Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Four-Component Regio-divergent Carbonylative Condensations in the Sustainable Syntheses of Acylhydrazones

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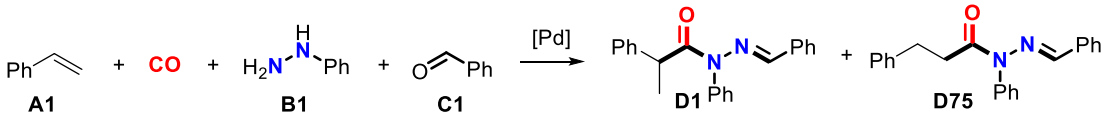
1. General

Experimental: Deuterated solvents were bought from Cambridge Isotope Laboratories, distilled accordingly, and stored over molecular sieves (3 Å). Other chemicals were purchased from commercial vendors and used without further purification. NMR spectra were collected on a Varian INOVA 400 MHz spectrometer. Chemical shifts (δ) are reported in ppm relative to residual solvent signal. Coupling constants (J) are given in Hz (coupling patterns: s: singlet, s_br: broad singlet, d: doublet, t: triplet, q: quartet, m: multiplet). GC analyses were carried out using an Agilent Technologies 6890N system equipped with a Machinery-Nagel (MN) Optima 5 HT column (30 m, 320 µm, 0.25 µm) or an Agilent Technologies 6850 system equipped with a MN Optima 17 column (30 m, 320 µm, 0.25 µm). GC-MS analyses were carried out on an Agilent 7890A/MSD 5975C system equipped with a HP-5MS column (30 m, 320 µm, 0.25 µm). High resolution mass spectra (HRMS) were recorded on Bruker MicroTOF-QII mass (ESI). MN silica gel 60 (0.040 – 0.063 mm particle size) was used for flash column chromatography.

2. Screening of reaction parameters

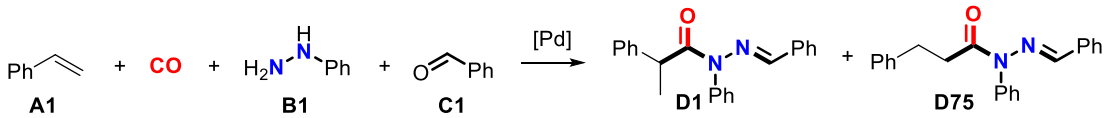
2.1 Screening of reaction parameters for the branched acylhydrazone



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, alkene (**A1**), hydrazine (**B1**), aldehyde (**C1**), [Pd], ligand, and solvent. Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO and immersed into a pre-heated metal bath for desired time. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1**.

Entry	Parameter
Table S1	The difference of ligand screening
Table S2	The difference of catalyst screening
Table S3	The loading catalyst screening
Table S4	The loading of solvent screening
Table S5	The difference of solvent screening
Table S6	The loading of **A1** screening
Table S7	The loading of **B1** screening
Table S8	The loading of **C1** screening
Table S9	Reaction pressure screening
Table S10	Reaction temperature screening
Table S11	Reaction time screening

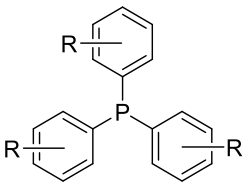
Table S1: The difference of ligand screening [a]



Entry	Ligand (mmol)	**D1** (%)	**D75** (%)	**D1+D75** (%)
1	**L1**	2	1	3
2	**L2**	1	1	2
3	**L3**	2	1	3
4	**L4**	6	1	7
5	**L5**	36	7	43
6	**L6**	44	22	66
7	**L7**	26	29	55
8	**L8**	26	30	56
9	**L9**	36	17	53
10	**L10**	28	13	41
11	**L11**	31	33	64
12	**L12**	69	1	70
13	**L13**	45	1	46
14	**L14**	**94**	**1**	**95**
15	**L15**	80	1	81
16	**L16**	62	1	63
17	**L17**	61	1	62
18	**L18**	0	0	0
19	**L19**	0	1	1
20	**L20**	0	1	1
21	**L21**	1	2	3
22	**L22**	20	22	42
23	**L23**	39	42	81
24	**L24**	1	2	3
25	**L25**	2	3	5
26	**L26**	**10**	**78**	**88**

Entry	Ligand (mmol)	**D1** (%)	**D75** (%)	**D1+D75** (%)
27	**L27**	11	56	67
28	**L28**	12	57	69
29	**L29**	8	70	78
30	**L30**	7	65	72
31	**L31**	1	3	4
32	**L32**	1	2	3
33	**L33**	14	41	55
34	**L34**	1	3	4
35	**L35**	3	9	12
36	**L36**	1	2	3
37	-	0	0	0

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), DCM (2.0 mL), $PdCI_2(CH_3CN)_2$ (0.02 mmol), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and **D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.



L1, PCy_3

L2, $^tBu_3P{\bullet}HBF_4$

L3, $P(^nBu)Ad_2$

L4, PPh_2(2-Py)

L5, $PPh_2(3,5\text{-}Me_2Ph)$

L6, $PPh_2(3,5\text{-}F_2Ph)$

L7, R = H

L8, R = 4-Me

L9, R = 3-Me

L10, R = 2-Me

L11, R = 4-F

L12, R = 3-F

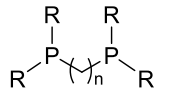
L13, R = 2-F

L14, R = 3,5-F_2

L15, R = 3,5-Me_2

L16, R = 3,5-$(MeO)_2$

L17, R = 3,5-$(CF_3)_2$



L18, n = 1, R = Ph

L19, n = 2, R = Ph

L20, n = 3, R = Ph

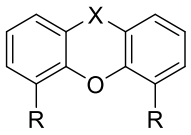
L21, n = 4, R = Ph

L22, n = 5, R = Ph

L23, n = 6, R = Ph

L24, n = 3, R = Cy

L25, n = 4, R = Cy



L26, X = CMe_2, R = PPh_2

L27, X = NH, R = PPh_2

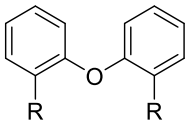
L28, X = $SiMe_2$, R = PPh_2

L29, X = CMe_2, R = PPh(2-MePh)

L30, X = CMe_2, R = PPh(2-MeOPh)

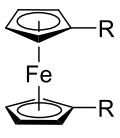
L31, X = CMe_2, R = PCy_2

L32, X = CMe_2, R = P^tBu_2



L33, R = PPh_2

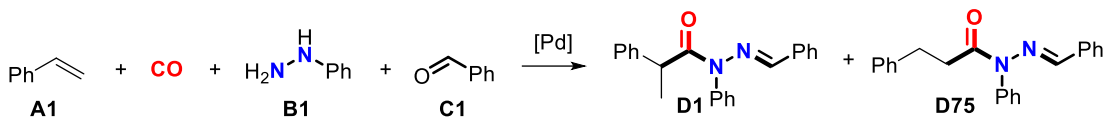
L34, R = PCy_2



L35, R = PPh_2

L36, R = PCy_2

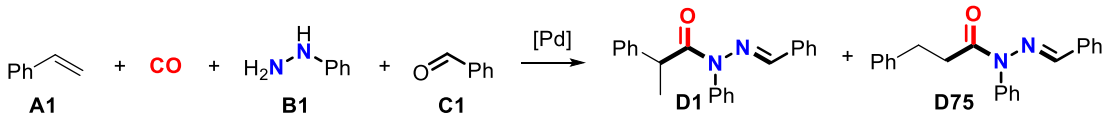
Table S2: The difference of catalyst screening [a]



Entry	Catalyst (0.02 mmol)	**D1** (%)	**D1:D75**
1	$PdCl_2$	20	>99:1
2	$PdBr_2$	23	96:4
3	PdI_2	<5	-
4	$Pd(OAc)_2$	<5	-
5	$Pd(TFA)_2$	<5	-
6	$PdCl_2(CH_3CN)_2$	94	>99:1
7	$PdBr_2(CH_3CN)_2$	42	>99:1
8	$PdCl_2(COD)$	31	92:8
9	$PdBr_2(COD)$	26	90:10
10	$PdCl_2(PhCN)_2$	68	96:4
11[b]	$[PdCl(CH_2{=}CHCH_2)]_2$	12	92:8
12[b]	$[PdCl(PhCH_2{=}CHCH_2)]_2$	16	90:10
13[c]	$PdCl_2(Ph_3P)_2$	42	96:4
14[c]	$Pd(Ph_3P)_4$	<5	-
15[c]	$Pd(^tBu_3P)_2$	<5	-
16	Pd/C	<5	-
17[c]	**$PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$**	**96**	**>99:1**
18[c]	-	<5	-

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), DCM (2.0 mL), $P(3,5\text{-}F_2Ph)_3$ (0.05 mmol), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard. [b] [Pd] (0.01 mmol). [c] $P(3,5\text{-}F_2Ph)_3$ omitted.

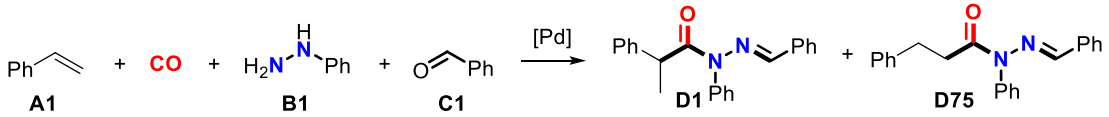
Table S3: The loading catalyst screening [a]



Entry	**Cat.** (mmol)	**D1** (%)	**D1:D75**
1	0	0	-
2	0.005	46	>99:1
3	0.01	89	>99:1
4	**0.02**	**96**	**>99:1**
6	0.03	95	>99:1
7	0.05	96	>99:1

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), DCM (2.0 mL), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

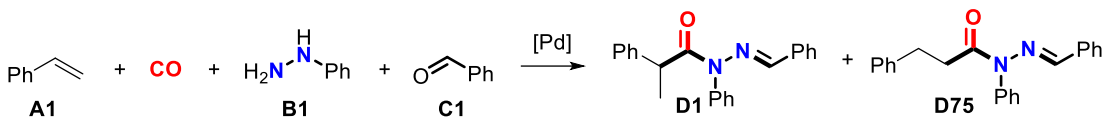
Table S4: The loading of solvent screening [a]



Entry	DCM (ml)	**D1** (%)	**D1:D75**
1	-	16	80:20
2	0.5	43	90:10
3	1.0	72	95:5
4	1.5	84	>99:1
5	**2.0**	**96**	**>99:1**
6	2.5	90	>99:1
7	3.0	89	>99:1

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

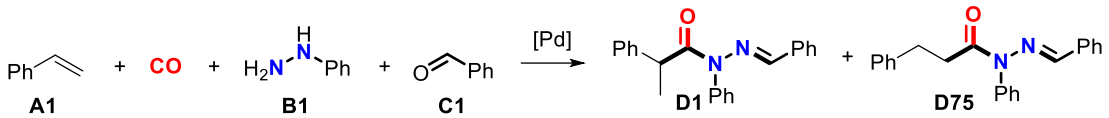
Table S5: The difference of solvent screening[a]



Entry	Solvent (2 mL)	**D1** (%)	**D1:D75**
1	DMAc	<5	-
2	DMF	<5	-
3	DMSO	<5	-
4	THF	61	>99:1
5	PE	34	>99:1
6	1,4-dioxane	72	>99:1
7	anisole	95	>99:1
8	1,2-dimethoxyethane	83	>99:1
9	mesitylene	34	>99:1
10	nitrobenzene	<5	-
11	toluene	22	>99:1
12	Et_3N	<5	-
13	Py	<5	-
14	EtOH	<5	-
15	IPA	21	>99:1
16	2-Methyl-2-propanol	41	>99:1
17	2-Methyl-2-butanol	43	>99:1
18	EA	52	>99:1
19	hexane	38	>99:1
20	acetonitrile	90	>99:1
21	**DCM**	**96**	**>99:1**
22	DCE	13	>99:1
23	$CHCI_3$	38	>99:1
24	CH_3NO_2	<5	-

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), solvent (2.0 mL), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

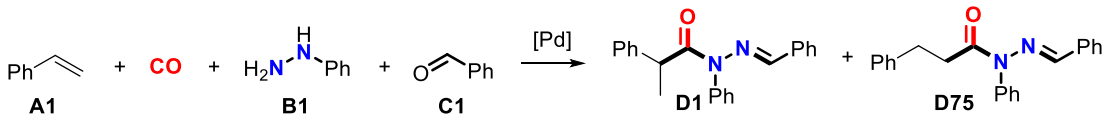
Table S6: The loading of **A1** screening [a]



Entry	A1 (mmol)	D1 (%)	D1:D75
1	0.5	81	>99:1
2	1.0	90	>99:1
3	1.25	91	>99:1
4	**1.4**	**95**	**>99:1**
5	1.5	96	>99:1
6	1.6	96	>99:1
7	1.75	95	>99:1
8	2.0	96	>99:1

[a] Reaction conditions: **A1**, **B1** (1.0 mmol), **C1** (1.5 mmol), DCM (2.0 mL), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

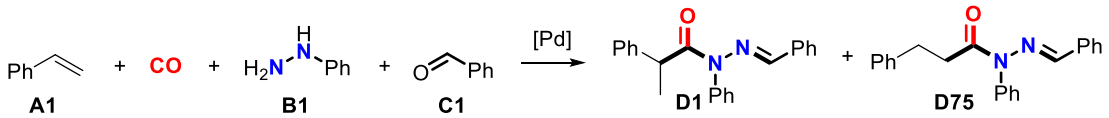
Table S7: The loading of **B1** screening [a]



Entry	**B1** (mmol)	**D1** (%)	**D1:D75**
1	0.5	54	>99:1
2	0.8	79	>99:1
3	0.9	92	>99:1
4	**1.0**	**96**	**>99:1**
5	1.1	95	>99:1
6	1.2	94	>99:1
7	1.4	91	>99:1
8	1.5	88	>99:1

[a] Reaction conditions: **A1** (1.4 mmol), **C1** (1.5 mmol), DCM (2.0 mL), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

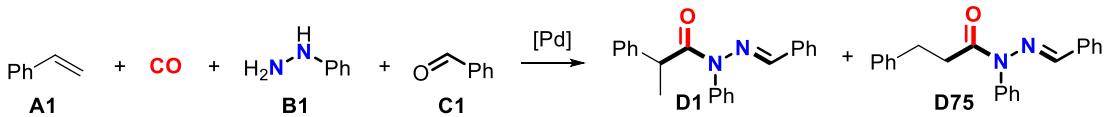
Table S8: The loading of **C1** screening [a]



Entry	**C1** (mmol)	**D1** (%)	**D1:D75**
1	1.0	74	>99:1
2	1.1	79	>99:1
3	1.2	80	>99:1
4	1.3	84	>99:1
5	1.4	92	>99:1
6	**1.5**	**96**	**>99:1**
7	1.75	95	>99:1
8	2.0	94	>99:1

[a] Reaction conditions: **A1** (1.4 mmol), **B1** (1.0 mmol), DCM (2.0 mL), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), CO (2.5 MPa), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

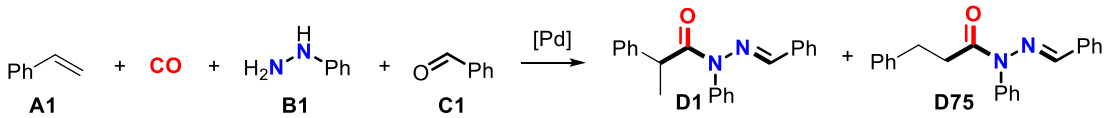
Table S9: Reaction pressure screening [a]



Entry	P [MPa]	**D1** (%)	**D1:D75**
1	0	0	-
2	0.1	<5	-
3	1.0	79	>99:1
4	2.0	91	>99:1
5	**2.5**	**96**	**>99:1**
6	3.0	95	>99:1
7	4.0	96	>99:1

[a] Reaction conditions: **A1** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), DCM (2.0 mL), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), 120 °C, 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

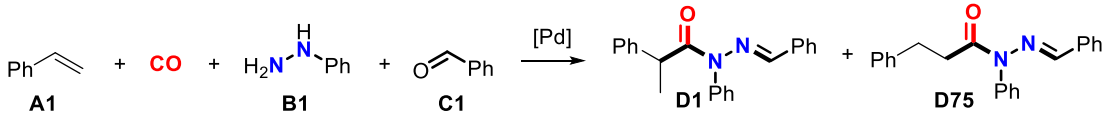
Table S10: Reaction time screening [a]



Entry	t [h]	**D1** (%)	**D1:D75**
1	2	51	>99:1
2	4	73	>99:1
3	**6**	**96**	**>99:1**
4	8	96	>99:1
5	10	95	>99:1
6	12	96	>99:1

[a] Reaction conditions: **A1** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), DCM (2.0 mL), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), CO (2.5 MPa), 120 °C, Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 µL) as internal standard.

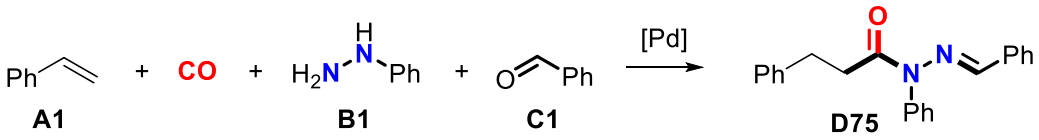
Table S11: Reaction temperature screening [a]



Entry	T [° C]	**D1** (%)	**D1:D75**
1	RT	0	-
2	40	<5	-
3	60	24	>99:1
4	80	36	>99:1
5	100	81	>99:1
6	**120**	**96**	**>99:1**
7	130	93	>99:1
8	140	90	>99:1

[a] Reaction conditions: **A1** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), DCM (2.0 mL), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol), CO (2.5 MPa), 6 h. Yield of **D1** and the ratio of **D1**:**D75** determined by GC-analysis using *n*-dodecane (100 µL) as internal standard.

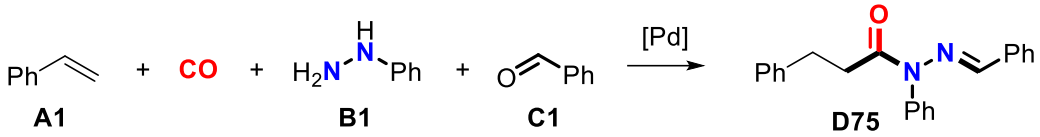
2.2 Screening of reaction parameters for the line acylhydrazone



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, alkene (**A1**), hydrazine (**B1**), aldehyde (**C1**), [Pd], ligand, and solvent. Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO and immersed into a pre-heated metal bath for desired time. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75**.

Entry	Parameter
Table S12	The loading catalyst screening
Table S13	The loading of solvent screening
Table S14	The difference of solvent screening
Table S15	The loading of **A1** screening
Table S16	The loading of **B1** screening
Table S17	The loading of **C1** screening
Table S18	Reaction pressure screening
Table S19	Reaction temperature screening
Table S20	Reaction time screening

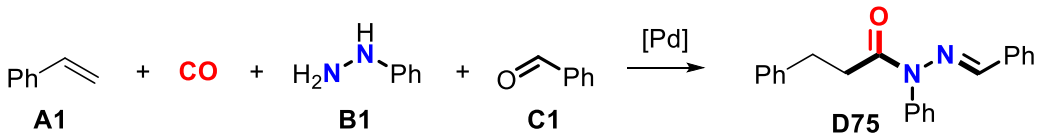
Table S12: The loading catalyst screening [a]



Entry	**Cat.** (mmol)	**D75** (%)	**D75:D1**
1	0	0	-
2	0.005	31	89:11
3	0.01	82	90:10
4	**0.02**	**93**	**89:11**
6	0.03	92	90:10
7	0.05	93	89:11

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2(Xantphos)_2$, anisole (2.0 mL), CO (3.0 MPa), 120 °C, 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

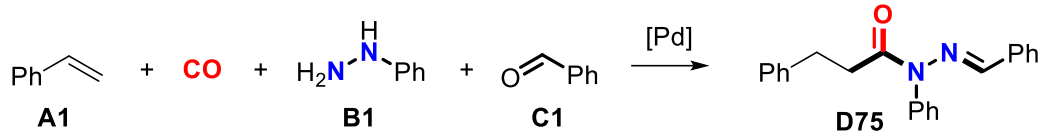
Table S13: The loading of solvent screening [a]



Entry	anisole (ml)	**D75** (%)	**D75:D1**
1	-	26	70:30
2	0.5	63	89:11
3	1.0	82	90:10
4	1.5	90	89:11
5	**2.0**	**93**	**89:11**
6	2.5	92	89:11
7	3.0	90	90:10

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), CO (3.0 MPa), 120 °C, 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

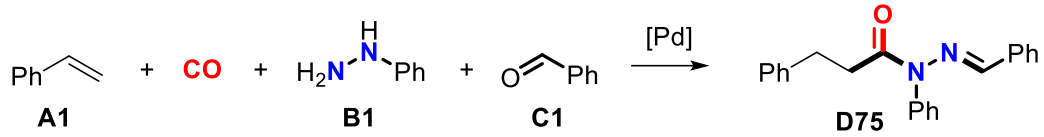
Table S14: The difference of solvent screening [a]



Entry	Solvent (2 mL)	**D75** (%)	**D75:D1**
1	DMAc	<5	-
2	DMF	<5	-
3	DMSO	<5	-
4	THF	23	80:20
5	PE	26	81:19
6	1,4-dioxane	56	90:10
7	**anisole**	**93**	**89:11**
8	1,2-dimethoxyethane	81	90:10
9	mesitylene	43	80:20
10	nitrobenzene	32	92:8
11	toluene	68	80:20
12	Et_3N	20	80:20
13	Py	12	91:9
14	EtOH	<5	-
15	IPA	<5	-
16	2-Methyl-2-propanol	36	85:15
17	2-Methyl-2-butanol	43	80:20
18	EA	32	87:13
19	hexane	12	80:20
20	acetonitrile	42	85:15
21	DCM	39	80:20
22	DCE	48	85:15
23	$CHCl_3$	<5	-
24	CH_3NO_2	<5	-

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), CO (3.0 MPa), 120 °C, 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

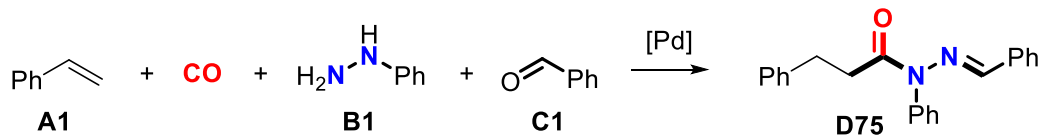
Table S15: The loading of **A1** screening [a]



Entry	A1 (mmol)	D75 (%)	D75:D1
1	0.5	41	62:38
2	1.0	71	81:19
3	1.25	82	85:15
4	1.4	90	85:15
5	**1.5**	**93**	**89:11**
6	1.6	92	89:11
7	1.75	93	89:11
8	2.0	92	89:11

[a] Reaction conditions: **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), anisole (2.0 mL), CO (3.0 MPa), 120 °C, 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

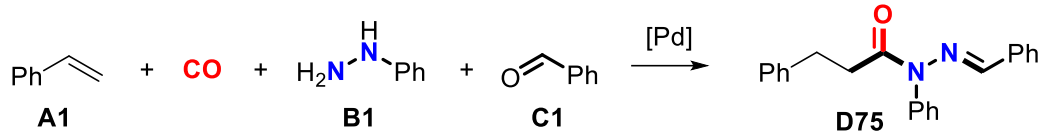
Table S16: The loading of **B1** screening [a]



Entry	B1 (mmol)	D75 (%)	D75:D1
1	0.5	81	88:12
2	0.8	90	89:11
3	0.9	92	88:12
4	**1.0**	**93**	**89:11**
5	1.1	92	89:11
6	1.2	90	90:10
7	1.4	86	89:11
8	1.5	81	88:12

[a] Reaction conditions: **A1** (1.5 mmol), **C1** (1.5 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), anisole (2.0 mL), CO (3.0 MPa), 120 °C, 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

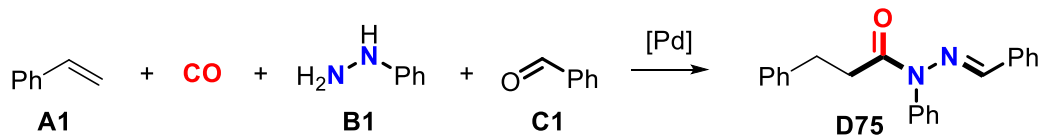
Table S17: The loading of **C1** screening [a]



Entry	**C1** (mmol)	**D75** (%)	**D75:D1**
1	1.0	66	88:12
2	1.1	70	89:11
3	1.2	76	89:11
4	1.3	83	90:10
5	1.4	90	89:11
6	**1.5**	**93**	**89:11**
7	1.75	92	89:11
8	2.0	93	90:10

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), anisole (2.0 mL), CO (3.0 MPa), 120 °C, 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

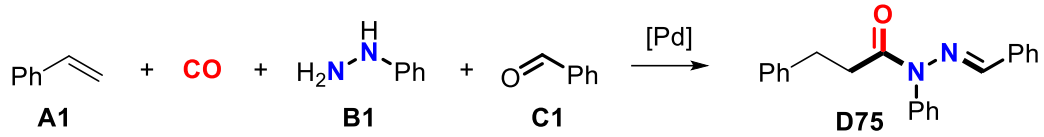
Table S18: Reaction pressure screening [a]



Entry	P [MPa]	**D75** (%)	**D75:D1**
1	0	0	-
2	0.1	<5	-
3	1.0	44	80:20
4	2.0	75	89:11
5	2.5	84	90:10
6	**3.0**	**93**	**89:11**
7	3.5	93	90:10

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1**(1.5 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), anisole (2.0 mL), 120 °C, 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 μL) as internal standard.

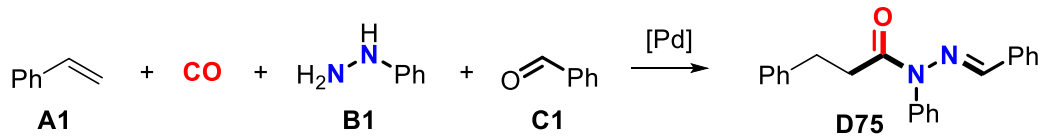
Table S19: Reaction time screening [a]



Entry	t [h]	**D75** (%)	**D75:D1**
1	2	11	89:11
2	4	42	90:10
3	8	81	89:11
4	**16**	**93**	**89:11**
5	24	93	90:10
6	36	93	90:10

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1**(1.5 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), anisole (2.0 mL), CO (3.0 MPa), 120 °C. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 µL) as internal standard.

Table S20: Reaction temperature screening [a]

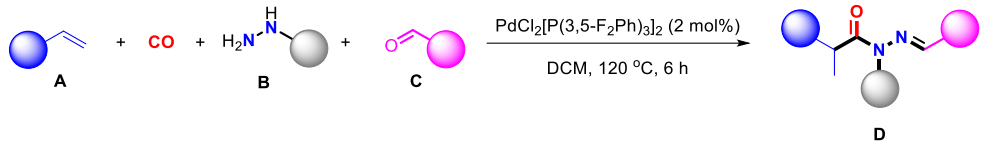


Entry	T [° C]	**D75** (%)	**D75:D1**
1	RT	0	-
2	40	<5	-
3	60	<5	-
4	80	<5	-
5	100	81	89:11
6	**120**	**93**	**89:11**
7	130	92	90:10
8	140	90	86:14

[a] Reaction conditions: **A1** (1.5 mmol), **B1** (1.0 mmol), **C1**(1.5 mmol), $PdCl_2(Xantphos)_2$ (0.02 mmol), anisole (2.0 mL), CO (3.0 MPa), 16 h. Yield of **D75** and the ratio of **D75**:**D1** determined by GC-analysis using *n*-dodecane (100 µL) as internal standard.

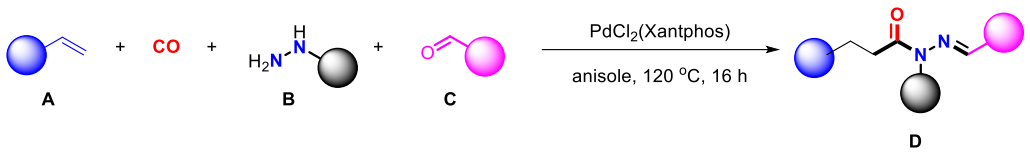
3. Experimental characterization data for products

3.1 Substrate scope of branched acylhydrazones



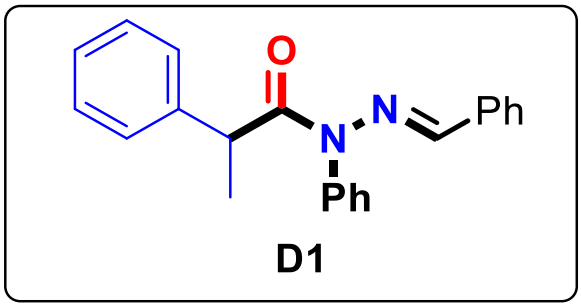
Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, alkenes (**A** 1.4 mmol), hydrazines (**B** 1.0 mmol), aldehydes (**C** 1.5 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 5:1) on silica gel to give the corresponding products **D1-D60**.

3.2 Substrate scope of line acylhydrazones



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, alkenes (**A** 1.5 mmol), hydrazines (**B** 1.0 mmol), aldehydes (**C** 1.5 mmol), $PdCl_2$(Xantphos) (0.02 mmol, 2 mol%), and anisole (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 °C) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 5:1) on silica gel to give the corresponding products **D75-D91**.

4. Characterization data



***N'*-benzylidene-*N*,2-diphenylpropanehydrazide (D1)**

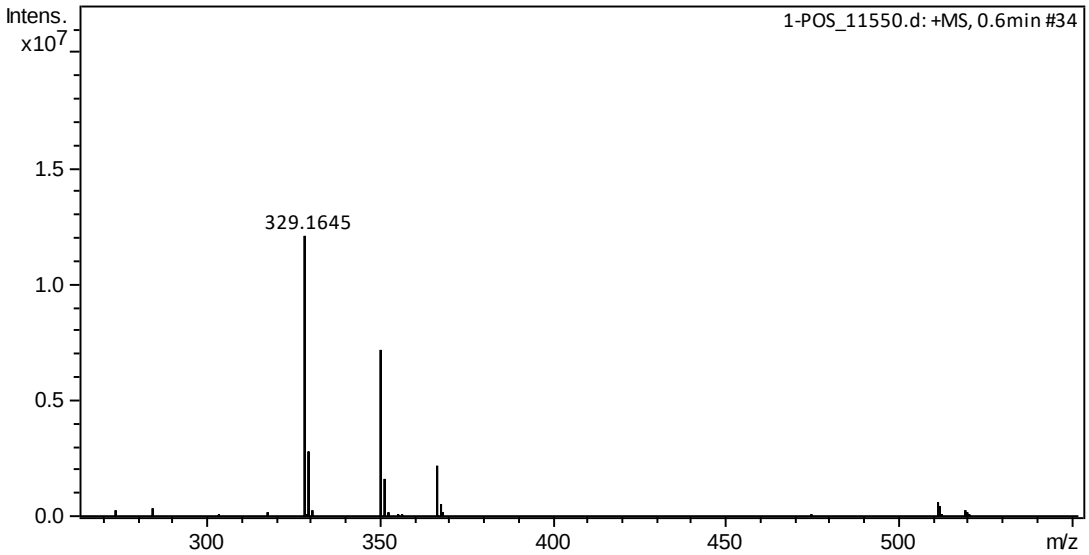
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 285.4 mg, 87% yield.

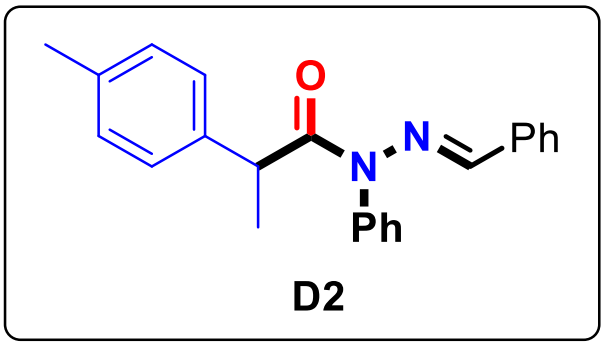
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.46 (m, 6H), 7.45 – 7.40 (m, 1H), 7.36 – 7.28 (m, 5H), 7.23 – 7.17 (m, 1H), 7.14 (s, 1H), 7.07 (d, *J* = 7.6 Hz, 2H), 5.09 (d, *J* = 7.2 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.5, 141.5, 136.3, 134.4, 130.2, 129.8, 129.2, 128.7, 128.6, 127.8, 127.3, 126.7, 42.9, 19.5 ppm.

MS (70 eV): m/z (%) = 328 $[M]^+$, 225, 196, 105.

HRMS (ESI) calcd. for $C_{22}H_{21}N_2O$ [M+H]: 329.1648, found: 329.1645.





***N′*-benzylidene-*N*-phenyl-2-(*p*-tolyl)propanehydrazide (D2)**

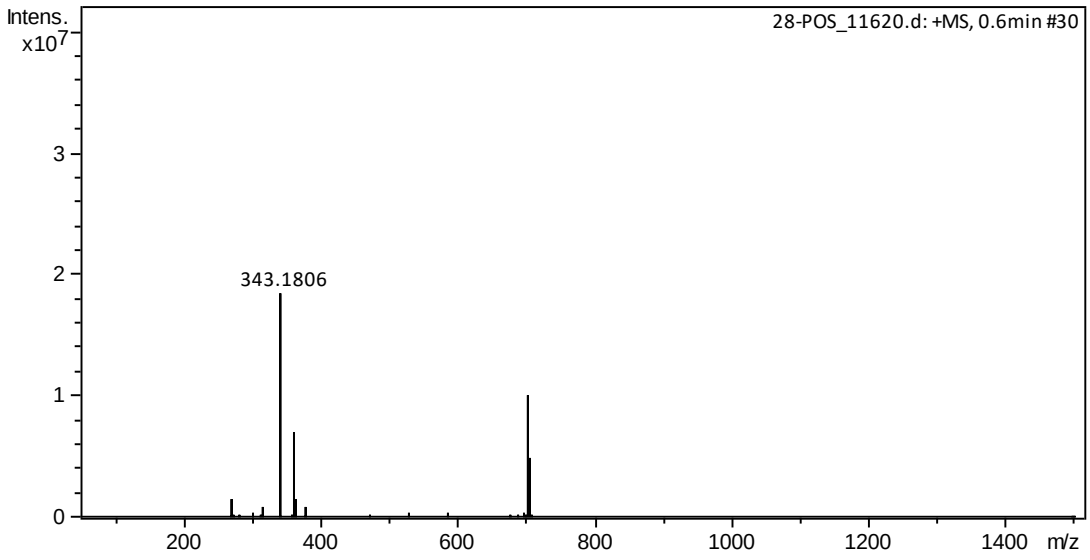
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 311.2 mg, 91% yield.

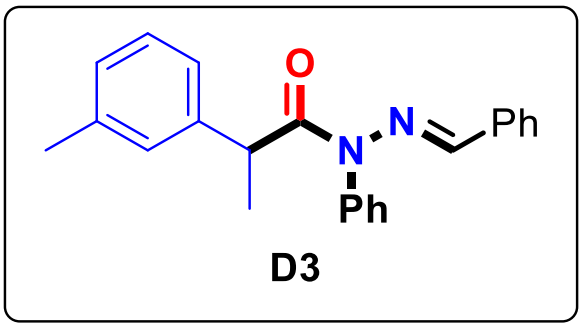
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 6.4 Hz, 2H), 7.47 – 7.43 (m, 2H), 7.42 – 7.33 (m, 3H), 7.32 – 7.27 (m, 3H), 7.16 – 7.08 (m, 3H), 7.05 (d, *J* = 7.6 Hz, 2H), 5.07 (d, *J* = 7.2 Hz, 1H), 2.25 (s, 3H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.0, 141.5, 139.6, 136.4, 136.2, 134.6, 130.2, 129.9, 129.5, 129.3, 128.8, 127.8, 127.3, 42.6, 21.2, 19.7 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 223, 196, 119.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1806.





***N′*-benzylidene-*N*-phenyl-2-(*m*-tolyl)propanehydrazide (D3)**

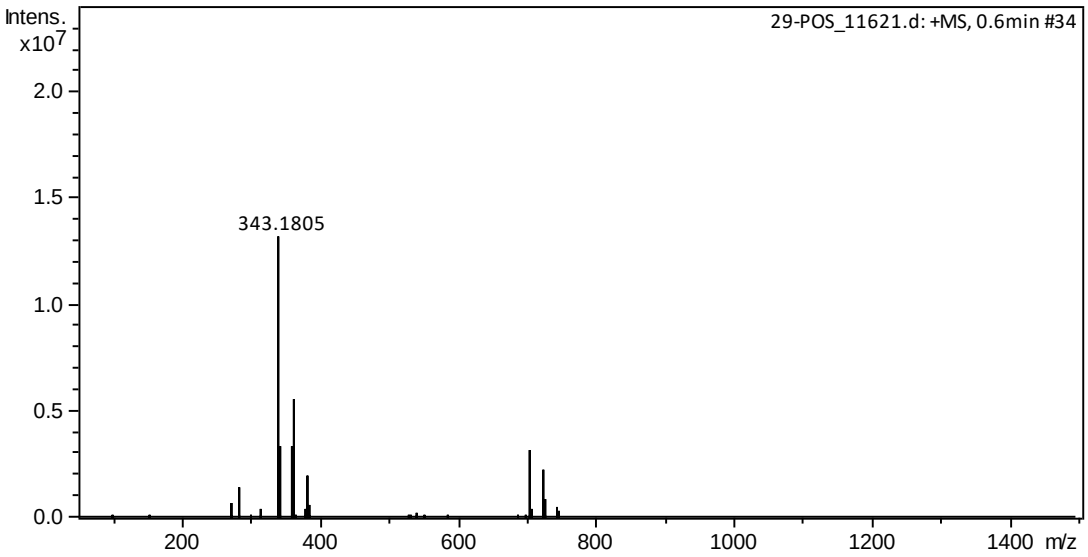
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 287.3 mg, 84% yield.

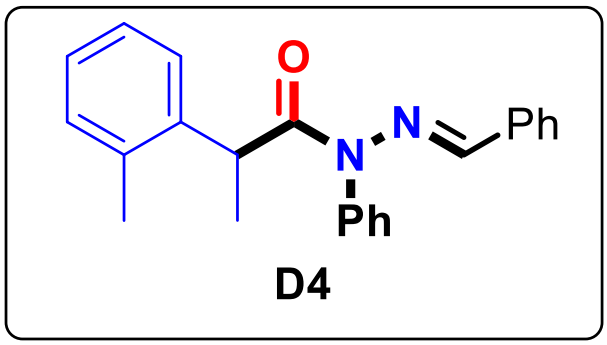
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.44 (m, 4H), 7.43 – 7.37 (m, 1H), 7.36 – 7.24 (m, 5H), 7.22 – 7.16 (m, 1H), 7.13 (s, 1H), 7.06 (d, *J* = 7.6 Hz, 2H), 7.00 (d, *J* = 7.2 Hz, 1H), 5.03 (d, *J* = 7.2 Hz, 1H), 2.31 (s, 3H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 142.5, 141.5, 138.2, 136.4, 134.5, 130.2, 129.9, 129.3, 128.7, 127.5, 127.3, 124.9, 43.1, 21.6, 19.6 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 196, 119, 91.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1805.





***N′*-benzylidene-*N*-phenyl-2-(*o*-tolyl)propanehydrazide (D4)**

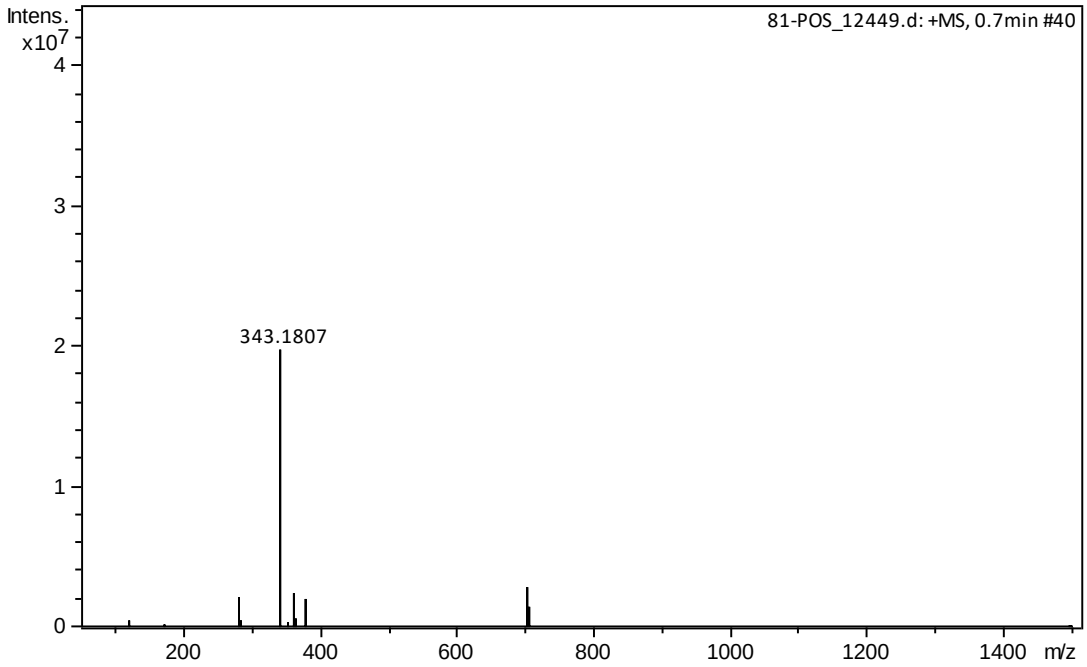
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 249.7 mg, 73% yield.

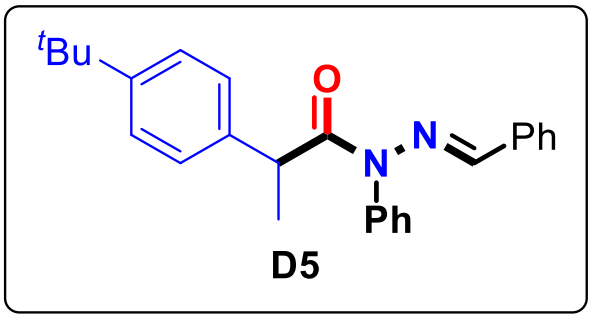
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 – 7.45 (m, 2H), 7.43 – 7.33 (m, 4H), 7.29 – 7.24 (m, 3H), 7.21 – 7.15 (m, 2H), 7.14 – 7.07 (m, 4H), 5.12 (d, *J* = 6.8 Hz, 1H), 2.56 (s, 3H), 1.52 (d, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.3, 142.0, 141.4, 136.5, 135.1, 134.4, 130.5, 130.3, 129.8, 129.3, 128.6, 127.4, 126.6, 126.2, 39.7, 19.8, 18.5 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 196, 119, 91.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1807.





***N′*-benzylidene-2-(4-(*tert*-butyl)phenyl)-*N*-phenylpropanehydrazide (D5)**

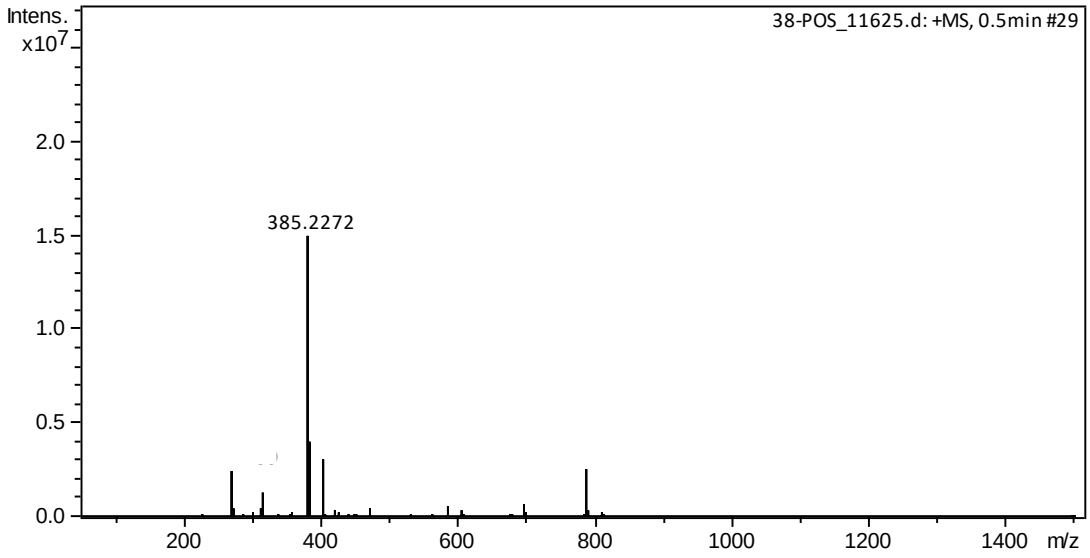
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 345.6 mg, 90% yield.

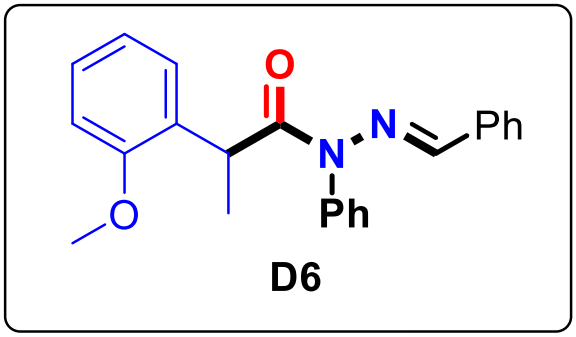
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 6.8 Hz, 2H), 7.47 – 7.41 (m, 4H), 7.37 (d, *J* = 7.2 Hz, 1H), 7.35 – 7.26 (m, 5H), 7.14 (s, 1H), 7.05 (d, *J* = 7.6 Hz, 2H), 5.12 (d, *J* = 6.8 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H), 1.27 (s, 9H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.1, 149.44, 141.5, 139.3, 136.4, 134.6, 130.2, 129.9, 129.3, 128.8, 127.5, 127.4, 125.6, 42.2, 34.5, 31.6, 19.6 ppm.

MS (70 eV): m/z (%) = 384 $[M]^+$ (100), 252, 196, 105.

HRMS (ESI) calcd. for $C_{26}H_{29}N_2O$ [M+H]: 385.2274, found: 385.2272.





***N′*-benzylidene-2-(2-methoxyphenyl)-*N*-phenylpropanehydrazide (D6)**

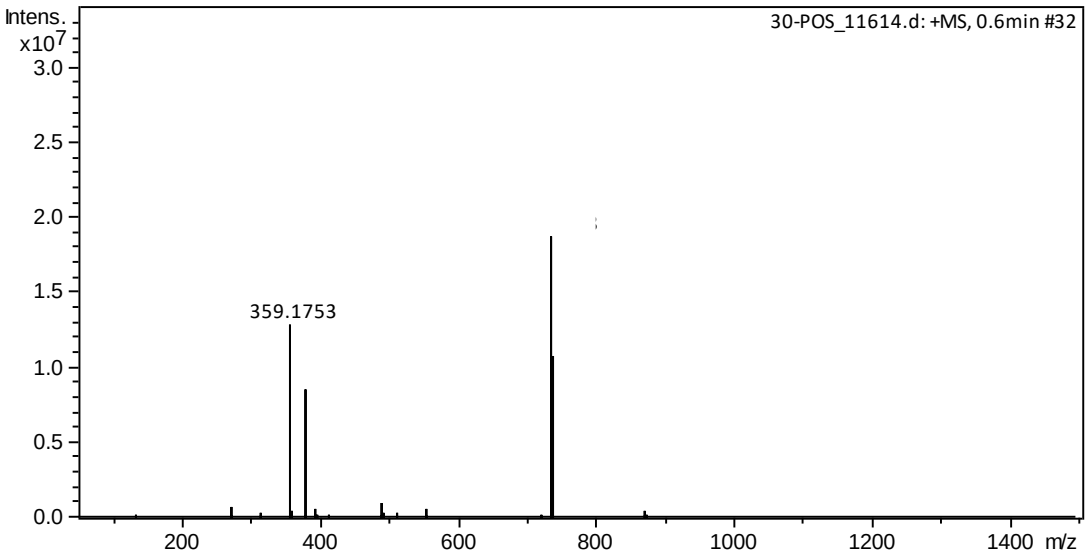
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 250.6 mg, 70% yield.

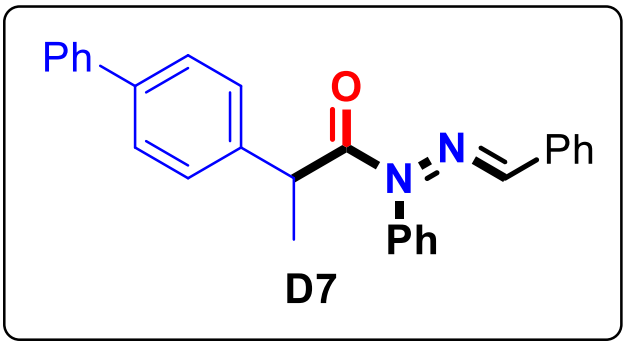
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.32 (m, 6H), 7.26 – 7.21 (m, 3H), 7.17 – 7.05 (m, 4H), 6.93 – 6.82 (m, 2H), 5.43 (d, *J* = 6.8 Hz, 1H), 3.90 (s, 3H), 1.52 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.7, 156.2, 140.8, 136.5, 134.8, 131.7, 130.2, 129.7, 129.3, 128.6, 127.7, 127.4, 127.2, 120.9, 110.4, 55.4, 36.6, 18.3 ppm.

MS (70 eV): m/z (%) = 358 $[M]^+$ (100), 196, 135, 105.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O_2$ [M+H]: 359.1754, found: 359.1753.





2-([1,1'-biphenyl]-4-yl)-1-(2-benzylidene-1-phenyl-1l4,2l4-diazenyl)propan-1-one (D7)

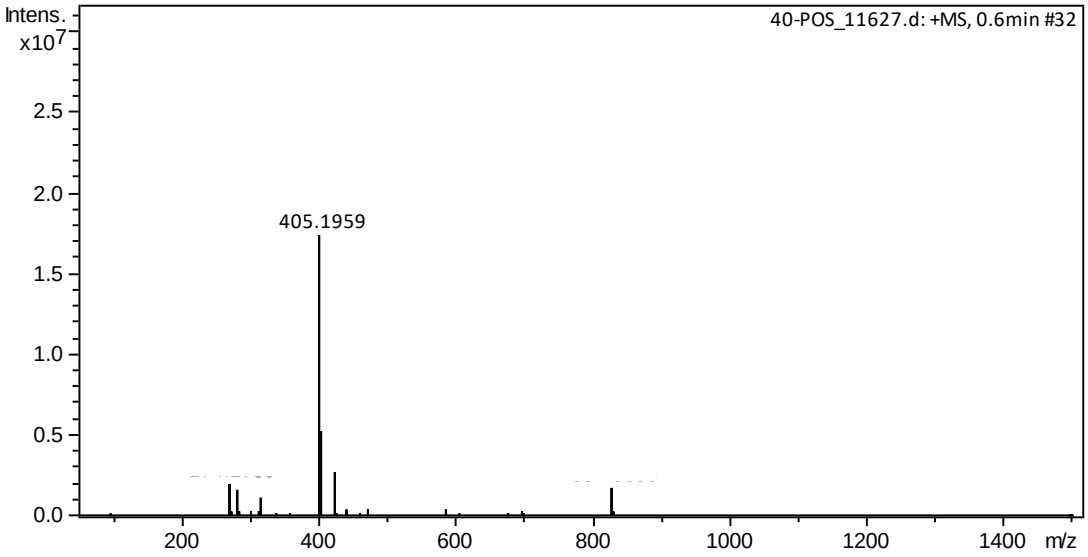
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 331.3 mg, 82% yield.

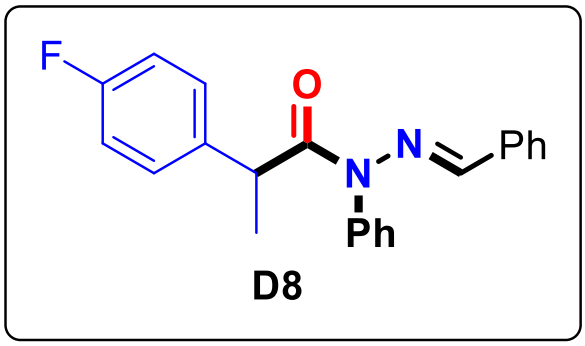
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.70 (m, 8H), 7.69 – 7.62 (m, 2H), 7.60 – 7.47 (m, 6H), 7.47 – 7.42 (m, 1H), 7.37 (s, 1H), 7.27 (d, *J* = 7.2 Hz, 2H), 5.38 (d, *J* = 6.8 Hz, 1H), 1.87 (d, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 141.8, 141.1, 139.7, 136.4, 134.6, 130.4, 130.1, 129.4, 128.9, 128.5, 127.5, 127.4, 127.2, 42.7, 19.7 ppm.

MS (70 eV): m/z (%) = 404 $[M]^+$ (100), 384, 196, 161.

HRMS (ESI) calcd. for $C_{28}H_{25}N_2O$ [M+H]: 405.1961, found: 405.1959.





***N′*-benzylidene-2-(4-fluorophenyl)-*N*-phenylpropanehydrazide (D8)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 283.7 mg, 82% yield.

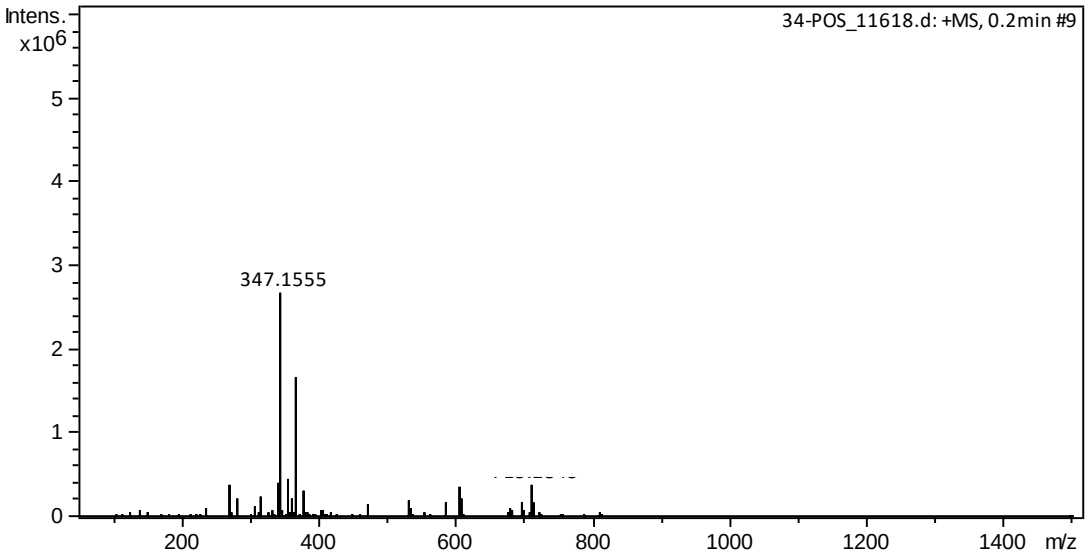
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 – 7.55 (m, 6H), 7.54 – 7.49 (m, 1H), 7.46 – 7.42 (m, 3H), 7.32 –7.28 (m, 1H), 7.18 (d, *J* = 7.6 Hz, 2H), 7.10 (t, *J* = 8.4 Hz, 2H), 5.23 (d, *J* = 5.2 Hz, 1H), 1.79 – 1.65 (m, 3H) ppm.

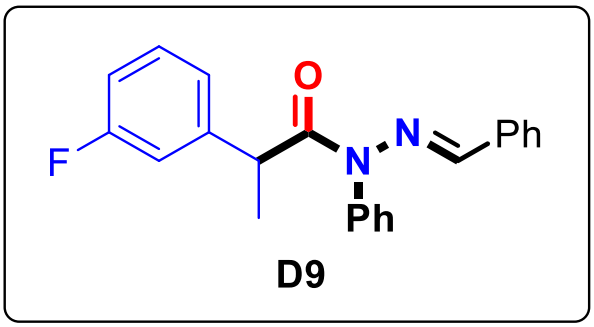
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.6, 163.0, 160.6, 141.8, 138.2, 136.2, 134.4, 130.3, 130.0, 129.5, 129.4, 129.2, 128.9, 127.3, 115.6, 115.4, 42.1, 19.6 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -116.1.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 243, 196, 123.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1555.





***N′*-benzylidene-2-(3-fluorophenyl)-*N*-phenylpropanehydrazide (D9)**

The title compound was prepared according to the general procedure and purified by column chromatography to give the light-yellow oil, 252.6 mg, 73% yield.

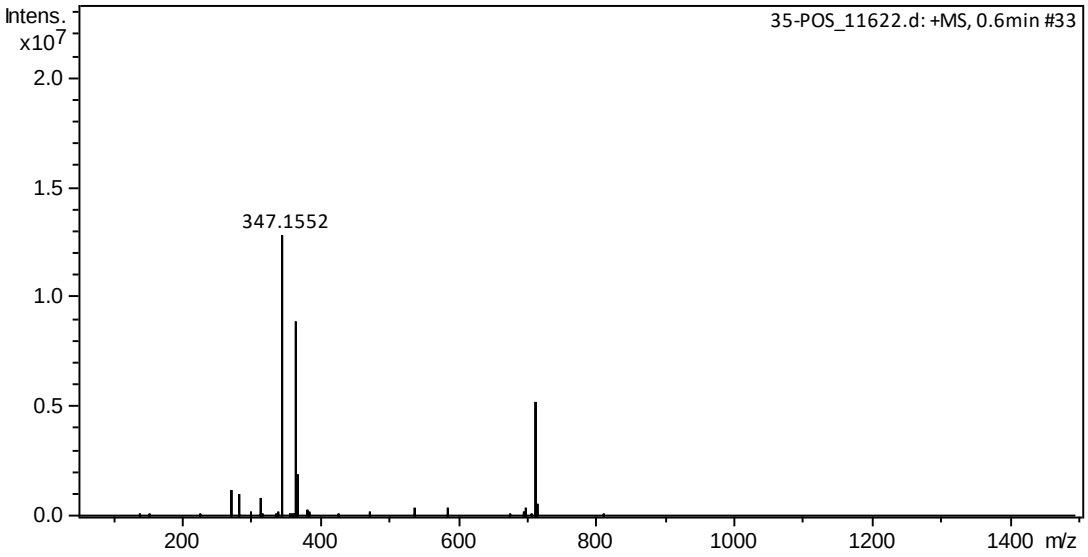
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 – 7.44 (m, 4H), 7.42 – 7.36 (m, 1H), 7.34 – 7.20 (m, 6H), 7.17 (s, 1H), 7.06 (d, *J* = 7.6 Hz, 2H), 7.89 – 7.83 (m, 1H), 5.10 (d, *J* = 7.2 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

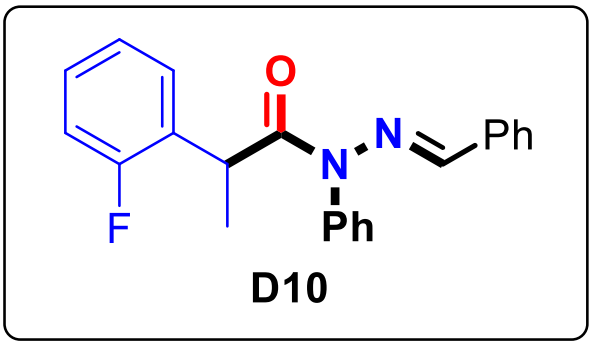
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.2, 164.3, 161.9, 145.1, 141.9, 136.2, 134.3, 130.3, 130.2, 130.1, 129.4, 129.2, 128.9, 127.3, 123.6, 114.9, 114.7, 113.8, 113.6, 42.8, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -112.8.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 243, 196, 123.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1552.





***N'*-benzylidene-2-(2-fluorophenyl)-*N*-phenylpropanehydrazide (D10)**

The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 231.8 mg, 67% yield.

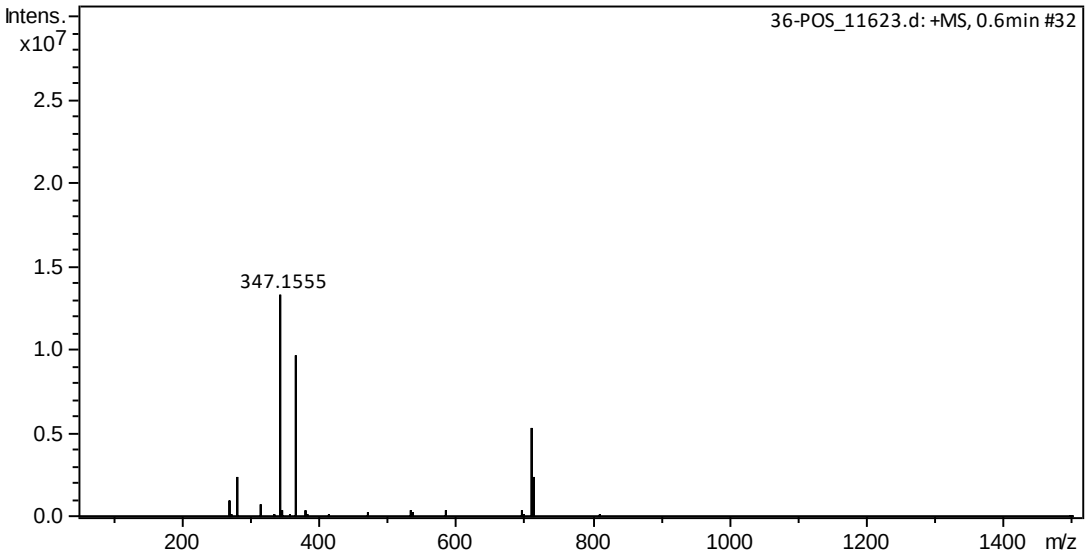
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.37 (m, 6H), 7.28 – 7.24 (m, 3H), 7.16 – 7.01 (m, 6H), 5.36 (d, *J* = 6.8 Hz, 1H), 1.65 – 1.49 (m, 3H) ppm.

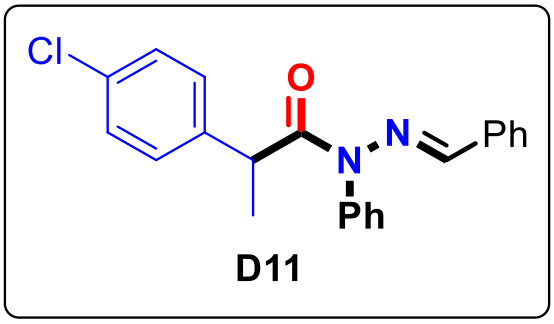
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.3, 161.3, 158.9, 141.9, 136.2, 134.3, 130.3, 129.9, 129.4, 129.3, 128.7, 128.4, 128.3, 128.2, 127.4, 124.6, 124.5, 115.6, 115.4, 36.0, 18.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -118.6.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 243, 196, 123.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1555.





D11

***N′*-benzylidene-2-(4-chlorophenyl)-*N*-phenylpropanehydrazide (D11)**

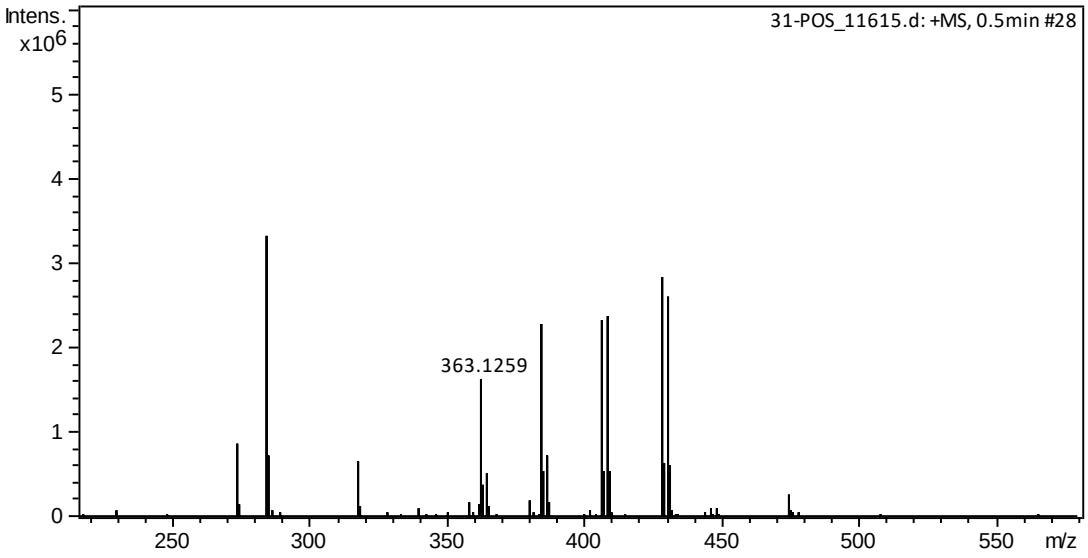
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 300.5 mg, 83% yield.

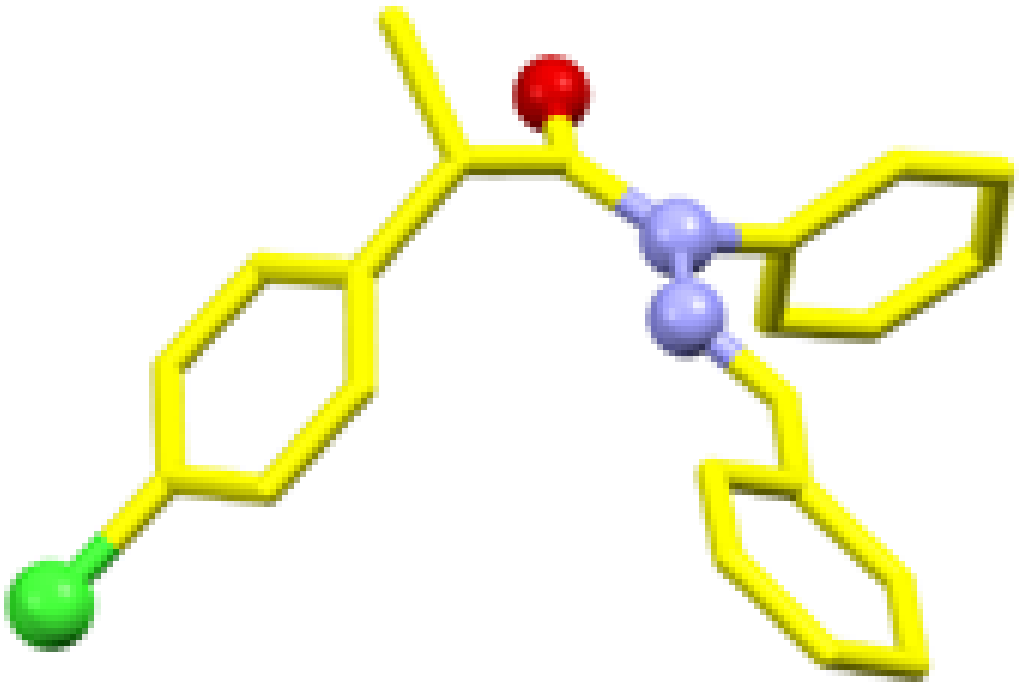
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 – 7.45 (m, 4H), 7.42 (d, *J* = 8.0 Hz, 3H), 7.37 – 7.30 (m, 3H), 7.26 (d, *J* = 8.4 Hz, 2H), 7.16 (s, 1H), 7.06 (d, *J* = 7.6 Hz, 2H), 5.08 (d, *J* = 7.2 Hz, 1H), 1.57 (d, *J* = 7.2 Hz, 3H) ppm.

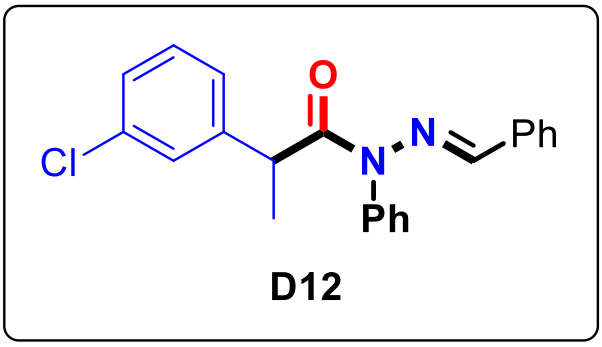
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.3, 141.9, 141.0, 136.1, 134.3, 132.5, 130.3, 130.0, 129.4, 129.3, 129.2, 128.8, 127.3, 42.3, 19.5 ppm.

MS (70 eV): m/z (%) = 362 $[M]^+$ (100), 230, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}ClN_2O$ [M+H]: 363.1258, found: 363.1259.







***N′*-benzylidene-2-(3-chlorophenyl)-*N*-phenylpropanehydrazide (D12)**

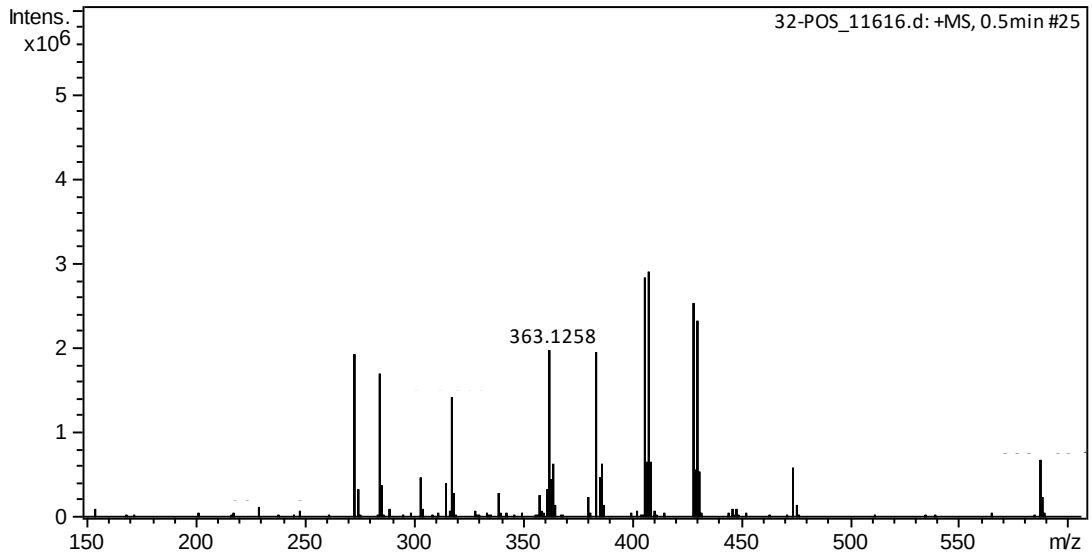
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 267.9 mg, 74% yield.

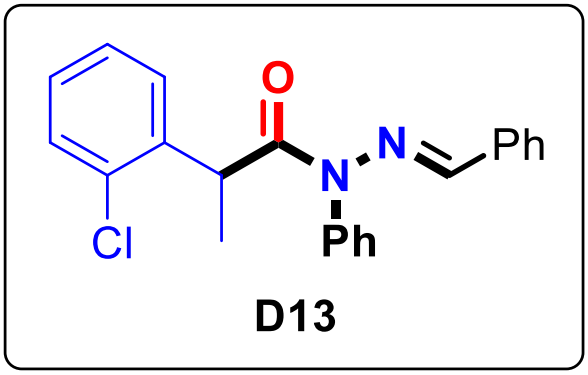
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.43 (m, 5H), 7.43 – 7.28 (m, 5H), 7.22 – 7.13 (m, 3H), 7.06 (d, *J* = 7.6 Hz, 2H), 5.03 (d, *J* = 7.2 Hz, 1H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.0, 144.6, 142.0, 136.1, 134.4, 134.3, 130.3, 130.1, 130.0, 129.4, 129.2, 128.9, 128.3, 127.4, 127.0, 126.0, 42.9, 19.5 ppm.

MS (70 eV): m/z (%) = 362 $[M]^+$ (100), 259, 196, 139.

HRMS (ESI) calcd. for $C_{22}H_{20}ClN_2O$ [M+H]: 363.1258, found: 363.1258.





D13

***N′*-benzylidene-2-(2-chlorophenyl)-*N*-phenylpropanehydrazide (D13)**

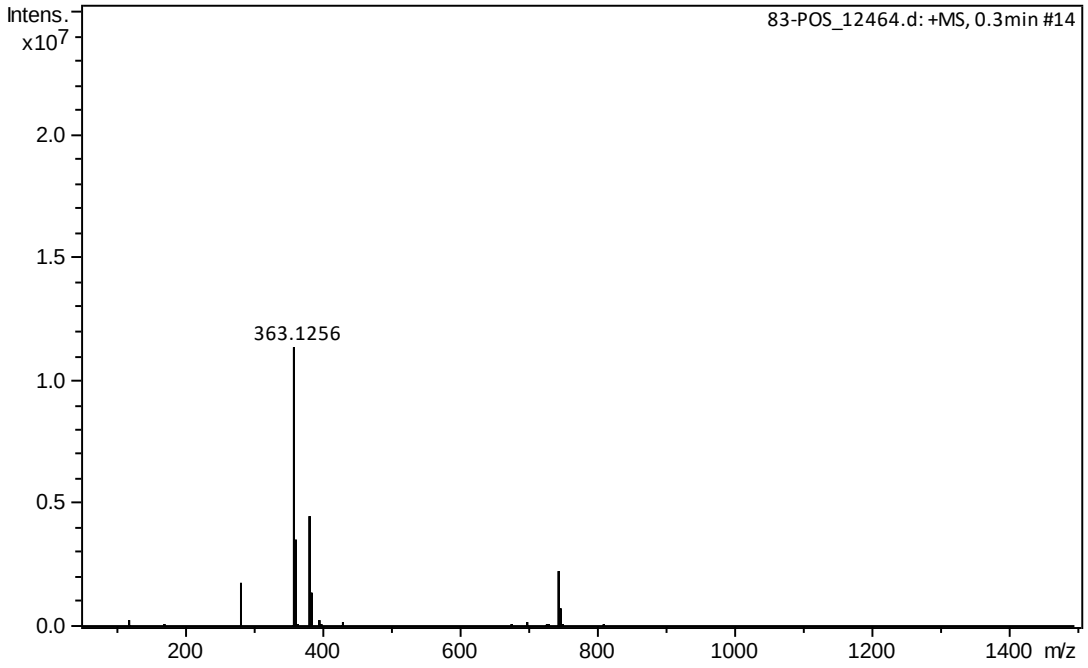
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 246.2 mg, 68% yield.

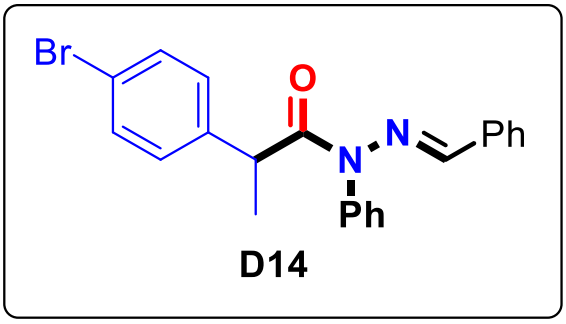
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.47 (m, 4H), 7.45 – 7.37 (m, 3H), 7.26 (s, 3H), 7.20 (t, *J* = 7.6 Hz, 1H), 7.15 – 7.07 (m, 4H), 5.42 (d, *J* = 6.8 Hz, 1H), 1.55 (d, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.4, 142.0, 140.8, 136.2, 134.2, 133.3, 130.3, 129.9, 129.7, 129.4, 129.2, 128.6, 127.9, 127.8, 127.5, 127.4, 40.6, 17.9 ppm.

MS (70 eV): m/z (%) = 362 $[M]^+$ (100), 224, 196, 139.

HRMS (ESI) calcd. for $C_{22}H_{20}ClN_2O$ [M+H]: 363.1259, found: 363.1256.





***N′*-benzylidene-2-(4-bromophenyl)-*N*-phenylpropanehydrazide (D14)**

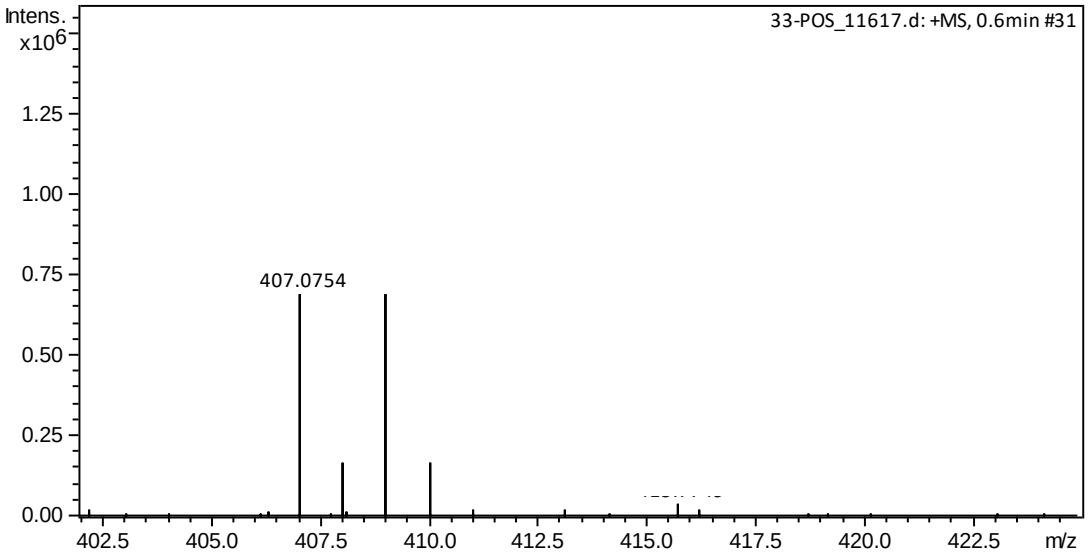
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 324.8 mg, 80% yield.

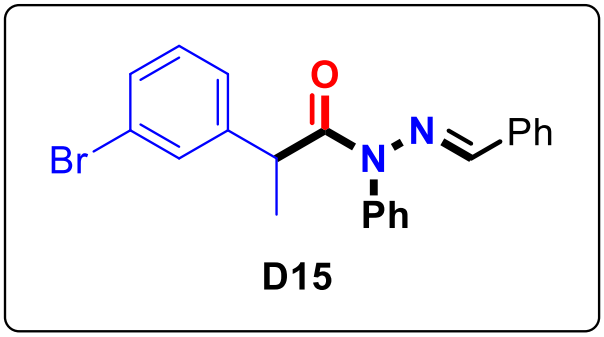
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.51 (m, 4H), 7.48 – 7.40 (m, 3H), 7.40 – 7.32 (m, 5H), 7.18 (s, 1H), 7.09 (d, *J* = 7.6 Hz, 2H), 5.08 (d, *J* = 7.2 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.2, 141.9, 141.4, 136.0, 134.2, 131.7, 130.2, 130.0, 129.6, 129.3, 129.1, 128.8, 127.2 120.5, 42.4, 19.3 ppm.

MS (70 eV): m/z (%) = 406 $[M]^+$ (100), 196, 104, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}BrN_2O$ [M+H]: 407.0754, found: 407.0754.





***N′*-benzylidene-2-(3-bromophenyl)-*N*-phenylpropanehydrazide (D15)**

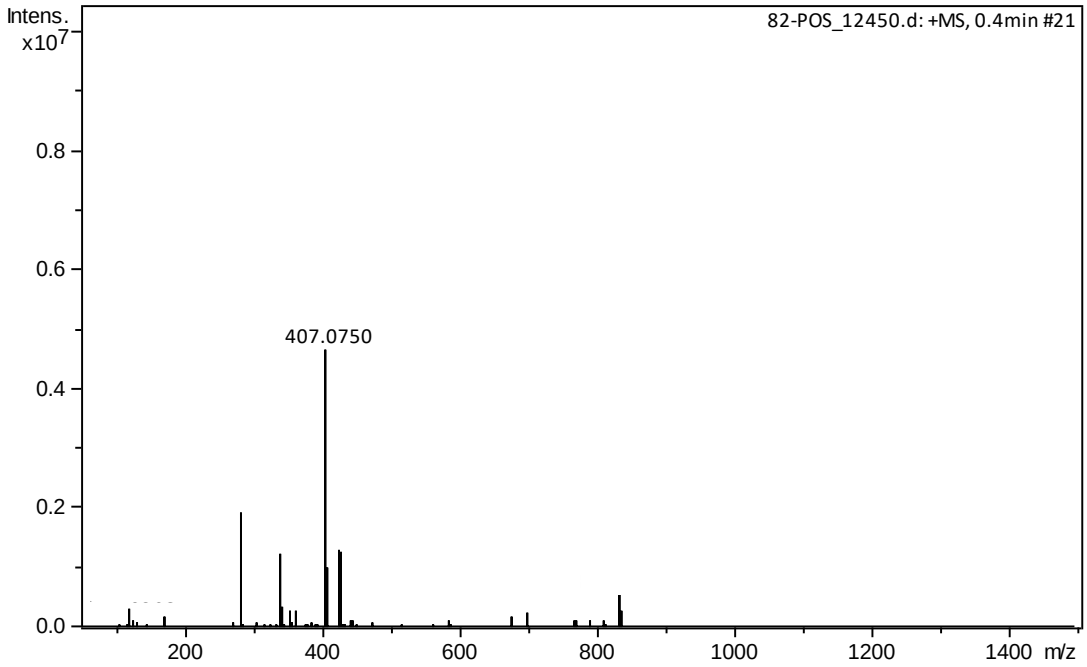
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 284.2 mg, 70% yield.

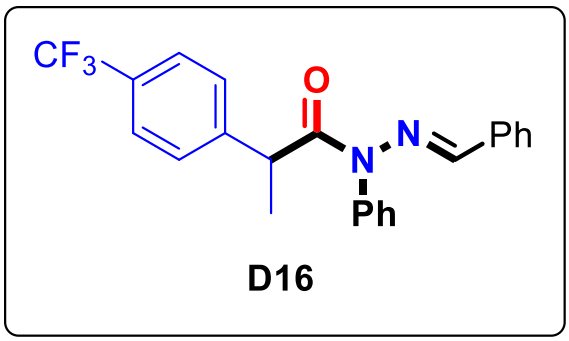
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (s, 1H), 7.52 – 7.44 (m, 4H), 7.43 – 7.36 (m, 2H), 7.35 – 7.27 m, 4H), 7.17 – 7.10 (m, 2H), 7.06 (d, *J* = 7.6 Hz, 2H), 5.00 (d, *J* = 7.2 Hz, 1H), 1.57 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.0, 144.9, 142.0, 136.1, 134.3, 131.3, 130.3, 130.1, 129.9, 129.4, 129.2, 128.9, 127.4, 126.4, 122.7, 43.0, 19.5 ppm.

MS (70 eV): m/z (%) = 406 $[M]^+$ (100), 196, 167, 104.

HRMS (ESI) calcd. for $C_{22}H_{20}BrN_2O$ [M+H]: 407.0753, found: 407.0750.





***N′*-benzylidene-*N*-phenyl-2-(4-(trifluoromethyl)phenyl)propanehydrazide (D16)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a light-yellow solid, 293.0 mg, 74% yield.

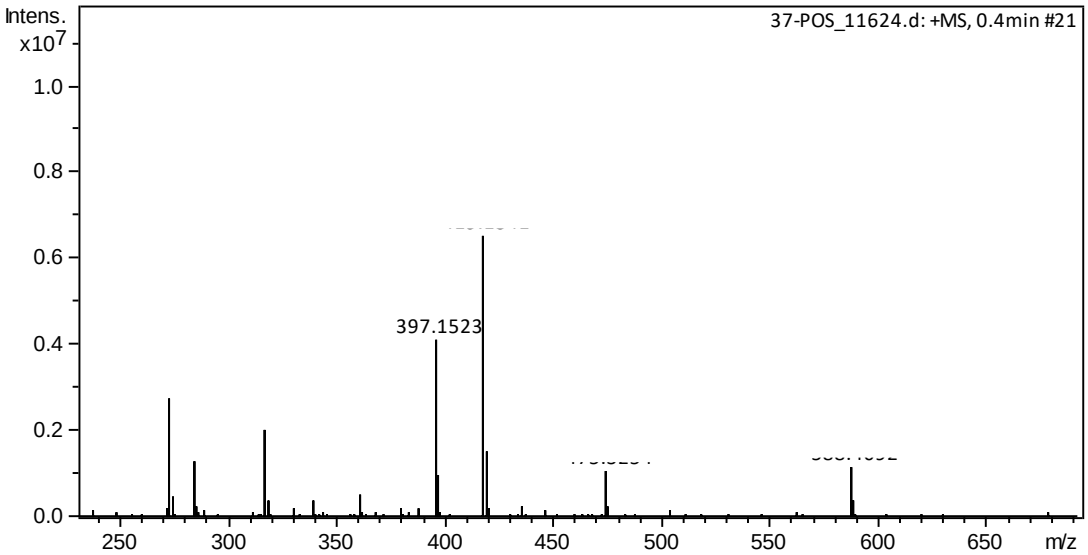
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.55 (m, 4H), 7.53 – 7.47 (m, 4H), 7.45 – 7.40 (m, 1H), 7.37 – 7.29 (m, 3H), 7.19 (s, 1H), 7.08 (d, *J* = 7.6 Hz, 2H), 5.17 (d, *J* = 7.2 Hz, 1H), 1.62 (d, *J* = 7.2 Hz, 3H) ppm.

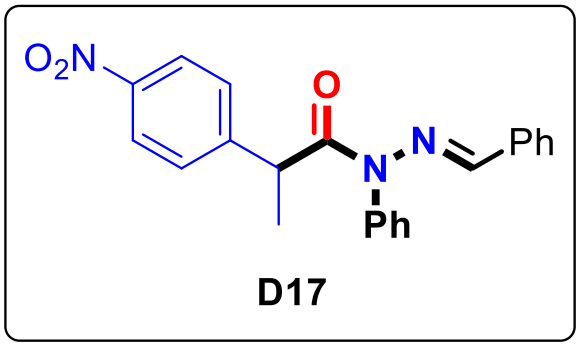
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.0, 146.5, 142.2, 136.0, 134.2, 130.3, 130.1, 129.4, 129.1, 128.8, 128.3, 127.3, 125.6, 42.9, 19.4 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -62.2.

MS (70 eV): m/z (%) = 396 $[M]^+$ (100), 293, 196, 173.

HRMS (ESI) calcd. for $C_{23}H_{20}F_3N_2O$ [M+H]: 397.1522, found: 397.1523.





***N′*-benzylidene-2-(4-nitrophenyl)-*N*-phenylpropanehydrazide (D17)**

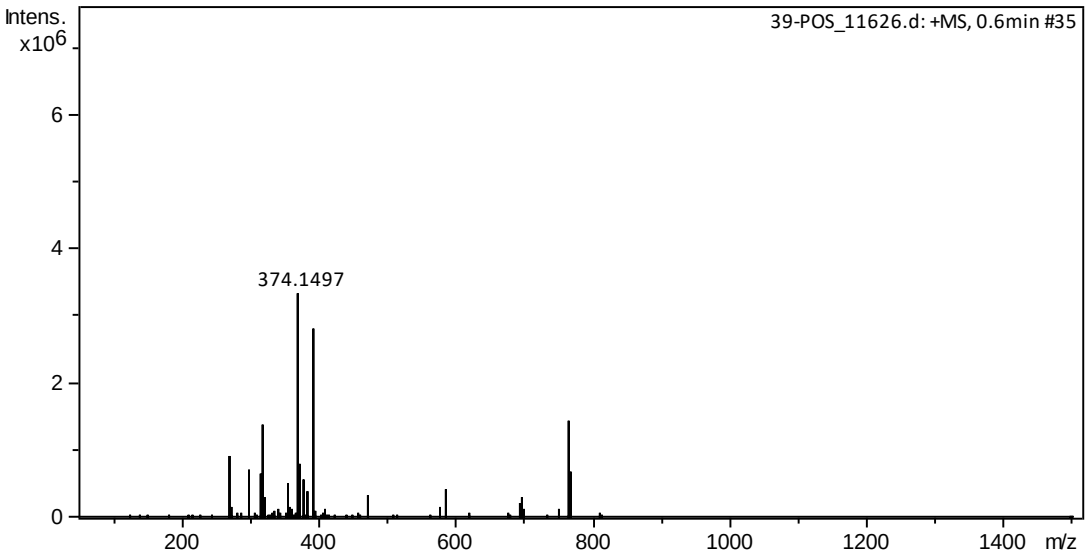
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 160.4 mg, 43% yield.

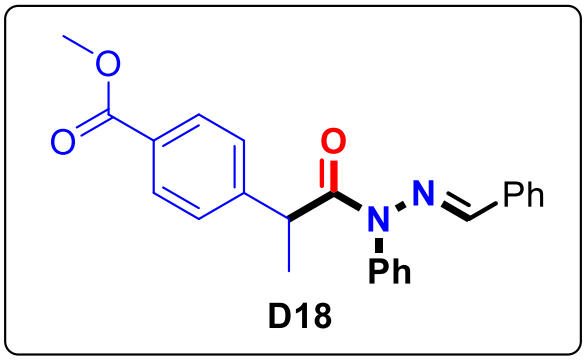
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.8 Hz, 2H), 7.65 (d, *J* = 8.8 Hz, 2H), 7.57 – 7.44 (m, 5H), 7.39 – 7.33 (m, 3H), 7.26 – 7.16 (m, 2H), 7.09 (d, *J* = 7.6 Hz, 2H), 5.19 (d, *J* = 7.2 Hz, 1H), 1.63 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.3, 150.0, 146.8, 142.5, 135.7, 134.0, 130.3, 130.2, 129.5, 129.0, 128.8, 128.7, 127.2, 123.9, 43.0, 19.2 ppm.

MS (70 eV): m/z (%) = 373 $[M]^+$ (100), 270, 196, 120.

HRMS (ESI) calcd. for $C_{22}H_{20}N_3O_3$ [M+H]: 374.1499, found: 374.1497.





D18

methyl-4-(1-(2-benzylidene-1-phenylhydrazineyl)-1-oxopropan-2-yl)benzoate (D18)

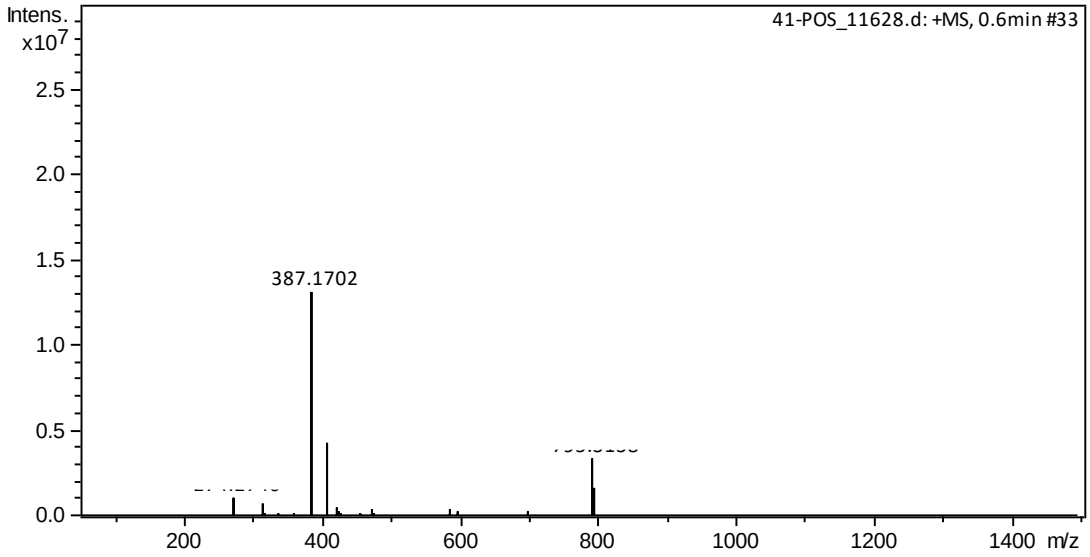
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 312.7 mg, 81% yield.

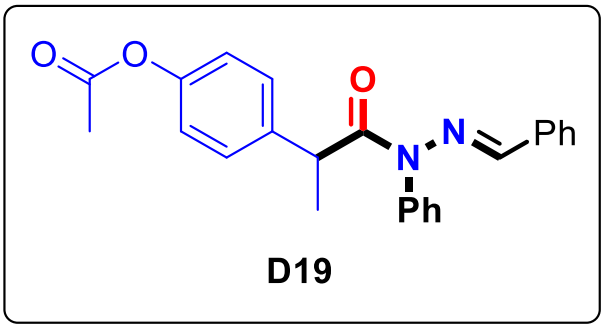
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (d, *J* = 7.8 Hz, 2H), 7.58 (d, *J* = 7.8 Hz, 2H), 7.51 – 7.44 (m, 4H), 7.42 – 7.37 (m, 1H), 7.34 – 7.27 (m, 3H), 7.17 (s, 1H), 7.08 (d, *J* = 7.6 Hz, 2H), 5.14 (d, *J* = 7.2 Hz, 1H), 3.80 (s, 3H), 1.61 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.9, 166.9, 147.9, 141.9, 136.1, 134.2, 130.3, 130.0, 129.4, 129.1, 128.8, 128.7, 127.8, 127.3, 52.0, 43.3, 19.3 ppm.

MS (70 eV): m/z (%) = 386 $[M]^+$ (100), 283, 196, 163.

HRMS (ESI) calcd. for $C_{24}H_{23}N_2O_3$ [M+H]: 387.1703, found: 387.1702.





D19

4-(1-(2-benzylidene-1-phenylhydrazineyl)-1-oxopropan-2-yl)phenyl acetate (D19)

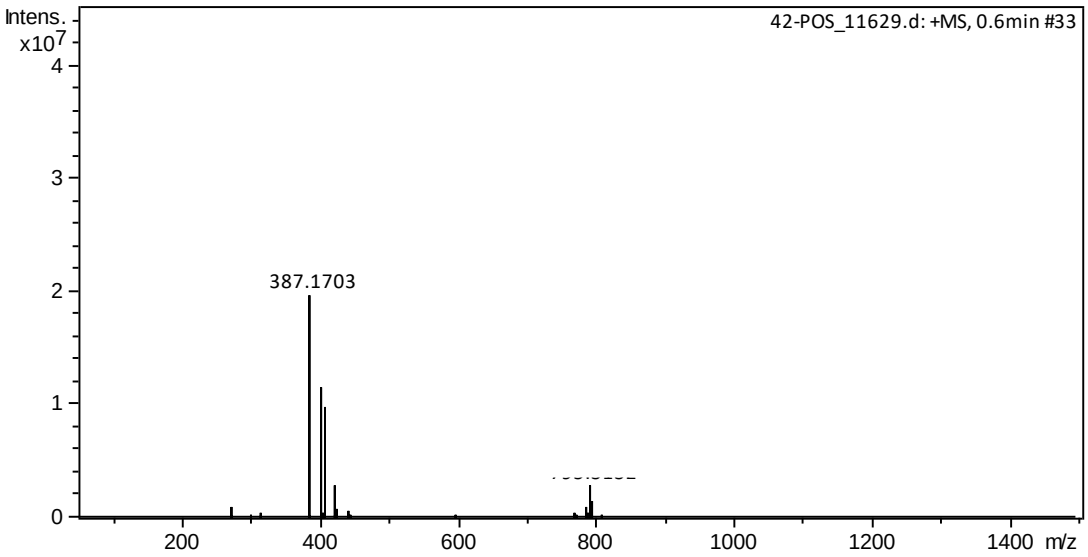
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 293.4 mg, 76% yield.

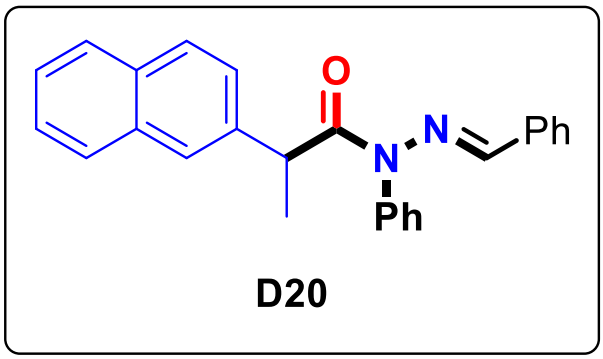
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.43 (m, 6H), 7.43 – 7.37 (m, 1H), 7.36 – 7.28 (m, 3H), 7.17 (s, 1H), 7.11 – 7.02 (m, 4H), 5.13 (d, *J* = 7.2 Hz, 1H), 2.20 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.5, 169.5, 149.5, 141.8, 139.8, 136.2, 134.4, 130.2, 129.9, 129.3, 129.2, 128.9, 128.8, 127.3, 121.6, 42.1, 21.2, 19.5 ppm.

MS (70 eV): m/z (%) = 386 $[M]^+$ (100), 196, 121, 77.

HRMS (ESI) calcd. for $C_{24}H_{23}N_2O_3$ [M+H]: 387.1703, found: 387.1703.





***N′*-benzylidene-2-(naphthalen-2-yl)-*N*-phenylpropanehydrazide (D20)**

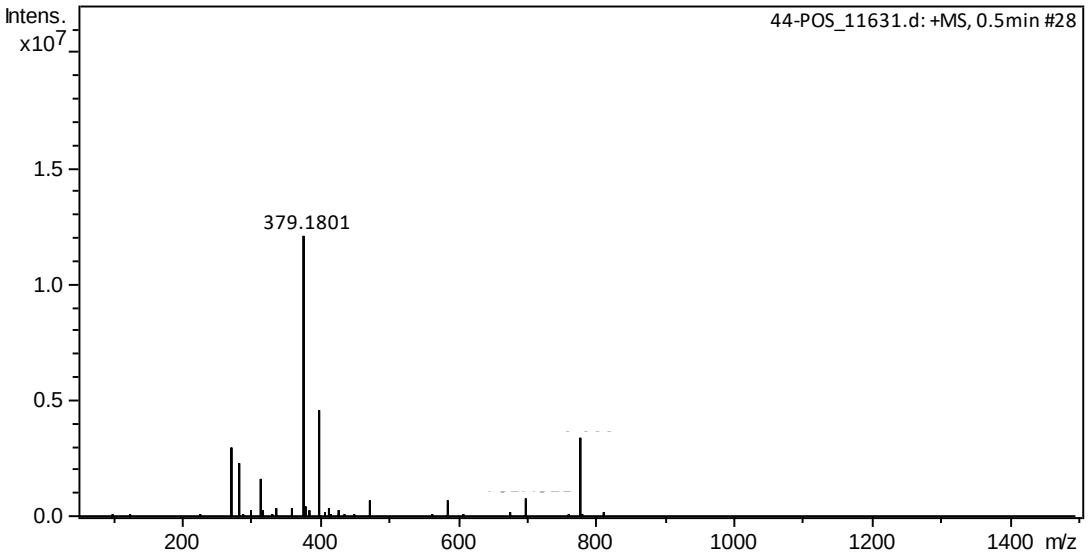
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 332.6 mg, 88% yield.

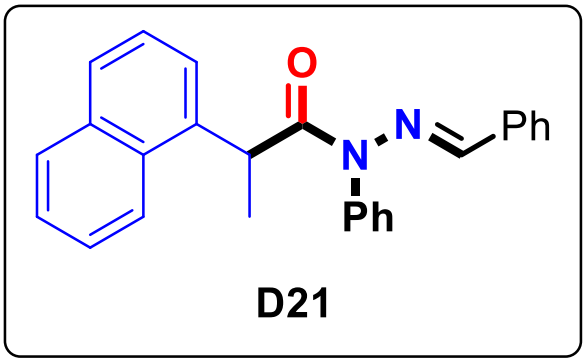
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.89 – 7.81 (m, 3H), 7.71 (d, *J* = 8.4 Hz, 1H), 7.65 – 7.51 (m, 4H), 7.51 – 7.43 (m, 3H), 7.42 – 7.34 (m, 3H), 7.18 (s, 1H), 7.13 (d, *J* = 7.6 Hz, 2H), 5.30 (d, *J* = 7.2 Hz, 1H), 1.74 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 141.6, 140.0, 136.3, 134.4, 133.8, 132.5, 130.2, 129.8, 129.3, 129.2, 128.7, 128.3, 127.8, 127.7, 127.3, 126.5, 126.3, 126.0, 125.5, 43.2, 19.5 ppm.

MS (70 eV): m/z (%) = 378 $[M]^+$ (100), 258, 196, 155.

HRMS (ESI) calcd. for $C_{26}H_{23}N_2O$ [M+H]: 379.1805, found: 379.1801.





***N′*-benzylidene-2-(naphthalen-1-yl)-*N*-phenylpropanehydrazide (D21)**

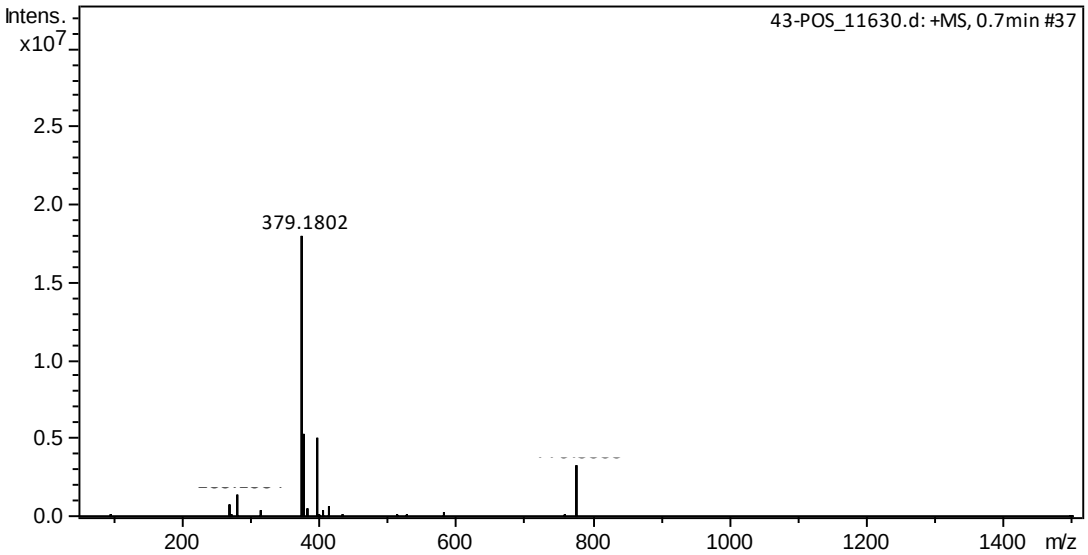
The title compound was prepared according to the general procedure and purified by column chromatography to give the light-yellow oil, 272.2 mg, 72% yield.

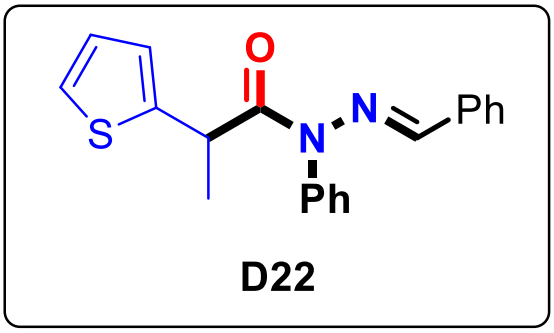
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (d, *J* = 8.8 Hz, 1H), 7.79 (d, *J* = 8.0 Hz, 1H), 7.67 – 7.55 (m, 3H), 7.49 – 7.30 (m, 5H), 7.11 – 7.03 (m, 3H), 7.00 (s, 1H), 6.99 – 6.87 (m, 4H), 5.72 (d, *J* = 7.2 Hz, 1H), 1.69 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.4, 141.5, 140.0, 136.4, 134.4, 134.2, 131.4, 130.4, 129.7, 129.4, 129.3, 128.5, 127.3, 126.4, 126.1, 125.8, 123.8, 123.6, 39.4, 19.1 ppm.

MS (70 eV): m/z (%) = 378 $[M]^+$ (100), 196, 155, 77.

HRMS (ESI) calcd. for $C_{26}H_{23}N_2O$ [M+H]: 379.1805, found: 379.1802.





***N′*-benzylidene-*N*-phenyl-2-(thiophen-2-yl)propanehydrazide (D22)**

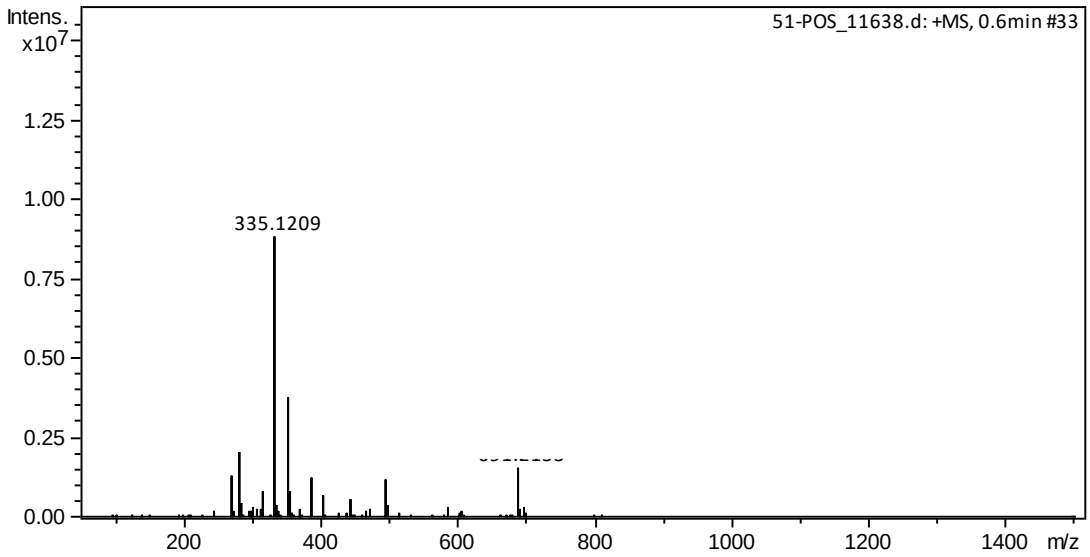
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 113.6 mg, 34% yield.

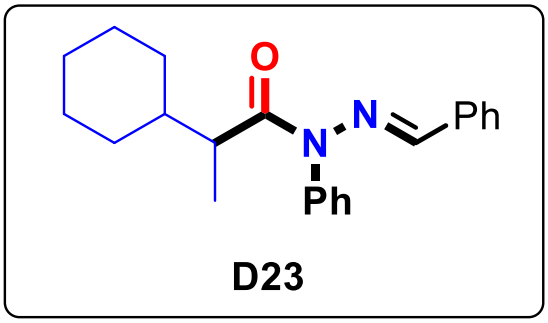
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.59 (m, 2H), 7.55 – 7.49 (m, 2H), 7.47 – 7.43 (m, 1H), 7.39 – 7.36 (d, *J* = 5.0 Hz, 3H), 7.25 (d, *J* = 2.8 Hz, 2H), 7.18 – 7.06 (m, 4H), 6.96 – 6.93 (m, 1H), 5.46 (d, *J* = 6.8 Hz, 1H), 1.70 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.8, 144.5, 141.8, 136.0, 134.2, 130.2, 130.0, 129.3, 129.1, 128.8, 127.4, 126.6, 124.5, 124.1, 37.6, 19.5 ppm.

MS (70 eV): m/z (%) = 334 $[M]^+$ (100), 196, 111, 77.

HRMS (ESI) calcd. for $C_{20}H_{19}N_2OS$ [M+H]: 335.1212, found: 335.1209.





***N′*-benzylidene-2-cyclohexyl-*N*-phenylpropanehydrazide (D23)**

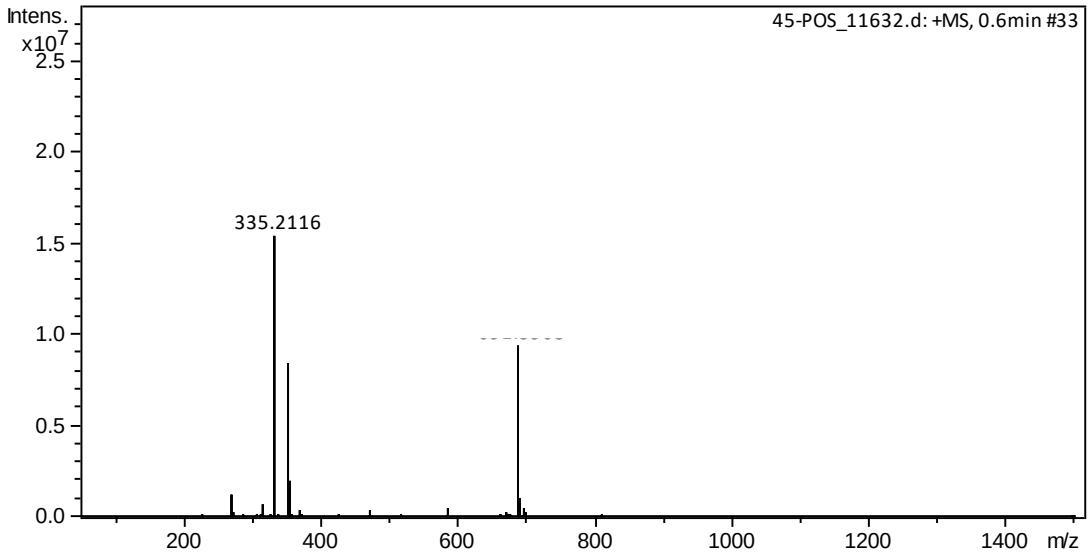
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 267.2 mg, 80% yield.

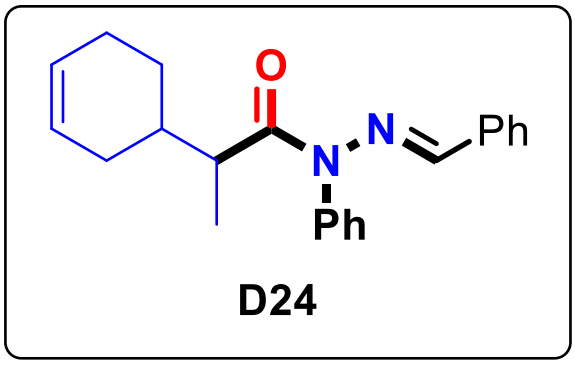
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.52 (m, 4H), 7.47 – 7.43 (m, 1H), 7.37 – 7.34 (m, 3H), 7.22 (s, 1H), 7.15 (d, *J* = 7.6 Hz, 2H), 3.87 – 3.63 (m, 1H), 1.93 (d, *J* = 12.4 Hz, 1H), 1.88 – 1.56 (m, 6H), 1.30 – 1.22 (m, 7H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 178.6, 140.9, 136.6, 134.6, 130.2, 129.7, 129.3, 129.1, 128.8, 127.1, 41.3, 41.1, 31.8, 29.9, 26.6, 26.5, 14.4 ppm.

MS (70 eV): m/z (%) = 334 $[M]^+$ (100), 196, 111, 69.

HRMS (ESI) calcd. for $C_{22}H_{27}N_2O$ [M+H]: 335.2117, found: 335.2116.





***N′*-(benzylidene)-2-(cyclohex-3-en-1-yl)-*N*-phenylpropanehydrazide (D24)**

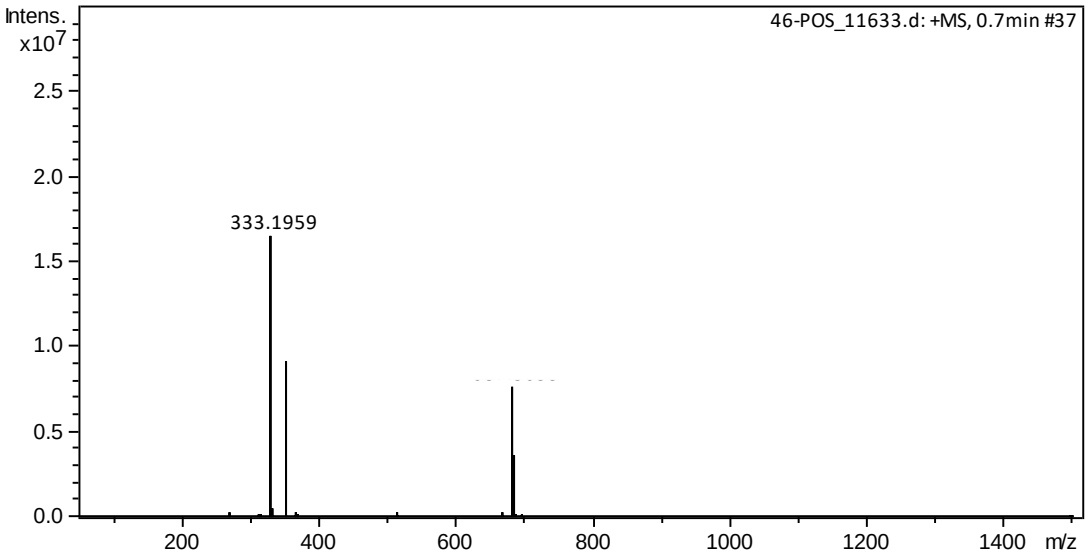
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 249.0 mg, 75% yield.

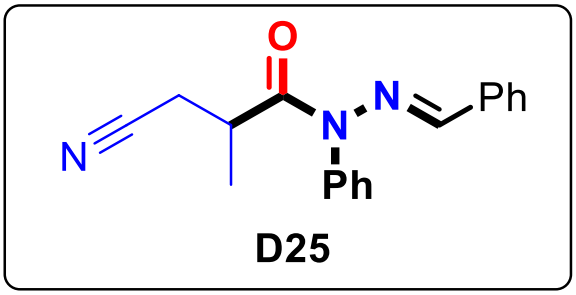
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.51 (m, 4H), 7.49 – 7.43 (m, 1H), 7.40 – 7.32 (m, 3H), 7.26 – 7.22 (m, 1H), 7.21 – 7.11 (m, 2H), 5.68 (d, *J* = 14.4 Hz, 2H), 3.87 (d, *J* = 17.6 Hz, 1H), 2.44 – 1.63 (m, 7H), 1.35 – 1.20 (m, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 178.3, 178.2, 141.2, 141.2, 136.5, 134.6, 130.2, 129.8, 129.3, 129.2, 128.8, 127.2, 126.9, 126.6, 126.4, 41.2, 40.2, 37.1, 36.8, 30.0, 28.8, 27.8, 25.8, 25.5, 25.4, 14.3 ppm.

