Electronic Supplementary Material (ESI) for Chemical Communications

One-Pot Catalysis of Dehydrogenation of Cyclohexanones to Phenols and Oxidative Heck Coupling: Expedient Synthesis of Coumarins

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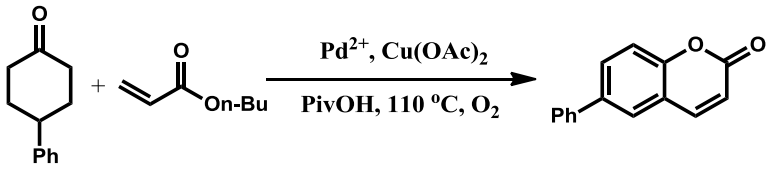
I. General Methods and Materials. Unless stated otherwise, reactions were performed in flame-dried glassware under a positive pressure of nitrogen. Analytical thin layer chromatography (TLC) was performed on precoated silica gel 60 F_{254} plates and visualization on TLC was achieved by UV light (254 and 354nm). Flash column chromatography was undertaken on silica gel (400-630 mesh). ^{1}H NMR was recorded on 400 MHz and chemical shifts were quoted in parts per million (ppm) referenced to the appropriate solvent peak or 0.0 ppm for tetramethylsilane. The following abbreviations were used to describe peak splitting patterns when appropriate: br = broad, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublet. Coupling constants, *J*, were reported in hertz unit (Hz). ^{13}C NMR was recorded on 100 MHz and was fully decoupled by broad band proton decoupling. Chemical shifts were reported in ppm referenced to the center line of a triplet at 77.0 ppm of chloroform-*d*. High resolution mass spectra were obtained from the Korea Basic Science Institute (Daegu) by using EI method. Dichloromethane was distilled from calcium hydride. Unless otherwise stated, all commercial reagents and solvents were used without additional purification.

II. Optimization Study

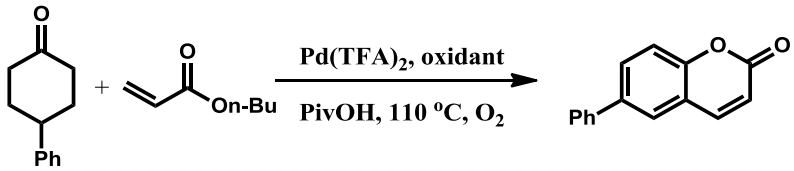
Table S1. Screen of Pd[a]



entry	Palladium (0.2 eq)	Oxidant (1 eq)	Yield (%)[b]
1	$Pd(acac)_2$	$Cu(OAc)_2$	52
2	$PdCl_2$	$Cu(OAc)_2$	Trace
3	$Pd(dppf)Cl_2$	$Cu(OAc)_2$	N.R
4	$(IPr)Pd(OAc)_2$	$Cu(OAc)_2$	30
5	$Pd(OAc)_2$	$Cu(OAc)_2$	63
6	**$Pd(TFA)_2$**	**$Cu(OAc)_2$**	**81**

[a] Reactions were conducted with 4-phenylcyclohexaneone (1.0 equiv), *n*-butylacrylate (1.2 equiv), PdL_2 (0.2 equiv), and oxidant (1.0 equiv) in PivOH at 110 ℃ for 20 h under 1 atm O_2. [b] Yield of isolated product.

Table S2. Screen of oxidants.[a]



entry	Oxidant (1 eq)	additive (eq)	Yield (%)[b]
1	O_2 (1 atm)	-	N.R.
2	Oxone	-	Trace
3	$K_2S_2O_8$	-	Trace
4	HPMV	-	N.R
5	CAN	-	S.M. decomposed
6	DDQ	-	Trace
7	$Fe(acac)_3$	-	N.R.
8	$Cu(OTf)_2$	-	S.M. decomposed
9	$CuCl_2$	-	S.M. decomposed
10	$CuBr_2$	-	S.M. decomposed
11	CuI	-	Trace
12	$Cu(SO_4)_2 \cdot 5H_2O$	-	Trace
13	$Cu(BF_4)_2$	-	20
14	CuO	-	68
15	$Cu(OMe)_2$	-	63
16	-	*p*-TsOH (0.4)	phenol (68%)
	-	CSA (0.4)	phenol (~20%)
17	-	DMSO (0.5 eq)	only cyclohexnone (~50%)
18	$Cu(OAc)_2$	*p*-TsOH (0.4)	27
19	$Cu(OAc)_2$	2-Me_2N-pyridine (0.4)	<10
20	$Cu(OAc)_2$	NaOAc (1)	45
21	$CuCO_3 \cdot Cu(OH)_2$	-	80
22	**$Cu(OAc)_2$**	**-**	**81**

[a] Reactions were conducted with 4-phenylcyclohexaneone (1.0 equiv), *n*-butylacrylate (1.2 equiv), PdL_2 (0.2 equiv), and oxidant (1.0 equiv) in PivOH at 110 ℃ for 20 h under 1 atm O_2. [b] Yield of isolated product.

III. Reaction Profiles

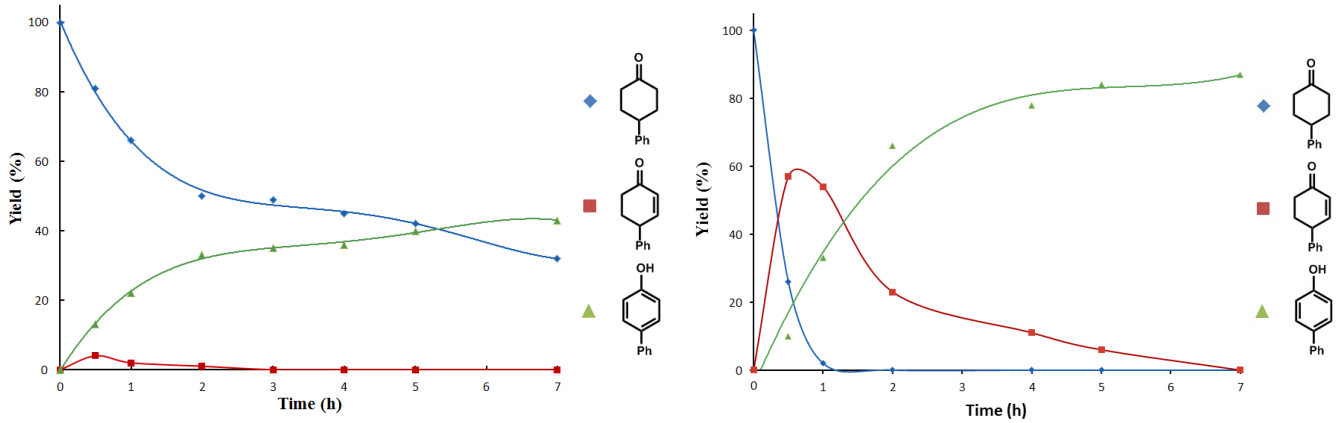


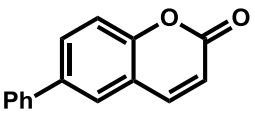
Figure S1. Reaction profile of the Pd(II)-catalyzed dehydrogentation of 4-phenylcyclohexanone. (a) Reactions were conducted with 4-phenylcyclohexanone (1.0 equiv), $Pd(TFA)_2$ (0.2 equiv), and TsOH (0.4 eq) in PivOH at 110 ℃ under 1 atm O_2. (b) Reactions were conducted with 4-phenylcyclohexanone (1.0 equiv), $Pd(TFA)_2$ (0.2 equiv), and $Cu(OAc)_2$ (1 eq) in PivOH at 110 ℃ under 1 atm O_2.

IV. Experimental Procedure

General Procedure (GP) for Oxidation and Oxidative Heck coupling of Cyclohexanone to Coumarin.

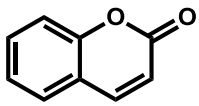
Cyclohexanone (1.0 eq), $Pd(TFA)_2$ (0.2 eq) and $Cu(OAc)_2$ (1.0 eq) were combined in PivOH (0.1 M) under O_2 (1 atm, balloon). The reaction mixture was heated to 110 ^oC. The mixture was monitored by TLC using EtOAc and *n*-hexane as the mobile. Acrylate (1.2 eq) was added to the reaction mixture and the reaction mixture was stirred until corresponding phenol disappeared. The reaction mixture was diluted with CH_2Cl_2 and the excess aqueous $NaHCO_3$ was added to neutralize the PivOH. After stirring the mixture for 10 min, the residue was extracted with aqueous $NaHCO_3$, NH_4Cl three times. The organic layer was dried over $MgSO_4$. After removal of solvent, the residue was purified by flash chromatography on silica gel to give the desired product.

V. Compound characterizations

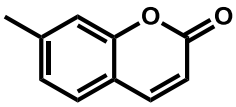


6-Phenyl-2H-chromen-2-one (3a). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 6 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 15 h. The

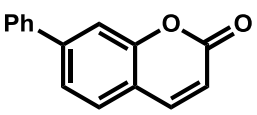
residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (32.3 mg, 81%); This compound is known.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.76–7.70 (m, 2H), 7.64 (d, *J* = 2.2 Hz, 1H), 7.58–7.52 (m, 2H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.40–7.34 (m, 2H), 6.44 (d, *J* = 9.5 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.6, 153.4, 143.4, 139.3, 137.8, 130.7, 129.0, 127.7, 127.0, 126.0, 119.0, 117.2, 117.0.; [Ref]. *J. Org. Chem.* **1988**, *53*, 3936-3943.



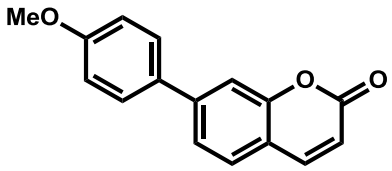
2H-Chromen-2-one (3b). Cyclohexenone (20.0 mg, 0.208 mmol) was oxidized to phenol according to GP for 5 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 12 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (17.6 mg, 72%); ^{1}H NMR (400 MHz, Chloroform-d) δ 7.67 (d, *J* = 9.5 Hz, 1H), 7.48 (td, *J* = 8.0, 1.6 Hz, 1H), 7.45 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.27 (d, *J* = 8.4 Hz, 1H), 7.23 (td, *J* = 7.5, 1.2 Hz, 1H), 6.37 (d, *J* = 9.5 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.6, 153.9, 143.4, 131.7, 127.8, 124.3, 118.7, 116.7, 116.5.; [Ref]. *J. Org. Chem.* **1988**, *53*, 3936-3943.



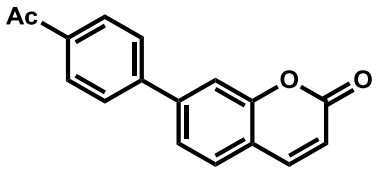
7-Methyl-2H-chromen-2-one (3c). 3-Methylcyclohexanone (24.3 mg, 0.199 mmol) was oxidized to phenol according to GP for 11 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 12 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (18.7 mg, 59%); This compound is known.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.64 (d, *J* = 9.5 Hz, 1H), 7.33 (d, *J* = 7.8 Hz, 1H), 7.11 (s, 1H), 7.06 (d, *J* = 7.9 Hz, 1H), 6.32 (d, *J* = 9.5 Hz, 1H), 2.42 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 161.0, 154.1, 143.3, 143.1, 127.5, 125.6, 117.0, 116.4, 115.4, 21.7.; [Ref]. *J. Org. Chem.* **1988**, *53*, 3936-3943.



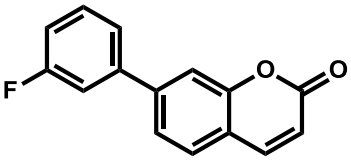
7-Phenyl-2H-chromen-2-one (3d) 3-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 5 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 14 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (22.2 mg, 56%); ^{1}H NMR (400 MHz, Chloroform-d) δ 7.70 (d, *J* = 12.0 Hz, 1H), 7.61–7.57 (m, 2H), 7.53–7.43 (m, 5H), 7.42–7.36 (m, 1H), 6.39 (d, *J* = 9.5 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.8, 154.4, 145.0, 143.0, 139.1, 129.0, 128.5, 128.1, 127.1, 123.3, 117.7, 116.2, 115.0.; [Ref]. *J. Org. Chem.* **1988**, *53*, 3936-3943.



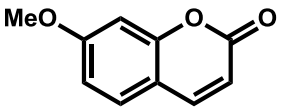
7-(4-Methoxyphenyl)-2H-chromen-2-one (3e). 3-Phenylcyclohexanone (36.0 mg, 0.176 mmol) was oxidized to phenol according to GP for 5 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 14 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (23.1 mg, 52%); This compound is known.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.70 (d, *J* = 9.5 Hz, 1H), 7.55 (d, *J* = 8.9 Hz, 2H), 7.51–7.43 (m, 3H), 6.99 (d, *J* = 8.9 Hz, 2H), 6.37 (d, *J* = 9.5 Hz, 1H), 3.85 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 161.0, 160.1, 154.6, 144.7, 143.1, 131.5, 128.3, 128.1, 122.8, 117.3, 115.9, 114.5, 114.4, 55.4.; [Ref]. *J. Med. Chem.* **2011**, *54*, 248-261.



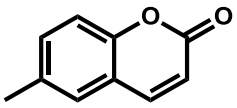
7-(4-Acetylphenyl)-2H-chromen-2-one (3f). 3-(4-Acetylphenyl)cyclohexanone (71.0 mg, 0.328 mmol) was oxidized to phenol according to GP for 11 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 24 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (60.7 mg, 64%); mp 158-160 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 8.02 (d, *J* = 9.5 Hz, 2H), 7.72 (d, *J* = 9.6, 1H), 7.67 (d, *J* = 8.0 Hz, 2H), 7.57–7.48 (m, 3H), 6.41 (d, *J* = 9.5 Hz, 1H), 2.61 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 197.4, 160.5, 154.4, 143.4, 142.8, 136.7, 129.0, 128.3, 127.3, 123.3, 118.4, 116.8, 115.2, 26.6.; HRMS (EI^{+}) m/z calcd. for $C_{17}H_{12}O_3^{+}$ $[M]^{+}$: 264.0786, found: 264.0786.



7-(3-Fluorophenyl)-2H-chromen-2-one (3g). 3-(3-Fluorophenyl)cyclohexanone (49.0 mg, 0.245 mmol) was oxidized to phenol according to GP for 9 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 23 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (27.1 mg, 46%); mp 129–132 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.72 (d, *J* = 9.5 Hz 1H), 7.55–7.45 (m, 3H), 7.45–7.36 (m, 2H), 7.33–7.27 (m, 1H), 7.09 (tdd, *J* = 8.1, 2.5, 1.2 Hz, 1H), 6.42 (d, *J* = 9.5 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 163.2 (d, *J* = 246.8 Hz), 160.6, 154.4, 143.6, 142.9, 141.4 (d, *J* = 7.7 Hz), 130.6 (d, *J* = 8.4 Hz), 128.3, 123.2, 122.9 (d, *J* = 2.8 Hz), 118.2, 116.7, 115.4 (d, *J* = 21.2 Hz), 115.1, 114.2 (d, *J* = 22.4 Hz).; HRMS (EI^{+}) m/z calcd. for $C_{15}H_9FO_2^{+}$ $[M]^{+}$: 240.0587, found: 240.0585.

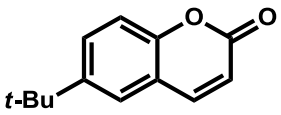


7-Methoxy-2H-chromen-2-one (3h). 3-Methoxycyclohexanone (30.0 mg, 0.234 mmol), $Pd(TFA)_2$ (0.2 eq) and $Cu(OAc)_2$ (1.0 eq) were combined in 1,4-dioxane : PivOH (5 : 1) under O_2. The reaction mixture was heated to 110 ^{o}C for 8 h. The mixture was monitored by TLC using EtOAc and *n*-hexane as the mobile phase. *n*-Butylacrylate (1.2 eq) was added to the reaction mixture under O_2, and the reaction mixture was stirred for 10 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (24.7 mg, 56%); This compound is known; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.61 (d, *J* = 9.4 Hz, 1H), 7.34 (d, *J* = 8.5 Hz, 1H), 6.83–6.77 (m, 2H), 6.22 (d, *J* = 9.4 Hz, 1H), 3.84 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 162.8, 161.1, 155.9, 143.4, 128.7, 113.1, 112.5, 112.5, 100.8, 55.7.; [Ref]. *J. Am. Chem. Soc.* **2003**, *125*, 4518-4526.

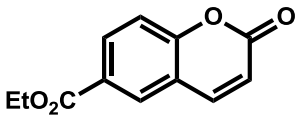


6-Methyl-2H-chromen-2-one (3i). 4-Methylcyclohexanone (27.5 mg, 0.245 mmol) was oxidized to phenol according to GP for 4 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 14 h. The

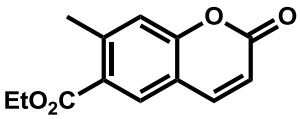
residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (30.2 mg, 77%); This compound is known; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.62 (d, *J* = 9.5 Hz, 1H), 7.29 (dd, *J* = 8.4, 2.2 Hz, 1H), 7.23 (s, 1H), 7.18 (d, *J* = 8.4 Hz, 1H), 6.35 (d, *J* = 9.6 Hz, 1H), 2.36 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 161.0, 152.1, 143.3, 134.1, 132.7, 127.6, 118.5, 116.5, 116.5, 20.6.; [Ref]. *J. Org. Chem.* **1988**, *53*, 3936-3943.



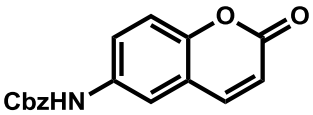
6-(*tert*-Butyl)-2H-chromen-2-one (3j). 4-*tert*-Butylcyclohexanone (27.5 mg, 0.178 mmol) was oxidized to phenol according to GP for 4 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 14 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (28.1 mg, 78%); This compound is known.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.68 (d, *J* = 9.5 Hz, 1H), 7.55 (dd, *J* = 8.7, 2.4 Hz, 1H), 7.42 (d, *J* = 2.4 Hz, 1H), 7.24 (d, *J* = 8.8 Hz, 1H), 6.38 (d, *J* = 9.5 Hz, 1H), 1.33 (s, 9H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 161.1, 152.0, 147.5, 143.8, 129.5, 124.1, 118.2, 116.4, 116.4, 34.5, 31.3.; [Ref]. *J. Org. Chem.* **2004**, *69*, 3669-3671.



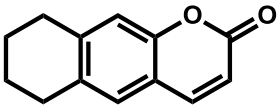
Ethyl 2-oxo-2H-chromene-6-carboxylate (3k). Ethyl 4-oxocyclohexanecarboxylate (32.5 mg, 0.190 mmol) was oxidized to phenol according to GP for 6 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 18 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (33.5 mg, 81%); mp 125-127 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 8.22–8.11 (m, 2H), 7.73 (d, *J* = 8.0 Hz, 1H), 7.33 (d, *J* = 8.2 Hz, 1H), 6.45 (d, *J* = 9.6 Hz, 1H), 4.38 (q, *J* = 7.1 Hz, 2H), 1.39 (t, *J* = 7.2 Hz, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 165.1, 159.8, 156.8, 143.1, 132.7, 129.8, 126.9, 118.5, 117.4, 117.0, 61.4, 14.3.; HRMS (EI^{+}) m/z calcd. for $C_{12}H_{10}O_4^{+}$ $[M]^{+}$: 218.0579, found: 218.0577.



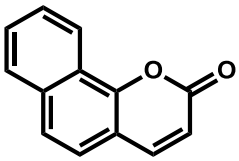
Ethyl 7-methyl-2-oxo-2H-chromene-6-carboxylate (3l). Ethyl 2-methyl-4-oxocyclohex-2-enecarboxylate (32.5 mg, 0.160 mmol) was oxidized to phenol according to GP for 4 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 14 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (31.5 mg, 85%); mp 121-123 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 8.07 (s, 1H), 7.68 (d, *J* = 9.6 Hz, 1H), 7.15 (s, 1H), 6.37 (d, *J* = 9.5 Hz, 1H), 4.35 (q, *J* = 7.1 Hz, 2H), 2.66 (s, 3H), 1.39 (t, *J* = 7.1 Hz, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 166.0, 160.2, 155.7, 145.1, 142.9, 130.9, 126.4, 119.5, 116.5, 116.4, 61.1, 22.3, 14.3.; HRMS (EI^{+}) m/z calcd. for $C_{13}H_{12}O_4^{+}$ [M]$^{+}$: 232.0736, found: 232.0734.



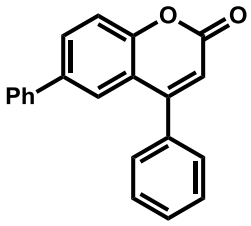
Benzyl (2-oxo-2H-chromen-6-yl)carbamate (3m). Benzyl (4-oxocyclohexyl)carbamate (44.0 mg, 0.177 mmol) was oxidized to phenol according to GP for 5 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 12 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (19.9 mg, 38%); mp 138-141 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.76 (bs, 1H), 7.63 (d, *J* = 9.5 Hz, 1H), 7.40–7.30 (m, 6H), 7.24 (d, *J* = 12.0 Hz,1H), 6.86 (bs, 1H), 6.41 (d, *J* = 9.5 Hz, 1H), 5.20 (s, 2H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.7, 153.3, 150.0, 143.2, 135.7, 134.3, 128.6, 128.5, 128.3, 122.5, 119.1, 117.3, 117.3, 116.9, 67.3.; HRMS (EI^{+}) m/z calcd. for $C_{17}H_{13}NO_4^{+}$ [M]$^{+}$: 295.0845, found: 295.0842.



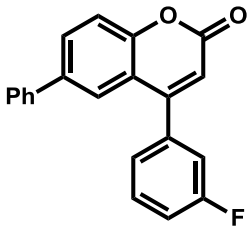
6,7,8,9-Tetrahydro-2H-benzo[g]chromen-2-one (3n). Octahydronaphthalen-2(1H)-one (29.5 mg, 0.184 mmol) was oxidized to phenol according to GP for 4 h. *n*-Butylacrylate (1.2 eq) was added, and the reaction mixture was stirred for 14 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (17.6 mg, 48%); mp 123-125 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.59 (d, *J* = 9.5 Hz, 1H), 7.12 (s, 1H), 6.99 (s, 1H), 6.29 (d, *J* = 9.5 Hz, 1H), 2.80 (d, *J* = 20.9 Hz, 4H), 1.83–1.75 (m, 4H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 161.3, 152.0, 143.3, 142.4, 133.7, 127.5, 116.7, 116.4, 115.4, 29.8, 28.7, 22.9, 22.6.; HRMS (EI^{+}) m/z calcd. for $C_{13}H_{12}O_2^{+}$ [M]$^{+}$: 200.0837, found: 200.0839.



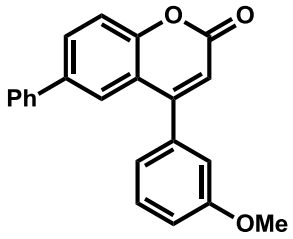
2H-Benzo[h]chromen-2-one (3o). 3,4-Dihydronaphthalen-1(2H)-one (33.0 mg, 0.225 mmol), *n*-butylacrylate (1.2 eq), $Pd(TFA)_2$ (0.2 eq) and $Cu(OAc)_2$ (2.0 eq) were combined in PivOH (0.1 M) under O_2 (1 atm, balloon pressure). The reaction mixture was heated to 110 ^oC. The mixture was monitored by TLC using EtOAc and *n*-hexane as the mobile phase and stirred until starting material disappeared. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (24.7 mg, 56%); ^1H NMR (400 MHz, Chloroform-d) δ 8.55–8.46 (m, 1H), 7.88–7.82 (m, 1H), 7.80 (d, *J* = 9.5 Hz, 1H), 7.65 (d, *J* = 8.4 Hz, 1H), 7.64–7.59 (m, 2H), 7.43 (d, *J* = 8.5 Hz, 1H), 6.49 (d, *J* = 9.5 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.9, 151.3, 144.1, 134.8, 128.7, 127.8, 127.2, 124.4, 123.5, 123.1, 122.3, 115.9, 114.2.; [Ref]. *J. Org. Chem.* **1988**, *53*, 3936-3943.



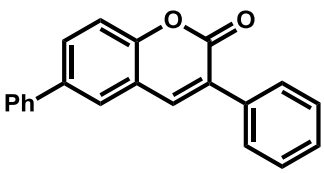
4,6-Diphenyl-2H-chromen-2-one (4a). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. Methyl cinnamate (1.2 eq) was added, and the reaction mixture was stirred for 13 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (31.3 mg, 59%); This compound is known.; ^1H NMR (400 MHz, Chloroform-d) δ 7.75 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.66 (d, *J* = 2.2 Hz, 1H), 7.55–7.51 (m, 3H), 7.51–7.43 (m, 5H), 7.43–7.37 (m, 2H), 7.36–7.30 (m, 1H), 6.40 (s, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.6, 155.6, 153.6, 139.6, 137.5, 135.1, 130.8, 129.7, 128.9, 128.9, 128.4, 127.6, 127.0, 125.2, 119.1, 117.7, 115.5.; [Ref]. *J. Org. Chem.* **2004**, *69*, 3669-3671.



4-(3-Fluorophenyl)-6-phenyl-2H-chromen-2-one (4b). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. (*E*)-Methyl 3-(3-fluorophenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 26 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (32.1 mg, 57%); mp 138-140 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.76 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.59 (d, *J* = 2.2 Hz, 1H), 7.54–7.37 (m, 6H), 7.37–7.31 (m, 1H), 7.26 (dt, *J* = 7.6, 1.3 Hz, 1H), 7.24–7.17 (m, 2H), 6.40 (s, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 162.8 (d, *J* = 248.6 Hz), 160.3, 154.3, 153.6, 139.5, 137.8, 137.1 (d, *J* = 7.9 Hz), 131.1, 130.8 (d, *J* = 8.3 Hz), 129.0, 127.8, 127.1, 124.9, 124.2, 118.8, 117.8, 116.8 (d, *J* = 20.9 Hz), 115.9, 115.6 (d, *J* = 22.8 Hz).; HRMS (EI^{+}) m/z calcd. for $C_{21}H_{13}FO_2^{+}$ $[M]^{+}$: 316.0900, found: 316.0896.

