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Supporting Information

Domino Reaction of Bindone and 1,3-Dipolarophiles for Synthesis of Diverse Spiro and Fused Indeno[1,2-*a*]fluorenes

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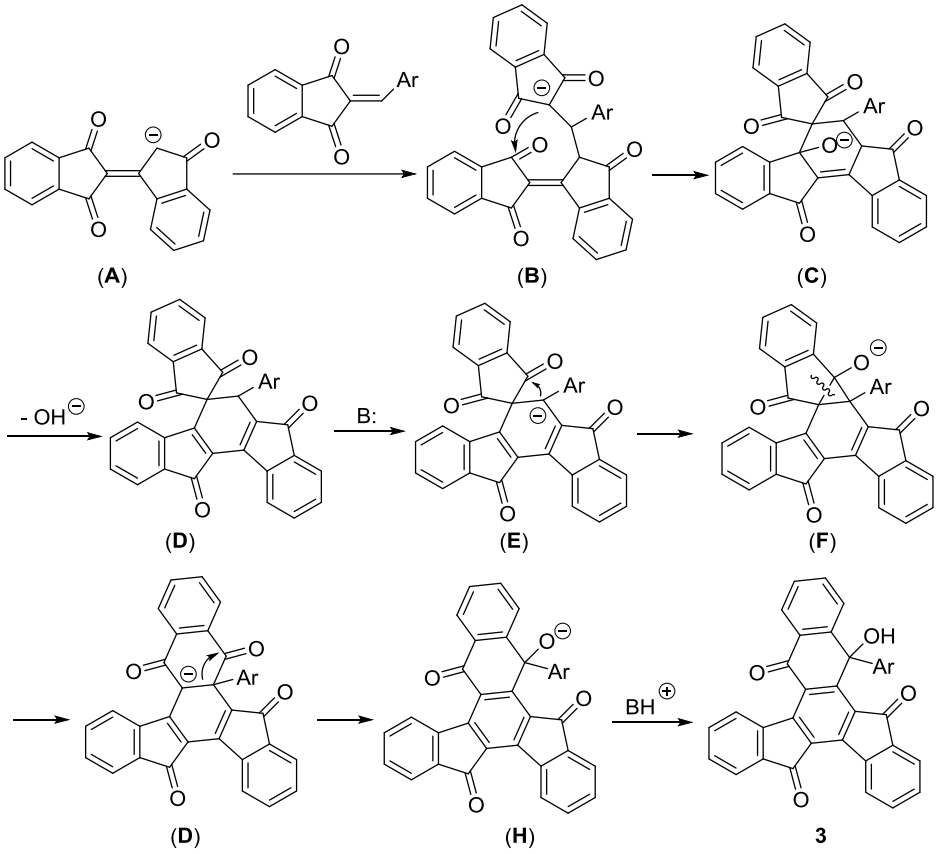
Table of Contents



Scheme s1 Proposed reaction mechanism for the compounds **7**

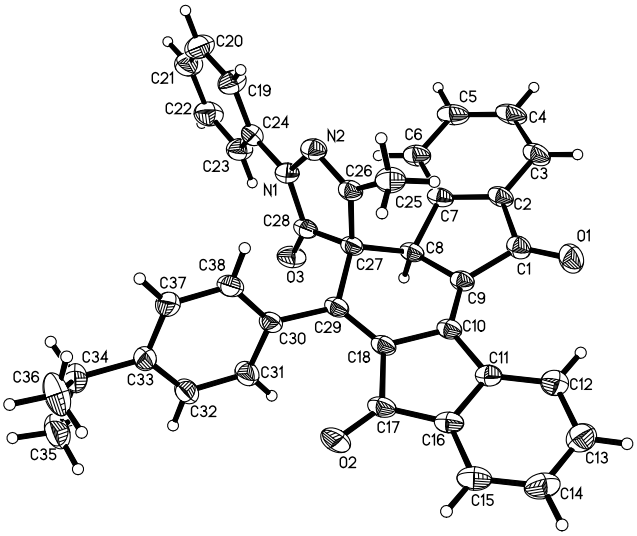


Fig. s1 ORTEP drawing (30%) of the crystal structure of **5e**

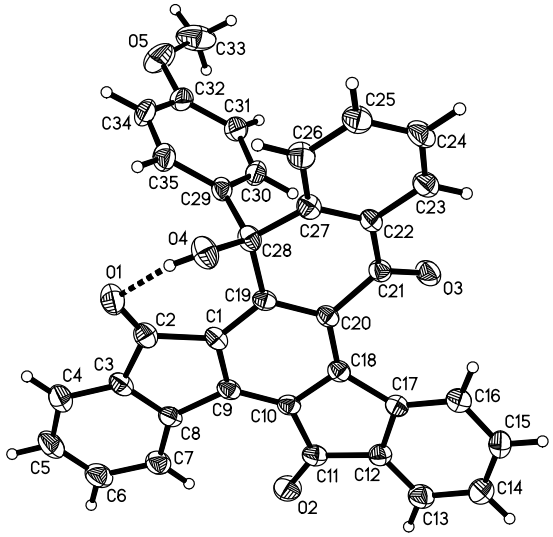


Fig. s2 ORTEP drawing (30%) of the crystal structure of **7b**

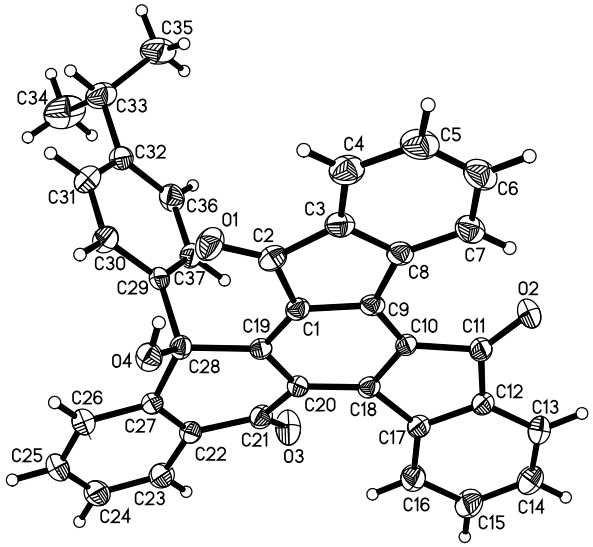


Fig. s3 ORTEP drawing (30%) of the crystal structure of **7g**

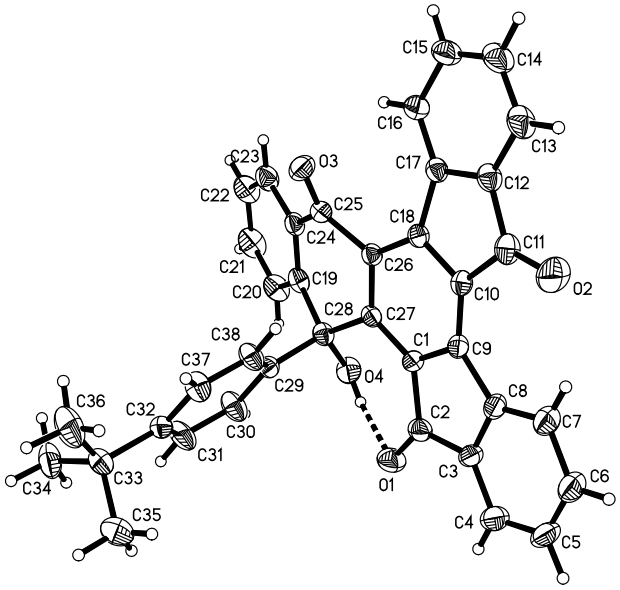


Fig. s4 ORTEP drawing (30%) of the crystal structure of **7h**

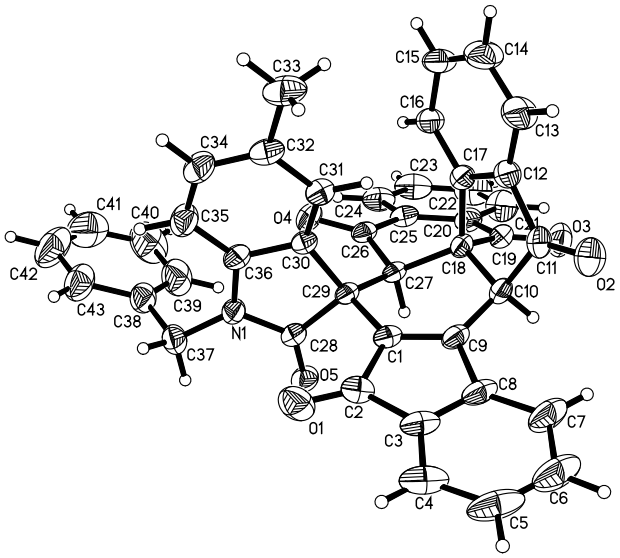


Fig. s5 ORTEP drawing (30%) of the crystal structure of **8b**

Table S1 The single crystal date of compounds **3b, 5a, 5e**

Phase	**3b**	**5a**	**5e**
Empirical formula	$C_{37}H_{23}N_3O_4$	$C_{35}H_{22}N_2O_3$	$C_{38}H_{28}N_2O_3$
Formula weight	573.58	518.54	560.62
Temperature/K	296(2) K	296(2) K	296(2) K
Wavelength/ Å	0.71073	0.71073	0.71073
Crystal system	Orthorhombic	Monoclinic	Monoclinic
Space group	Pbca	P2(1)	P2(1)
a /Å	17.4162(16)	10.5877(14)	9.7066(6)
b / Å	11.9045(11)	12.8107(16)	12.5713(7)
c / Å	34.111(3)	18.985(3)	23.8206(14)
α (°)	90	90	90
β (°)	90	91.436(5)	100.881(2)
γ (°)	90	90	90
V (Å ^{3})	7072.2(11)	2574.2(6)	2854.4(3)
Z	8	4	4
Calculated density (g·cm^{-3})	1.077	1.338	1.305
Absorption coefficient (mm^{-1})	0.071	0.086	0.083
F(000)	2384	1080	1176
θ range / (°)	2.157 to 25.998	2.146 to 25.992	2.137 to 25.998
Limiting indices	-21<=h<=18, -14<=k<=12, -42<=l<=42	-13<=h<=12, -13<=k<=15, -23<=l<=23	-11<=h<=10, -15<=k<=15, -28<=l<=29
Reflections collected/unique	55584 / 6945 [R(int) = 0.1433]	21391 / 5023 [R(int) = 0.0377]	27056 / 5589 [R(int) = 0.0436]
Completeness to theta	99.8 %	99.2 %	99.6 %
Max. and min. transmission	0.7456 and 0.6451	0.7456 and 0.6747	0.7455 and 0.6107
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data/restraints/parameters	6945 / 7 / 399	5023 / 0 / 362	5589 / 0 / 391
Goodness-of-fit on F^2	1.023	1.034	1.026
Final *R* indices[I>2sigma(I)]	R1 = 0.0859, wR2 = 0.2212	R1 = 0.0465, wR2 = 0.0943	R1 = 0.0469, wR2 = 0.1061
R indices (all data)	R1 = 0.1964, wR2 = 0.2761	R1 = 0.0820, wR2 = 0.1090	R1 = 0.0807, wR2 = 0.1197
Largest diff. peak and hole /(e ·Å^{-3})	0.279 and -0.164	0.202 and -0.167	0.177 and -0.156

Table S2 The single crystal date of compounds **7a, 7b, 7g**

Phase	**7a**	**7b**	**7g**
Empirical formula	$C_{35}H_{20}O_4$	$C_{35}H_{20}O_5$	$C_{37}H_{24}O_4$
Formula weight	504.51	520.51	532.56
Temperature/K	273(2) K	296(2) K	296(2) K
Wavelength/ Å	0.71073	0.71073	0.71073
Crystal system	Triclinic	Monoclinic	Triclinic
Space group	P-1	P2(1)	P-1
a /Å	7.992(3)	8.5047(11)	8.2970(4)
b / Å	8.725(3)	27.831(4)	12.8462(7)
c / Å	17.432(6)	10.6483(15)	13.7948(7)
α (°)	87.327(11)	90	114.9926(16)
β (°)	79.388(12)	107.629(4)	100.881(2)
γ (°)	89.684(11)	90	93.9003(16)
V (Å ^{3})	1193.4(8)	2402.1(6)	100.7507(18)
Z	2	4	2
Calculated density (g·cm^{-3})	1.404	1.439	1.370
Absorption coefficient (mm^{-1})	0.091	0.096	0.088
F(000)	524	1080	556
θ range / (°)	2.573 to 24.997	2.136 to 25.998	2.533 to 25.999
Limiting indices	-9<=h<=9, -10<=k<=10, 0<=l<=20	-10<=h<=10, -28<=k<=34, -13<=l<=12	-9<=h<=10, -15<=k<=15, -17<=l<=16
Reflections collected/unique	3142 / 3142 [R(int) = ?]	23093 / 4711 [R(int) = 0.1165]	18439 / 5053 [R(int) = 0.0424]
Completeness to theta	89.8 %	99.8 %	99.7 %
Max. and min. transmission	0.982 and 0.978	0.7456 and 0.6772	0.7456 and 0.6842
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data/restraints/parameters	3142 / 1 / 354	4711 / 0 / 363	5053 / 0 / 373
Goodness-of-fit on F^2	0.984	1.010	1.021
Final *R* indices[I>2sigma(I)]	R1 = 0.0651, wR2 = 0.1094	R1 = 0.0659, wR2 = 0.1091	R1 = 0.0512, wR2 = 0.1148
R indices (all data)	R1 = 0.1546,wR2 = 0.1271	R1 = 0.1941, wR2 = 0.1460	R1 = 0.0936, wR2 = 0.1336
Largest diff. peak and hole /(e ·Å^{-3})	0.278 and -0.229	0.237 and -0.175	0.251 and -0.181

Table S3 The single crystal date of compounds **7h, 8a, 8b**

Phase	**7h**	**8a**	**8b**
Empirical formula	$C_{38}H_{26}O_4$	$C_{42H5}NO_5$	$C_{43}H_{27}NO_5$
Formula weight	546.59	623.63	637.65
Temperature/K	296(2) K	296(2) K	296(2) K
Wavelength/ Å	0.71073	0.71073	0.71073
Crystal system	Monoclinic	Monoclinic	Monoclinic
Space group	P2(1)/c	P2(1)	P2(1)
a /Å	18.978(2)	12.9685(9)	13.3642(11)
b / Å	12.4830(13)	13.8484(11)	14.9517(12)
c / Å	11.7028(12)	20.7097(16)	20.5922(15)
α (°)	90	90	90
β (°)	94.907(3)	93.367(2)	90.279(2)
γ (°)	90	90	90
V (Å ^{3})	2762.2(5)	3712.9(5)	4114.6(6)
Z	4	4	4
Calculated density (g·cm^{-3})	1.314	1.116	1.029
Absorption coefficient (mm^{-1})	0.084	0.073	0.067
F(000)	1144	1296	1328
θ range / (°)	2.154 to 25.999	1.970 to 25.997	2.044 to 26.000
Limiting indices	-20<=h<=23, -15<=k<=15, -14<=l<=13	-15<=h<=15, -14<=k<=17, -25<=l<=23	-16<=h<=16, -18<=k<=16, -25<=l<=24
Reflections collected/unique	22520 / 5377 [R(int) = 0.0858]	34303 / 7270 [R(int) = 0.0692]	33607 / 8083 [R(int) = 0.1086]
Completeness to theta	99.0 %	99.8 %	99.6 %
Max. and min. transmission	0.7456 and 0.6101	0.7456 and 0.6399	0.7456 and 0.6410
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data/restraints/parameters	5377 / 84 / 414	7270 / 0 / 433	8083 / 0 / 443
Goodness-of-fit on F^2	1.006	1.034	0.975
Final *R* indices[I>2sigma(I)]	R1 = 0.0588, wR2 = 0,1190	R1 = 0.0595, wR2 =	R1 = 0.0622, wR2 = 0.1425
R indices (all data)	R1 = 0.1616, wR2 = 0.1569	R1 = 0.1350, wR2 =	R1 = 0.1722, wR2 = 0.1831
Largest diff. peak and hole /(e ·Å^{-3})	0.187 and -0.222	0.159 and -0.211	0.174 and -0.154

Experimental section

1. General procedure for the reactions of bindone and isatylidene malononitriles: A mixture of bindane (1.0 mmol), isatylidene malononitrile (1.0 mmol) and triethylamine (2.0 mmol) in dry dichloromethane (20.0 mL) was stirred at room temperature for twelve hours. After removing the solvent, the residue was recrystallized in alcohol to give the pure product **3a-3j** for analysis.

3'-amino-1''-benzyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3a): yellow solid, 0.514 g, 92%, m.p. 292-294 ^{o}C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.38-8.25 (m, 4H), 7.55 (d, J = 7.6 Hz, 2H), 7.45 (d, J = 7.2 Hz, 1H), 7.39-7.10 (m, 8H), 6.92 (d, J = 8.0 Hz, 1H), 6.54 (s, 2H), 5.94 (d, J = 7.2 Hz, 1H), 5.08 (d, J = 16.0 Hz, 1H), 5.03 (d, J = 16.0 Hz, 1H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 195.5, 195.3, 191.8, 174.8, 152.0, 150.1, 143.7, 143.4, 142.4, 140.1, 139.0, 138.8, 136.2, 135.2, 133.2, 130.7, 130.5, 129.9, 128.9, 127.8, 127.7, 125.9, 125.6, 124.0, 123.6, 120.6, 117.2, 110.3, 77.6, 61.6, 49.8, 44.1; HRMS (ESI-TOF) Calcd. For $C_{36}H_{22}N_3O_4$ ([M+H]$^+$): 560.1605, found: 560.1618.

3'-amino-1''-benzyl-5''-methyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3b): yellow solid, 0.532 g, 93%, m.p. 291-293 ^{o}C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.37-8.27 (m, 4H), 7.54 (d, J = 6.8 Hz, 2H), 7.38-7.30 (m, 5H), 7.24 (t, J = 8.0 Hz, 1H), 7.18 (t, J = 7.6 Hz, 1H), 7.08 (d, J = 8.0 Hz, 1H), 6.79 (d, J = 8.0 Hz, 1H), 6.52 (s, 2H), 5.94 (d, J = 7.2 Hz, 1H), 5.05 (d, J = 16.0 Hz, 1H), 5.00 (d, J = 16.0 Hz, 1H), 2.27 (s, 3H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 195.5, 195.3, 191.8, 174.67, 151.8, 150.0, 143.7, 142.3, 141.0, 140.1, 139.0, 138.8, 136.3, 135.2, 133.2, 132.6, 130.7, 130.6, 130.0, 129.9, 128.9, 127.8, 127.6, 125.9, 125.6, 124.5, 124.0, 120.6, 117.2, 110.1, 77.8, 61.6, 49.8, 44.1, 21.2; HRMS (ESI-TOF) Calcd. For $C_{37}H_{24}N_3O_4$ ([M+H]$^+$): 574.1761, found: 574.1771.

3'-amino-1''-benzyl-5''-chloro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3c): yellow solid, 0.539 g, 91%, m.p. 293-295 ^{o}C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.38-8.26 (m, 4H), 7.55-7.47 (m, 3H), 7.40-7.29 (m, 5H), 7.25 (t, J = 7.6 Hz, 1H), 7.19 (t, J = 7.6 Hz, 1H), 6.96 (d, J = 7.6 Hz, 1H), 6.68 (s, 2H), 5.97 (d, J = 7.2 Hz, 1H), 5.09 (d, J = 16.0 Hz, 1H), 5.05 (d, J = 16.0 Hz, 1H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 195.3, 195.2, 191.7, 174.5, 152.4, 150.6, 143.8, 142.3, 142.2, 139.9, 139.2, 138.8, 135.9, 135.3, 132.6, 132.5, 130.8, 129.9, 129.8, 129.0, 127.9, 127.7, 127.6, 126.0, 125.7, 124.2, 124.1, 120.8, 117.0, 112.0, 76.6, 61.6, 49.8, 44.1; HRMS (ESI-TOF) Calcd. For $C_{36}H_{21}ClN_3O_4$ ([M+H]$^+$):

594.1215, found: 594.1214.

3'-amino-1''-benzyl-5''-fluoro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3d): yellow solid, 0.553 g, 96%, m.p. 233-235 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.39-8.25 (m, 4H), 7.55 (d, *J* = 7.2 Hz, 2H), 7.40-7.15 (m, 8H), 6.94 (s, 1H), 6.65 (s, 2H), 5.97 (d, *J* = 7.2 Hz, 1H), 5.09 (d, *J* = 16.0 Hz, 1H), 5.04 (d, *J* = 16.0 Hz, 1H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 195.3, 195.2, 191.6, 174.7, 159.9 (d, *J* = 238.4 Hz), 152.3, 150.5, 143.8, 142.2, 139.9, 139.6, 139.0 (d, *J* = 30,5 Hz), 136.0, 135.2, 132.6, 132.4, 132.3, 130.8, 129.8, 128.9, 127.9, 127.7, 126.0, 125.7, 124.2, 120.8, 117.0, 116.3 (d, *J* = 23.6 Hz), 111.8, 111.4 (d, *J* = 8.0 Hz), 76.8, 61.6, 56.5, 50.0, 44.2, 19.0; HRMS (ESI-TOF) Calcd. For $C_{36}H_{21}FN_3O_4$ ([M+H]$^+$): 578.1511, found: 578.1519.

3'-amino-1''-butyl-5''-methyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3e): yellow solid, 0.495 g, 92%, m.p. 288-290 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.36-8.26 (m, 4H), 7.30 (d, *J* = 7.2 Hz, 1H), 7.24-7.14 (m, 4H), 7.08 (d, *J* = 8.0 Hz, 1H), 6.45 (s, 2H), 5.91 (d, *J* = 7.6 Hz, 1H), 3.78-3.74 (m, 2H), 2.30 (s, 3H), 1.71-1.64 (m, 2H), 1.48-1.42 (m, 2H), 0.94 (t, *J* = 7.6 Hz, 3H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 195.6, 195.4, 191.7, 174.2, 151.6, 149.7, 143.6, 142.3, 141.4, 140.1, 138.9, 138.7, 135.1, 133.4, 132.1, 130.6, 130.5, 130.1, 129.9, 125.9, 125.5, 124.5, 123.9, 120.5, 117.0, 109.5, 77.9, 61.5, 49.6, 29.4, 21.2, 19.9, 14.2; HRMS (ESI-TOF) Calcd. For $C_{34}H_{26}N_3O_4$ ([M+H]$^+$): 540.1918, found: 540.1934.

3'-amino-1''-butyl-5''-chloro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3f): yellow solid, 0.503 g, 90%, m.p. 210-212 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.38-8.25 (m, 4H), 7.47-7.45 (m, 2H), 7.33 (d, *J* = 7.2 Hz, 1H), 7.29-7.15 (m, 3H), 6.62 (s, 2H), 5.95 (d, *J* = 7.2 Hz, 1H), 3.84-3.77 (m, 2H), 1.72-1.64 (m, 2H), 1.50-1.40 (m, 2H), 0.95 (t, *J* = 7.2 Hz, 3H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 195.3, 195.2, 191.6, 174.1, 152.2, 150.2, 143.8, 142.8, 142.2, 139.9, 139.1, 138.8, 135.2, 132.6, 132.6, 130.8, 129.8, 127.2, 125.9, 125.7, 124.1, 124.0, 120.7, 116.8, 111.5, 76.7, 61.6, 49.6, 29.4, 19.9, 14.1; HRMS (ESI-TOF) Calcd. For $C_{33}H_{23}ClN_3O_4$ ([M+H]$^+$): 560.1372, found: 560.1381.

3'-amino-1''-butyl-5''-fluoro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'H-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3g): yellow solid, 0.472 g, 87%, m.p. 280-282 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.38-8.24 (m, 4H), 7.32 (d, *J* = 7.2 Hz, 1H), 7.28-7.21 (m, 4H), 7.17

(t, *J* = 7.2 Hz, 1H), 6.58 (s, 2H), 5.95 (d, *J* = 7.6 Hz, 1H), 3.82-3.78 (m, 2H), 1.72-1.65 (m, 2H), 1.50-1.41 (m, 2H), 0.95 (t, *J* = 7.6 Hz, 3H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 195.4, 195.3, 191.5, 174.2, 159.1 (d, *J* = 237.6 Hz), 152.1, 150.2, 143.7, 142.1, 140.0, 139.9, 138.9 (d, *J* = 30.3 Hz), 135.1, 132.7, 132.4, 132.3, 130.7, 129.8, 125.9, 125.7 (d, *J* = 32.5 Hz), 120.7, 116.8, 116.3 (d, *J* = 22.8 Hz), 111.6, 111.4, 110.9 (d, *J* = 7.6 Hz), 76.9, 61.5, 49.8, 29.4, 19.9, 14.2.; HRMS (ESI-TOF) Calcd. For $C_{33}H_{23}FN_3O_4$ ([M+H]$^+$): 544.1667, found: 544.1682.

Ethyl 3'-amino-1''-benzyl-5''-methyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carboxylate (3h): purple solid, 0.527 g, 85%, m.p. 281-283 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.40-8.29 (m, 4H), 7.65 (d, *J* = 7.2 Hz, 2H), 7.49 (s, 1H), 7.41 (t, *J* = 6.0 Hz, 2H), 7.33-7.28 (m, 3H), 7.22-7.12 (m, 3H), 7.01 (d, *J* = 8.0 Hz, 1H), 6.84 (d, *J* = 7.6 Hz, 1H, NH), 5.90 (d, *J* = 7.2 Hz, 1H, NH), 5.03 (d, *J* = 15.6 Hz, 1H), 4.84 (d, *J* = 15.6 Hz, 1H), 3.82-3.77 (m, 1H), 3.46-3.42 (m, 1H), 2.23 (s, 3H), 0.53 (t, *J* = 7.2 Hz, 3H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 196.3, 195.9, 191.9, 176.9, 167.9, 153.3, 147.8, 143.6, 142.7, 142.5, 139.9, 139.1, 138.9, 137.2, 134.9, 133.2, 131.2, 130.3, 129.8, 128.8, 128.7, 128.7, 127.8, 125.8, 125.6, 123.7, 123.6, 120.2, 109.0, 94.3, 62.3, 59.5, 49.8, 46.2, 21.2, 13.9, 9.1; HRMS (ESI-TOF) Calcd. For $C_{39}H_{28}N_2NaO_6$ ([M+Na]$^+$): 643.1840, found: 643.1842.

Ethyl 3'-amino-1''-benzyl-5''-chloro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carboxylate (3i): purple solid, 0.524 g, 82%, m.p. 234-236 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.80 (d, *J* = 7.2 Hz, 1H), 8.42 (s, 1H), 7.57-7.55 (m, 2H), 7.48 (t, *J* = 7.6 Hz, 1H), 7.34-7.28 (m, 2H), 7.22-7.04 (m, 5H), 6.92 (t, *J* = 7.6 Hz, 2H), 6.67 (d, *J* = 8.4 Hz, 1H), 6.35 (d, *J* = 7.2 Hz, 1H), 6.34 (s, 2H), 4.80 (d, *J* = 16.0 Hz, 1H), 4.40 (d, *J* = 16.0 Hz, 1H), 3.92-3.86 (m, 1H), 3.67-3.62 (m, 1H), 0.65 (t, *J* = 7.2 Hz, 3H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 183.7, 180.7, 168.9, 167.8, 166.9, 151.5, 145.3, 142.4, 142.1, 140.0, 138.7, 135.9, 130.5, 130.1, 130.0, 128.7, 127.2, 126.3, 125.6, 125.2, 125.1, 124.0, 121.9, 118.7, 111.5, 110.1, 99.1, 68.5, 59.4, 58.8, 46.2, 13.9, 9.1; HRMS (ESI-TOF) Calcd. For $C_{38}H_{26}ClN_2O_6$ ([M+H]$^+$): 641.1474, found: 641.1485.

Ethyl 3'-amino-1''-benzyl-5''-fluoro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carboxylate (3j): purple solid, 0.549 g, 88%, m.p. 230-232 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.80 (d, *J* = 7.2 Hz, 1H), 8.40 (s, 1H), 7.55 (d, *J* = 7.6 Hz, 1H), 7.47 (t, *J* = 7.2 Hz, 1H), 7.35-7.27 (m, 2H), 7.22-7.03 (m, 6H), 6.92 (t, *J* = 7.6 Hz, 2H), 6.65-6.62 (m,

1H), 6.37 (s, 2H), 6.36 (d, *J* = 7.6 Hz, 1H), 4.80 (d, *J* = 16.0 Hz, 1H), 4.39 (d, *J* = 16.0 Hz, 1H), 3.92-3.86 (m, 1H), 3.64-3.60 (m, 1H), 0.64 (t, *J* = 7.2 Hz, 3H); ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 183.7, 180.7, 169.1, 167.9, 166.9, 157.8 (d, *J* = 234.9 Hz), 151.4, 145.3, 142.5, 140.1, 139.4, 138.8, 136.1, 130.3 (d, *J* = 24.9 Hz), 130.1, 129.9, 128.6, 127.1, 126.3, 125.1, 124.1, 121.9, 118.6, 115.0 (d, *J* = 22.7 Hz), 114.9, 113.1 (d, *J* = 23.7 Hz), 111.5, 99.2, 68.5, 60.1, 59.3, 58.9, 46.2, 13.9, 9.1; HRMS (ESI-TOF) Calcd. For $C_{38}H_{25}FN_2NaO_6$ ([M+H]$^+$): 647.1589, found: 647.1585.

2. **General procedure for the reactions of bindone and 4-arylidene-pyrazol-3-ones:** A mixture of bindone (1.0 mmol), 4-arylidene-pyrazol-3-one (1.0 mmol), and DABCO (2.0 mmol) in DCM (20 mL) was stirred at room temperature for 24 hours. After removing the solvent by rotatory evaporating at reduced pressure, the resulting residue was purified by column chromatography on silica gel with ethyl acetate and petroleum ether (1:4) as eluent to afford the desired products **5a-5j**.

3'-methyl-1',6-diphenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5a): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.383 g, 74%, m.p. 264-266 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) *δ*: **major isomer**: 9.55 (d, *J* = 8.0 Hz, 1H), 8.01 (d, *J* = 6.0 Hz, 1H), 7.87 (t, *J* = 7.6 Hz, 2H), 7.67 (t, *J* = 7.6 Hz, 1H), 7.58 (t, *J* = 8.0 Hz, 2H), 7.54-7.53 (m, 2H), 7.38 (t, *J* = 7.6 Hz, 6H), 7.25-7.16 (m, 3H), 5.15 (s, 1H), 1.76 (s, 3H); **ratio of major/minor = 15:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) *δ*: 189.7, 187.1, 173.3, 161.4, 157.2, 145.9, 145.2, 140.6, 140.3, 140.2, 139.3, 138.9, 137.3, 137.0, 135.8, 135.7, 135.5, 134.9, 134.0, 133.4, 132.5, 132.3, 130.0, 129.8, 129.3, 129.3, 129.2, 129.1, 129.0, 128.8, 128.7, 128.1, 126.3, 126.0, 125.7, 124.9, 124.7, 124.5, 123.9, 123.7, 119.5, 119.4, 65.1, 45.7, 43.8, 15.5, 15.0; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{35}H_{22}N_2NaO_3$ ([M+Na]$^+$): 541.1523, found: 541.1525.

3'-methyl-1'-phenyl-6-(p-tolyl)-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4*bH*)-trione (5b): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.414 g, 78%, m.p. 240-242 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) *δ*: **major isomer**: 9.54 (d, *J* = 8.0 Hz, 1H), 8.01-7.99 (m, 1H), 7.88-7.85 (m, 2H), 7.68-7.63 (m, 3H), 7.54-7.51 (m, 2H), 7.40 (t, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 7.6 Hz, 1H), 7.17 (s, 5H), 5.13 (s, 1H), 2.34 (s, 3H), 1.76 (s, 3H); **ratio of major/minor = 14:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) *δ*: 189.7, 188.1, 187.0, 173.5, 157.6, 155.6, 146.6, 146.3, 145.2, 144.3, 140.4, 140.2, 140.1, 139.3, 137.6, 137.1, 135.7, 135.6, 135.4, 134.9, 133.8, 132.5, 132.2, 130.6, 129.3, 129.1, 129.0, 128.9, 128.8, 126.1, 125.9, 125.6,

124.7, 124.6, 123.9, 123.7, 119.5, 119.4, 65.2, 47.1, 46.0, 43.8, 21.5, 21.4, 15.6, 15.0; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{36}H_{24}N_2NaO_3$ ($[M+Na]^+$): 555.1679, found: 555.1682.

6-(4-methoxyphenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5c): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.438 g, 80%, m.p. 268-270 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: **major isomer**: 9.55 (d, *J* = 8.0 Hz, 1H), 8.01-7.99 (m, 1H), 7.86 (t, *J* = 8.0 Hz, 2H), 7.67 (d, *J* = 8.0 Hz, 3H), 7.53-7.51 (m, 2H), 7.41 (t, *J* = 8.0 Hz, 2H), 7.27 (s, 1H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.18-7.17 (m, 1H), 6,88 (d, *J* = 8.4 Hz, 2H), 5.12 (s, 1H), 3.81 (s, 3H), 1.75 (s, 3H); **ratio of major/minor = 13:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 189.7, 189.3, 187.3, 187.0, 173.6, 168.0, 162.0, 161.1, 161.0, 158.0, 146.6, 146.2, 145.1, 144.2, 141.2, 140.5, 140.4, 140.0, 139.2, 138.9, 138.8, 138.0, 137.0, 135.7, 135.5, 135.4, 134.8, 133.6, 133.3, 132.5, 132.2, 129.3, 129.2, 129.1, 129.0, 128.8, 126.0, 125.9, 125.8, 125.6, 125.5, 124.8, 124.7, 124.6, 124.0, 123.9, 123.6, 119.5, 119.3, 113.6, 113.4, 65.1, 63.8, 55.2, 55.2, 46.2, 43.9, 15.6, 15.0; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{36}H_{24}N_2NaO_4$ ($[M+Na]^+$): 571.1628, found: 571.1631.

6-(3-methoxyphenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5d): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.471 g, 86%, m.p. 245-247 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: **major isomer**: 9.54 (d, *J* = 8.0 Hz, 1H), 8.01-7.99 (m, 1H), 7.88-7.85 (m, 2H), 7.68 (d, *J* = 7.2 Hz, 1H), 7.63 (d, *J* = 8.0 Hz, 2H), 7.55-7.52 (m, 2H), 7.39 (t, *J* = 8.0 Hz, 2H), 7.32-7.28 (m, 1H), 7.25-7.22 (m, 2H), 7.17 (d, *J* = 7.6 Hz, 1H), 6.93-6.91 (m, 1H), 6,83 (s, 1H), 5.13 (s, 1H), 3.73 (s, 3H), 1.75 (s, 3H); **minor isomer:** 9.55 (d, *J* = 8.0 Hz, 1H), 7.96 (s, 1H), 7.82 (d, *J* = 7.6 Hz, 2H), 7.65 (s, 2H), 7.58 (s, 1H), 7.55 (s, 1H), 7.50 (s, 1H), 6.99-6.96 (m, 2H), 4.86 (s, 1H), 3.62 (s, 3H), 2.17 (s, 3H); **ratio of major/minor = 10:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 189.7, 186.9, 173.2, 159.1, 157.3, 145.6, 145.1, 140.3, 140.2, 139.2, 137.3, 137.0, 135.8, 135.5, 134.6, 134.0, 132.5, 129.3, 129.1, 129.0, 126.3, 125.9, 124.7, 124.5, 123.9, 119.4, 119.2, 115.8, 65.0, 55.2, 45.8, 15.6; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{36}H_{24}N_2NaO_4$ ($[M+Na]^+$): 571.1628, found: 571.1631.

6-(4-isopropylphenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5e): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.397 g, 71%, m.p. 241-243 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: **major isomer**: 9.54 (d, *J* = 8.4 Hz, 1H), 8.01-8.00 (m, 1H), 7.88-7.85 (m, 2H), 7.68-7.51 (m, 6H), 7.38 (t, *J* = 7.6 Hz, 2H),

7.25-7.21 (m, 5H), 5.13 (s, 1H), 2.96-2.86 (m, 1H), 1.75 (s, 3H), 1.22 (s, 3H), 1.20 (s, 3H); **minor isomer:** 9.56 (d, *J* = 8.4 Hz, 1H), 7.96 (d, *J* = 7.6 Hz, 1H), 7.82 (d, *J* = 7.2 Hz, 2H), 7.46 (t, *J* = 7.6 Hz, 3H), 7.32 (t, *J* = 7.6 Hz, 3H), 7.15 (d, *J* = 7.6 Hz, 2H), 4.85 (s, 1H), 2.09 (s, 3H), 1.29 (s, 3H), 1.28 (s, 3H); **ratio of major/minor = 4:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) *δ*: 189.7, 187.1, 173.4, 157.4, 151.2, 150.7, 146.5, 145.2, 140.4, 140.2, 139.2, 137.5, 136.9, 135.7, 135.6, 135.4, 134.8, 133.6, 132.5, 132.2, 130.8, 129.2, 129.1, 128.9, 128.8, 126.2, 126.1, 126.0, 125.6, 124.7, 124.6, 123.9, 123.6, 119.8, 119.4, 65.1, 45.6, 43.9, 33.9, 23.8, 23.6, 15.5, 15.0; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{38}H_{28}N_2NaO_3$ ($[M+Na]^+$): 583.1992, found: 583.1992.

6-(4-(tert-butyl)phenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5f): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.436 g, 76%, m.p. 259-261 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) *δ*: **major isomer**: 9.55 (d, *J* = 8.0 Hz, 1H), 8.02-7.99 (m, 1H), 7.89-7.85 (m, 2H), 7.67 (t, *J* = 7.2 Hz, 1H), 7.55-7.53 (m, 2H), 7.48 (t, *J* = 8.0 Hz, 2H), 7.38-7.35 (m, 4H), 7.24-7.18 (m, 4H), 5.13 (s, 1H), 1.75 (s, 3H), 1.28 (s, 9H, $3CH_3$); **minor isomer:** 9.56 (d, *J* = 8.0 Hz, 1H), 7.96 (d, *J* = 7.6 Hz, 1H), 7.83-7.81 (m, 1H), 7.63-7.57 (m, 5H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.15 (d, *J* = 8.8 Hz, 1H), 4.85 (s, 1H), 2.09 (s, 3H), 1.34 (s, 9H, $3CH_3$); **ratio of major/minor = 9:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) *δ*: 189.7, 187.2, 173.4, 157.4, 152.9, 146.5, 145.3, 140.4, 140.2, 139.2, 137.4, 136.9, 135.7, 135.4, 133.6, 132.5, 130.5, 129.2, 129.1, 128.9, 126.1, 126.0, 125.0, 124.7, 124.6, 123.9, 119.9, 65.1, 45.5, 34.7, 31.1, 15.5; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{39}H_{31}N_2O_3$ ($[M+H]^+$): 575.2329, found: 575.2331.