MS (70 eV): m/z (%) = 332 $[M]^+$ (100), 252, 196, 109.

HRMS (ESI) calcd. for $C_{22}H_{25}N_2O$ [M+H]: 333.1961, found: 333.1959.





D25

***N′*-benzylidene-3-cyano-2-methyl-*N*-phenylpropanehydrazide (D25)**

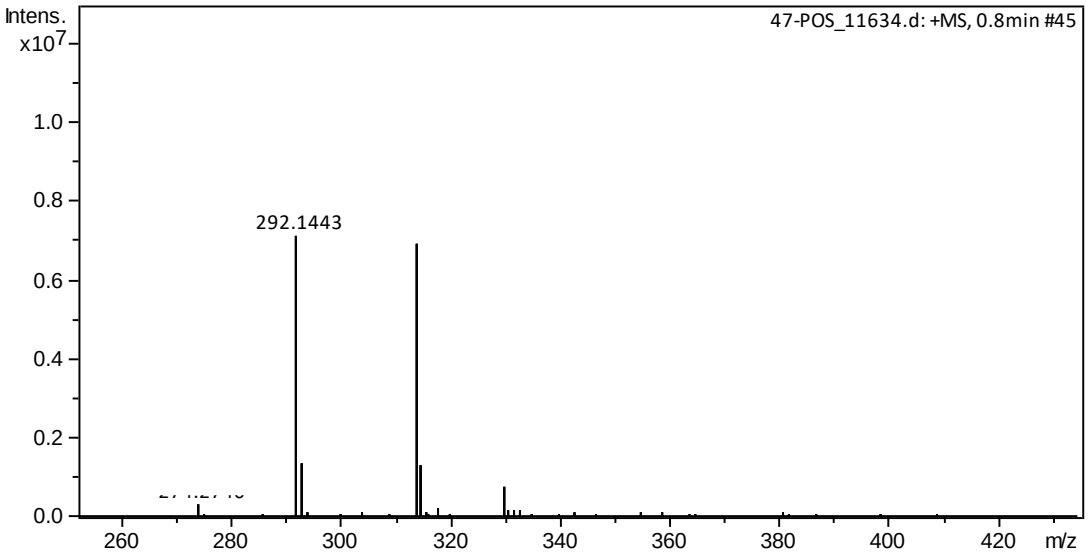
The title compound was prepared according to the general procedure and purified by column chromatography to give the light-yellow oil, 186.2 mg, 64% yield.

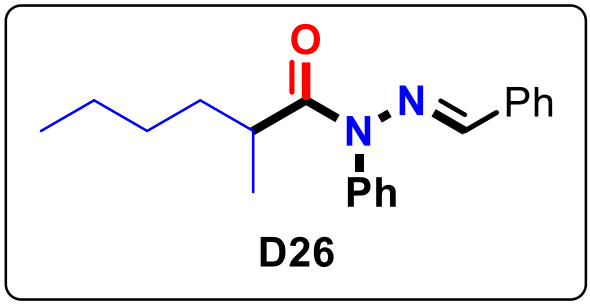
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.51 (m, 4H), 7.50 – 7.44 (m, 1H), 7.40 – 7.33 (m, 3H), 7.31 (s, 1H), 7.16 (d, *J* = 7.6 Hz, 2H), 4.17 – 4.09 (m, 1H), 2.83 – 2.75 (m, 1H), 2.67 – 2.59 (m, 1H), 1.52 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.7, 142.8, 135.5, 133.9, 130.4, 130.3, 129.6, 129.1, 128.9, 127.4, 118.9, 34.5, 21.1, 17.3 ppm.

MS (70 eV): m/z (%) = 291 $[M]^+$ (100), 196, 167, 77.

HRMS (ESI) calcd. for $C_{18}H_{18}N_3O$ [M+H]: 292.1444, found: 292.1443.





***N′*-benzylidene-2-methyl-*N*-phenylhexanehydrazide (D26)**

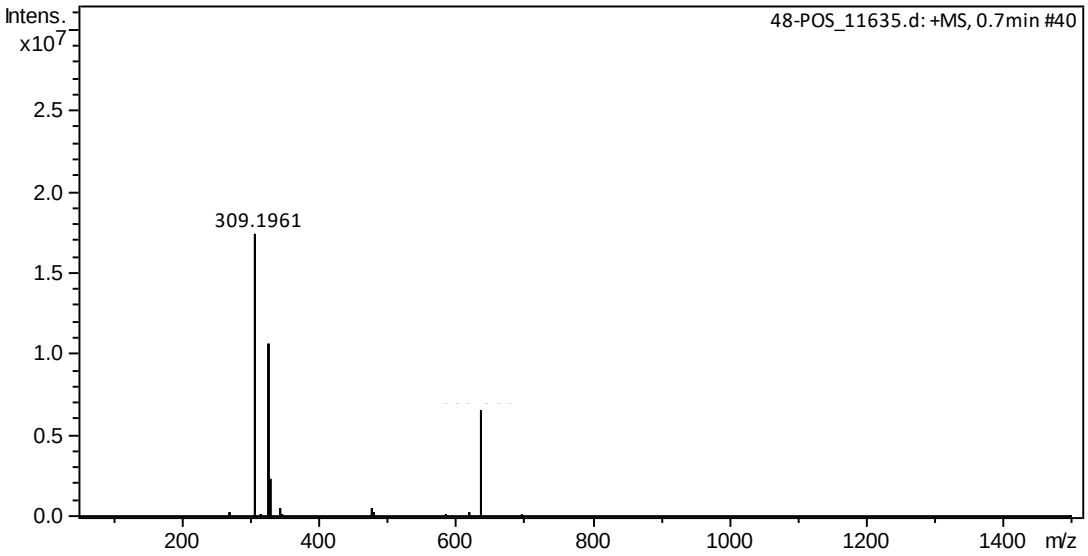
The title compound was prepared according to the general procedure and purified by column chromatography to give the light-yellow oil, 194.0 mg, 63% yield.

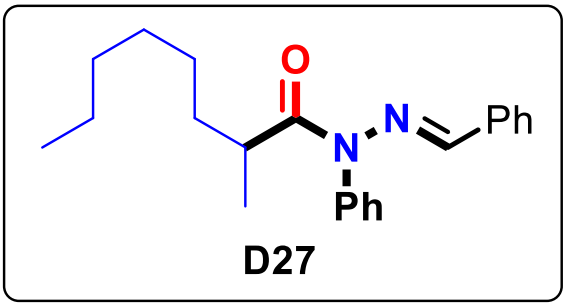
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.50 (m, 4H), 7.47 – 7.42 (m, 1H), 7.39 – 7.30 (m, 3H), 7.25 – 7.22 (m, 1H), 7.15 (d, *J* = 7.6 Hz, 2H), 3.86 (d, *J* = 6.8 Hz, 1H), 1.92 – 1.83 (m, 1H), 1.58 – 1.23 (m, 8H), 0.91 (t, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 178.7, 141.1, 136.5, 134.6, 130.2, 129.8, 129.3, 129.1, 128.7, 127.2, 36.3, 33.7, 29.8, 22.9, 17.3, 14.2, 12.2 ppm.

MS (70 eV): m/z (%) = 308 $[M]^+$ (100), 196, 85, 43.

HRMS (ESI) calcd. for $C_{20}H_{25}N_2O$ [M+H]: 309.1961, found: 309.1961.





_N′_-benzylidene-2-methyl-_N_-phenyloctanehydrazide (D27)

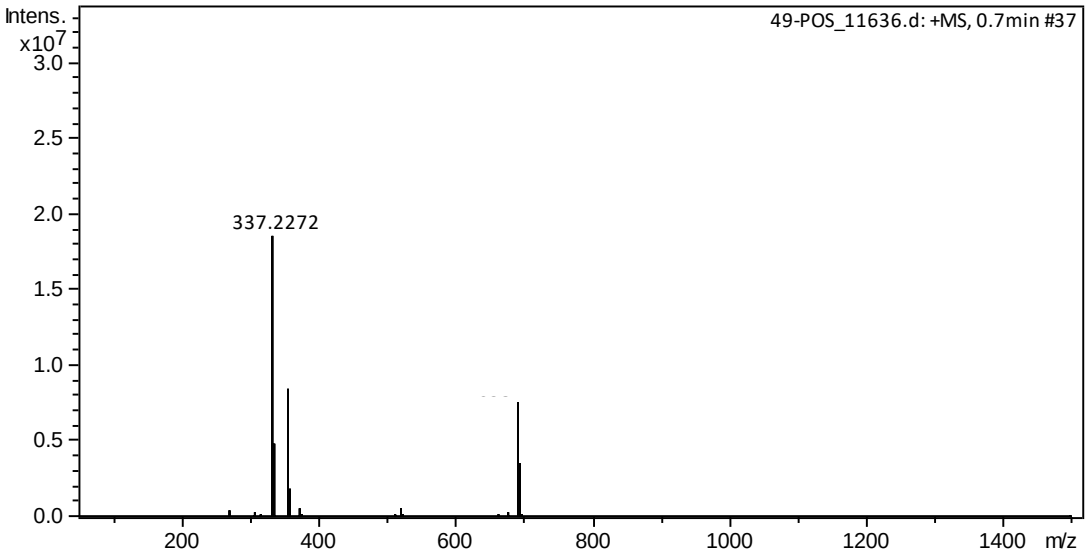
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 225.1 mg, 67% yield.

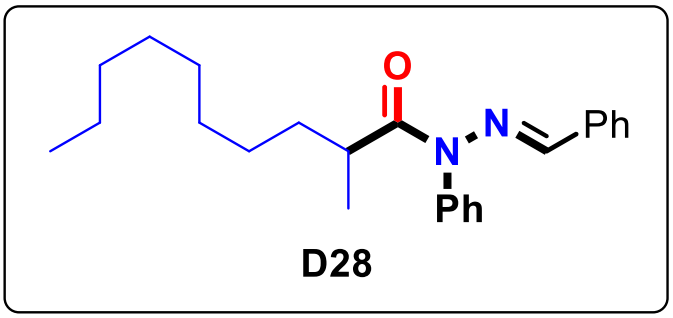
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.51 (m, 4H), 7.47 – 7.42 (m, 1H), 7.36 – 7.33 (m, 3H), 7.24 (s, 1H), 7.14 (d, *J* = 7.6 Hz, 2H), 3.86 (d, *J* = 6.6 Hz, 1H), 1.93 – 1.85 (m, 1H), 1.42 – 1.21 (m, 12H), 0.87 (t, *J* = 6.6 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 178.7, 141.1, 136.5, 134.6, 130.2, 129.7, 129.3, 129.1, 128.7, 127.2, 36.2, 34.1, 31.9, 29.5, 27.5, 22.7, 17.3, 14.1 ppm.

MS (70 eV): m/z (%) = 336 $[M]^+$ (100), 196, 149, 57.

HRMS (ESI) calcd. for $C_{22}H_{29}N_2O$ [M+H]: 337.2274, found: 337.2272.





***N′*-benzylidene-2-methyl-*N*-phenyldecanehydrazide--methane (1/1) (D28)**

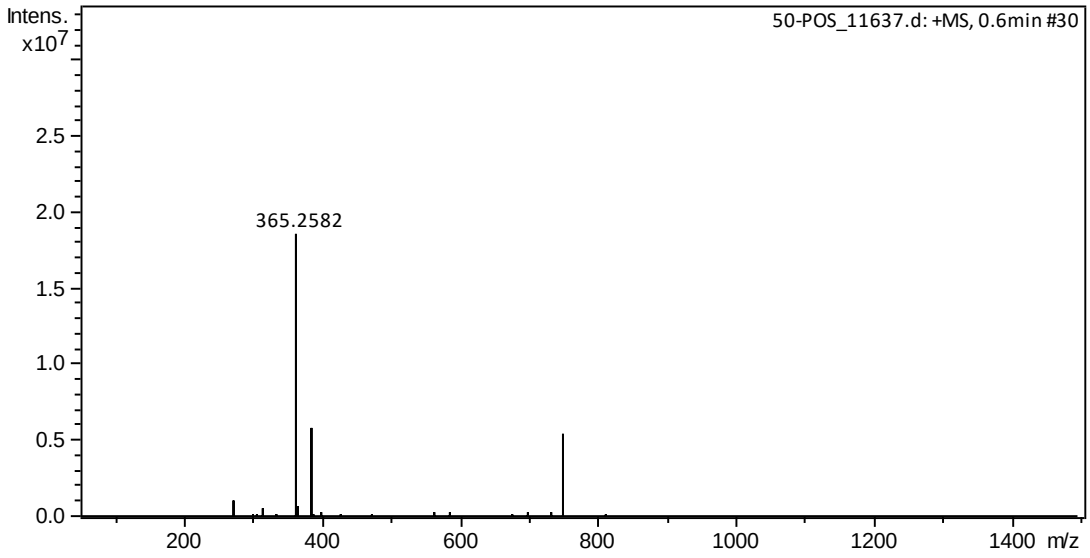
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 254.8 mg, 70% yield.

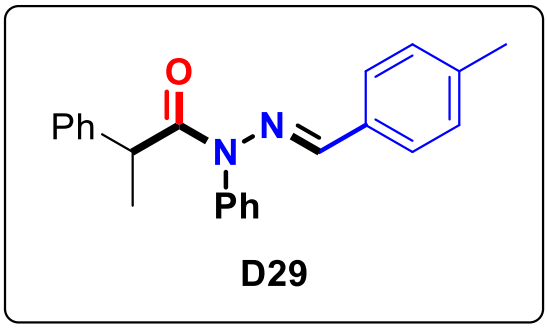
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.50 (m, 4H), 7.46 – 7.41 (m, 1H), 7.36 – 7.32 (m, 3H), 7.24 (s, 1H), 7.14 (d, *J* = 7.6 Hz, 2H), 3.87 (d, *J* = 6.6 Hz, 1H), 1.52 – 1.09 (m, 17H), 0.86 (t, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 178.7, 141.1, 136.5, 134.6, 130.2, 129.8, 129.3, 129.1, 128.7, 127.2, 36.2, 34.1, 31.9, 29.9, 29.7, 29.4, 27.6, 22.8, 17.3, 14.2 ppm.

MS (70 eV): m/z (%) = 364 $[M]^+$ (100), 196, 149, 85.

HRMS (ESI) calcd. for $C_{24}H_{33}N_2O$ [M+H]: 365.2587, found: 365.2582.





***N′*-(4-methylbenzylidene)-*N*,2-diphenylpropanehydrazide (D29)**

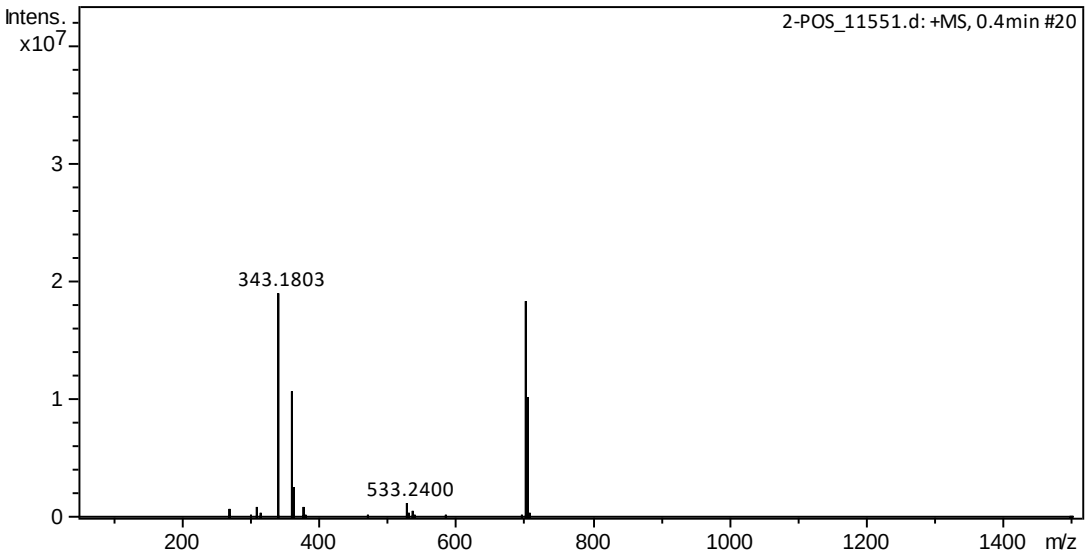
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 314.6 mg, 92% yield.

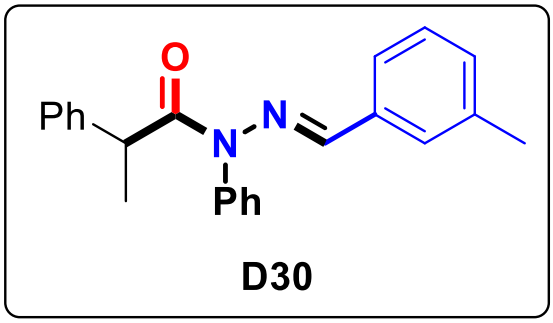
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 – 7.46 (m, 4H), 7.45 – 7.39 (m, 3H), 7.31 (t, *J* = 7.6 Hz, 2H), 7.24 – 7.19 (m, 1H), 7.19 – 7.14 (m, 2H), 7.12 (s, 1H), 7.08 (d, *J* = 7.6 Hz, 2H), 5.09 (d, *J* = 7.2 Hz, 1H), 2.35 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 142.5, 141.6, 140.0, 136.3, 131.7, 130.1, 129.5, 129.2, 129.1, 128.6, 127.8, 127.2, 126.6, 42.9, 21.5, 19.4 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 225, 210, 105.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1803.





***N′*-(3-methylbenzylidene)-*N*,2-diphenylpropanehydrazide (D30)**

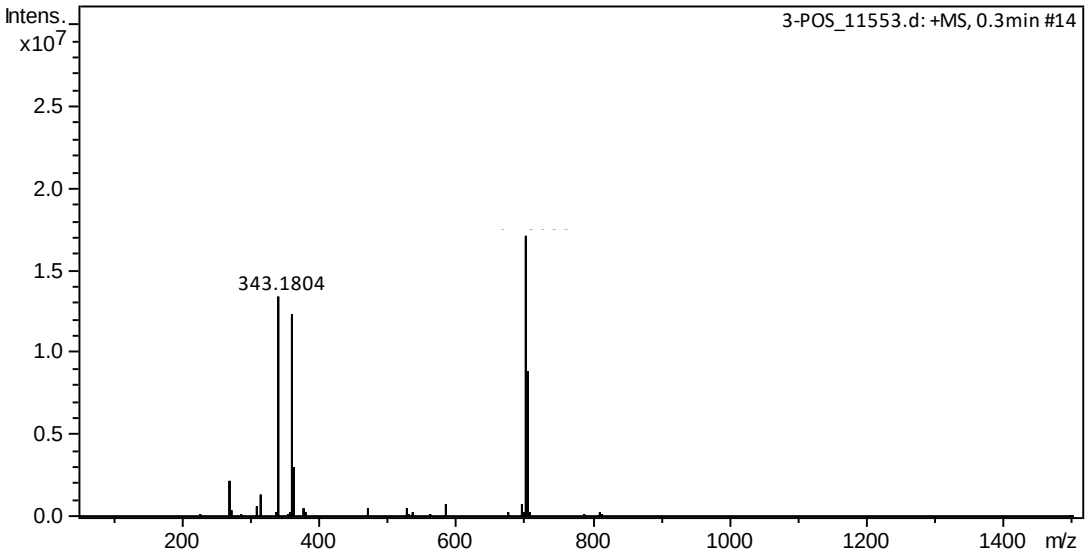
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 283.9 mg, 83% yield.

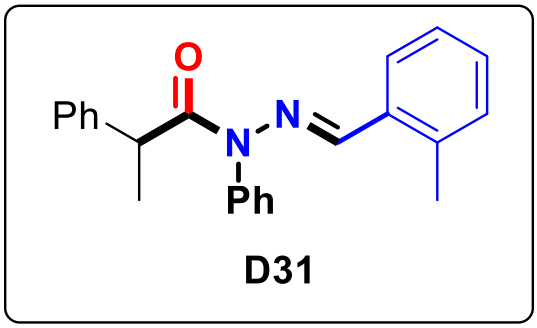
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 – 7.42 (m, 4H), 7.39 – 7.34 (m, 1H), 7.32 – 7.27 (m, 4H), 7.21 – 7.14 (m, 2H), 7.12 – 7.08 (m, 2H), 7.04 (d, *J* = 7.6 Hz, 2H), 5.08 (d, *J* = 7.2 Hz, 1H), 2.30 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.7, 141.8, 138.4, 136.4, 134.5, 130.7, 130.3, 129.3, 128.7, 128.1, 127.9, 126.8, 124.5, 43.1, 21.5, 19.7 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 210, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1804.





***N′*-(2-methylbenzylidene)-*N*,2-diphenylpropanehydrazide (D31)**

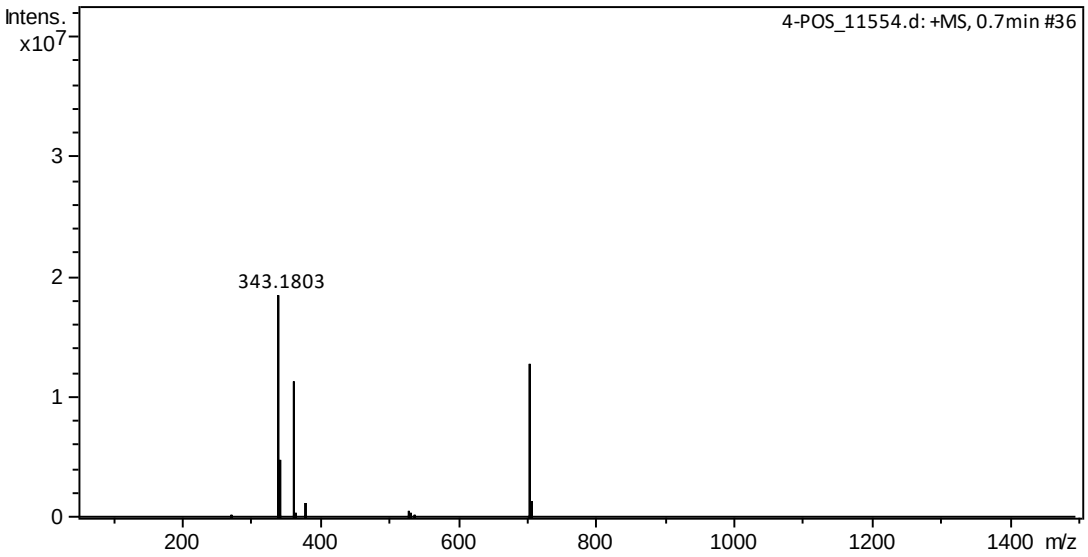
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 273.6 mg, 80% yield.

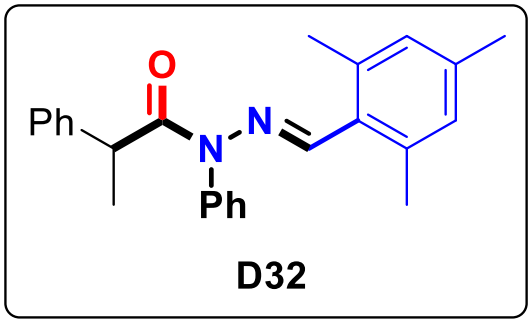
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 – 7.64 (m, 1H), 7.57 – 7.38 (m, 6H), 7.32 (t, *J* = 7.6 Hz, 2H), 7.26 – 7.19 (m, 3H), 7.13 – 7.07 (m, 3H), 5.09 (d, *J* = 6.8 Hz, 1H), 2.14 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.4, 140.5, 136.9, 136.4, 132.3, 130.8, 130.2, 129.5, 129.2, 129.1, 128.6, 127.8, 126.6, 126.5, 126.2, 42.8, 19.6, 19.4 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 225, 210, 105.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1803.





***N*,2-diphenyl-*N′*-(2,4,6-trimethylbenzylidene)propanehydrazide (D32)**

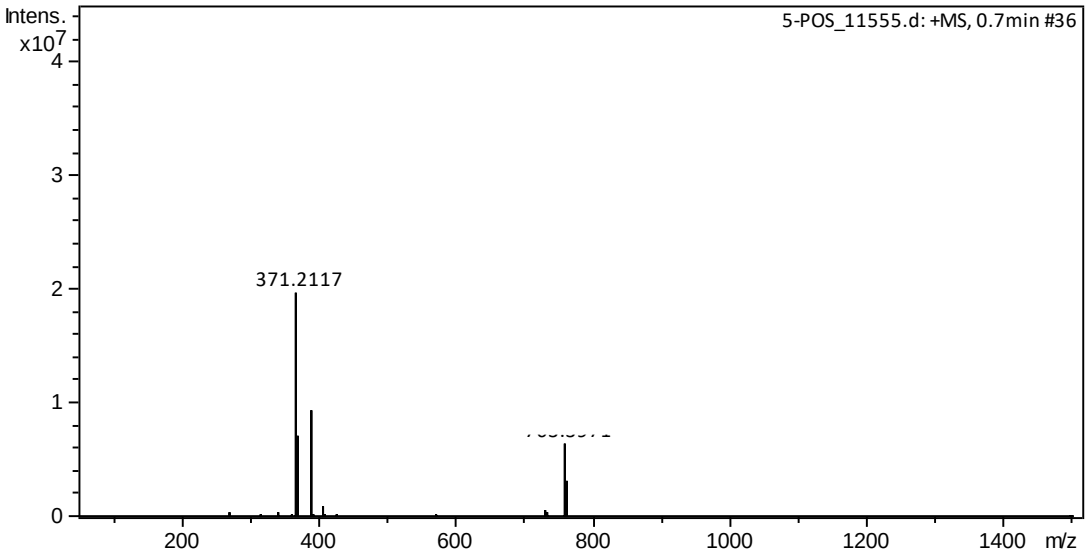
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 299.7 mg, 81% yield.

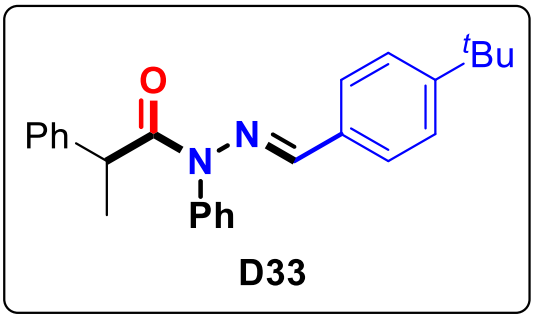
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (s, 1H), 7.70 – 7.63 (m, 4H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.40 – 7.32 (m, 3H), 6.99 (s, 2H), 5.29 (d, *J* = 6.8 Hz, 1H), 2.40 (d, *J* = 6.8 Hz, 9H), 1.81 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 143.1, 142.4, 138.8, 137.5, 136.8, 130.4, 129.7, 129.5, 129.3, 128.7, 128.5, 128.0, 126.8, 42.4, 21.3, 20.1 ppm.

MS (70 eV): m/z (%) = 370 $[M]^+$ (100), 225, 105, 93.

HRMS (ESI) calcd. for $C_{25}H_{27}N_2O$ [M+H]: 371.2118, found: 371.2117.





***N'*-(4-(*tert*-butyl)benzylidene)-*N*,2-diphenylpropanehydrazide (D33)**

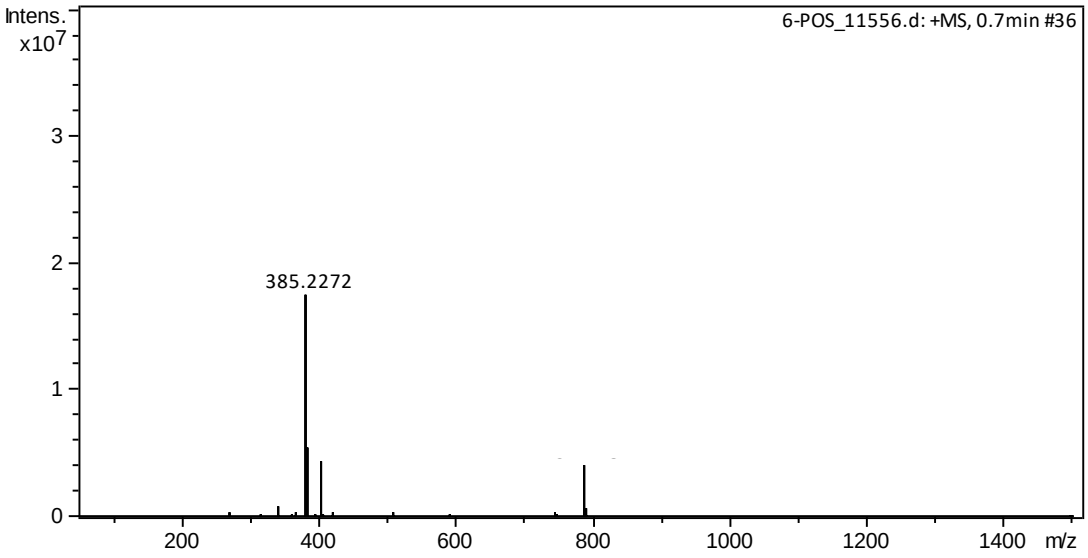
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 334.1 mg, 87% yield.

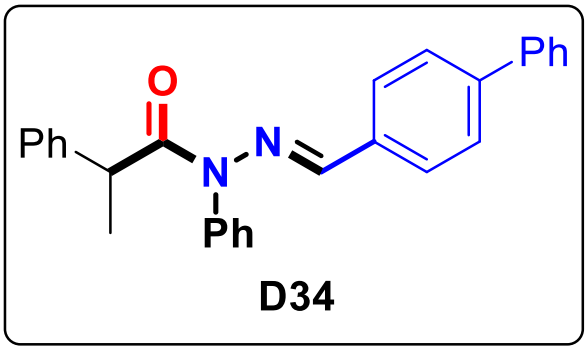
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.41 (m, 7H), 7.37 (d, *J* = 8.4 Hz, 2H), 7.32 (t, *J* = 7.6 Hz, 2H), 7.24 – 7.18 (m, 1H), 7.14 (s, 1H), 7.07 (d, *J* = 7.6 Hz, 2H), 5.09 (d, *J* = 7.2 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H), 1.32 (s, 9H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 153.2, 142.5, 141.5, 136.4, 131.7, 130.1, 129.2, 129.1, 128.6, 127.8, 127.0, 126.6, 125.7, 42.8, 34.9, 31.2, 19.4 ppm.

MS (70 eV): m/z (%) = 384 $[M]^+$ (100), 252, 195, 105.

HRMS (ESI) calcd. for $C_{26}H_{29}N_2O$ [M+H]: 385.2274, found: 385.2272.





***N'*-([1,1'-biphenyl]-4-ylmethylene)-*N*,2-diphenylpropanehydrazide (D34)**

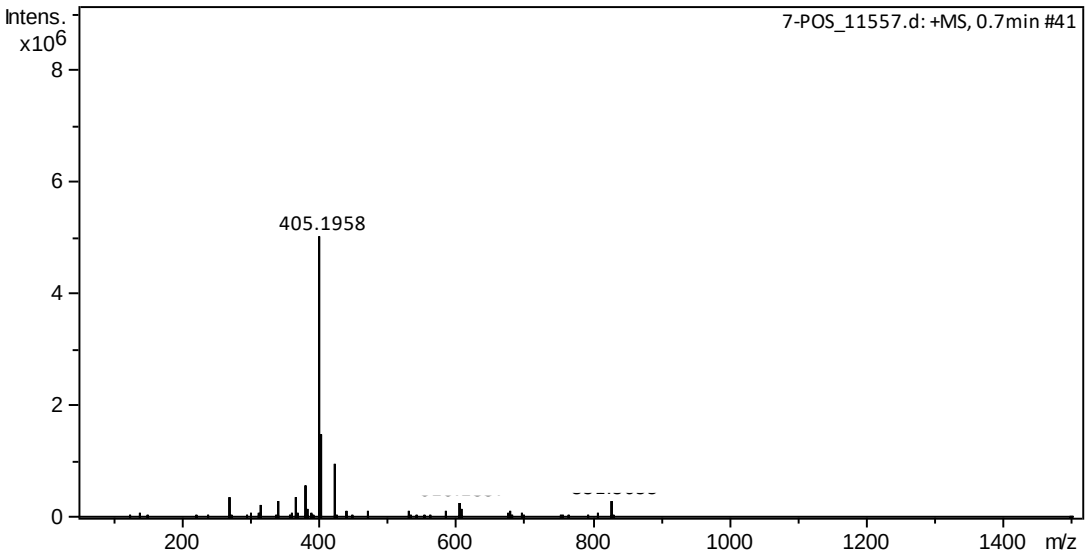
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 335.3 mg, 83% yield.

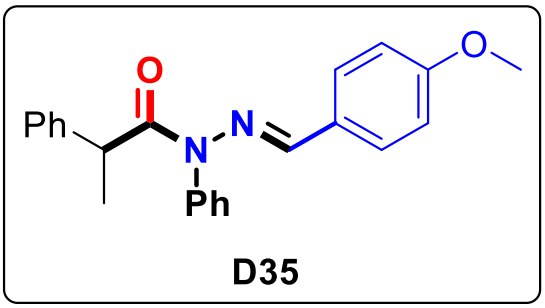
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.47 (m, 8H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.38 – 7.33 (m, 3H), 7.32 – 7.24 (m, 3H), 7.19 – 7.13 (m, 2H), 7.04 (d, *J* = 7.6 Hz, 2H), 5.11 (d, *J* = 7.2 Hz, 1H), 1.61 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.7, 142.6, 141.2, 140.4, 136.4, 133.6, 130.3, 129.4, 129.3, 129.1, 128.8, 128.0, 127.9, 127.5, 127.2, 126.9, 43.2, 19.8 ppm.

MS (70 eV): m/z (%) = 404 $[M]^+$ (100), 281, 207, 105.

HRMS (ESI) calcd. for $C_{28}H_{25}N_2O$ [M+H]: 405.1961, found: 405.1958.





***N′*-(4-methoxybenzylidene)-*N*,2-diphenylpropanehydrazide (D35)**

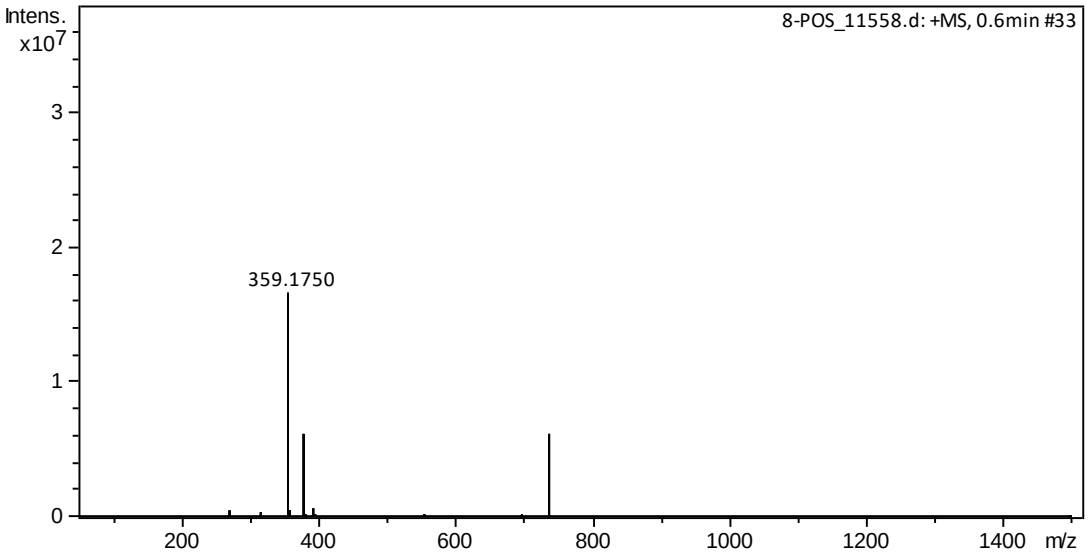
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 322.2 mg, 90% yield.

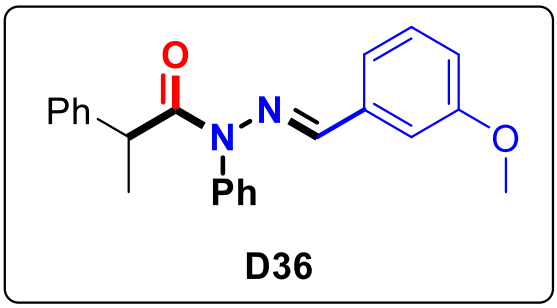
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 – 7.41 (m, 6H), 7.39 – 7.33 (m, 1H), 7.29 (t, *J* = 7.6 Hz, 2H), 7.19 – 7.14 (m, 1H), 7.10 (s, 1H), 7.05 (d, *J* = 7.6 Hz, 2H), 6.84 (d, *J* = 8.8 Hz, 2H), 5.09 (d, *J* = 7.2 Hz, 1H), 3.72 (s, 3H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.6, 161.1, 142.7, 141.5, 136.5, 130.2, 129.3, 129.2, 128.8, 128.7, 127.9, 127.2, 126.7, 114.3, 55.4, 43.0, 19.6 ppm.

MS (70 eV): m/z (%) = 358 $[M]^+$ (100), 226, 182, 105.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O_2$ [M+H]: 359.1754, found: 359.1750.





D36

***N′*-(3-methoxybenzylidene)-*N*,2-diphenylpropanehydrazide (D36)**

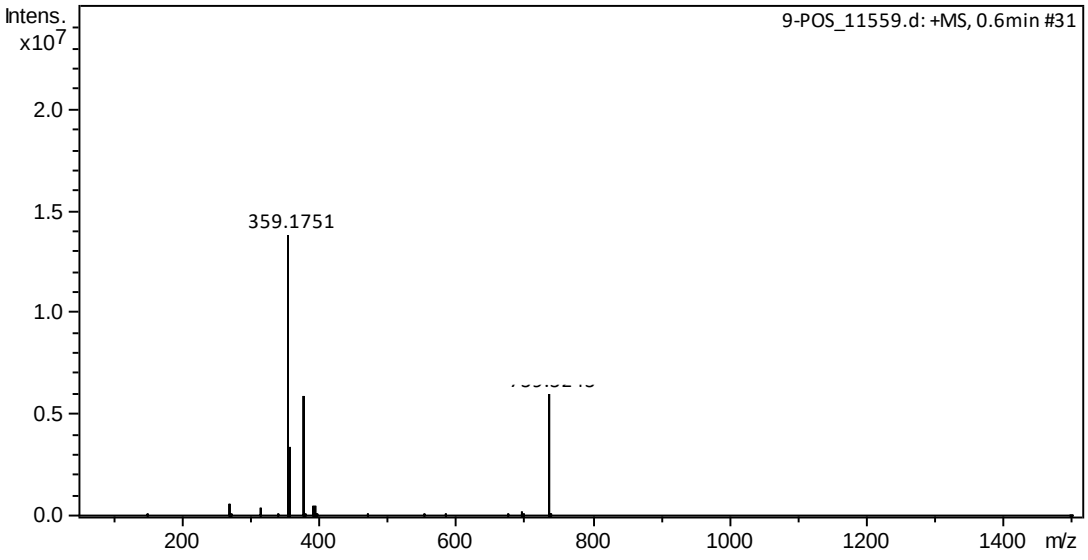
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 290.0 mg, 81% yield.

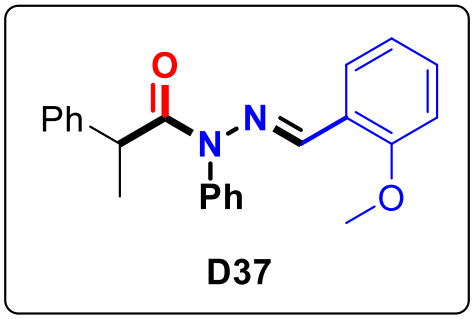
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (t, *J* = 7.6 Hz, 4H), 7.42 – 7.37 (m, 1H), 7.30 (t, *J* = 7.6 Hz, 2H), 7.23 – 7.17 (m, 2H), 7.15 – 7.10 (m, 2H), 7.07 (d, *J* = 7.6 Hz, 2H), 7.00 (d, *J* = 7.6 Hz, 1H), 6.89 – 6.83 (m, 1H), 5.07 (d, *J* = 7.2 Hz, 1H), 3.79 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 160.0, 142.6, 141.4, 136.3, 135.8, 130.2, 129.8, 129.3, 129.2, 128.7, 127.7, 126.7, 120.5, 116.3, 111.2, 55.4, 43.2, 19.7 ppm.

MS (70 eV): m/z (%) = 358 $[M]^+$ (100), 226, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O_2$ [M+H]: 359.1754, found: 359.1751.





D37

***N′*-(2-methoxybenzylidene)-*N*,2-diphenylpropanehydrazide (D37)**

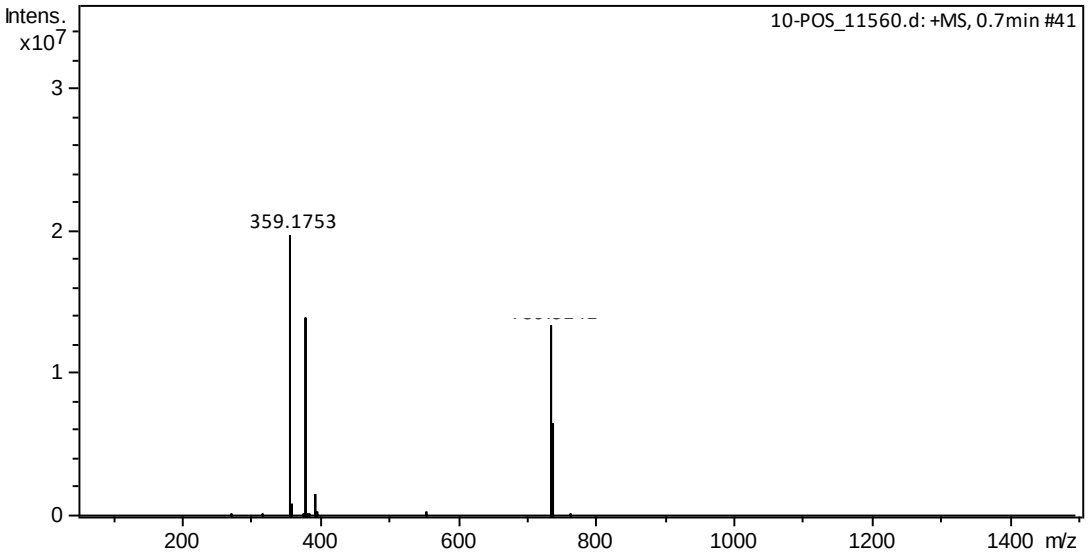
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 261.3 mg, 73% yield.

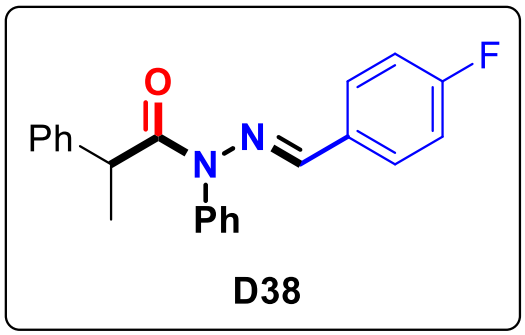
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 7.6 Hz, 1H), 7.49 (s, 1H), 7.39 – 7.32 (m, 4H), 7.28 – 7.23 (m, 1H), 7.21 – 7.13 (m, 3H), 7.08 – 7.04 (m, 1H), 6.96 (d, *J* = 7.6 Hz, 2H), 6.87 (t, *J* = 7.6 Hz, 1H), 6.64 (d, *J* = 8.4 Hz, 1H), 4.99 (d, *J* = 7.2 Hz, 1H), 3.44 (s, 3H), 1.48 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.6, 156.9, 141.5, 136.7, 135.4, 130.0, 128.9, 128.0, 127.9, 127.5, 126.7, 125.5, 125.0, 121.8, 119.7, 109.9, 54.2, 41.8, 18.4 ppm.

MS (70 eV): m/z (%) = 358 $[M]^+$ (100), 226, 210, 105.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O_2$ [M+H]: 359.1754, found: 359.1753.





***N′*-(4-fluorobenzylidene)-*N*,2-diphenylpropanehydrazide (D38)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 304.5 mg, 88% yield.

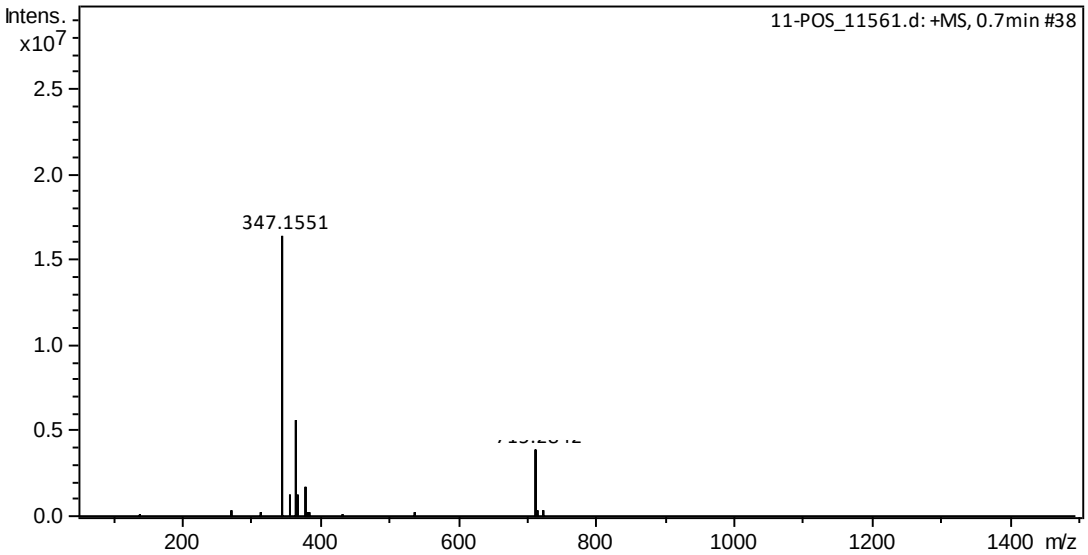
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.39 (m, 7H), 7.32 (t, *J* = 7.5 Hz, 2H), 7.23 – 7.17 (m, 4.3 Hz, 1H), 7.13 – 6.97 (m, 5H), 5.04 (d, *J* = 7.2 Hz, 1H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

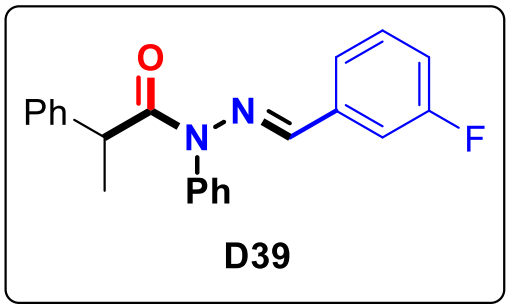
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.6, 164.9, 162.4, 142.5, 140.2, 136.2, 130.7, 130.2, 129.3, 19.1, 129.0, 128.9, 128.6, 127.7, 126.7, 115.9, 115.7, 43.0, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -110.4.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 214, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1551.





D39

***N′*-(3-fluorobenzylidene)-*N*,2-diphenylpropanehydrazide (D39)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 245.7 mg, 71% yield.

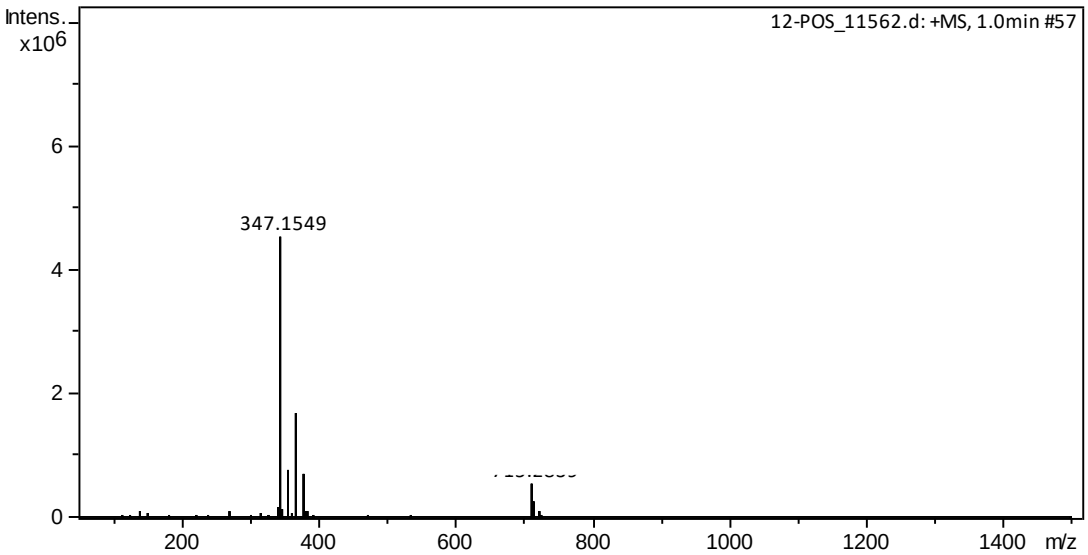
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 – 7.45 (m, 4H), 7.43 – 7.37 (m, 1H), 7.34 – 7.23 (m, 4H), 7.23 – 7.15 (m, 2H), 7.11 – 7.02 (m, 3H), 7.01 – 6.95 (m, 1H), 5.03 (d, *J* = 6.8 Hz, 1H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

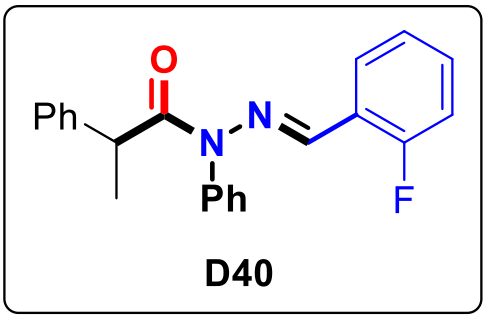
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 164.3, 161.9, 142.5, 140.1, 136.9, 136.8, 136.1, 130.3, 129.4, 129.1, 128.7, 127.7, 126.8, 123.6, 123.5, 116.9, 116.6, 113.3, 113.1, 43.2, 19.6 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -112.4.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 214, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1549.





D40

***N′*-(2-fluorobenzylidene)-*N*,2-diphenylpropanehydrazide (D40)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 214.5 mg, 62% yield.

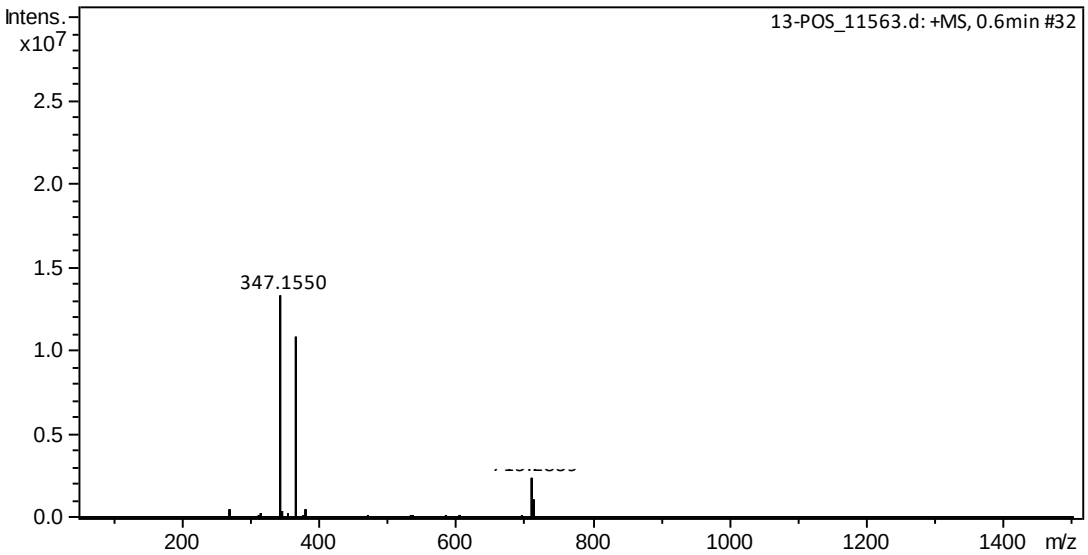
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (s, 1H), 7.53 – 7.39 (m, 5H), 7.37 (d, *J* = 7.6 Hz, 1H), 7.35 – 7.27 (m, 2H), 7.26 – 7.11 (m, 3H), 7.06 (d, *J* = 7.5 Hz, 2H), 6.95 – 6.88 (m, 1H), 5.09 (s, 1H), 1.69 – 1.53 (m, 3H) ppm.

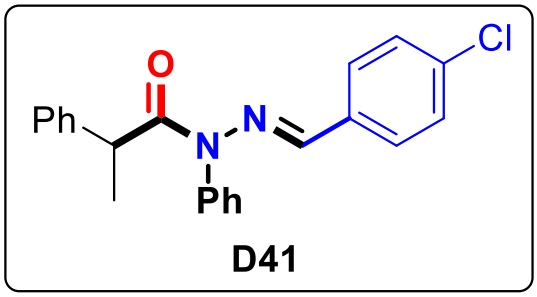
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 162.7, 160.2, 142.5, 136.1, 134.8, 131.4, 131.3, 130.3, 129.4, 129.1, 128.7, 127.8, 126.8, 124.5, 122.4, 122.3, 116.0, 115.8, 43.1, 19.7 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -120.5.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 214, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1550.





***N′*-(4-chlorobenzylidene)-*N*,2-diphenylpropanehydrazide (D41)**

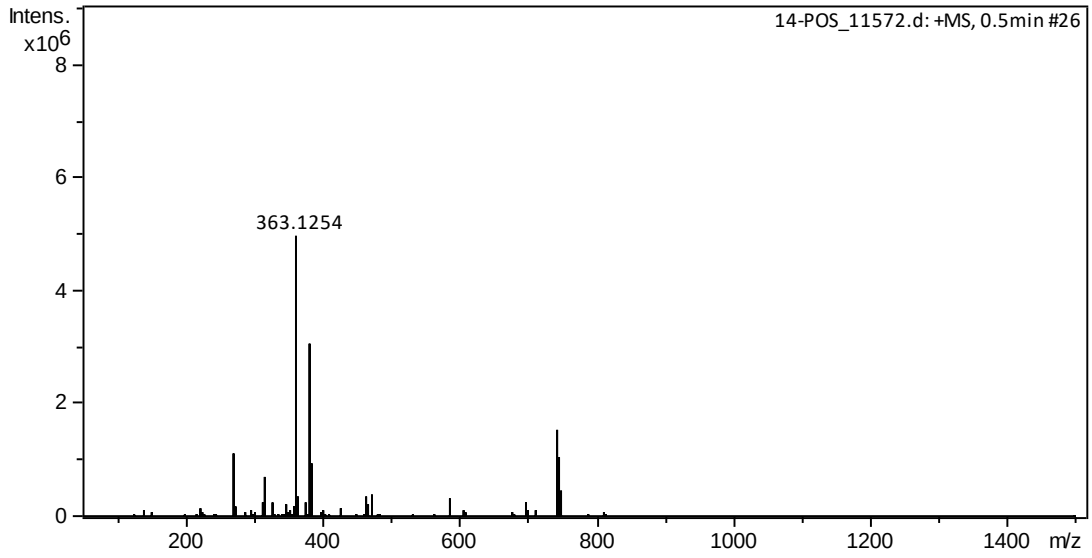
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 311.3 mg, 86% yield.

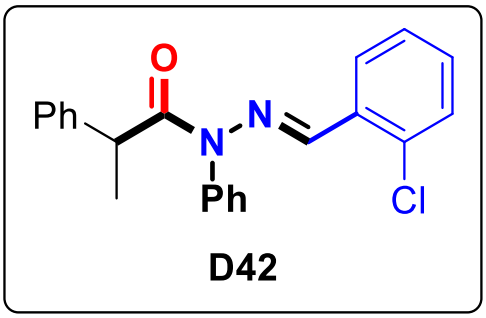
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.37 (m, 7H), 7.52 – 7.40 (m, 4H), 7.22 – 7.17 (m, 1H), 7.09 – 7.04 (m, 3H), 5.08 (d, *J* = 6.8 Hz, 1H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 142.4, 140.1, 136.1, 135.6, 133.0, 130.2, 129.4, 129.1, 129.0, 128.7, 128.4, 127.7, 126.7, 43.1, 19.6 ppm.

MS (70 eV): m/z (%) = 362 $[M]^+$ (100), 230, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}ClN_2O$ [M+H]: 363.1258, found: 363.1254.





D42

***N′*-(2-chlorobenzylidene)-*N*,2-diphenylpropanehydrazide (D42)**

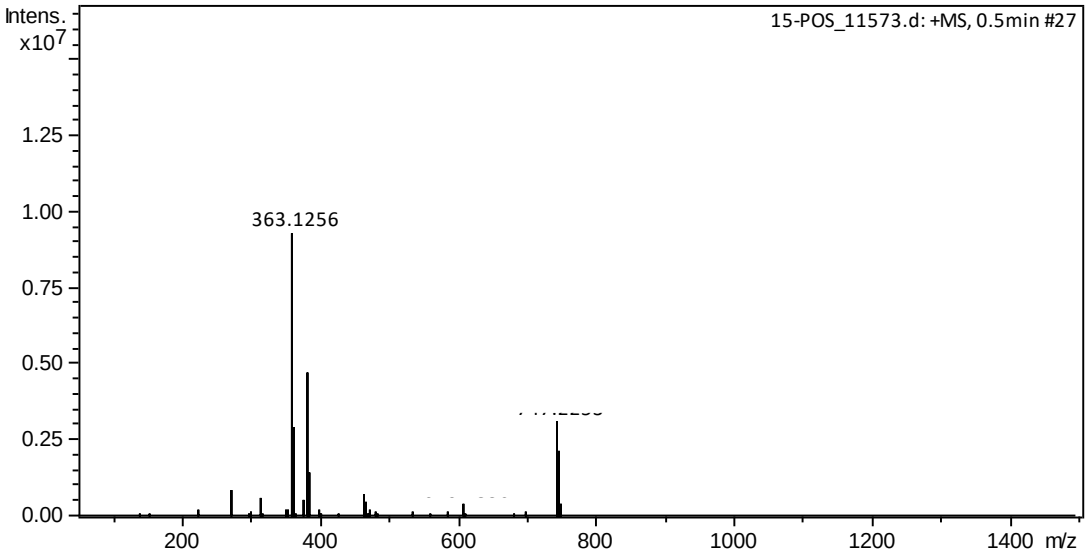
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 224.4 mg, 62% yield.

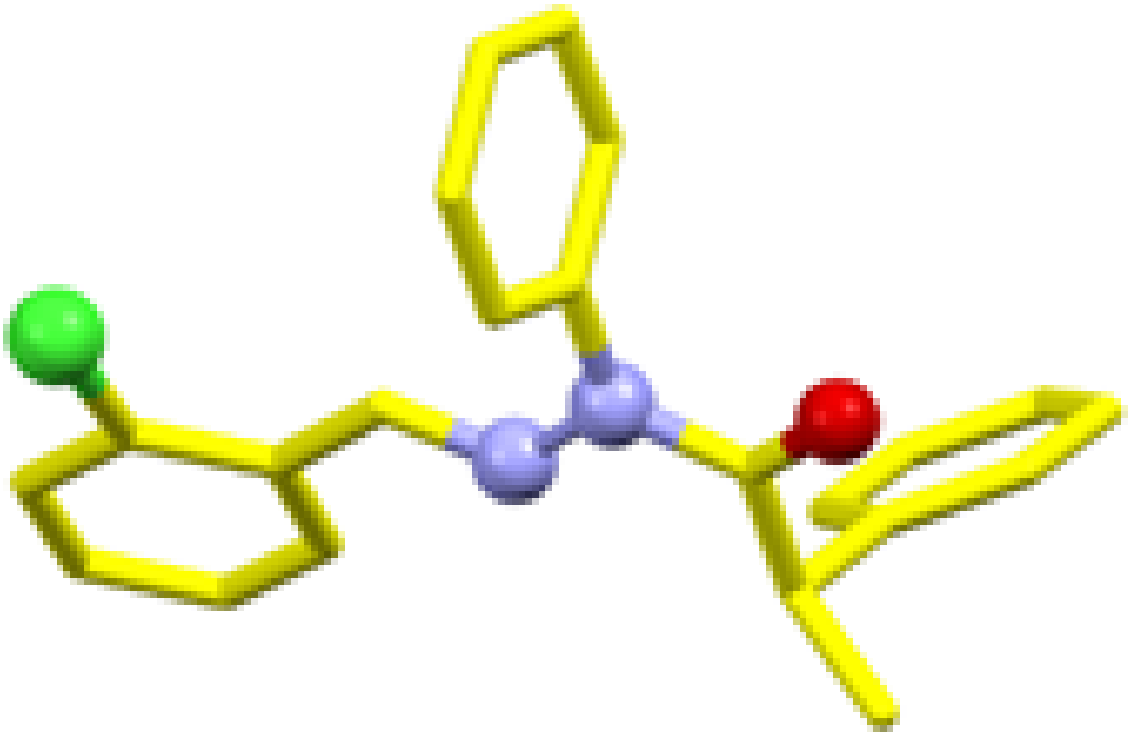
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.6 Hz, 1H), 7.59 (s, 1H), 7.51 – 7.45 (m, 4H), 7.40 (t, *J* = 7.6 Hz, 1H), 7.34 – 7.27 (m, 2H), 7.27 – 7.23 (m, 1H), 7.23 – 7.16 (m, 3H), 7.09 (d, *J* = 7.6 Hz, 2H), 5.05 (d, *J* = 6.8 Hz, 1H), 1.60 (d, *J* = 7.2 Hz, 3H) ppm.

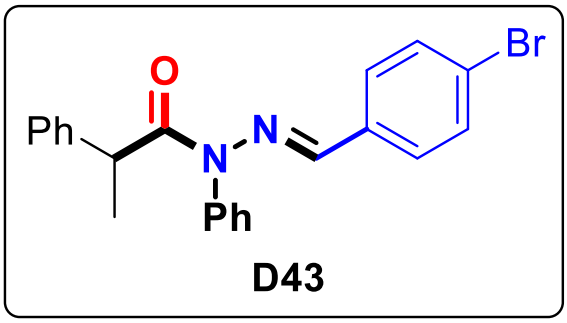
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.5, 138.3, 136.2, 134.4, 131.9, 130.7, 130.3, 129.9, 129.5, 129.0, 128.8, 127.8, 127.1, 126.8, 43.2, 19.7 ppm.

MS (70 eV): m/z (%) = 362 $[M]^+$ (100), 224, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}ClN_2O$ [M+H]: 363.1258, found: 363.1256.







***N′*-(4-bromobenzylidene)-*N*,2-diphenylpropanehydrazide (D43)**

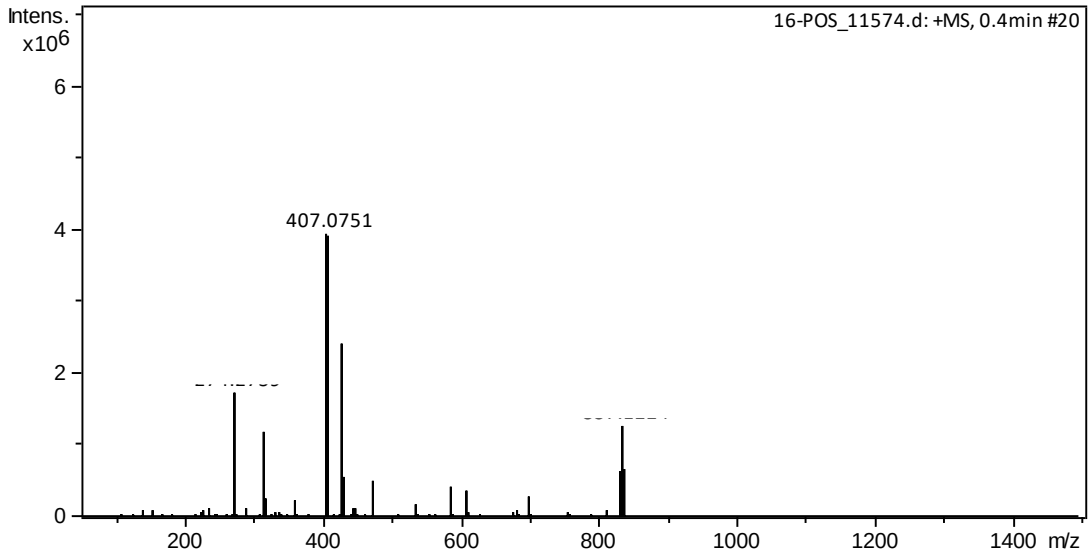
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 332.9 mg, 82% yield.

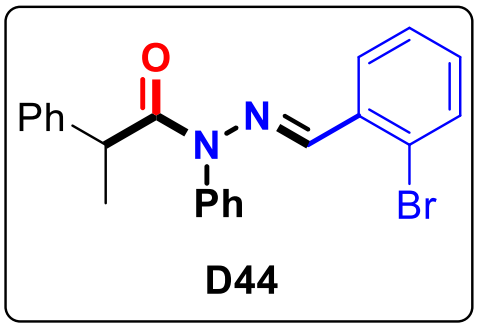
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.35 (m, 7H), 7.34 – 7.25 (m, 4H), 7.16 (t, *J* = 7.6 Hz, 1H), 7.06 – 7.01 (m, 3H), 5.03 (d, *J* = 7.2 Hz, 1H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 142.6, 140.1, 136.2, 133.5, 132.0, 130.3, 129.4, 129.2, 128.8, 128.7, 127.7, 126.8, 124.0, 43.2, 19.7 ppm.

MS (70 eV): m/z (%) = 406 $[M]^+$ (100), 274, 194, 105.

HRMS (ESI) calcd. for $C_{22}H_{20}BrN_2O$ [M+H]: 407.0753, found: 407.0751.





***N'*-(2-bromobenzylidene)-*N*,2-diphenylpropanehydrazide (D44)**

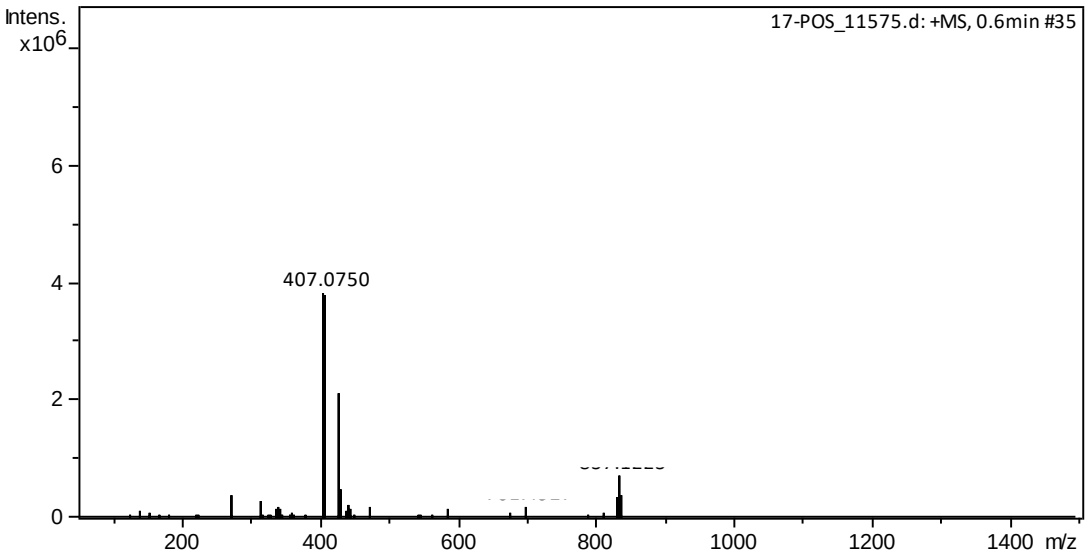
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 296.4 mg, 73% yield.

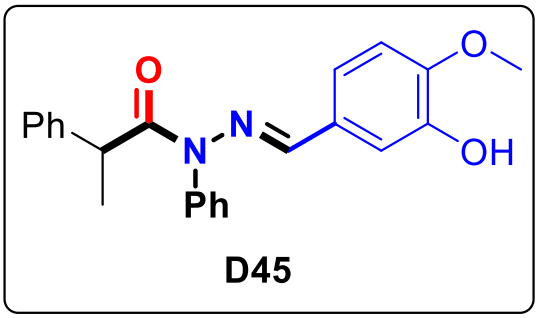
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.6 Hz, 1H), 7.56 – 7.49 (m, 3H), 7.48 – 7.40 (m, 4H), 7.33 (t, *J* = 7.6 Hz, 3H), 7.24 – 7.19 (m, 1H), 7.18 – 7.13 (m, 1H), 7.10 (d, *J* = 7.6 Hz, 2H), 5.03 (d, *J* = 6.8 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 142.4, 140.8, 136.1, 133.3, 133.1, 130.9, 130.3, 129.4, 128.9, 128.7, 127.7, 127.6, 127.4, 126.7, 124.5, 43.1, 19.6 ppm.

MS (70 eV): m/z (%) = 406 $[M]^+$ (100), 274, 225, 195.

HRMS (ESI) calcd. for $C_{22}H_{20}BrN_2O$ [M+H]: 407.0753, found: 407.0750.





D45

***N′*-(3-hydroxy-4-methoxybenzylidene)-*N*,2-diphenylpropanehydrazide (D45)**

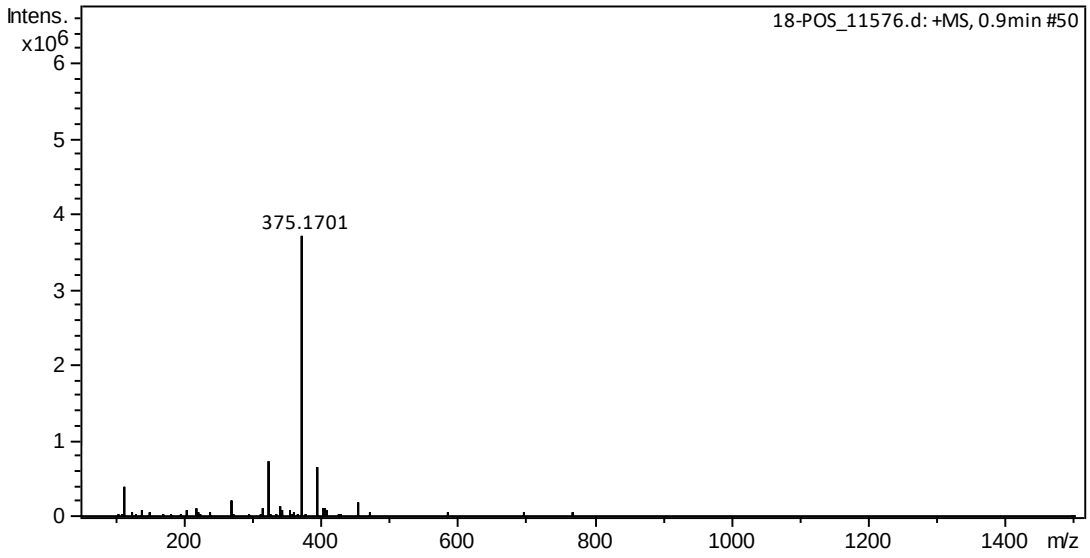
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 299.2 mg, 80% yield.

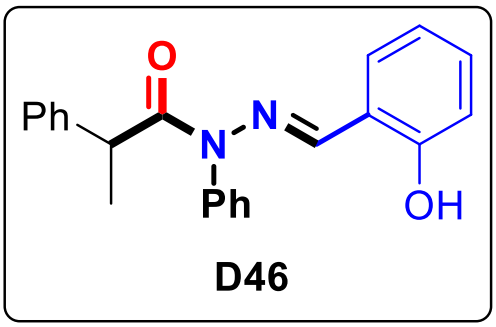
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (t, *J* = 7.6 Hz, 4H), 7.41 – 7.37 (m, 1H), 7.30 (t, *J* = 7.6 Hz, 2H), 7.21 – 7.15 (m, 2H), 7.10 – 7.05 (m, 3H), 6.82 – 6.75 (m, 2H), 6.36 (s, 1H), 5.04 (d, *J* = 7.2 Hz, 1H), 3.88 (s, 3H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.6, 147.9, 147.2, 142.9, 142.1, 136.4, 130.2, 129.2, 128.7, 127.6, 126.8, 126.7, 122.5, 114.6, 108.1, 56.0, 43.3, 19.7 ppm.

MS (70 eV): m/z (%) = 374 $[M]^+$ (100), 281, 242, 207.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O_3$ [M+H]: 375.1703, found: 375.1701.





D46

***N′*-(2-hydroxybenzylidene)-*N*,2-diphenylpropanehydrazide (D46)**

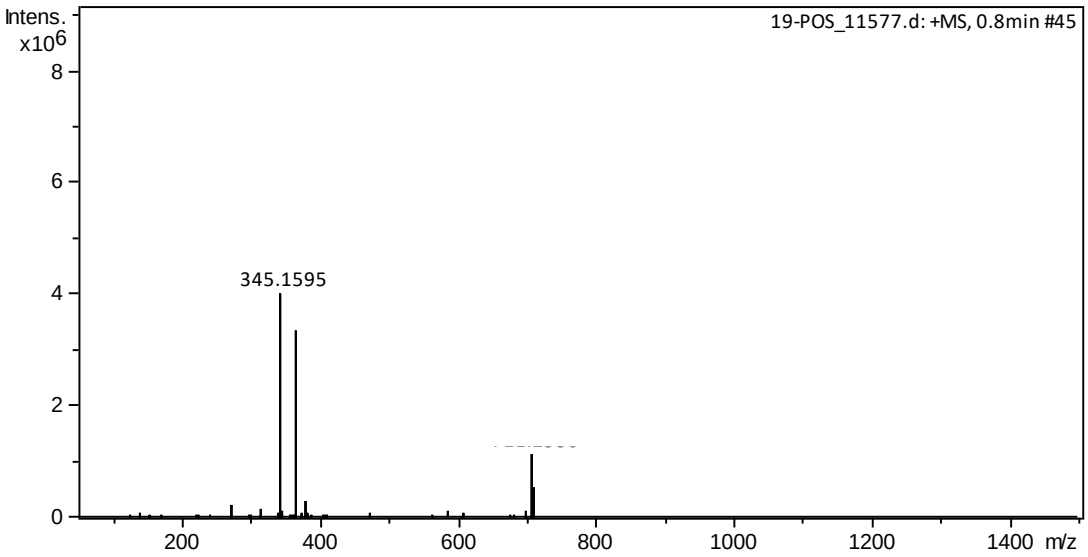
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 251.1 mg, 73% yield.

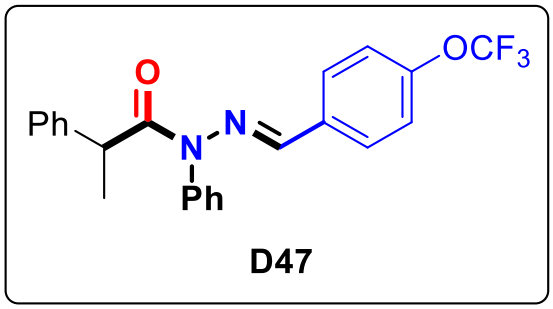
^{1}H NMR (400 MHz, $CDCl_3$) δ 11.86 – 10.26 (m, 1H), 7.55 – 7.40 (m, 5H), 7.35 – 7.25 (m, 2H), 7.23 – 7.15 (m, 3H), 7.13 (s, 1H), 6.96 (d, *J* = 8.0 Hz, 2H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.74 (t, *J* = 7.2 Hz, 1H), 4.67 – 3.58 (m, 1H), 1.57 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.2, 157.4, 146.2, 141.0, 135.3, 131.6, 130.5, 129.7, 129.4, 129.0, 127.5, 127.1, 127.1, 119.6, 117.6, 116.8, 112.5, 43.5, 20.5 ppm.

MS (70 eV): m/z (%) = 344 $[M]^+$ (100), 281, 212, 105.

HRMS (ESI) calcd. for $C_{22}H_{21}N_2O_2$ [M+H]: 345.1597, found: 345.1595.





D47

***N*,2-diphenyl-*N'*-(4-(trifluoromethoxy)benzylidene)propanehydrazide (D47)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 358.4 mg, 87% yield.

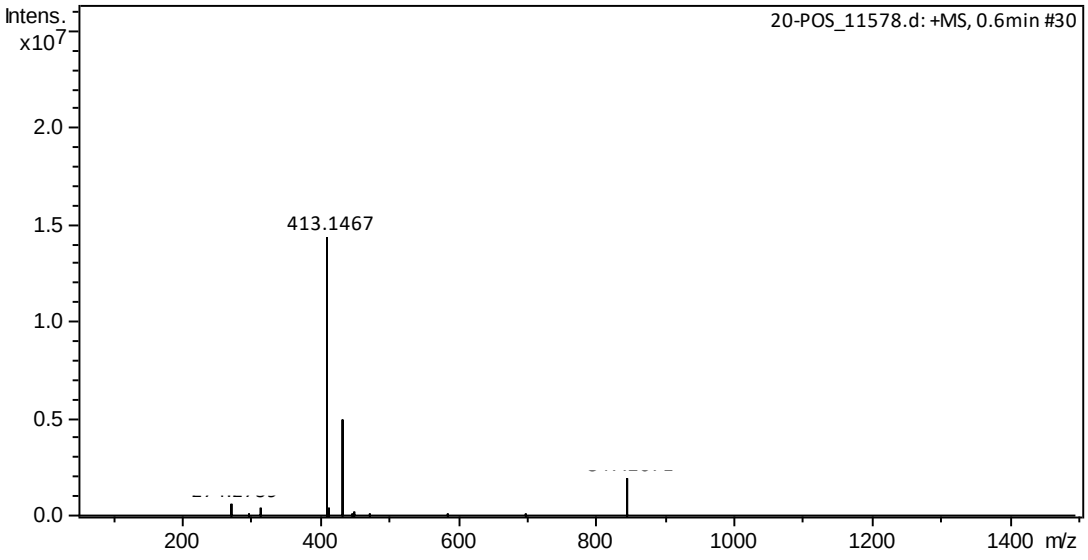
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (t, *J* = 8.8 Hz, 4H), 7.46 (d, *J* = 7.2 Hz, 3H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.25 – 7.17 (m, 3H), 7.14 – 7.05 (m, 3H), 5.03 (d, *J* = 6.8 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

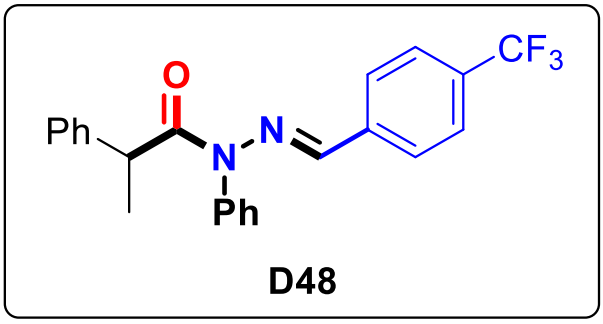
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 150.0, 142.4, 139.7, 136.1, 133.1, 130.2, 129.3, 129.1, 128.7, 128.6, 127.6, 126.7, 121.7, 121.0, 119.1, 43.1, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -57.7.

MS (70 eV): m/z (%) = 412 $[M]^+$ (100), 280, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{20}F_3N_2O_2$ [M+H]: 413.1471, found: 413.1467.





D48

***N*,2-diphenyl-*N′*-(4-(trifluoromethyl)benzylidene)propanehydrazide (D48)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 328.7 mg, 83% yield.

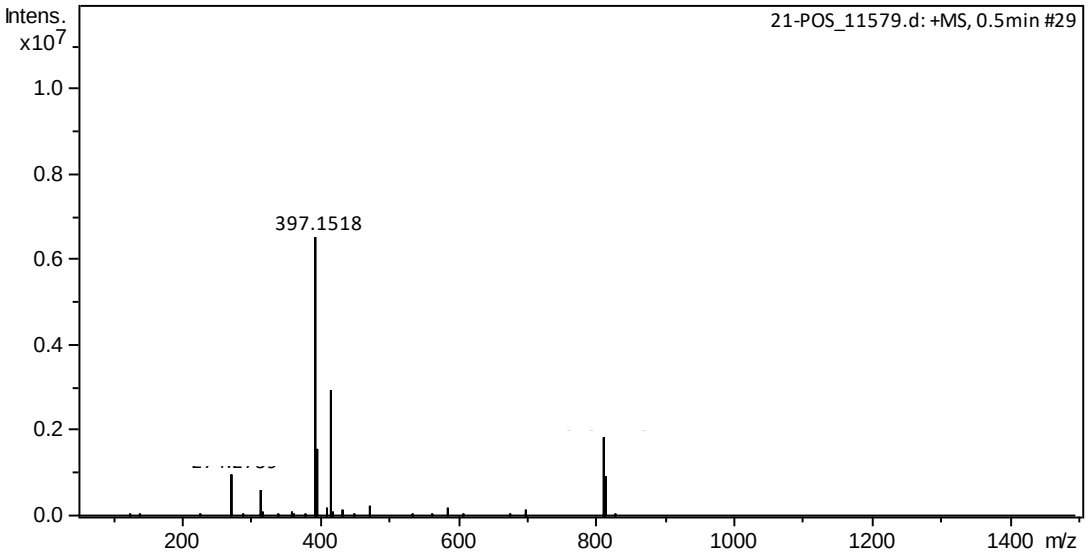
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (s, 4H), 7.56 – 7.51 (m, 2H), 7.49 – 7.44 (m, 3H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.25 – 7.20 (m, 1H), 7.15 (s, 1H), 7.09 (d, *J* = 7.6 Hz, 2H), 5.03 (d, *J* = 6.8 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

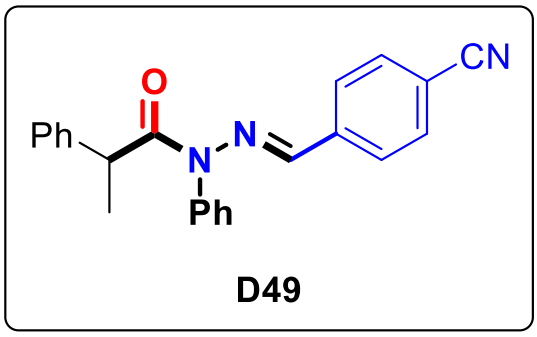
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.3, 139.5, 137.8, 136.0, 131.4, 131.0, 130.3, 129.5, 129.0, 128.7, 127.6, 127.3, 126.7, 125.6, 125.3, 122.6, 43.2, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -62.7.

MS (70 eV): m/z (%) = 396 $[M]^+$ (100), 264, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{20}F_3N_2O$ [M+H]: 397.1522, found: 397.1518.





D49

***N′*-(4-cyanobenzylidene)-*N*,2-diphenylpropanehydrazide (D49)**

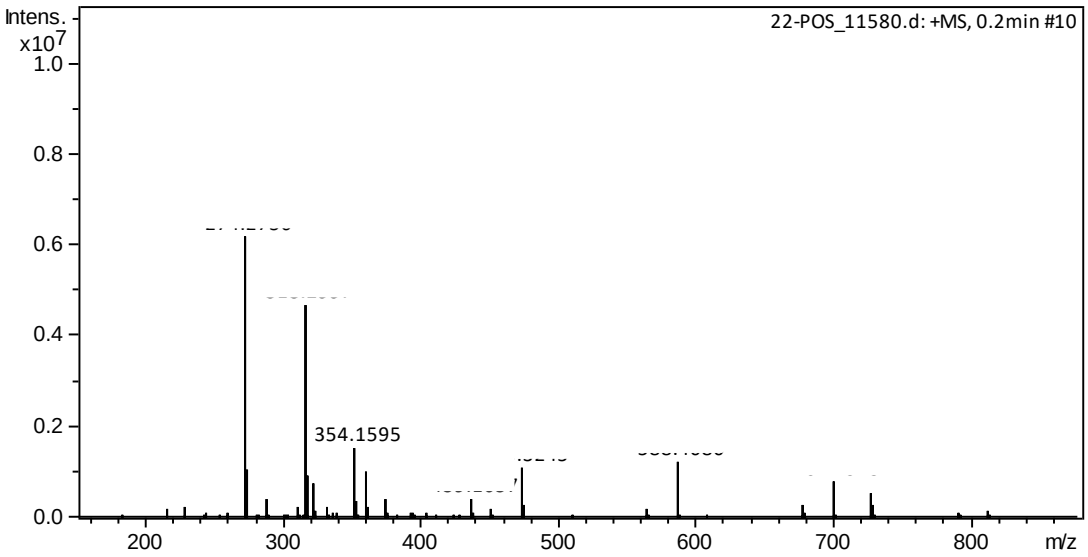
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 289.5 mg, 82% yield.

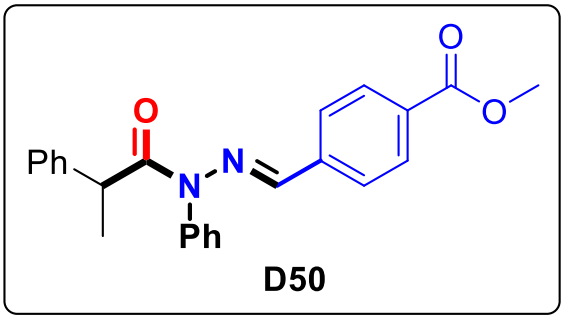
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.55 (m, 4H), 7.52 – 7.40 (m, 5H), 7.34 – 7.26 (m, 2H), 7.22 – 7.17 (m, 1H), 7.11 (s, 1H), 7.07 (d, *J* = 7.6 Hz, 2H), 5.03 (d, *J* = 6.8 Hz, 1H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.3, 139.1, 138.7, 135.8, 132.5, 130.4, 129.6, 129.0, 128.8, 127.6, 126.9, 118.7, 112.7, 43.3, 19.7 ppm.

MS (70 eV): m/z (%) = 353 $[M]^+$ (100), 221, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{20}N_3O$ [M+H]: 354.1600, found: 354.1595.





methyl-4-((2-phenyl-2-(2-phenylpropanoyl)hydrazineylidene)methyl)benzoate (D50)

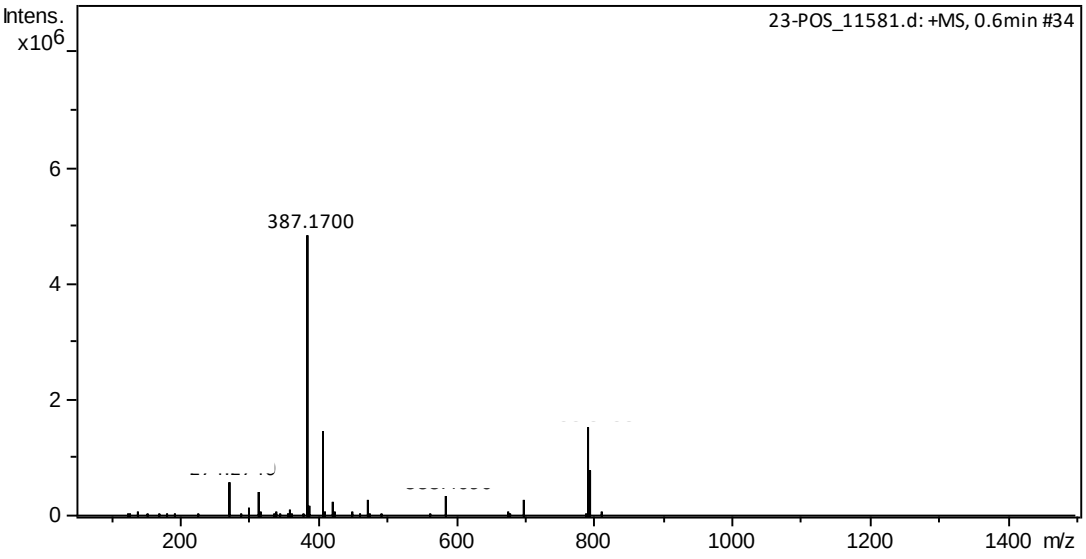
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 347.4 mg, 90% yield.

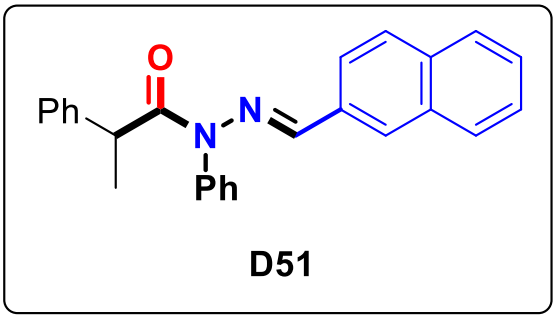
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 8.4 Hz, 2H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.49 – 7.43 (m, 4H), 7.40 – 7.35 (m, 1H), 7.31 – 7.26 (m, 2H), 7.18 – 7.14 (m, 2H), 7.05 (d, *J* = 7.6 Hz, 2H), 5.06 (d, *J* = 6.8 Hz, 1H), 3.82 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 177.6, 175.8, 166.5, 142.4, 140.5, 140.1, 138.7, 136.0, 130.9, 130.3, 130.0, 129.5, 129.1, 128.8, 128.7, 127.7, 127.1, 126.8, 52.2, 45.3, 43.2, 19.7, 18.5 ppm.

MS (70 eV): m/z (%) = 386 $[M]^+$ (100), 254, 105, 77.

HRMS (ESI) calcd. for $C_{24}H_{23}N_2O_3$ [M+H]: 387.1703, found: 387.1700.





D51

***N′*-(naphthalen-2-ylmethylene)-*N*,2-diphenylpropanehydrazide (D51)**

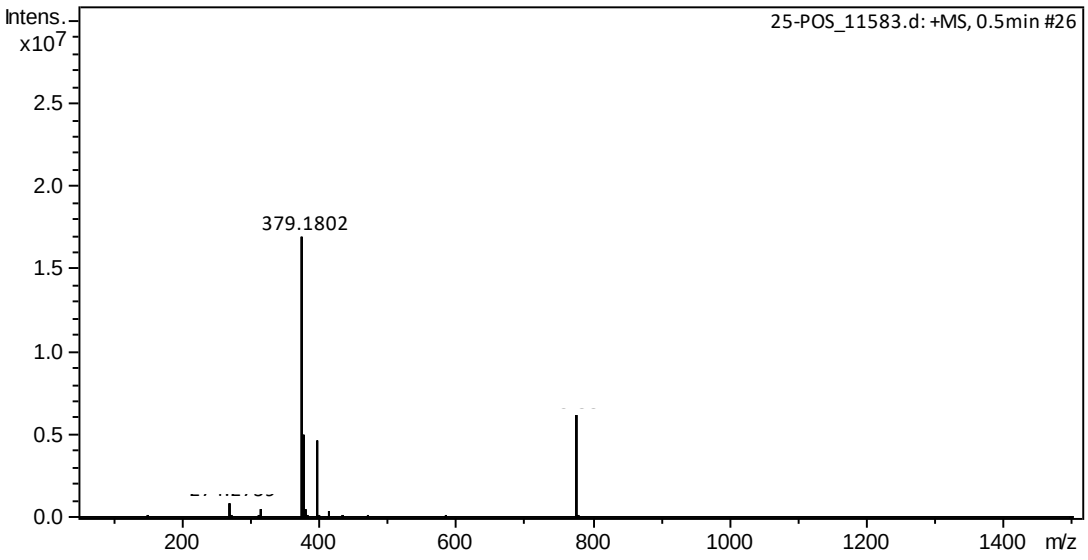
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 347.8 mg, 92% yield.

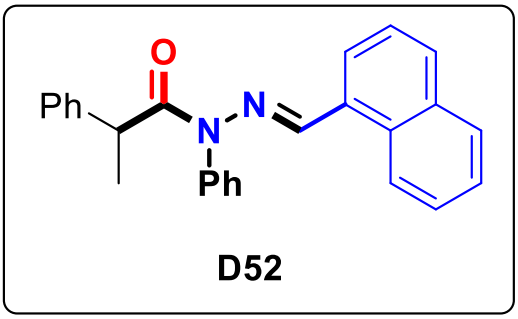
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, *J* = 8.4 Hz, 1H), 7.86 – 7.79 (m, 2H), 7.75 – 7.71 (m, 1H), 7.66 (s, 1H), 7.55 – 7.50 (m, 4H), 7.49 – 7.40 (m, 3H), 7.36 – 7.29 (m, 3H), 7.22 – 7.18 (m, 1H), 7.12 (d, *J* = 7.6 Hz, 2H), 5.14 (d, *J* = 7.2 Hz, 1H), 1.62 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.5, 141.6, 136.3, 134.1, 133.2, 132.2, 130.2, 129.2, 129.1, 128.7, 128.6, 128.2, 127.9, 127.8, 127.0, 126.7, 126.6, 122.8, 43.0, 19.5 ppm.

MS (70 eV): m/z (%) = 378 $[M]^+$ (100), 246, 207, 153.

HRMS (ESI) calcd. for $C_{26}H_{23}N_2O$ [M+H]: 379.1805, found: 379.1802.





D52

***N′*-(naphthalen-1-ylmethylene)-*N*,2-diphenylpropanehydrazide (D52)**

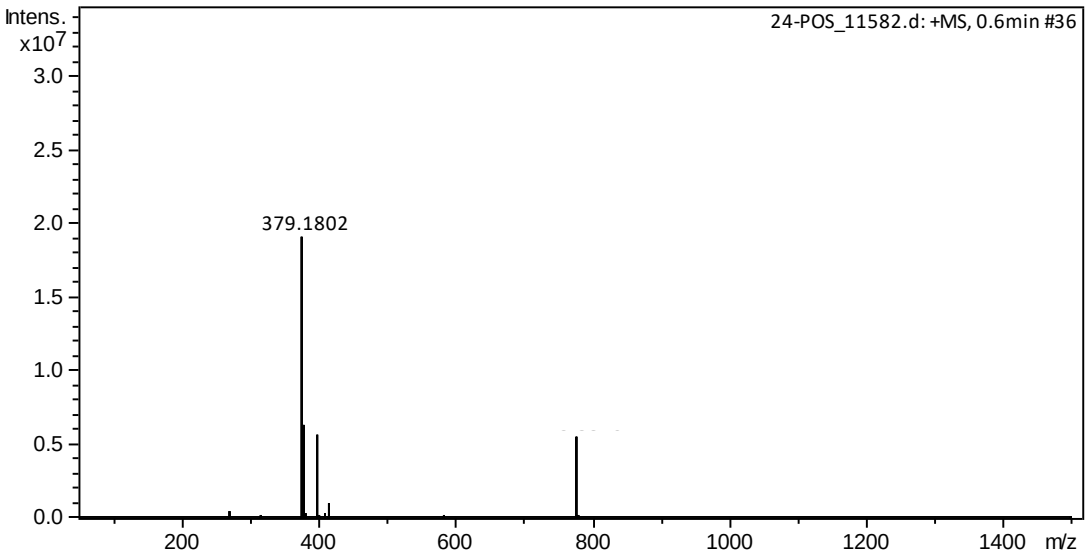
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 306.2 mg, 81% yield.

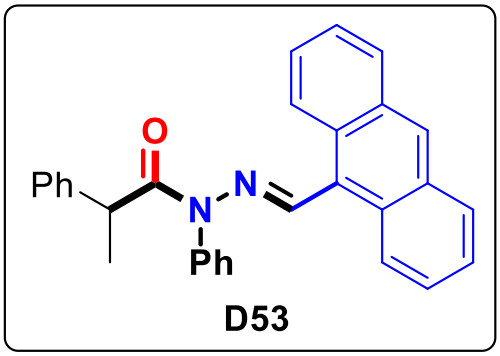
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (d, *J* = 7.2 Hz, 1H), 7.84 (s, 1H), 7.73 (d, *J* = 8.4 Hz, 2H), 7.67 (d, *J* = 7.2 Hz, 1H), 7.54 (d, *J* = 7.2 Hz, 2H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.42 – 7.34 (m, 4H), 7.30 (t, *J* = 7.6 Hz, 2H), 7.19 – 7.12 (m, 3H), 5.15 (d, *J* = 6.8 Hz, 1H), 1.64 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 142.6, 141.3, 136.5, 134.0, 130.9, 130.6, 130.5, 130.0, 129.5, 129.0, 128.9, 128.0, 127.2, 127.1, 126.9, 126.3, 125.5, 123.8, 43.2, 20.1 ppm.

MS (70 eV): m/z (%) = 378 $[M]^+$ (100), 246, 153, 105.

HRMS (ESI) calcd. for $C_{26}H_{23}N_2O$ [M+H]: 379.1805, found: 379.1802.





***N′*-(anthracen-9-ylmethylene)-*N*,2-diphenylpropanehydrazide (D53)**

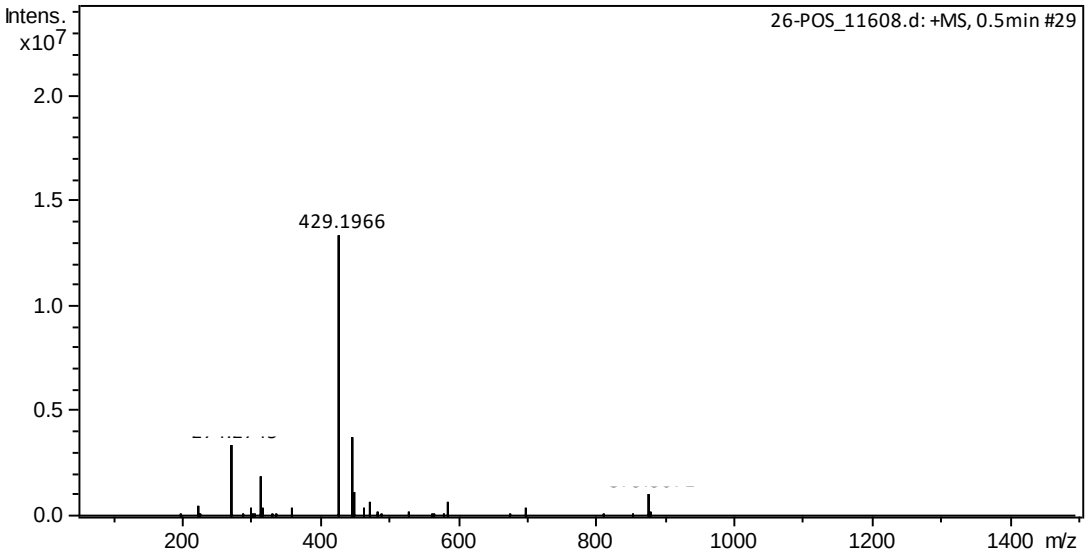
The title compound was prepared according to the general procedure and purified by column chromatography to give a yellow solid, 329.6 mg, 77% yield.

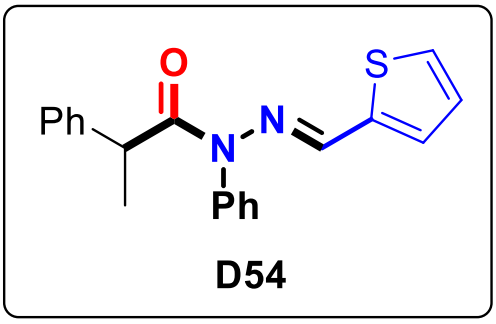
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.36 (s, 1H), 8.25 (s, 1H), 7.98 (d, *J* = 8.4 Hz, 2H), 7.92 (d, *J* = 8.0 Hz, 2H), 7.61 (t, *J* = 7.6 Hz, 2H), 7.50 (d, *J* = 7.6 Hz, 1H), 7.47 – 7.40 (m, 5H), 7.39 – 7.31 (m, 5H), 7.27 (d, *J* = 7.2 Hz, 1H), 5.08 (d, *J* = 7.2 Hz, 1H), 1.58 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.1, 142.4, 141.2, 136.6, 131.3, 130.6, 130.0, 129.6, 129.4, 129.2, 129.1, 129.0, 128.9, 128.8, 128.0, 127.8, 126.8, 126.0, 125.4, 124.8, 119.8, 47.9, 42.6, 20.1, 18.7 ppm.

MS (70 eV): m/z (%) = 428 $[M]^+$ (100), 378, 246, 105.

HRMS (ESI) calcd. for $C_{30}H_{25}N_2O$ [M+H]: 429.1961, found: 429.1966.





***N*,2-diphenyl-*N′*-(thiophen-2-ylmethylene)propanehydrazide (D54)**

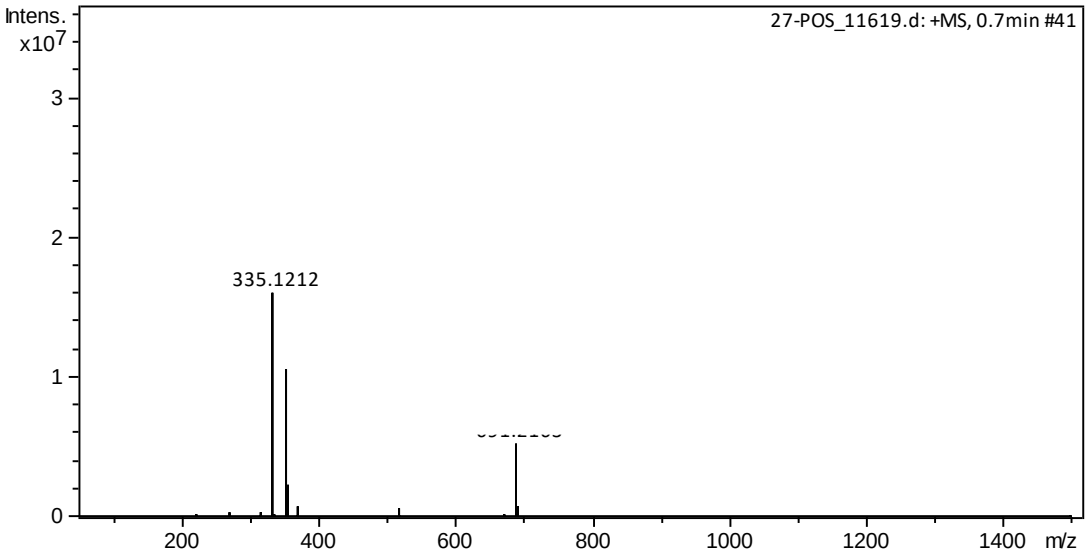
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 136.9 mg, 41% yield.

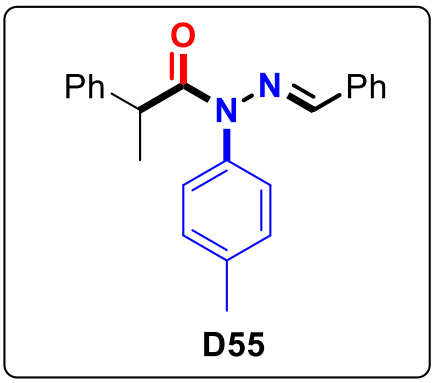
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.46 (m, 4H), 7.45 – 7.40 (m, 1H), 7.34 – 7.28 (m, 3H), 7.27 – 7.18 (m, 2H), 7.05 (d, *J* = 7.6 Hz, 2H), 6.94 (d, *J* = 3.4 Hz, 2H), 4.99 (d, *J* = 7.2 Hz, 1H), 1.56 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.4, 142.3, 139.8, 136.1, 135.9, 130.2, 129.6, 129.3, 129.1, 128.6, 128.0, 127.7, 127.4, 126.6, 42.8, 19.3 ppm.

MS (70 eV): m/z (%) = 334 $[M]^+$ (100), 202, 105, 77.

HRMS (ESI) calcd. for $C_{20}H_{19}N_2OS$ [M+H]: 335.1212, found: 335.1212.





_N′_-benzylidene-2-phenyl-_N_-(_p_-tolyl)propanehydrazide (D55)

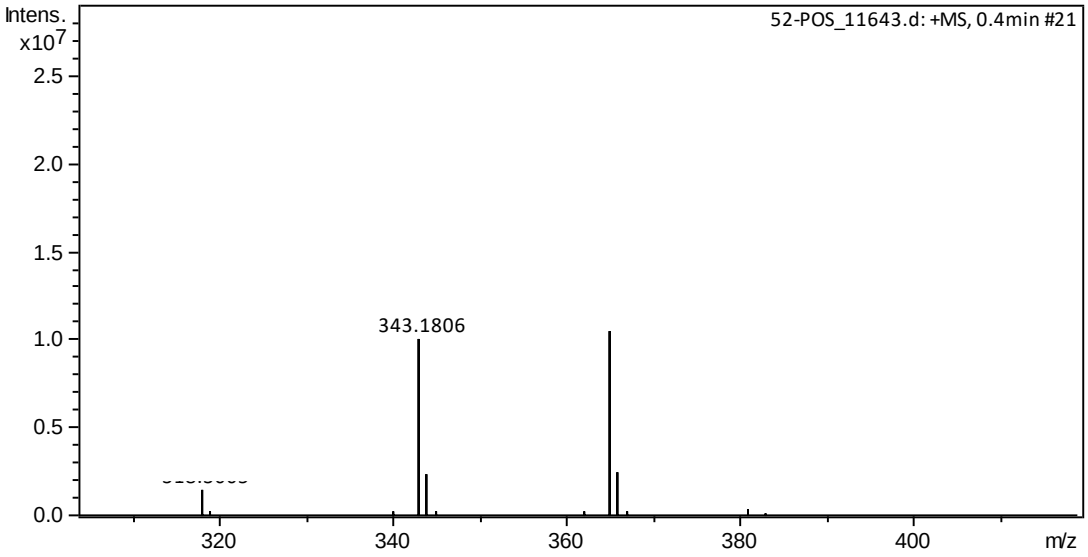
The title compound was prepared according to the general procedure and purified by column chromatography to give the light-yellow oil, 311.2 mg, 91% yield.

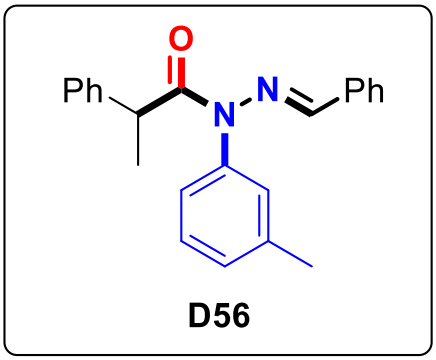
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 7.2 Hz, 4H), 7.31 – 7.22 (m, 7H), 7.17 – 7.11 (m, 2H), 6.92 (d, *J* = 7.6 Hz, 2H), 5.09 (d, *J* = 7.2 Hz, 1H), 2.33 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.7, 141.5, 139.3, 134.6, 133.6, 131.0, 129.9, 129.0, 128.8, 128.7, 127.9, 127.3, 126.8, 43.1, 21.5, 19.7 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 210, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1806.





***N′*-benzylidene-2-phenyl-*N*-(*m*-tolyl)propanehydrazide (D56)**

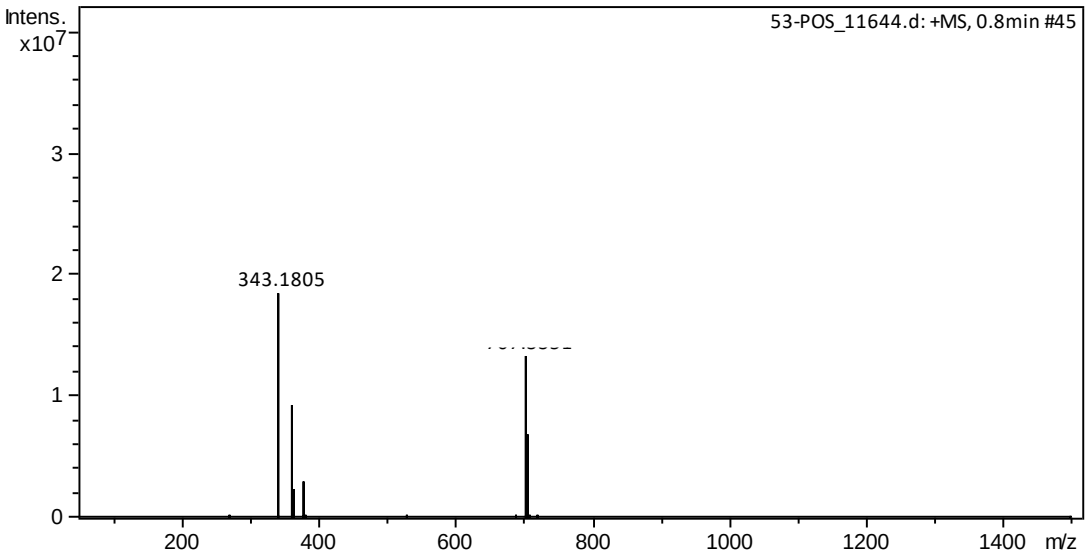
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 273.6 mg, 80% yield.

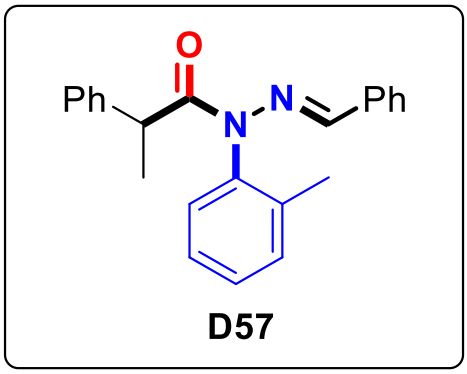
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 6.8 Hz, 4H), 7.37 – 7.25 (m, 6H), 7.21 – 7.13 (m, 3H), 6.87 – 6.83 (m, 2H), 5.09 (d, *J* = 6.8 Hz, 1H), 2.32 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 142.6, 141.6, 140.3, 136.2, 134.6, 130.2, 130.2, 129.9, 129.7, 128.8, 128.7, 127.9, 127.3, 126.7, 126.1, 43.0, 21.5, 19.6 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 210, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1805.





_N′_-benzylidene-2-phenyl-_N_-(_o_-tolyl)propanehydrazide (D57)

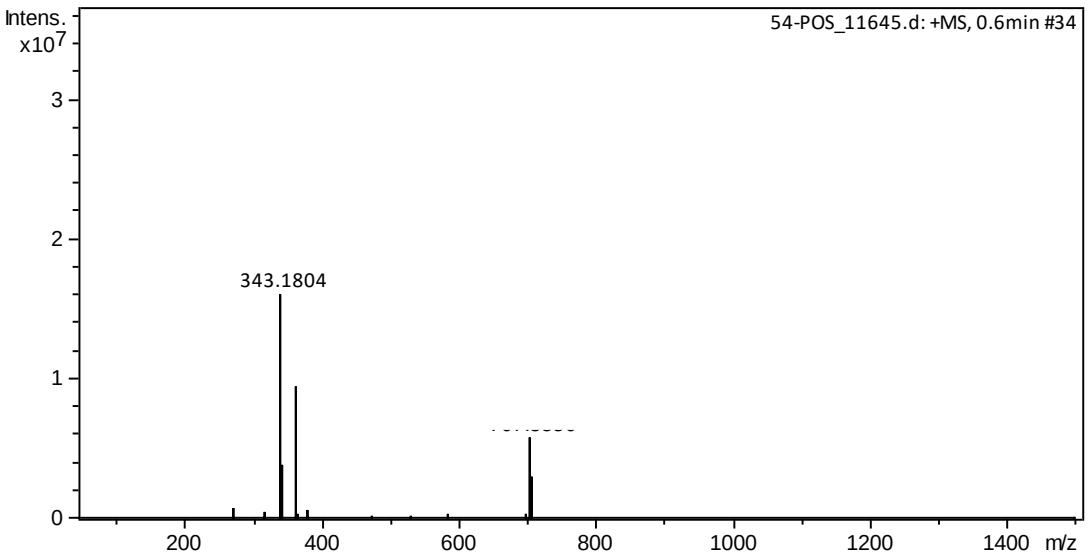
The title compound was prepared according to the general procedure and purified by column chromatography to give the light-yellow oil, 174.4 mg, 51% yield.

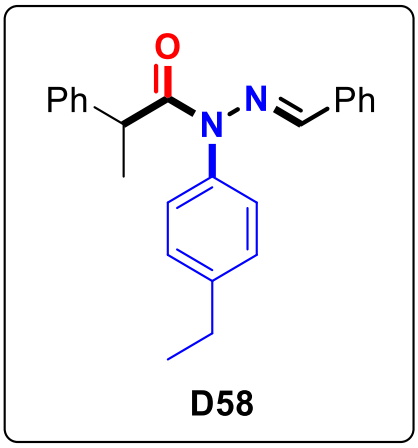
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.34 (m, 4H), 7.28 – 7.10 (m, 8H), 7.10 – 7.03 (m, 1H), 7.01 – 6.97 (m, 1H), 6.89 (s, 1H), 6.75 (d, *J* = 7.6 Hz, 1H), 5.02 (d, *J* = 7.2 Hz, 1H), 2.00 (s, 1H), 1.54 (s, 2H), 1.53 – 1.47 (m, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.5, 175.2, 142.5, 142.2, 140.8, 137.3, 136.8, 135.2, 134.9, 134.6, 131.6, 131.5, 129.9, 129.7, 129.4, 129.2, 128.8, 128.7, 128.6, 128.1, 127.9, 127.8, 127.7, 127.3, 126.8, 42.8, 19.5, 19.2, 17.6, 16.9 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 239, 210, 105.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1804.





