Diastereorically Synthesis of *trans*-2,3-Dihydrofurans with Pyridinium Ylide Assisted Tandem Reaction

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Supporting Information

Table 1 1

Table 2 2

Table 3 3

Scheme 1 3

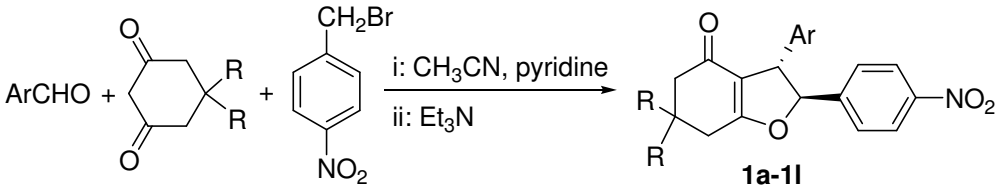
Fig. S1-S4 4-5

Characterization of compounds 5-34

X-Ray Crystallographic Data CIF in separate file.

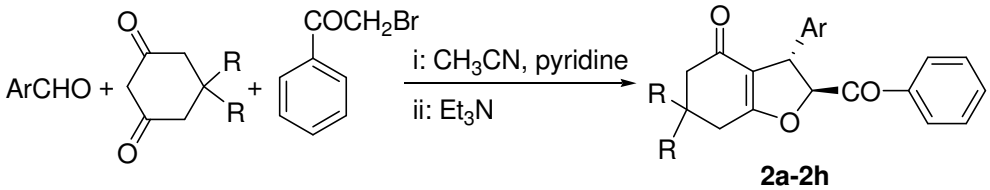
Crystallographic data (**1f**: CCDC 737948; **1g**: CCDC 737949; **2a**: 737950; **3e**: CCDC 737951) have been deposited vat the Cambridge Crystallographic Database Centre and is available on request from the Director, CCDC, 12 Union Road, Cambridge, CB2 1EZ, UK (Fax: +44-1223-336033; e-mail: deposit@ccdc.cam.ac.uk or www:http//www.ccdc.cam.ac.uk).

TABLE 1. 3,5,6,7-tetrahedro-2H-benzofuran-4-ones from reactions of *p*-nitrobenzyl bromide



Entry	Compd	Ar	R	Yield (%)
1	**1a**	Ph	H	72
2	**1b**	*p*-$CH_3C_6H_4$	H	88
3	**1c**	*p*-$CH_3OC_6H_4$	H	56
4	**1d**	*p*-BrC_6H_4	H	79
5	**1e**	*m*-$NO_2C_6H_4$	H	74
6	**1f**	PhCH=CH	H	87
7	**1g**	Ph	CH_3	74
8	**1h**	*p*-$CH_3C_6H_4$	CH_3	78
9	**1i**	*p*-$CH_3OC_6H_4$	CH_3	61
10	**1j**	*p*-BrC_6H_4	CH_3	77
11	**1k**	*m*-$NO_2C_6H_4$	CH_3	86
12	**1l**	PhCH=CH	CH_3	78

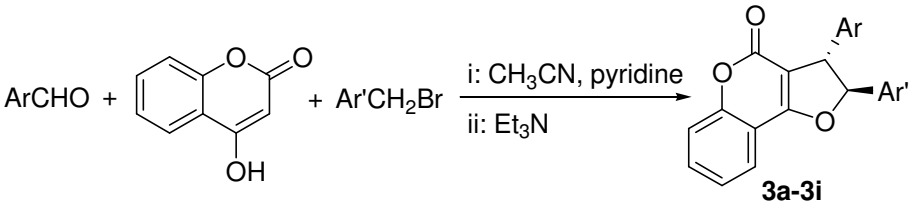
TABLE 2. 3,5,6,7-tetrahedro-2H-benzofuran-4-ones from reactions of phenacyl bromide



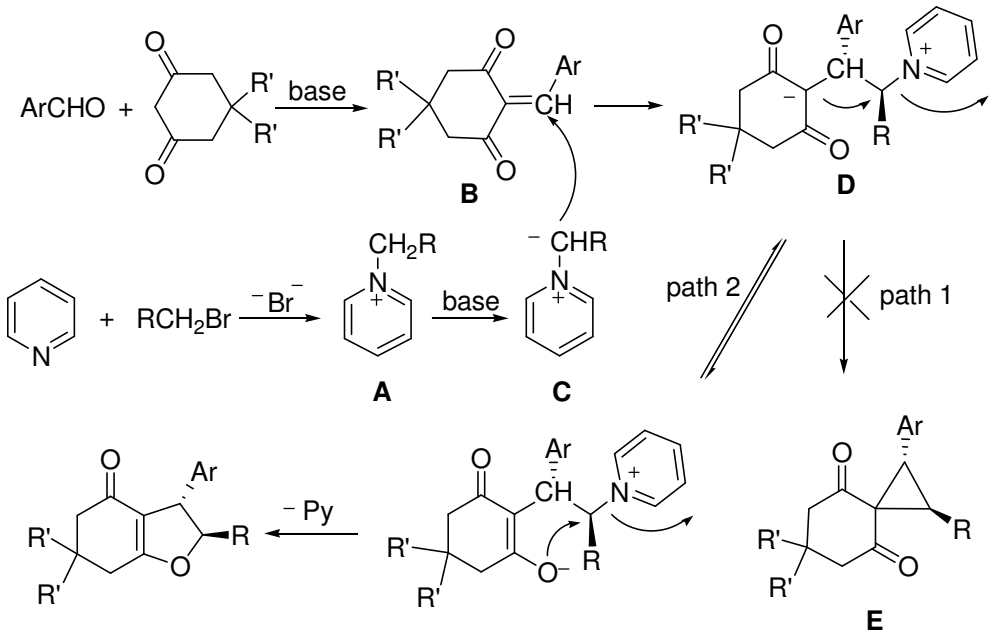
2a-2h

Entry	Compd	Ar	R	Yield (%)
1	**2a**	Ph	H	66
2	**2b**	*p*-$CH_3C_6H_4$	H	50
3	**2c**	*p*-$CH_3OC_6H_4$	H	47
4	**2d**	*p*-BrC_6H_4	H	46
5	**2e**	Ph	CH_3	63
6	**2f**	*p*-$CH_3C_6H_4$	CH_3	71
7	**2g**	*p*-$CH_3OC_6H_4$	CH_3	71
8	**2h**	*p*-ClC_6H_4	CH_3	75

TABLE 3. 2,3-dihydrofuro[3,2-c]chromen-4-ones from reactions of 4-hydroxycoumarin



Entry	Compd	Ar	Ar'	Yield (%)
1	**3a**	Ph	p-$NO_2C_6H_4$	62
2	**3b**	p-$CH_3C_6H_4$	p-$NO_2C_6H_4$	56
3	**3c**	p-$CH_3OC_6H_4$	p-$NO_2C_6H_4$	53
4	**3d**	p-ClC_6H_4	p-$NO_2C_6H_4$	53
5	**3e**	Ph	PhCO	75
6	**3f**	p-$CH_3C_6H_4$	PhCO	81
7	**3g**	p-$CH_3OC_6H_4$	PhCO	62
8	**3h**	p-ClC_6H_4	PhCO	68
9	**3i**	m-$NO_2C_6H_4$	PhCO	50



SCHEME 1. The proposed formation mechanism of 2,3-dihydrofuran derivatives

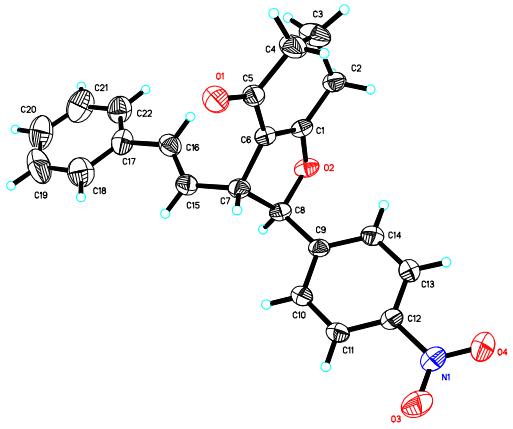


FIGURE S1. Molecular structure of 3,5,6,7-tetrahedro-2H-benzofuran-4-one **1f**

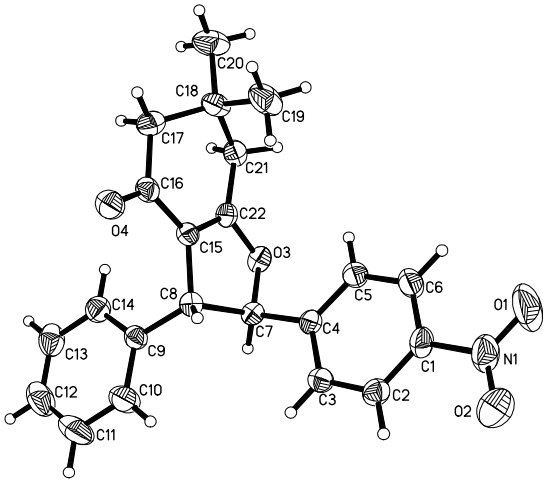


FIGURE S2. Molecular structure of 3,5,6,7-tetrahedro-2H-benzofuran-4-one **1g**

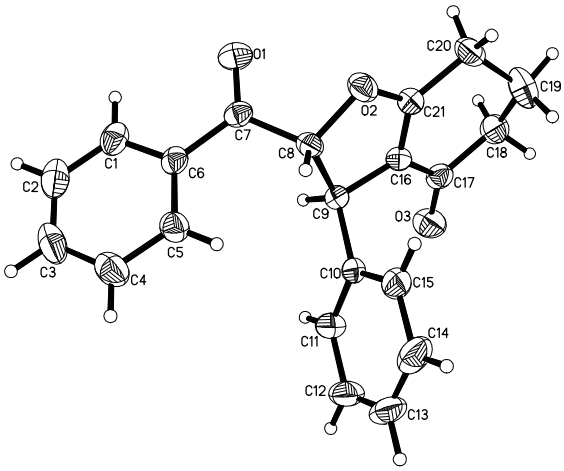


FIGURE S3. Molecular structure of 3,5,6,7-tetrahedro-2H-benzofuran-4-one **2a**

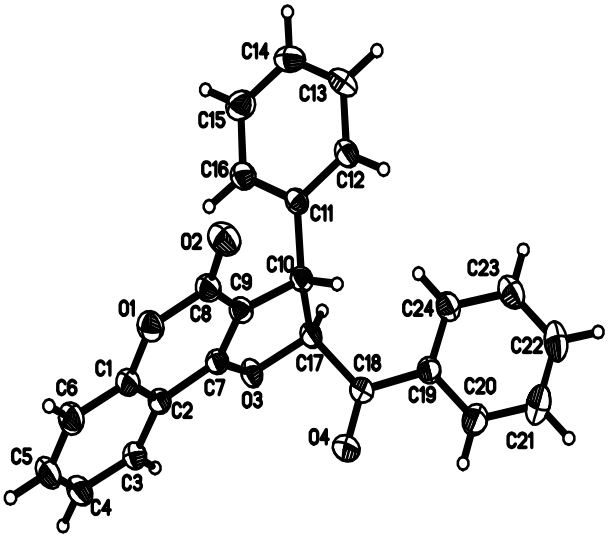


FIGURE S4. Molecular struture of 2,3-dihydrofuro[3,2-c]chromen-4-one **3e**

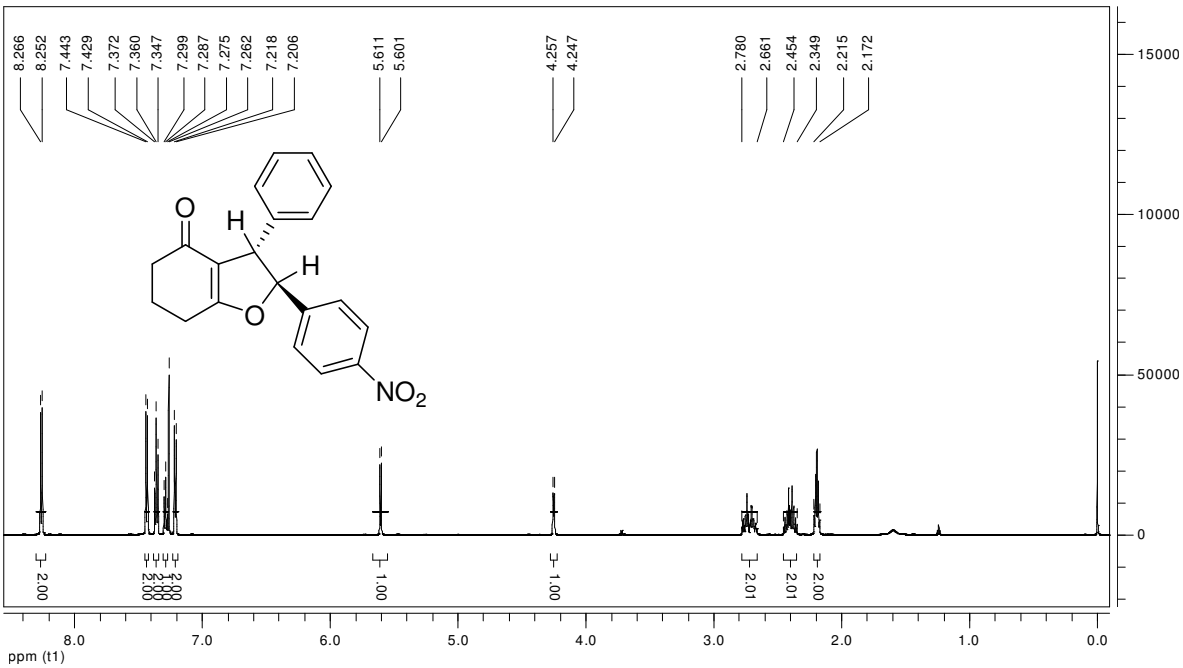
Experimental Section

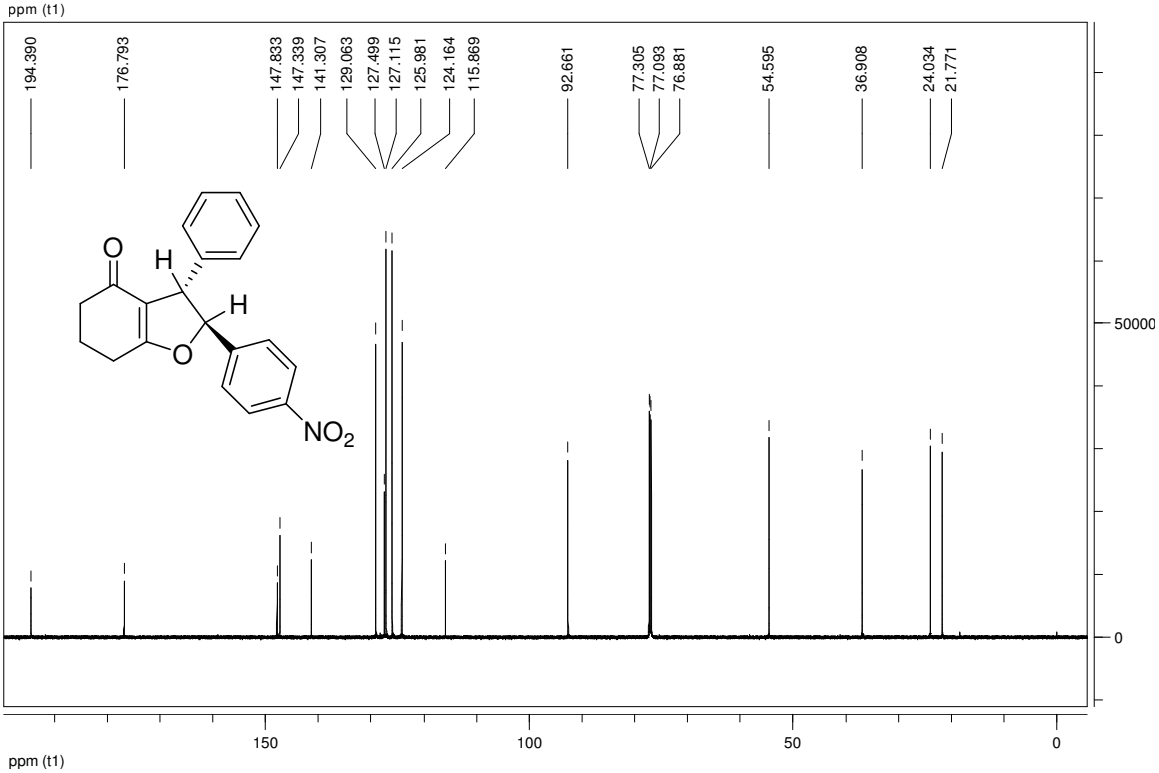
General Methods: All reagents and solvents were commercial available with analytical grade and used as received. Further purification and drying by standard method were employed and distilled prior to use when necessary. All evaporations of organic solvents were carried out with a rotary evaporator in conjunction with a water aspirator. Melting points were taken on a hot-plate microscope apparatus and are uncorrected. ^{1}H NMR and ^{13}C NMR spectra were recorded with a Bruker AV-600 spectrometer. IR spectra were obtained on a Bruker Tensor27 spectrometer (KBr disc). Elemental analyses were obtained on PE 2400C instrument. X-ray data were collected on a Bruker Smart APEX-2 CCD diffractometer.

Procedure for the preparation 2-(*p*-nitrophenyl)-3-aryl-3,5,6,7-tetrahedro-2H-benzofuran-4-ones 1a-1l

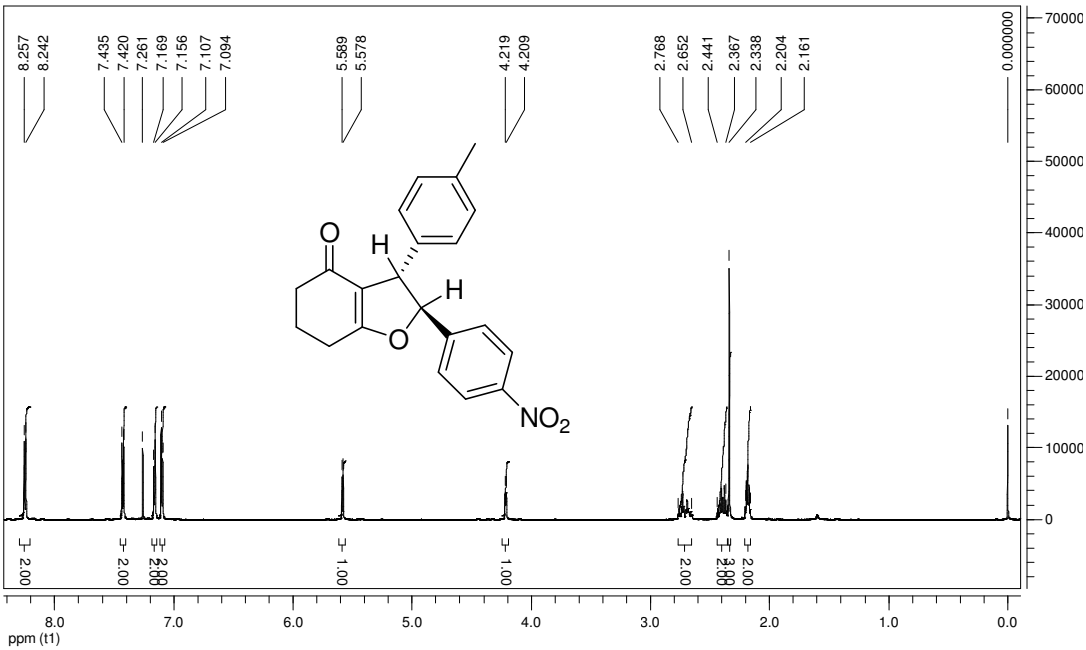
A mixture of aromatic aldehyde (2.0 mmol), 1,3-cyclohexanedione (2.0 mmol), *p*-nitrobenzyl bromide (2.1 mmol), pyridine (5.0 mmol) in acetonitrile (10 mL) was refluxed for two hours. Subsequently triethylamine (5.0 mmol) was added to the solution. The resulting mixture was refluxed about 12 hours. After completion of the reaction was checked by TLC, the solvent was evaporated in a rotatory evaporator and the crude product was washed with water and filtered off. Recrystallization from ethanol gave pure products **1a-1f**.

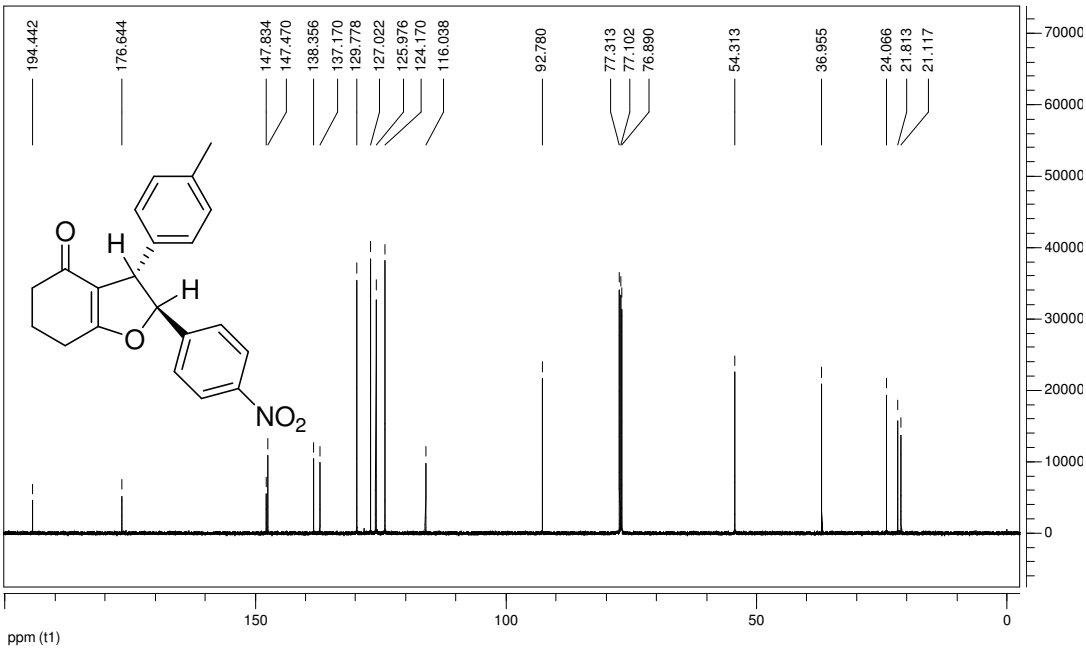
2-(*p*-Nitrophenyl)-3-phenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1a): yield: 72%. m.p. 156°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.26 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.44 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.36 (t, *J* = 7.2Hz, 2H, C_6H_5), 7.29 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.21 (d, *J* = 7.2Hz, 2H, C_6H_5), 5.61 (d, *J* = 6.0Hz, 1H, CH), 4.25 (d, *J* = 6.0Hz, 1H, CH), 2.78-2.66 (m, 2H, CH_2), 2.45-2.35 (m, 2H, CH_2), 2.22-2.17 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.4, 176.8, 147.8, 147.3, 141.3, 129.1, 127.5, 127.1, 126.0, 124.2, 115.9, 92.7, 54.6, 36.9, 24.0, 21.8. MS(ESI-): m/z = 334.82. IR (KBr): 3444(w), 2896(w), 1641(vs), 1602(m), 1517(s), 1454(m), 1392(s), 1350(s), 1255(m), 1224(w), 1175(m), 1144(w), 1109(w), 1066(m), 1027(w), 978(m), 947(w), 836(m), 759(m), 703(m) cm^{-1}. Anal Calcd for $C_{20}H_{17}NO_4$: C 71.63, H 5.11, N 4.18; Found: C 71.46, H 5.40, N 3.82.