6-(4-chlorophenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5g): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.463 g, 84%, m.p. 277-279 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) *δ*: **major isomer**: 9.53 (d, *J* = 8.0 Hz, 1H), 7.89-7.81 (m, 3H), 7.68 (t, *J* = 7.6 Hz, 1H), 7.64-7.62 (m, 2H), 7.58-7.53 (m, 2H), 7.44-7.28 (m, 6H), 7.18-7.14 (m, 2H), 5.12 (s, 1H), 1.75 (s, 3H); **minor isomer:** 9.54 (d, *J* = 7.6 Hz, 1H), 8.01-7.96 (m, 3H), 7.52-7.46 (m, 3H), 7.24 (s, 1H), 4.84 (s, 1H), 2.15 (s, 3H); **ratio of major/minor = 2:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) *δ*: 189.7, 187.0, 173.2, 161.2, 157.3, 145.0, 144.3, 144.1, 141.0, 140.6, 140.3, 139.1, 138.8, 137.8, 137.0, 136.8, 136.2, 136.0, 135.9, 135.6, 135.1, 134.5, 132.6, 132.4, 131.8, 131.6, 129.4, 129.2, 129.1, 128.9, 128.5, 126.4, 126.2, 125.8, 125.3, 125.0, 124.8, 124.5, 124.0, 123.9, 119.4, 119.3, 101.3, 65.0, 45.8, 43.7, 29.7, 15.6, 15.1; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{38}H_{21}ClN_2NaO_3$ ($[M+Na]^+$): 575.1133, found: 575.1139.

6-(3-chlorophenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5h): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.419 g, 76%, m.p. 257-259 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: **major isomer**: 9.53 (d, *J* = 8.0 Hz, 1H), 8.01 (d, *J* = 8.4 Hz, 1H), 7.87 (d, *J* = 7.2 Hz, 2H), 7.68 (t, *J* = 7.2 Hz, 1H), 7.57-7.53 (m, 3H), 7.42-7.29 (m, 5H), 7.24 (d, *J* = 7.6 Hz, 1H), 7.16 (d, *J* = 5.2 Hz, 1H), 5.13 (s, 1H), 1.75 (s, 3H); **minor isomer:** 9.54 (d, *J* = 8.0 Hz, 1H), 7,97 (d, *J* = 7.2 Hz, 1H), 7.90 (s, 1H), 7.82 (d, *J* = 7.6 Hz, 2H), 7.48 (d, *J* = 7.6 Hz, 1H), 4.85 (s, 1H), 2.18 (s, 3H); **ratio of major/minor = 4:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 189.7, 186.9, 173.1, 161.0, 157.0, 145.0, 144.2, 144.1, 143.6, 143.4, 141.0, 140.7, 140.3, 140.3, 139.2, 139.1, 138.8, 136.8, 136.7, 136.0, 135.9, 135.6, 135.2, 135.1, 135.0, 134.9, 134.8, 134.7, 134.2, 132.6, 132.4, 130.0, 129.8, 129.7, 129.6, 129.4, 129.3, 129.2, 129.0, 128.9, 126.6, 126.1, 125.9, 125.4, 125.0, 124.8, 124.5, 124.0, 123.8, 123.7, 119.7, 119.5, 64.9, 63.7, 45.6, 43.6, 43.1, 15.5, 15.1; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{35}H_{22}ClN_2O_3$ ($[M+H]^+$): 553.1313, found: 553.1320.

6-(4-bromophenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5i): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.429 g, 72%, m.p. 275-277 ℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: **major isomer**: 9.43 (d, *J* = 8.0 Hz, 1H), 8.02-7.95 (m, 2H), 7.82-7.78 (m, 2H), 7.69 (t, *J* = 8.0 Hz, 1H), 7.63-7.56 (m, 5H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.31-7.20 (m, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 5.17 (s, 1H), 1.72 (s, 3H); **ratio of major/minor = 14:1**; ^{13}C{1H} NMR (100 MHz, DMSO-d_6) δ: 189.6, 186.9, 173.4, 158.1, 145.4, 142.8, 140.3, 139.3, 136.9, 136.4, 134.8, 133.3, 133.0, 131.3, 129.7, 128.7, 126.9, 126.6, 124.9, 124.2, 123.3, 119.6, 64.8, 45.5, 15.6; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{35}H_{22}BrN_2O_3$ ($[M+H]^+$): 597.0808, found: 597.0808.

3'-methyl-6-(4-nitrophenyl)-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5j): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, yellow solid, 0.461 g, 82%, m.p. 273-275 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: **major isomer**: 9.53 (d, *J* = 8.0 Hz, 1H), 8.23 (d, *J* = 8.8 Hz, 2H), 8.03-7.99 (m, 1H), 7.92-7.82 (m, 2H), 7.71-7.66 (m, 1H), 7.61-7.50 (m, 5H), 7.40 (t, *J* = 8.0 Hz, 2H), 7.33 (t, *J* = 7.2 Hz, 1H), 7.23-7.13 (m, 2H), 5.16 (s, 1H), 1.78 (s, 3H); **minor isomer:** 7.97 (s, 1H), 7.50 (s, 1H), 4.88 (s, 1H), 2.19 (s, 3H); **ratio of major/minor = 3:1**; ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 189.6, 187.0, 172.8, 167.6, 160.5, 156.8, 148.3, 144.8, 144.0, 142.0, 141.4, 140.9, 140.8, 140.5, 140.2, 139.9, 139.0, 138.6, 137.0, 136.7, 136.4, 136.3,

136.2, 135.9, 135.5, 135.4, 132.9, 132.6, 131.0, 129.6, 129.5, 129.4, 129.3, 129.2, 129.1, 128.7, 128.1, 127.0, 126.3, 126.1, 125.9, 125.2, 124.9, 124.5, 124.2, 124.0, 123.8, 123.5, 119.3, 119.1, 64.8, 63.8, 45.6, 43.6, 15.6, 15.3; MS (*m*/*z*): HRMS (ESI-TOF) Calcd. For $C_{35}H_{21}N_3NaO_5$ ([M+Na]$^+$): 586.1373, found: 586.1380.

3. General Procedure for the reaction of bindone and 2-arylidene-1,3-indanediones: A mixture of bindone (1.0 mmol), bindone (1.0 mmol), 2-arylidene-1,3-indanedione (1.0 mmol) and Et_3N (2.0 mmol) in toluene (3.0 mL) in sealed tube was heated 120 ^{o}C in oil bath at for twelve hours. After removing the solvent, the residue was recrystallized in ethyl acetate to give the pure product **7a-7h** for analysis.

15-hydroxy-15-(m-tolyl)diindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione [7a]: light yellow solid, 0.413g, 82%, m.p. >300℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.16 (d, *J* = 7.6 Hz ,1H), 8.30 (d, *J* = 7.6 Hz, 1H), 8.10-8.07 (m, 2H), 7.88 (s, 1H) 7.81 (d, *J* = 7.2 Hz ,1H), 7.66-7.60 (m, 4H), 7.51-7.48 (m, 1H), 7.44-7.40 (m, 2H), 7.28 (s, 1H), 7.14 (s, 1H), 7.10-7.06 (m, 1H), 6.90 (d, *J* = 7.2 Hz, 1H), 2.21 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.4, 191.9, 186.6, 154.4, 150.9, 147.8, 146.7, 145.9, 142.2, 141.3, 138.2, 136.2, 135.6, 135.2, 134.7, 134.3, 131.7, 131.4, 130.7, 130.4, 129.8, 128.5, 128.4, 128.2, 127.8, 127.5, 126.4, 126.0, 125.4, 124.8, 124.2, 121.9, 7.59, 21.6; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{35}H_{20}NaO_4$ ([M+Na]$^+$): 527.1254, found:527.1259.

15-hydroxy-15-(4-methoxyphenyl)diindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione (7b): light yellow solid, 0.395g, 76%, m.p. 286-288^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.16 (d, *J* = 8.0 Hz ,1H), 9.29 (d, *J* = 8.0 Hz, 1H), 8.11-8.07 (m, 2H), 7.94 (s, 1H), 7.81 (d, *J* = 7.6 Hz, 1H), 7.65-7.61 (m, 4H), 7.51-7.48 (m, 1H), 7.44-7.41 (m, 2H), 7.10-7.04 (m, 2H), 6.91 (d, *J* = 7.6 Hz, 1H), 6.62 (d, *J* = 10.4 Hz, 1H), 3.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.5, 191.9, 186.4, 159.5, 154.1, 151.1, 151.0, 150.7, 147.9, 147.6, 146.4, 145.8, 142.2, 141.3, 136.3, 135.9, 135.6, 135.3, 134.7, 134.3, 131.8, 131.5, 131.5, 130.7, 130.5, 129.8, 129.5, 128.6, 127.9, 127.6, 126.4, 126.1, 124.9, 124.2, 117.3, 112.2, 111.3, 74.5, 55.2; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{35}H_{20}NaO_5$ ([M+Na]$^+$): 543.1203, found: 543.1203.

15-hydroxy-15-(3-methoxyphenyl)diindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione (7c): light yellow solid, 0.338g, 65%, m.p. 290-292^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.17 (d, *J* =

8.0 Hz ,1H), 8.30 (d, *J* = 7.6 Hz, 1H), 8.10-8.07 (m, 2H), 7.94 (s, 1H), 7.82 (d, *J* = 7.2 Hz,2H), 7.66-7.62 (m, 4H), 7.52-7.48 (m, 1H), 7.45-7.41 (m, 2H), 7.10-7.03 (m, 2H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.62 (d, *J* = 8.4 Hz 1H), 3.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.4, 191.8, 186.4, 159.5, 154.1, 151.0, 147.8, 147.6, 146.4, 142.2, 141.2, 136.2, 135.5, 135.2, 134.6, 134.3, 131.7, 131.4, 130.7, 130.4, 129.8, 129.5, 128.5, 127.9, 127.6, 126.4, 126.1, 124.8, 124.2, 117.3, 112.2, 111.2, 74.5, 55.2; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{35}H_{20}NaO_5$ ($[M+Na]^+$): 543.1203, found: 543.1197.

15-hydroxy-15-(2-methoxyphenyl)diindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione (7d): light yellow solid, 0.411g, 79%, m.p. 297-299°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.17 (d, *J* = 8.0 Hz ,1H), 8.30 (d, *J* = 8.0 Hz, 1H), 8.10-8.05 (m, 2H), 7.92 (s, 1H), 7.83 (d, *J* = 7.2 Hz, 1H), 7.68-7.62 (m, 4H), 7.53-7.49 (m, 1H), 7.46-7.42 (m, 2H), 7.41-7.37 (m, 2H), 6.89-6.84 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.4, 191.9, 186.4, 159.5, 154.1, 151.0, 147.8, 147.6, 146.4, 142.2, 141.3, 136.3, 135.6, 135.2, 134.7, 134.3, 131.8, 131.5, 131.4, 130.7, 130.5, 129.8, 129.5, 128.6, 127.9, 127.6, 126.4, 126.1, 124.9, 124.2, 117.3, 112.2, 111.2, 74.5, 55.2; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{35}H_{20}NaO_5$ ($[M+Na]^+$): 543.1203, found:543.1211.

15-(4-fluorophenyl)-15-hydroxydiindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione (7e): light yellow solid, 0.340g, 67%, m.p. 285-287°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.17 (d, *J* = 8.0 Hz ,1H), 8.3 (d, *J* = 8.0 Hz , 1H), 8.10-8.05 (m, 2H), 7.92 (s, 1H), 7.83 (d, J = 7.2 Hz, 1H), 7.68-7.62 (m, 4H), 7.53-7.49 (m, 1H), 7.46-7.42 (m, 2H), 7.41-7.37 (m, 2H), 6.89-6.84 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.5, 191.9, 186.4, 159.5, 154.1, 151.1, 147.7 (d, *J* = 26.3 Hz), 146.4, 142.2, 141.3, 136.3, 135.6, 135.2, 134.7, 134.3, 131.6, 131.5, 130.7, 129.8, 129.5, 128.6, 127.9, 127.6, 126.4, 126.1, 124.9, 124.2, 117.3, 112.2, 111.3, 74.6, 55.1, 29.7; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{34}H_{17}FNaO_4$ ($[M+Na]^+$): 531.1003, found: 532.1020.

15-(3-fluorophenyl)-15-hydroxydiindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione (7f): light yellow solid, 0.360g, 71%, m.p. 286-287°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.17 (d, *J* = 8.0 Hz, 1H), 8.30 (d, *J* = 8.0 Hz, 1H), 8.11-8.06 (m, 2H), 7.97 (s, 1H), 7.83 (d, *J* = 7.6 Hz ,1H), 7.69-7.63 (m, 4H), 7.53-7.50 (m, 1H), 7.47-7.42 (m, 2H), 7.23 (s, 1H), 7.15-7.06 (m, 2H), 6.82-6.77(m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.5, 191.7, 186.2, 162.6 (d, *J* = 245.7 Hz), 153.4, 151.3, 148.7, 148.6, 147.8, 145.9, 142.1, 141.2, 136.4, 135.5, 135.3, 134.6, 134.5, 131.7, 131.6, 130.7, 130.6, 130.1 (d, *J* = 8.2 Hz), 129.6, 128.6, 128.5, 128.2, 127.6, 126.4, 126.2, 124.9, 124.2, 120.5,

114.4 (d, *J* = 21.0 Hz), 112.3 (d, *J* = 23.1 Hz), 74.2, 73.0; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{34}H_{17}FNaO_4$ ([M+Na]$^+$): 531.1003, found: 531.1016.

15-hydroxy-15-(4-isopropylphenyl)diindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione (7g): light yellow solid, 0.276g, 52%, m.p. 294-296^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.18 (d, *J* = 7.2 Hz, 1H), 8.32 (d, *J* = 7.6 Hz, 1H), 8.11-8.07 (m, 2H), 7.94 (s, 1H), 7.83 (d, *J* = 7.2 Hz ,1H), 7.66-7.62 (m, 4H), 7.53-7.49 (m, 1H), 7.45-7.40 (m, 2H), 7.31 (d, *J* = 7.6 Hz, 2H), 7.02 (d, *J* = 8.0 Hz, 2H), 2.78-2.71 (m, 1H, CH), 1.10 (d, *J* = 6.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.4, 191.8, 186.6, 154.6, 150.9, 147.8, 147.7, 146.9, 143.2, 142.2, 141.2, 136.1, 135.6, 135.2, 134.7, 134.3, 131.7, 131.4, 130.7, 130.3, 129.8, 128.5, 127.7, 127.6, 126.6, 126.4, 126.0, 124.8, 124.7, 124.1, 74.6, 33.4, 23.7, 23.6; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{37}H_{24}NaO_4$ ([M+Na]$^+$): 555.1567, found: 555.1573.

15-(4-(tert-butyl)phenyl)-15-hydroxydiindeno[1,2-a:1',2'-c]anthracene-5,10,16(15*H*)-trione (7h): light yellow solid, 0.317g, 58 %, m.p. >300 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.12 (d, *J* = 8.8 Hz, 1H), 8.28 (d, *J* = 7.6 Hz, 1H), 8.10-8.05 (m, 2H), 7.92 (s, 1H), 7.79 (d, *J* = 6.8 Hz ,1H), 7.65-7.55 (m, 4H), 7.50-7.39 (m, 3H), 7.31-7.26 (m, 2H), 7.17 (d, *J* = 8.4 Hz, 2H), 1.17 (s, 9H, $3CH_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.3, 191.7, 186.6, 154.6, 150.9, 149.9, 147.7, 146.9, 142.7, 142.1, 141.2, 136.1, 135.5, 135.1, 134.6, 134.3, 131.6, 131.4, 131.3, 130.7, 130.3, 129.8, 128.5, 127.7, 127.5, 126.4, 126.0, 125.5, 124.7, 124.4, 124.1, 74.6, 34.3, 31.1; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{38}H_{26}NaO_4$ ([M+Na]$^+$): 569.1723, found: 569.1713.

4. **General Procedure for the reaction of 1,3-indanedione and isatins**: A mixture of 1,3-indanedione (1.0 mmol), isatin (1.0 mmol) and triethylamine (2.0 mmol) in toluene (10.0 mL) was heated in oil bath at 90 ^{o}C for sixteen hours. After removing the solvent, the residue was subjected to column chromatography with a mixture of ethyl acetate and light petroleum (V/V = 1:4) as eluent to give the pure product **8a-8h** for analysis.

1'-benzyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8a): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.454 g, 73%, m.p. 291-293 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.15 (d, *J* = 7.6 Hz, 1H), 8.10 (d, *J* = 3.6 Hz, 1H), 8.00 (d, *J* = 7.6 Hz, 1H), 7.94 (d, *J* = 7.6 Hz, 1H), 7.87-7.77 (m, 2H), 7.65 (d, *J* = 7.6 Hz, 2H), 7.54-7.42 (m, 5H), 7.35-7.30 (m, 2H), 7.23 (s, 1H), 7.00-6.93 (m, 2H), 6.72 (d, *J* = 8.0 Hz, 1H), 6.28 (t, *J* = 7.6 Hz, 1H), 5.27 (d, *J* = 16.0 Hz, 1H), 5.19 (s, 1H), 5.04 (d, *J* = 16.0 Hz, 1H), 4.85

(d, *J* = 7.6 Hz, 1H), 4.66 (s, 2H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 197.5, 193.0, 192.6, 177.0, 152.5, 149.5, 145.0, 141.7, 135.8, 135.4, 135.3, 135.0, 134.9, 133.7, 132.3, 132.0, 130.6, 130.2, 129.4, 129.0, 128.7, 128.5, 127.4, 127.2, 126.8, 126.6, 125.2, 123.7, 122.4, 121.3, 109.6, 59.9, 57.1, 52.0, 49.2, 45.2; HRMS (ESI-TOF) Calcd. For $C_{42H5}NNaO_5$ ([M+Na]$^+$): 646.1625, found: 646.1629.

1'-benzyl-5'-methyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8b): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.515 g, 81%, m.p. 293-295 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.15 (d, *J* = 7.6 Hz, 1H), 8.11 (d, *J* = 3.6 Hz, 1H), 8.00 (d, *J* = 7.6 Hz, 1H), 7.96 (d, *J* = 7.6 Hz, 1H), 7.84-7.79 (m, 2H), 7.65 (d, *J* = 7.6 Hz, 2H), 7.56-7.48 (m, 2H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.33-7.26 (m, 3H), 7.24 (d, *J* = 7.6 Hz, 1H), 6.96 (d, *J* = 8.0 Hz, 1H), 6.79 (d, *J* = 8.0 Hz, 1H), 6.60 (d, *J* = 8.0 Hz, 1H), 5.25 (d, *J* = 16.0 Hz, 1H), 5.20 (s, 1H), 5.02 (d, *J* = 16.0 Hz, 1H), 4.65 (s, 1H), 4.60 (s, 1H), 1.65 (s, 3H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 197.6, 193.0, 192.6, 192.5, 176.8, 152.3, 149.6, 142.5, 141.7, 135.9, 135.3, 135.3, 135.2, 135.0, 133.7, 132.3, 130.6, 130.3, 130.1, 129.3, 129.0, 128.8, 128.6, 127.5, 127.4, 127.3, 127.1, 126.8, 126.5, 126.4, 123.6, 122.4, 109.3, 59.9, 57.0, 52.0, 49.2, 45.2, 20.6; HRMS (ESI-TOF) Calcd. For $C_{43}H_{27}NNaO_5$ ([M+Na]$^+$): 660.1781, found: 660.1785.

1'-benzyl-5'-chloro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8c): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.519 g, 79%, m.p. 298-300 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.16-8.11 (m, 2H), 8.01-7.95 (m, 2H), 7.88-7.79 (m, 2H), 7.64 (d, *J* = 7.2 Hz, 2H), 7.59 (t, *J* = 7.2 Hz, 1H), 7.51 (t, *J* = 7.2 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.39-7.34 (m, 2H), 7.30 (d, *J* = 7.6 Hz, 1H), 7.23 (s, 1H), 6.97-6.93 (m, 2H), 6.62 (d, *J* = 8.4 Hz, 1H), 5.26 (d, *J* = 16.0 Hz, 1H), 5.20 (s, 1H), 5.02 (d, *J* = 16.0 Hz, 1H), 4.66 (s, 1H), 4.64 (d, *J* = 8.4 Hz, 1H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 197.1, 192.6, 192.3, 176.6, 153.1, 149.0, 143.5, 141.5, 135.7, 135.4, 135.4, 135.2, 135.2, 134.8, 133.8, 132.4, 131.3, 130.8, 130.5, 129.6, 129.1, 128.9, 128.8, 128.4, 127.5, 127.4, 127.2, 126.8, 126.7, 126.5, 126.0, 123.8, 122.5, 110.4, 59.8, 57.1, 52.1, 49.1, 45.3; HRMS (ESI-TOF) Calcd. For $C_{42H4}ClNNaO_5$ ([M+Na]$^+$): 680.1235, found: 680.1241.

1'-benzyl-5'-fluoro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8d): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.493 g, 77%, m.p. 297-299 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.16 (d, *J* = 7.6 Hz, 1H), 8.12 (d, *J* = 7.6 Hz, 1H), 8.00 (d, *J* = 7.2 Hz, 1H), 7.96 (d, *J* = 7.6 Hz, 1H), 7.88-7.80 (m, 2H),

7.64 (d, *J* = 7.2 Hz, 2H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 1H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 2H), 7.29 (d, *J* = 6.8 Hz, 1H), 7.23 (d, *J* = 6.8 Hz, 1H), 6.96 (d, *J* = 8.0 Hz, 1H), 6.69 (t, *J* = 7.6 Hz, 1H), 6.63-6.60 (m, 1H), 5.27 (d, *J* = 16.0 Hz, 1H), 5.20 (s, 1H), 5.01 (d, *J* = 16.0 Hz, 1H), 4.66 (s, 1H), 4.49 (d, *J* = 9.2 Hz, 1H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 197.2, 192.7, 192.3, 176.7, 159.0, 153.0, 149.1, 141.5, 141.0, 135.6, 135.5, 135.4, 135.2, 134.8, 133.8, 132.4, 131.4, 130.6, 130.5, 129.5, 129.1, 128.9, 128.7, 127.5, 127.4, 127.2, 126.8, 126.5, 123.8, 122.5, 114.6, 113.6, 59.8, 57.1, 52.1, 49.4, 45.3; HRMS (ESI-TOF) Calcd. For $C_{42H4}FNNaO_5$ ($[M+Na]^+$): 664.1531, found: 664.1540.

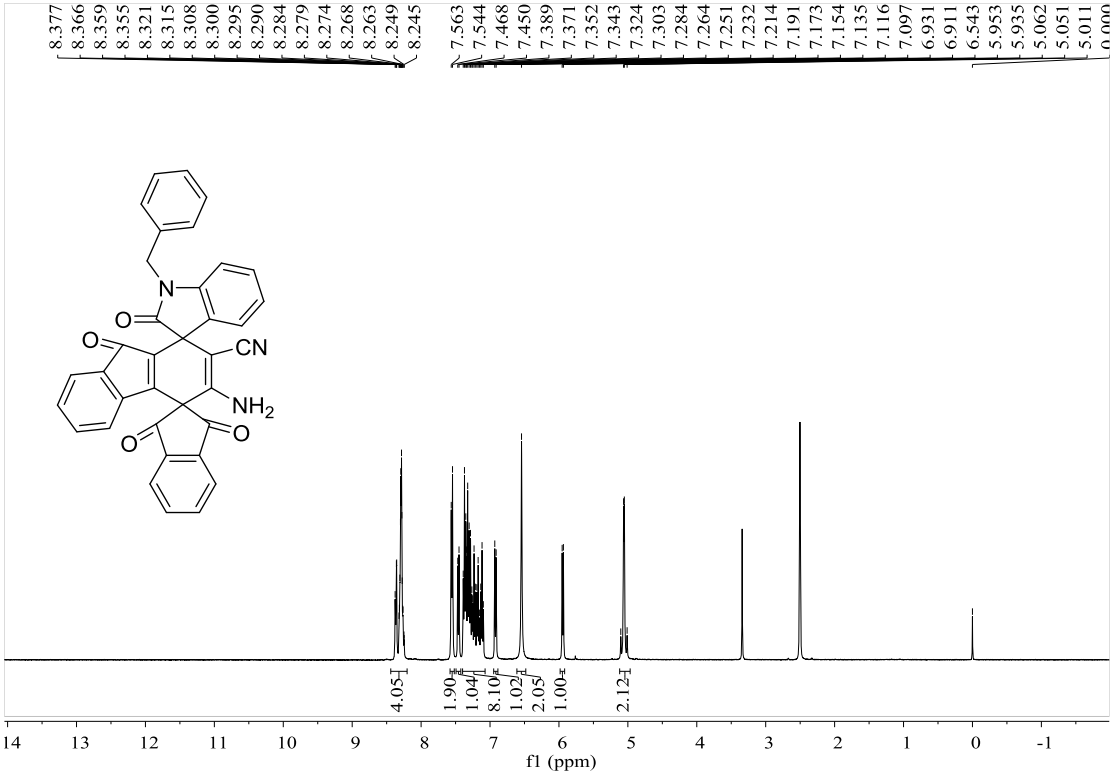
1'-butyl-5'-methyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8e): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.518 g, 86%, m.p. 299-301 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.09 (t, *J* = 7.2 Hz, 2H), 7.99-7.94 (m, 2H), 7.84-7.76 (m, 2H), 7.55 (t, *J* = 7.6 Hz, 1H), 7.49 (t, *J* = 7.6 Hz, 1H), 7.32 (t, *J* = 8.0 Hz, 1H), 7.23-7.19 (m, 2H), 6.93 (t, *J* = 7.6 Hz, 2H), 6.84 (d, *J* = 8.0 Hz, 1H), 5.17 (s, 1H), 4.58 (d, *J* = 7.2 Hz, 2H), 3.95-3.88 (m, 1H), 3.85-3.78 (m, 1H), 1.94-1.85 (m, 2H), 1.69 (s, 3H), 1.60-1.55 (m, 2H), 1.05 (t, *J* = 7.2 Hz, 3H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 197.7, 192.9, 192.6, 192.5, 176.1, 152.2, 149.7, 142.8, 141.8, 135.4, 135.3, 135.2, 135.0, 134.9, 133.6, 132.3, 132.2, 130.6, 130.0, 129.8, 129.2, 129.0, 128.8, 127.5, 127.3, 126.7, 126.6, 126.5, 123.5, 122.3, 108.1, 59.9, 56.9, 52.0, 49.0, 40.8, 29.0, 20.6, 20.4, 13.9; HRMS (ESI-TOF) Calcd. For $C_{40}H_{30}NNaO_5$ ($[M+H]^+$): 604.2118, found: 604.2118.

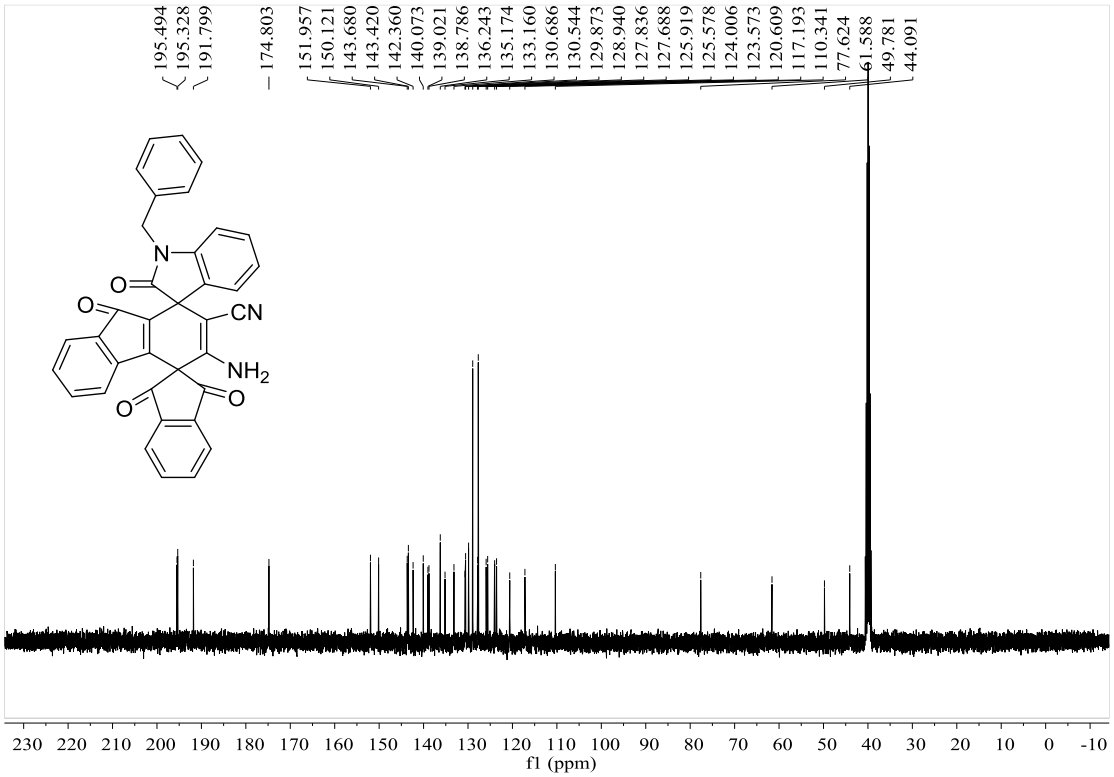
1'-butyl-5'-chloro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8f): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.417 g, 67%, m.p. 286-288 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.11 (d, *J* = 7.6 Hz, 2H), 7.97 (t, *J* = 8.0 Hz, 2H), 7.86-7.77 (m, 2H), 7.59 (t, *J* = 7.6 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 1H), 7.39 (t, *J* = 7.6 Hz, 1H), 7.25-7.21 (m, 1H), 7.11 (d, *J* = 7.6 Hz, 1H), 7.02 (t, *J* = 7.2 Hz, 1H), 6.92 (d, *J* = 7.6 Hz, 1H), 6.87 (d, *J* = 8.4 Hz, 1H), 5.17 (s, 1H), 4.65 (s, 1H), 4.55 (s, 1H), 3.95-3.78 (m, 2H), 1.92-1.85 (m, 2H), 1.58-1.53 (m, 2H), 1.05 (t, *J* = 7.6 Hz, 3H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 197.2, 192.8, 192.6, 192.3, 175.9, 152.9, 149.0, 143.8, 141.6, 135.7, 135.4, 135.2, 135.1, 134.8, 133.8, 132.4, 131.4, 130.7, 130.5, 129.5, 129.1, 128.4, 127.1, 126.7, 126.7, 126.1, 123.7, 122.4, 109.2, 59.7, 57.0, 52.1, 49.0, 40.9, 28.9, 20.4, 13.8; HRMS (ESI-TOF) Calcd. For $C_{39}H_{24}ClNNaO_5$ ($[M+Na]^+$): 646.1392, found: 646.1395.

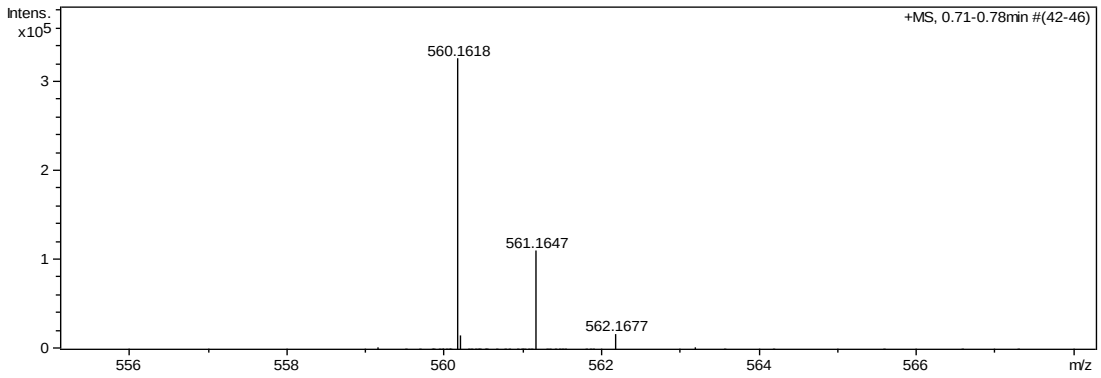
1'-butyl-5'-fluoro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8g): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.370 g, 61%, m.p. 241-243 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.10 (d, *J* = 7.6 Hz, 2H), 7.97 (t, *J* =7.6 Hz, 2H), 7.85-7.78 (m, 2H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.49 (t, *J* = 7.2 Hz, 1H), 7.37 (t, *J* = 7.6 Hz, 1H), 7.24-7.21 (m, 2H), 6.94 (d, *J* = 8.0 Hz, 1H), 6.88-6.81 (m, 2H), 5.17 (s, 1H), 4.58 (s, 1H), 4.49 (d, *J* = 7.2 Hz, 1H), 3.95-3.88 (m, 1H), 3.85-3.78 (m, 1H), 1.93-1.84 (m, 2H), 1.60-1.56 (m, 1H), 1.55-1.51 (m, 1H), 1.05 (t, *J* = 7.6 Hz, 3H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 197.3, 192.8, 192.6, 192.4, 175.9, 157.7 (d, *J* = 238.4 Hz), 152.8, 149.2, 141.6, 141.2, 135.6, 135.4, 135.2, 135.1, 134.8, 133.7, 132.3, 131.5, 130.5, 130.5, 129.5, 129.1, 127.2, 126.7, 123.7, 122.4, 114.7 (d, *J* = 22.9 Hz), 113.7 (d, *J* = 26.5 Hz), 108.6 (d, *J* = 8.1 Hz), 59.8, 57.0, 52.1, 49.3, 40.9, 28.9, 20.4, 13.8; HRMS (ESI-TOF) Calcd. For $C_{39}H_{26}FNNaO_5$ ($[M+Na]^+$): 630.1687, found: 630.1693.

5'-chloro-1'-methyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8h): ethyl acetate and petroleum ether (v/v=1:4) as the eluent, white solid, 0.447 g, 77%, m.p. >300 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.10-8.05 (m, 2H), 7.98-7.92 (m, 4H), 7.69 (t, *J* = 7.6 Hz, 1H), 7.63 (t, *J* = 7.6 Hz, 1H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.35 (t, *J* = 7.6 Hz, 1H), 7.25-7.21 (m, 2H), 7.11 (d, *J* = 7.6 Hz, 1H), 6.83 (d, *J* = 8.0 Hz, 1H), 5.25 (s, 1H), 5.11 (s, 1H), 4.53 (s, 1H), 3.30 (s, 3H); ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ: 198.2, 193.7, 193.1, 192.4, 176.0, 154.1, 150.0, 144.9, 141.6, 136.1, 134.8, 134.6, 132.6, 131.5, 130.3, 130.1, 129.5, 128.8, 128.7, 127.3, 126.9, 125.7, 125.2, 124.1, 59.6, 56.3, 53.2, 48.9, 27.3; HRMS (ESI-TOF) Calcd. For $C_{36}H_{21}ClNO_5$ ($[M+H]^+$): 582.1103, found: 582.1109.