***N′*-benzylidene-*N*-(4-ethylphenyl)-2-phenylpropanehydrazide (D58)**

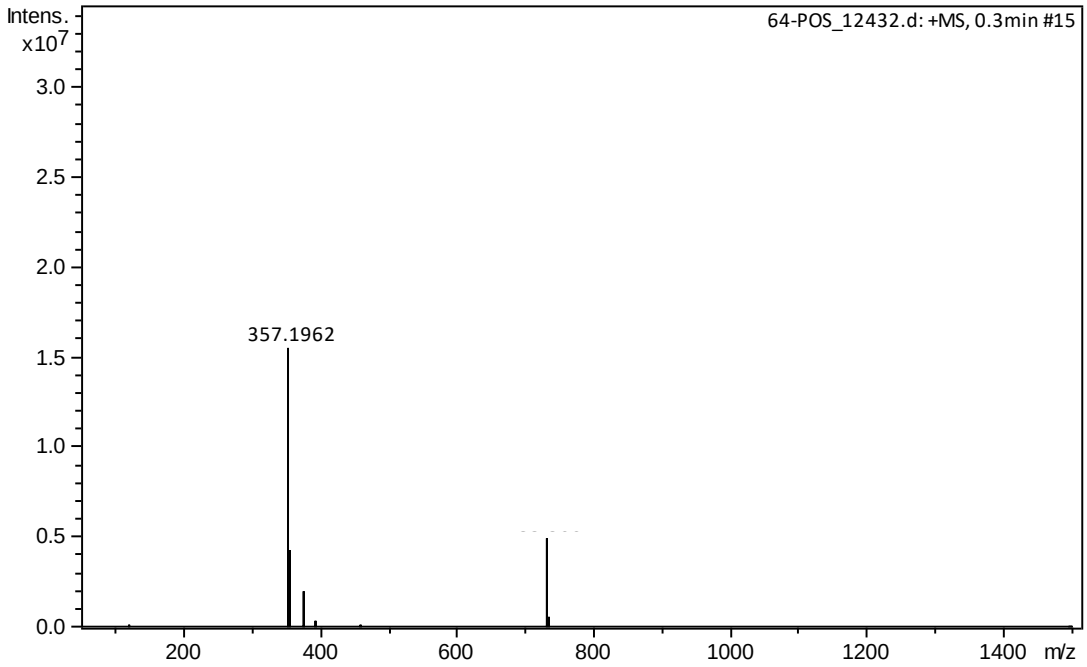
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 327.5 mg, 92% yield.

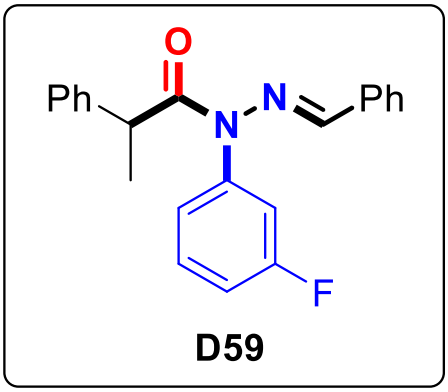
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 7.2 Hz, 4H), 7.32 – 7.23 (m, 7H), 7.18 – 7.12 (m, 2H), 6.95 (d, *J* = 8.0 Hz, 2H), 5.09 (d, *J* = 7.2 Hz, 1H), 2.65 (q, *J* = 7.6 Hz, 2H), 1.59 (d, *J* = 7.2 Hz, 3H), 1.23 (t, *J* = 7.6 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 145.4, 142.7, 141.5, 134.6, 133.7, 129.8, 129.7, 129.0, 128.8, 128.7, 127.9, 127.3, 126.7, 43.0, 28.8, 19.7, 15.5 ppm.

MS (70 eV): m/z (%) = 356 $[M]^+$ (100), 253, 224, 105.

HRMS (ESI) calcd. for $C_{24}H_{25}N_2O$ [M+H]: 357.1961, found: 357.1962.





D59

***N'*-benzylidene-*N*-(3-fluorophenyl)-2-phenylpropanehydrazide (D59)**

The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 269.9 mg, 78% yield.

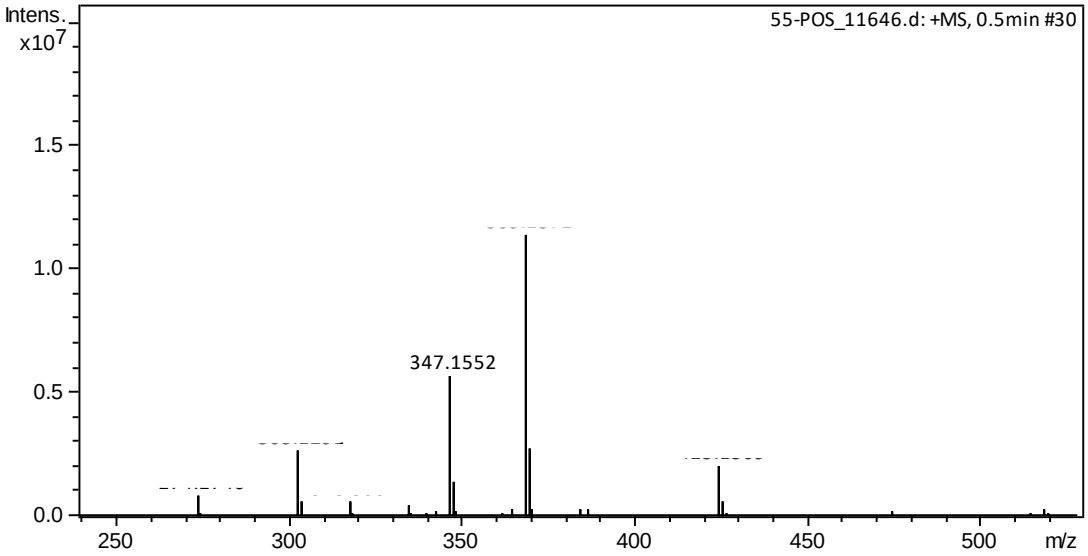
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 – 7.38 (m, 2H), 7.37 – 7.28 (m, 3H), 7.25 – 7.15 (m, 5H), 7.10 – 6.97 (m, 3H), 6.76 – 6.67 (m, 2H), 4.94 (d, *J* = 4.8 Hz, 1H), 1.48 (d, *J* = 7.2 Hz, 3H) ppm.

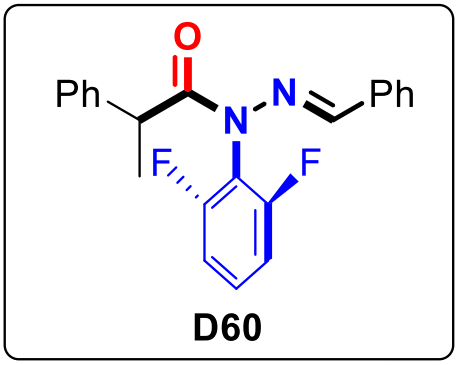
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 164.8, 162.3, 142.2, 141.9, 137.8, 137.7, 134.2, 131.5, 131.4, 130.1, 128.8, 127.8, 127.4, 126.8, 125.2, 125.1, 116.9, 116.7, 116.5, 43.0, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -110.0.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 214, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1552.





***N′*-benzylidene-*N*-(2,6-difluorophenyl)-2-phenylpropanehydrazide (D60)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 152.9 mg, 42% yield.

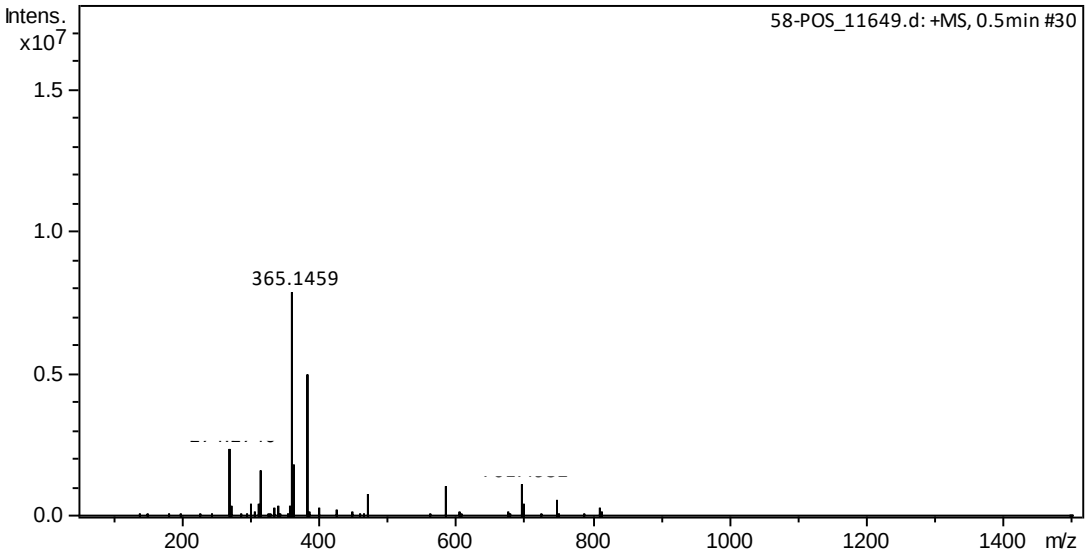
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 – 7.52 (m, 2H), 7.46 (d, *J* = 7.2 Hz, 2H), 7.44 – 7.25 (m, 6H), 7.23 – 7.14 (m, 2H), 7.11 – 6.97 (m, 2H), 5.06 (d, *J* = 7.2 Hz, 1H), 1.61 (d, *J* = 7.2 Hz, 3H) ppm.

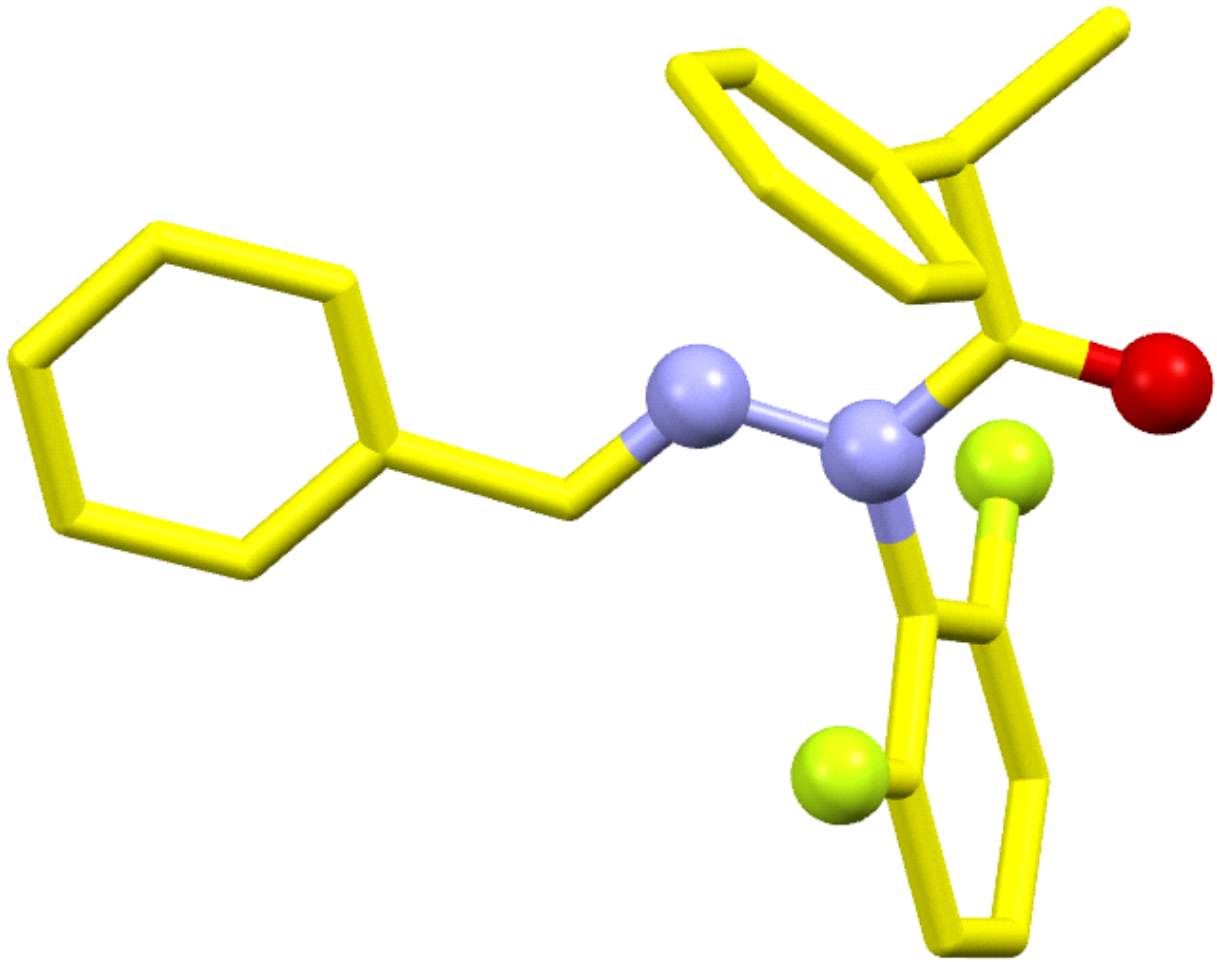
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.4, 160.5, 160.3, 160.2, 158.0, 157.9, 157.8, 157.7, 141.9, 141.0, 133.9, 131.6, 131.5, 131.4, 130.1, 128.7, 128.5, 127.8, 127.5, 126.7, 112.7, 112.6, 112.5, 112.4, 112.3, 43.2, 19.4 ppm.

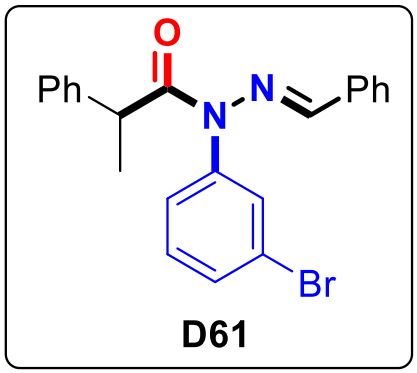
^{19}F NMR (376 MHz, $CDCl_3$) δ -115.5, -115.9.

MS (70 eV): m/z (%) = 364 $[M]^+$ (100), 232, 209, 105.

HRMS (ESI) calcd. for $C_{22}H_{19}F_2N_2O$ [M+H]: 365.1459, found: 365.1459.







***N′*-benzylidene-*N*-(3-bromophenyl)-2-phenylpropanehydrazide (D61)**

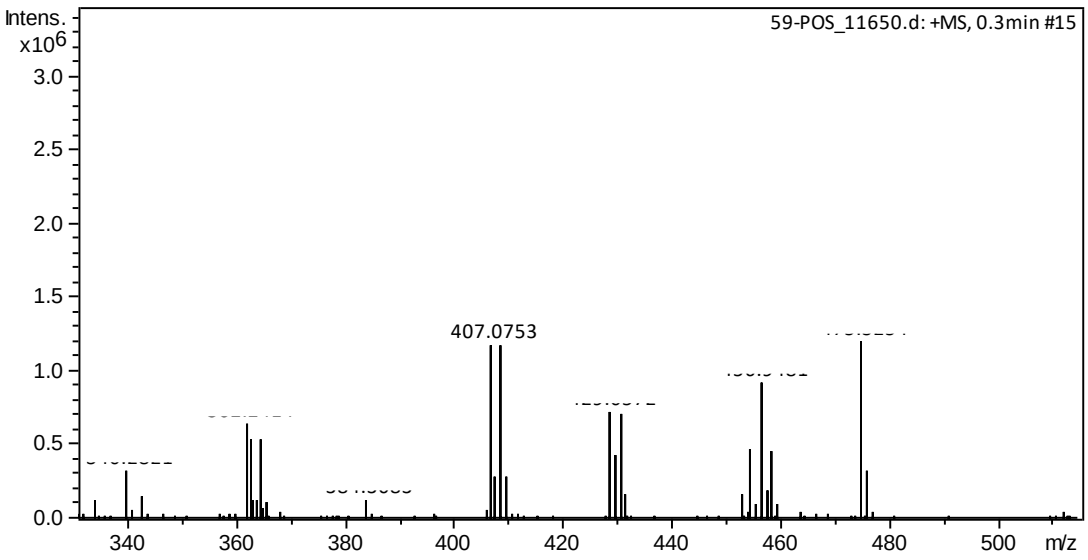
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 337.0 mg, 83% yield.

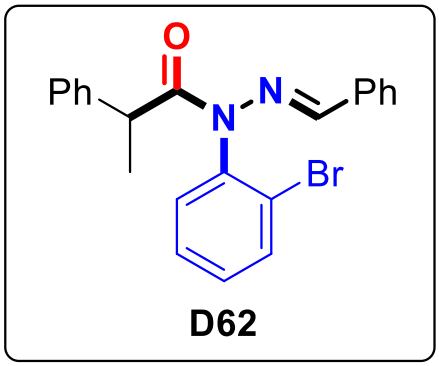
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 – 7.48 (m, 3H), 7.44 (d, *J* = 6.8 Hz, 2H), 7.34 – 7.27 (m, 6H), 7.23 (s, 1H), 7.19 – 7.14 (t, *J* = 7.4 Hz, 1H), 7.11 (s, 1H), 6.99 (d, *J* = 8.0 Hz, 1H), 5.02 (d, *J* = 5.6 Hz, 1H), 1.56 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 142.2, 142.0, 138.2, 137.6, 134.2, 132.6, 132.4, 131.4, 130.5, 130.1, 128.8, 128.1, 127.8, 127.4, 126.8, 126.4, 123.6, 122.3, 115.5, 111.4, 43.0, 19.5 ppm.

MS (70 eV): m/z (%) = 406 $[M]^+$ (100), 274, 105, 77.

HRMS (ESI) calcd. for $C_{22}H_{20}BrN_2O$ [M+H]: 407.0753, found: 407.0753.





D62

***N′*-benzylidene-*N*-(2-bromophenyl)-2-phenylpropanehydrazide (D62)**

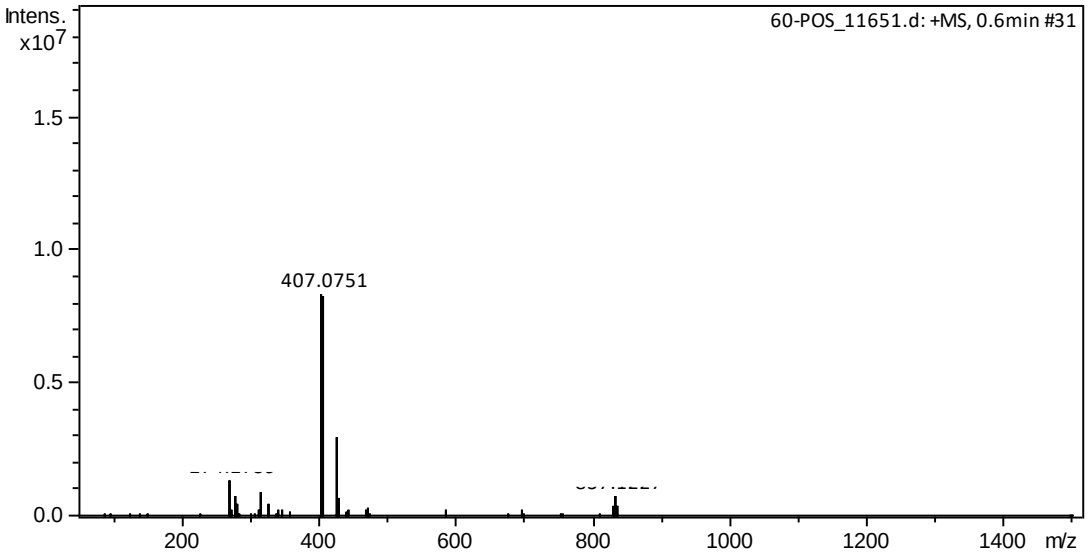
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 162.4 mg, 40% yield.

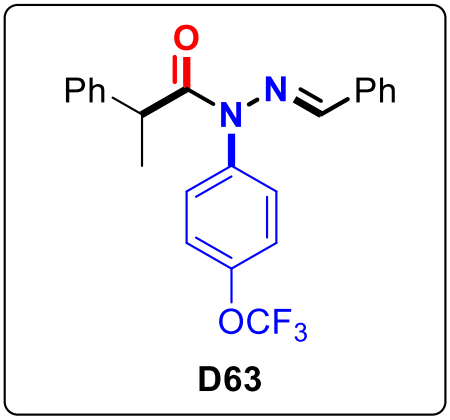
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.68 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.60 – 7.54 (m, 2H), 7.53 – 7.47 (m, 2H), 7.48 – 7.39 (m, 1H), 7.40 – 7.28 (m, 5H), 7.27 – 7.16 (m, 2H), 7.05 (dd, *J* = 7.6, 1.6 Hz, 1H), 6.99 (d, *J* = 3.2 Hz, 1H), 5.30 – 4.94 (m, 1H), 1.62 (d, *J* = 7.2, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.3, 175.1, 142.1, 141.4, 141.0, 135.7, 135.4, 134.3, 134.1, 133.9, 131.4, 131.3, 130.9, 129.9, 129.2, 129.1, 128.7, 128.6, 128.3, 127.9, 127.3, 126.7, 123.9, 123.7, 42.7, 19.4, 19.1 ppm.

MS (70 eV): m/z (%) = 406 $[M]^+$ (100), 274, 194, 105.

HRMS (ESI) calcd. for $C_{22}H_{20}BrN_2O$ [M+H]: 407.0753, found: 407.0751.





D63

***N′*-benzylidene-2-phenyl-*N*-(4-(trifluoromethoxy)phenyl)propanehydrazide (D63)**

The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 346.1 mg, 84% yield.

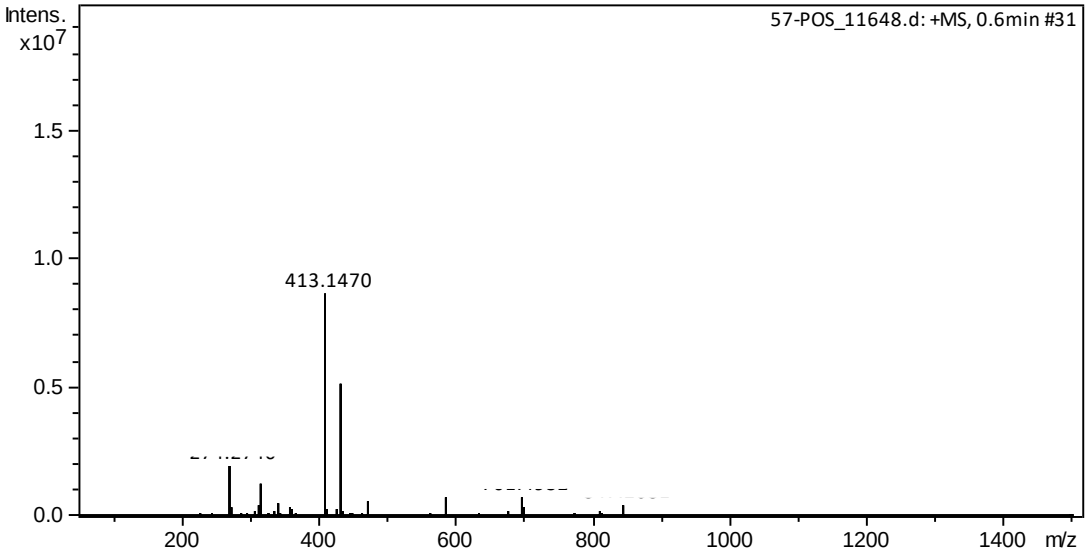
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 – 7.52 (m, 2H), 7.47 (d, *J* = 7.2 Hz, 2H), 7.38 – 7.25 (m, 7H), 7.20 – 7.13 (m, 2H), 7.09 (d, *J* = 8.8 Hz, 2H), 5.07 (d, *J* = 6.4 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

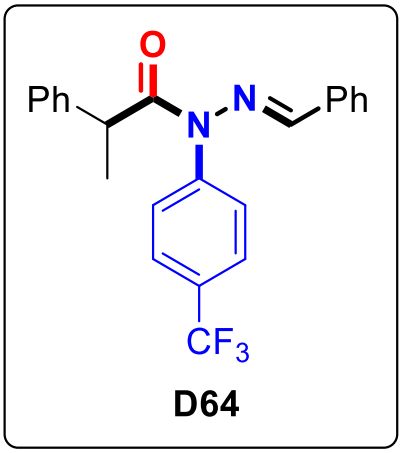
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 149.4, 142.3, 141.8, 134.7, 134.2, 131.0, 130.1, 128.8, 127.8, 127.4, 126.8, 122.6, 43.0, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -57.7.

MS (70 eV): m/z (%) = 412 $[M]^+$ (100), 280, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{20}F_3N_2O_2$ [M+H]: 413.1471, found: 413.1470.





***N′*-benzylidene-2-phenyl-*N*-(4-(trifluoromethyl)phenyl)propanehydrazide (D64)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 316.8 mg, 80% yield.

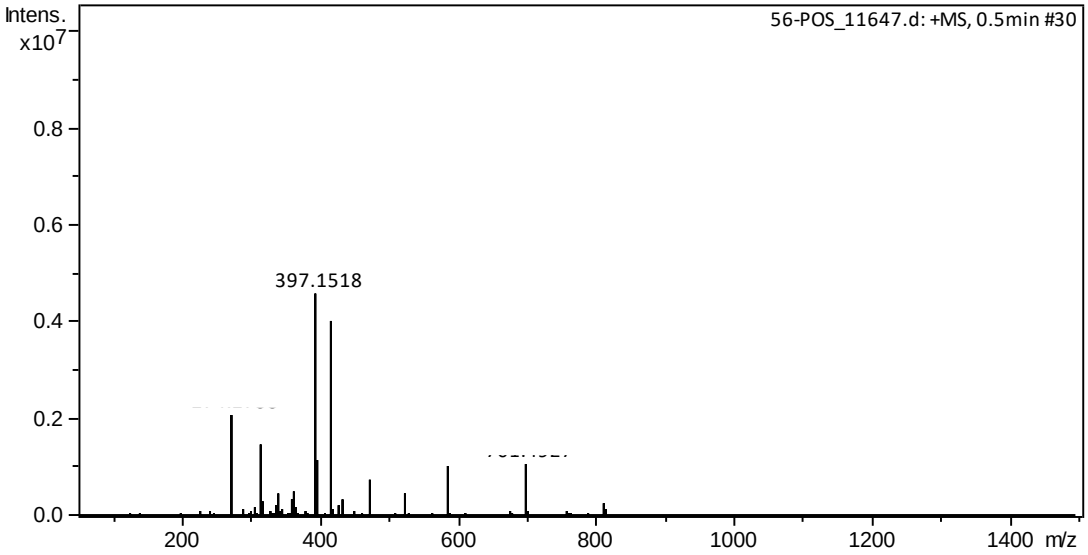
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.4 Hz, 2H), 7.56 – 7.52 (m, 2H), 7.47 (d, *J* = 7.6 Hz, 2H), 7.40 – 7.25 (m, 5H), 7.23 – 7.16 (m, 3H), 7.13 (s, 1H), 5.06 (d, *J* = 5.6 Hz, 1H), 1.59 (d, *J* = 7.2 Hz, 3H) ppm.

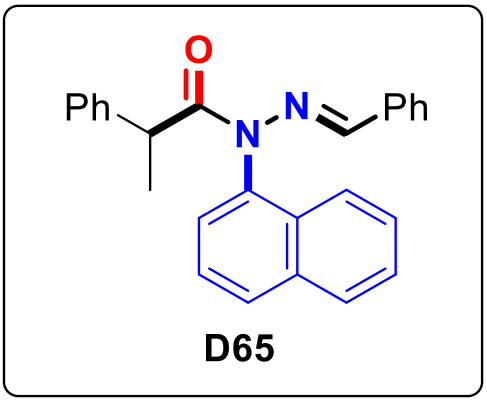
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.7, 142.1, 139.8, 134.1, 131.5, 131.1, 130.2, 130.0, 128.9, 128.8, 127.8, 127.4, 126.9, 125.2, 122.5, 43.1, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -62.6.

MS (70 eV): m/z (%) = 396 $[M]^+$ (100), 264, 105, 77.

HRMS (ESI) calcd. for $C_{23}H_{20}F_3N_2O$ [M+H]: 397.1522, found: 397.1518.





***N′*-benzylidene-*N*-(naphthalen-1-yl)-2-phenylpropanehydrazide (D65)**

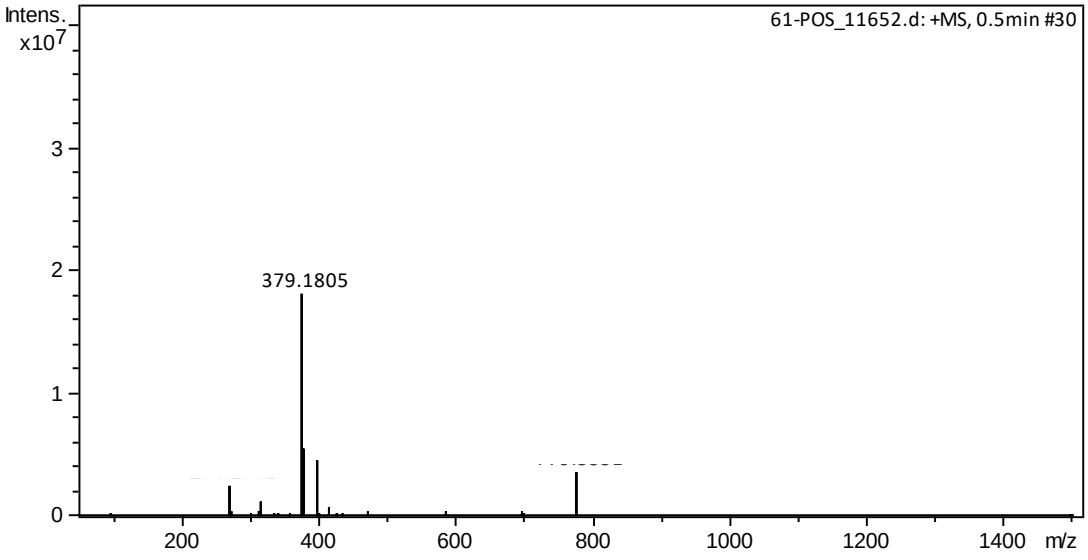
The title compound was prepared according to the general procedure and purified by column chromatography to give the yellow oil, 162.5 mg, 43% yield.

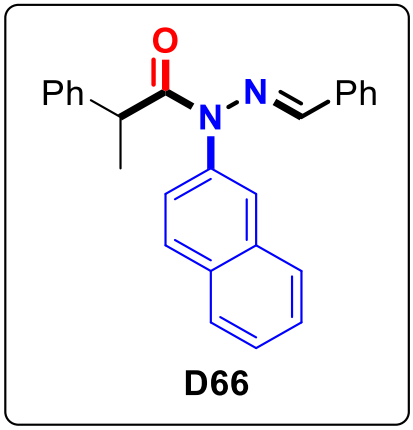
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (dd, *J* = 26.0, 8.0 Hz, 2H), 7.60 – 7.54 (m, 3H), 7.52 – 7.43 (m, 3H), 7.42 – 7.34 (m, 3H), 7.33 – 7.24 (m, 4H), 7.19 – 7.12 (m, 1H), 6.94 (s, 1H), 6.81 (d, *J* = 8.4 Hz, 1H), 5.32 – 5.21 (m, 1H), 1.66 (t, *J* = 8.0 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.1, 175.9, 142.5, 142.3, 141.8, 134.8, 134.5, 134.4, 133.1, 132.8, 130.0, 129.9, 129.8, 128.8, 128.7, 128.6, 128.2, 128.0, 127.8, 127.7, 127.5, 127.3, 127.0, 126.8, 126.7, 126.0, 125.9, 122.6, 122.3, 43.2, 43.1, 19.6, 19.3 ppm.

MS (70 eV): m/z (%) = 378 $[M]^+$ (100), 246, 142, 105.

HRMS (ESI) calcd. for $C_{26}H_{23}N_2O$ [M+H]: 379.1805, found: 379.1805.





***N′*-benzylidene-*N*-(naphthalen-2-yl)-2-phenylpropanehydrazide (D66)**

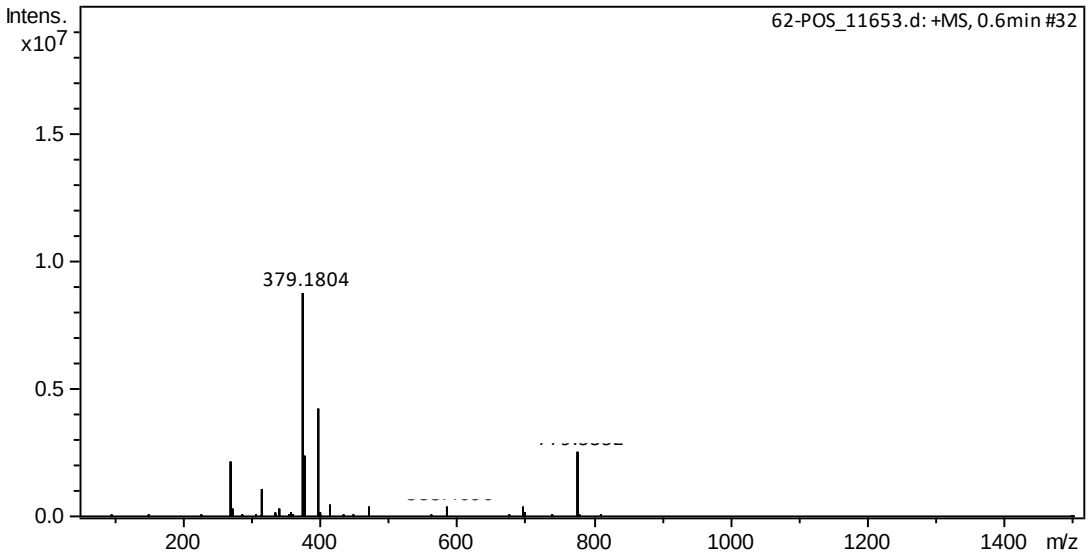
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 310.0 mg, 82% yield.

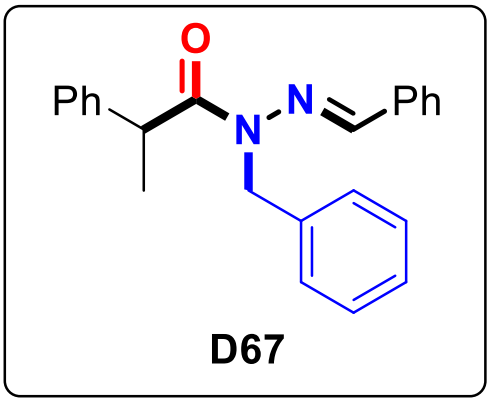
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.8 Hz, 1H), 7.89 (d, *J* = 7.6 Hz, 1H), 7.83 (d, *J* = 7.6 Hz, 1H), 7.62 (s, 1H), 7.60 – 7.41 (m, 6H), 7.41 – 7.25 (m, 5H), 7.24 – 7.17 (m, 2H), 7.12 (d, *J* = 8.4 Hz, 1H), 5.15 (d, *J* = 6.8 Hz, 1H), 1.63 (d, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.0, 142.5, 141.8, 134.4, 133.9, 133.6, 133.3, 130.3, 129.8, 128.7, 128.3, 127.9, 127.3, 127.2, 126.7, 126.2, 43.0, 19.5 ppm.

MS (70 eV): m/z (%) = 378 $[M]^+$ (100), 246, 105, 77.

HRMS (ESI) calcd. for $C_{26}H_{23}N_2O$ [M+H]: 379.1805, found: 379.1804.





***N*-benzyl-*N'*-benzylidene-2-phenylpropanehydrazide (D67)**

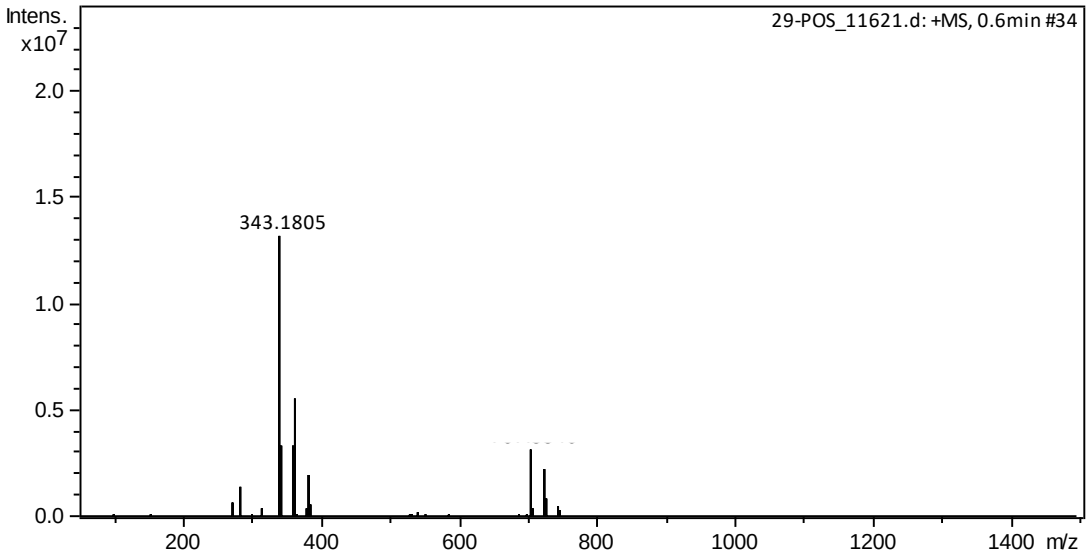
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 249.7 mg, 73% yield.

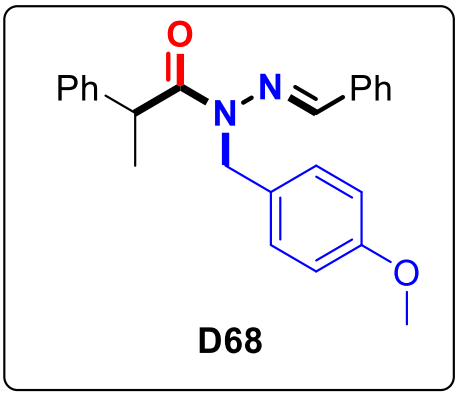
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.51 (m, 3H), 7.49 – 7.43 (m, 2H), 7.36 – 7.26 (m, 5H), 7.24 – 7.13 (m, 4H), 7.00 (d, *J* = 6.8 Hz, 2H), 5.30 (d, *J* = 16.4 Hz, 1H), 5.17 – 5.06 (m, 2H), 1.61 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.2, 142.3, 139.9, 135.2, 134.8, 129.7, 128.9, 128.7, 128.6, 127.9, 127.3, 127.2, 126.8, 126.3, 44.8, 42.4, 19.5 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 238, 196, 182.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1805.





***N′*-benzylidene-*N*-(4-methoxybenzyl)-2-phenylpropanehydrazide (D68)**

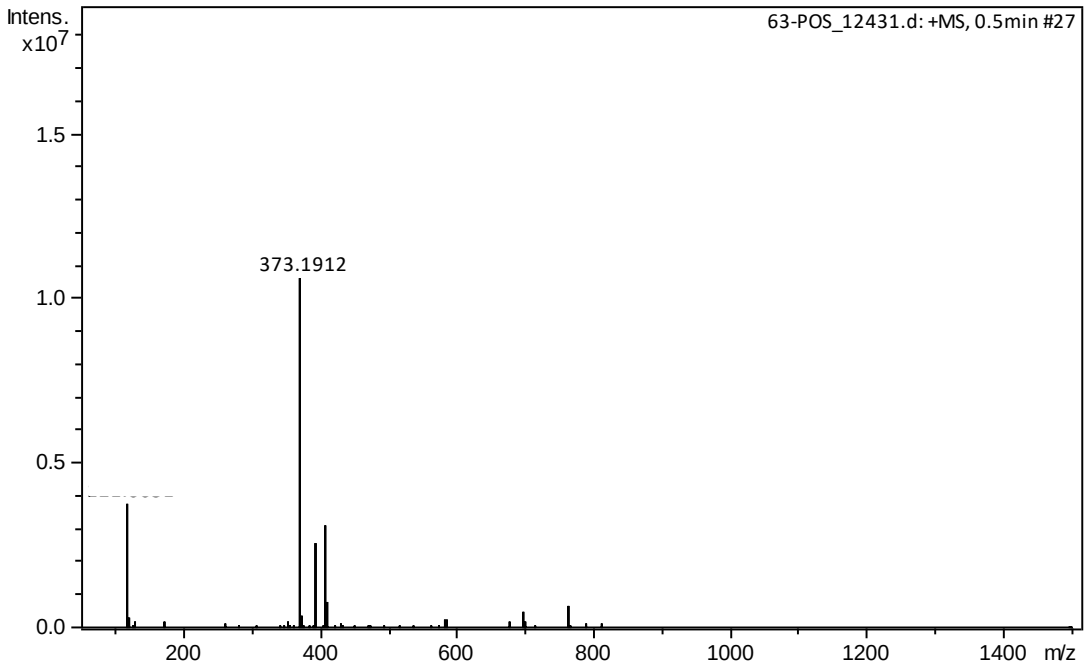
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 264.1 mg, 71% yield.

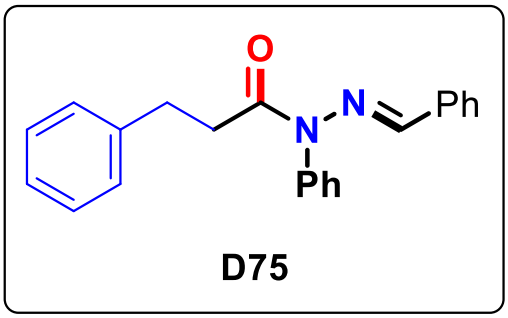
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.53 (m, 3H), 7.50 – 7.41 (m, 3H), 7.36 – 7.27 (m, 5H), 7.22 – 7.16 (m, 2H), 6.94 (d, *J* = 8.8 Hz, 2H), 6.75 (d, *J* = 8.8 Hz, 2H), 5.24 (d, *J* = 16.4 Hz, 1H), 5.13 – 5.04 (m, 2H), 3.71 (s, 3H), 1.60 (d, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.2, 158.8, 142.3, 139.8, 134.8, 129.6, 128.9, 128.7, 128.6, 127.9, 127.6, 127.1, 126.7, 126.3, 114.3, 114.1, 55.3, 44.2, 42.3, 19.4 ppm.

MS (70 eV): m/z (%) = 372 $[M]^+$ (100), 268, 136, 121.

HRMS (ESI) calcd. for $C_{24}H_{25}N_2O_2$ [M+H]: 373.1911, found: 373.1912.





***N'*-benzylidene-*N*,3-diphenylpropanehydrazide (D75)**

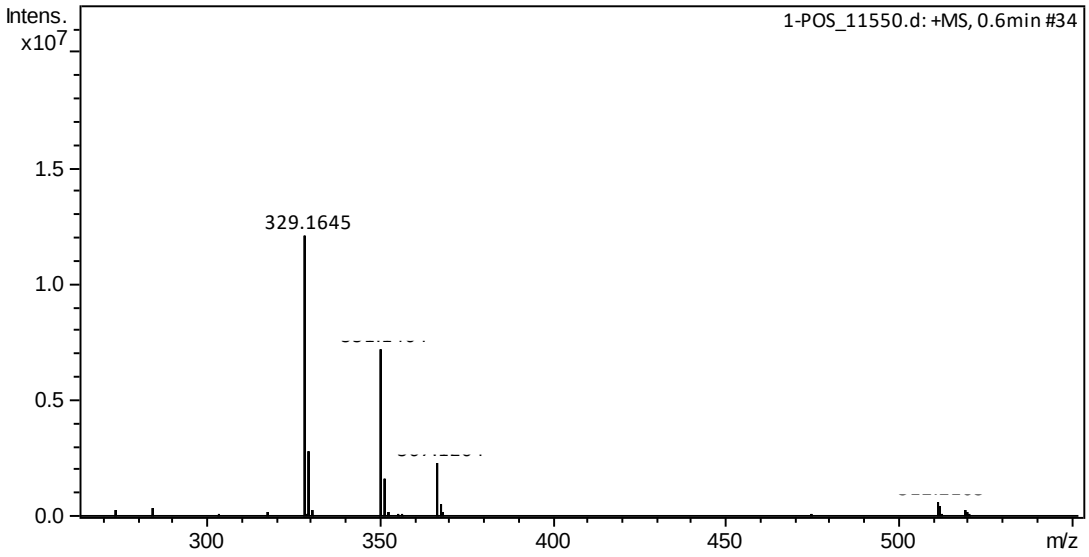
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 262.4 mg, 80% yield.

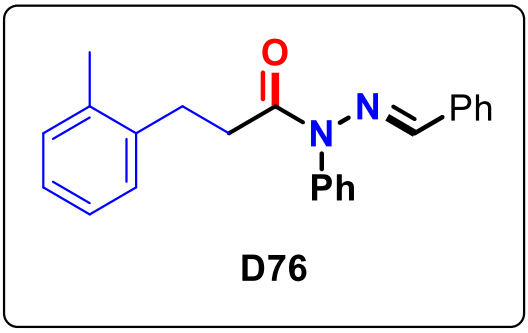
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.51 (m, 4H), 7.50 – 7.44 (m, 1H), 7.37 – 7.28 (m, 7H), 7.24 – 7.17 (m, 2H), 7.14 (d, *J* = 8.0 Hz, 2H), 3.36 (s, 2H), 3.23 – 2.99 (m, 2H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.3, 141.6, 136.1, 134.3, 130.2, 129.9, 129.3, 128.7, 128.5, 127.2, 126.1, 36.0, 31.3 ppm.

MS (70 eV): m/z (%) = 328 $[M]^+$ (100), 225, 196, 105.

HRMS (ESI) calcd. for $C_{22}H_{21}N_2O$ [M+H]: 329.1648, found: 329.1645.





***N'*-benzylidene-*N*-phenyl-3-(*o*-tolyl)propanehydrazide (D76)**

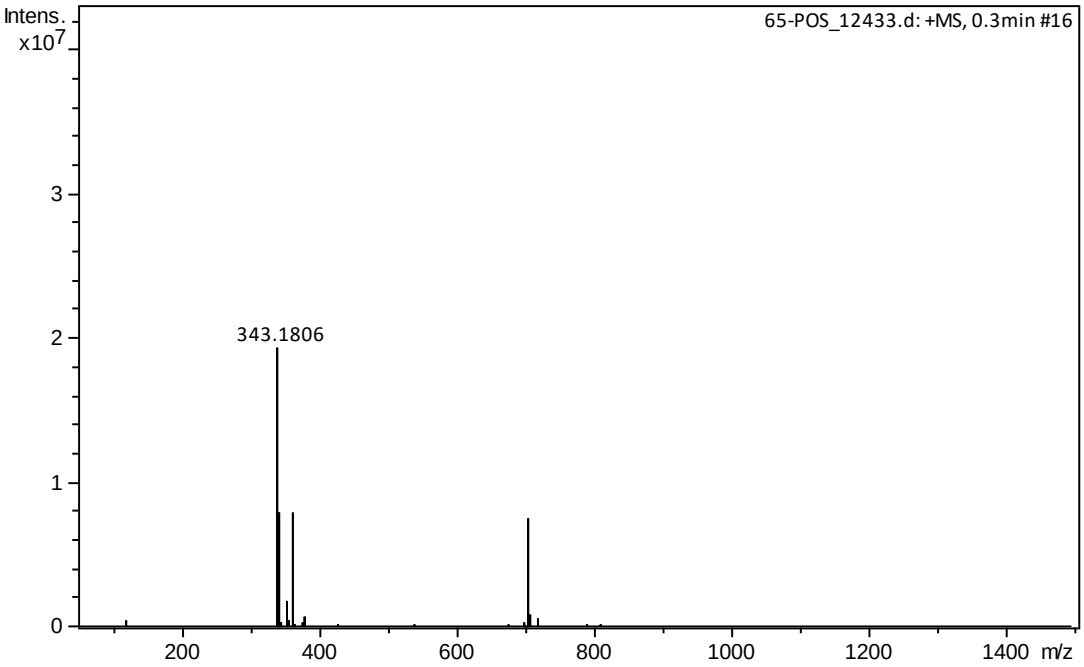
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 277.0 mg, 81% yield.

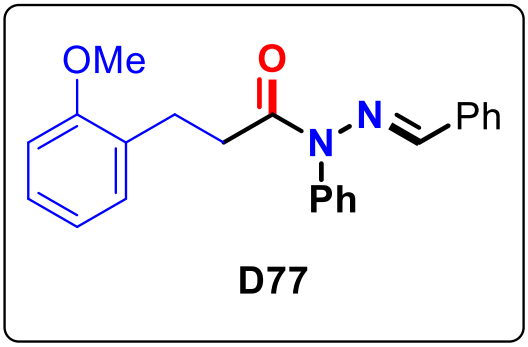
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.47 (m, 4H), 7.46 – 7.41 (m, 1H), 7.33 – 7.26 (m, 4H), 7.21 (s, 1H), 7.16 – 7.08 (m, 5H), 3.32 (s, 2H), 3.16 – 3.08 (m, 2H), 2.39 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.5, 141.8, 139.7, 136.3, 134.4, 130.4, 130.3, 130.0, 129.4, 129.2, 128.8, 127.3, 126.4, 126.2, 34.6, 28.9, 19.6 ppm.

MS (70 eV): m/z (%) = 342 $[M]^+$ (100), 196, 105, 93.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O$ [M+H]: 343.1805, found: 343.1806.





***N′*-benzylidene-3-(2-methoxyphenyl)-*N*-phenylpropanehydrazide (D77)**

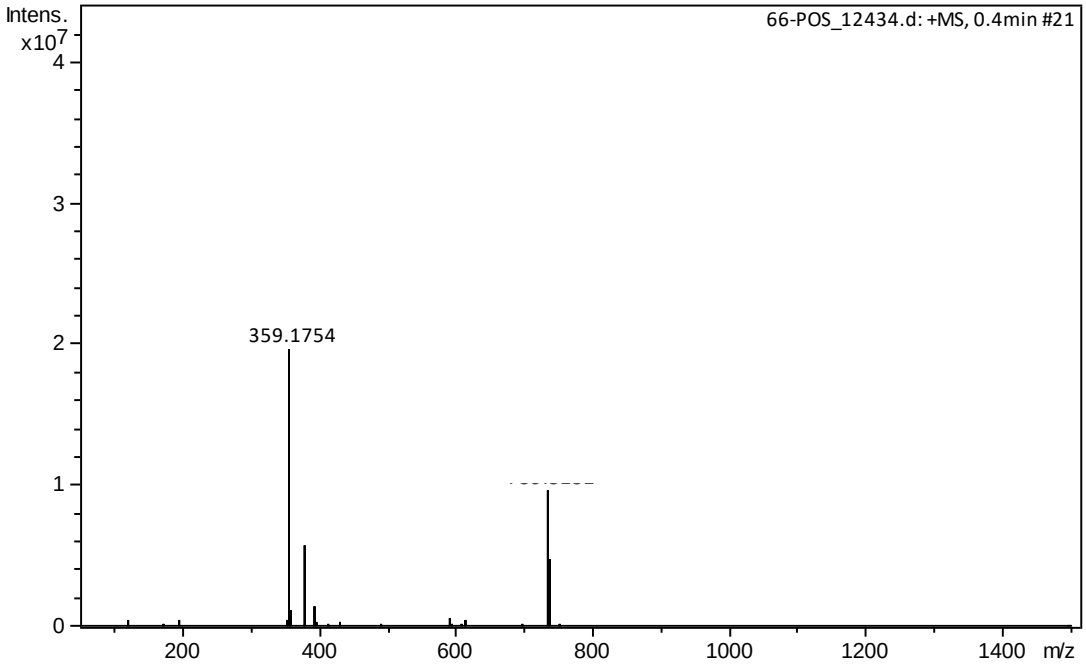
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 275.7 mg, 77% yield.

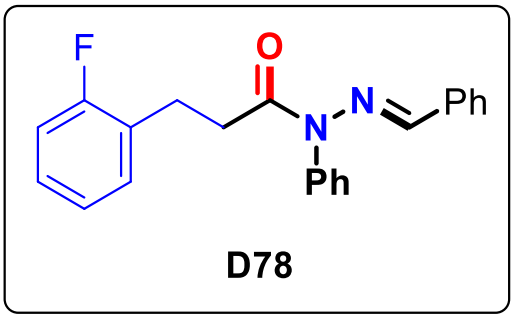
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.51 (m, 4H), 7.49 – 7.43 (m, 1H), 7.35 – 7.31 (m, 3H), 7.28 – 7.24 (m, 1H), 7.23 – 7.18 (m, 2H), 7.14 (d, *J* = 7.2 Hz, 2H), 6.91 (t, *J* = 7.6 Hz, 1H), 6.85 (d, *J* = 8.4 Hz, 1H), 3.85 (s, 3H), 3.33 (s, 2H), 3.15 – 3.10 (m, 2H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.9, 157.7, 141.2, 136.3, 134.5, 130.4, 130.2, 129.8, 129.7, 129.3, 129.2, 128.6, 127.4, 127.2, 120.4, 110.3, 55.3, 34.3, 26.5 ppm.

MS (70 eV): m/z (%) = 358 $[M]^+$ (100), 255, 196, 121.

HRMS (ESI) calcd. for $C_{23}H_{23}N_2O_2$ [M+H]: 359.1754, found: 359.1754.





***N'*-benzylidene-3-(2-fluorophenyl)-*N*-phenylpropanehydrazide (D78)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 245.7 mg, 71% yield.

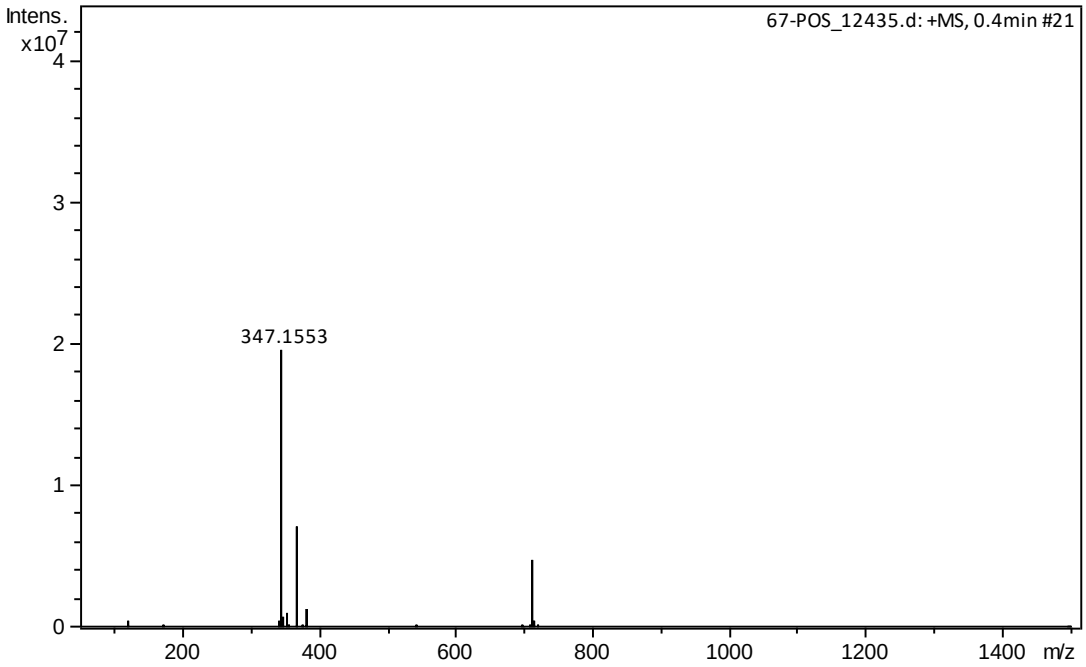
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.36 (m, 4H), 7.33 – 7.28 (m, 1H), 7.23 – 7.16 (m, 4H), 7.07 (s, 1H), 7.04 – 6.97 (m, 3H), 6.95 – 6.91 (m, 1H), 6.90 – 6.82 (m, 1H), 3.25 (s, 2H), 3.04 (t, *J* = 7.6 Hz, 2H) ppm.

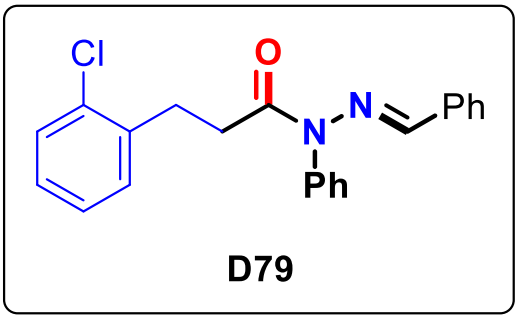
^{13}C NMR (101 MHz, $CDCl_3$) δ 174.2, 162.7, 160.3, 141.7, 136.1, 134.3, 131.2, 130.3, 130.0, 129.4, 129.3, 128.8, 128.4, 128.2, 128.0, 127.3, 124.1, 115.5, 115.2, 34.5, 25.2, 25.1 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -118.0.

MS (70 eV): m/z (%) = 346 $[M]^+$ (100), 243, 196, 109.

HRMS (ESI) calcd. for $C_{22}H_{20}FN_2O$ [M+H]: 347.1554, found: 347.1553.





***N′*-benzylidene-3-(2-chlorophenyl)-*N*-phenylpropanehydrazide (D79)**

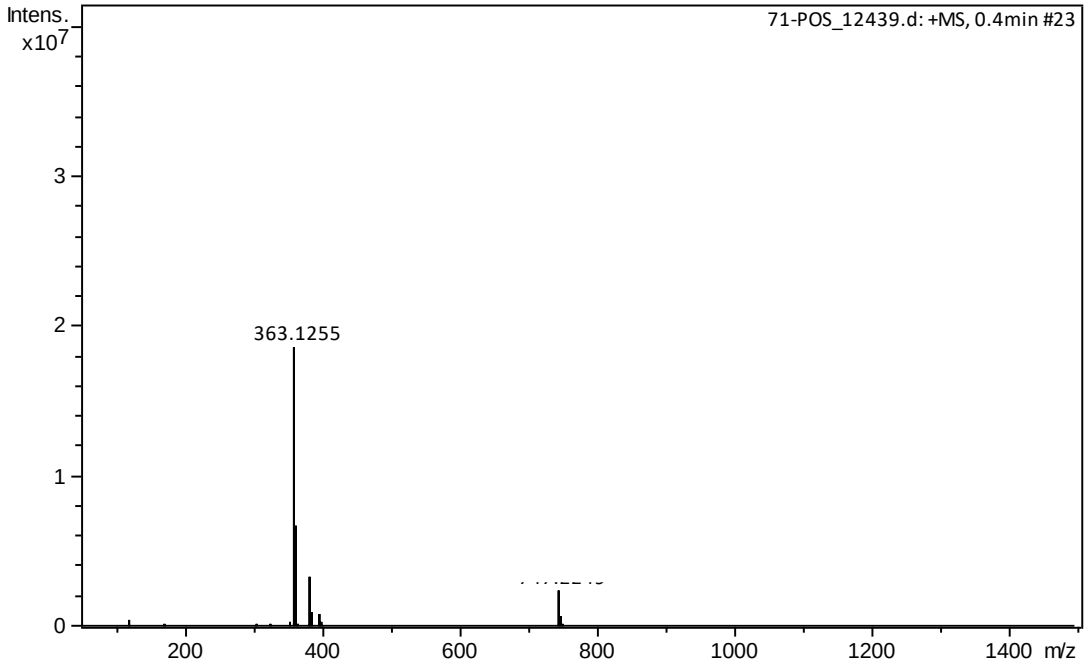
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 253.4 mg, 70% yield.

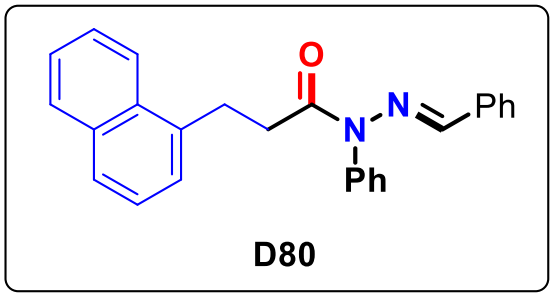
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.49 (m, 4H), 7.46 – 7.41 (m, 1H), 7.38 – 7.29 (m, 5H), 7.20 – 7.16 (m, 2H), 7.13 (d, *J* = 8.0 Hz, 3H), 3.39 (s, 2H), 3.27 – 3.21 (m, 2H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.2, 141.8, 139.1, 136.1, 134.3, 134.2, 131.0, 130.3, 130.0, 129.6, 129.4, 129.3, 128.7, 127.7, 127.3, 126.9, 33.9, 29.4 ppm.

MS (70 eV): m/z (%) = 362 $[M]^+$ (100), 224, 196, 125.

HRMS (ESI) calcd. for $C_{22}H_{20}ClN_2O$ [M+H]: 363.1259, found: 363.1255.





D80

***N′*-benzylidene-3-(naphthalen-1-yl)-*N*-phenylpropanehydrazide (D80)**

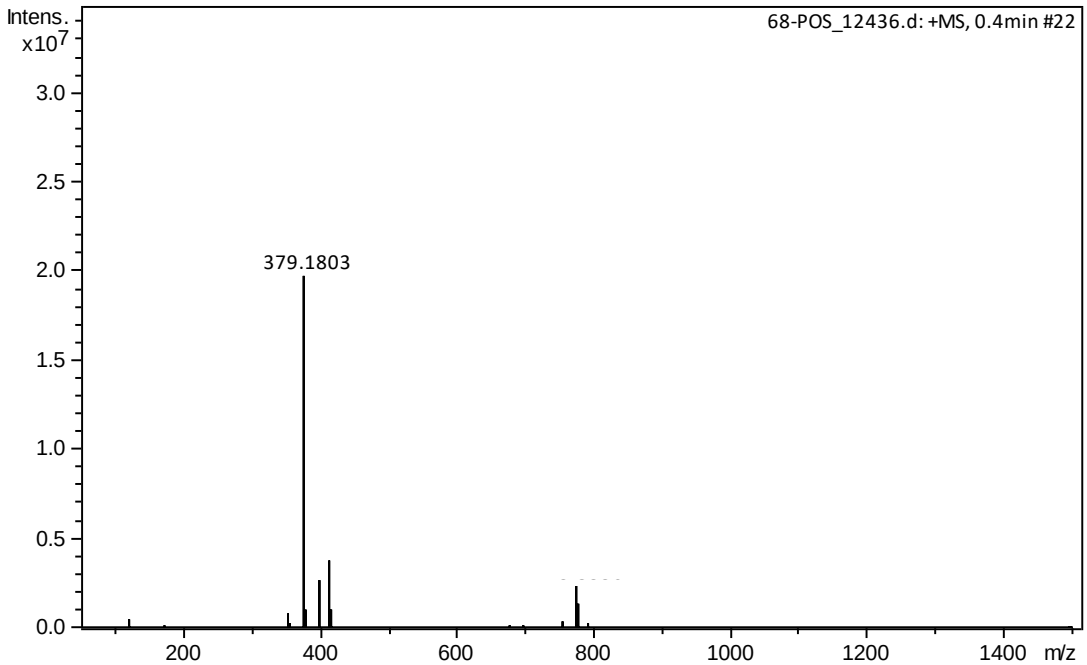
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 275.9 mg, 73% yield.

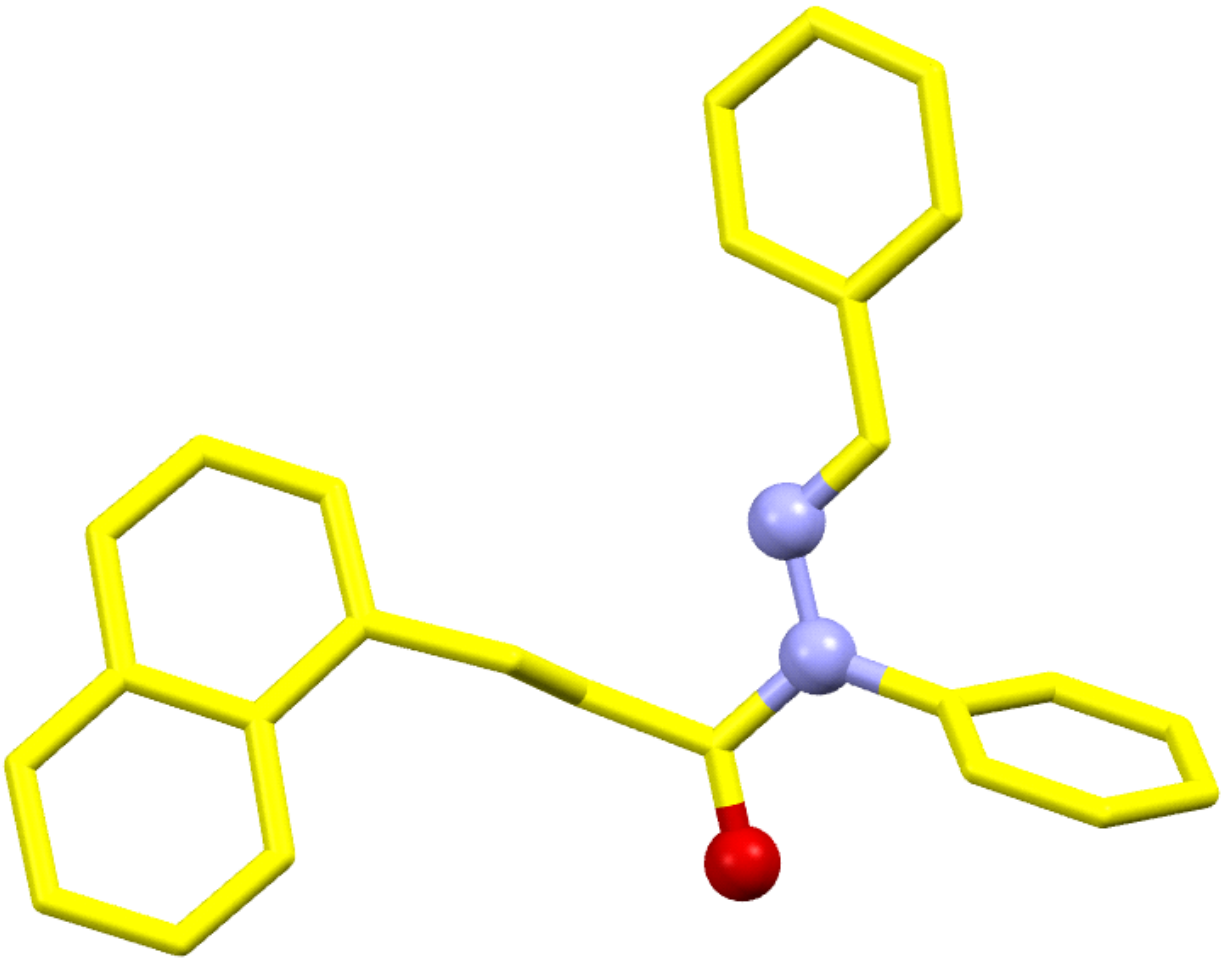
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 7.8 Hz, 1H), 7.79 (d, *J* = 8.0 Hz, 1H), 7.68 (d, *J* = 8.0 Hz, 1H), 7.52 – 7.44 (m, 5H), 7.43 – 7.35 (m, 5H), 7.25 – 7.21 (m, 3H), 7.17 (s, 1H), 7.11 (d, *J* = 7.6 Hz, 2H), 3.61 – 3.56 (m, 2H), 3.55 – 3.44 (m, 2H) ppm.

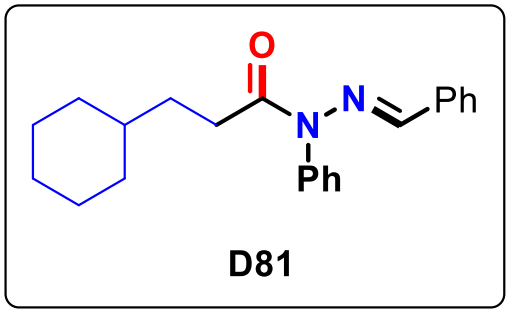
^{13}C NMR (101 MHz, $CDCl_3$) δ 174.6, 142.0, 137.7, 136.3, 134.3, 134.1, 132.1, 130.4, 130.0, 129.5, 129.4, 129.1, 128.8, 127.4, 127.2, 126.6, 126.2, 125.8, 125.7, 124.1, 35.5, 29.0 ppm.

MS (70 eV): m/z (%) = 378 $[M]^+$ (100), 251, 155, 77.

HRMS (ESI) calcd. for $C_{26}H_{23}N_2O$ [M+H]: 379.1805, found: 379.1803.







_N′_-benzylidene-3-cyclohexyl-_N_-phenylpropanehydrazide (D81)

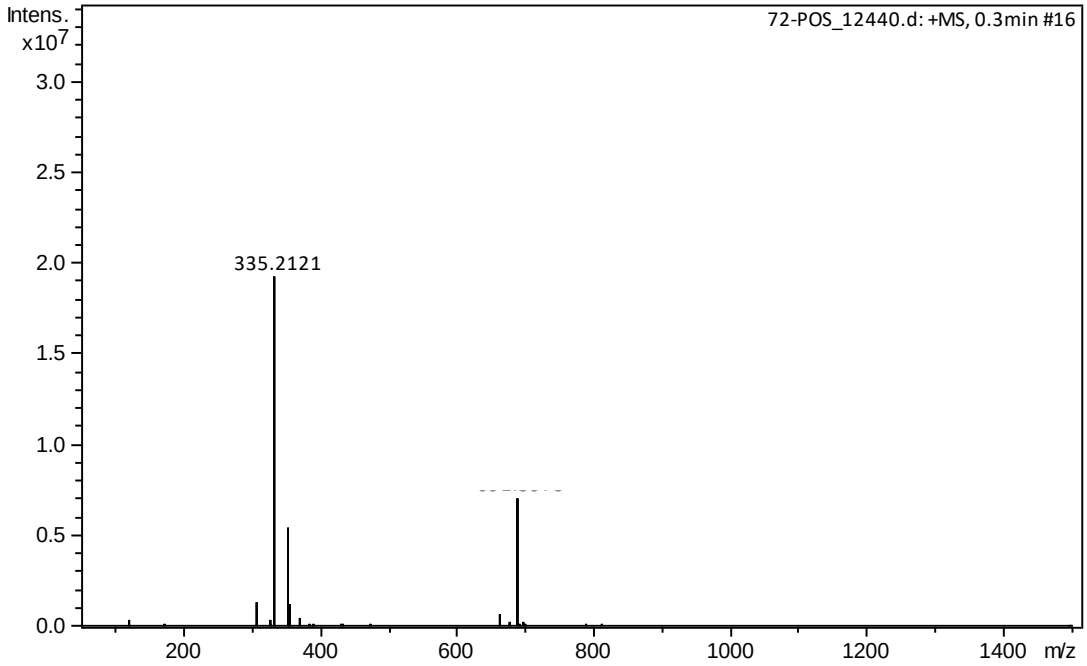
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 257.2 mg, 77% yield.

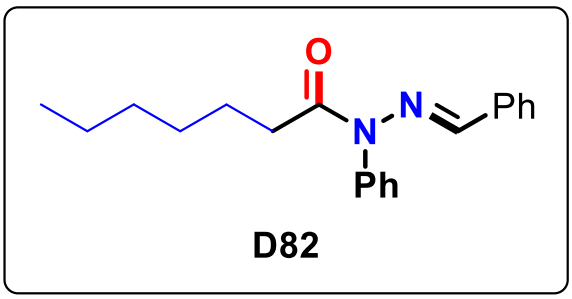
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 – 7.41 (m, 4H), 7.38 – 7.33 (m, 1H), 7.29 – 7.22 (m, 3H), 7.13 (s, 1H), 7.06 (d, *J* = 7.6 Hz, 2H), 2.94 (s, 2H), 1.74 (d, *J* = 12.8 Hz, 2H), 1.66 – 1.55 (m, 5H), 1.21 – 1.09 (m, 4H), 0.95 – 0.87 (m, 2H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 141.3, 136.3, 134.5, 130.2, 129.8, 129.3, 129.2, 128.7, 127.2, 37.7, 33.3, 32.8, 31.9, 26.7, 26.4, 25.3, 22.7, 14.2 ppm.

MS (70 eV): m/z (%) = 334 $[M]^+$ (100), 196, 93, 55.

HRMS (ESI) calcd. for $C_{22}H_{27}N_2O$ [M+H]: 335.2118, found: 335.2121.





***N′*-benzylidene-*N*-phenylheptanehydrazide (D82)**

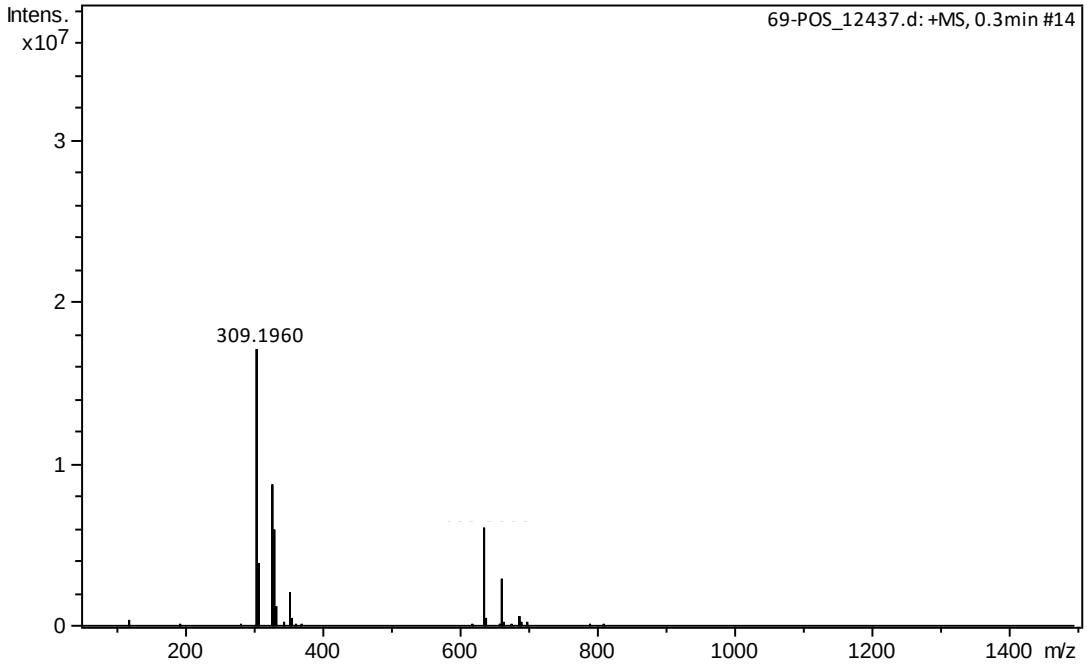
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 246.4 mg, 80% yield.

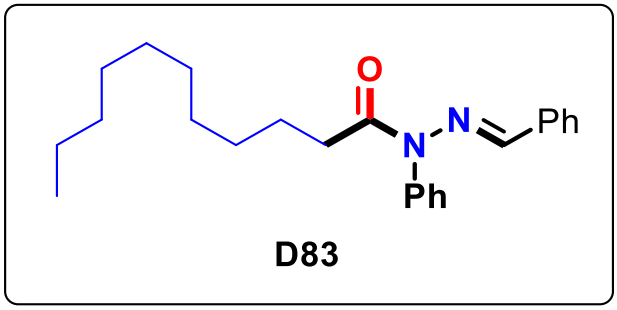
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.51 (m, 4H), 7.49 – 7.43 (m, 1H), 7.38 – 7.32 (m, 3H), 7.25 – 7.21 (m, 1H), 7.16 (d, *J* = 7.6 Hz, 2H), 3.02 (s, 2H), 1.85 – 1.79 (m, 2H), 1.78 – 1.69 (m, 1H), 1.47 – 1.23 (m, 5H), 0.91 (t, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.4, 141.2, 136.3, 134.5, 130.2, 129.8, 129.3, 129.2, 128.7, 127.1, 37.7, 34.2, 33.3, 32.8, 31.8, 29.3, 26.7, 26.4, 25.2, 22.6, 14.2 ppm.

MS (70 eV): m/z (%) = 308 $[M]^+$ (100), 196, 193, 43.

HRMS (ESI) calcd. for $C_{20}H_{25}N_2O$ [M+H]: 309.1961, found: 309.1960.





***N′*-benzylidene-*N*-phenylundecanehydrazide--methane (1/1) (D83)**

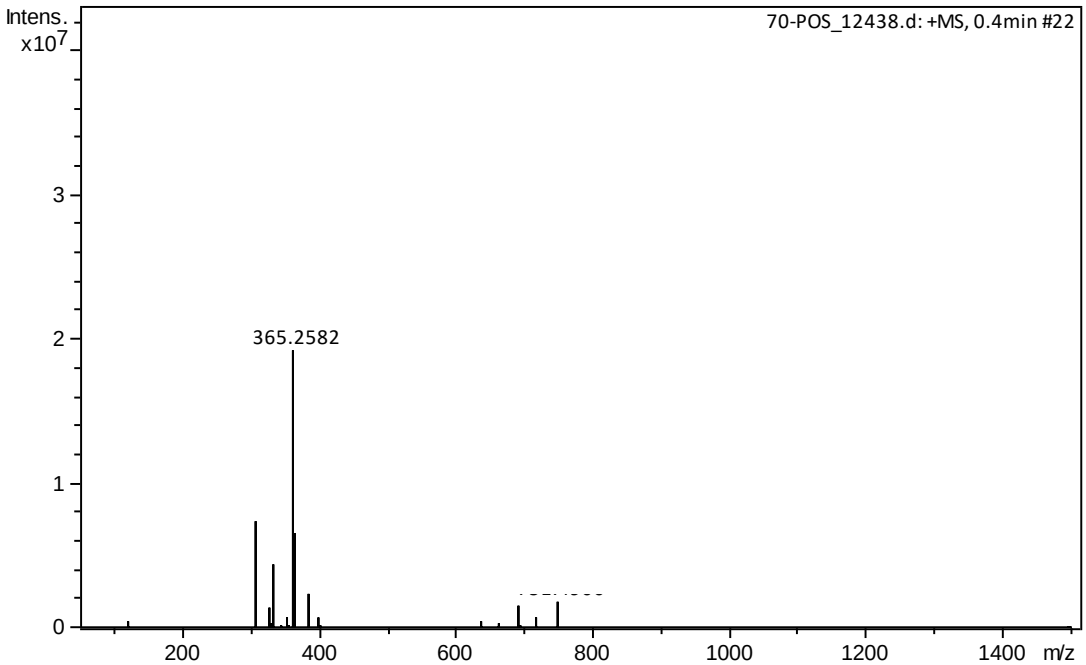
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 262.1 mg, 72% yield.

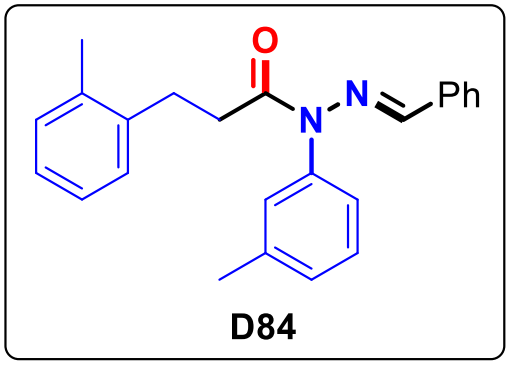
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.53 (m, 4H), 7.50 – 7.45 (m, 1H), 7.39 – 7.35 (m, 3H), 7.24 (s, 1H), 7.18 (d, *J* = 7.2 Hz, 2H), 3.04 (s, 2H), 1.87 – 1.78 (m, 2H), 1.47 – 1.26 (m, 14H), 0.89 (t, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.4, 141.2, 136.3, 134.5, 130.2, 129.8, 129.3, 129.2, 128.7, 127.1, 120.4, 119.8, 34.2, 32.0, 29.7, 29.6, 29.5, 29.4, 27.6, 25.3, 22.7, 18.1, 14.2 ppm.

MS (70 eV): m/z (%) = 364 $[M]^+$ (100), 281, 196, 93.

HRMS (ESI) calcd. for $C_{24}H_{33}N_2O$ [M+H]: 365.2587, found: 365.2582.





D84

***N′*-benzylidene-*N*-(*m*-tolyl)-3-(*o*-tolyl)propanehydrazide (D84)**

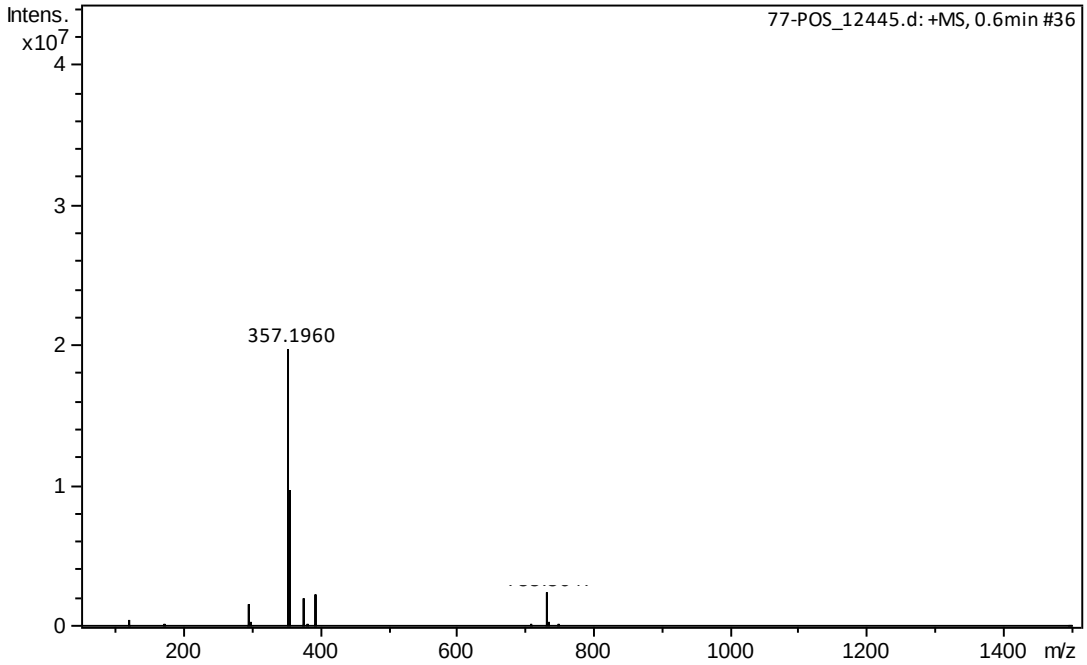
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 288.4 mg, 81% yield.

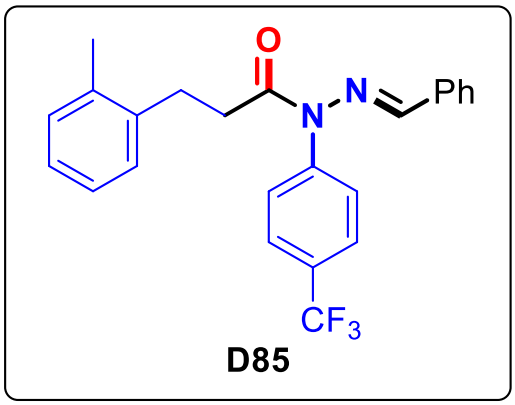
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.51 (m, 2H), 7.44 – 7.37 (m, 1H), 7.32 – 7.23 (m, 5H), 7.22 (s, 1H), 7.16 – 7.11 (m, 3H), 6.96 – 6.92 (m, 2H), 3.32 (s, 2H), 3.14 – 3.09 (m, 2H), 2.39 (s, 6H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.5, 141.8, 140.4, 139.8, 136.3, 136.1, 134.4, 130.4, 130.2, 130.1, 129.9, 129.8, 129.2, 128.8, 127.3, 126.4, 126.2, 34.6, 28.9, 21.5, 19.6 ppm.

MS (70 eV): m/z (%) = 356 $[M]^+$ (100), 210, 105, 91.

HRMS (ESI) calcd. for $C_{24}H_{25}N_2O$ [M+H]: 357.1961, found: 357.1960.





***N'*-benzylidene-3-(*o*-tolyl)-*N*-(4-(trifluoromethyl)phenyl)propanehydrazide (D85)**

The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 270.6 mg, 66% yield.

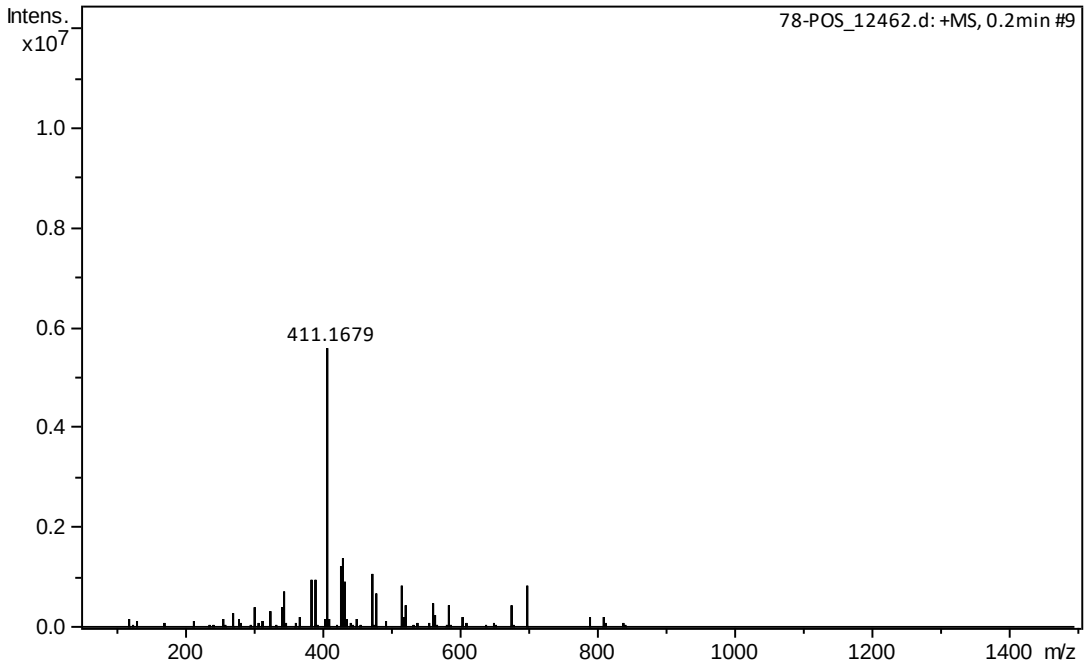
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, *J* = 8.4 Hz, 2H), 7.62 – 7.49 (m, 2H), 7.38 – 7.32 (m, 3H), 7.28 (d, *J* = 8.4 Hz, 3H), 7.20 (s, 1H), 7.17 – 7.12 (m, 3H), 3.38 – 3.23 (m, 2H), 3.21 – 3.04 (m, 2H), 2.40 (s, 3H) ppm.

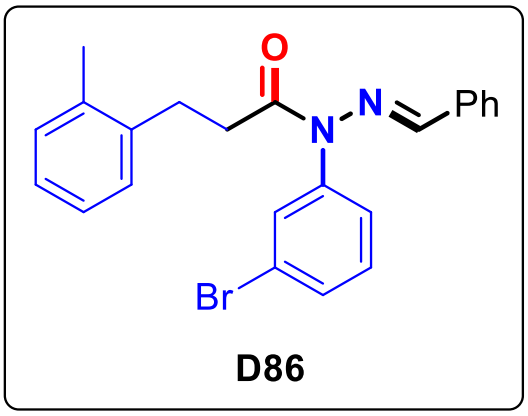
^{13}C NMR (101 MHz, $CDCl_3$) δ 174.4, 142.3, 139.6, 139.4, 136.3, 133.9, 131.5, 131.2, 130.4, 130.3, 130.0, 129.2, 128.8, 127.4, 126.4, 126.2, 125.1, 122.4, 34.4, 28.7, 19.5 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -62.6.

MS (70 eV): m/z (%) = 410 $[M]^+$ (100), 264, 161, 105.

HRMS (ESI) calcd. for $C_{24}H_{22}F_3N_2O$ [M+H]: 411.1679, found: 411.1679.





D86

***N'*-benzylidene-*N*-(3-bromophenyl)-3-(*o*-tolyl)propanehydrazide (D86)**

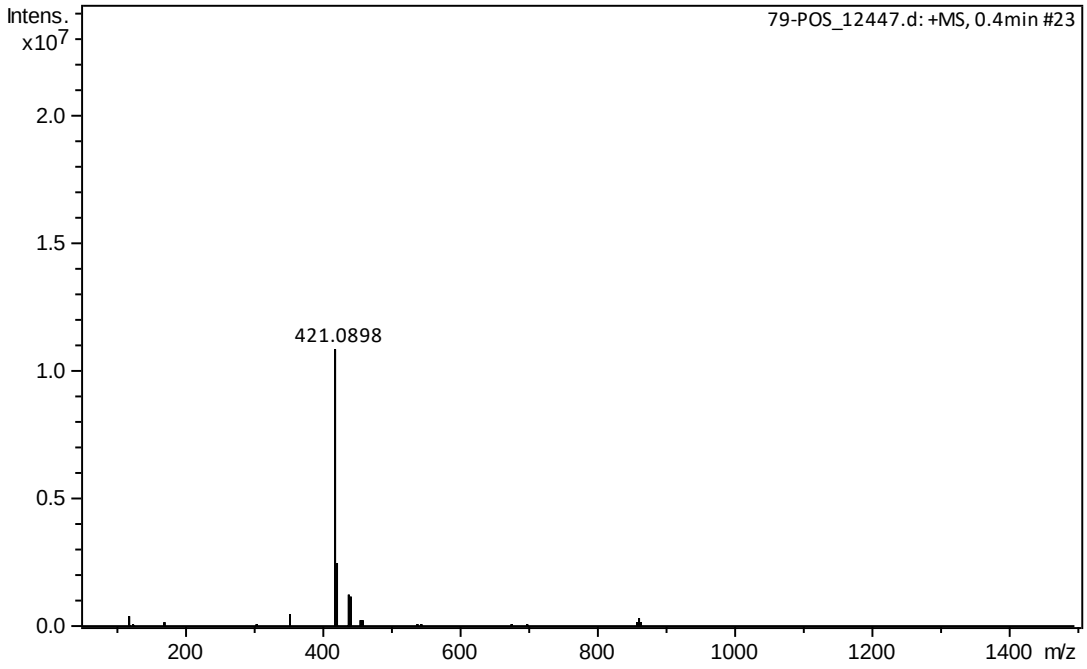
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 264.6 mg, 63% yield.

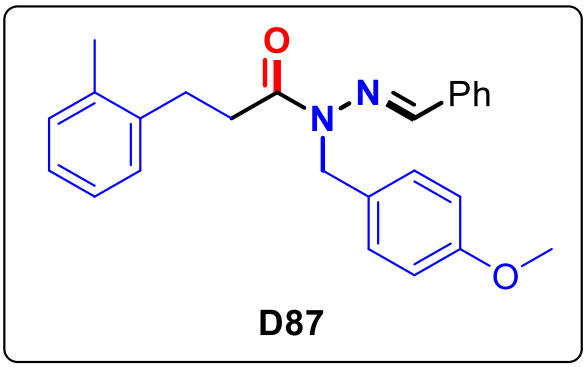
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.51 (m, 3H), 7.42 – 7.31 (m, 5H), 7.26 (d, *J* = 6.8 Hz, 1H), 7.21 (s, 1H), 7.19 – 7.11 (m, 3H), 7.09 (d, *J* = 8.0 Hz, 1H), 3.37 – 3.20 (m, 2H), 3.17 – 3.05 (m, 2H), 2.39 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.4, 142.2, 139.5, 137.6, 136.3, 134.0, 132.6, 131.5, 130.4, 130.2, 129.2, 128.8, 128.2, 127.4, 126.5, 126.2, 123.7, 34.5, 28.8, 19.6 ppm.

MS (70 eV): m/z (%) = 420 $[M]^+$ (100), 273, 105, 91.

HRMS (ESI) calcd. for $C_{23}H_{22}BrN_2O$ [M+H]: 421.0910, found: 421.0898.





***N′*-benzylidene-*N*-(4-methoxybenzyl)-3-(*o*-tolyl)propanehydrazide (D87)**

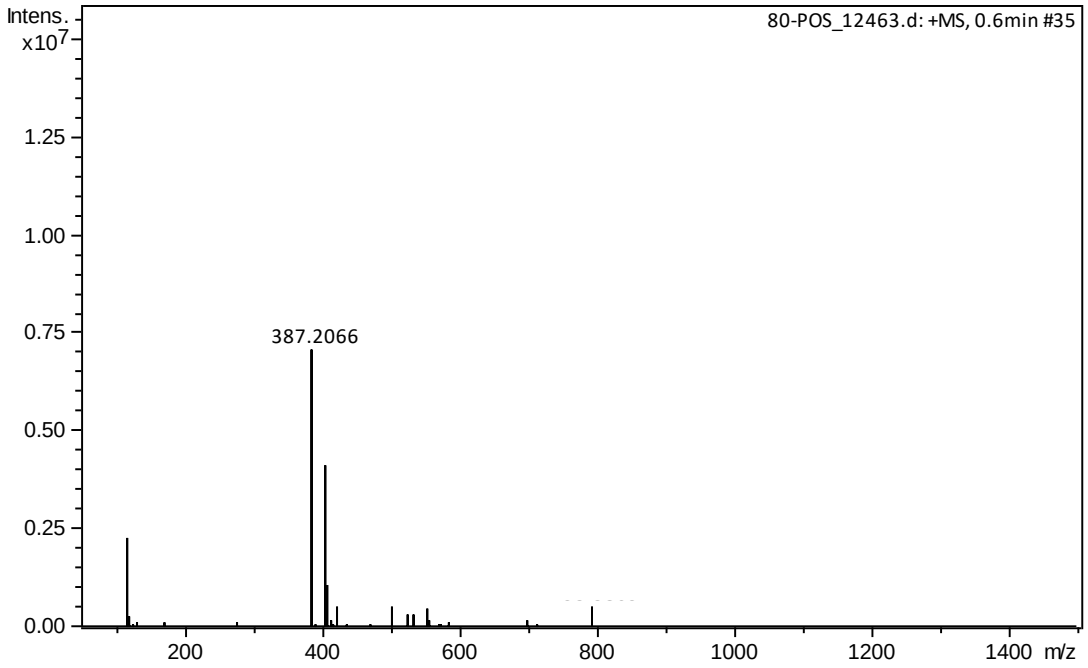
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 289.5 mg, 75% yield.

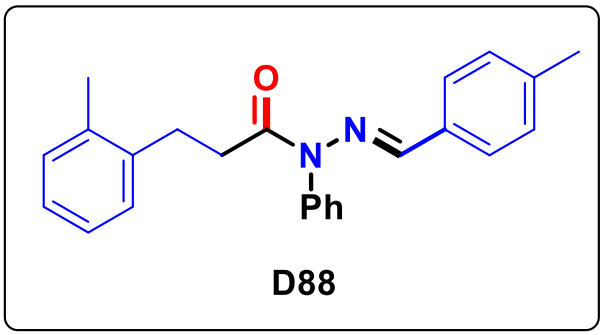
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (s, 1H), 7.56 – 7.52 (m, 2H), 7.33 – 7.29 (m, 3H), 7.28 – 7.24 (m, 1H), 7.18 – 7.13 (m, 3H), 7.08 (d, *J* = 8.8 Hz, 2H), 6.83 (d, *J* = 8.8 Hz, 2H), 5.19 (s, 2H), 3.74 (s, 3H), 3.32 – 3.25 (m, 2H), 3.14 – 3.07 (m, 2H), 2.39 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.9, 158.9, 140.0, 139.7, 136.3, 134.7, 130.3, 129.7, 129.0, 128.7, 127.8, 127.2, 127.1, 126.3, 126.2, 114.4, 55.3, 44.2, 34.1, 29.0, 19.5 ppm.

MS (70 eV): m/z (%) = 386 $[M]^+$ (100), 282, 136, 121.

HRMS (ESI) calcd. for $C_{25}H_{27}N_2O_2$ [M+H]: 387.2067, found: 387.2066.





***N'*-(4-methylbenzylidene)-*N*-phenyl-3-(*o*-tolyl)propanehydrazide (D88)**

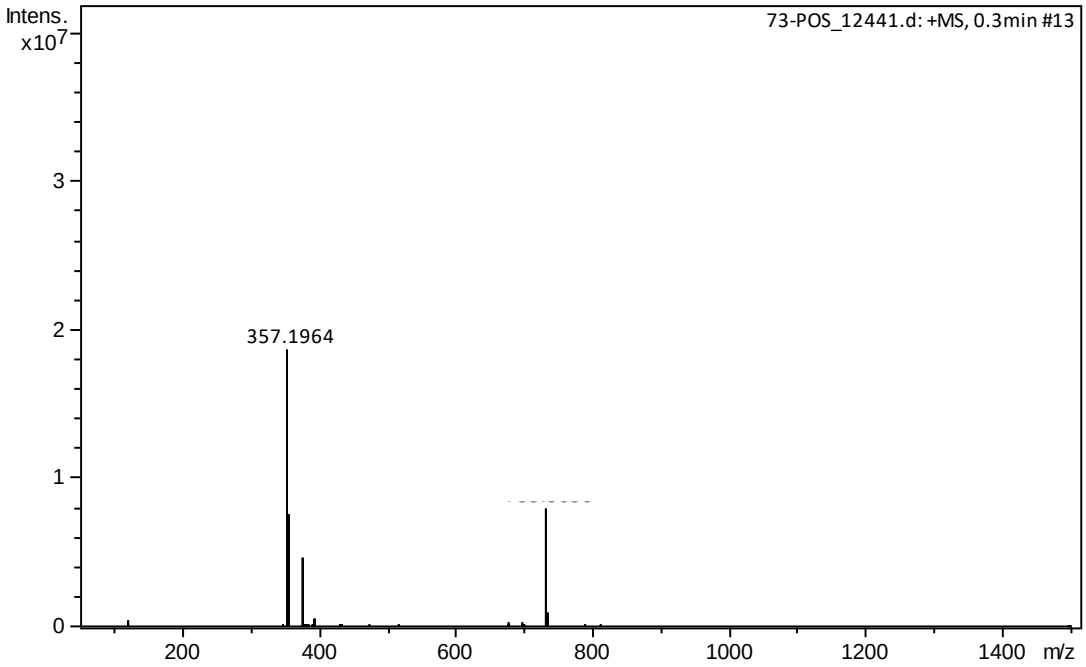
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 288.4 mg, 81% yield.

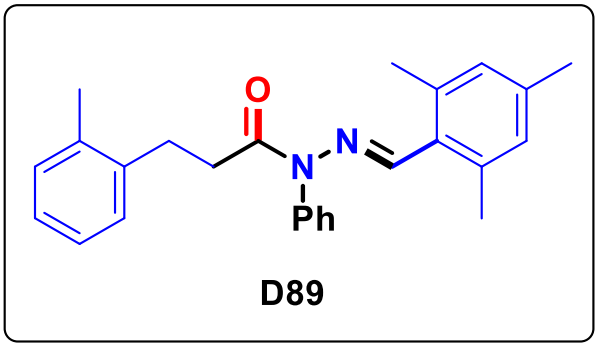
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 – 7.63 (m, 2H), 7.56 (d, *J* = 7.2 Hz, 3H), 7.45 – 7.41 (m, 1H), 7.34 (s, 1H), 7.31 – 7.23 (m, 7H), 3.46 (s, 2H), 3.29 – 3.25 (m, 2H), 2.54 (s, 3H), 2.46 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.5, 142.0, 140.2, 139.8, 136.3, 131.7, 130.4, 130.3, 129.5, 129.4, 129.3, 129.2, 127.3, 126.4, 126.2, 34.6, 29.0, 21.6, 19.6 ppm.

MS (70 eV): m/z (%) = 356 $[M]^+$ (100), 210, 105, 93.

HRMS (ESI) calcd. for $C_{24}H_{25}N_2O$ [M+H]: 357.1961, found: 357.1964.





***N*-phenyl-3-(*o*-tolyl)-*N'*-(2,4,6-trimethylbenzylidene)propanehydrazide (D89)**

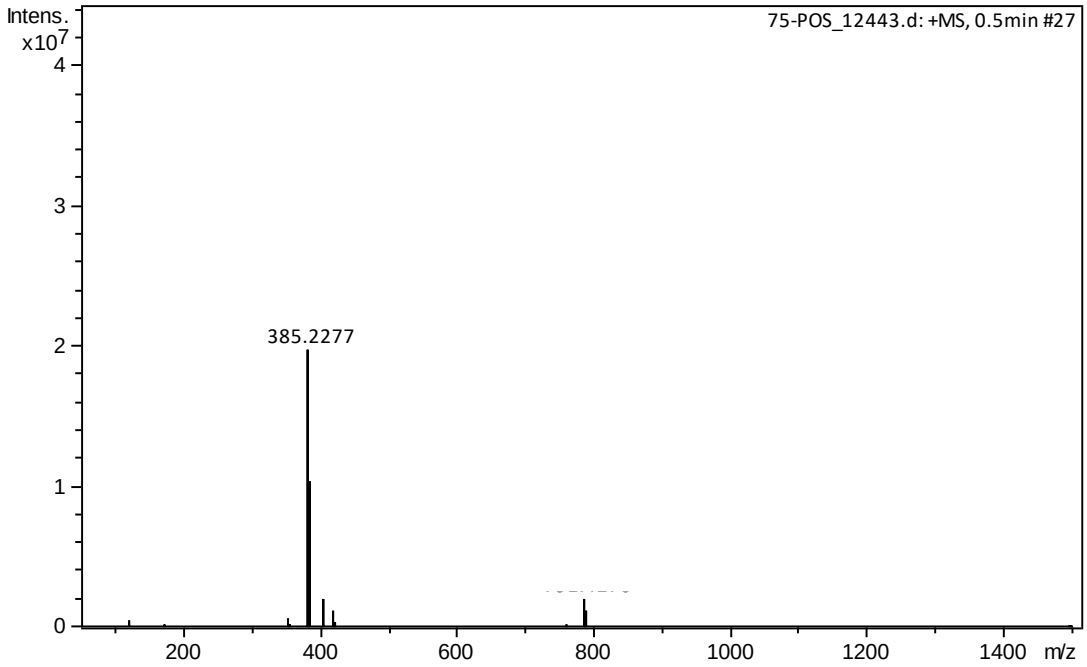
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 203.5 mg, 53% yield.

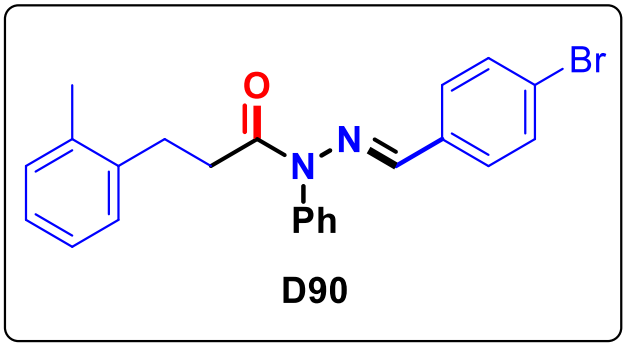
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 – 7.50 (m, 3H), 7.45 – 7.40 (m, 1H), 7.23 (d, *J* = 6.4 Hz, 1H), 7.17 (d, *J* = 7.2 Hz, 2H), 7.14 – 7.08 (m, 3H), 6.81 (s, 2H), 3.25 (s, 2H), 3.13 – 3.05 (m, 2H), 2.33 (s, 3H), 2.23 (s, 9H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.5, 142.5, 139.7, 138.8, 137.4, 136.4, 136.3, 130.3, 129.7, 129.4, 129.3, 128.8, 128.4, 126.2, 126.1, 34.3, 28.5, 21.3, 21.2, 19.5 ppm.

MS (70 eV): m/z (%) = 384 $[M]^+$ (100), 238, 222, 146.

HRMS (ESI) calcd. for $C_{26}H_{29}N_2O$ [M+H]: 385.2274, found: 385.2277.





D90

***N'*-(4-bromobenzylidene)-*N*-phenyl-3-(*o*-tolyl)propanehydrazide (D90)**

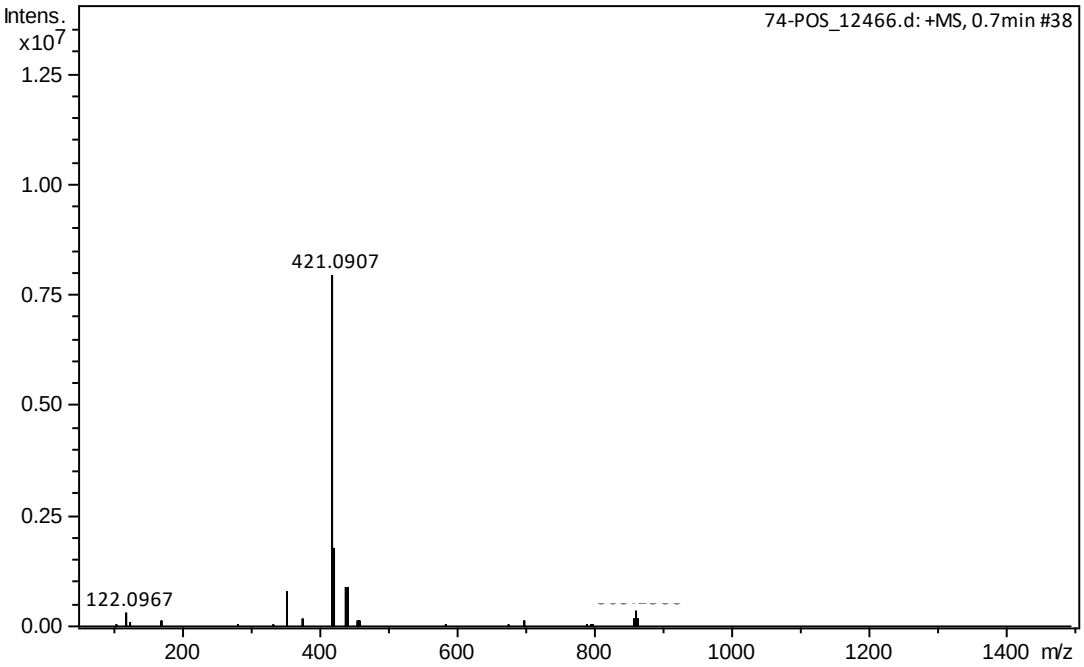
The title compound was prepared according to the general procedure and purified by column chromatography to give a white solid, 298.2 mg, 71% yield.

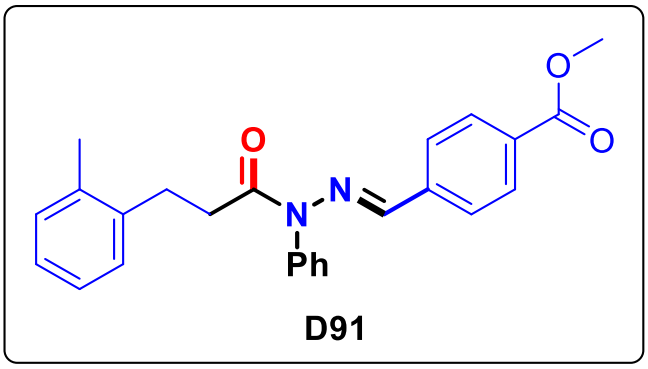
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (t, *J* = 7.6 Hz, 2H), 7.46 – 7.40 (m, 3H), 7.37 – 7.33 (m, 2H), 7.25 (d, *J* = 6.8 Hz, 1H), 7.22 – 7.04 (m, 6H), 3.30 (s, 2H), 3.15 – 3.05 (m, 2H), 2.38 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.5, 140.4, 139.6, 136.3, 136.1, 133.3, 132.0, 130.4, 129.5, 129.3, 129.2, 128.7, 126.5, 126.2, 124.1, 34.5, 28.9, 19.6 ppm.

MS (70 eV): m/z (%) = 420 $[M]^+$ (100), 273, 105, 91.

HRMS (ESI) calcd. for $C_{23}H_{22}BrN_2O$ [M+H]: 421.0910, found: 421.0907.





methyl-4-((2-phenyl-2-(3-(*o*-tolyl)propanoyl)hydrazineylidene)methyl)benzoate (D91)

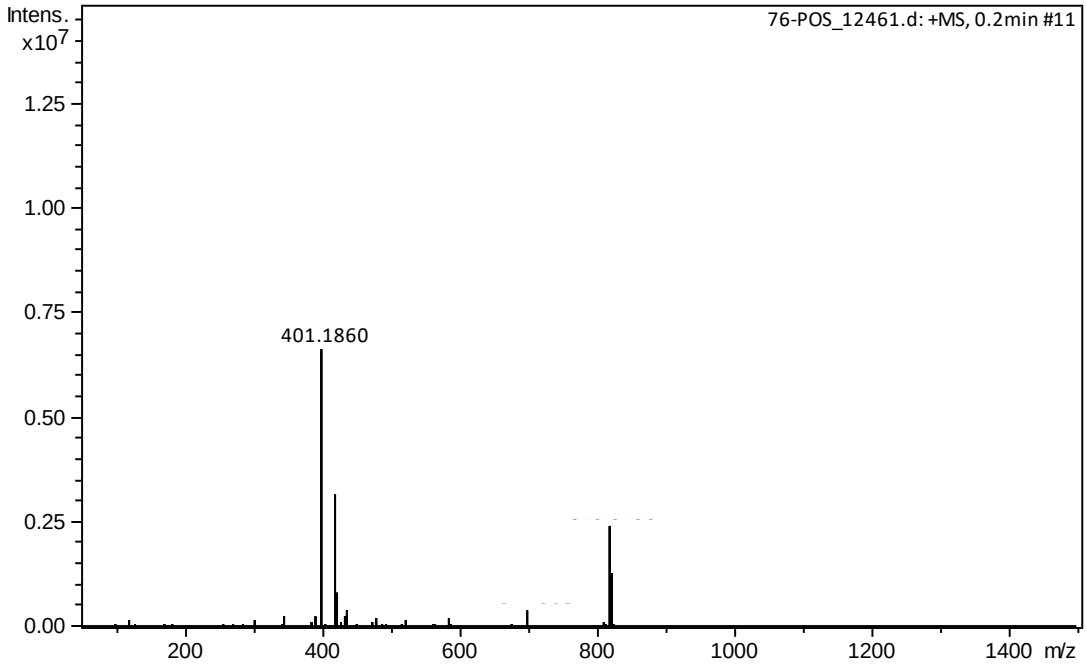
The title compound was prepared according to the general procedure and purified by column chromatography to give the colorless oil, 332.0 mg, 83% yield.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 8.4 Hz, 2H), 7.62 – 7.49 (m, 4H), 7.47 – 7.43 (m, 1H), 7.27 (d, *J* = 6.8 Hz, 1H), 7.23 (s, 1H), 7.16 – 7.10 (m, 5H), 3.86 (s, 3H), 3.33 (s, 2H), 3.18 – 3.04 (m, 2H), 2.39 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.6, 166.6, 140.3, 139.5, 138.5, 136.2, 136.0, 131.0, 130.4, 130.0, 129.6, 129.2, 127.1, 126.4, 126.2, 52.3, 34.5, 28.9, 19.5 ppm.

MS (70 eV): m/z (%) = 400 $[M]^+$ (100), 207, 193, 44.

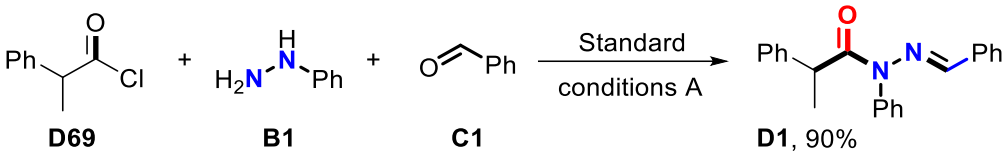
HRMS (ESI) calcd. for $C_{25}H_{25}N_2O_3$ [M+H]: 401.1859 found: 401.1860.



5. Mechanism investigations

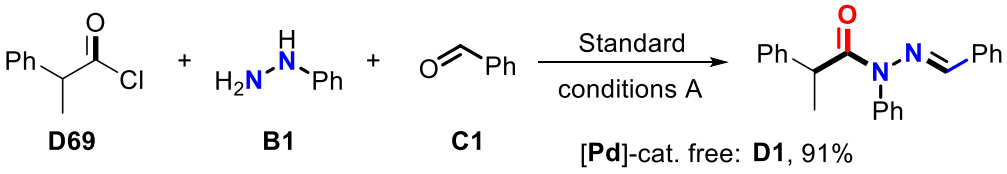
5.1 Control experiments for branched acylhydrazones

5.1.1 Control experiments with D69



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D69** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 90% yield.

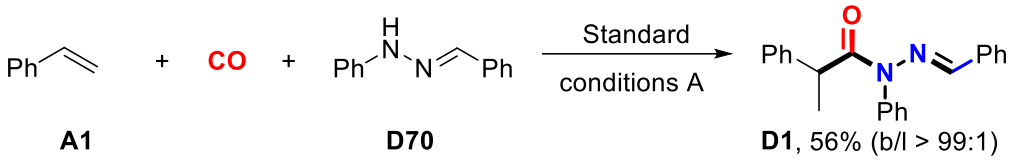
5.1.2 Control experiments with D69 in the absence of [Pd]



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D69** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), and DCM (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography

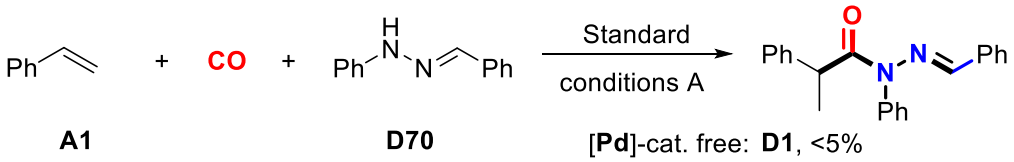
(petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 91% yield.

5.1.3 Control experiments with D70



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **D70** (1.0 mmol), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 56% yield.

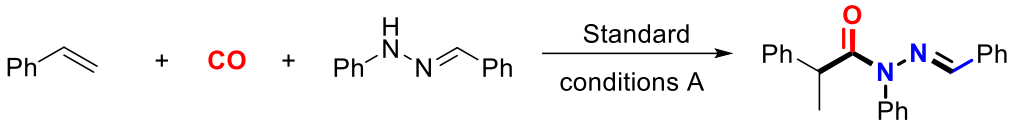
5.1.4 Control experiments with D70 in the absence of [Pd]



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **D70** (1.0 mmol) , and DCM (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction

was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in <5% yield and **D70** was recovered in 97% yield.

5.1.5 Control experiments with D70 and D92 in the presence of H_2O

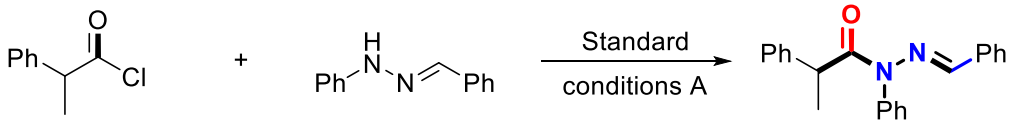


A1 **D70**

with H_2O (1 equiv): **D1**, 91% (b/l > 99:1)

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **D70** (1.0 mmol), H_2O (1.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 91% yield.