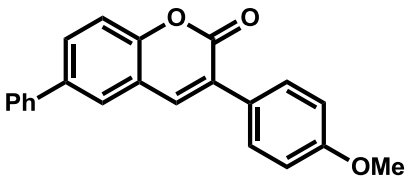


4-(3-Methoxyphenyl)-6-phenyl-2H-chromen-2-one (4c). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. (*E*)-Methyl 3-(3-methoxyphenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 26 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (36.2 mg, 62%); yellowish oil.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.75 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.68 (d, *J* = 2.2 Hz, 1H), 7.48–7.37 (m, 6H), 7.36–7.32 (m, 1H), 7.07–7.03 (m, 2H), 7.01–6.98 (m, 1H), 6.41 (s, 1H), 3.85 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.7, 159.9, 155.6, 153.5, 139.6, 137.6, 136.4, 130.9, 130.0, 128.9, 127.7, 127.1, 125.2, 120.7, 119.1, 117.7, 115.5, 115.2, 114.0, 55.4.; HRMS (EI^{+}) m/z calcd. for $C_{22}H_{16}O_3^{+}$ $[M]^{+}$: 328.1099, found: 328.1100.

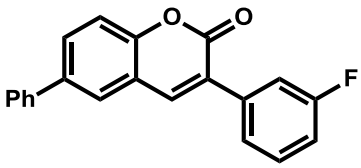


3,6-Diphenyl-2H-chromen-2-one (4d). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. 2-Phenylacrylic acid (1.2 eq) was added, and the reaction mixture was stirred for 14 h. The

residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (35.5 mg, 67%); yellowish oil.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.83 (s, 1H), 7.74–7.69 (m, 4H), 7.61–7.56 (m, 2H), 7.49–7.36 (m, 7H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.5, 152.8, 139.9, 139.5, 137.8, 134.6, 130.3, 129.0, 128.9, 128.6, 128.5, 128.5, 127.8, 127.0, 126.0, 119.8, 116.8.; HRMS (EI^{+}) m/z calcd. for $C_{21}H_{14}O_2^{+}$ $[M]^{+}$: 298.0994, found: 298.0991.

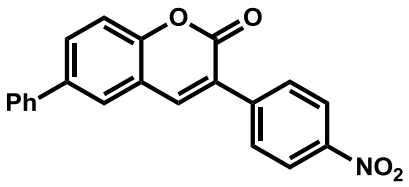


3-(4-Methoxyphenyl)-6-phenyl-2H-chromen-2-one (4e). 4-Phenylcyclohexanone (31 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(4-methoxyphenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 22 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (42.1 mg, 73%); mp 146-149 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.80 (s, 1H), 7.73–7.64 (m, 4H), 7.61–7.55 (m, 2H), 7.46 (t, *J* = 7.5 Hz, 2H), 7.43–7.34 (m, 2H), 6.97 (d, *J* = 8.8 Hz, 2H), 3.84 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.2, 152.6, 139.6, 138.5, 137.8, 129.9, 129.8, 129.0, 128.1, 127.7, 127.0, 127.0, 125.8, 120.0, 116.7, 113.9, 55.4.; HRMS (EI^{+}) m/z calcd. for $C_{22}H_{16}O_3^{+}$ $[M]^{+}$: 328.1099, found: 328.1098.

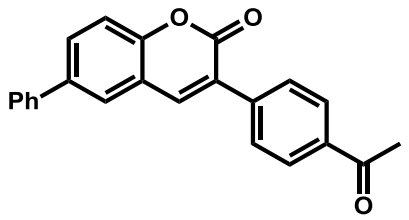


3-(3-Fluorophenyl)-6-phenyl-2H-chromen-2-one (4f). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(3-fluorophenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 16 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (41.7 mg, 75%); mp 131-133 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.88 (s, 1H), 7.75 (dd, *J* = 8.5, 2.2 Hz, 1H), 7.72 (d, *J* = 2.1 Hz, 1H), 7.61–7.56 (m, 2H), 7.52–7.44 (m, 4H), 7.44–7.35 (m, 3H), 7.10 (td, *J* = 8.2, 2.6 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 162.6 (d, *J* = 246.2 Hz), 160.1, 152.9, 140.4, 139.3, 138.0, 136.6 (d, *J* = 8.2 Hz), 130.7, 130.0 (d, *J* = 8.4 Hz), 129.0, 127.8, 127.3 (d, *J* = 2.4 Hz), 127.0, 126.2,

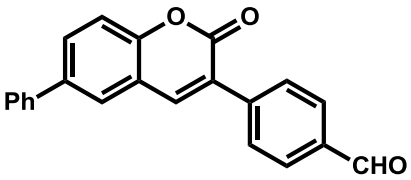
124.1 (d, *J* = 3.0 Hz), 119.6, 116.8, 115.8 (d, *J* = 13.5 Hz), 115.6 (d, *J* = 15.5 Hz).; HRMS (EI^+) m/z calcd. for $C_{21}H_{13}FO_2^+$ $[M]^+$: 316.0900, found: 316.0897.



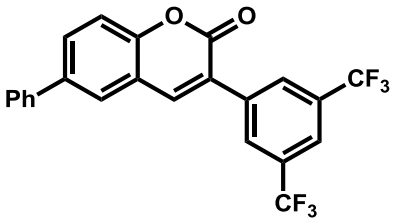
3-(4-Nitrophenyl)-6-phenyl-2H-chromen-2-one (4g). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(4-nitrophenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 16 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (37.5 mg, 62%); mp 216-219 ^oC.; ^1H NMR (400 MHz, Chloroform-d) δ 8.30 (d, *J* = 8.7 Hz, 2H), 7.99 (s, 1H), 7.92 (d, *J* = 8.6 Hz, 2H), 7.80 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.77 (s, 1H), 7.58 (d, *J* = 7.2 Hz, 2H), 7.53–7.43 (m, 3H), 7.40 (t, *J* = 7.3 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 159.8, 153.2, 147.8, 141.7, 141.0, 139.2, 138.3, 131.5, 129.5, 129.1, 128.0, 127.0, 126.4, 126.4, 123.7, 119.3, 117.0.; HRMS (EI^+) m/z calcd. for $C_{21}H_{13}NO_4^+$ $[M]^+$: 343.0845, found: 343.0847.



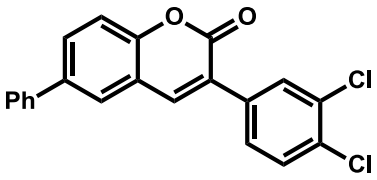
3-(4-Acetylphenyl)-6-phenyl-2H-chromen-2-one (4h). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(4-acetylphenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 12 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product. (34.1 mg, 63%); mp 176-178 ^oC.; ^1H NMR (400 MHz, Chloroform-d) δ 8.02 (d, *J* = 8.4 Hz, 2H), 7.93 (s, 1H), 7.82 (d, *J* = 8.4 Hz, 2H), 7.78–7.71 (m, 2H), 7.58 (d, *J* = 6.9 Hz, 2H), 7.46 (t, *J* = 7.5 Hz, 2H), 7.42 (d, *J* = 8.5 Hz, 1H), 7.41–7.35 (m, 1H), 2.62 (s, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 197.5, 160.1, 153.0, 140.8, 139.3, 139.1, 138.1, 137.0, 130.9, 129.0, 128.7, 128.4, 127.9, 127.4, 127.0, 126.3, 119.5, 116.9, 26.7.; HRMS (EI^+) m/z calcd. for $C_{23}H_{16}O_3^+$ $[M]^+$: 340.1099, found: 340.1097.



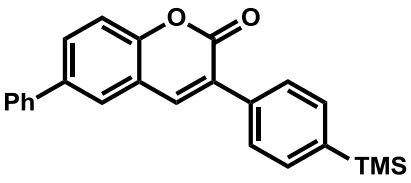
4-(2-Oxo-6-phenyl-2H-chromen-3-yl)benzaldehyde (4i). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(4-formylphenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 10 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (40.4 mg, 70%); mp 171-173 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 10.06 (s, 1H), 7.96 (d, *J* = 2.2 Hz, 3H), 7.90 (d, *J* = 8.3 Hz, 2H), 7.78 (dd, *J* = 8.5, 2.2 Hz, 1H), 7.75 (d, *J* = 2.1 Hz, 1H), 7.61–7.55 (m, 2H), 7.51–7.43 (m, 3H), 7.42–7.36 (m, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 191.6, 159.9, 153.1, 141.2, 140.5, 139.3, 138.2, 136.2, 131.1, 129.7, 129.2, 129.4, 127.9, 127.3, 127.0, 126.3, 119.5, 116.9.; HRMS (EI^{+}) m/z calcd. for $C_{22}H_{14}O_3^{+}$ $[M]^{+}$: 326.0943, found: 326.0943.



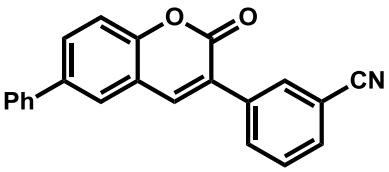
3-(3,5-Bis(trifluoromethyl)phenyl)-6-phenyl-2H-chromen-2-one (4j). 4-Phenylcyclohexanone (34.8 mg, 0.200 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(3,5-bis(trifluoromethyl)phenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 19 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (48.4 mg, 56%); mp 116-118 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 8.20 (s, 2H), 8.00 (s, 1H), 7.92 (s, 1H), 7.82 (dd, *J* = 8.5, 2.2 Hz, 1H), 7.79 (d, *J* = 2.2 Hz, 1H), 7.59 (d, *J* = 6.9 Hz, 2H), 7.48 (t, *J* = 7.5 Hz, 3H), 7.40 (t, *J* = 7.3 Hz, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 159.7, 153.1, 141.6, 139.1, 138.4, 136.6, 131.9 (q, *J* = 33.0 Hz), 131.5, 129.1, 128.7, 128.0, 127.0, 126.4, 125.7, 123.1 (q, *J* = 272.0 Hz), 122.5, 119.2, 117.1.; HRMS (EI^{+}) m/z calcd. for $C_{23}H_{12}F_6O_2^{+}$ $[M]^{+}$: 434.0741, found: 434.0742.



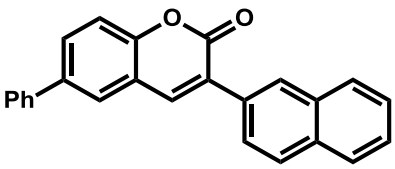
3-(3,4-Dichlorophenyl)-6-phenyl-2H-chromen-2-one (4k). 4-Phenylcyclohexanone (34.8 mg, 0.200 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(3,4-dichlorophenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 10 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (47.3 mg, 65%); mp 164-166 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.86 (s, 1H), 7.82 (d, *J* = 2.1 Hz, 1H), 7.75 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.71 (d, *J* = 2.2 Hz, 1H), 7.60–7.54 (m, 3H), 7.49 (d, *J* = 6.9 Hz, 1H), 7.47 (d, *J* = 8.0 Hz, 1H), 7.45 (d, *J* = 6.3 Hz, 1H), 7.42–7.36 (m, 2H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 159.9, 152.9, 140.4, 139.2, 138.1, 134.4, 133.1, 132.7, 130.9, 130.4, 130.3, 129.0, 127.9, 127.8, 127.0, 126.2, 126.1, 119.4, 116.9.; HRMS (EI^{+}) m/z calcd. for $C_{21}H_{12}Cl_2O_2^{+}$ $[M]^{+}$: 366.0214, found: 366.0218.



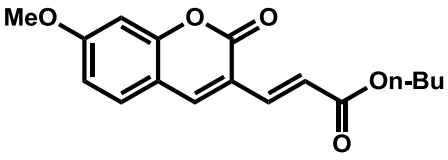
6-Phenyl-3-(4-(trimethylsilyl)phenyl)-2H-chromen-2-one (4l). 4-Phenylcyclohexanone (34.8 mg, 0.200 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(4-(trimethylsilyl)phenyl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 15 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (42.6 mg, 58%); mp 152-155 ^{o}C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.86 (s, 1H), 7.76–7.67 (m, 4H), 7.64–7.57 (m, 4H), 7.47 (t, *J* = 7.5 Hz, 2H), 7.44–7.35 (m, 2H), 0.30 (s, 9H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.5, 152.9, 141.6, 139.7, 139.5, 137.8, 135.0, 133.5, 130.3, 129.0, 128.7, 127.7, 127.7, 127.0, 126.1, 119.9, 116.8, -1.2.; HRMS (EI^{+}) m/z calcd. for $C_{24}H_{22}O_2Si^{+}$ $[M]^{+}$: 370.1389, found: 370.1385.



3-(2-Oxo-6-phenyl-2H-chromen-3-yl)benzonitrile (4m). 4-Phenylcyclohexanone (34.8 mg, 0.200 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(3-cyanophenyl)acrylate (1.2 eq) was added and the reaction mixture was stirred for 12 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (26.5 mg, 41%); mp 140-143 °C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 8.02 (t, *J* = 1.6 Hz, 1H), 7.98 (dt, *J* = 7.7, 1.4 Hz, 1H), 7.92 (s, 1H), 7.79 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.75 (d, *J* = 2.1 Hz, 1H), 7.69 (dt, *J* = 7.7, 1.4 Hz, 1H), 7.61–7.54 (m, 3H), 7.52–7.42 (m, 3H), 7.43–7.36 (m, 1H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 159.9, 153.0, 141.0, 139.2, 138.3, 135.9, 132.9, 132.2, 132.1, 131.2, 129.3, 129.1, 127.9, 127.0, 126.4, 126.3, 119.4, 117.0, 112.9.; HRMS (EI^{+}) m/z calcd. for $C_{22}H_{13}NO_2^{+}$ $[M]^{+}$: 323.0946, found: 323.0947.

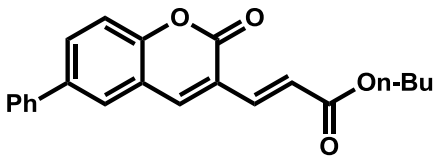


3-(Naphthalen-2-yl)-6-phenyl-2H-chromen-2-one (4n). 4-Phenylcyclohexanone (31.0 mg, 0.178 mmol) was oxidized to phenol according to GP for 7 h. Methyl 2-(naphthalen-2-yl)acrylate (1.2 eq) was added, and the reaction mixture was stirred for 28 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product**.** (37.8 mg, 61%); mp 155-158 °C.; ^{1}H NMR (400 MHz, Chloroform-d) δ 8.24 (d, *J* = 1.7 Hz, 1H), 7.96 (s, 1H), 7.93–7.88 (m, 2H), 7.86–7.83 (m, 1H), 7.79 (dd, *J* = 8.6, 1.8 Hz, 1H), 7.74 (dd, *J* = 8.0, 1.8 Hz, 1H), 7.73 (s, 1H), 7.63–7.57 (m, 2H), 7.54–7.37 (m, 6H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 160.6, 152.8, 140.1, 139.5, 137.8, 133.3, 133.1, 132.0, 130.3, 129.0, 128.5, 128.1, 128.0, 127.,3 127.6, 127.0, 126.7, 126.4, 126.1, 125.8, 119.9, 116.8.; HRMS (EI^{+}) m/z calcd. for $C_{25}H_{16}O_2^{+}$ $[M]^{+}$: 348.1150, found: 348.1148.



3-*n*-Butylacrylated 7-methoxycoumarin (5a). 3-Methoxycyclohexanone (30.0 mg, 0.234 mmol), $Pd(TFA)_2$ (0.3 eq) and $Cu(OAc)_2$ (1.0 eq) were combined in 1,4-dioxane : PivOH (5 : 1) under O_2. The reaction mixture was heated to 110 °C. The mixture was monitored by TLC using EtOAc and *n*-hexane as the mobile phase. *n*-Butylacrylate (1.2 eq) was then added to the reaction mixture. After 10 h, *n*-butylacrylate (2 eq) and K_2CO_3 (3 eq) were added and stirred for another 8 h. The residue was purified by flash column chromatography (EtOAc and *n*-

hexane) to produce the desired product (23.8 mg, 33%); ^{1}H NMR(400 MHz, Chloroform-d) δ 7.79 (s, 1H), 7.51 (dd, *J* = 15.9, 0.6 Hz, 1H), 7.42 (d, *J* = 8.6 Hz, 1H), 7.02 (d, *J* = 15.8 Hz, 1H), 6.86 (dd, *J* = 8.6, 2.4 Hz, 1H), 6.81 (d, *J* = 2.5 Hz, 1H), 4.18 (t, *J* = 6.6 Hz, 2H), 3.88 (s, 3H), 1.70–1.62 (m, 2H), 1.46–1.36 (m, 2H), 0.94 (t, *J* = 7.4 Hz, 3H).; ^{13}C NMR (100 MHz, Chloroform-d) δ 167.3, 163.9, 159.3, 155.6, 143.7, 138.2, 129.6, 122.3, 118.9, 113.4, 112.7, 100.5, 64.5, 55.9, 30.8, 19.2, 13.7.; [Ref]. *Chem. Comm.* **2013**, *49*, 196-198.

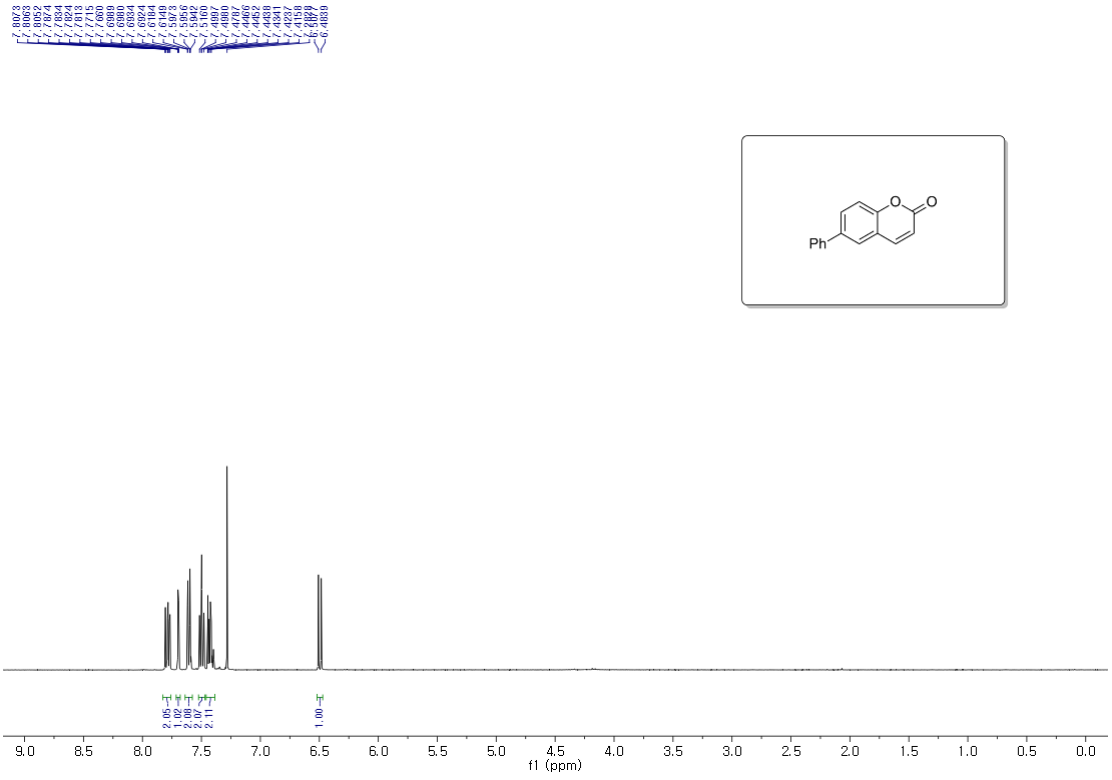


(*E*)-Butyl 3-(2-oxo-6-phenyl-2H-chromen-3-yl)acrylate (5b). 4-Phenylclohexanone (32.8 mg, 0.200 mmol), $Pd(TFA)_2$ (0.3 eq) and $Cu(OAc)_2$ (1.0 eq) were combined in PivOH (0.1 M) under O_2. The reaction mixture was heated to 110 ^{o}C. The mixture was monitored by TLC using EtOAc and *n*-hexane. *n*-Butylacrylate (1.2 eq) was added to the reaction mixture. After 12 h, *n*-butylacrylate (2 eq) and K_2CO_3 (3 eq) were added and stirred for another 9 h. The residue was purified by flash column chromatography (EtOAc and *n*-hexane) to produce the desired product (26.1 mg, 38%); mp 135-138 ^{o}C.; ^{1}H NMR (400 MHz, Methylene Chloride-d_2) δ 7.96 (s, 1H), 7.82 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.76 (d, *J* = 2.2 Hz, 1H), 7.64–7.59 (m, 2H), 7.56 (dd, *J* = 15.9, 0.7 Hz, 1H), 7.52–7.46 (m, 2H), 7.44–7.37 (m, 2H), 7.05 (d, *J* = 15.9 Hz, 1H), 4.20 (t, *J* = 6.7 Hz, 2H), 1.74–1.64 (m, 2H), 1.51–1.38 (m, 2H), 0.97 (t, *J* = 7.4 Hz, 3H).; ^{13}C NMR (100 MHz, Methylene Chloride-d_2) δ 167.0, 159.3, 153.3, 143.9, 139.5, 138.3, 138.0, 132.0, 129.4, 128.2, 127.3, 126.9, 123.9, 123.0, 119.6, 117.2, 64.9, 31.1, 19.6, 13.9.; HRMS (EI^+) m/z calcd. for $C_{22}H_{20}O_4^+$ $[M]^+$: 348.1362, found: 348.1360.