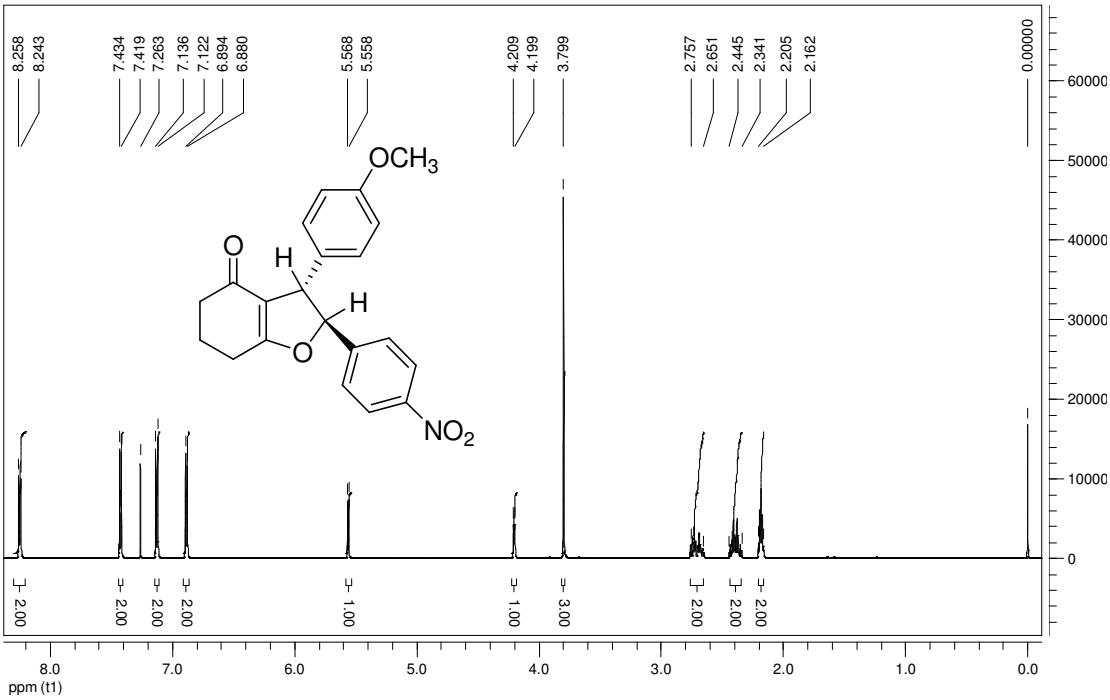


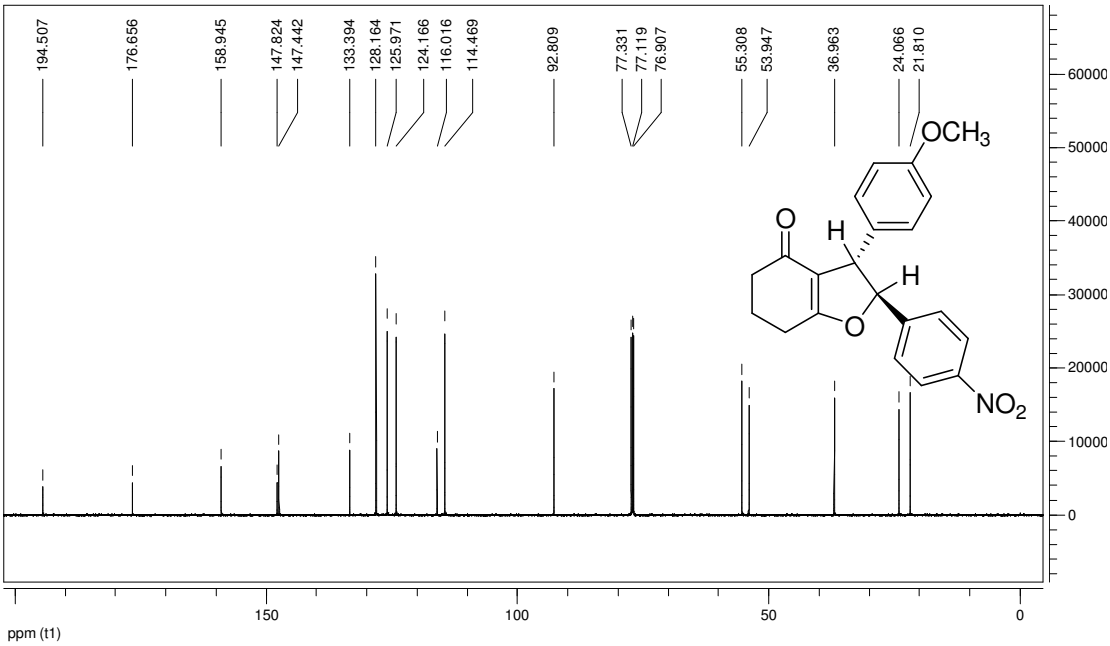
2-(*p*-Nitrophenyl)-3-*p*-methylphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1b): yield: 88%. m.p. 204°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.25 (d, *J* = 9.0Hz, 2H, *p*-$NO_2C_6H_4$), 7.43 (d, *J* = 9.0Hz, 2H, *p*-$NO_2C_6H_4$), 7.16 (d, *J* = 7.8Hz, 2H, *p*-$CH_3C_6H_4$), 7.10 (d, *J* = 7.8Hz, 2H, *p*-$CH_3C_6H_4$), 5.58 (d, *J* = 6.0Hz, 1H, CH), 4.21 (d, *J* = 6.0Hz, 1H, CH), 2.77-2.65 (m, 2H, CH_2), 2.44-2.38 (m, 2H, CH_2), 2.34 (s, 3H, CH_3), 2.20-2.16 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.4, 176.6, 147.8, 147.5, 138.4, 137.2, 129.8, 127.0, 126.0, 124.2, 116.0, 92.8, 54.3, 37.0, 24.1, 21.8, 21.1. MS(ESI+): m/z = 350.52. IR (KBr): 3441(w), 2943(w), 1630(vs), 1516(s), 1458(w), 1396(m), 1346(s), 1218(m), 1170(m), 1140(w), 1112(w), 1058(vw), 1014(w), 941(m), 850(w), 793(w), 742(vw), 716(vw) cm^{-1}. Anal Calcd for $C_{21}H_{19}NO_4$: C 72.19, H 5.48, N 4.01; Found: C 71.86, H 5.77, N 3.83.



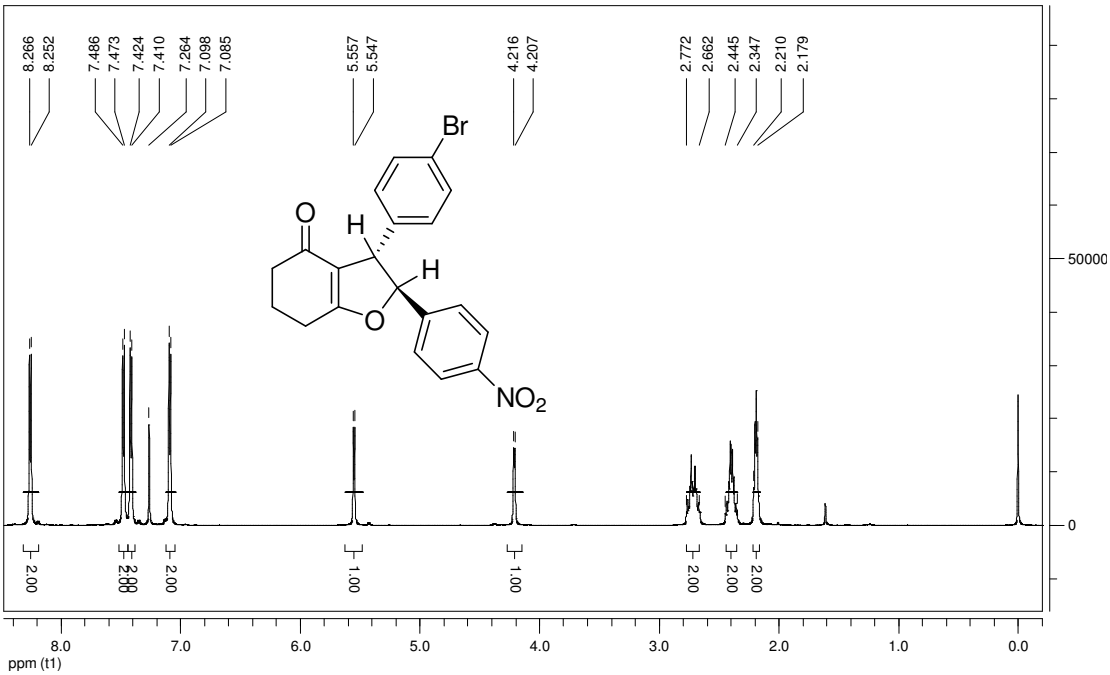


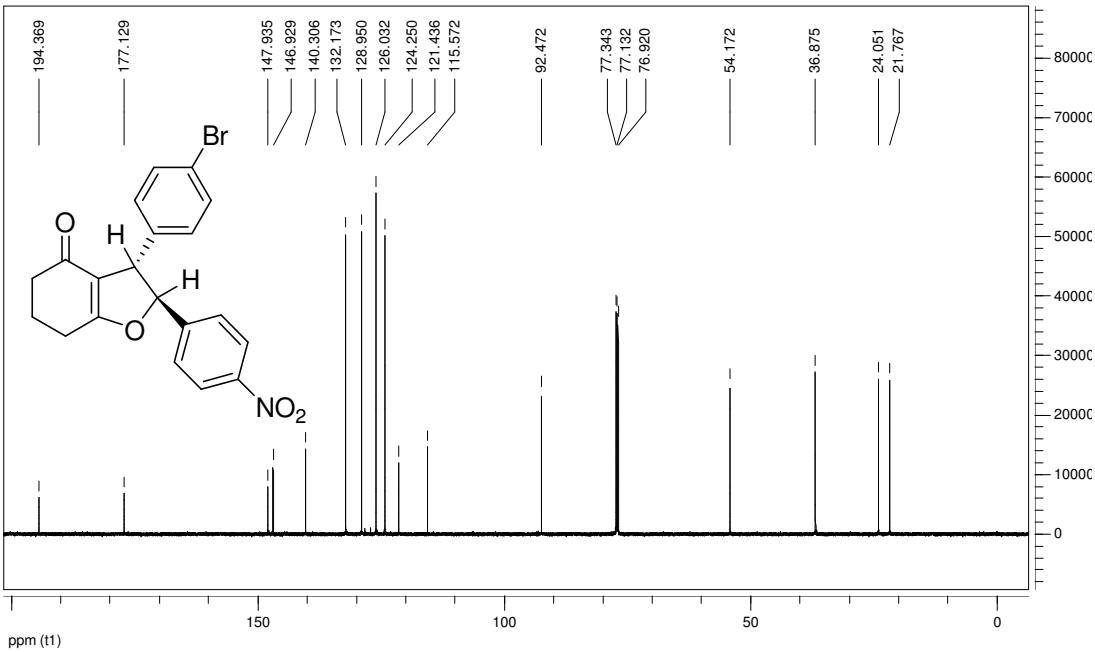
2-(*p*-Nitrophenyl)-3-*p*-methoxyphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1c): yield: 56%. m.p. 192°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.25 (d, J = 9.0Hz, 2H, p-$NO_2C_6H_4$), 7.43 (d, J = 9.0Hz, 2H, p-$NO_2C_6H_4$), 7.13 (d, J = 8.4Hz, 2H, p-$CH_3OC_6H_4$), 6.89 (d, J = 8.4Hz, 2H, p-$CH_3OC_6H_4$), 5.56 (d, J = 6.0Hz, 1H, CH), 4.20 (d, J = 6.0Hz, 1H, CH), 3.80 (s, 3H, CH_3O), 2.76-2.65 (m, 2H, CH_2), 2.45-2.34 (m, 2H, CH_2), 2.21-2.16 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.5, 176.7, 158.9, 147.8, 147.4, 133.4, 128.2, 126.0, 124.2, 116.0, 114.5, 92.8, 55.3, 53.9, 37.0, 24.1, 21.8. MS(ESI-): m/z = 364.84. IR (KBr): 3431(w), 2962(w), 1637(vs), 1605(m), 1514(vs), 1455(w), 1421(w), 1394(m), 1344(vs), 1252(s), 1177(s), 1141(w), 1112(m), 1061(w), 1029(m), 954(m), 843(m), 784(w), 744(w), 697(w) cm^{-1}. Anal Calcd for $C_{21}H_{19}NO_5$: C 69.03, H 5.24, N 3.83; Found: C 68.67, H 5.61, N 3.47.



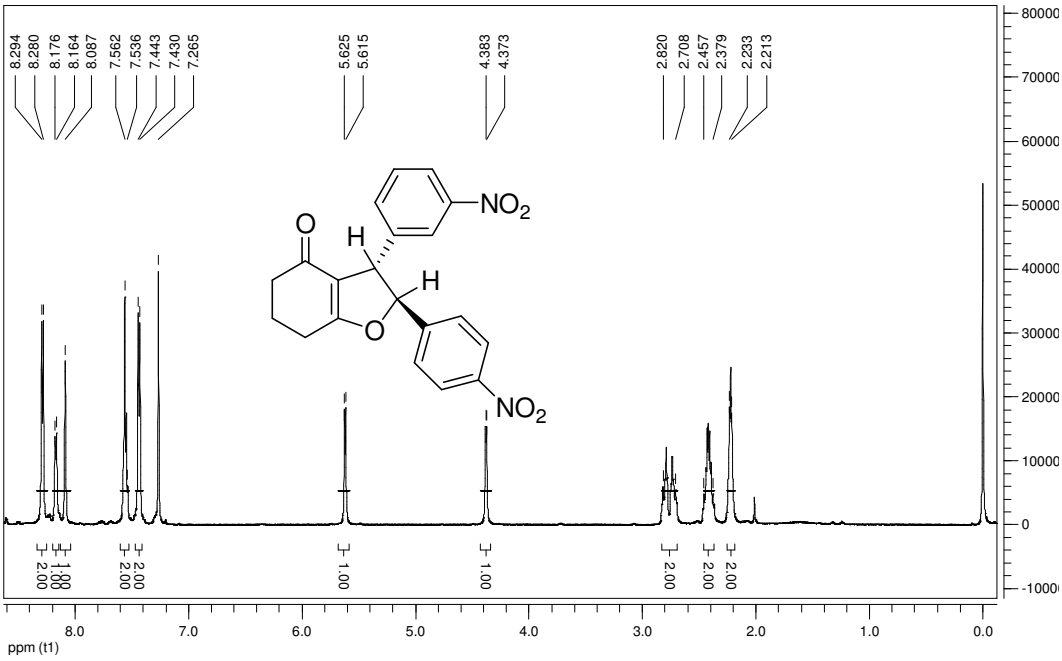


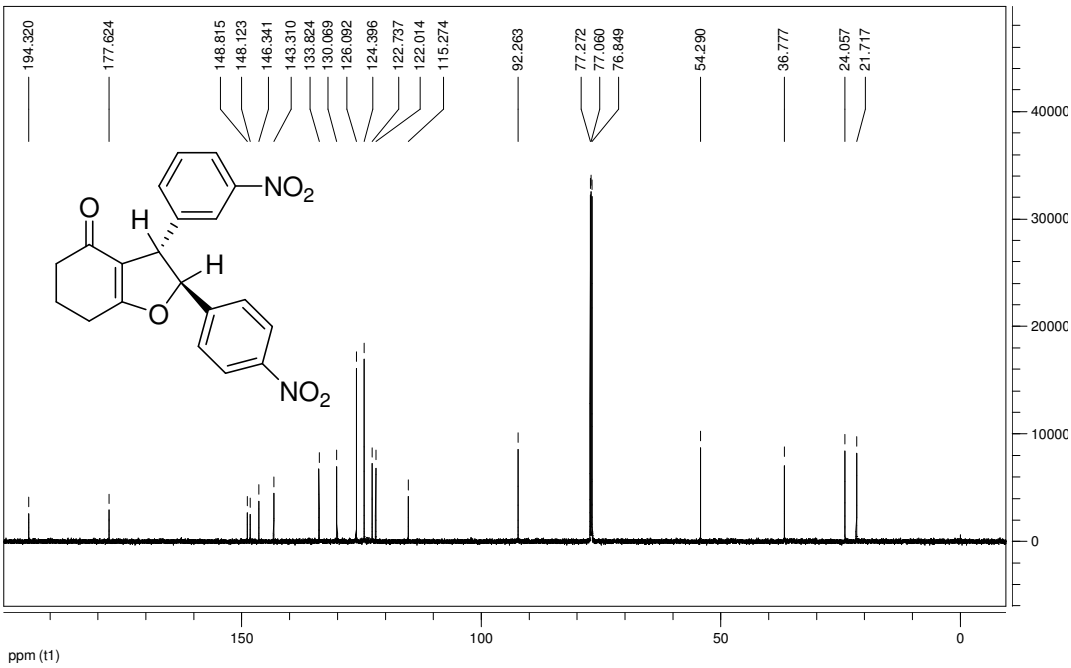
2-(*p*-Nitrophenyl)-3-*p*-bromophenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1d): yield: 79%. m.p. 206°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.26 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.48 (d, *J* = 7.8Hz, 2H, *p*-BrC_6H_4), 7.42 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.09 (d, *J* = 7.2Hz, 2H, *p*-BrC_6H_4), 5.55 (d, *J* = 6.0Hz, 1H, CH), 4.21 (d, *J* = 5.4Hz, 1H, CH), 2.77-2.66 (m, 2H, CH_2), 2.45-2.35 (m, 2H, CH_2), 2.21-2.18 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.4, 177.1, 147.9, 146.9, 140.3, 132.2, 129.0, 126.0, 124.3, 121.4, 115.6, 92.5, 54.2, 36.9, 24.1, 21.8. MS(ESI-): m/z = 412.46. IR (KBr): 3439(w), 2949(w), 2874(w), 1639(s), 1602(m), 1516(s), 1452(w), 1395(s), 1247(s), 1177(m), 1144(m), 1110(w), 1064(m), 1014(m), 959(m), 894(m), 848(w), 788(m), 748(w), 720(w) cm^{-1}. Anal Calcd for $C_{20}H_{16}BrNO_4$: C 57.99, H 3.89, N 3.38; Found: C 57.71, H 4.10, N 3.53.



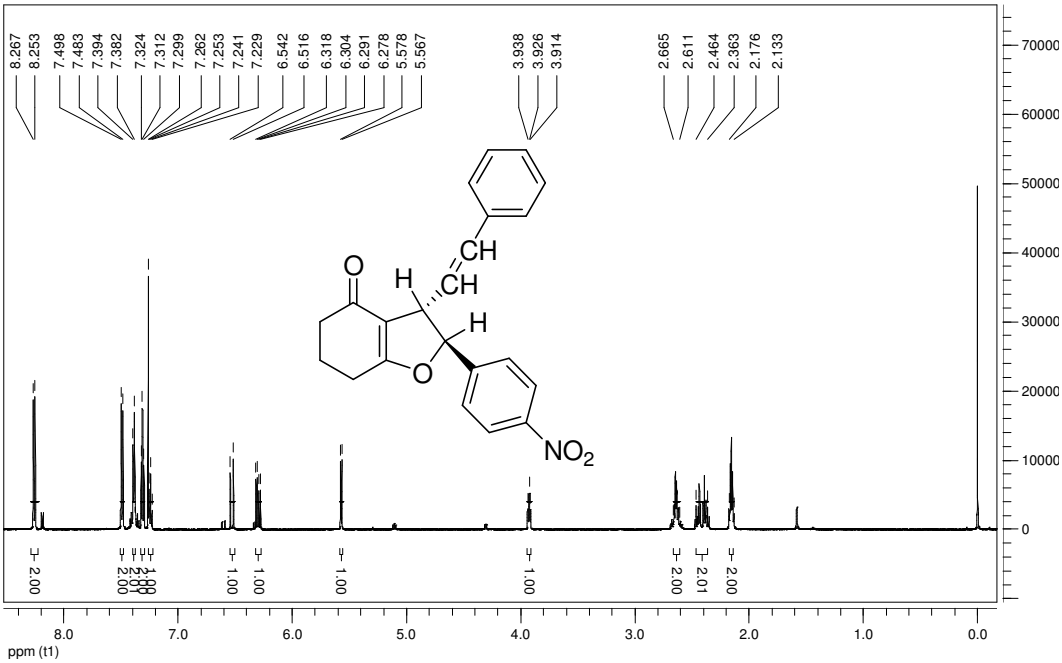


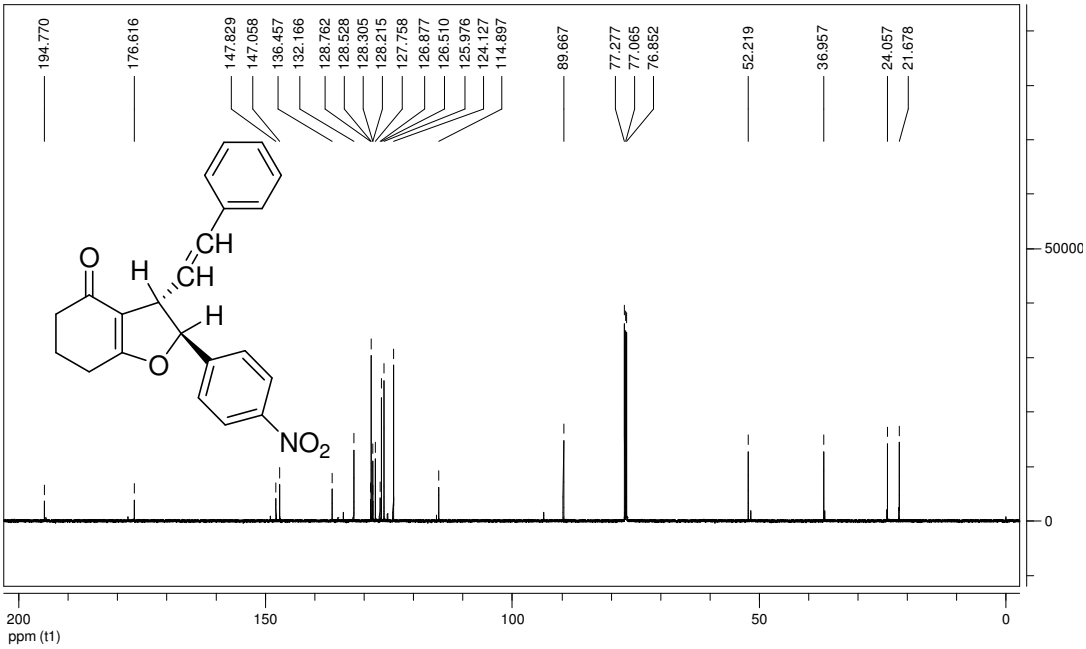
2-(*p*-Nitrophenyl)-3-*m*-nitrophenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1e): yield: 74%. m.p. 210°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.29 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 8.17 (d, *J* = 7.2Hz, 1H, *m*-$NO_2C_6H_4$), 8.09 (s, 1H, *m*-$NO_2C_6H_4$), 7.56-7.54 (m, 2H, *m*-$NO_2C_6H_4$), 7.44 (d, *J* = 7.8Hz, 2H, *p*-$NO_2C_6H_4$), 5.62 (d, *J* = 6.0Hz, 1H, CH), 4.38 (d, *J* = 6.0Hz, 1H, CH), 2.82-2.71 (m, 2H, CH_2), 2.46-2.38 (m, 2H, CH_2), 2.23-2.21 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.3, 177.6, 148.8, 148.1, 146.3, 143.3, 133.8, 130.1, 126.1, 124.4, 122.7, 122.0, 115.3, 92.3, 54.3, 36.8, 24.1, 21.7. MS(ESI-): m/z = 379.57. IR (KBr): 3443(w), 3076(w), 2948(w), 1631(s), 1528(s), 1394(m), 1351(s), 1244(w), 1219(m), 1173(m), 1141(w), 1107(w), 1061(w), 1013(w), 944(m), 851(w), 803(w), 725(w) cm^{-1}. Anal Calcd for $C_{20}H_{16}N_2O_6$: C 63.16, H 4.24, N 7.37; Found: C 63.40, H 4.39, N 6.97.