5.1.6 Control experiments with D70 and D69 in the absence of [Pd]



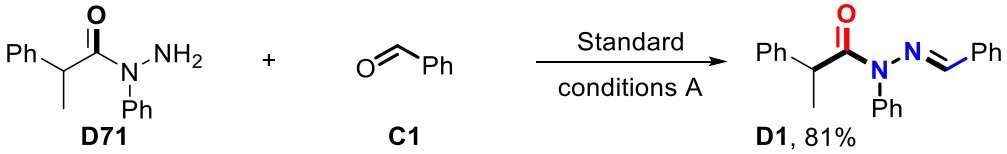
D69 **D70**

[**Pd**]-cat. free: **D1**, 92%

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D69** (1.4 mmol), **D70** (1.0 mmol), and DCM (2.0

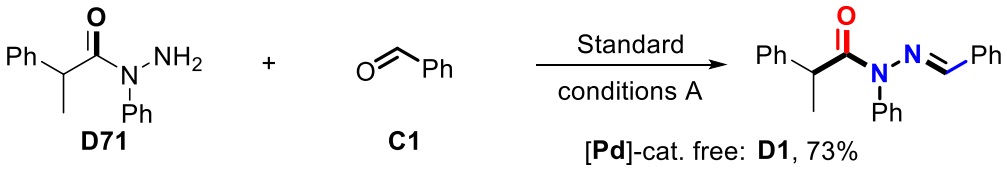
mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 92% yield.

5.1.7 Control experiments with D71



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **C1** (1.5 mmol), **D71** (1.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 81% yield.

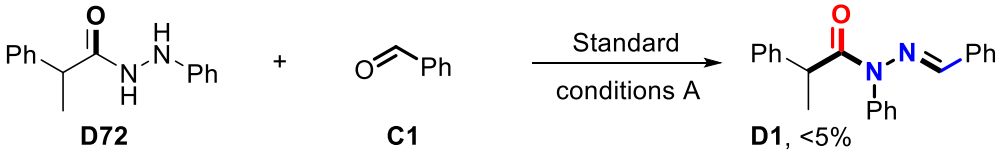
5.1.8 Control experiments with D71 in the absence of [Pd]



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **C1** (1.5 mmol), **D71** (1.0 mmol), and DCM (2.0

mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 73% yield.

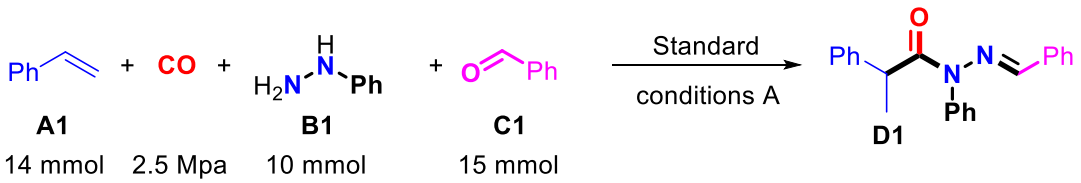
5.1.9 Control experiments with D72



D72 **C1** **D1**, <5%

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **C1** (1.5 mmol), **D72** (1.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in <5% yield and **D72** was recovered in 95% yield.

5.2 Time conversion plot experiments for branched acylhydrazones



Using a nitrogen-filled glove box, an oven-dried pressure tube (50.0 mL) was charged with a magnetic stirring bar, **A1** (14.0 mmol), **B1** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 0 – 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1**.

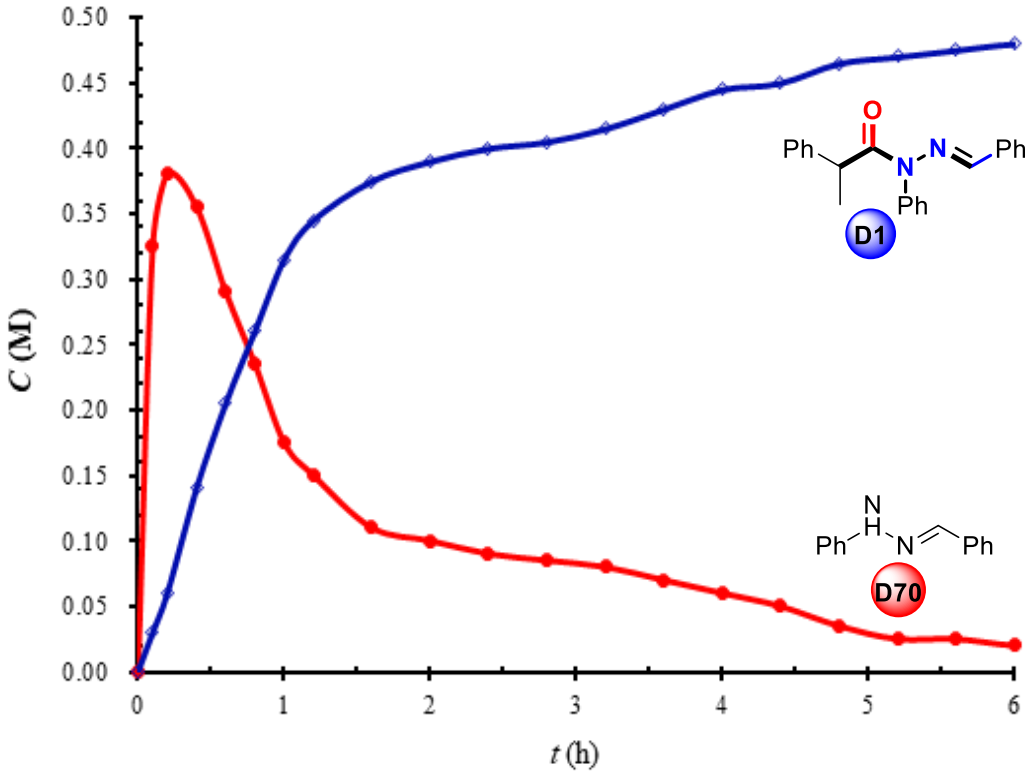


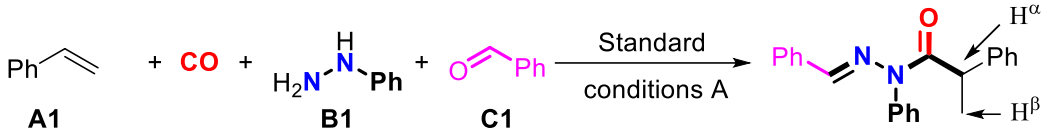
Table S21 Time conversion plot experiments

Entry	Time/h	**D70** (M)	**D1** (M)
1	0	0	0
2	0.1	0.325	0.03
3	0.2	0.38	0.06
4	0.4	0.355	0.14
5	0.6	0.29	0.205
6	0.8	0.235	0.26
7	1	0.175	0.315
8	1.2	0.15	0.345
9	1.6	0.11	0.375
10	2	0.1	0.39
11	2.4	0.09	0.4
12	2.8	0.085	0.405
13	3.2	0.08	0.415
14	3.6	0.07	0.43
15	4	0.06	0.445
16	4.4	0.05	0.45
17	4.8	0.035	0.465
18	5.2	0.025	0.47
19	5.6	0.025	0.475
20	6	0.02	0.48

Reaction conditions A: **A1** (14 mmol), **B** (10 mmol), **C1** (15 mmol), $PdCl_2[P(3,5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), DCM (20 mL), CO (2.5 MPa), 120 ºC, 0 – 6 h.

5.3 Labelled investigations for branched acylhydrazones

5.3.1 Labelled investigations with CCl_2D_2

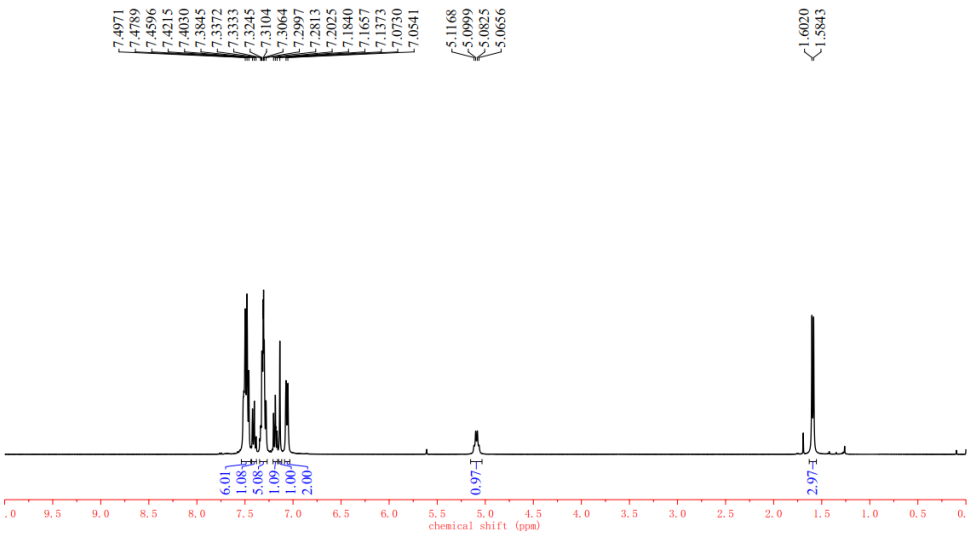


with CCl_2D_2 as solvent: **D73-*d*** : 83% (b/l > 99:1)

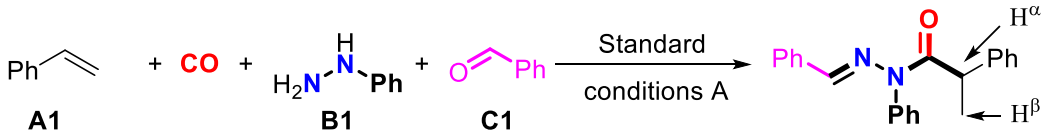
H^{α}: 3% D H^{β}: 1% D

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and CCl_2D_2 (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D73-*d*** in 83% yield.

$$H^{\alpha} = \frac{1-0.97}{1} \times 100\% = 3\% \qquad H^{\beta} = \frac{3-2.97}{3} \times 100\% = 1\%$$



5.3.2 Labelled investigations with D_2O

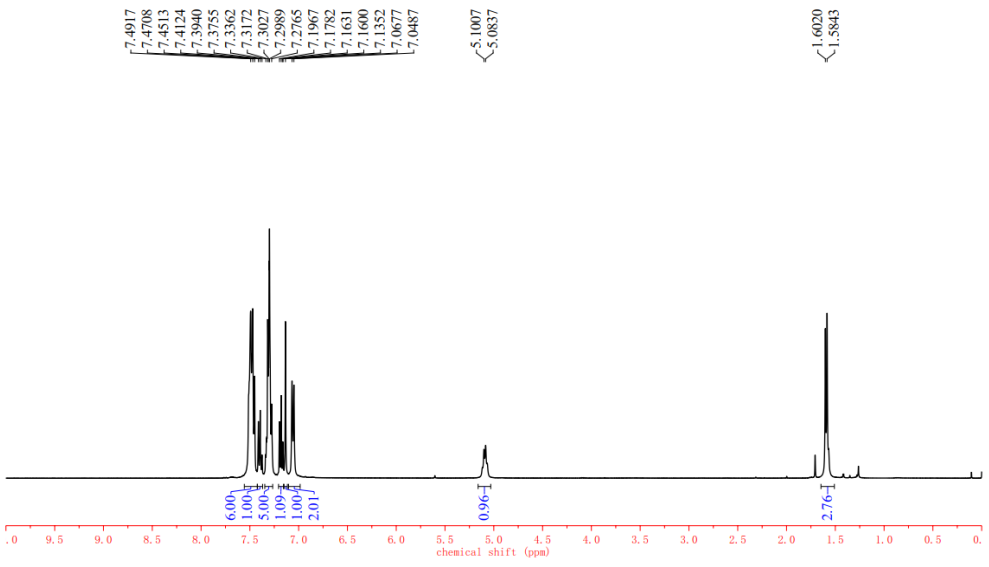


with D_2O (1 equiv): **D73-*d*** : 86% (b/l > 99:1)

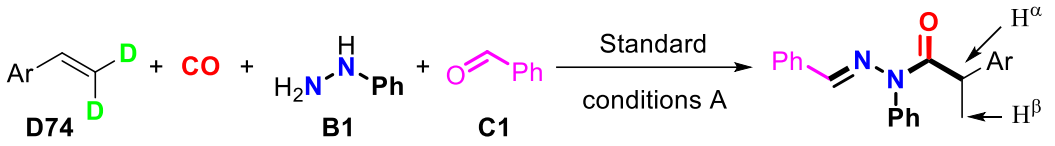
H^{α}: 4% **D** H^{β}: 8% **D**

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), D_2O (1.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 °C) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D73-*d*** in 86% yield.

$$H^{\alpha} = \frac{1-0.96}{1} \times 100\% = 4\% \qquad H^{\beta} = \frac{3-2.76}{3} \times 100\% = 8\%$$



5.3.3 Labelled investigations with D74



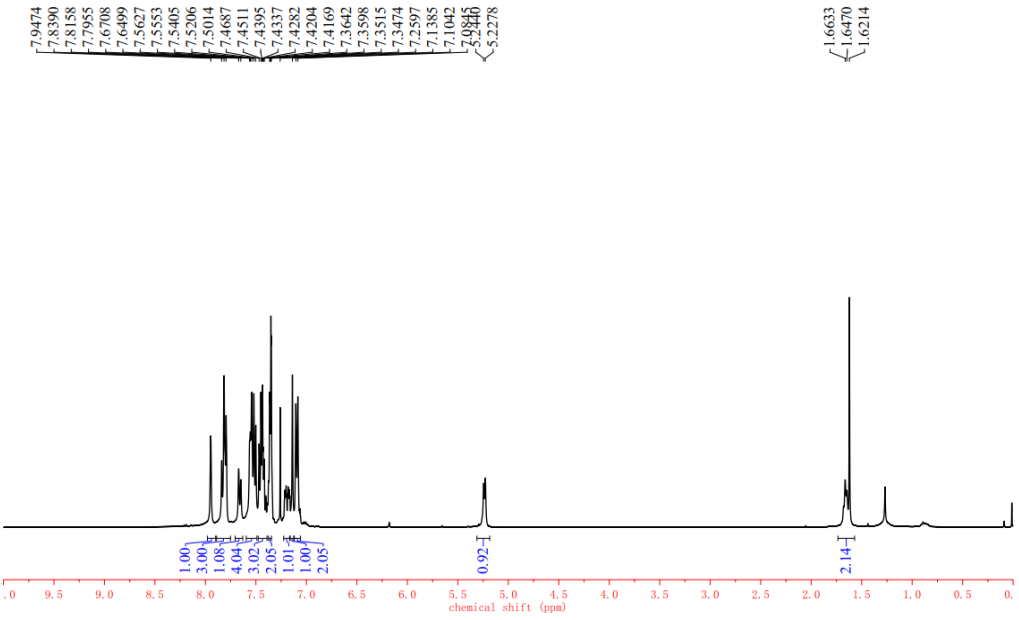
Ar = 2-naphthyl

D20-*d* : 81% (b/l > 99:1)

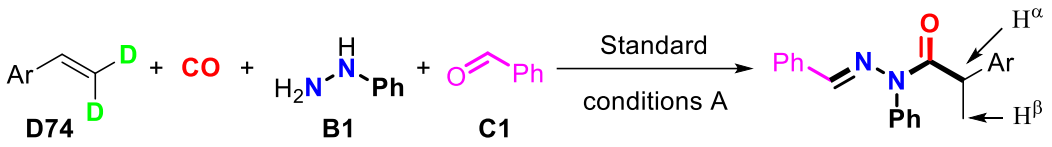
H^{α}: 8% **D** H^{β}: 28% **D**

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D74** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D20-*d*** in 81% yield.

$$H^{\alpha} = \frac{1-0.92}{1} \times 100\% = 8\% \qquad H^{\beta} = \frac{3-2.14}{3} \times 100\% = 28\%$$



5.3.4 Labelled investigations with D74 in the presence of D_2O



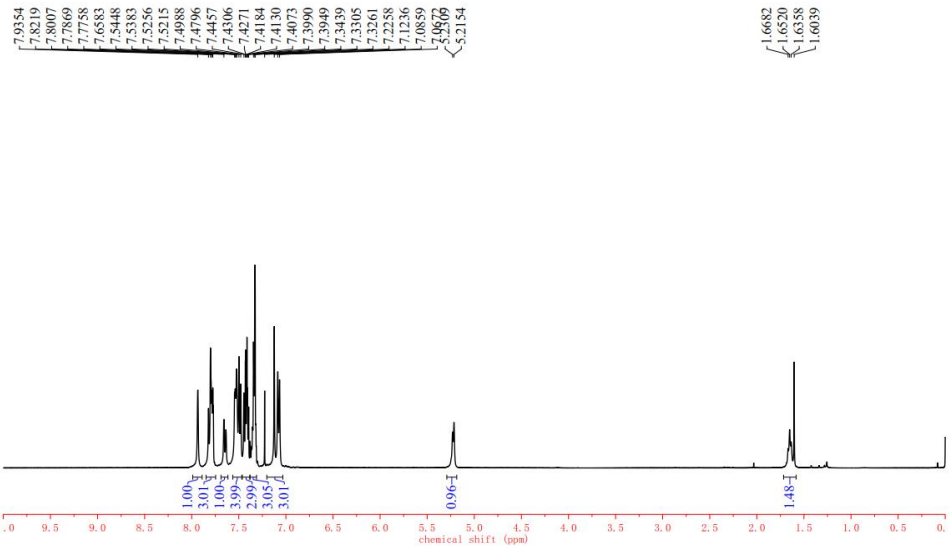
Ar = 2-naphthyl

with D_2O (1 equiv): **D20-*d*** : 82% (b/l > 99:1)

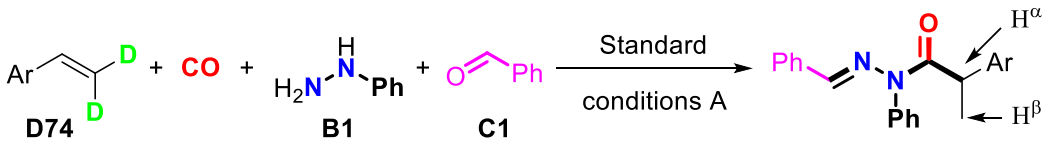
H^{α}: 4% **D** H^{β}: 51% **D**

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D74** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), D_2O (1.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and DCM (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 °C) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D20-*d*** in 82% yield.

$$H^{\alpha} = \frac{1-0.96}{1} \times 100\% = 4\% \qquad H^{\beta} = \frac{3-1.48}{3} \times 100\% = 51\%$$



5.3.5 Labelled investigations with D74 in the presence of CCl_2D_2



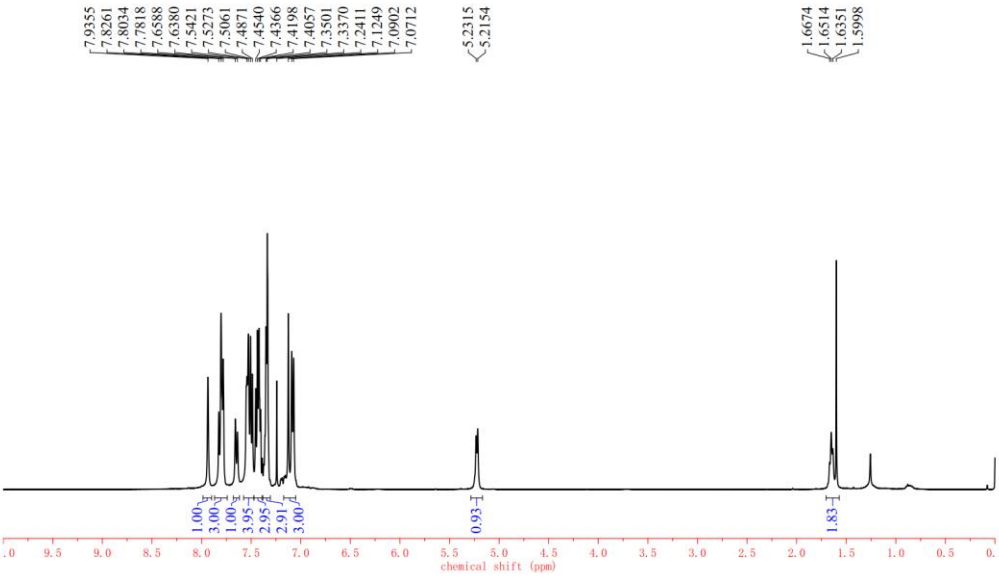
Ar = 2-naphthyl

with CCl_2D_2 as solvent: **D20-*d*** : 80% (b/l > 99:1)

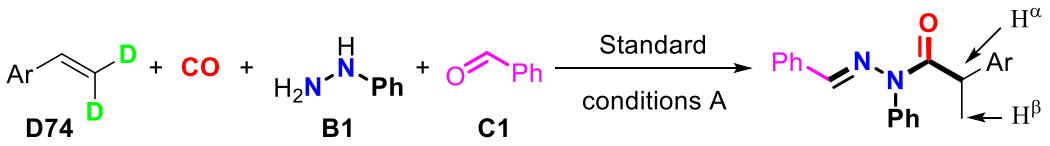
H^{α}: 7% D H^{β}: 39% D

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D74** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and CCl_2D_2 (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D20-*d*** in 80% yield.

$$H^{\alpha} = \frac{1-0.93}{1} \times 100\% = 7\% \qquad H^{\beta} = \frac{3-1.83}{3} \times 100\% = 39\%$$



5.3.6 Labelled investigations with D74 in the presence of D_2O and CCl_2D_2

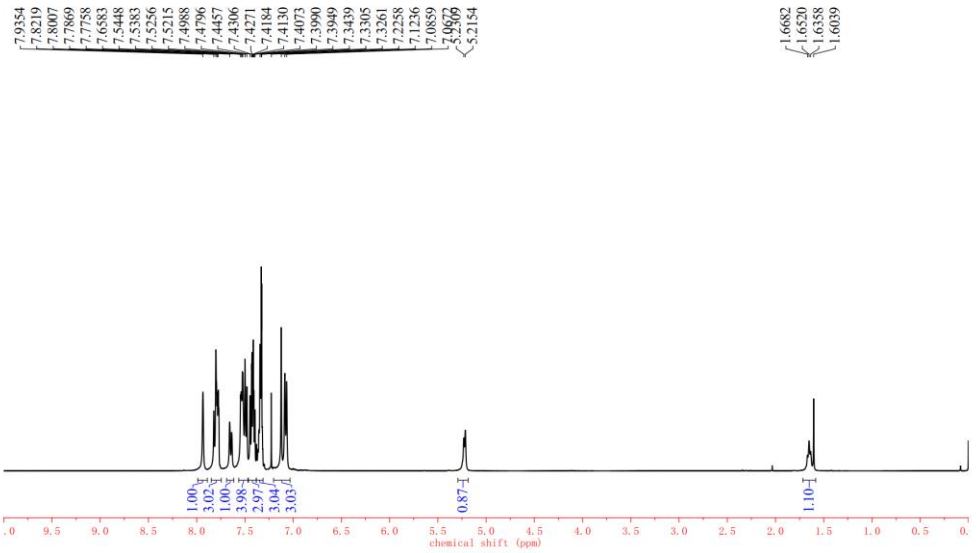


Ar = 2-naphthyl *with* D_2O (1 equiv) and CCl_2D_2 as solvent: **D20-*d*** : 80% (b/l > 99:1)

H^{α}: 13% D H^{β}: 63% D

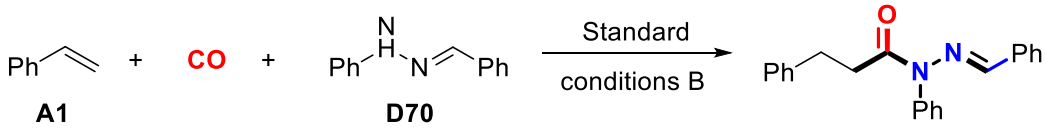
Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D74** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), D_2O (1.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.02 mmol, 2 mol%), and CCl_2D_2 (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 °C) for 6 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D20-*d*** in 80% yield.

$$H^{\alpha} = \frac{1-0.87}{1} \times 100\% = 13\% \qquad H^{\beta} = \frac{3-1.10}{3} \times 100\% = 63\%$$



5.4 Control experiments for branched acylhydrazones

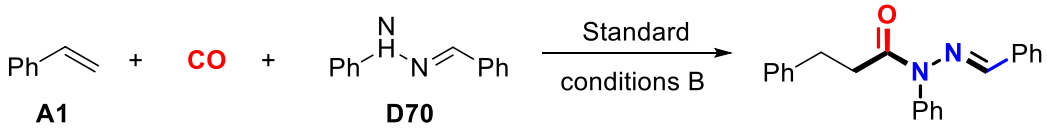
5.4.1 Control experiments with D70



D75, 52% (l/b = 90:10)

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **D70** (1.0 mmol), $PdCl_2$(Xantphos) (0.02 mmol, 2 mol%), and anisole (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 ℃) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75** in 52% yield.

5.4.2 Control experiments with D70 in the presence of H_2O

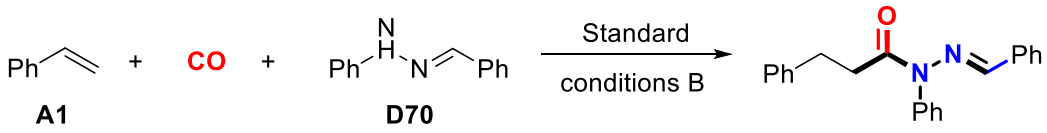


with H_2O (1 equiv): **D75**, 83% (l/b = 89:19)

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **D70** (1.0 mmol), H_2O (1.0 mmol), $PdCl_2$(Xantphos) (0.02 mmol, 2 mol%), and anisole (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 ℃) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot

of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75** in 83% yield.

5.4.3 Control experiments with D70 in the absence of [Pd]

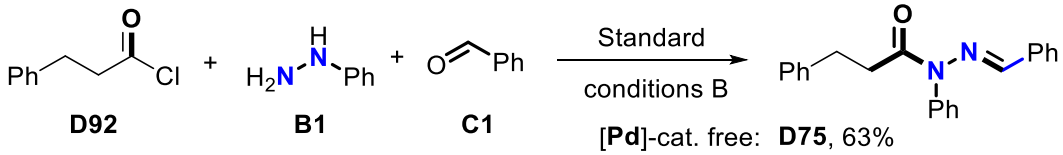


A1 **D70**

[**Pd**]-cat. free: **D75**, 0%

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **D70** (1.0 mmol), and anisole (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 ℃) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75** in 0% yield and **D70** was recovered in 97% yield.

5.4.4 Control experiments with D92 in the absence of [Pd]



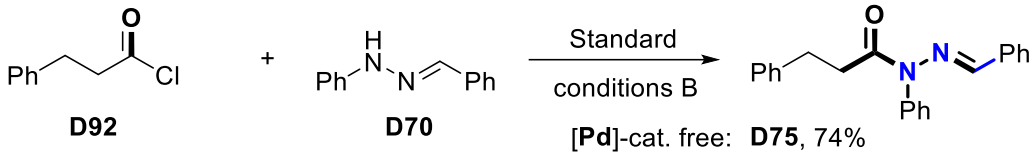
D92 **B1** **C1**

[**Pd**]-cat. free: **D75**, 63%

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D92** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), and anisole (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 16 hours.

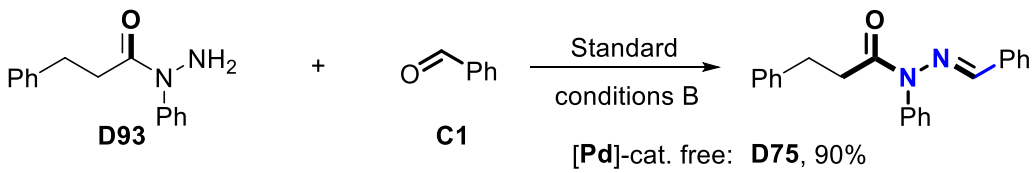
After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75** in 63% yield.

5.4.5 Control experiments with D70 and D92 in the absence of [Pd]



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D92** (1.4 mmol), **D70** (1.0 mmol), and anisole (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 °C) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75** in 74% yield.

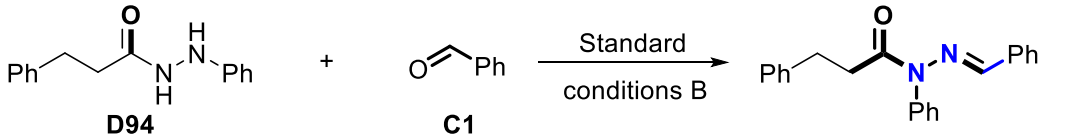
5.4.6 Control experiments with D93 in the absence of [Pd]



Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D93** (1.0 mmol), **C1** (1.5 mmol), and anisole (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the

tube immersed into a pre-heated metal bath (120 ℃) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75** in 90% yield.

5.4.7 Control experiments with D94 in the absence of [Pd]

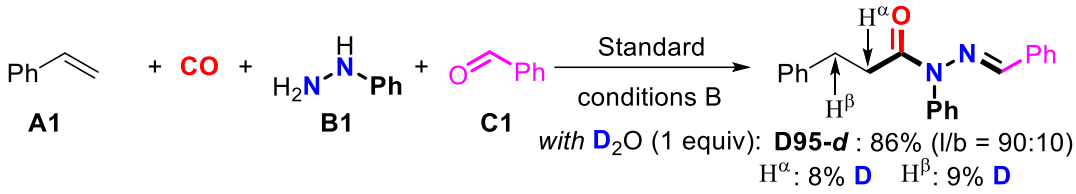


[**Pd**]-cat. free: **D75**, 0; recovered **D94**,96%

Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D94** (1.0 mmol), **C1** (1.5 mmol), and anisole (2.0 mL). Then the glass tube was closed tightly and removed from the glove box. Then the tube immersed into a pre-heated metal bath (120 ℃) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D75** in 0% yield and **D94** was recovered in 96% yield.

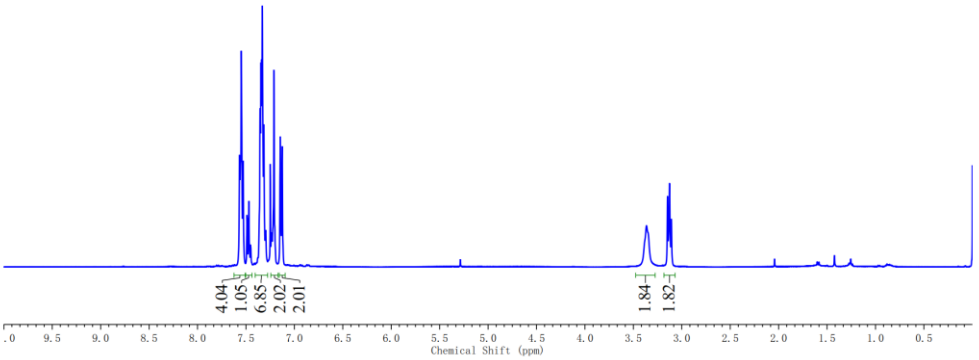
5.5 Labelled investigations for branched acylhydrazones

5.5.1 Labelled investigations in the presence of D_2O

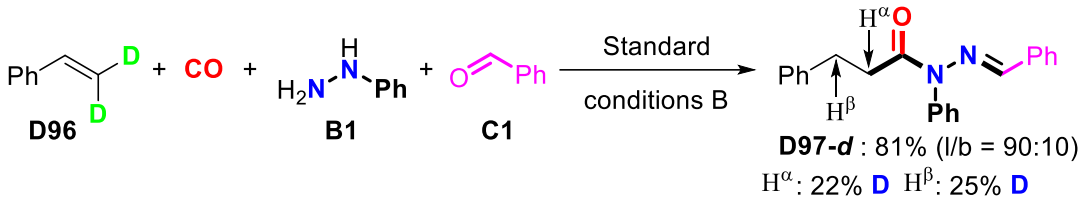


Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **A1** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), D_2O (1.0 mmol), $PdCl_2$(Xantphos) (0.02 mmol, 2 mol%), and anisole (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 °C) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D95-*d*** in 86% yield.

$$H^{\alpha} = \frac{2-1.84}{2} \times 100\% = 8\% \qquad H^{\beta} = \frac{2-1.82}{2} \times 100\% = 9\%$$

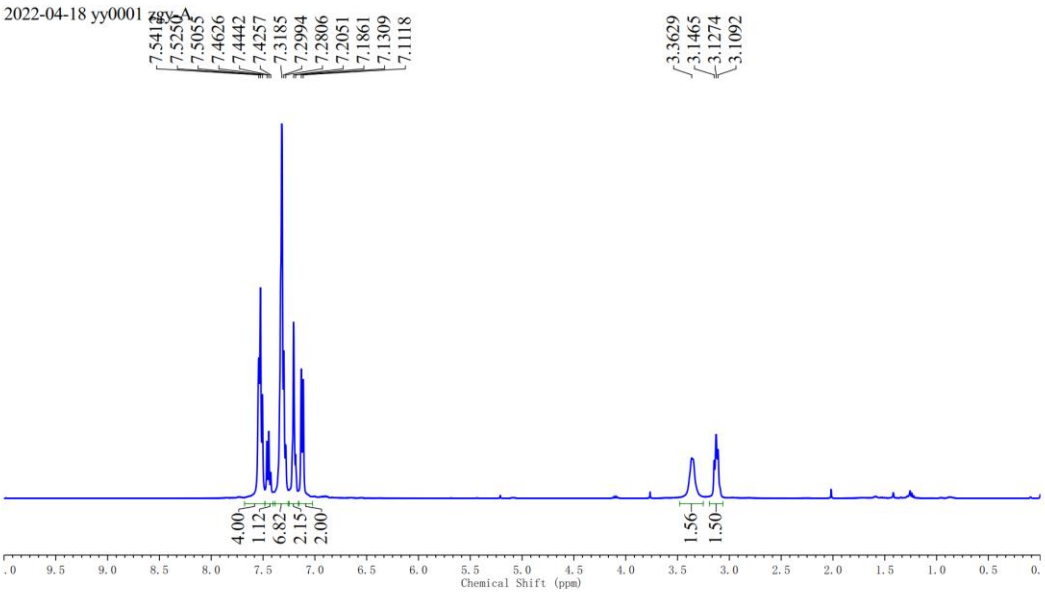


5.5.2 Labelled investigations with D96

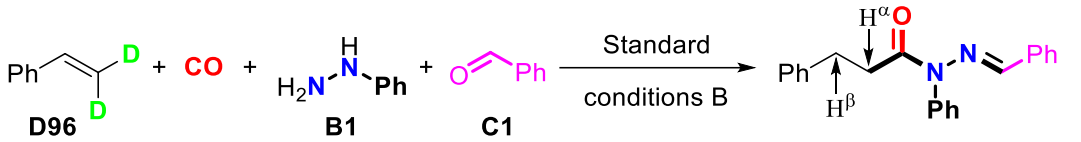


Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D96** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), $PdCl_2$(Xantphos) (0.02 mmol, 2 mol%), and anisole (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 °C) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D97-*d*** in 81% yield.

$$H^{\alpha} = \frac{2-1.56}{2} \times 100\% = 22\% \qquad H^{\beta} = \frac{2-1.50}{2} \times 100\% = 25\%$$



5.5.3 Labelled investigations with D96 in the presence of D_2O

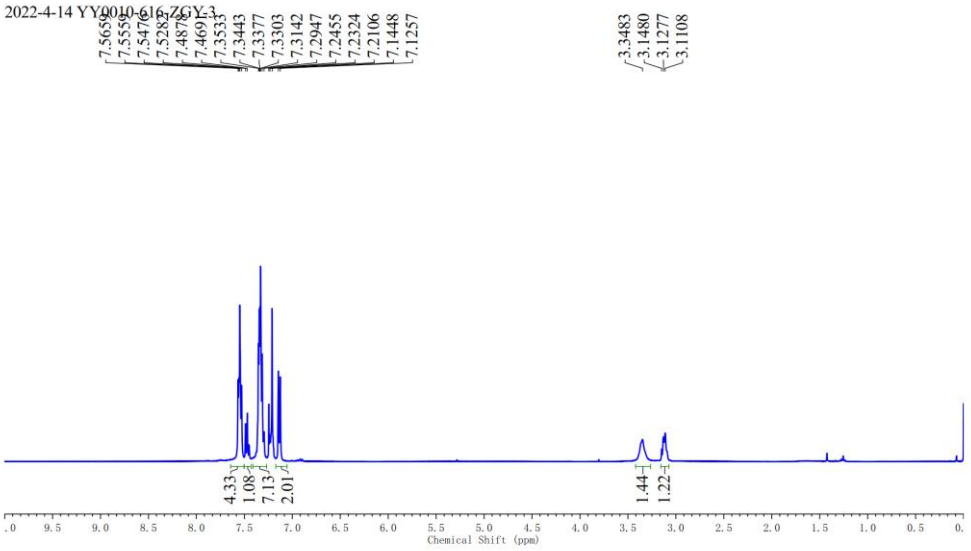


with D_2O (1 equiv): **D97-*d*** : 80% (l/b = 89:11)

H^{α}: 28% D H^{β}: 39% D

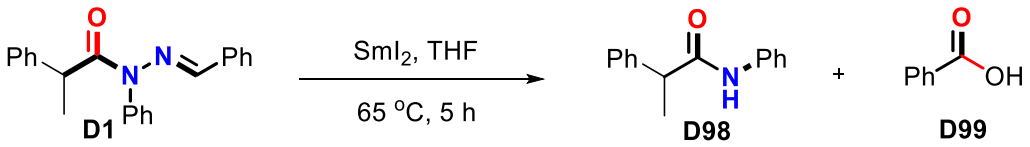
Using a nitrogen-filled glove box, an oven-dried pressure tube (10.0 mL) was charged with a magnetic stirring bar, **D96** (1.4 mmol), **B1** (1.0 mmol), **C1** (1.5 mmol), D_2O (1.0 mmol), $PdCl_2$(Xantphos) (0.02 mmol, 2 mol%), and anisole (2.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 °C) for 16 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D97-*d*** in 80% yield.

$$H^{\alpha} = \frac{2-1.44}{2} \times 100\% = 28\% \qquad H^{\beta} = \frac{2-1.22}{2} \times 100\% = 39\%$$



6. Further Transformation

6.1 Synthesis of *N*,2-diphenylpropanamide



Using a nitrogen-filled glove box, add a magnetic stir bar, **D1** (328 mg, 1.0 mmol), SmI_2 (219 μL, 0.5 mmol), and THF (5.0 mL) to the dried pressure tube (38 mL volume). Then the sealing tube was closed tightly with teflon cover and immersed in a preheated metal bath (65 ℃) for 5 hours. A small fraction of the organic phase was analyzed by gas chromatography and gas chromatography-mass spectrometry to monitor product formation. Then the solvent was evaporated under reduced pressure, and the residue was purified on silica gel by flash column chromatography to obtain products **D98** (180.0 mg, 80%) and **D99** (86.6 mg, 71%).

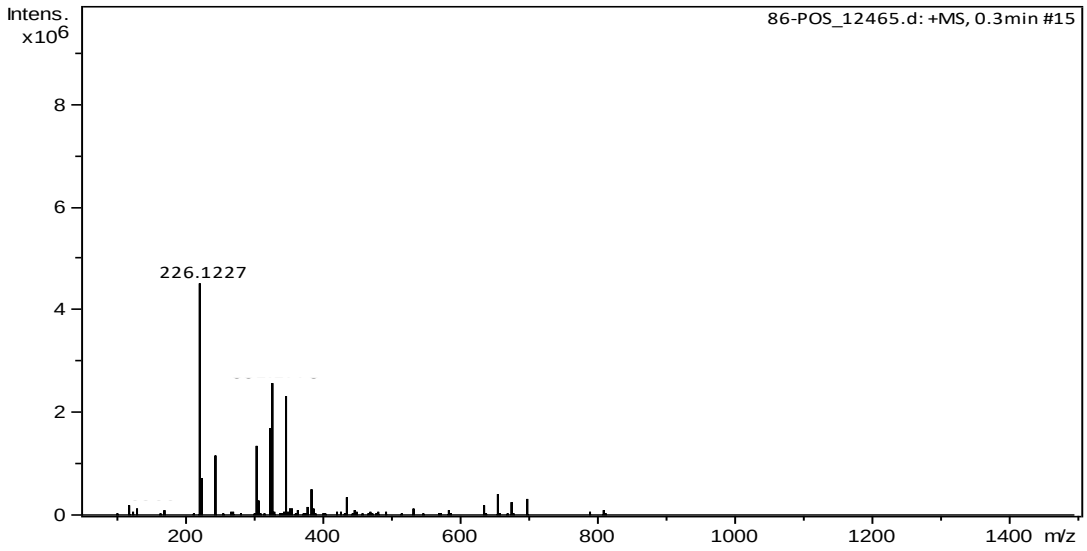
***N*,2-diphenylpropanamide** [1]

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.34 (m, 6H), 7.33 – 7.24 (m, 3H), 7.10 – 7.03 (m, 2H), 3.71 (q, *J* = 7.2 Hz, 1H), 1.64 – 1.57 (m, 3H) ppm.

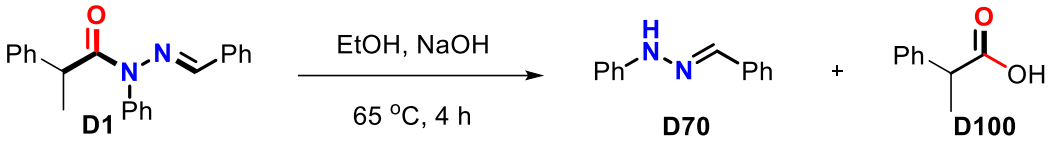
^{13}C NMR (101 MHz, $CDCl_3$) δ 172.3, 140.9, 137.9, 129.2, 128.9, 127.7, 127.6, 124.3, 119.7, 48.2, 18.6 ppm.

MS (70 eV): m/z (%) = 225 $[M]^+$ (100), 132, 105, 93.

HRMS (ESI) calcd. for $C_{15}H_{16}NO$ [M+H]: 226.1227, found: 226.1227.



6.2 Synthesis of 1-benzylidene-2-phenylhydrazine



Using a nitrogen-filled glove box, add a magnetic stir bar, **D1** (328 mg, 1.0 mmol), NaOH (160 mg, 4.0 mmol), and EtOH (5.0 mL) to the dried pressure tube (38 mL volume). Then the sealing tube was closed tightly with teflon cover and immersed in a preheated metal bath (65 ℃) for 4 hours. A small fraction of the organic phase was analyzed by gas chromatography and gas chromatography-mass spectrometry to monitor product formation. Then the solvent was evaporated under reduced pressure, and the residue was purified on silica gel by flash column chromatography to obtain products **D70** (180.3mg, 92%) and **D100** (128.8 mg, 71%).

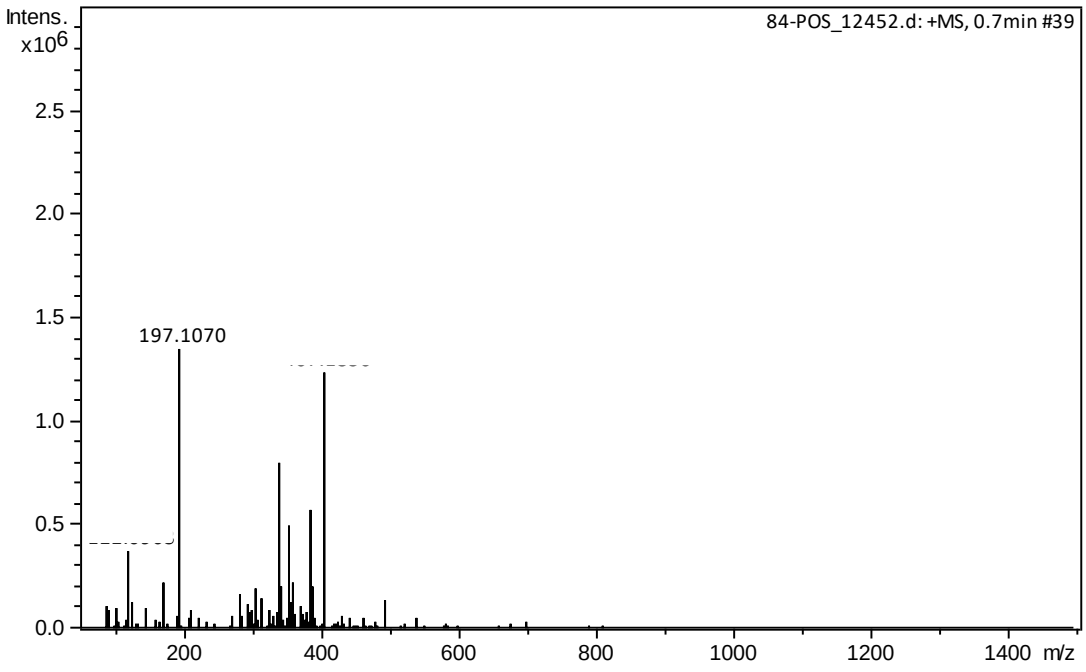
1-benzylidene-2-phenylhydrazine [2]

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.62 (m, 3H), 7.36 (t, *J* = 7.2 Hz, 2H), 7.31 – 7.23 (m, 3H), 7.11 (d, *J* = 7.6 Hz, 2H), 6.87 (t, *J* = 7.2 Hz, 1H) ppm.

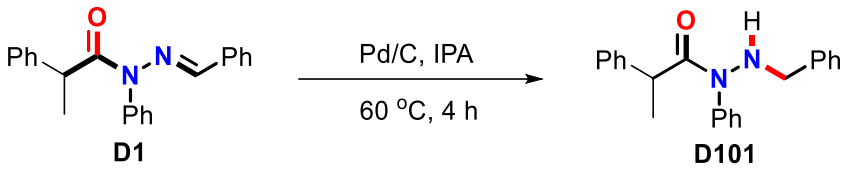
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.7, 137.3, 135.3, 129.3, 128.6, 128.5, 126.2, 120.1, 112.8 ppm.

MS (70 eV): m/z (%) = 196 $[M]^+$ (100), 92, 65, 39.

HRMS (ESI) calcd. for $C_{13}H_{13}N_2$ [M+H]: 197.1073, found: 197.1070.



6.3 Synthesis of *N*′-benzyl-*N*,2-diphenylpropanehydrazide



Using a nitrogen-filled glove box, add a magnetic stir bar, **D1** (328 mg, 1.0 mmol), Pd/C (21.2 mg, 0.2 mmol), and IPA (5.0 mL) to the dried pressure tube (38 mL volume). $HCOONH_4$ (315 mg, 5.0 mmol) and H_2O (480 μL, 30 mmol) were added while stirring, then the tubes were tightly sealed with teflon caps and immersed in a preheated metal bath (60 ℃) for 4 hours. A small fraction of the organic phase was analyzed by gas chromatography and gas chromatography-mass spectrometry to monitor product formation. Then the solvent was evaporated under reduced pressure, and the residue was purified on silica gel by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 5:1) to obtain product **D101** (313.5 mg, 95%).

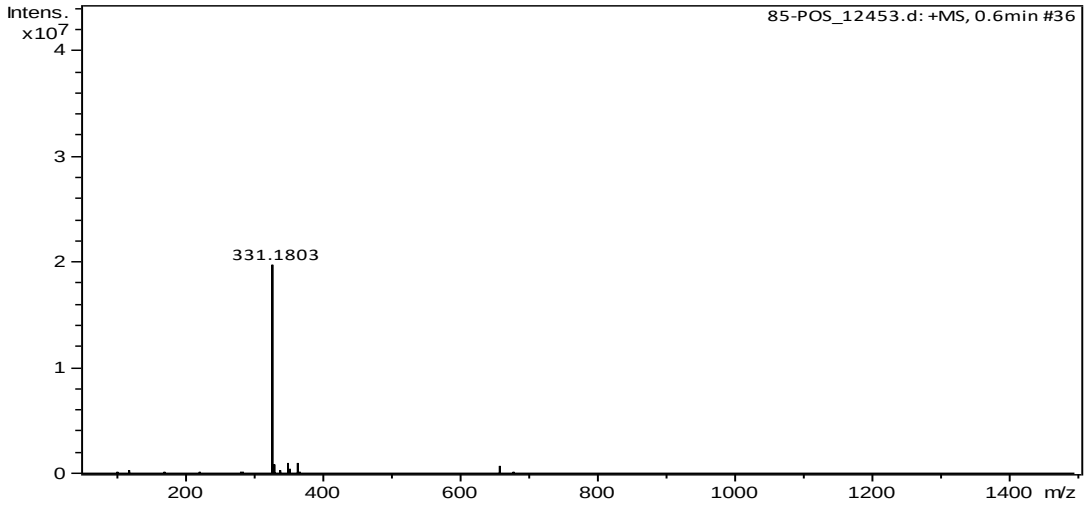
***N*′-benzyl-*N*,2-diphenylpropanehydrazide**

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.22 (m, 4H), 7.22 – 7.18 (m, 2H), 7.15 (s, 4H), 6.97 – 6.94 (m, 3H), 6.76 – 6.72 (m, 2H), 6.33 (s, 1H), 5.40 (s, 1H), 5.20 (s, 1H) ppm.

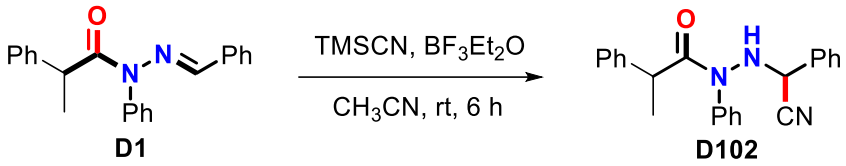
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.7, 136.2, 134.0, 131.9, 128.8, 127.9, 127.7, 127.5, 127.2, 126.9, 126.1, 125.6, 110.2, 60.3 ppm.

MS (70 eV): m/z (%) = 330 $[M]^+$ (100), 225, 105, 91.

HRMS (ESI) calcd. for $C_{22}H_{23}N_2O$ [M+H]: 331.1805, found: 331.1803.



6.4 Synthesis of *N′*-(cyano(phenyl)methyl)-*N*,2-diphenylpropanehydrazide



Using a nitrogen-filled glove box, add a magnetic stir bar, **D1** (328 mg, 1.0 mmol), TMSCN (252 μL, 2.0 mmol), BF_3Et_2O (24 μL, 0.2 mmol) and CH_3CN (5.0 mL) to the dried pressure tube (38 mL volume). Then close the teflon cover of the sealing tube and react for 6 hours at room temperature. A small fraction of the organic phase was analyzed by gas chromatography and gas chromatography-mass spectrometry to monitor product formation. Then the solvent was evaporated under reduced pressure, and the residue was purified on silica gel by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 5:1) to obtain product **D102** (294.7 mg, 83%).

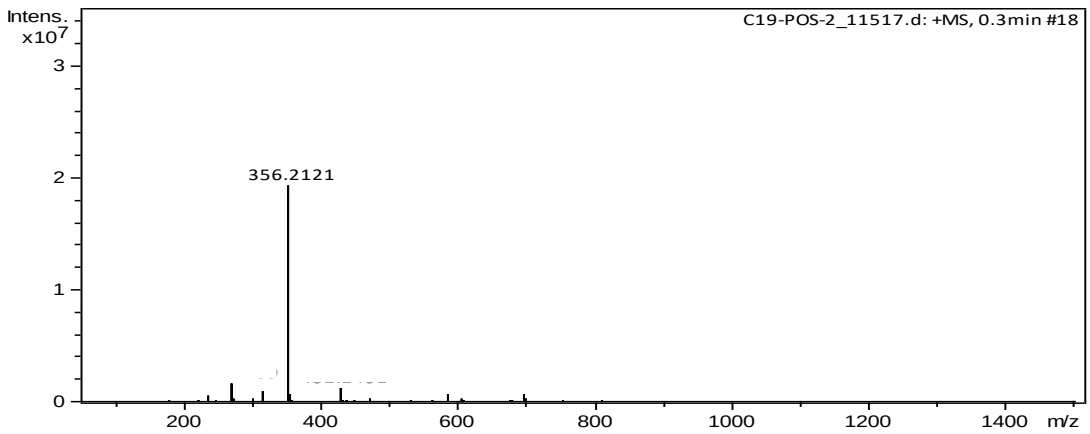
***N′*-(cyano(phenyl)methyl)-*N*,2-diphenylpropanehydrazide**

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 – 7.46 (m, 2H), 7.40 – 7.33 (m, 6H), 7.24 – 7.14 (m, 4H), 7.11 – 7.06 (m, 1H), 7.06 – 7.01 (m, 1H), 7.01 – 6.96 (m, 1H), 6.21 (dd, *J* = 46.4, 6.8 Hz, 1H), 5.00 (dd, *J* = 45.6, 6.8 Hz, 1H), 3.78 – 3.66 (m, 1H), 1.54 – 1.39 (m, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 174.1, 173.8, 140.7, 140.6, 140.3, 139.9, 131.8, 131.6, 129.8, 129.5, 129.3, 129.1, 128.8, 128.7, 128.6, 128.4, 128.3, 128.2, 128.1, 127.5, 127.4, 127.1, 118.0, 117.9, 54.8, 54.7, 43.1, 42.8, 20.2, 19.9 ppm.

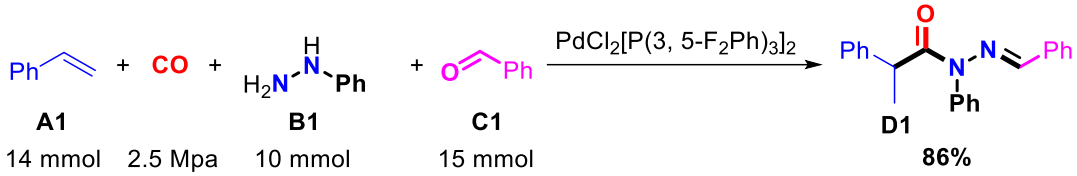
MS (70 eV): m/z (%) = 355 $[M]^+$ (100), 250, 105, 91.

HRMS (ESI) calcd. for $C_{23}H_{22}N_3O$ [M+H]: 356.2121, found: 356.2121.



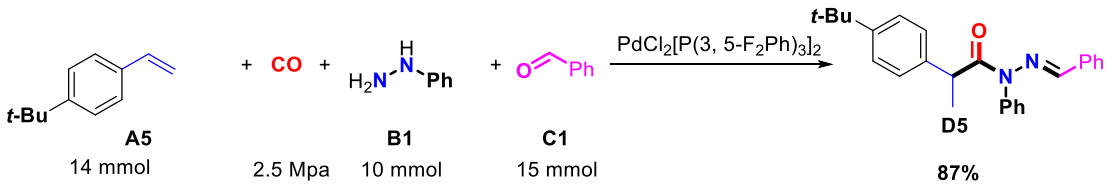
7. Gram-scale experiment

7.1 10 mmol scale for A1



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A1** (14.0 mmol), **B1** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 86% yield (2.8 g).

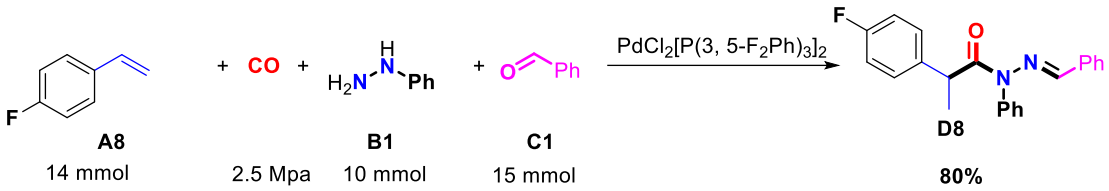
7.2 10 mmol scale for A5



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A5** (14.0 mmol), **B1** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A

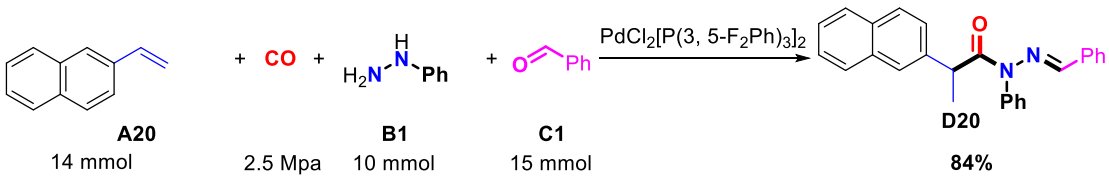
small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D5** in 87% yield (3.4 g).

7.3 10 mmol scale for A8



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A8** (14.0 mmol), **B1** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D8** in 80% yield (2.9 g).

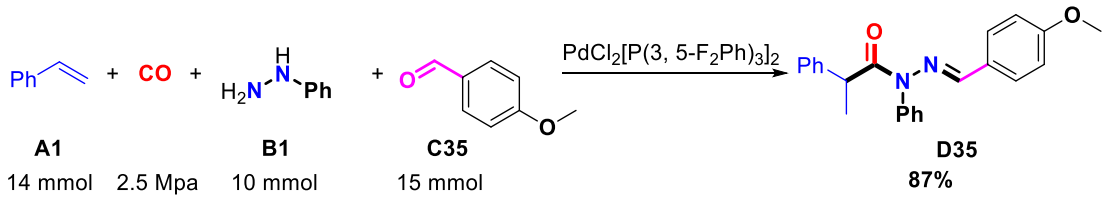
7.4 10 mmol scale for A20



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A20** (14.0 mmol), **B1** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass

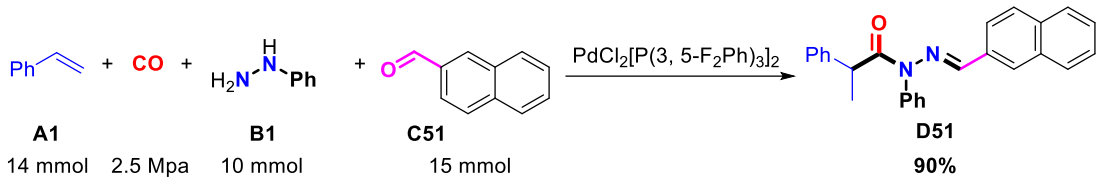
tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D20** in 84% yield (3.2 g).

7.5 10 mmol scale for C35



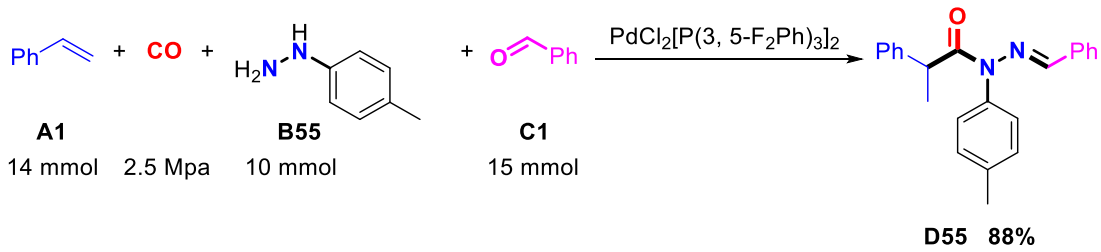
Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A1** (14.0 mmol), **B1** (10.0 mmol), **C35** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D35** in 87% yield (3.1 g).

7.6 10 mmol scale for C51



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A1** (14.0 mmol), **B1** (10.0 mmol), **C51** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 °C) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D51** in 90% yield (3.4 g).

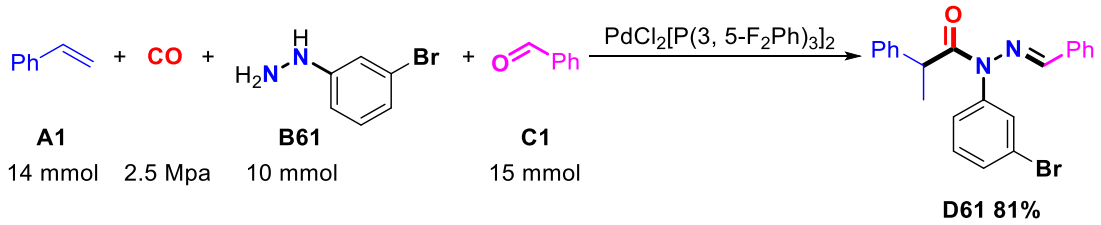
7.7 10 mmol scale for B55



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A1** (14.0 mmol), **B55** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 °C) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A

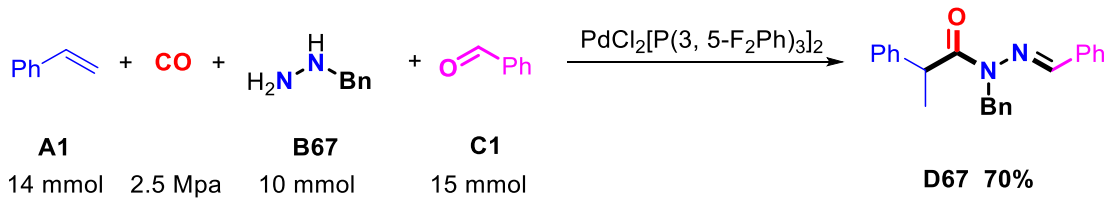
small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D55** in 88% yield (3.0 g).

7.8 10 mmol scale for B61



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A1** (14.0 mmol), **B61** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D61** in 81% yield (3.3 g).

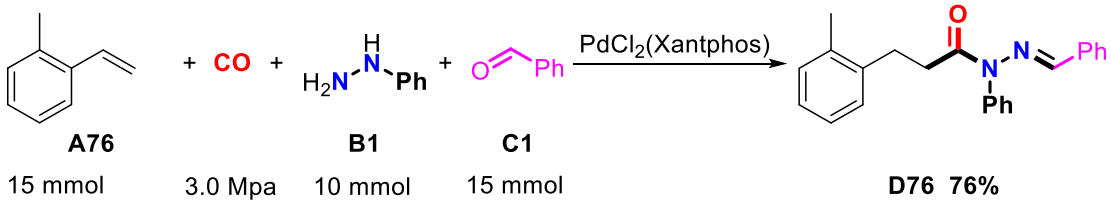
7.9 10 mmol scale for B67



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A1** (14.0 mmol), **B67•HCl** (10.0 mmol), **C1** (15.0

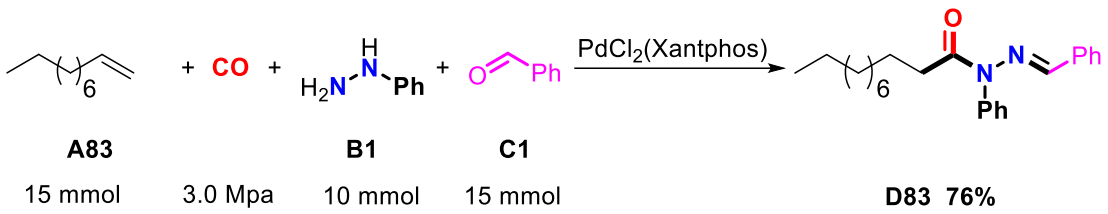
mmol), KOH (10.0 mmol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.2 mmol, 2 mol%), and DCM (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 24 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D67** in 70% yield (2.4 g).

7.10 10 mmol scale for A76



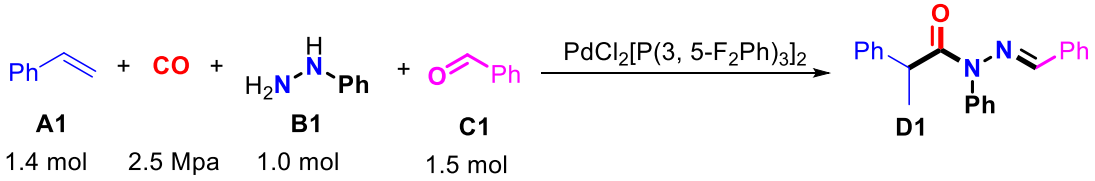
Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A76** (15.0 mmol), **B1** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2$(Xantphos) (0.2 mmol, 2 mol%), and anisole (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 ℃) for 48 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D76** in 76% yield (2.6 g).

7.11 10 mmol scale for A83



Using a nitrogen-filled glove box, an oven-dried pressure tube (100.0 mL) was charged with a magnetic stirring bar, **A83** (15.0 mmol), **B1** (10.0 mmol), **C1** (15.0 mmol), $PdCl_2$(Xantphos) (0.2 mmol, 2 mol%), and anisole (20.0 mL). Then the glass tube was placed in an autoclave which was closed tightly and removed from the glove box. Then the autoclave was purged and charged with CO (3.0 MPa) and immersed into a pre-heated metal bath (120 ℃) for 48 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D83** in 76% yield (2.9 g).

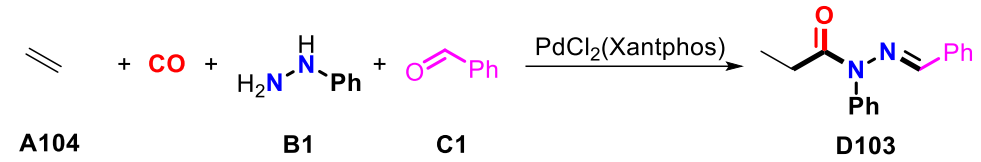
7.12 1.0 mol scale for A1



An oven-dried pressure tube (2.5 L) was charged with a magnetic stirring bar, **A1** (1.4 mol), **B1** (1.0 mol), **C1** (1.5 mol), $PdCl_2[P(3, 5\text{-}F_2Ph)_3]_2$ (0.01 mol, 1 mol%), and DCM (1.0 L). Then the glass tube was placed in an autoclave which was closed tightly. Then the autoclave was purged and charged with CO (2.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 72 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the

residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D1** in 78% yield (255.8 g).

7.13 1.0 mol scale for A103



An oven-dried pressure tube (2.5 L) was charged with a magnetic stirring bar, **A104** (0.5 MPa), **B1** (1.0 mol), **C1** (1.5 mol), $PdCl_2$(Xantphos) (0.001 mol, 1 mol‰), and anisole (1.0 L). Then the glass tube was placed in an autoclave which was closed tightly. Then the autoclave was purged and charged with CO (0.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 60 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D103** in 61% yield (153.7 g).

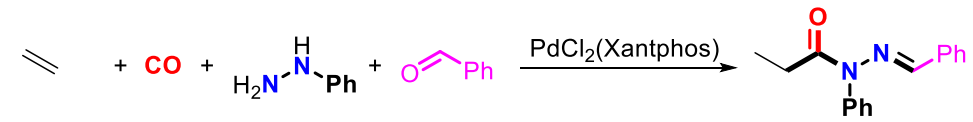
***N′*-benzylidene-*N*-phenylpropionohydrazide**

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.46 (m, 4H), 7.44 – 7.37 (m, 1H), 7.30 (s, 3H), 7.22 (s, 1H), 7.13 (d, J = 7.6 Hz, 2H), 3.03 (s, 2H), 1.29 (t, J = 7.2 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 141.2, 136.3, 134.5, 130.3, 129.9, 129.4, 129.3, 128.8, 127.2, 27.7, 9.4 ppm.

MS (70 eV): m/z (%) = 252 $[M]^+$ (100), 196, 149, 92.

7.14 1.0 mol scale for A103



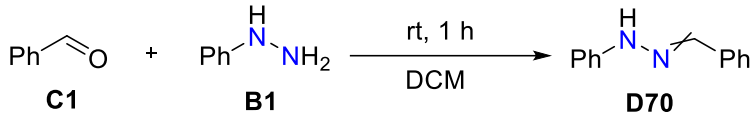
A104 **B1** **C1** **D103**

0.5 MPa 0.5 MPa 1.0 mol 1.5 mol

An oven-dried pressure tube (2.5 L) was charged with a magnetic stirring bar, **A104** (0.5 MPa), **B1** (1.0 mol), **C1** (1.5 mol), $PdCl_2$(Xantphos) (0.005 mol, 5 mol‰), and anisole (1.0 L). Then the glass tube was placed in an autoclave which was closed tightly. Then the autoclave was purged and charged with CO (0.5 MPa) and immersed into a pre-heated metal bath (120 ℃) for 60 hours. After the reaction was finished, the autoclave was cooled to room temperature and the pressure was carefully released. A small aliquot of the reaction mixture was analyzed by GC and GC-MS to monitor product formation. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D103** in 91% yield (229.3 g).

8. The synthesis of the intermediates

8.1 Synthesis of D70

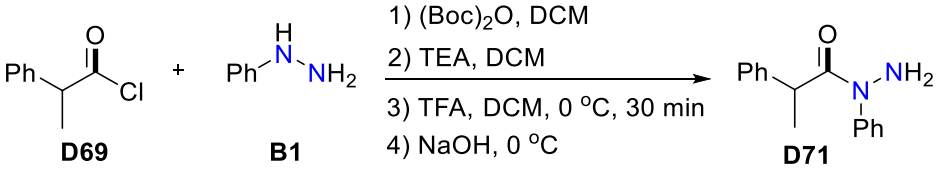


Using a nitrogen-filled glove box, add **C1** (106 μL, 1.0 mmol) in DCM (5.0 mL) to a 50.0 mL oven-dried round-bottomed flask containing a magnetic stirring bar and **B1** (98 μL, 1.0 mmol). Stir the reaction mixture for 1 hour at room temperature. After complete consumption of aldehyde, monitor the reaction by thin layer chromatography. If a precipitate forms, pour the reaction mixture over a Buchner funnel. Wash the solid with a minimum of cold methanol to give the corresponding product **D70** in 96% yield (216.0 mg).

1-benzylidene-2-phenylhydrazine [2]

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.62 (m, 3H), 7.36 (t, *J* = 7.2 Hz, 2H), 7.31 – 7.23 (m, 3H), 7.11 (d, *J* = 7.6 Hz, 2H), 6.87 (t, *J* = 7.2 Hz, 1H) ppm.

8.2 Synthesis of D71



Under the nitrogen, a mixture of **B1** (980 μL, 10.0 mmol) and DCM (10.0 mL) was placed in a round-bottomed flask equipped with a magnetic stir bar and the temperature was kept at 0 ℃ by adding ice. Over the course of 20 minutes, $(Boc)_2O$ (2.8 mL, 12.0 mmol) was added to this mixture and the reaction was allowed to proceed for at least an hour, during which time a constant check was performed by TLC. Once the reaction had progressed to the desired extent, **D69** (1.8 mL, 12.0 mmol) was added drop by drop to the reaction mixture. Under vigorous agitation, triethylamine (3.5 mL, 25.0 mmol) was added through a constant-pressure funnel within 30 minutes. After

completion of the TLC-monitored reaction, the solution was stirred for an additional 4 hours. Filter all sediment, then place the remaining mixture in a round-bottomed flask fitted with a magnetic stir bar. Stir the mixture vigorously, keeping the temperature at 0 ℃ by adding additional ice. Trifluoroacetic acid (1.0 mL, 13.0 mmol) was added drop by drop to the reaction mixture. The reaction was allowed to run for at least 30 minutes, during which time the TLC was checked for constancy. Once the reaction has progressed to the desired extent, a saturated aqueous NaOH solution is added to the reaction mixture drop by drop until pH > 7. After the TLC-monitored reaction was complete, all precipitates were filtered and then the remaining mixture was extracted with DCM. The organic phase was washed with saturated salt solution and filtered and dried with $MgSO_4$. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 10:1 – 3:1) on silica gel to give the corresponding product **D71** in 63% yield (1.5 g).

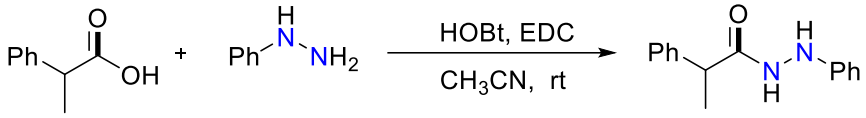
***N*,2-diphenylpropanehydrazide**

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.27 (m, 4H), 7.26 – 7.17 (m, 3H), 7.14 – 7.04 (m, 3H), 4.37 (br, 2H), 3.73 (d, J = 5.6 Hz, 1H), 1.44 (d, J = 6.8 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 173.2, 142.2, 141.3, 129.3, 128.5, 128.3, 127.5, 126.9, 42.8, 20.1 ppm.

MS (70 eV): m/z (%) = 240 $[M]^+$ (100), 108, 77, 51.

8.3 Synthesis of D72

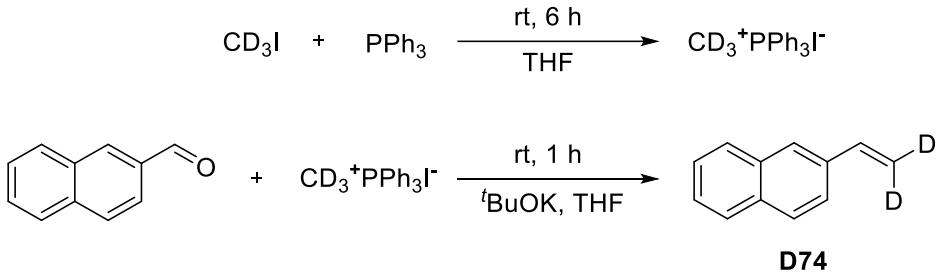


B1 **D72**

The acid (5.4 mL, 40.0 mmol) was dissolved or suspended in CH_3CN (80.0 mL) at room temperature. HOBt (6.5 g, 48.0 mmol) was added in one portion followed by EDC (3.8 mL, 48.0 mmol). The mixture was stirred at room temperature, and the reaction progress was monitored by HPLC until all of the acid was converted to the activated ester/amide mixture. The resulting mixture was then slowly added to a solution of **B1** (7.8 mL, 80.0 mmol) and cyclohexene (1.0 mL, 10.0 mmol) in CH_3CN

(40.0 mL) while the temperature was maintained at 0-10 °C. The reaction was usually complete upon the completion of addition. Water (40.0 mL) was added. The aqueous CH_3CN mixture was extracted with ethyl acetate followed by a carbonate wash of the organic layer to remove HOBt. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 10:1 – 3:1) on silica gel to give the corresponding product **D72** in 50% yield (4.8 g).[3]

8.4 Synthesis of D74



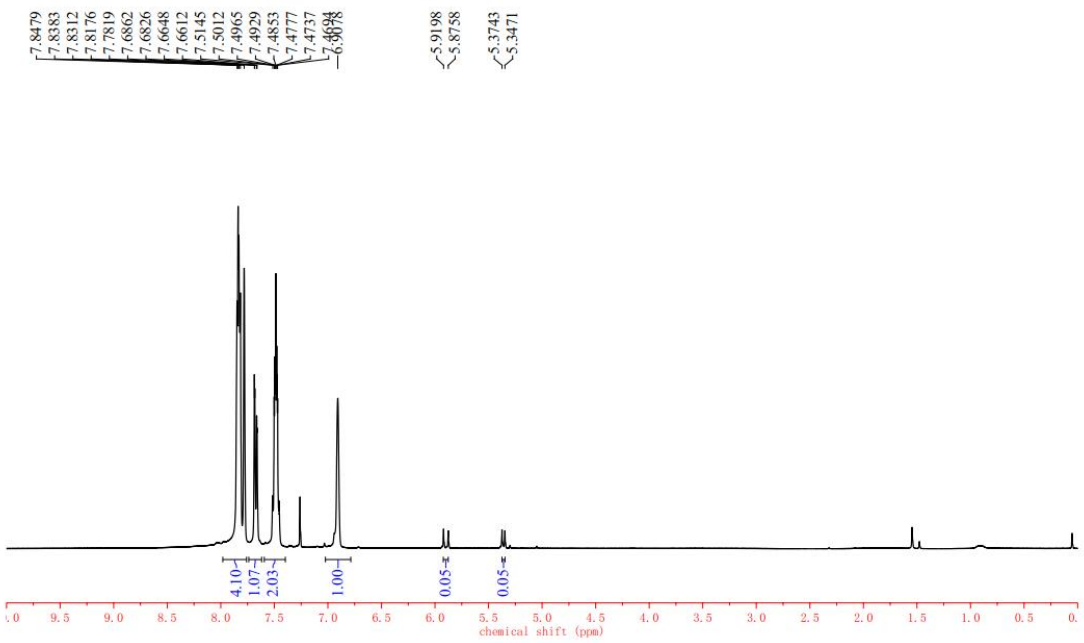
D74

To a stirred round bottomed flask which charged with PPh_3 (524.0 mg, 2.0 mmol), THF (10.0 ml) was dropwise added CD_3I (435.0 mg, 3.0 mmol) at room temperature. After completed the reaction (about 6 hours), the mixture was filtered by a Buchner funnel and washed by THF. The methyl-D_3-triphenylphosphonium iodide was obtained in 91% yield (740.7 mg).

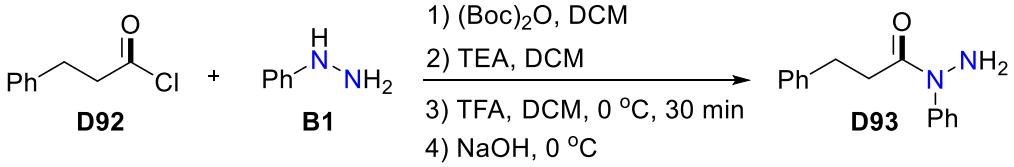
To a 25 ml flask were added methyl-D_3-triphenylphosphonium iodide (488.4 mg, 1.2 mmol), ^{t}BuOK (134.4 mg, 1.2 mmol) and THF (5.0 mL). The mixture was stirred at room temperature for 1 hour. Then, a solution of 2-naphthaldehyde (156.0 mg, 1.0 mmol) in THF (1.0 ml) was added to the flask. The reaction was stirred at room temperature for overnight. After completion of the reaction, the mixture was diluted with DCM (5.0 ml x 3) and washed with brine (5.0 mL). The organic phase was washed with saturated salt solution and filtered and dried with $MgSO_4$. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 100:1 – 10:1) on silica gel to give the corresponding product **D74** in 79% yield (123.0 mg).

2-(vinyl-2,2-d_2) naphthalene [4]

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 – 7.76 (m, 4H), 7.67 (dd, *J* = 8.8, 1.2 Hz, 1H), 7.52 – 7.45 (m, 2H), 6.91 (s, 1H), 5.90 (d, *J* = 17.6 Hz, 0.05H), 5.36 (d, *J* = 10.8 Hz, 0.05H) ppm.



8.5 Synthesis of D93



Under the nitrogen, a mixture of **B1** (980 μL, 10.0 mmol) and DCM (10.0 mL) was placed in a round-bottomed flask equipped with a magnetic stir bar and the temperature was kept at 0 ℃ by adding ice. Over the course of 15 to 20 minutes, $(Boc)_2O$ (2.8 mL, 12.0 mmol) was added to this mixture and the reaction was allowed to proceed for at least 1 hour, during which time a constant check was performed by TLC. Once the reaction had progressed to the desired extent, **D92** (1.8 mL, 12.0 mmol) was added drop by drop to the reaction mixture. Under vigorous agitation, triethylamine (3.5 mL, 25.0 mmol) was added through a constant-pressure funnel within 30 minutes.

After completion of the TLC-monitored reaction, the solution was stirred for an additional 4 hours. Filter all sediment, then place the remaining mixture in a round-bottomed flask fitted with a magnetic stir bar. Stir the mixture vigorously, keeping the temperature at 0 ℃ by adding additional ice. Trifluoroacetic acid (1.0 mL, 13.0 mmol) was added drop by drop to the reaction mixture. The reaction was allowed to run for at least 30 minutes, during which time the TLC was checked for constancy. Once the reaction has progressed to the desired extent, a saturated aqueous NaOH solution is added to the reaction mixture drop by drop until PH > 7. After the TLC-monitored reaction was complete, all precipitates were filtered and then the remaining mixture was extracted with DCM. The organic phase was washed with saturated salt solution and filtered and dried with $MgSO_4$. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 10:1 – 3:1) on silica gel to give the corresponding product **D93** in 69% yield (1.7 g).

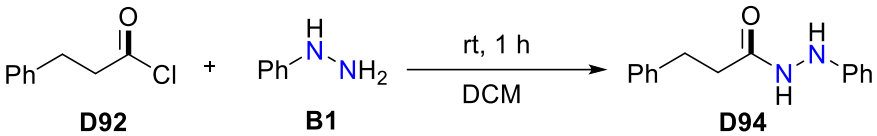
***N*,3-diphenylpropanehydrazide**

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.03 (m, 10H), 4.78 (s, 2H), 2.94 (t, *J* = 7.6 Hz, 2H), 2.49 (t, *J* = 7.2 Hz, 2H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.2, 142.3, 140.8, 129.4, 128.5, 128.4, 128.0, 126.9, 126.2, 35.4, 31.7 ppm.

MS (70 eV): m/z (%) = 240 $[M]^+$ (100), 108, 91, 65.

8.6 Synthesis of D94



Under the nitrogen, a mixture of **B1** (980 μL, 10.0 mmol) and DCM (10.0 ml) was placed in a round-bottomed flask equipped with a magnetic stir bar. **D92** (1.8 mL, 12.0 mmol) was added to the mixture and the reaction was allowed to proceed for at least 1 hour at room temperature, during which time a constant check was performed by TLC. Once the reaction had progressed to the desired extent, the organic phase was washed

with saturated salt solution and filtered and dried with $MgSO_4$. Then the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography (petroleum ether/ethyl acetate = 10:1 – 3:1) on silica gel to give the corresponding product **D94** in 85% yield (2.0 g).

***N'*,3-diphenylpropanehydrazide**

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.91 (s, 1H), 8.51 (s, 1H), 7.51 – 6.79 (m, 10H), 2.92 – 2.76 (m, 2H), 2.53 – 2.32 (m, 2H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.7, 141.5, 140.6, 140.3, 129.6, 128.5, 128.4, 127.8, 126.3, 124.8, 35.6, 31.1 ppm.

MS (70 eV): m/z (%) = 240 $[M]^+$ (100), 108, 91, 65.

9. References

[1] Métro, T. X.; Bonnamour, J.; Reidon, T.; Duprez, A.; Sarpoulet, J.; Martinez, J.; Lamaty, F. Comprehensive study of the organic-solventfree CDI-mediated acylation of various nucleophiles by mechanochemistry. *Chem.-Eur. J*. **2015**, *21*, 12787–12796.

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[3] Zhang, X. N.; Breslav, M.; Grimm, J.; Guan, K. L.; Huang, A. H.; Liu, F. Q.; Maryanoff, C. A.; Palmer, D.; Patel, M.; Qian, Y.; Shaw, C.; Sorgi, K.; Stefanick, S.; Xu, D. W. A new procedure for preparation of carboxylic acid hydrazides. *J. Org. Chem.* **2002***, 67*, 9471−9474.