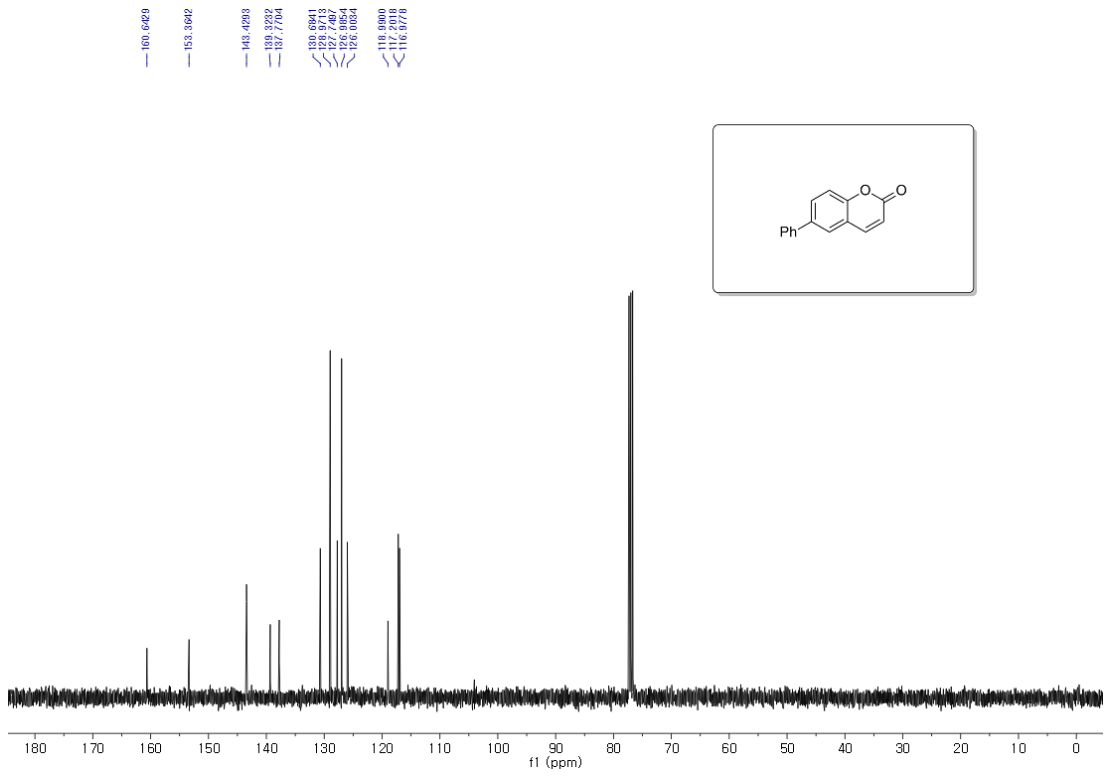
Appendix I

Spectral Copies of ^{1}H and ^{13}C NMR Data Obtained in this Study

6-phenyl-2H-chromen-2-one (3a)

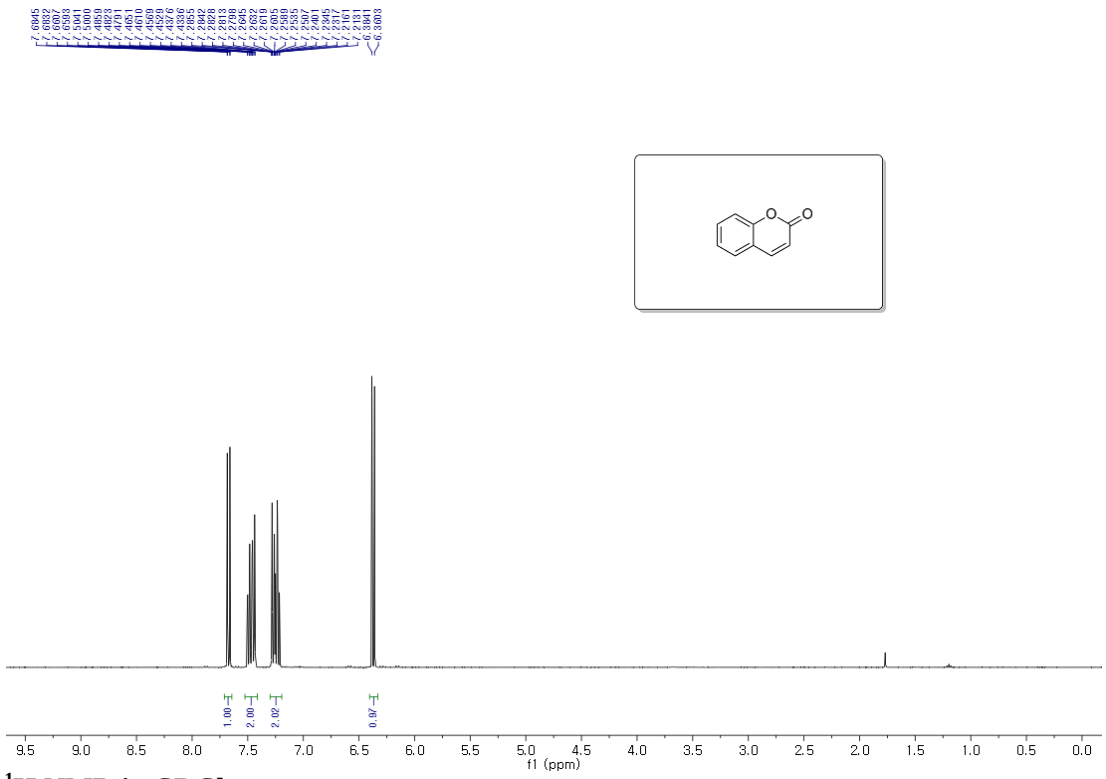


400 MHz, ^{1}H NMR in $CDCl_3$

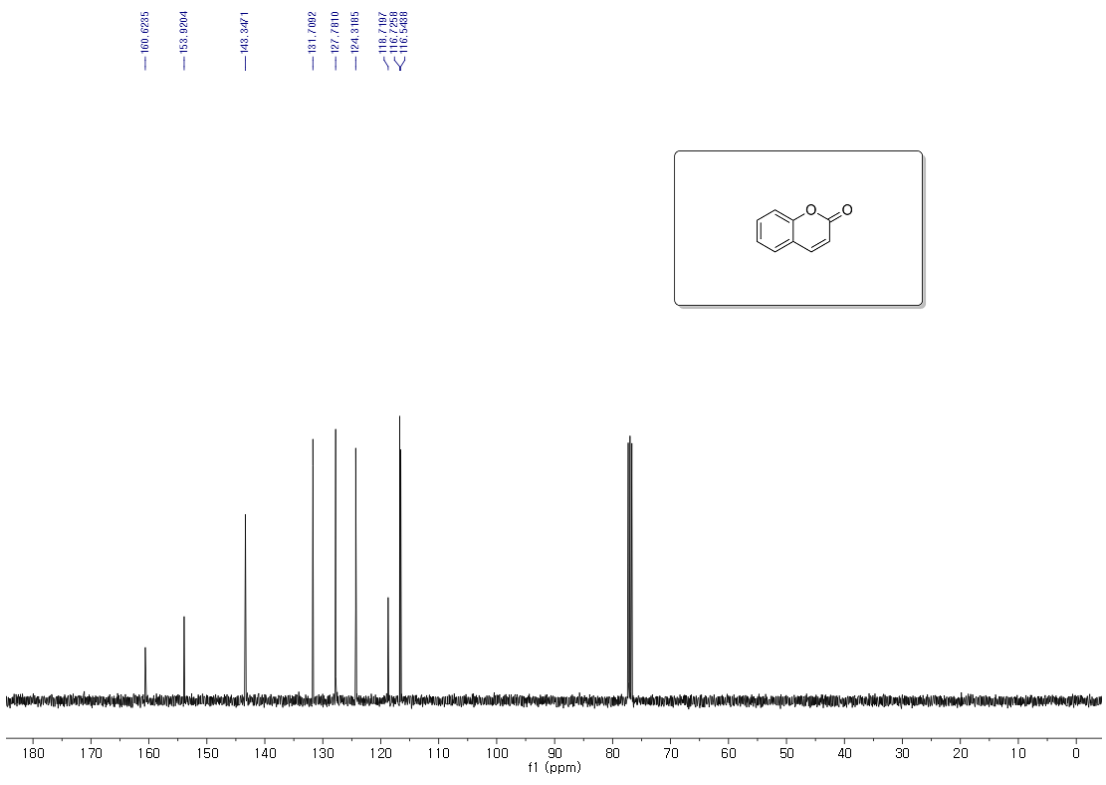


100 MHz, ^{13}C NMR in $CDCl_3$

2H-chromen-2-one (3b)

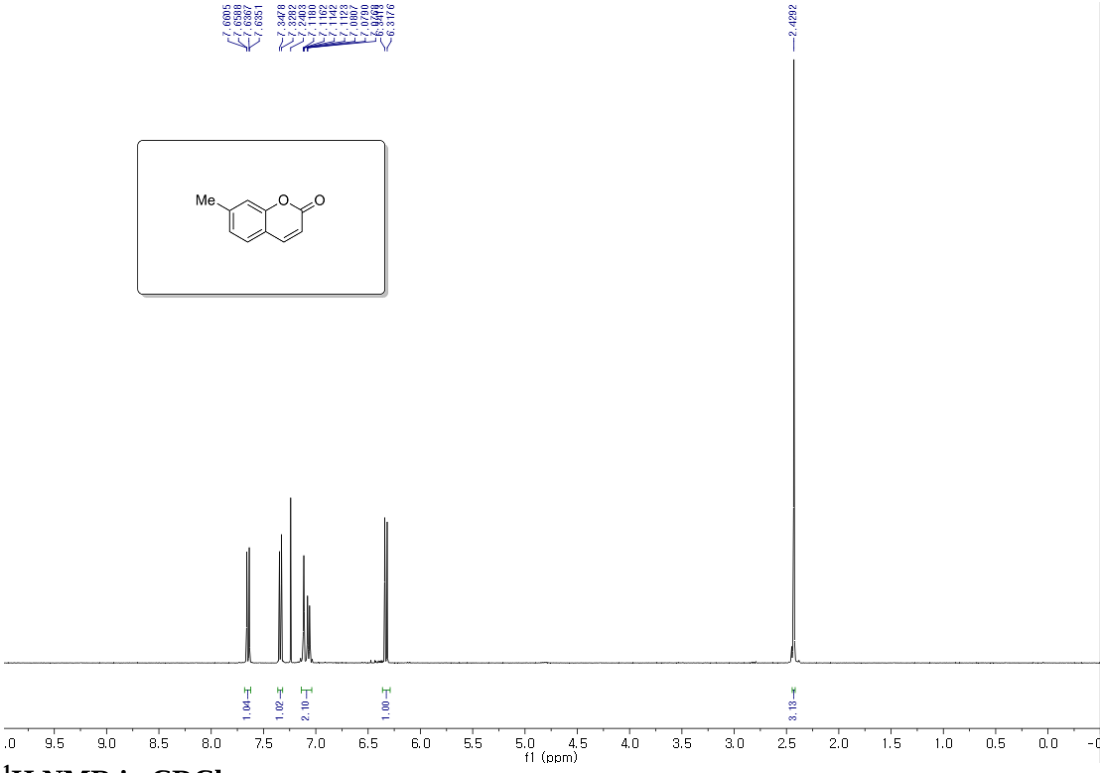


400 MHz, ^{1}H NMR in $CDCl_3$

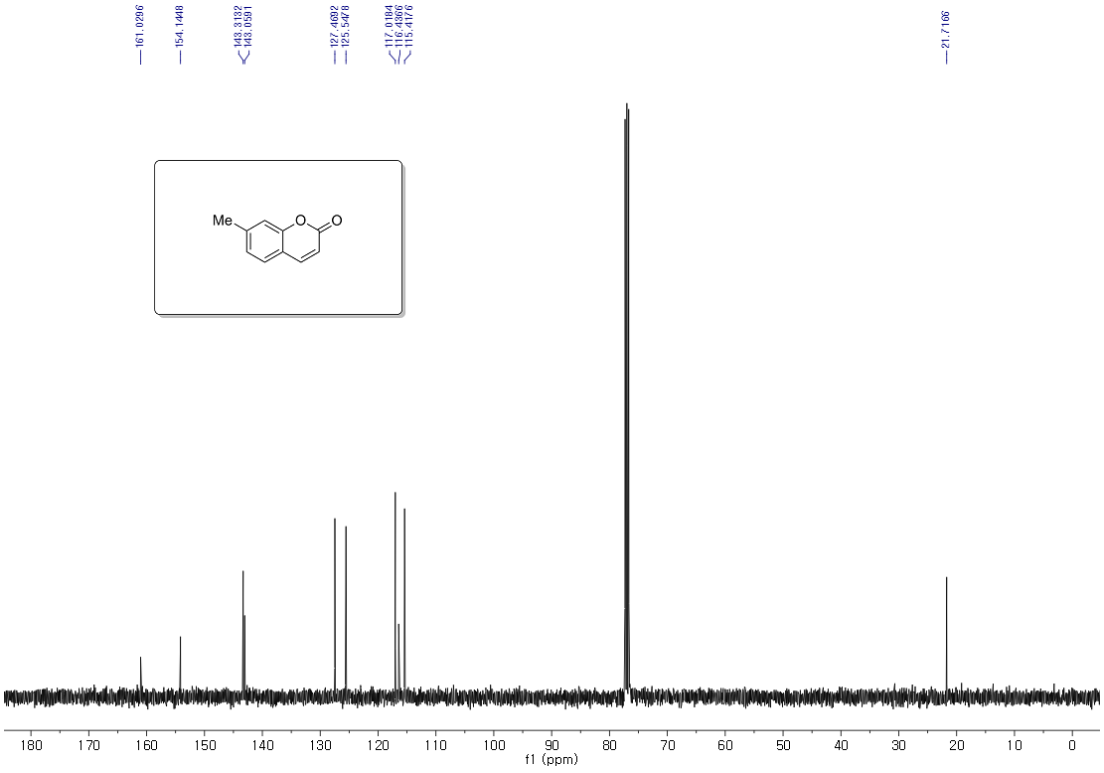


100 MHz, ^{13}C NMR in $CDCl_3$

7-methyl-2H-chromen-2-one (3c)

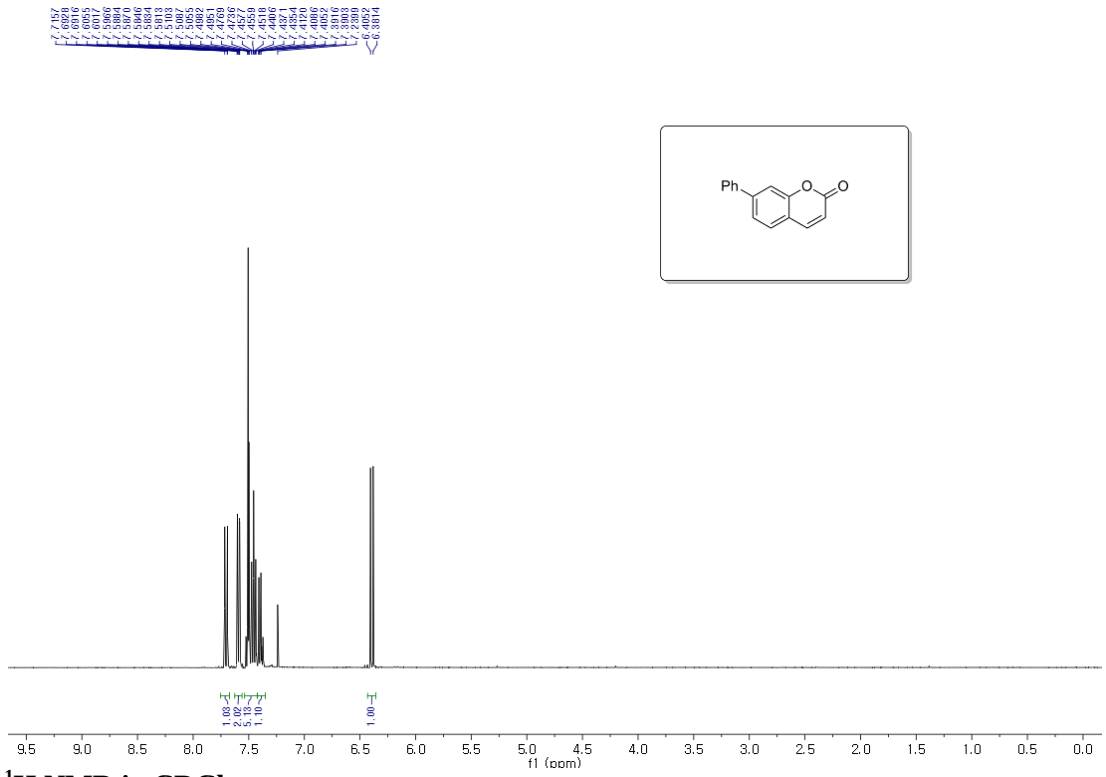


400 MHz, ^{1}H NMR in $CDCl_3$

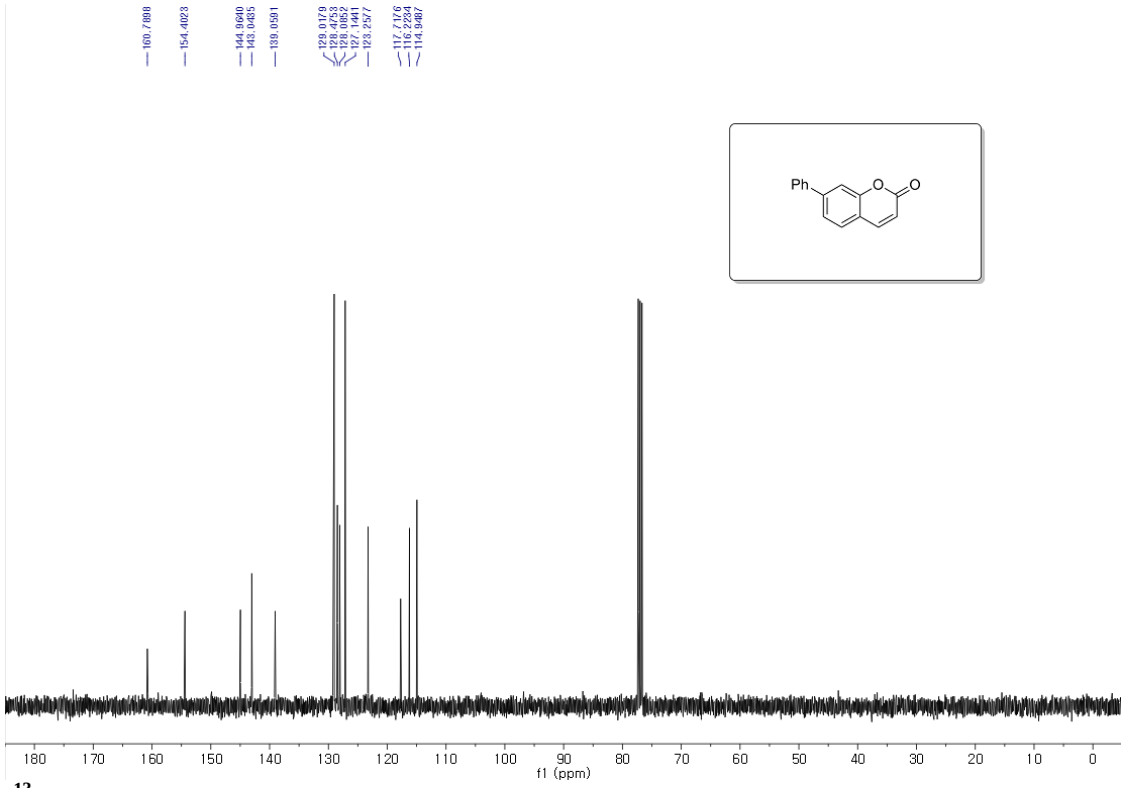


100 MHz, ^{13}C NMR in $CDCl_3$

7-phenyl-2H-chromen-2-one (3d)

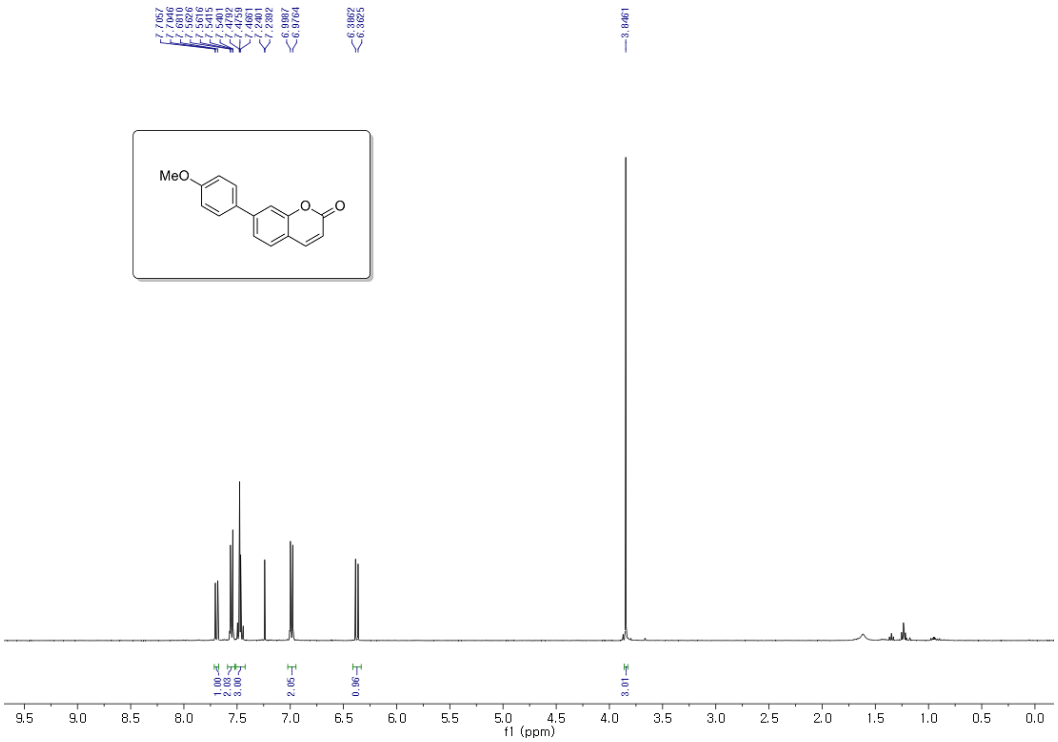


400 MHz, ^{1}H NMR in $CDCl_3$

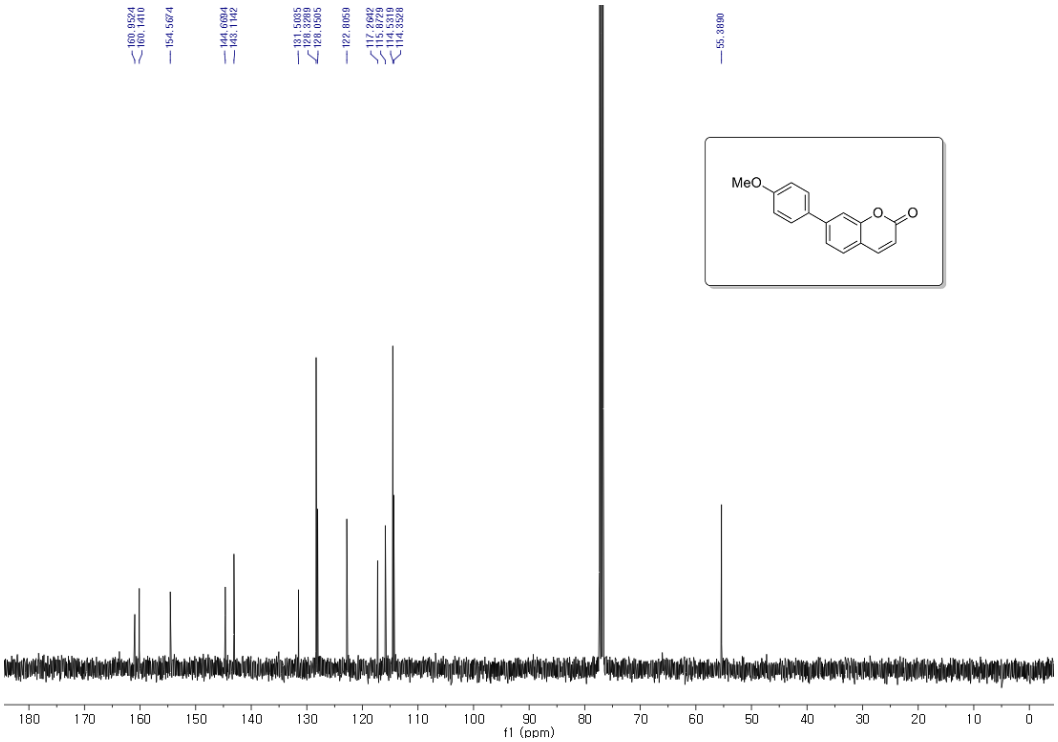


100 MHz, ^{13}C NMR in $CDCl_3$

7-(4-methoxyphenyl)-2H-chromen-2-one (3e)

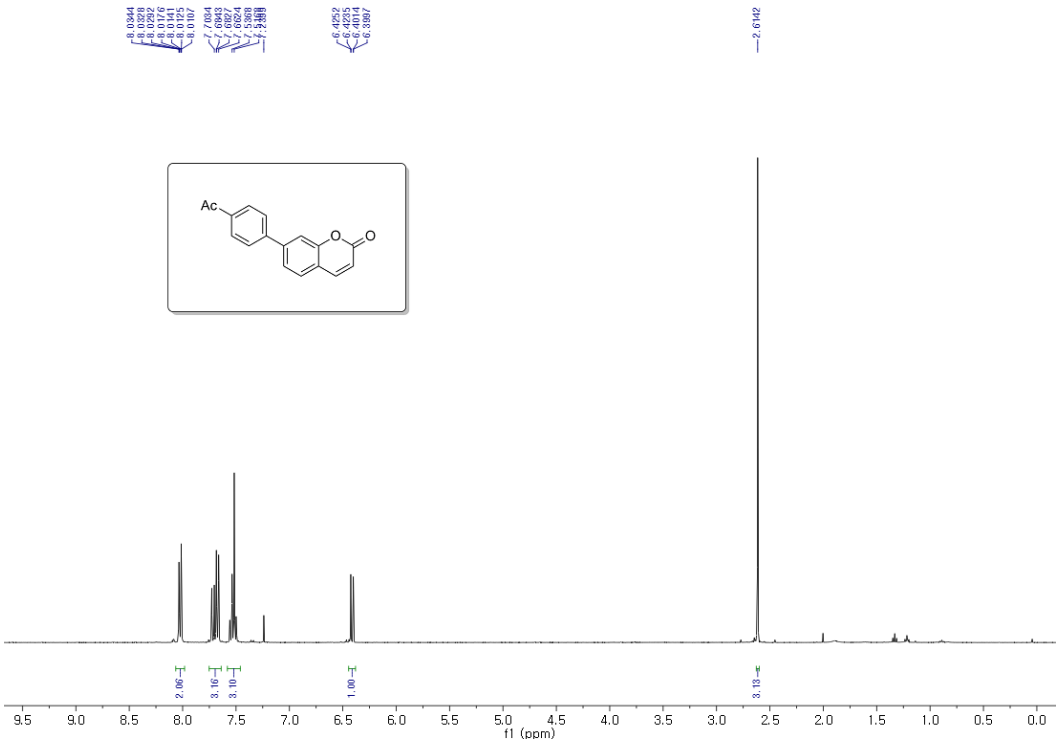


400 MHz, ^{1}H NMR in $CDCl_3$

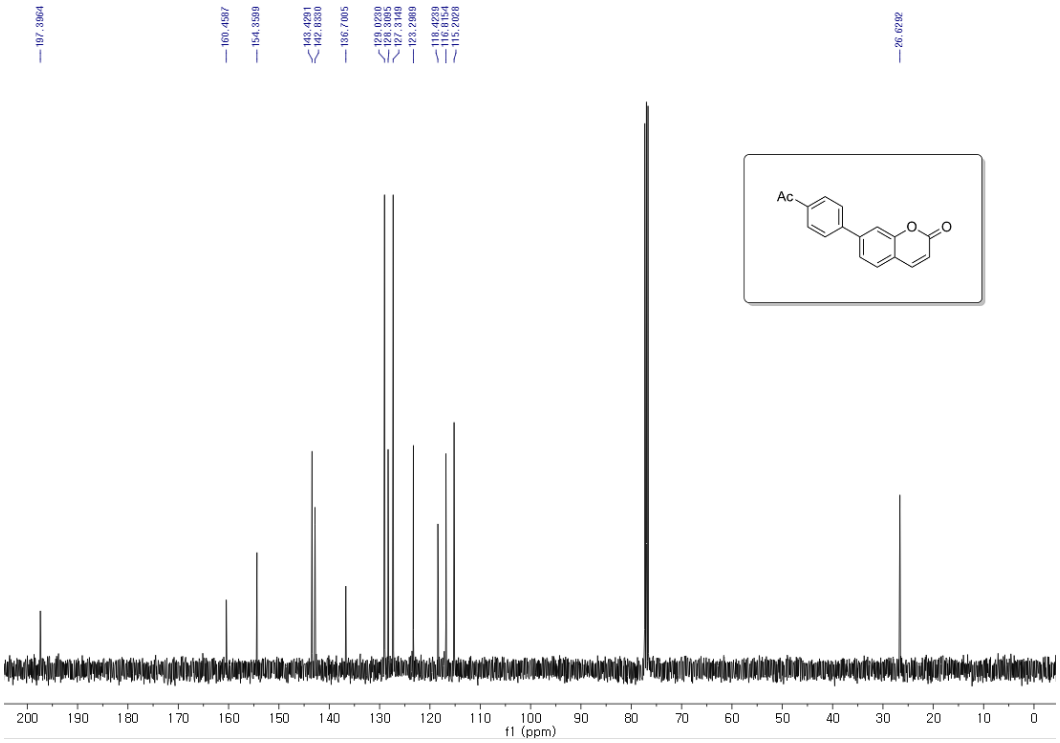


100 MHz, ^{13}C NMR in $CDCl_3$

7-(4-acetylphenyl)-2H-chromen-2-one (3f)

