6749	4832	40
H(13B)	8876	7259	4140	40
H(13C)	9456	6486	4602	40
H(3)	4147	-61	3292	31
H(14)	4676	3468	2555	36
H(15)	5126	1148	2890	36

H(16)	3108	1236	3021	35
H(3E)	4132	-131	3118	31
H(14A)	4960	3163	2448	36
H(15A)	5262	893	2963	36
H(16A)	3250	1616	3005	35
H(5D)	2760(20)	390(40)	5080(20)	16(12)
H(17)	3327	1289	6100	35
H(18)	4565	922	6021	40
H(19)	3540	-281	4383	28
H(5K)	4860(40)	240(80)	5130(40)	60(20)
H(17A)	4513	1120	6177	40
H(18A)	3246	1093	6119	35
H(19A)	3786	-296	4468	28

Table S34. Torsion angles [°] for **18b**.

O(1)-C(4)-C(5)-C(1)	-56.4(2)	C(2)-C(1)-C(12)-C(11)	173.44(18)
O(2)-C(6)-C(10)-O(4)	-179.54(17)	C(3)-O(1)-C(4)-C(5)	61.3(2)
O(2)-C(6)-C(10)-C(9)	2.2(3)	C(4)-O(1)-C(3)-C(2)	-62.0(2)
O(2)-C(7)-C(8)-C(9)	2.0(3)	C(5)-C(1)-C(2)-C(3)	-51.4(2)
O(3)-C(9)-C(10)-O(4)	-0.1(3)	C(5)-C(1)-C(6)-O(2)	-96.5(2)
O(3)-C(9)-C(10)-C(6)	178.2(2)	C(5)-C(1)-C(6)-C(10)	84.3(2)
O(4)-C(11)-C(12)-C(1)	-40.8(3)	C(5)-C(1)-C(12)-C(11)	-65.6(2)
O(5)-N(1)-C(11)-O(4)	-0.6(4)	C(6)-O(2)-C(7)-C(8)	-1.4(3)
O(5)-N(1)-C(11)-C(12)	175.85(19)	C(6)-O(2)-C(7)-C(13)	177.22(17)
O(5A)-N(1A)-C(11)-O(4)	-178.9(5)	C(6)-C(1)-C(2)-C(3)	-172.79(17)
O(5A)-N(1A)-C(11)-C(12)	1.0(10)	C(6)-C(1)-C(5)-C(4)	173.91(17)
N(1)-C(11)-C(12)-C(1)	142.4(2)	C(6)-C(1)-C(12)-C(11)	52.7(2)
N(1A)-C(11)-C(12)-C(1)	139.3(6)	C(7)-O(2)-C(6)-C(1)	179.98(16)
C(1)-C(2)-C(3)-O(1)	57.6(2)	C(7)-O(2)-C(6)-C(10)	-0.7(3)
C(1)-C(6)-C(10)-O(4)	-0.3(3)	C(7)-C(8)-C(9)-O(3)	179.7(2)
C(1)-C(6)-C(10)-C(9)	-178.53(18)	C(7)-C(8)-C(9)-C(10)	-0.5(3)
C(2)-C(1)-C(5)-C(4)	51.1(2)	C(8)-C(9)-C(10)-O(4)	-179.87(17)
C(2)-C(1)-C(6)-O(2)	24.1(2)	C(8)-C(9)-C(10)-C(6)	-1.5(3)
C(2)-C(1)-C(6)-C(10)	-155.18(19)	C(10)-O(4)-C(11)-N(1)	179.2(2)

C(10)-O(4)-C(11)-N(1A)	-177.2(4)	C(14A)-N(2A)-C(16A)-N(3A)	-2(3)
C(10)-O(4)-C(11)-C(12)	2.8(3)	C(15A)-N(3A)-C(16A)-N(2A)	7(4)
C(11)-O(4)-C(10)-C(6)	19.2(3)	C(16A)-N(2A)-C(14A)-C(15A)	-3(2)
C(11)-O(4)-C(10)-C(9)	-162.41(18)	C(16A)-N(3A)-C(15A)-C(14A)	-9(3)
C(12)-C(1)-C(2)-C(3)	71.4(2)	N(5)-C(17)-C(18)-N(4)	1(6)
C(12)-C(1)-C(5)-C(4)	-71.4(2)	C(17)-N(5)-C(19)-N(4)	3(4)
C(12)-C(1)-C(6)-O(2)	144.10(17)	C(18)-N(4)-C(19)-N(5)	-2(3)
C(12)-C(1)-C(6)-C(10)	-35.2(3)	C(19)-N(4)-C(18)-C(17)	0(5)
C(13)-C(7)-C(8)-C(9)	-176.4(2)	C(19)-N(5)-C(17)-C(18)	-2(5)
N(2)-C(14)-C(15)-N(3)	-5(2)	N(5A)-C(17A)-C(18A)-N(4A)	-2(6)
C(14)-N(2)-C(16)-N(3)	2.9(18)	C(17A)-N(5A)-C(19A)-N(4A)	2(3)
C(15)-N(3)-C(16)-N(2)	-6(2)	C(18A)-N(4A)-C(19A)-N(5A)	-3(4)
C(16)-N(2)-C(14)-C(15)	1.2(15)	C(19A)-N(4A)-C(18A)-C(17A)	3(5)
C(16)-N(3)-C(15)-C(14)	6(2)	C(19A)-N(5A)-C(17A)-C(18A)	0(5)
N(2A)-C(14A)-C(15A)-N(3A)	8(3)		

Table S35. Hydrogen bonds for **18b** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(5)-H(5D)...N(5)#1	0.80(5)	1.83(5)	2.63(4)	174(5)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1/2,y,-z+1

8.6 Intermediate 14a

X-ray diffraction data were collected at 100K on a four-circle Rigaku Synergy S diffractometer equipped with a HyPix6000HE area-detector (kappa geometry, shutterless ω-scan technique), using monochromatized Cu K_α-radiation. The intensity data were integrated and corrected for absorption and decay by the CrysAlisPro program.[6] The structure was solved by direct methods using SHELXT[4] and refined on F^2 using SHELXL-2018[5] in the OLEX2 program.[7] All non-hydrogen atoms were refined with individual anisotropic displacement parameters. Location of amino hydrogen atom (H2) was found from the electron density-difference map; this hydrogen atom was refined with individual isotropic displacement parameters. All other hydrogen atoms were placed in ideal calculated positions and refined as riding atoms with relative isotropic displacement parameters.

Table S36. Crystal data and structure refinement for **14a**.