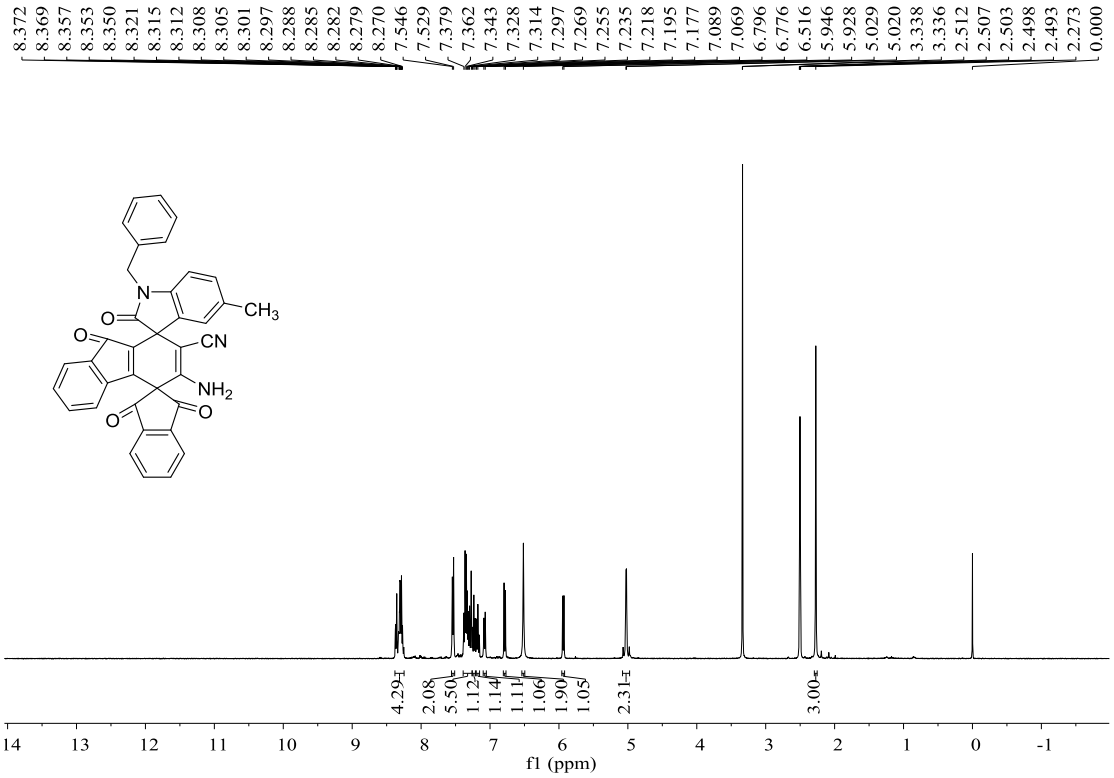
3'-amino-1''-benzyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3a):

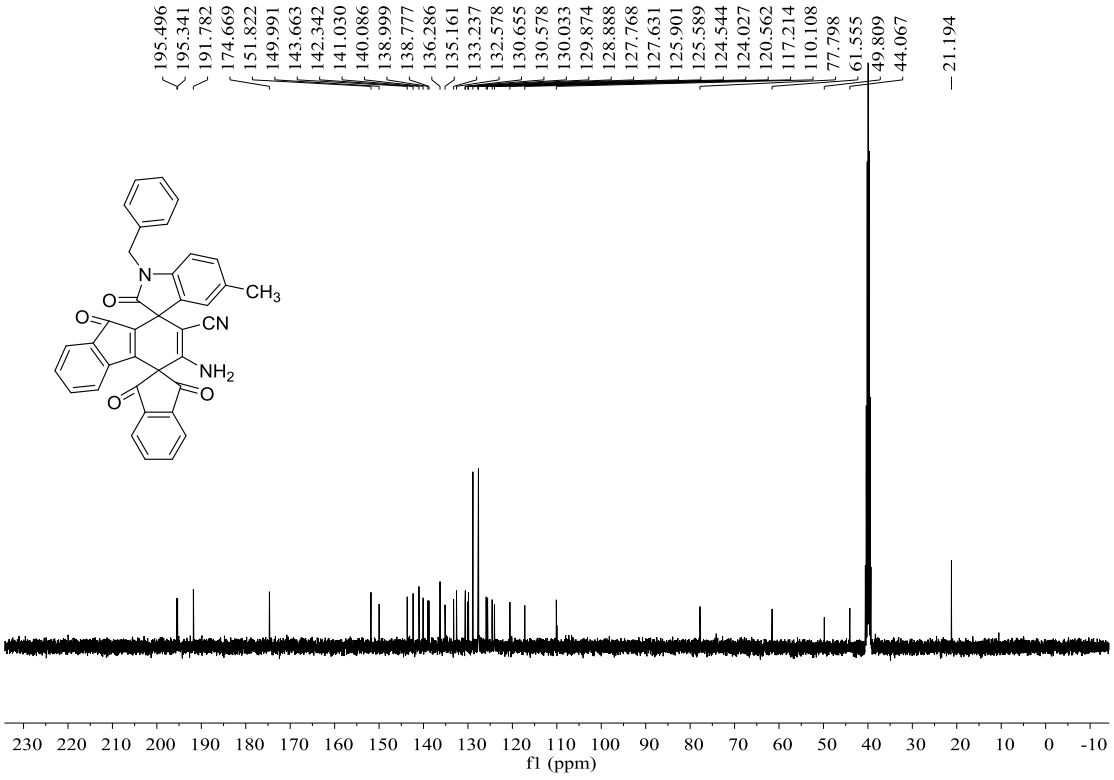


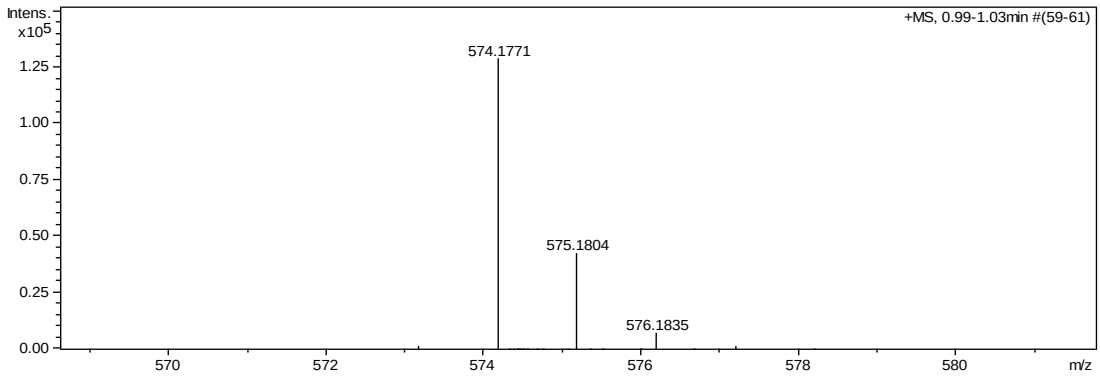



Intens.
x10^5
+MS, 0.71-0.78min #(42-46)
560.1618
561.1647
562.1677
0
1
2
3
556
558
560
562
564
566
m/z

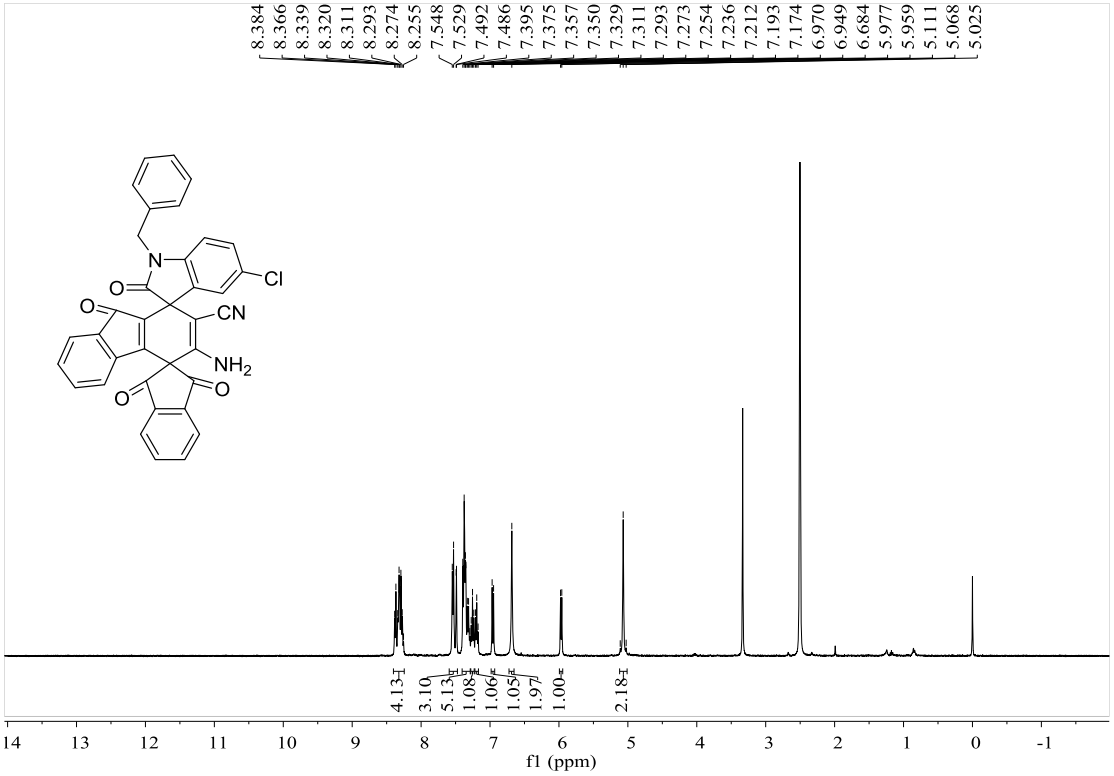
3'-amino-1''-benzyl-5''-methyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3b):

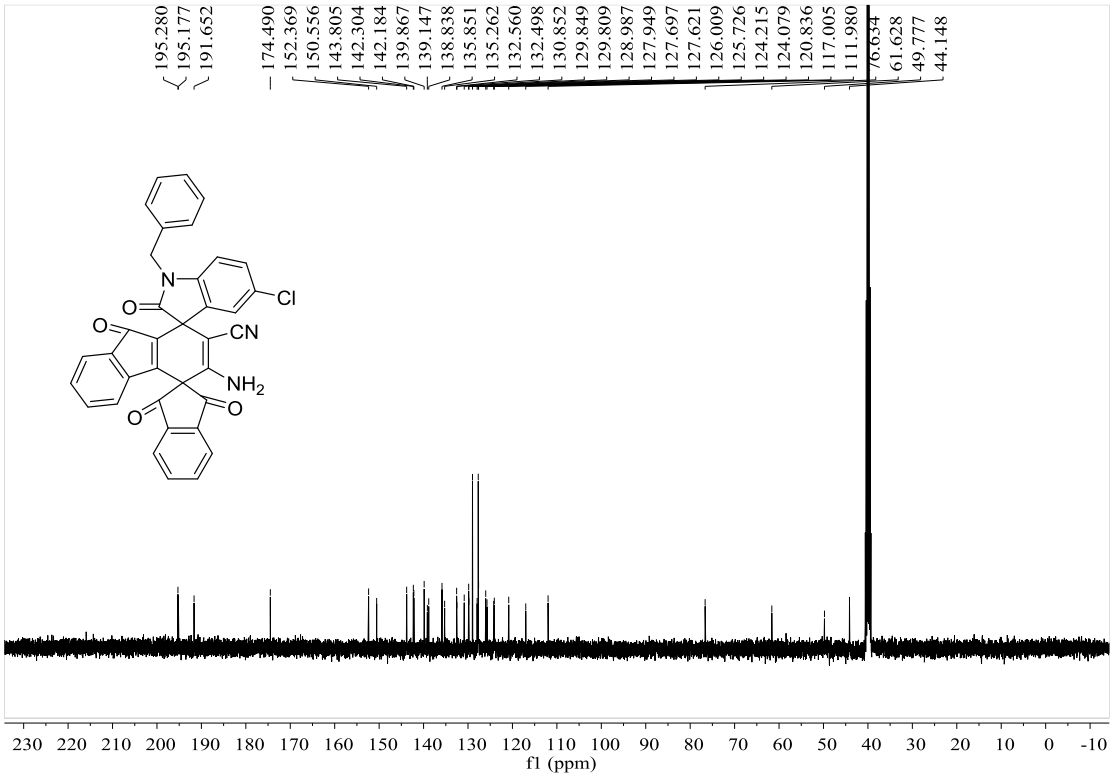


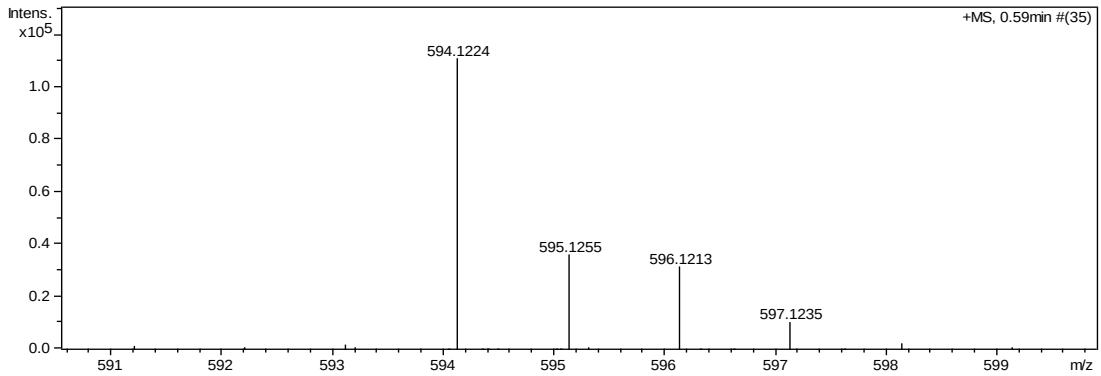



Intens.
x10^5
+MS, 0.99-1.03min #(59-61)
574.1771
575.1804
576.1835
1.25
1.00
0.75
0.50
0.25
0.00
570
572
574
576
578
580
m/z

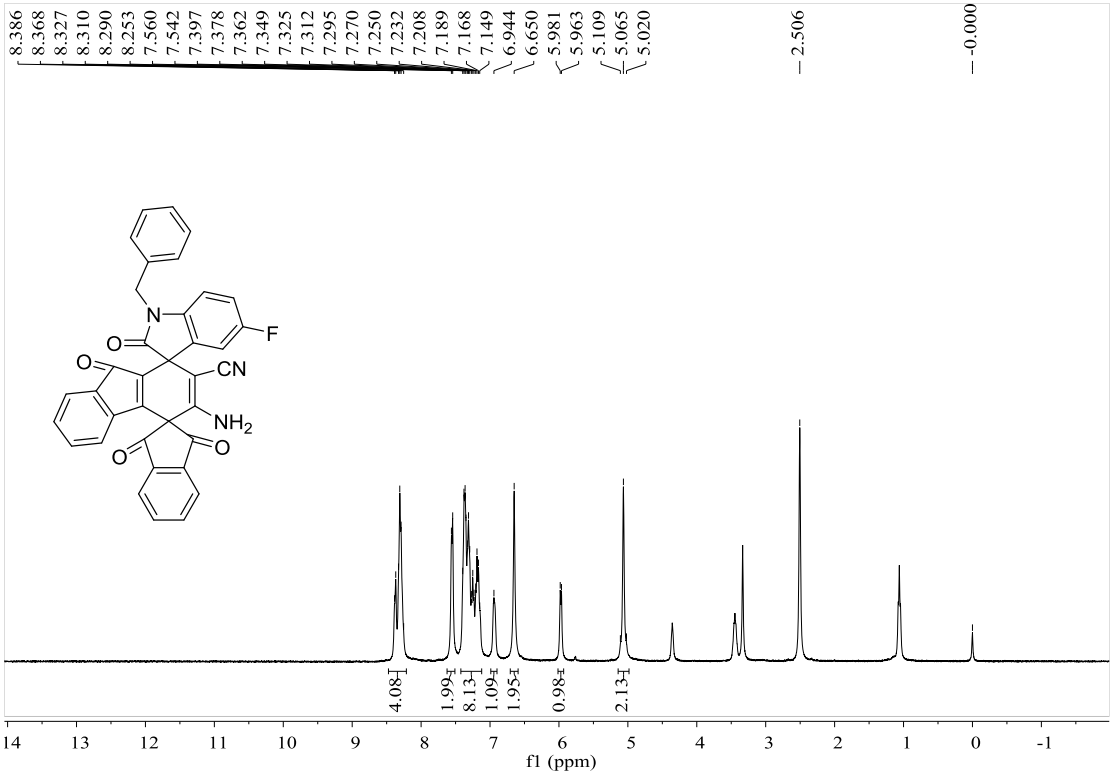
3'-amino-1''-benzyl-5''-chloro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3c):

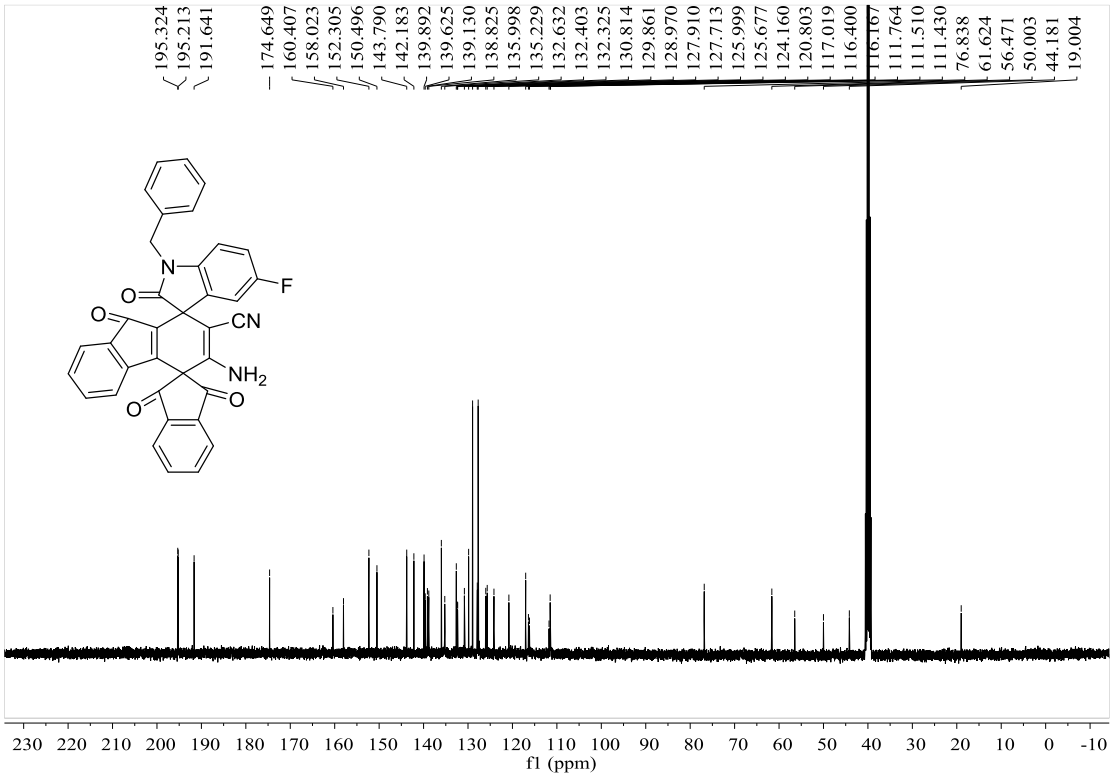


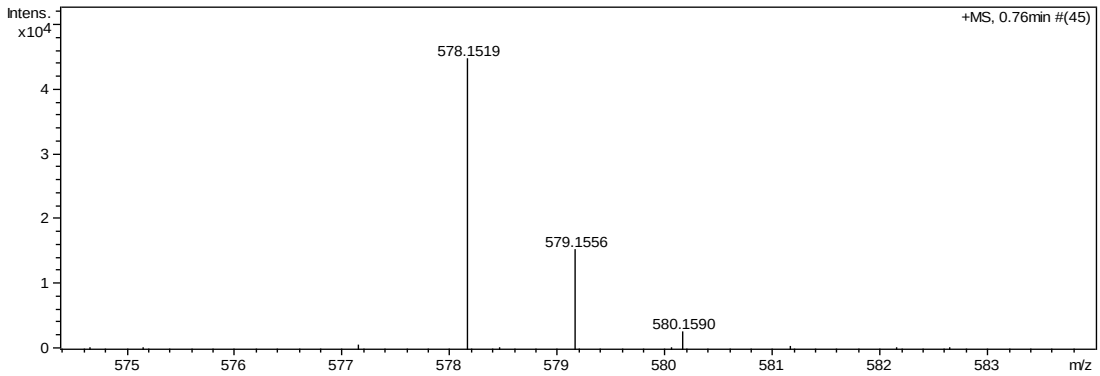



Intens.
x10^5
+MS, 0.59min #(35)
1.0
0.8
0.6
0.4
0.2
0.0
594.1224
595.1255
596.1213
597.1235
591
592
593
594
595
596
597
598
599
m/z

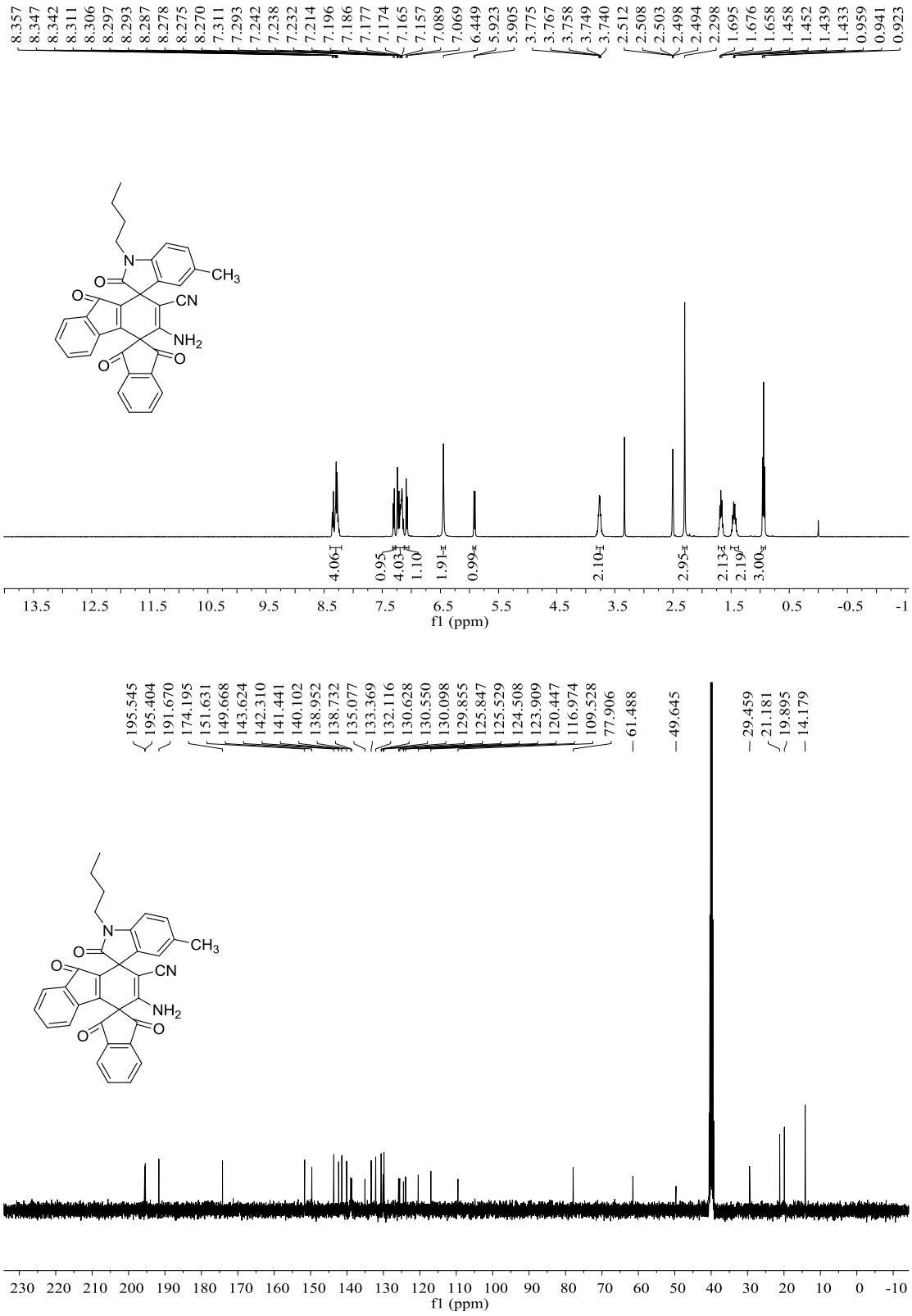
3'-amino-1''-benzyl-5''-fluoro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3d):

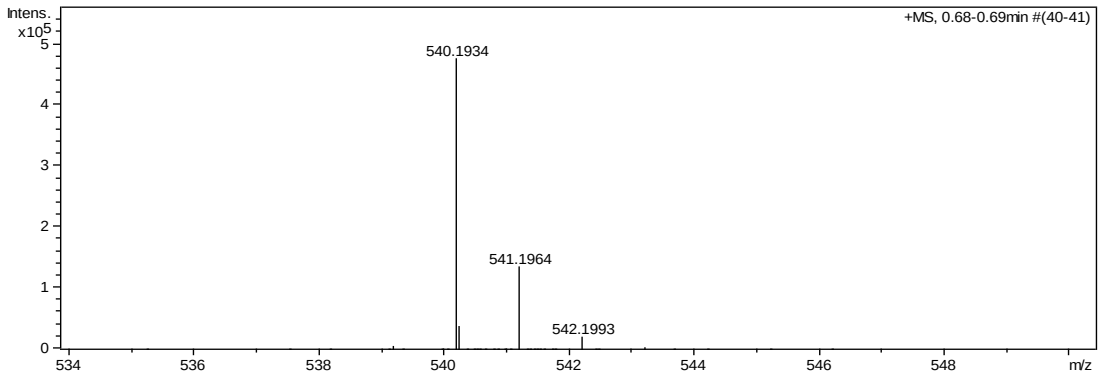




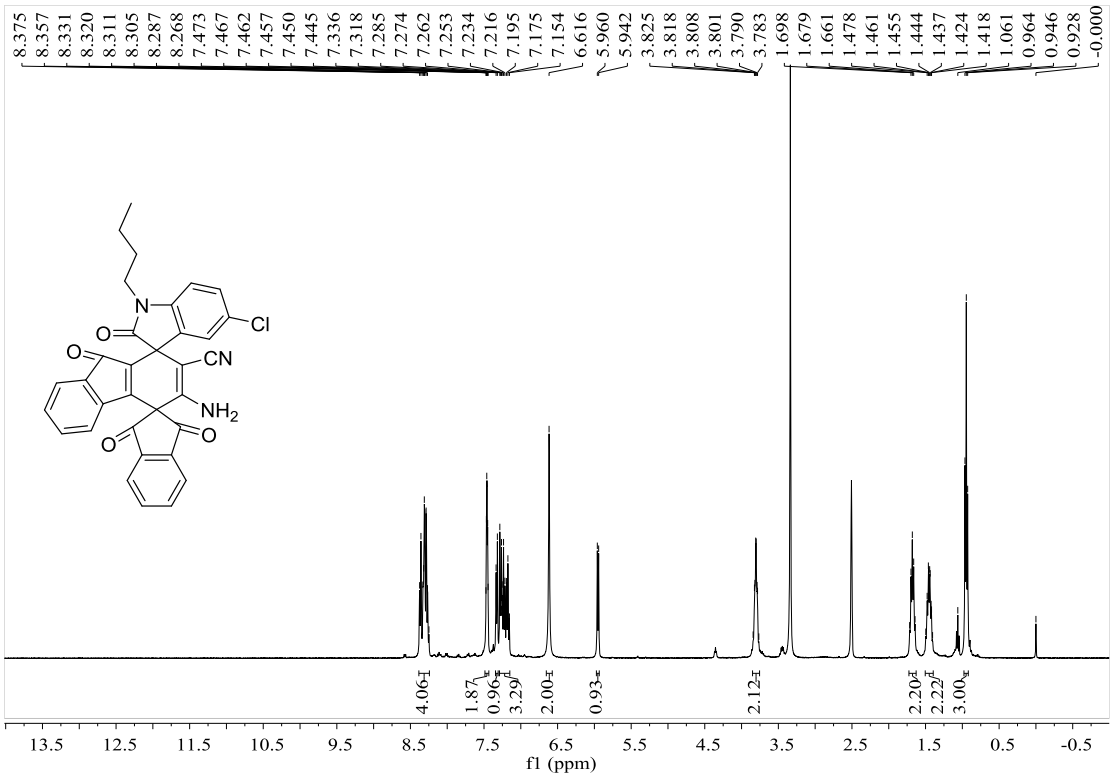

Intens.
x10^4
+MS, 0.76min #(45)
578.1519
579.1556
580.1590
0
1
2
3
4
575
576
577
578
579
580
581
582
583
m/z

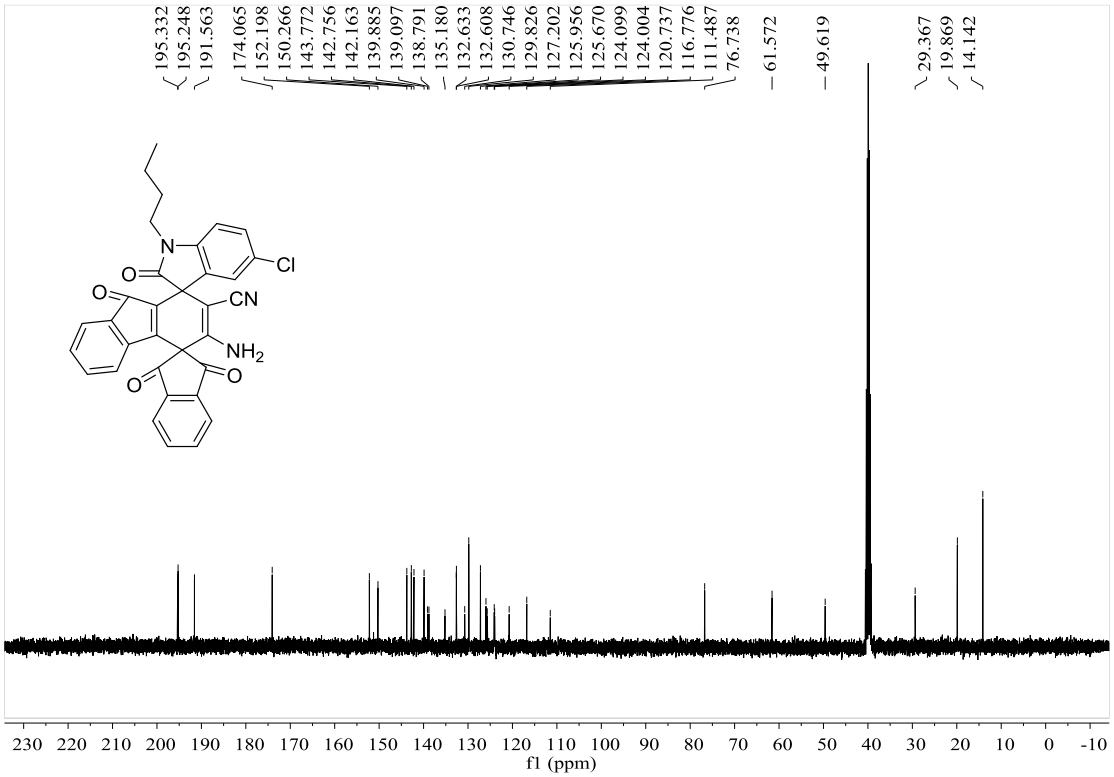
3'-amino-1''-butyl-5''-methyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3e):

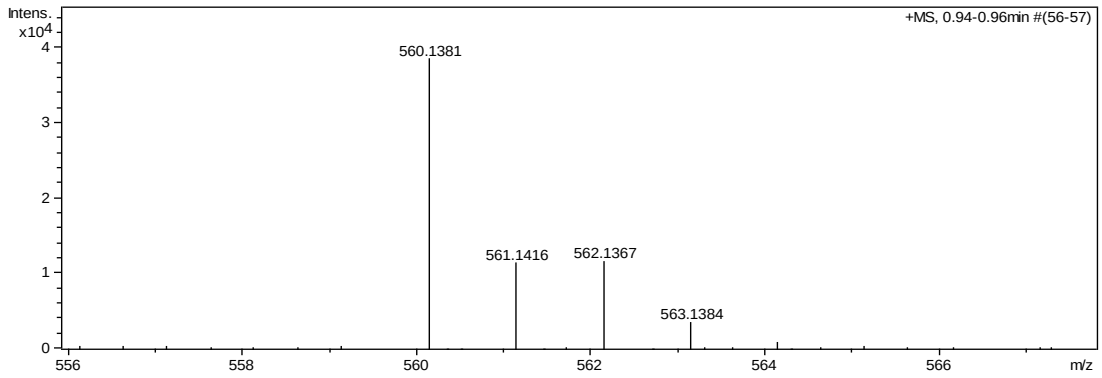



Intens.
x10^5
+MS, 0.68-0.69min #(40-41)
540.1934
541.1964
542.1993
m/z

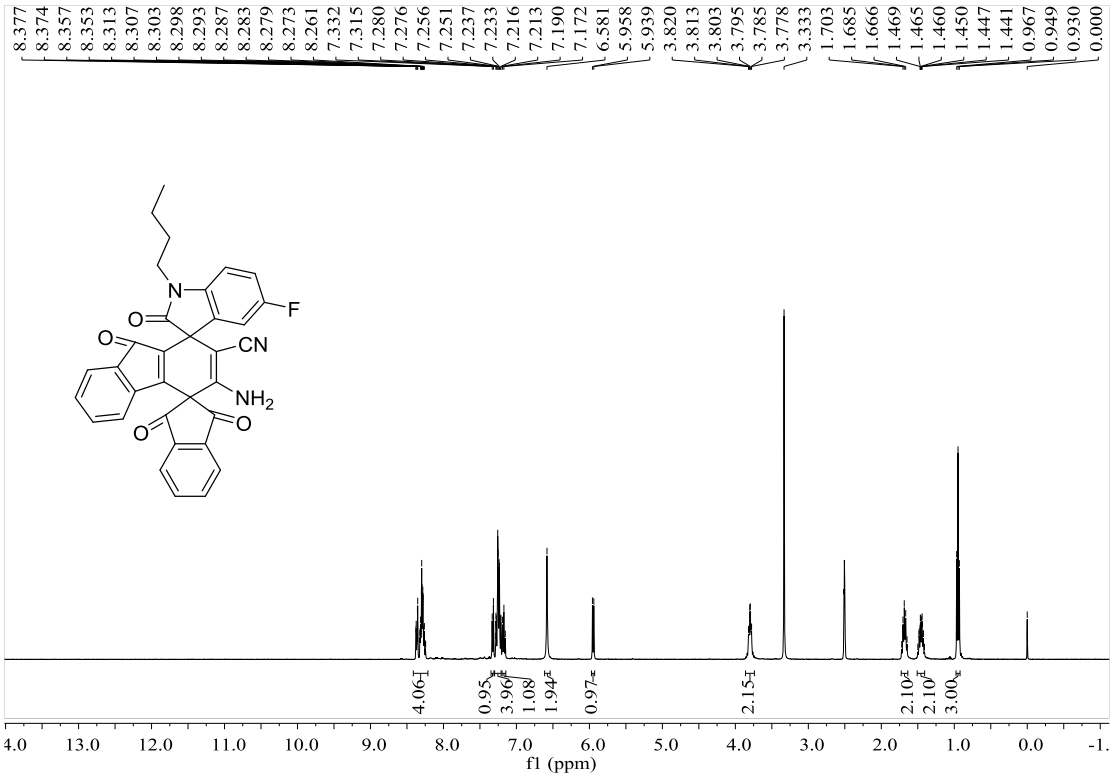
3'-amino-1''-butyl-5''-chloro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3f):

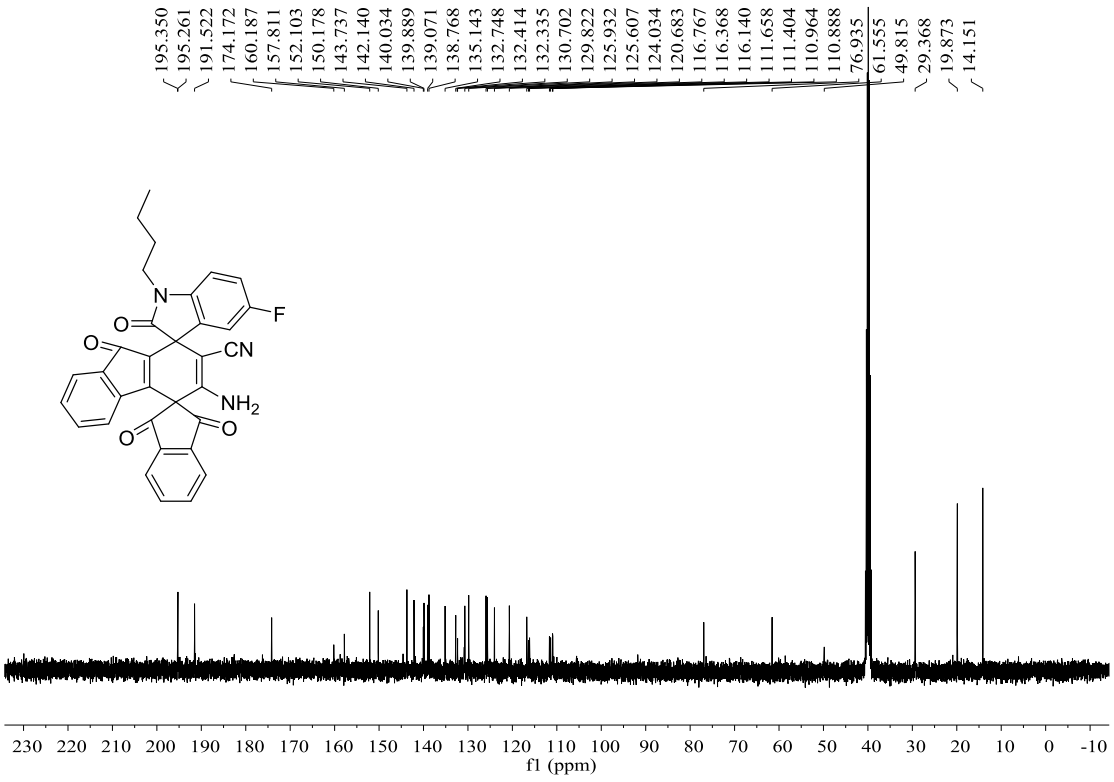


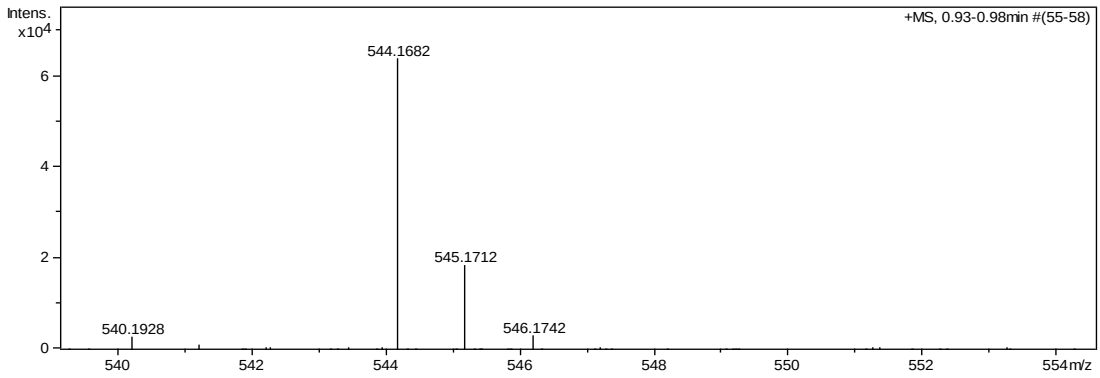



Intens.
x10^4
+MS, 0.94-0.96min #(56-57)
560.1381
561.1416
562.1367
563.1384
0
1
2
3
4
556
558
560
562
564
566
m/z

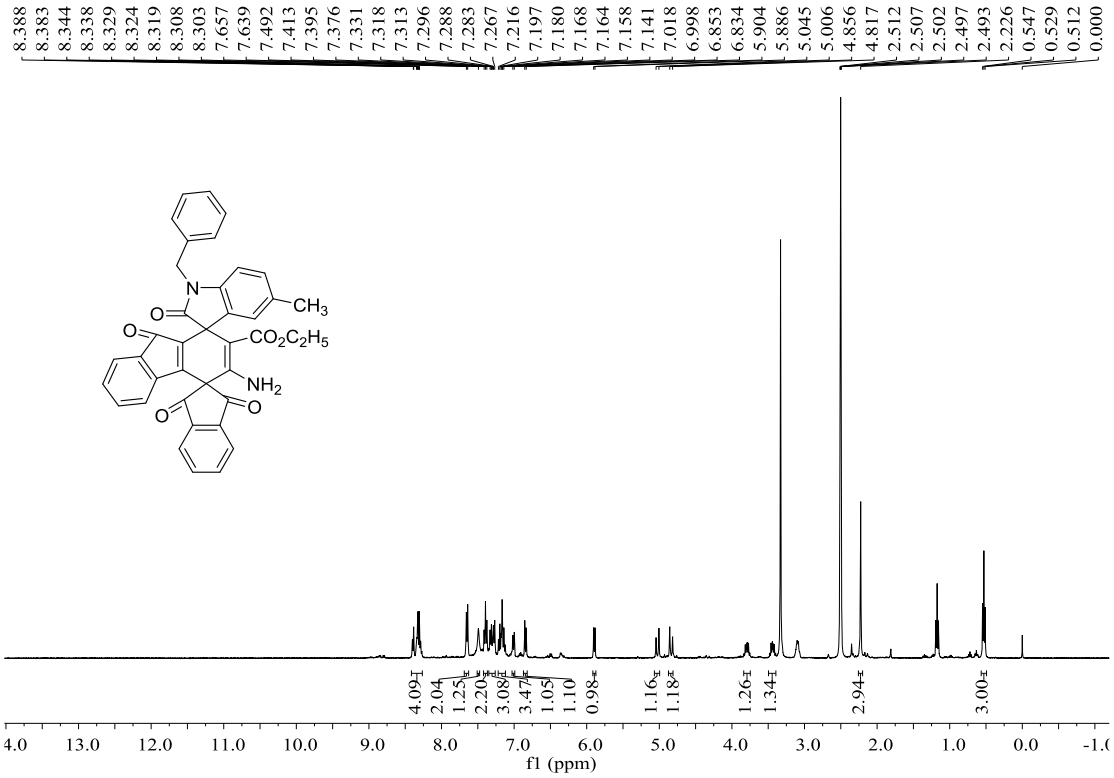
3'-amino-1''-butyl-5''-fluoro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'H-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carbonitrile (3g):