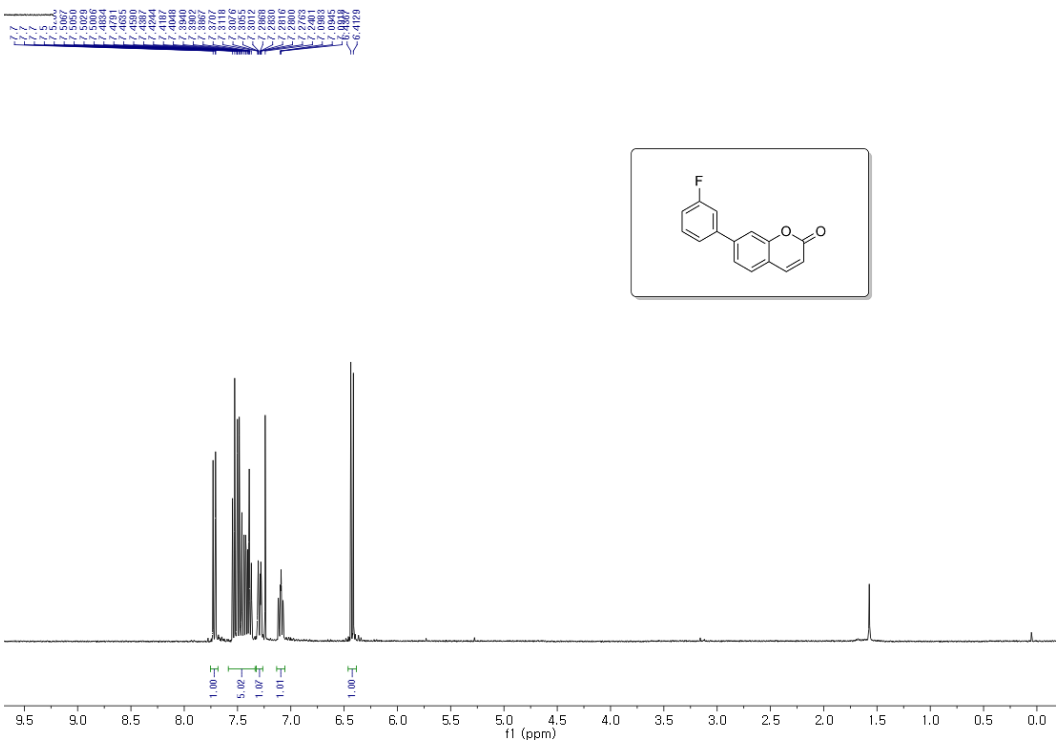


400 MHz, ^{1}H NMR in $CDCl_3$

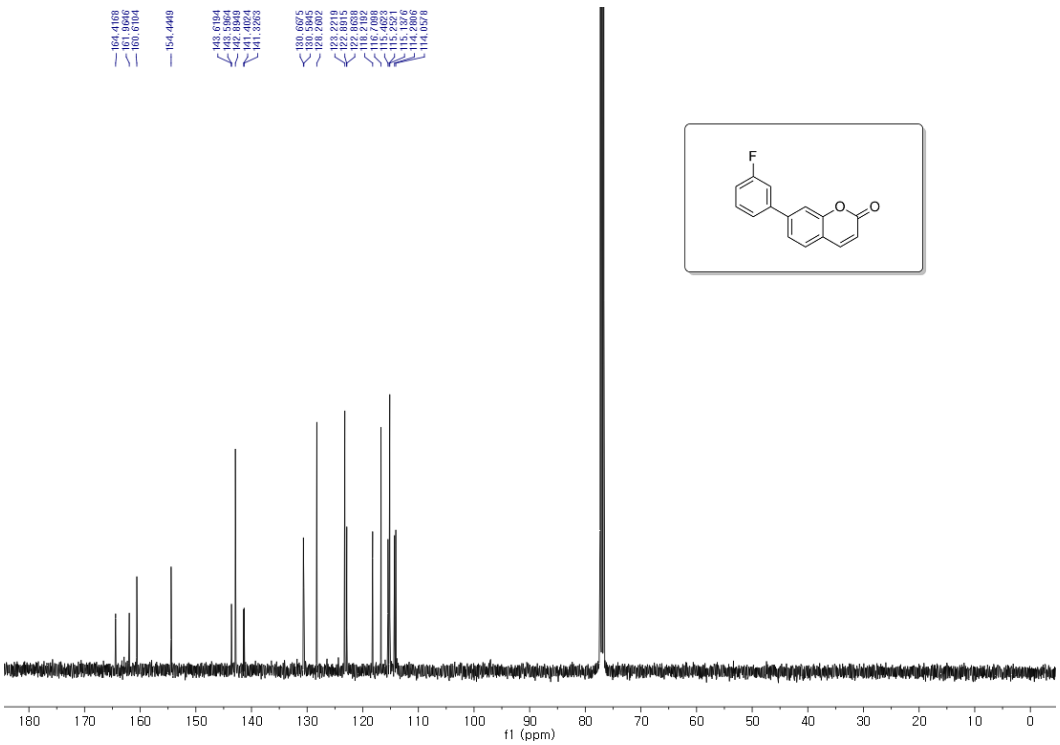


100 MHz, ^{13}C NMR in $CDCl_3$

7-(3-fluorophenyl)-2H-chromen-2-one (3g)

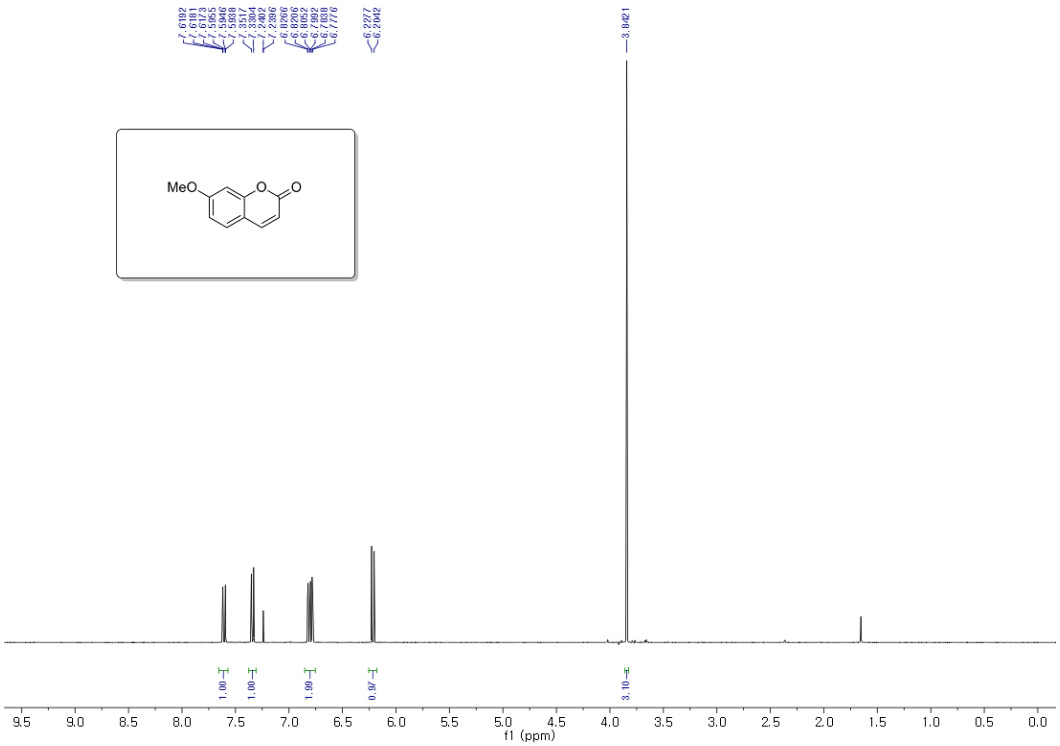


400 MHz, ^{1}H NMR in $CDCl_3$

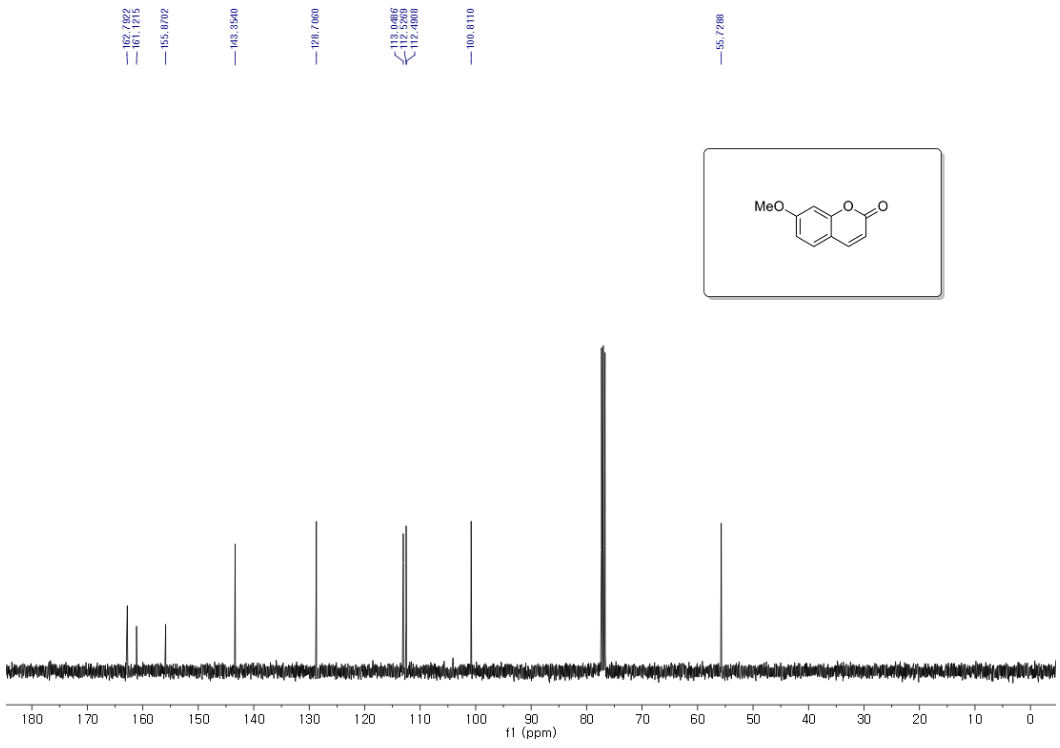


100 MHz, ^{13}C NMR in $CDCl_3$

7-methoxy-2H-chromen-2-one (3h)

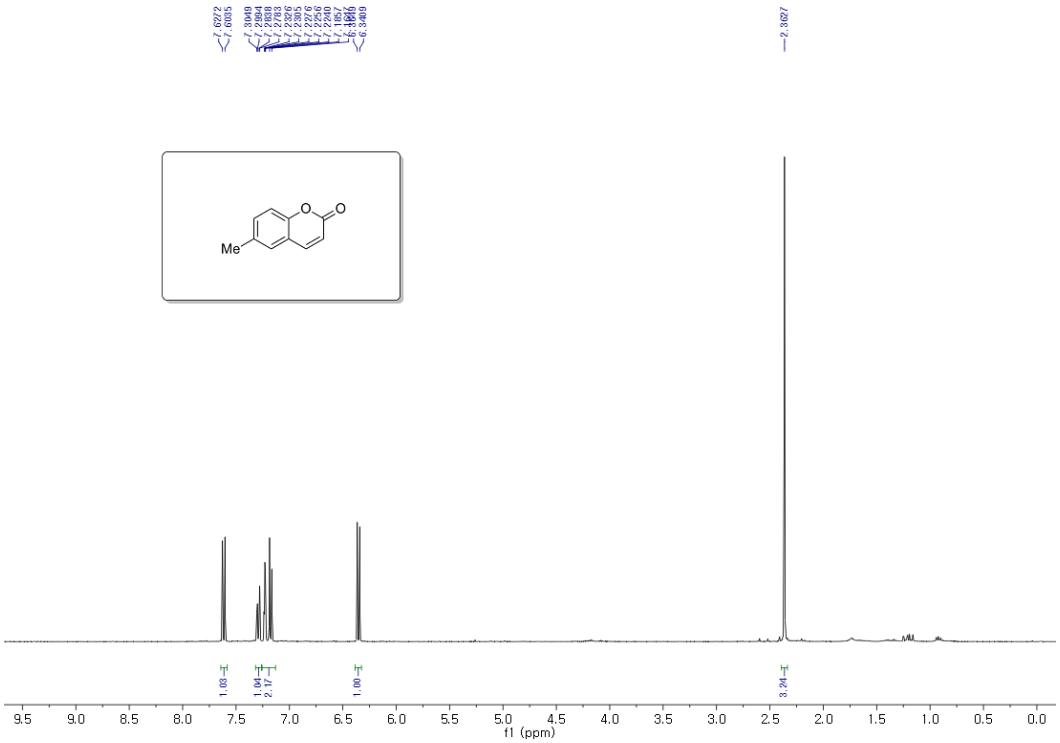


400 MHz, ^{1}H NMR in $CDCl_3$

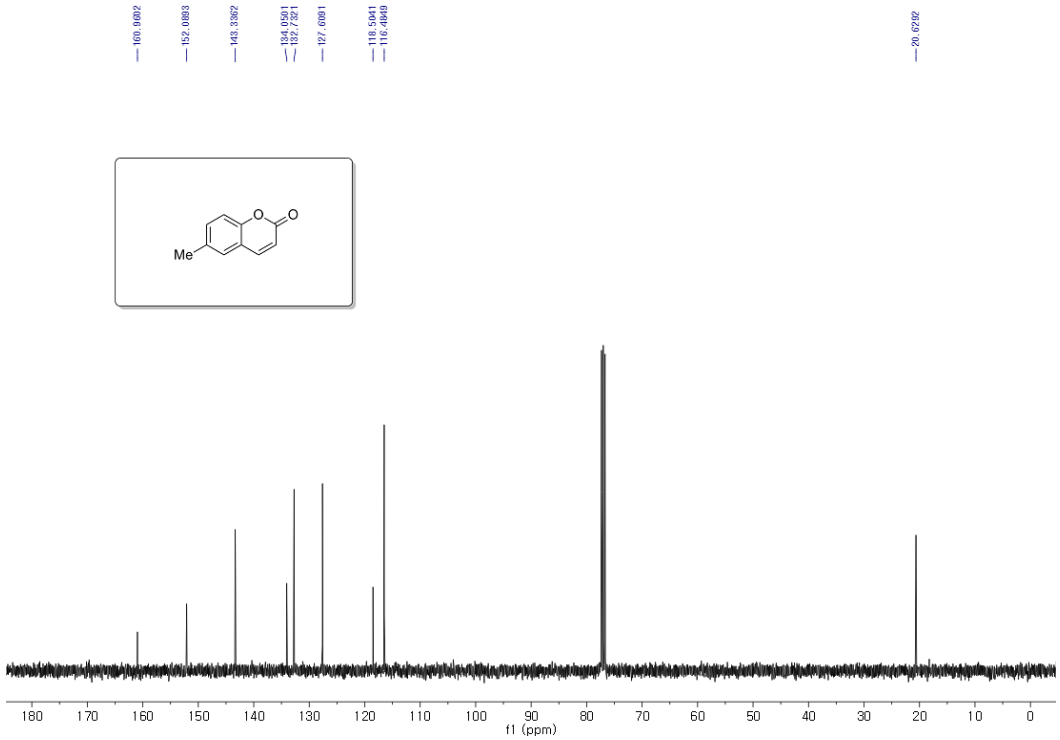


100 MHz, ^{13}C NMR in $CDCl_3$

6-methyl-2H-chromen-2-one (3i)

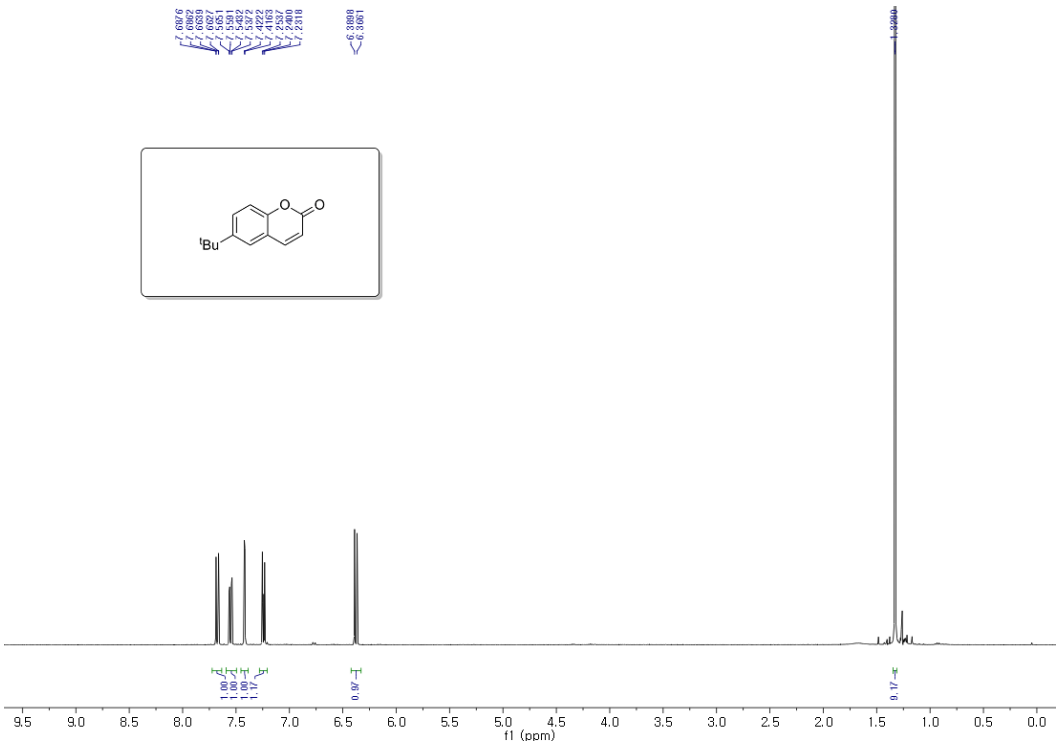


400 MHz, ^{1}H NMR in $CDCl_3$

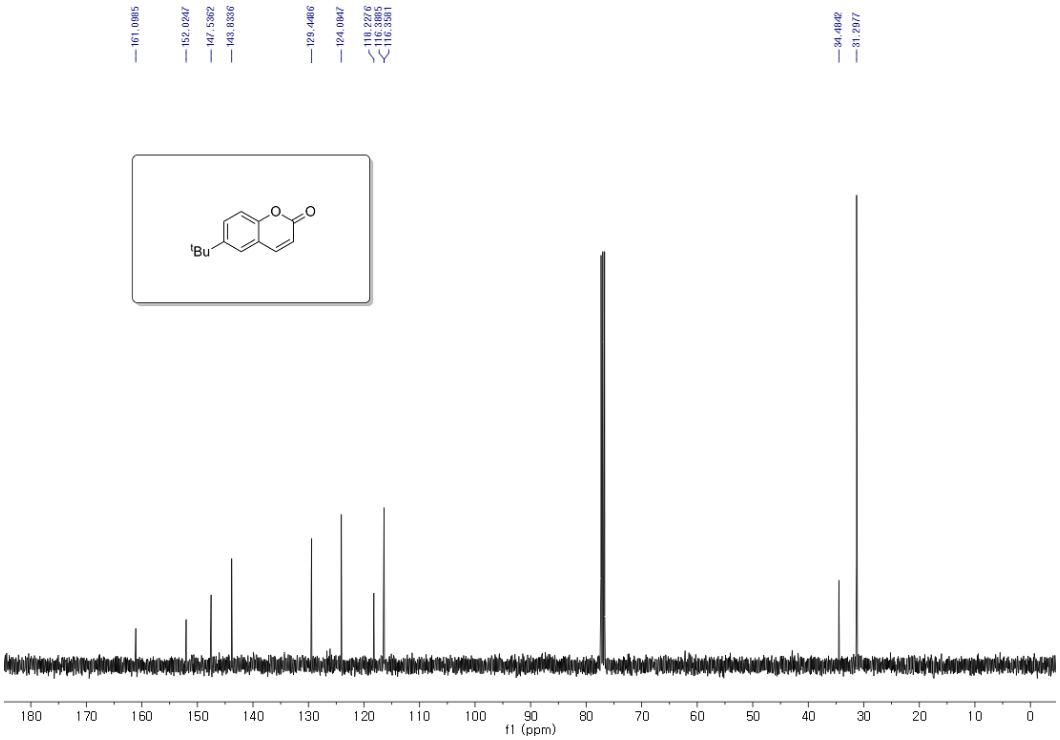


100 MHz, ^{13}C NMR in $CDCl_3$

6-(tert-butyl)-2H-chromen-2-one (3j)

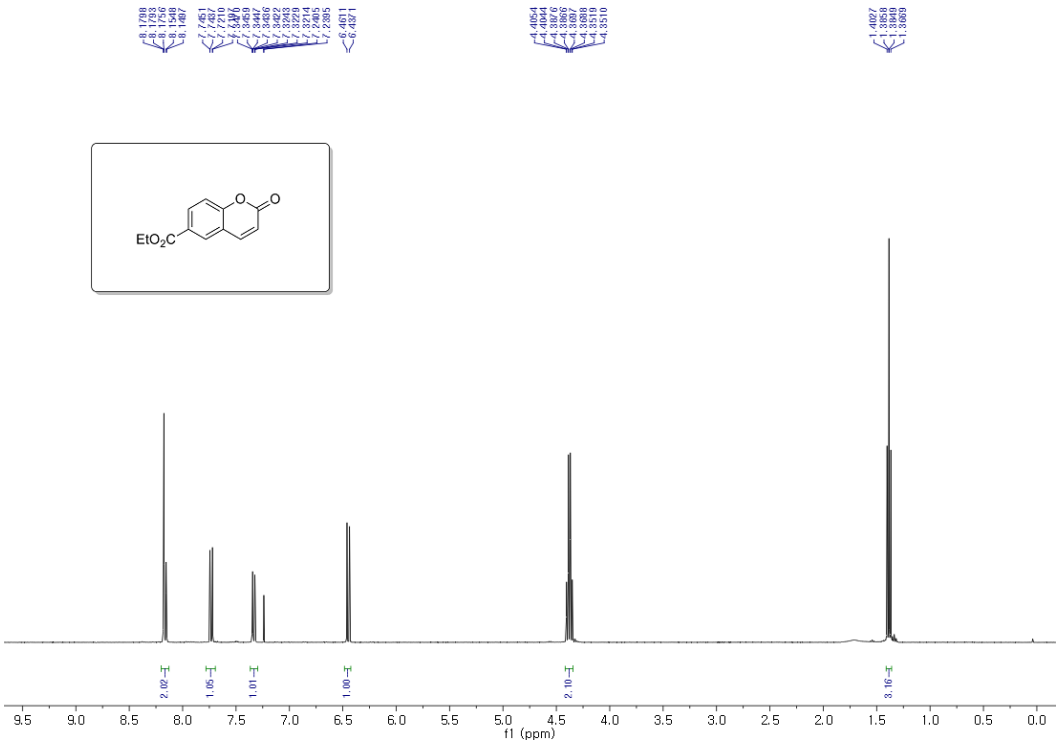


400 MHz, ^{1}H NMR in $CDCl_3$

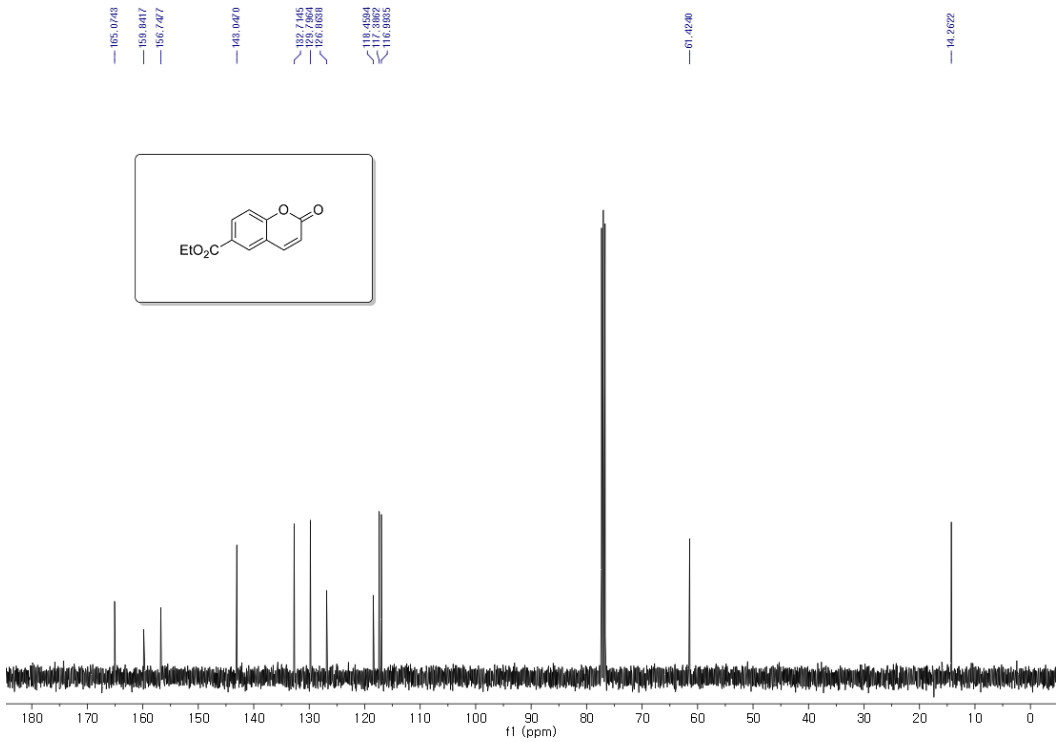


100 MHz, ^{13}C NMR in $CDCl_3$

ethyl 2-oxo-2H-chromene-6-carboxylate (3k)