Identification code	**14a**	
Empirical formula	C30 H32 N4 O6	
Formula weight	544.59	
Temperature	100.0(2) K	
Wavelength	1.54184 Å	
Crystal system	Monoclinic	
Space group	P 2_1/n	
Unit cell dimensions	a = 19.3210(2) Å	□= 90°.
	b = 7.16745(8) Å	□= 110.0334(14)°.
	c = 20.9490(3) Å	□ = 90°.
Volume	2725.53(6) Å^3	
Z	4	
Density (calculated)	1.327 g/cm^3	
Absorption coefficient	0.768 mm^{-1}	
F(000)	1152	
Crystal size	0.16 x 0.04 x 0.02 mm^3	
Theta range for data collection	2.687 to 77.833°.	
Index ranges	-24<=h<=24, -7<=k<=9, -26<=l<=26	
Reflections collected	33634	

Independent reflections	5757 [R(int) = 0.0450]
Observed reflections	4980
Completeness to theta = 67.684°	100.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	1.00000 and 0.66569
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	5757 / 0 / 367
Goodness-of-fit on F^2	1.054
Final R indices [I>2sigma(I)]	R1 = 0.0413, wR2 = 0.1061
R indices (all data)	R1 = 0.0481, wR2 = 0.1108
Largest diff. peak and hole	0.416 and -0.241 e.Å^{-3}
CCDC	2270309

Table S37. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **14a**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	4830(1)	2143(1)	1949(1)	18(1)
O(2)	5931(1)	942(1)	3934(1)	25(1)
O(3)	4623(1)	2702(1)	3606(1)	18(1)
O(4)	4349(1)	51(1)	4067(1)	26(1)
O(5)	4450(1)	7826(1)	2327(1)	26(1)
O(6)	2198(1)	1690(2)	1678(1)	26(1)
N(1)	4806(1)	4796(2)	2617(1)	17(1)
N(2)	5514(1)	5120(2)	3075(1)	18(1)
N(3)	4252(1)	2947(2)	4501(1)	20(1)
N(4)	4095(1)	3851(2)	5452(1)	28(1)
C(1)	4542(1)	2920(2)	2448(1)	16(1)
C(2)	4777(1)	1672(2)	3082(1)	17(1)
C(3)	5596(1)	1156(2)	3326(1)	20(1)
C(4)	5889(1)	829(2)	2791(1)	22(1)
C(5)	5496(1)	1273(2)	2145(1)	20(1)

C(6)	5715(1)	864(2)	1544(1)	26(1)
C(7)	4411(1)	1713(2)	4048(1)	20(1)
C(8)	4204(1)	2415(2)	5117(1)	25(1)
C(9)	4065(1)	5397(2)	5041(1)	25(1)
C(10)	4169(1)	4879(2)	4460(1)	22(1)
C(11)	4332(1)	6161(2)	2258(1)	19(1)
C(12)	3671(1)	5169(2)	1773(1)	20(1)
C(13)	3697(1)	3184(2)	2063(1)	17(1)
C(14)	3247(1)	3119(2)	2544(1)	20(1)
C(15)	2422(1)	3193(2)	2147(1)	24(1)
C(16)	2557(1)	1829(2)	1189(1)	25(1)
C(17)	3390(1)	1681(2)	1512(1)	21(1)
C(18)	6058(1)	5772(2)	2829(1)	18(1)
C(19)	5986(1)	5731(2)	2144(1)	21(1)
C(20)	6562(1)	6339(2)	1942(1)	25(1)
C(21)	7211(1)	7015(2)	2413(1)	26(1)
C(22)	7281(1)	7042(2)	3096(1)	24(1)
C(23)	6715(1)	6418(2)	3306(1)	21(1)
C(24)	2705(1)	5676(3)	-195(1)	35(1)
C(25)	3017(1)	7372(3)	74(1)	40(1)
C(26)	3773(1)	7593(3)	312(1)	44(1)
C(27)	4215(1)	6099(3)	286(1)	46(1)
C(28)	3907(1)	4399(3)	26(1)	39(1)
C(29)	3136(1)	4167(2)	-225(1)	33(1)
C(30)	2783(1)	2360(3)	-521(1)	42(1)

Table S38. Bond lengths [Å] and angles [°] for **14a**.

O(1)-C(1)	1.4528(15)	O(6)-C(15)	1.4227(17)
O(1)-C(5)	1.3601(16)	O(6)-C(16)	1.4240(18)
O(2)-C(3)	1.2252(17)	N(1)-N(2)	1.3967(14)
O(3)-C(2)	1.4364(15)	N(1)-C(1)	1.4382(16)
O(3)-C(7)	1.3362(16)	N(1)-C(11)	1.3736(17)
O(4)-C(7)	1.1994(18)	N(2)-H(2)	0.87(2)
O(5)-C(11)	1.2139(17)	N(2)-C(18)	1.3994(17)

N(3)-C(7)	1.4069(18)	C(19)-H(19)	0.9500
N(3)-C(8)	1.3777(18)	C(19)-C(20)	1.390(2)
N(3)-C(10)	1.3936(19)	C(20)-H(20)	0.9500
N(4)-C(8)	1.303(2)	C(20)-C(21)	1.390(2)
N(4)-C(9)	1.392(2)	C(21)-H(21)	0.9500
C(1)-C(2)	1.5342(17)	C(21)-C(22)	1.390(2)
C(1)-C(13)	1.5668(17)	C(22)-H(22)	0.9500
C(2)-H(2A)	1.0000	C(22)-C(23)	1.384(2)
C(2)-C(3)	1.5328(18)	C(23)-H(23)	0.9500
C(3)-C(4)	1.436(2)	C(24)-H(24)	0.9500
C(4)-H(4)	0.9500	C(24)-C(25)	1.387(3)
C(4)-C(5)	1.3429(19)	C(24)-C(29)	1.379(3)
C(5)-C(6)	1.4880(19)	C(25)-H(25)	0.9500
C(6)-H(6A)	0.9800	C(25)-C(26)	1.383(3)
C(6)-H(6B)	0.9800	C(26)-H(26)	0.9500
C(6)-H(6C)	0.9800	C(26)-C(27)	1.381(3)
C(8)-H(8)	0.9500	C(27)-H(27)	0.9500
C(9)-H(9)	0.9500	C(27)-C(28)	1.383(3)
C(9)-C(10)	1.351(2)	C(28)-H(28)	0.9500
C(10)-H(10)	0.9500	C(28)-C(29)	1.409(2)
C(11)-C(12)	1.5109(18)	C(29)-C(30)	1.496(3)
C(12)-H(12A)	0.9900	C(30)-H(30A)	0.9800
C(12)-H(12B)	0.9900	C(30)-H(30B)	0.9800
C(12)-C(13)	1.5404(18)	C(30)-H(30C)	0.9800
C(13)-C(14)	1.5408(18)	C(5)-O(1)-C(1)	120.93(10)
C(13)-C(17)	1.5412(18)	C(7)-O(3)-C(2)	116.73(10)
C(14)-H(14A)	0.9900	C(15)-O(6)-C(16)	109.72(11)
C(14)-H(14B)	0.9900	N(2)-N(1)-C(1)	120.31(10)
C(14)-C(15)	1.5260(18)	C(11)-N(1)-N(2)	124.75(11)
C(15)-H(15A)	0.9900	C(11)-N(1)-C(1)	114.77(10)
C(15)-H(15B)	0.9900	N(1)-N(2)-H(2)	114.7(13)
C(16)-H(16A)	0.9900	N(1)-N(2)-C(18)	118.97(10)
C(16)-H(16B)	0.9900	C(18)-N(2)-H(2)	115.3(13)
C(16)-C(17)	1.5210(18)	C(8)-N(3)-C(7)	123.97(12)
C(17)-H(17A)	0.9900	C(8)-N(3)-C(10)	106.85(12)
C(17)-H(17B)	0.9900	C(10)-N(3)-C(7)	129.02(12)
C(18)-C(19)	1.3948(18)	C(8)-N(4)-C(9)	105.99(12)
C(18)-C(23)	1.3988(18)	O(1)-C(1)-C(2)	109.07(10)