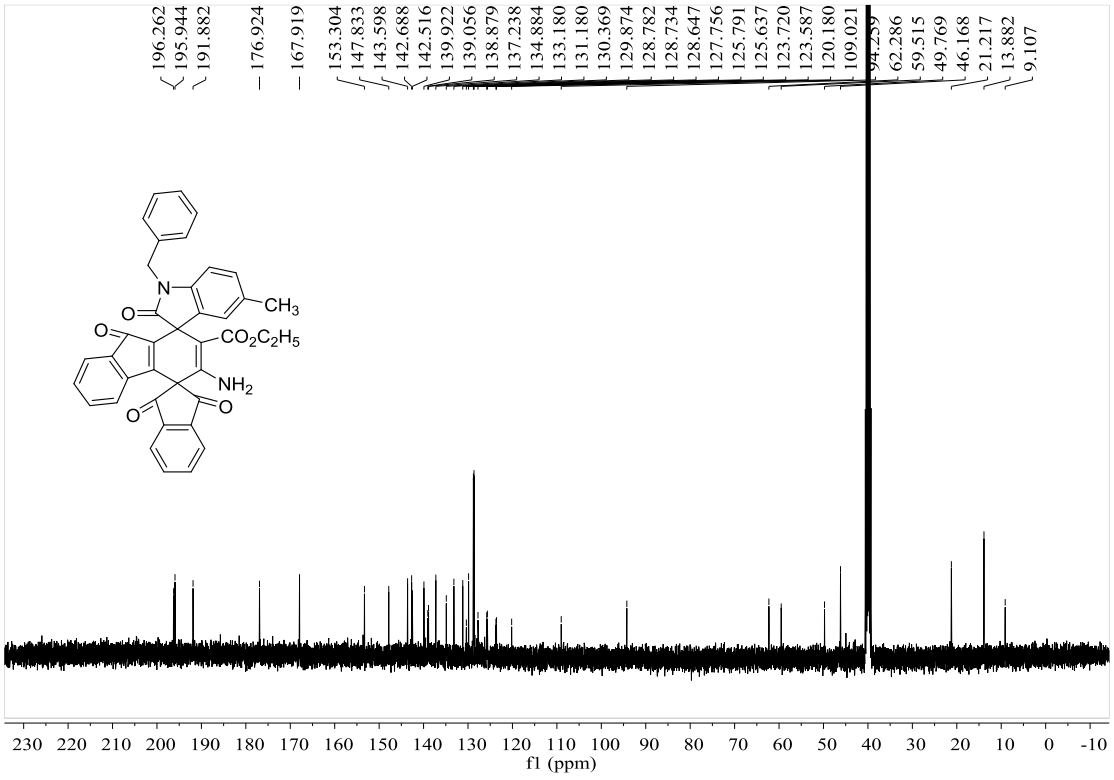


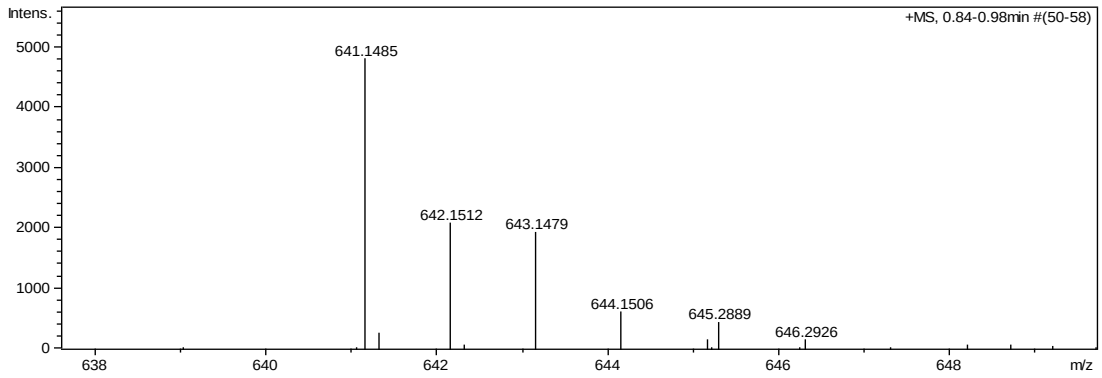



Intens.
x10^4
+MS, 0.93-0.98min #(55-58)
544.1682
545.1712
540.1928
546.1742
6
4
2
0
540
542
544
546
548
550
552
554 m/z

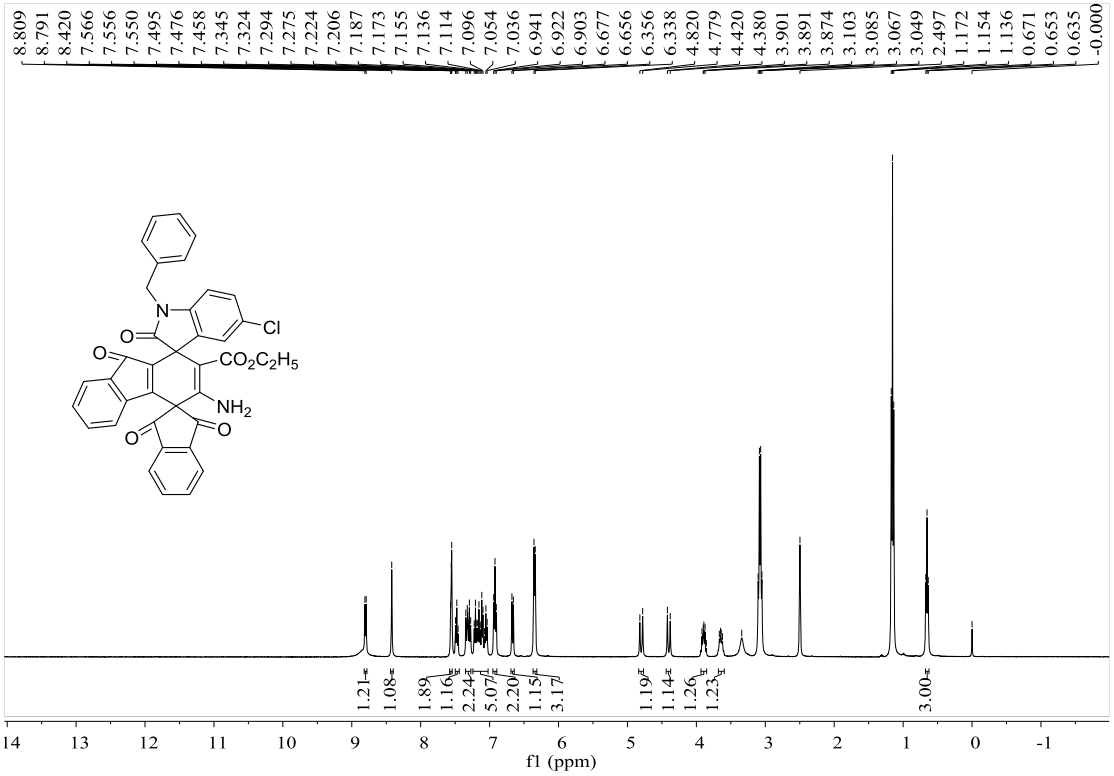
Ethyl 3'-amino-1''-benzyl-5''-methyl-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carboxylate (3h):

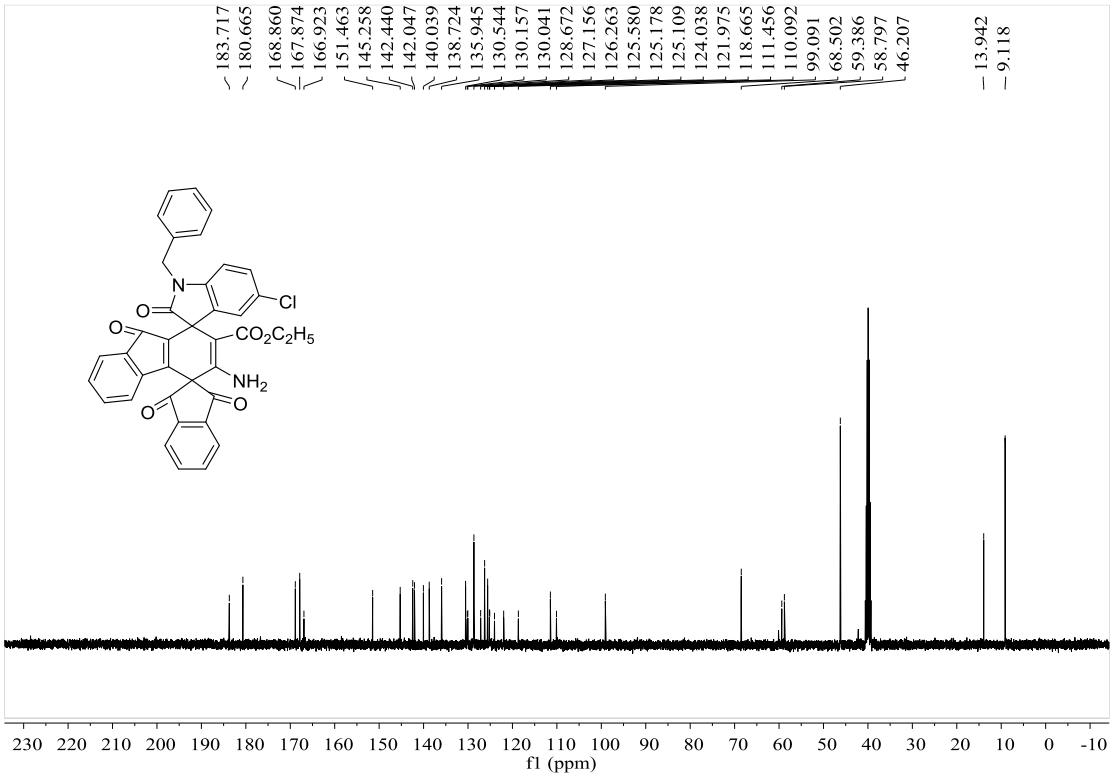


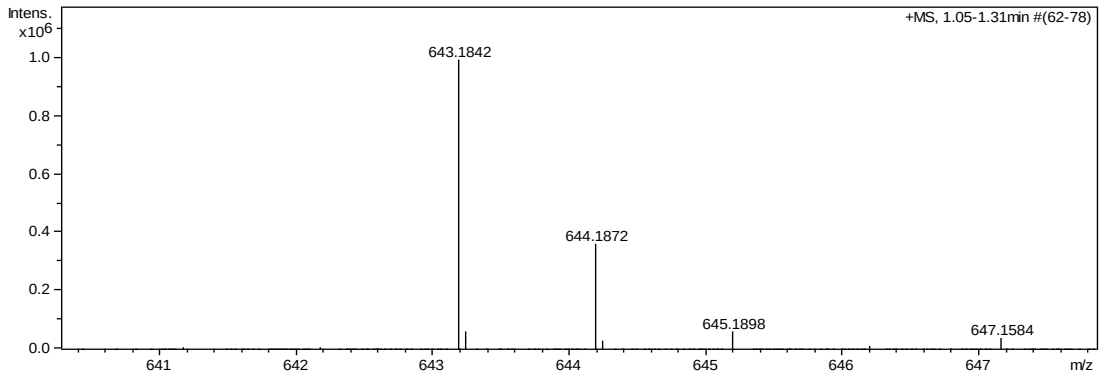



Intens.
+MS, 0.84-0.98min #(50-58)
5000
4000
3000
2000
1000
0
641.1485
642.1512
643.1479
644.1506
645.2889
646.2926
638
640
642
644
646
648
m/z

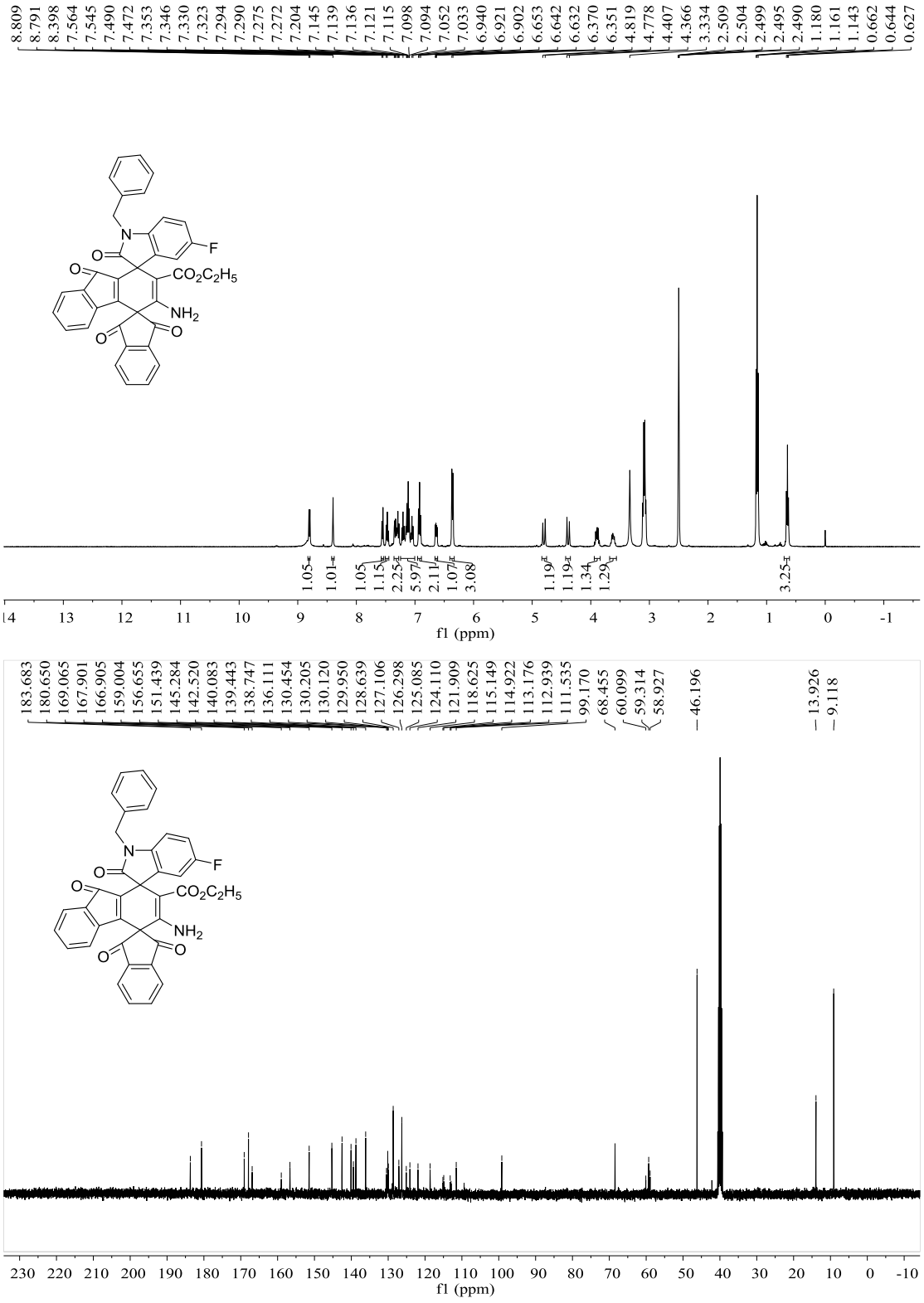
Ethyl 3'-amino-1''-benzyl-5''-chloro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carboxylate (3i):

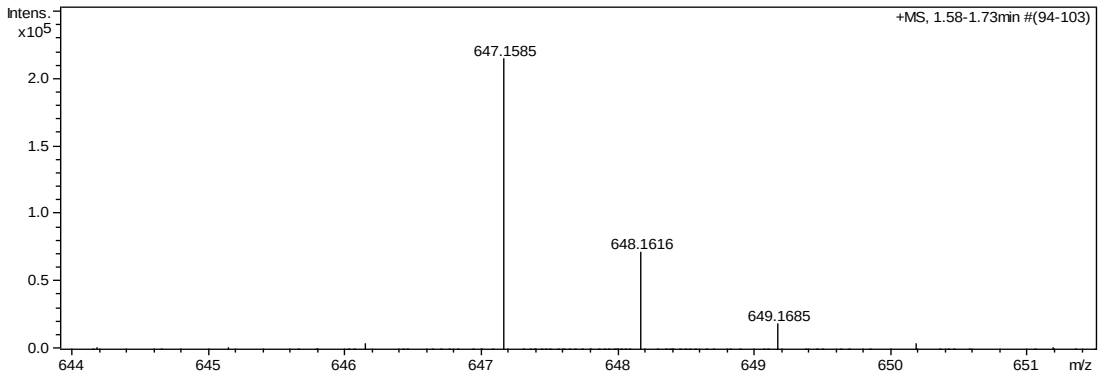




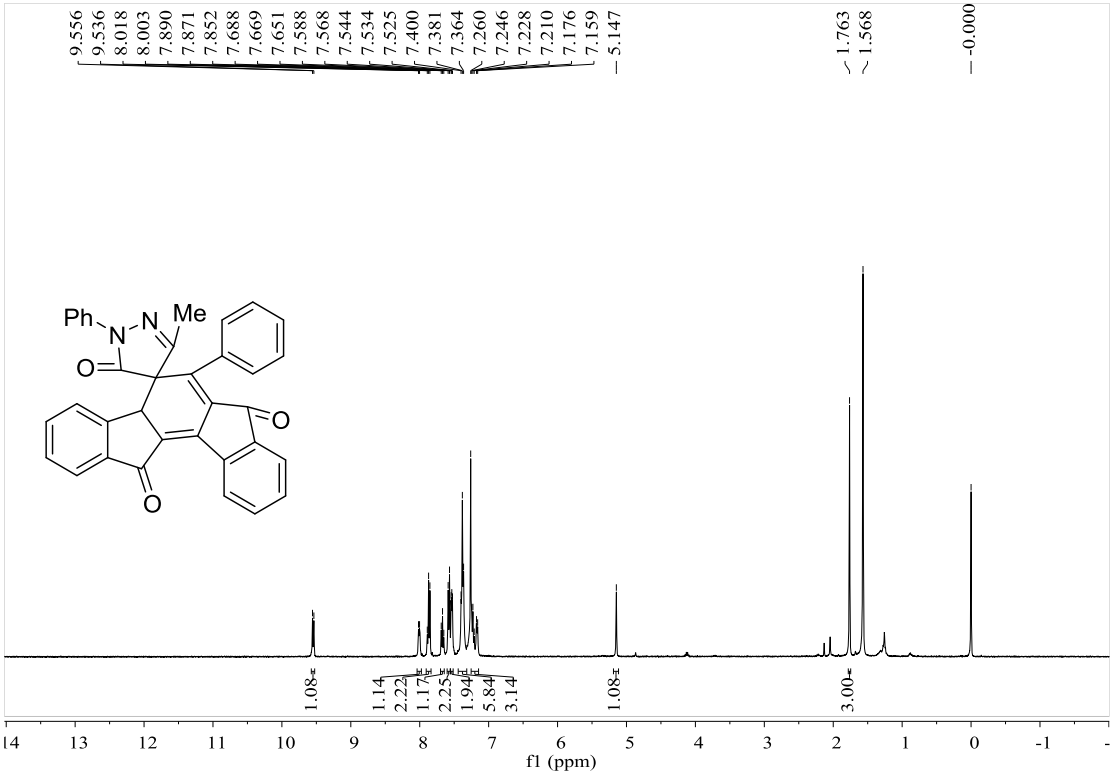

Intens.
x10^6
1.0
0.8
0.6
0.4
0.2
0.0
+MS, 1.05-1.31min #(62-78)
643.1842
644.1872
645.1898
647.1584
641
642
643
644
645
646
647
m/z

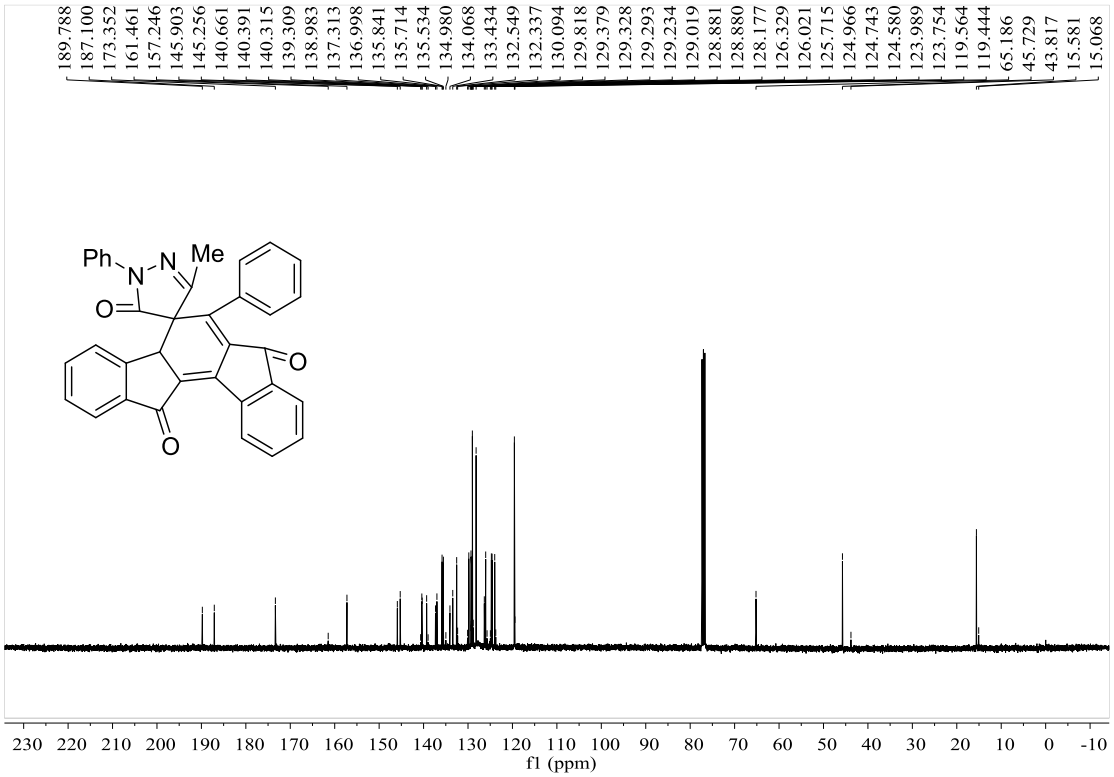
Ethyl 3'-amino-1''-benzyl-5''-fluoro-1,2'',3,9'-tetraoxo-1,3-dihydro-9'*H*-dispiro[indene-2,4'-fluorene-1',3''-indoline]-2'-carboxylate (3j):

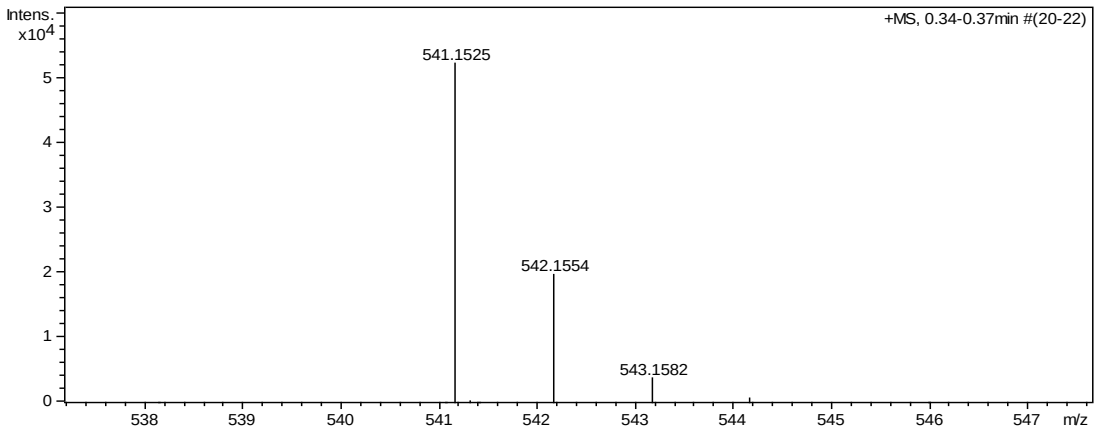



Intens.
x10^5
+MS, 1.58-1.73min #(94-103)
647.1585
648.1616
649.1685
2.0
1.5
1.0
0.5
0.0
644
645
646
647
648
649
650
651
m/z

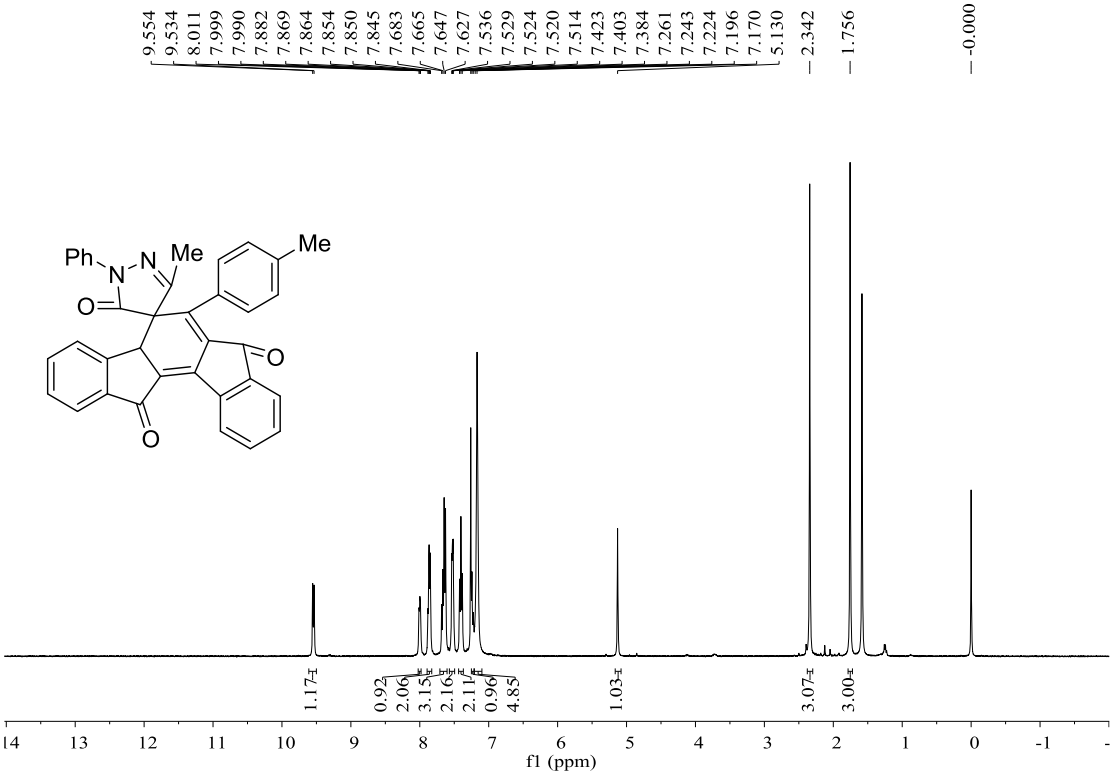
3'-methyl-1',6-diphenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5a):

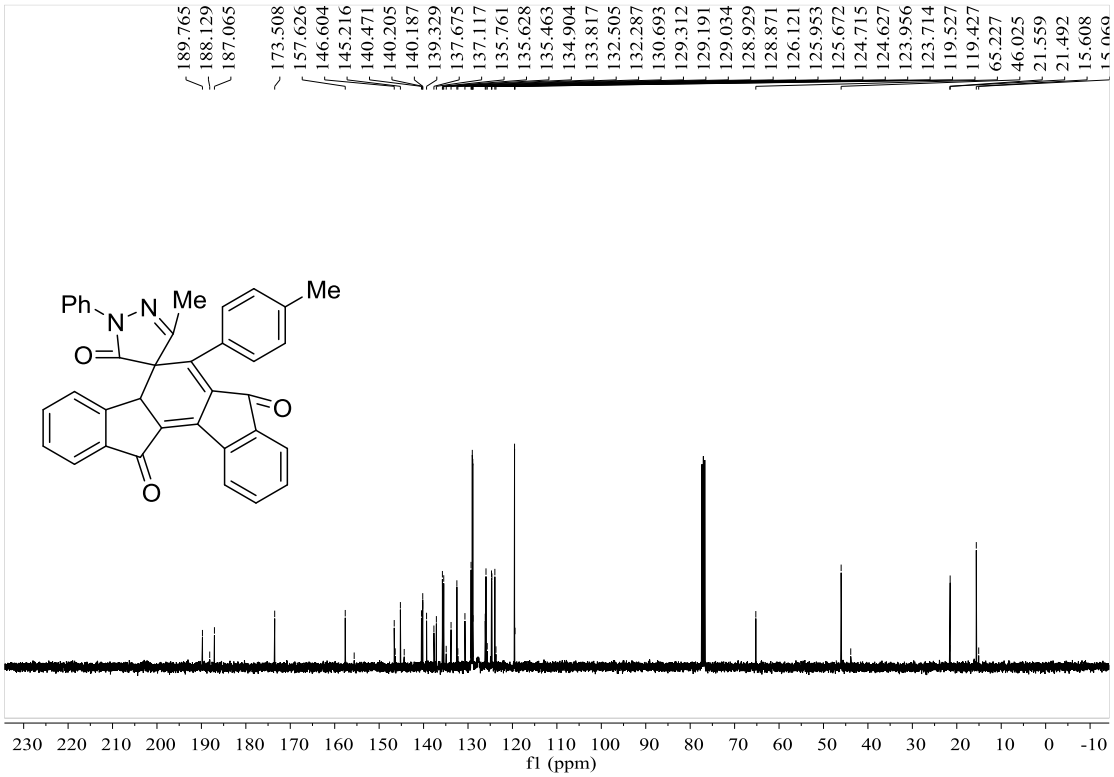


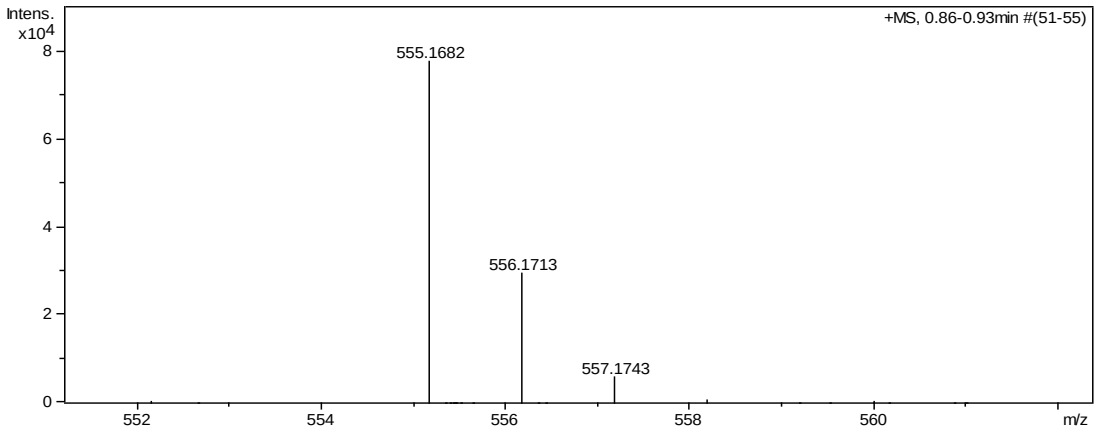



Intens.
x10^4
+MS, 0.34-0.37min #(20-22)
541.1525
542.1554
543.1582
0
1
2
3
4
5
538
539
540
541
542
543
544
545
546
547
m/z

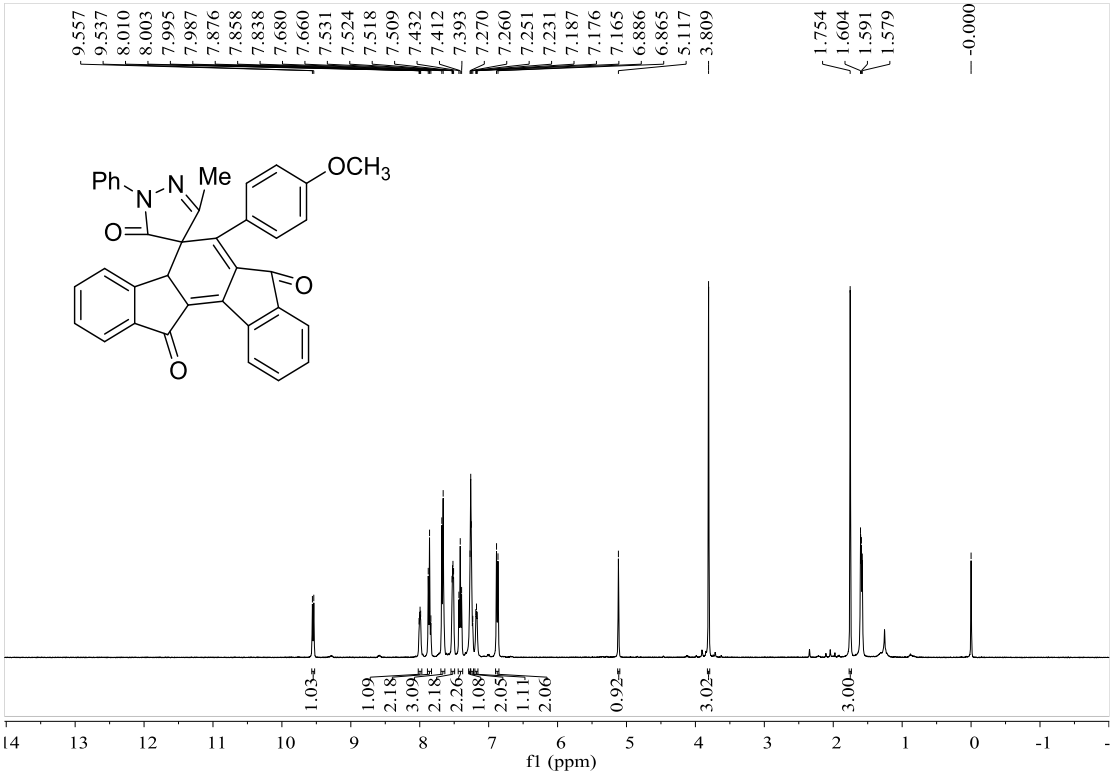
3'-methyl-1'-phenyl-6-(p-tolyl)-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4*bH*)-trione (5b):

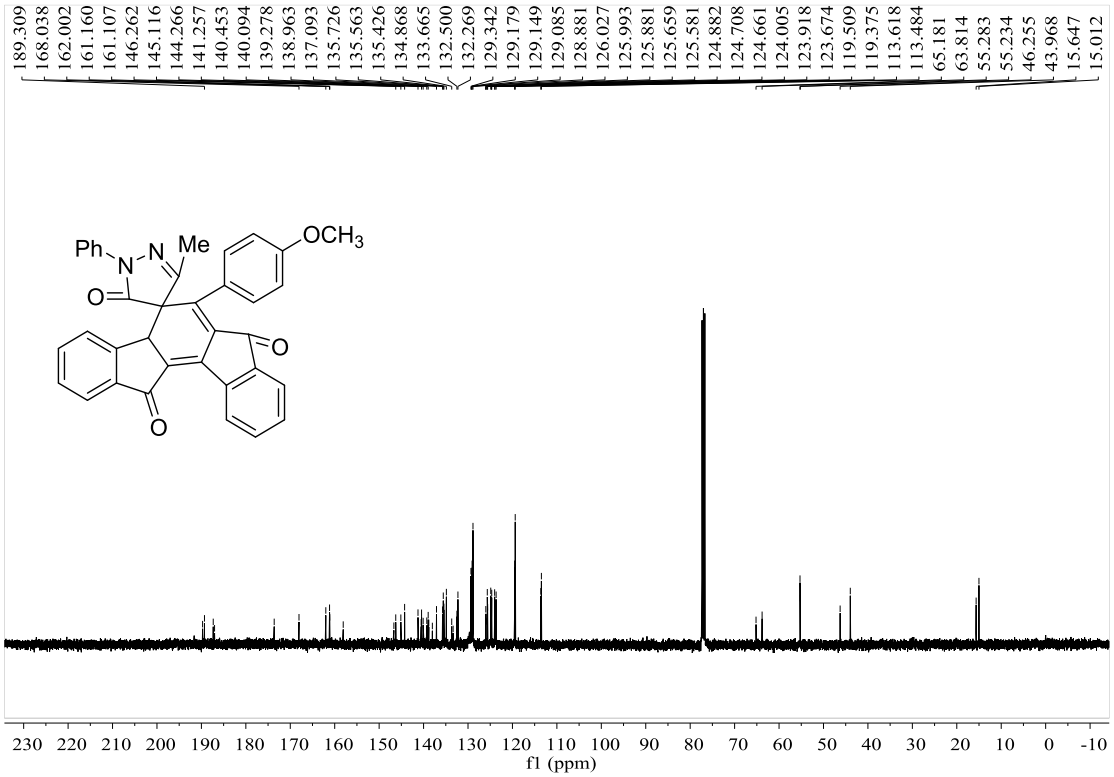


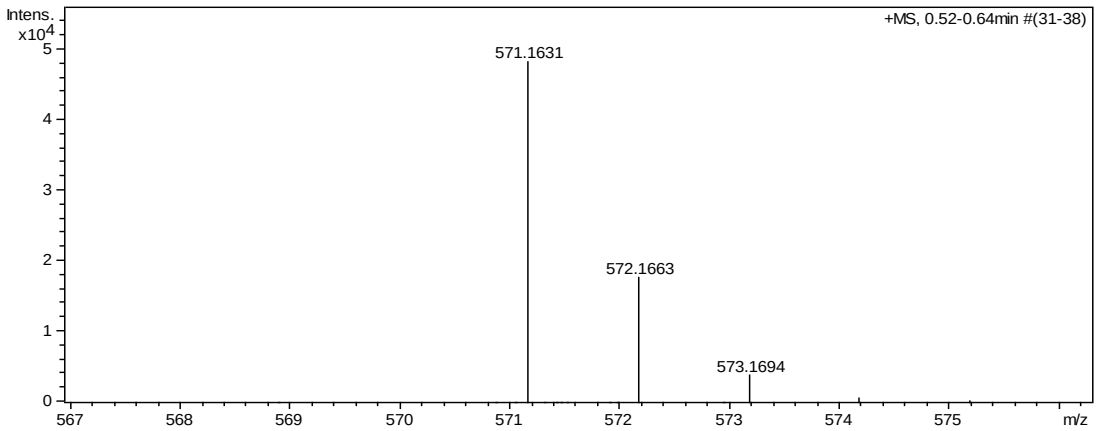



Intens.
x10^4
+MS, 0.86-0.93min #(51-55)
555.1682
556.1713
557.1743
8
6
4
2
0
552
554
556
558
560
m/z