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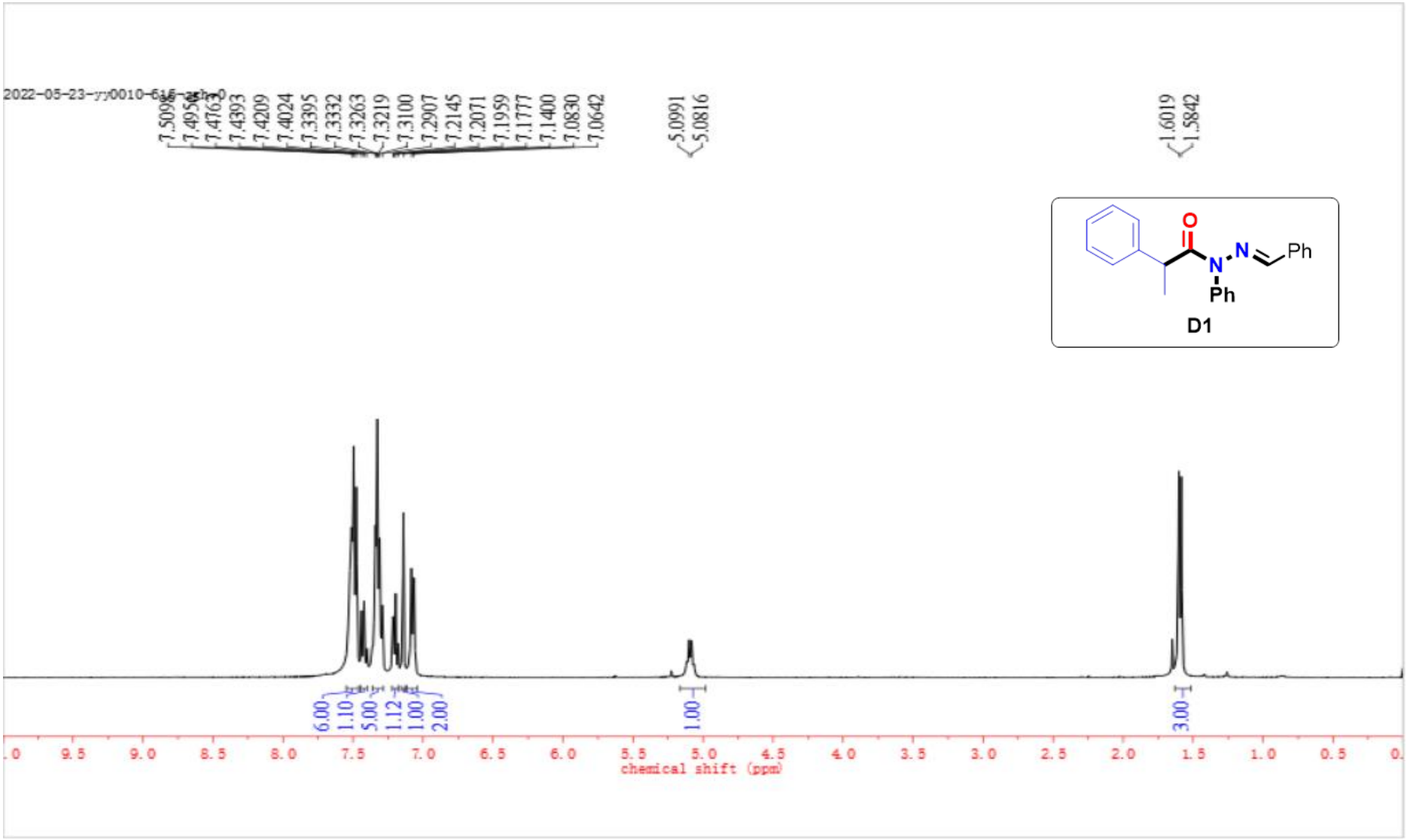
10. NMR Spectra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7.2907
7.2145
7.2071
7.1959
7.1777
7.1400
7.0830
7.0642
5.0991
5.0816
1.6019
1.5842
O
N
N
Ph
Ph
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1.10
5.00
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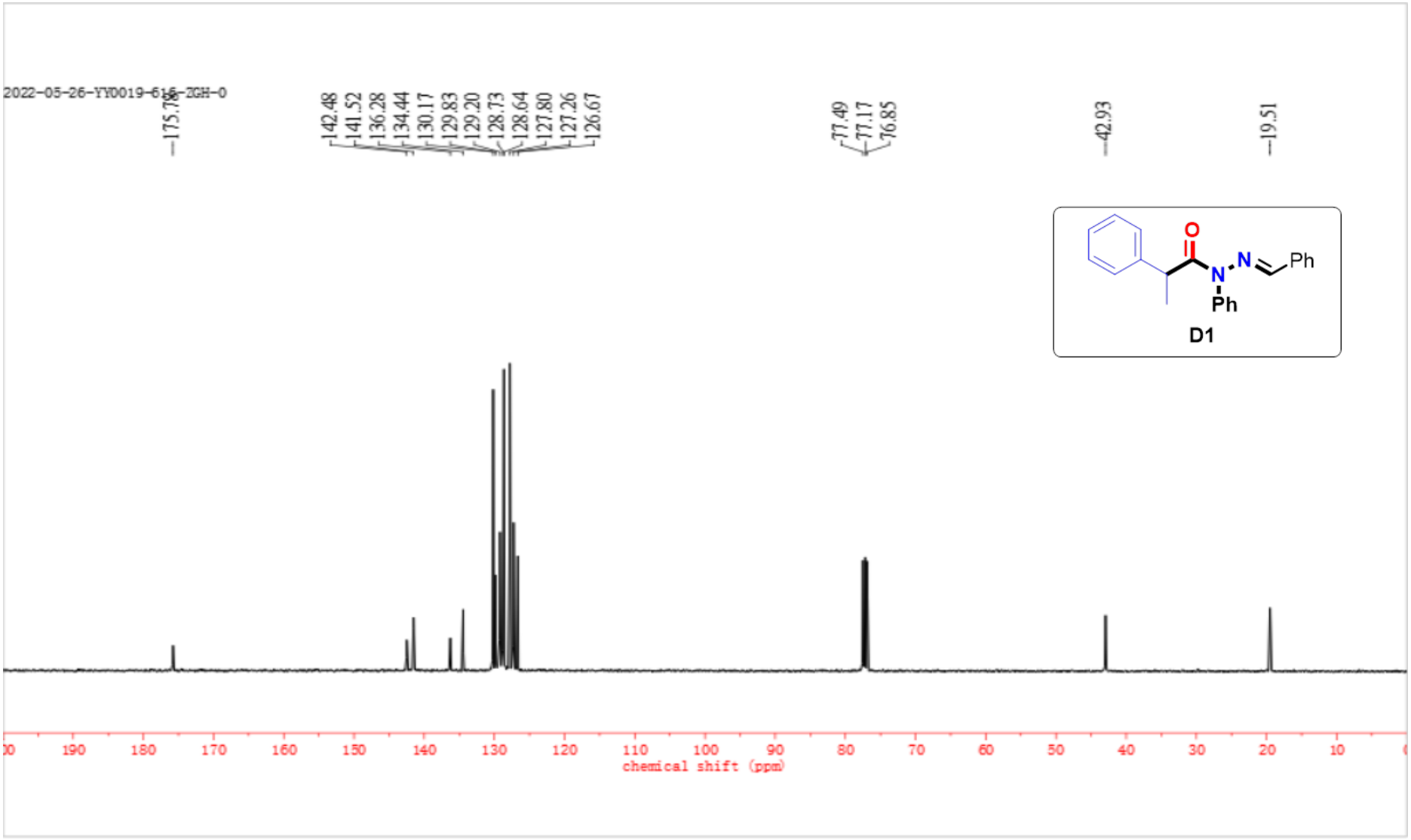
1.00
2.00
1.00
3.00
chemical shift (ppm)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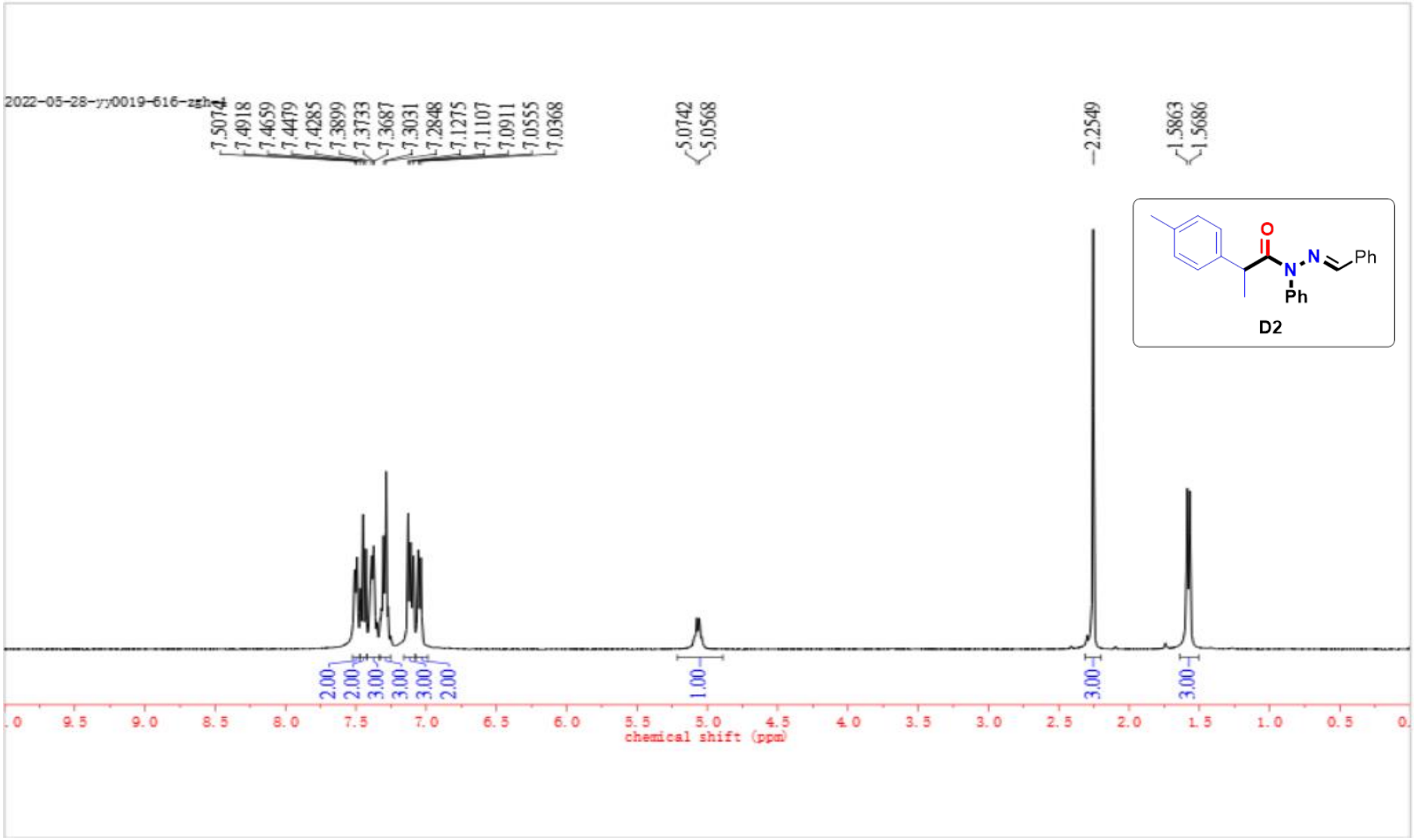
42.93
19.51
O
N
N
Ph
Ph
D1
chemical shift (ppm)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7.1107
7.0911
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N
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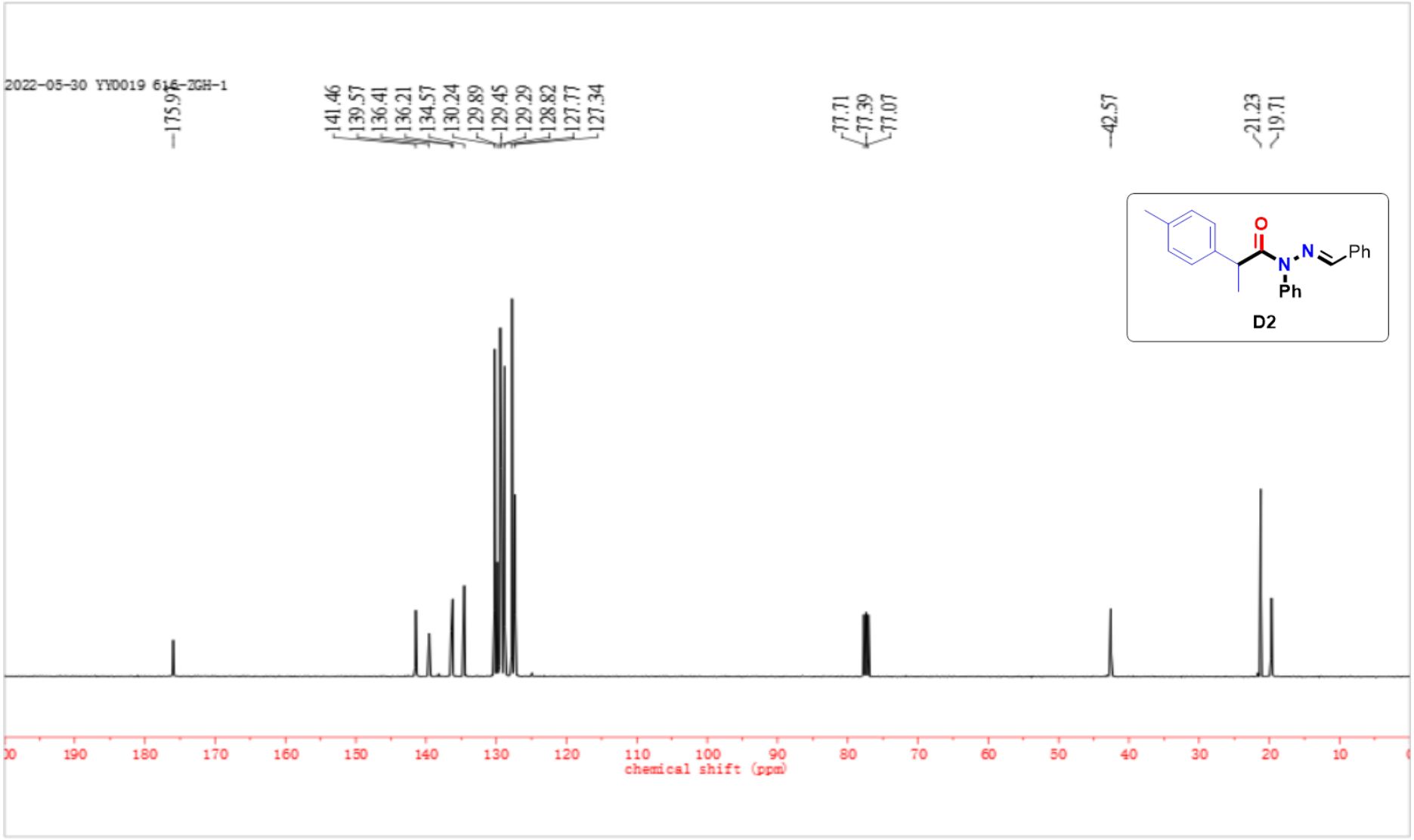
3.00
chemical shift (ppm)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127.34
77.71
77.39
77.07
42.57
21.23
19.71
O
N
N
Ph
Ph
D2
190
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140
130
120
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60
50
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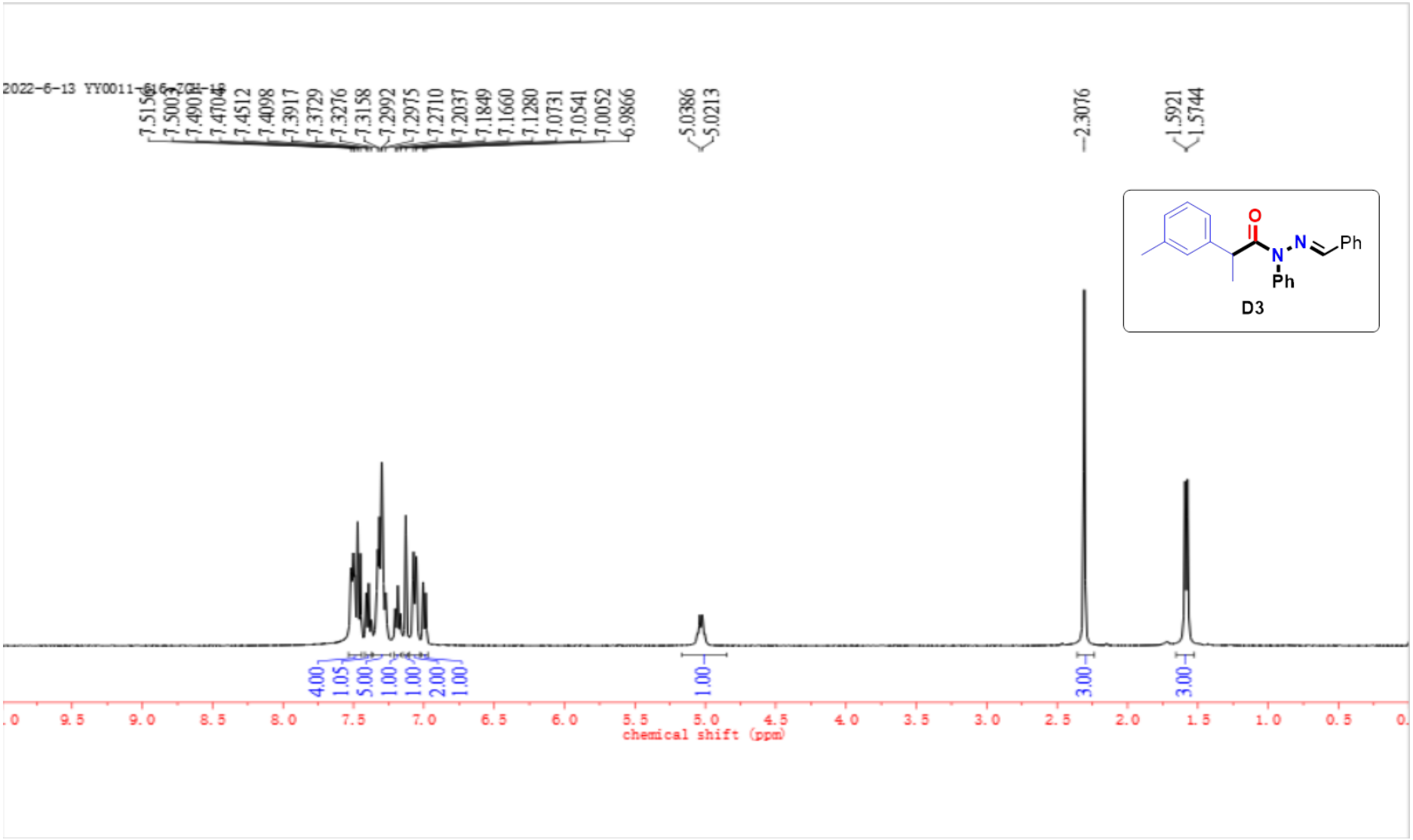
20
10
chemical shift (ppm)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Ph
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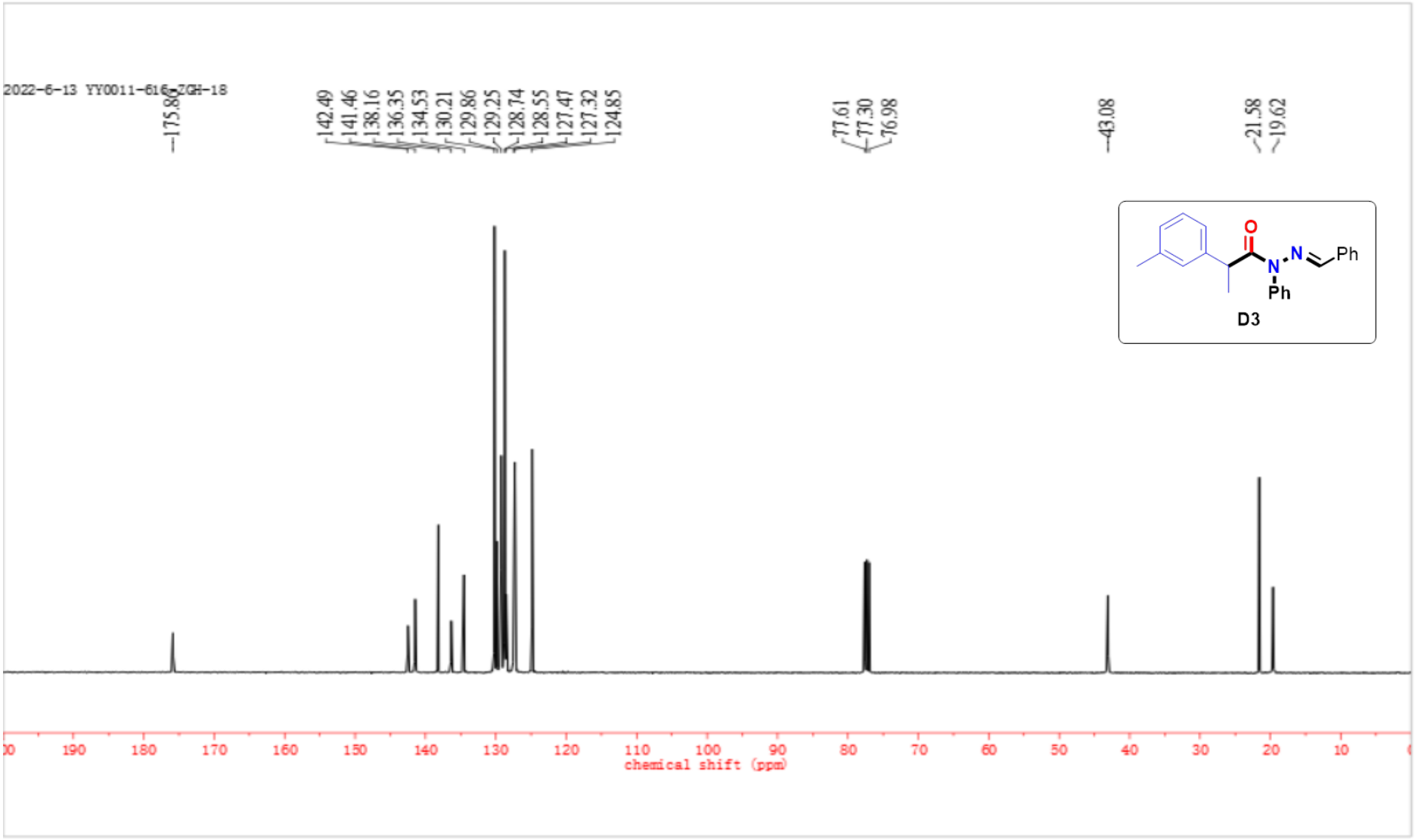
chemical shift (ppm)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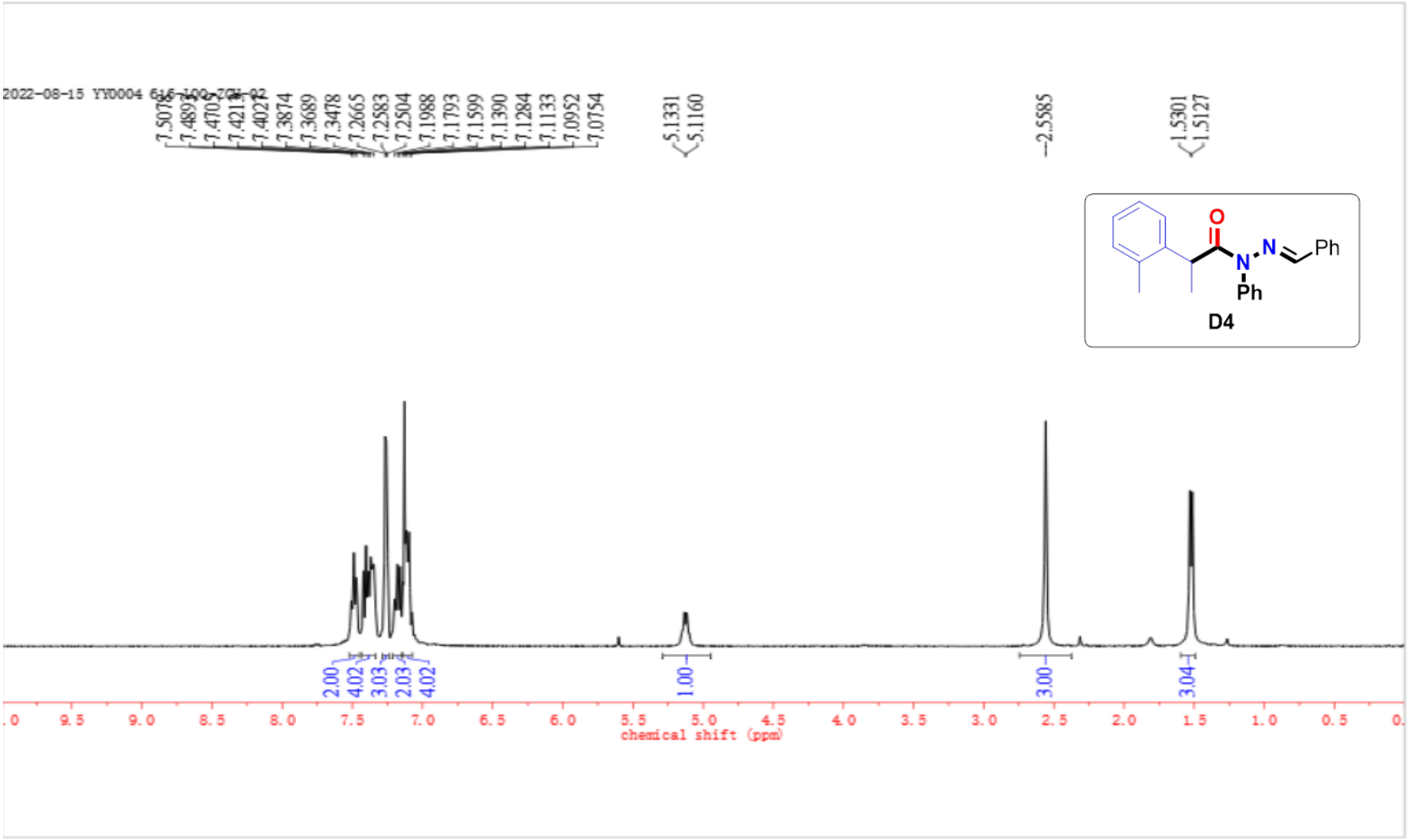
Ph
Ph
D3
chemical shift (ppm)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7.1793
7.1599
7.1390
7.1284
7.1133
7.0952
7.0754
5.1331
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2.5585
1.5301
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O
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Ph
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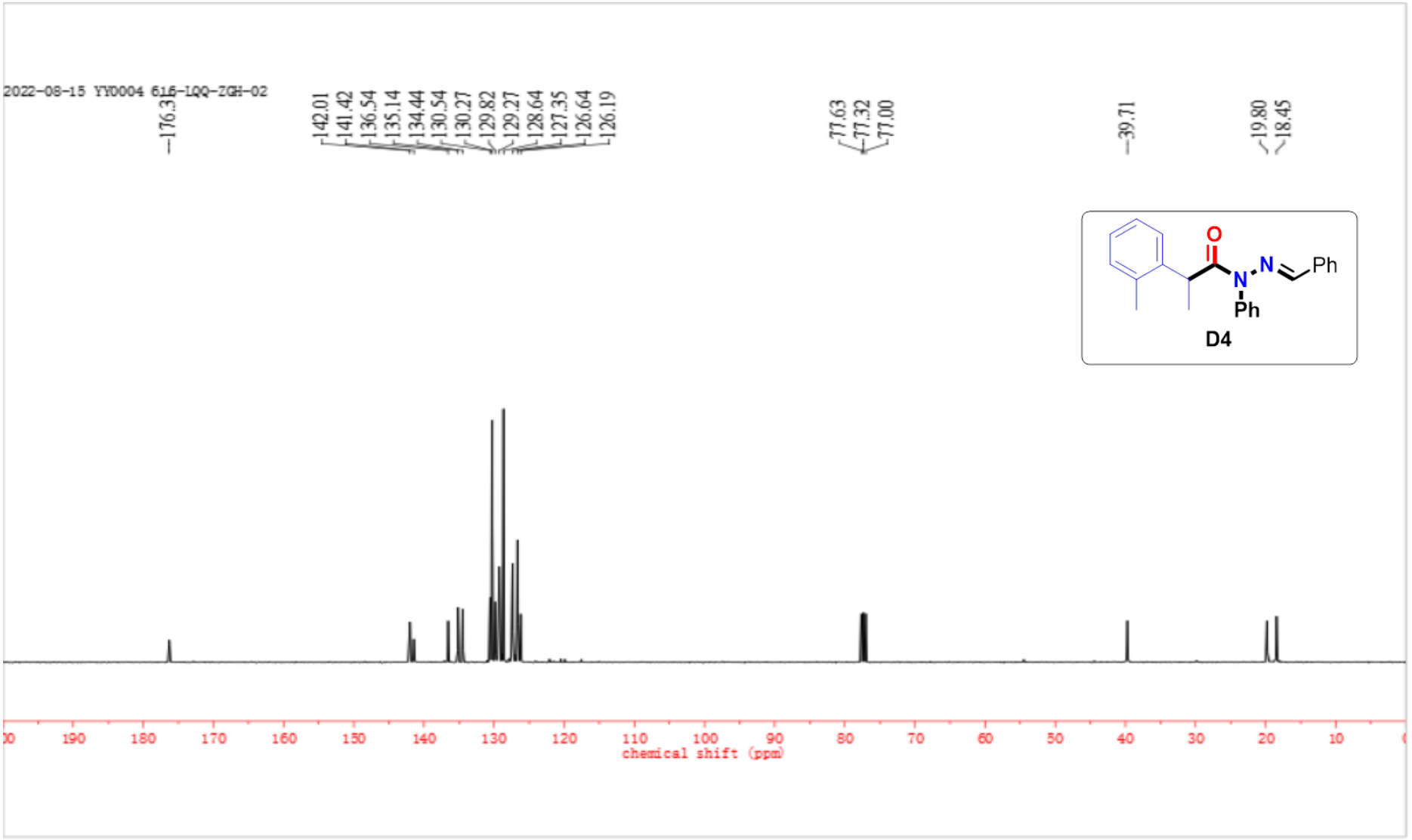
chemical shift (ppm)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129.27
128.64
127.35
126.64
126.19
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Ph
Ph
D4
190
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20
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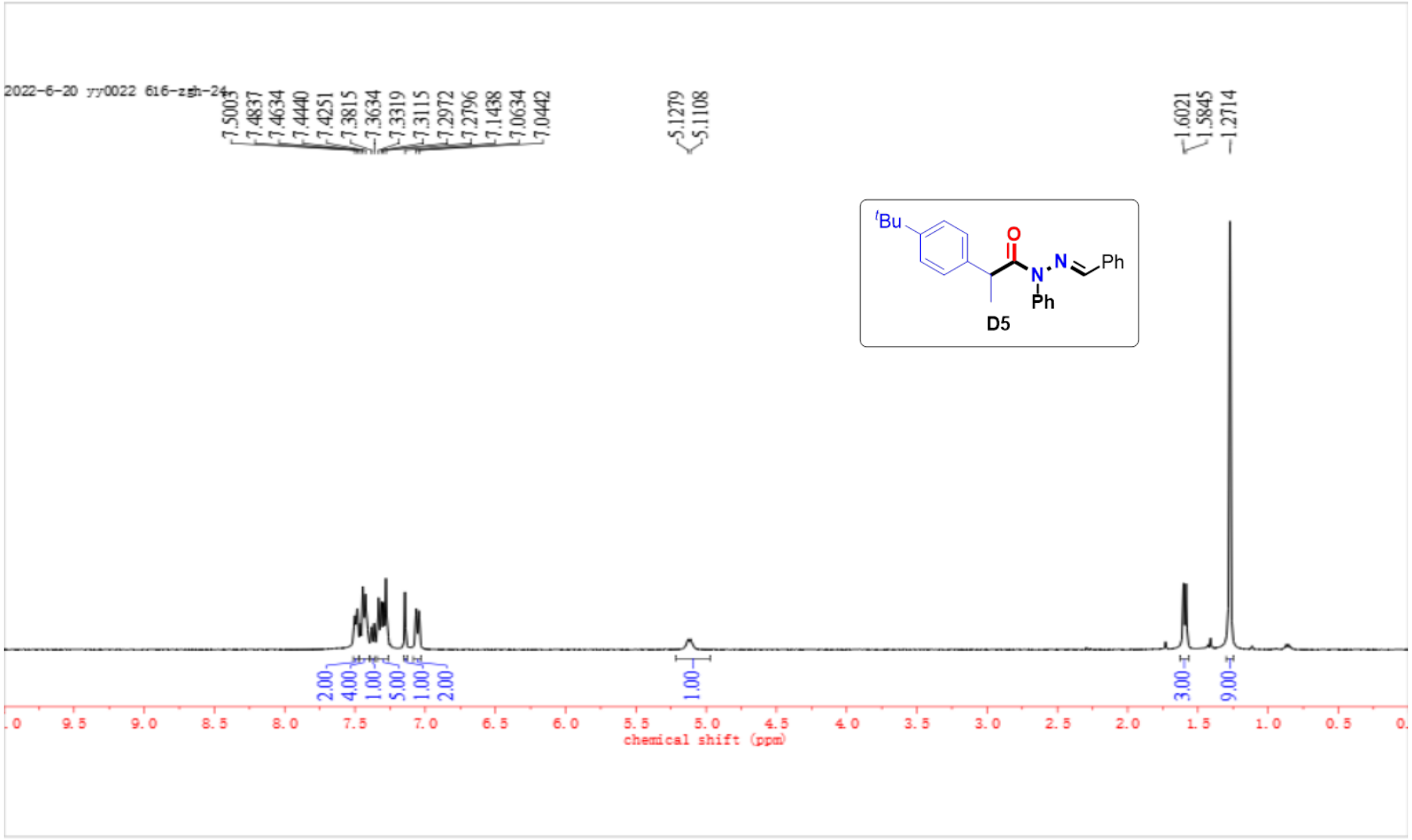
chemical shift (ppm)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7.0442
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1.2714
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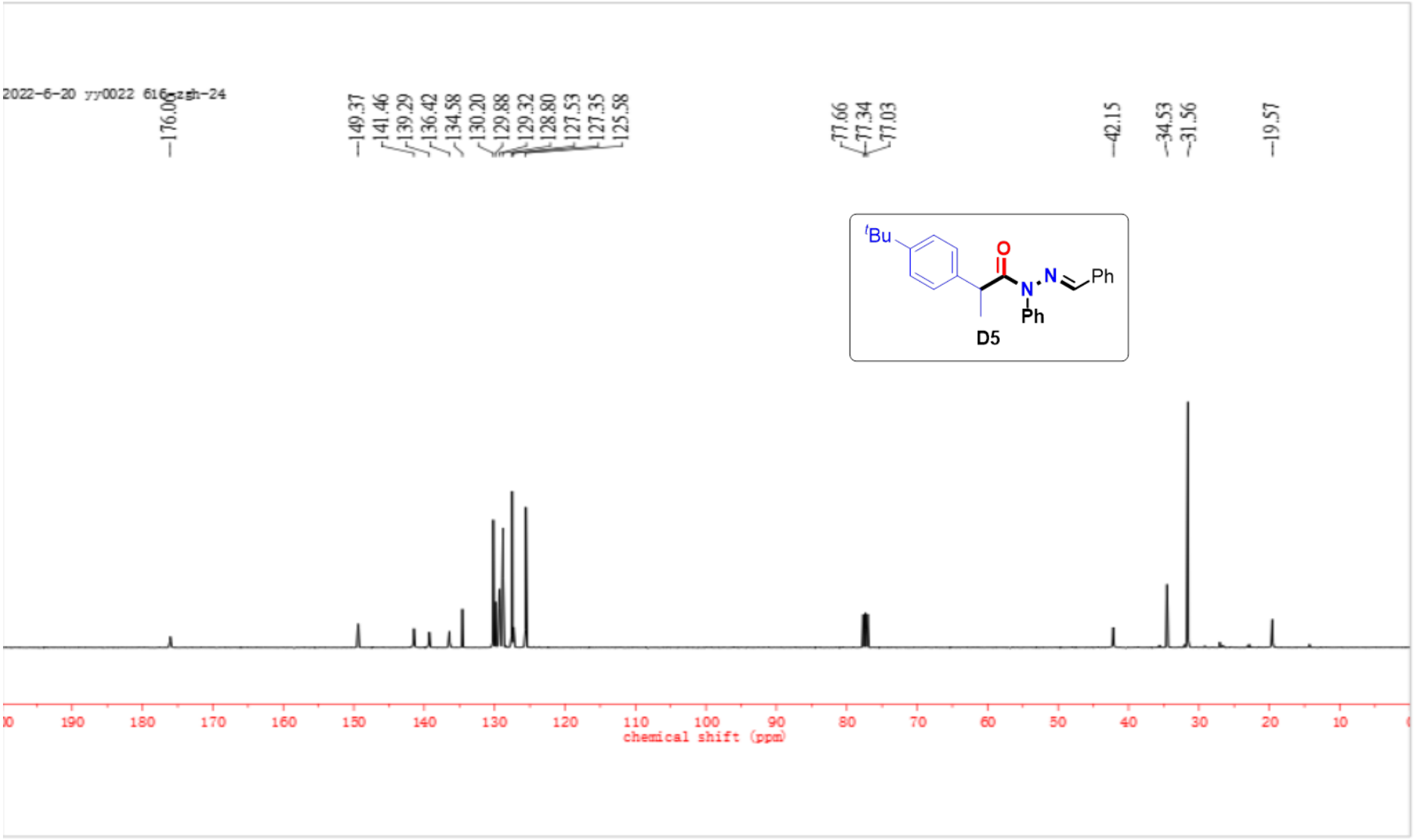
chemical shift (ppm)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N
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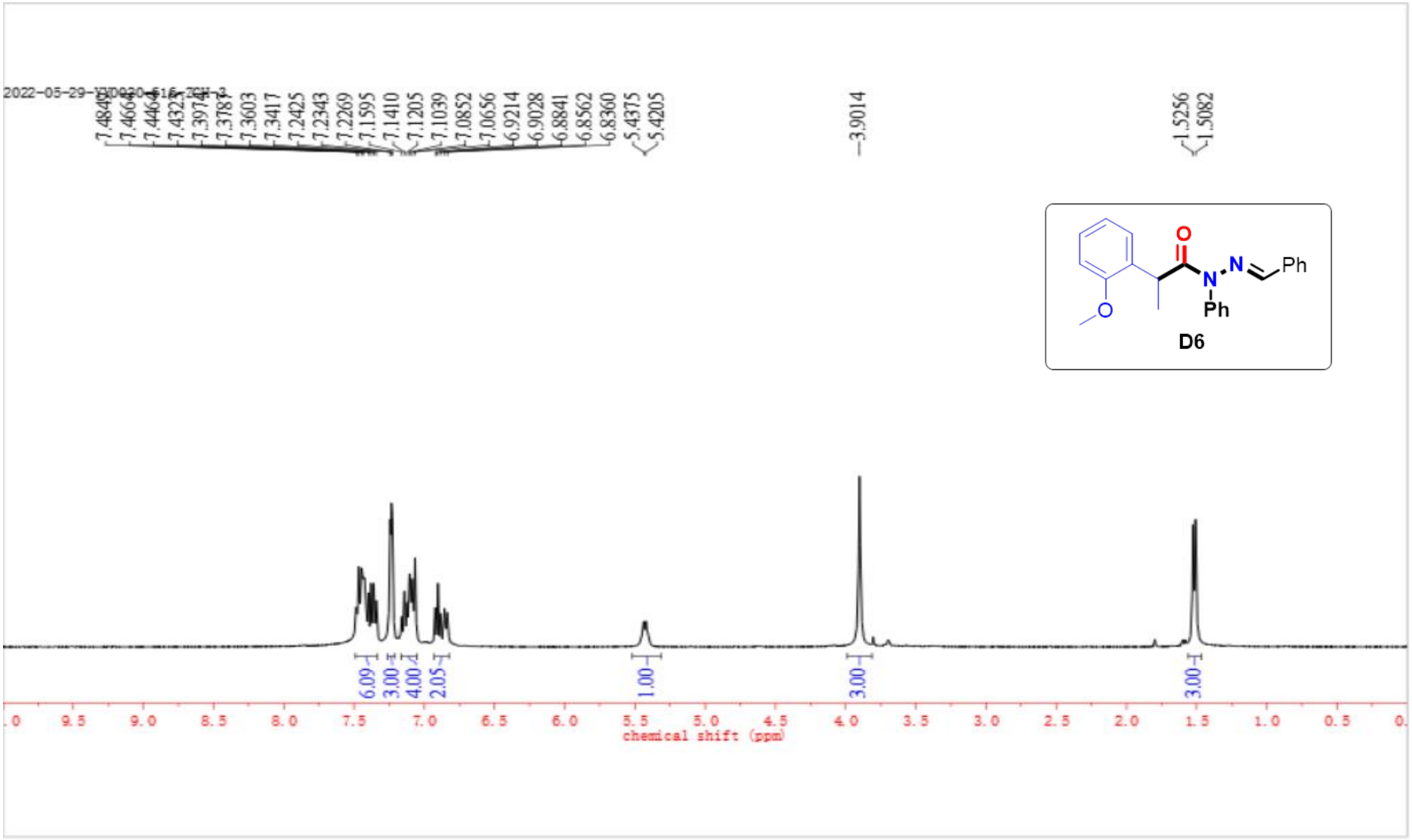
Ph
Ph
D5
chemical shift (ppm)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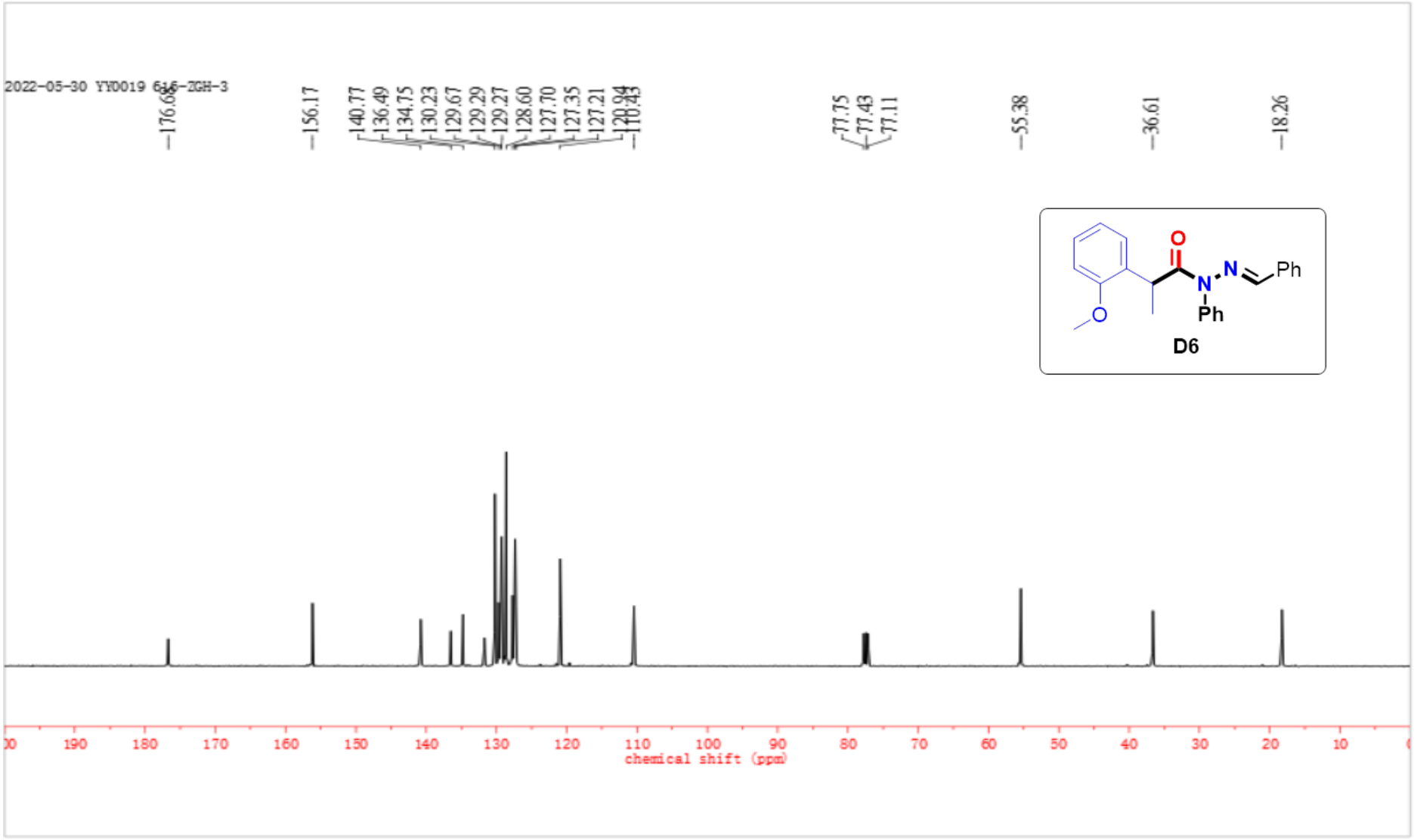
chemical shift (ppm)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55.38
36.61
18.26
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O
Ph
D6
190
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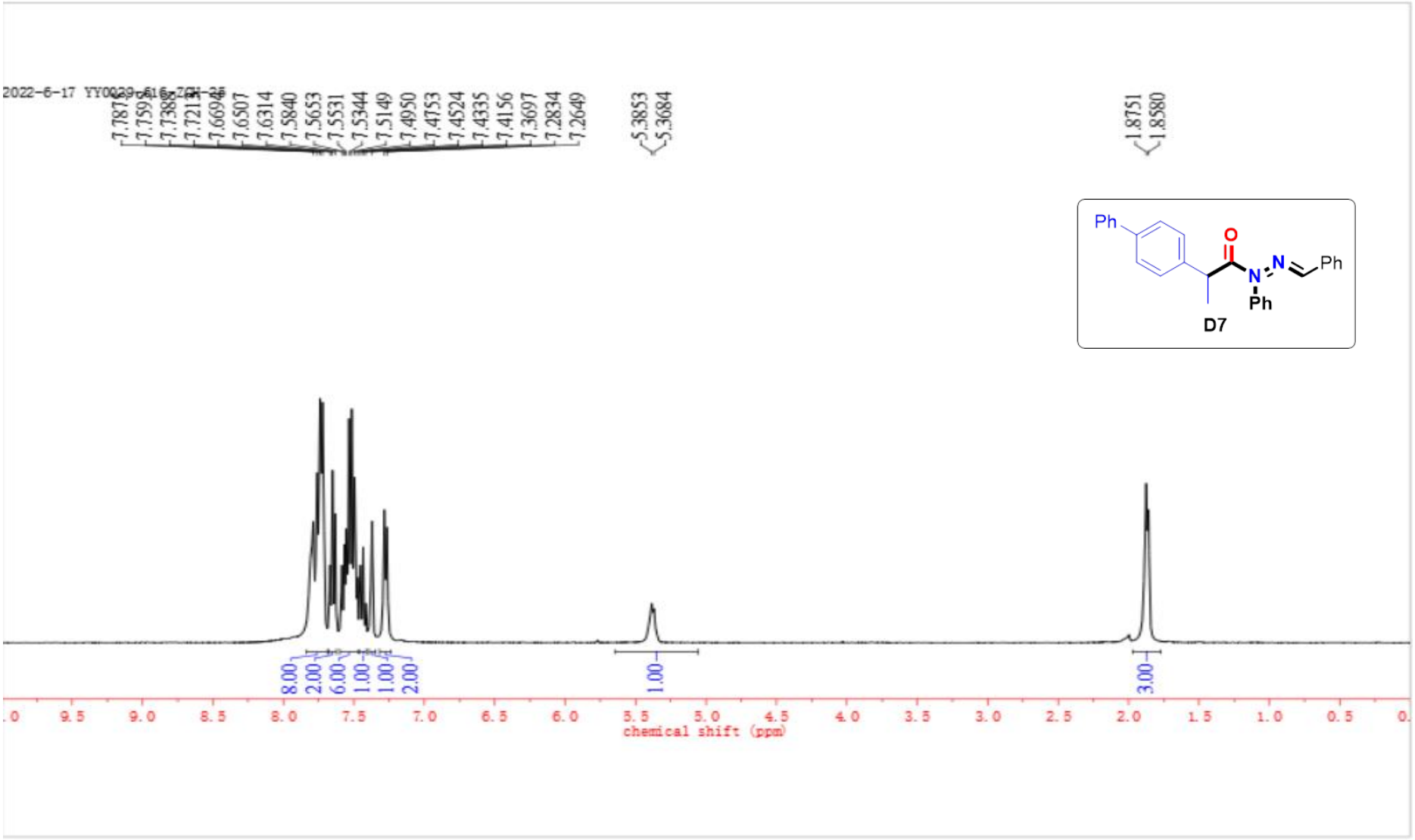
chemical shift (ppm)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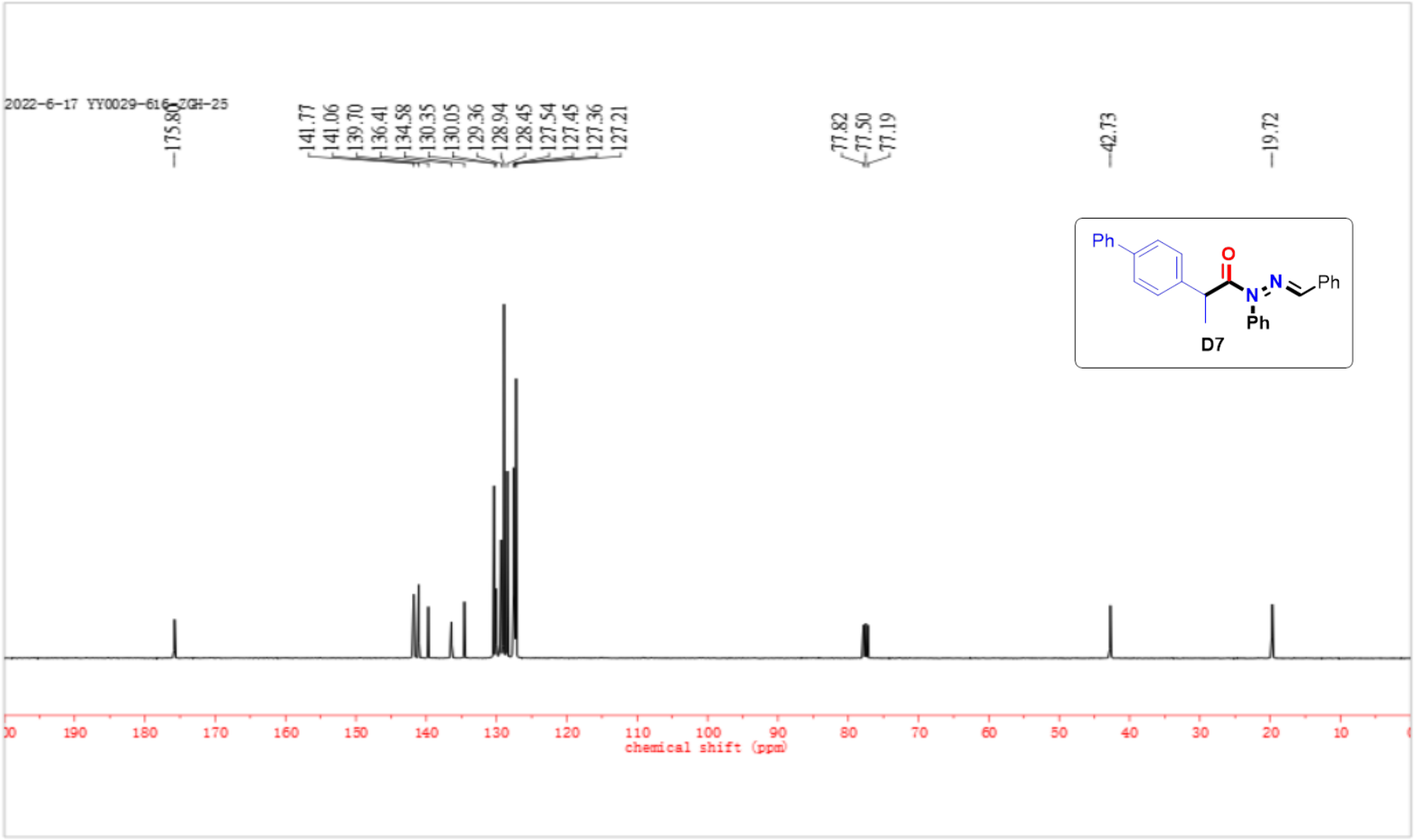
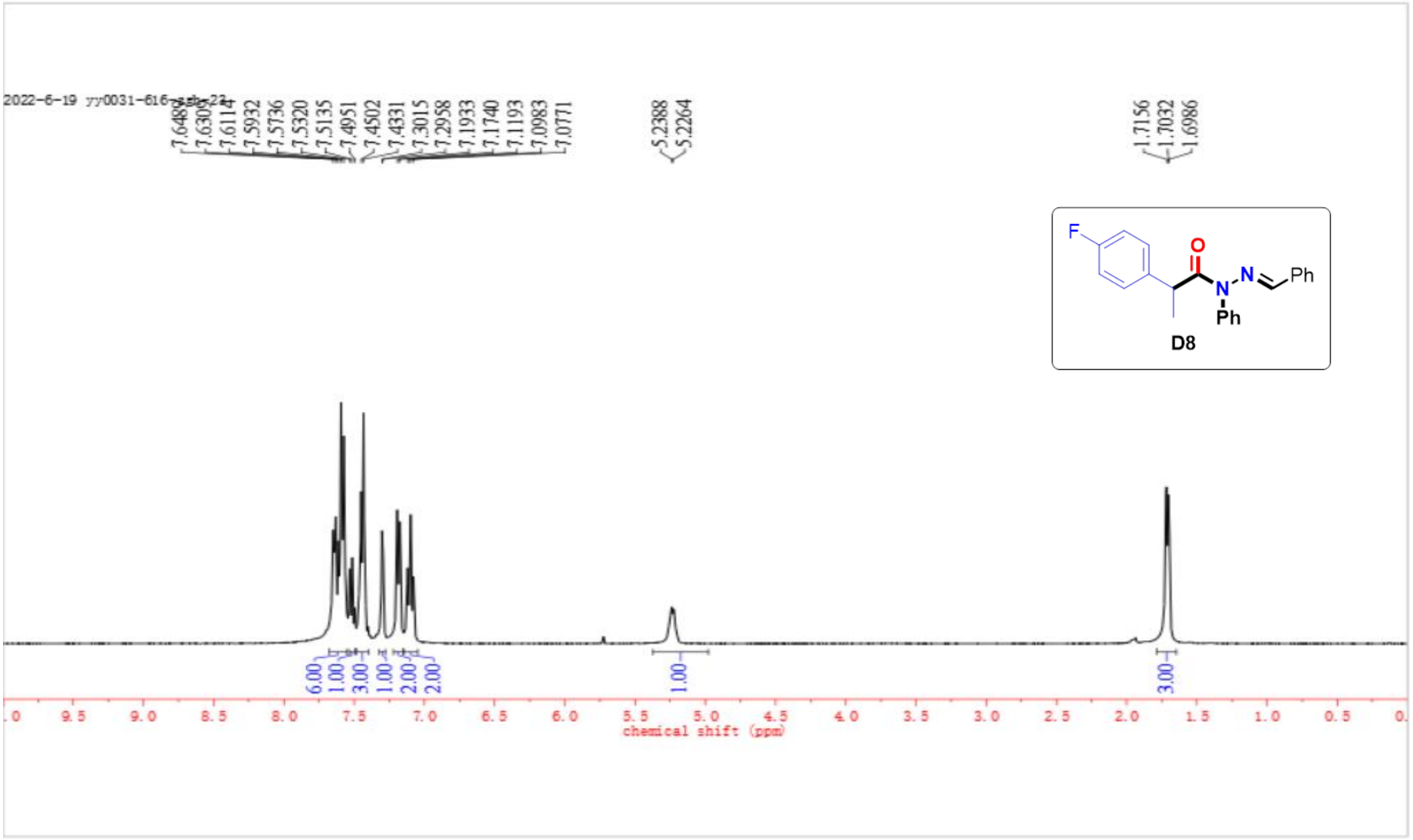
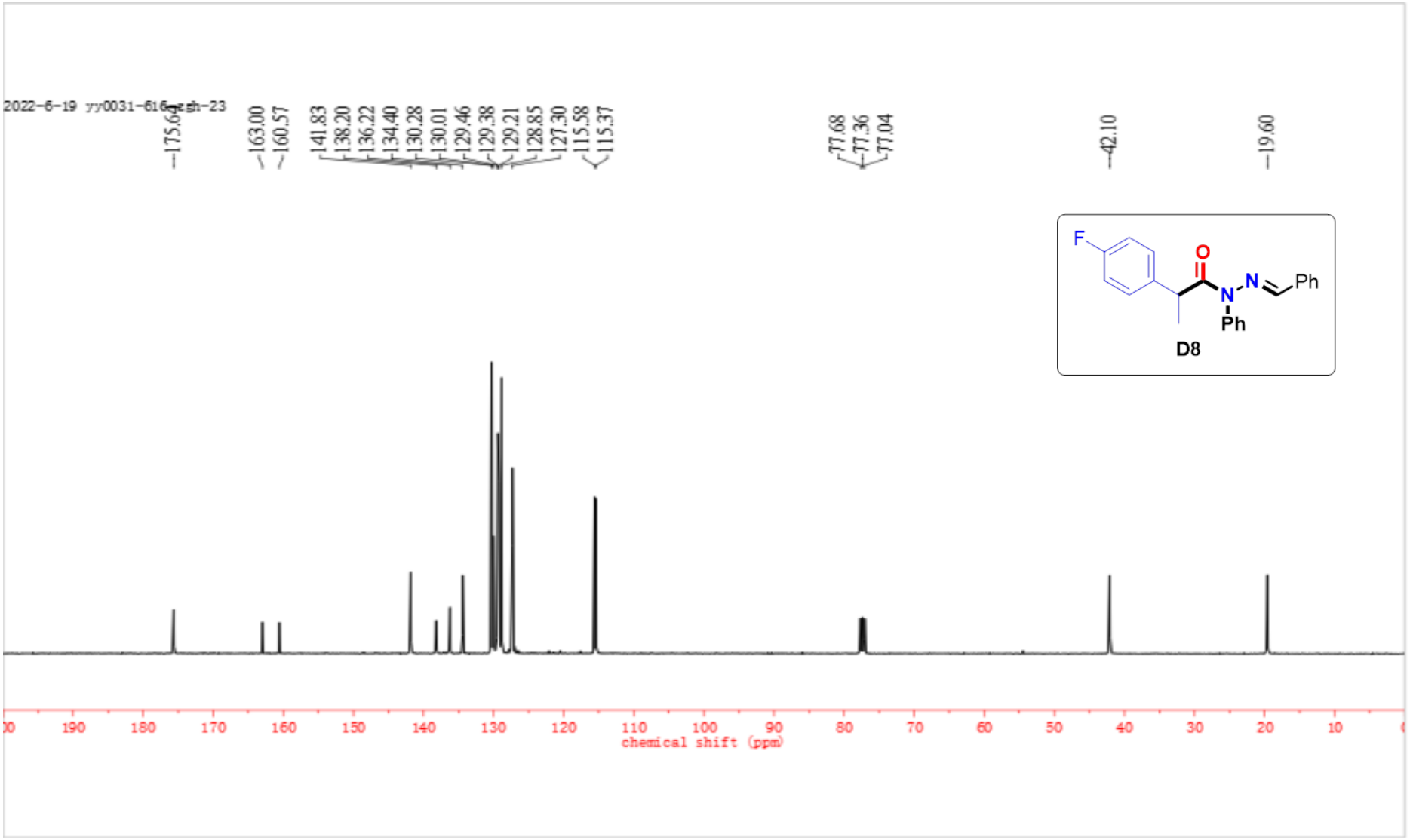
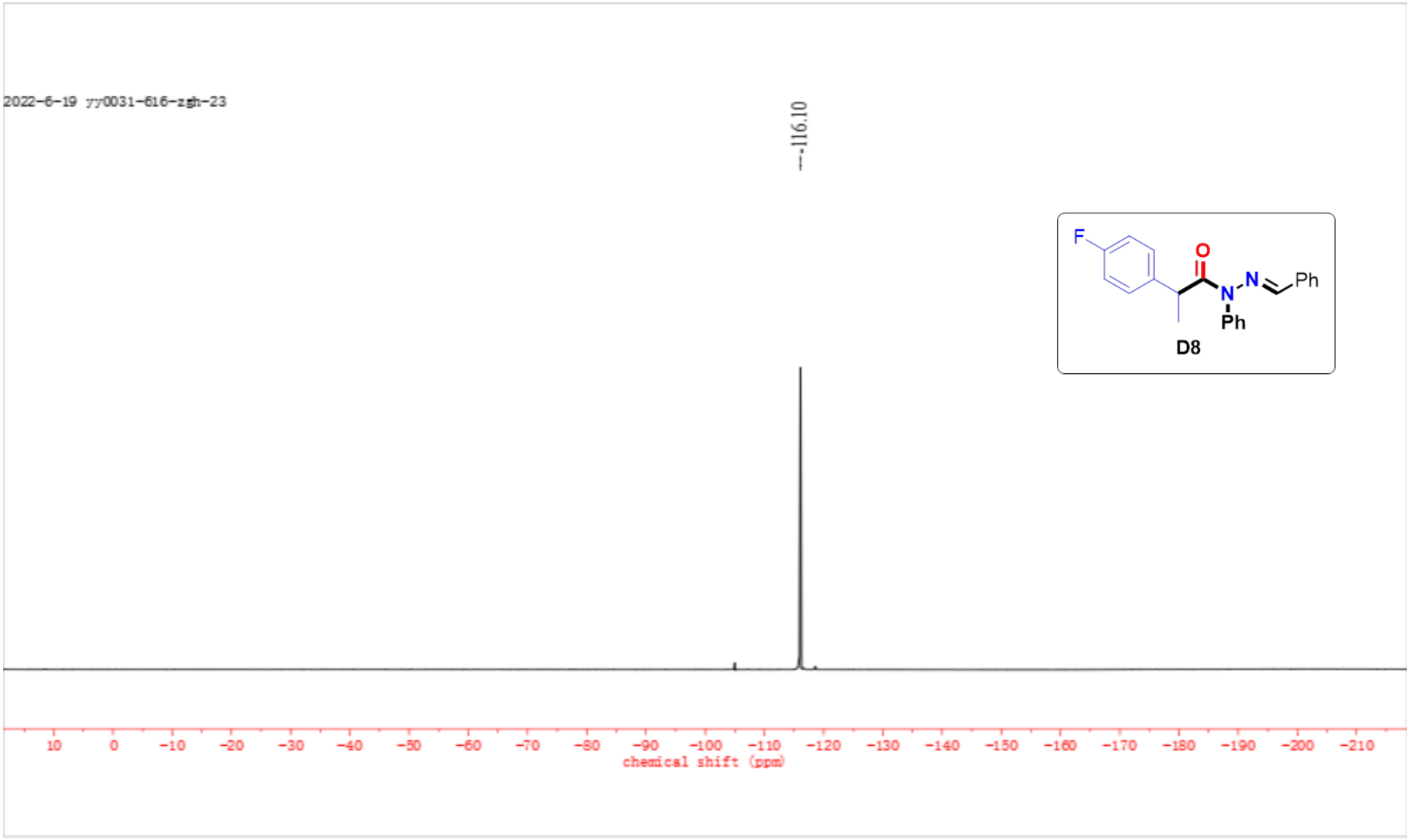
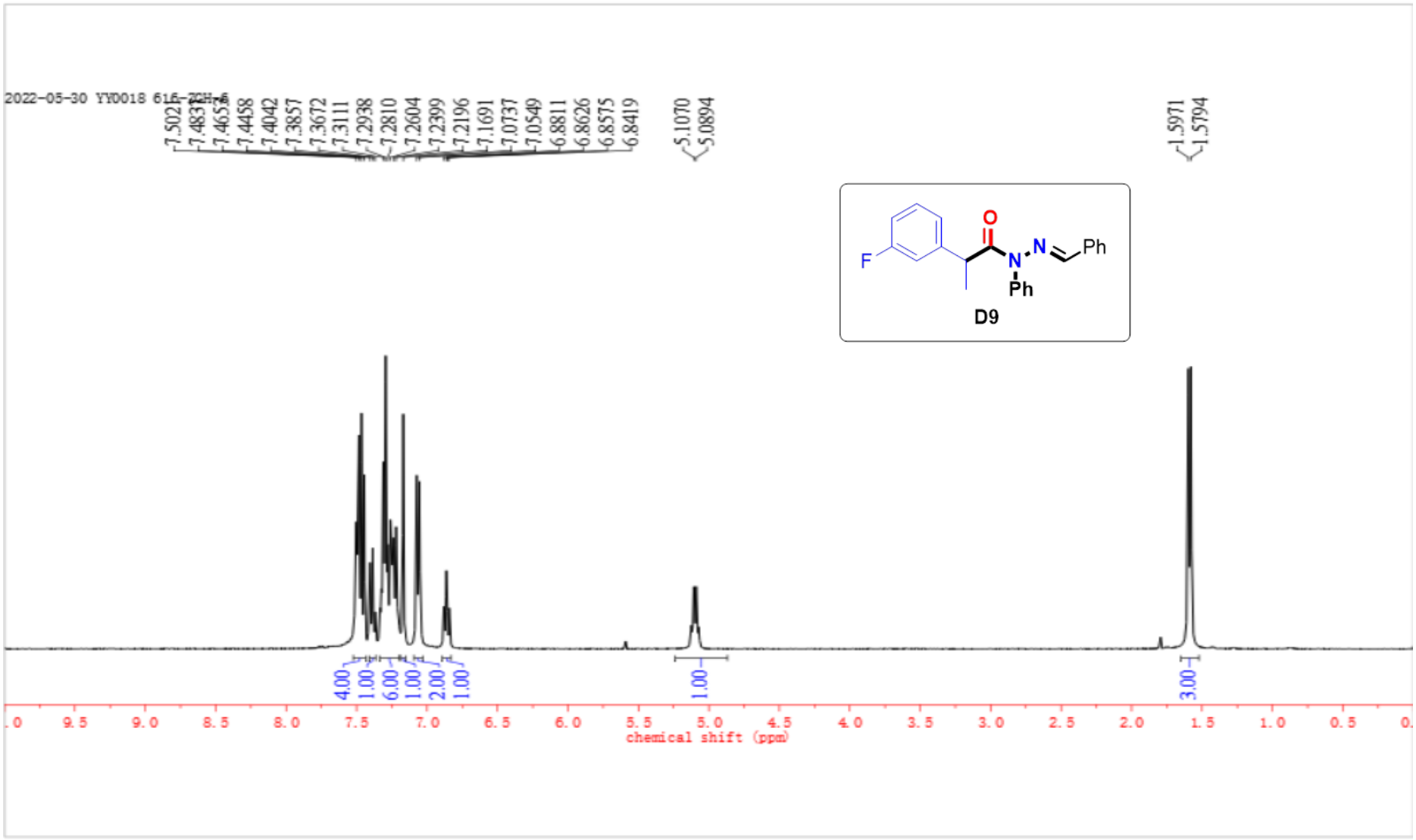
7.3697
7.2834
7.2649
5.3853
5.3684
1.8751
1.8580
Ph
O
N
N
Ph
Ph
D7
8.00
2.00
6.00
1.00
1.00
2.00
1.00
3.00
chemical shift (ppm)

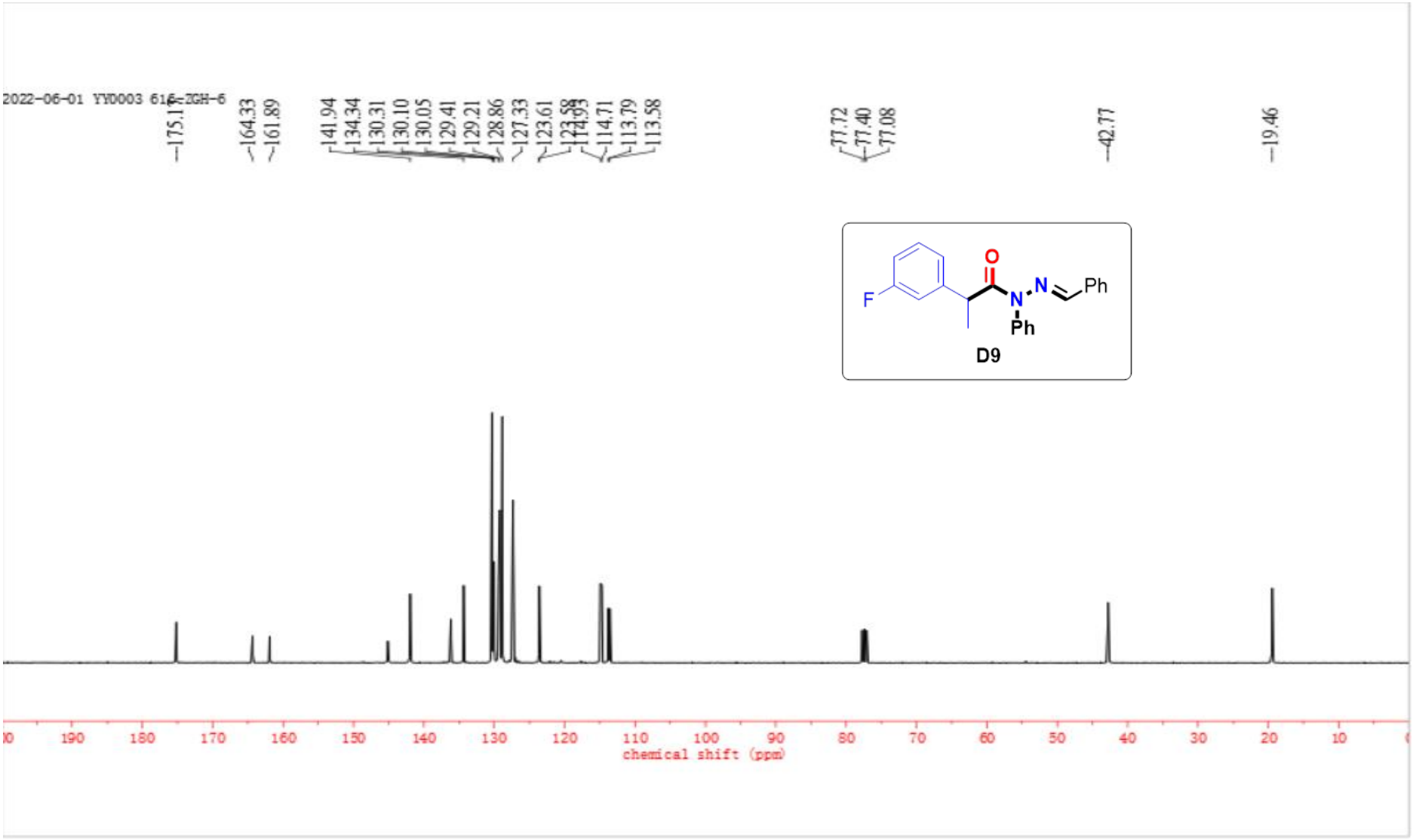

2022-6-17 YY0029-616-ZGH-25
175.80
141.77
141.06
139.70
136.41
134.58
130.35
130.05
129.36
128.94
128.45
127.54
127.45
127.36
127.21
77.82
77.50
77.19
42.73
19.72
Ph
O
N
N
Ph
Ph
D7
chemical shift (ppm)

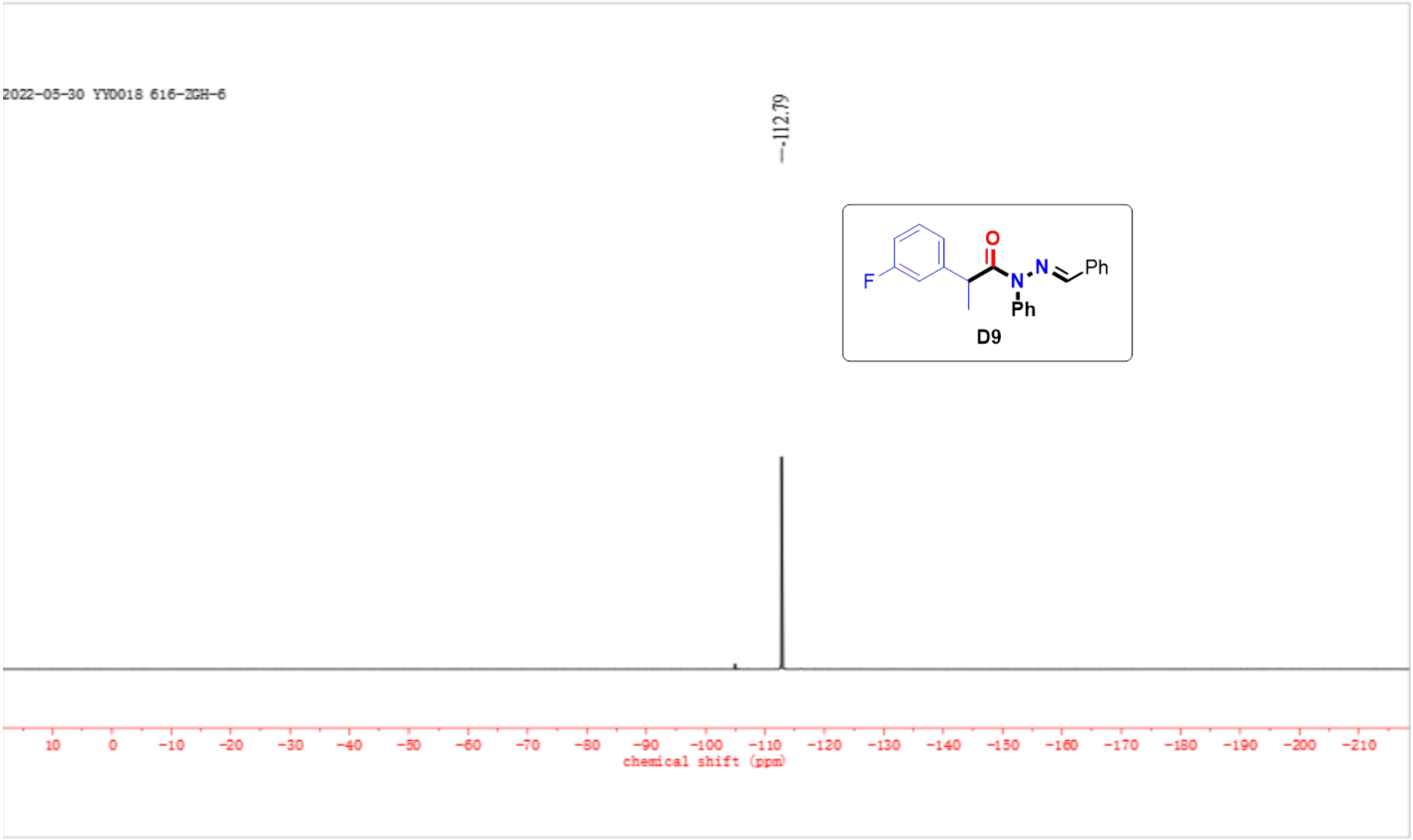

2022-6-19 yy0031-616
7.6489
7.6309
7.6114
7.5932
7.5736
7.5320
7.5135
7.4951
7.4502
7.4331
7.3015
7.2958
7.1933
7.1740
7.1193
7.0983
7.0771
5.2388
5.2264
1.7156
1.7032
1.6986
F
O
N
N
Ph
Ph
D8
6.00
1.00
3.00
1.00
2.00
2.00
1.00
3.00
chemical shift (ppm)

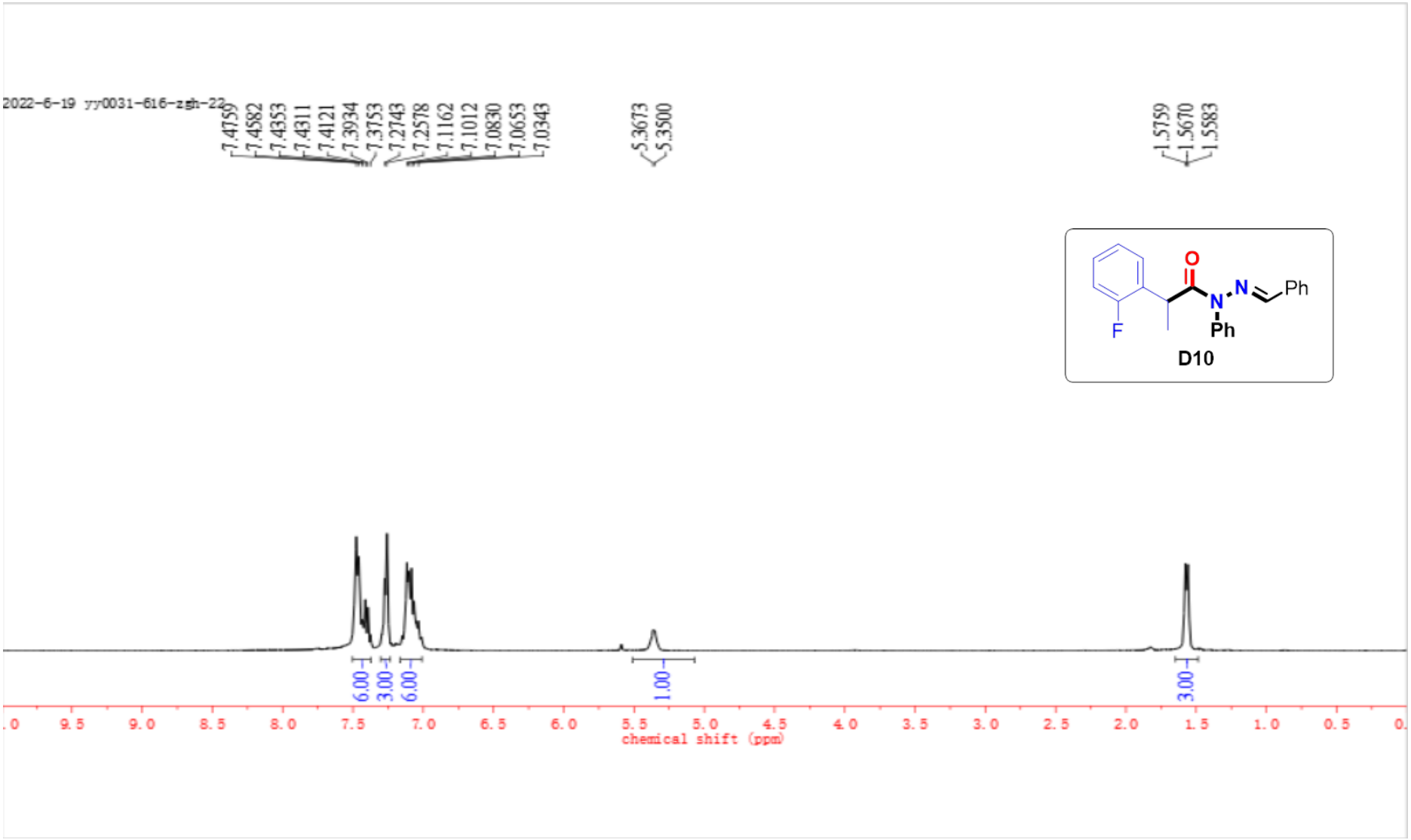

2022-6-19 yy0031-616-zgh-23
175.64
163.00
160.57
141.83
138.20
136.22
134.40
130.28
130.01
129.46
129.38
129.21
128.85
127.30
115.58
115.37
77.68
77.36
77.04
42.10
19.60
F
O
N
N
Ph
Ph
D8
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

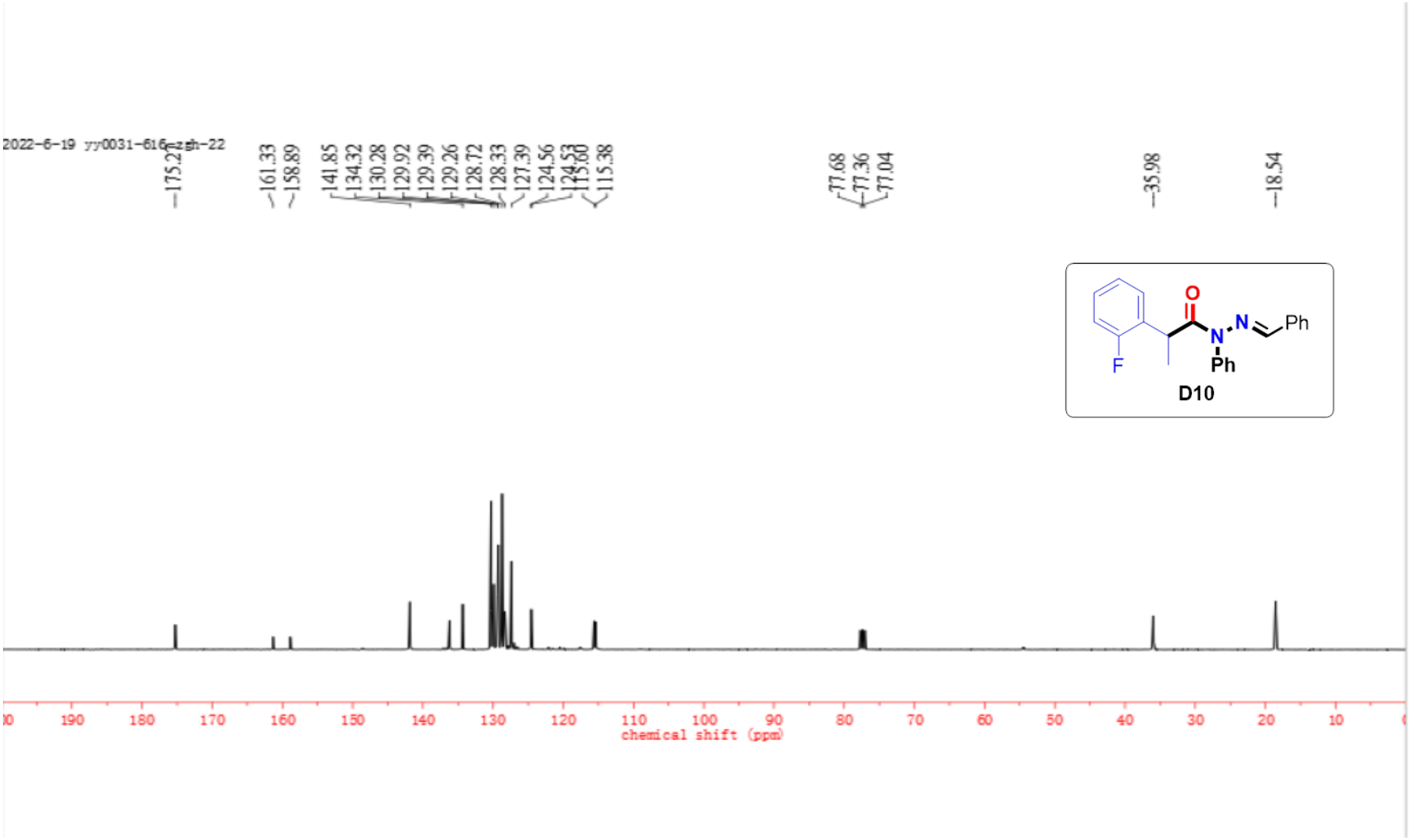

2022-6-19 yy0031-616-zgh-23
-116.10
F
O
N
N
Ph
Ph
D8
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
chemical shift (ppm)

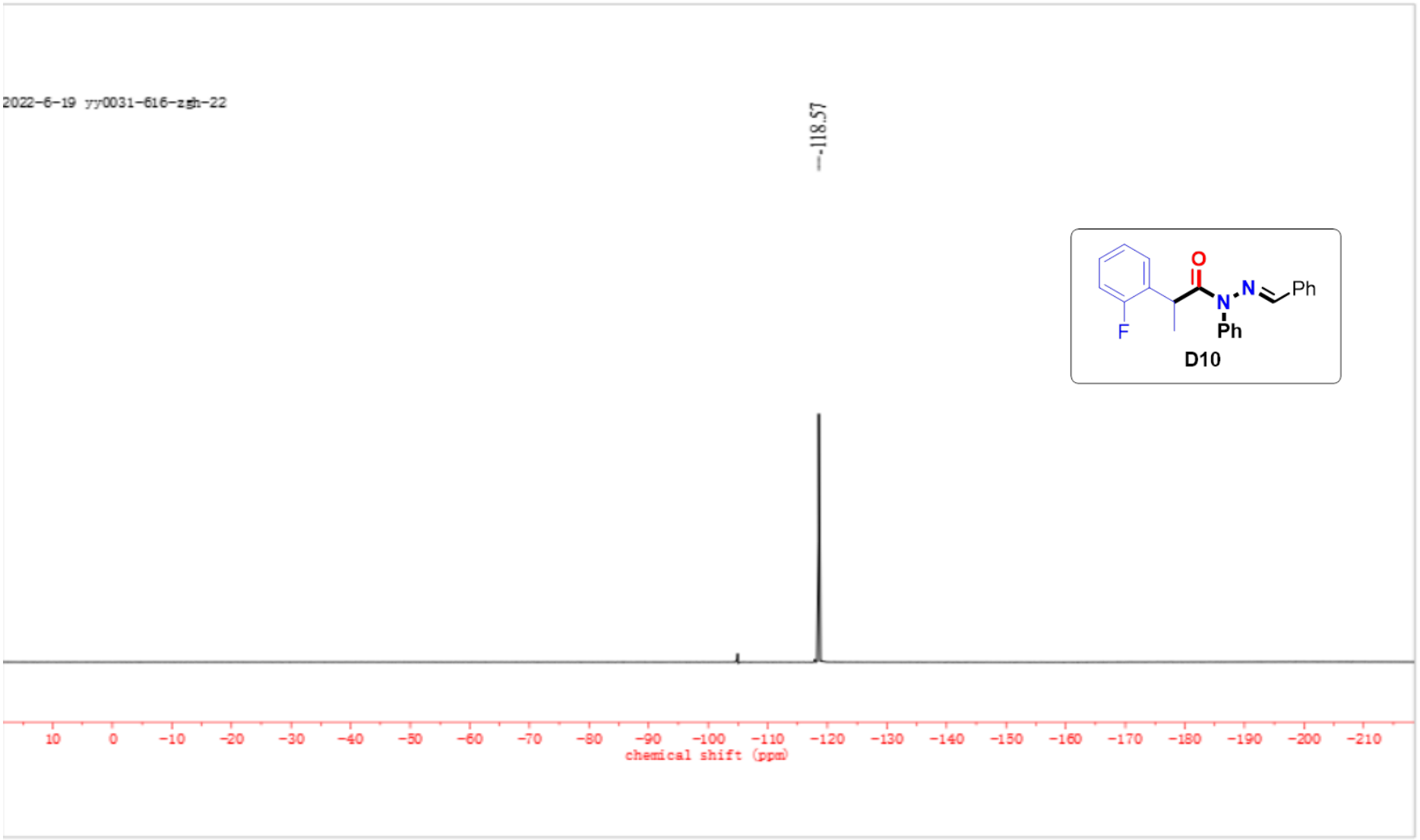

2022-05-30 YWD018 616-
7.5021
7.4837
7.4653
7.4458
7.4042
7.3857
7.3672
7.3111
7.2938
7.2810
7.2604
7.2399
7.2196
7.1691
7.0737
7.0549
6.8811
6.8626
6.8575
6.8419
5.1070
5.0894
1.5971
1.5794
F
O
N
N
Ph
Ph
D9
4.00
1.00
6.00
1.00
2.00
1.00
1.00
3.00
chemical shift (ppm)

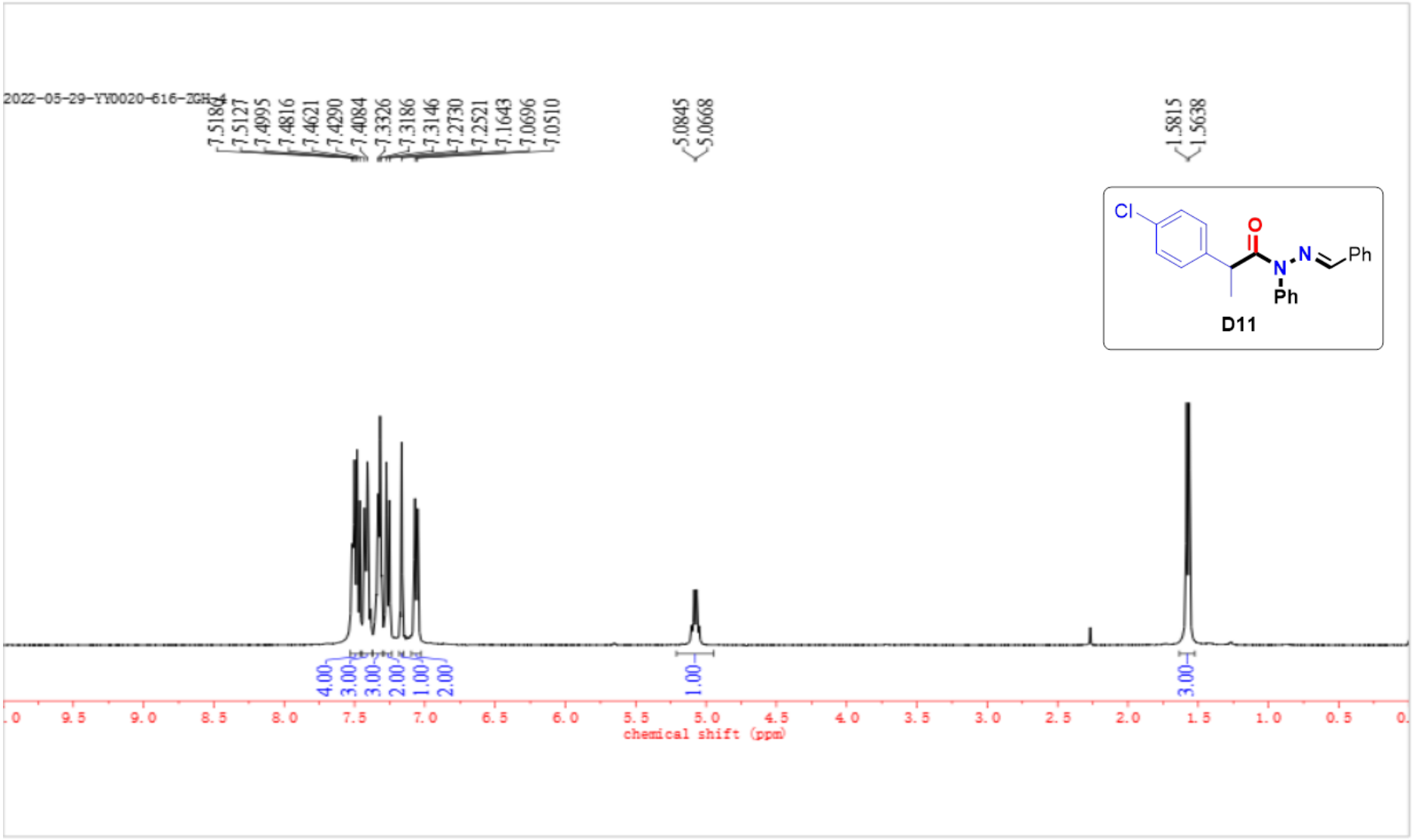

2022-06-01 YYD003 616-ZGH-6
175.17
164.33
161.89
141.94
134.34
130.31
130.10
130.05
129.41
129.21
128.86
127.33
123.61
123.58
114.93
114.71
113.79
113.58
77.72
77.40
77.08
42.77
19.46
F
O
N
N
Ph
Ph
D9
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

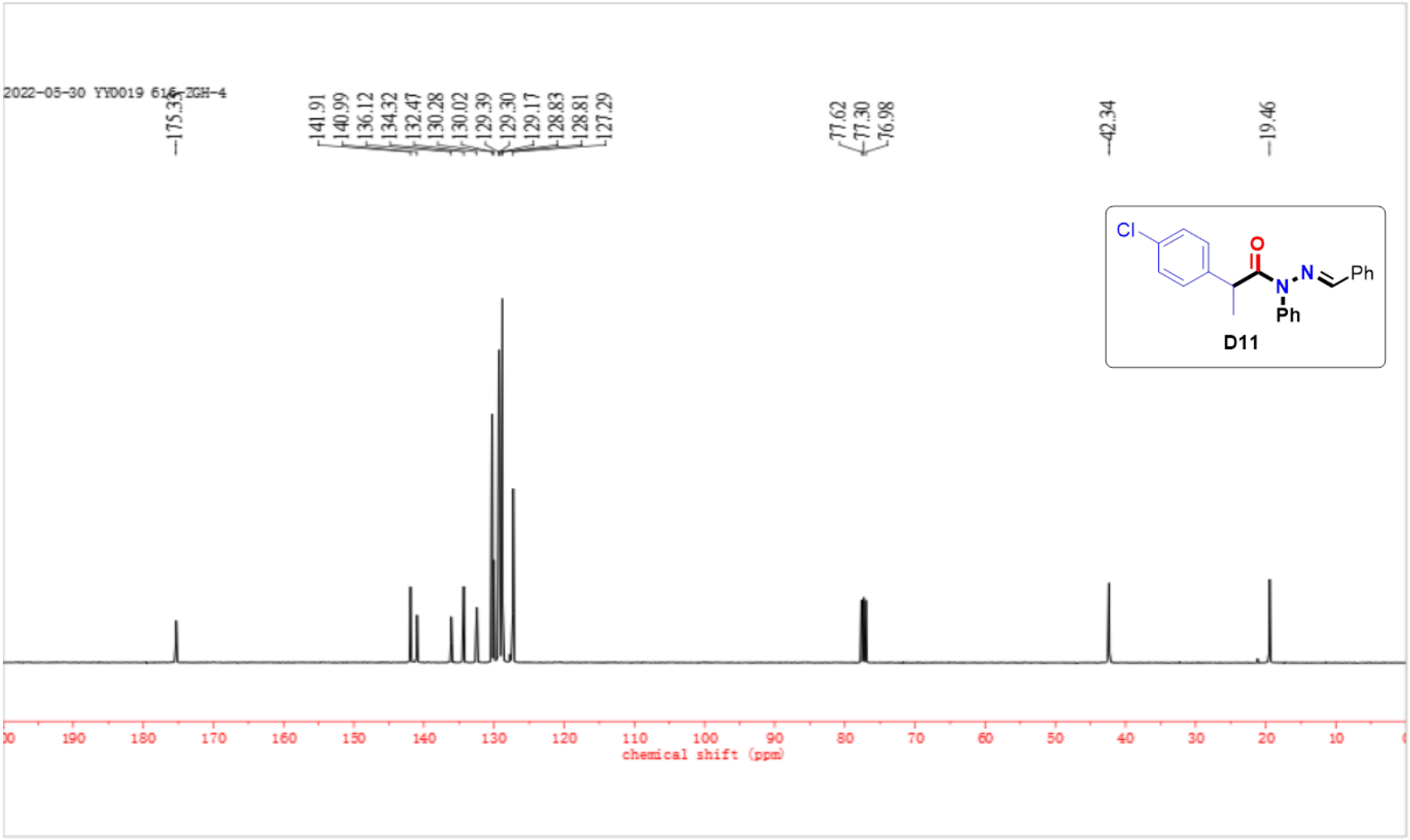

2022-05-30 YWD018 616-ZGH-6
-112.79
F
O
N
N
Ph
Ph
D9
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

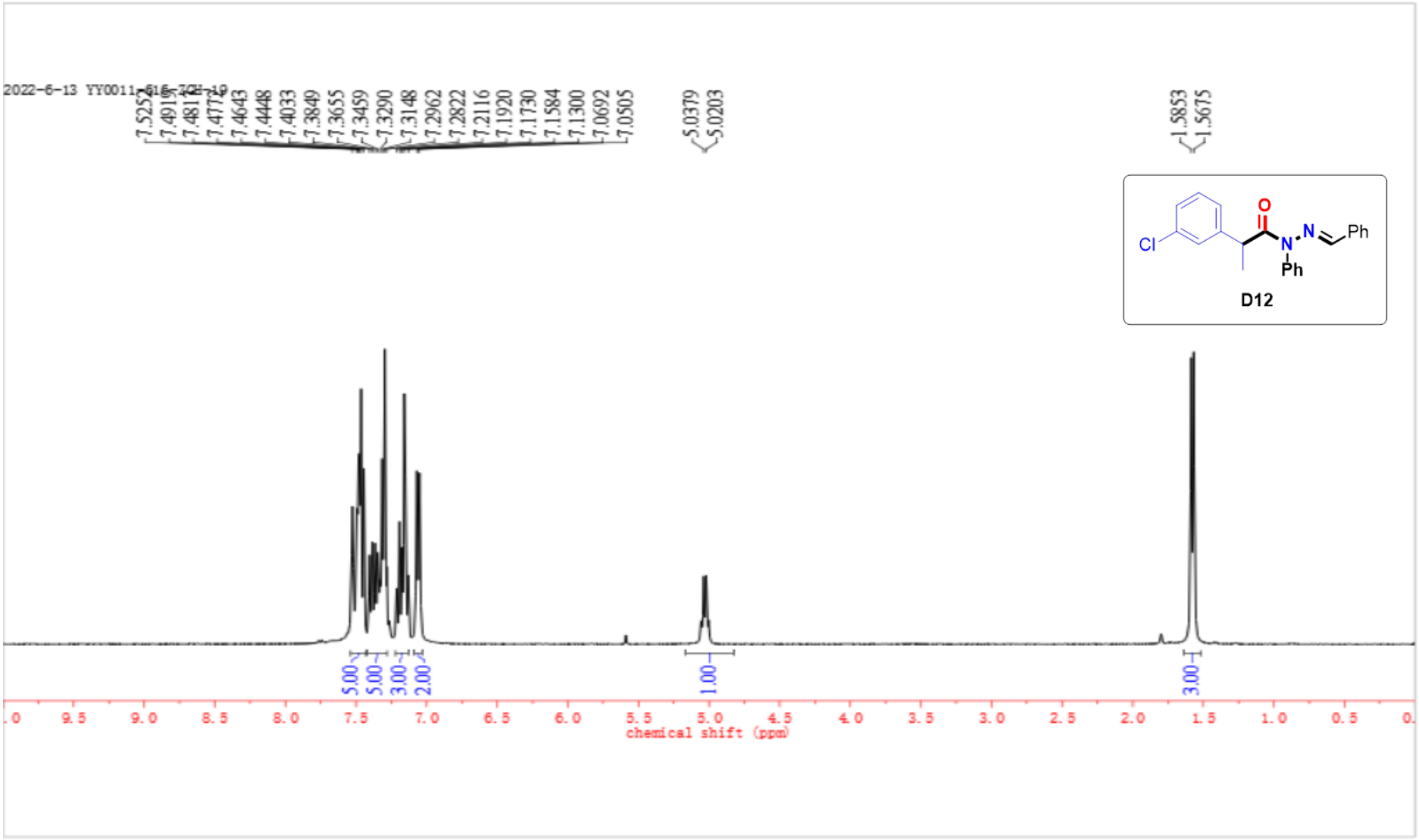

2022-6-19 yy0031-616-zgh-22
7.4759
7.4582
7.4353
7.4311
7.4121
7.3934
7.3753
7.2743
7.2578
7.1162
7.1012
7.0830
7.0653
7.0343
5.3673
5.3500
1.5759
1.5670
1.5583
O
N
N
Ph
Ph
F
D10
6.00
3.00
6.00
1.00
3.00
chemical shift (ppm)

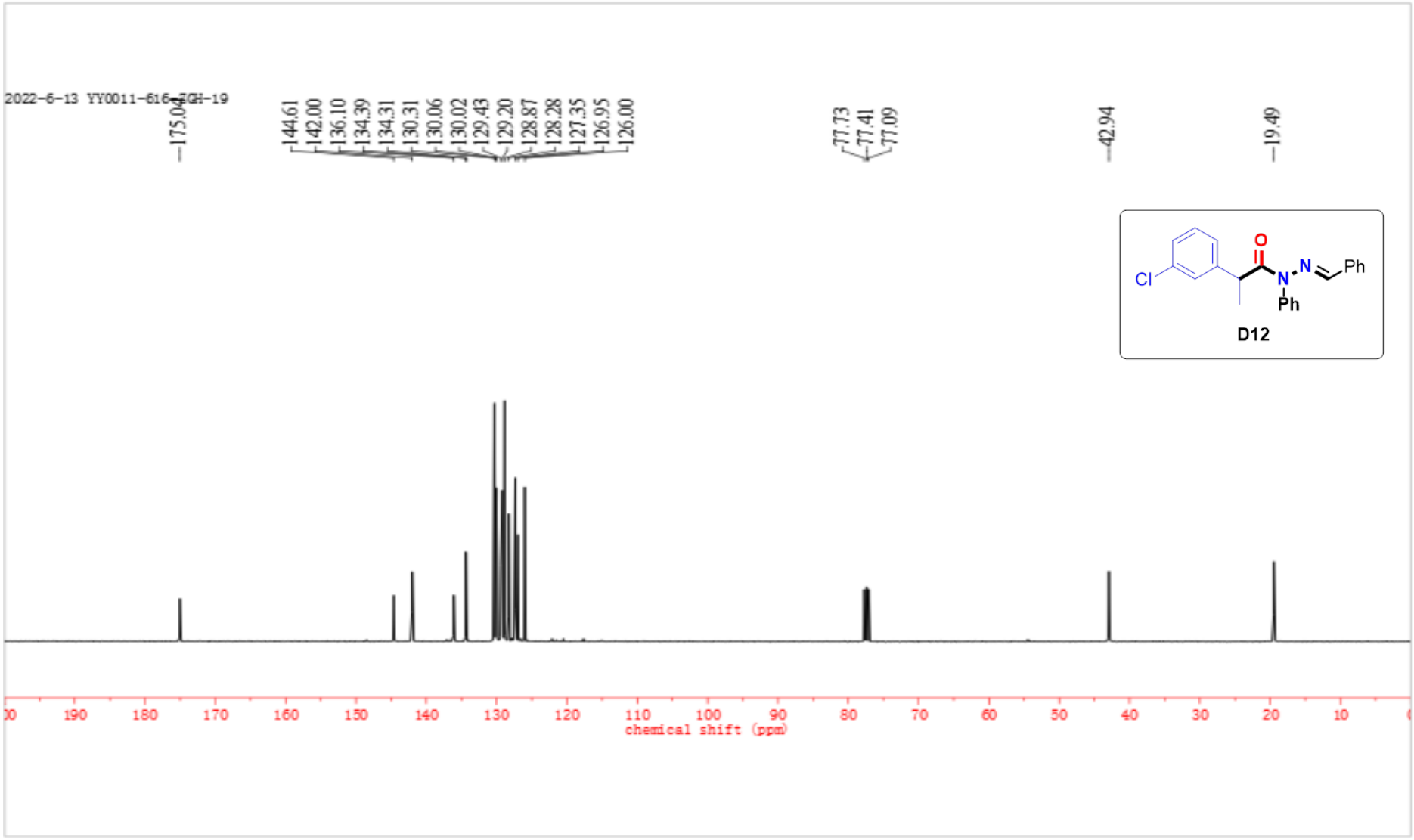

2022-6-19 yy0031-616-zgh-22
175.27
161.33
158.89
141.85
134.32
130.28
129.92
129.39
129.26
128.72
128.33
127.39
124.56
124.53
115.60
115.38
77.68
77.36
77.04
35.98
18.54
O
N
N
Ph
F
Ph
D10
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

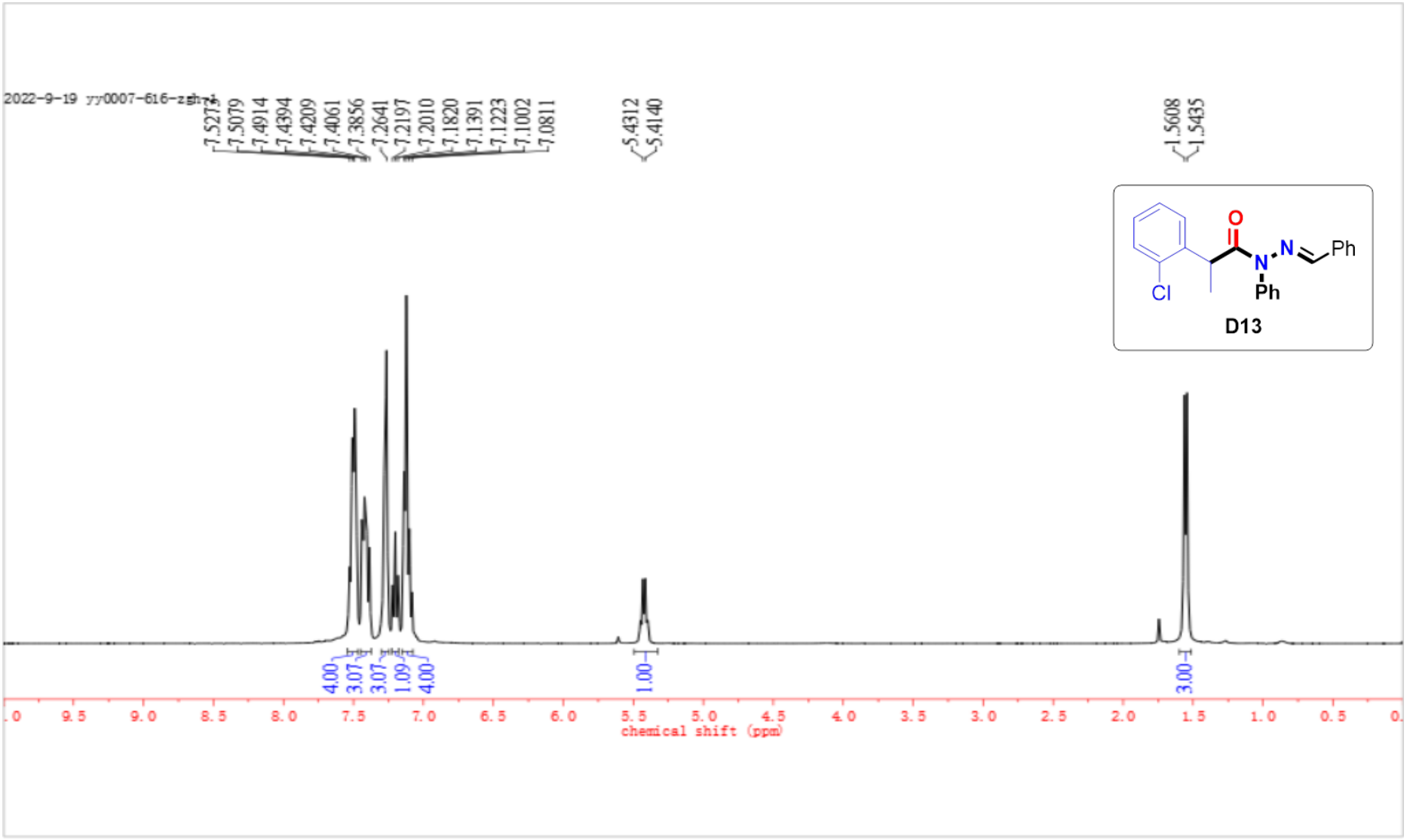

2022-6-19 yy0031-616-zgh-22
-118.57
O
N
N
Ph
Ph
F
D10
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
chemical shift (ppm)

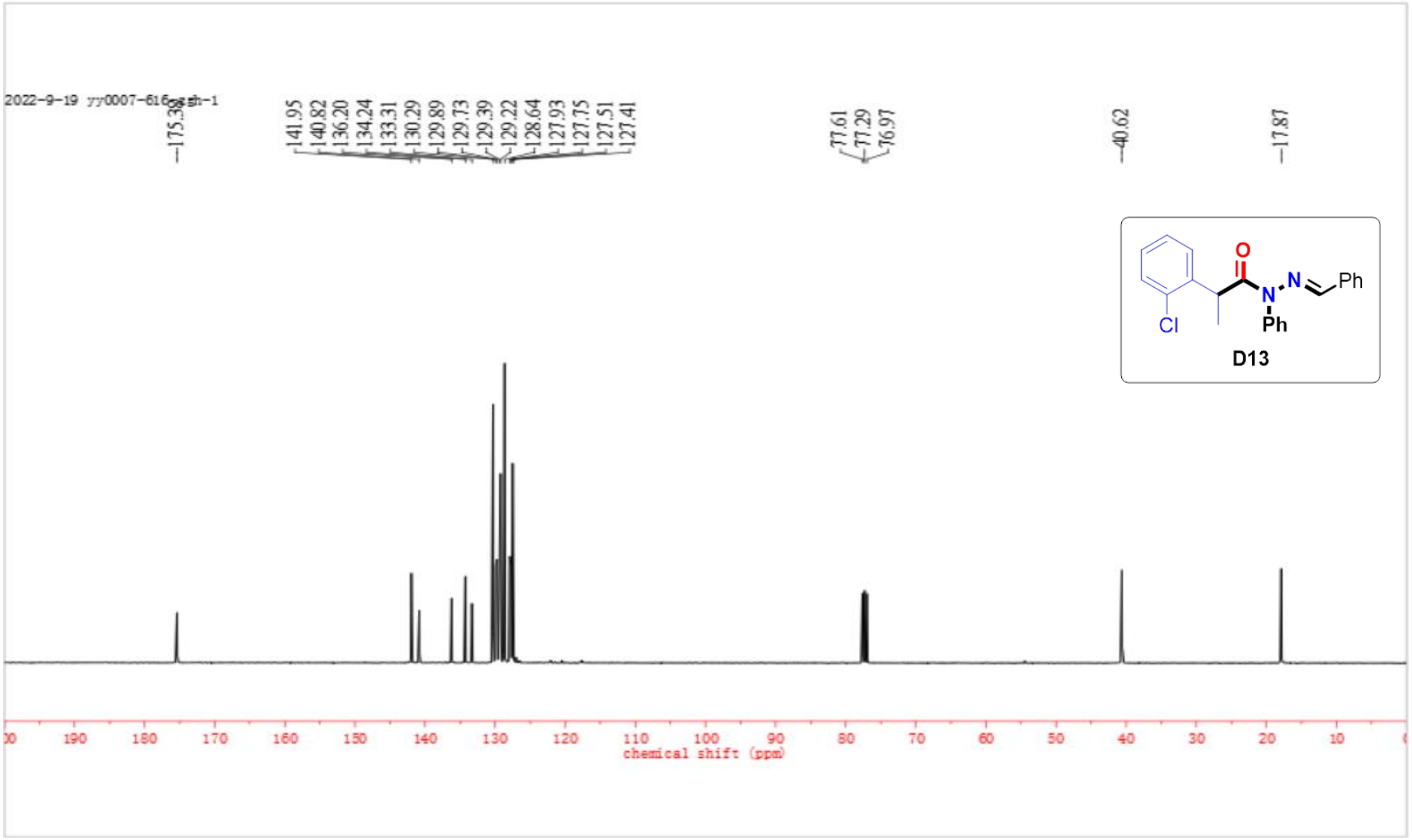

2022-05-29-YYD020-616-ZGH-4
7.5184
7.5127
7.4995
7.4816
7.4621
7.4290
7.4084
7.3326
7.3186
7.3146
7.2730
7.2521
7.1643
7.0696
7.0510
5.0845
5.0668
1.5815
1.5638
Cl
O
N
N
Ph
Ph
D11
4.00
3.00
3.00
2.00
1.00
2.00
1.00
3.00
chemical shift (ppm)

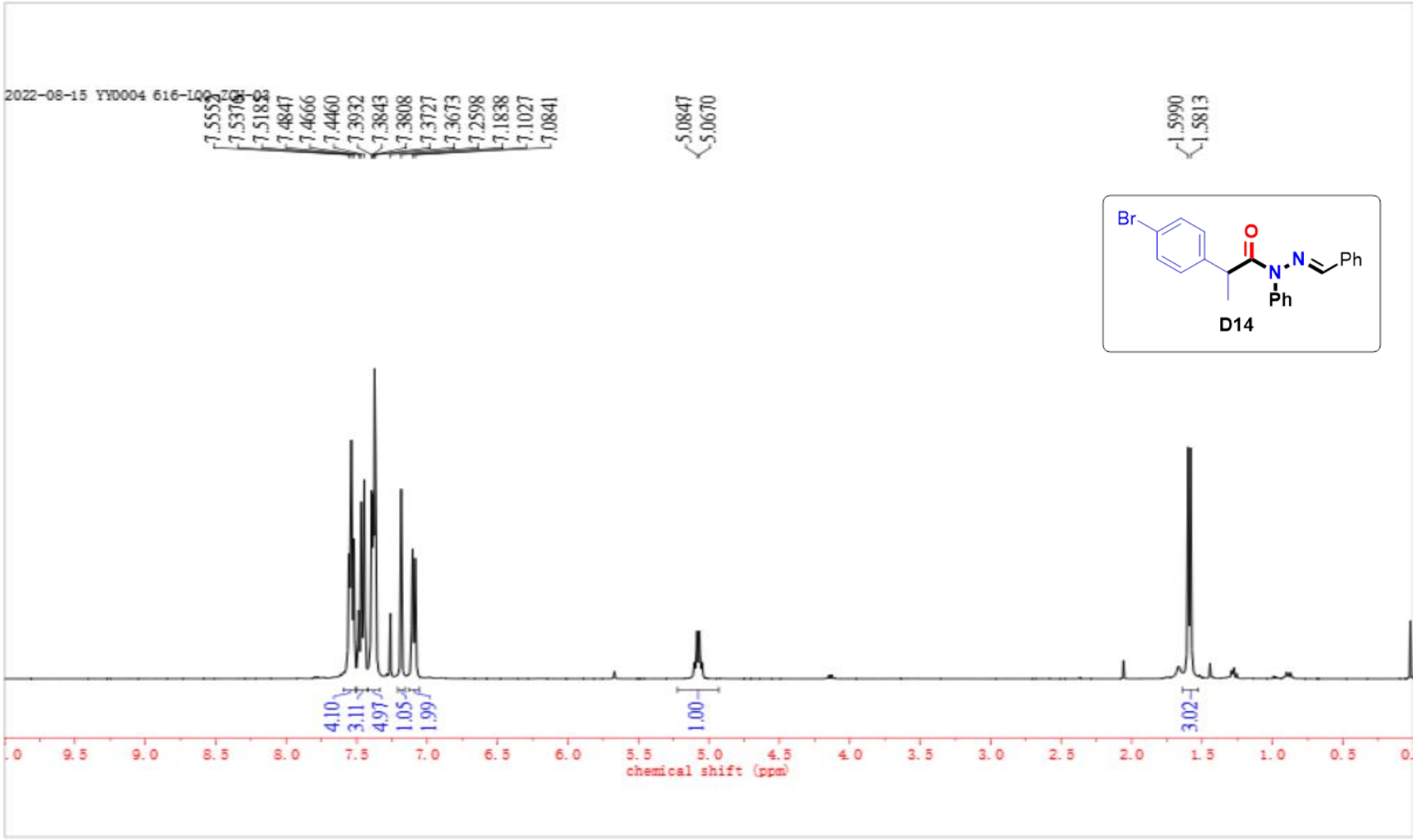

2022-05-30 YYD019 616 ZGH-4
175.33
141.91
140.99
136.12
134.32
132.47
130.28
130.02
129.39
129.30
129.17
128.83
128.81
127.29
77.62
77.30
76.98
42.34
19.46
Cl
O
N
N
Ph
Ph
D11
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

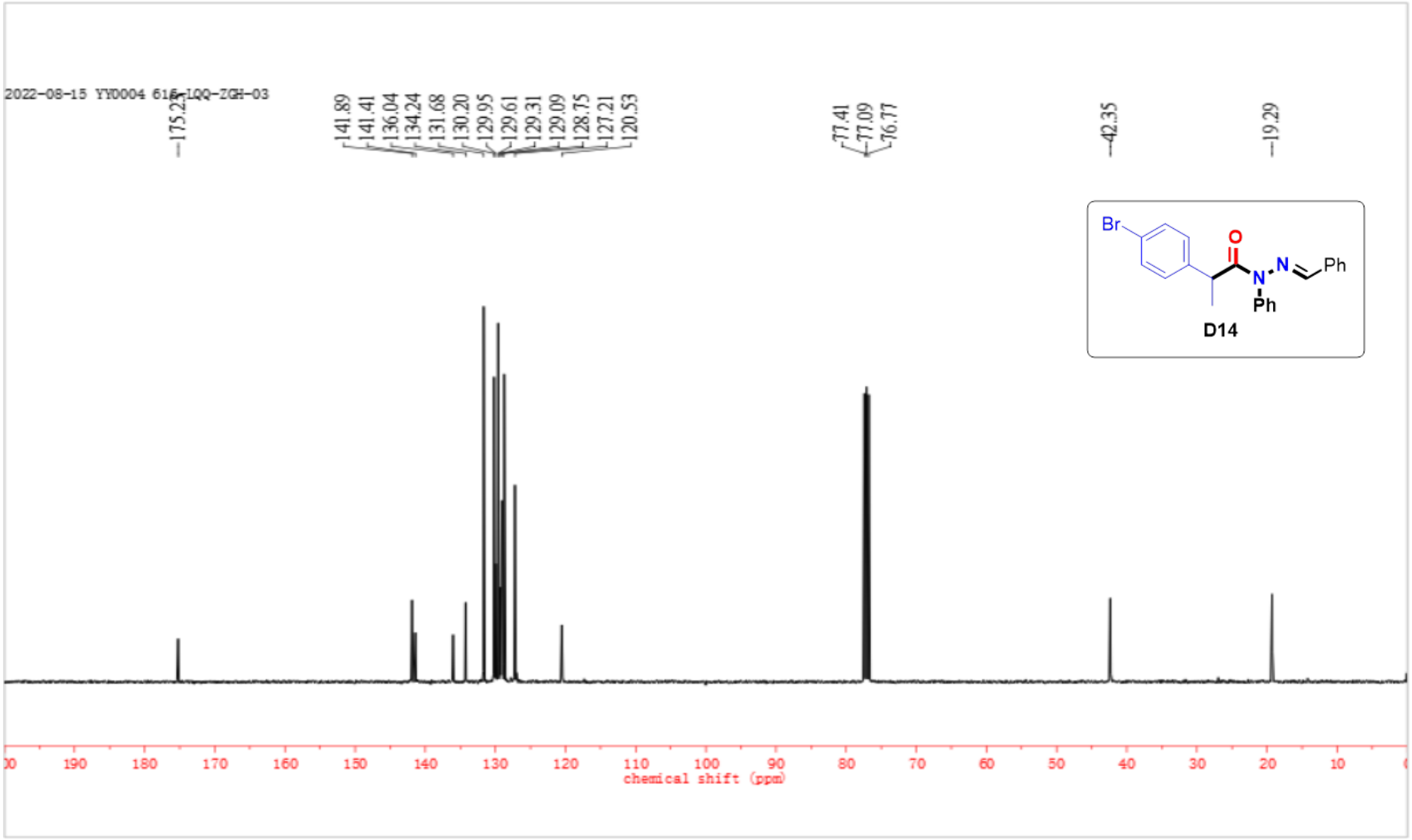

2022-6-13 YY0011-616-2CH-19
7.5252
7.4919
7.4811
7.4772
7.4643
7.4448
7.4033
7.3849
7.3655
7.3459
7.3290
7.3148
7.2962
7.2822
7.2116
7.1920
7.1730
7.1584
7.1300
7.0692
7.0505
5.0379
5.0203
1.5853
1.5675
Cl
O
N
N
Ph
Ph
D12
5.00
5.00
3.00
2.00
1.00
3.00
chemical shift (ppm)

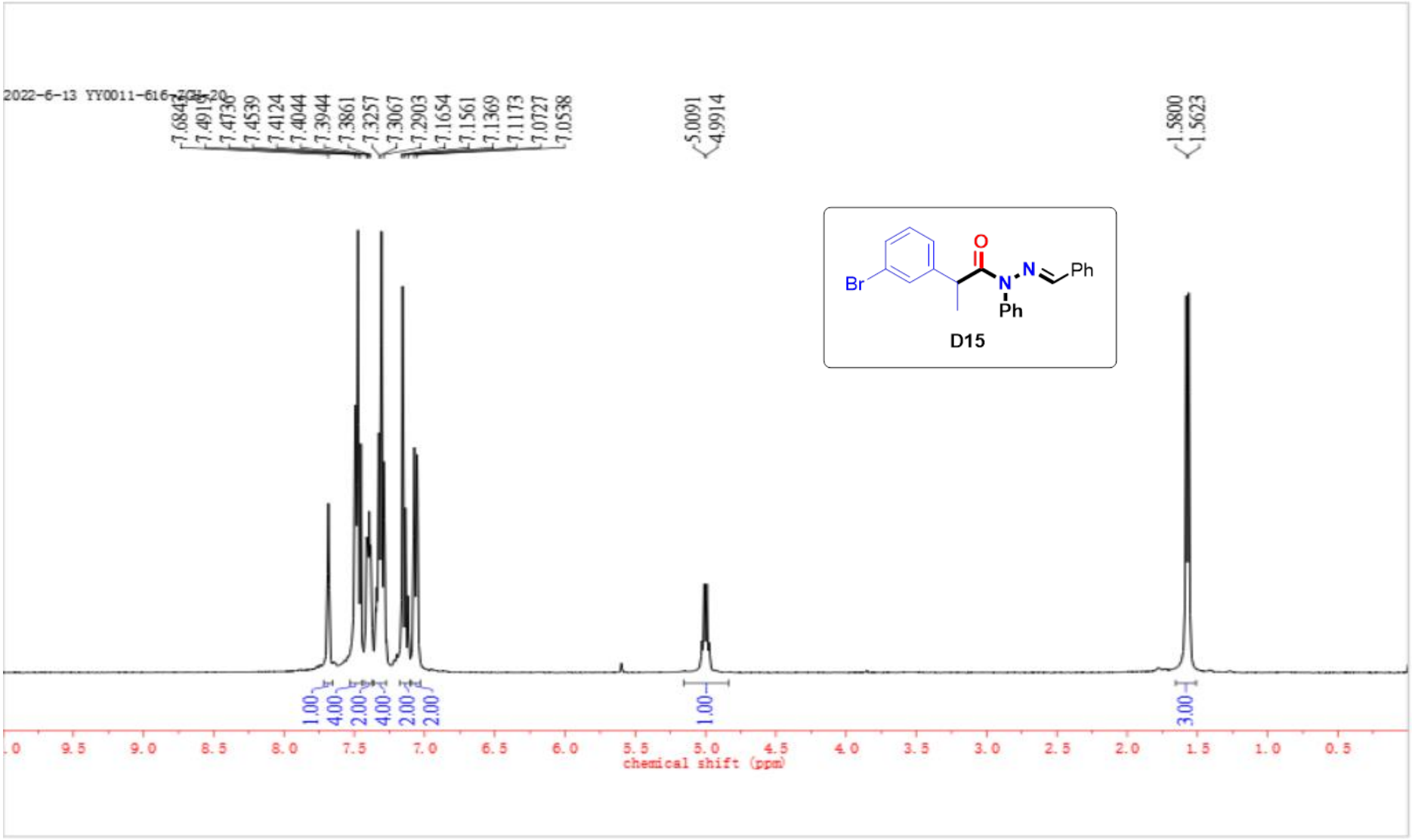

2022-6-13 YY0011-616-ZGH-19
175.04
144.61
142.00
136.10
134.39
134.31
130.31
130.06
130.02
129.43
129.20
128.87
128.28
127.35
126.95
126.00
77.73
77.41
77.09
42.94
19.49
Cl
O
N
N
Ph
Ph
D12
chemical shift (ppm)

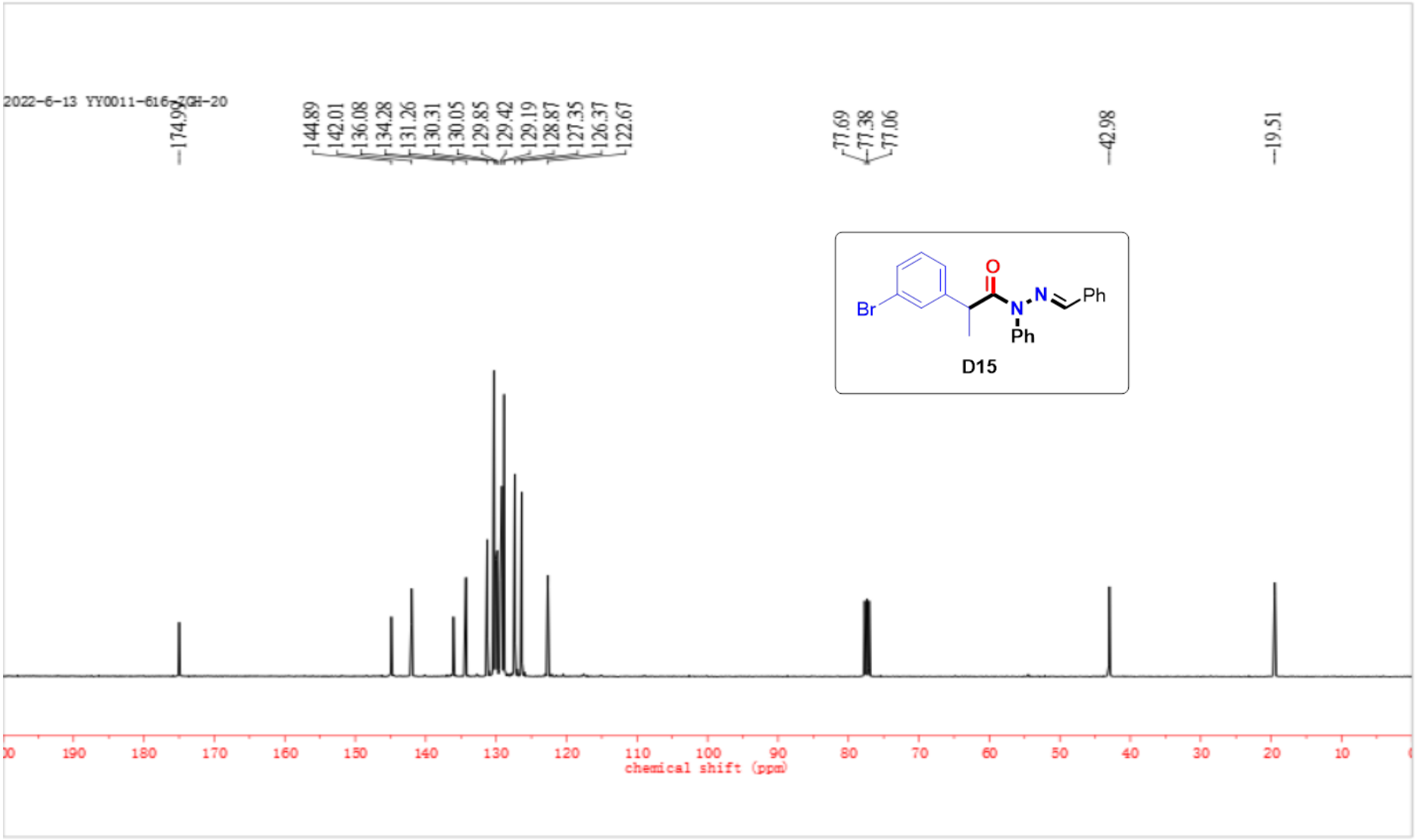

2022-9-19 yy0007-616-zgh-1
7.5273
7.5079
7.4914
7.4394
7.4209
7.4061
7.3856
7.2641
7.2197
7.2010
7.1820
7.1391
7.1223
7.1002
7.0811
5.4312
5.4140
1.5608
1.5435
Cl
O
N
N
Ph
Ph
D13
4.00
3.07
3.07
1.09
4.00
1.00
3.00
chemical shift (ppm)

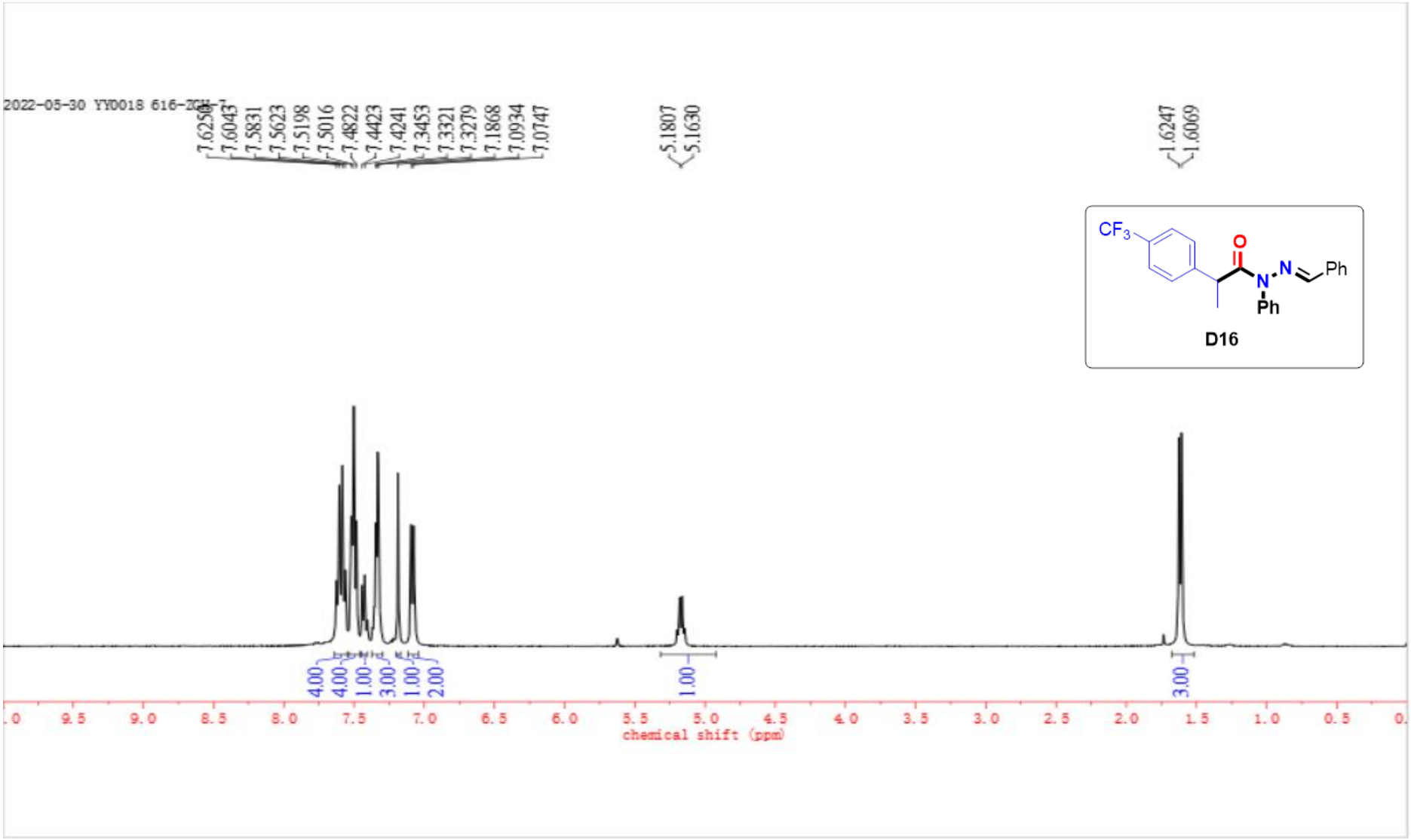

2022-9-19 yy0007-616
175.38
141.95
140.82
136.20
134.24
133.31
130.29
129.89
129.73
129.39
129.22
128.64
127.93
127.75
127.51
127.41
77.61
77.29
76.97
40.62
17.87
O
N
N
Ph
Cl
Ph
D13
chemical shift (ppm)

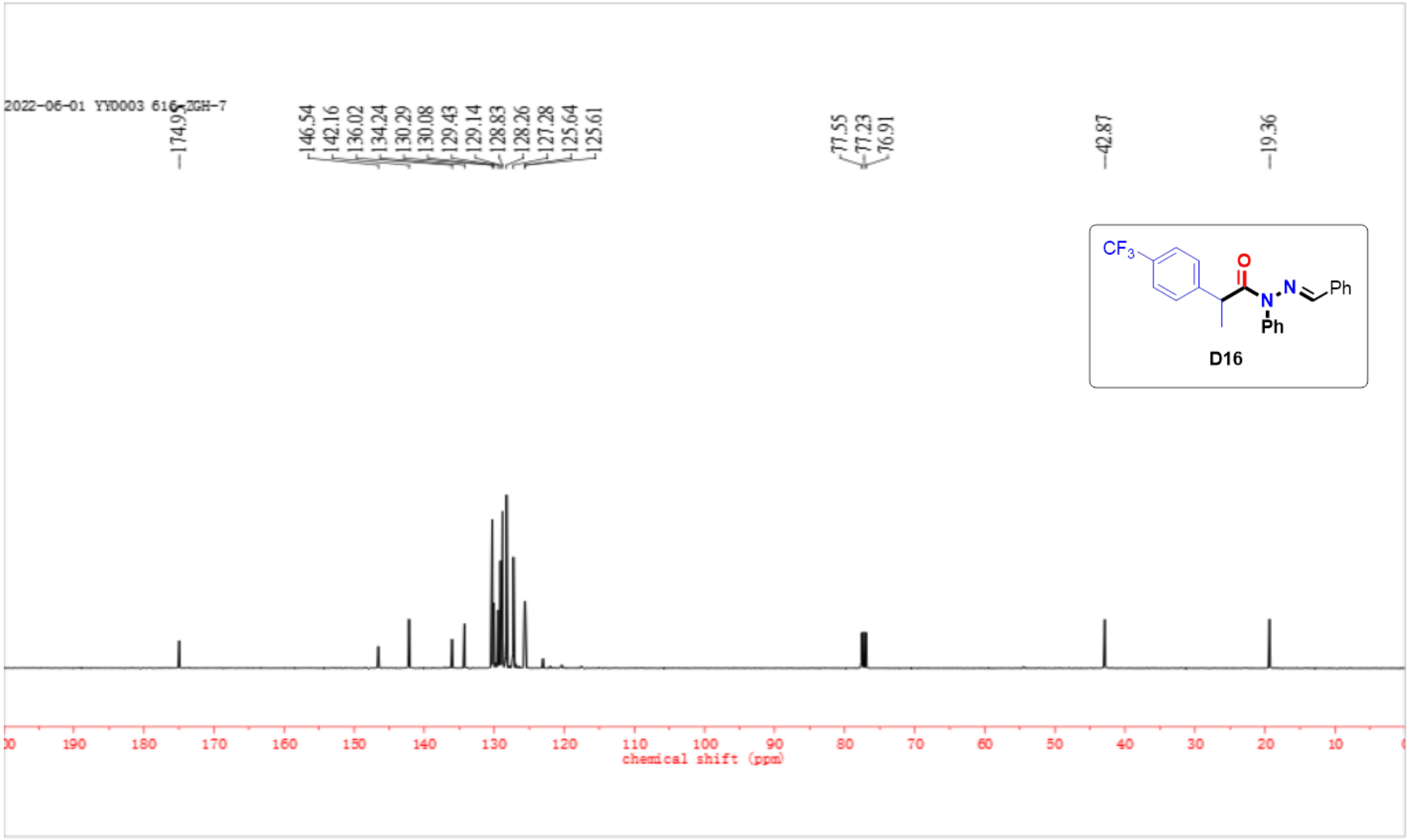

2022-08-15 YY0004 616-L00_ZQ1-02
7.5552
7.5376
7.5182
7.4847
7.4666
7.4460
7.3932
7.3843
7.3808
7.3727
7.3673
7.2598
7.1838
7.1027
7.0841
5.0847
5.0670
1.5990
1.5813
Br
O
N
N
Ph
Ph
D14
4.10
3.11
4.97
1.05
1.99
1.00
3.02
chemical shift (ppm)

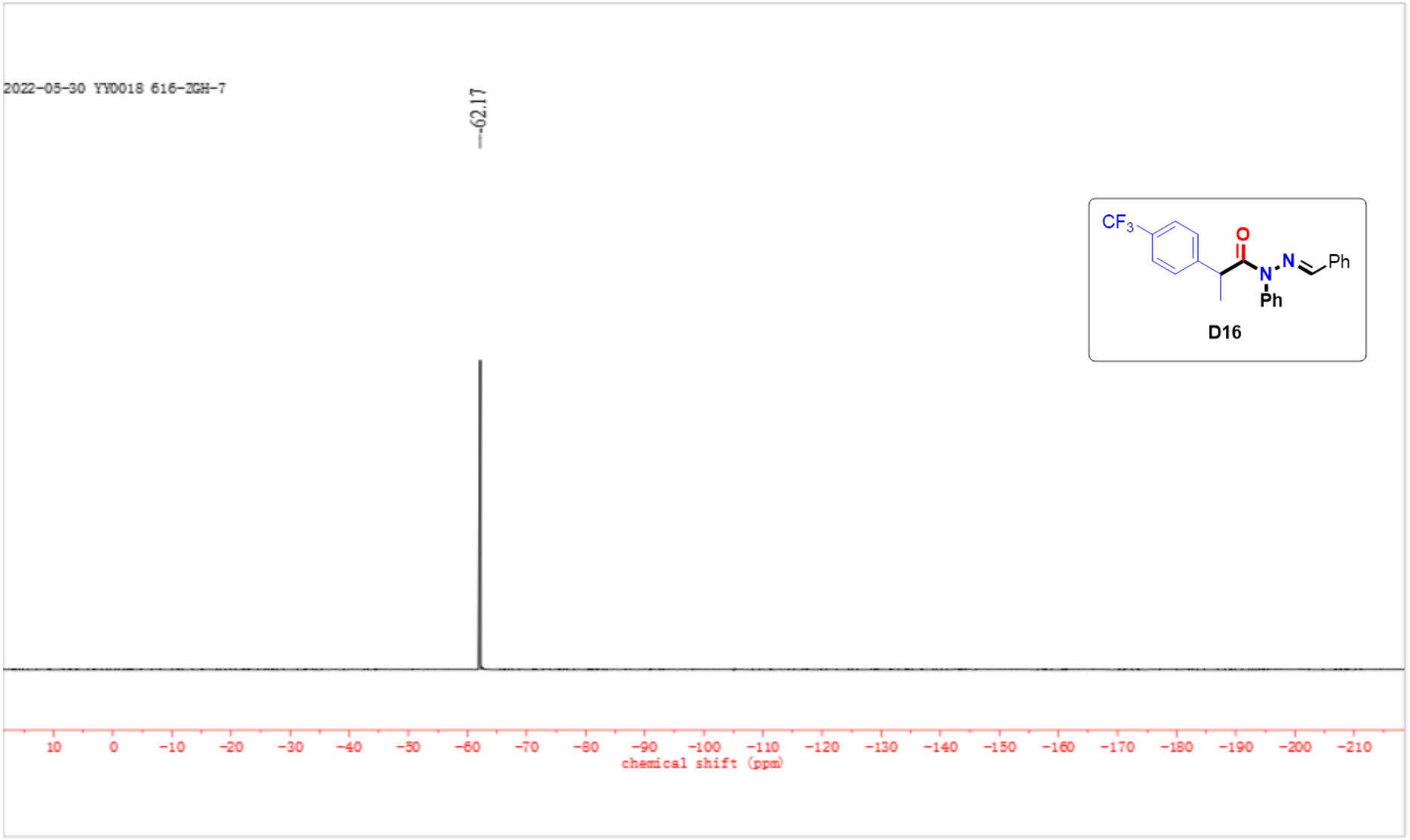

2022-08-15 YYD004 616-LQQ-ZGH-03
175.23
141.89
141.41
136.04
134.24
131.68
130.20
129.95
129.61
129.31
129.09
128.75
127.21
120.53
77.41
77.09
76.77
42.35
19.29
Br
O
N
N
Ph
Ph
D14
chemical shift (ppm)

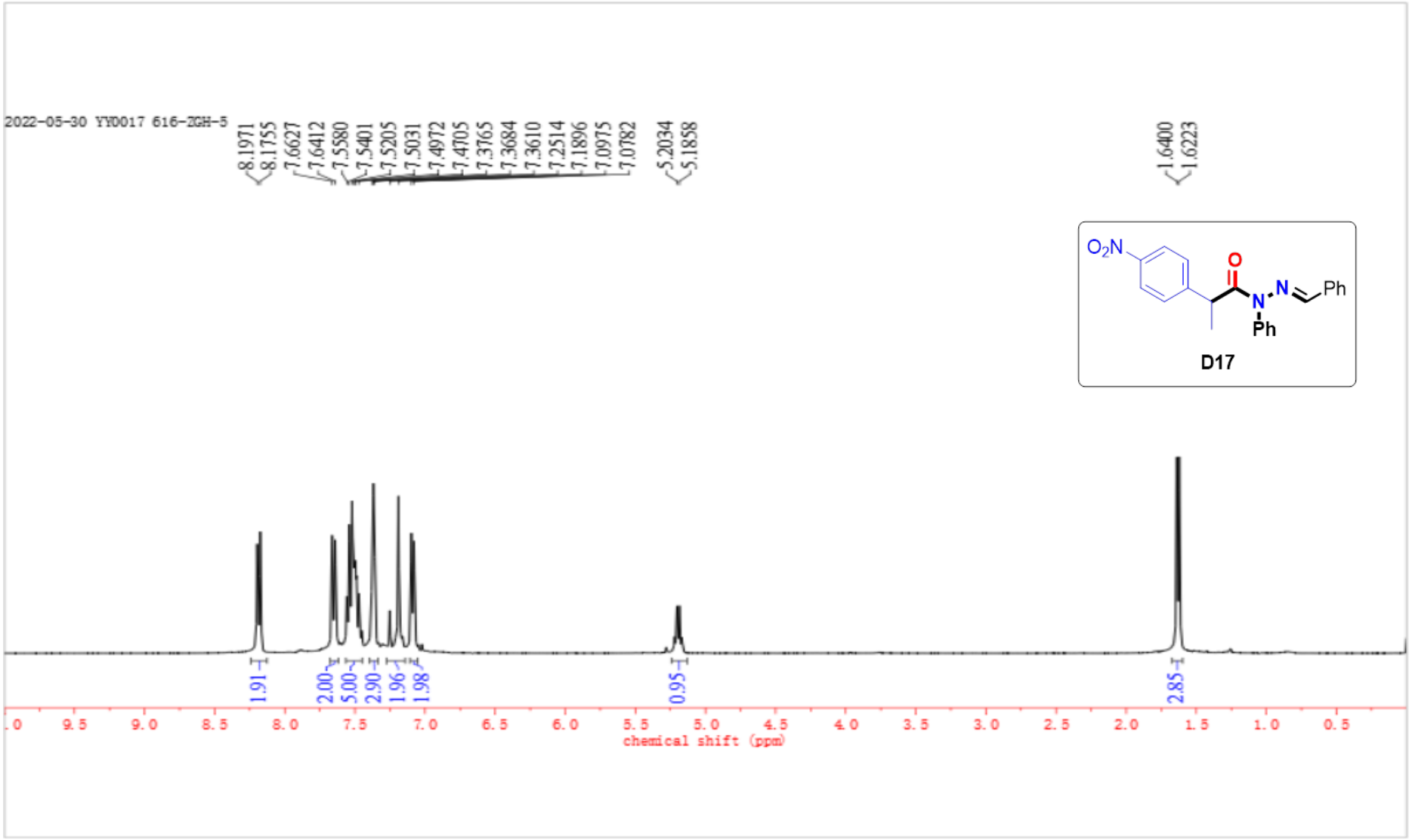

2022-6-13 YY0011-616-1CH-20
7.6842
7.4919
7.4736
7.4539
7.4124
7.4044
7.3944
7.3861
7.3257
7.3067
7.2903
7.1654
7.1561
7.1369
7.1173
7.0727
7.0538
5.0091
4.9914
1.5800
1.5623
Br
O
N
N
Ph
Ph
D15
1.00
4.00
2.00
4.00
2.00
2.00
1.00
3.00
chemical shift (ppm)

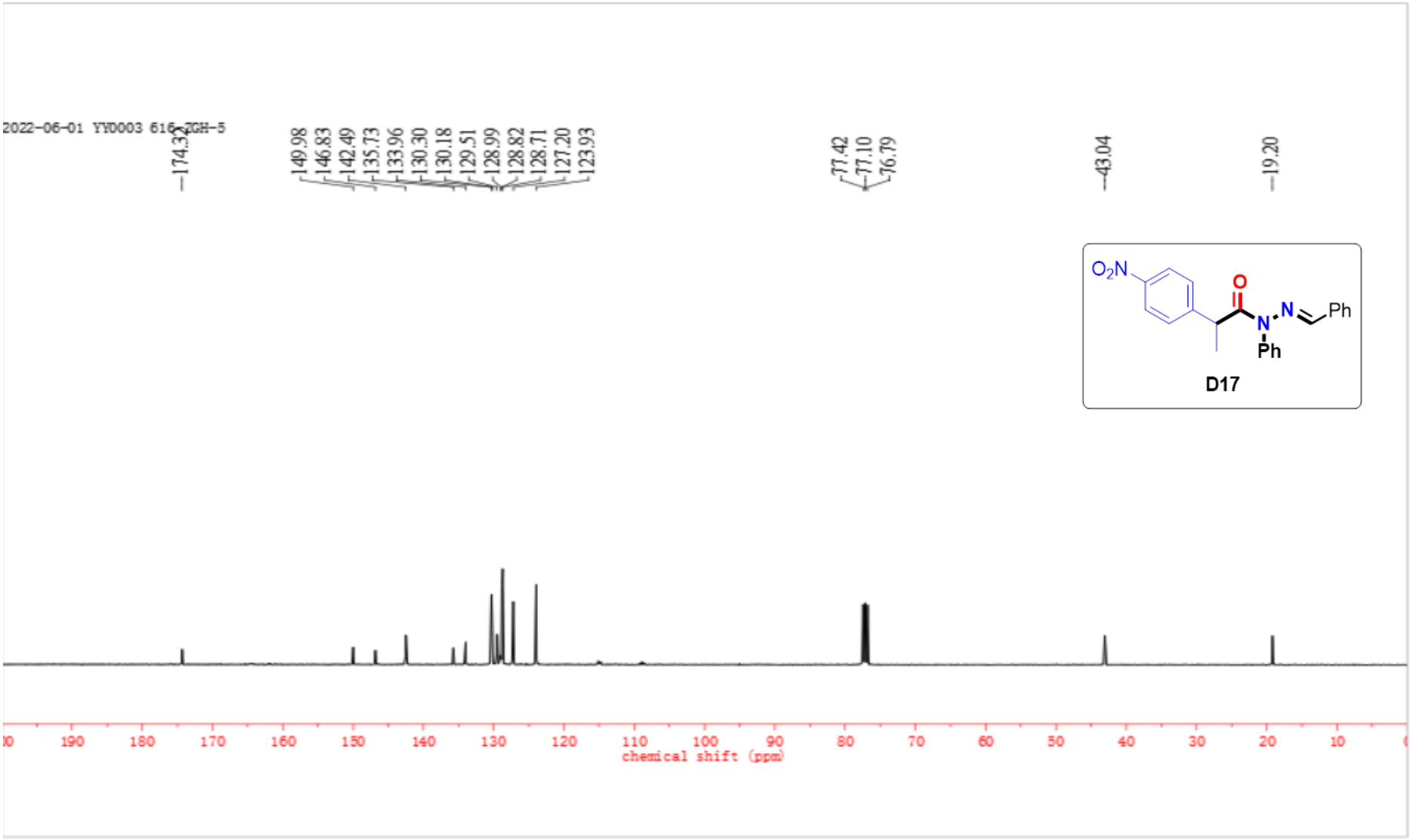

2022-6-13 YY0011-616-ZGH-20
174.99
144.89
142.01
136.08
134.28
131.26
130.31
130.05
129.85
129.42
129.19
128.87
127.35
126.37
122.67
77.69
77.38
77.06
42.98
19.51
Br
O
N
N
Ph
Ph
D15
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