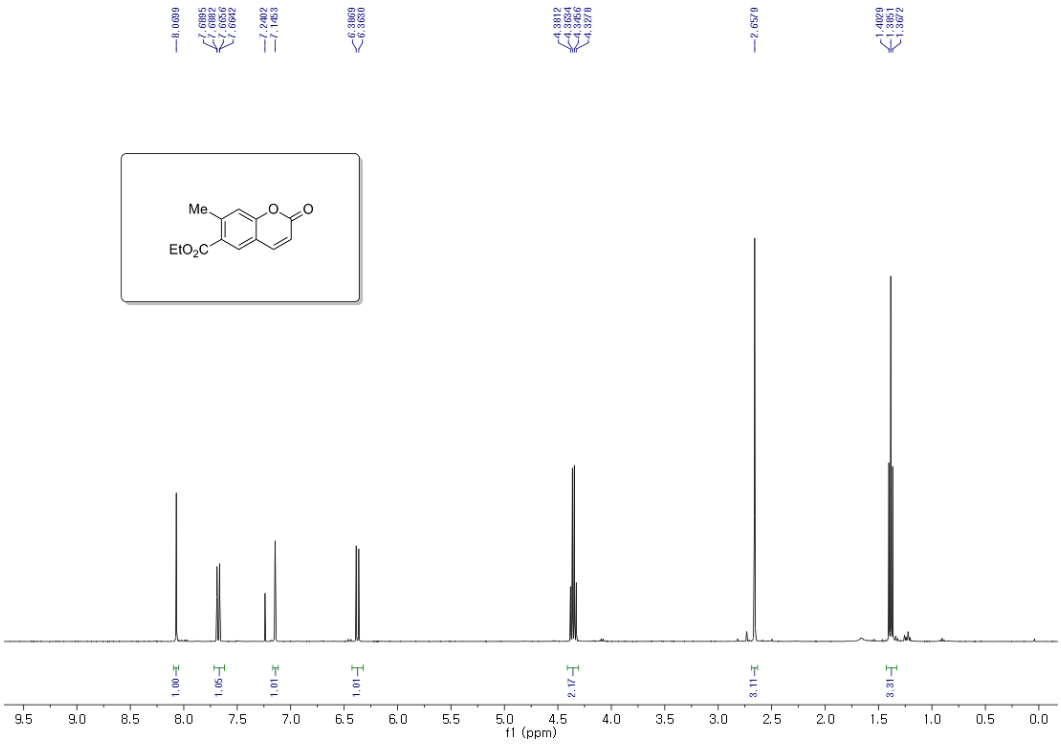


400 MHz, ^{1}H NMR in $CDCl_3$

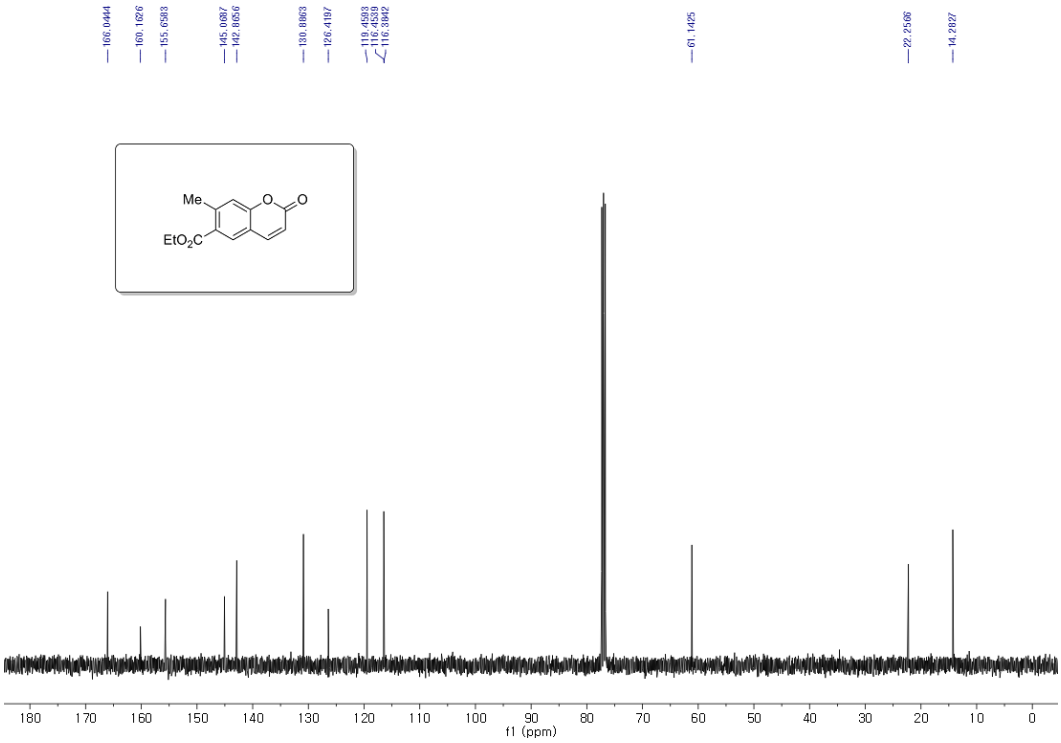


100 MHz, ^{13}C NMR in $CDCl_3$

ethyl 7-methyl-2-oxo-2H-chromene-6-carboxylate (3l)

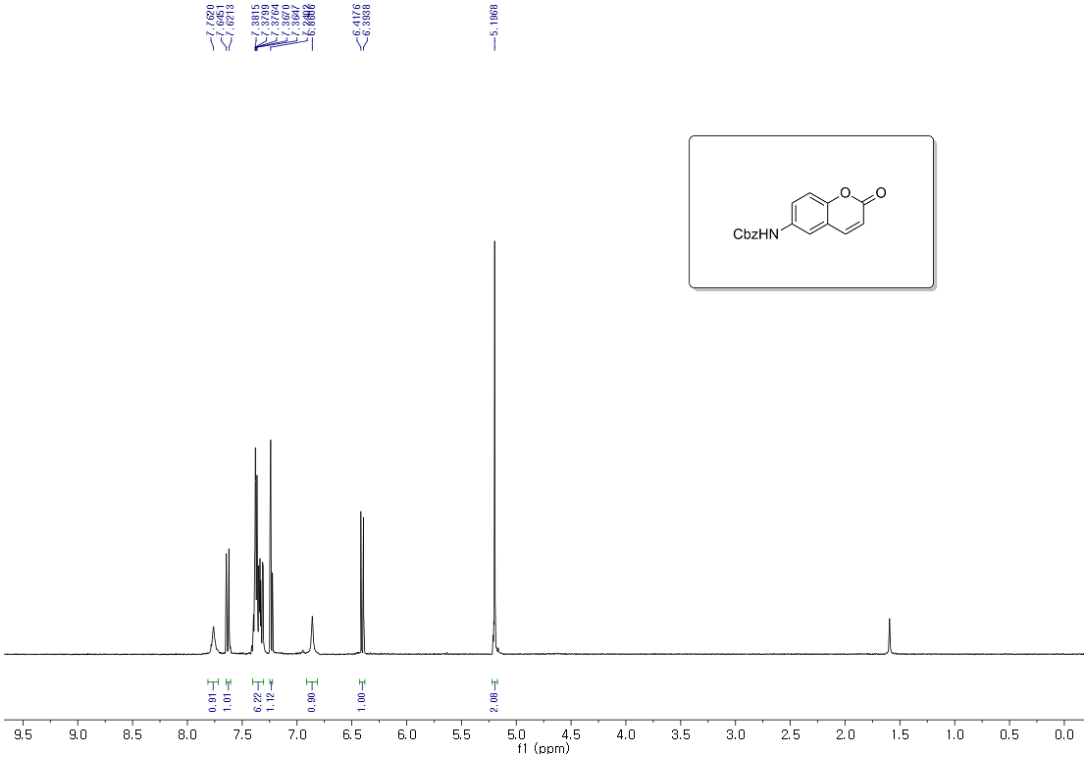


400 MHz, ^{1}H NMR in $CDCl_3$

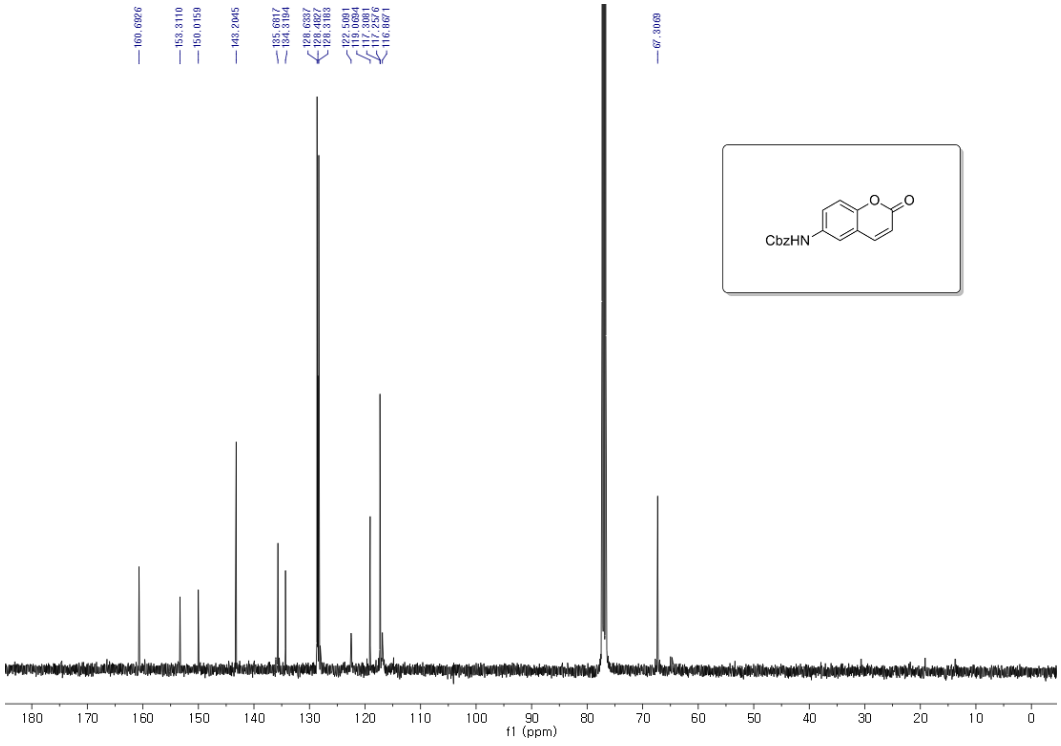


100 MHz, ^{13}C NMR in $CDCl_3$

benzyl (2-oxo-2H-chromen-6-yl)carbamate (3m)

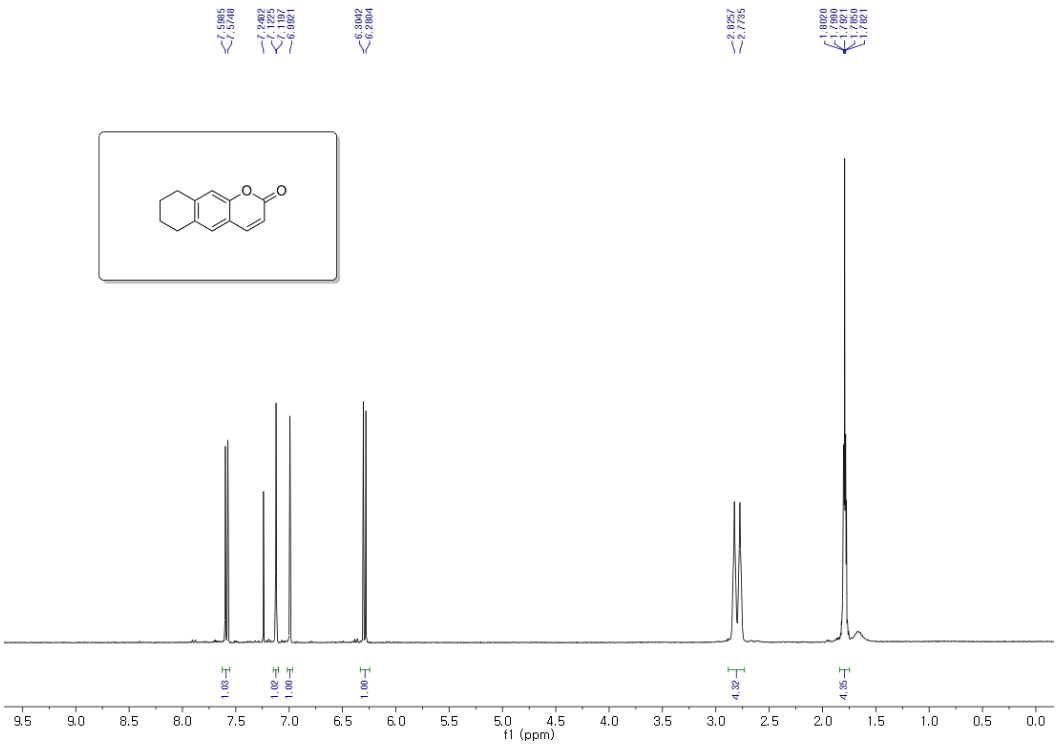


400 MHz, ^{1}H NMR in $CDCl_3$

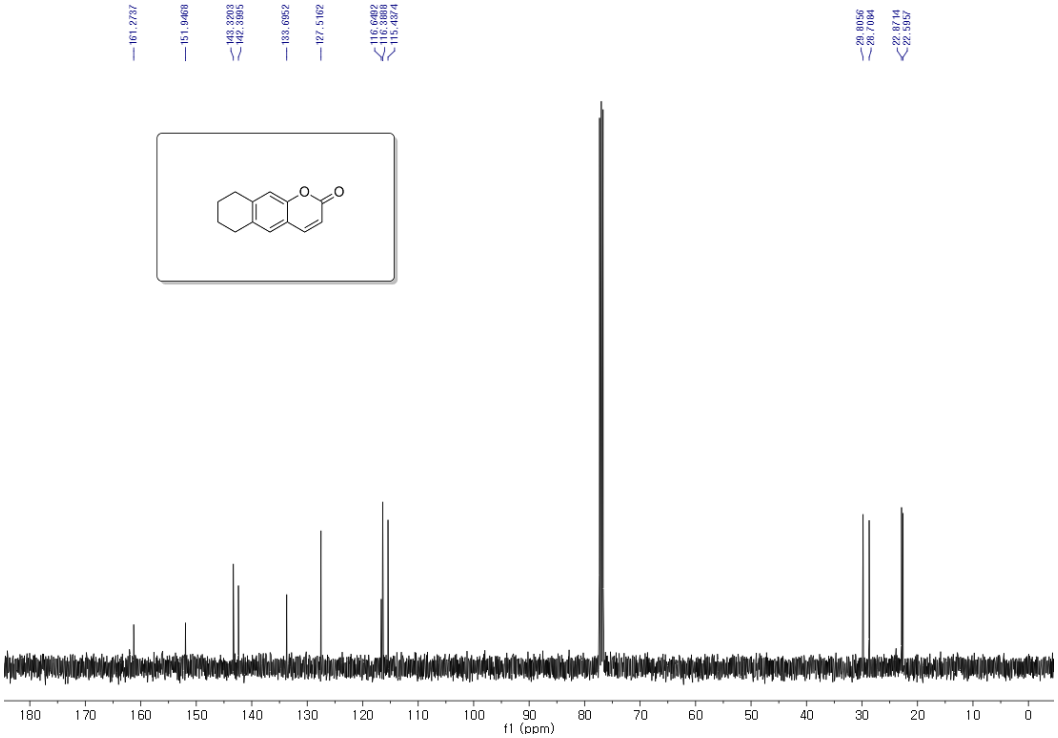


100 MHz, ^{13}C NMR in $CDCl_3$

6,7,8,9-tetrahydro-2H-benzo[g]chromen-2-one (3n)

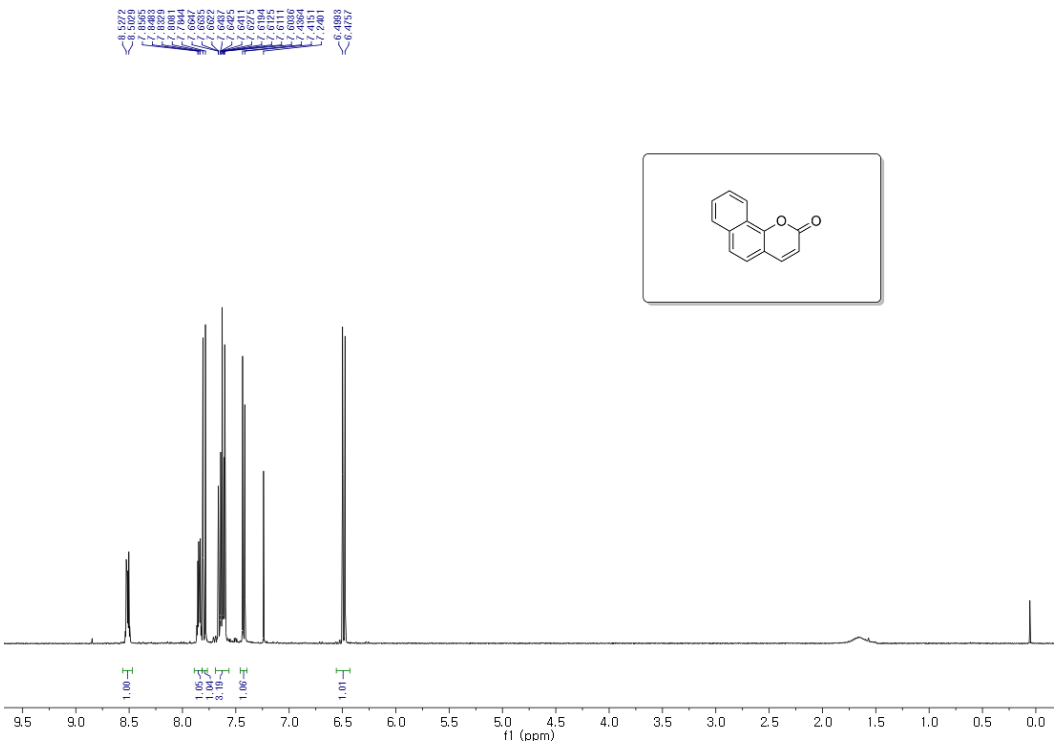


400 MHz, ^{1}H NMR in $CDCl_3$

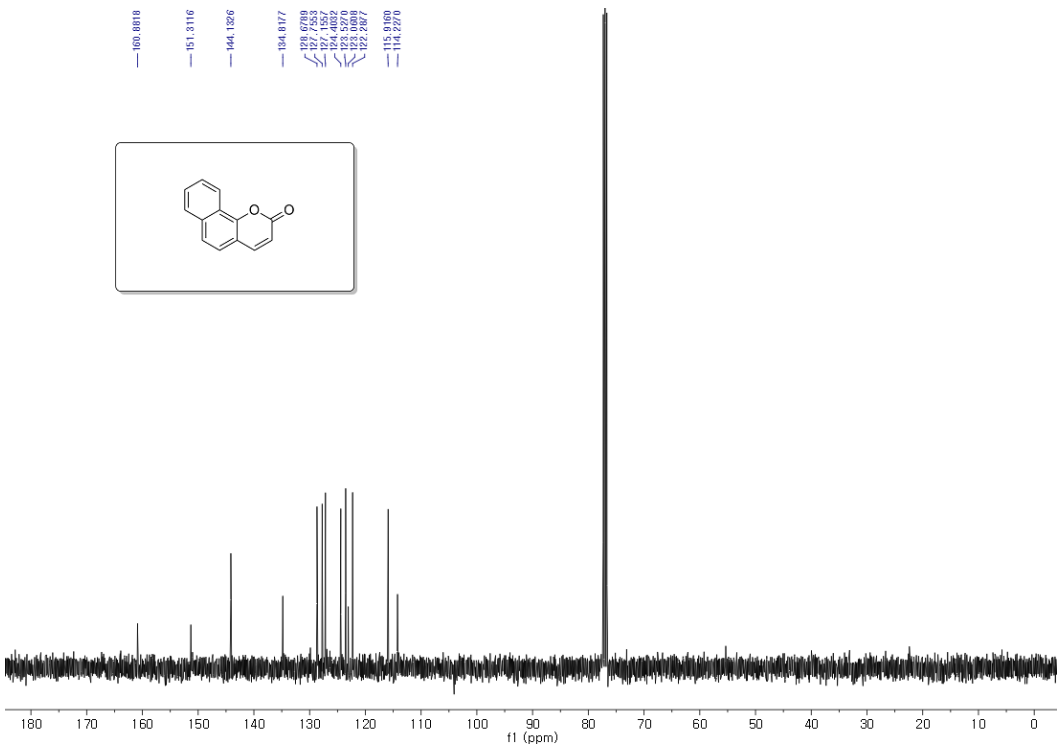


100 MHz, ^{13}C NMR in $CDCl_3$

2H-benzo[h]chromen-2-one (3o)

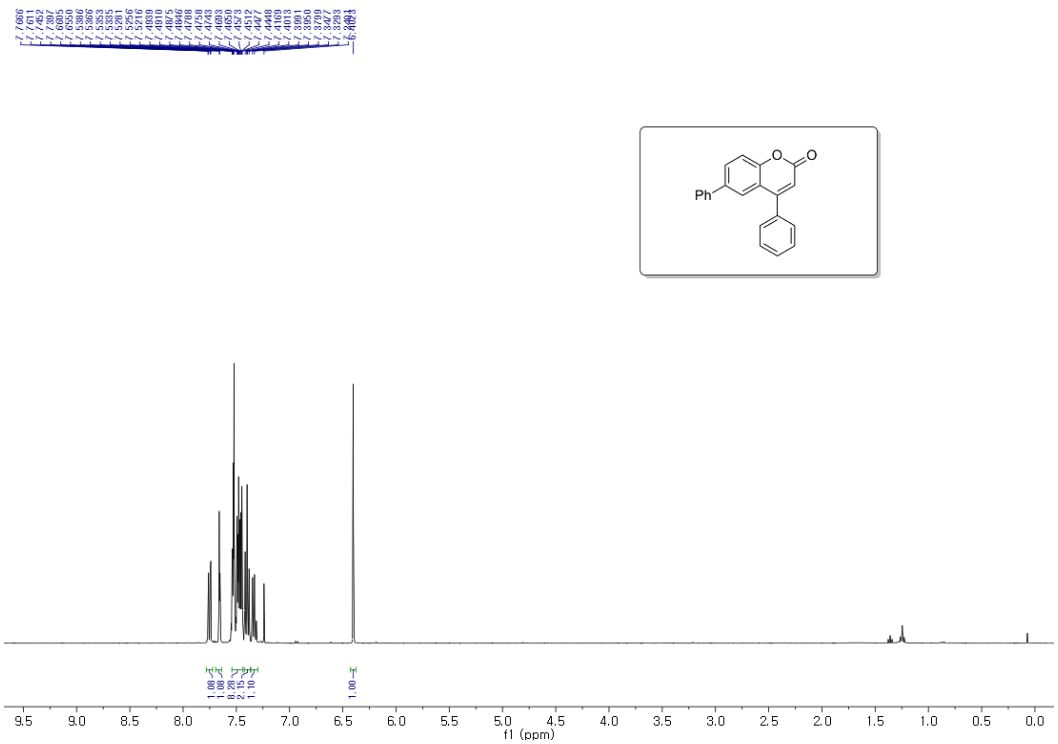


400 MHz, ^{1}H NMR in $CDCl_3$

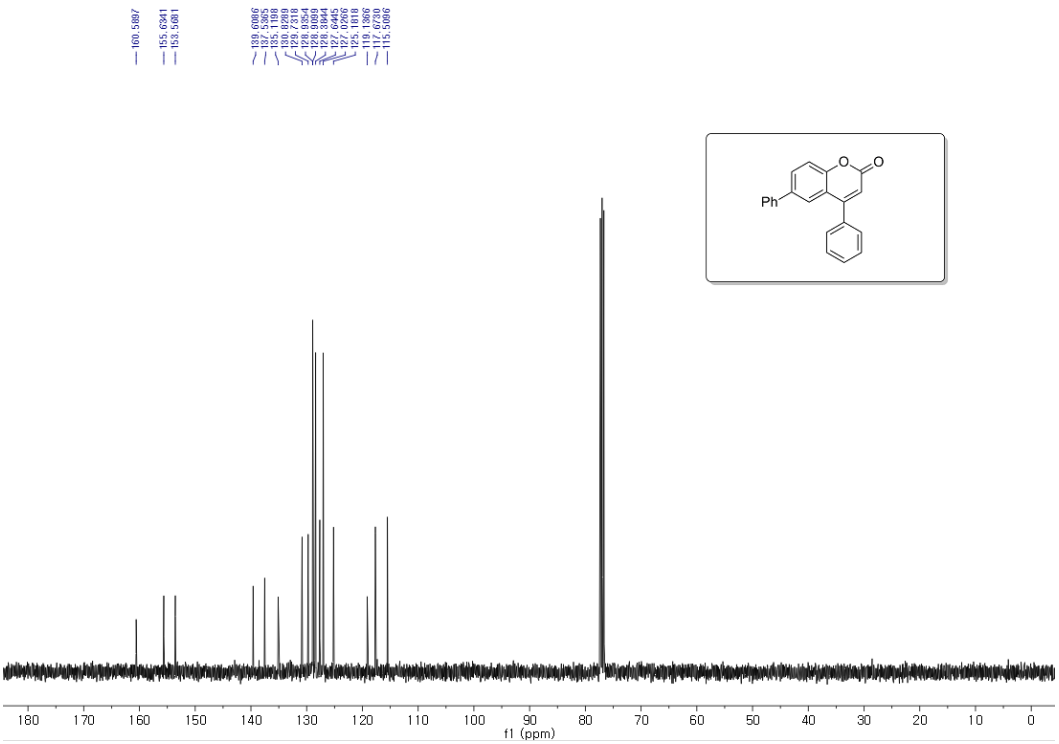


100 MHz, ^{13}C NMR in $CDCl_3$

4,6-diphenyl-2H-chromen-2-one (4a)