O(1)-C(1)-C(13)	105.30(9)	O(5)-C(11)-N(1)	125.00(12)
N(1)-C(1)-O(1)	110.13(10)	O(5)-C(11)-C(12)	128.51(12)
N(1)-C(1)-C(2)	111.00(10)	N(1)-C(11)-C(12)	106.48(11)
N(1)-C(1)-C(13)	103.41(10)	C(11)-C(12)-H(12A)	110.7
C(2)-C(1)-C(13)	117.61(10)	C(11)-C(12)-H(12B)	110.7
O(3)-C(2)-C(1)	106.54(10)	C(11)-C(12)-C(13)	105.30(10)
O(3)-C(2)-H(2A)	109.2	H(12A)-C(12)-H(12B)	108.8
O(3)-C(2)-C(3)	109.27(10)	C(13)-C(12)-H(12A)	110.7
C(1)-C(2)-H(2A)	109.2	C(13)-C(12)-H(12B)	110.7
C(3)-C(2)-C(1)	113.22(11)	C(12)-C(13)-C(1)	101.67(10)
C(3)-C(2)-H(2A)	109.2	C(12)-C(13)-C(14)	109.64(11)
O(2)-C(3)-C(2)	119.56(12)	C(12)-C(13)-C(17)	113.48(11)
O(2)-C(3)-C(4)	125.63(13)	C(14)-C(13)-C(1)	112.41(10)
C(4)-C(3)-C(2)	114.63(11)	C(14)-C(13)-C(17)	108.11(11)
C(3)-C(4)-H(4)	119.7	C(17)-C(13)-C(1)	111.51(10)
C(5)-C(4)-C(3)	120.61(12)	C(13)-C(14)-H(14A)	109.4
C(5)-C(4)-H(4)	119.7	C(13)-C(14)-H(14B)	109.4
O(1)-C(5)-C(6)	110.43(11)	H(14A)-C(14)-H(14B)	108.0
C(4)-C(5)-O(1)	124.23(12)	C(15)-C(14)-C(13)	111.15(11)
C(4)-C(5)-C(6)	125.33(13)	C(15)-C(14)-H(14A)	109.4
C(5)-C(6)-H(6A)	109.5	C(15)-C(14)-H(14B)	109.4
C(5)-C(6)-H(6B)	109.5	O(6)-C(15)-C(14)	111.28(11)
C(5)-C(6)-H(6C)	109.5	O(6)-C(15)-H(15A)	109.4
H(6A)-C(6)-H(6B)	109.5	O(6)-C(15)-H(15B)	109.4
H(6A)-C(6)-H(6C)	109.5	C(14)-C(15)-H(15A)	109.4
H(6B)-C(6)-H(6C)	109.5	C(14)-C(15)-H(15B)	109.4
O(3)-C(7)-N(3)	108.92(11)	H(15A)-C(15)-H(15B)	108.0
O(4)-C(7)-O(3)	127.45(13)	O(6)-C(16)-H(16A)	109.2
O(4)-C(7)-N(3)	123.62(13)	O(6)-C(16)-H(16B)	109.2
N(3)-C(8)-H(8)	124.4	O(6)-C(16)-C(17)	112.12(11)
N(4)-C(8)-N(3)	111.16(13)	H(16A)-C(16)-H(16B)	107.9
N(4)-C(8)-H(8)	124.4	C(17)-C(16)-H(16A)	109.2
N(4)-C(9)-H(9)	124.7	C(17)-C(16)-H(16B)	109.2
C(10)-C(9)-N(4)	110.55(13)	C(13)-C(17)-H(17A)	109.4
C(10)-C(9)-H(9)	124.7	C(13)-C(17)-H(17B)	109.4
N(3)-C(10)-H(10)	127.3	C(16)-C(17)-C(13)	111.16(11)
C(9)-C(10)-N(3)	105.44(13)	C(16)-C(17)-H(17A)	109.4
C(9)-C(10)-H(10)	127.3	C(16)-C(17)-H(17B)	109.4