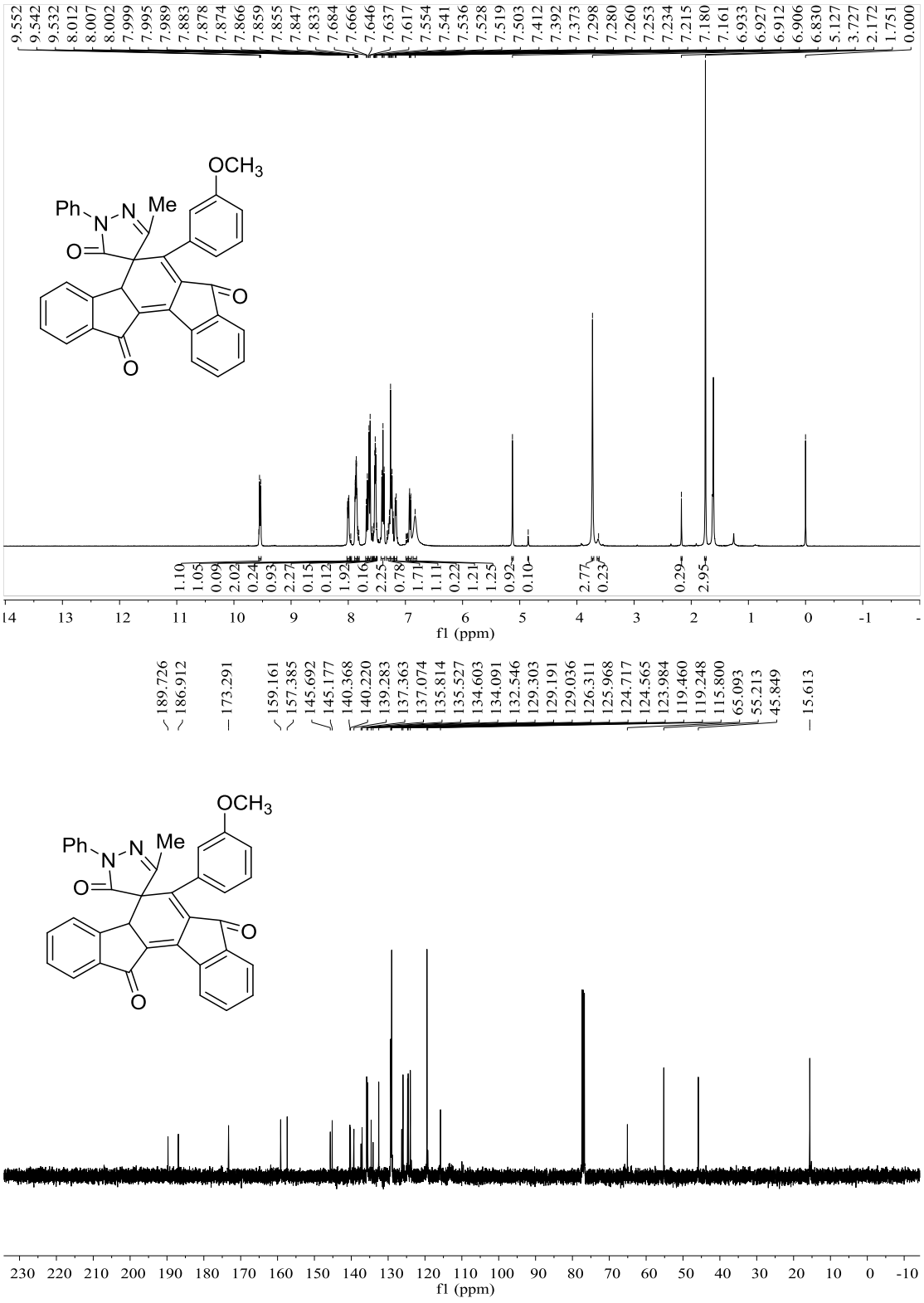
6-(4-methoxyphenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5c):

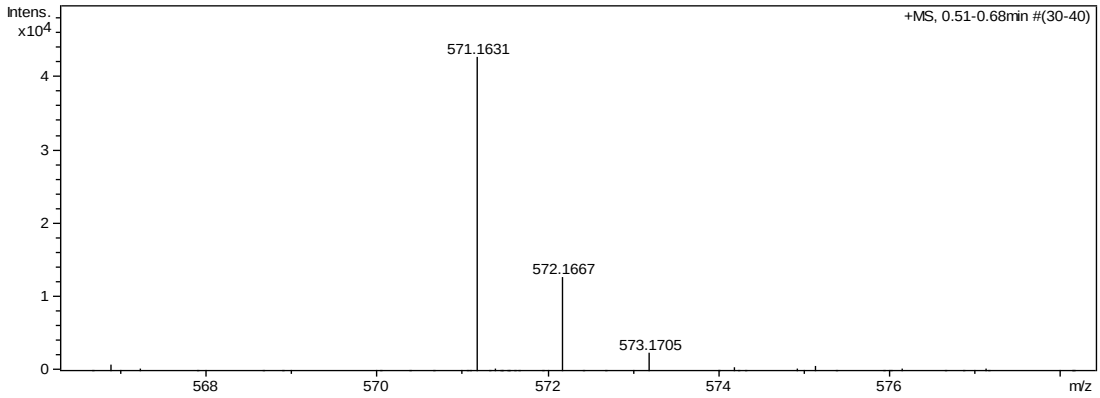




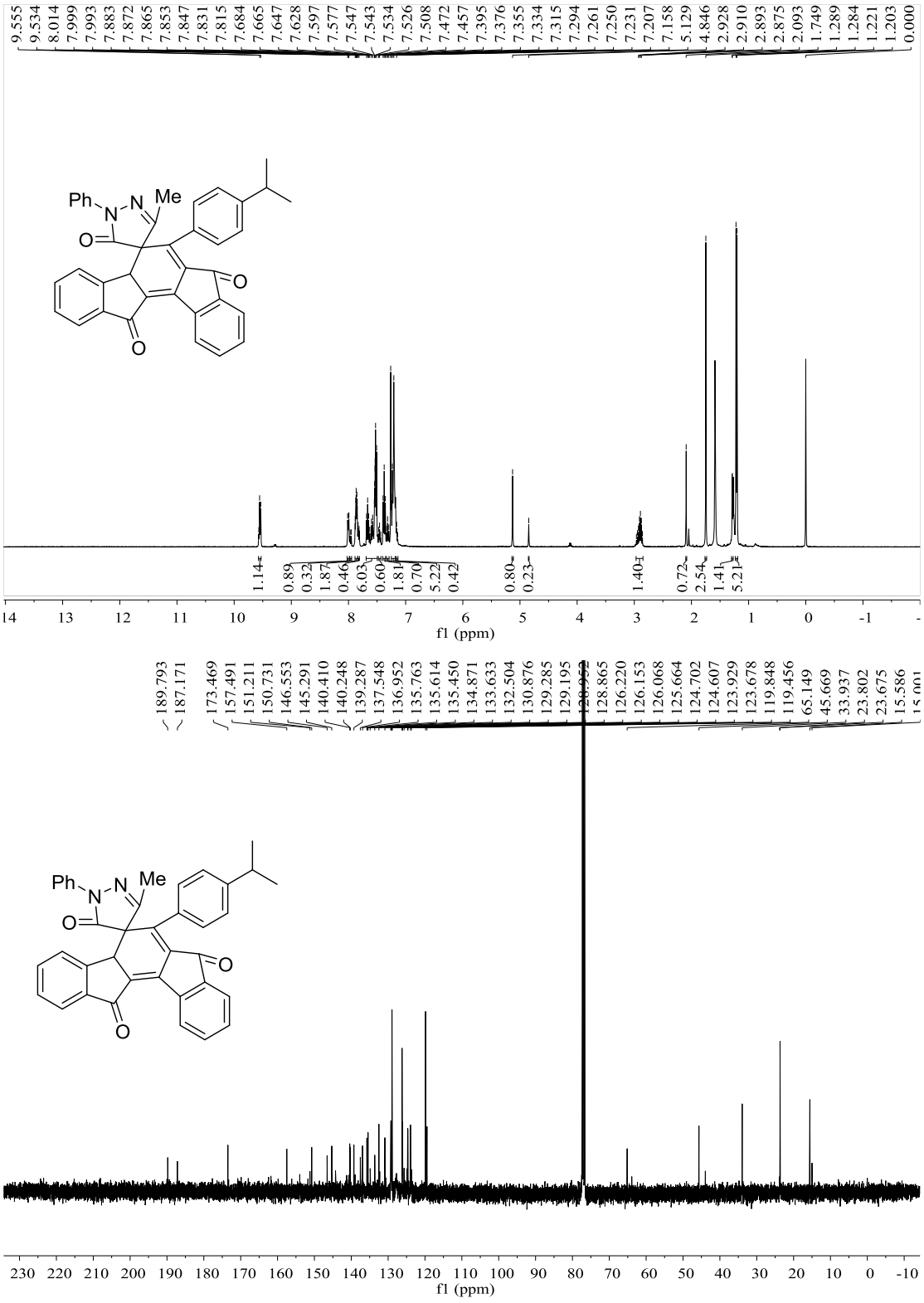

Intens.
x10^4
+MS, 0.52-0.64min #(31-38)
571.1631
572.1663
573.1694
m/z

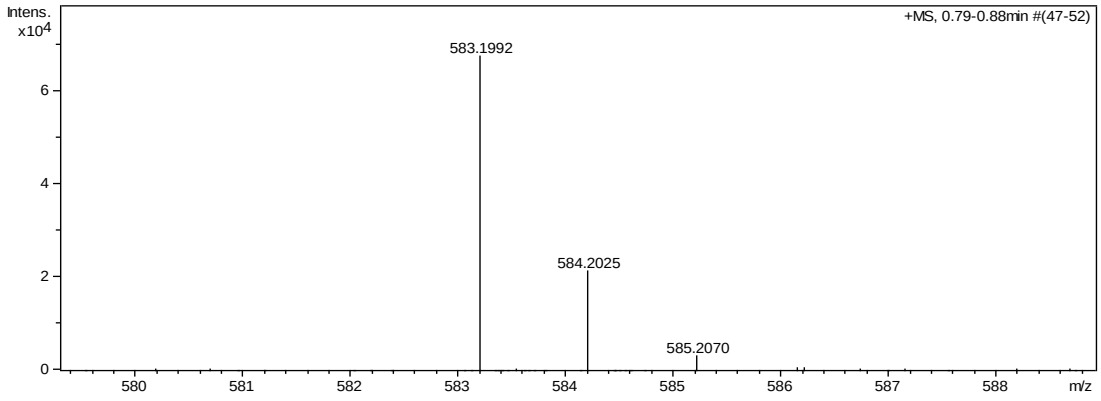
6-(3-methoxyphenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5d):



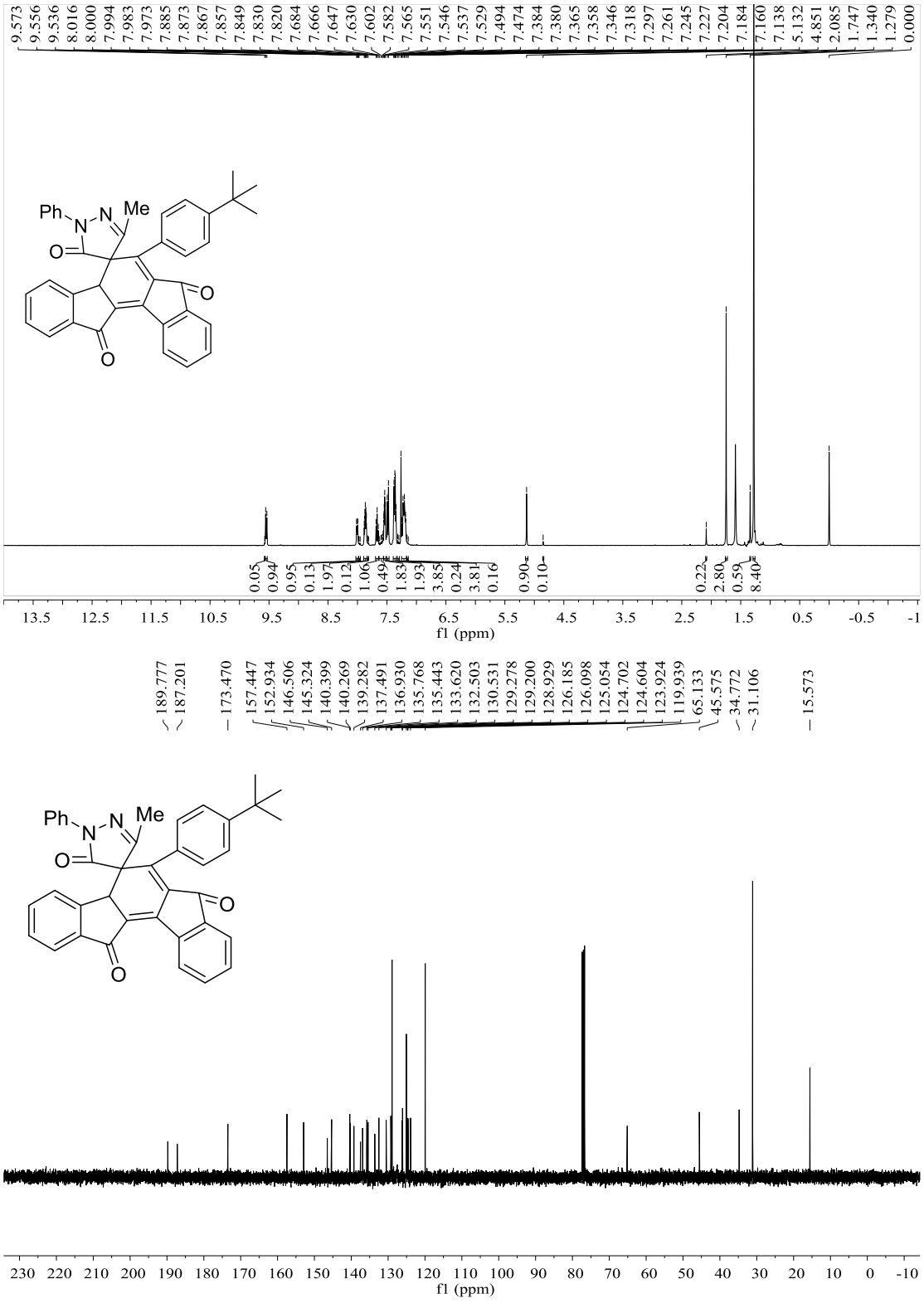

Intens.
x10^4
+MS, 0.51-0.68min #(30-40)
571.1631
572.1667
573.1705
0
1
2
3
4
568
570
572
574
576
m/z

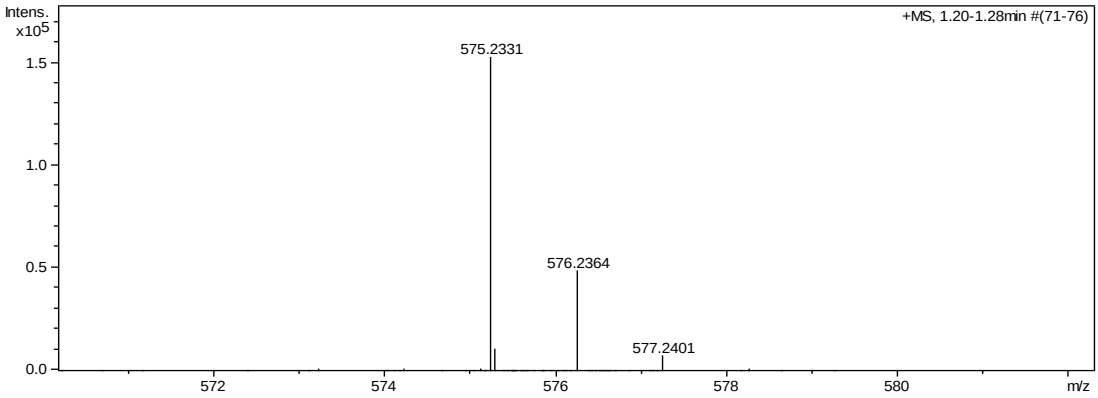
6-(4-isopropylphenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5e):



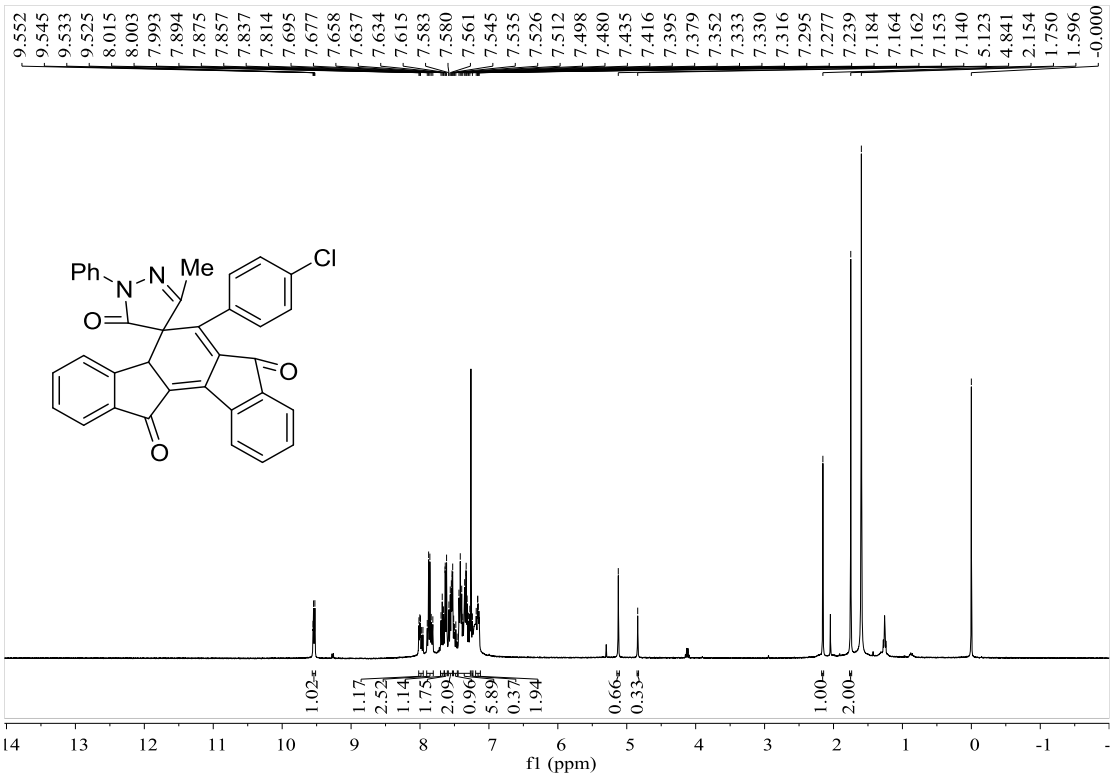

Intens.
x10^4
+MS, 0.79-0.88min #(47-52)
583.1992
584.2025
585.2070
6
4
2
0
580
581
582
583
584
585
586
587
588
m/z

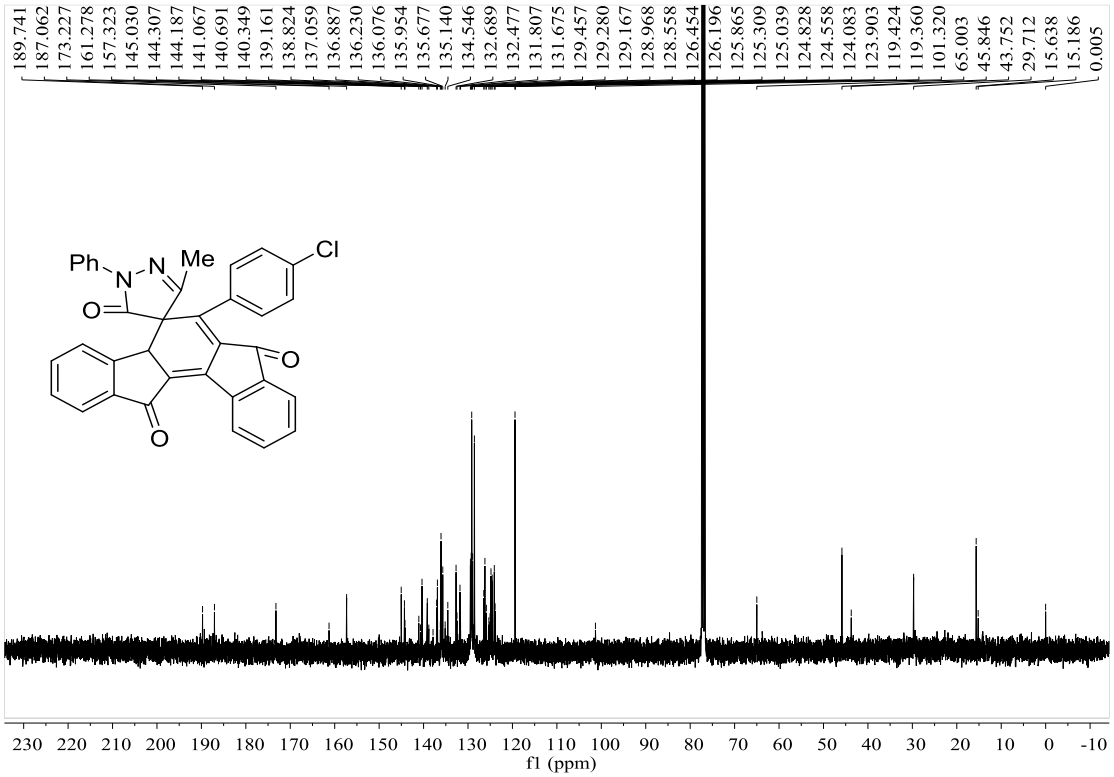
6-(4-(tert-butyl)phenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5f):

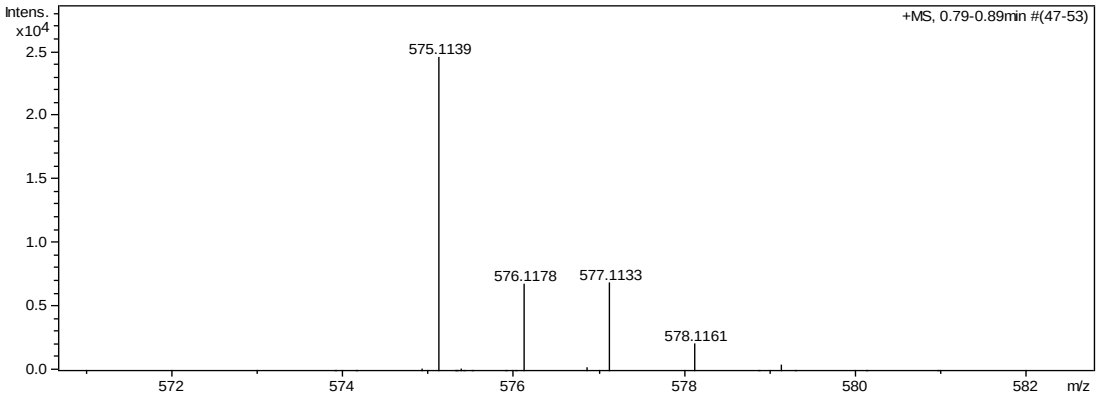



Intens.
x10^5
+MS, 1.20-1.28min #(71-76)
575.2331
576.2364
577.2401
1.5
1.0
0.5
0.0
572
574
576
578
580
m/z

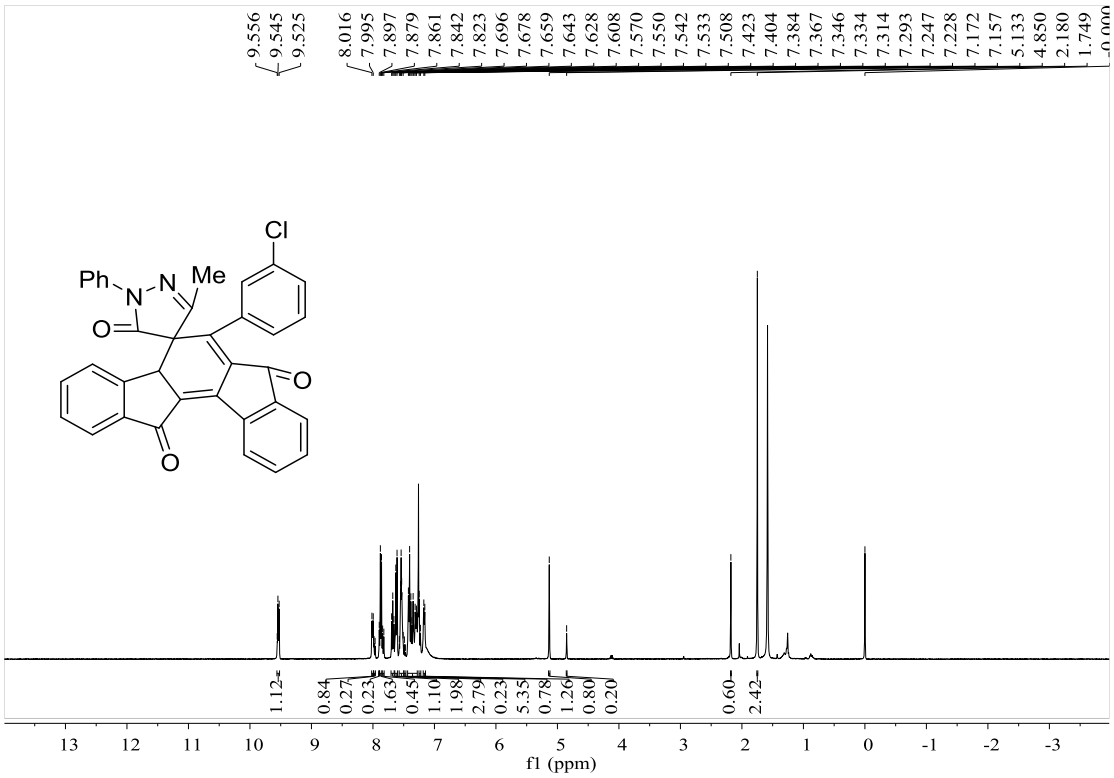
6-(4-chlorophenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5g):

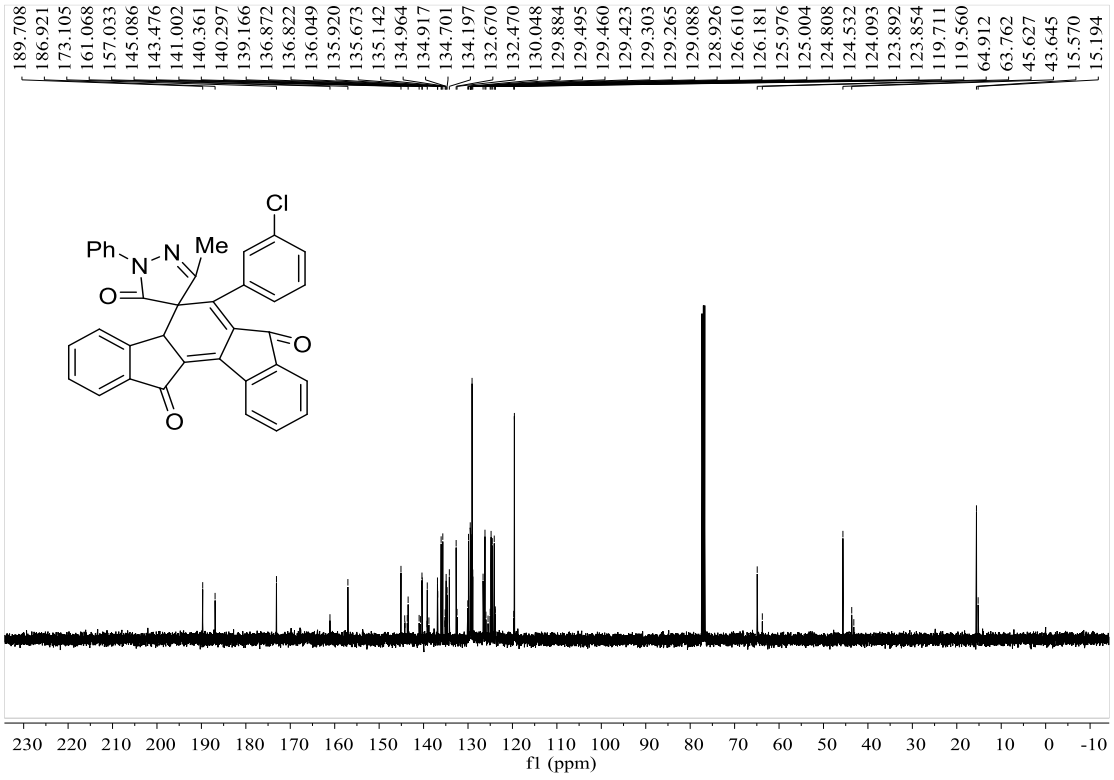


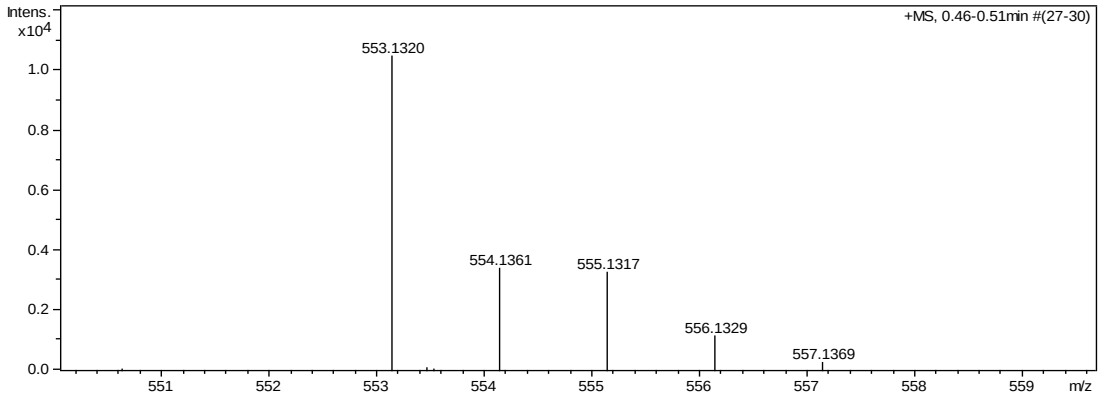



Intens.
x10^4
+MS, 0.79-0.89min #(47-53)
2.5
2.0
1.5
1.0
0.5
0.0
575.1139
576.1178
577.1133
578.1161
572
574
576
578
580
582
m/z

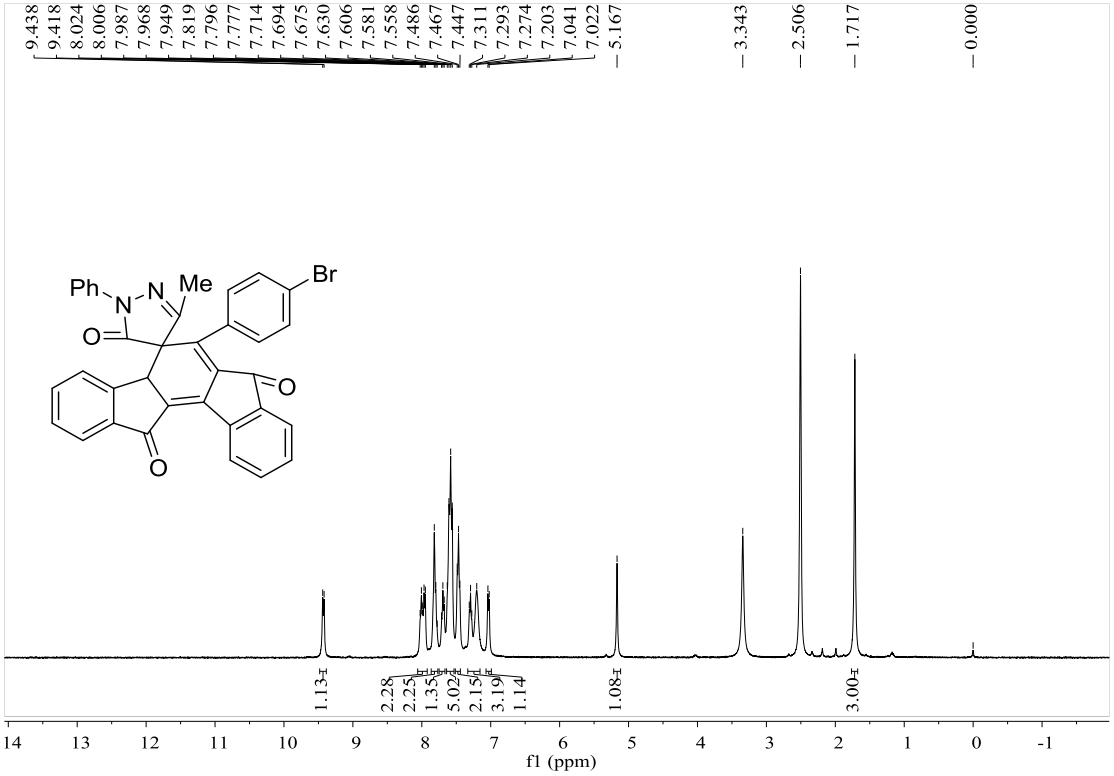
6-(3-chlorophenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5h):

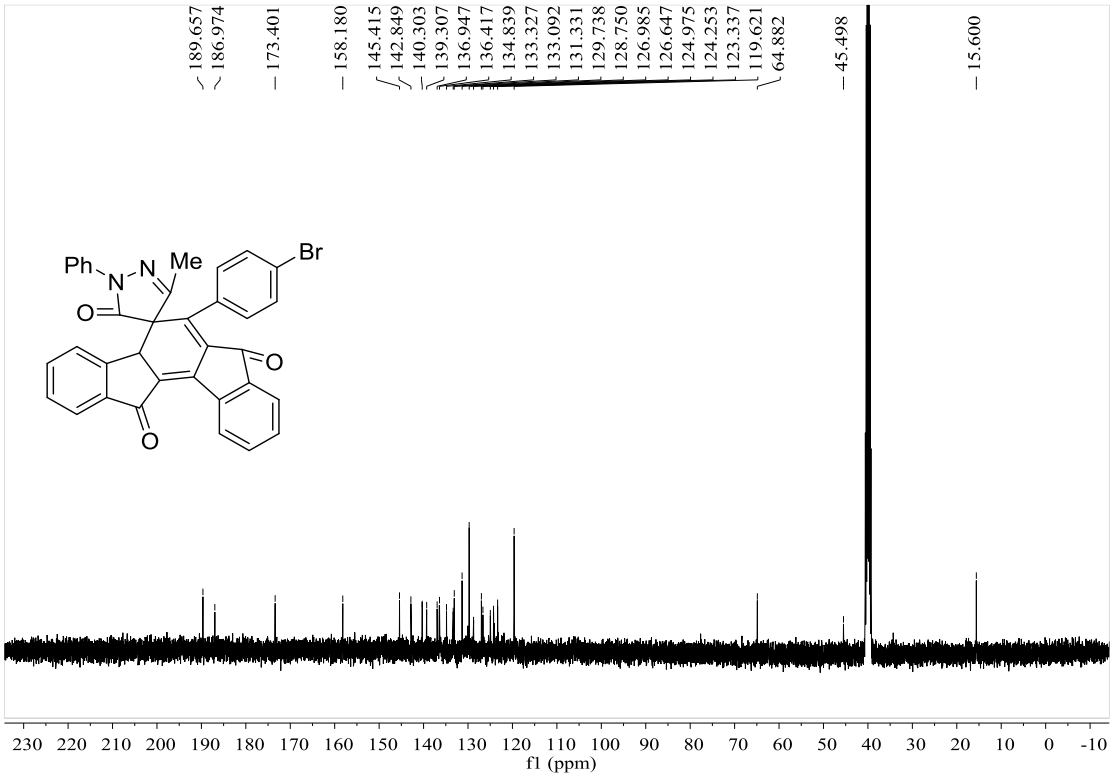


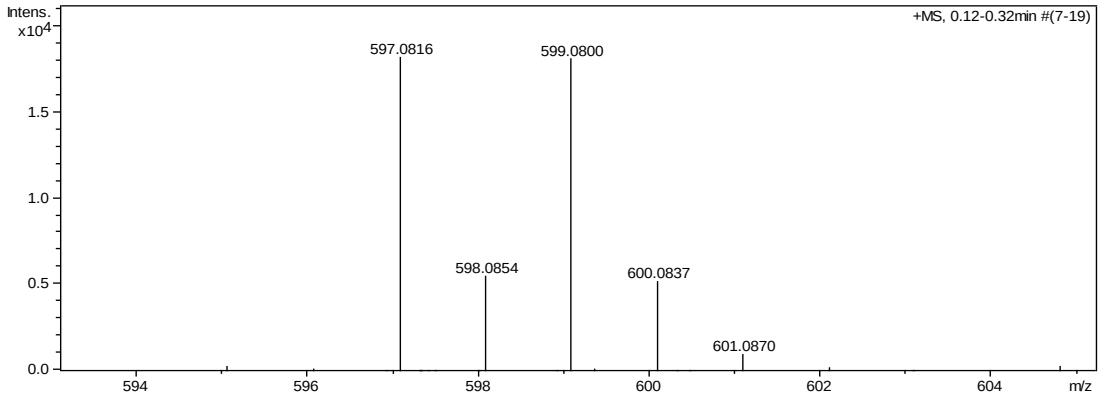



Intens.
x10^4
+MS, 0.46-0.51min #(27-30)
553.1320
554.1361
555.1317
556.1329
557.1369
1.0
0.8
0.6
0.4
0.2
0.0
551
552
553
554
555
556
557
558
559
m/z