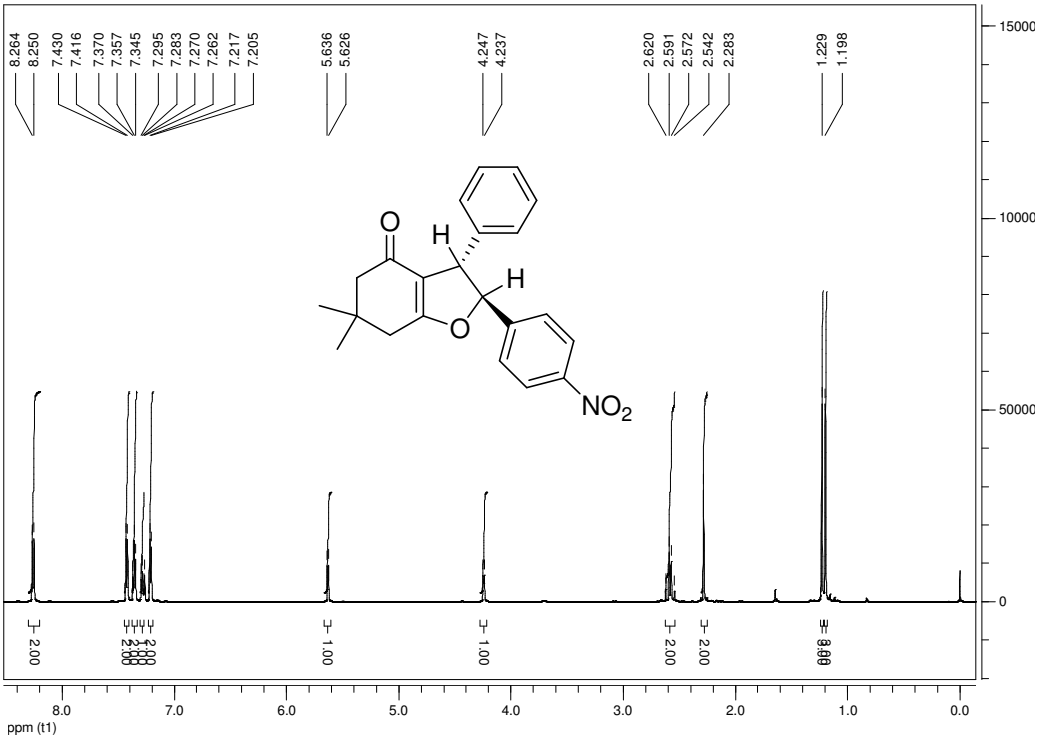


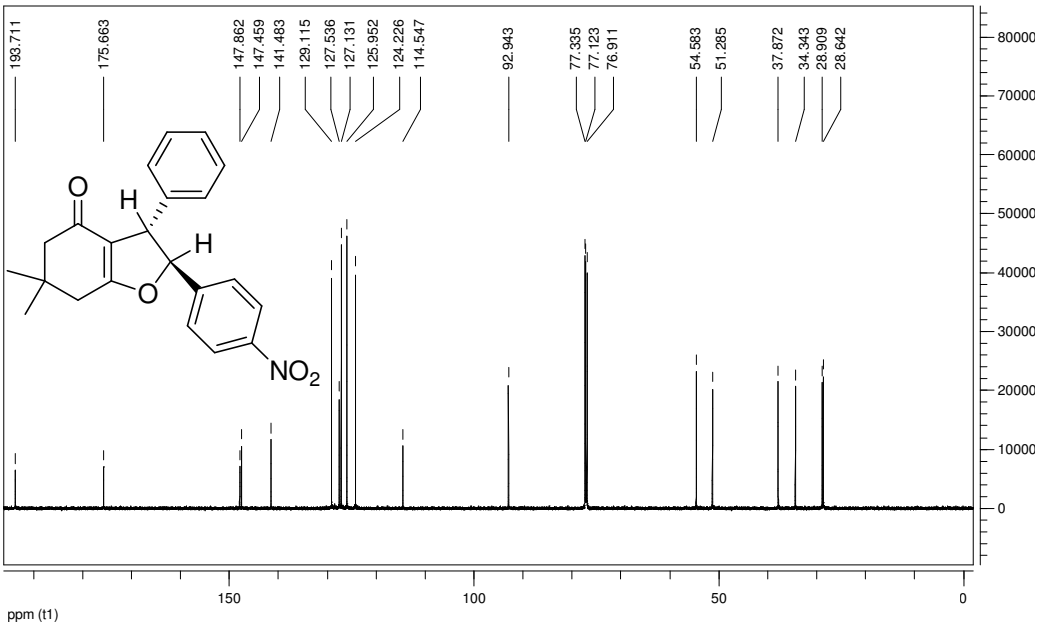
2-(*p*-Nitrophenyl)-3-phenylvinyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1f): yield: 87%. m.p. 172°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.26 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.49 (d, *J* = 9.0Hz, 2H, *p*-$NO_2C_6H_4$), 7.39 (d, *J* = 7.2Hz, 2H, C_6H_5), 7.31 (t, *J* = 7.2Hz, 2H, C_6H_5), 7.24 (t, *J* = 7.2Hz, 1H, C_6H_5), 6.53 (d, *J* = 15.6Hz, 1H, CH=), 6.32-6.28 (m, 1H, CH=), 5.57 (d, *J* = 6.6Hz, 1H, CH), 3.93 (t, *J* = 7.2Hz, 1H, CH), 2.67-2.61 (m, 2H, CH_2), 2.46-2.36 (m, 2H, CH_2), 2.18-2.23 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.8, 176.6, 147.8, 147.1, 136.5, 132.2, 128.8, 128.5, 128.3, 128.2, 127.8, 126.9, 126.5, 126.0, 124.1, 114.9, 89.7, 52.2, 37.0, 24.1, 21.7. MS(ESI-): m/z = 360.56. IR (KBr): 3432(w), 3025(w), 2955(w), 1630(vs), 1517(s), 1455(w), 1396(s), 1345(s), 1221(m), 1176(m), 1113(m), 1060(w), 1014(w), 969(w), 941(m), 851(w), 738(w), 692(w) cm^{-1}. Anal Calcd for $C_{22}H_{19}NO_4$: C 73.12, H 5.30, N 3.88; Found: C 73.34, H 5.67, N 3.52.



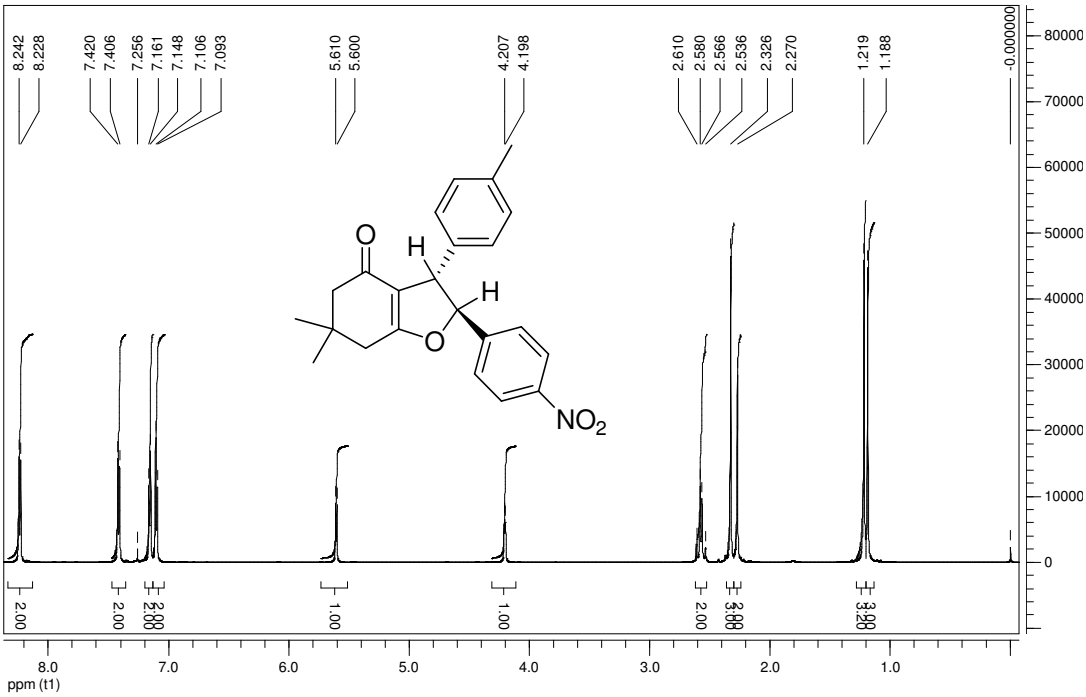


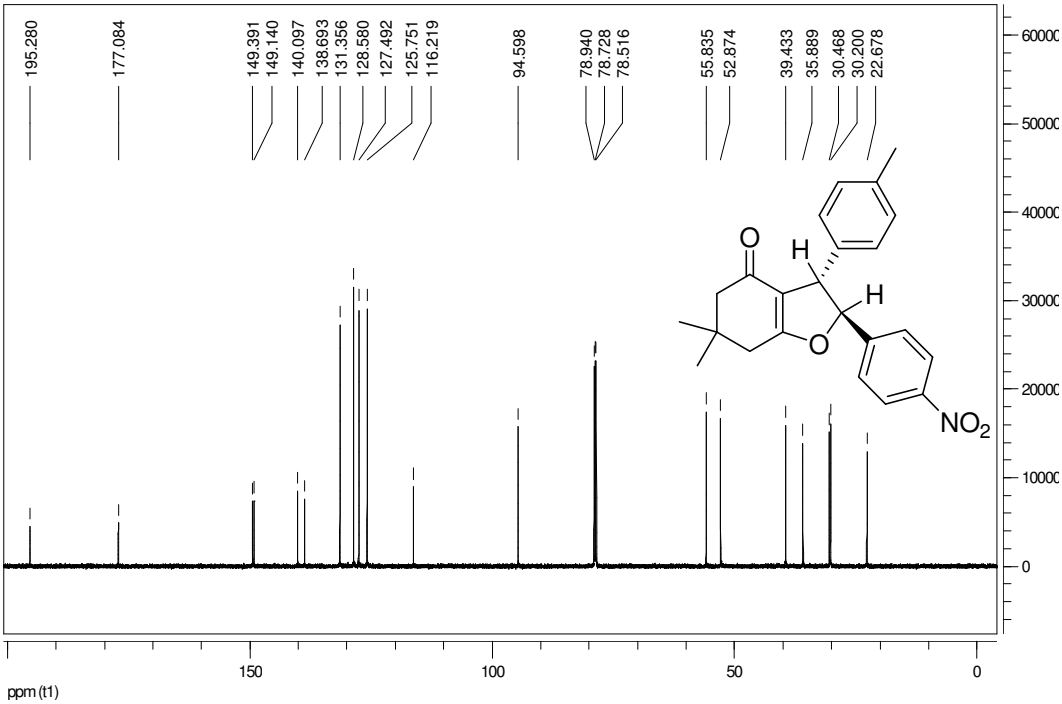
6,6-Dimethyl-2-(*p*-nitrophenyl)-3-phenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1g): Ar＝C_6H_5, yield: 74%. m.p. 161°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.26 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.42 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.36 (t, *J* = 7.2Hz, 2H, C_6H_5), 7.28 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.21 (d, *J* = 7.2Hz, 2H, C_6H_5), 5.63 (d, *J* = 6.0Hz, 1H, CH), 4.24 (d, *J* = 6.0Hz, 1H, CH), 2.58-2.54 (m, 2H, CH_2), 2.28 (s, 2H, CH_2), 1.23 (s, 3H, CH_3), 1.20 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.7, 175.7, 147.9, 147.5, 141.5, 129.1, 127.5, 127.1, 126.0, 124.2, 114.5, 92.9, 54.6, 51.3, 37.9, 51.3, 37.9, 34.3, 28.9, 28.6. MS(ESI-): m/z = 363.14. IR (KBr): 3449(w), 2957(w), 1636(vs), 1601(m), 1512(s), 1455(w), 1396(m), 1343(s), 1198(w), 1166(w), 1104(m), 1055(m), 977(m), 884(vw), 851(w), 754(w), 698(m) cm^{-1}. Anal Calcd for $C_{22}H_{21}NO_4$: C 72.71, H 5.82, N 3.85; Found: C 72.56, H 6.18, N 3.49.



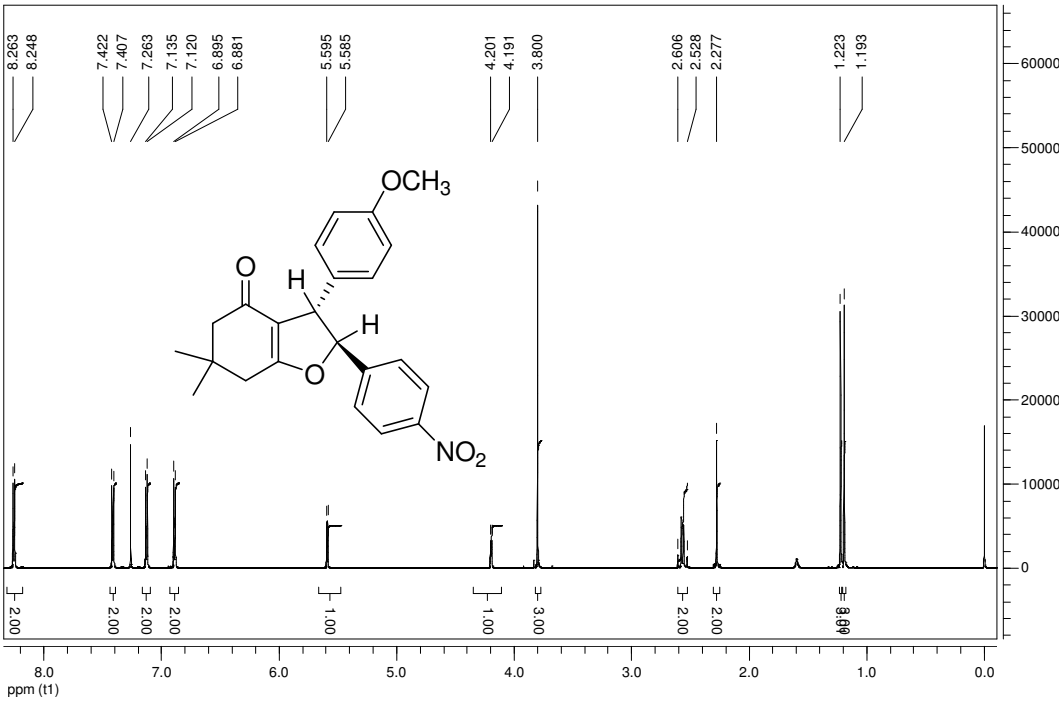


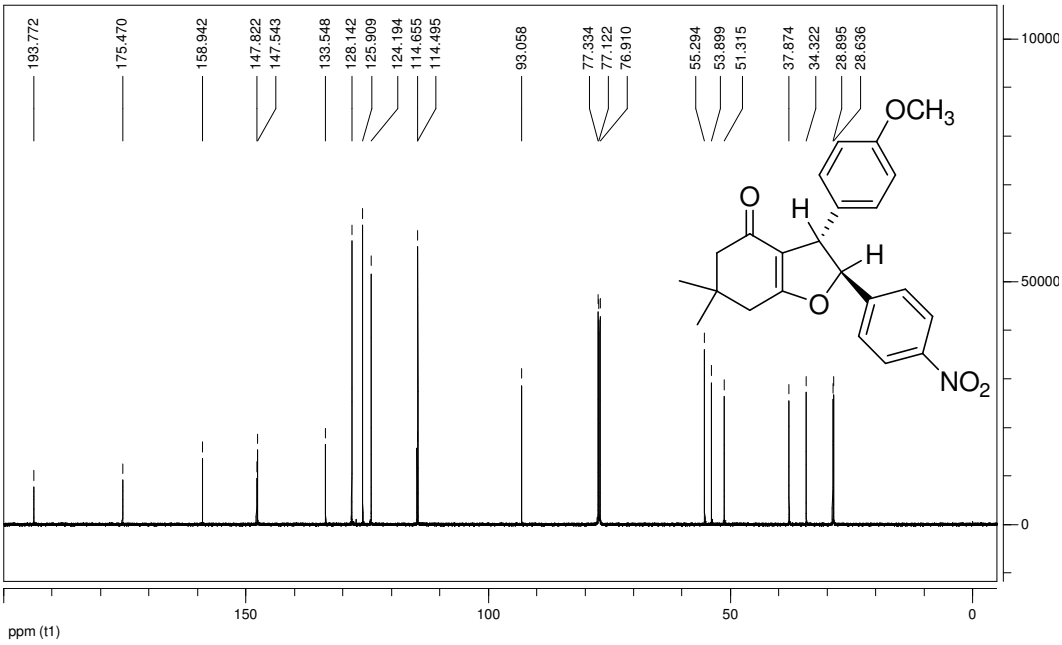
6,6-Dimethyl-2-(*p*-nitrophenyl)-3-*p*-methylphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1h): yield: 78%. m.p. 168°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.24 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.41 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.15 (d, *J* = 7.8Hz, 2H, *p*-$CH_3C_6H_4$), 7.10 (d, *J* = 7.8Hz, 2H, *p*-$CH_3C_6H_4$), 5.61 (d, *J* = 6.0Hz, 1H, CH), 4.20 (d, *J* = 5.4Hz, 1H, CH), 2.61-2.54 (m, 2H, CH_2), 2.33 (s, 3H, CH_3), 2.27 (s, 2H, CH_2), 1.22 (s, 3H, CH_3), 1.19 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 195.3, 177.1, 149.4, 149.1, 140.1, 138.7, 131.4, 128.6, 127.5, 125.8, 116.2, 94.6, 55.8, 52.9, 39.4, 35.9, 30.5, 30.2, 22.7. MS(ESI-): m/z = 376.71. IR (KBr): 3432(w), 2961(m), 1642(vs), 1603(m), 1517(s), 1394(s), 1345(s), 1289(w), 1218(m), 1189(w), 1156(w), 1113(w), 1044(m), 963(m), 849(m), 735(w), 696(vw) cm^{-1}. Anal Calcd for $C_{23}H_{23}NO_4$: C 73.19, H 6.14, N 3.71; Found: C 72.86, H 6.35, N 3.42.



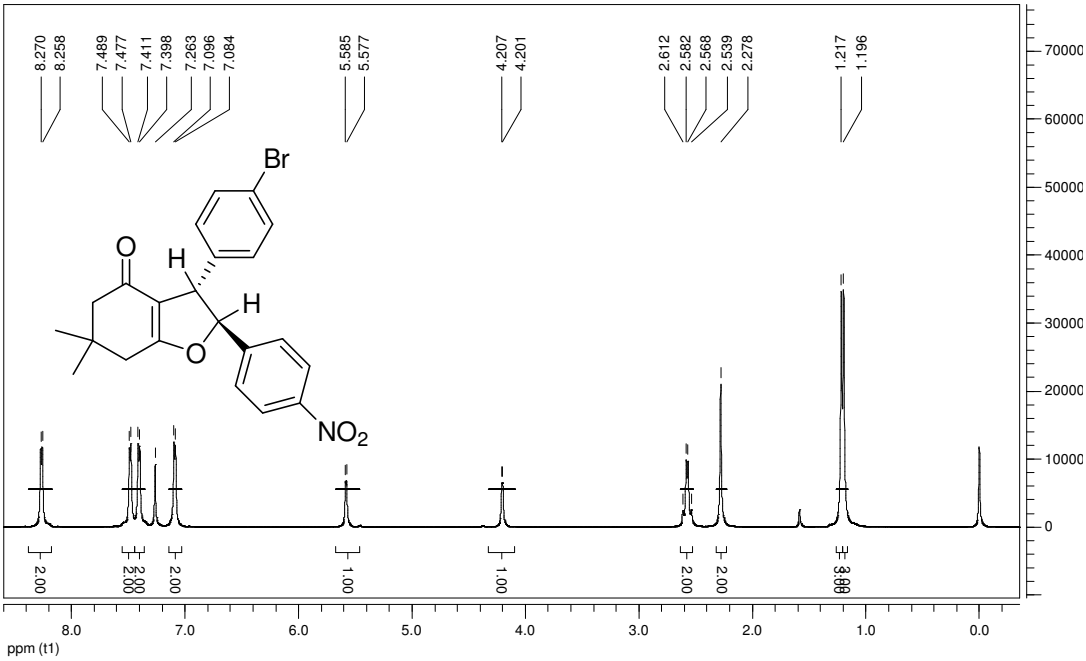


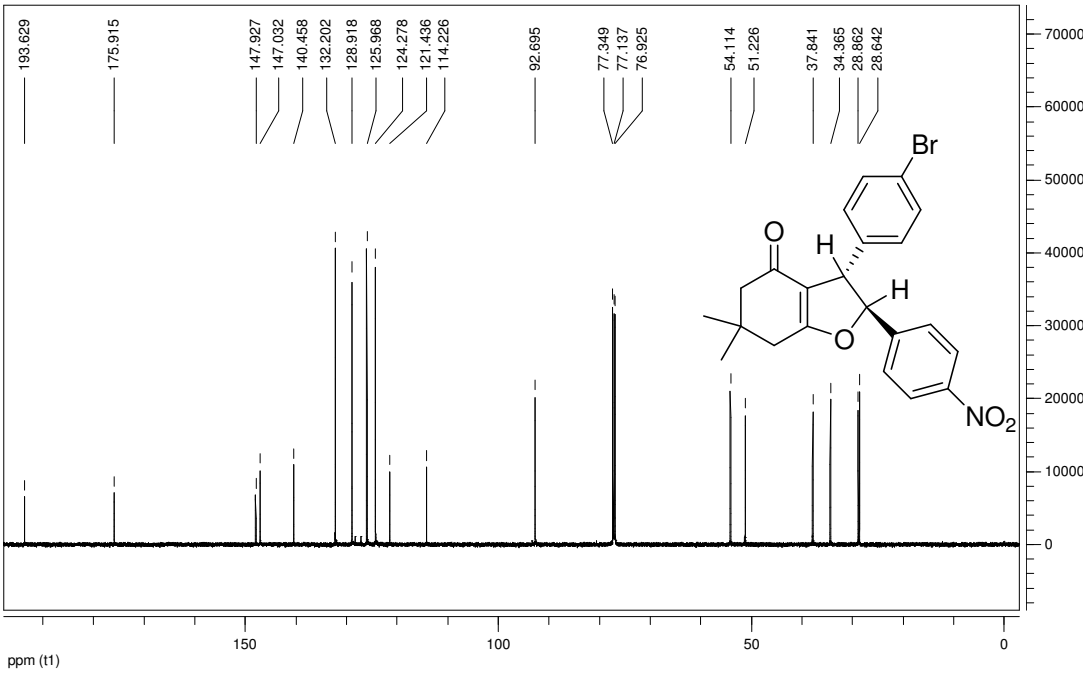
6,6-Dimethyl-2-(*p*-nitrophenyl)-3-*p*-methoxyphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (**1i**): yield: 61%. m.p. 136-138°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.26 (d, *J* = 9.0Hz, 2H, *p*-$NO_2C_6H_4$), 7.42 (d, *J* = 9.0Hz, 2H, *p*-$NO_2C_6H_4$), 7.13 (d, *J* = 9.0Hz, 2H, *p*-$CH_3OC_6H_4$), 6.89 (d, *J* = 8.4Hz, 2H, *p*-$CH_3OC_6H_4$), 5.59 (d, *J* = 6.0Hz, 1H, CH), 4.20 (d, *J* = 6.0Hz, 1H, CH), 3.80 (s, 3H, CH_3O), 2.61-2.53 (m, 2H, CH_2), 2.28 (s, 2H, CH_2), 1.22 (s, 3H, CH_3), 1.19 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.8, 175.5, 158.9, 147.8, 147.5, 133.5, 128.1, 125.9, 124.2, 114.7, 114.5, 93.1, 55.3, 53.9, 51.3, 37.9, 34.3, 28.9, 28.6. MS(ESI-): m/z = 393.02. IR (KBr): 3448(w), 2961(w), 1638(vs), 1605(m), 1515(vs), 1460(w), 1395(s), 1347(s), 1305(w), 1253(s), 1218(m), 1182(m), 1147(w), 1112(w), 1037(w), 958(m), 847(m), 744(m) cm^{-1}. Anal Calcd for $C_{23}H_{23}NO_5$: C 70.21, H 5.89, N 3.56; Found: C 70.06, H 5.62, N 3.28.