H(17A)-C(17)-H(17B)	108.0	C(24)-C(25)-H(25)	119.9
C(19)-C(18)-N(2)	123.33(12)	C(26)-C(25)-C(24)	120.30(18)
C(19)-C(18)-C(23)	119.23(12)	C(26)-C(25)-H(25)	119.9
C(23)-C(18)-N(2)	117.38(12)	C(25)-C(26)-H(26)	120.4
C(18)-C(19)-H(19)	120.1	C(27)-C(26)-C(25)	119.20(18)
C(20)-C(19)-C(18)	119.87(13)	C(27)-C(26)-H(26)	120.4
C(20)-C(19)-H(19)	120.1	C(26)-C(27)-H(27)	119.6
C(19)-C(20)-H(20)	119.5	C(26)-C(27)-C(28)	120.71(17)
C(19)-C(20)-C(21)	121.02(13)	C(28)-C(27)-H(27)	119.6
C(21)-C(20)-H(20)	119.5	C(27)-C(28)-H(28)	119.8
C(20)-C(21)-H(21)	120.6	C(27)-C(28)-C(29)	120.48(18)
C(20)-C(21)-C(22)	118.81(13)	C(29)-C(28)-H(28)	119.8
C(22)-C(21)-H(21)	120.6	C(24)-C(29)-C(28)	117.92(16)
C(21)-C(22)-H(22)	119.6	C(24)-C(29)-C(30)	120.08(16)
C(23)-C(22)-C(21)	120.83(13)	C(28)-C(29)-C(30)	122.00(17)
C(23)-C(22)-H(22)	119.6	C(29)-C(30)-H(30A)	109.5
C(18)-C(23)-H(23)	119.9	C(29)-C(30)-H(30B)	109.5
C(22)-C(23)-C(18)	120.22(13)	C(29)-C(30)-H(30C)	109.5
C(22)-C(23)-H(23)	119.9	H(30A)-C(30)-H(30B)	109.5
C(25)-C(24)-H(24)	119.3	H(30A)-C(30)-H(30C)	109.5
C(29)-C(24)-H(24)	119.3	H(30B)-C(30)-H(30C)	109.5
C(29)-C(24)-C(25)	121.39(16)		

Table S39. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for **14a**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2 a^{*2} U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	18(1)	21(1)	17(1)	-2(1)	6(1)	2(1)
O(2)	23(1)	27(1)	22(1)	5(1)	4(1)	2(1)
O(3)	21(1)	19(1)	16(1)	1(1)	7(1)	-1(1)
O(4)	33(1)	22(1)	26(1)	2(1)	12(1)	-3(1)
O(5)	29(1)	16(1)	31(1)	0(1)	6(1)	0(1)
O(6)	19(1)	31(1)	26(1)	-3(1)	6(1)	-6(1)

N(1)	15(1)	16(1)	17(1)	0(1)	3(1)	-2(1)
N(2)	16(1)	22(1)	14(1)	-2(1)	3(1)	-4(1)
N(3)	19(1)	25(1)	16(1)	1(1)	6(1)	1(1)
N(4)	26(1)	38(1)	21(1)	-2(1)	9(1)	0(1)
C(1)	17(1)	17(1)	16(1)	-2(1)	7(1)	-1(1)
C(2)	18(1)	17(1)	17(1)	-1(1)	7(1)	0(1)
C(3)	20(1)	16(1)	22(1)	4(1)	5(1)	-1(1)
C(4)	18(1)	20(1)	26(1)	1(1)	7(1)	2(1)
C(5)	17(1)	17(1)	26(1)	-2(1)	8(1)	-2(1)
C(6)	25(1)	30(1)	26(1)	-4(1)	12(1)	2(1)
C(7)	17(1)	24(1)	17(1)	2(1)	4(1)	0(1)
C(8)	25(1)	32(1)	19(1)	2(1)	8(1)	-2(1)
C(9)	18(1)	33(1)	22(1)	-4(1)	3(1)	3(1)
C(10)	18(1)	25(1)	20(1)	0(1)	3(1)	2(1)
C(11)	21(1)	18(1)	19(1)	1(1)	7(1)	0(1)
C(12)	18(1)	21(1)	20(1)	2(1)	4(1)	1(1)
C(13)	16(1)	18(1)	17(1)	0(1)	4(1)	0(1)
C(14)	18(1)	24(1)	19(1)	-1(1)	6(1)	0(1)
C(15)	18(1)	29(1)	25(1)	-2(1)	7(1)	-1(1)
C(16)	20(1)	31(1)	21(1)	-3(1)	4(1)	-4(1)
C(17)	19(1)	21(1)	20(1)	-3(1)	4(1)	-2(1)
C(18)	18(1)	16(1)	20(1)	0(1)	6(1)	1(1)
C(19)	22(1)	22(1)	19(1)	-1(1)	6(1)	-2(1)
C(20)	28(1)	26(1)	24(1)	2(1)	12(1)	1(1)
C(21)	22(1)	25(1)	35(1)	1(1)	15(1)	-1(1)
C(22)	17(1)	24(1)	30(1)	-2(1)	7(1)	-1(1)
C(23)	19(1)	21(1)	21(1)	-1(1)	4(1)	1(1)
C(24)	33(1)	38(1)	29(1)	9(1)	4(1)	1(1)
C(25)	46(1)	34(1)	35(1)	7(1)	6(1)	2(1)
C(26)	52(1)	42(1)	34(1)	2(1)	12(1)	-14(1)
C(27)	35(1)	71(1)	34(1)	4(1)	13(1)	-12(1)
C(28)	40(1)	51(1)	31(1)	5(1)	18(1)	5(1)
C(29)	40(1)	39(1)	24(1)	5(1)	14(1)	-2(1)
C(30)	54(1)	39(1)	36(1)	-1(1)	22(1)	-4(1)

Table S40. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **14a**.

	x	y	z	U(eq)
H(2)	5530(10)	5580(30)	3466(10)	32(5)
H(2A)	4475	505	2983	20
H(4)	6364	293	2895	26
H(6A)	5363	-12	1244	39
H(6B)	6209	310	1696	39
H(6C)	5718	2024	1298	39
H(8)	4245	1165	5276	30
H(9)	3982	6642	5153	30
H(10)	4183	5666	4100	26
H(12A)	3700	5128	1311	24
H(12B)	3209	5809	1752	24
H(14A)	3364	1957	2815	24
H(14B)	3386	4188	2862	24
H(15A)	2147	3135	2468	29
H(15B)	2300	4391	1898	29
H(16A)	2430	3039	949	29
H(16B)	2376	823	848	29
H(17A)	3618	1828	1157	25
H(17B)	3522	429	1718	25
H(19)	5543	5288	1815	26
H(20)	6512	6292	1475	30
H(21)	7600	7451	2271	31
H(22)	7723	7494	3424	29
H(23)	6774	6429	3775	25
H(24)	2184	5551	-362	42
H(25)	2708	8386	95	48
H(26)	3987	8758	491	52
H(27)	4735	6241	449	55
H(28)	4218	3380	16	47
H(30A)	2486	1894	-259	62
H(30B)	3166	1446	-505	62
H(30C)	2467	2556	-994	62

Table S41. Torsion angles [°] for **14a**.