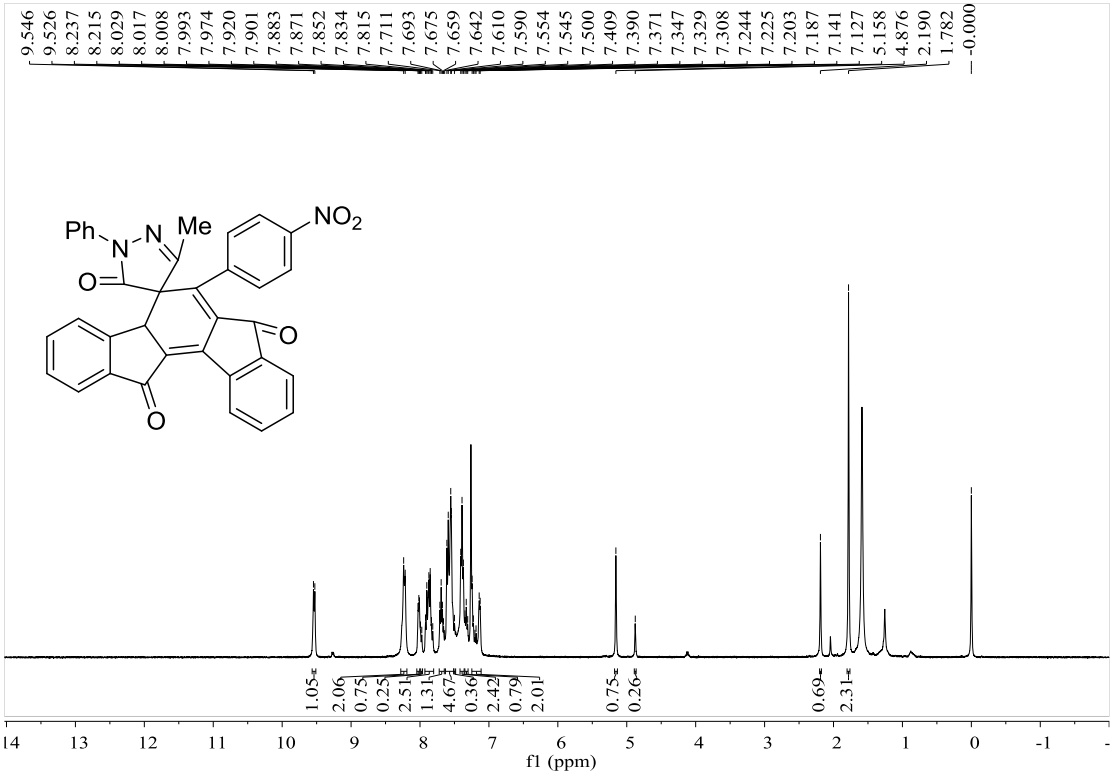
6-(4-bromophenyl)-3'-methyl-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5i):

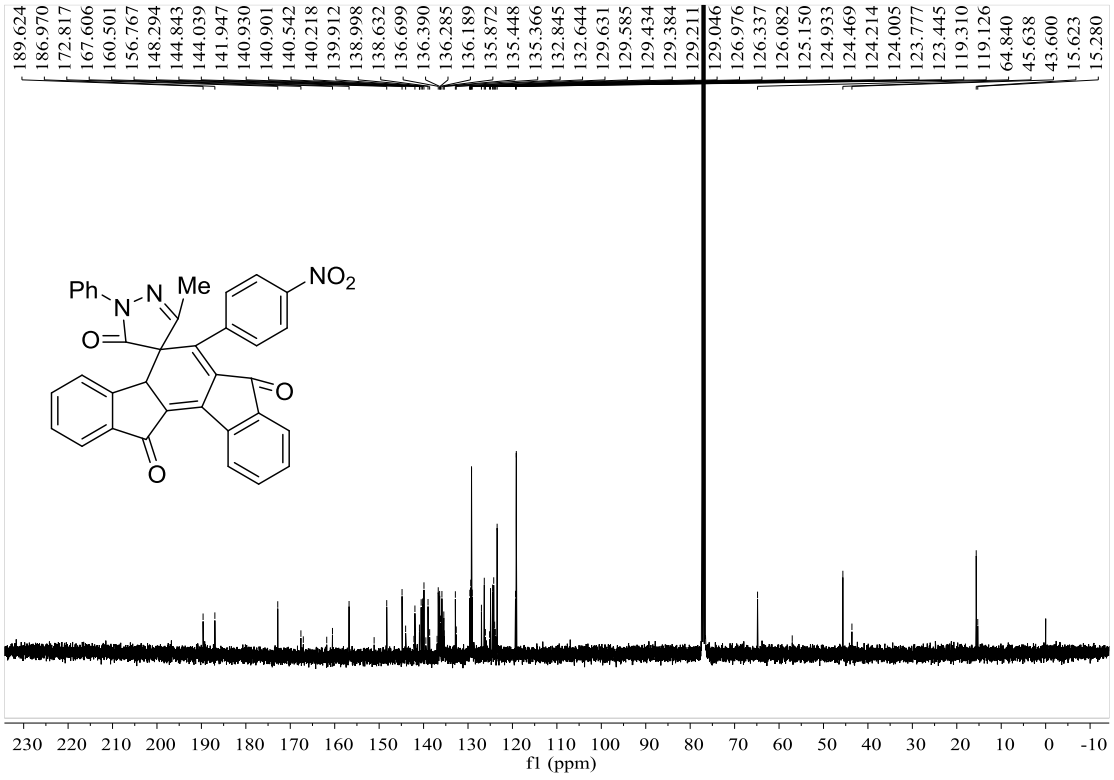


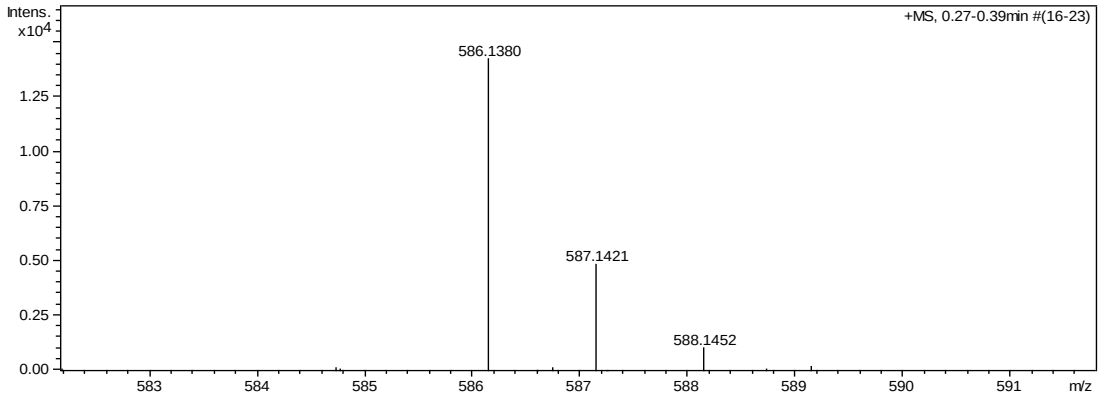



Intens.
x10^4
+MS, 0.12-0.32min #(7-19)
597.0816
599.0800
598.0854
600.0837
601.0870
1.5
1.0
0.5
0.0
594
596
598
600
602
604
m/z

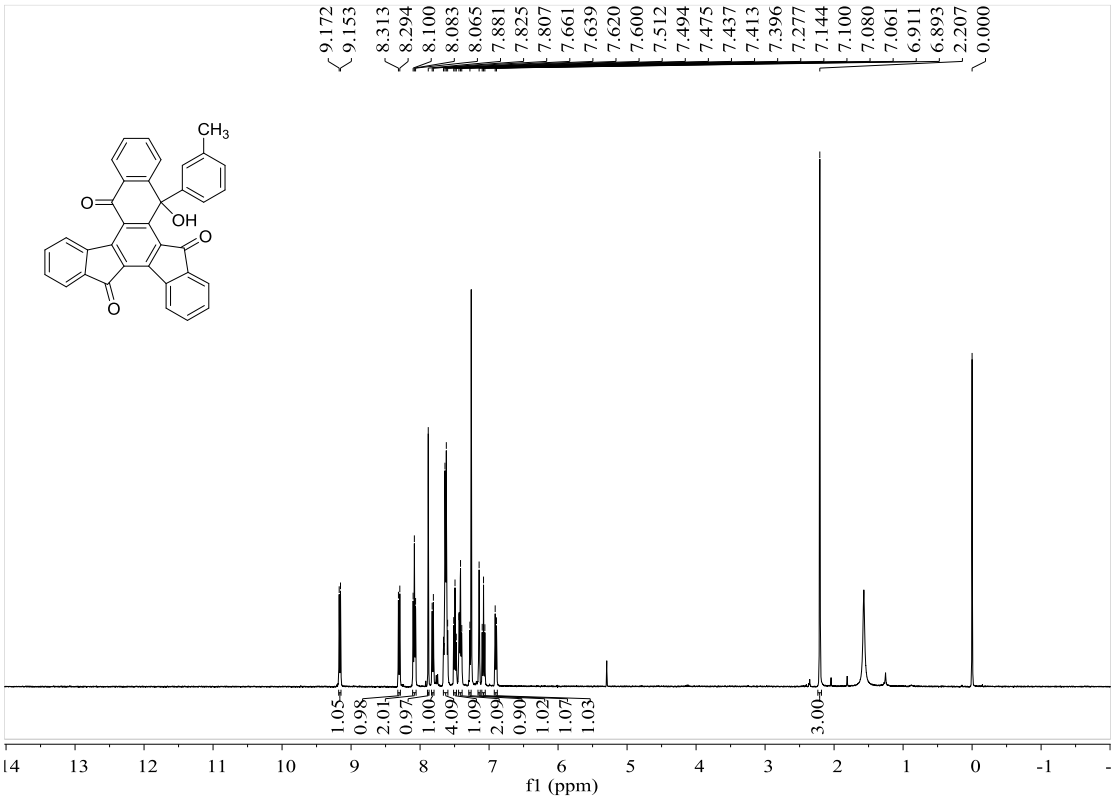
3'-methyl-6-(4-nitrophenyl)-1'-phenyl-7*H*-spiro[indeno[1,2-*a*]fluorene-5,4'-pyrazole]-5',7,12(1'*H*,4b*H*)-trione (5j):

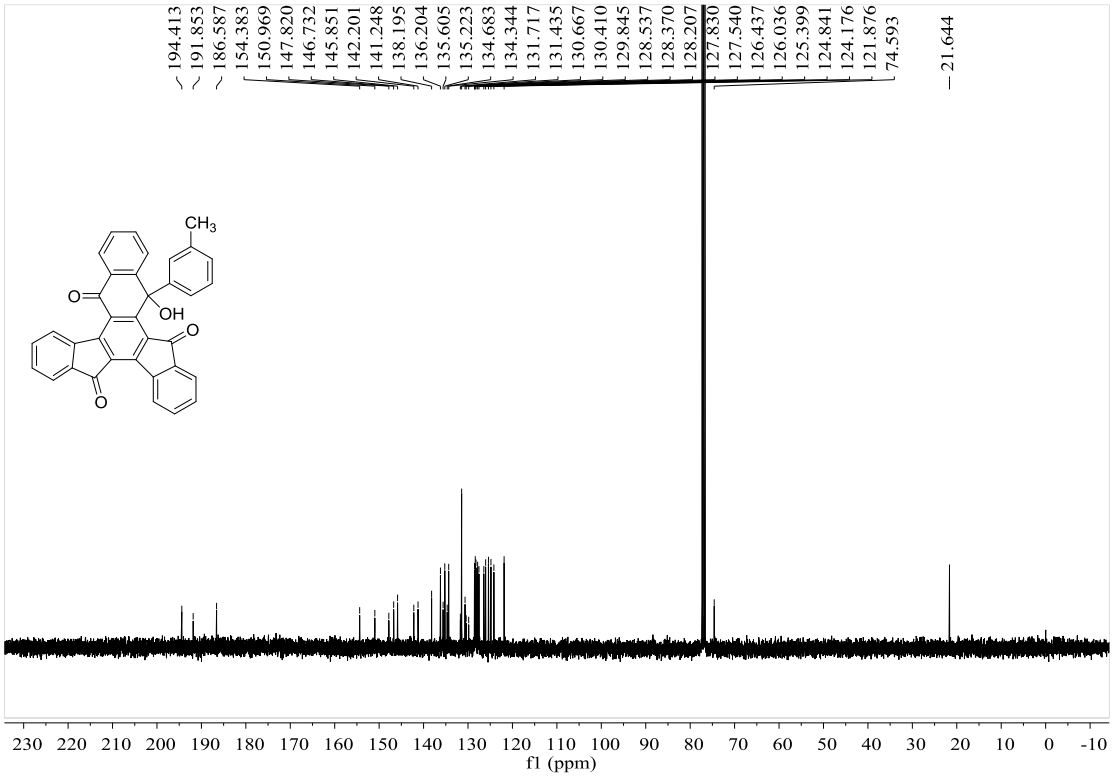


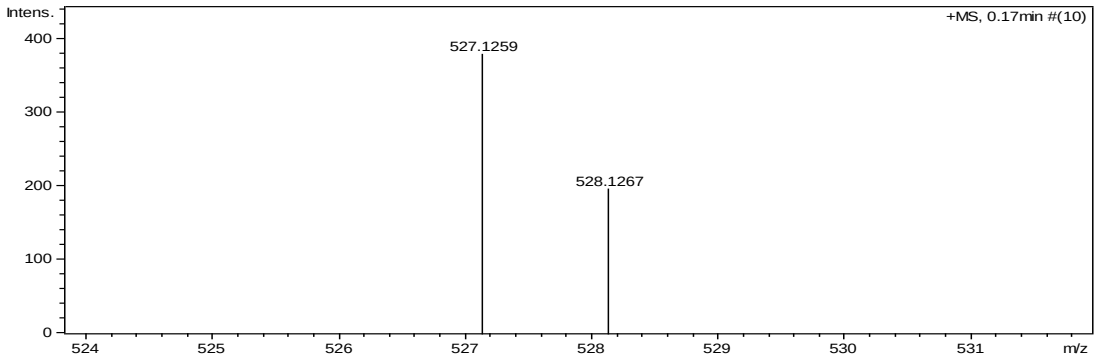



Intens.
x10^4
+MS, 0.27-0.39min #(16-23)
586.1380
587.1421
588.1452
1.25
1.00
0.75
0.50
0.25
0.00
583
584
585
586
587
588
589
590
591
m/z

15-hydroxy-15-(*m*-tolyl)diindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione[7a] :

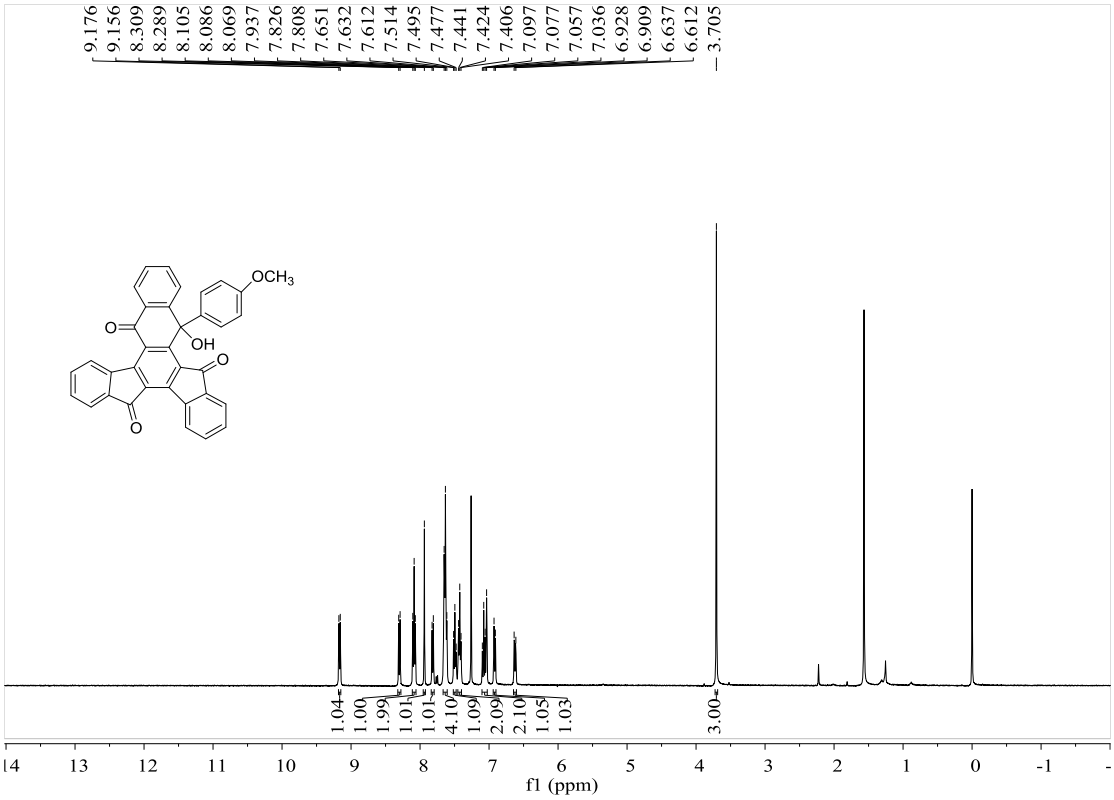


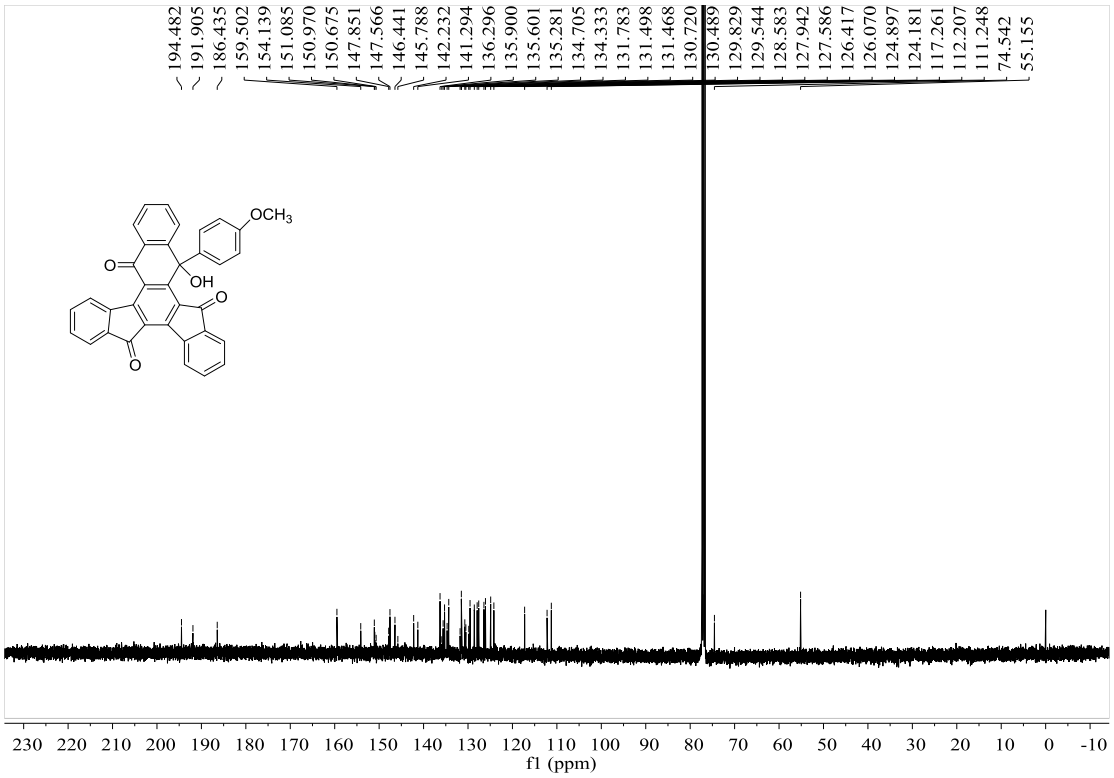


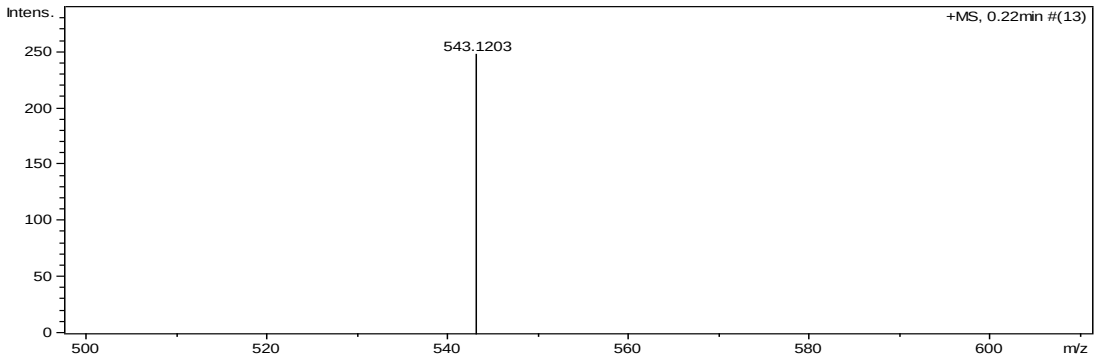

Intens.
+MS, 0.17min #(10)
400
300
200
100
0
527.1259
528.1267
524
525
526
527
528
529
530
531
m/z

15-hydroxy-15-(4-methoxyphenyl)diindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione

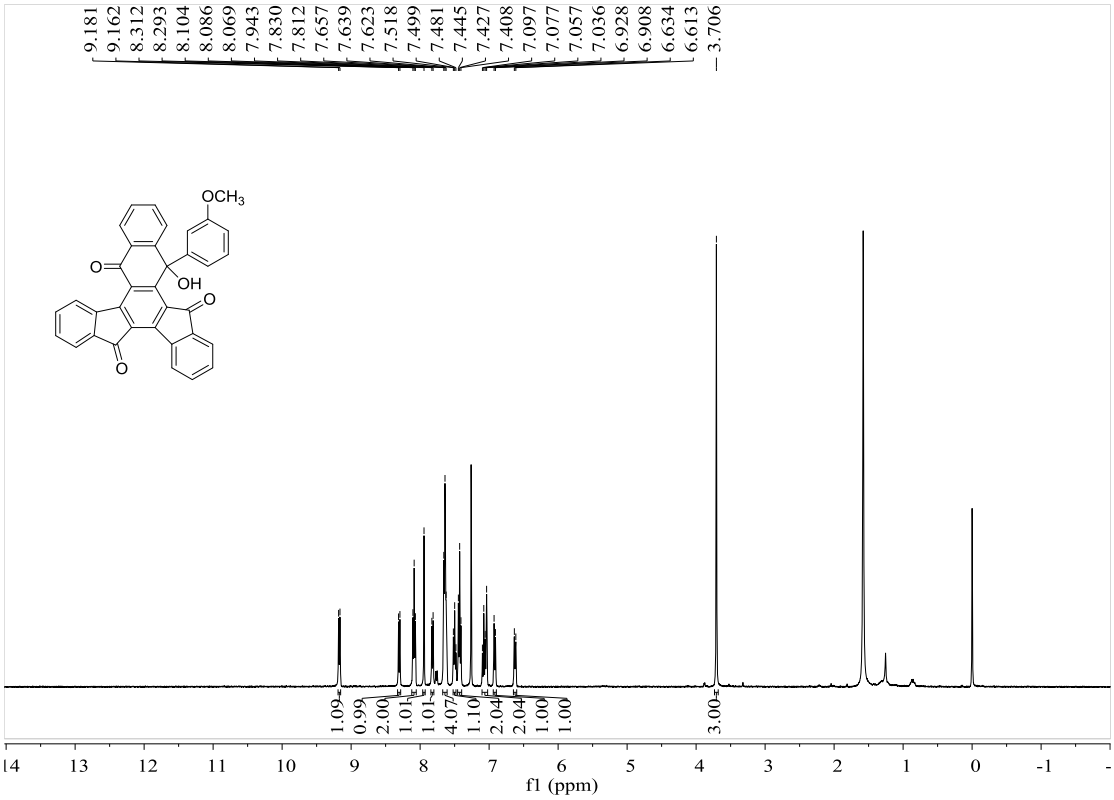
(7b) :

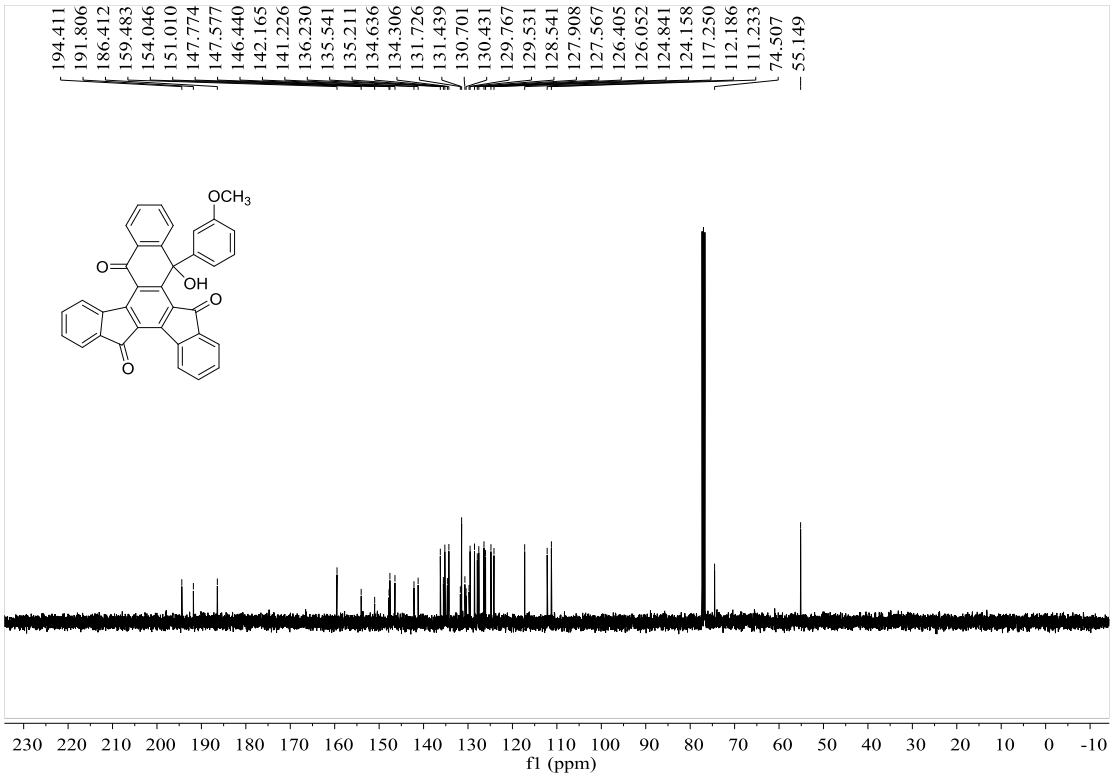


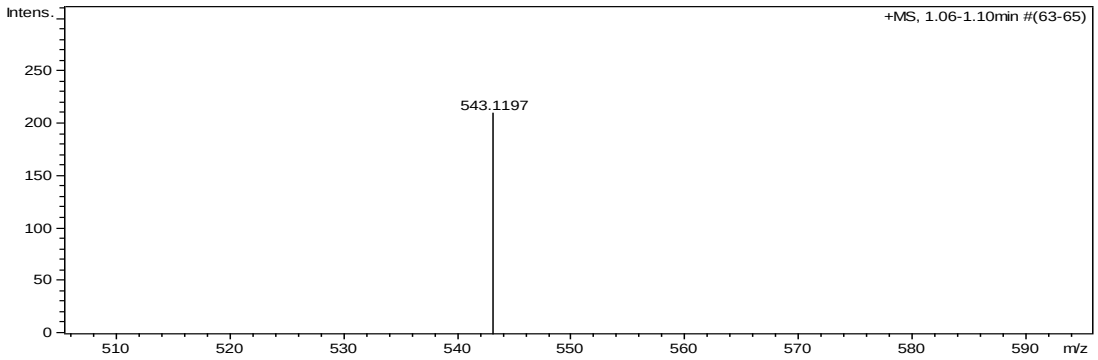



Intens.
+MS, 0.22min #(13)
543.1203
250
200
150
100
50
0
500
520
540
560
580
600
m/z

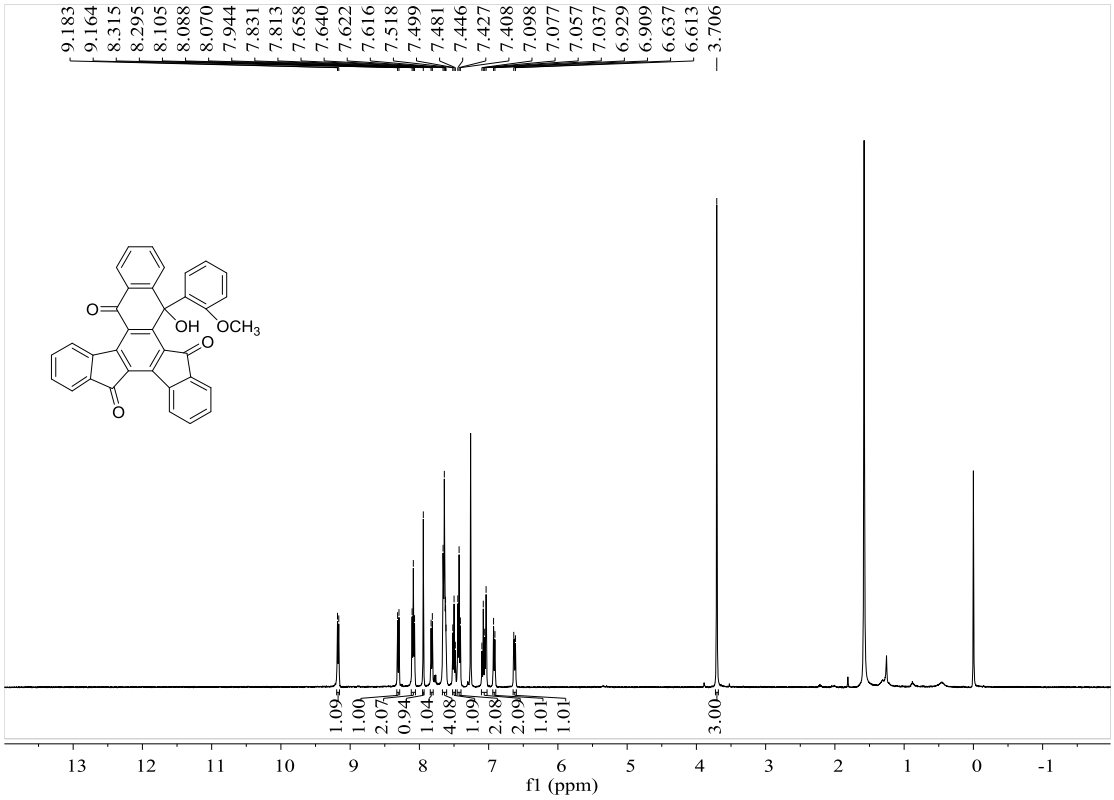
15-hydroxy-15-(3-methoxyphenyl)diindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione (7c):

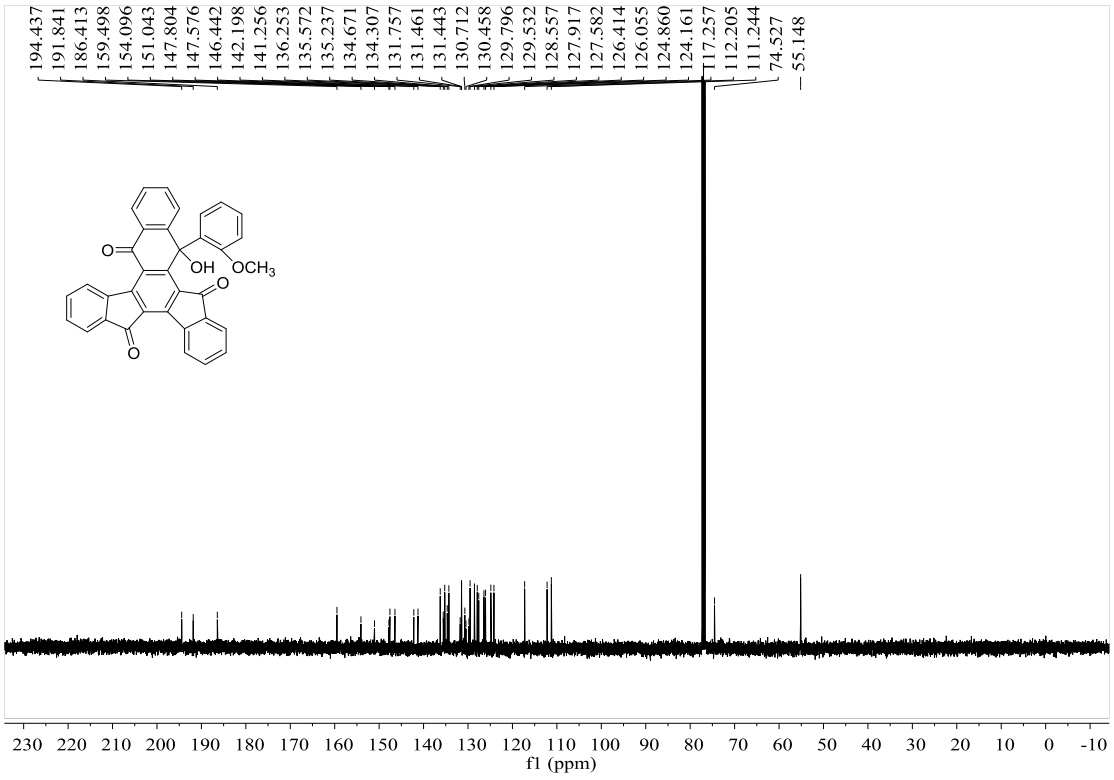


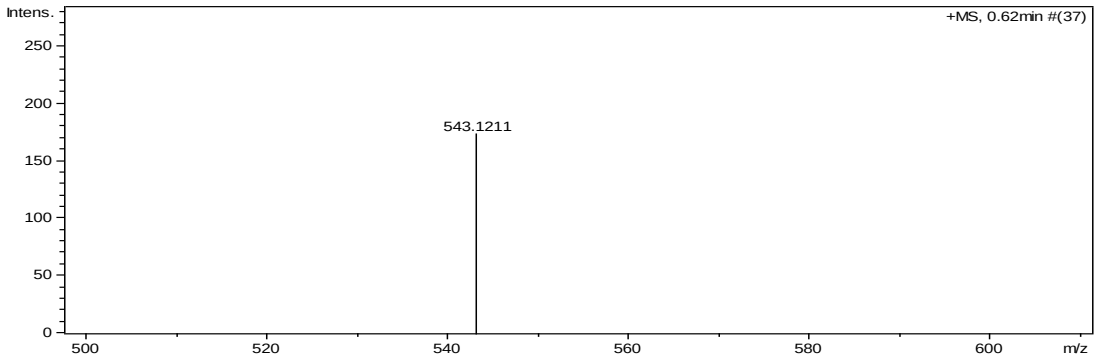



Intens.
+MS, 1.06-1.10min #(63-65)
543.1197
250
200
150
100
50
0
510
520
530
540
550
560
570
580
590
m/z

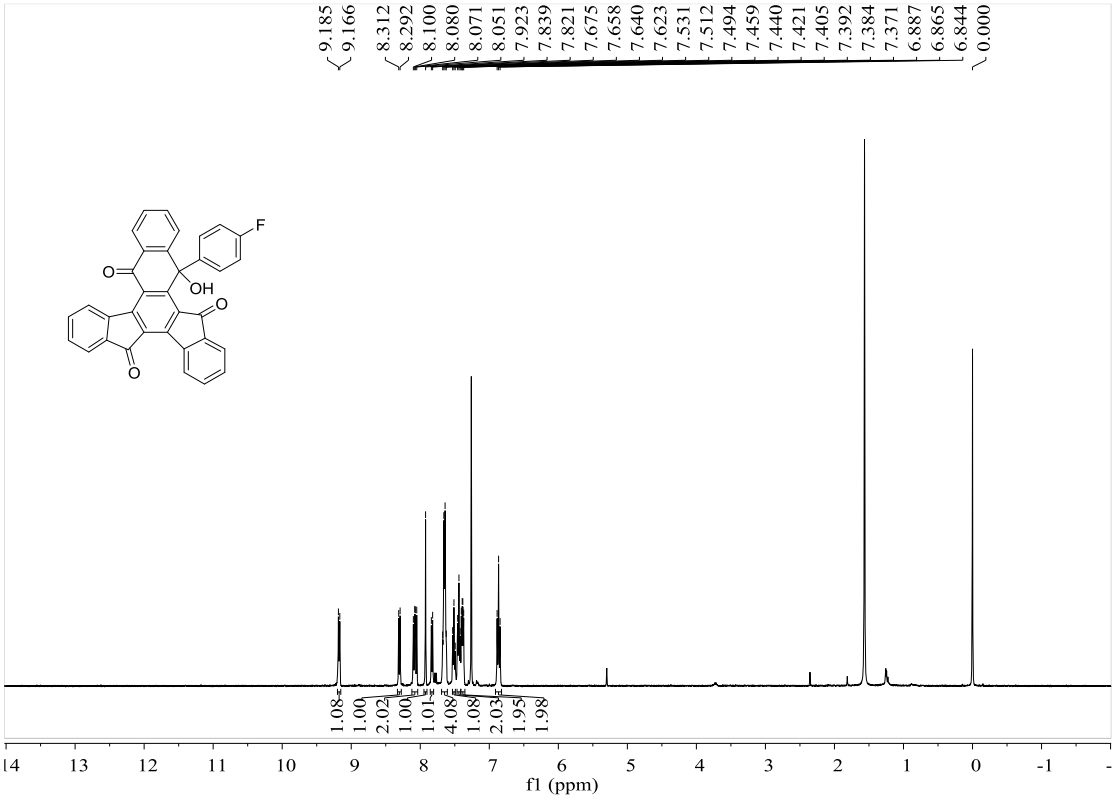
15-hydroxy-15-(2-methoxyphenyl)diindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione (7d):