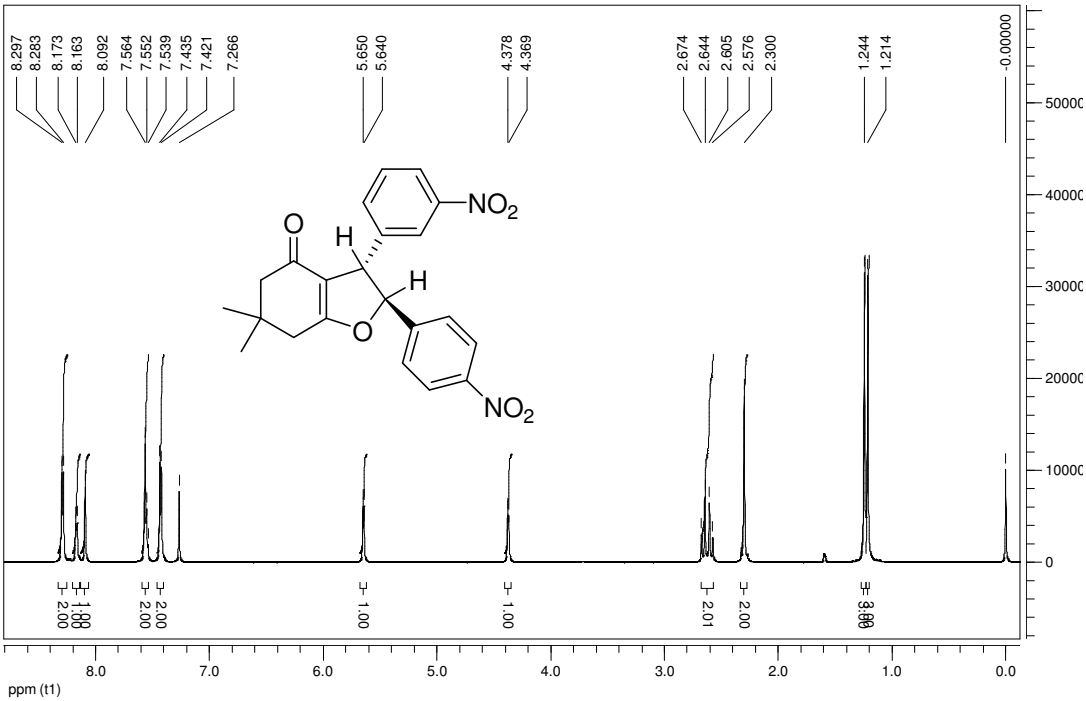


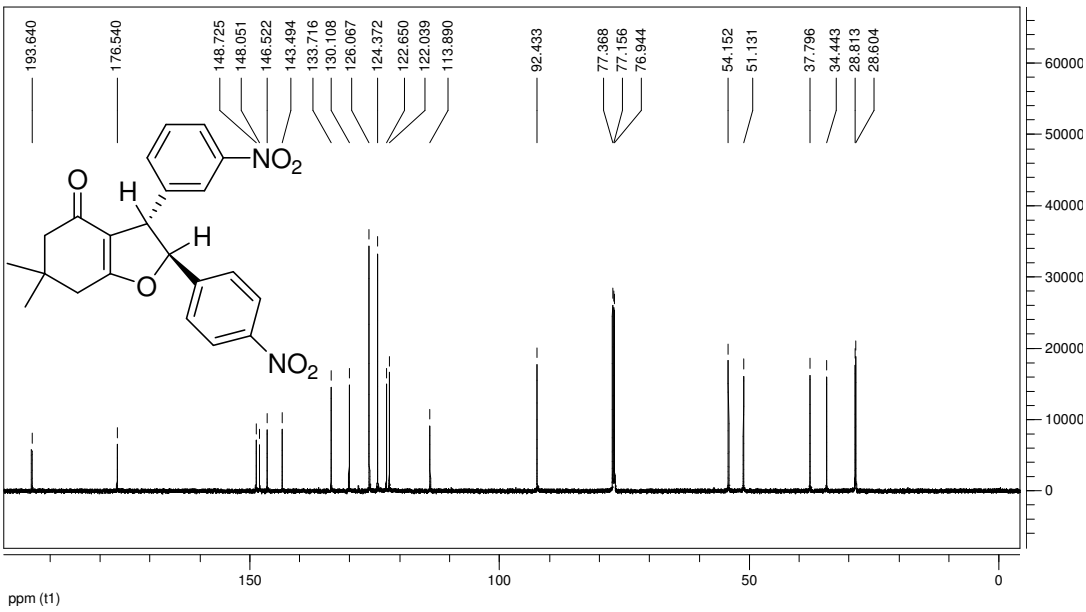
6,6-Dimethyl-2-(*p*-nitrophenyl)-3-*p*-bromophenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1j): yield: 77%. m.p. 146-148°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.26 (d, *J* = 7.2Hz, 2H, *p*-$NO_2C_6H_4$), 7.48 (d, *J* = 7.2Hz, 2H, *p*-$NO_2C_6H_4$), 7.41 (d, *J* = 7.8Hz, 2H, *p*-BrC_6H_4), 7.09 (d, *J* = 7.2Hz, 2H, *p*-BrC_6H_4), 5.58 (d, *J* = 4.8Hz, 1H, CH), 4.20 (d, *J* = 3.6Hz, 1H, CH), 2.61-2.54 (m, 2H, CH_2), 2.28 (s, 2H, CH_2), 1.22 (s, 3H, CH_3), 1.20 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.6, 175.9, 147.9, 147.0, 140.5, 132.2, 128.9, 126.0, 124.3, 121.4, 114.2, 92.7, 54.1, 51.2, 37.8, 34.4, 28.9, 28.6. MS(ESI-): m/z = 442.30. IR (KBr): 3444(w), 2962(m), 1641(vs), 1603(m), 1519(s), 1487(m), 1392(m), 1346(s), 1218(m), 1186(w), 1108(w), 1045(w), 1010(w), 964(m), 849(m), 730(w), 699(w) cm^{-1}. Anal Calcd for $C_{22}H_{20}BrNO_4$: C 59.74, H 4.56, N 3.17; Found: C 59.72, H 4.83, N 3.40.



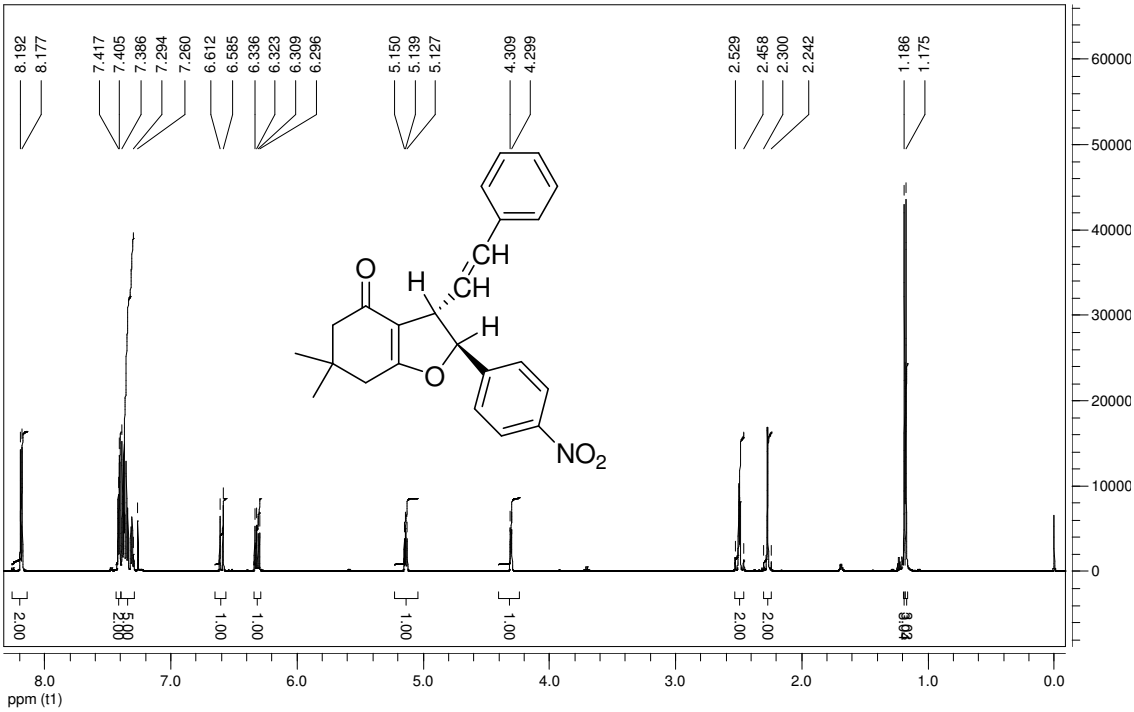


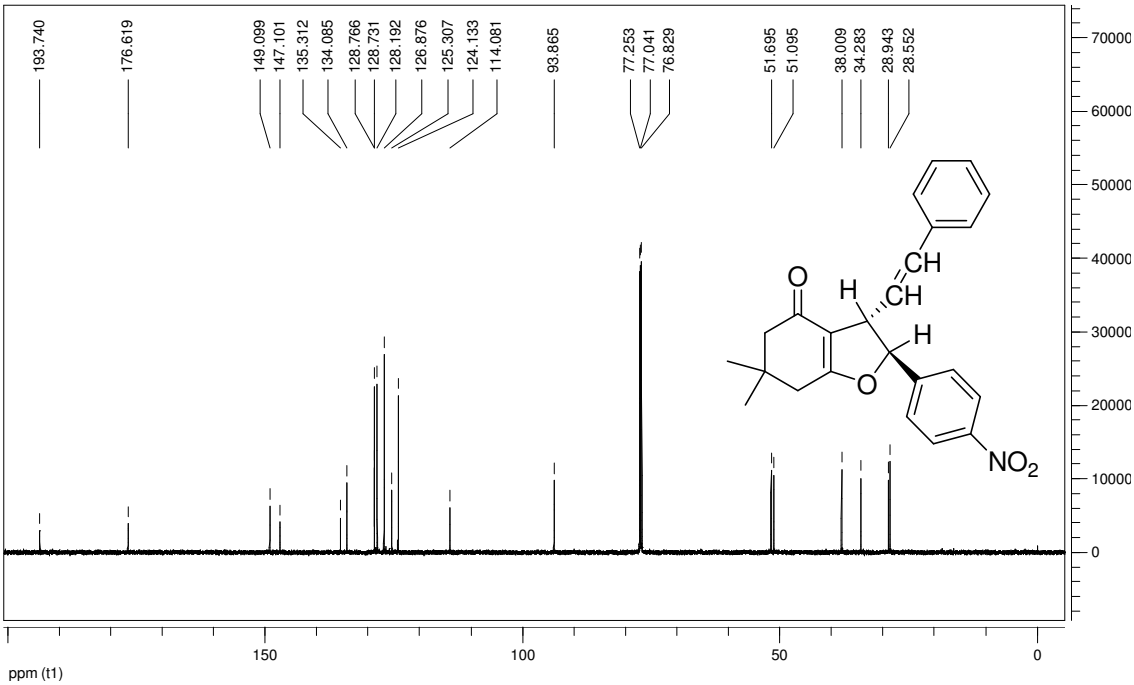
6,6-Dimethyl-2-(*p*-nitrophenyl)-3-*m*-nitrophenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1k): yield: 86%. m.p. 166-168°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.29 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 8.17 (d, *J* = 6.0Hz, 1H, *m*-$NO_2C_6H_4$), 8.09 (s, 1H, *m*-$NO_2C_6H_4$), 7.55 (t, *J* = 7.2Hz, 2H, *m*-$NO_2C_6H_4$), 7.43 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 5.65 (d, *J* = 6.0Hz, 1H, CH), 4.37 (d, *J* = 5.4Hz, 1H, CH), 2.67-2.58 (m, 2H, CH_2), 2.30 (s, 2H, CH_2), 1.24 (s, 3H, CH_3), 1.21 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.6, 176.5, 148.7, 148.1, 146.5, 143.5, 133.7, 130.1, 126.1, 124.4, 122.7, 122.0, 113.9, 92.4, 54.2, 51.1, 37.8, 34.4, 28.8, 28.6. MS(ESI-): m/z = 407.58. IR (KBr): 3444(w), 3082(w), 2957(w), 1636(vs), 1526(vs), 1400(s), 1348(vs), 1216(s), 1143(w), 1101(w), 1036(w), 959(m), 897(vw), 843(m), 809(w), 732(m), 687(w) cm^{-1}. Anal Calcd for $C_{22}H_{20}N_2O_6$: C 64.70, H 4.94, N 6.86; Found: C 64.61, H 5.23, N 6.55.





6,6-Dimethyl-2-(*p*-nitrophenyl)-3-phenylvinyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (1l): yield: 78%. m.p. 160°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.19 (d, *J* = 9.0Hz, 2H, *p*-$NO_2C_6H_4$), 7.41 (d, *J* = 7.2Hz, 2H, *p*-$NO_2C_6H_4$), 7.39-7.29 (m, 5H, C_6H_5), 6.60 (d, *J* = 16.2Hz, 1H, CH=), 6.34-6.30 (m, 1H, CH=), 5.13 (t, *J* = 7.2Hz, 1H, CH), 4.30 (d, *J* = 6.0Hz, 1H, CH), 2.53-2.46 (m, 2H, CH_2), 2.30-2.24 (m, 2H, CH_2), 1.19 (s, 3H, CH_3), 1.18 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.7, 176.6, 149.1, 147.1, 135.3, 134.1, 128.8, 128.7, 128.2, 126.9, 125.3, 124.1, 114.1, 93.9, 51.7, 51.1, 38.0, 34.3, 28.9, 28.6. MS(ESI-): m/z = 388.52. IR (KBr): 3445(w), 3076(w), 2955(m), 2871(w), 1638(s), 1514(s), 1392(s), 1344(s), 1214(s), 1154(w), 1111(w), 1037(m), 979(m), 926(w), 848(w), 749(m), 696(m) cm^{-1}. Anal Calcd for $C_{24}H_{23}NO_4$: C 74.02, H 5.95, N 3.60; Found: C 73.85, H 6.27, N 3.51.

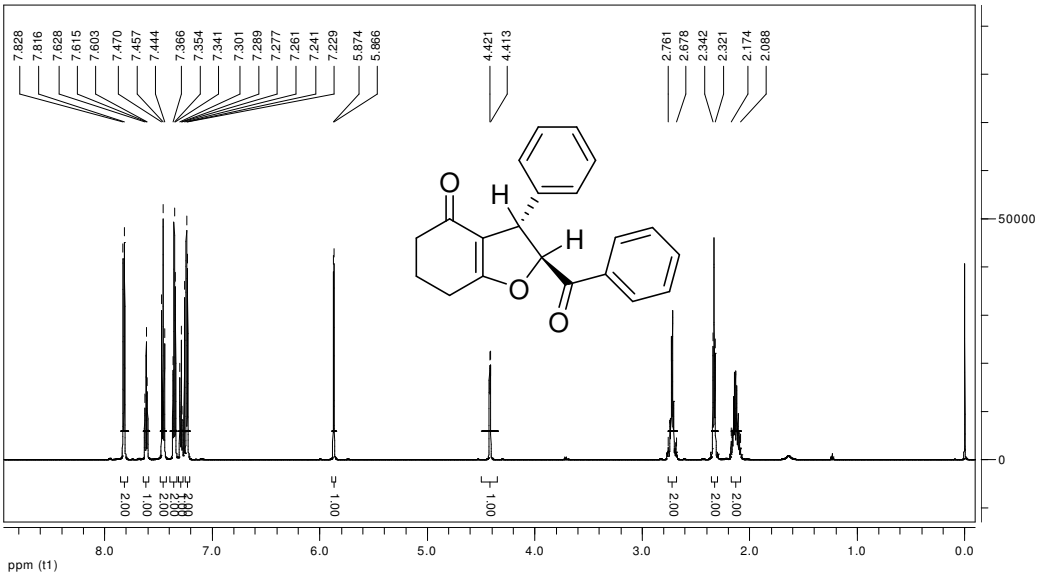


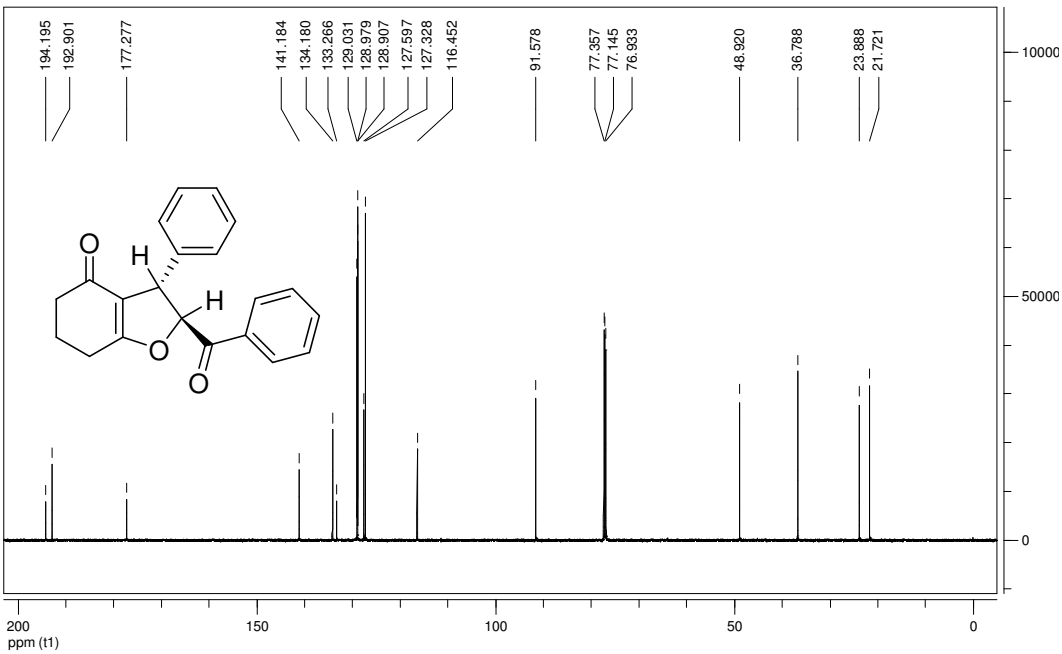


Procedure for the preparation 2-benzoyl-3-aryl-3,5,6,7-tetrahedro-2H-benzofuran-4-ones 2a-2h

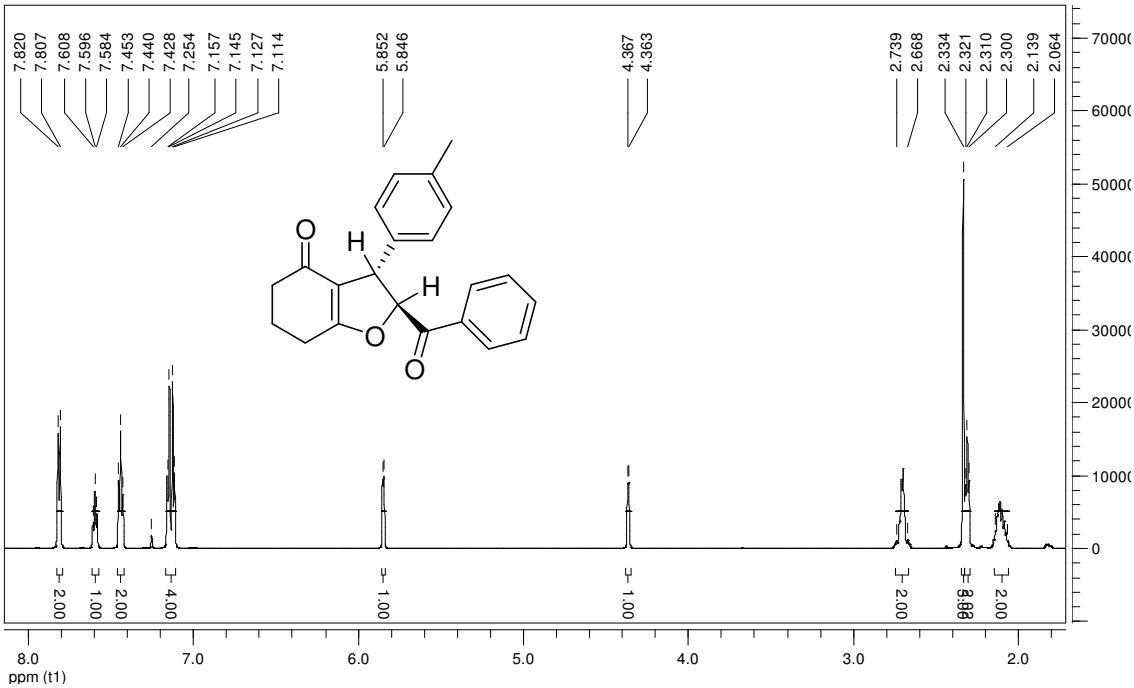
A mixture of aromatic aldehyde (2.0 mmol), 1,3-cyclohexanedione (2.0 mmol), phenacyl bromide (2.1 mmol), pyridine (5.0 mmol) in acetonitrile (10 mL) was refluxed for two hours. Subsequently triethylamine (5.0 mmol) was added to the mixture. The resulting mixture was refluxed about 12 hours. Recrystallization from ethanol gave pure products **2a-2h.**

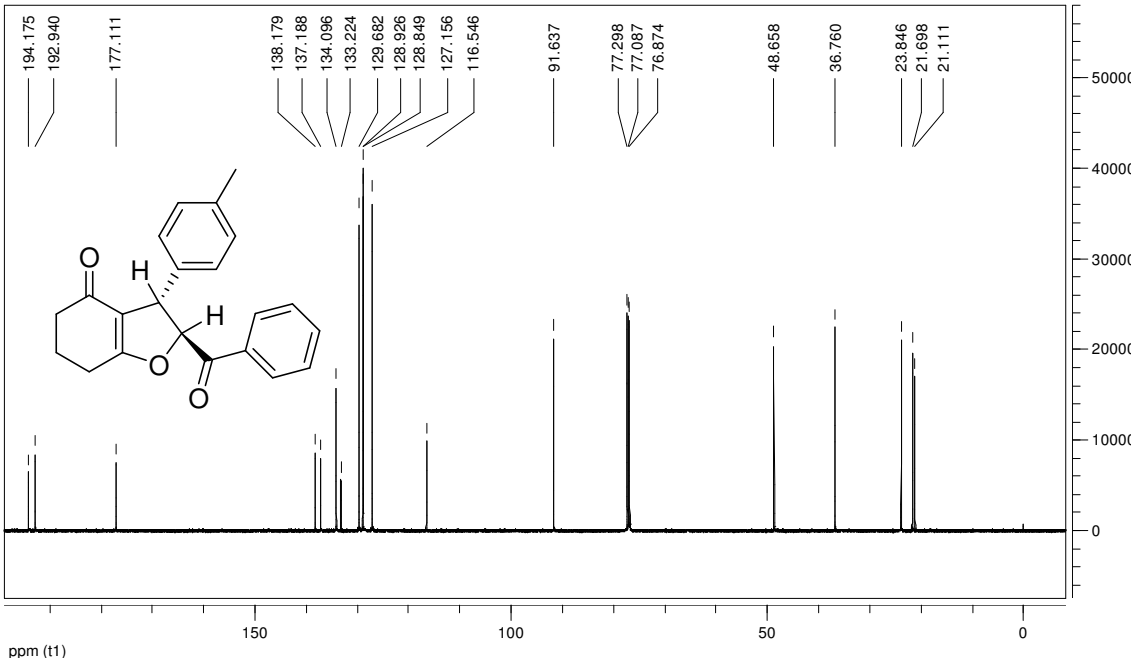
2-Benzoyl-3-phenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2a): yield: 66%. m.p. 128-130°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.82 (d, *J* = 7.2Hz, 2H, C_6H_5), 7.62 (t, *J* = 7.8Hz, 1H, C_6H_5), 7.46 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.35 (t, *J* = 7.2Hz, 2H, C_6H_5), 7.29 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.24 (d, *J* = 7.2Hz, 2H, C_6H_5), 5.87 (d, *J* = 4.8Hz, 1H, CH), 4.42 (d, *J* = 4.8Hz, 1H, CH), 2.76-2.68 (m, 2H, CH_2), 2.34-2.32 (m, 2H, CH_2), 2.17-2.09 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.2, 192.9, 177.3, 141.2, 134.2, 133.3, 129.0, 128.9, 127.6, 127.3, 116.5, 91.6, 48.9, 36.8, 23.9, 21.7. MS(ESI-): m/z = 317.64. IR (KBr): 3443(w), 3058(w), 2974(w), 1701(s), 1639(vs), 1493(w), 1450(m), 1394(s), 1228(s), 1178(s), 1108(m), 1061(m), 1022(m), 961(s), 873(m), 777(m), 747(w), 698(s) cm^{-1}. Anal Calcd for $C_{21}H_{18}O_3$: C 79.22, H 5.70; Found: C 79.50, H 5.93.