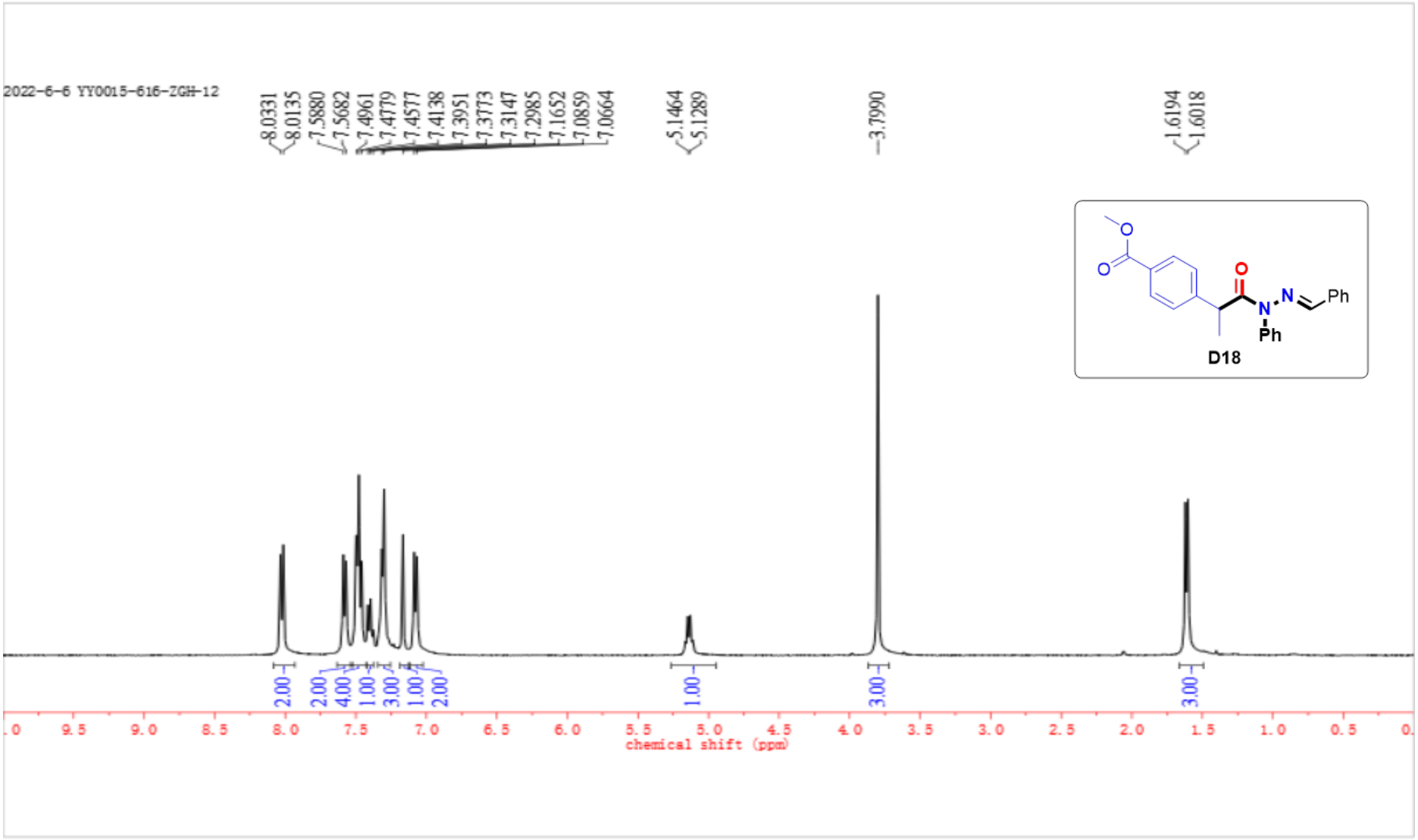

2022-05-30 YYD018 616-2
7.6250
7.6043
7.5831
7.5623
7.5198
7.5016
7.4822
7.4423
7.4241
7.3453
7.3321
7.3279
7.1868
7.0934
7.0747
5.1807
5.1630
1.6247
1.6069
CF3
O
N
N
Ph
Ph
D16
4.00
4.00
1.00
3.00
1.00
2.00
1.00
3.00
chemical shift (ppm)

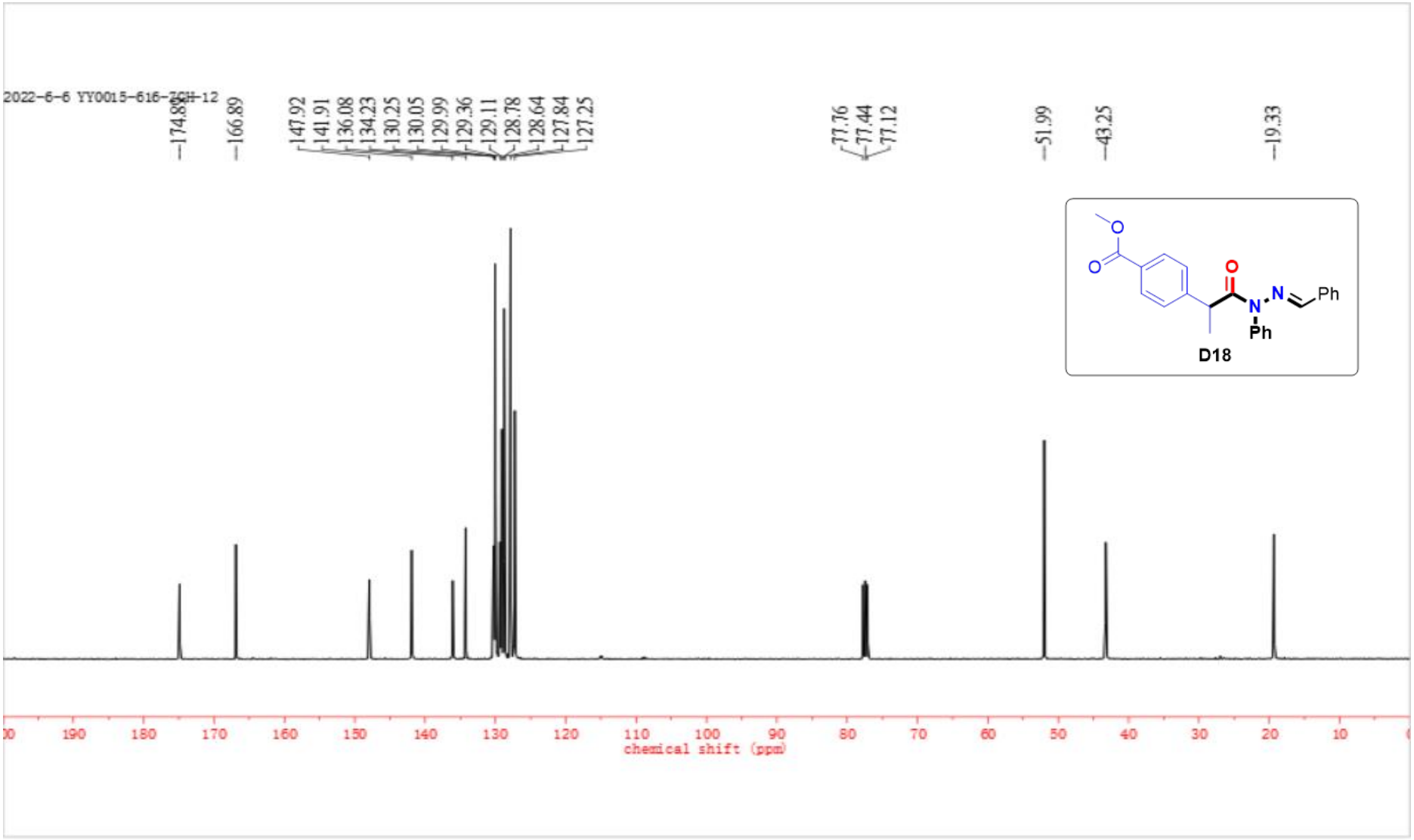

2022-06-01 YYD003 616-ZGH-7
174.93
146.54
142.16
136.02
134.24
130.29
130.08
129.43
129.14
128.83
128.26
127.28
125.64
125.61
77.55
77.23
76.91
42.87
19.36
CF3
O
N
N
Ph
Ph
D16
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

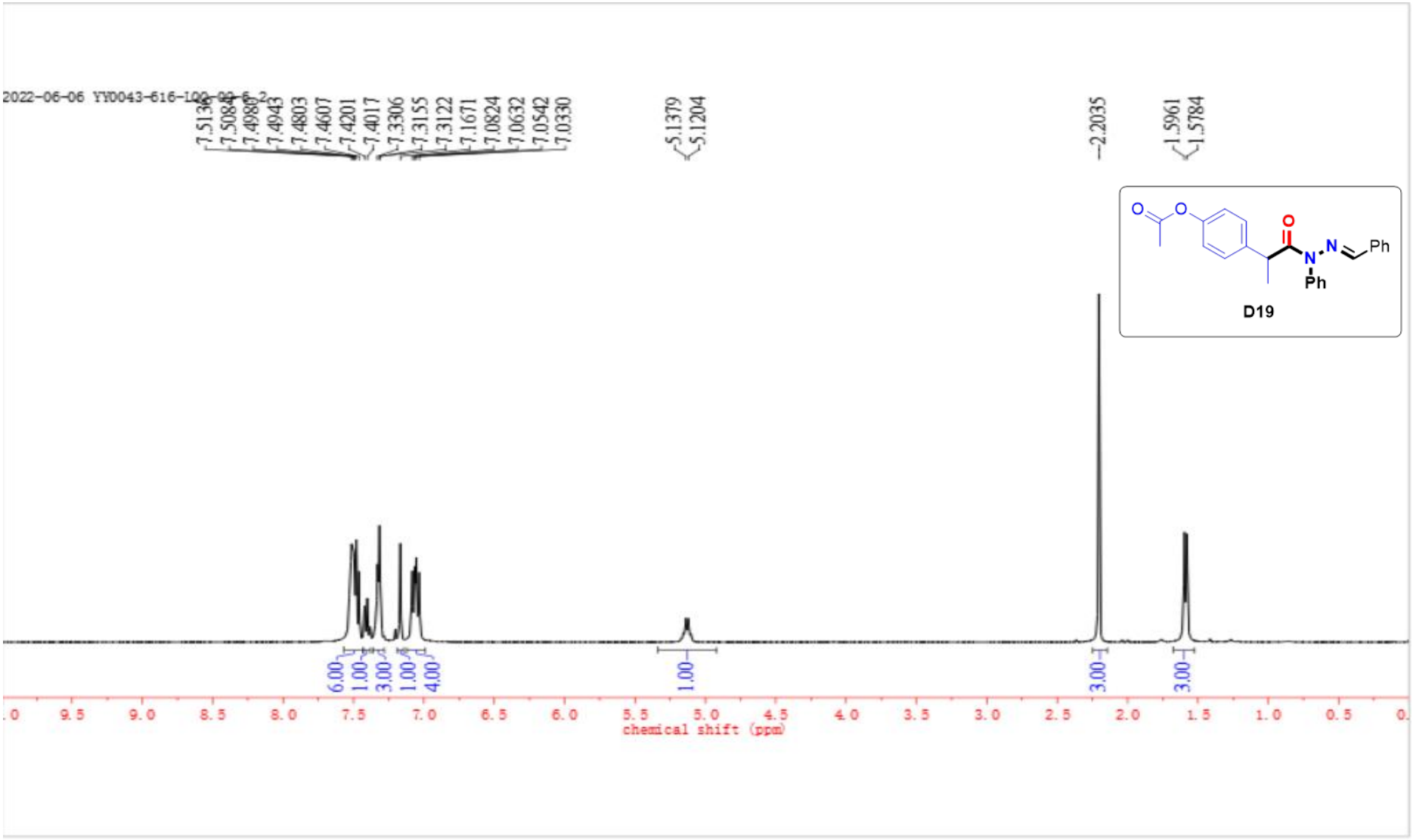

2022-05-30 YYD018 616-ZGH-7
-62.17
CF3
O
N
N
Ph
Ph
D16
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
chemical shift (ppm)

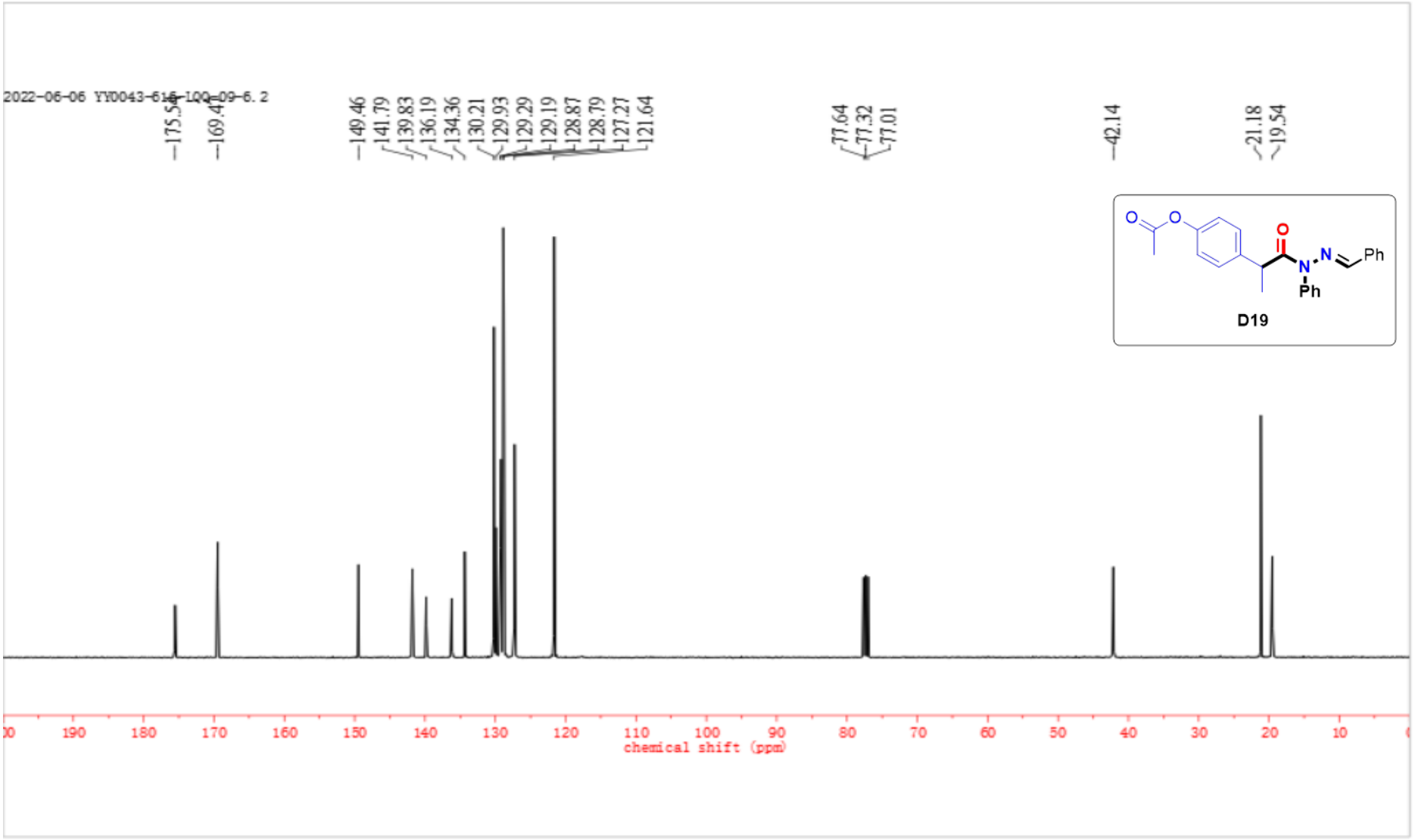

2022-05-30 YYD017 616-2GH-5
8.1971
8.1755
7.6627
7.6412
7.5580
7.5401
7.5205
7.5031
7.4972
7.4705
7.3765
7.3684
7.3610
7.2514
7.1896
7.0975
7.0782
5.2034
5.1858
1.6400
1.6223
O2N
O
N
N
Ph
Ph
D17
1.91
2.00
5.00
2.90
1.96
1.98
0.95
2.85
chemical shift (ppm)

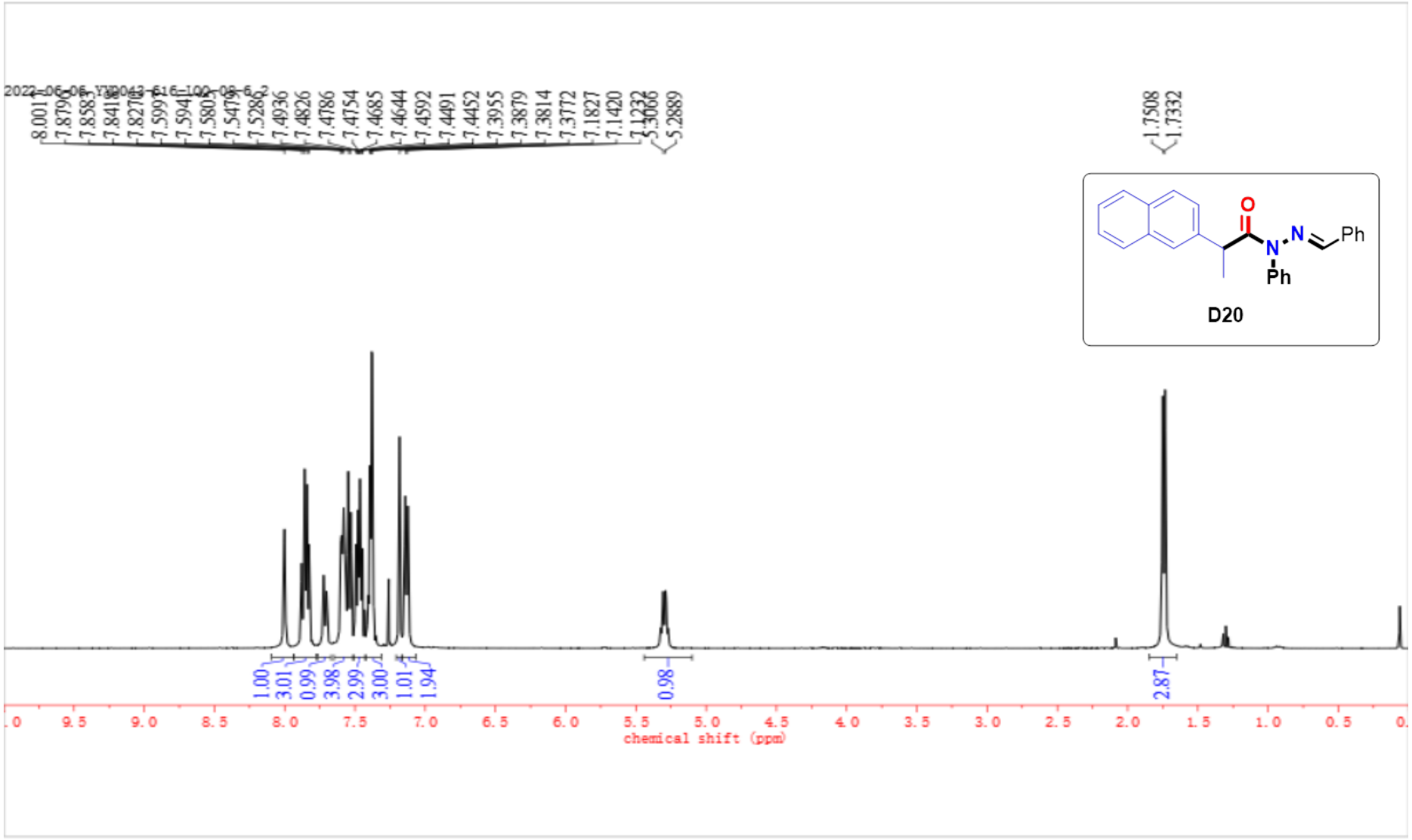

2022-06-01 YYD003 616_2GH-5
174.32
149.98
146.83
142.49
135.73
133.96
130.30
130.18
129.51
128.99
128.82
128.71
127.20
123.93
77.42
77.10
76.79
43.04
19.20
O2N
O
N
N
Ph
Ph
D17
chemical shift (ppm)

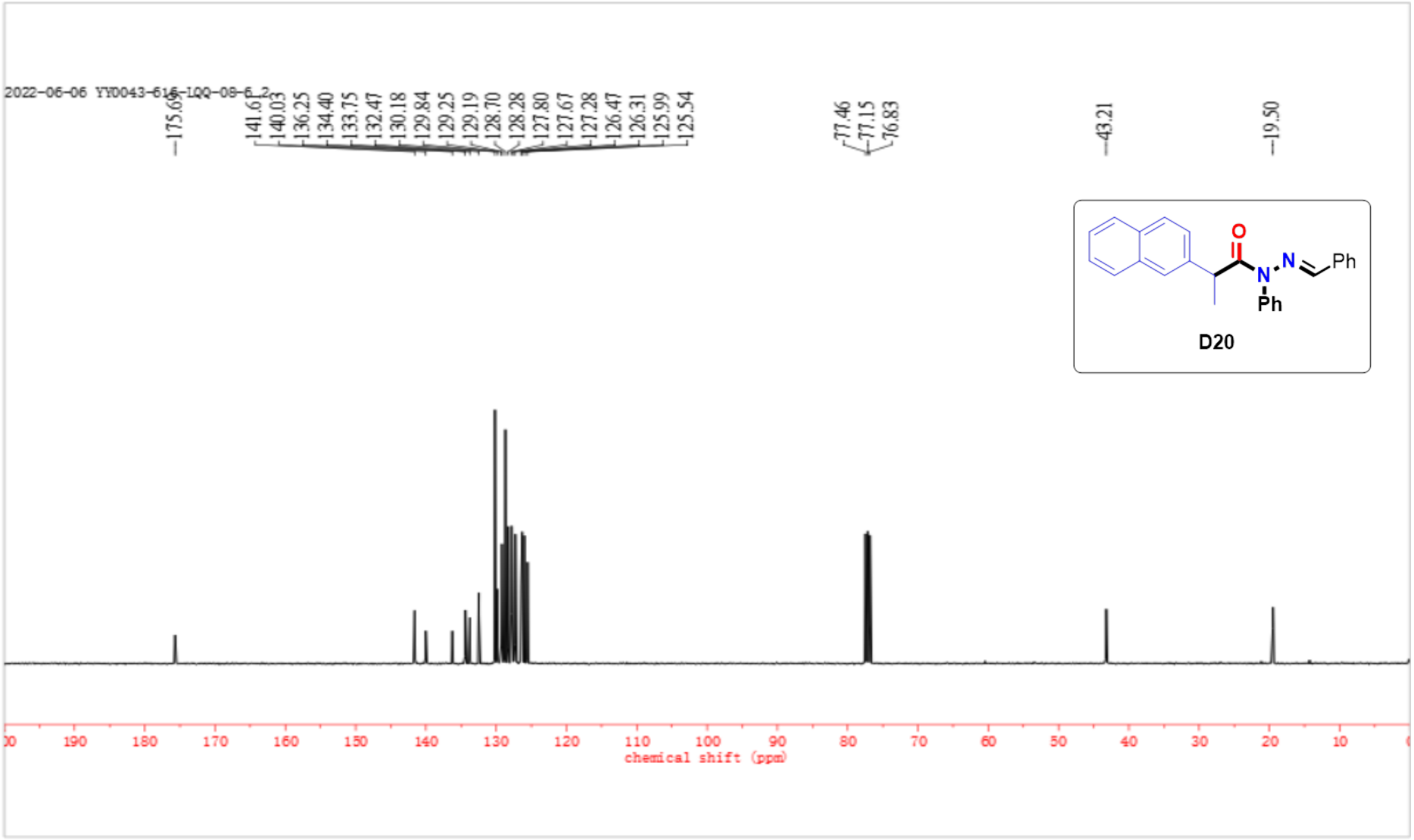

2022-6-6 YY0015-616-ZGH-12
8.0331
8.0135
7.5880
7.5682
7.4961
7.4779
7.4577
7.4138
7.3951
7.3773
7.3147
7.2985
7.1652
7.0859
7.0664
5.1464
5.1289
3.7990
1.6194
1.6018
D18
2.00
2.00
4.00
1.00
3.00
1.00
2.00
1.00
3.00
3.00
chemical shift (ppm)

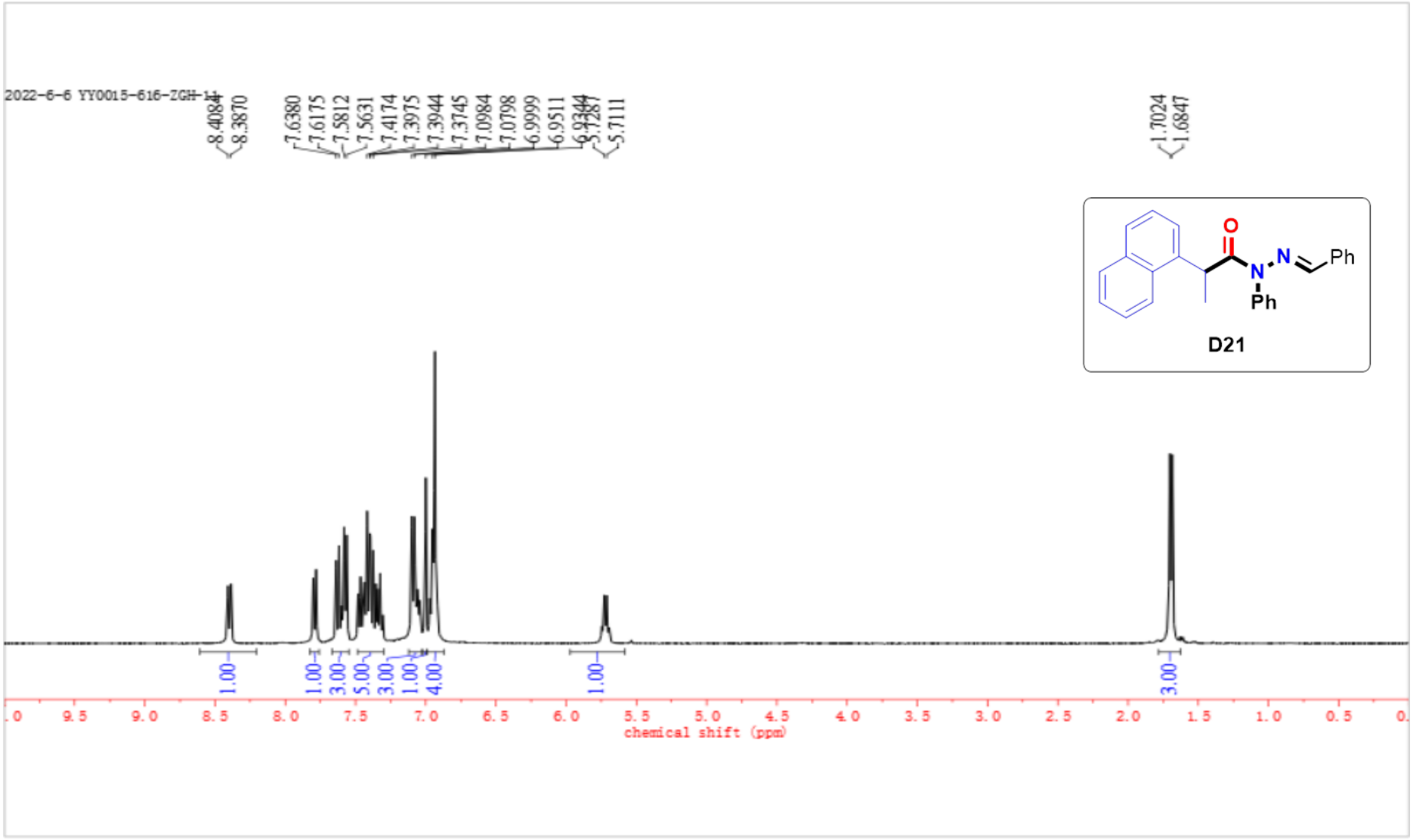

2022-6-6 YY0015-616-ZGH-12
174.89
166.89
147.92
141.91
136.08
134.23
130.25
130.05
129.99
129.36
129.11
128.78
128.64
127.84
127.25
77.76
77.44
77.12
51.99
43.25
19.33
Ph
Ph
D18
chemical shift (ppm)

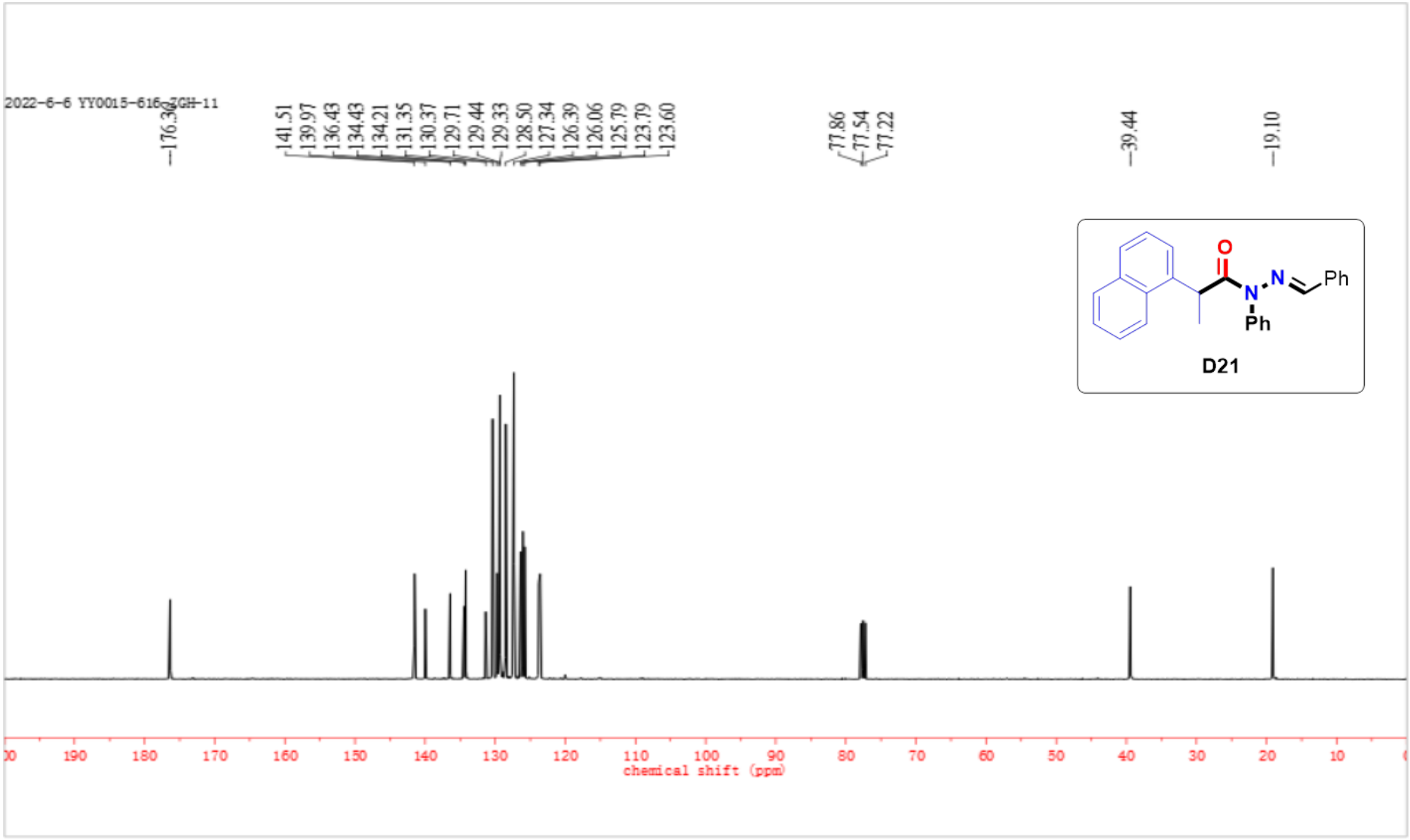

2022-06-06 YYD043-616-1H-2-2
7.5136
7.5084
7.4980
7.4943
7.4803
7.4607
7.4201
7.4017
7.3306
7.3155
7.3122
7.1671
7.0824
7.0632
7.0542
7.0330
5.1379
5.1204
2.2035
1.5961
1.5784
Ph
N
N
Ph
O
O
O
D19
6.00
1.00
3.00
1.00
4.00
1.00
3.00
3.00
chemical shift (ppm)

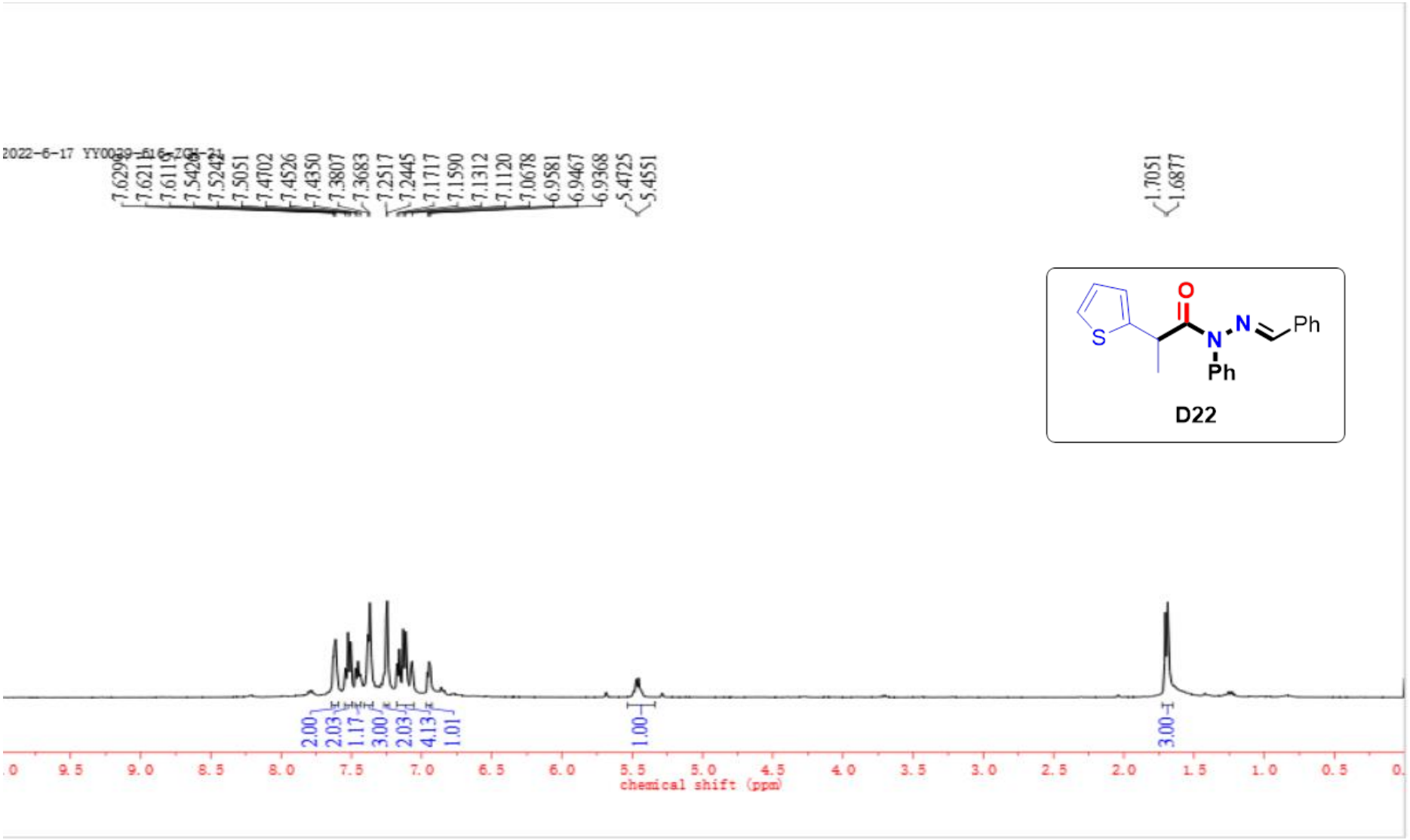

2022-06-06 YY0043-616-LQQ-09-6.2
175.54
169.47
149.46
141.79
139.83
136.19
134.36
130.21
129.93
129.29
129.19
128.87
128.79
127.27
121.64
77.64
77.32
77.01
42.14
21.18
19.54
O
O
O
N
N
Ph
Ph
D19
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

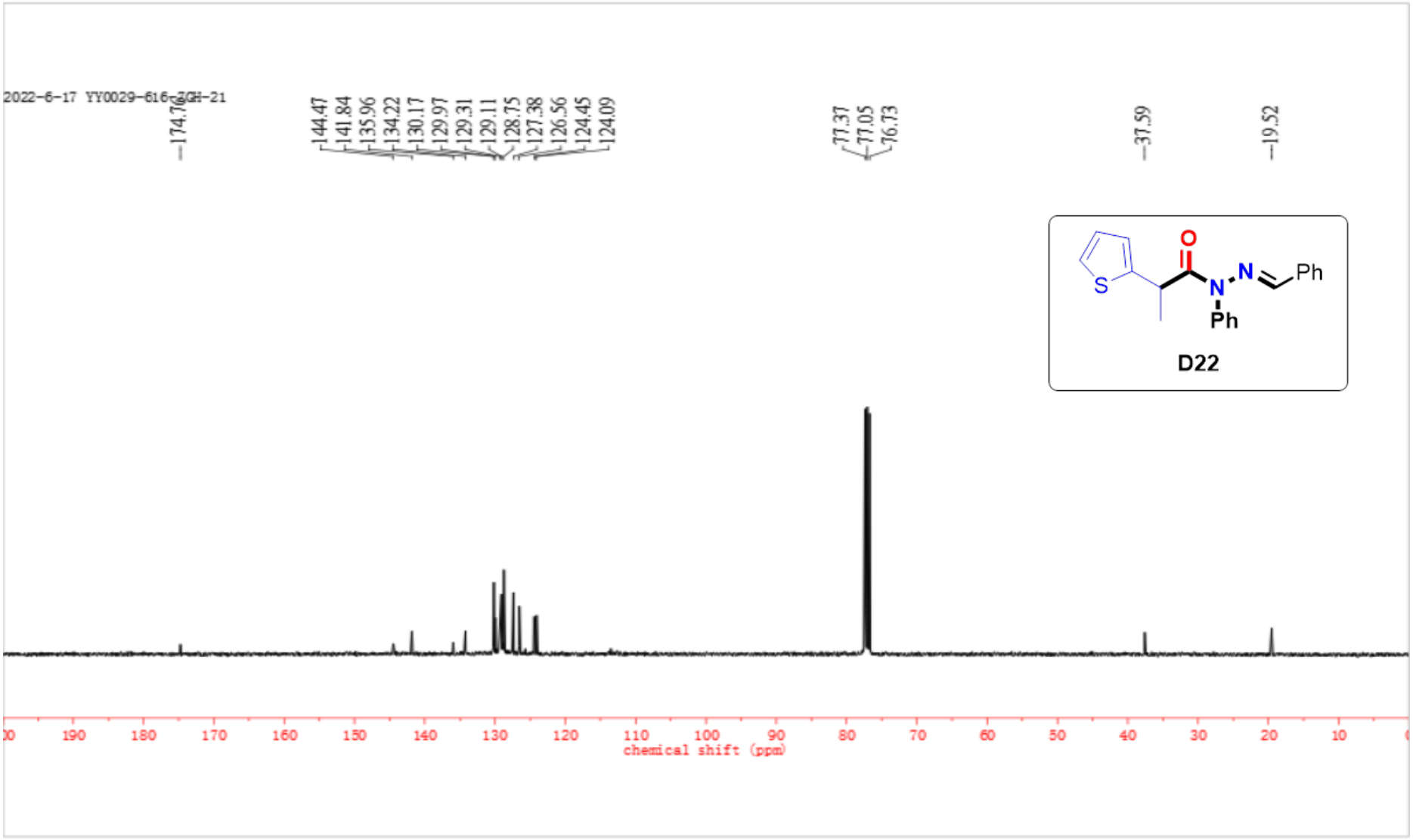

8.0011
7.8790
7.8583
7.8418
7.8270
7.5997
7.5941
7.5803
7.5479
7.5286
7.4936
7.4826
7.4786
7.4754
7.4685
7.4644
7.4592
7.4491
7.4452
7.3955
7.3879
7.3814
7.3772
7.1827
7.1420
5.3066
5.2889
1.7508
1.7332
O
N
N
Ph
Ph
D20
1.00
3.01
0.99
3.98
2.99
3.00
1.01
1.94
0.98
2.87
chemical shift (ppm)

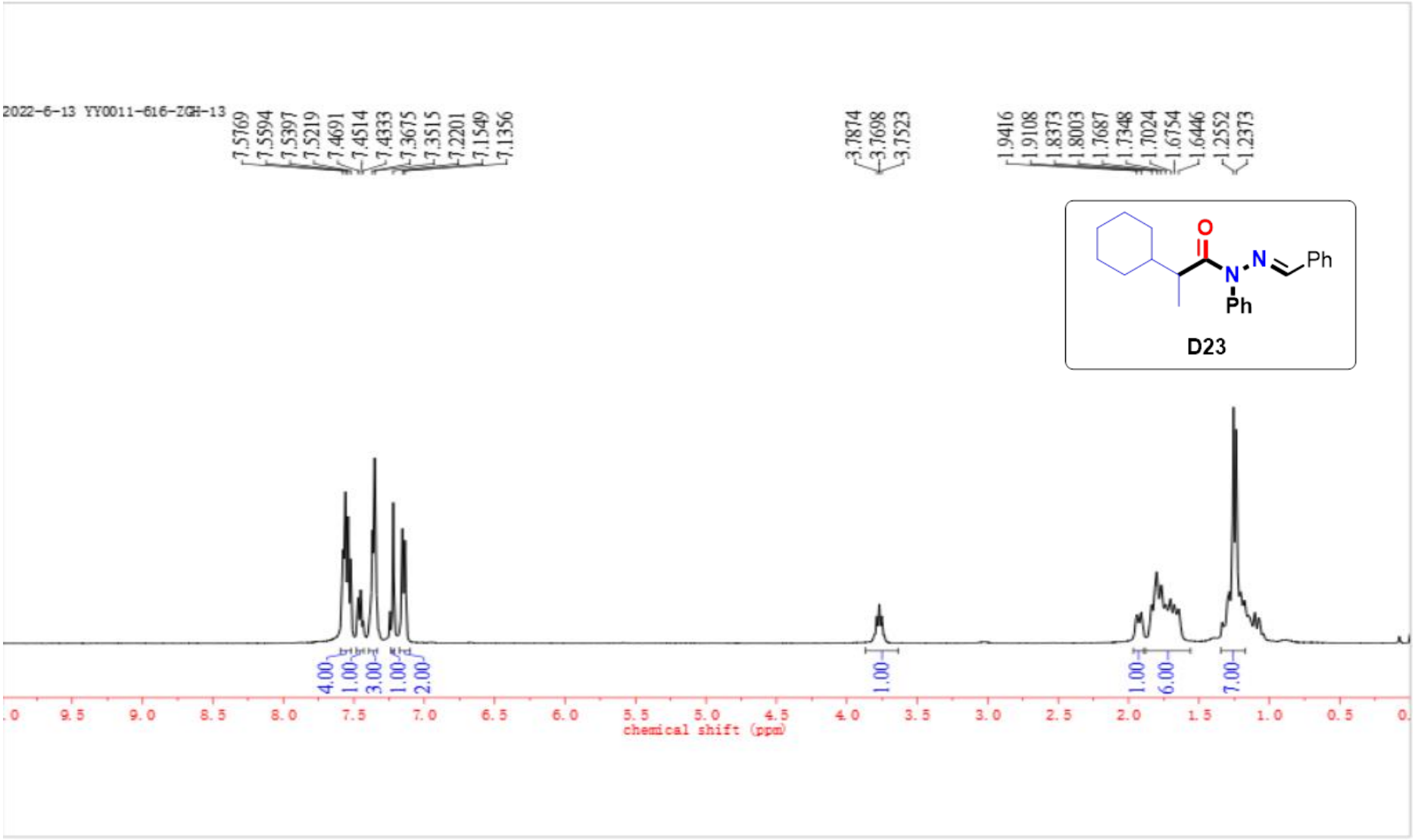

2022-06-06 YY0043-616-LQQ-09-6_2
175.63
141.61
140.03
136.25
134.40
133.75
132.47
130.18
129.84
129.25
129.19
128.70
128.28
127.80
127.67
127.28
126.47
126.31
125.99
125.54
77.46
77.15
76.83
43.21
19.50
O
N
N
Ph
Ph
D20
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

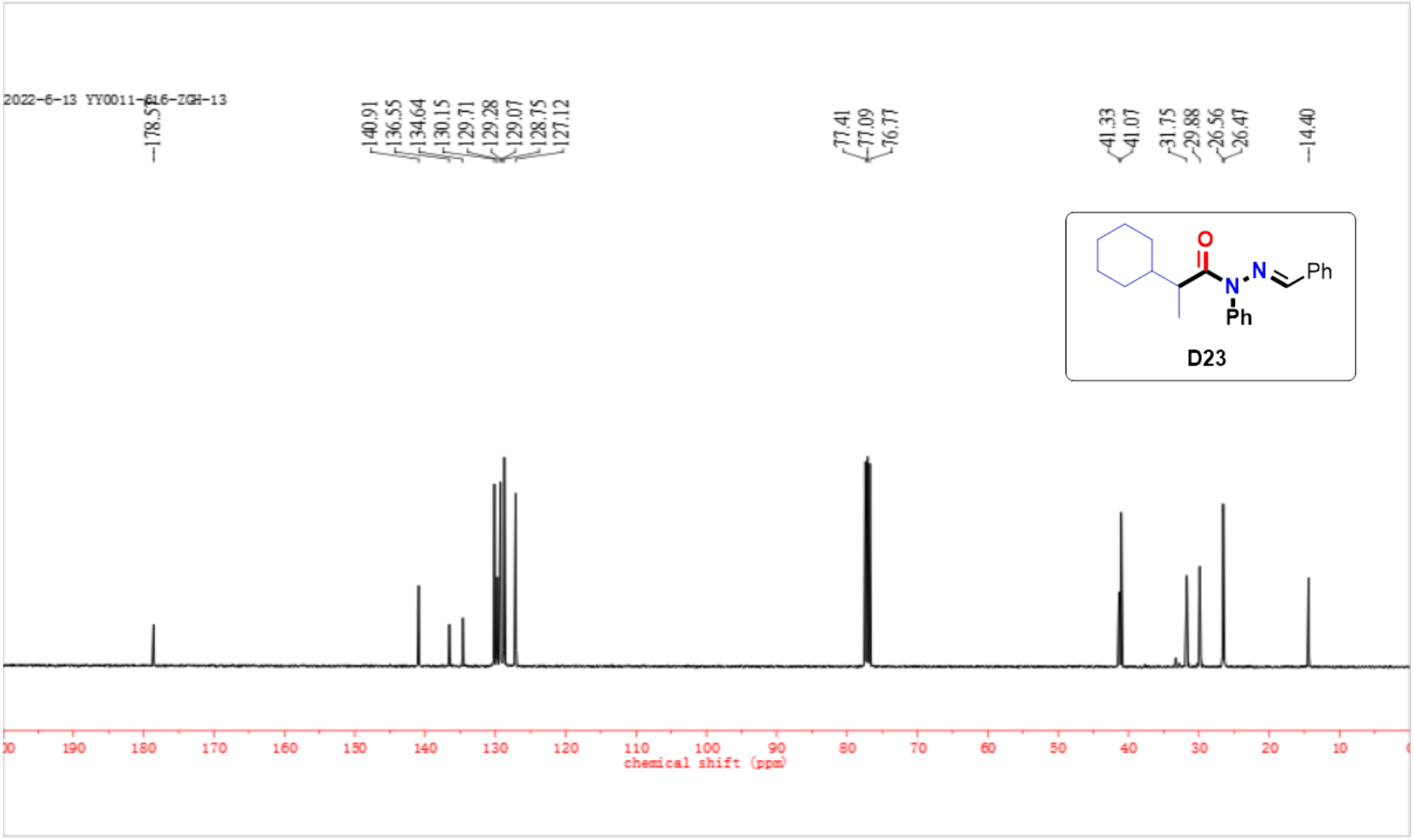

2022-6-6 YY0015-616-ZGH-1
8.4084
8.3870
7.6380
7.6175
7.5812
7.5631
7.4174
7.3975
7.3944
7.3745
7.0984
7.0798
6.9999
6.9511
5.7111
1.7024
1.6847
O
N
N
Ph
Ph
D21
1.00
1.00
3.00
5.00
3.00
1.00
4.00
1.00
3.00
chemical shift (ppm)

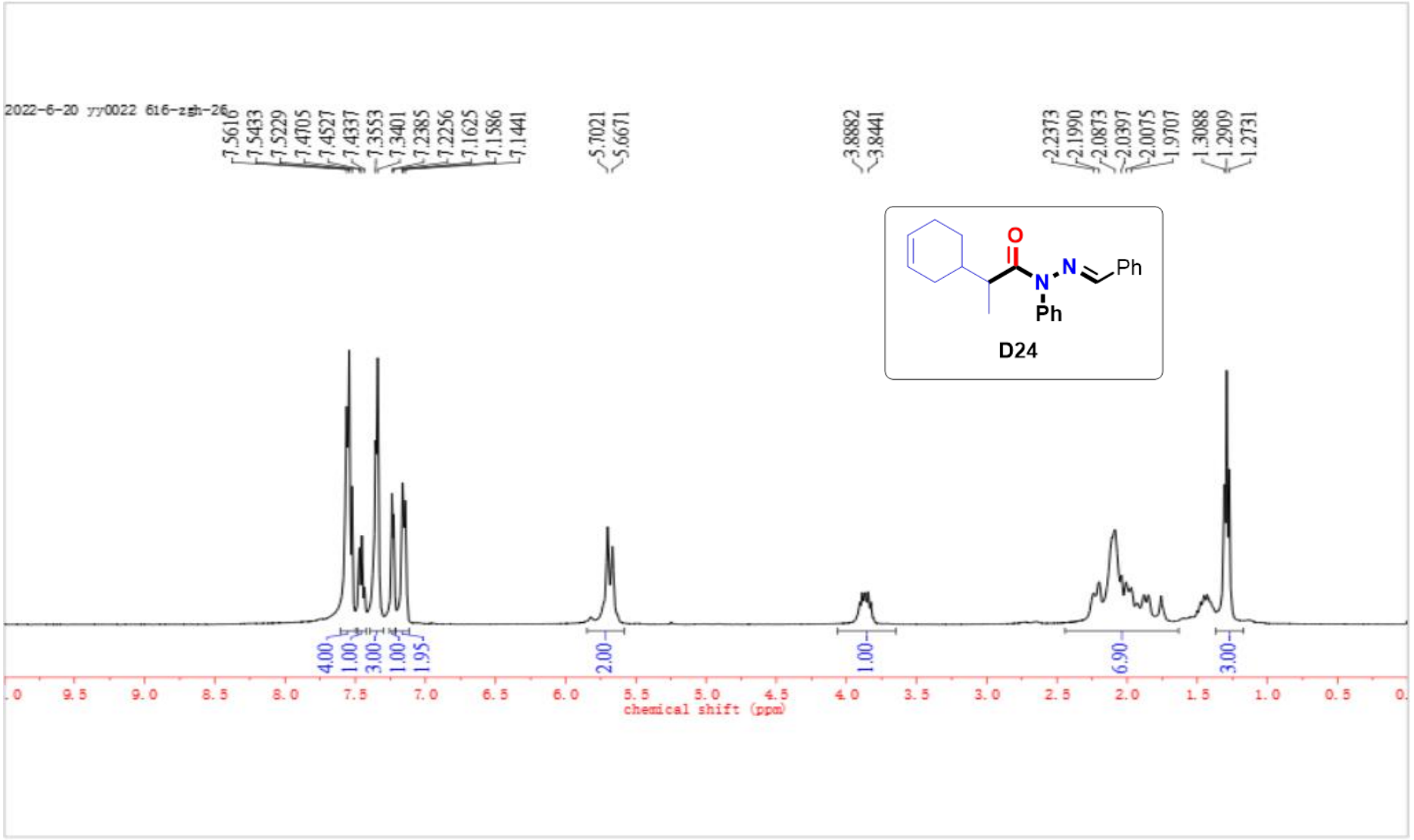

2022-6-6 YY0015-616-ZGH-11
176.30
141.51
139.97
136.43
134.43
134.21
131.35
130.37
129.71
129.44
129.33
128.50
127.34
126.39
126.06
125.79
123.79
123.60
77.86
77.54
77.22
39.44
19.10
O
N
N
Ph
Ph
D21
chemical shift (ppm)

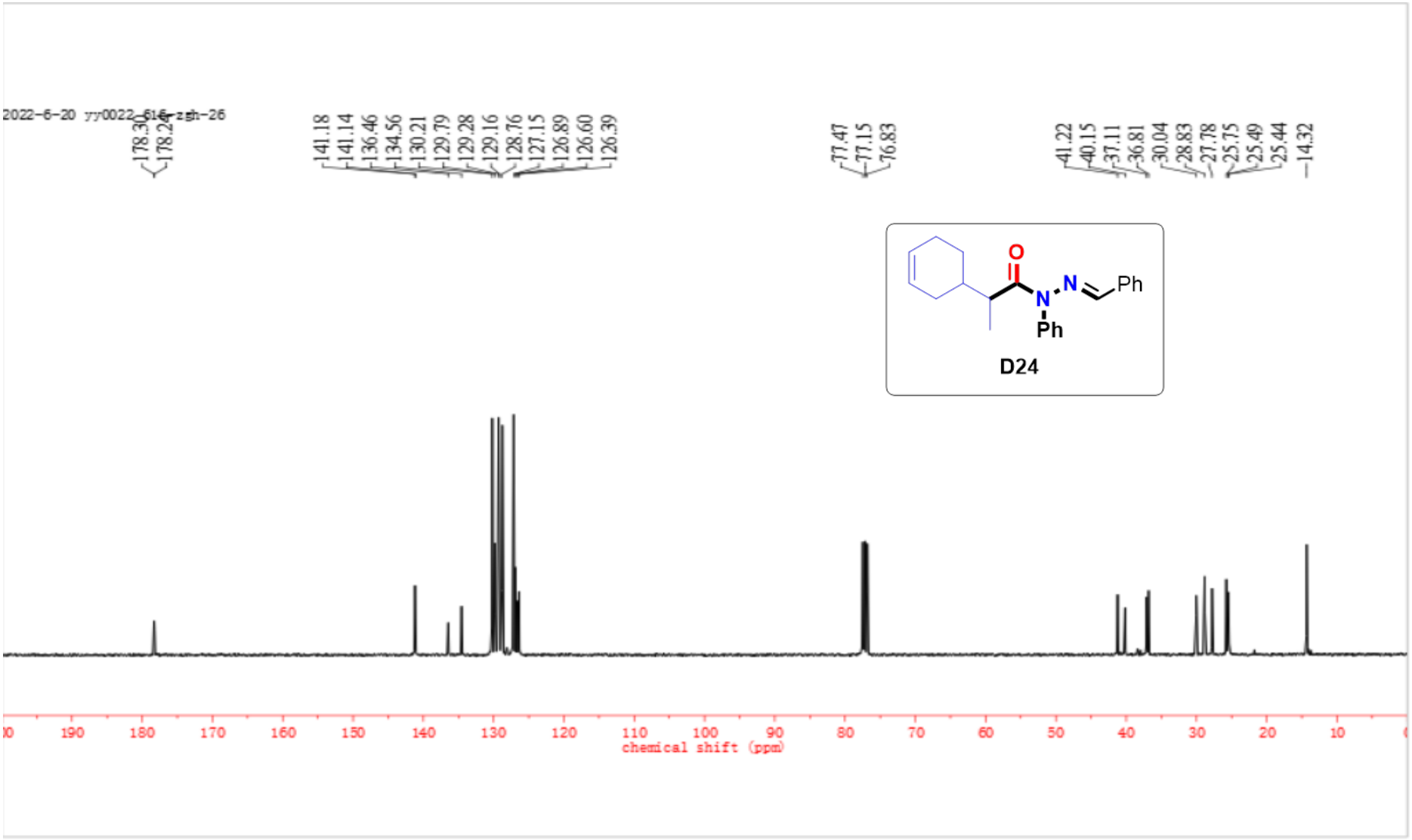

2022-6-17 YY0039-516-ZGL-21
7.6299
7.6211
7.6119
7.5426
7.5242
7.5051
7.4702
7.4526
7.4350
7.3807
7.3683
7.2517
7.2445
7.1717
7.1590
7.1312
7.1120
7.0678
6.9581
6.9467
6.9368
5.4725
5.4551
1.7051
1.6877
O
N
N
Ph
S
Ph
D22
2.00
2.03
1.17
3.00
2.03
4.13
1.01
1.00
3.00
chemical shift (ppm)

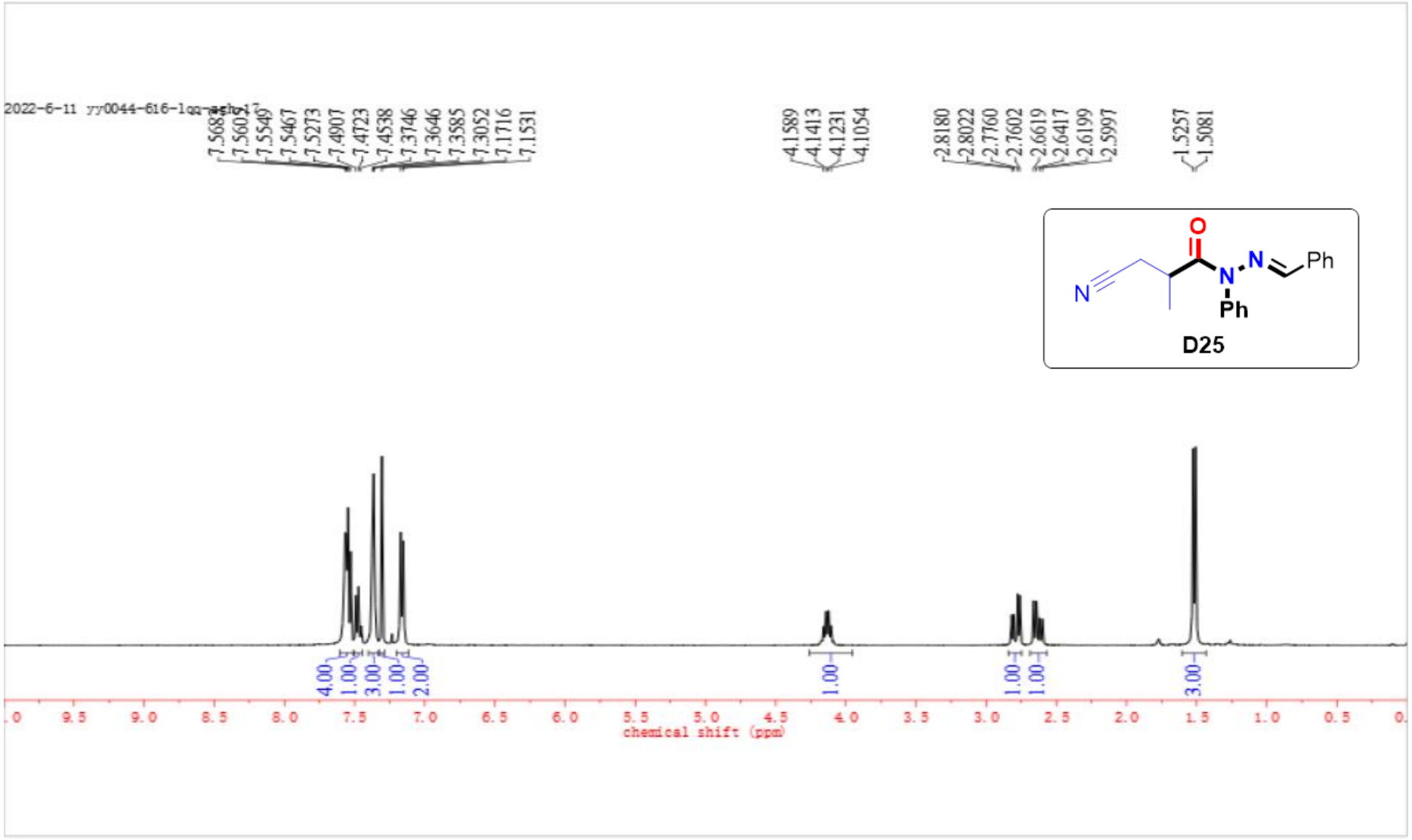

2022-6-17 YY0029-616-ZGH-21
174.76
144.47
141.84
135.96
134.22
130.17
129.97
129.31
129.11
128.75
127.38
126.56
124.45
124.09
77.37
77.05
76.73
37.59
19.52
O
S
N
N
Ph
Ph
D22
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

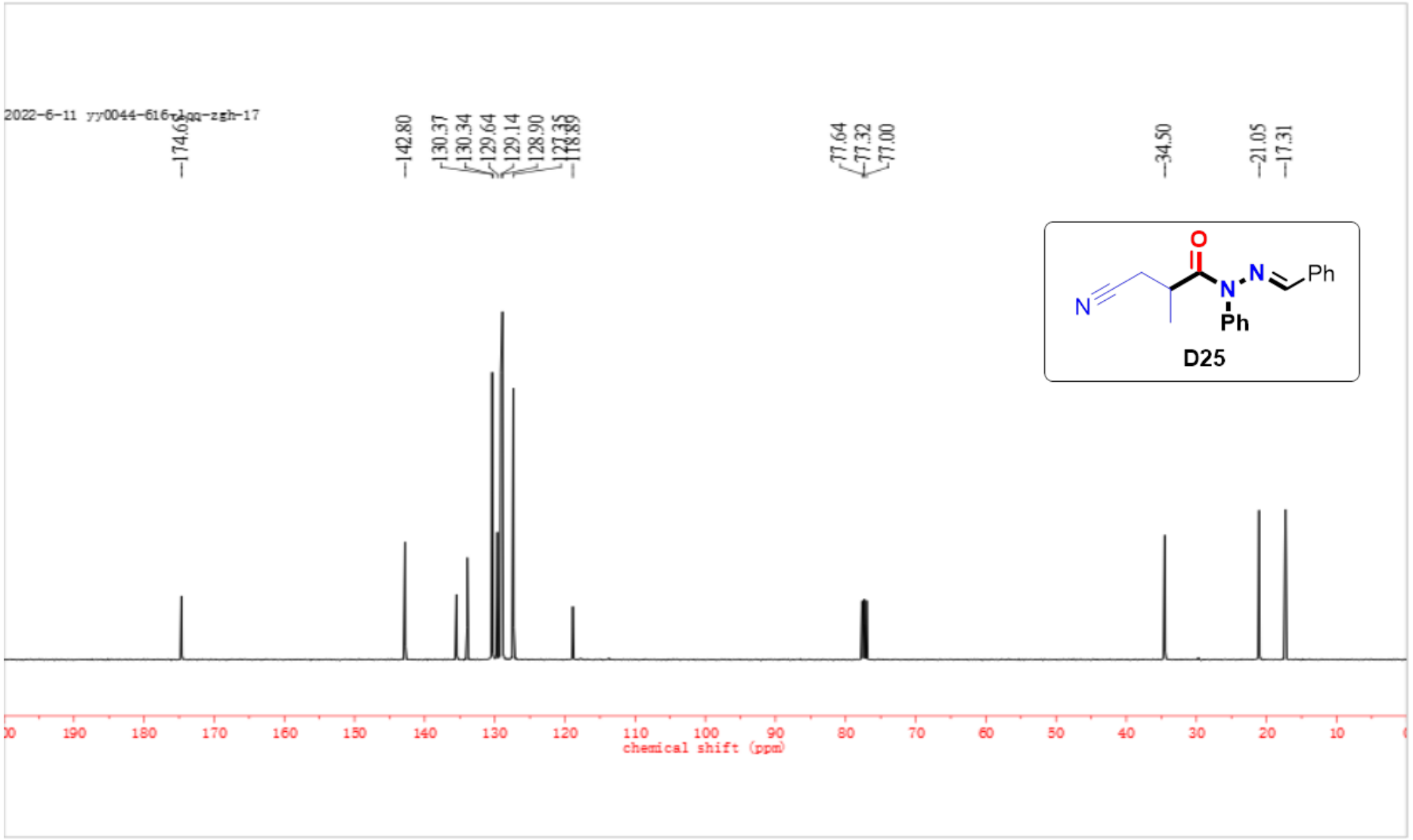

2022-6-13 YY0011-616-ZGH-13
7.5769
7.5594
7.5397
7.5219
7.4691
7.4514
7.4333
7.3675
7.3515
7.2201
7.1549
7.1356
3.7874
3.7698
3.7523
1.9416
1.9108
1.8373
1.8003
1.7687
1.7348
1.7024
1.6754
1.6446
1.2552
1.2373
O
N
N
Ph
Ph
D23
4.00
1.00
3.00
1.00
2.00
1.00
1.00
6.00
7.00
chemical shift (ppm)

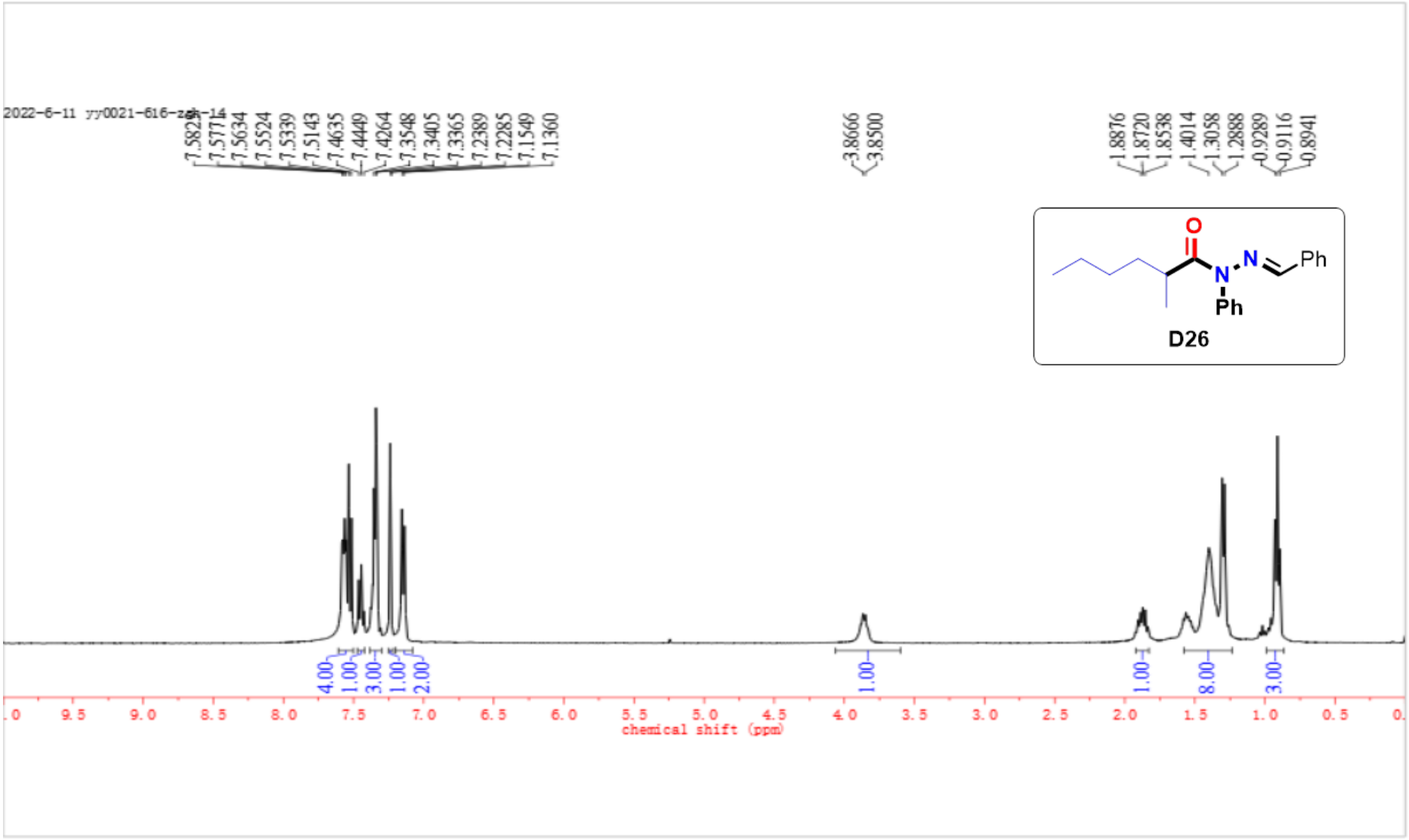

2022-6-13 YY0011-616-ZGH-13
178.57
140.91
136.55
134.64
130.15
129.71
129.28
129.07
128.75
127.12
77.41
77.09
76.77
41.33
41.07
31.75
29.88
26.56
26.47
14.40
O
N
N
Ph
Ph
D23
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

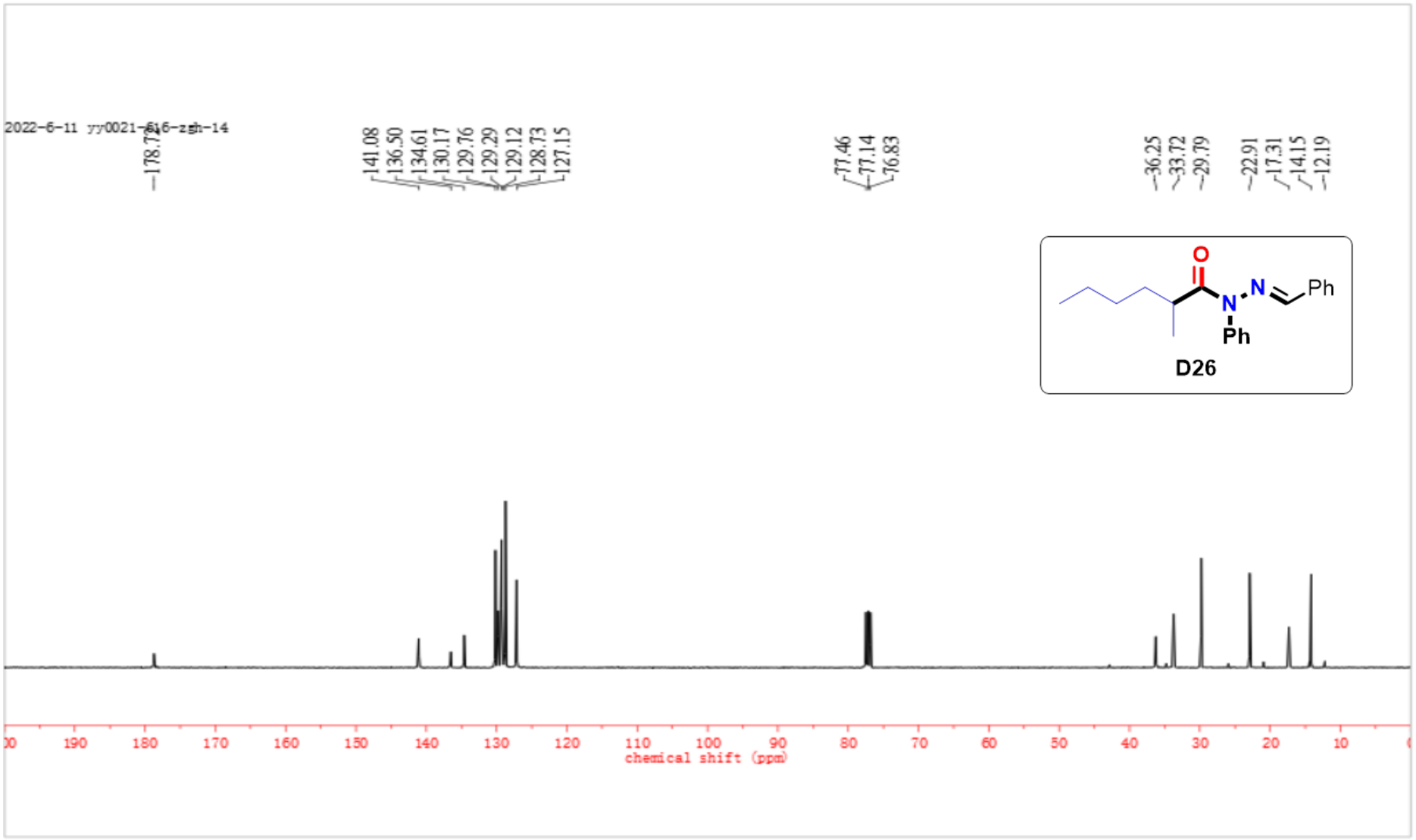

2022-6-20 yy0022 616-zgh-26
7.5616
7.5433
7.5229
7.4705
7.4527
7.4337
7.3553
7.3401
7.2385
7.2256
7.1625
7.1586
7.1441
5.7021
5.6671
3.8882
3.8441
2.2373
2.1990
2.0873
2.0397
2.0075
1.9707
1.3088
1.2909
1.2731
O
N
N
Ph
Ph
D24
4.00
1.00
3.00
1.00
1.95
2.00
1.00
6.90
3.00
chemical shift (ppm)

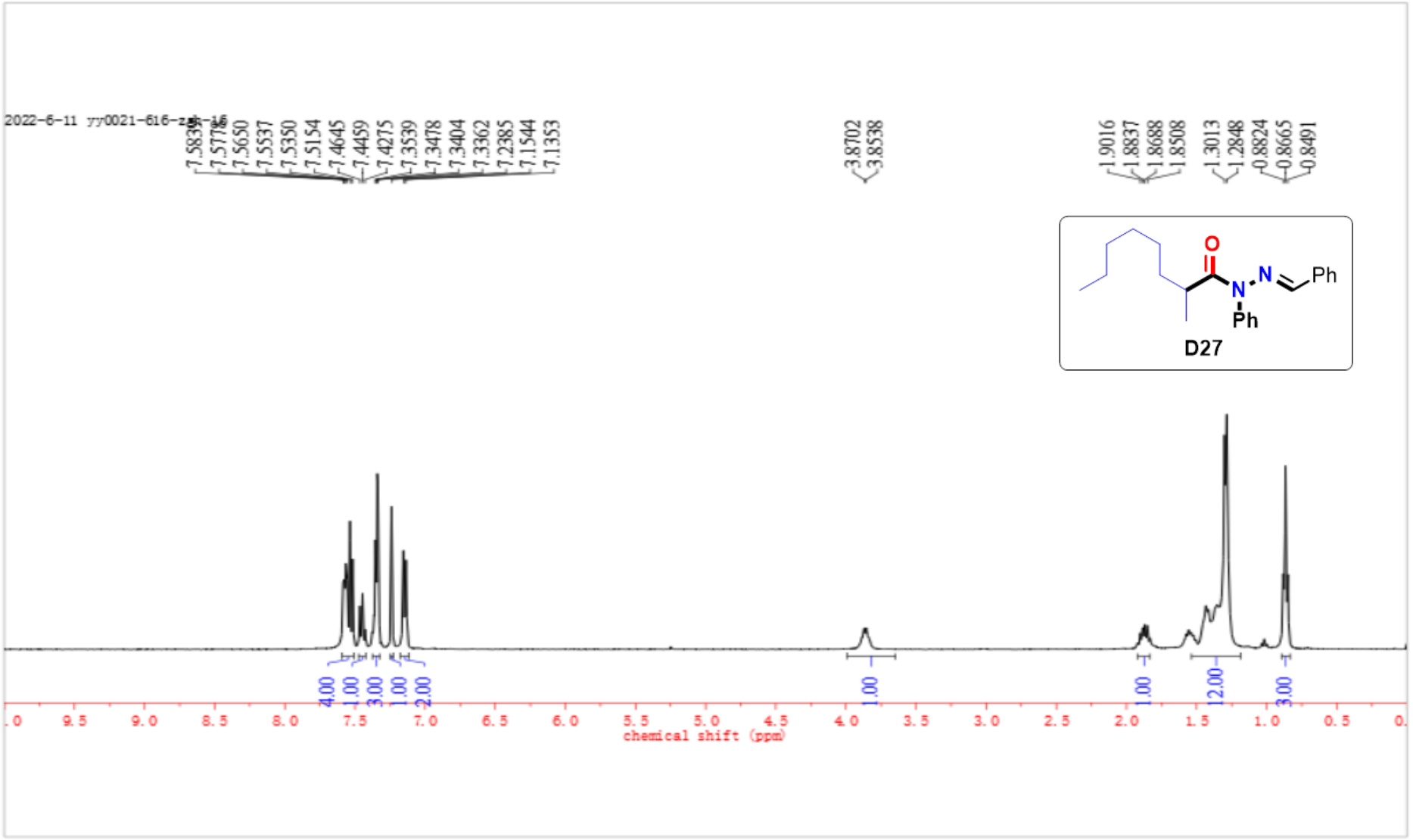

2022-6-20 yy0022_616_zgh-26
178.30
178.24
141.18
141.14
136.46
134.56
130.21
129.79
129.28
129.16
128.76
127.15
126.89
126.60
126.39
77.47
77.15
76.83
41.22
40.15
37.11
36.81
30.04
28.83
27.78
25.75
25.49
25.44
14.32
O
N
N
Ph
Ph
D24
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

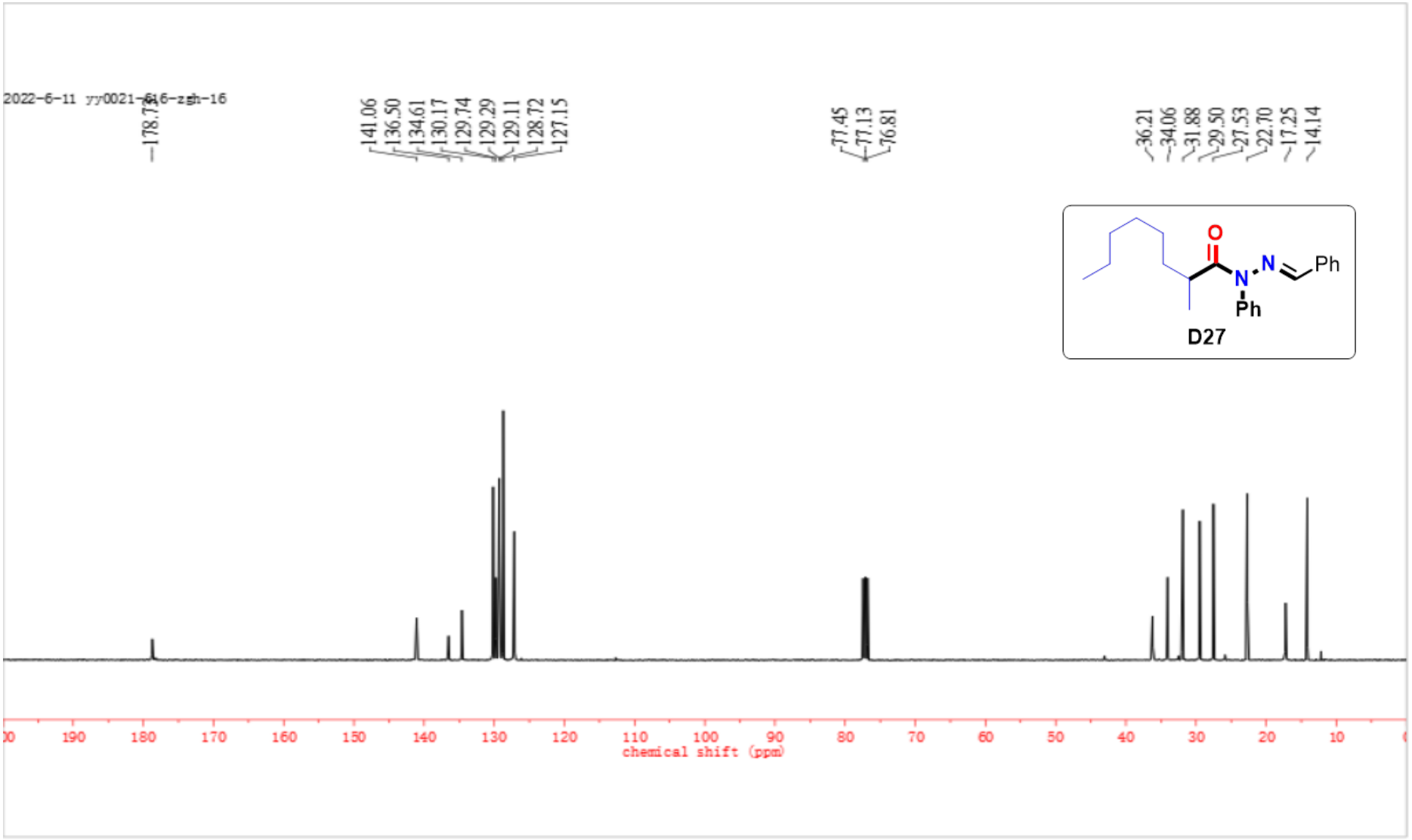

2022-6-11 yy0044-616-1
7.5684
7.5603
7.5549
7.5467
7.5273
7.4907
7.4723
7.4538
7.3746
7.3646
7.3585
7.3052
7.1716
7.1531
4.1589
4.1413
4.1231
4.1054
2.8180
2.8022
2.7760
2.7602
2.6619
2.6417
2.6199
2.5997
1.5257
1.5081
O
N
N
Ph
N
Ph
D25
4.00
1.00
3.00
1.00
2.00
1.00
1.00
1.00
3.00
chemical shift (ppm)

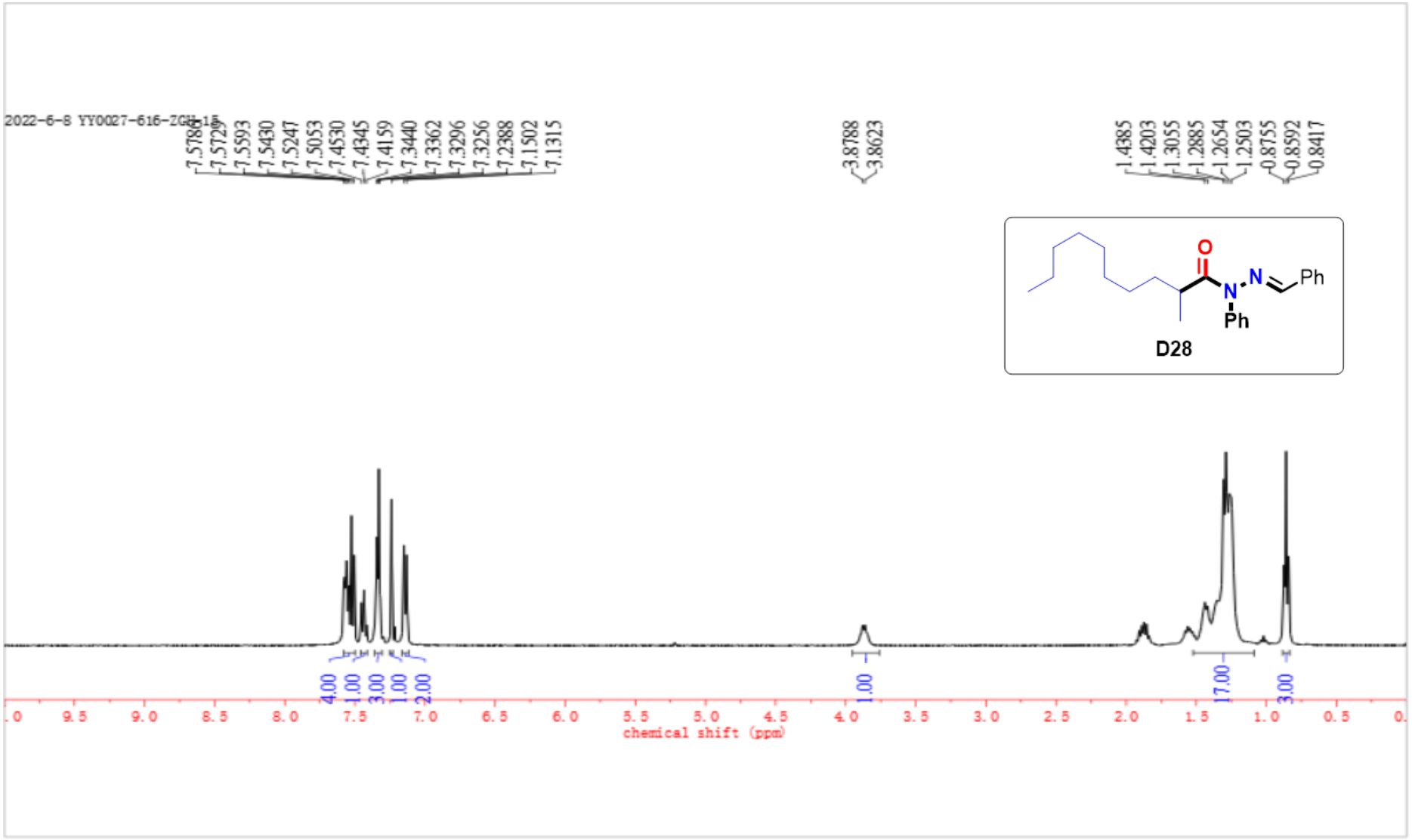

2022-6-11 yy0044-616-1qq-zgh-17
174.63
142.80
130.37
130.34
129.64
129.14
128.90
77.64
77.32
77.00
34.50
21.05
17.31
N
O
N
N
Ph
Ph
D25
chemical shift (ppm)

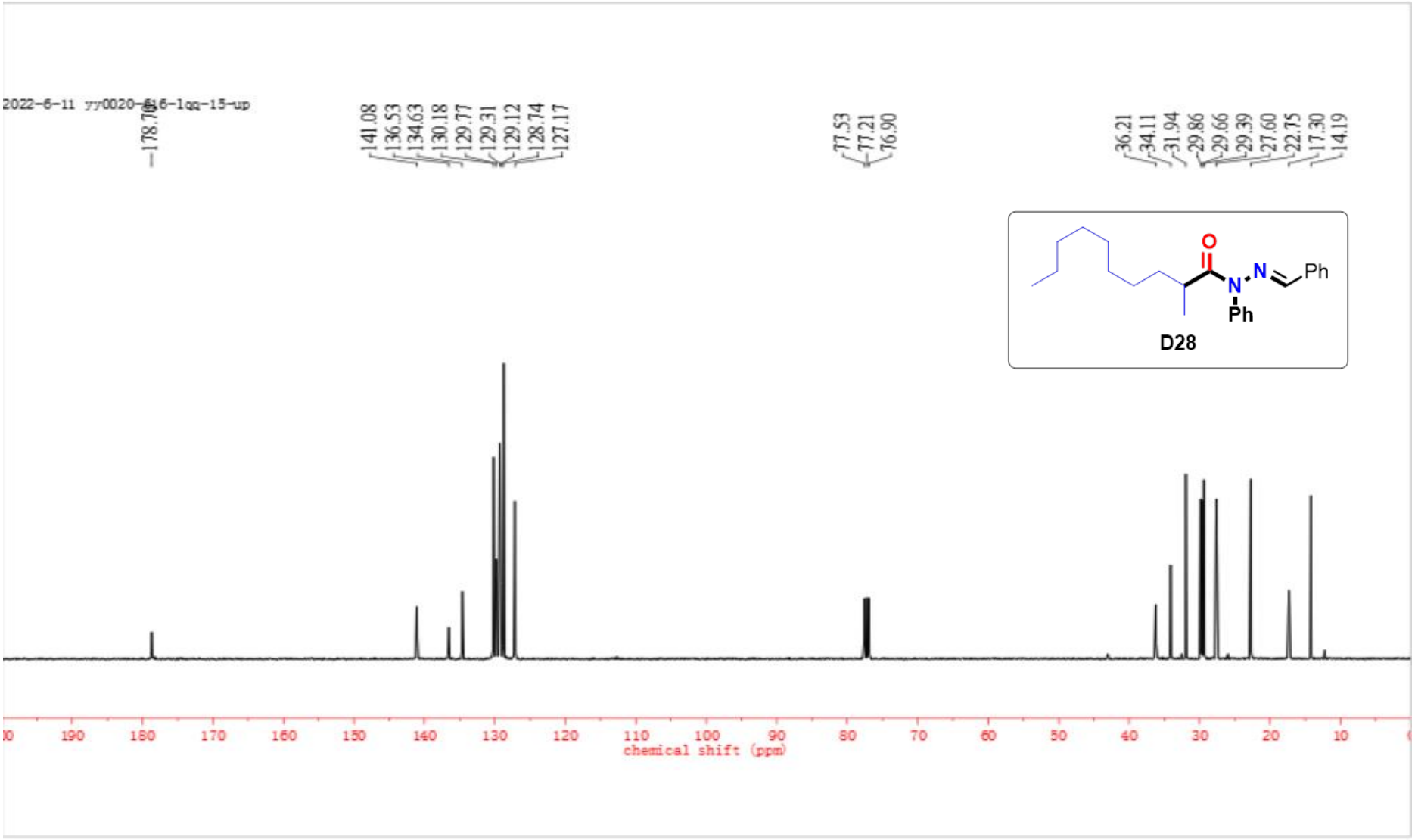

2022-6-11 yy0021-616-zgh-14
7.5825
7.5771
7.5634
7.5524
7.5339
7.5143
7.4635
7.4449
7.4264
7.3548
7.3405
7.3365
7.2389
7.2285
7.1549
7.1360
3.8666
3.8500
1.8876
1.8720
1.8538
1.4014
1.3058
1.2888
0.9289
0.9116
0.8941
O
N
N
Ph
Ph
D26
4.00
1.00
3.00
1.00
2.00
1.00
1.00
8.00
3.00
chemical shift (ppm)

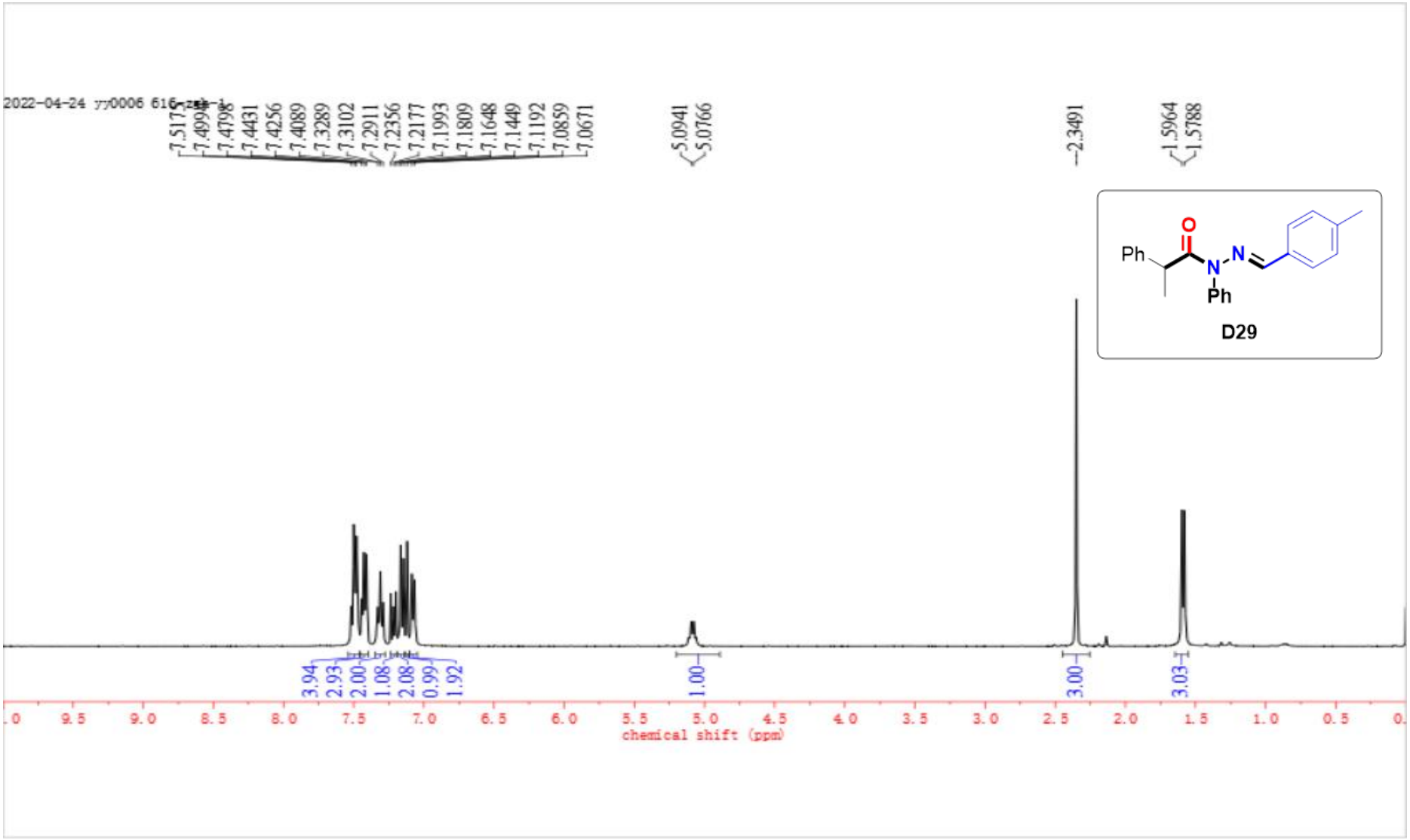

2022-6-11 yy0021-616-zgh-14
178.72
141.08
136.50
134.61
130.17
129.76
129.29
129.12
128.73
127.15
77.46
77.14
76.83
36.25
33.72
29.79
22.91
17.31
14.15
12.19
O
N
N
Ph
Ph
D26
chemical shift (ppm)

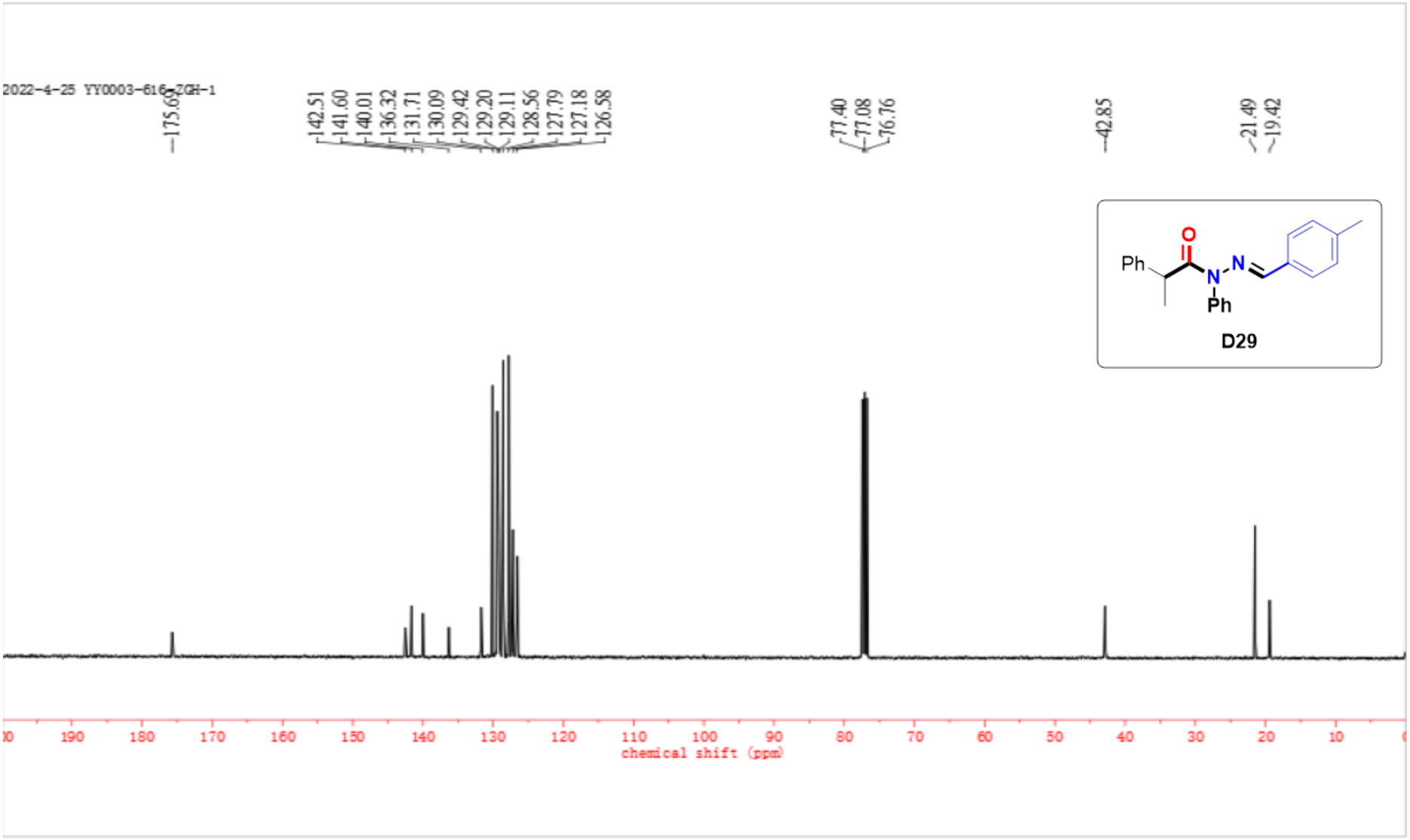

2022-6-11 yy0021-616-zzk-1H
7.5839
7.5778
7.5650
7.5537
7.5350
7.5154
7.4645
7.4459
7.4275
7.3539
7.3478
7.3404
7.3362
7.2385
7.1544
7.1353
3.8702
3.8538
1.9016
1.8837
1.8688
1.8508
1.3013
1.2848
0.8824
0.8665
0.8491
O
N
N
Ph
Ph
D27
4.00
1.00
3.00
1.00
2.00
1.00
1.00
12.00
3.00
chemical shift (ppm)

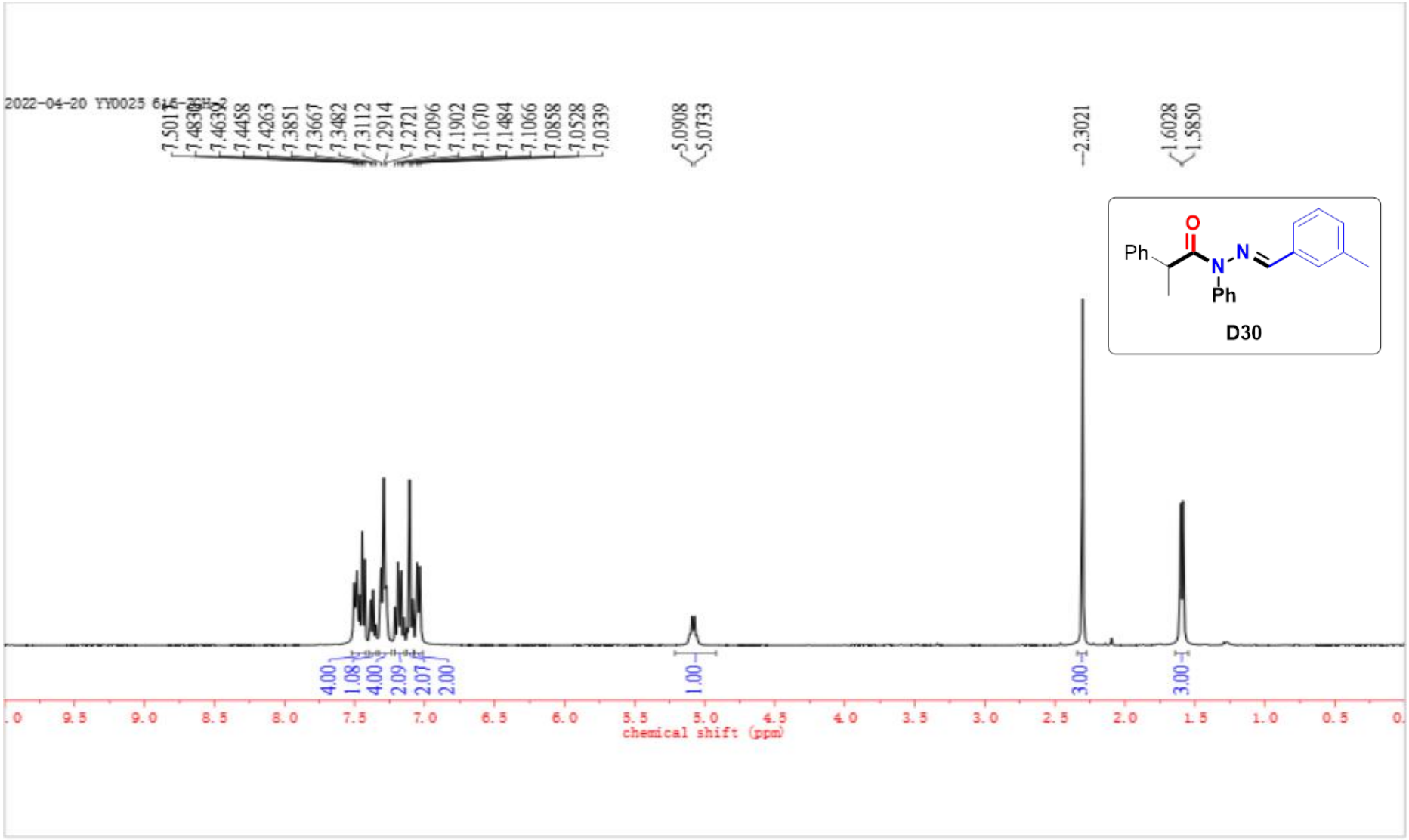

2022-6-11 yy0021-616-zgh-16
178.73
141.06
136.50
134.61
130.17
129.74
129.29
129.11
128.72
127.15
77.45
77.13
76.81
36.21
34.06
31.88
29.50
27.53
22.70
17.25
14.14
O
N
N
Ph
Ph
D27
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

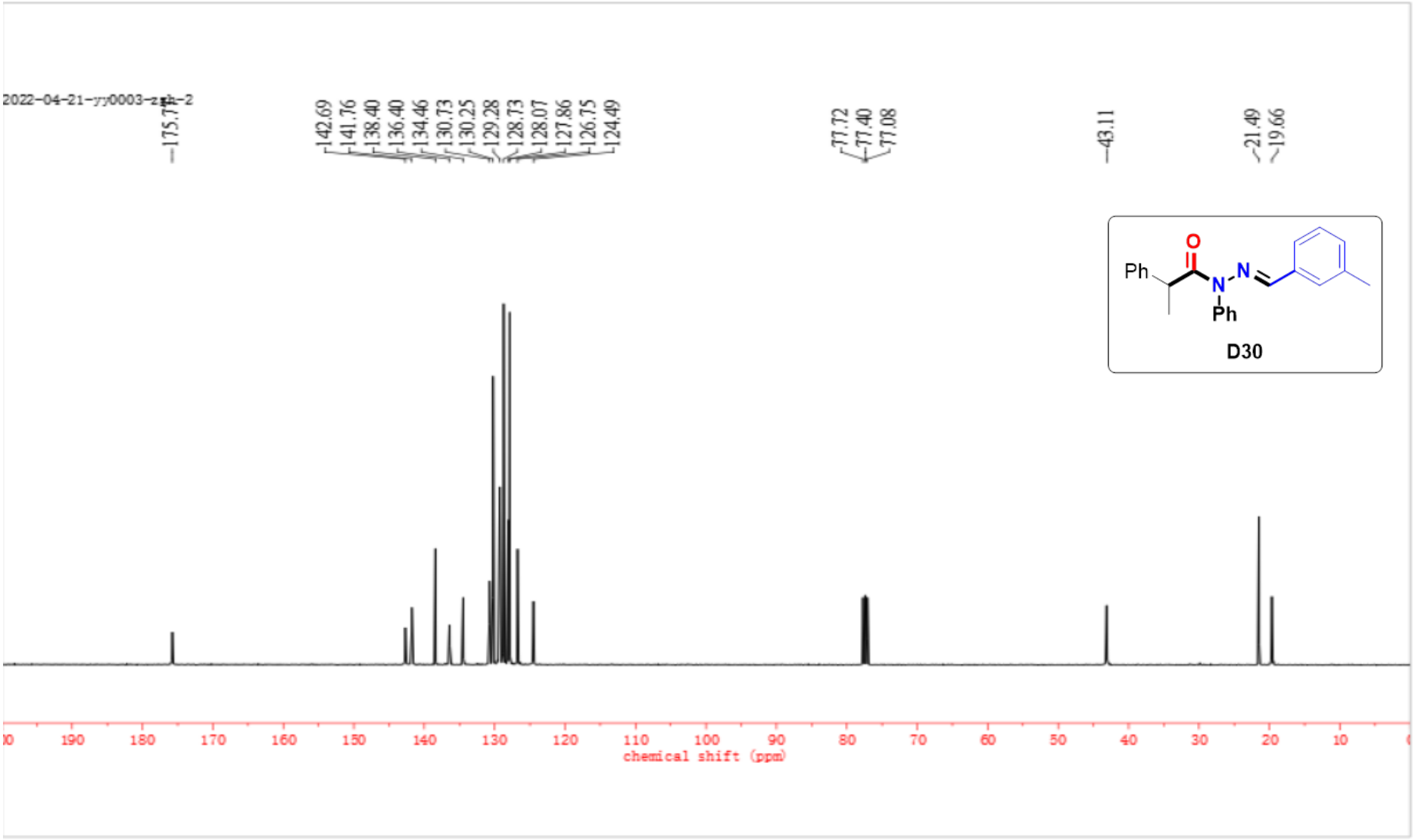

2022-6-8 YY0027-616-ZGH-1H
7.5786
7.5729
7.5593
7.5430
7.5247
7.5053
7.4530
7.4345
7.4159
7.3440
7.3362
7.3296
7.3256
7.2388
7.1502
7.1315
3.8788
3.8623
1.4385
1.4203
1.3055
1.2885
1.2654
1.2503
0.8755
0.8592
0.8417
O
N
N
Ph
Ph
D28
4.00
1.00
3.00
1.00
2.00
1.00
17.00
3.00
chemical shift (ppm)

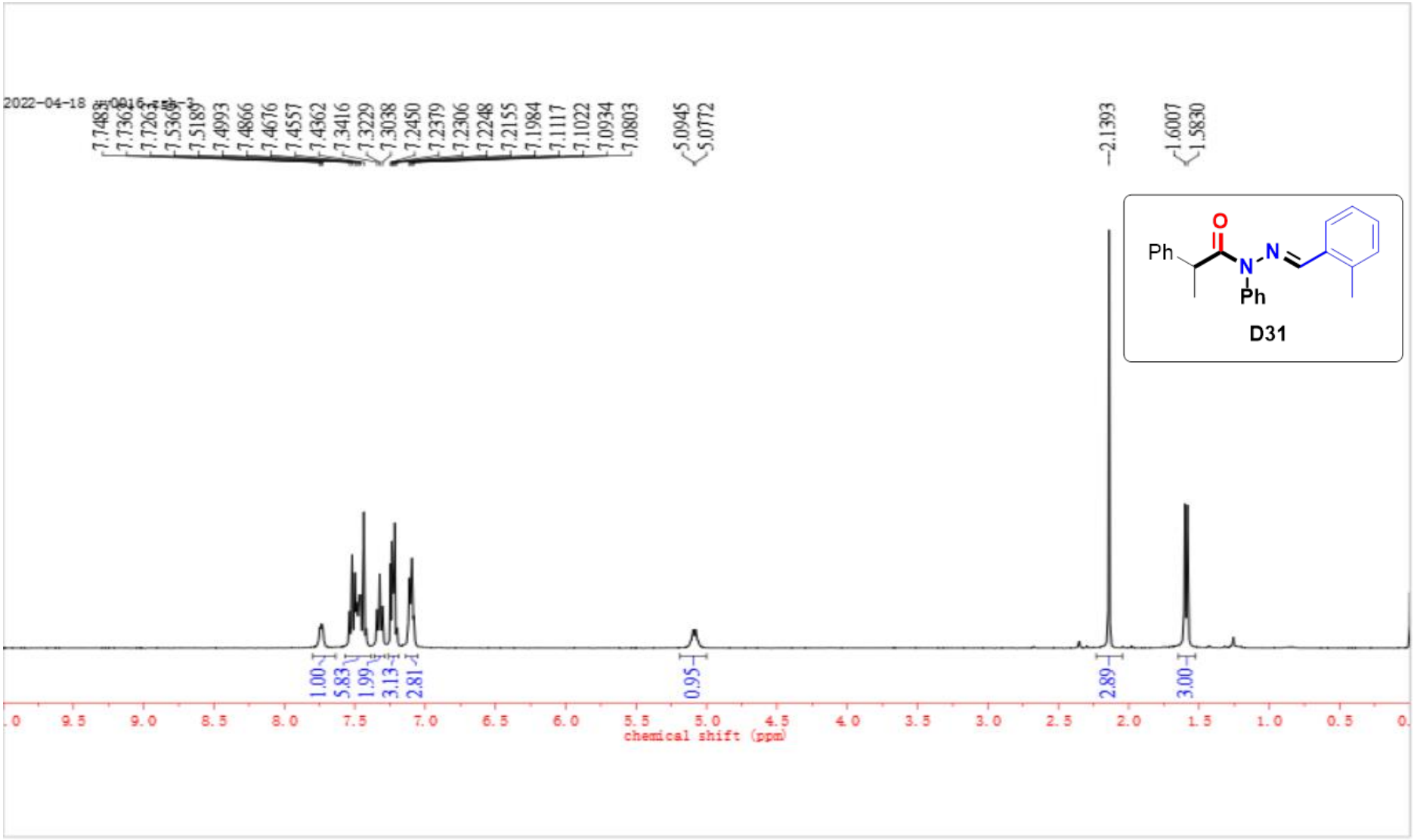

2022-6-11 yy0020-fq16-1qq-15-up
178.78
141.08
136.53
134.63
130.18
129.77
129.31
129.12
128.74
127.17
77.53
77.21
76.90
36.21
34.11
31.94
29.86
29.66
29.39
27.60
22.75
17.30
14.19
O
N
N
Ph
Ph
D28
chemical shift (ppm)

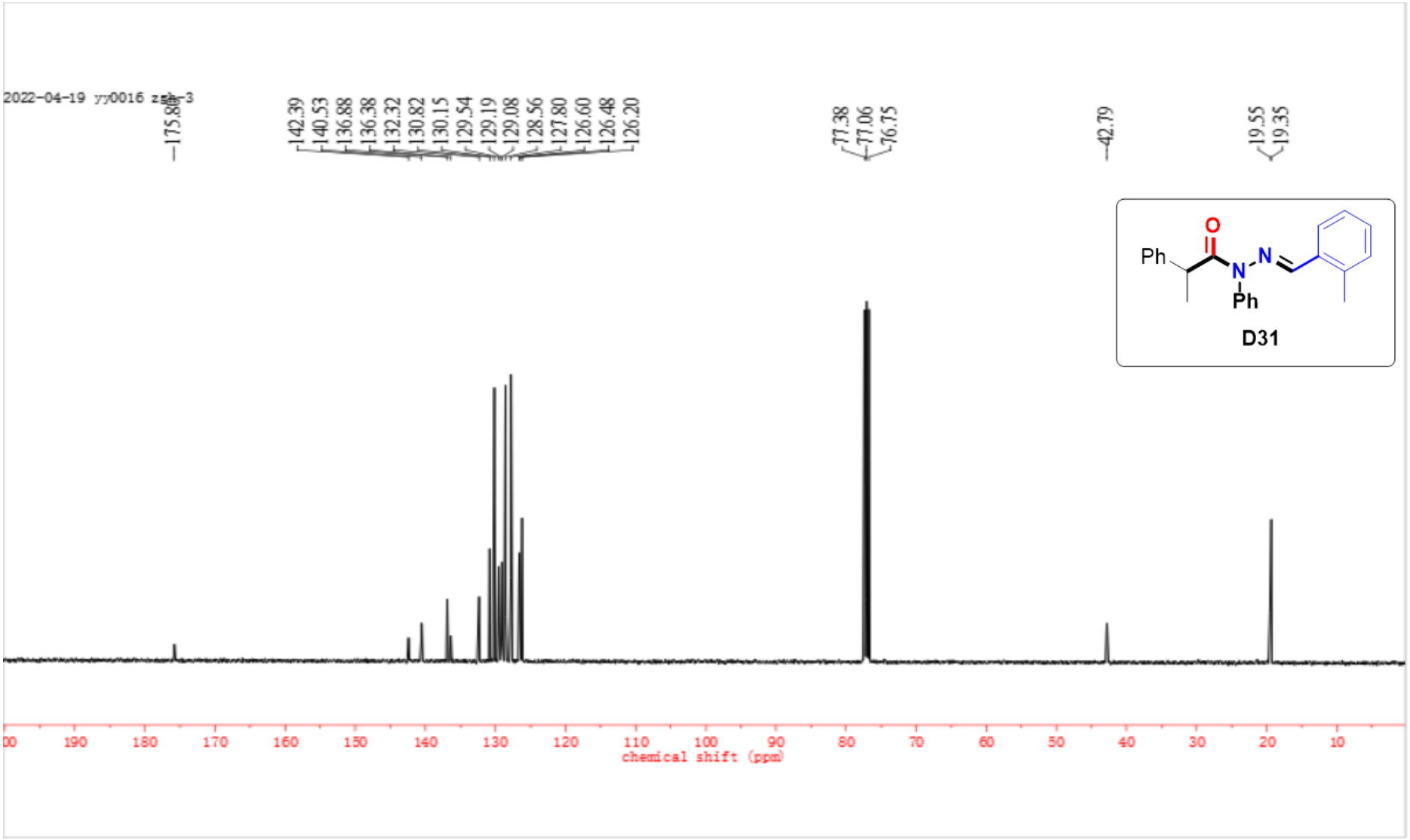

2022-04-24 yy0006 616-zzs-1
7.5175
7.4994
7.4798
7.4431
7.4256
7.4089
7.3289
7.3102
7.2911
7.2356
7.2177
7.1993
7.1809
7.1648
7.1449
7.1192
7.0859
7.0671
5.0941
5.0766
2.3491
1.5964
1.5788
Ph
O
N
N
Ph
D29
3.94
2.93
2.00
1.08
2.08
0.99
1.92
1.00
3.00
3.03
chemical shift (ppm)