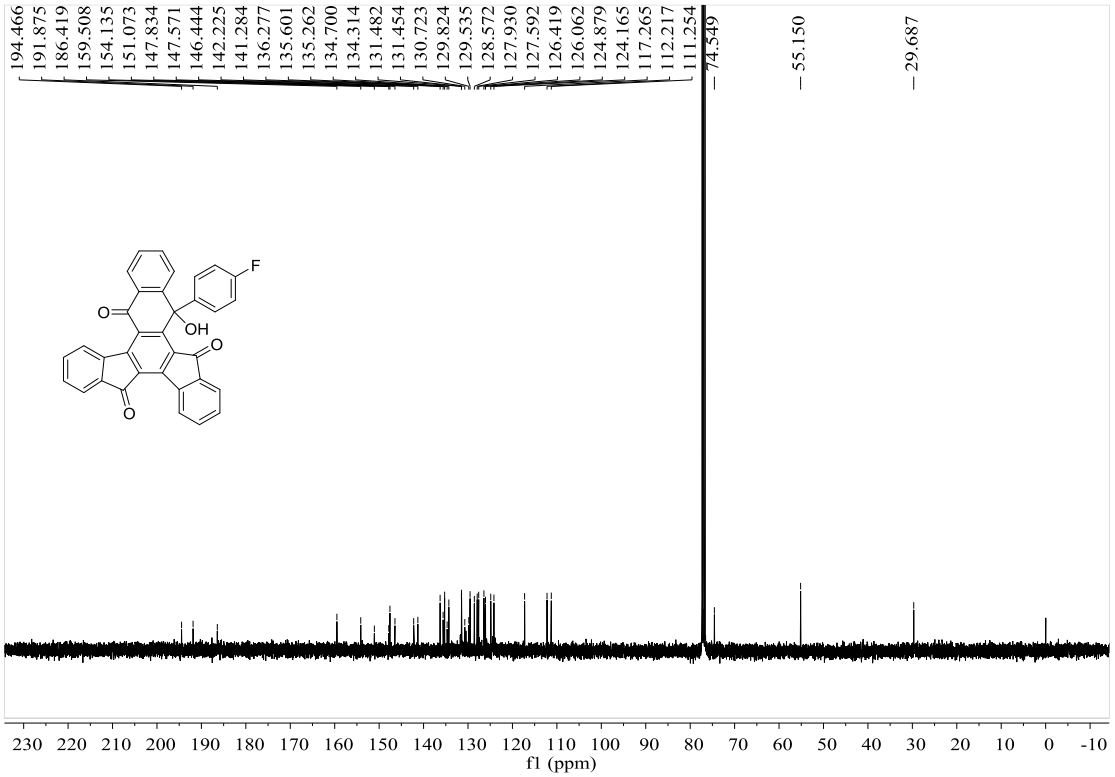


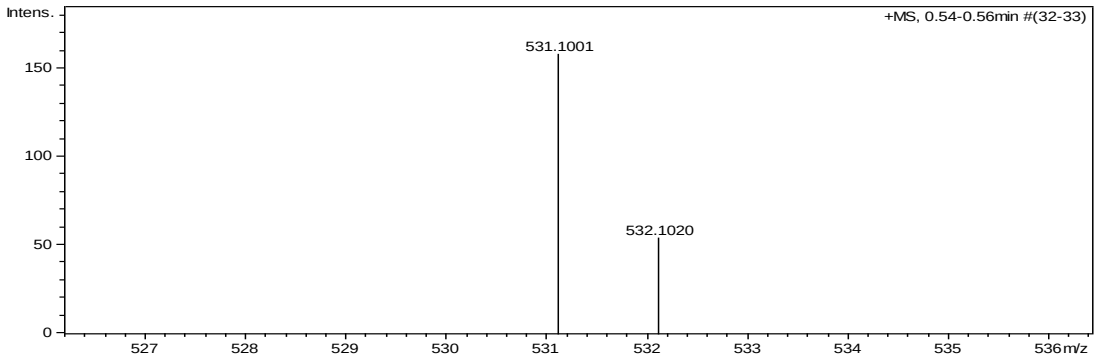



Intens.
+MS, 0.62min #(37)
250
200
543.1211
150
100
50
0
500
520
540
560
580
600
m/z

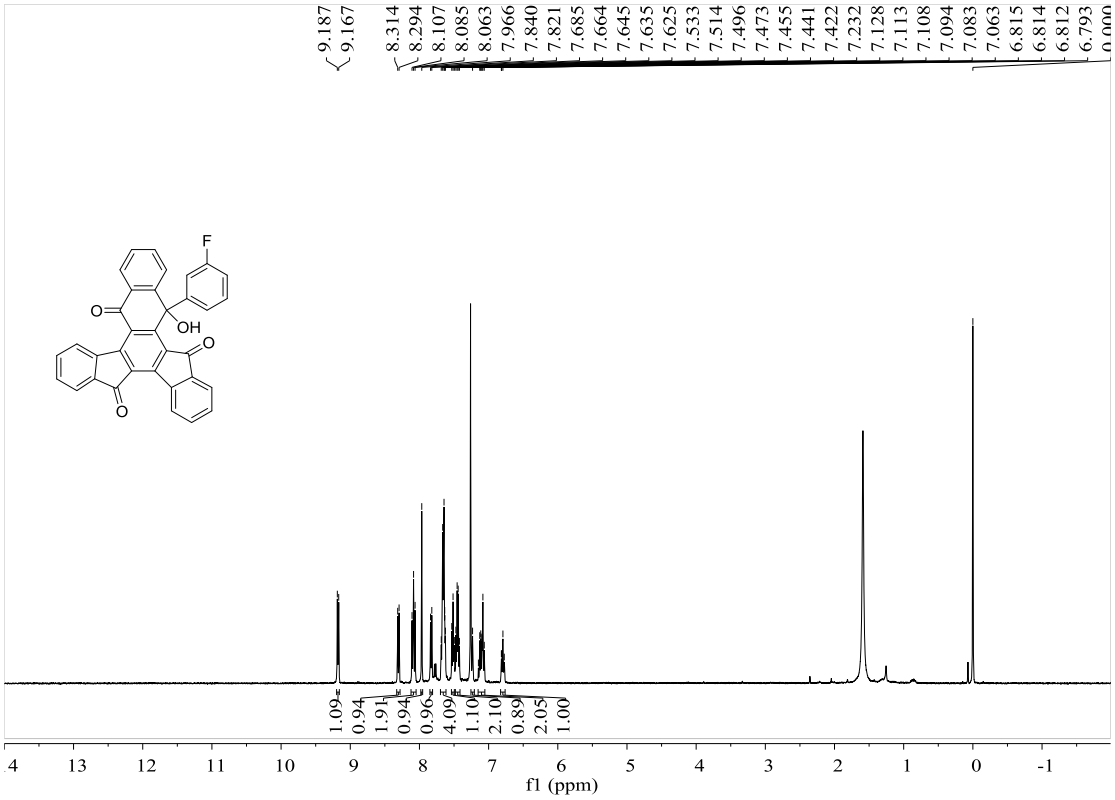
15-(4-fluorophenyl)-15-hydroxydiindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione (7e):

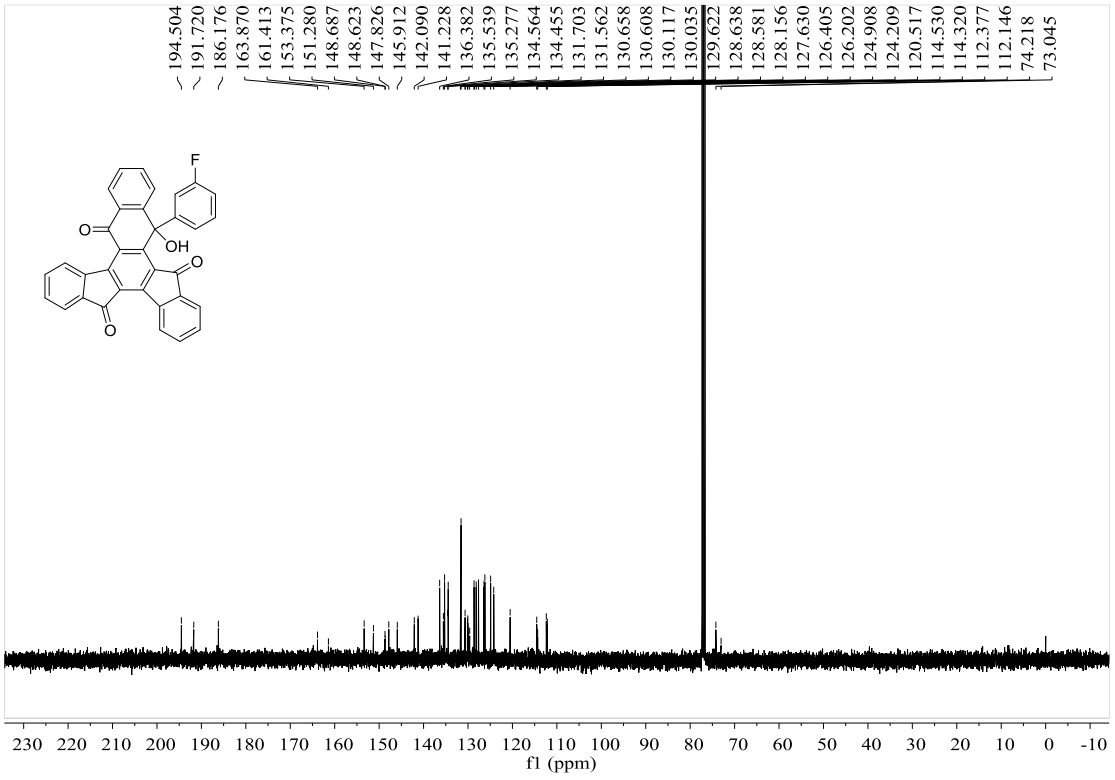


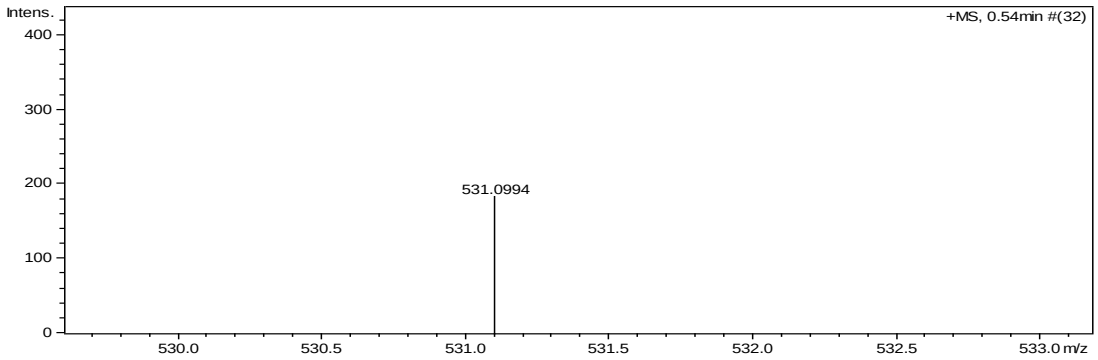



Intens.
+MS, 0.54-0.56min #(32-33)
531.1001
532.1020
150
100
50
0
527
528
529
530
531
532
533
534
535
536 m/z

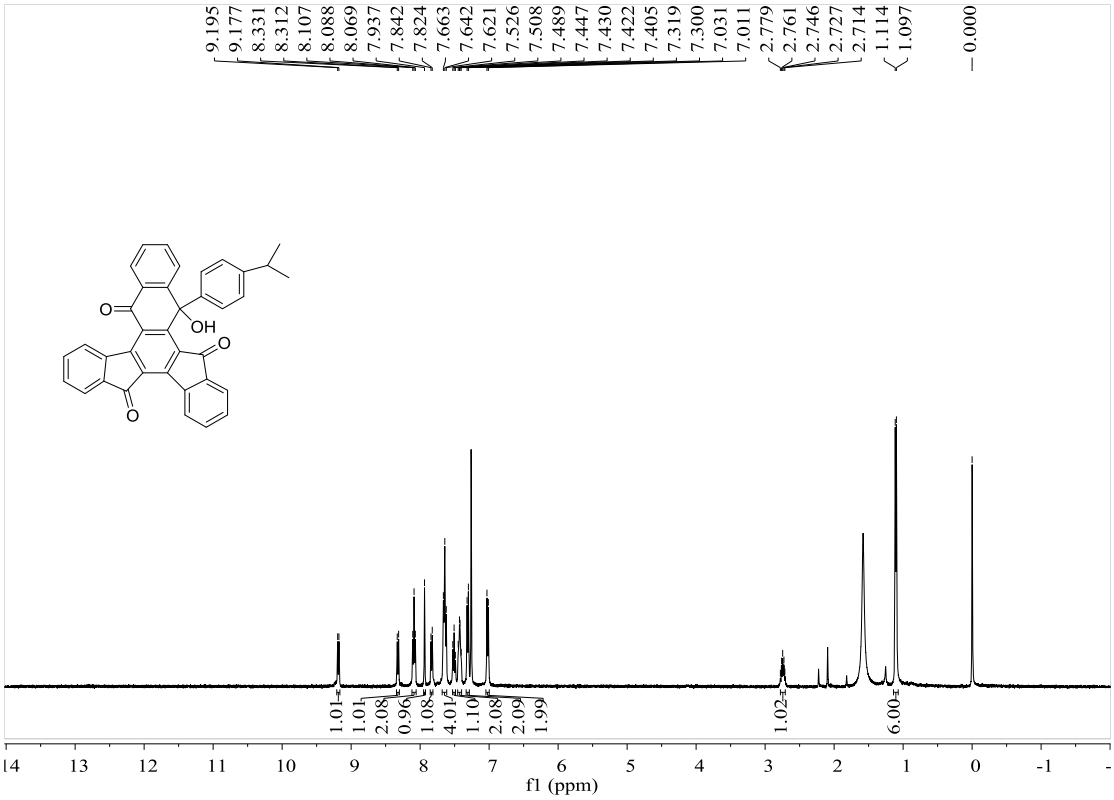
15-(3-fluorophenyl)-15-hydroxydiindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione (7f):

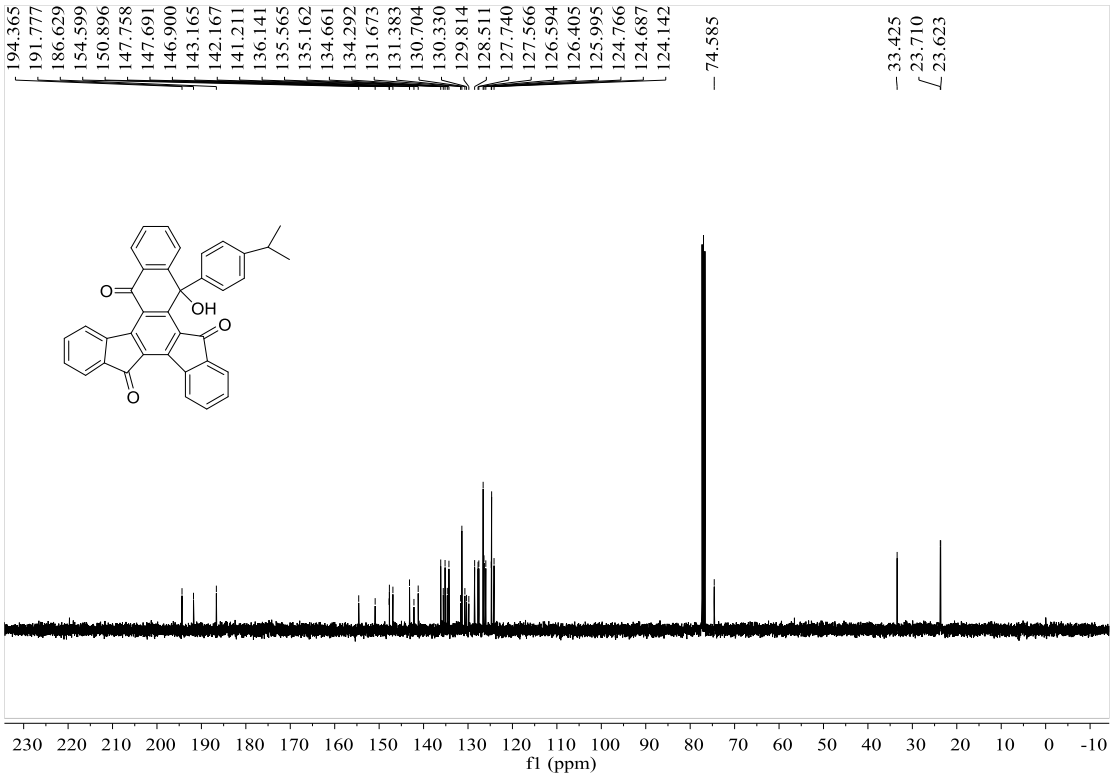


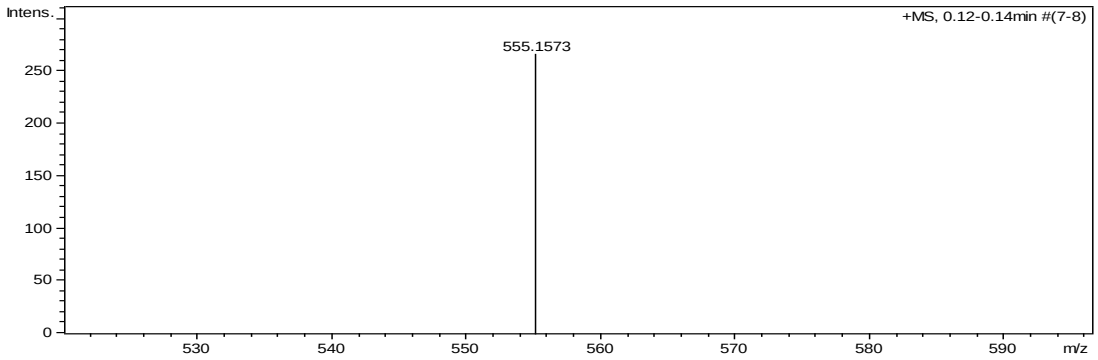



Intens.
+MS, 0.54min #(32)
400
300
200
100
0
531.0994
530.0
530.5
531.0
531.5
532.0
532.5
533.0 m/z

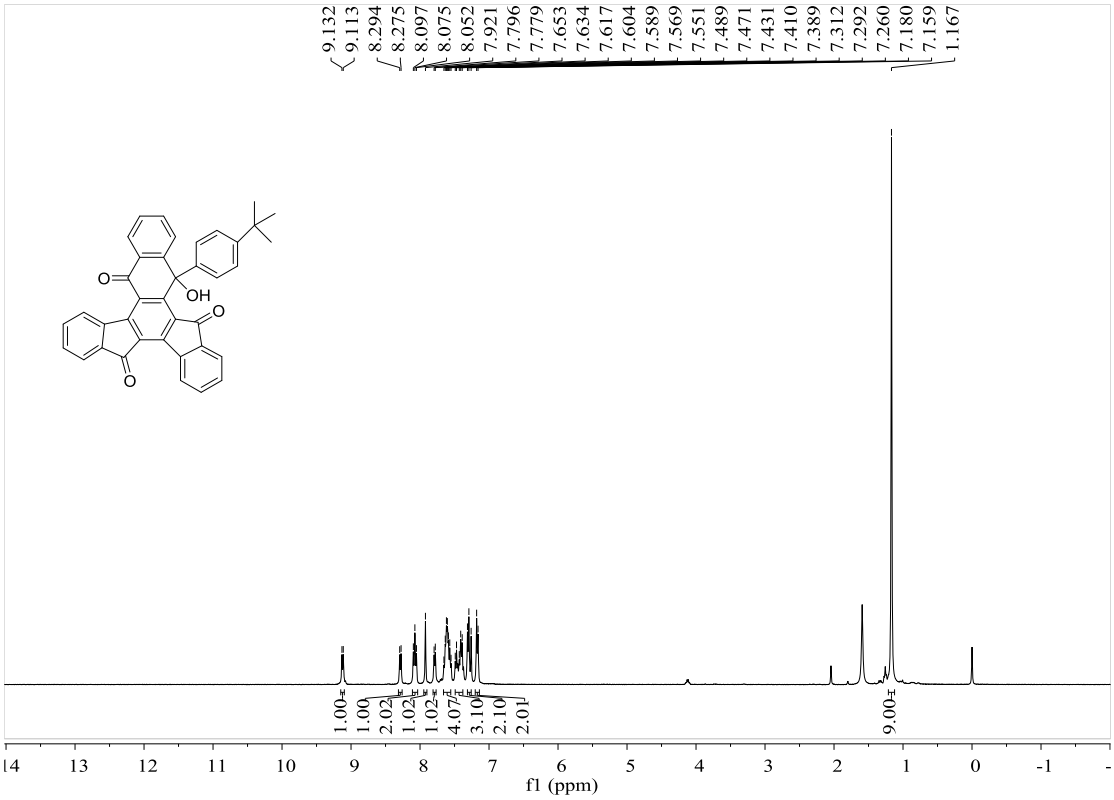
15-hydroxy-15-(4-isopropylphenyl)diindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione (7g):

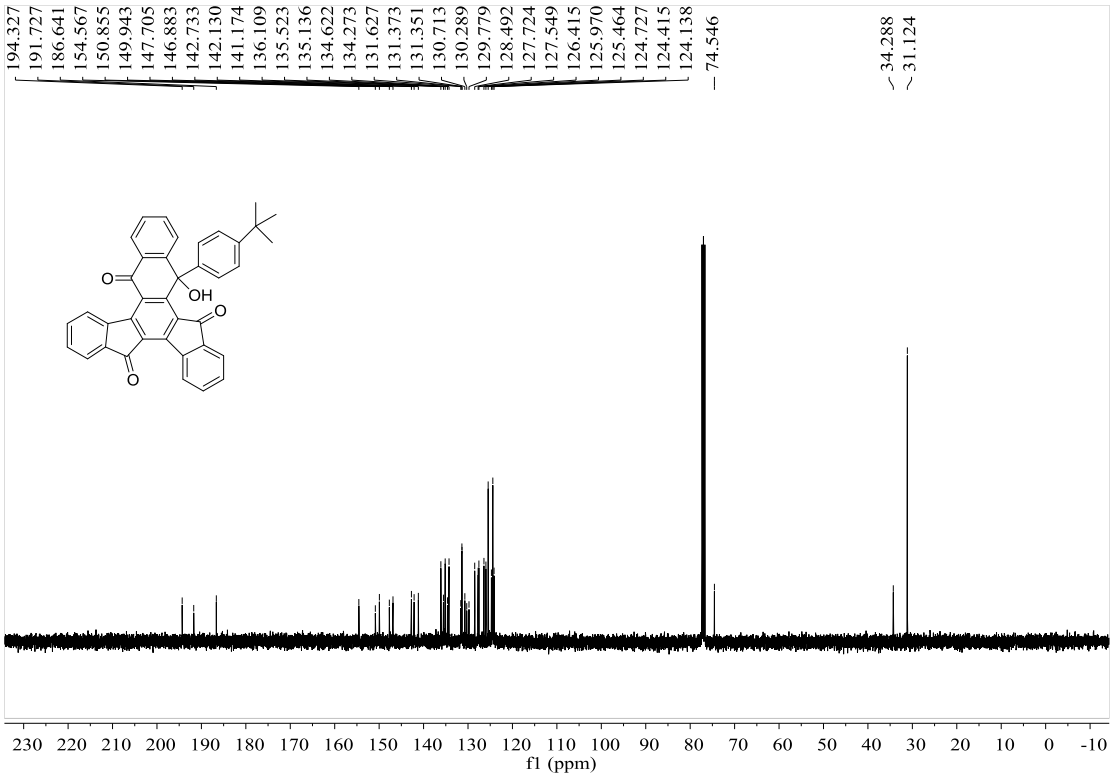


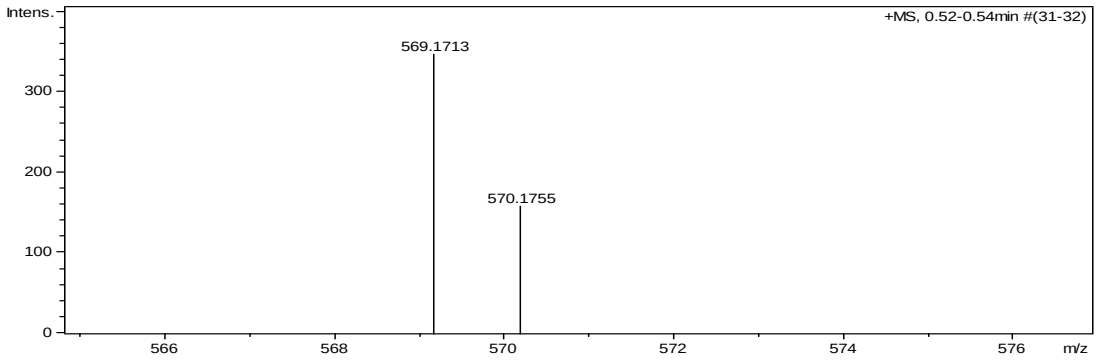



Intens.
+MS, 0.12-0.14min #(7-8)
555.1573
250
200
150
100
50
0
530
540
550
560
570
580
590
m/z

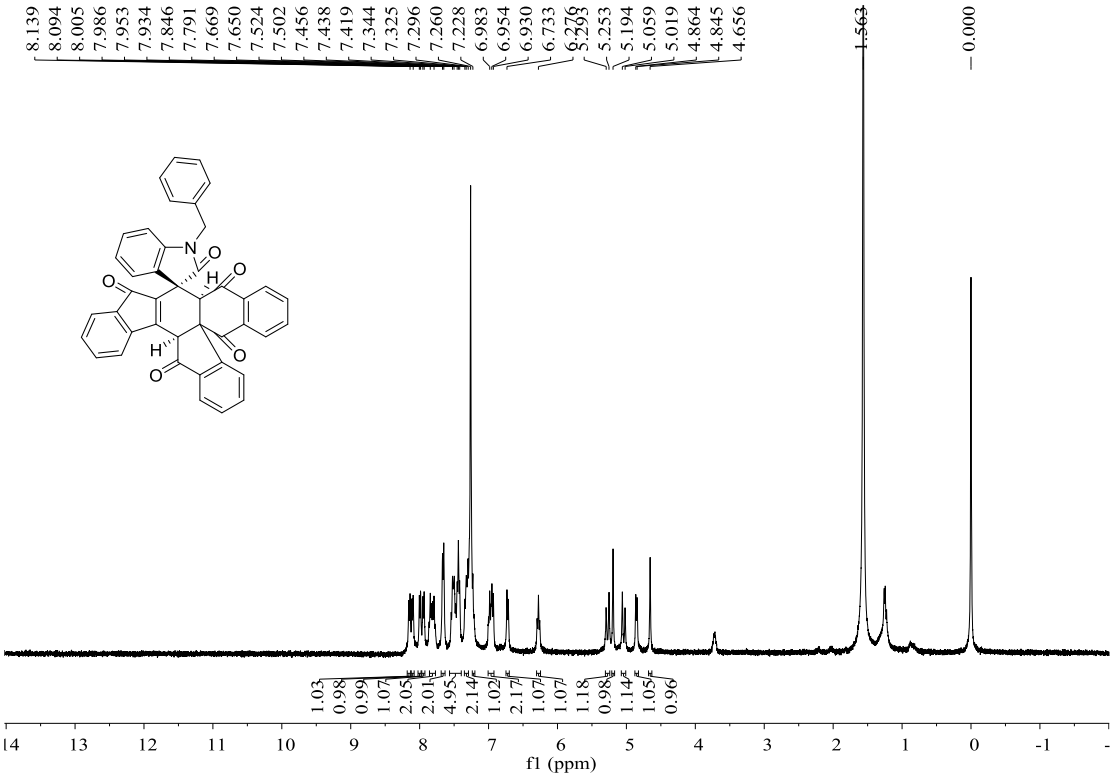
15-(4-(tert-butyl)phenyl)-15-hydroxydiindeno[1,2-*a*:1',2'-*c*]anthracene-5,10,16(15*H*)-trione (7h):

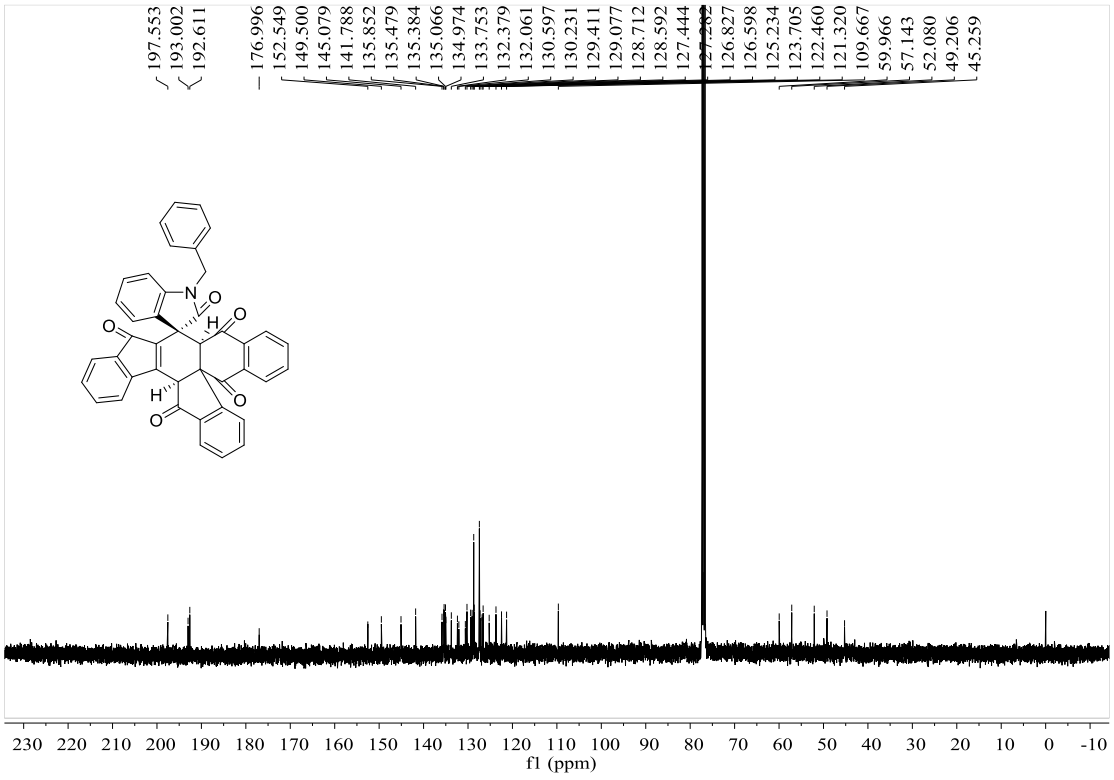


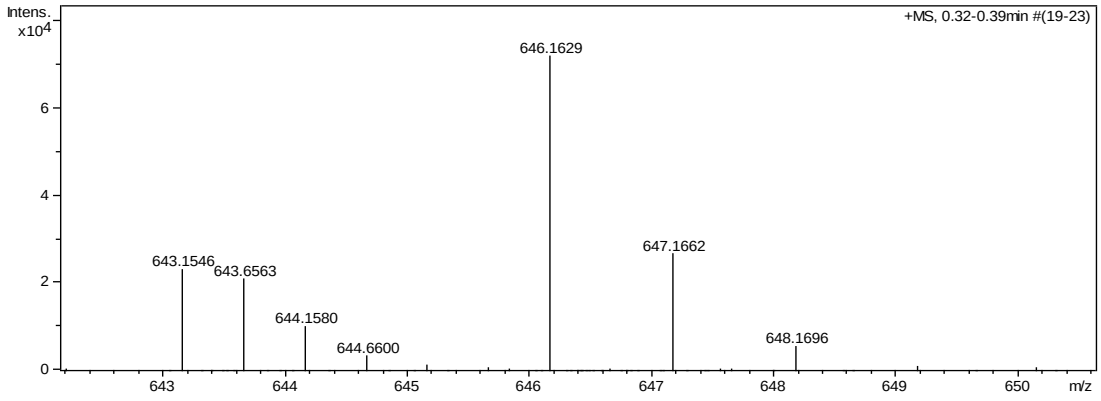



Intens.
+MS, 0.52-0.54min #(31-32)
569.1713
570.1755
300
200
100
0
566
568
570
572
574
576
m/z

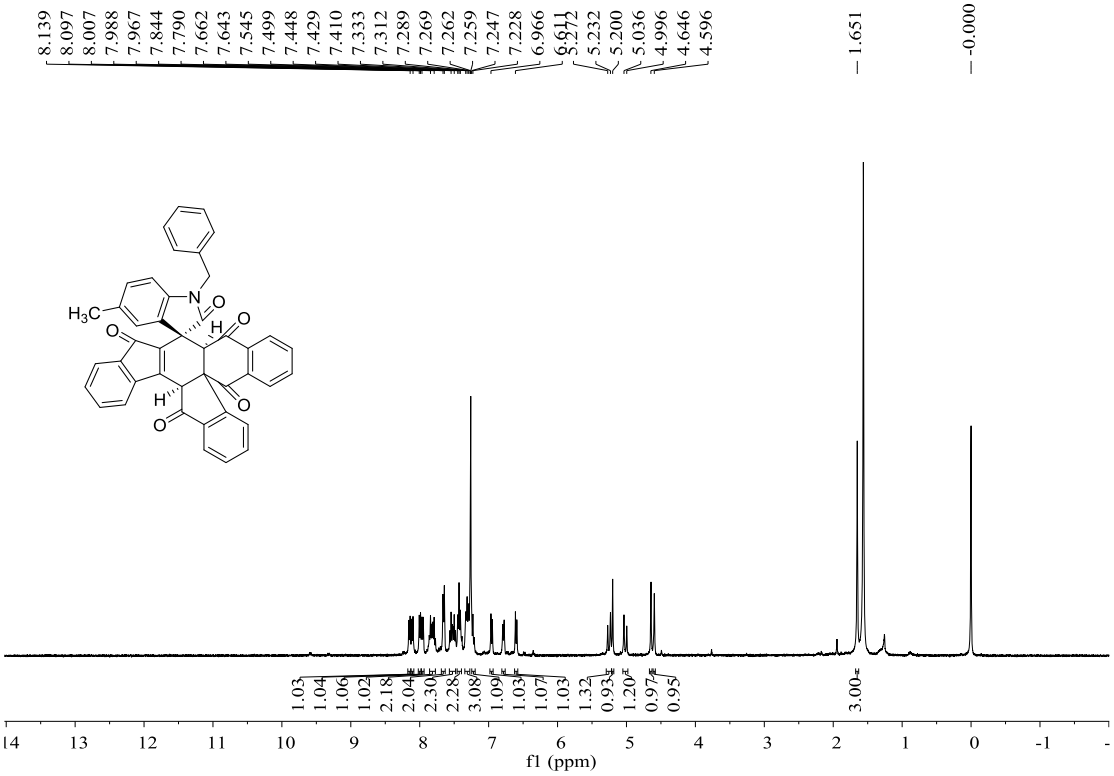
1'-benzyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8a):

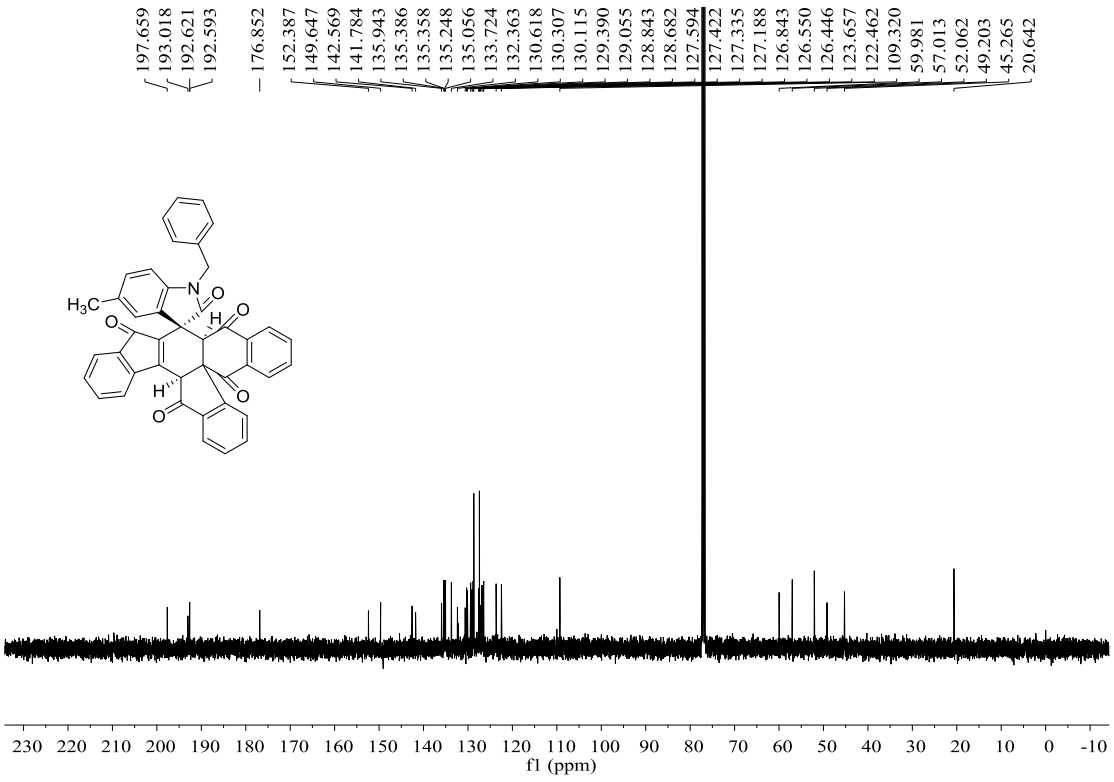


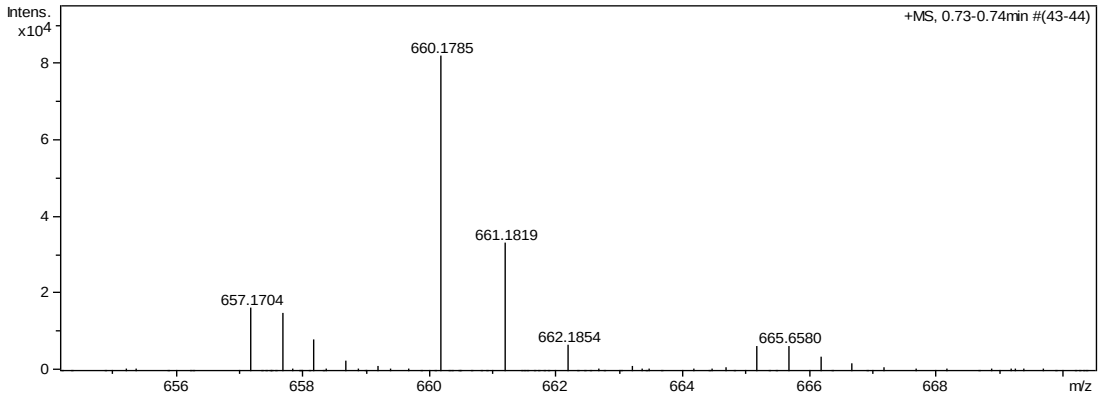



Intens.
x10^4
+MS, 0.32-0.39min #(19-23)
646.1629
647.1662
643.1546
643.6563
644.1580
644.6600
648.1696
0
2
4
6
643
644
645
646
647
648
649
650
m/z