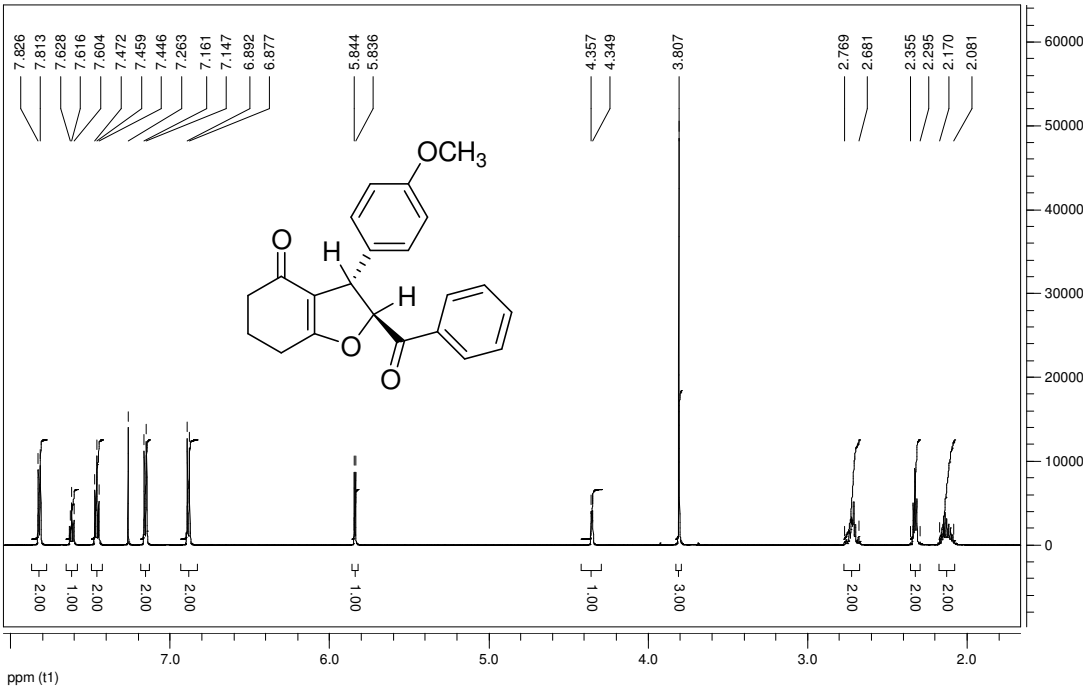


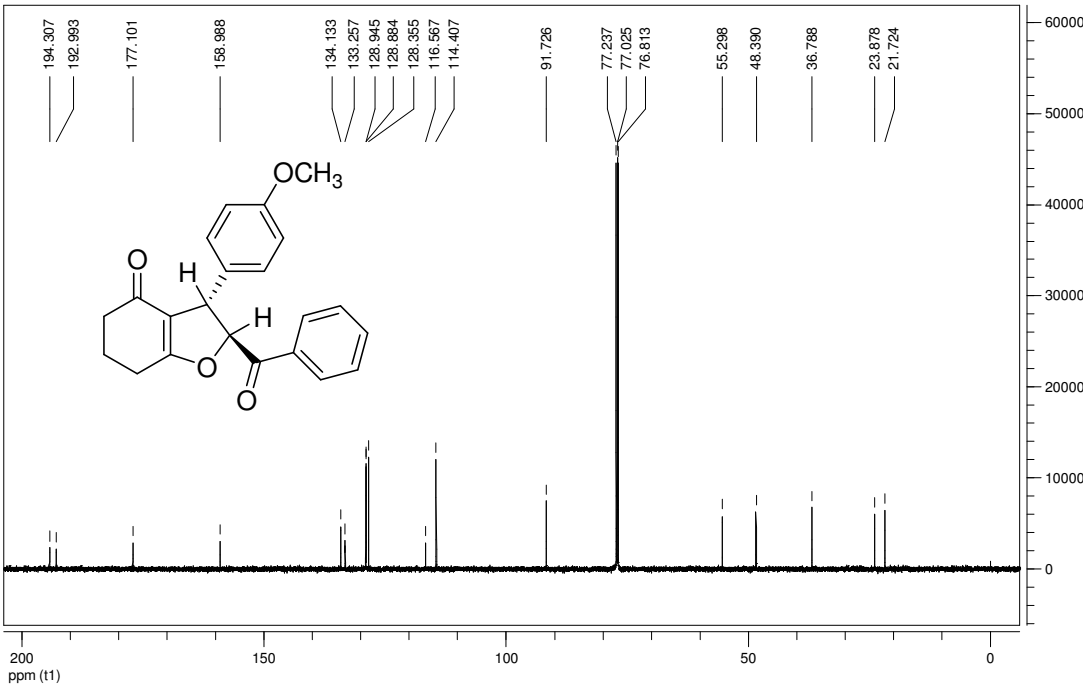
2-Benzoyl-3-*p*-methylphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2b): yield: 50%. m.p. 94°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.81 (d, *J* = 7.8Hz, 2H, C_6H_5), 7.60 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.44 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.14 (ABq, *J* = 7.2Hz, 4H, *p*-$CH_3C_6H_4$), 5.85 (d, *J* = 3.6Hz, 1H, CH), 4.36 (d, *J* = 2.4Hz, 1H, CH), 2.74-2.67 (m, 2H, CH_2), 2.33 (s, 3H, CH_3), 2.31 (t, *J* = 6.6Hz, 2H, CH_3), 2.14-2.06 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.2, 192.9, 177.1, 138.2, 137.2, 134.1, 133.2, 129.7, 128.9, 128.8, 127.2, 116.5, 91.6, 48.7, 36.8, 23.8, 21.7, 21.1. MS(ESI-): m/z = 332.03. IR (KBr): 3442(w), 2943(m), 1698(s), 1636(vs), 1512(w), 1449(m), 1396(s), 1228(s), 1176(m), 1143(w), 1108(w), 1056(w), 1007(m), 957(s), 893(w), 831(w), 786(m), 690(m) cm^{-1}. Anal Calcd for $C_{22}H_{20}O_3$: C 79.50, H 6.06; Found: C 79.22, H 6.45.



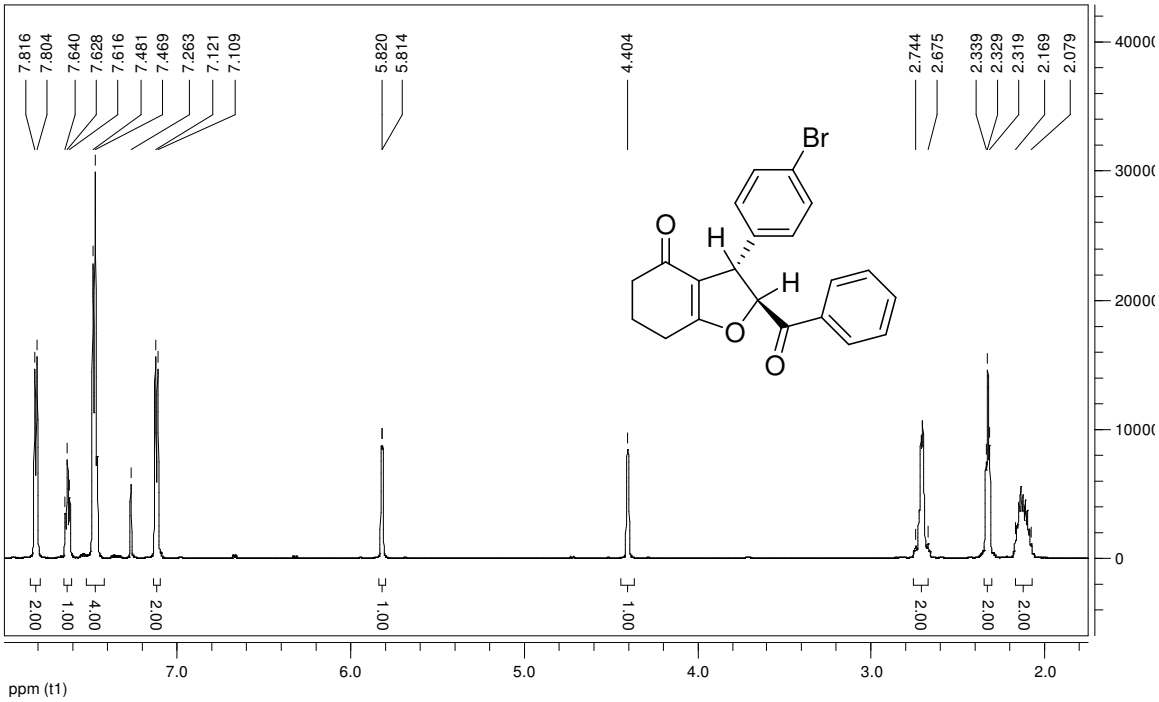


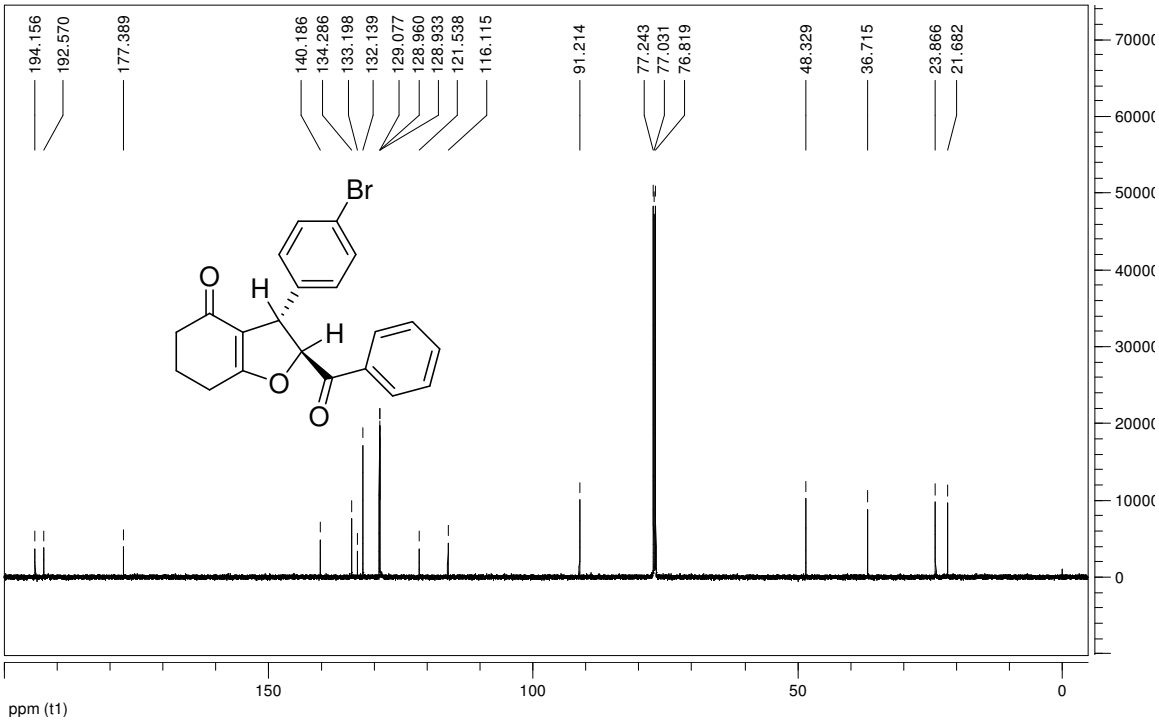
2-Benzoyl-3-*p*-methoxyphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2c): yield: 47%. m.p. 118°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.82 (d, *J* = 7.8Hz, 2H, C_6H_5), 7.62 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.46 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.15 (d, *J* = 8.4Hz, 2H, *p*-$CH_3OC_6H_4$), 6.88 (d, *J* = 8.4Hz, 2H, *p*-$CH_3OC_6H_4$), 5.84 (d, *J* = 4.8Hz, 1H, CH), 4.35 (d, *J* = 4.8Hz, 1H, CH), 3.81 (s, 3H, CH_3), 2.77-2.68 (m, 2H, CH_2), 2.36-2.30 (m, 2H, CH_2), 2.17-2.08 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.3, 193.0, 177.1, 159.0, 134.1, 133.3, 128.9, 128.4, 116.6, 114.4, 91.7, 55.3, 48.4, 36.8, 23.9, 21.7. MS(ESI-): m/z = 347.80. IR (KBr): 3449(w), 2953(w), 1694(m), 1633(vs), 1512(m), 1450(w), 1392(s), 1306(w), 1251(m), 1225(m), 1175(m), 1114(w), 1056(w), 1025(m), 960(m), 876(w), 837(w), 791(w), 765(w) cm^{-1}. Anal Calcd for $C_{22}H_{20}O_4$: C 75.84, H 5.79; Found: C 75.47, H 5.82.



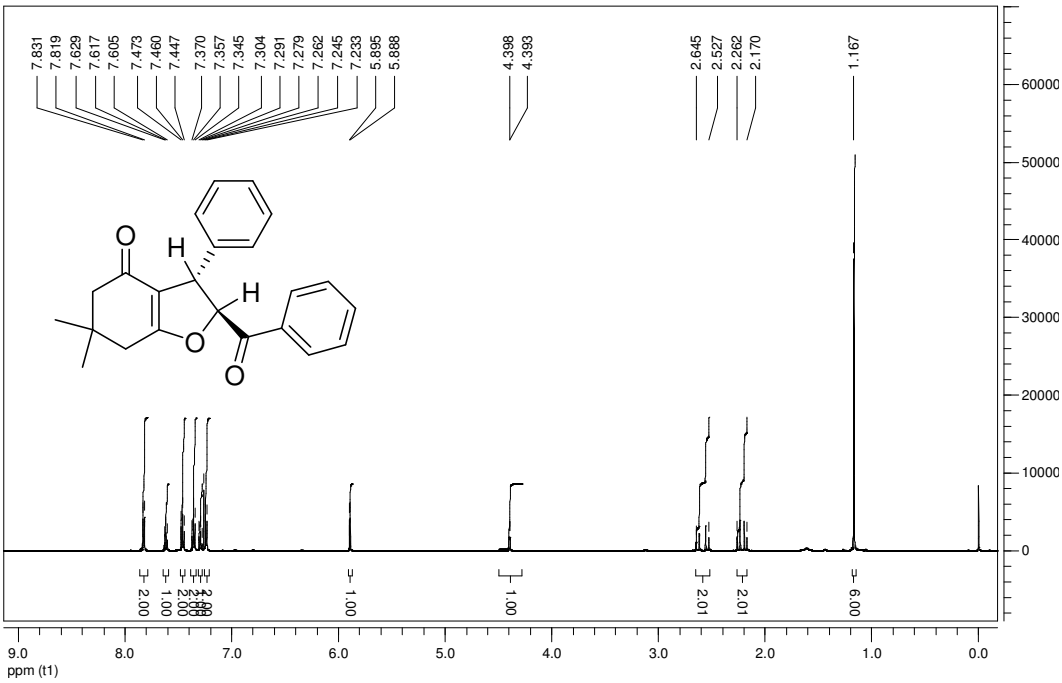


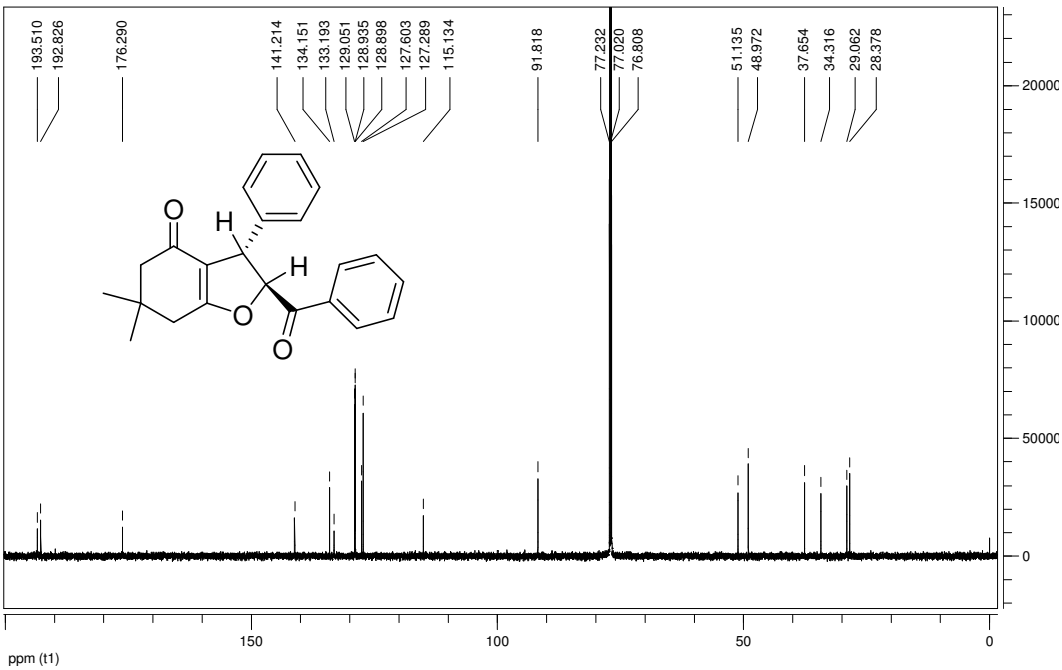
2-Benzoyl-3-*p*-bromophenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2d): yield: 46%. m.p. 112-114°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.87 (d, J = 7.2Hz, 2H, C_6H_5), 7.62 (t, J = 7.2Hz, 1H, C_6H_5), 7.48 (d, J = 7.2Hz, 4H, C_6H_5, p-BrC_6H_4), 7.12 (d, J = 7.2Hz, 2H, p-BrC_6H_4), 5.82 (d, J = 3.6Hz, 1H, CH), 4.40 (s, 1H, CH), 2.74-2.68 (m, 2H, CH_2), 2.33 (t, J = 6.0Hz, 2H, CH_2), 2.17-2.08 (m, 2H, CH_2). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 194.2, 192.6, 177.4, 140.2, 134.3, 133.2, 132.1, 129.1, 129.0, 128.9, 121.5, 116.1, 91.2, 48.3, 36.7, 23.9, 21.7. MS(ESI-): m/z = 395.91. IR (KBr): 3441(w), 2941(w), 1701(s), 1634(vs), 1487(w), 1451(w), 1395(s), 1228(s), 1176(m), 1138(w), 1111(w), 1067(w), 1010(m), 957(m), 873(w), 811(w), 775(w), 694(m) cm^{-1}. Anal Calcd for $C_{21}H_{17}BrO_3$: C 63.49, H 4.31; Found: C 63.29, H 4.66.



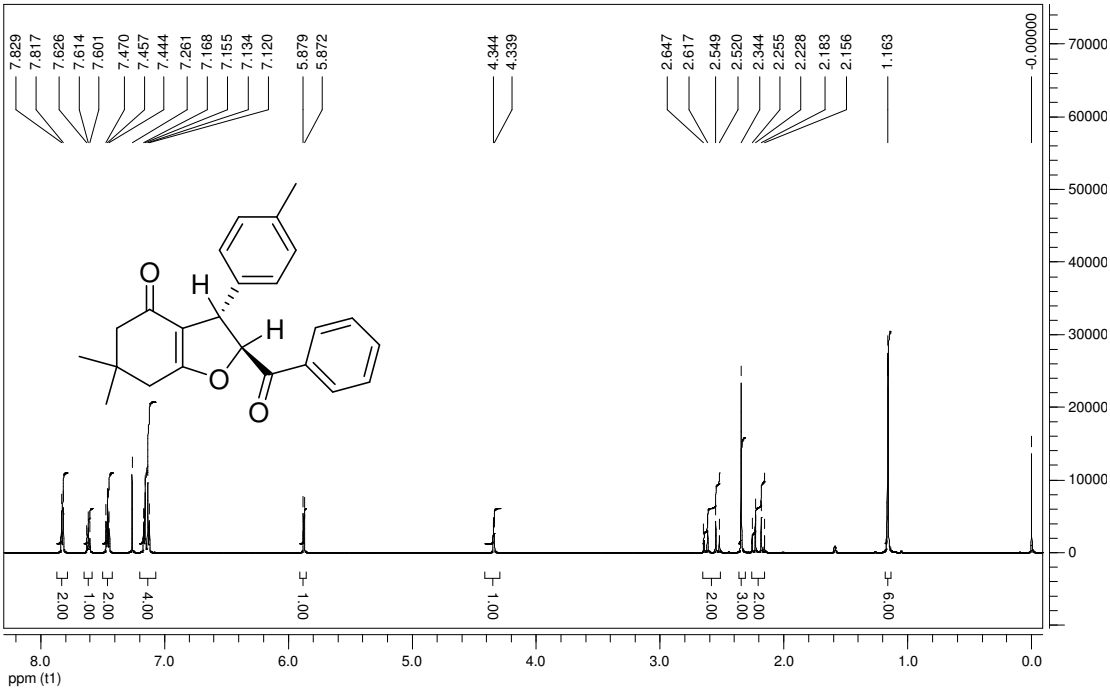


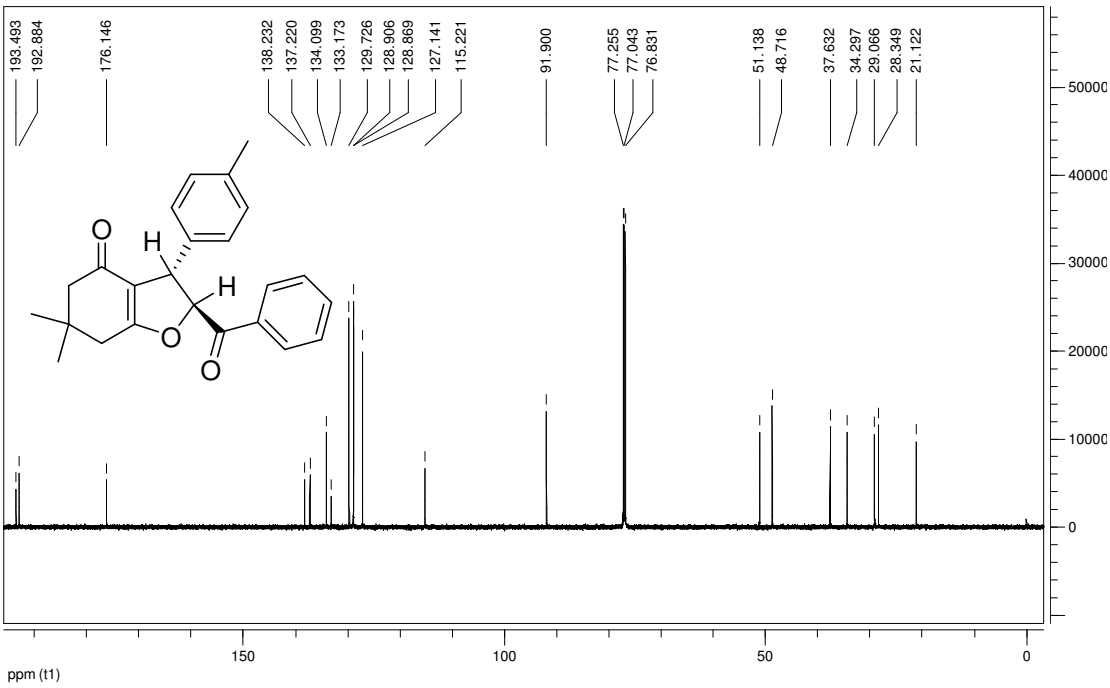
6,6-Dimethyl-2-benzoyl-3-phenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2e): yield: 63%. m.p. 120°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.81 (d, *J* = 7.2Hz, 2H, C_6H_5), 7.62 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.46 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.36 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.29 (t, *J* = 7.8Hz, 1H, C_6H_5), 7.24 (d, *J* = 7.2Hz, 2H, C_6H_5), 5.89 (d, *J* = 4.2Hz, 1H, CH), 4.39 (d, *J* = 3.0Hz, 1H, CH), 2.65-2.53 (m, 2H, CH_2), 2.26-2.17 (m, 2H, CH_2), 1.17 (s, 6H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.5, 192.8, 176.3, 141.2, 134.2, 133.2, 129.1, 128.9, 127.6, 127.3, 115.1, 91.8, 51.1, 49.0, 37.7, 34.3, 29.1, 28.4. MS(ESI-): m/z = 345.61. IR (KBr): 3448(w), 3027(vw), 2965(w), 2874(w), 1694(m), 1632(vs), 1493(w), 1450(w), 1394(s), 1296(w), 1223(s), 1091(w), 1036(w), 958(m), 879(w), 822(vw), 769(w), 726(w), 694(m) cm^{-1}. Anal Calcd for $C_{23}H_{22}O_3$: C 79.74, H 6.40; Found: C 79.65, H 6.62.