O(1)-C(1)-C(2)-O(3)	167.55(9)	C(2)-O(3)-C(7)-N(3)	-177.23(10)
O(1)-C(1)-C(2)-C(3)	47.43(14)	C(2)-C(1)-C(13)-C(12)	149.17(11)
O(1)-C(1)-C(13)-C(12)	-89.14(11)	C(2)-C(1)-C(13)-C(14)	32.01(15)
O(1)-C(1)-C(13)-C(14)	153.70(10)	C(2)-C(1)-C(13)-C(17)	-89.58(13)
O(1)-C(1)-C(13)-C(17)	32.10(14)	C(2)-C(3)-C(4)-C(5)	11.00(19)
O(2)-C(3)-C(4)-C(5)	-173.76(14)	C(3)-C(4)-C(5)-O(1)	4.0(2)
O(3)-C(2)-C(3)-O(2)	28.68(17)	C(3)-C(4)-C(5)-C(6)	-174.89(13)
O(3)-C(2)-C(3)-C(4)	-155.77(11)	C(5)-O(1)-C(1)-N(1)	87.11(13)
O(5)-C(11)-C(12)-C(13)	-161.88(14)	C(5)-O(1)-C(1)-C(2)	-34.94(15)
O(6)-C(16)-C(17)-C(13)	-57.12(15)	C(5)-O(1)-C(1)-C(13)	-162.02(11)
N(1)-N(2)-C(18)-C(19)	-14.79(19)	C(7)-O(3)-C(2)-C(1)	146.02(10)
N(1)-N(2)-C(18)-C(23)	168.04(12)	C(7)-O(3)-C(2)-C(3)	-91.33(12)
N(1)-C(1)-C(2)-O(3)	46.04(13)	C(7)-N(3)-C(8)-N(4)	176.08(12)
N(1)-C(1)-C(2)-C(3)	-74.09(13)	C(7)-N(3)-C(10)-C(9)	-176.40(12)
N(1)-C(1)-C(13)-C(12)	26.46(12)	C(8)-N(3)-C(7)-O(3)	-162.53(12)
N(1)-C(1)-C(13)-C(14)	-90.70(12)	C(8)-N(3)-C(7)-O(4)	18.5(2)
N(1)-C(1)-C(13)-C(17)	147.70(11)	C(8)-N(3)-C(10)-C(9)	-0.94(14)
N(1)-C(11)-C(12)-C(13)	19.18(14)	C(8)-N(4)-C(9)-C(10)	-1.03(16)
N(2)-N(1)-C(1)-O(1)	-79.95(13)	C(9)-N(4)-C(8)-N(3)	0.40(16)
N(2)-N(1)-C(1)-C(2)	40.94(15)	C(10)-N(3)-C(7)-O(3)	12.23(18)
N(2)-N(1)-C(1)-C(13)	167.95(10)	C(10)-N(3)-C(7)-O(4)	-166.77(13)
N(2)-N(1)-C(11)-O(5)	-5.1(2)	C(10)-N(3)-C(8)-N(4)	0.34(16)
N(2)-N(1)-C(11)-C(12)	173.90(11)	C(11)-N(1)-N(2)-C(18)	-67.72(17)
N(2)-C(18)-C(19)-C(20)	-177.50(13)	C(11)-N(1)-C(1)-O(1)	95.57(12)
N(2)-C(18)-C(23)-C(22)	178.50(13)	C(11)-N(1)-C(1)-C(2)	-143.54(11)
N(4)-C(9)-C(10)-N(3)	1.21(15)	C(11)-N(1)-C(1)-C(13)	-16.54(14)
C(1)-O(1)-C(5)-C(4)	9.56(19)	C(11)-C(12)-C(13)-C(1)	-27.74(13)
C(1)-O(1)-C(5)-C(6)	-171.40(11)	C(11)-C(12)-C(13)-C(14)	91.41(12)
C(1)-N(1)-N(2)-C(18)	107.32(14)	C(11)-C(12)-C(13)-C(17)	-147.60(11)
C(1)-N(1)-C(11)-O(5)	179.63(13)	C(12)-C(13)-C(14)-C(15)	73.14(14)
C(1)-N(1)-C(11)-C(12)	-1.38(15)	C(12)-C(13)-C(17)-C(16)	-71.58(15)
C(1)-C(2)-C(3)-O(2)	147.24(12)	C(13)-C(1)-C(2)-O(3)	-72.72(13)
C(1)-C(2)-C(3)-C(4)	-37.21(16)	C(13)-C(1)-C(2)-C(3)	167.15(11)
C(1)-C(13)-C(14)-C(15)	-174.55(11)	C(13)-C(14)-C(15)-O(6)	58.42(15)
C(1)-C(13)-C(17)-C(16)	174.32(11)	C(14)-C(13)-C(17)-C(16)	50.26(14)
C(2)-O(3)-C(7)-O(4)	1.73(19)	C(15)-O(6)-C(16)-C(17)	62.27(15)

C(16)-O(6)-C(15)-C(14)	-62.61(14)	C(24)-C(25)-C(26)-C(27)	-0.8(3)
C(17)-C(13)-C(14)-C(15)	-51.04(14)	C(25)-C(24)-C(29)-C(28)	-0.1(2)
C(18)-C(19)-C(20)-C(21)	-0.8(2)	C(25)-C(24)-C(29)-C(30)	-179.71(15)
C(19)-C(18)-C(23)-C(22)	1.2(2)	C(25)-C(26)-C(27)-C(28)	0.0(3)
C(19)-C(20)-C(21)-C(22)	1.2(2)	C(26)-C(27)-C(28)-C(29)	0.8(3)
C(20)-C(21)-C(22)-C(23)	-0.4(2)	C(27)-C(28)-C(29)-C(24)	-0.7(2)
C(21)-C(22)-C(23)-C(18)	-0.8(2)	C(27)-C(28)-C(29)-C(30)	178.89(16)
C(23)-C(18)-C(19)-C(20)	-0.4(2)	C(29)-C(24)-C(25)-C(26)	0.9(3)

8.7 Compound 19

X-ray diffraction data were collected at 100K on a four-circle Rigaku Synergy S diffractometer equipped with a HyPix6000HE area-detector (kappa geometry, shutterless ω-scan technique), using graphite monochromatized Cu K_α-radiation. The intensity data were integrated and corrected for absorption and decay by the CrysAlisPro program.[6] The structure was solved by direct methods using SHELXT[4] and refined on F^2 using SHELXL-2018[5] in the OLEX2 program.[7] All non-hydrogen atoms were refined with individual anisotropic displacement parameters. Locations of amino hydrogen atoms (H1A, H1B, H2A and H2B) were found from the electron density-difference map; these hydrogen atoms were refined with individual isotropic displacement parameters. All other hydrogen atoms were placed in ideal calculated positions and refined as riding atoms with relative isotropic displacement parameters.