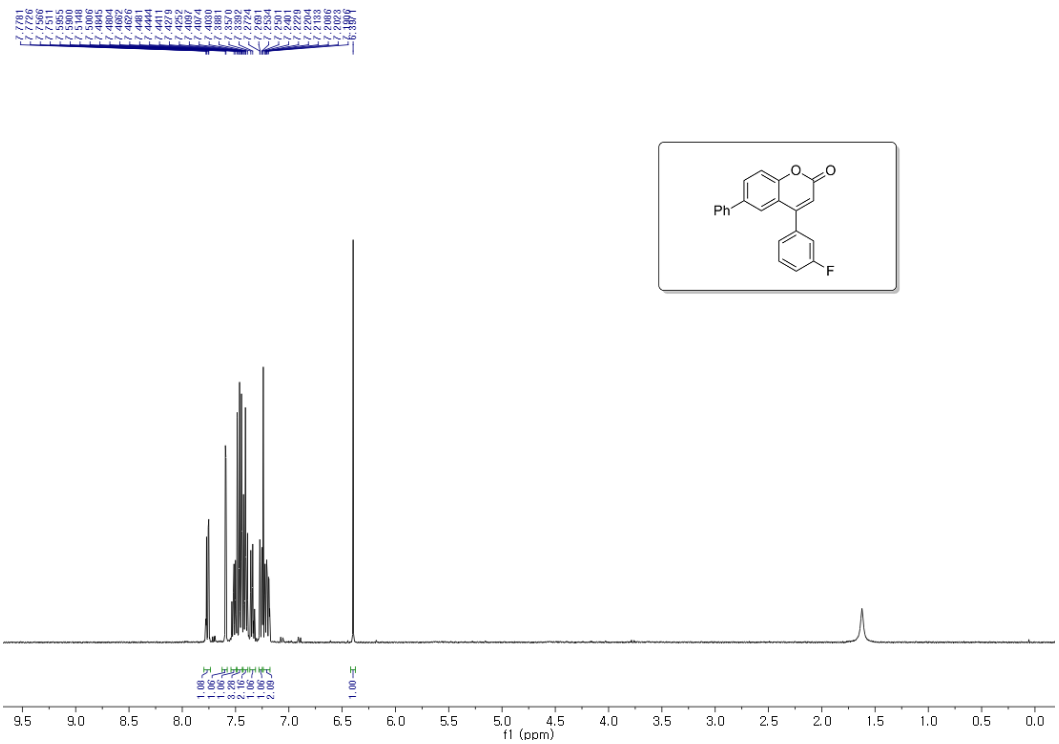


400 MHz, ^{1}H NMR in $CDCl_3$

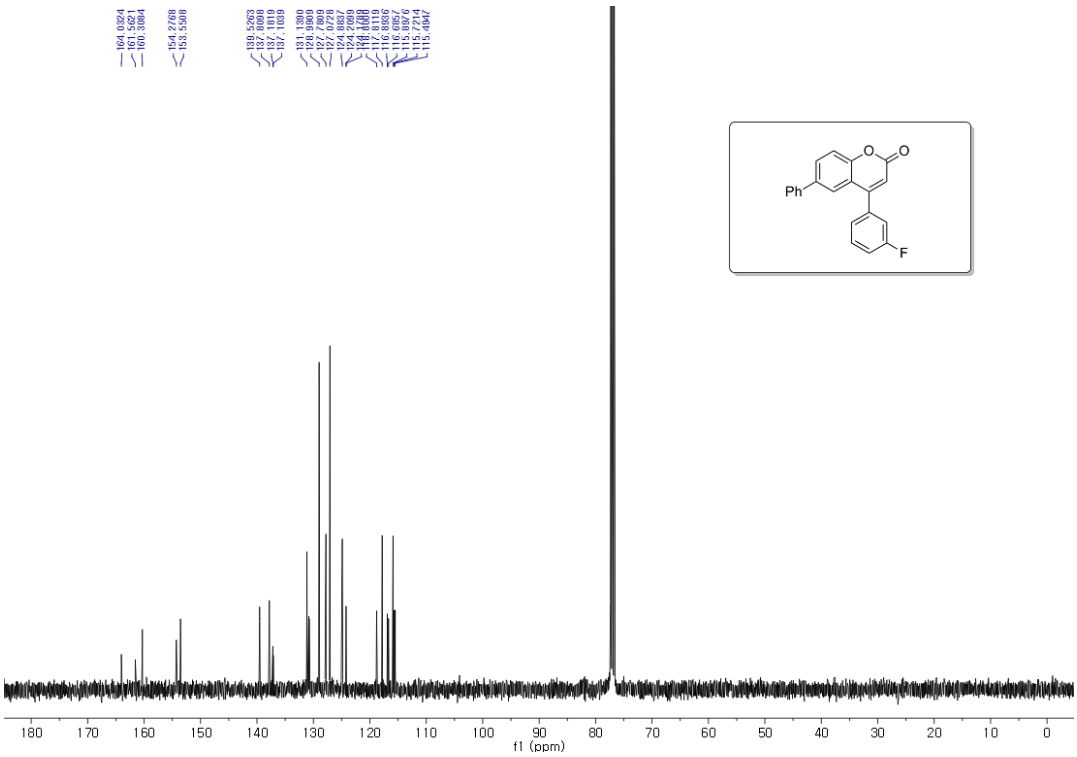


100 MHz, ^{13}C NMR in $CDCl_3$

4-(3-fluorophenyl)-6-phenyl-2H-chromen-2-one (4b)



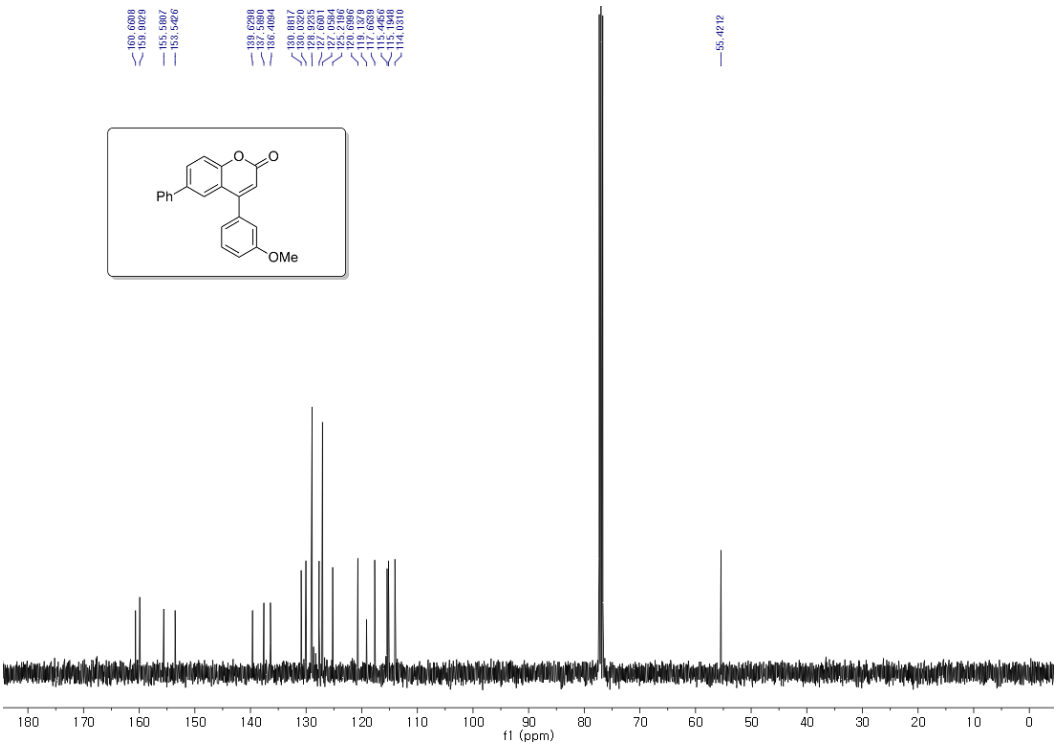
400 MHz, ^{1}H NMR in $CDCl_3$



100 MHz, ^{13}C NMR in $CDCl_3$

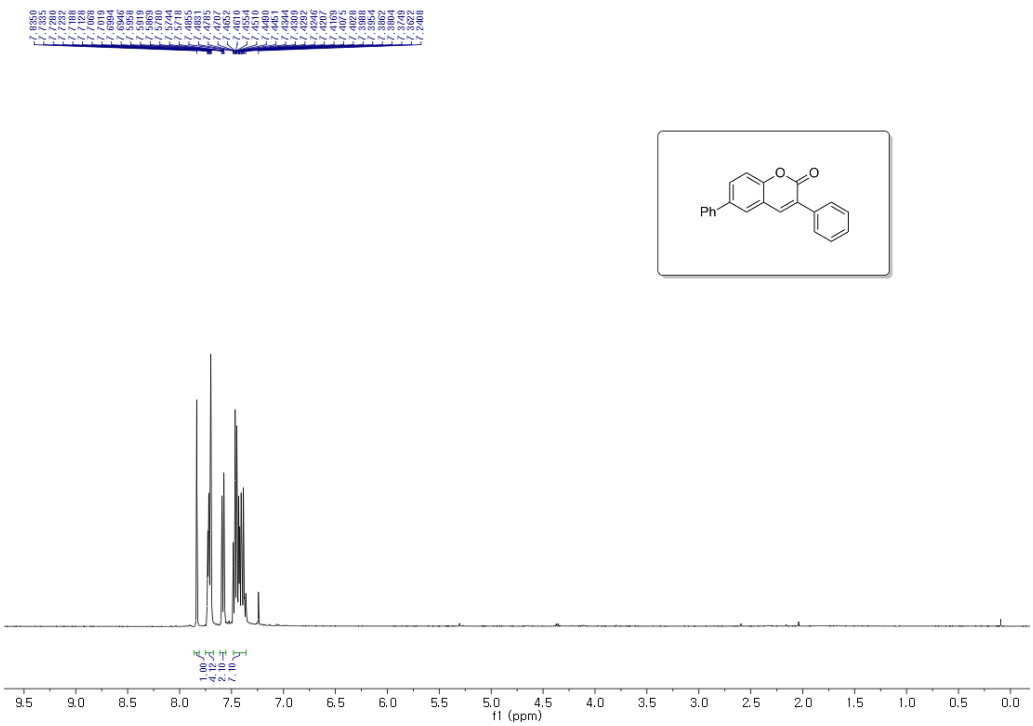
4-(3-methoxyphenyl)-6-phenyl-2H-chromen-2-one (4c)

400 MHz, ^{1}H NMR in $CDCl_3$

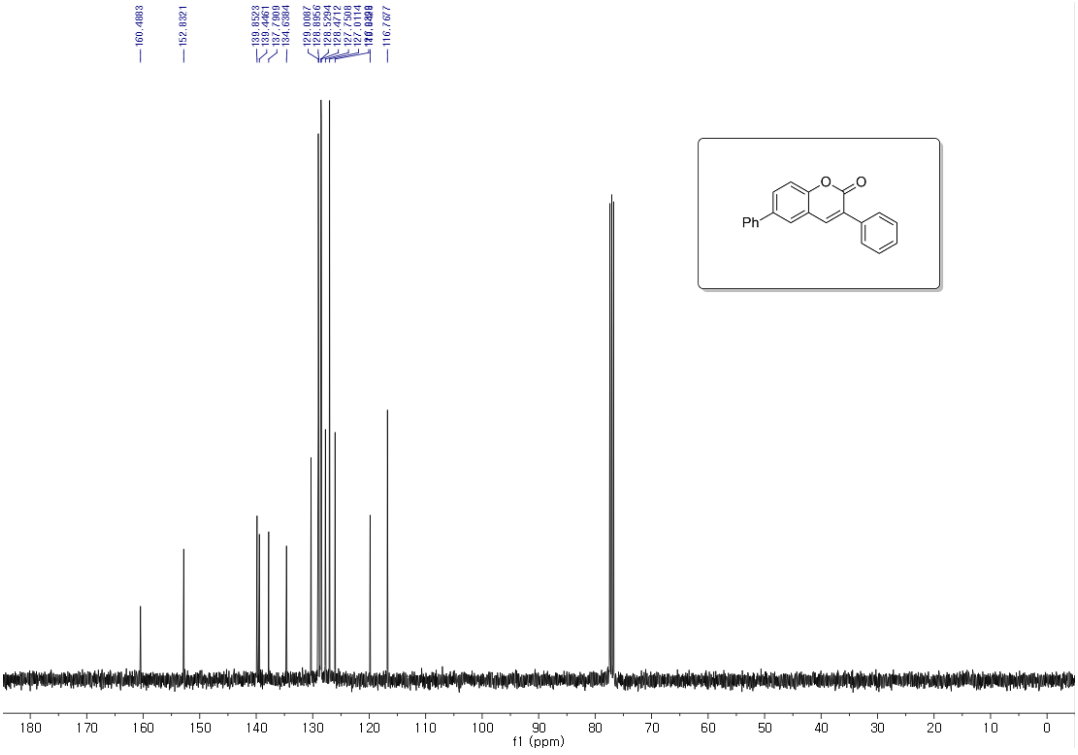


100 MHz, ^{13}C NMR in $CDCl_3$

3,6-diphenyl-2H-chromen-2-one (4d)

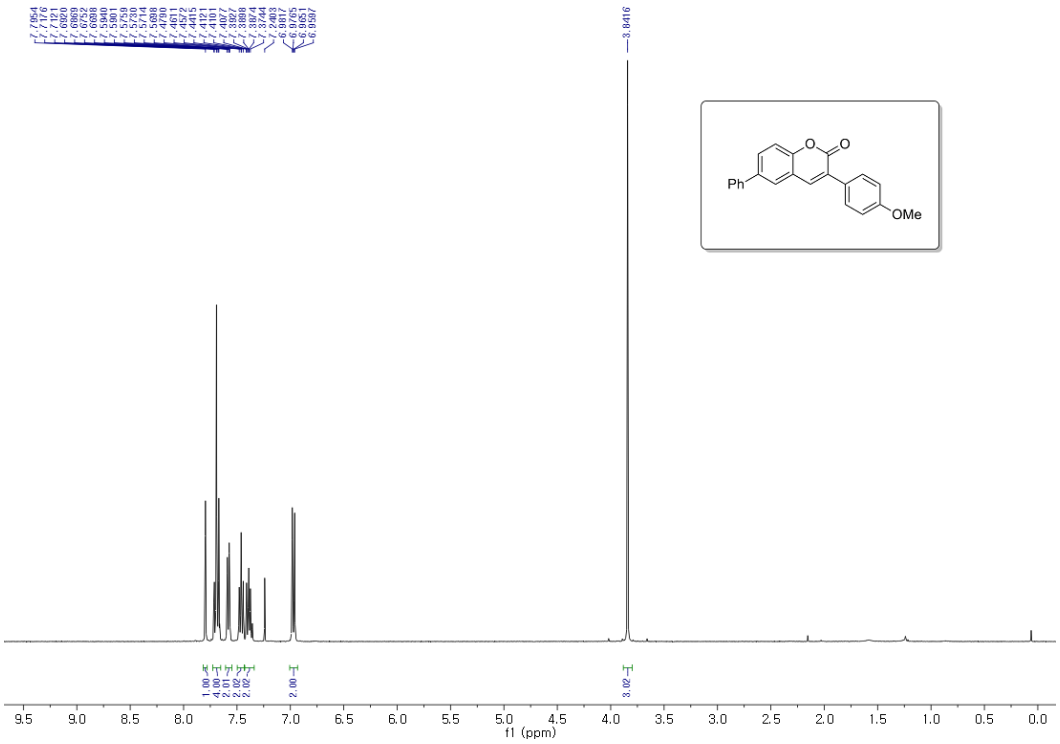


400 MHz, ^{1}H NMR in $CDCl_3$

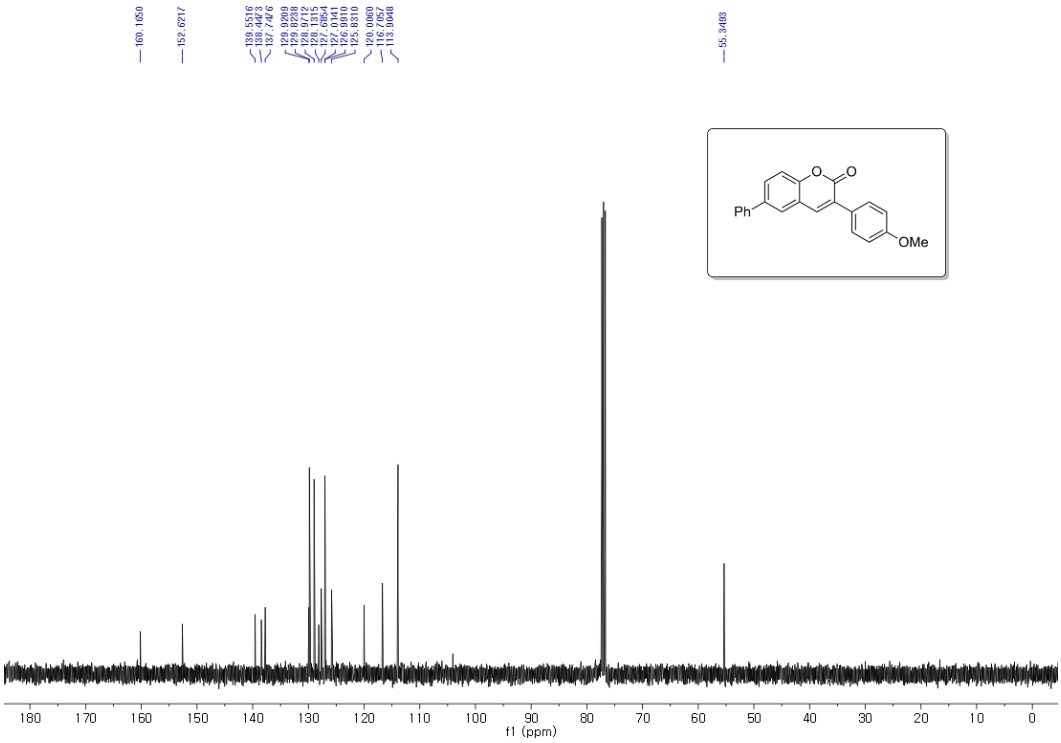


100 MHz, ^{13}C NMR in $CDCl_3$

3-(4-methoxyphenyl)-6-phenyl-2H-chromen-2-one (4e)

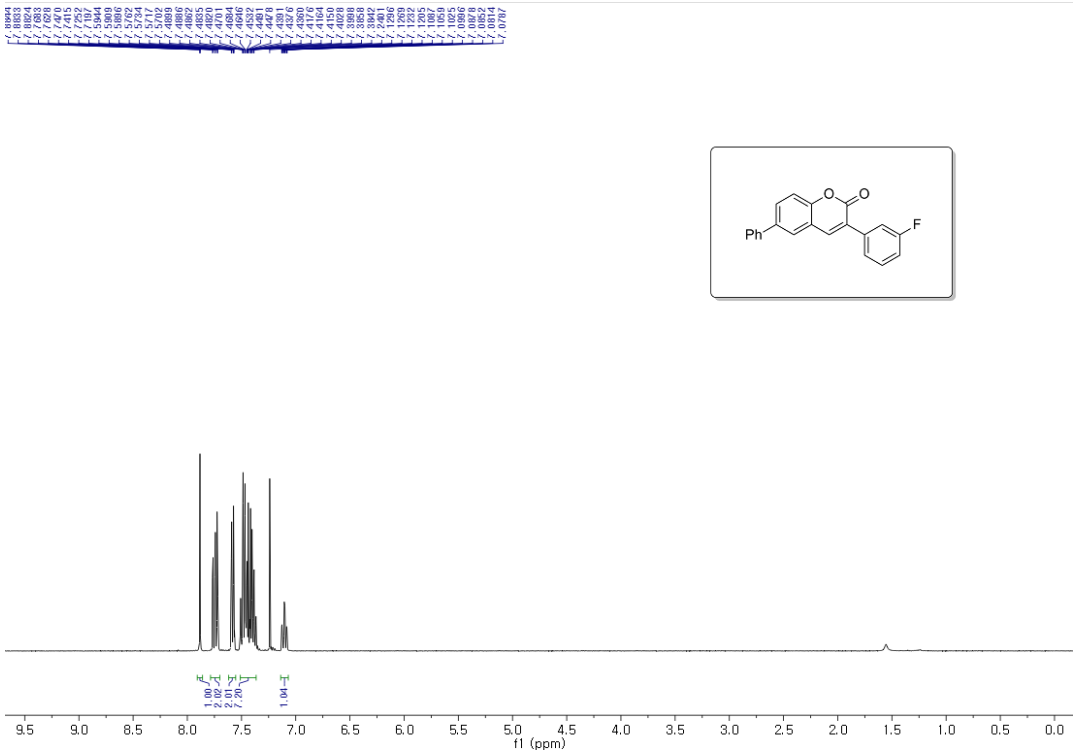


400 MHz, ^{1}H NMR in $CDCl_3$

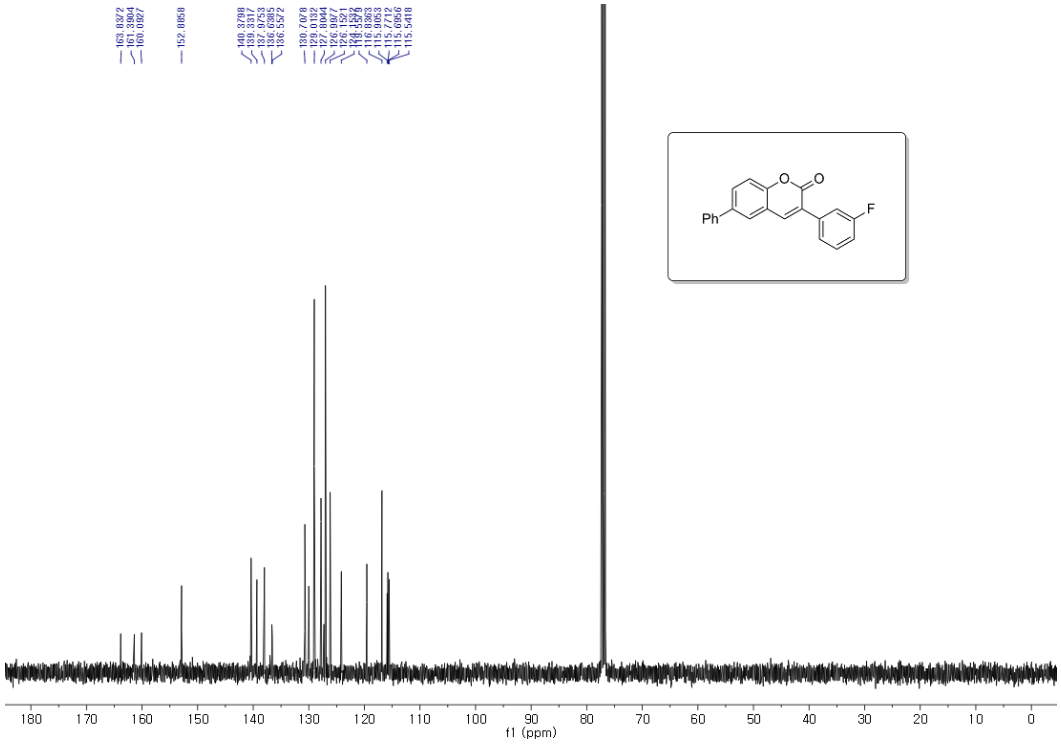


100 MHz, ^{13}C NMR in $CDCl_3$

3-(3-fluorophenyl)-6-phenyl-2H-chromen-2-one (4f)