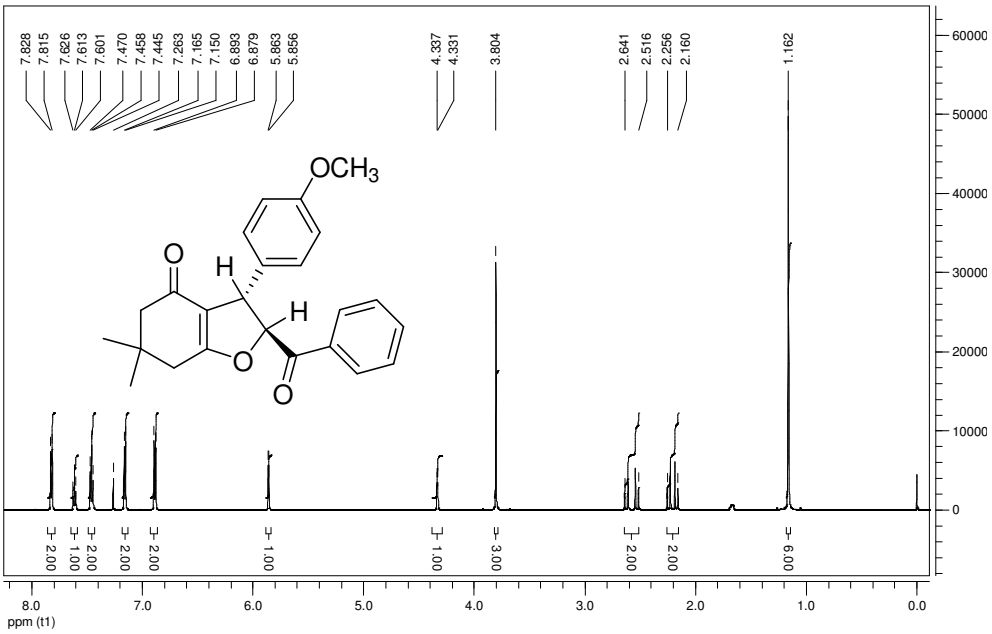


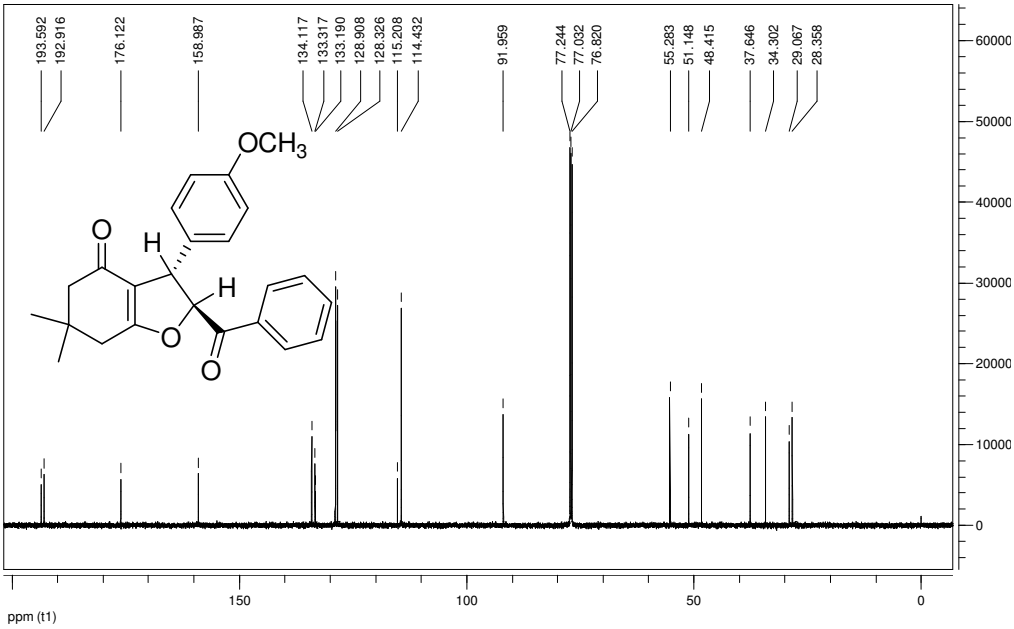
6,6-Dimethyl-2-benzoyl-3-*p*-methylphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2f): yield: 71%. m.p. 155°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.82 (d, *J* = 7.2Hz, 2H, C_6H_5), 7.61 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.46 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.17-7.12 (m, 4H, *p*-$CH_3C_6H_4$), 5.87 (d, *J* = 4.2Hz, 1H, CH), 4.34 (d, *J* = 3.0Hz, 1H, CH), 2.65-2.52 (m, 2H, CH_2), 2.34 (s, 3H, CH_3), 2.26-2.16 (m, 2H, CH_2), 1.16 (s, 6H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.5, 192.9, 176.1, 138.2, 137.2, 134.1, 133.2, 129.7, 128.9, 127.1, 115.2, 91.9, 51.1, 48.7, 37.6, 34.3, 29.1, 28.3, 21.1. MS(ESI-): m/z = 359.82. IR (KBr): 3438(w), 2961(w), 1694(m), 1631(vs), 1512(w), 1451(w), 1394(m), 1296(w), 1224(m), 1188(w), 1087(w), 1039(w), 960(w), 880(w), 791(w), 738(w) cm^{-1}. Anal Calcd for $C_{24}H_{24}O_3$: C 79.97, H 6.70; Found: C 79.78, H 7.01.



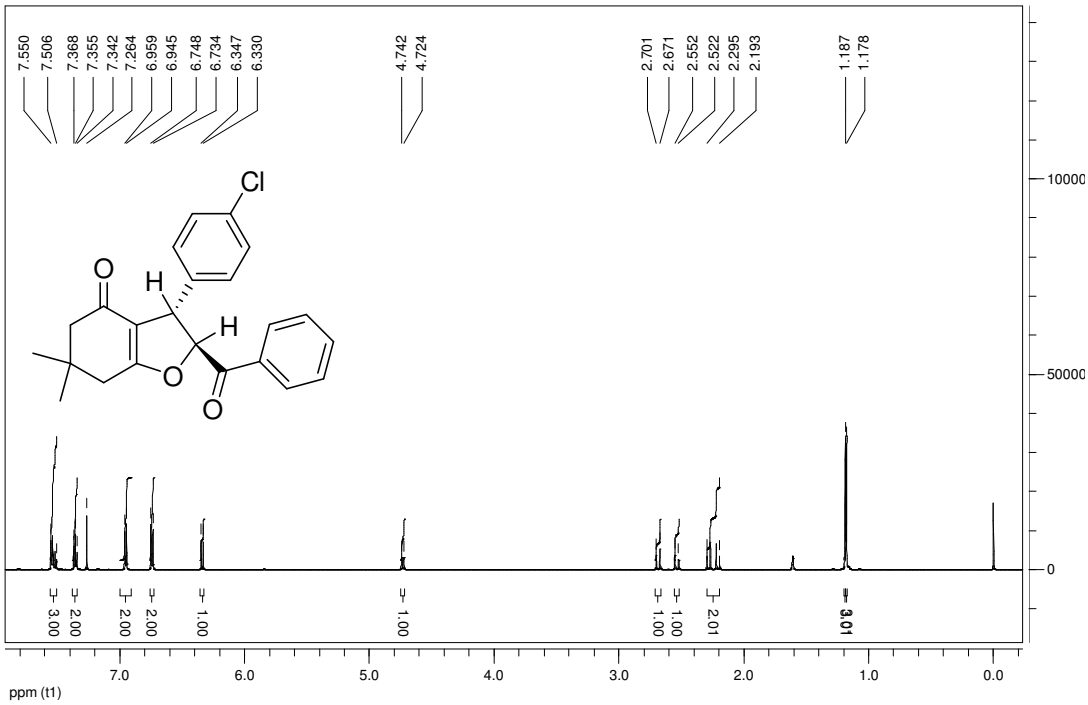


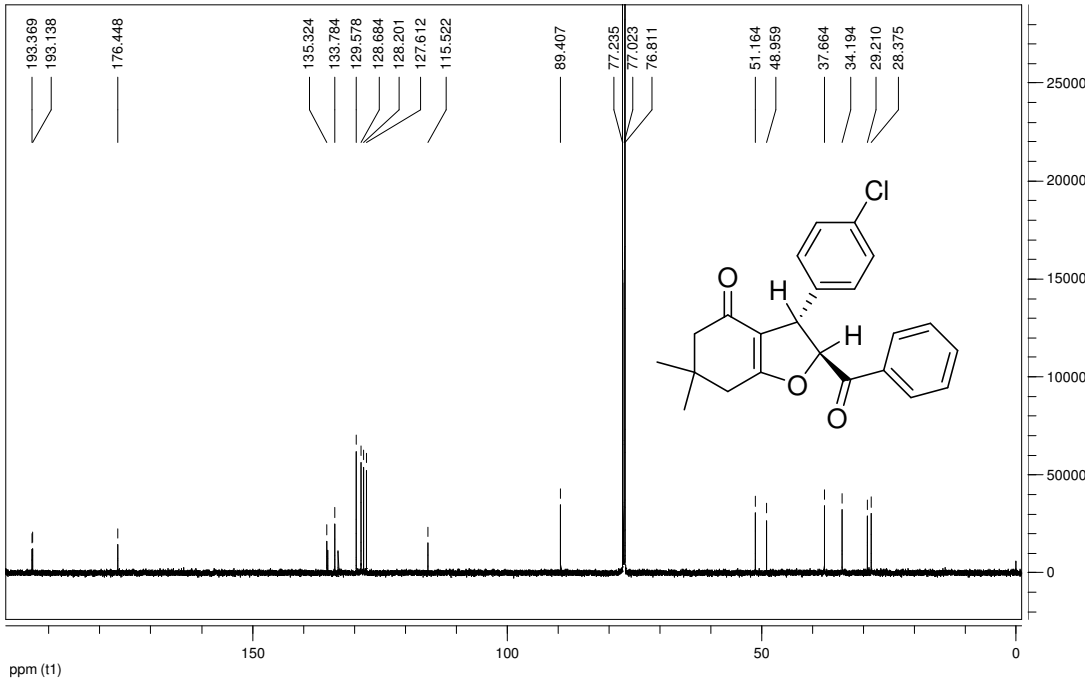
6,6-Dimethyl-2-benzoyl-3-*p*-methoxyphenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2g): Ar = *p*-$CH_3OC_6H_4$, yield: 71%. m.p. 148°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.82 (d, *J* = 7.8Hz, 2H, C_6H_5), 7.61 (t, *J* = 7.8Hz, 1H, C_6H_5), 7.46 (t, *J* = 7.2Hz, 2H, C_6H_5), 7.16 (d, *J* = 8.4Hz, 2H, *p*-$CH_3OC_6H_4$), 6.89 (d, *J* = 8.4Hz, 2H, *p*-$CH_3OC_6H_4$), 5.86 (d, *J* = 4.2Hz, 1H, CH), 4.33 (d, *J* = 3.6Hz, 1H, CH), 3.80 (s, 3H, CH_3O), 2.64-2.52 (m, 2H, CH_2), 2.26-2.16 (m, 2H, CH_2), 1.16 (s, 6H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.6, 192.9, 176.1, 159.0, 134.1, 133.3, 133.2, 128.9, 128.3, 115.2, 114.4, 92.0, 55.3, 51.1, 48.4, 37.6, 34.3, 29.1, 28.4. MS(ESI-): m/z = 375.99. IR (KBr): 3446(w), 3067(w), 3021(w), 2958(m), 2873(w), 1693(s), 1631(s), 1508(s), 1456(m), 1394(s), 1249(s), 1174(s), 1109(w), 1084(w), 1029(s), 960(m), 881(w), 835(w), 792(w), 762(w), 697(m) cm^{-1}. Anal Calcd for $C_{24}H_{24}O_4$: C 76.57, H 6.43; Found: C 76.43, H 6.75.





6,6-Dimethyl-2-benzoyl-3-*p*-chlorophenyl-3,5,6,7-tetrahedro-2H-benzofuran-4-one (2h): yield: 75%. m.p. 164-166°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.55-7.51 (m, 3H, C_6H_5), 7.36 (t, J = 7.8Hz, 2H, C_6H_5), 6.95 (d, J = 8.4Hz, 2H, p-ClC_6H_4), 6.74 (d, J = 8.4Hz, 2H, p-ClC_6H_4), 6.34 (d, J = 10.2Hz, 1H, CH), 4.73 (d, J = 10.8Hz, 1H, CH), 2.70-2.67 (m, 1H, CH_2), 2.55-2.52 (m, 1H, CH_2), 2.30-2.19 (m, 2H, CH_2), 1.19 (s, 3H, CH_3), 1.18 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 193.4, 193.1, 176.4, 135.3, 133.8, 129.6, 128.7, 128.2, 127.6, 115.5, 89.4, 51.2, 49.0, 37.7, 34.2, 29.2, 28.4. MS(ESI-): m/z = 380.08. IR (KBr): 3450(m), 2959(w), 1695(m), 1645(vs), 1450(w), 1393(m), 1283(w), 1213(m), 1165(w), 1108(w), 1086(w), 1037(w), 977(w), 923(w), 879(m), 843(w), 763(w), 691(m) cm^{-1}. Anal Calcd for $C_{23}H_{21}ClO_3$: C 72.53, H 5.56; Found: C 72.36, H 5.82.

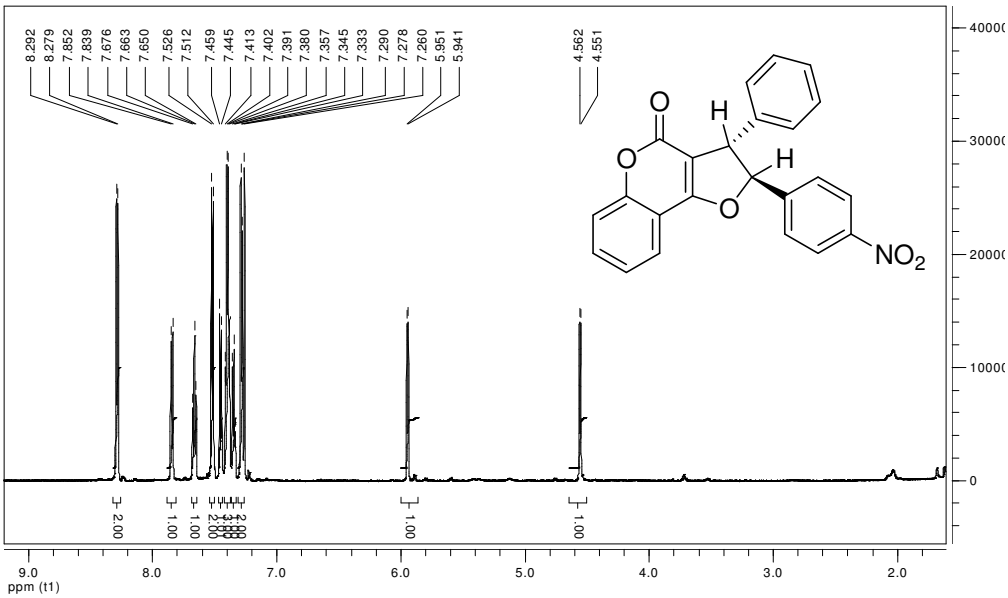


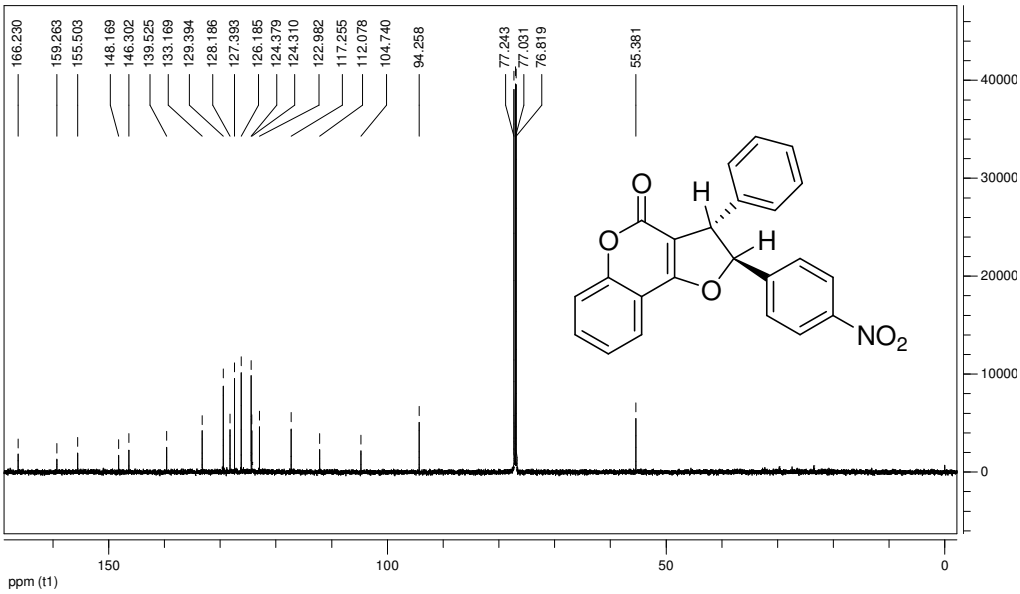


Procedure for the preparation 2-(*p*-nitrophenyl)-3-aryl-2,3-dihydrofuro[3,2-c]chromen-4-ones 3a-3d

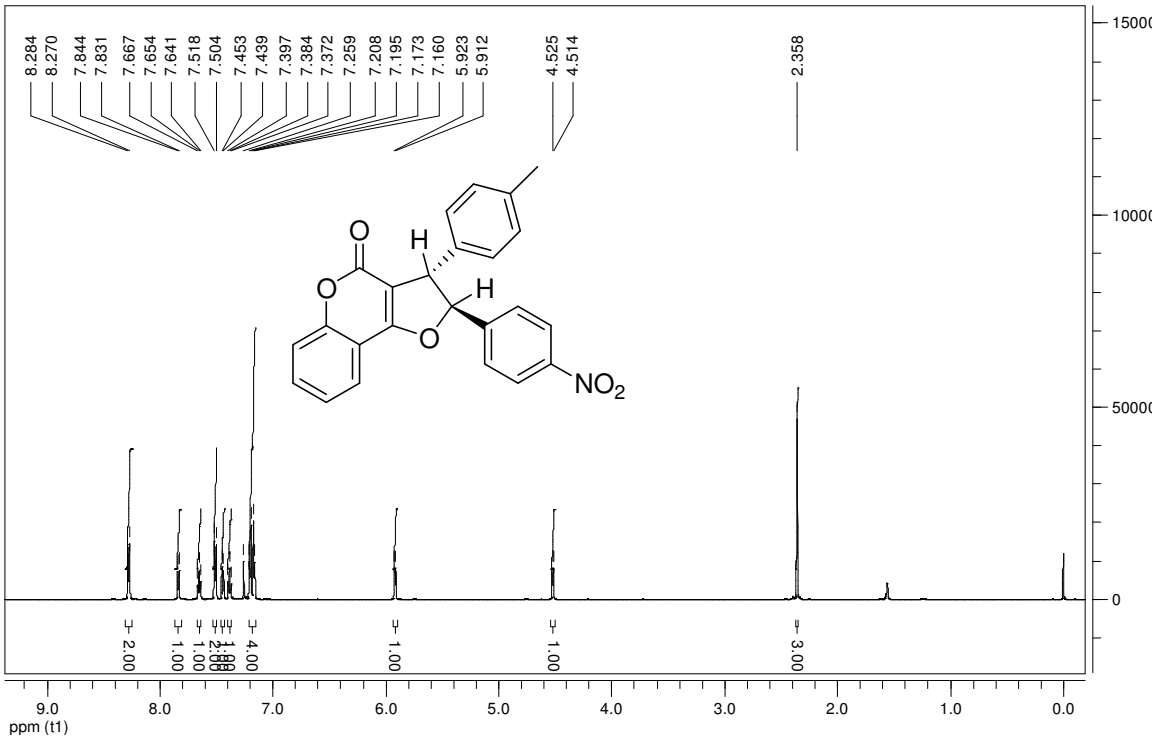
A mixture of aromatic aldehyde (1.0 mmol), 4-hydroxycoumarin (1.0 mmol), *p*-nitrobenzyl bromide (1.05 mmol), pyridine (3.0 mmol) in acetonitrile (10 mL) was refluxed for two hours. Subsequently triethylamine (3.0 mmol) was added to the mixture. The resulting mixture was refluxed about 12 hours. Recrystallization from ethanol gave pure products **3a-3d**.