Table S42. Crystal data and structure refinement for **19**.

Identification code	**19**	
Empirical formula	C19 H20 N2 O4	
Formula weight	340.37	
Temperature	100.00(10) K	
Wavelength	1.54184 Å	
Crystal system	Monoclinic	
Space group	$P2_1/c$	
Unit cell dimensions	a = 9.80840(10) Å	a= 90°.
	b = 14.35350(10) Å	b= 108.4030(10)°.
	c = 12.24630(10) Å	g = 90°.
Volume	1635.92(3) $Å^3$	
Z	4	
Density (calculated)	1.382 Mg/m^3	
Absorption coefficient	0.803 mm^{-1}	
F(000)	720	
Crystal size	0.5 x 0.3 x 0.2 mm^3	
Theta range for data collection	4.751 to 77.731°.	
Index ranges	-12<=h<=11, -18<=k<=18, -15<=l<=15	
Reflections collected	41248	
Independent reflections	3480 [R(int) = 0.0322]	
Completeness to theta = 67.684°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	1.00000 and 0.69322	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3480 / 0 / 234	
Goodness-of-fit on F^2	1.061	
Final R indices [I>2sigma(I)]	R1 = 0.0369, wR2 = 0.0938	
R indices (all data)	R1 = 0.0377, wR2 = 0.0944	
Largest diff. peak and hole	0.225 and -0.219 $e.Å^{-3}$	
CCDC	2270313	

Table S43. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$ x 10^3) for **19**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	875(1)	5959(1)	4834(1)	27(1)
O(2)	5611(1)	3570(1)	7430(1)	21(1)
O(3)	5198(1)	5749(1)	8706(1)	27(1)
O(4)	7471(1)	2865(1)	8731(1)	31(1)
N(1)	2785(1)	5316(1)	6219(1)	19(1)
N(2)	2780(1)	5995(1)	7048(1)	20(1)
C(1)	1782(1)	5355(1)	5127(1)	21(1)
C(2)	2095(1)	4552(1)	4460(1)	24(1)
C(3)	3251(1)	3947(1)	5323(1)	18(1)
C(4)	3733(1)	4565(1)	6402(1)	18(1)
C(5)	2594(1)	3032(1)	5592(1)	23(1)
C(6)	2095(1)	2393(1)	4534(1)	28(1)
C(7)	3294(1)	2208(1)	4011(1)	27(1)
C(8)	3931(1)	3118(1)	3746(1)	23(1)
C(9)	4480(1)	3716(1)	4833(1)	21(1)
C(10)	4854(1)	4408(1)	7364(1)	18(1)
C(11)	5546(1)	4908(1)	8437(1)	21(1)
C(12)	6638(1)	4380(1)	9102(1)	23(1)
C(13)	6689(1)	3542(1)	8492(1)	23(1)
C(14)	1680(1)	5867(1)	7590(1)	20(1)
C(15)	1293(1)	6651(1)	8094(1)	24(1)
C(16)	290(1)	6562(1)	8675(1)	28(1)
C(17)	-317(1)	5702(1)	8750(1)	28(1)
C(18)	96(1)	4922(1)	8262(1)	25(1)
C(19)	1105(1)	5000(1)	7681(1)	22(1)

Table S44. Bond lengths [Å] and angles [°] for **19**.

O(1)-C(1)	1.2113(14)	C(12)-C(13)	1.4262(16)
O(2)-C(10)	1.4019(13)	C(14)-C(15)	1.3929(16)
O(2)-C(13)	1.3938(14)	C(14)-C(19)	1.3855(16)
O(3)-H(3)	0.95(2)	C(15)-H(15)	0.9500
O(3)-C(11)	1.3241(14)	C(15)-C(16)	1.3902(17)
O(4)-C(13)	1.2142(15)	C(16)-H(16)	0.9500
N(1)-N(2)	1.4078(13)	C(16)-C(17)	1.3852(19)
N(1)-C(1)	1.3886(15)	C(17)-H(17)	0.9500
N(1)-C(4)	1.3949(14)	C(17)-C(18)	1.3891(18)
N(2)-H(2)	0.916(17)	C(18)-H(18)	0.9500
N(2)-C(14)	1.4458(14)	C(18)-C(19)	1.3940(16)
C(1)-C(2)	1.4997(16)	C(19)-H(19)	0.9500
C(2)-H(2A)	0.9900	C(13)-O(2)-C(10)	108.12(9)
C(2)-H(2B)	0.9900	C(11)-O(3)-H(3)	106.5(13)
C(2)-C(3)	1.5499(16)	C(1)-N(1)-N(2)	120.22(9)
C(3)-C(4)	1.5373(15)	C(1)-N(1)-C(4)	114.86(9)
C(3)-C(5)	1.5443(15)	C(4)-N(1)-N(2)	124.91(9)
C(3)-C(9)	1.5423(15)	N(1)-N(2)-H(2)	108.2(10)
C(4)-C(10)	1.3524(16)	N(1)-N(2)-C(14)	114.66(9)
C(5)-H(5A)	0.9900	C(14)-N(2)-H(2)	109.3(10)
C(5)-H(5B)	0.9900	O(1)-C(1)-N(1)	123.00(11)
C(5)-C(6)	1.5360(16)	O(1)-C(1)-C(2)	130.21(11)
C(6)-H(6A)	0.9900	N(1)-C(1)-C(2)	106.77(9)
C(6)-H(6B)	0.9900	C(1)-C(2)-H(2A)	110.3
C(6)-C(7)	1.5291(17)	C(1)-C(2)-H(2B)	110.3
C(7)-H(7A)	0.9900	C(1)-C(2)-C(3)	106.90(9)
C(7)-H(7B)	0.9900	H(2A)-C(2)-H(2B)	108.6
C(7)-C(8)	1.5259(16)	C(3)-C(2)-H(2A)	110.3
C(8)-H(8A)	0.9900	C(3)-C(2)-H(2B)	110.3
C(8)-H(8B)	0.9900	C(4)-C(3)-C(2)	102.90(9)
C(8)-C(9)	1.5319(16)	C(4)-C(3)-C(5)	110.06(9)
C(9)-H(9A)	0.9900	C(4)-C(3)-C(9)	113.12(9)
C(9)-H(9B)	0.9900	C(5)-C(3)-C(2)	110.95(9)
C(10)-C(11)	1.4631(15)	C(9)-C(3)-C(2)	110.38(9)
C(11)-C(12)	1.3538(17)	C(9)-C(3)-C(5)	109.31(9)
C(12)-H(12)	0.9500	N(1)-C(4)-C(3)	107.39(9)