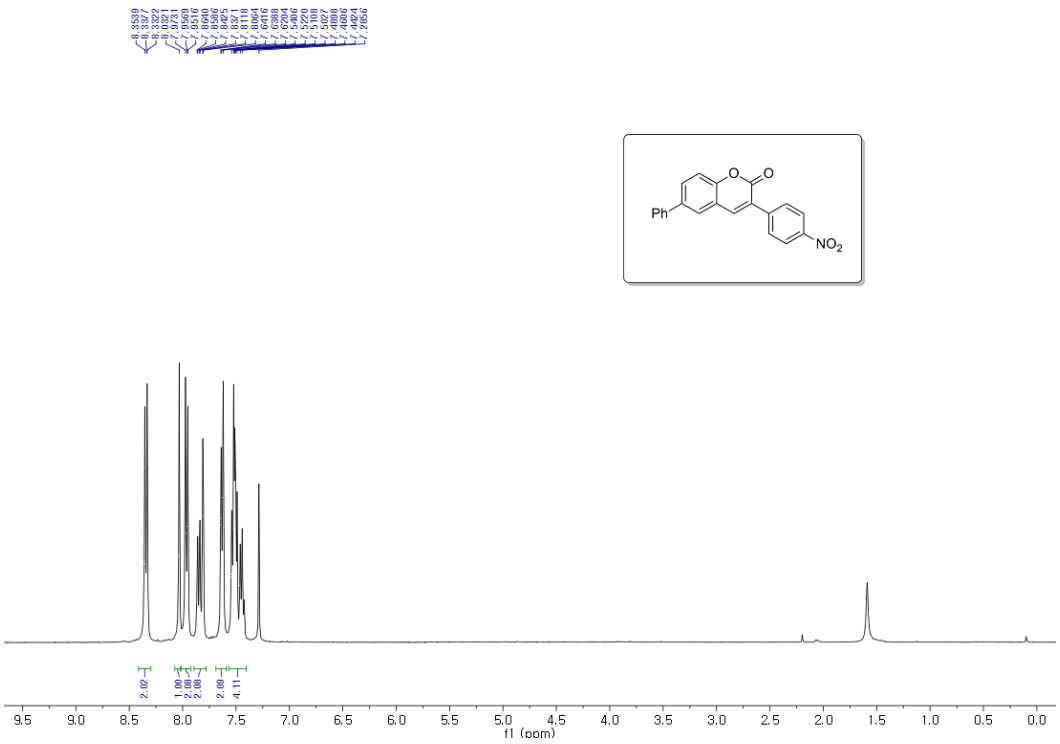


400 MHz, ^{1}H NMR in $CDCl_3$

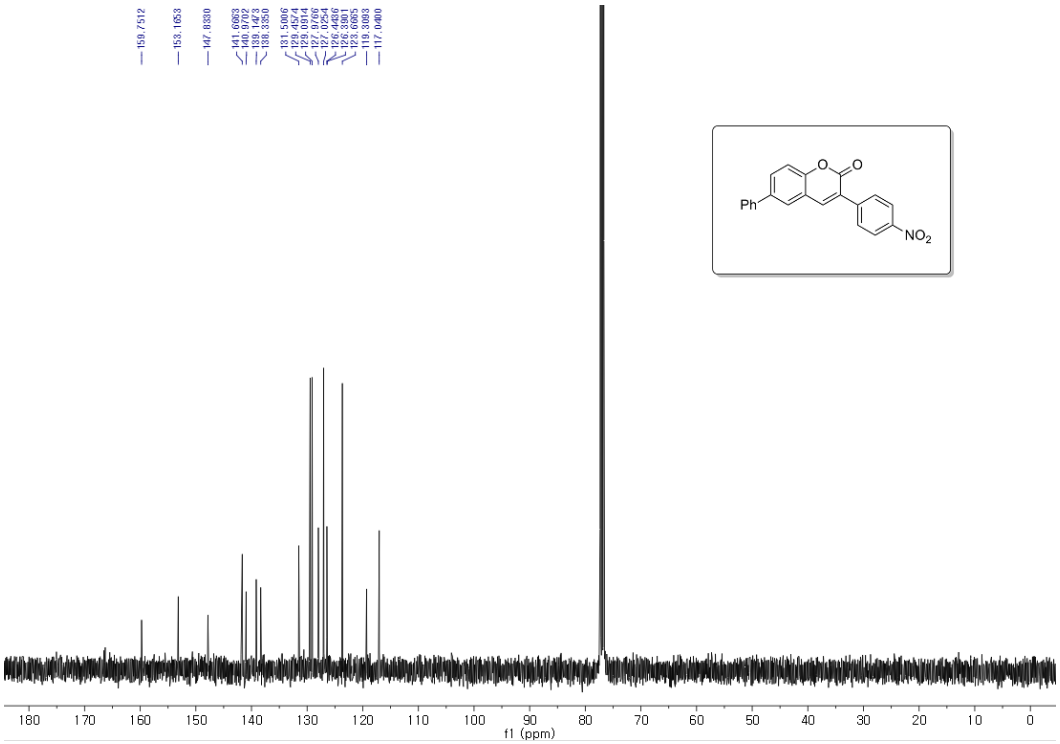


100 MHz, ^{13}C NMR in $CDCl_3$

3-(4-nitrophenyl)-6-phenyl-2H-chromen-2-one (4g)

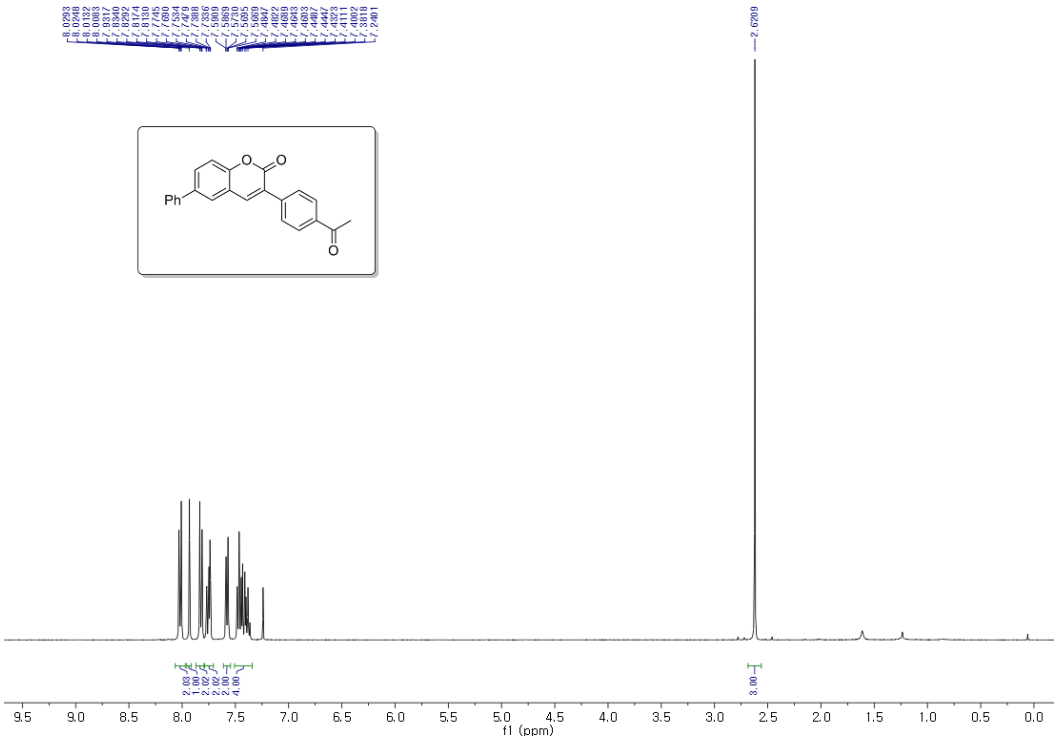


400 MHz, ^{1}H NMR in $CDCl_3$

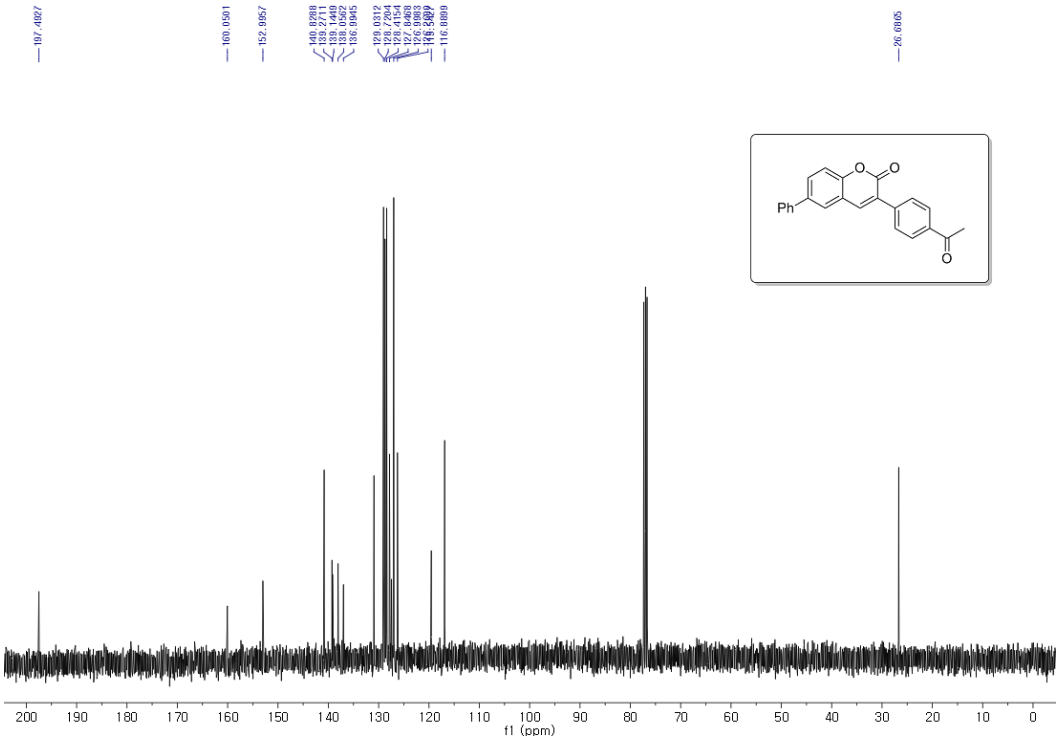


100 MHz, ^{13}C NMR in $CDCl_3$

3-(4-acetylphenyl)-6-phenyl-2H-chromen-2-one (4h)

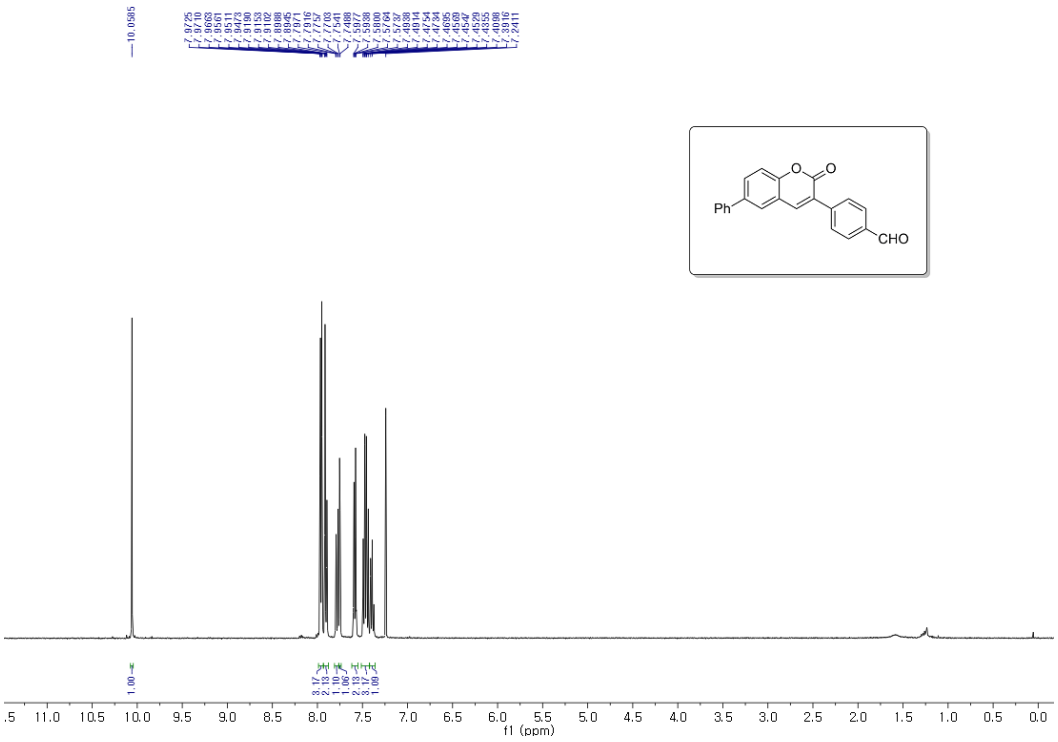


400 MHz, ^{1}H NMR in $CDCl_3$

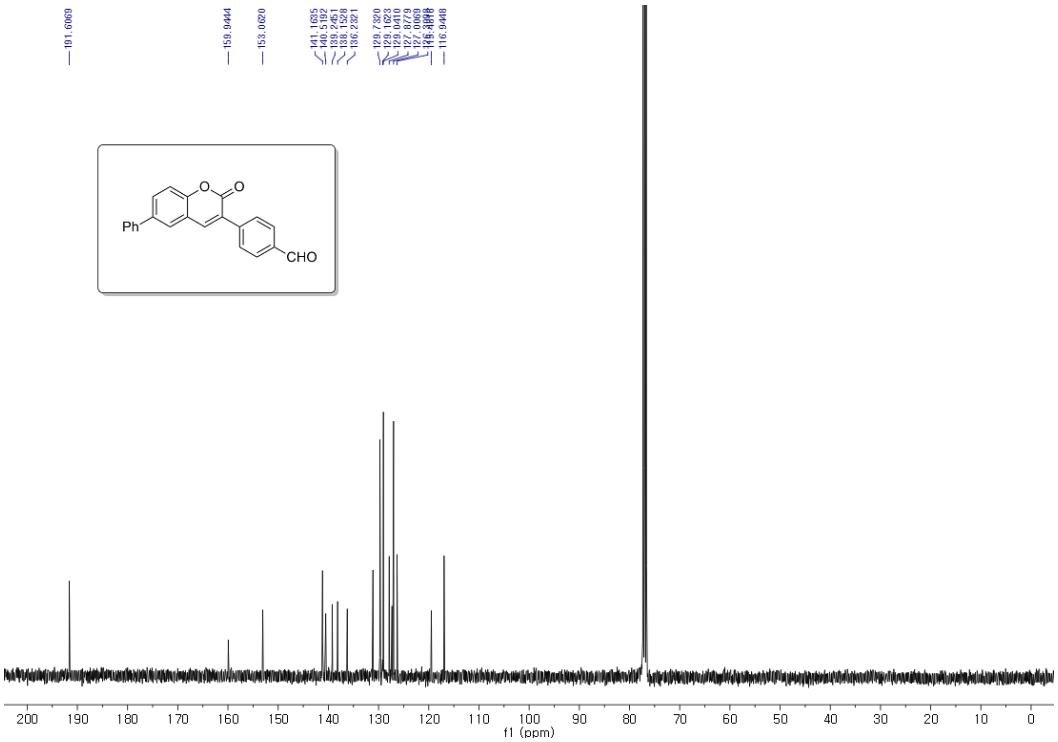


100 MHz, ^{13}C NMR in $CDCl_3$

4-(2-oxo-6-phenyl-2H-chromen-3-yl)benzaldehyde (4i)

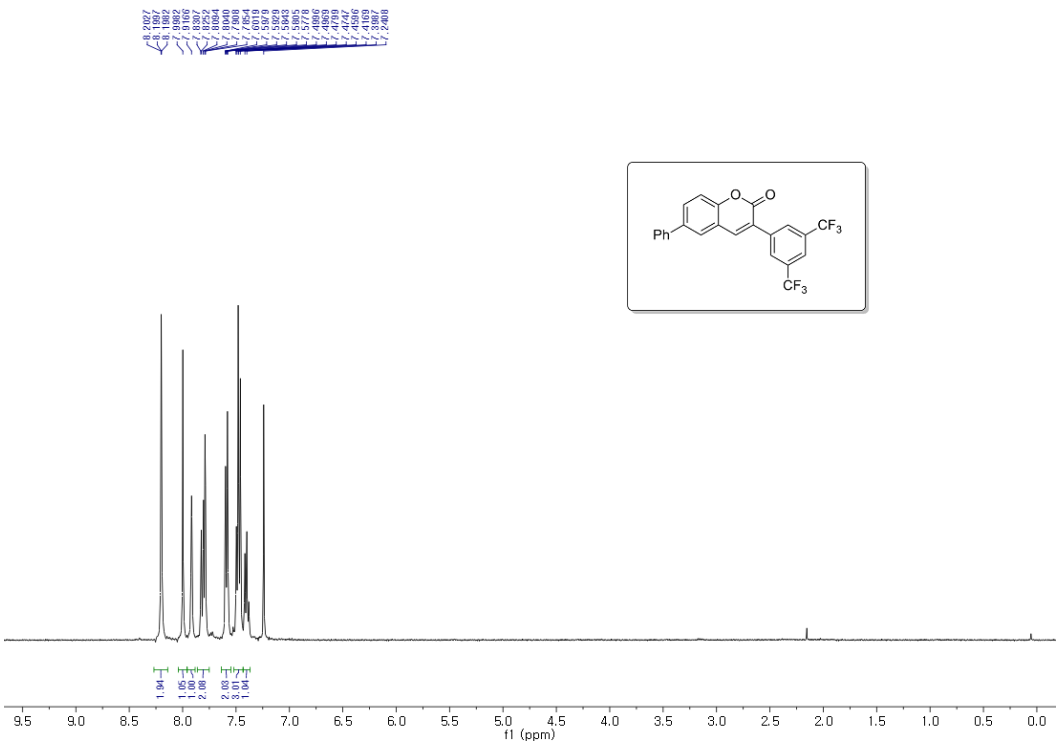


400 MHz, ^{1}H NMR in $CDCl_3$

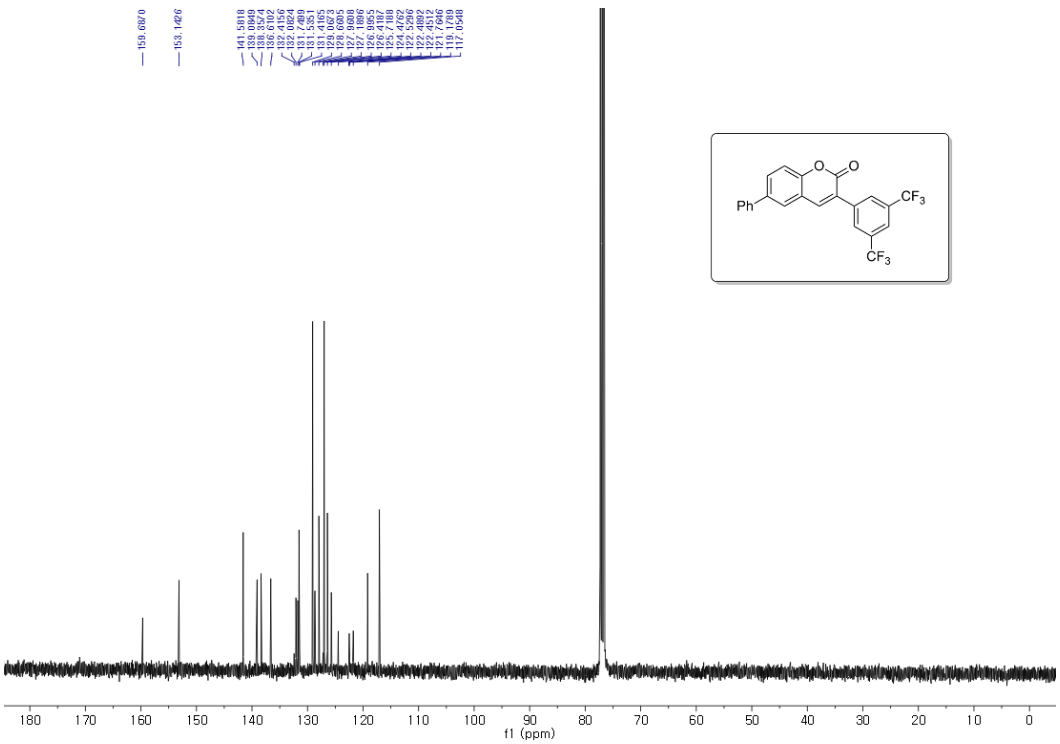


100 MHz, ^{13}C NMR in $CDCl_3$

3-(3,5-bis(trifluoromethyl)phenyl)-6-phenyl-2H-chromen-2-one (4j)

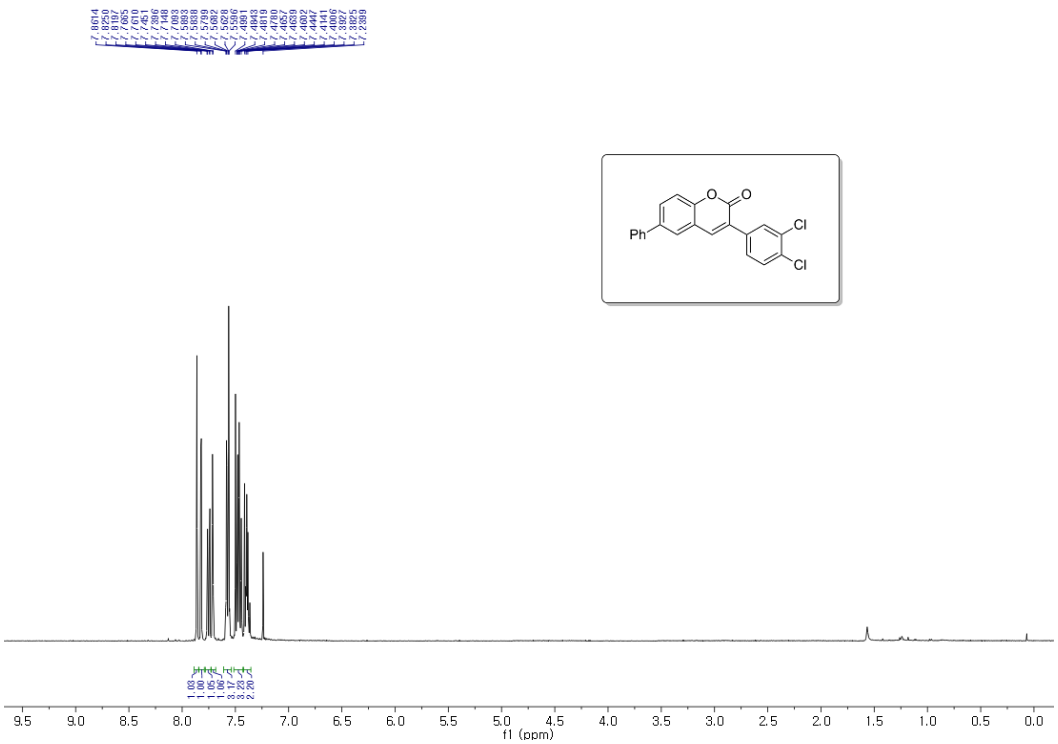


400 MHz, ^{1}H NMR in $CDCl_3$

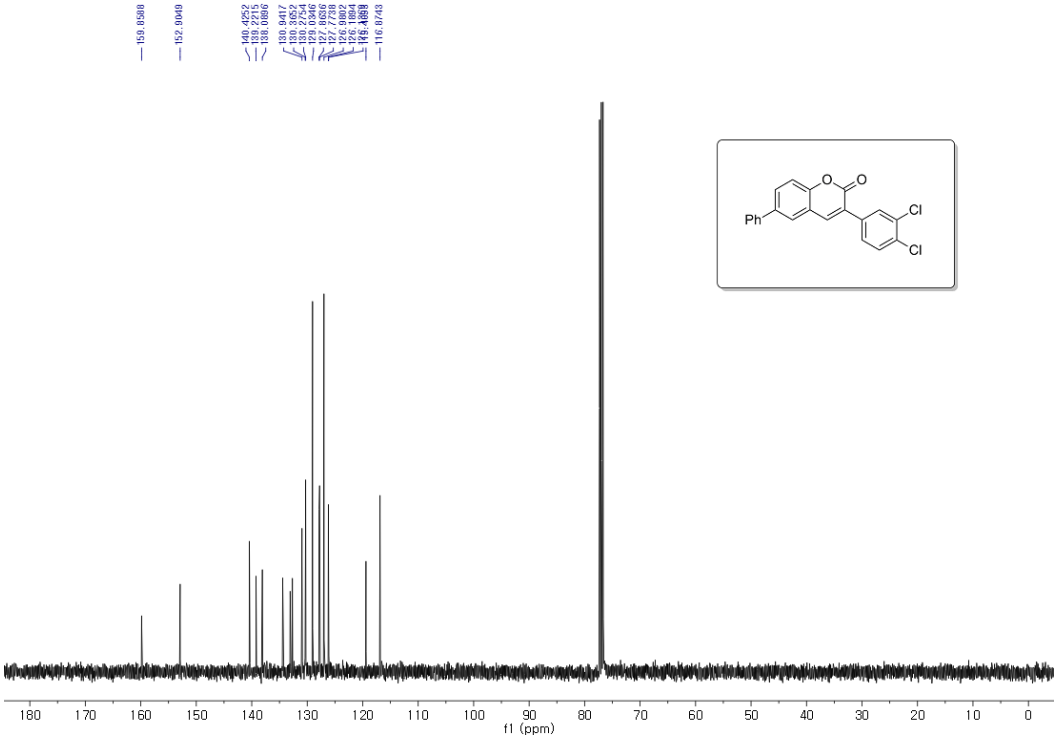


100 MHz, ^{13}C NMR in $CDCl_3$

3-(3,4-dichlorophenyl)-6-phenyl-2H-chromen-2-one (4k)