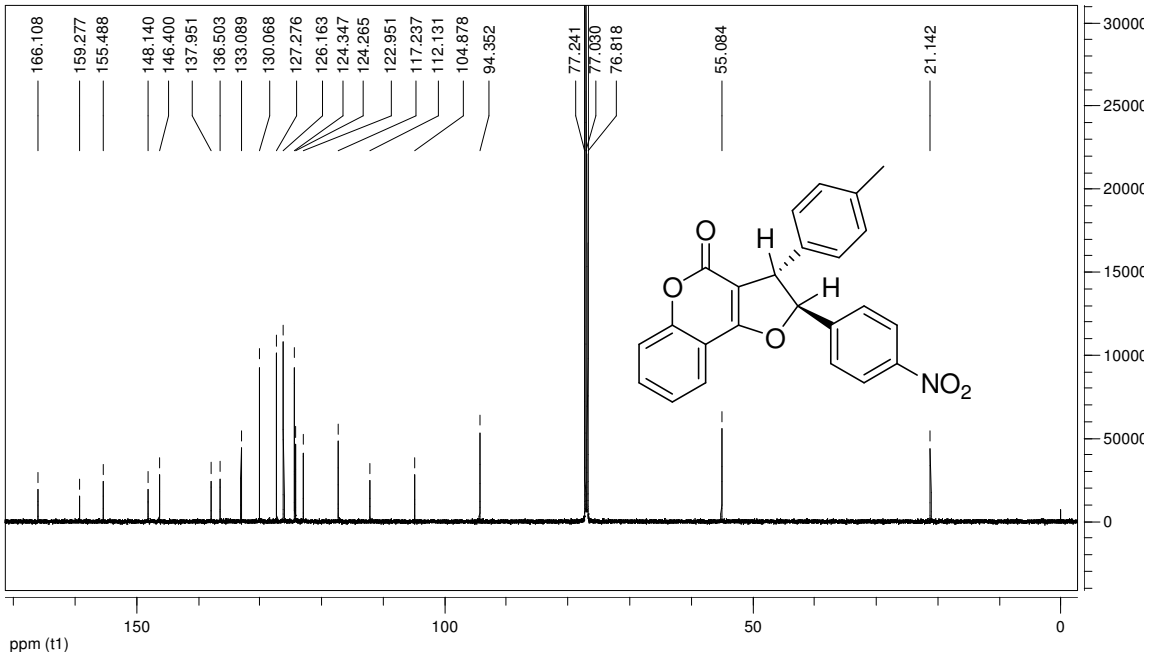
2-(*p*-Nitrophenyl)-3-phenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3a): yield: 62%. m.p. 186-188°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.29 (d, *J* = 7.8Hz, 2H, *p*-$NO_2C_6H_4$), 7.85 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.66 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.52 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.45 (d, *J* = 8.4Hz, 1H, C_6H_4), 7.41-7.38 (m, 3H, C_6H_4, C_6H_5), 7.34 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.28 (d, *J* = 7.2Hz, 2H, C_6H_5), 5.95 (d, *J* = 6.0Hz, 1H, CH), 4.56 (d, *J* = 6.0Hz, 1H, CH). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 166.2, 159.3, 155.5, 148.2, 146.3, 139.5, 133.2, 129.4, 128.2, 127.4, 126.2, 124.4, 124.3, 123.0, 117.3, 112.1, 104.7, 94.3, 55.4. MS(ESI-): m/z = 384.50. IR (KBr): 3434(w), 3073(w), 2922(w), 1723(vs), 1647(s), 1603(m), 1515(s), 1452(w), 1405(m), 1345(s), 1272(w), 1223(w), 1190(w), 1156(w), 1098(m), 1037(m), 970(w), 920(m), 853(w), 764(m) cm^{-1}. Anal Calcd for $C_{23}H_{15}NO_5$: C 71.68, H 3.92, N 3.63; Found: C 71.54, H 4.27, N 3.20.



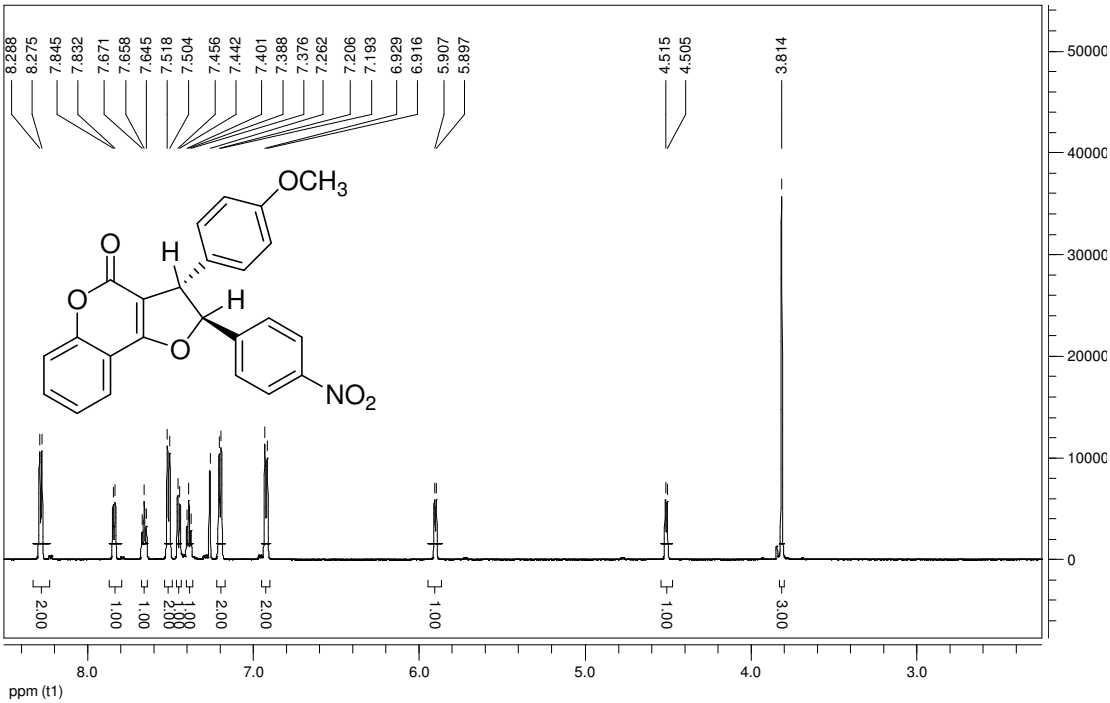


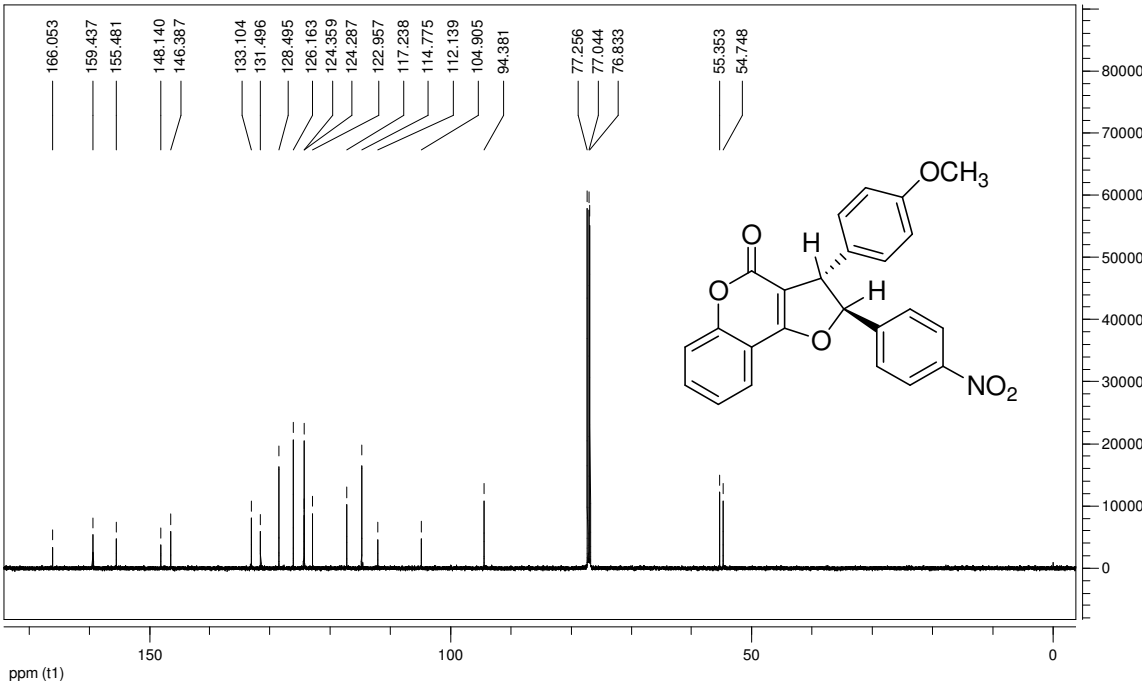
2-(*p*-Nitrophenyl)-3-*p*-methylphenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3b): yield: 56%. m.p. 158-160°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.28 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.84 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.65 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.51 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.45 (d, *J* = 8.4Hz, 1H, C_6H_4), 7.38 (t, *J* = 8.4Hz, 1H, C_6H_4), 7.21-7.16 (m, 4H, *p*-$CH_3C_6H_4$), 5.92 (d, *J* = 6.0Hz, 1H, CH), 4.52 (d, *J* = 6.0Hz, 1H, CH), 2.34 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 166.1, 159.3, 155.5, 148.1, 146.4, 138.0, 136.5, 130.1, 127.3, 126.2, 124.3, 123.0, 117.2, 112.1, 104.9, 94.4, 55.1, 21.1. MS(ESI-): m/z = 399.10. IR (KBr): 3433(w), 3062(w), 1723(vs), 1645(s), 1604(m), 1520(s), 1452(w), 1406(m), 1345(s), 1222(w), 1159(w), 1099(m), 1031(m), 970(w), 916(m), 847(w), 764(m), 720(w) cm^{-1}. Anal Calcd for $C_{24}H_{17}NO_5$: C 72.17, H 4.29, N 3.51; Found: C 71.80, H 4.63, N 3.37.



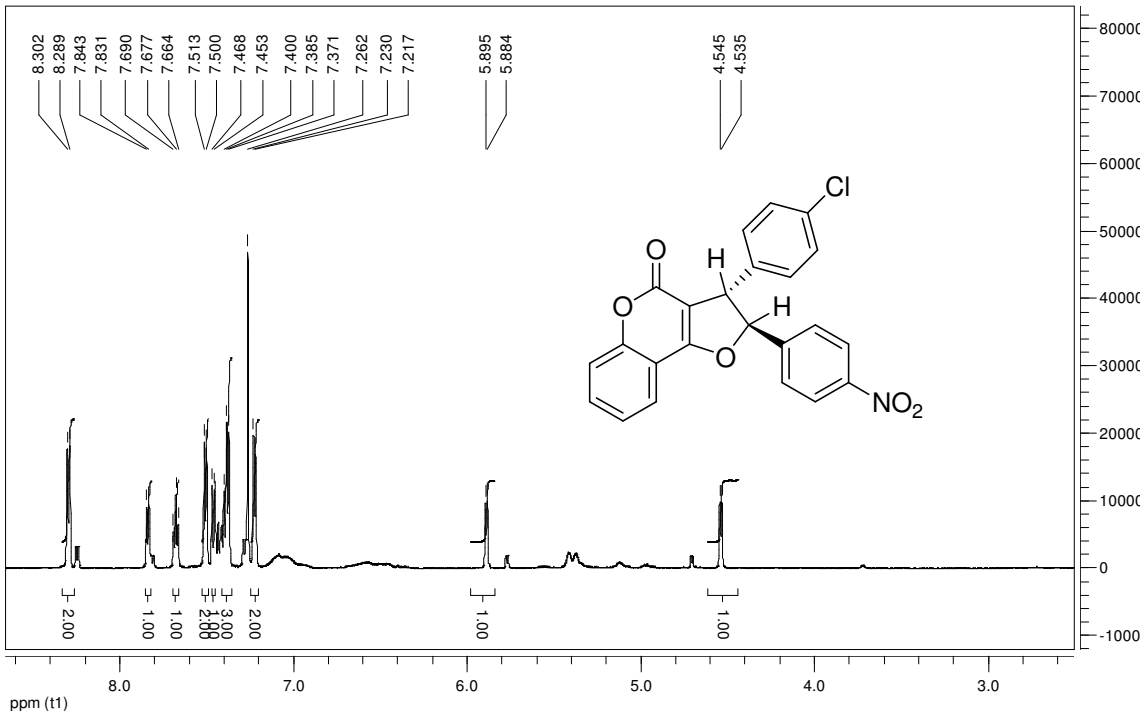


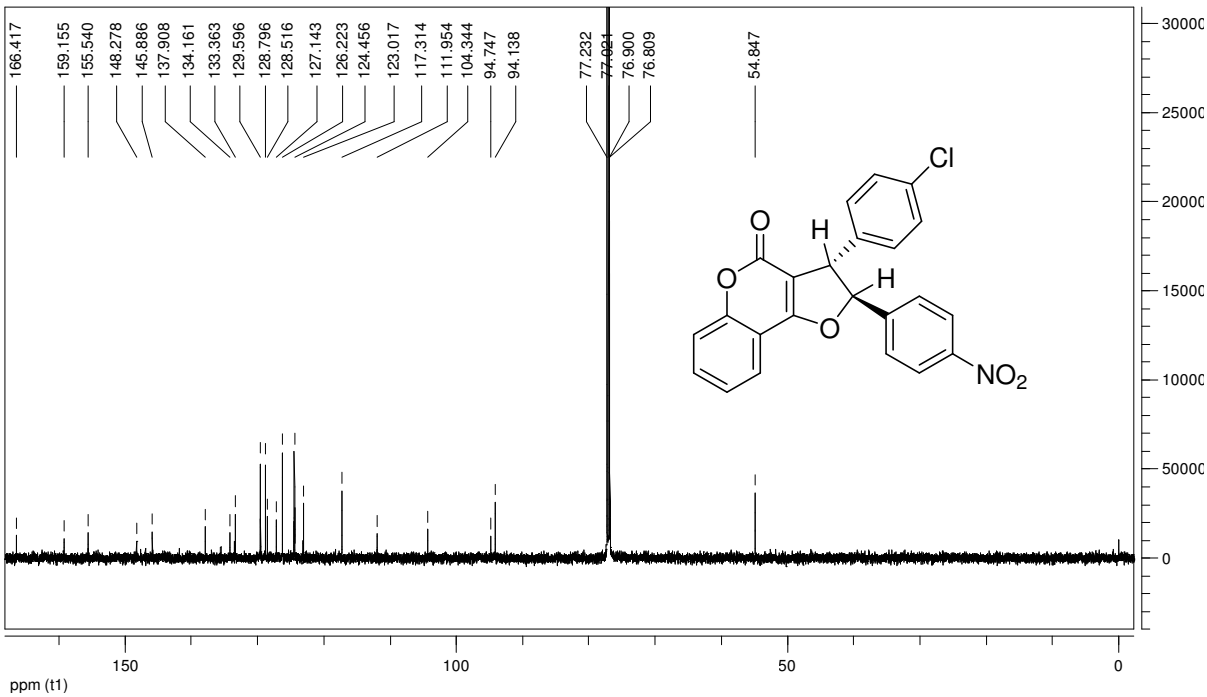
2-(*p*-Nitrophenyl)-3-*p*-methoxyphenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3c): yield: 53%. m.p. 144°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.28 (d, *J* = 7.8Hz, 2H, *p*-$NO_2C_6H_4$), 7.84 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.66 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.51 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.45 (d, *J* = 8.4Hz, 1H, C_6H_4), 7.39 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.20 (d, *J* = 7.8Hz, 2H, *p*-$CH_3OC_6H_4$), 6.92 (d, *J* = 7.8Hz, 2H, *p*-$CH_3OC_6H_4$), 5.90 (d, *J* = 6.0Hz, 1H, CH), 4.51 (d, *J* = 6.0Hz, 1H, CH), 3.81 (s, 3H, CH_3O). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 166.1, 159.4, 155.5, 148.1, 146.4, 133.1, 128.5, 126.2, 124.4, 124.3, 123.0, 117.2, 114.8, 112.1, 104.9, 94.4, 55.4, 54.7. MS(ESI-): m/z = 414.67. IR (KBr): 3431(m), 1725(vs), 1647(s), 1607(m), 1519(s), 1454(w), 1404(w), 1348(s), 1322(w), 1250(m), 1179(w), 1094(w), 1029(m), 921(w), 847(w), 764(w) cm^{-1}. Anal Calcd for $C_{24}H_{17}NO_6$: C 69.39, H 4.12, N 3.37; Found: C 69.55, H 4.60, N 3.05.





2-(*p*-Nitrophenyl)-3-*p*-chlorophenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3d): yield: 53%. m.p. 132°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.30 (d, *J* = 7.8Hz, 2H, *p*-$NO_2C_6H_4$), 7.84 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.68 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.51 (d, *J* = 8.4Hz, 2H, *p*-$NO_2C_6H_4$), 7.46 (d, *J* = 9.0Hz, 1H, C_6H_4), 7.39 (t, *J* = 9.0Hz, 3H, C_6H_4, *p*-ClC_6H_4), 7.22 (d, *J* = 7.8Hz, 2H, *p*-ClC_6H_4), 5.890 (d, *J* = 6.6Hz, 1H, CH), 4.54 (d, *J* = 6.0Hz, 1H, CH). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 166.4, 159.2, 155.5, 148.3, 145.9, 137.9, 134.2, 129.6, 128.8, 128.5, 127.1, 126.2, 124.5, 123.0, 117.3, 112.0, 104.3, 94.7, 94.1, 54.8. MS(ESI-): m/z = 418.83. IR (KBr): 3443(m), 2924(w), 1720(vs), 1650(s), 1606(m), 1569(w), 1519(s), 1454(w), 1406(m), 1348(s), 1277(w), 1180(w), 1091(m), 1039(m), 926(w), 892(w), 849(w), 759(m) cm^{-1}. Anal Calcd for $C_{23}H_{14}ClNO_5$: C 65.80, H 3.36, N 3.34; Found: C 65.67, H 3.51, N 3.19.

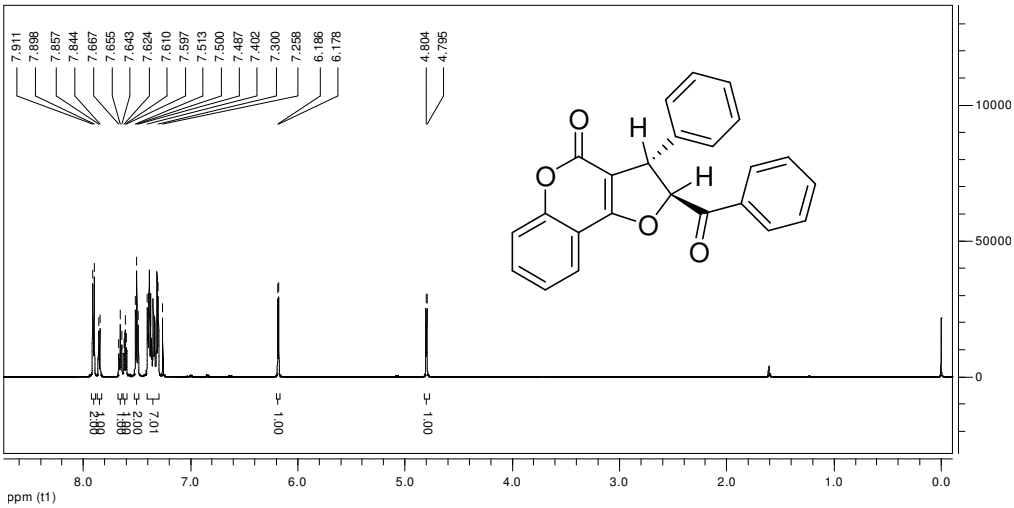


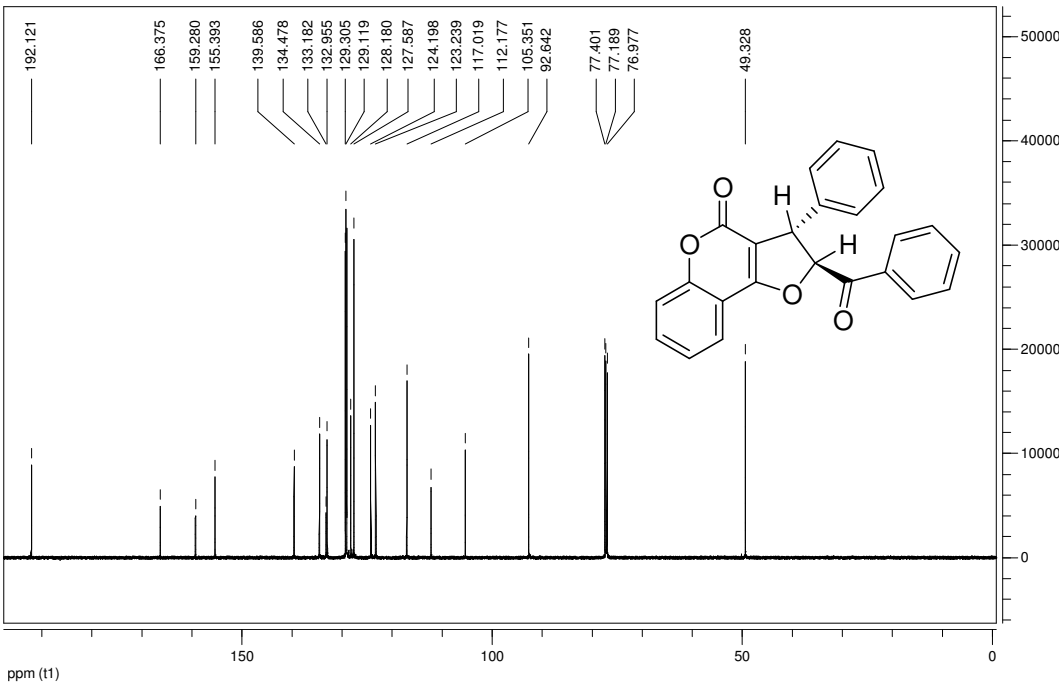


Procedure for the preparation 2-benzoyl-3-phenyl-2,3-dihydrofuro[3,2-c]chromen-4-ones 3e-3i

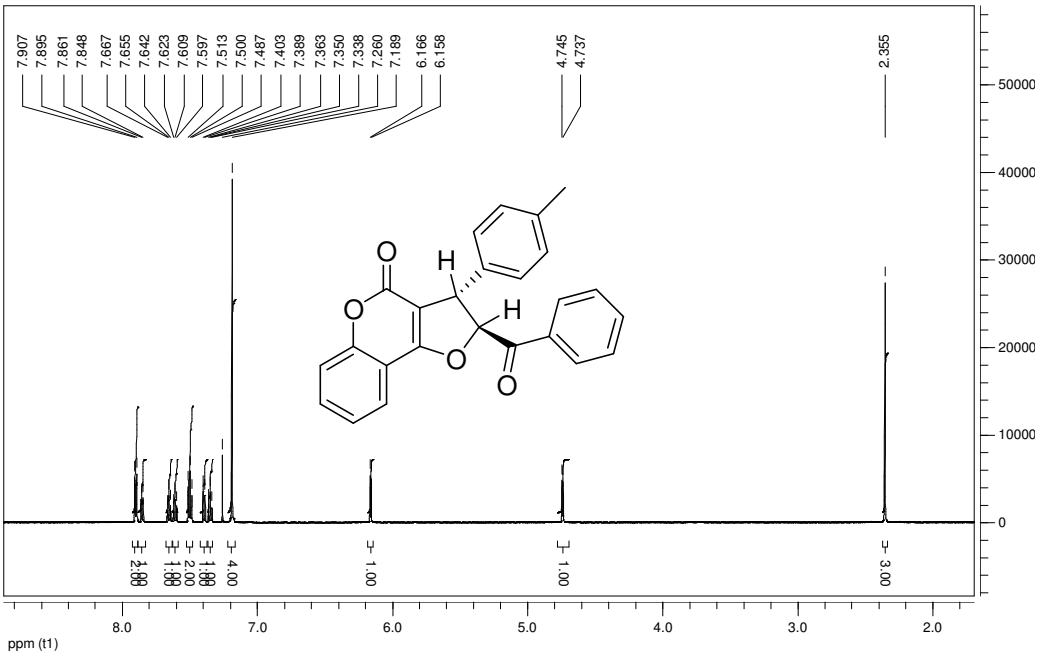
A mixture of aromatic aldehyde (1.0 mmol), 4-hydroxycoumarin (1.0 mmol), phenacyl bromide (1.05 mmol), pyridine (3.0 mmol) in acetonitrile (10 mL) was refluxed for two hours. Subsequently triethylamine (3.0 mmol) was added to the mixture. The resulting mixture was refluxed about 12 hours. Recrystallization from ethanol gave pure products **3e-3i**.