C(10)-C(4)-N(1)	125.93(10)	H(9A)-C(9)-H(9B)	108.1
C(10)-C(4)-C(3)	126.67(10)	O(2)-C(10)-C(11)	106.41(9)
C(3)-C(5)-H(5A)	109.3	C(4)-C(10)-O(2)	117.61(10)
C(3)-C(5)-H(5B)	109.3	C(4)-C(10)-C(11)	135.98(10)
H(5A)-C(5)-H(5B)	107.9	O(3)-C(11)-C(10)	126.02(10)
C(6)-C(5)-C(3)	111.75(9)	O(3)-C(11)-C(12)	125.32(11)
C(6)-C(5)-H(5A)	109.3	C(12)-C(11)-C(10)	108.63(10)
C(6)-C(5)-H(5B)	109.3	C(11)-C(12)-H(12)	126.0
C(5)-C(6)-H(6A)	109.2	C(11)-C(12)-C(13)	108.06(10)
C(5)-C(6)-H(6B)	109.2	C(13)-C(12)-H(12)	126.0
H(6A)-C(6)-H(6B)	107.9	O(2)-C(13)-C(12)	108.77(10)
C(7)-C(6)-C(5)	112.04(10)	O(4)-C(13)-O(2)	118.94(11)
C(7)-C(6)-H(6A)	109.2	O(4)-C(13)-C(12)	132.29(11)
C(7)-C(6)-H(6B)	109.2	C(15)-C(14)-N(2)	116.69(10)
C(6)-C(7)-H(7A)	109.4	C(19)-C(14)-N(2)	122.16(10)
C(6)-C(7)-H(7B)	109.4	C(19)-C(14)-C(15)	120.99(10)
H(7A)-C(7)-H(7B)	108.0	C(14)-C(15)-H(15)	120.4
C(8)-C(7)-C(6)	111.19(10)	C(16)-C(15)-C(14)	119.26(12)
C(8)-C(7)-H(7A)	109.4	C(16)-C(15)-H(15)	120.4
C(8)-C(7)-H(7B)	109.4	C(15)-C(16)-H(16)	119.9
C(7)-C(8)-H(8A)	109.6	C(17)-C(16)-C(15)	120.26(11)
C(7)-C(8)-H(8B)	109.6	C(17)-C(16)-H(16)	119.9
C(7)-C(8)-C(9)	110.48(9)	C(16)-C(17)-H(17)	120.0
H(8A)-C(8)-H(8B)	108.1	C(16)-C(17)-C(18)	120.04(11)
C(9)-C(8)-H(8A)	109.6	C(18)-C(17)-H(17)	120.0
C(9)-C(8)-H(8B)	109.6	C(17)-C(18)-H(18)	119.8
C(3)-C(9)-H(9A)	109.5	C(17)-C(18)-C(19)	120.30(12)
C(3)-C(9)-H(9B)	109.5	C(19)-C(18)-H(18)	119.8
C(8)-C(9)-C(3)	110.82(9)	C(14)-C(19)-C(18)	119.12(11)
C(8)-C(9)-H(9A)	109.5	C(14)-C(19)-H(19)	120.4
C(8)-C(9)-H(9B)	109.5	C(18)-C(19)-H(19)	120.4

Symmetry transformations used to generate equivalent atoms:

Table S45. Anisotropic displacement parameters ($Å^2$ x 10^3) for **19**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2} U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	25(1)	27(1)	27(1)	0(1)	5(1)	7(1)
O(2)	21(1)	20(1)	21(1)	-2(1)	3(1)	2(1)
O(3)	26(1)	24(1)	27(1)	-7(1)	4(1)	4(1)
O(4)	29(1)	23(1)	33(1)	-2(1)	0(1)	6(1)
N(1)	19(1)	20(1)	19(1)	-2(1)	8(1)	1(1)
N(2)	22(1)	18(1)	22(1)	-2(1)	10(1)	1(1)
C(1)	20(1)	24(1)	21(1)	1(1)	7(1)	0(1)
C(2)	25(1)	27(1)	20(1)	-2(1)	5(1)	5(1)
C(3)	18(1)	20(1)	18(1)	-1(1)	7(1)	0(1)
C(4)	18(1)	18(1)	20(1)	0(1)	10(1)	-1(1)
C(5)	25(1)	25(1)	21(1)	-2(1)	11(1)	-6(1)
C(6)	34(1)	27(1)	25(1)	-4(1)	11(1)	-11(1)
C(7)	38(1)	22(1)	23(1)	-4(1)	11(1)	-2(1)
C(8)	27(1)	23(1)	21(1)	-1(1)	11(1)	1(1)
C(9)	21(1)	23(1)	23(1)	-2(1)	11(1)	-2(1)
C(10)	19(1)	17(1)	21(1)	0(1)	8(1)	0(1)
C(11)	20(1)	21(1)	22(1)	-2(1)	9(1)	-2(1)
C(12)	21(1)	24(1)	22(1)	-2(1)	4(1)	-2(1)
C(13)	20(1)	24(1)	22(1)	1(1)	3(1)	-1(1)
C(14)	19(1)	24(1)	18(1)	1(1)	6(1)	3(1)
C(15)	25(1)	24(1)	24(1)	0(1)	9(1)	3(1)
C(16)	28(1)	33(1)	25(1)	-1(1)	11(1)	9(1)
C(17)	23(1)	40(1)	22(1)	3(1)	10(1)	5(1)
C(18)	22(1)	32(1)	22(1)	4(1)	6(1)	-1(1)
C(19)	22(1)	24(1)	21(1)	0(1)	7(1)	2(1)

Table S46. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$ x 10^3) for **19**.

	x	y	z	U(eq)
H(3)	4330(20)	5913(15)	8131(19)	62(6)
H(2)	2669(17)	6567(12)	6701(14)	32(4)
H(2A)	2456	4781	3839	29
H(2B)	1213	4183	4107	29
H(5A)	3317	2701	6223	27
H(5B)	1764	3180	5858	27
H(6A)	1765	1793	4760	33
H(6B)	1271	2686	3947	33
H(7A)	4060	1835	4555	32
H(7B)	2905	1844	3293	32
H(8A)	3189	3466	3147	27
H(8B)	4734	2979	3444	27
H(9A)	4893	4302	4647	25
H(9B)	5249	3377	5419	25
H(12)	7260	4541	9844	28
H(15)	1710	7240	8042	29
H(16)	19	7092	9022	33
H(17)	-1015	5647	9135	33
H(18)	-311	4331	8325	30
H(19)	1395	4466	7352	27

Table S47. Torsion angles [°] for **19**.