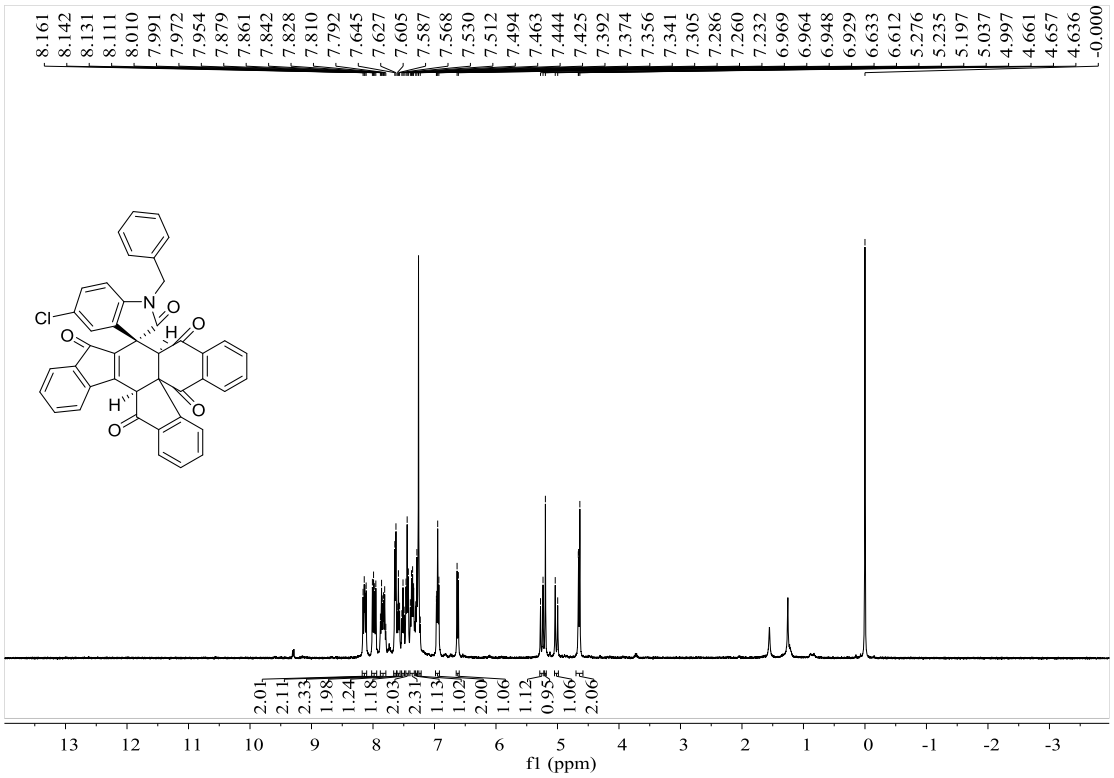
1'-benzyl-5'-methyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8b):

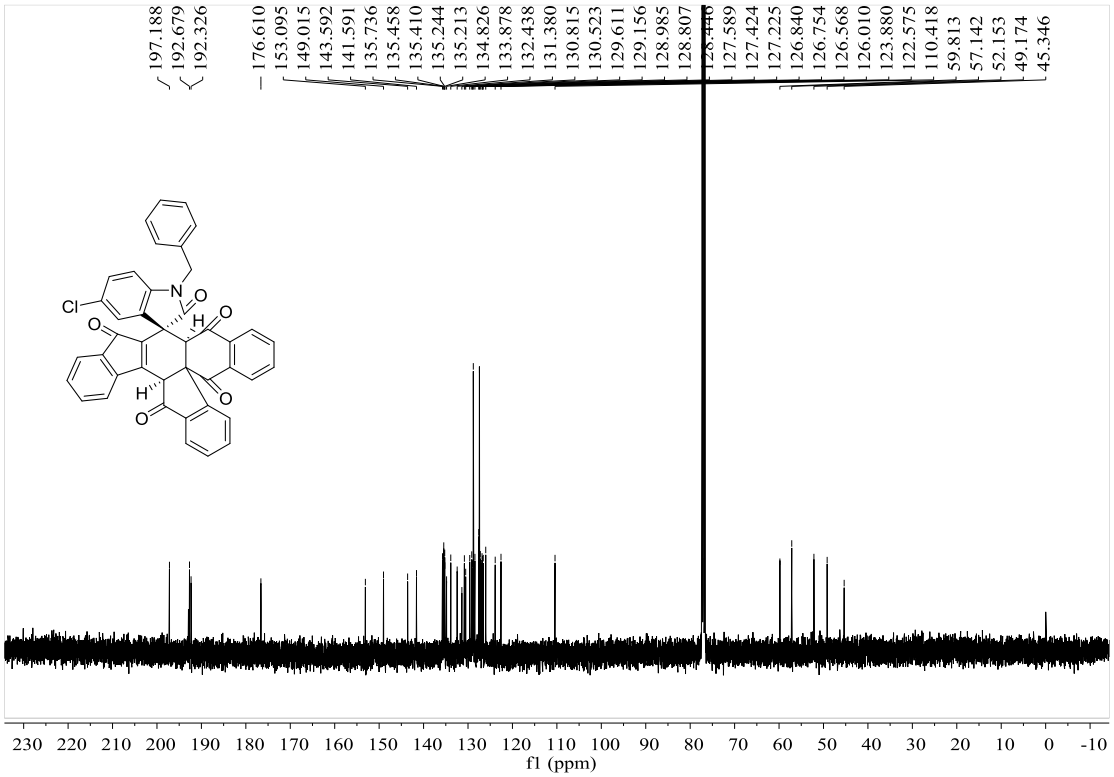


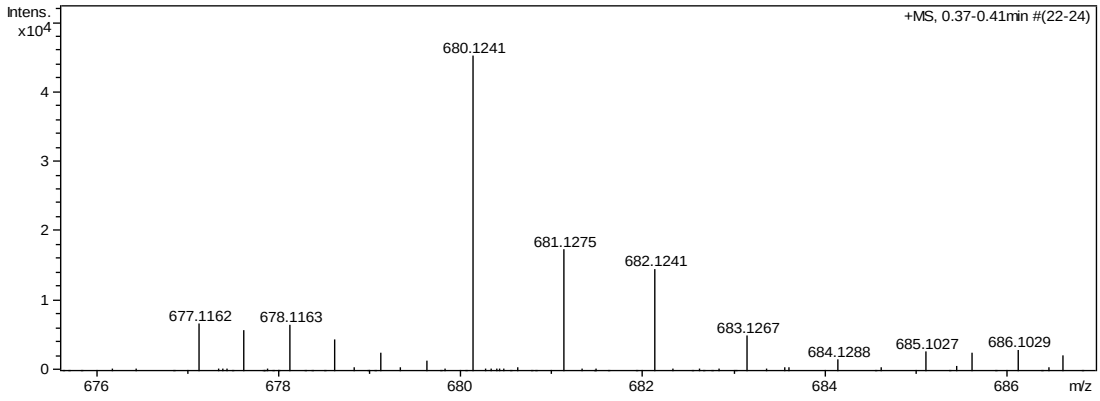



Intens.
x10^4
+MS, 0.73-0.74min #(43-44)
660.1785
661.1819
657.1704
662.1854
665.6580
0
2
4
6
8
656
658
660
662
664
666
668
m/z

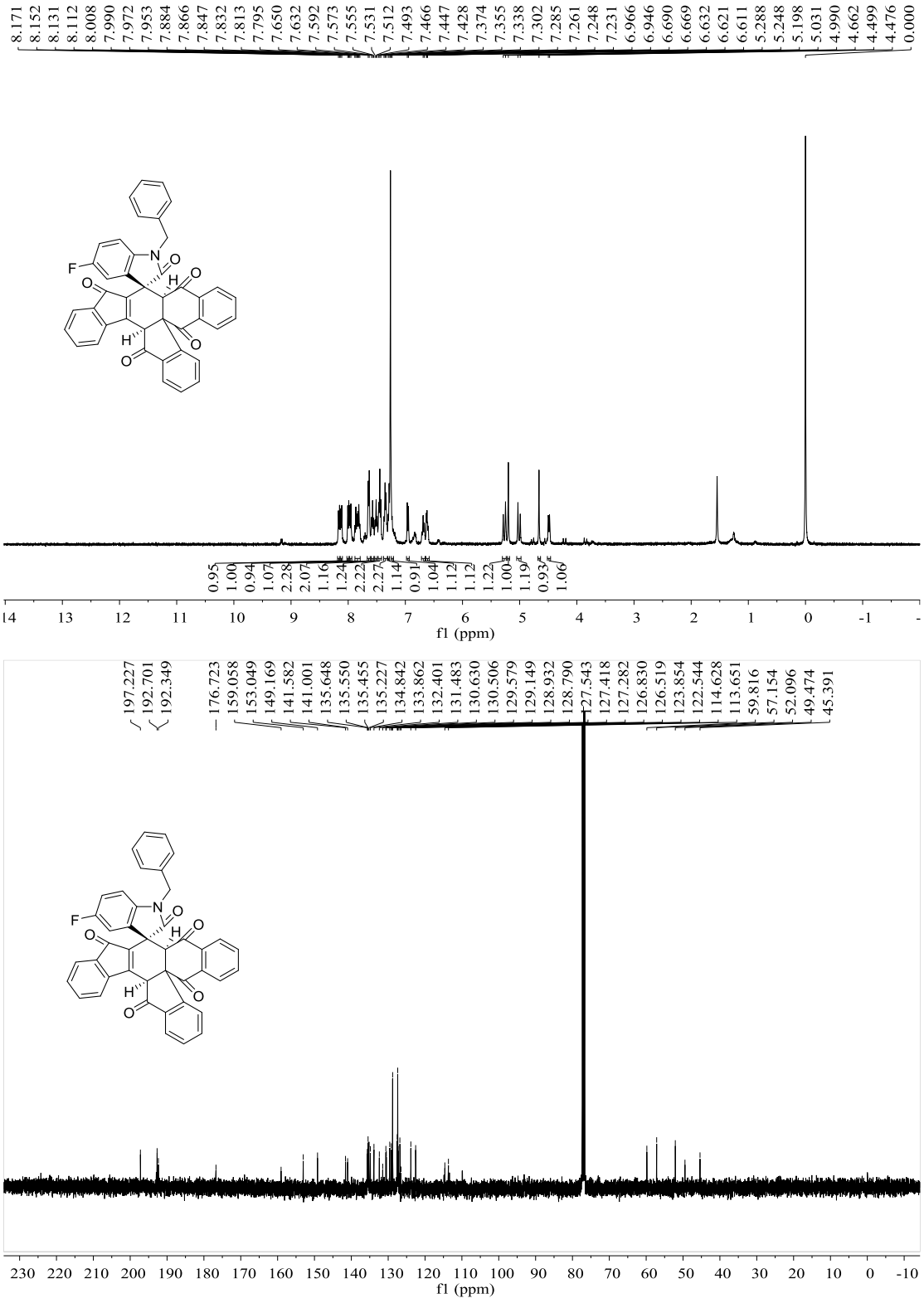
1'-benzyl-5'-chloro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8c):

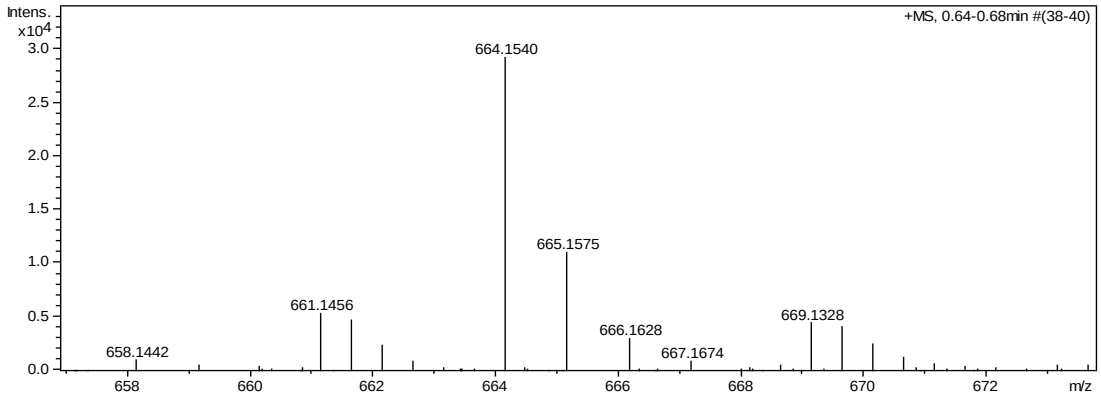




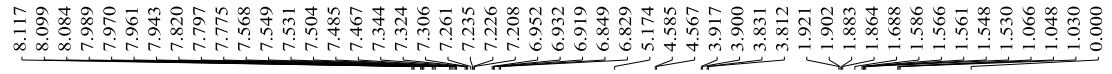

Intens.
x10^4
+MS, 0.37-0.41min #(22-24)
680.1241
681.1275
682.1241
677.1162
678.1163
683.1267
684.1288
685.1027
686.1029
0
1
2
3
4
676
678
680
682
684
686
m/z

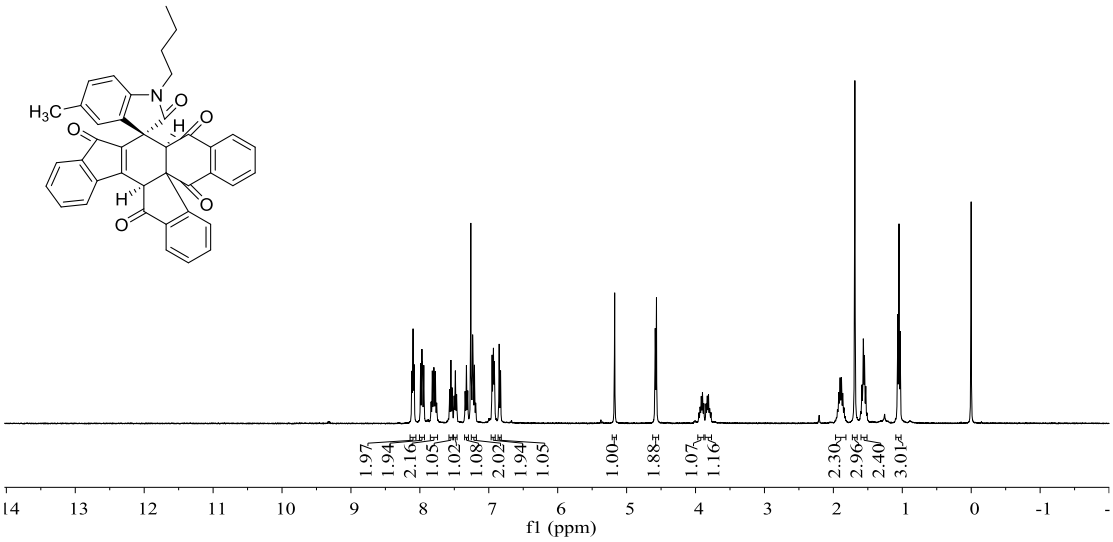
1'-benzyl-5'-fluoro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8d):

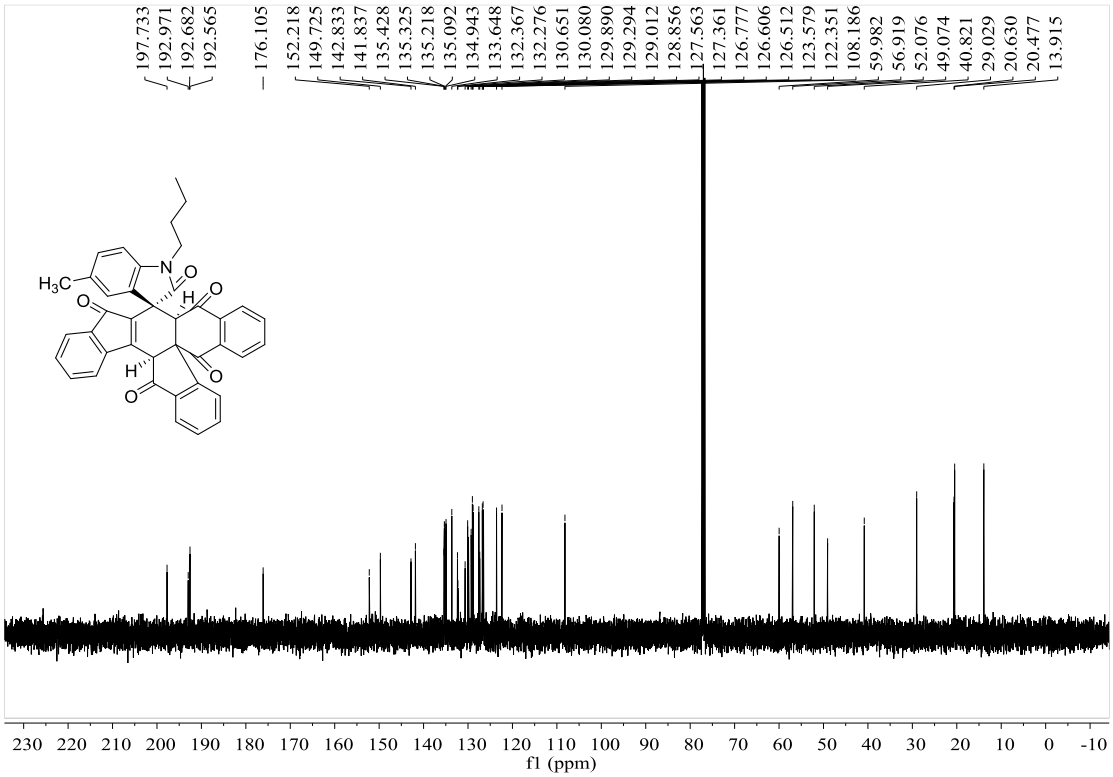


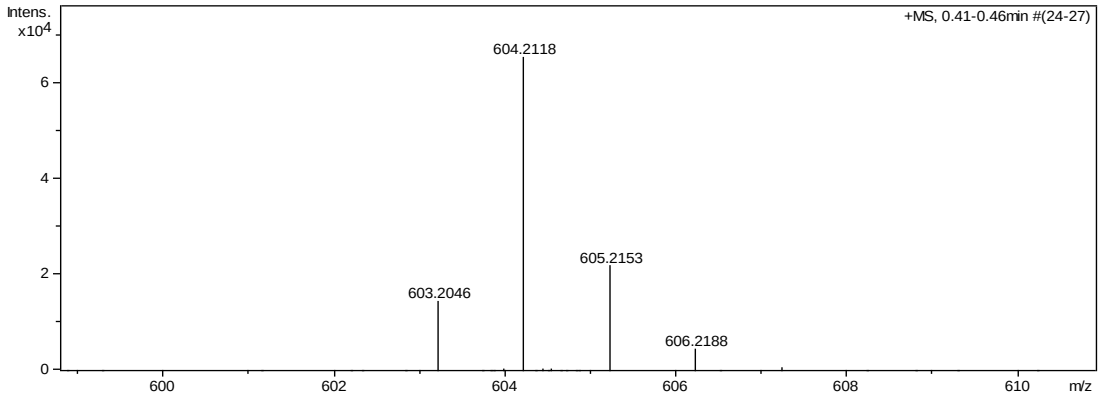

Intens.
x10^4
3.0
2.5
2.0
1.5
1.0
0.5
0.0
+MS, 0.64-0.68min #(38-40)
664.1540
665.1575
661.1456
666.1628
669.1328
658.1442
667.1674
658
660
662
664
666
668
670
672
m/z

1'-butyl-5'-methyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8e):

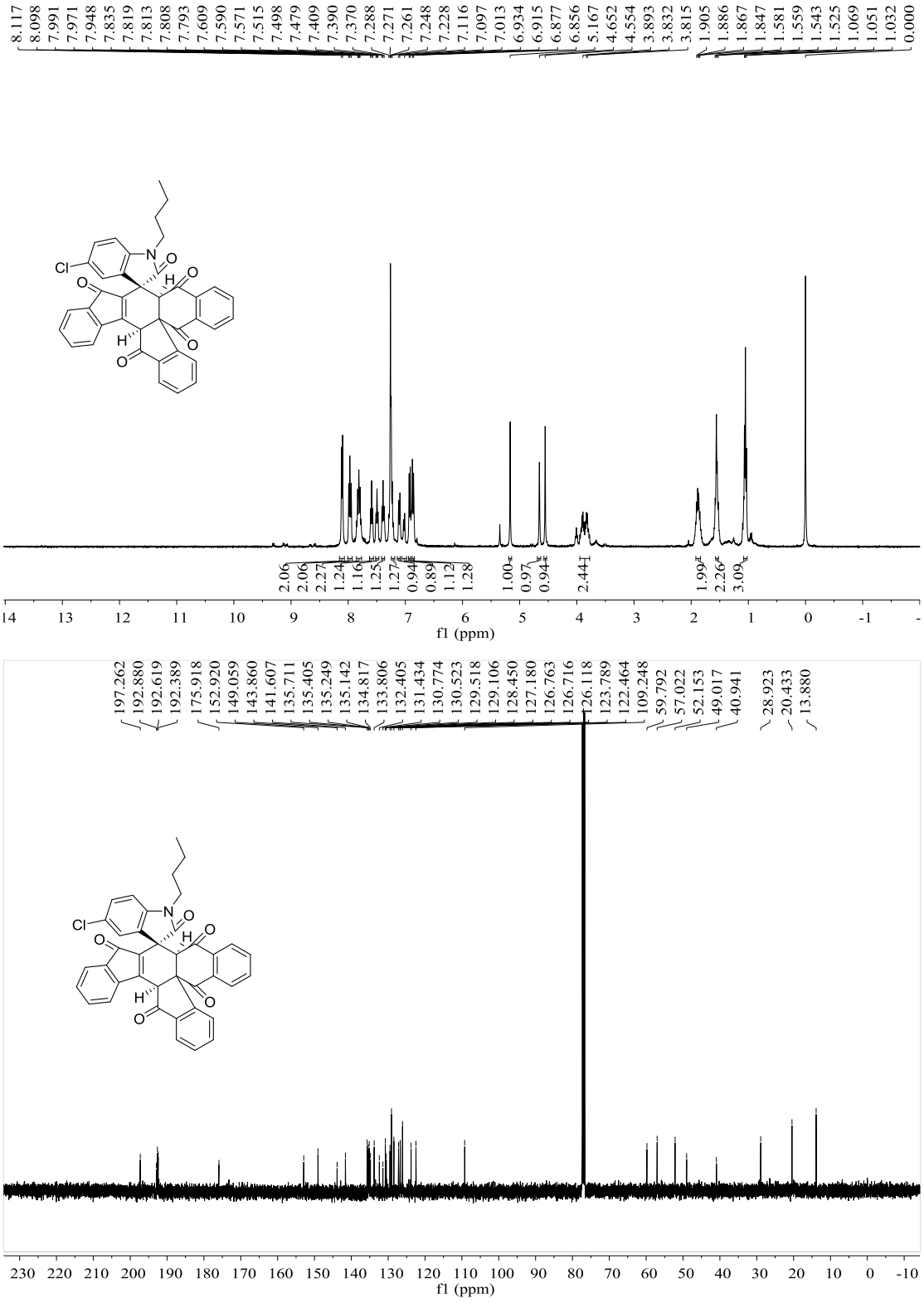


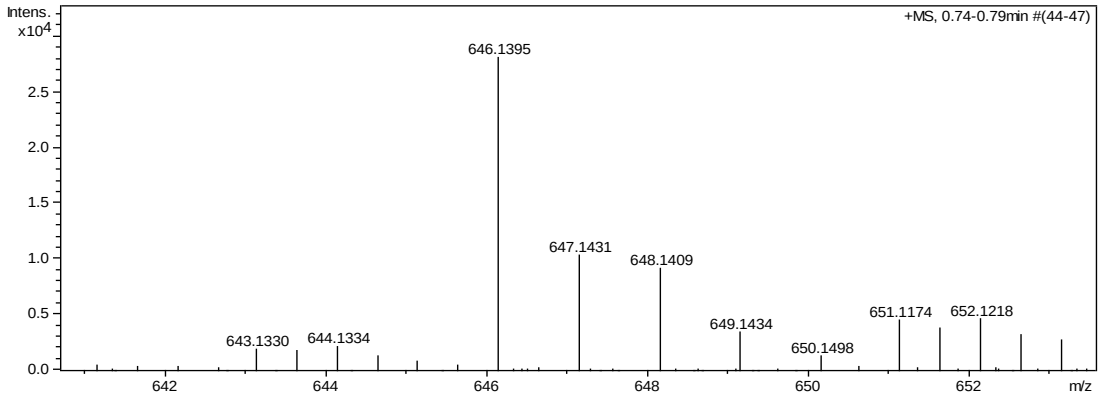




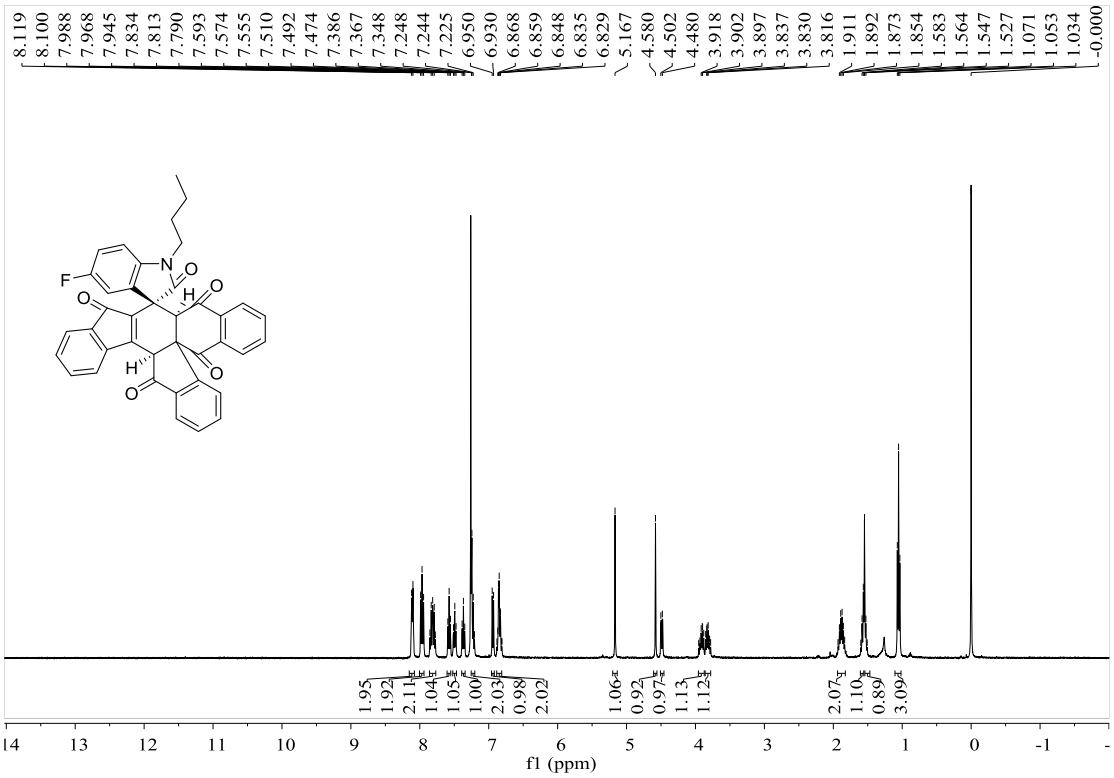

Intens.
x10^4
+MS, 0.41-0.46min #(24-27)
604.2118
605.2153
603.2046
606.2188
6
4
2
0
600
602
604
606
608
610
m/z

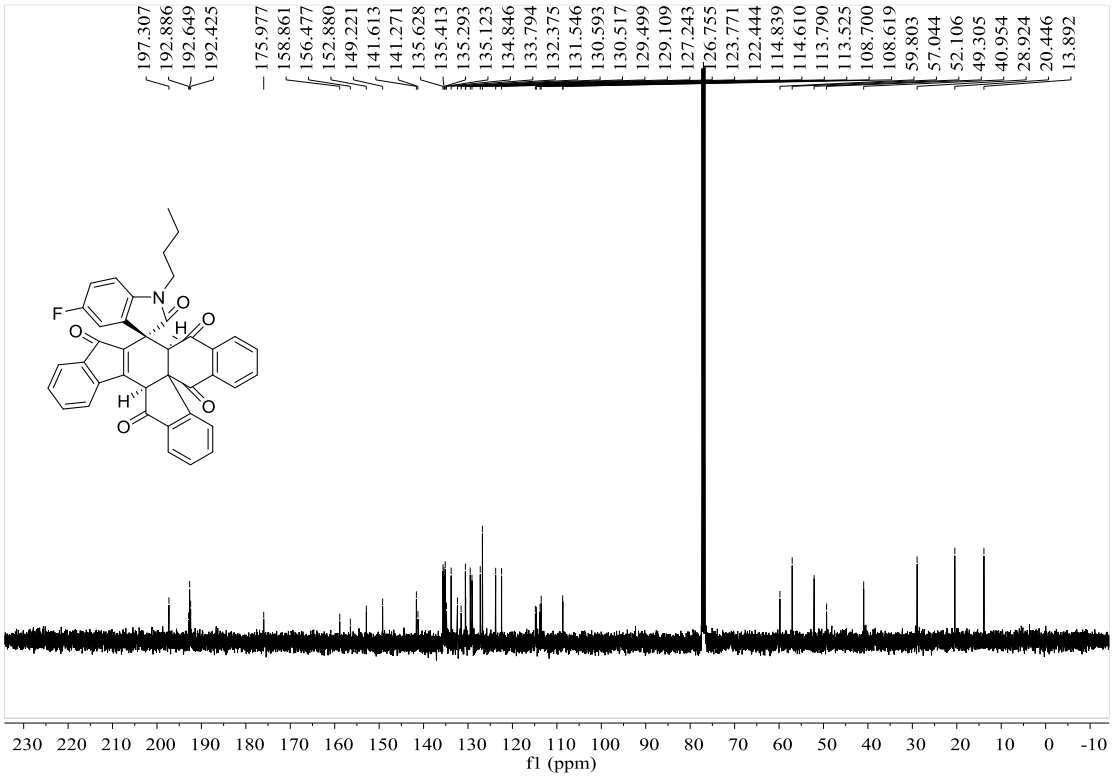
1'-butyl-5'-chloro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8f):

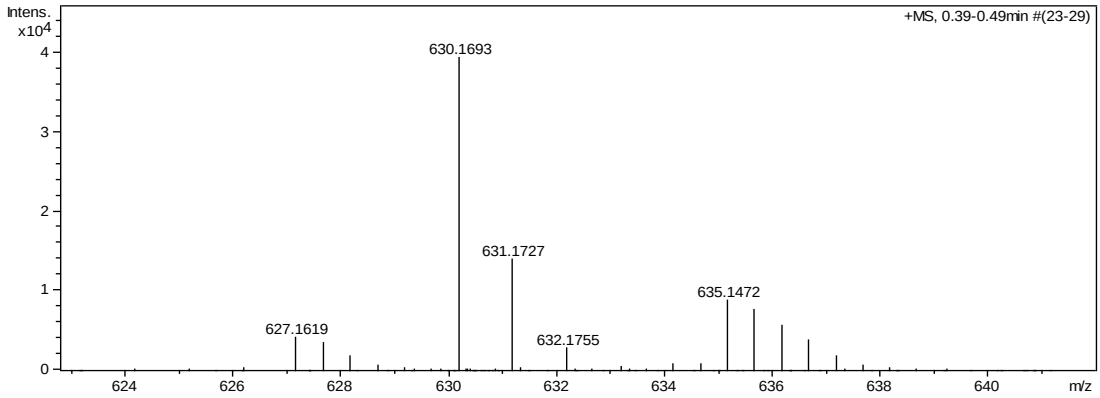



Intens.
x10^4
+MS, 0.74-0.79min #(44-47)
646.1395
647.1431
648.1409
643.1330
644.1334
649.1434
650.1498
651.1174
652.1218
2.5
2.0
1.5
1.0
0.5
0.0
642
644
646
648
650
652
m/z

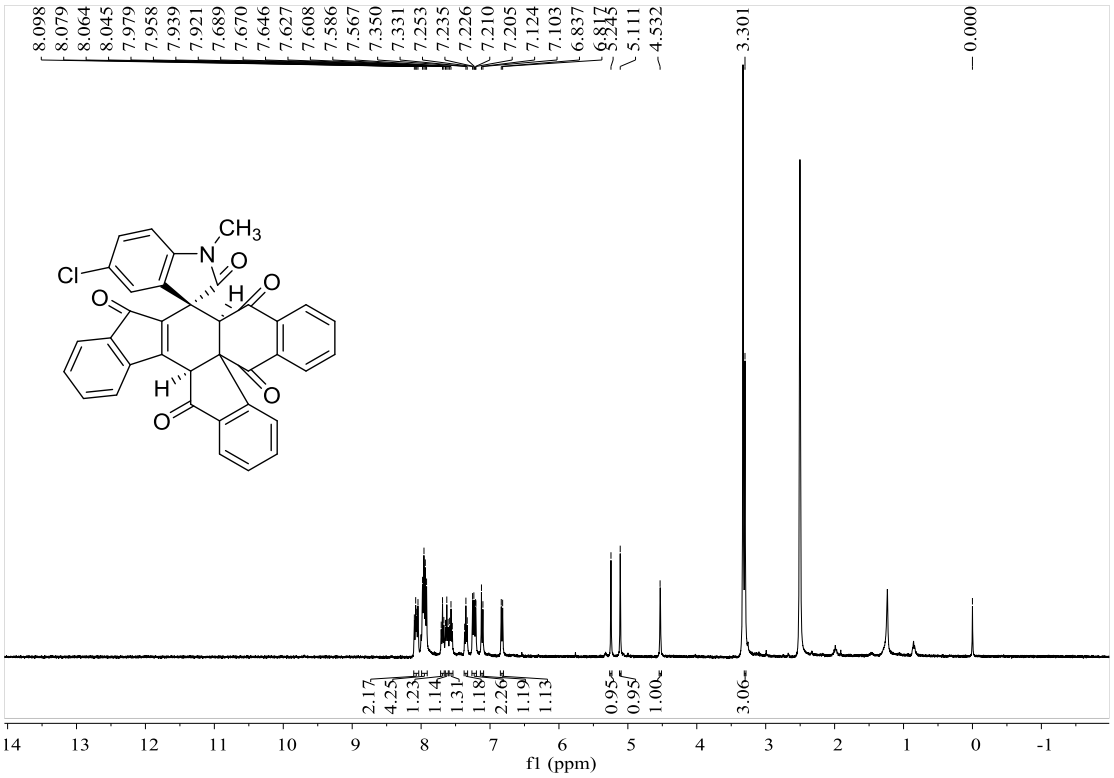
1'-butyl-5'-fluoro-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8g):

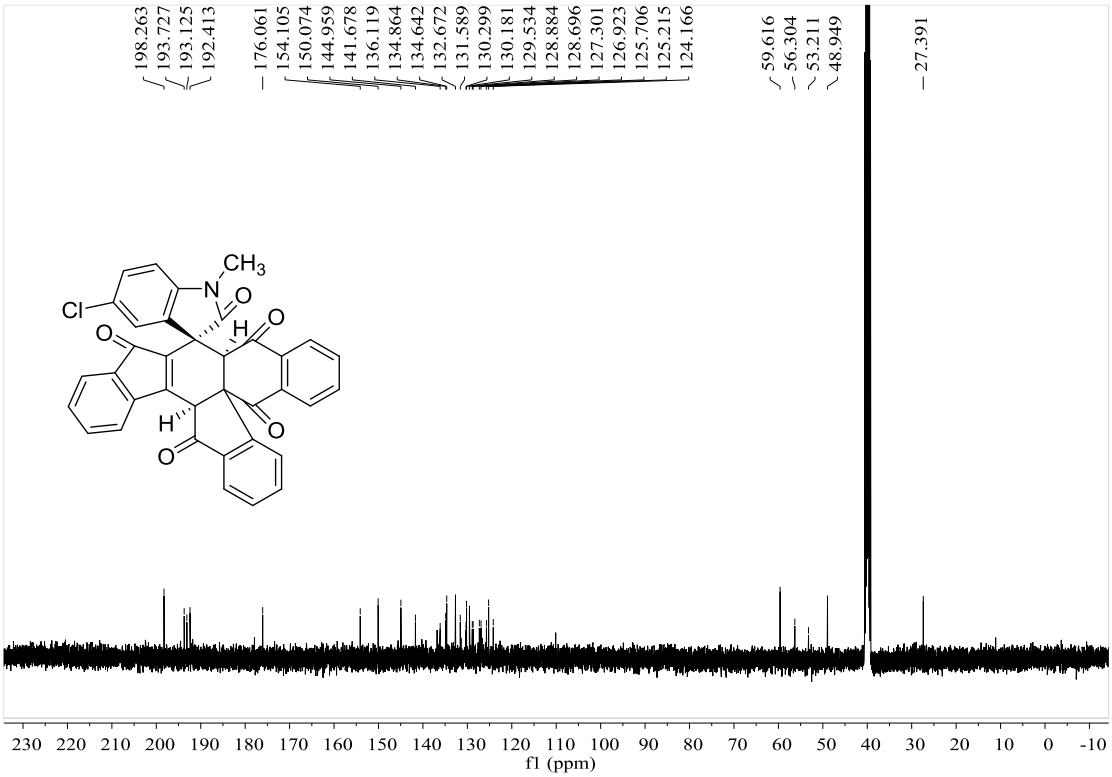


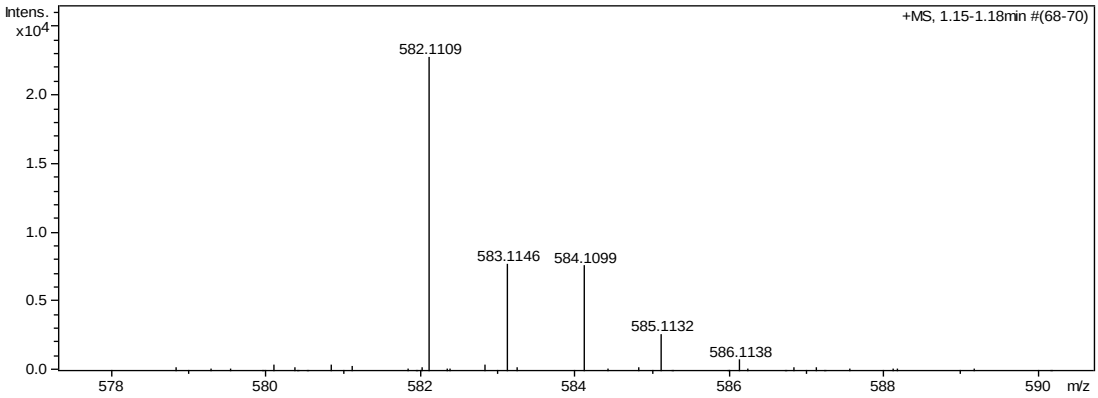



Intens.
x10^4
+MS, 0.39-0.49min #(23-29)
630.1693
631.1727
635.1472
627.1619
632.1755
0
1
2
3
4
624
626
628
630
632
634
636
638
640
m/z

5'-chloro-1'-methyl-10a,16c-dihydro-5*H*,12*H*-spiro[diindeno[2,1-*b*:2',1'-*d*]anthracene-11,3'-indoline]-2',5,10,12,17-pentaone (8h):






Intens.
x10^4
+MS, 1.15-1.18min #(68-70)
582.1109
583.1146
584.1099
585.1132
586.1138
2.0
1.5
1.0
0.5
0.0
578
580
582
584
586
588
590
m/z