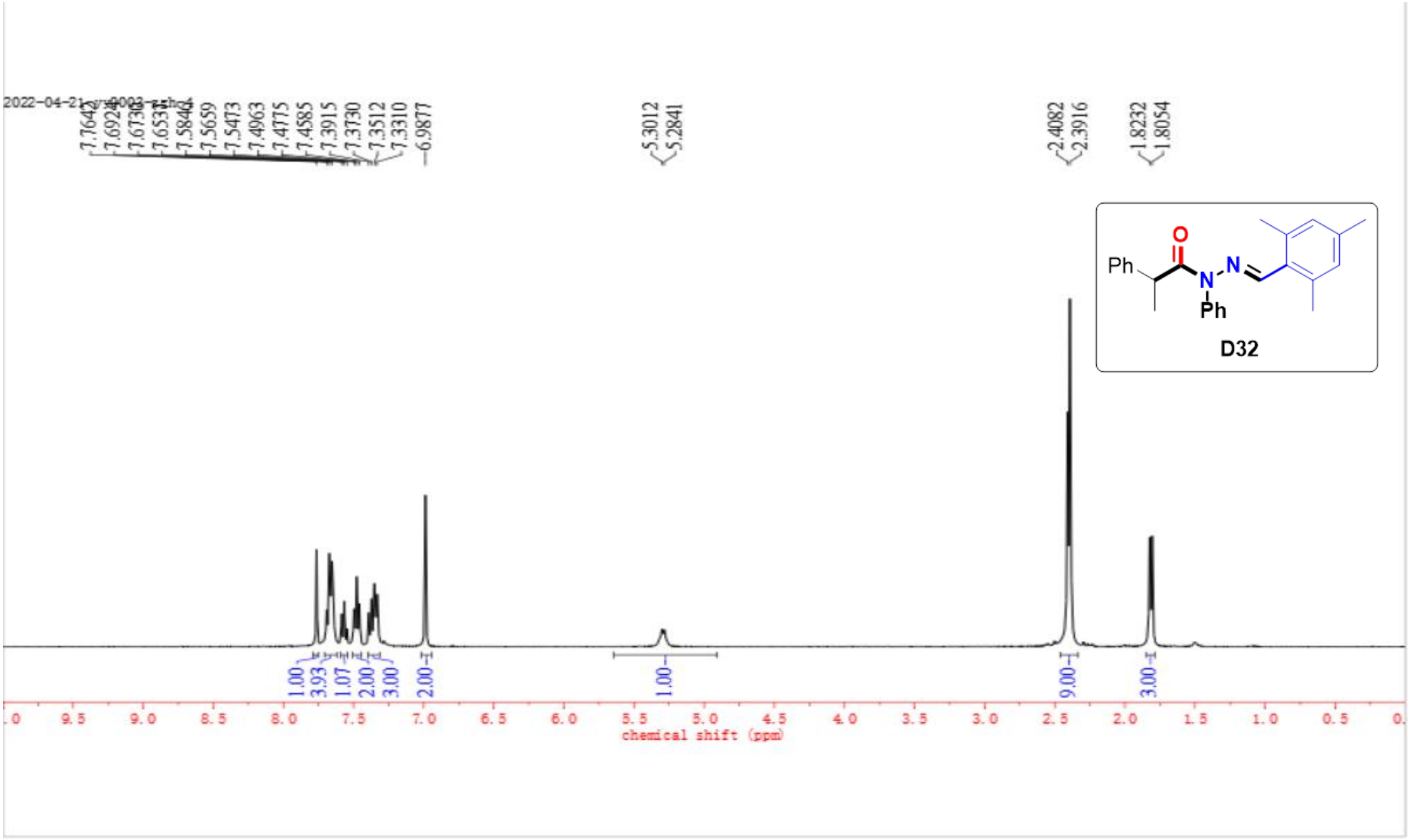

2022-4-25 YY0003-616-ZGH-1
175.69
142.51
141.60
140.01
136.32
131.71
130.09
129.42
129.20
129.11
128.56
127.79
127.18
126.58
77.40
77.08
76.76
42.85
21.49
19.42
Ph
O
N
N
Ph
D29
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

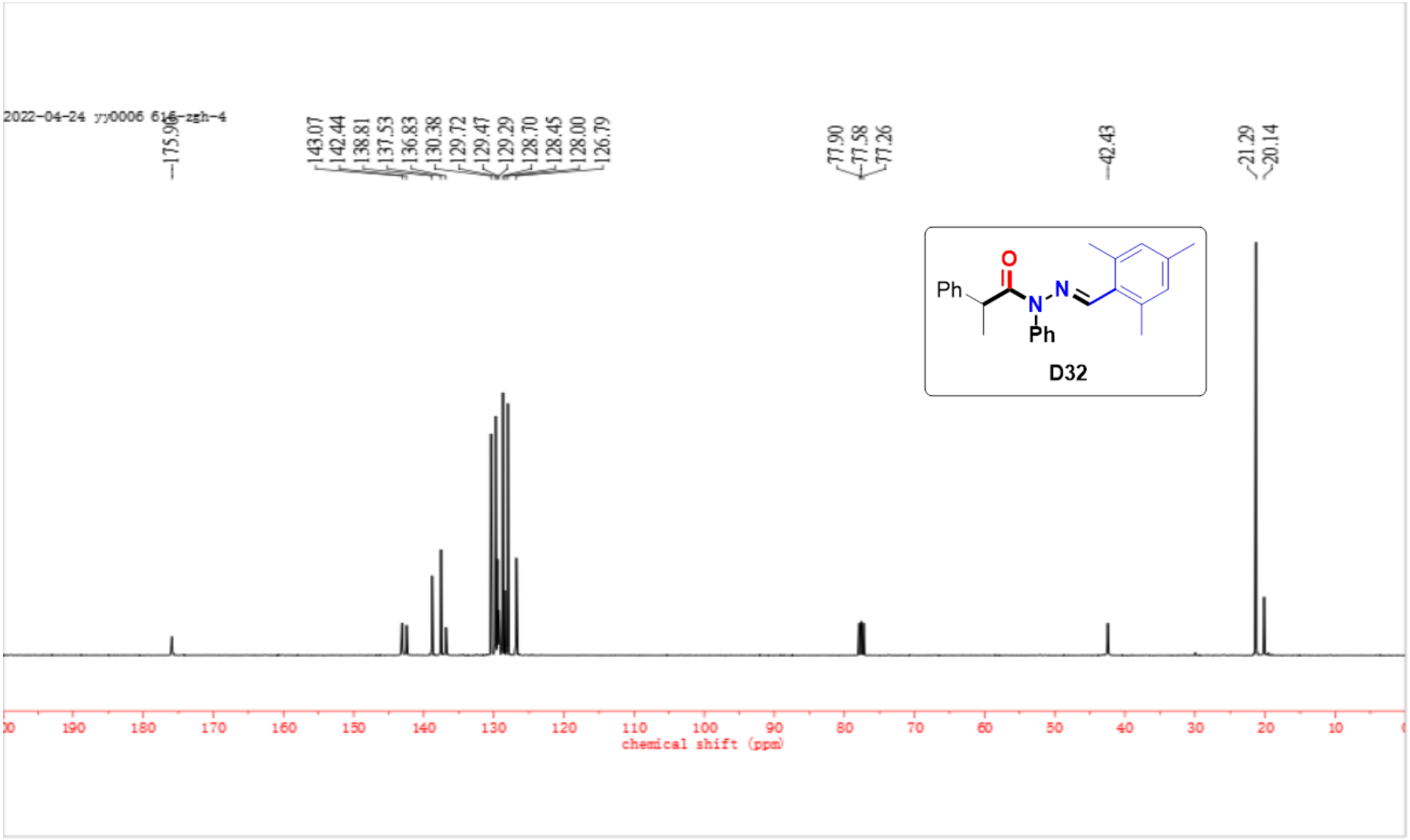

2022-04-20 YY0025
7.5017
7.4830
7.4632
7.4458
7.4263
7.3851
7.3667
7.3482
7.3112
7.2914
7.2721
7.2096
7.1902
7.1670
7.1484
7.1066
7.0858
7.0528
7.0339
5.0908
5.0733
2.3021
1.6028
1.5850
Ph
O
N
N
Ph
D30
4.00
1.08
4.00
2.09
2.07
2.00
1.00
3.00
3.00
chemical shift (ppm)

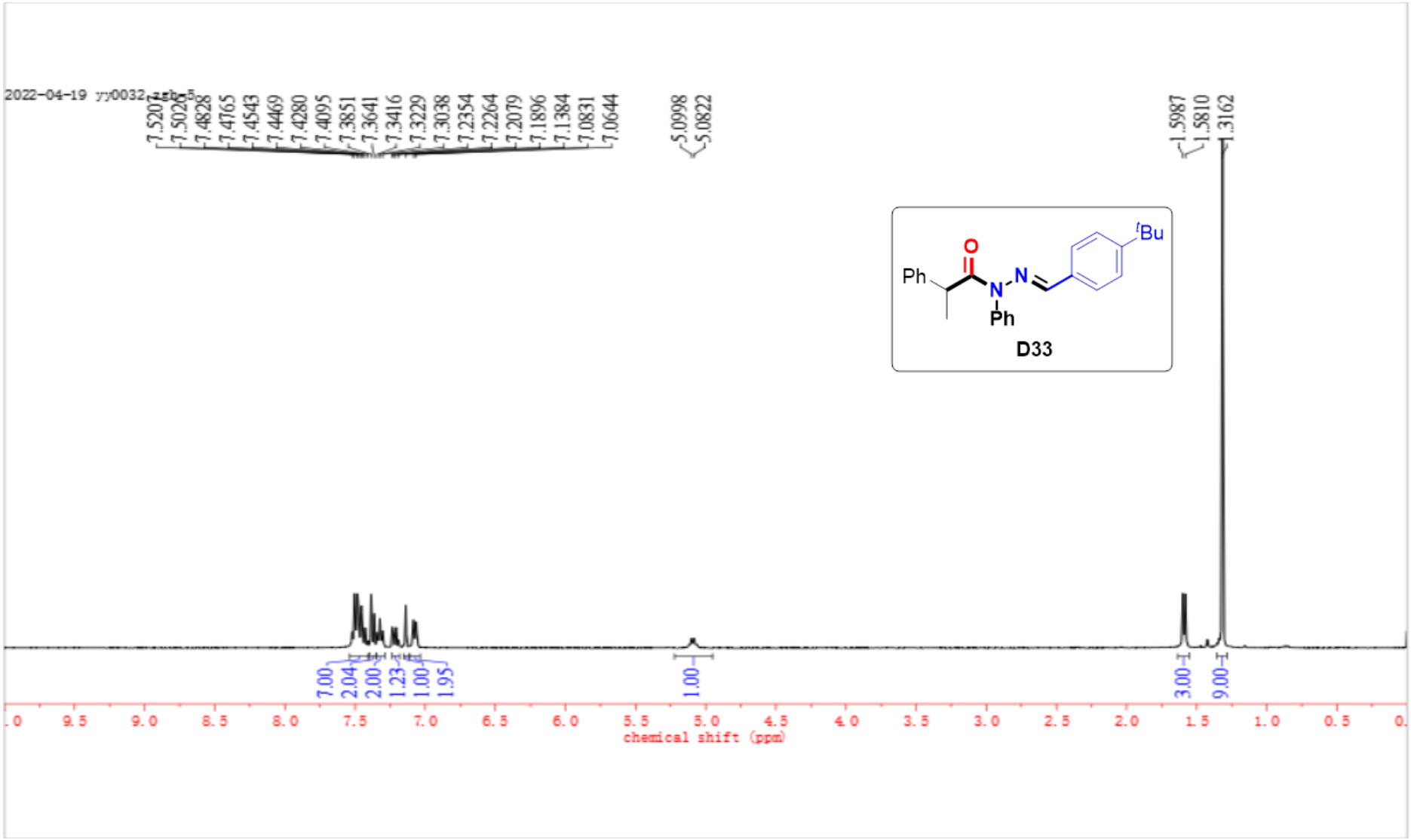

2022-04-21-yy0003-zsh-2
175.77
142.69
141.76
138.40
136.40
134.46
130.73
130.25
129.28
128.73
128.07
127.86
126.75
124.49
77.72
77.40
77.08
43.11
21.49
19.66
Ph
O
N
N
Ph
D30
chemical shift (ppm)

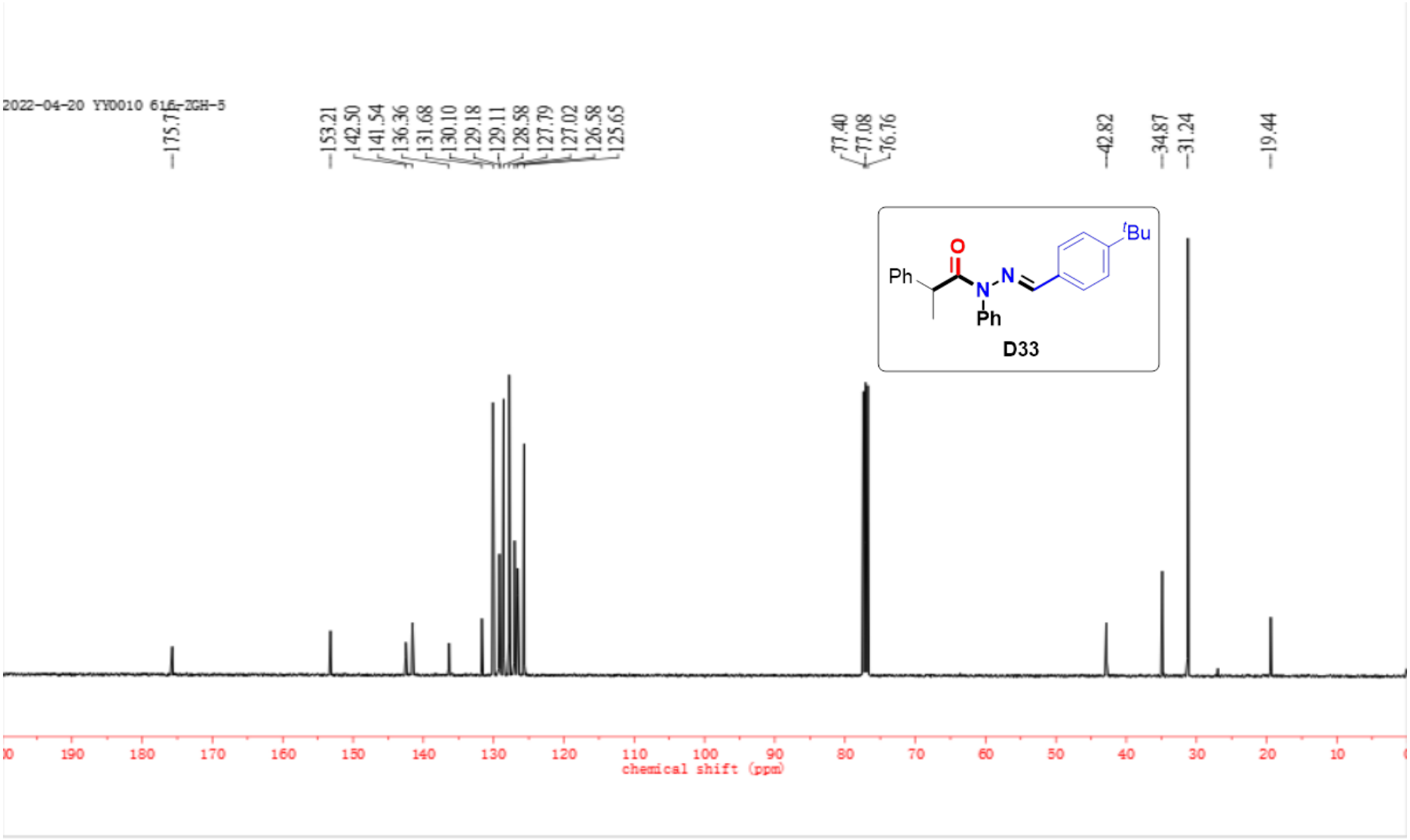

2022-04-18
7.7483
7.7362
7.7263
7.5367
7.5189
7.4993
7.4866
7.4676
7.4557
7.4362
7.3416
7.3229
7.3038
7.2450
7.2379
7.2306
7.2248
7.2155
7.1984
7.1117
7.1022
7.0934
7.0803
5.0945
5.0772
2.1393
1.6007
1.5830
Ph
O
N
N
Ph
D31
1.00
5.83
1.99
3.13
2.81
0.95
2.89
3.00
chemical shift (ppm)

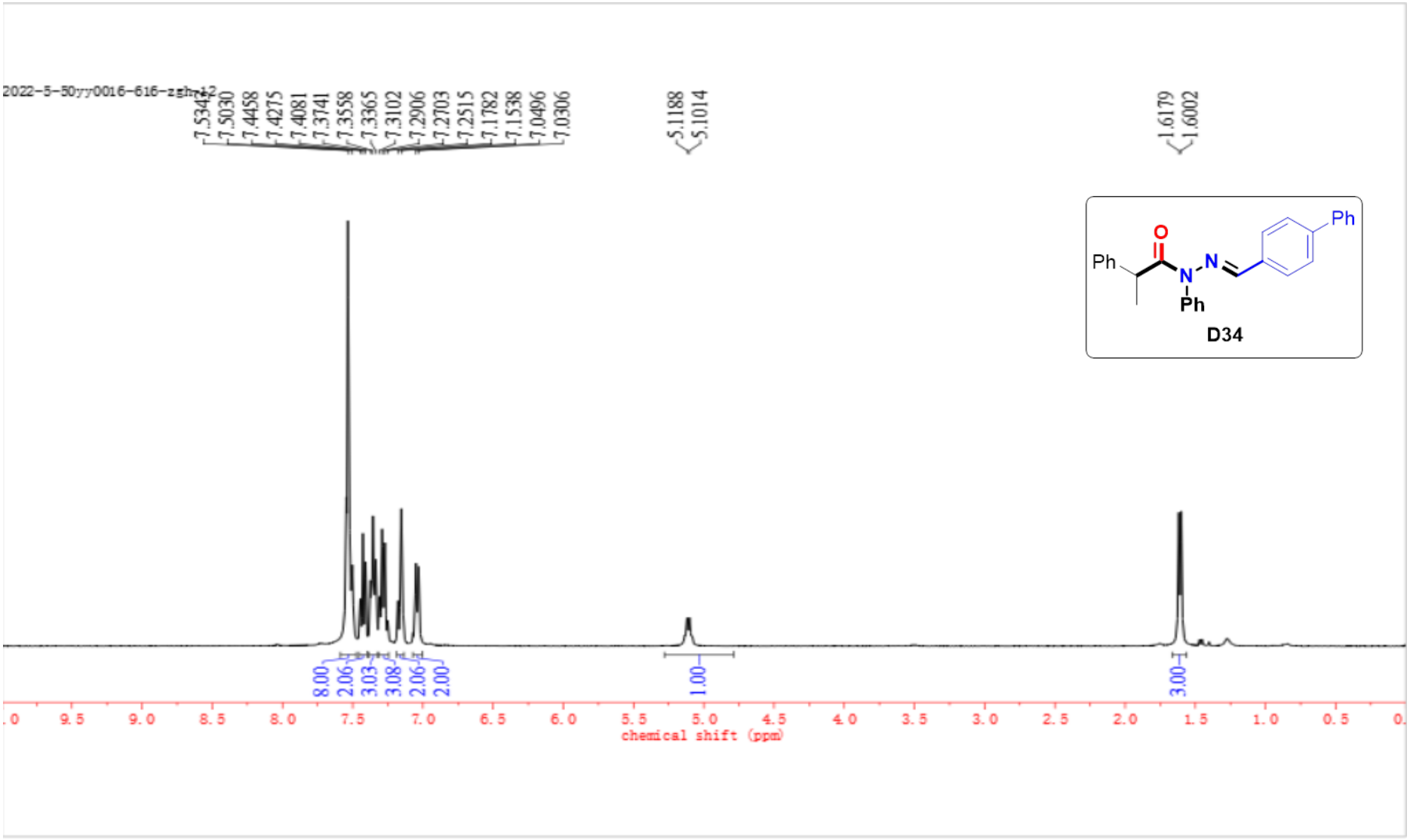

2022-04-19 yy0016 zsh-3
175.80
142.39
140.53
136.88
136.38
132.32
130.82
130.15
129.54
129.19
129.08
128.56
127.80
126.60
126.48
126.20
77.38
77.06
76.75
42.79
19.55
19.35
Ph
O
N
N
Ph
D31
chemical shift (ppm)

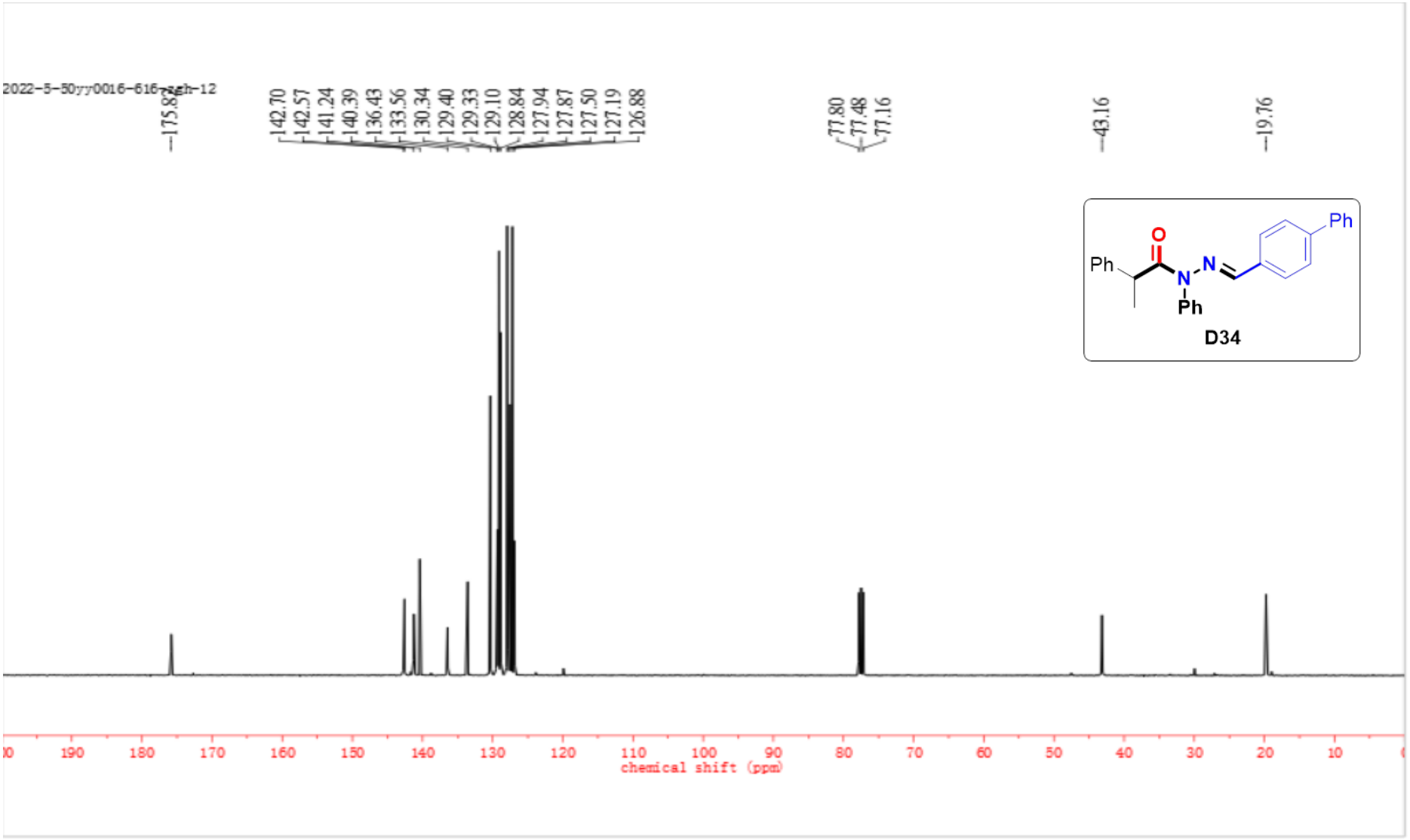

2022-04-21
7.6422
7.6924
7.6736
7.6531
7.5844
7.5659
7.5473
7.4963
7.4775
7.4585
7.3915
7.3730
7.3512
7.3310
6.9877
5.3012
5.2841
2.4082
2.3916
1.8232
1.8054
Ph
O
N
N
Ph
D32
1.00
3.93
1.07
2.00
3.00
2.00
1.00
9.00
3.00
chemical shift (ppm)

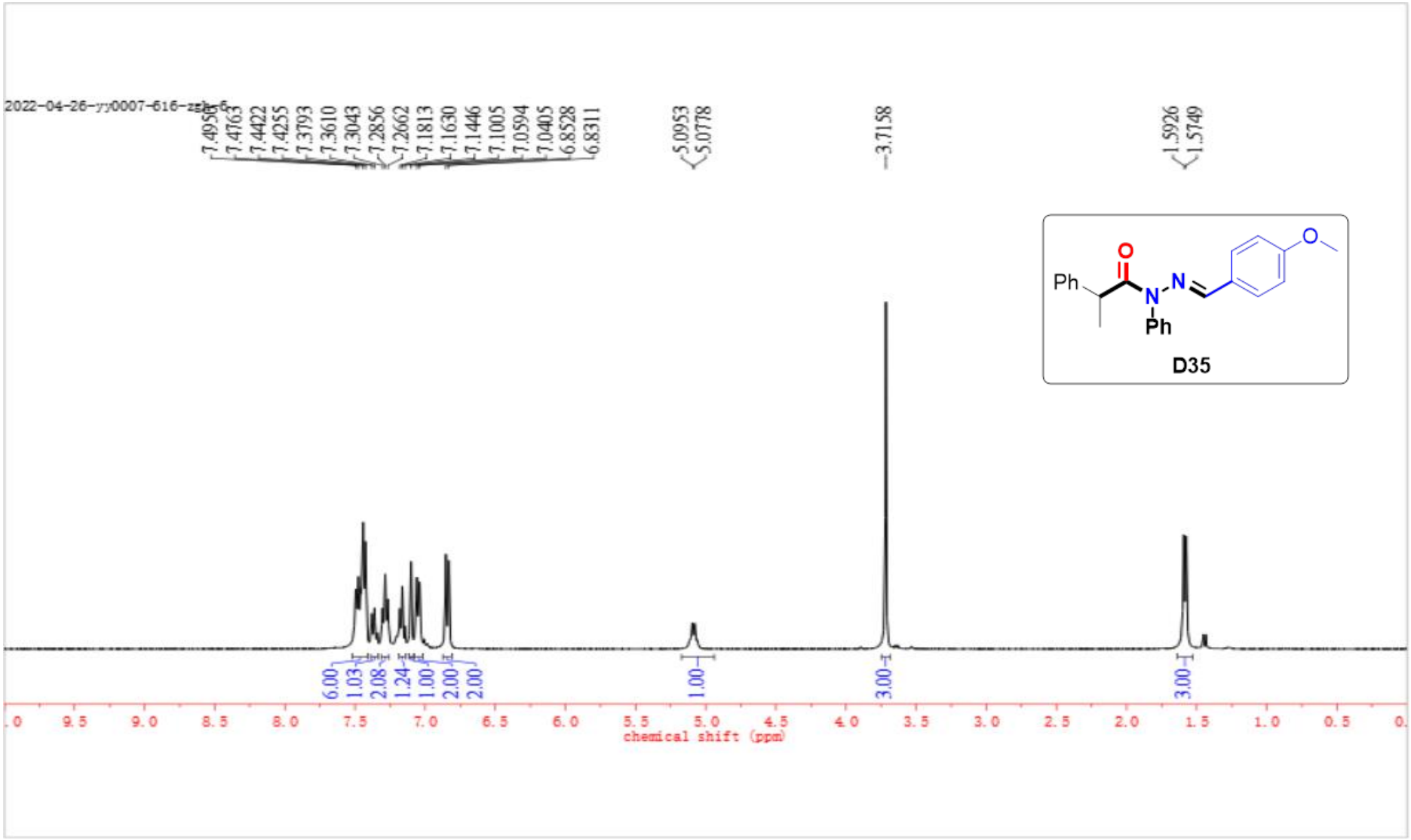

2022-04-24 yy0006 616-zgh-4
175.90
143.07
142.44
138.81
137.53
136.83
130.38
129.72
129.47
129.29
128.70
128.45
128.00
126.79
77.90
77.58
77.26
42.43
21.29
20.14
Ph
O
N
N
Ph
D32
chemical shift (ppm)

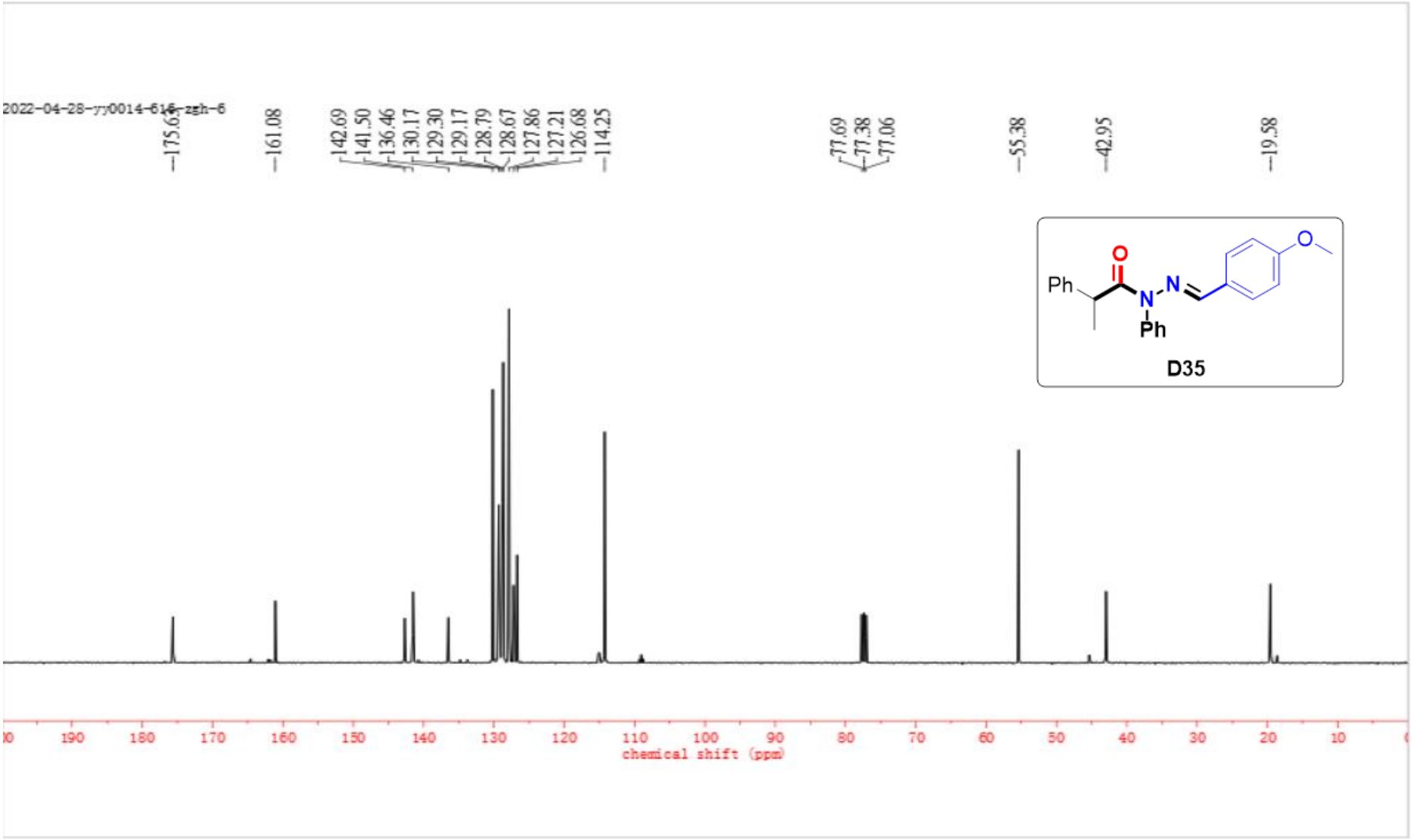

2022-04-19 yy0032-1h-r5
7.5207
7.5026
7.4828
7.4765
7.4543
7.4469
7.4280
7.4095
7.3851
7.3641
7.3416
7.3229
7.3038
7.2354
7.2264
7.2079
7.1896
7.1384
7.0831
7.0644
5.0998
5.0822
1.5987
1.5810
1.3162
Ph
O
N
N
Ph
tBu
D33
7.00
2.04
2.00
1.23
1.00
1.95
1.00
3.00
9.00
chemical shift (ppm)

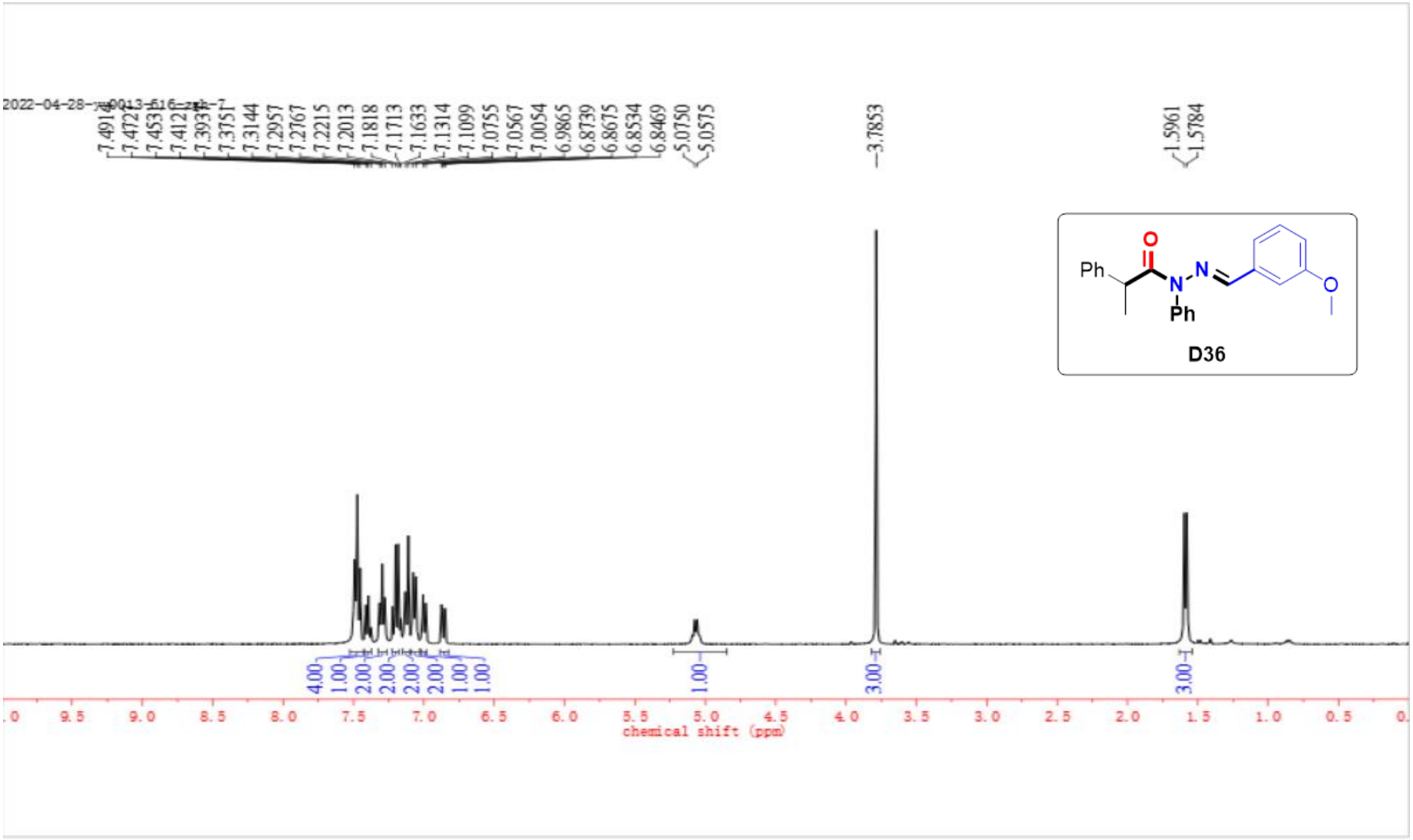

2022-04-20 YYD010 61A-ZGH-5
175.71
153.21
142.50
141.54
136.36
131.68
130.10
129.18
129.11
128.58
127.79
127.02
126.58
125.65
77.40
77.08
76.76
42.82
34.87
31.24
19.44
Ph
O
N
N
Ph
tBu
D33
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

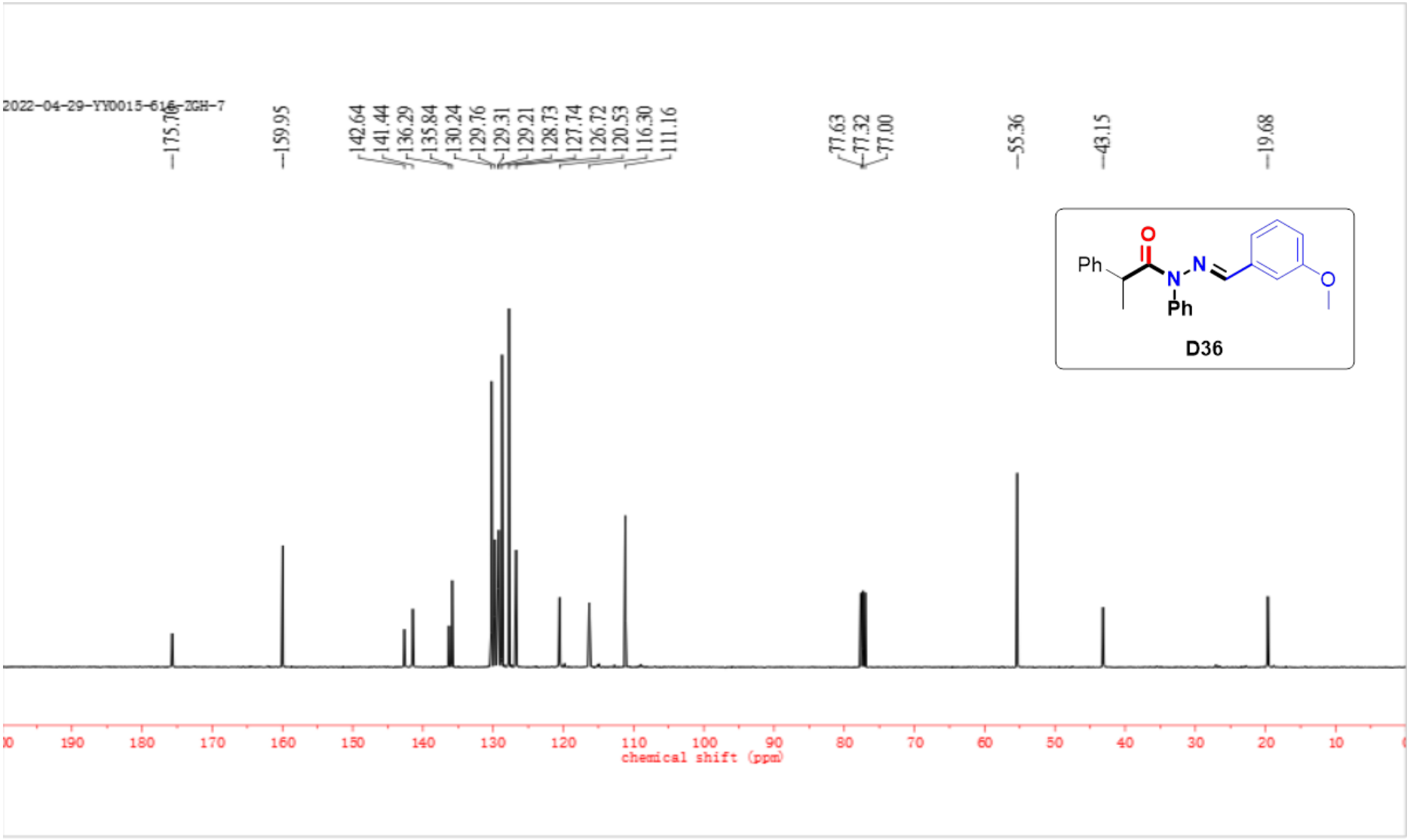

2022-5-50yy0016-616-zgh-1-2
7.5342
7.5030
7.4458
7.4275
7.4081
7.3741
7.3558
7.3365
7.3102
7.2906
7.2703
7.2515
7.1782
7.1538
7.0496
7.0306
5.1188
5.1014
1.6179
1.6002
Ph
O
N
N
Ph
Ph
D34
8.00
2.06
3.03
3.08
2.06
2.00
1.00
3.00
chemical shift (ppm)

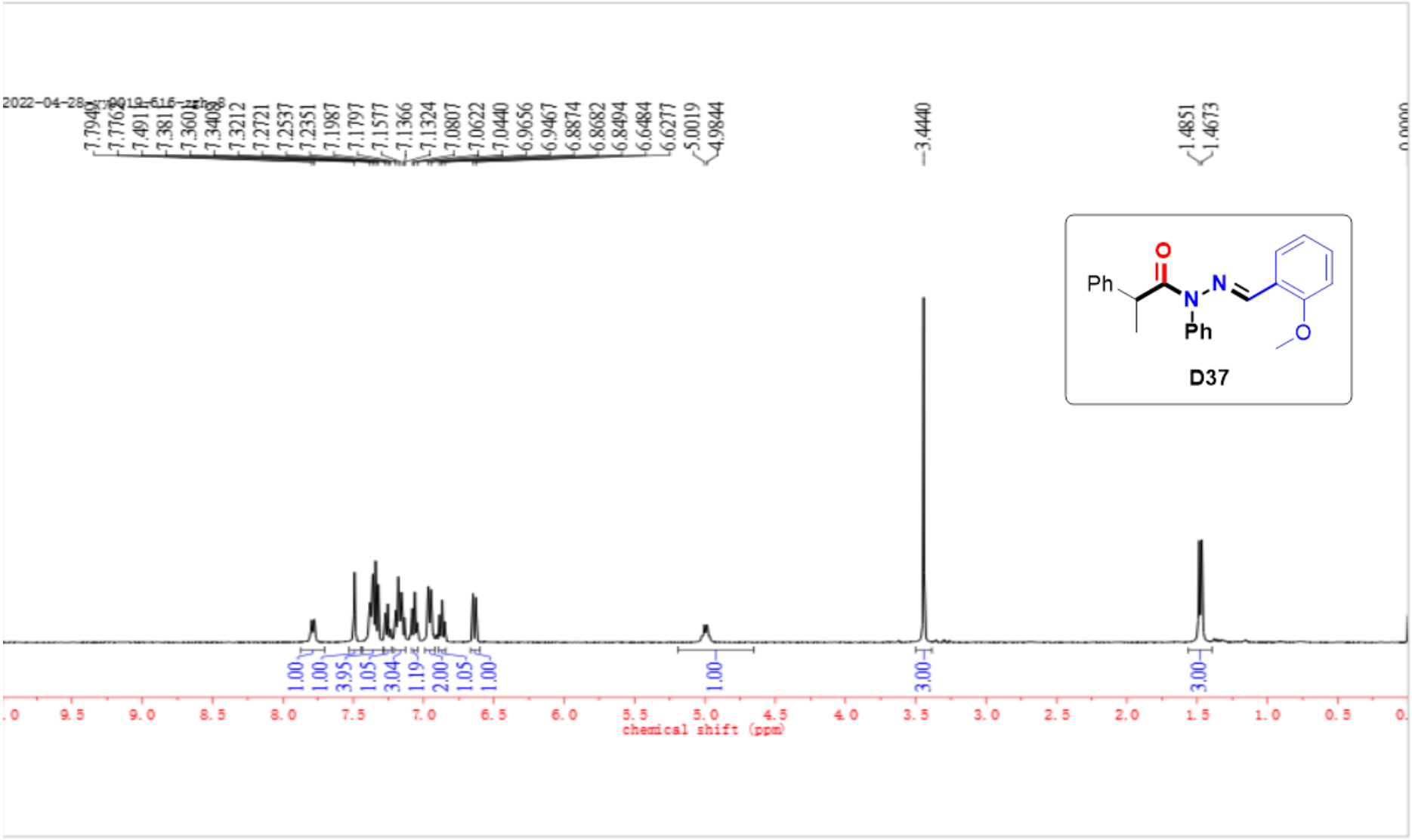

2022-5-50yy0016-616-sgh-12
175.82
142.70
142.57
141.24
140.39
136.43
133.56
130.34
129.40
129.33
129.10
128.84
127.94
127.87
127.50
127.19
126.88
77.80
77.48
77.16
43.16
19.76
Ph
O
N
N
Ph
Ph
D34
chemical shift (ppm)

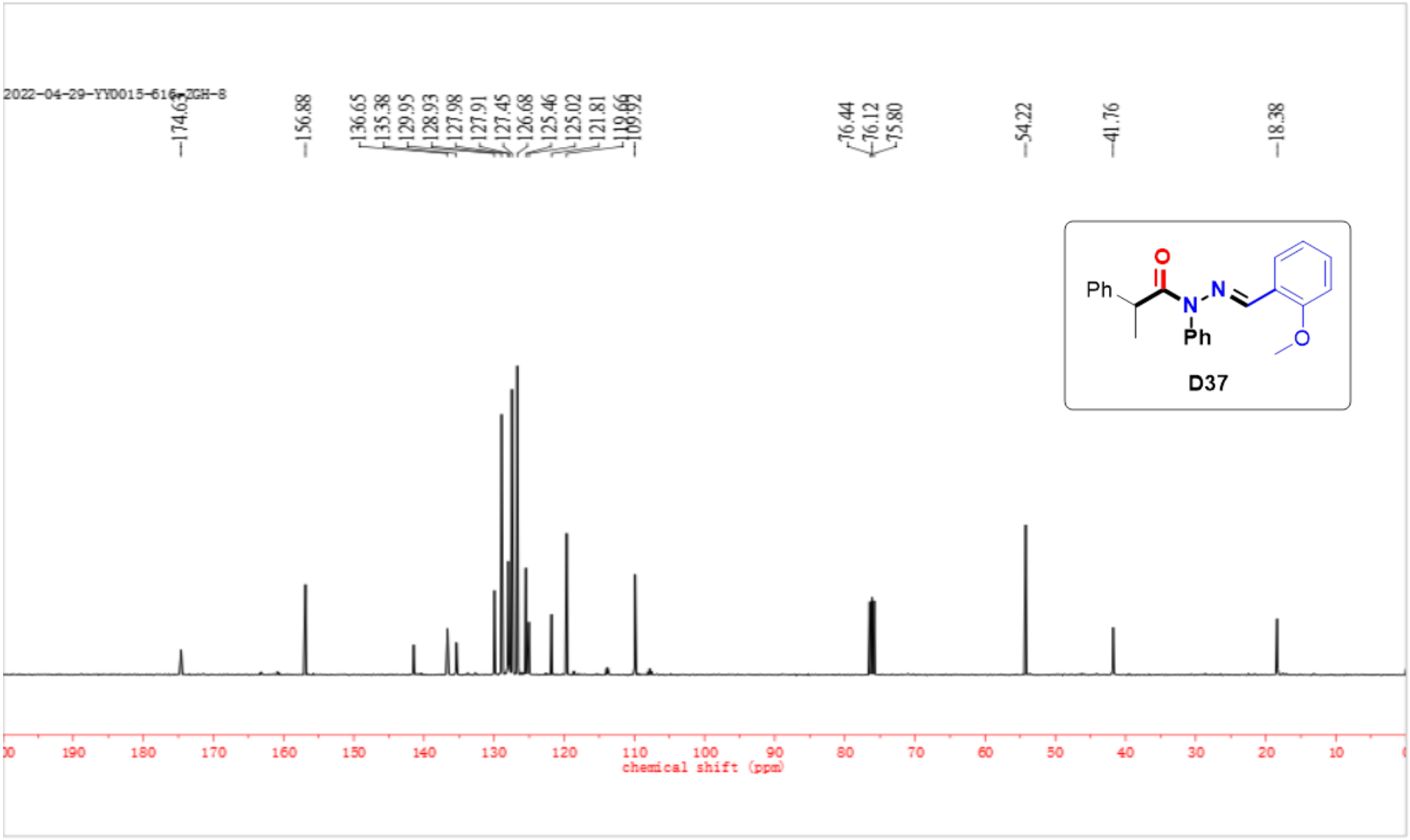

2022-04-26-yy0007-616-zsa-6
7.4956
7.4763
7.4422
7.4255
7.3793
7.3610
7.3043
7.2856
7.2662
7.1813
7.1630
7.1446
7.1005
7.0594
7.0405
6.8528
6.8311
5.0953
5.0778
3.7158
1.5926
1.5749
Ph
O
N
N
Ph
O
D35
6.00
1.03
2.08
1.24
1.00
2.00
2.00
1.00
3.00
3.00
chemical shift (ppm)

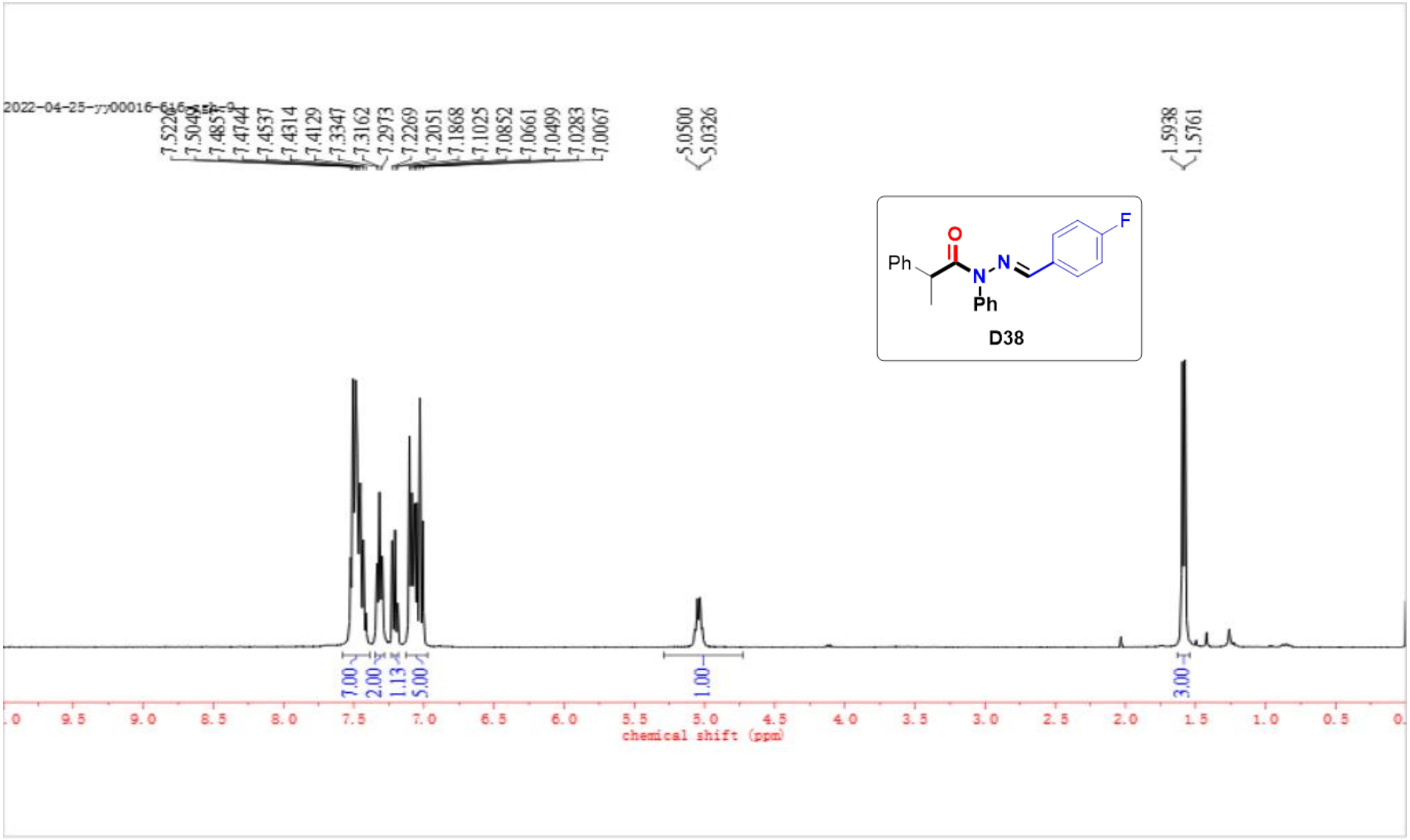

2022-04-28-yy0014-616-zgh-6
175.63
161.08
142.69
141.50
136.46
130.17
129.30
129.17
128.79
128.67
127.86
127.21
126.68
114.25
77.69
77.38
77.06
55.38
42.95
19.58
Ph
N
N
Ph
O
O
D35
chemical shift (ppm)

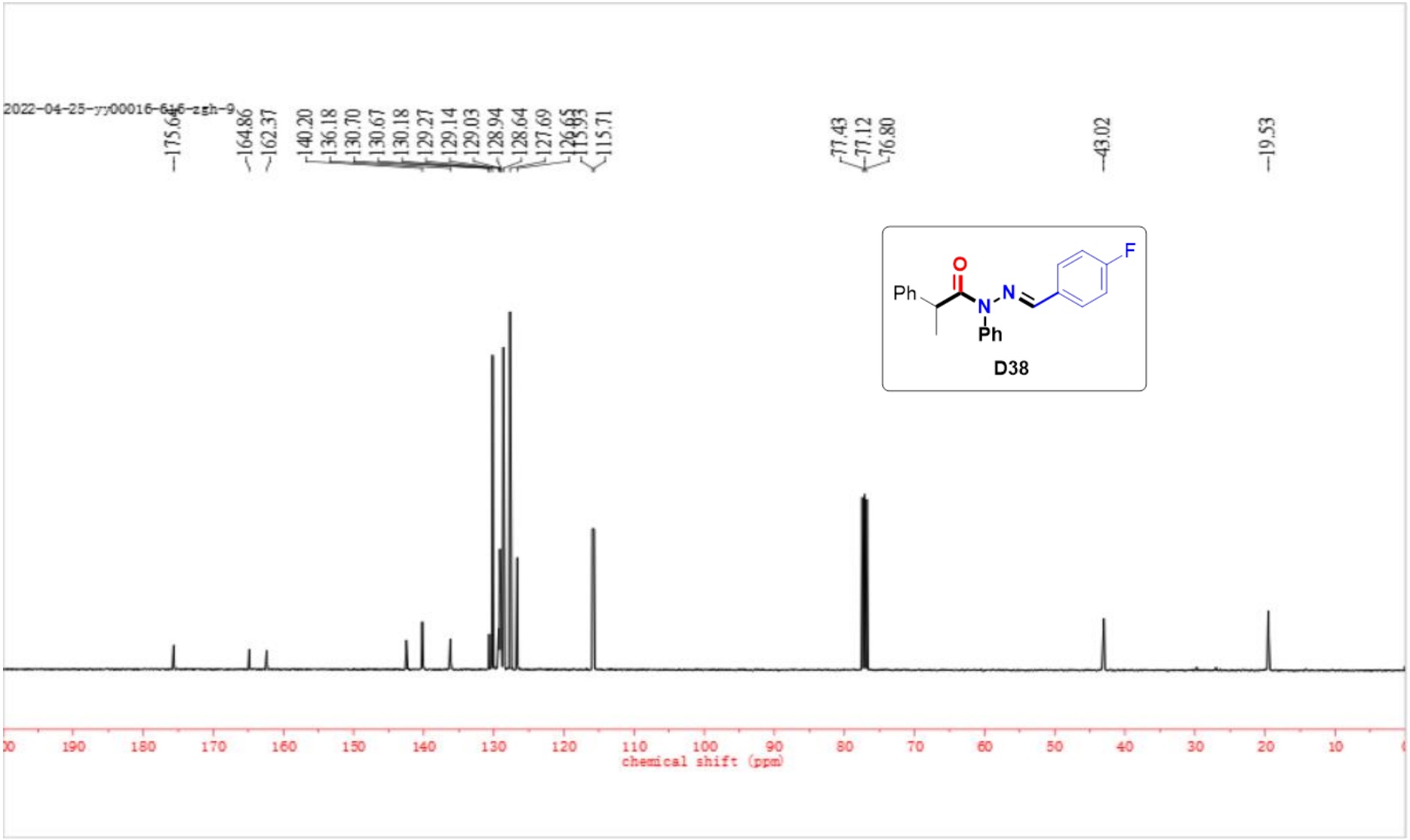

7.4914
7.4721
7.4531
7.4121
7.3937
7.3751
7.3144
7.2957
7.2767
7.2215
7.2013
7.1818
7.1713
7.1633
7.1314
7.1099
7.0755
7.0567
7.0054
6.9865
6.8739
6.8675
6.8534
6.8469
5.0750
5.0575
3.7853
1.5961
1.5784
Ph
O
N
N
Ph
O
D36
4.00
1.00
2.00
2.00
2.00
2.00
1.00
1.00
1.00
3.00
3.00
chemical shift (ppm)

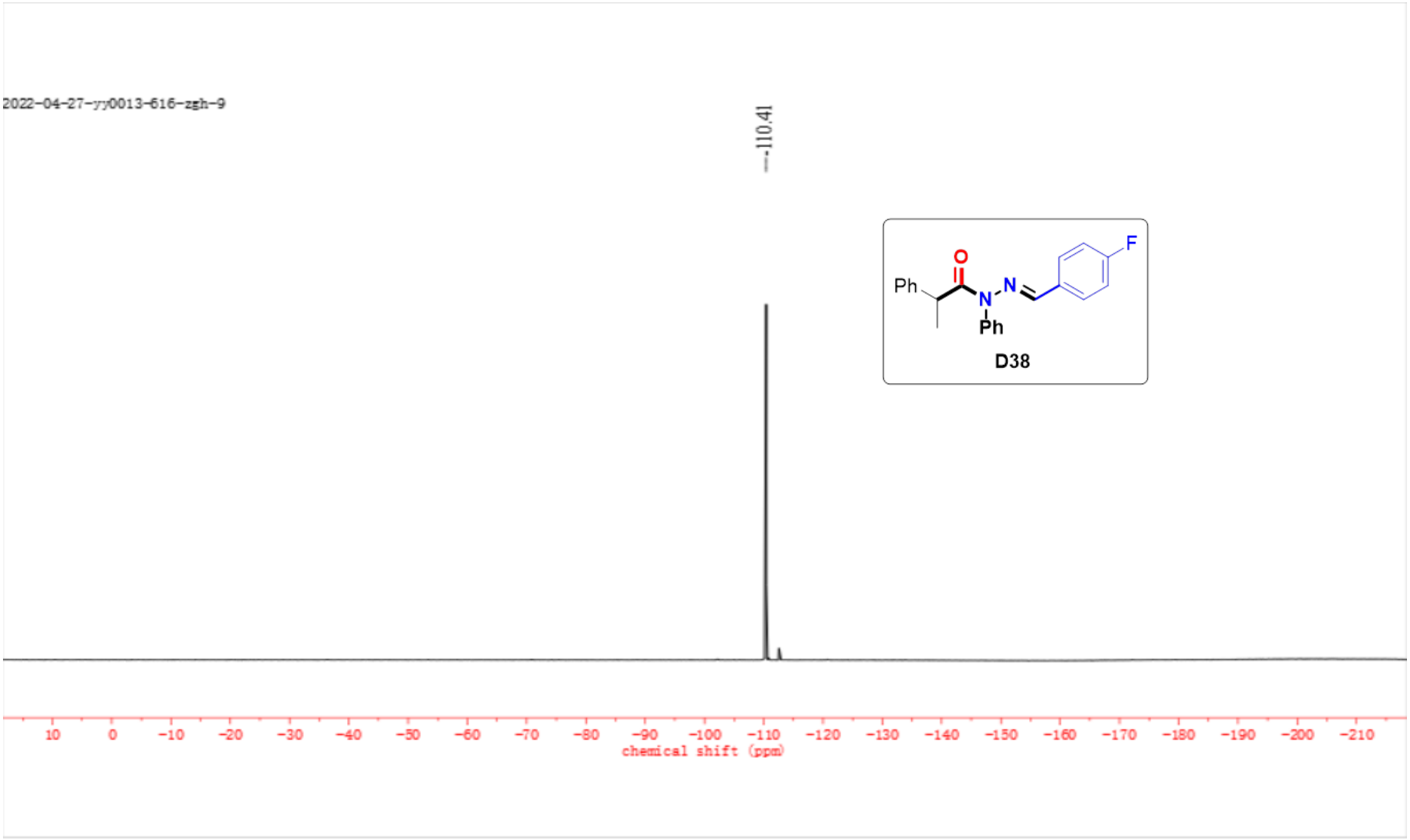

2022-04-29-YYD015-616-ZGH-7
175.76
159.95
142.64
141.44
136.29
135.84
130.24
129.76
129.31
129.21
128.73
127.74
126.72
120.53
116.30
111.16
77.63
77.32
77.00
55.36
43.15
19.68
Ph
N
N
Ph
O
O
D36
chemical shift (ppm)

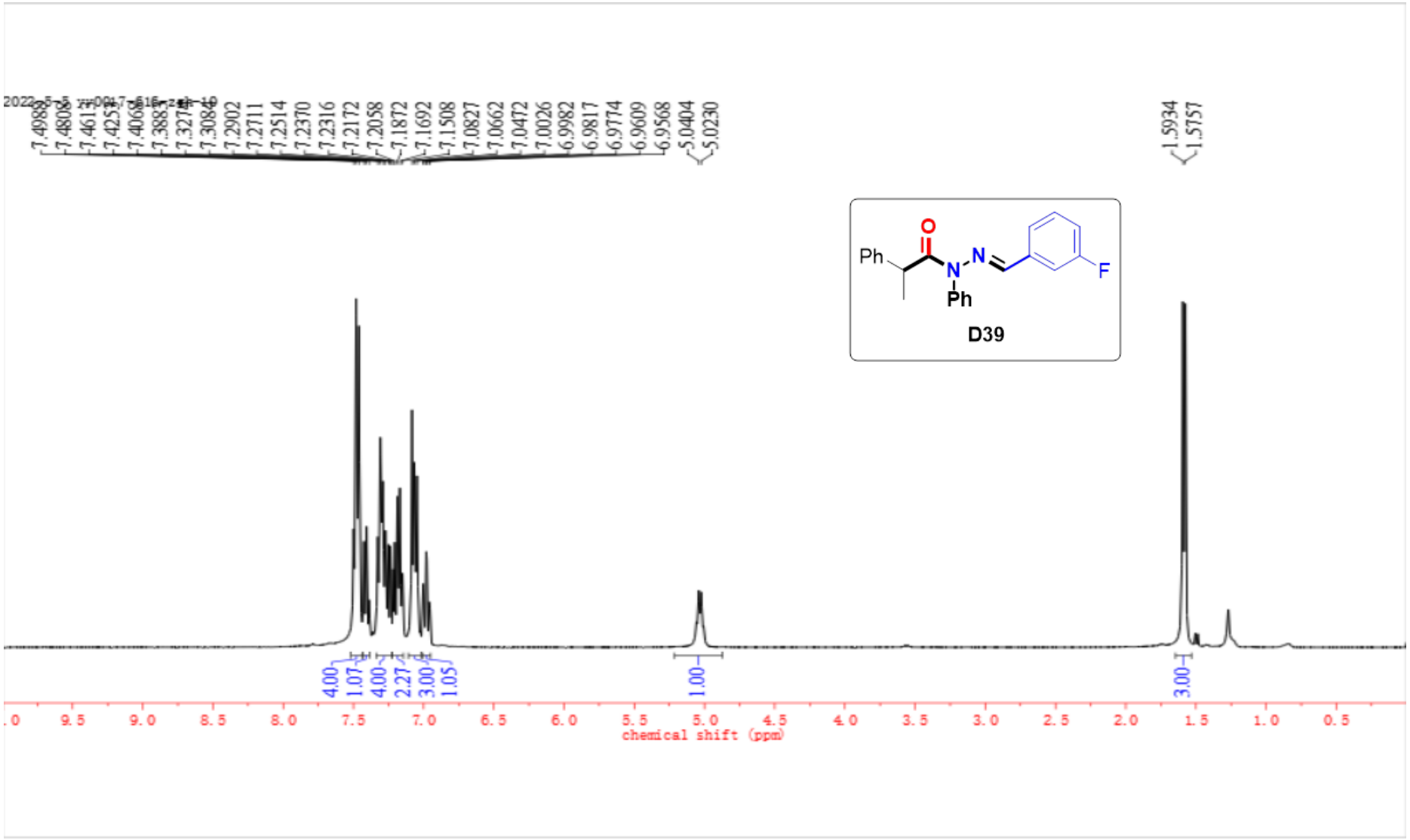

7.7949
7.7762
7.4911
7.3811
7.3601
7.3408
7.3212
7.2721
7.2537
7.2351
7.1987
7.1797
7.1577
7.1366
7.1324
7.0807
7.0622
7.0440
6.9656
6.9467
6.8874
6.8682
6.8494
6.6484
6.6277
5.0019
4.9844
3.4440
1.4851
1.4673
Ph
O
N
N
Ph
O
D37
1.00
1.00
3.95
1.05
3.04
1.19
2.00
1.05
1.00
1.00
3.00
3.00
chemical shift (ppm)

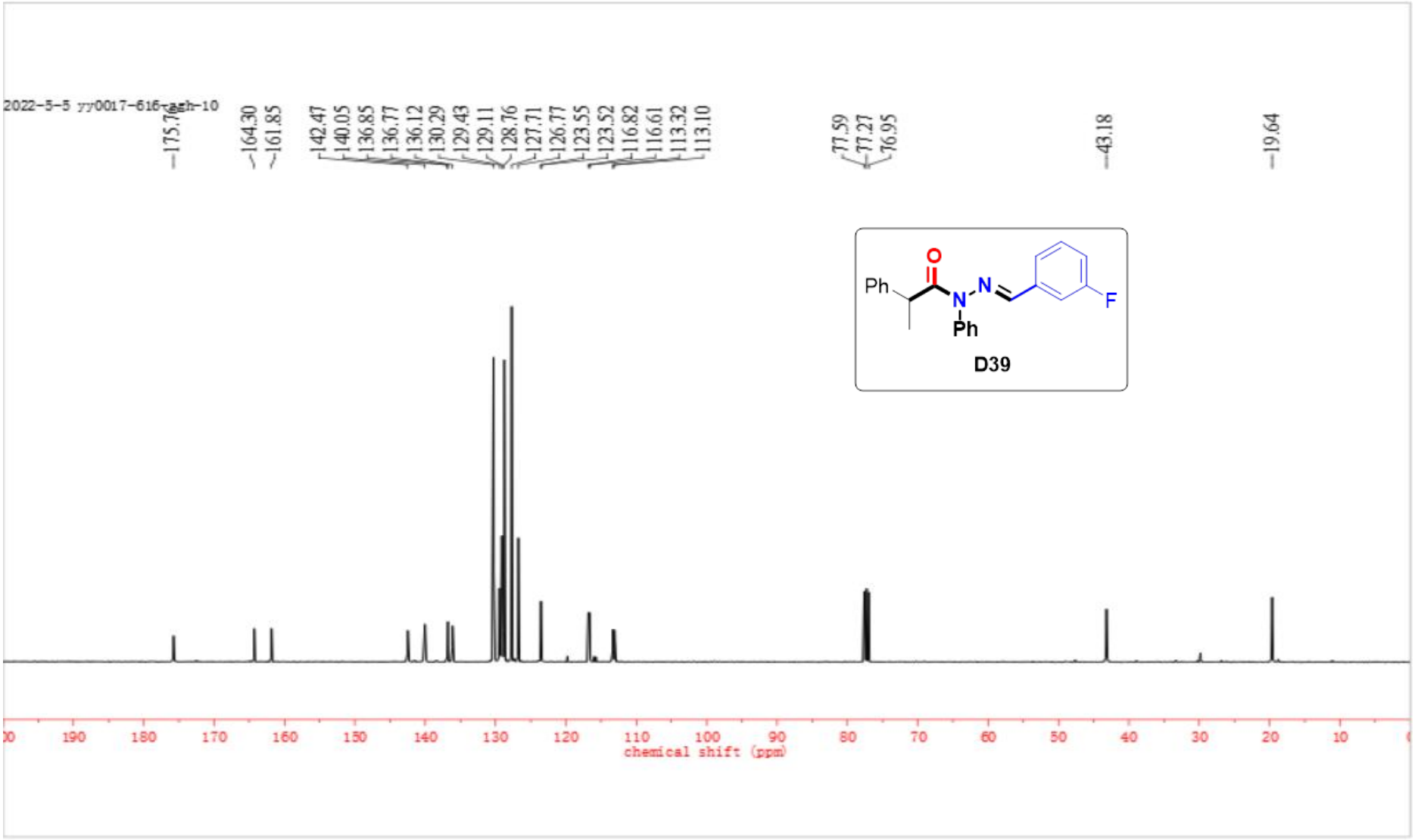

2022-04-29-YYD015-616-2GH-8
174.63
156.88
136.65
135.38
129.95
128.93
127.98
127.91
127.45
126.68
125.46
125.02
121.81
110.66
109.92
76.44
76.12
75.80
54.22
41.76
18.38
Ph
N
N
O
O
Ph
D37
chemical shift (ppm)

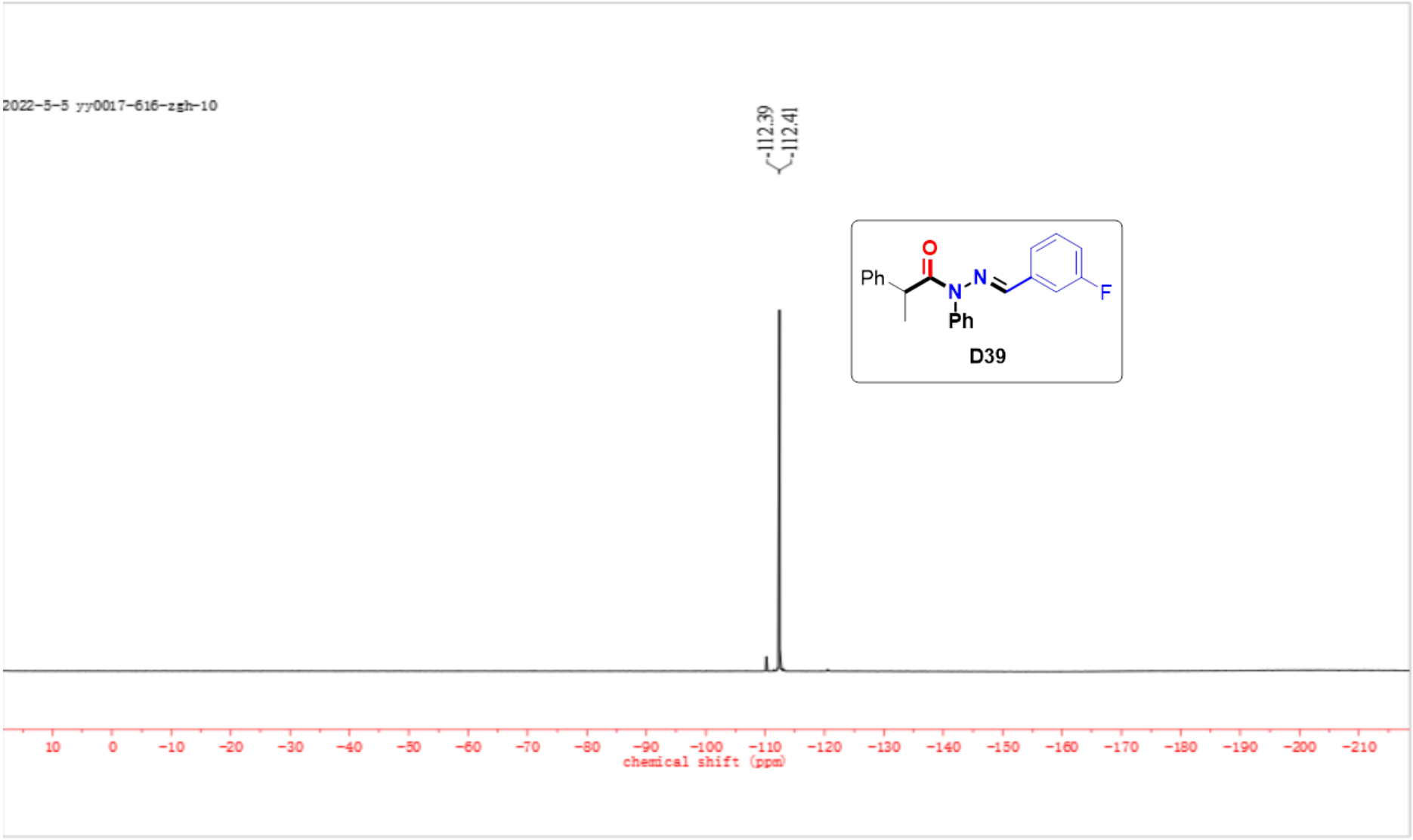

2022-04-25-yy00016-616-xsp-9
7.5226
7.5049
7.4857
7.4744
7.4537
7.4314
7.4129
7.3347
7.3162
7.2973
7.2269
7.2051
7.1868
7.1025
7.0852
7.0661
7.0499
7.0283
7.0067
5.0500
5.0326
1.5938
1.5761
Ph
O
N
N
Ph
F
D38
7.00
2.00
1.13
5.00
1.00
3.00
chemical shift (ppm)

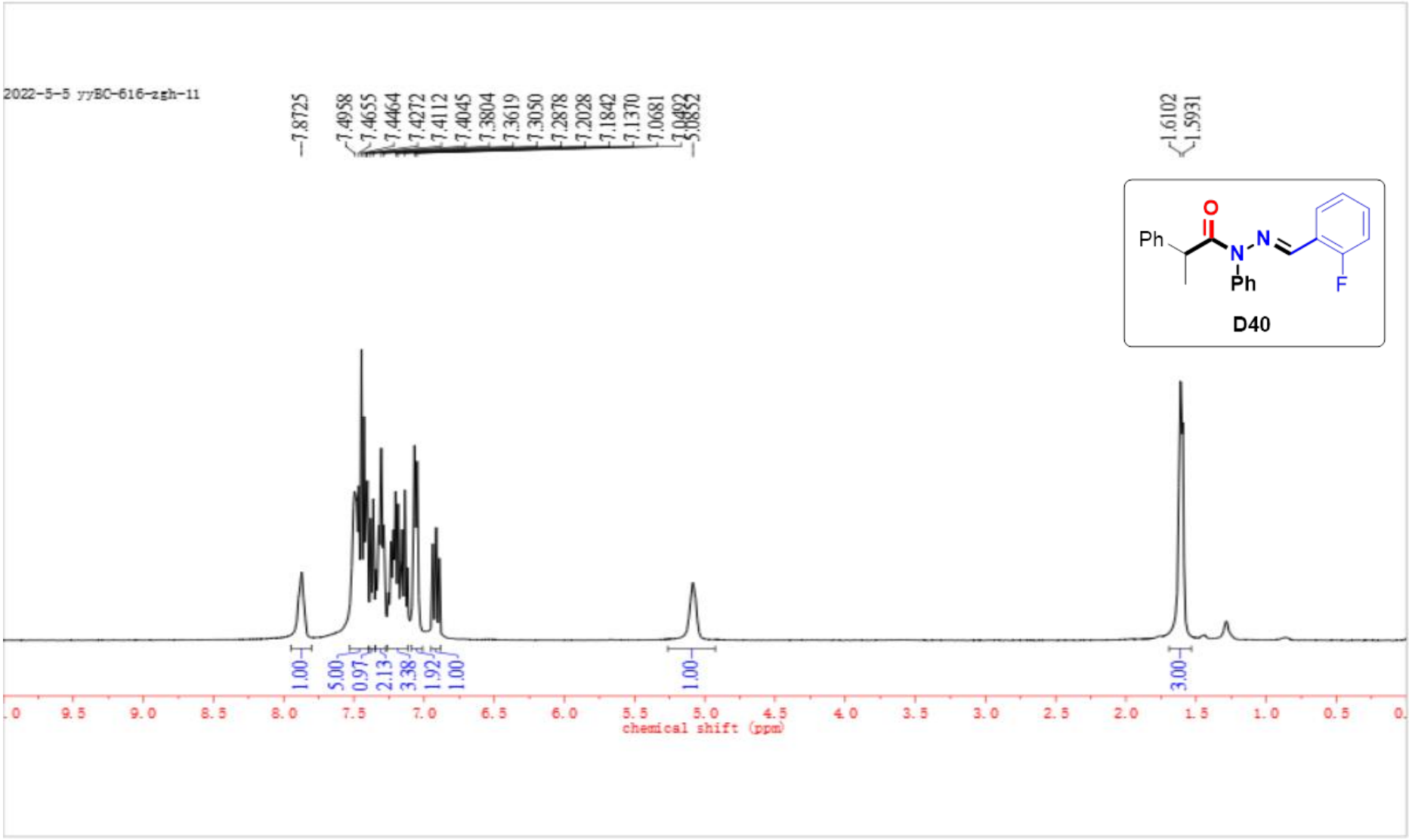

2022-04-25-yy00016-6i6-zgh-9
175.64
164.86
162.37
140.20
136.18
130.70
130.67
130.18
129.27
129.14
129.03
128.94
128.64
127.69
126.65
115.93
115.71
77.43
77.12
76.80
43.02
19.53
Ph
O
N
N
Ph
F
D38
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

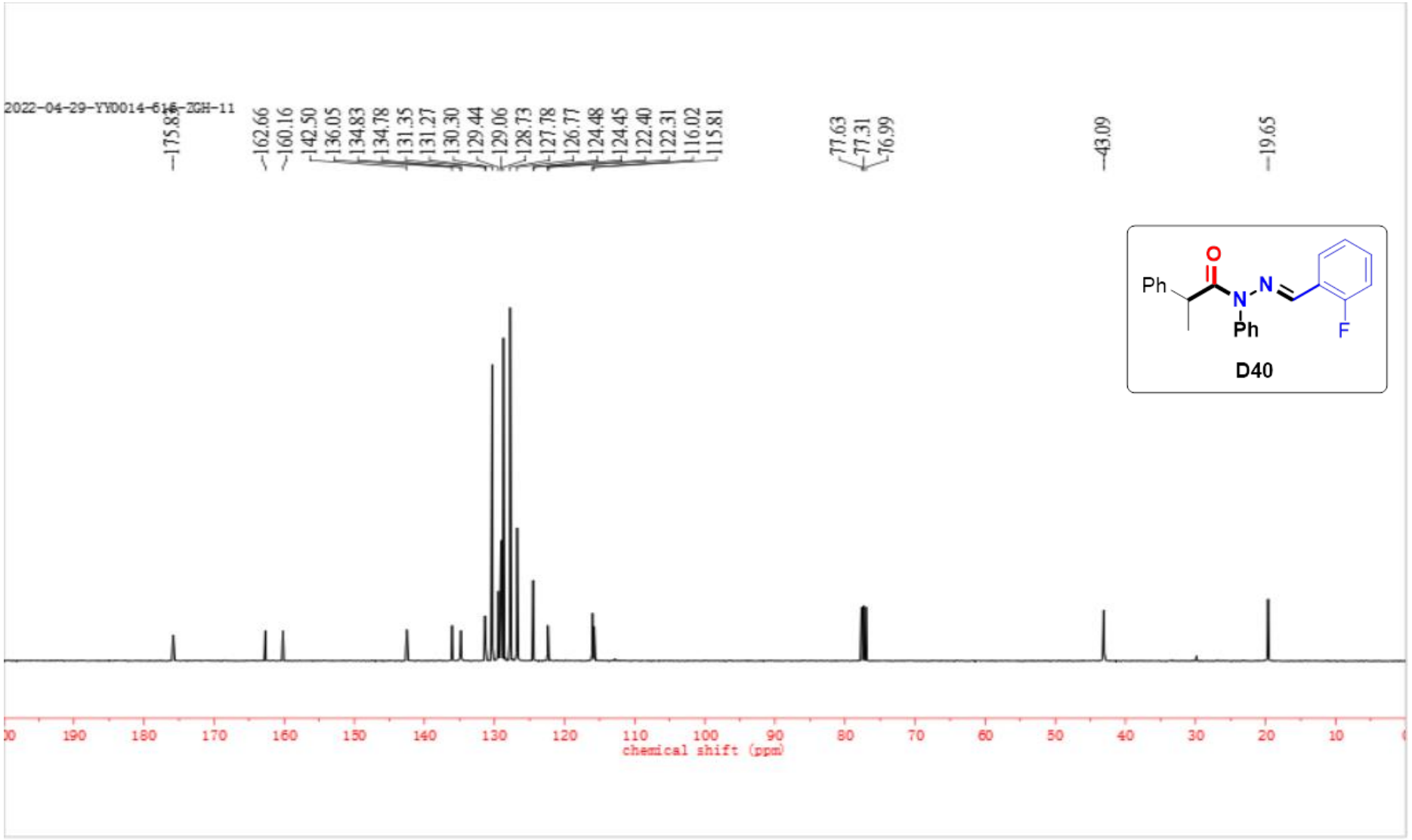

2022-04-27-yy0013-616-zgh-9
-110.41
Ph
O
N
N
Ph
F
D38
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

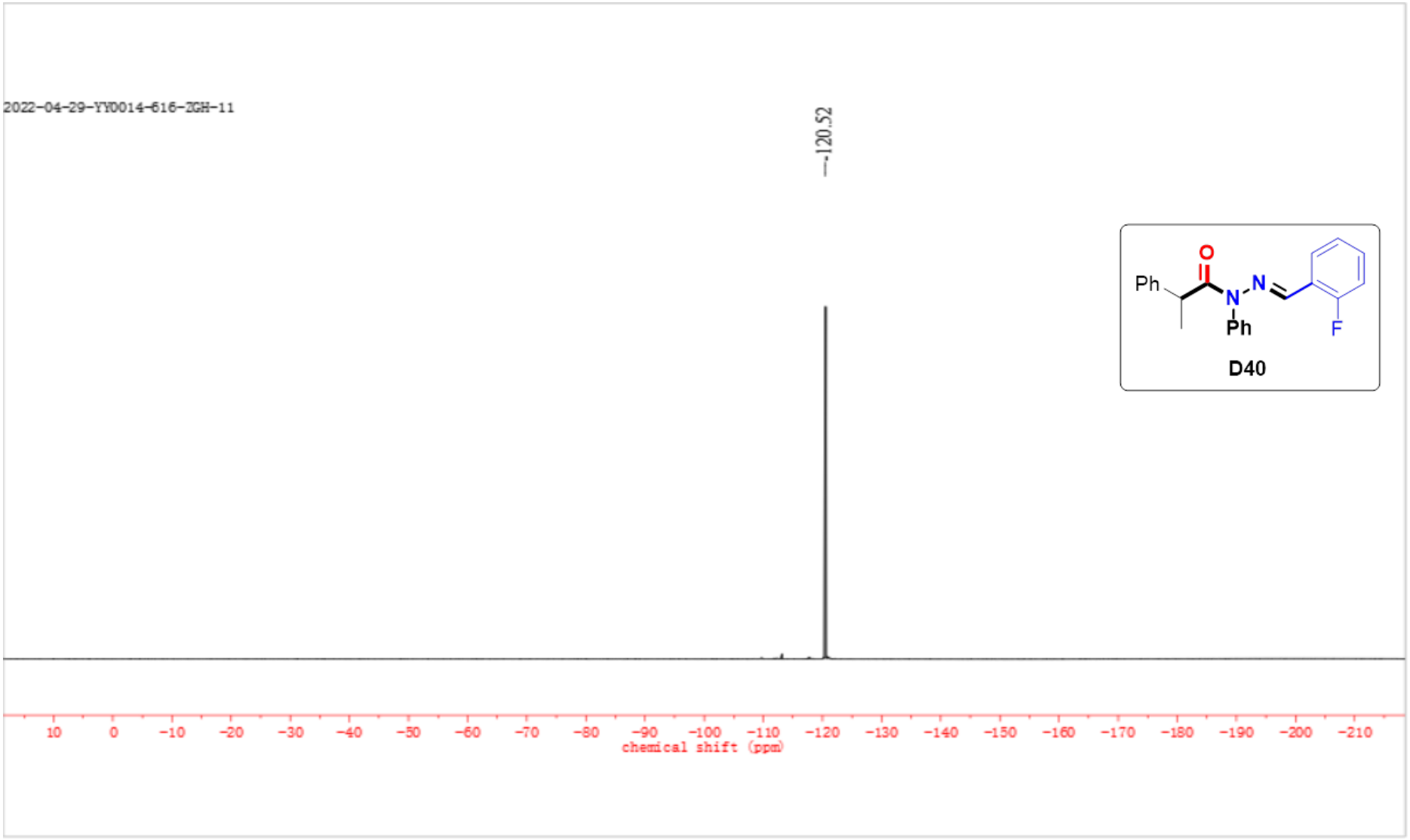

7.4988
7.4803
7.4613
7.4253
7.4066
7.3883
7.3274
7.3084
7.2902
7.2711
7.2514
7.2370
7.2316
7.2172
7.2058
7.1872
7.1692
7.1508
7.0827
7.0662
7.0472
7.0026
6.9982
6.9817
6.9774
6.9609
6.9568
5.0404
5.0230
1.5934
1.5757
Ph
O
N
N
Ph
F
D39
4.00
1.07
4.00
2.27
3.00
1.05
1.00
3.00
chemical shift (ppm)

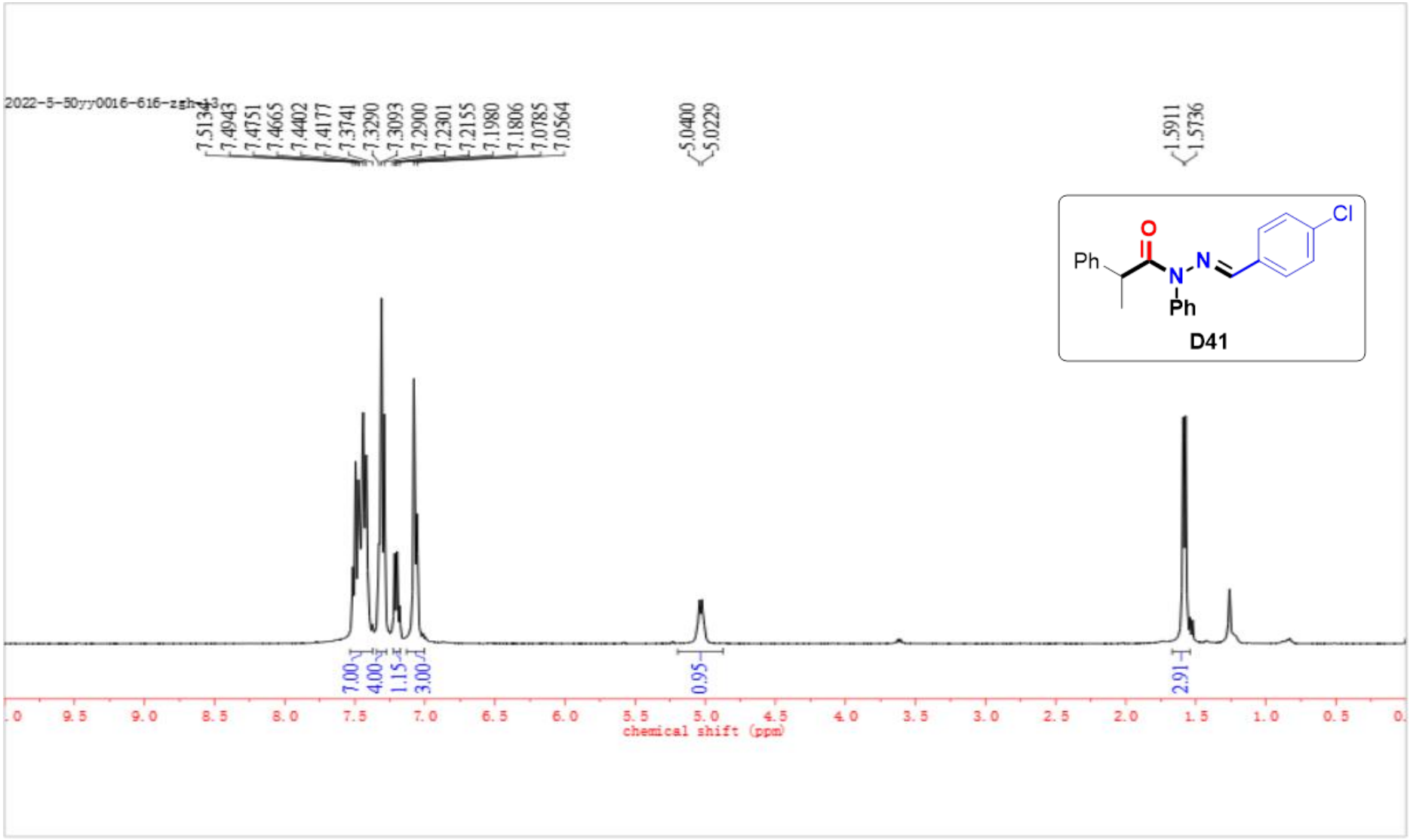

2022-5-5 yy0017-616-ash-10
175.76
164.30
161.85
142.47
140.05
136.85
136.77
136.12
130.29
129.43
129.11
128.76
127.71
126.77
123.55
123.52
116.82
116.61
113.32
113.10
77.59
77.27
76.95
43.18
19.64
Ph
O
N
N
Ph
F
D39
chemical shift (ppm)

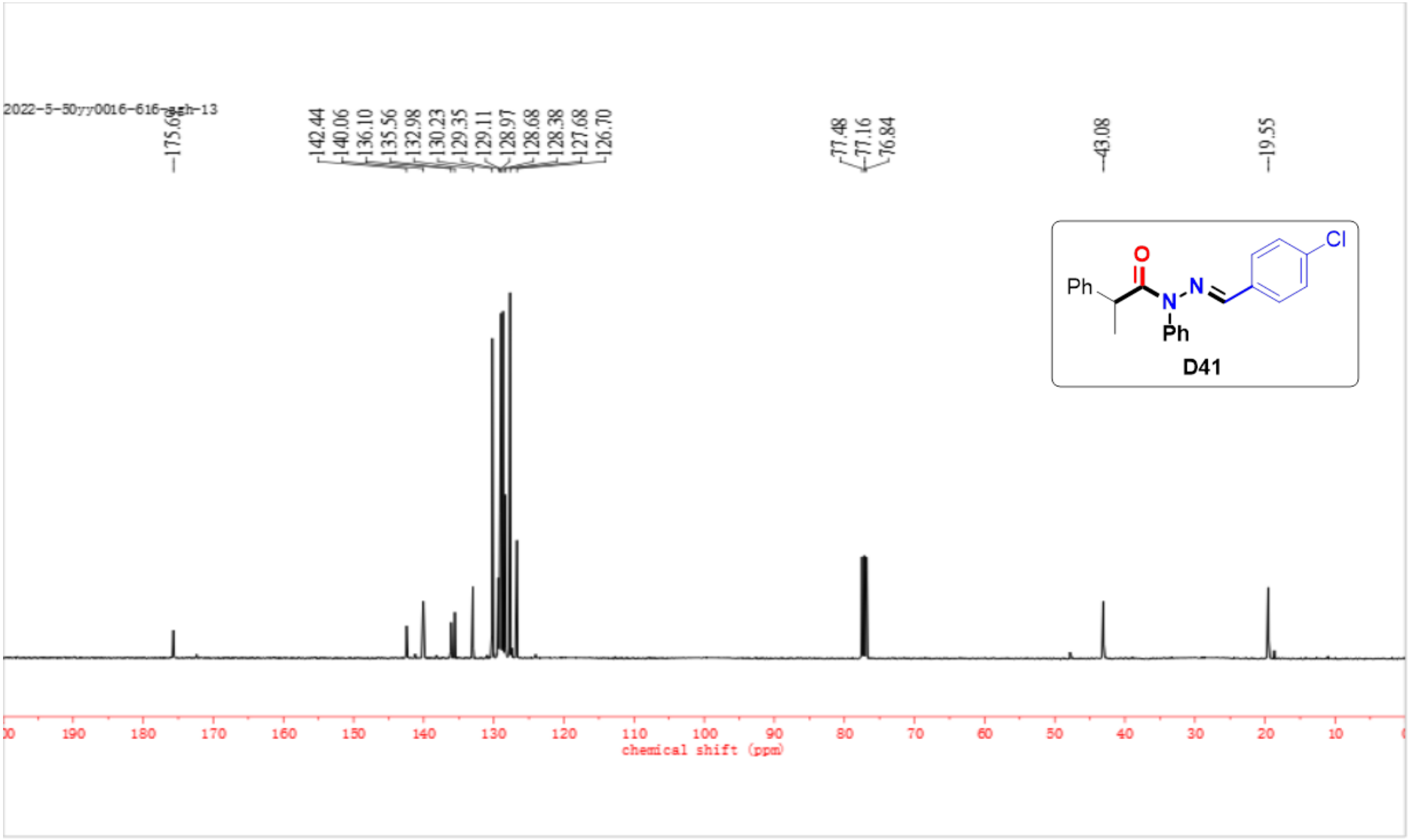

2022-5-5 yy0017-616-zgh-10
-112.39
-112.41
Ph
O
N
N
Ph
F
D39
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

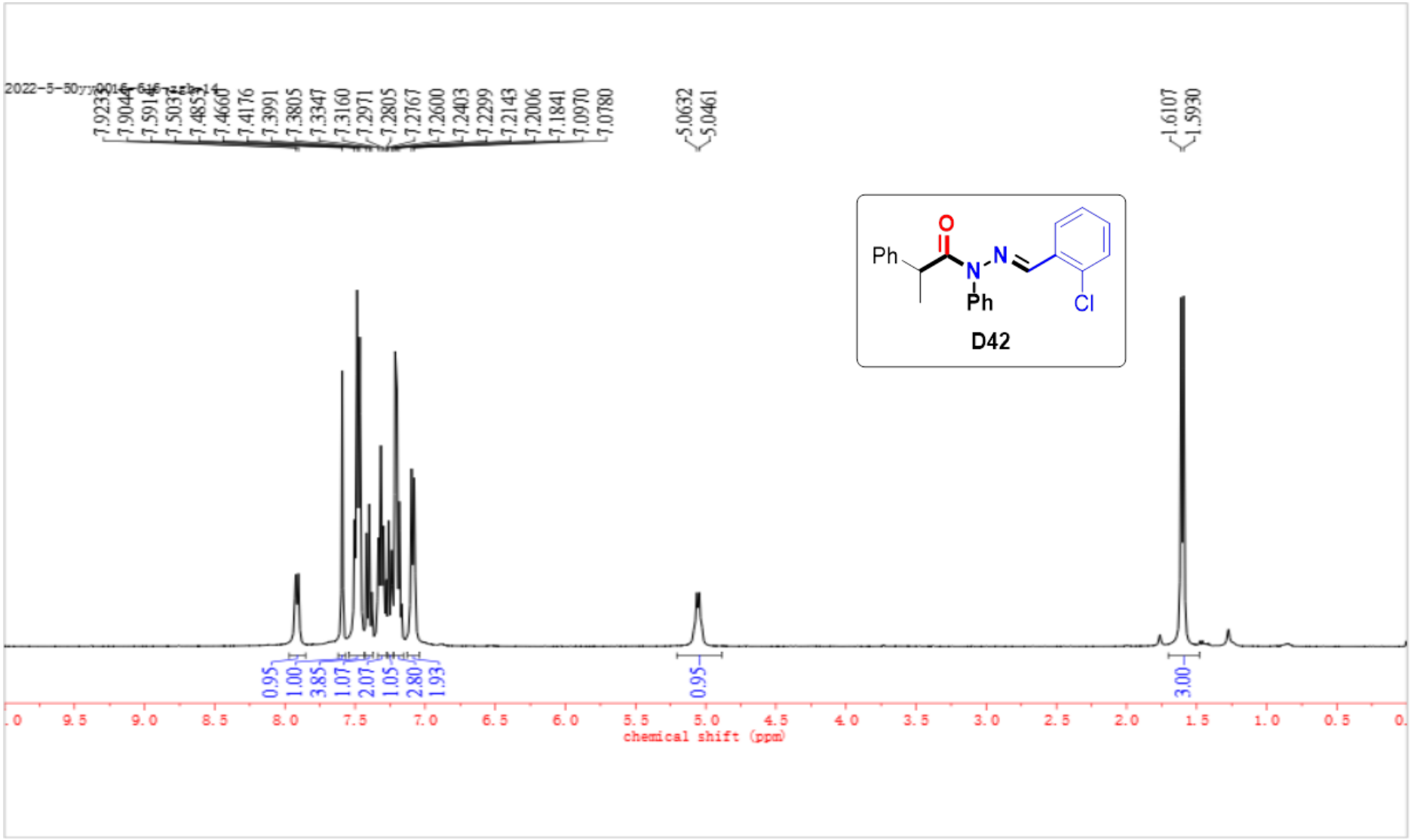

2022-5-5 yyBC-616-zgh-11
7.8725
7.4958
7.4655
7.4464
7.4272
7.4112
7.4045
7.3804
7.3619
7.3050
7.2878
7.2028
7.1842
7.1370
7.0681
1.6102
1.5931
Ph
O
N
N
Ph
F
D40
1.00
5.00
0.97
2.13
3.38
1.92
1.00
1.00
3.00
chemical shift (ppm)

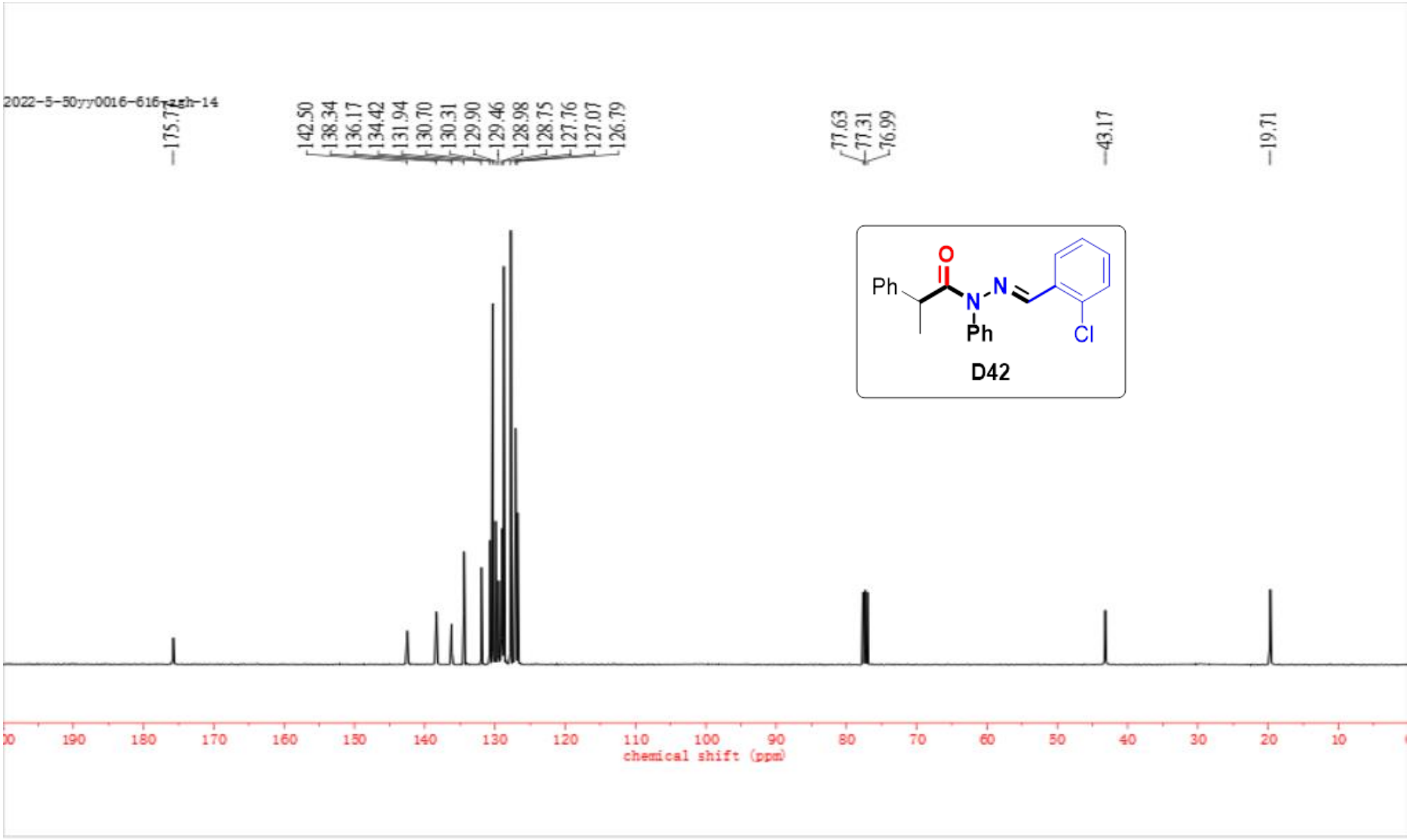

2022-04-29-YYD014-616-ZGH-11
175.83
162.66
160.16
142.50
136.05
134.83
134.78
131.35
131.27
130.30
129.44
129.06
128.73
127.78
126.77
124.48
124.45
122.40
122.31
116.02
115.81
77.63
77.31
76.99
43.09
19.65
Ph
O
N
N
Ph
F
D40
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

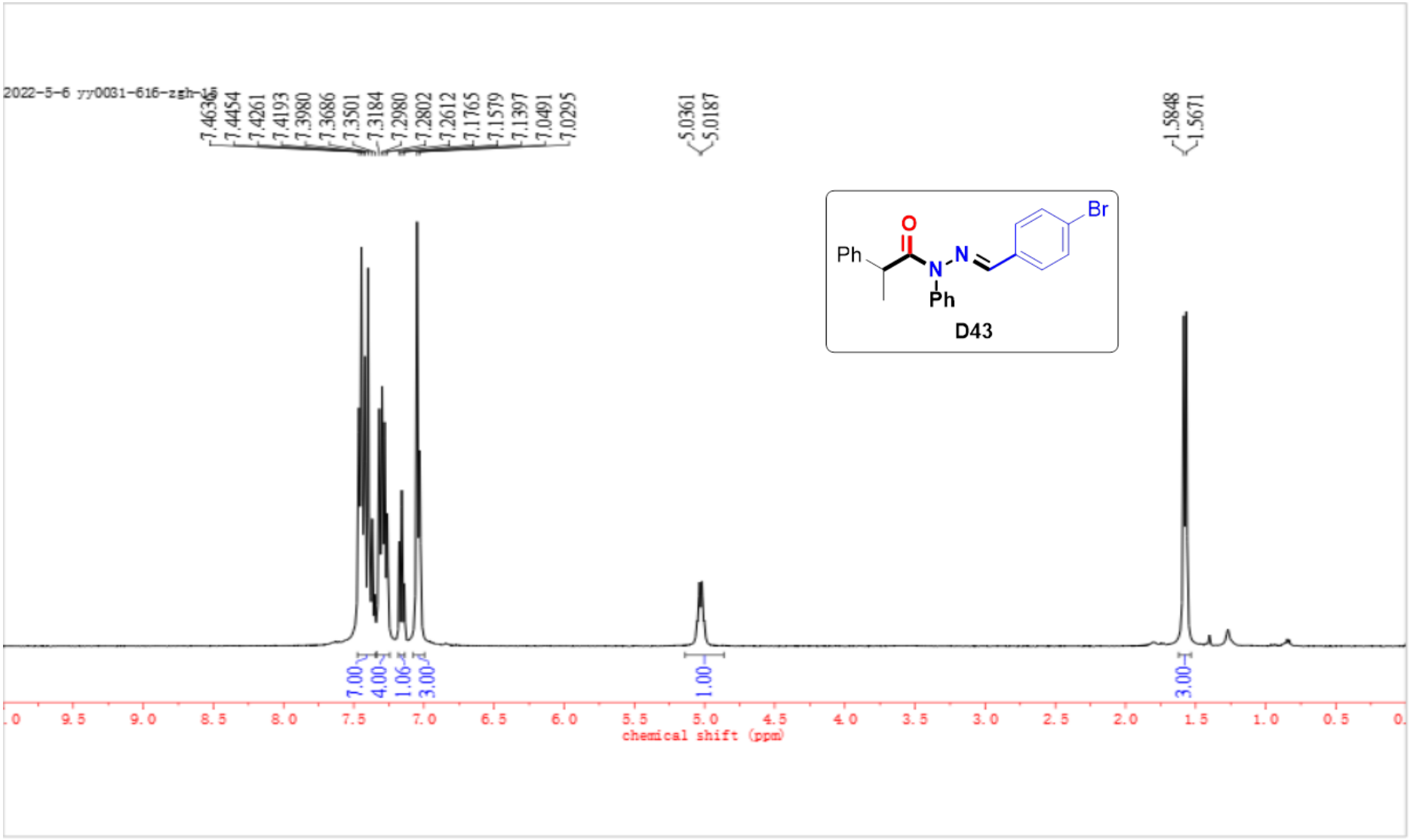

2022-04-29-YY0014-616-ZGH-11
-120.52
O
Ph
N
N
Ph
F
D40
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

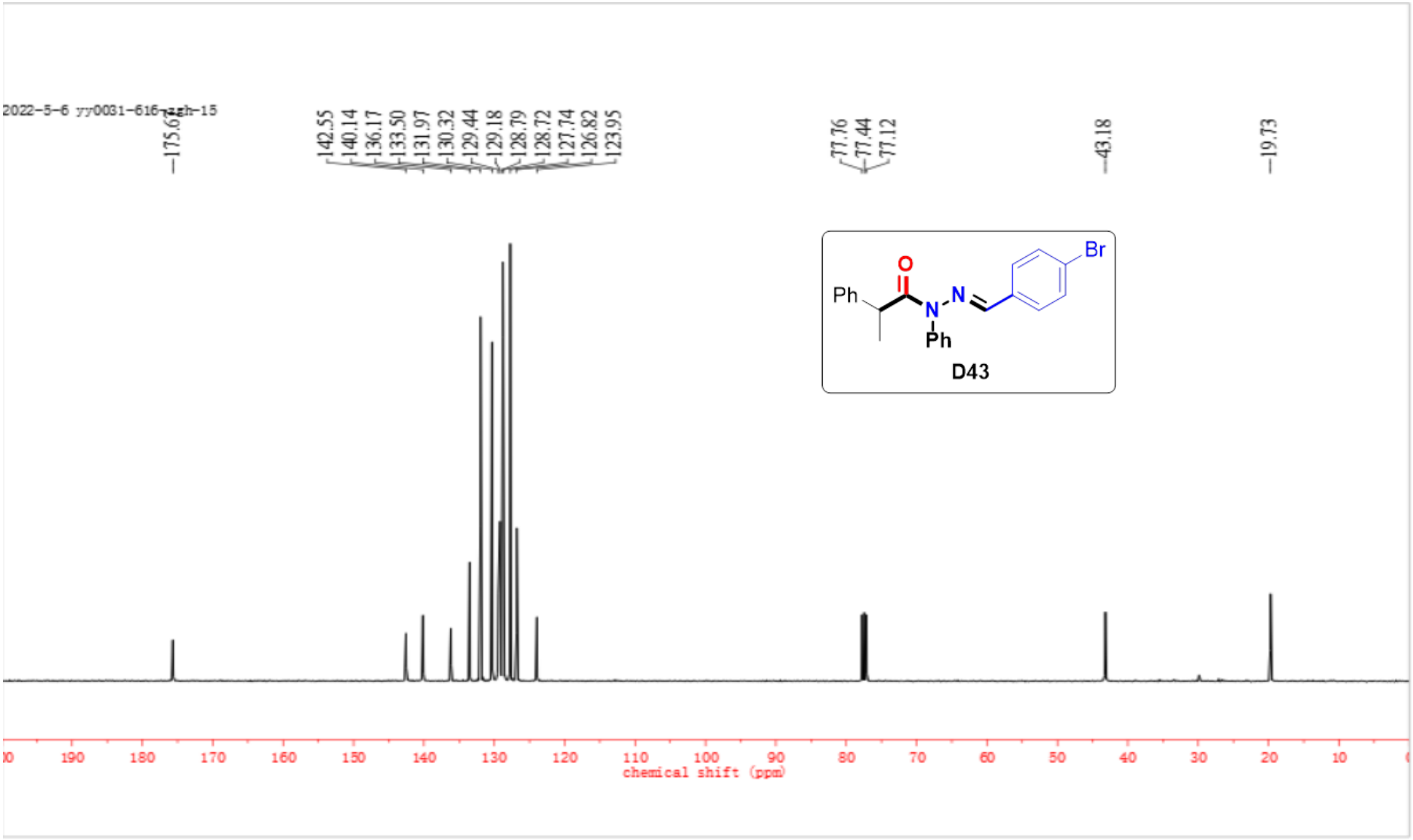

2022-5-50yy0016-616-zgh-1
7.5134
7.4943
7.4751
7.4665
7.4402
7.4177
7.3741
7.3290
7.3093
7.2900
7.2301
7.2155
7.1980
7.1806
7.0785
7.0564
5.0400
5.0229
1.5911
1.5736
Cl
O
Ph
N
N
Ph
D41
7.00
4.00
1.15
3.00
0.95
2.91
chemical shift (ppm)

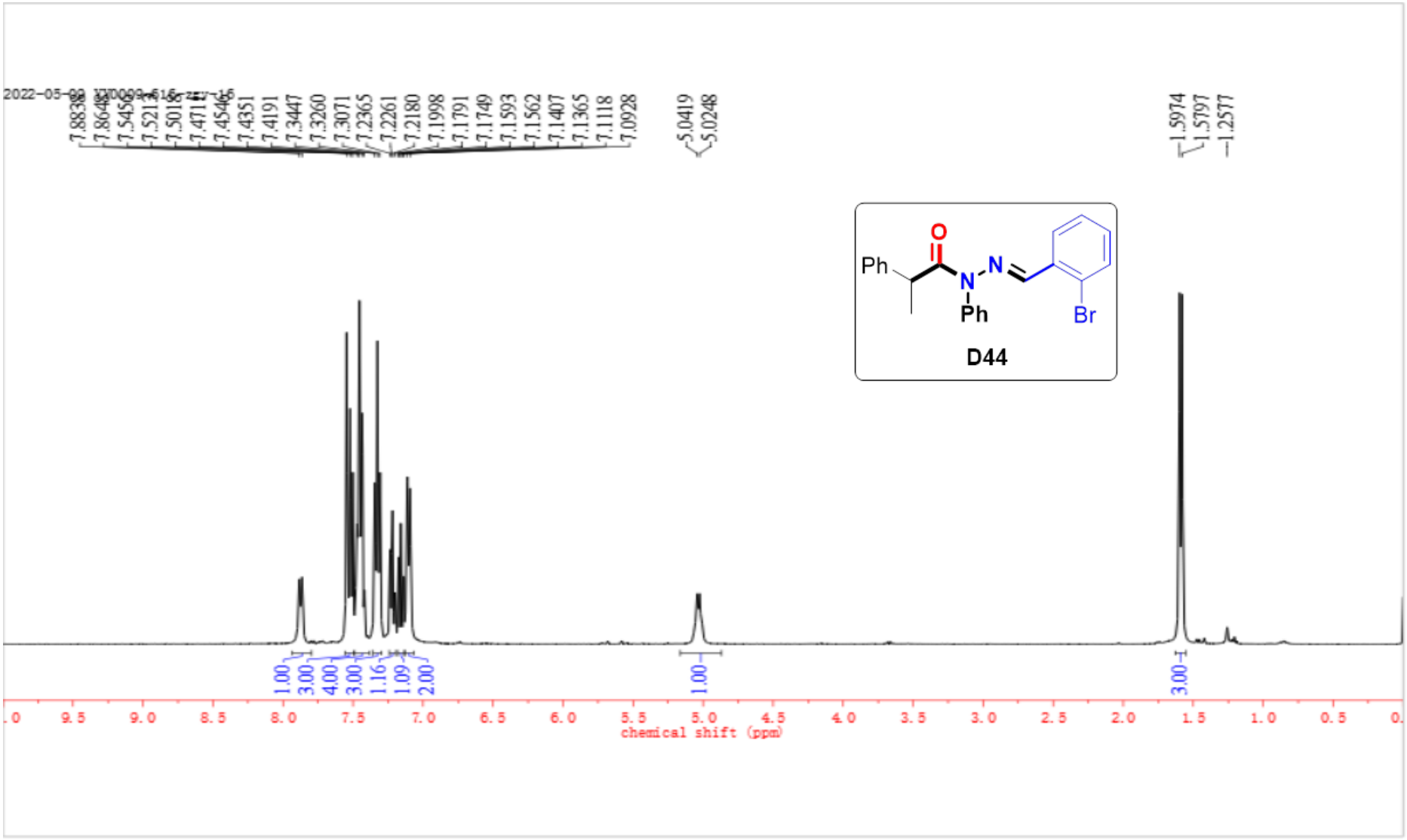

2022-5-50yy0016-616-agh-13
175.69
142.44
140.06
136.10
135.56
132.98
130.23
129.35
129.11
128.97
128.68
128.38
127.68
126.70
77.48
77.16
76.84
43.08
19.55
Ph
O
N
N
Ph
Cl
D41
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