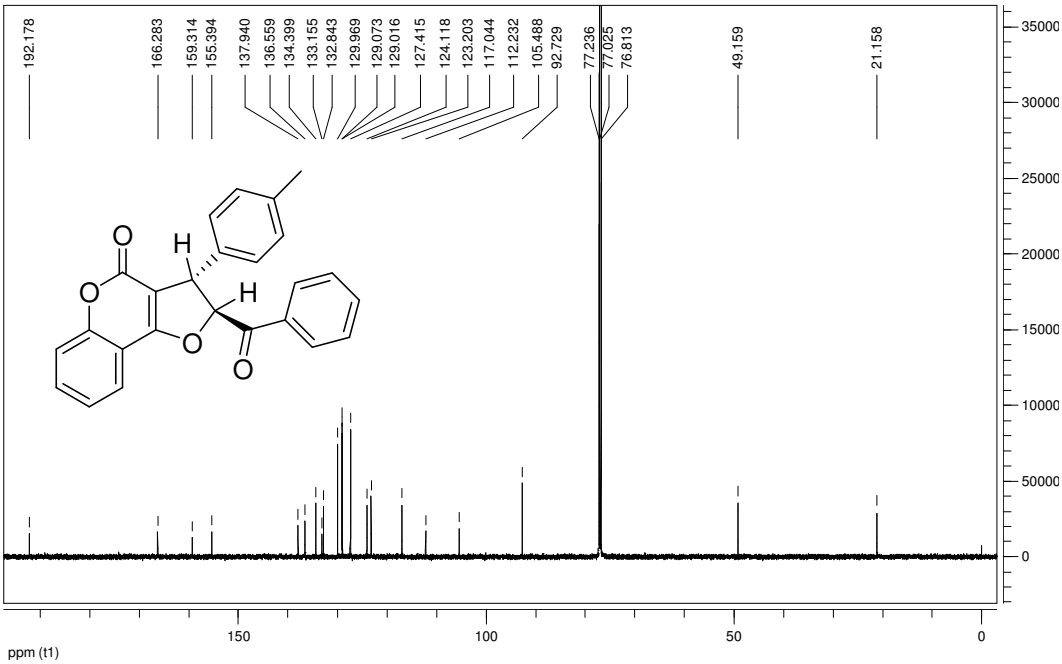
2-Benzoyl-3-phenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3e): yield: 75%. m.p. 193°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.90 (d, *J* = 7.8Hz, 2H, C_6H_5), 7.85 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.66 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.61 (t, *J* = 7.2Hz, 1H, C_6H_4), 7.50 (t, *J* = 7.2Hz, 2H, C_6H_5), 7.40-7.30 (m, 7H, C_6H_4, C_6H_5), 6.18 (d, *J* = 4.8Hz, 1H, CH), 4.80 (d, *J* = 5.4Hz, 1H, CH). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 192.1, 166.4, 159.3, 155.4, 139.6, 134.5, 133.2, 133.0, 129.3, 129.1, 128.2, 127.6, 124.2, 123.2, 117.0, 112.2, 105.4, 92.6, 49.3. MS(ESI-): m/z = 367.75. IR (KBr): 3414(w), 3062(w), 1716(vs), 1649(s), 1603(m), 1497(m), 1450(m), 1410(s), 1326(w), 1238(m), 1199(m), 1086(m), 1041(m), 932(m), 884(w), 810(w), 760(m), 694(m) cm^{-1}. Anal Calcd for $C_{24}H_{16}O_4$: C 78.25, H 4.48; Found: C 78.02, H 4.77.



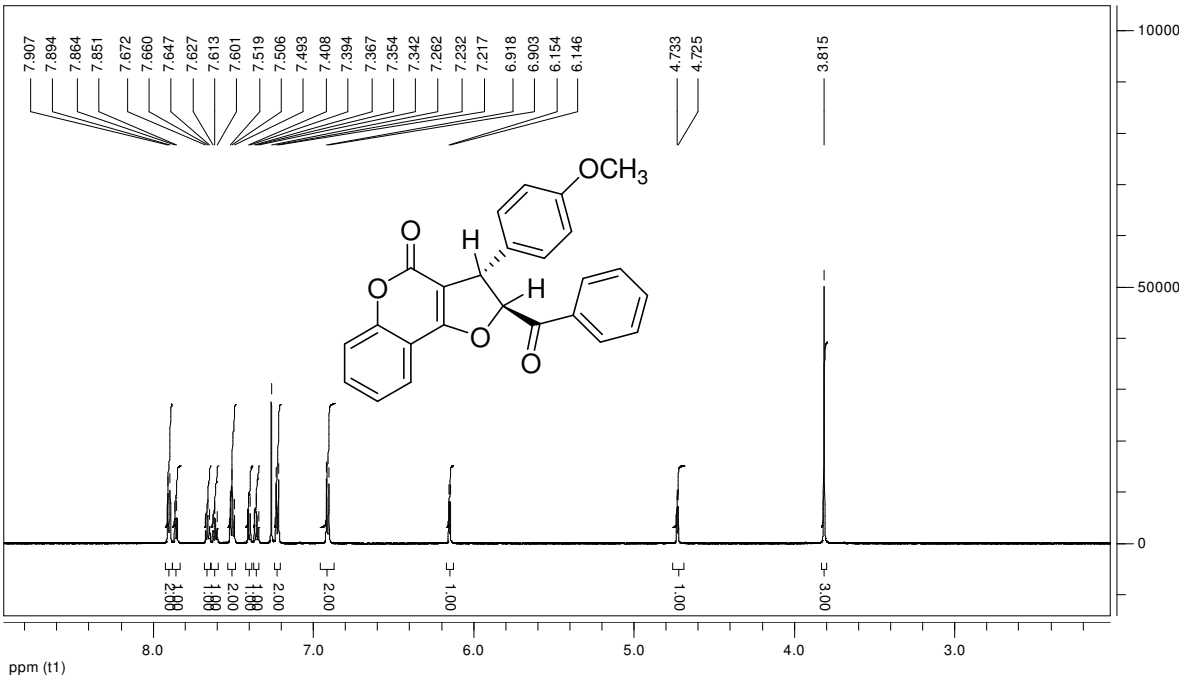


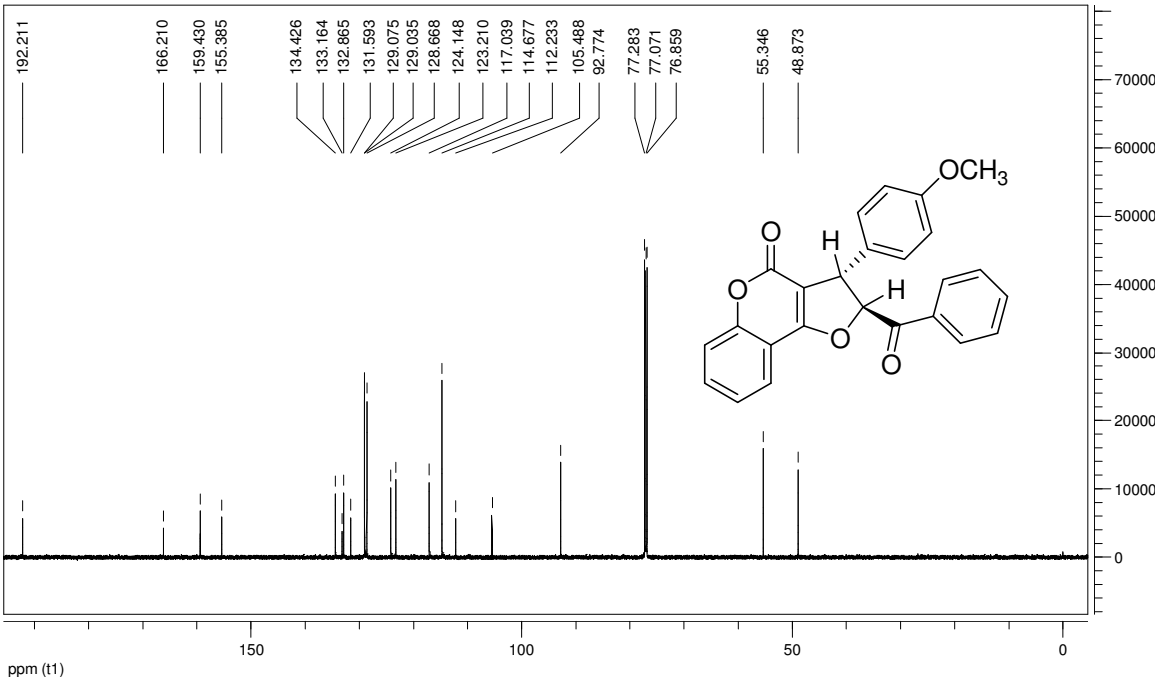
2-Benzoyl-3-*p*-methylphenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3f): yield: 81%. m.p. 192°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.90 (d, *J* = 7.2Hz, 2H, C_6H_5), 7.85 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.66 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.61 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.50 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.40 (d, *J* = 8.4Hz, 1H, C_6H_4), 7.35 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.19 (br, 4H, *p*-$CH_3C_6H_4$), 6.16 (d, *J* = 4.8Hz, 1H, CH), 4.74 (d, *J* = 4.8Hz, 1H, CH), 2.36 (s, 3H, CH_3). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 192.2, 166.3, 159.3, 155.4, 137.9, 136.6, 134.4, 133.2, 132.8, 130.0, 129.1, 129.0, 127.4, 124.1, 123.2, 117.0, 112.2, 105.5, 92.7, 49.2, 21.2. MS(ESI-): m/z = 382.04. IR (KBr): 3408(w), 3050(w), 1712(vs), 1649(s), 1604(w), 1500(w), 1449(w), 1410(m), 1326(w), 1239(m), 1197(w), 1088(w), 1040(m), 936(m), 887(w), 811(vw), 759(m) cm^{-1}. Anal Calcd for $C_{25}H_{18}O_4$: C 78.52, H 4.74; Found: C 78.59, H 5.04.



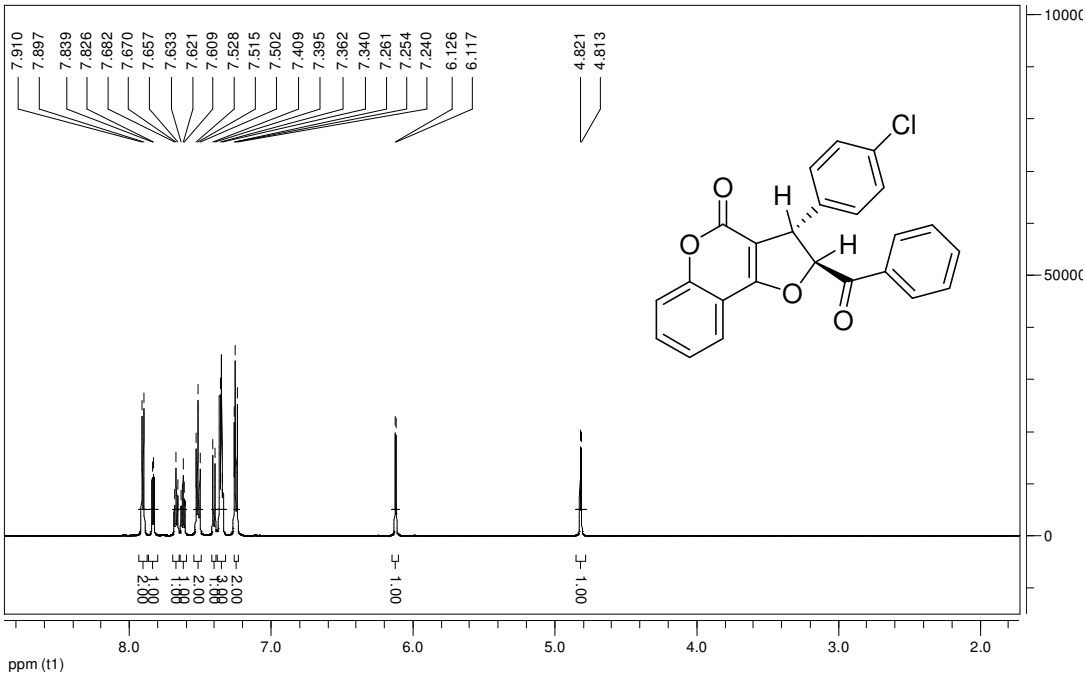


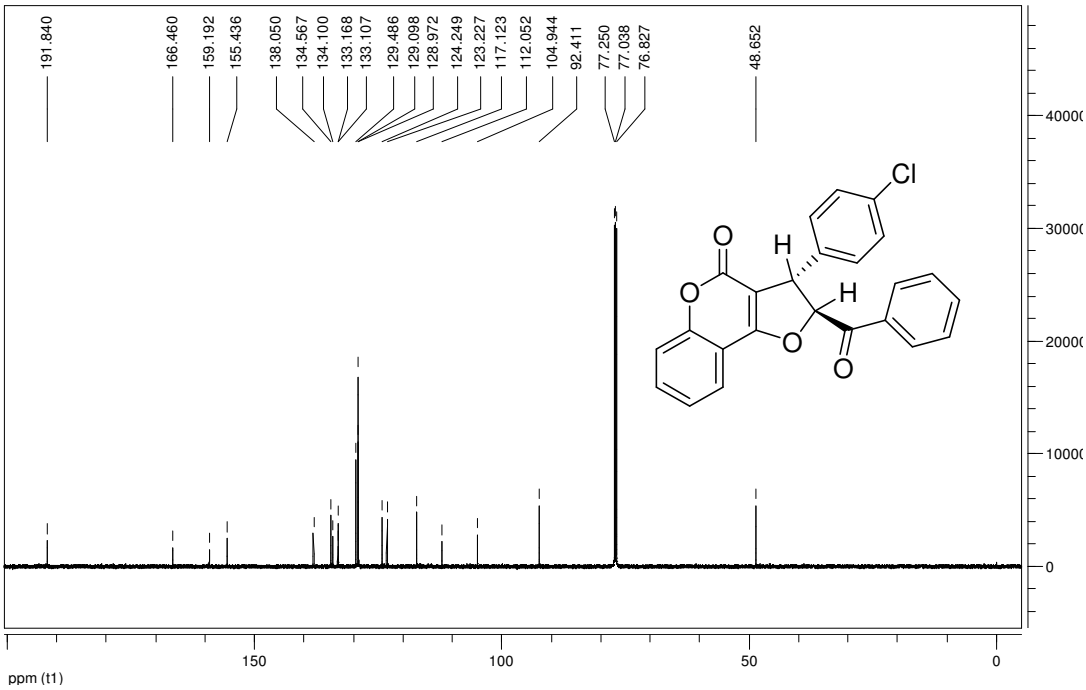
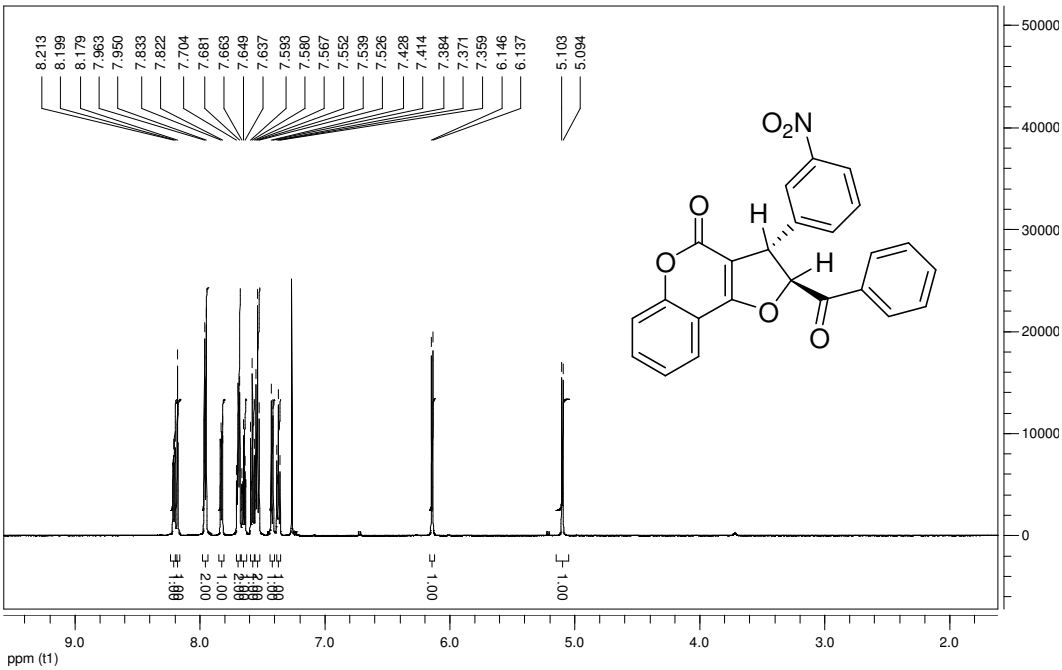
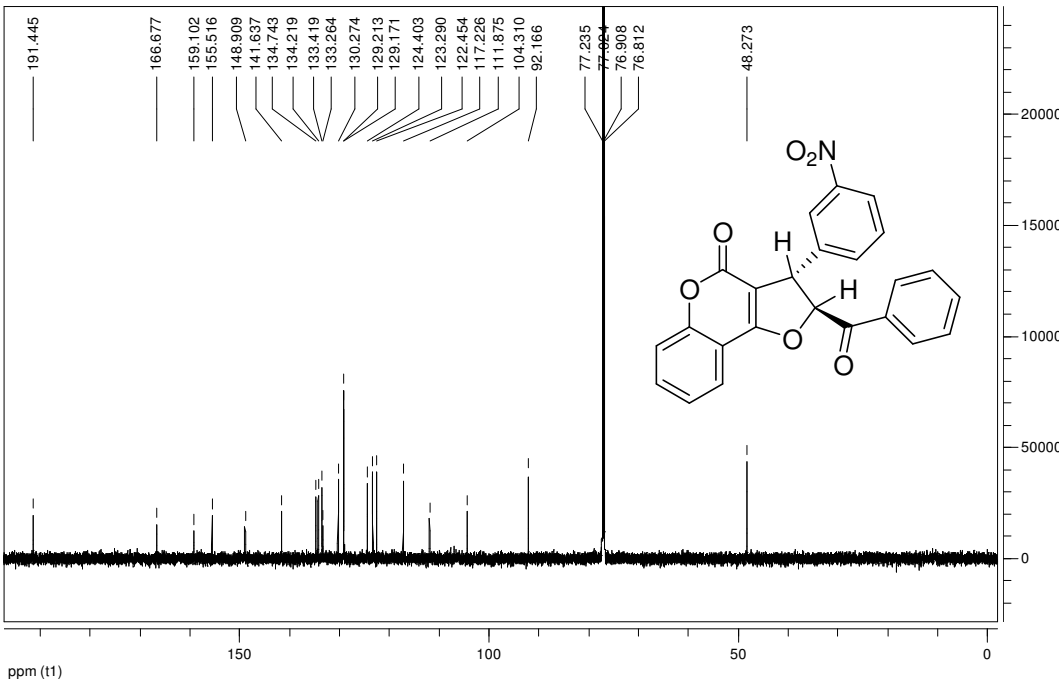
2-Benzoyl-3-*p*-methoxyphenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3g): yield: 62%. m.p. 180°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.90 (d, *J* = 7.8Hz, 2H, C_6H_5), 7.85 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.66 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.61 (t, *J* = 7.8Hz, 1H, C_6H_4), 7.51 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.40 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.35 (t, *J* = 7.2Hz, 1H, C_6H_4), 7.23 (d, *J* = 9.0Hz, 2H, *p*-$CH_3OC_6H_4$), 6.91 (d, *J* = 9.0Hz, 2H, *p*-$CH_3OC_6H_4$), 6.15 (d, *J* = 4.8Hz, 1H, CH), 4.73 (d, *J* = 4.8Hz, 1H, CH), 3.82 (s, 3H, CH_3O). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 192.2, 166.2, 159.4, 155.4, 134.4, 133.2, 132.9, 131.6, 129.1, 129.0, 128.7, 124.1, 123.2, 117.0, 114.7, 112.2, 105.5, 92.8, 55.3, 48.9. MS(ESI-): m/z = 397.89. IR (KBr): 3421(w), 3063(w), 1722(vs), 1648(s), 1606(s), 1509(s), 1449(m), 1410(s), 1328(w), 1249(s), 1179(s), 1090(m), 1031(s), 932(s), 886(w), 839(w), 811(w), 761(s), 690(m) cm^{-1}. Anal Calcd for $C_{25}H_{18}O_5$: C 75.37, H 4.55; Found: C 74.90, H 4.83.





2-Benzoyl-3-*p*-chlorophenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3h): yield: 68%. m.p. 170-172°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 7.90 (d, *J* = 7.8Hz, 2H, C_6H_5), 7.83 (d, *J* = 7.8Hz, 1H, C_6H_4), 7.67 (t, *J* = 7.2Hz, 1H, C_6H_5), 7.62 (t, *J* = 7.2Hz, 1H, C_6H_4), 7.52 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.40 (d, *J* = 8.4Hz, 1H, C_6H_4), 7.36-7.34 (m, 3H, C_6H_4, *p*-ClC_6H_4), 7.25 (d, *J* = 9.0Hz, 2H, *p*-ClC_6H_4), 6.12 (d, *J* = 5.4Hz, 1H, CH), 4.82 (d, *J* = 4.8Hz, 1H, CH). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 191.8, 166.5, 159.2, 155.4, 138.1, 134.6, 134.1, 133.2, 133.1, 129.5, 129.1, 129.0, 124.2, 123.2, 117.1, 112.1, 104.9, 92.4, 48.7. MS(ESI-): m/z = 401.66. IR (KBr): 3412(w), 3061(w), 1712(s), 1648(s), 1605(m), 1569(w), 1496(m), 1449(w), 1412(m), 1326(w), 1234(m), 1180(w), 1089(m), 1039(m), 936(m), 885(w), 808(w), 764(m), 689(w) cm^{-1}. Anal Calcd for $C_{24}H_{15}ClO_4$: C 71.56, H 3.75; Found: C 71.48, H 3.94.





2-Benzoyl-3-*m*-nitrophenyl-2,3-dihydrofuro[3,2-c]chromen-4-one (3i): yield: 50%. m.p. 224°C. ^{1}H NMR (600MHz, $CDCl_3$) δ(ppm): 8.21 (d, *J* = 8.4Hz, 1H, *m*-$NO_2C_6H_4$), 8.18 (s, 1H, *m*-$NO_2C_6H_4$), 7.96 (d, *J* = 7.8Hz, 2H, C_6H_5), 7.83 (d, *J* = 6.6Hz, 1H, C_6H_4), 7.70-7.68 (m, 2H, *m*-$NO_2C_6H_4$), 7.65 (t, *J* = 8.4Hz, 1H, C_6H_4), 7.58 (t, *J* = 7.8Hz, 1H, C_6H_5), 7.54 (t, *J* = 7.8Hz, 2H, C_6H_5), 7.42 (d, *J* = 8.4Hz, 1H, C_6H_4), 7.37 (t, *J* = 7.8Hz, 1H, C_6H_4), 6.14 (d, *J* = 5.4Hz, 1H, CH), 5.10 (d, *J* = 5.4Hz, 1H, CH). ^{13}C NMR (150MHz, $CDCl_3$) δ(ppm): 191.4, 166.7, 159.1, 155.5, 148.9, 141.6, 134.7, 134.2, 133.4, 133.3, 130.3, 129.2, 124.4, 123.3, 122.5, 117.2, 111.9, 104.3, 92.2, 48.3. MS(ESI-): m/z = 413.07. IR (KBr): 3420(w), 2979(w), 1720(vs), 1643(s), 1603(m), 1530(s), 1497(m), 1449(m), 1410(s), 1348(s), 1217(m), 1092(m), 1027(m), 929(s), 889(w), 860(w), 818(w), 766(m), 686(s) cm^{-1}. Anal Calcd for $C_{24}H_{15}NO_6$: C 69.73, H 3.66, N 3.39; Found: C 69.56, H 3.65, N 3.12.