O(1)-C(1)-C(2)-C(3)	-173.18(12)	C(4)-N(1)-C(1)-O(1)	179.28(10)
O(2)-C(10)-C(11)-O(3)	177.17(10)	C(4)-N(1)-C(1)-C(2)	-1.88(13)
O(2)-C(10)-C(11)-C(12)	-0.92(12)	C(4)-C(3)-C(5)-C(6)	179.95(10)
O(3)-C(11)-C(12)-C(13)	-177.90(11)	C(4)-C(3)-C(9)-C(8)	-178.76(9)
N(1)-N(2)-C(14)-C(15)	-158.36(10)	C(4)-C(10)-C(11)-O(3)	-2.9(2)
N(1)-N(2)-C(14)-C(19)	26.13(15)	C(4)-C(10)-C(11)-C(12)	179.05(13)
N(1)-C(1)-C(2)-C(3)	8.09(12)	C(5)-C(3)-C(4)-N(1)	-108.69(10)
N(1)-C(4)-C(10)-O(2)	174.49(9)	C(5)-C(3)-C(4)-C(10)	70.31(14)
N(1)-C(4)-C(10)-C(11)	-5.5(2)	C(5)-C(3)-C(9)-C(8)	58.22(12)
N(2)-N(1)-C(1)-O(1)	0.25(17)	C(5)-C(6)-C(7)-C(8)	-53.88(14)
N(2)-N(1)-C(1)-C(2)	179.10(9)	C(6)-C(7)-C(8)-C(9)	56.49(13)
N(2)-N(1)-C(4)-C(3)	173.75(9)	C(7)-C(8)-C(9)-C(3)	-59.37(13)
N(2)-N(1)-C(4)-C(10)	-5.26(17)	C(9)-C(3)-C(4)-N(1)	128.71(10)
N(2)-C(14)-C(15)-C(16)	-177.02(10)	C(9)-C(3)-C(4)-C(10)	-52.29(15)
N(2)-C(14)-C(19)-C(18)	177.04(10)	C(9)-C(3)-C(5)-C(6)	-55.24(12)
C(1)-N(1)-N(2)-C(14)	77.66(13)	C(10)-O(2)-C(13)-O(4)	179.35(10)
C(1)-N(1)-C(4)-C(3)	-5.22(12)	C(10)-O(2)-C(13)-C(12)	-1.18(12)
C(1)-N(1)-C(4)-C(10)	175.77(10)	C(10)-C(11)-C(12)-C(13)	0.21(13)
C(1)-C(2)-C(3)-C(4)	-10.63(11)	C(11)-C(12)-C(13)-O(2)	0.60(13)
C(1)-C(2)-C(3)-C(5)	107.04(11)	C(11)-C(12)-C(13)-O(4)	179.97(13)
C(1)-C(2)-C(3)-C(9)	-131.62(10)	C(13)-O(2)-C(10)-C(4)	-178.71(10)
C(2)-C(3)-C(4)-N(1)	9.61(11)	C(13)-O(2)-C(10)-C(11)	1.28(11)
C(2)-C(3)-C(4)-C(10)	-171.39(11)	C(14)-C(15)-C(16)-C(17)	-0.02(18)
C(2)-C(3)-C(5)-C(6)	66.72(12)	C(15)-C(14)-C(19)-C(18)	1.72(17)
C(2)-C(3)-C(9)-C(8)	-64.08(12)	C(15)-C(16)-C(17)-C(18)	1.20(19)
C(3)-C(4)-C(10)-O(2)	-4.33(16)	C(16)-C(17)-C(18)-C(19)	-0.92(18)
C(3)-C(4)-C(10)-C(11)	175.69(11)	C(17)-C(18)-C(19)-C(14)	-0.52(18)
C(3)-C(5)-C(6)-C(7)	53.73(14)	C(19)-C(14)-C(15)-C(16)	-1.46(18)
C(4)-N(1)-N(2)-C(14)	-101.26(12)		

Symmetry transformations used to generate equivalent atoms:

Table S48. Hydrogen bonds for **19** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(3)-H(3)...N(1)	0.95(2)	2.50(2)	3.2729(13)	138.2(17)
O(3)-H(3)...N(2)	0.95(2)	1.68(2)	2.6136(13)	169(2)
N(2)-H(2)...O(4)#1	0.916(17)	1.929(17)	2.8335(13)	168.9(15)

Symmetry transformations used to generate equivalent atoms:
#1 -x+1,y+1/2,-z+3/2

9. References

1. C. V. Milyutin, R. D. Galimova, A. N. Komogortsev, B. V. Lichitskii, V. G. Melekhina, V. A. Migulin, A. N. Fakhrutdinov and M. E. Minyaev. Photoinduced assembly of the 3,4,4a,7a-tetrahydro-1*H*-cyclopenta[*b*]pyridione-2,7-dione core on the basic of allomaltol derivatives. *Org. Biomol. Chem.* 2021, **19**, 9975-9985
2. Bruker. APEX-III. *Bruker AXS Inc.*, Madison, Wisconsin, USA, 2019.
3. L. Krause, R. Herbst-Irmer, G. M. Sheldrick and D. Stalke, Comparison of silver and molybdenum microfocus X-ray sources for single-crystal structure determination. *J. Appl. Cryst.* 2015, **48**, 3–10.
4. G. M. Sheldrick, SHELXT - Integrated space-group and crystal-structure determination. *Acta Cryst.* 2015, **A71**, 3-8.
5. G. M. Sheldrick, Crystal structure refinement with SHELXL. *Acta Cryst.* 2015, **C71**, 3-8.
6. CrysAlisPro. Version 1.171.41.106a. *Rigaku Oxford Diffraction*, 2021.
7. O. V. Dolomanov, L.J. Bourhis, R.J. Gildea, J.A.K. Howard and H. Puschmann OLEX2: a complete structure solution, refinement and analysis program. *J. Appl. Cryst.* 2009, **42**, 2, 229-341.
8. C. F. Macrae, I. Sovago, S. J. Cottrell, P. T. A. Galek, P. McCabe, E. Pidcock, M. Platings, G. P. Shields, J. S. Stevens, M. Towler and P. A. Wood, Mercury 4.0: from visualization to analysis, design and prediction. *J. Appl. Cryst.* 2020, **53**, 226-235.