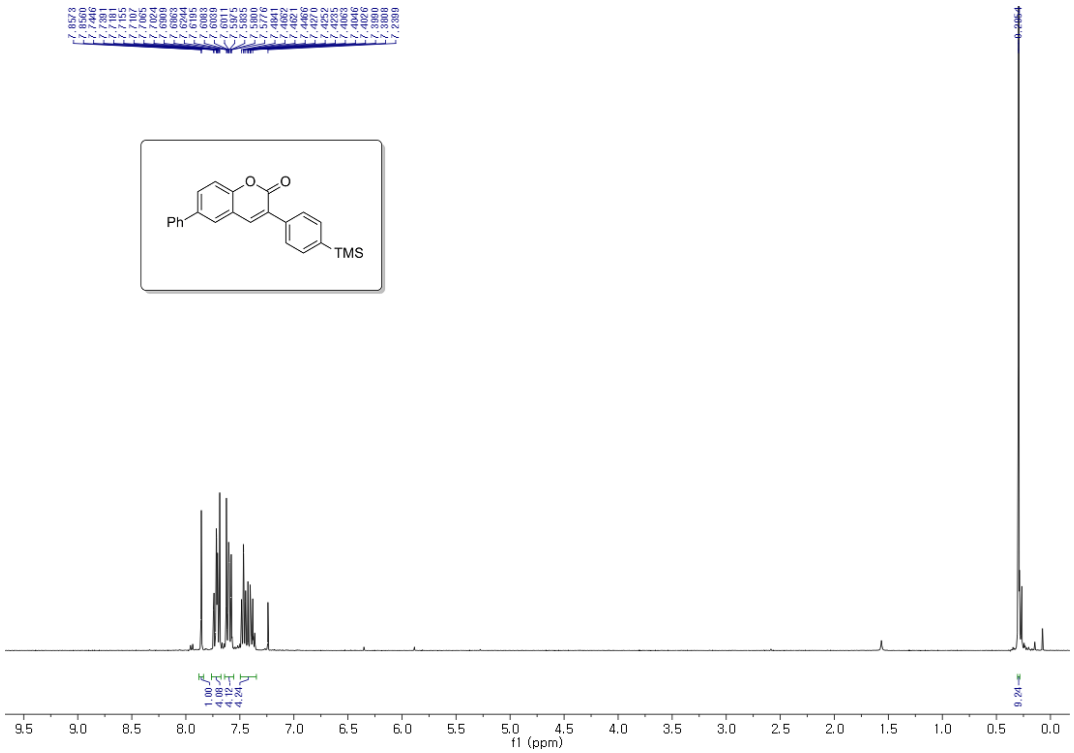


400 MHz, ^{1}H NMR in $CDCl_3$

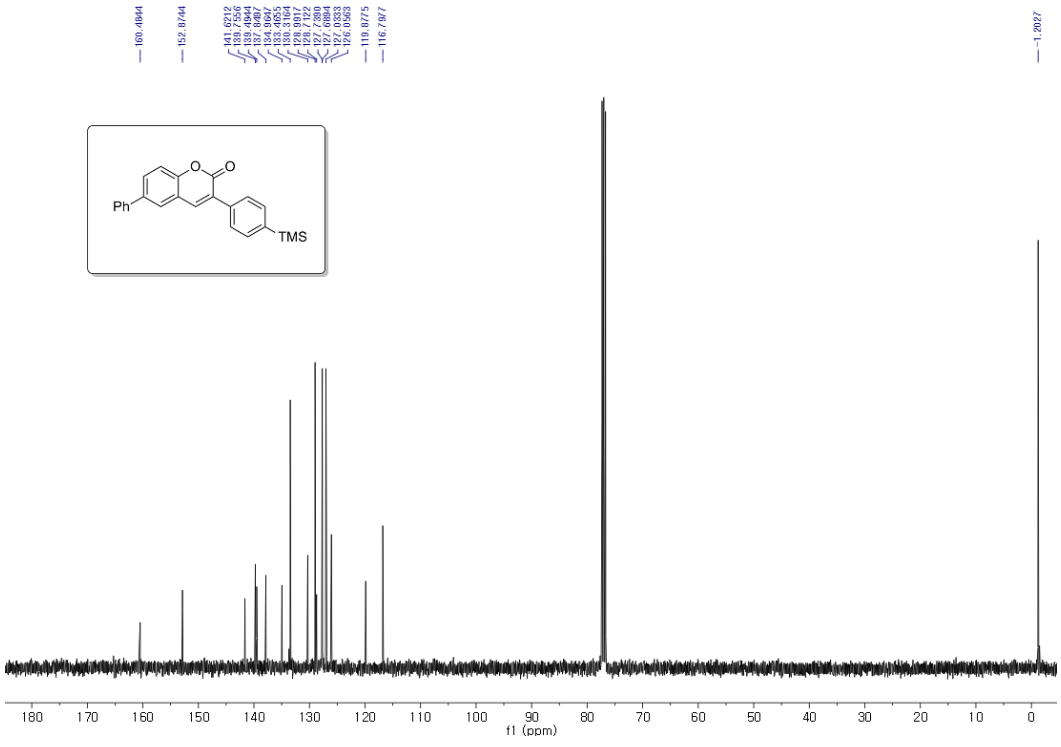


100 MHz, ^{13}C NMR in $CDCl_3$

6-phenyl-3-(4-(trimethylsilyl)phenyl)-2H-chromen-2-one (4l)

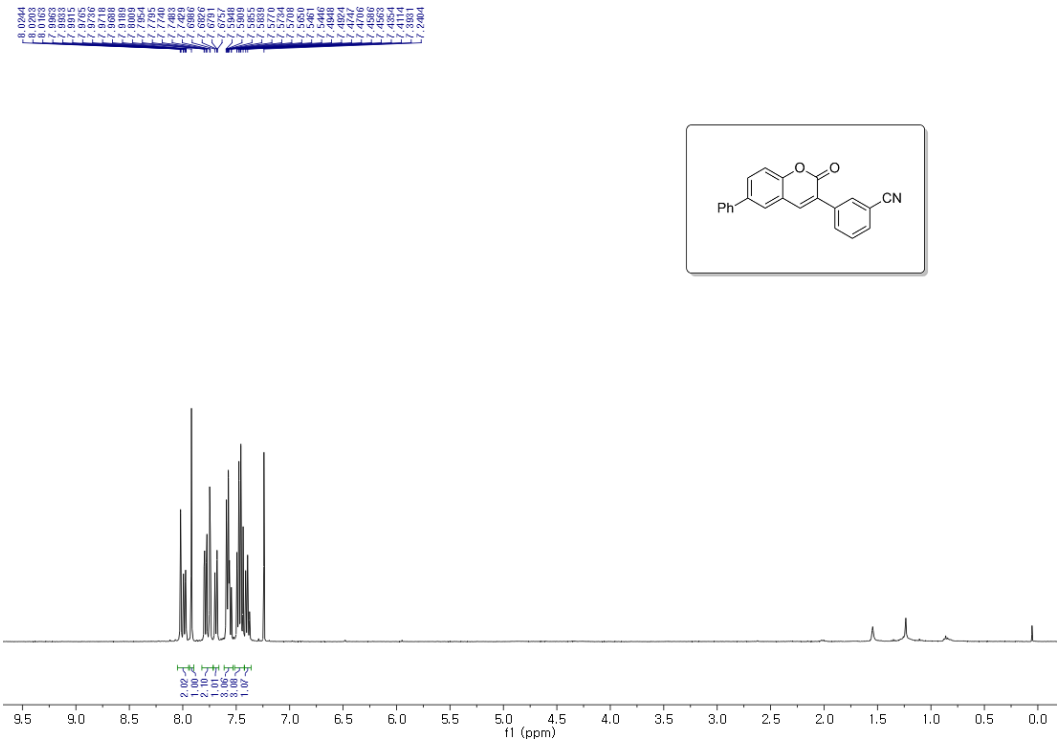


400 MHz, ^{1}H NMR in $CDCl_3$

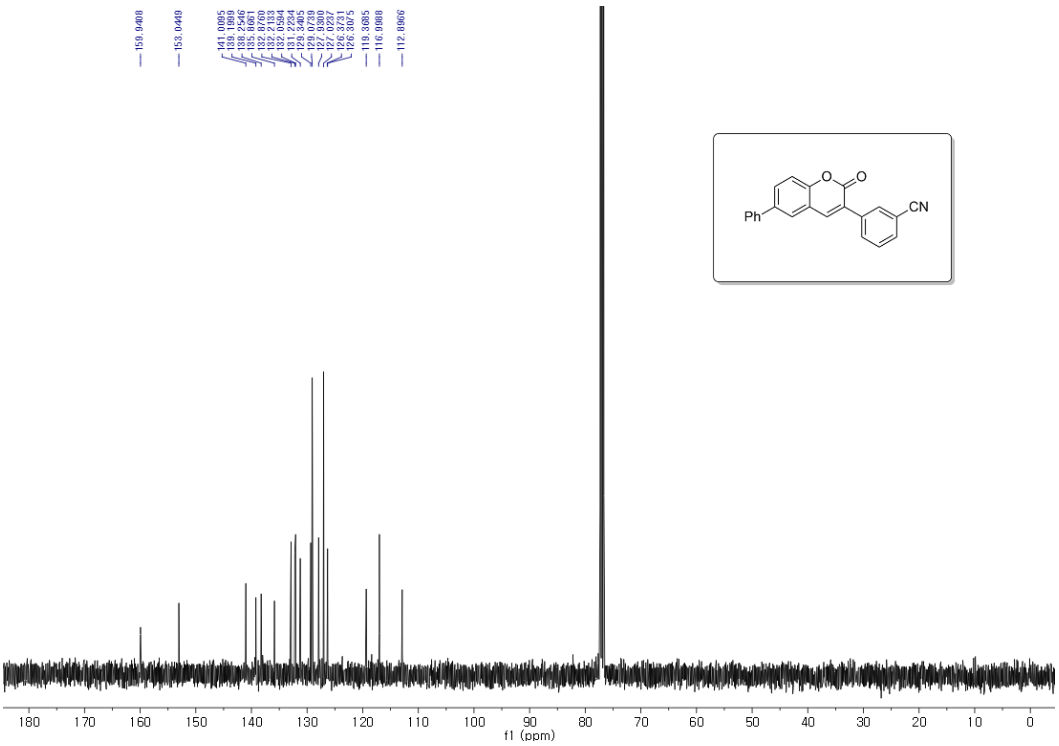


100 MHz, ^{13}C NMR in $CDCl_3$

3-(2-oxo-6-phenyl-2H-chromen-3-yl)benzonitrile (4m)

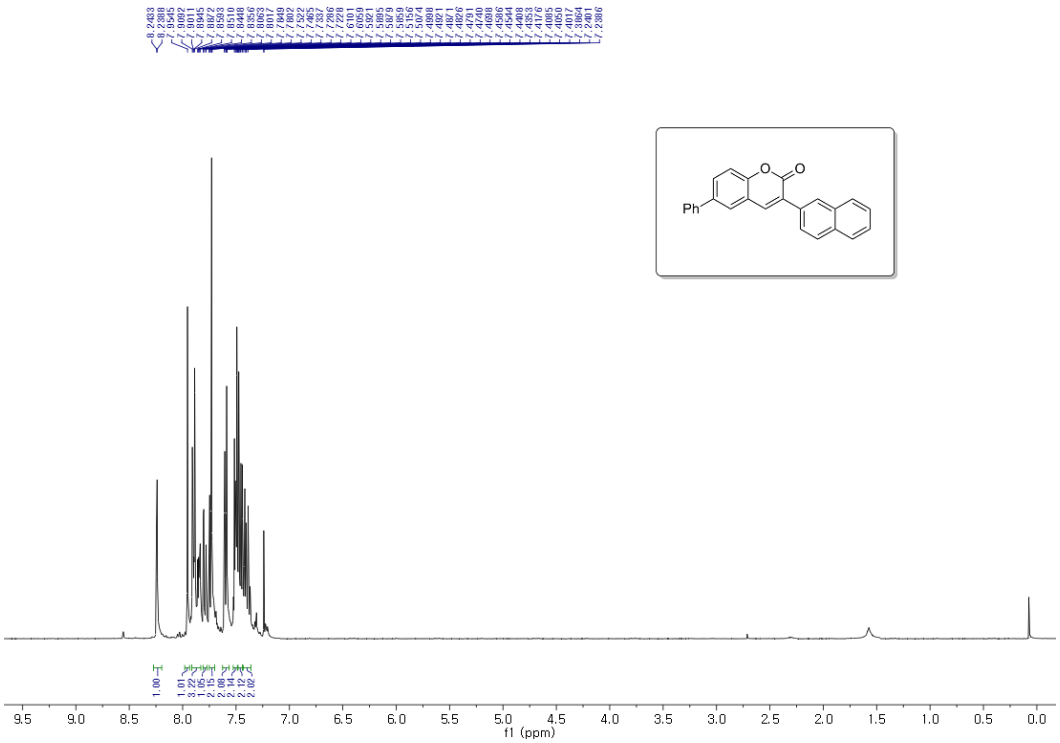


400 MHz, ^{1}H NMR in $CDCl_3$

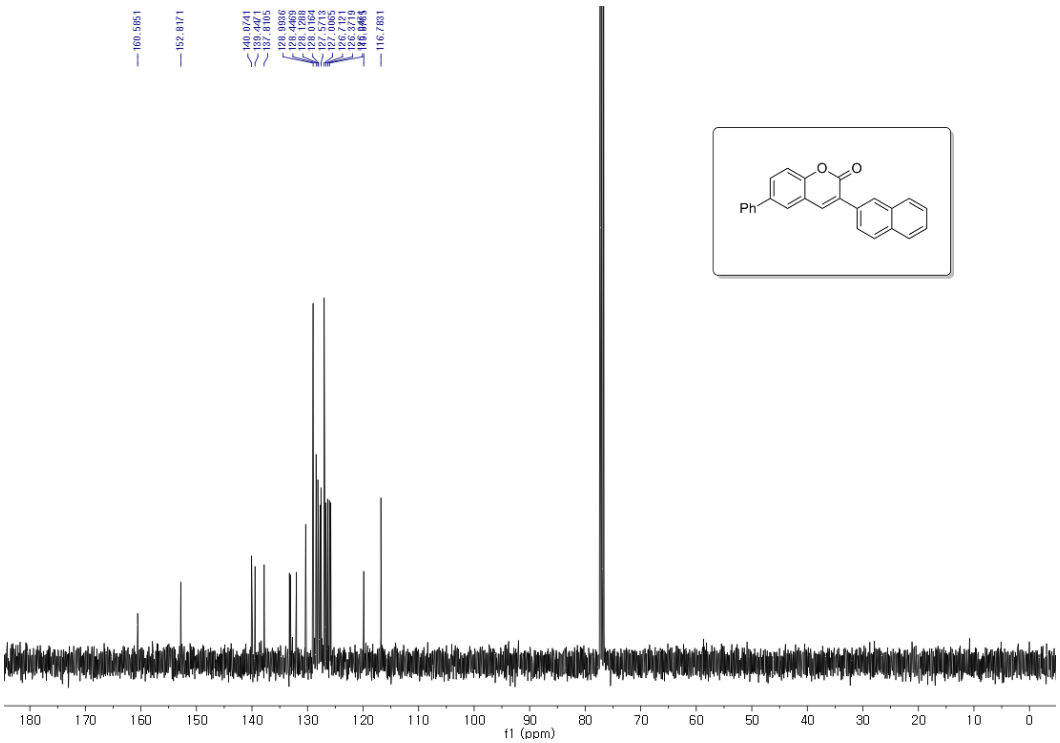


100 MHz, ^{13}C NMR in $CDCl_3$

3-(naphthalen-2-yl)-6-phenyl-2H-chromen-2-one (4n)

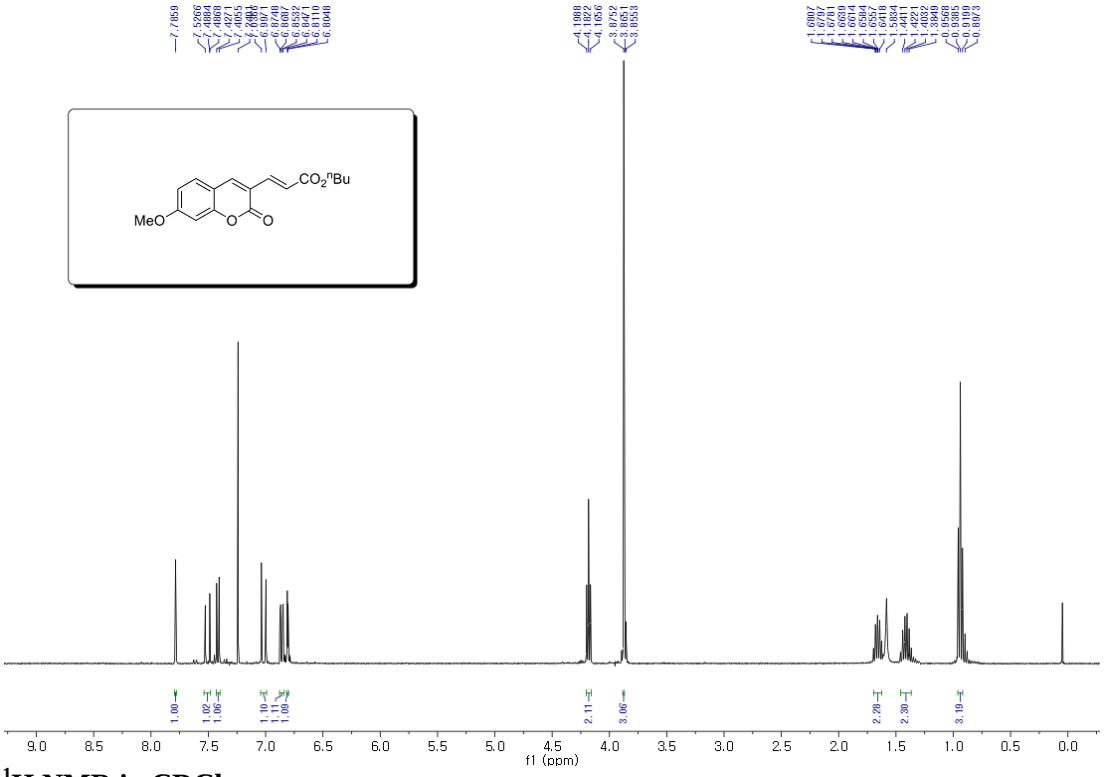


400 MHz, ^{1}H NMR in $CDCl_3$

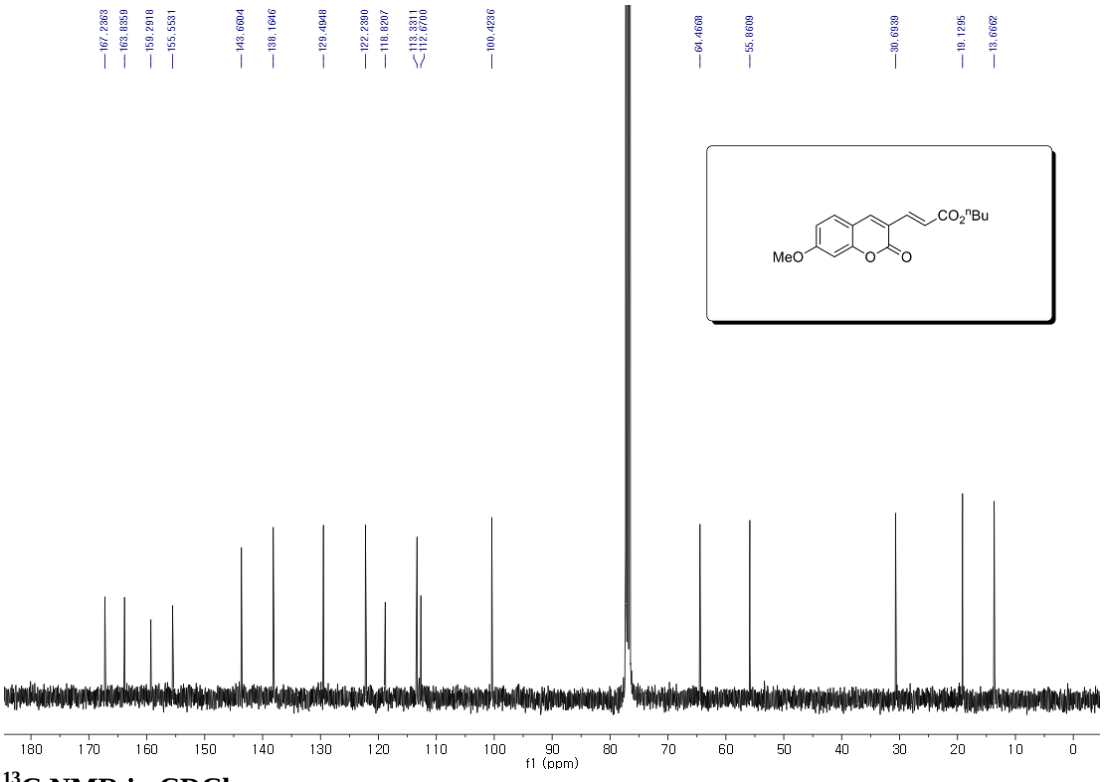


100 MHz, ^{13}C NMR in $CDCl_3$

(E)-butyl 3-(7-methoxy-2-oxo-2H-chromen-3-yl)acrylate (5a)

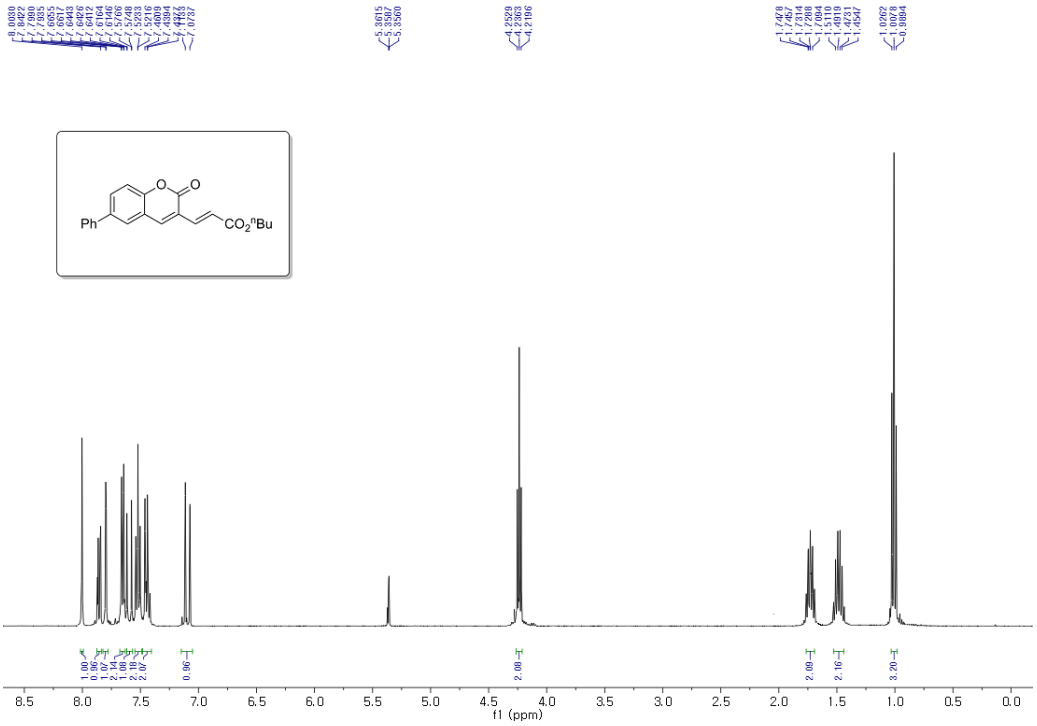


400 MHz, ^{1}H NMR in $CDCl_3$

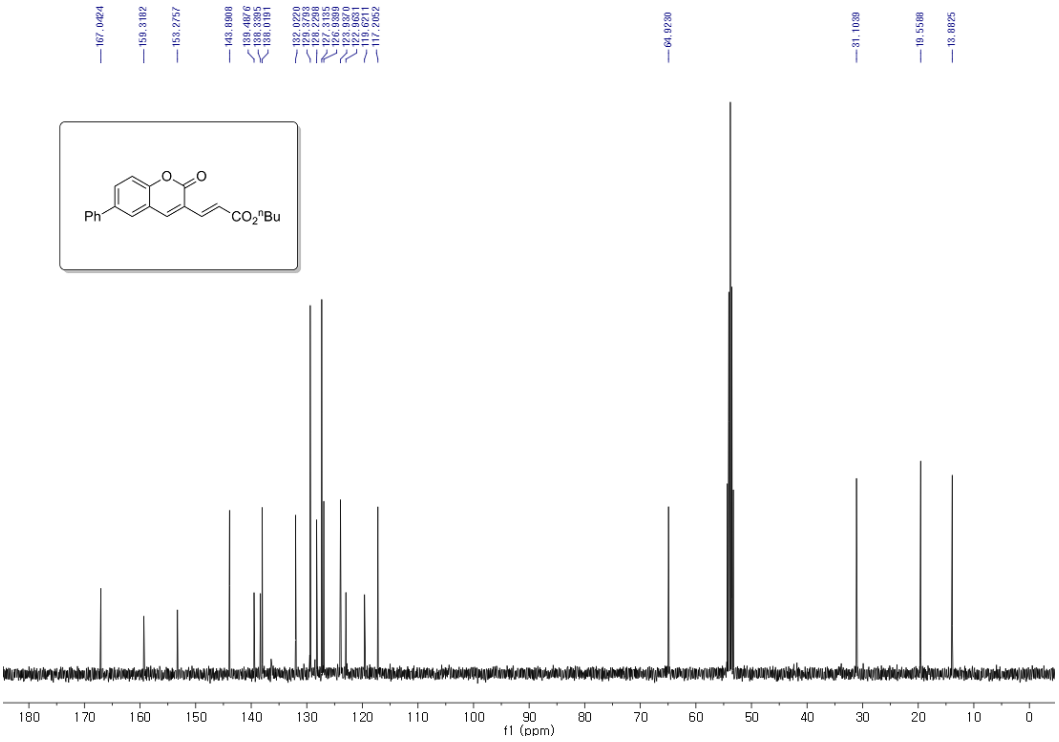


100 MHz, ^{13}C NMR in $CDCl_3$

(E)-butyl 3-(2-oxo-6-phenyl-2H-chromen-3-yl)acrylate (5b)



400 MHz, ^{1}H NMR in CD_2Cl_2



100 MHz, ^{13}C NMR in CD_2Cl_2