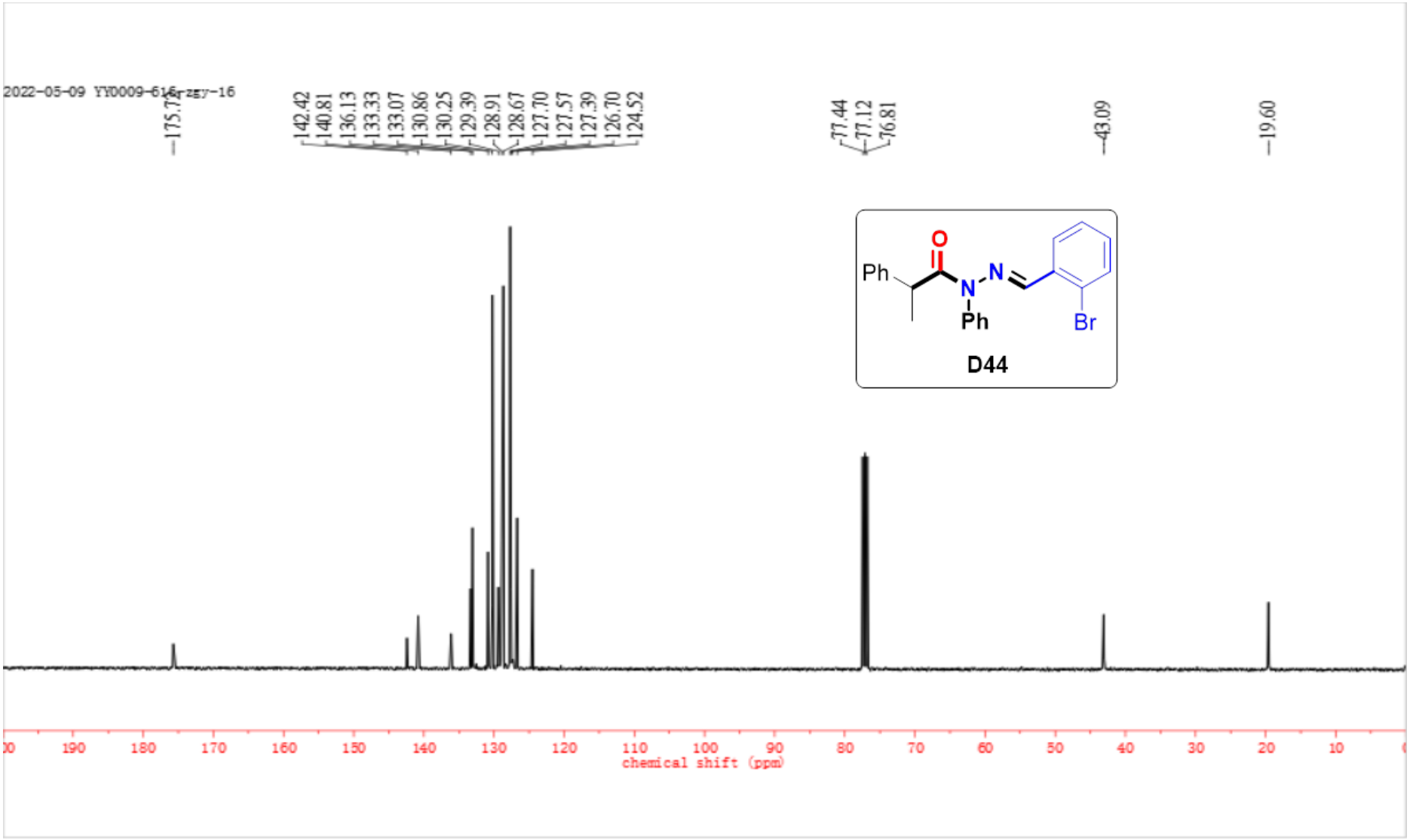

7.9233
7.9044
7.5914
7.5037
7.4853
7.4660
7.4176
7.3991
7.3805
7.3347
7.3160
7.2971
7.2805
7.2767
7.2600
7.2403
7.2299
7.2143
7.2006
7.1841
7.0970
7.0780
5.0632
5.0461
1.6107
1.5930
Ph
O
N
N
Ph
Cl
D42
0.95
1.00
3.85
1.07
2.07
1.05
2.80
1.93
0.95
3.00
chemical shift (ppm)

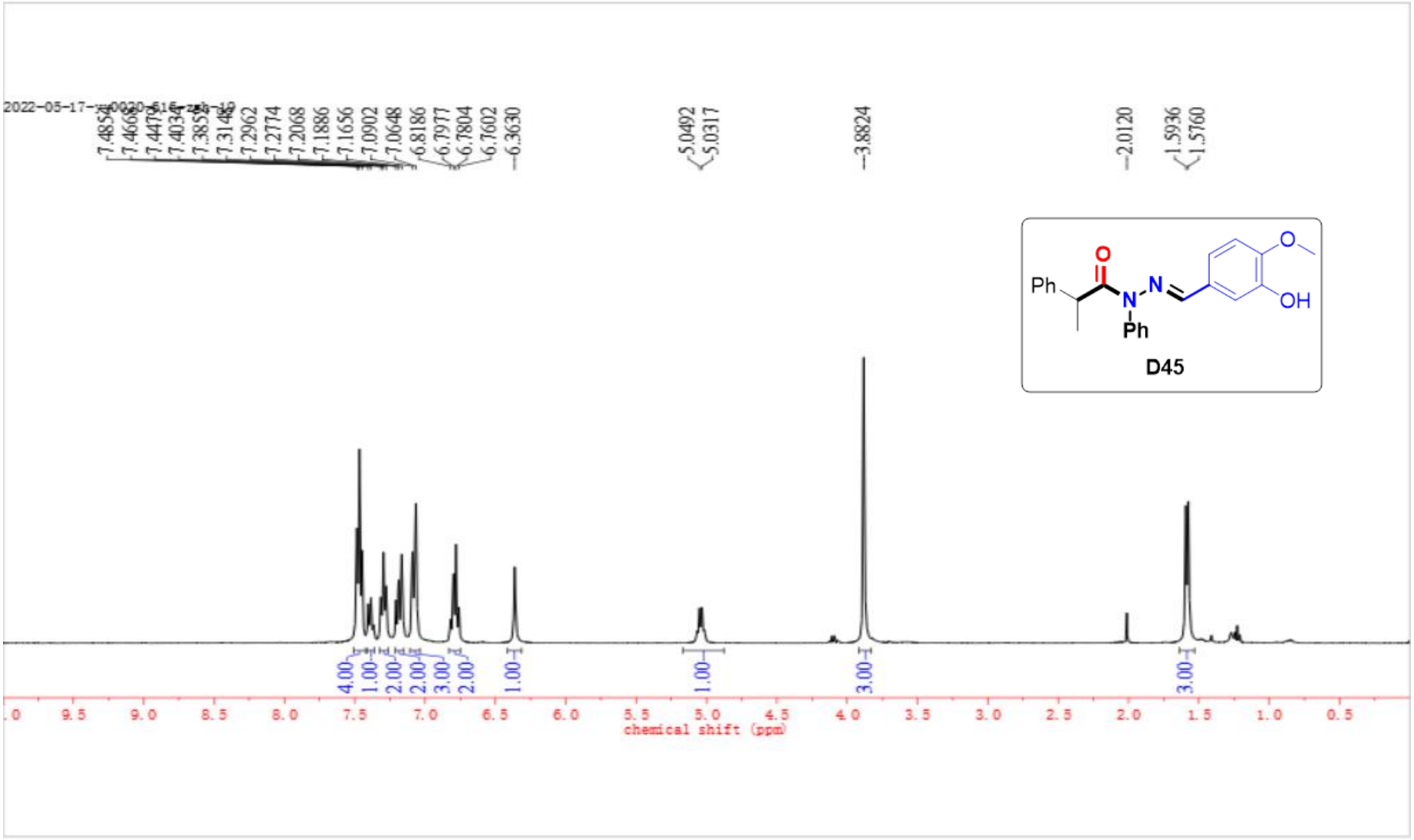

2022-5-30yy0016-616-zgh-14
175.77
142.50
138.34
136.17
134.42
131.94
130.70
130.31
129.90
129.46
128.98
128.75
127.76
127.07
126.79
77.63
77.31
76.99
43.17
19.71
Ph
O
N
N
Ph
Cl
D42
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

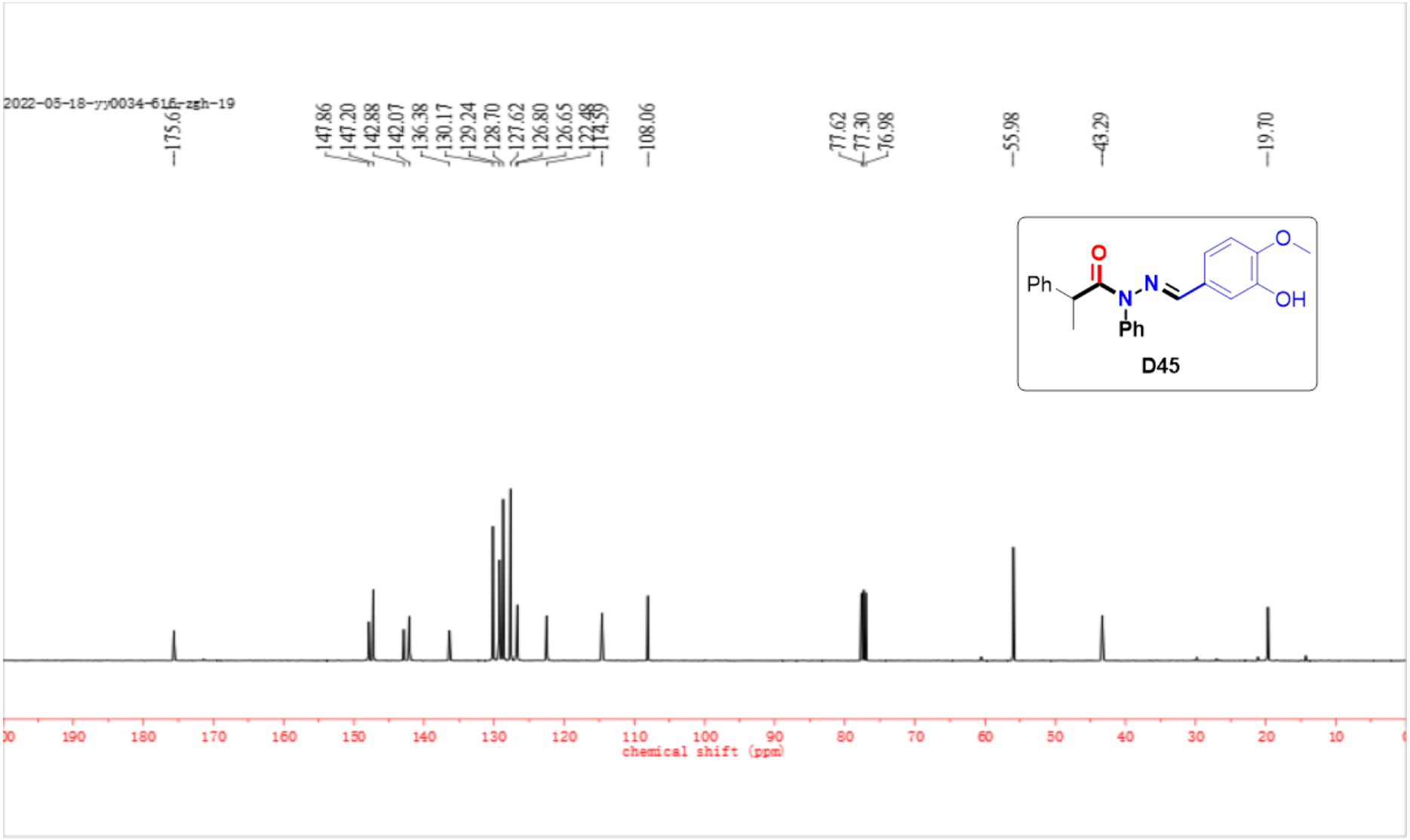

2022-5-6 yy0031-616-zgh-1
7.4636
7.4454
7.4261
7.4193
7.3980
7.3686
7.3501
7.3184
7.2980
7.2802
7.2612
7.1765
7.1579
7.1397
7.0491
7.0295
5.0361
5.0187
1.5848
1.5671
Br
O
Ph
N
N
Ph
D43
7.00
4.00
1.06
3.00
1.00
3.00
chemical shift (ppm)

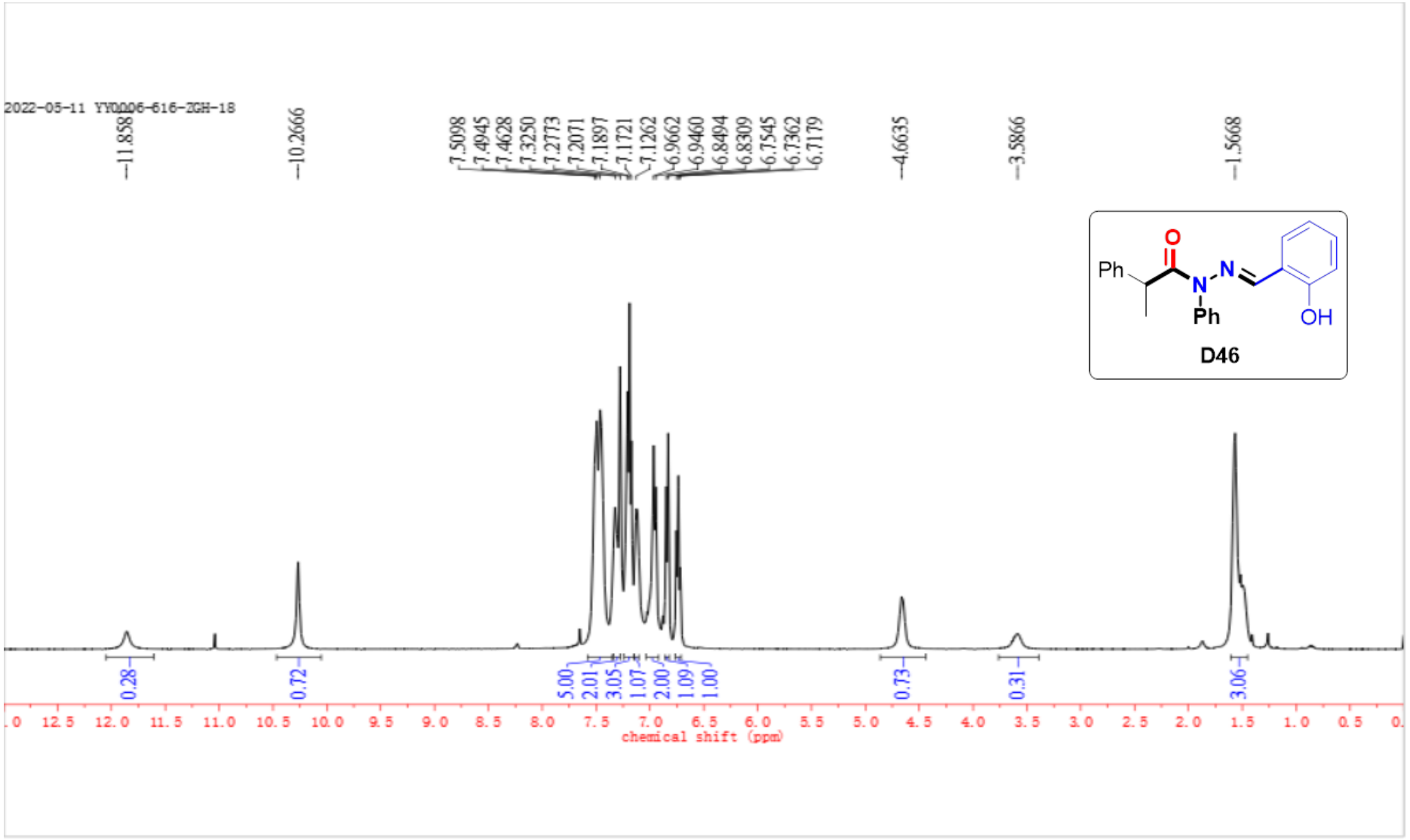

2022-5-6 yy0031-616-1gh-15
175.67
142.55
140.14
136.17
133.50
131.97
130.32
129.44
129.18
128.79
128.72
127.74
126.82
123.95
77.76
77.44
77.12
43.18
19.73
Ph
O
N
N
Ph
Br
D43
chemical shift (ppm)

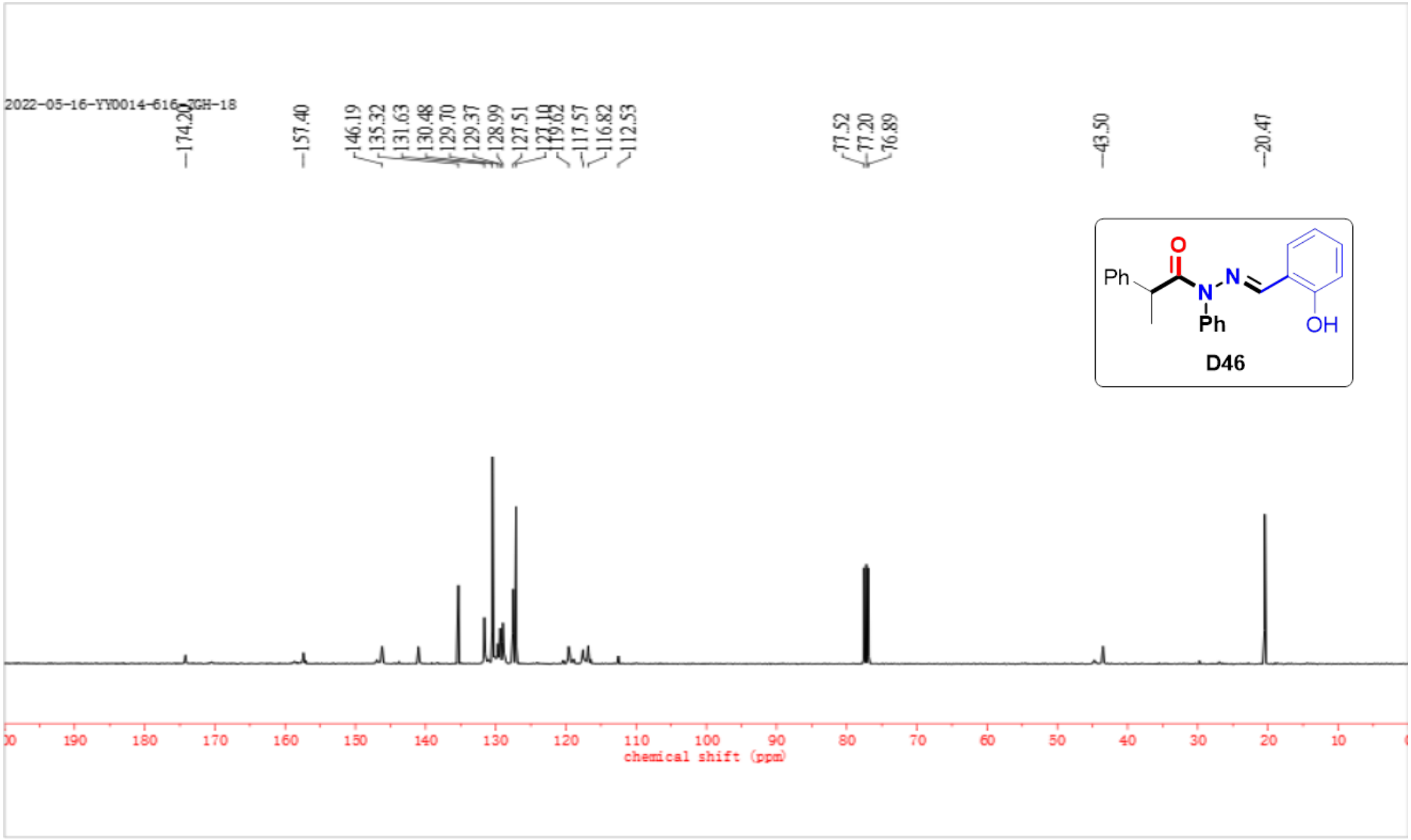

7.8838
7.8648
7.5456
7.5213
7.5018
7.4711
7.4546
7.4351
7.4191
7.3447
7.3260
7.3071
7.2365
7.2261
7.2180
7.1998
7.1791
7.1749
7.1593
7.1562
7.1407
7.1365
7.1118
7.0928
5.0419
5.0248
1.5974
1.5797
1.2577
Ph
O
N
N
Ph
Br
D44
1.00
3.00
4.00
3.00
1.16
1.09
2.00
1.00
3.00
chemical shift (ppm)

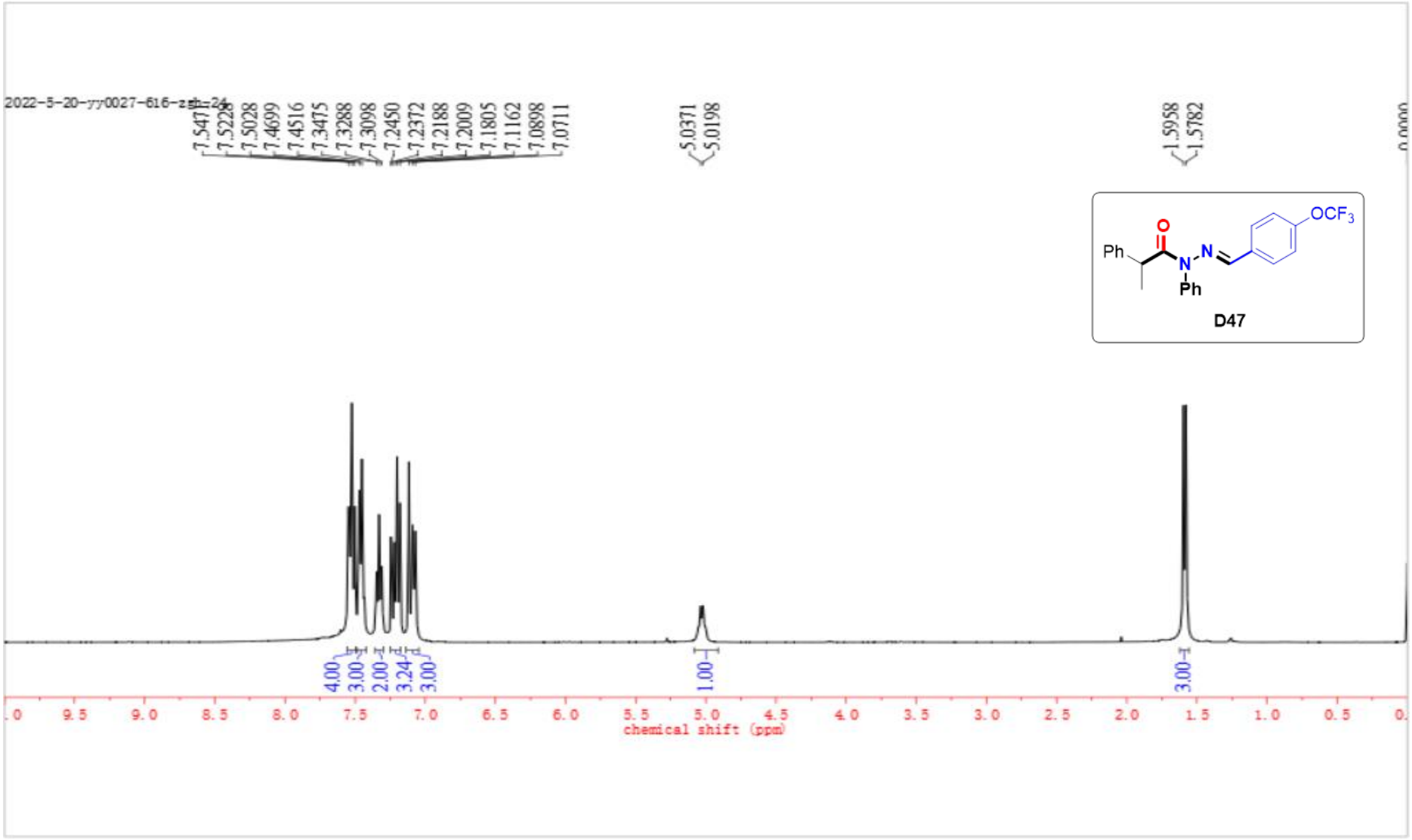

2022-05-09 YYD009-616-zsy-16
175.74
142.42
140.81
136.13
133.33
133.07
130.86
130.25
129.39
128.91
128.67
127.70
127.57
127.39
126.70
124.52
77.44
77.12
76.81
43.09
19.60
O
Ph
N
N
Ph
Br
D44
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

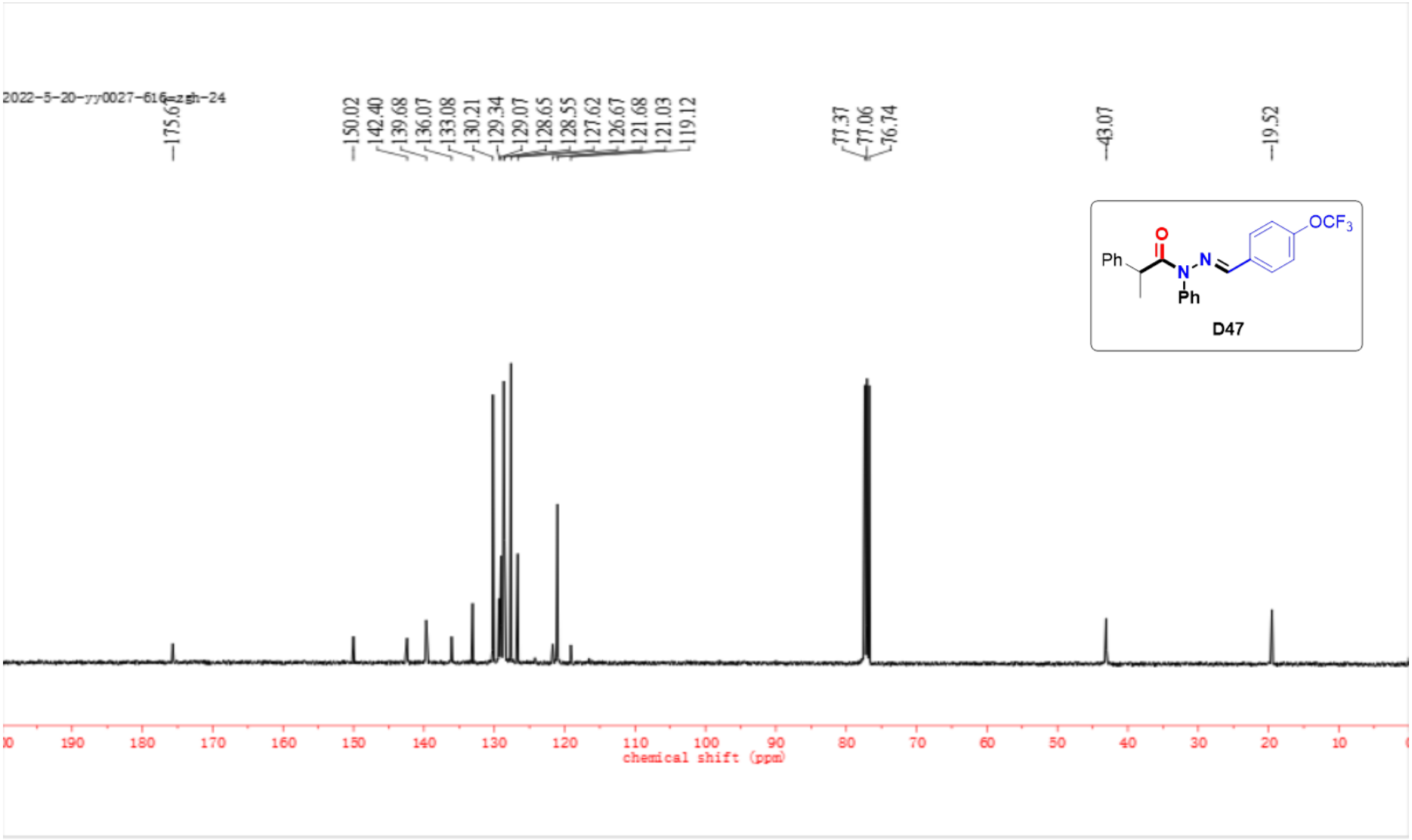

7.4854
7.4668
7.4479
7.4034
7.3855
7.3148
7.2962
7.2774
7.2068
7.1886
7.1656
7.0902
7.0648
6.8186
6.7977
6.7804
6.7602
6.3630
5.0492
5.0317
3.8824
2.0120
1.5936
1.5760
Ph
N
N
Ph
O
OH
D45
4.00
1.00
2.00
2.00
3.00
2.00
1.00
1.00
3.00
3.00
chemical shift (ppm)

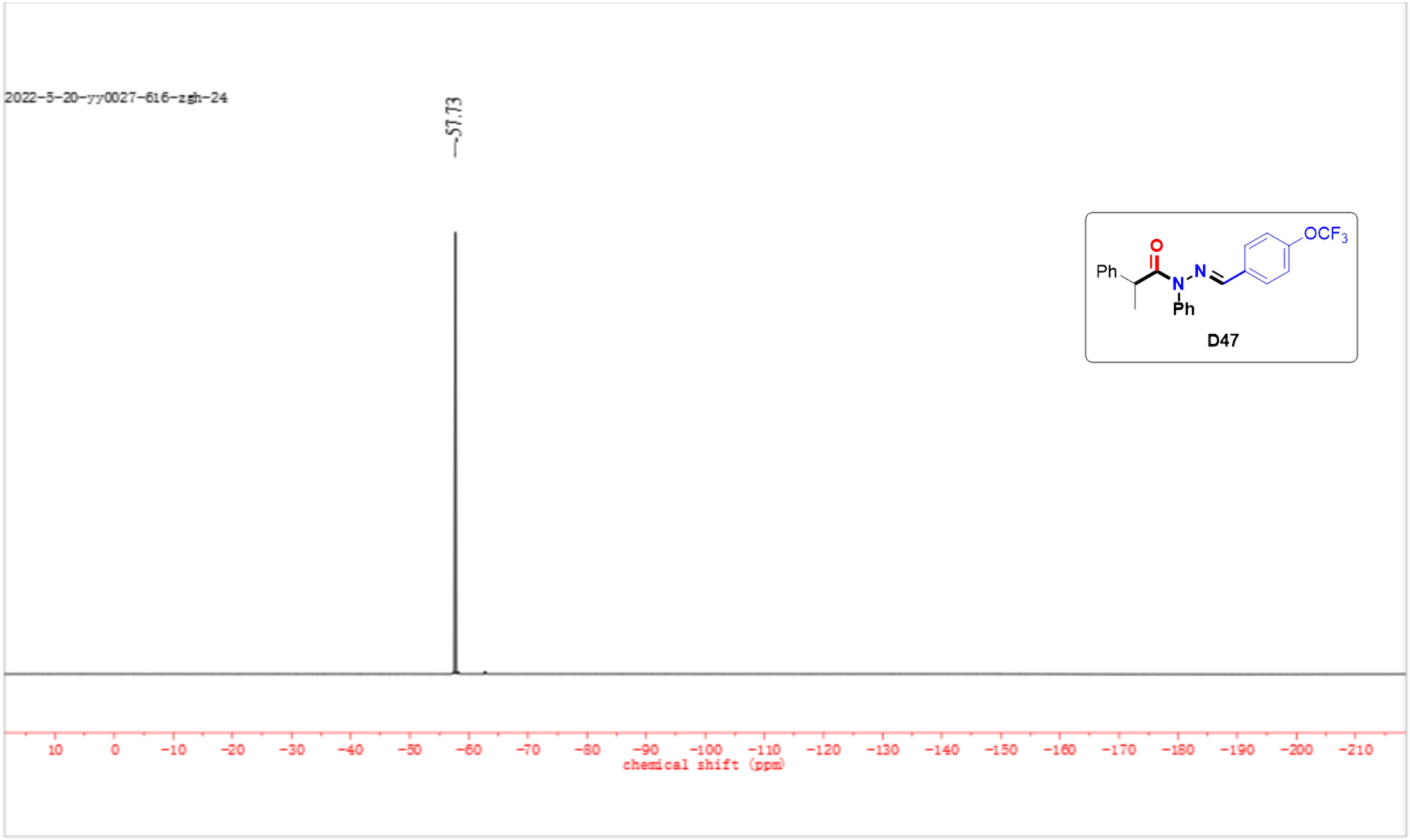

2022-05-18-yy0034-616-zgh-19
175.61
147.86
147.20
142.88
142.07
136.38
130.17
129.24
128.70
127.62
126.80
126.65
122.48
114.59
108.06
77.62
77.30
76.98
55.98
43.29
19.70
Ph
N
N
O
O
OH
Ph
D45
chemical shift (ppm)

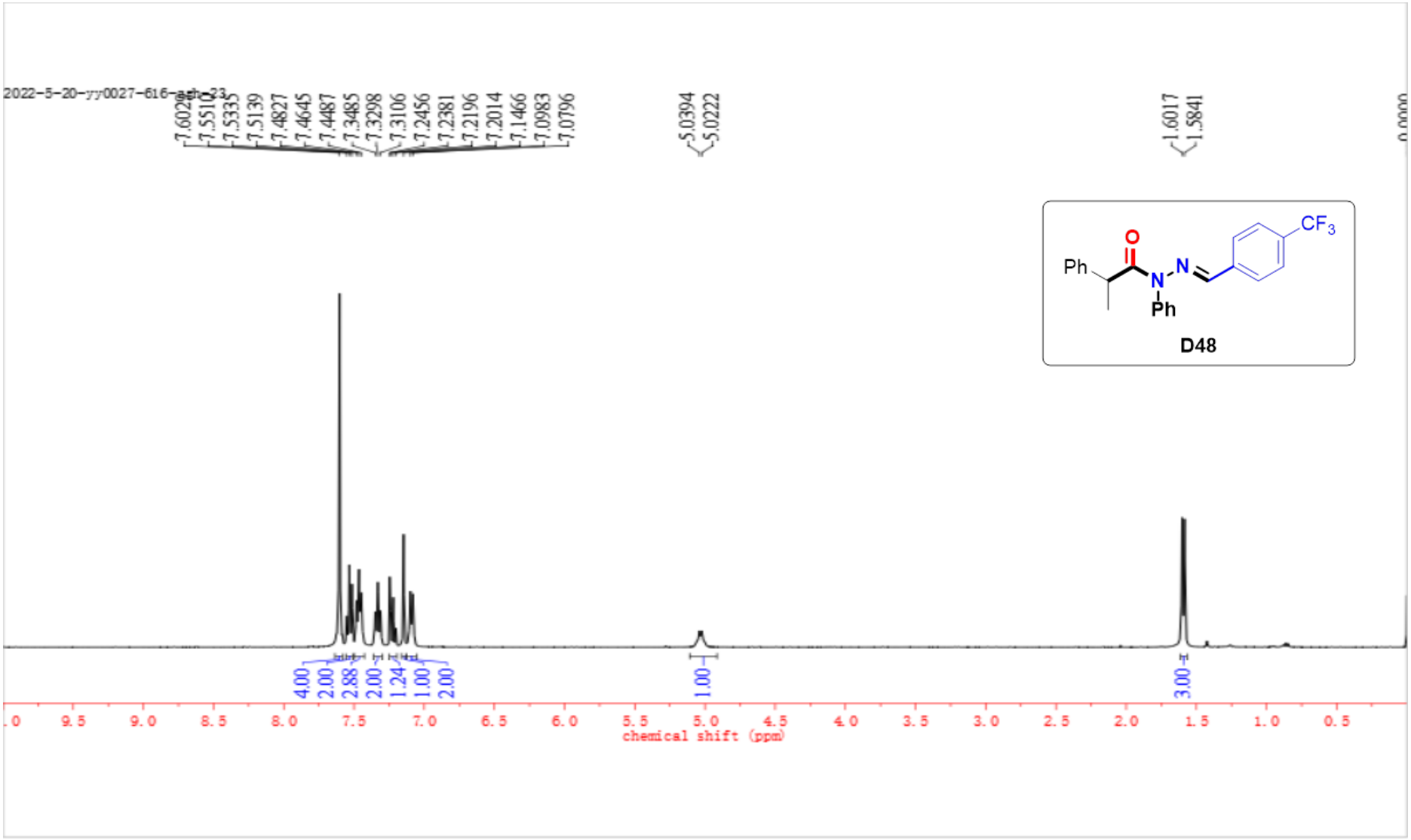

2022-05-11 YYQQQ6-616-2GH-18
11.8588
10.2666
7.5098
7.4945
7.4628
7.3250
7.2773
7.2071
7.1897
7.1721
7.1262
6.9662
6.9460
6.8494
6.8309
6.7545
6.7362
6.7179
4.6635
3.5866
1.5668
Ph
O
N
N
Ph
OH
D46
0.28
0.72
5.00
2.01
3.05
1.07
2.00
1.09
1.00
0.73
0.31
3.06
chemical shift (ppm)

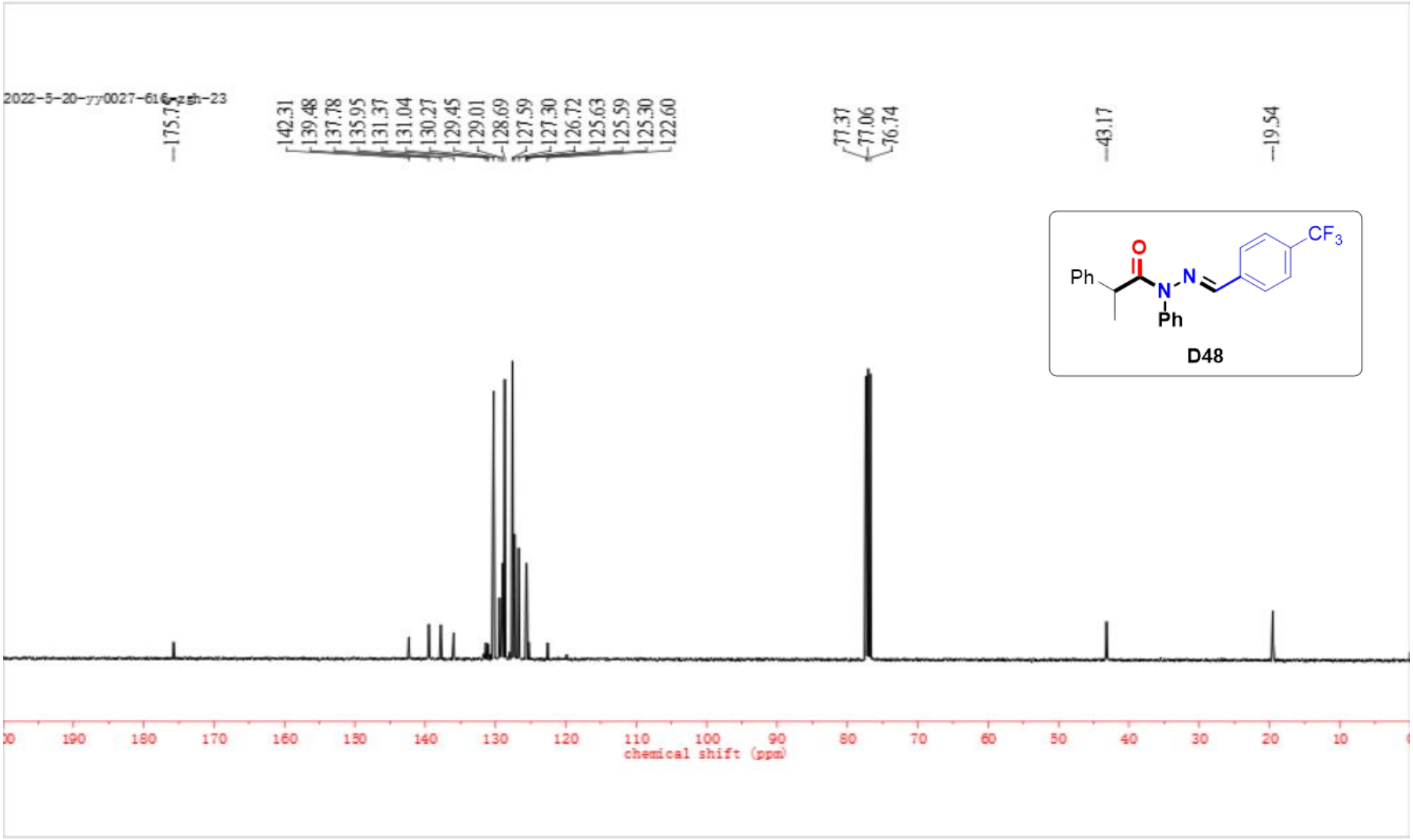

2022-05-16-YYD014-616-2GH-18
174.20
157.40
146.19
135.32
131.63
130.48
129.70
129.37
128.99
127.51
117.57
116.82
112.53
77.52
77.20
76.89
43.50
20.47
Ph
O
N
N
Ph
OH
D46
chemical shift (ppm)

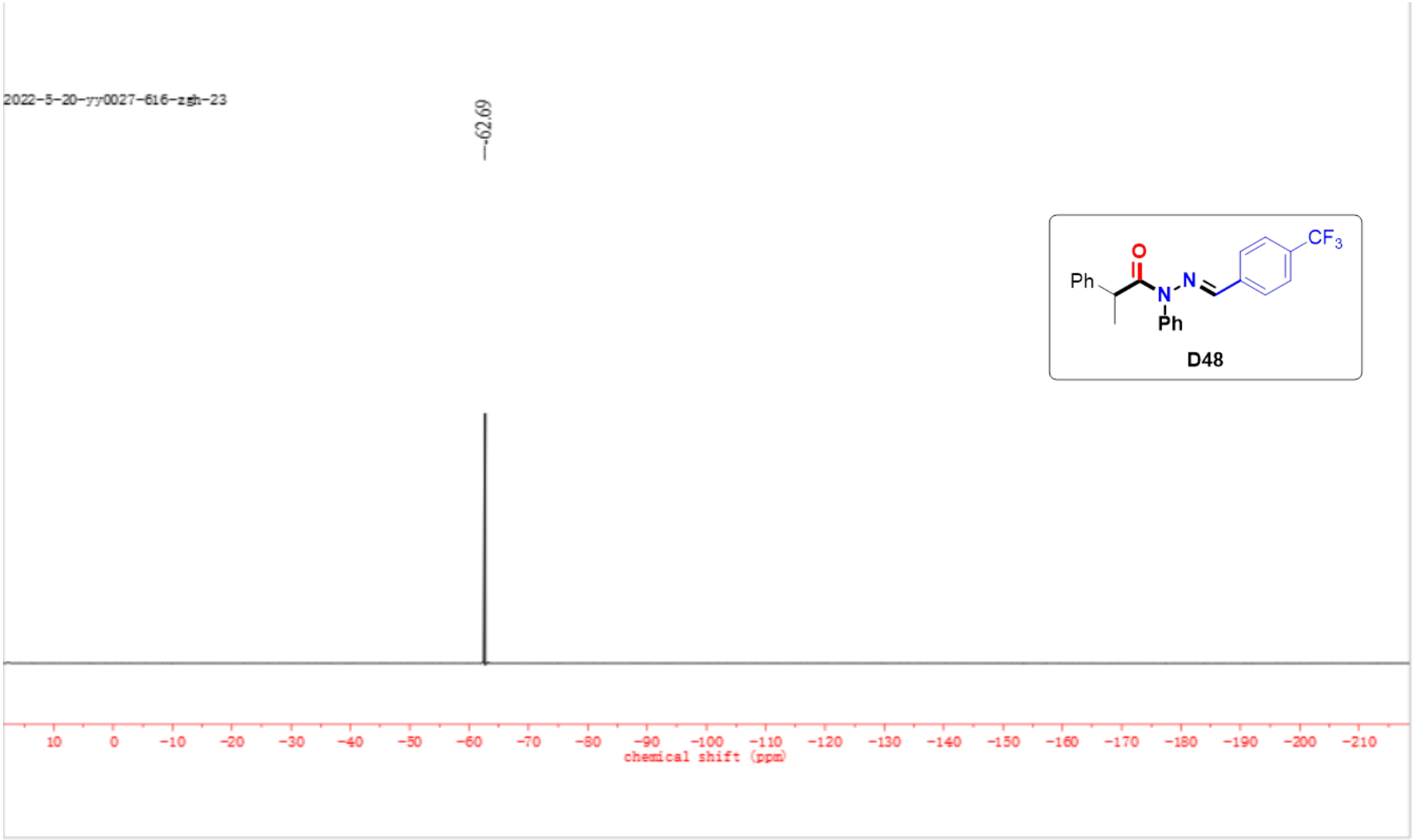

2022-5-20-yyy0027-616-zsh-24
7.5471
7.5228
7.5028
7.4699
7.4516
7.3475
7.3288
7.3098
7.2450
7.2372
7.2188
7.2009
7.1805
7.1162
7.0898
7.0711
5.0371
5.0198
1.5958
1.5782
Ph
O
N
N
Ph
OCF3
D47
4.00
3.00
2.00
3.24
3.00
1.00
3.00
chemical shift (ppm)

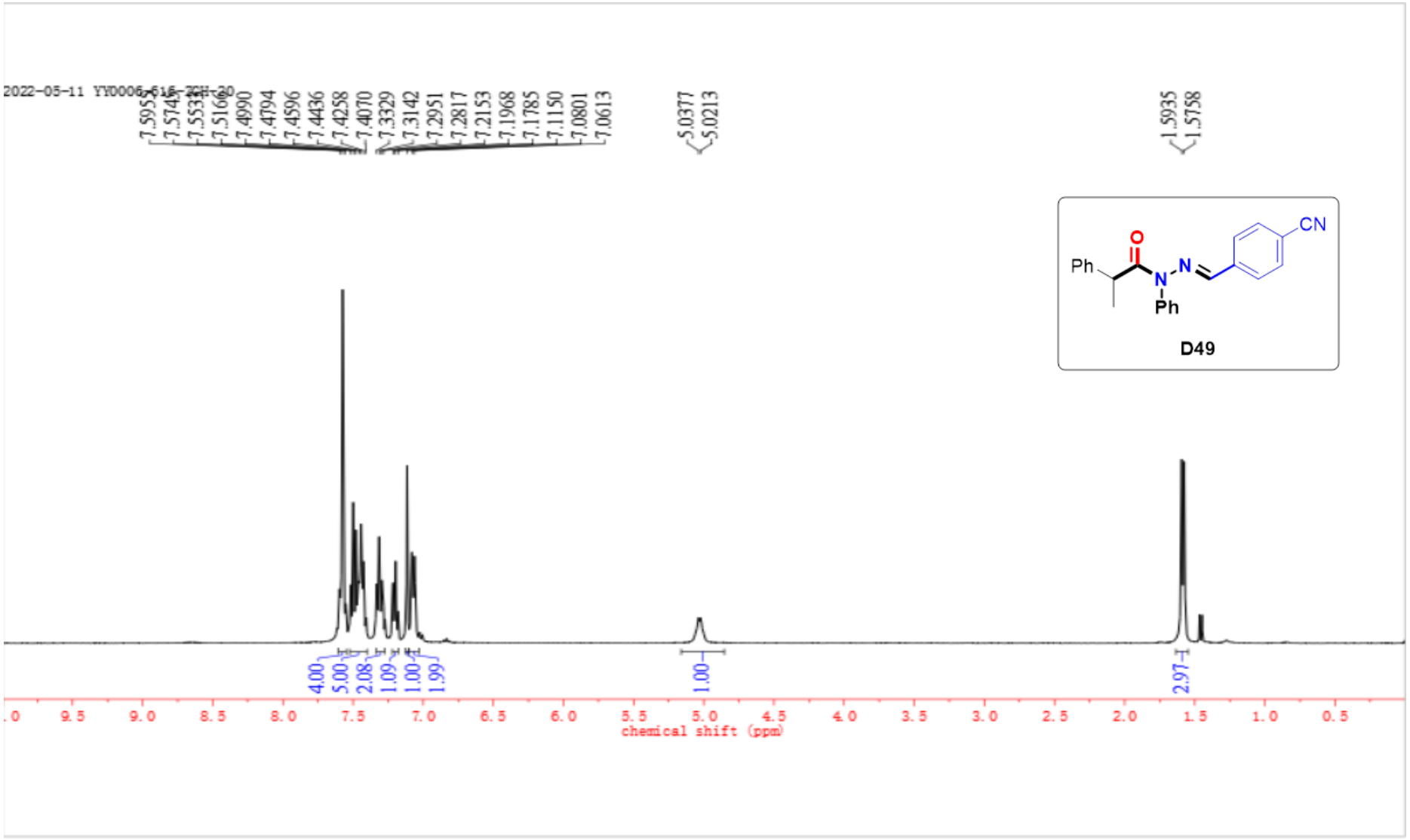

2022-5-20-yy0027-616-zgh-24
175.67
150.02
142.40
139.68
136.07
133.08
130.21
129.34
129.07
128.65
128.55
127.62
126.67
121.68
121.03
119.12
77.37
77.06
76.74
43.07
19.52
OCF3
O
Ph
N
N
Ph
D47
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

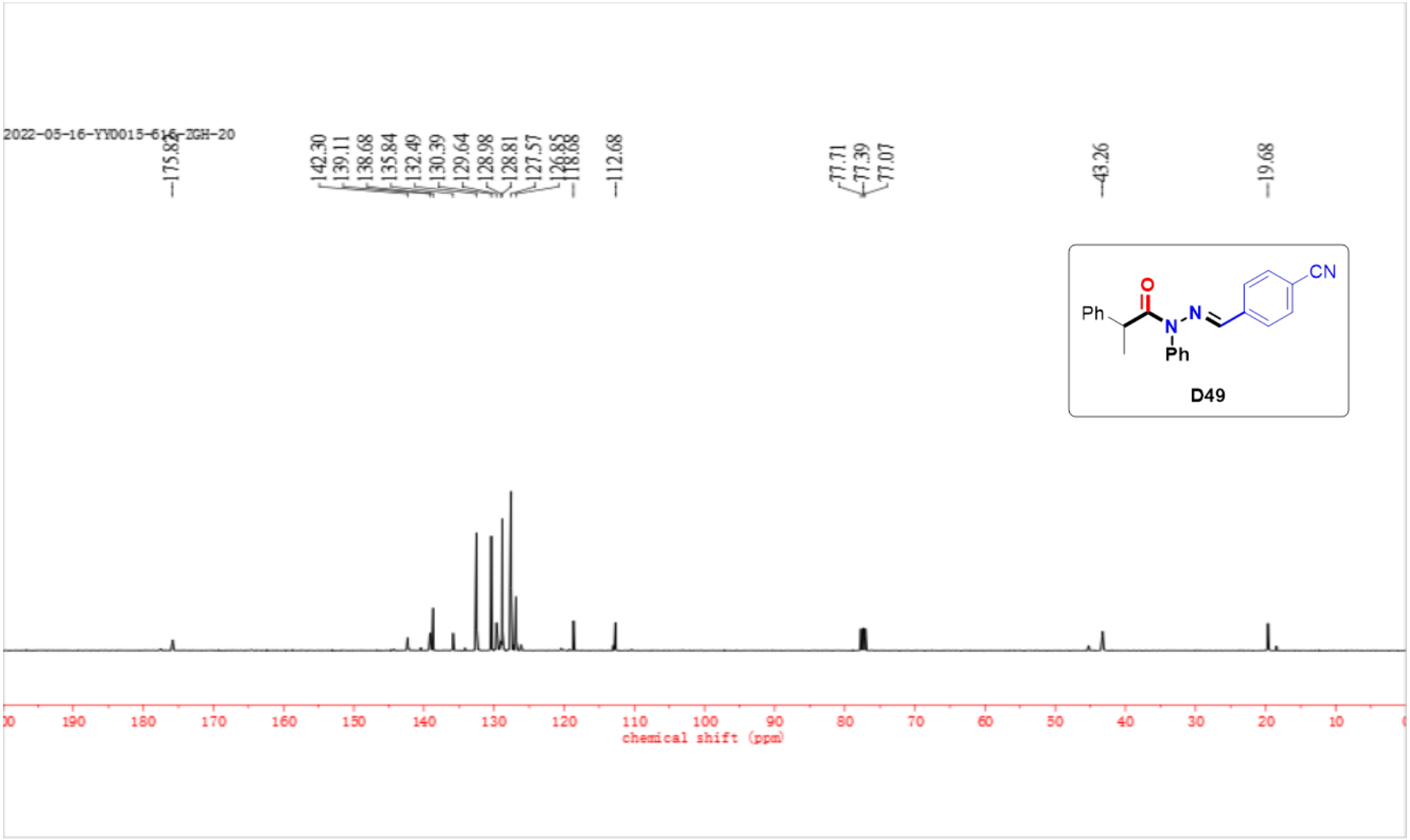

2022-5-20-yyy0027-616-zgh-24
-57.73
Ph
N
N
Ph
O
OCF3
D47
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

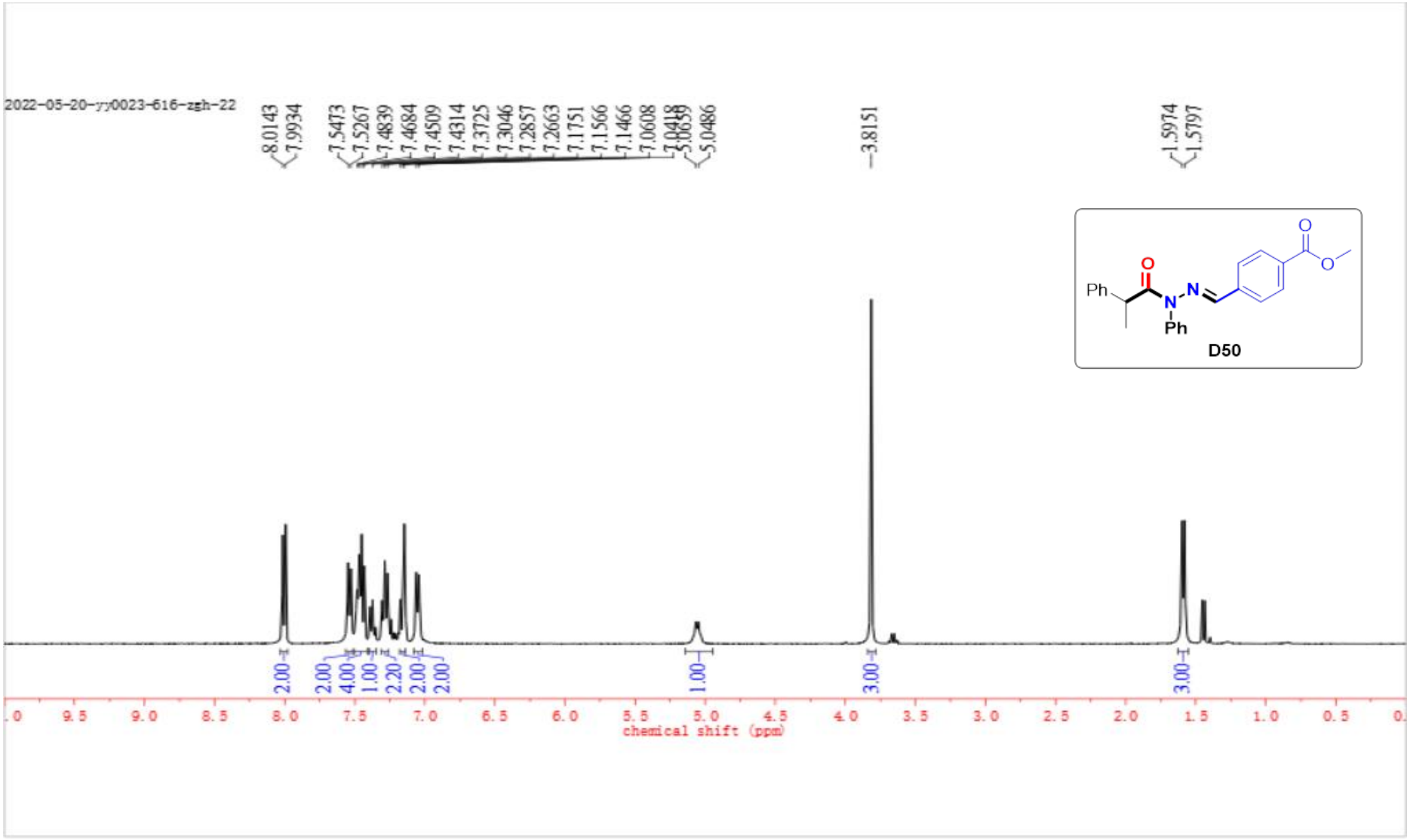

2022-5-20-yy0027-616-
7.6029
7.5510
7.5335
7.5139
7.4827
7.4645
7.4487
7.3485
7.3298
7.3106
7.2456
7.2381
7.2196
7.2014
7.1466
7.0983
7.0796
5.0394
5.0222
1.6017
1.5841
0.0000
Ph
O
N
N
Ph
CF3
D48
4.00
2.00
2.88
2.00
1.24
1.00
2.00
1.00
3.00
chemical shift (ppm)

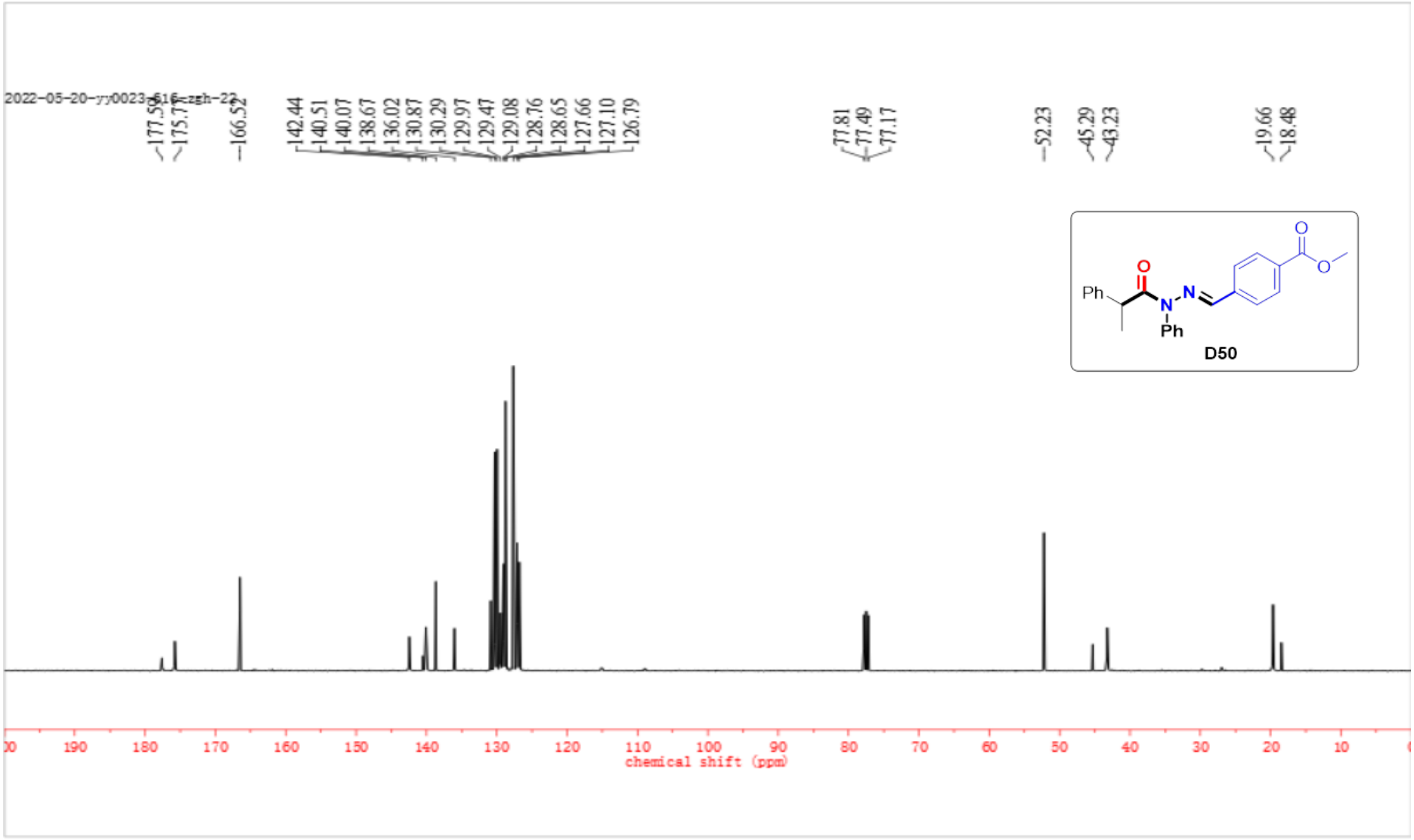

2022-5-20-yy0027-616-zsh-23
175.75
142.31
139.48
137.78
135.95
131.37
131.04
130.27
129.45
129.01
128.69
127.59
127.30
126.72
125.63
125.59
125.30
122.60
77.37
77.06
76.74
43.17
19.54
Ph
N
N
Ph
O
CF3
D48
chemical shift (ppm)

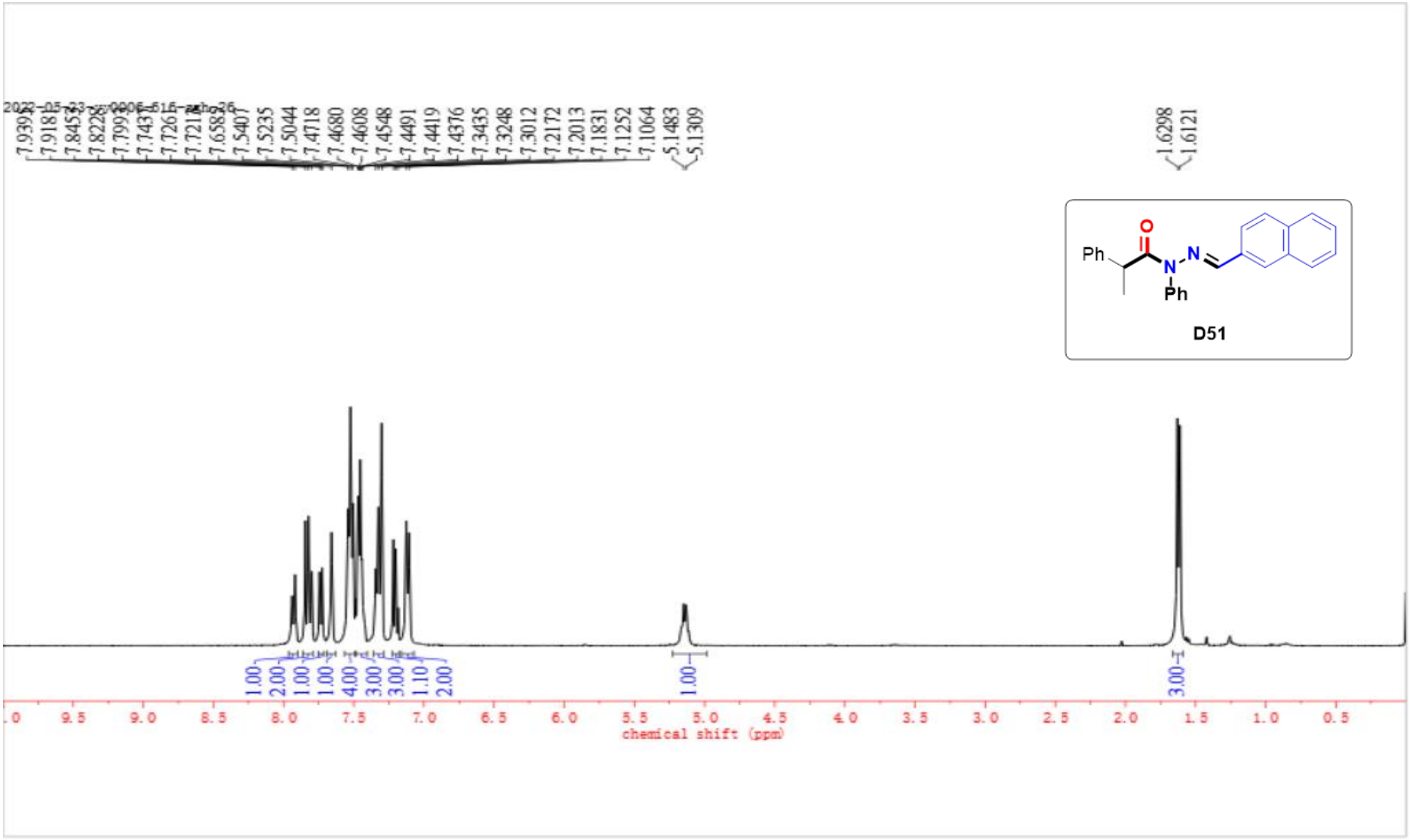

2022-5-20-yyr0027-616-zgh-23
-62.69
Ph
O
N
N
Ph
CF3
D48
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

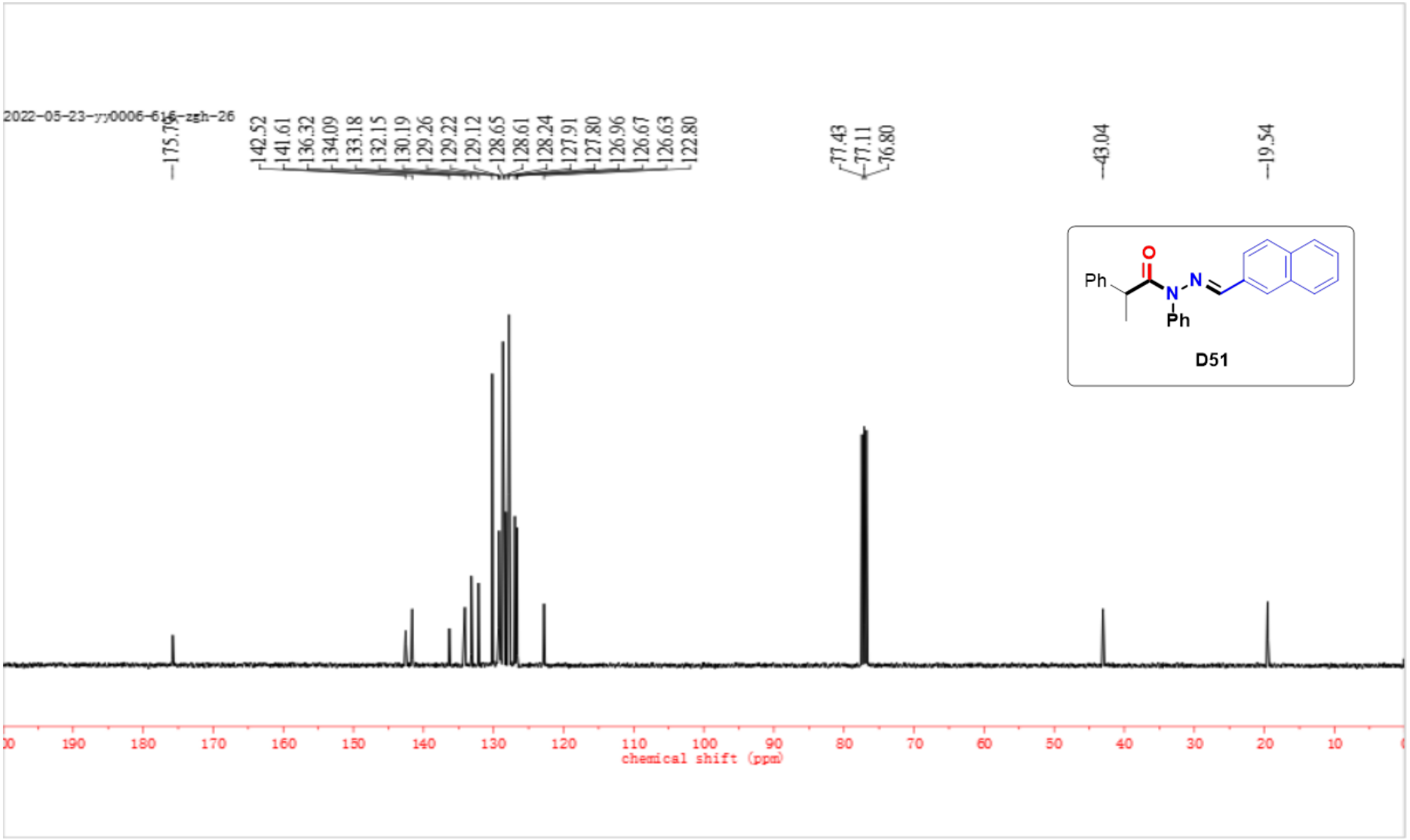

2022-05-11 YY0006_616_H_20
7.5955
7.5746
7.5534
7.5166
7.4990
7.4794
7.4596
7.4436
7.4258
7.4070
7.3329
7.3142
7.2951
7.2817
7.2153
7.1968
7.1785
7.1150
7.0801
7.0613
5.0377
5.0213
1.5935
1.5758
Ph
O
N
N
Ph
CN
D49
4.00
5.00
2.08
1.09
1.00
1.99
1.00
2.97
chemical shift (ppm)

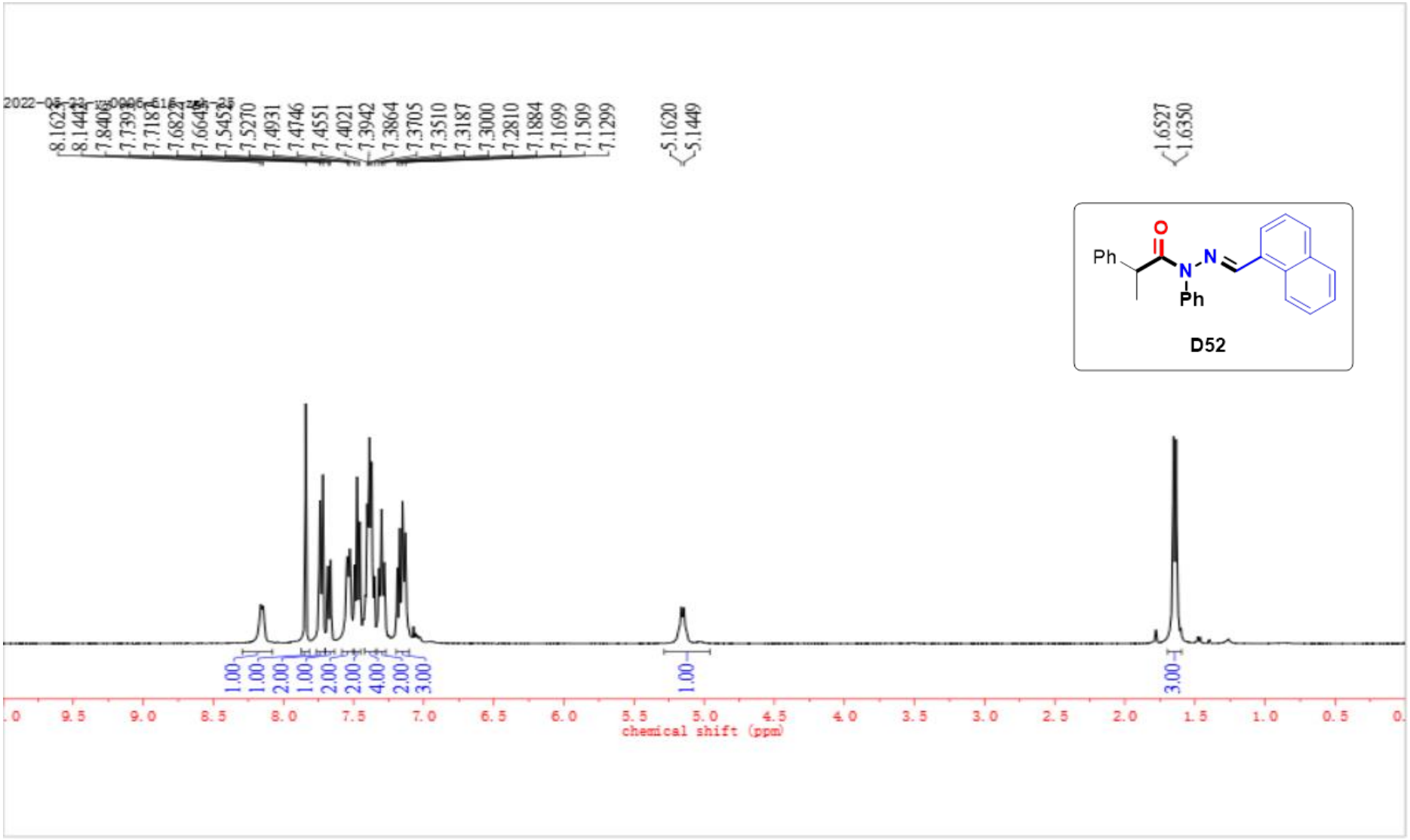

2022-05-16-YYD015-616-ZGH-20
175.82
142.30
139.11
138.68
135.84
132.49
130.39
129.64
128.98
128.81
127.57
126.85
118.68
112.68
77.71
77.39
77.07
43.26
19.68
Ph
O
N
N
Ph
CN
D49
chemical shift (ppm)

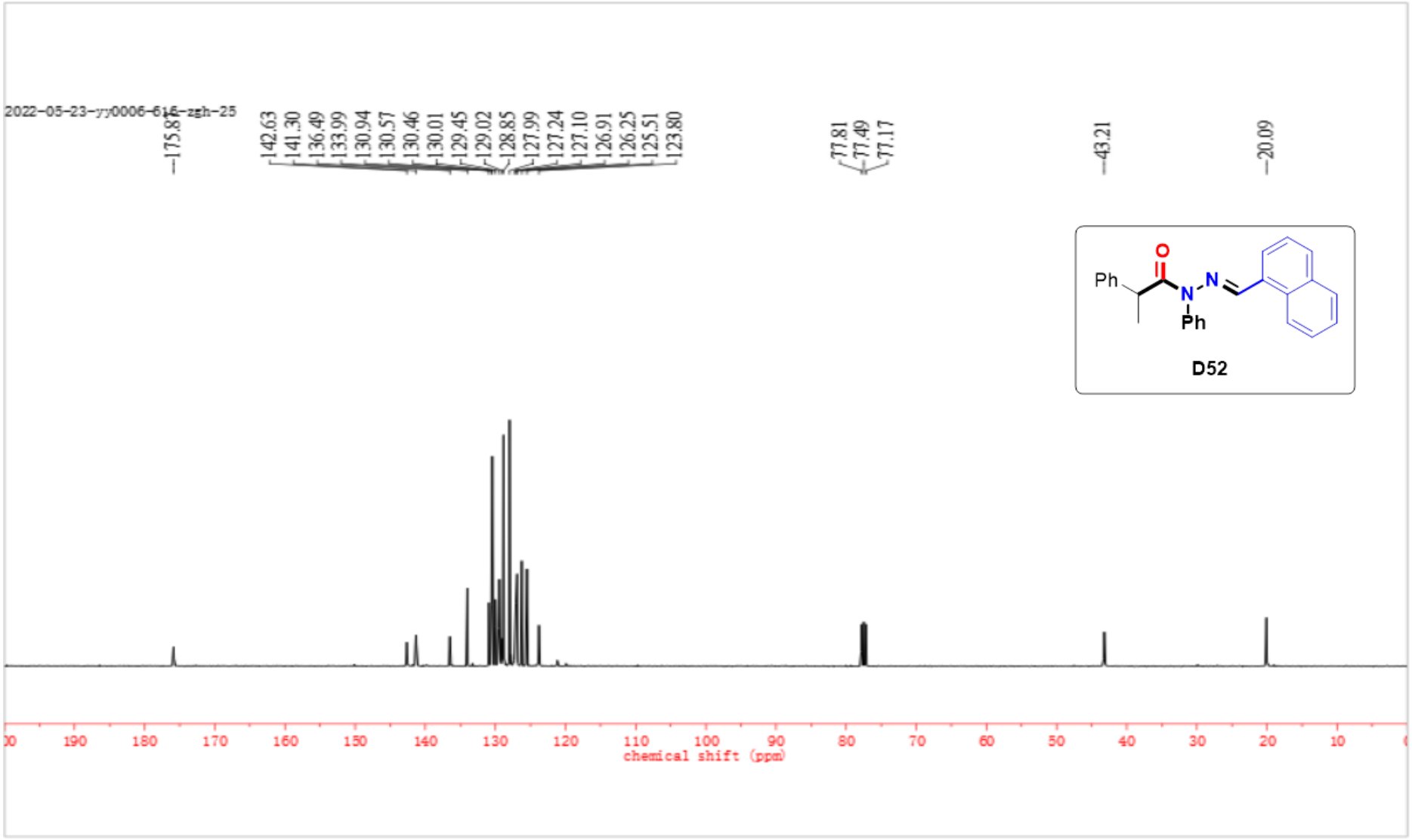

2022-05-20-yy0023-616-zgh-22
8.0143
7.9934
7.5473
7.5267
7.4839
7.4684
7.4509
7.4314
7.3725
7.3046
7.2857
7.2663
7.1751
7.1566
7.1466
7.0608
5.0486
3.8151
1.5974
1.5797
Ph
N
N
Ph
O
O
O
D50
2.00
2.00
4.00
1.00
2.20
2.00
2.00
1.00
3.00
3.00
chemical shift (ppm)

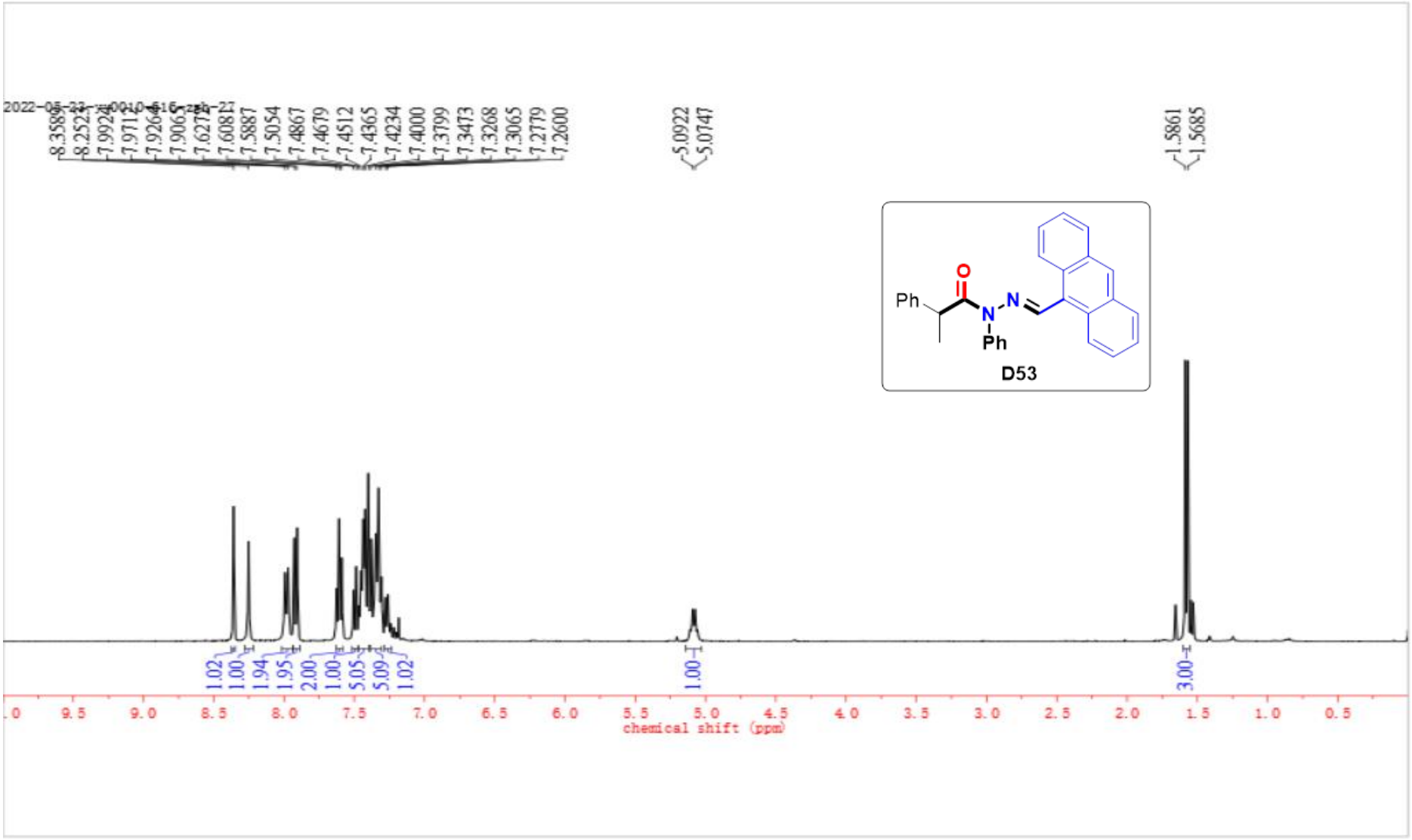

177.59
175.77
166.52
142.44
140.51
140.07
138.67
136.02
130.87
130.29
129.97
129.47
129.08
128.76
128.65
127.66
127.10
126.79
77.81
77.49
77.17
52.23
45.29
43.23
19.66
18.48
Ph
N
N
Ph
O
O
O
D50
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

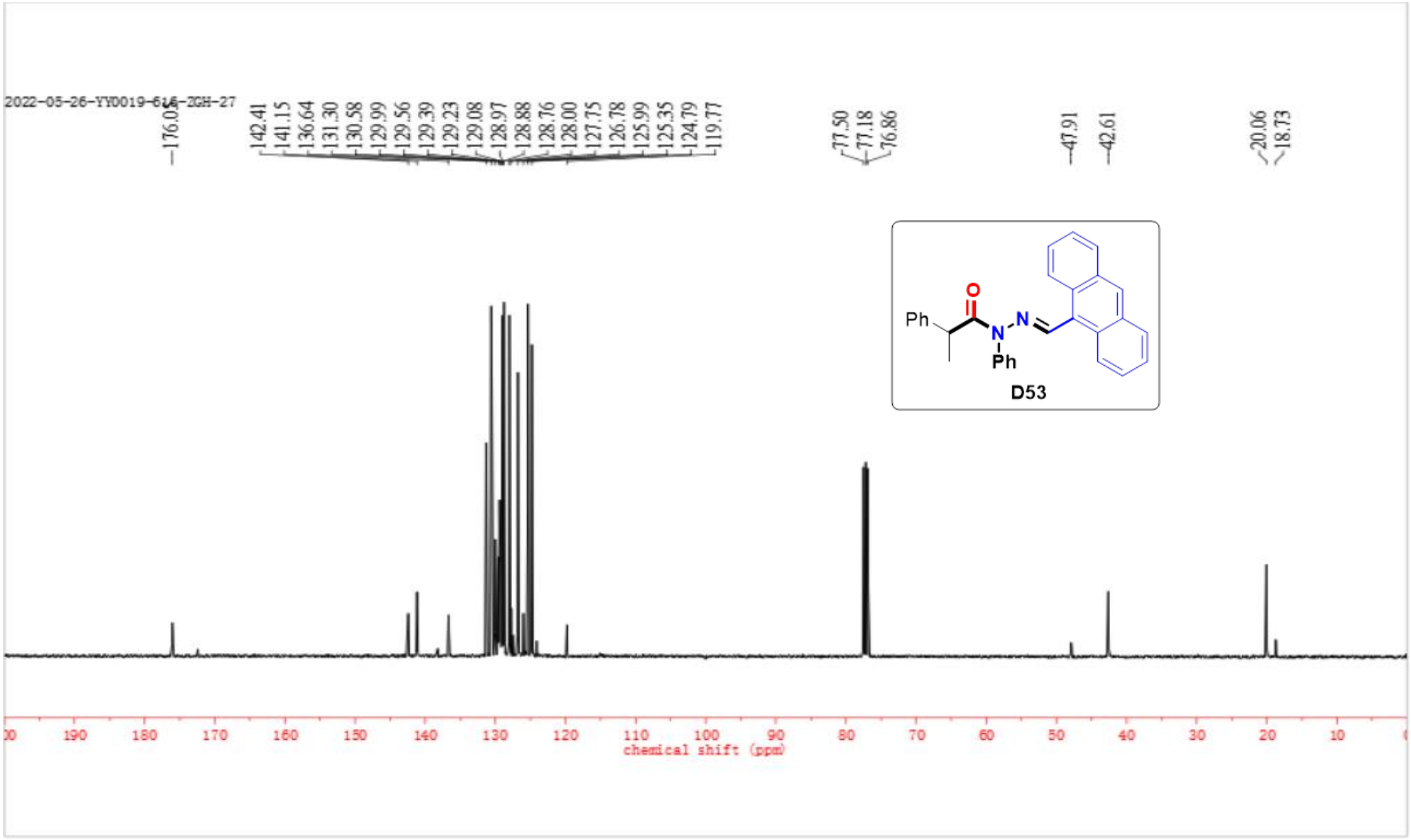

7.9392
7.9181
7.8453
7.8228
7.7993
7.7431
7.7261
7.7218
7.6582
7.5407
7.5235
7.5044
7.4718
7.4680
7.4608
7.4548
7.4491
7.4419
7.4376
7.3435
7.3248
7.3012
7.2172
7.2013
7.1831
7.1252
7.1064
5.1483
5.1309
1.6298
1.6121
Ph
O
N
N
Ph
D51
1.00
2.00
1.00
1.00
4.00
3.00
3.00
1.10
2.00
1.00
3.00
chemical shift (ppm)

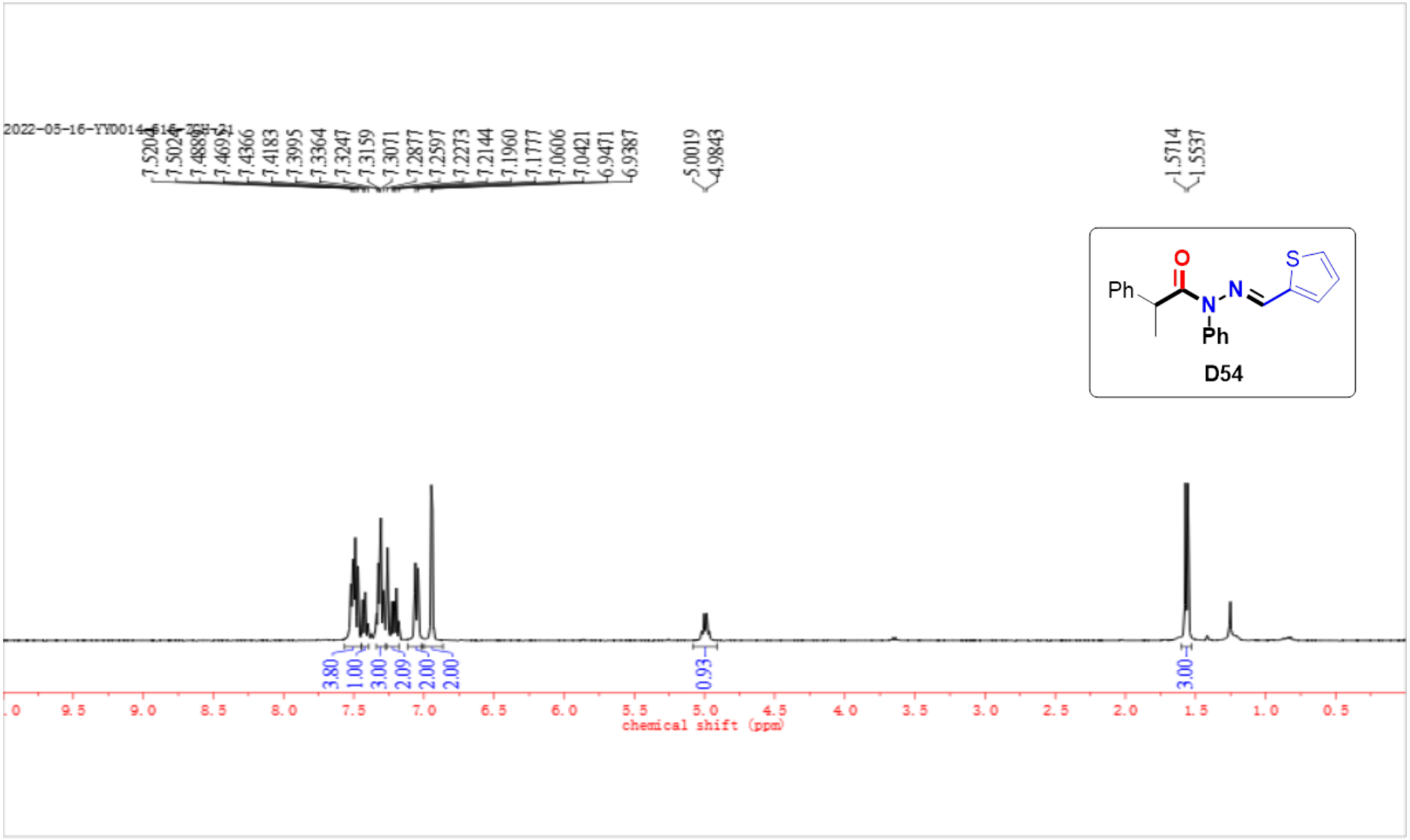

2022-05-23-yy0006-616-zgh-26
175.75
142.52
141.61
136.32
134.09
133.18
132.15
130.19
129.26
129.22
129.12
128.65
128.61
128.24
127.91
127.80
126.96
126.67
126.63
122.80
77.43
77.11
76.80
43.04
19.54
Ph
N
N
Ph
O
D51
chemical shift (ppm)

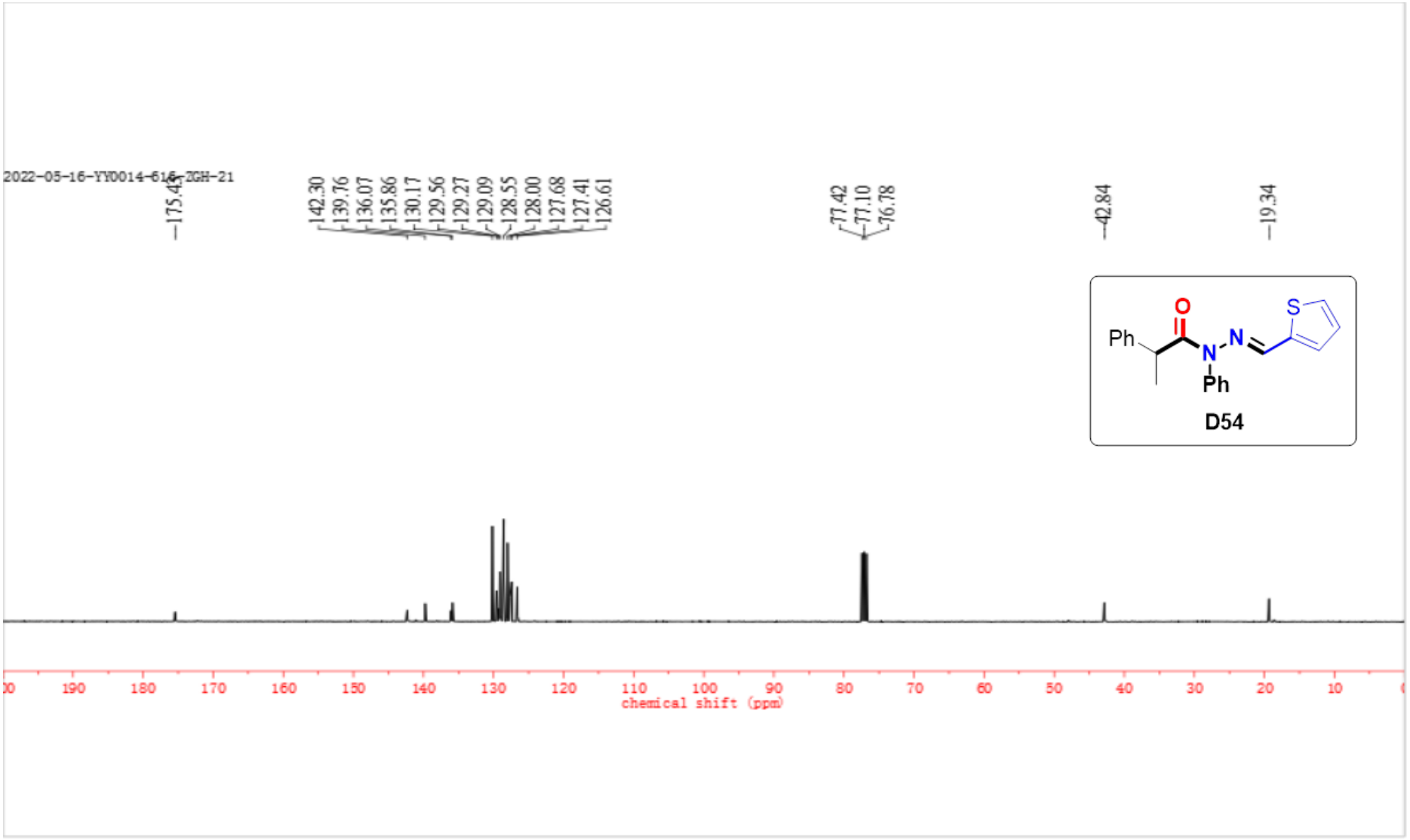

8.1622
8.1442
7.8406
7.7393
7.7187
7.6822
7.6645
7.5454
7.5270
7.4931
7.4746
7.4551
7.4021
7.3942
7.3864
7.3705
7.3510
7.3187
7.3000
7.2810
7.1884
7.1699
7.1509
7.1299
5.1620
5.1449
1.6527
1.6350
Ph
N
N
Ph
O
D52
1.00
1.00
2.00
1.00
2.00
2.00
4.00
2.00
3.00
1.00
3.00
chemical shift (ppm)

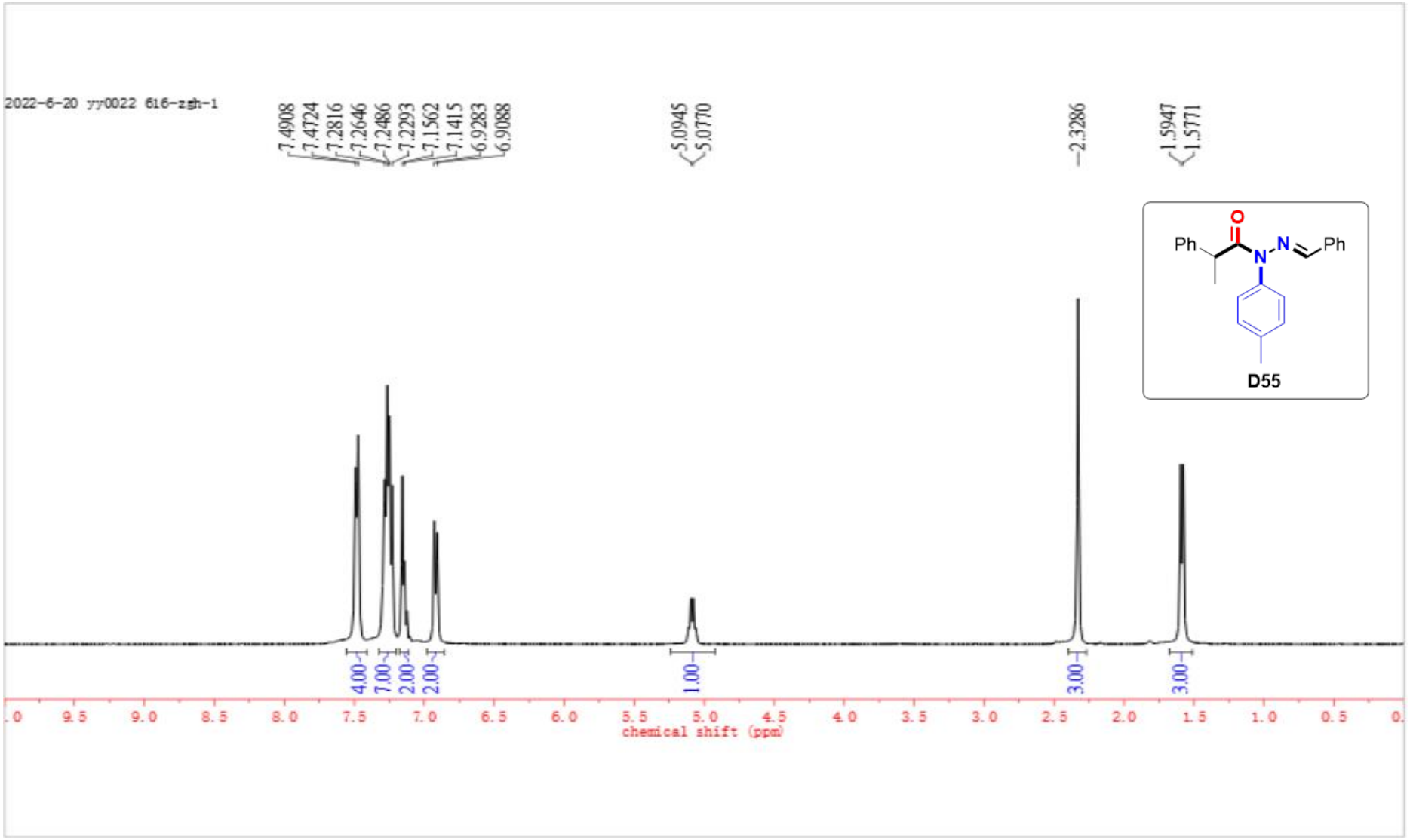

2022-05-23-yy0006-616-zgh-25
175.87
142.63
141.30
136.49
133.99
130.94
130.57
130.46
130.01
129.45
129.02
128.85
127.99
127.24
127.10
126.91
126.25
125.51
123.80
77.81
77.49
77.17
43.21
20.09
Ph
O
N
N
Ph
D52
chemical shift (ppm)

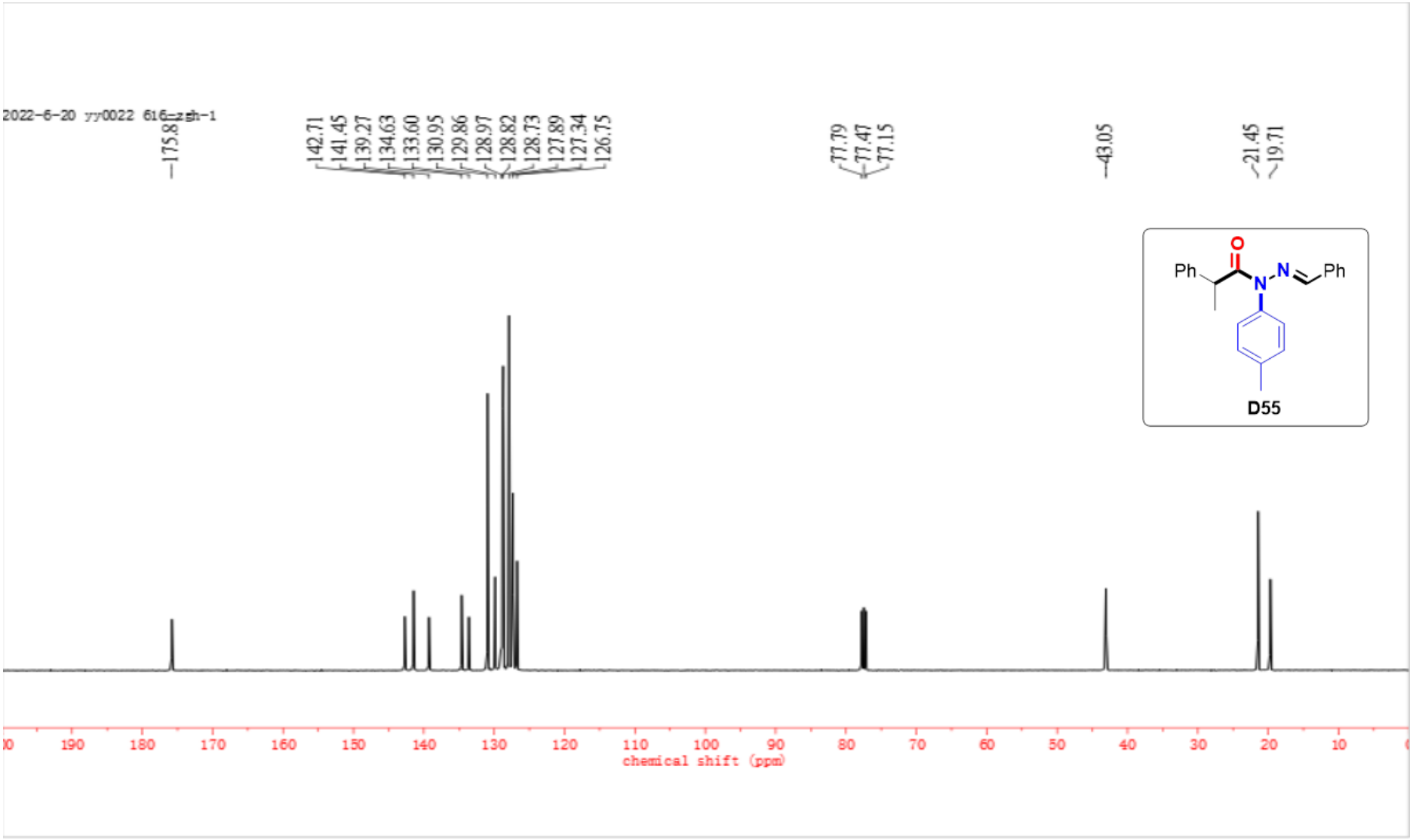

8.3589
8.2523
7.9924
7.9712
7.9264
7.9065
7.6279
7.6081
7.5887
7.5054
7.4867
7.4679
7.4512
7.4365
7.4234
7.4000
7.3799
7.3473
7.3268
7.3065
7.2779
7.2600
5.0922
5.0747
1.5861
1.5685
Ph
O
N
N
Ph
D53
1.02
1.00
1.94
1.95
2.00
1.00
5.05
5.09
1.02
1.00
3.00
chemical shift (ppm)

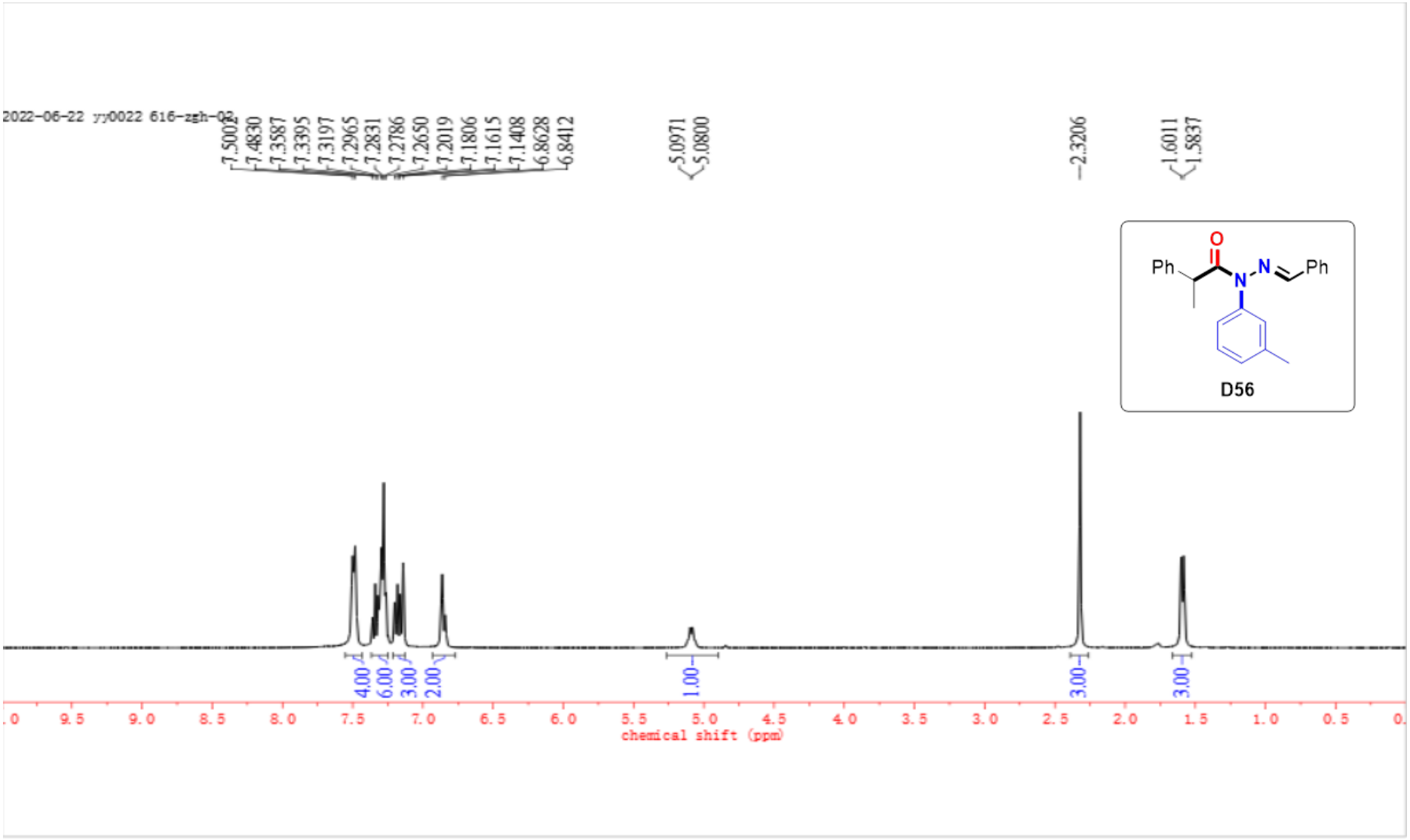

2022-05-26-YYD019-616-2GH-27
176.05
142.41
141.15
136.64
131.30
130.58
129.99
129.56
129.39
129.23
129.08
128.97
128.88
128.76
128.00
127.75
126.78
125.99
125.35
124.79
119.77
77.50
77.18
76.86
47.91
42.61
20.06
18.73
Ph
O
N
N
Ph
D53
chemical shift (ppm)

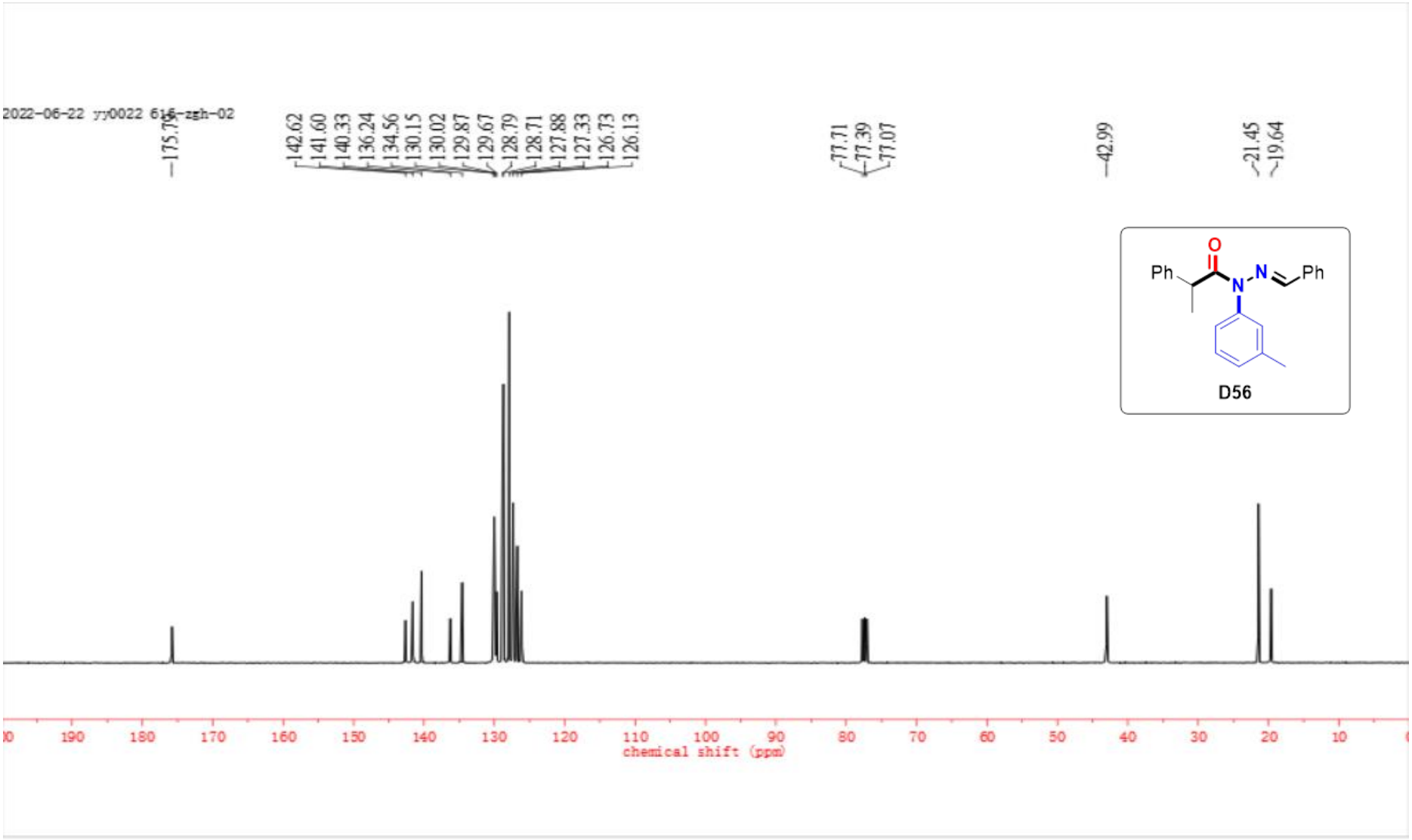

7.5204
7.5024
7.4693
7.4366
7.4183
7.3995
7.3364
7.3247
7.3159
7.3071
7.2877
7.2597
7.2273
7.2144
7.1960
7.1777
7.0606
7.0421
6.9471
6.9387
5.0019
4.9843
1.5714
1.5537
Ph
O
N
N
S
Ph
D54
3.80
1.00
3.00
2.09
2.00
2.00
0.93
3.00
chemical shift (ppm)

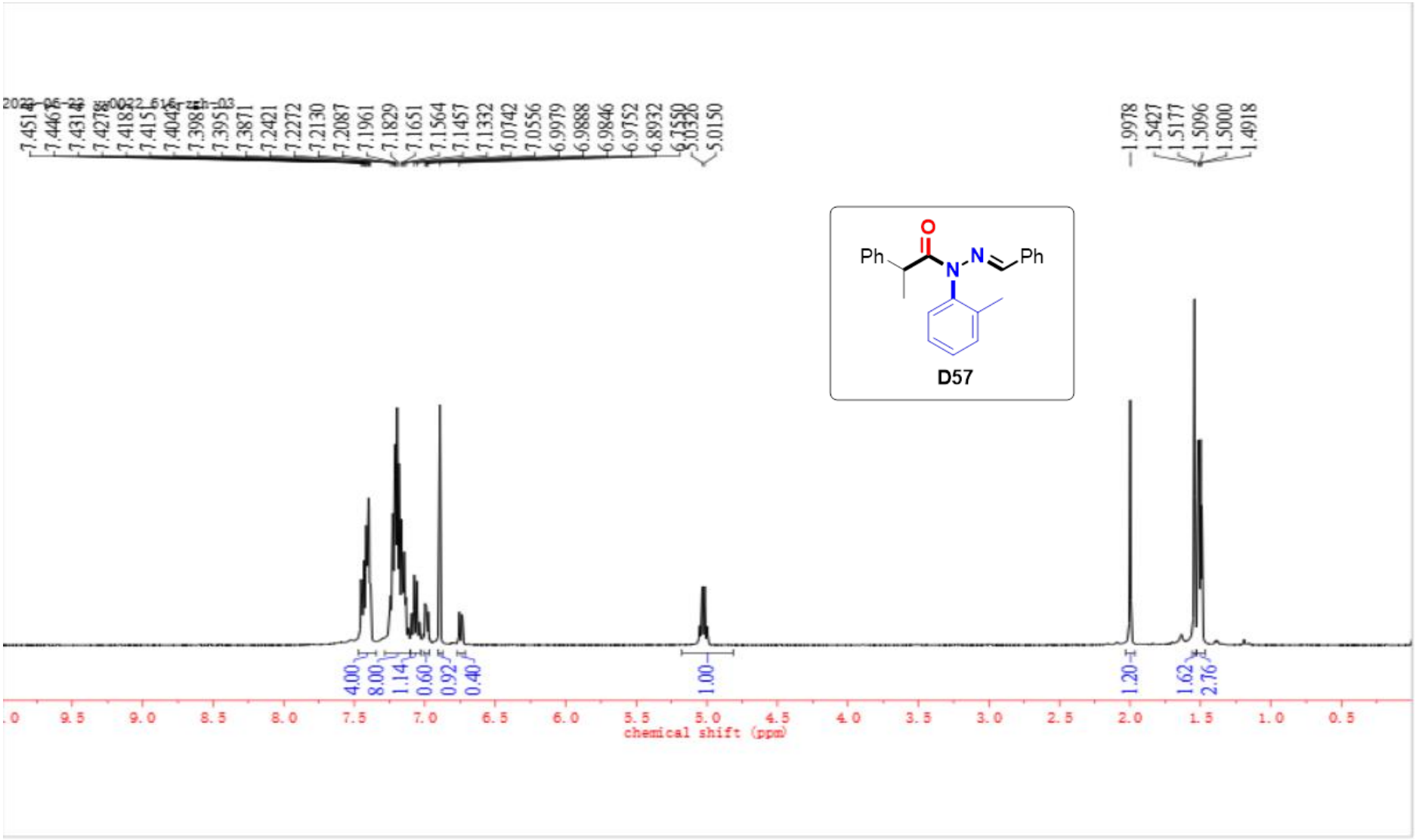

2022-05-16-YYD014-616-ZGH-21
175.43
142.30
139.76
136.07
135.86
130.17
129.56
129.27
129.09
128.55
128.00
127.68
127.41
126.61
77.42
77.10
76.78
42.84
19.34
O
S
Ph
N
N
Ph
D54
chemical shift (ppm)

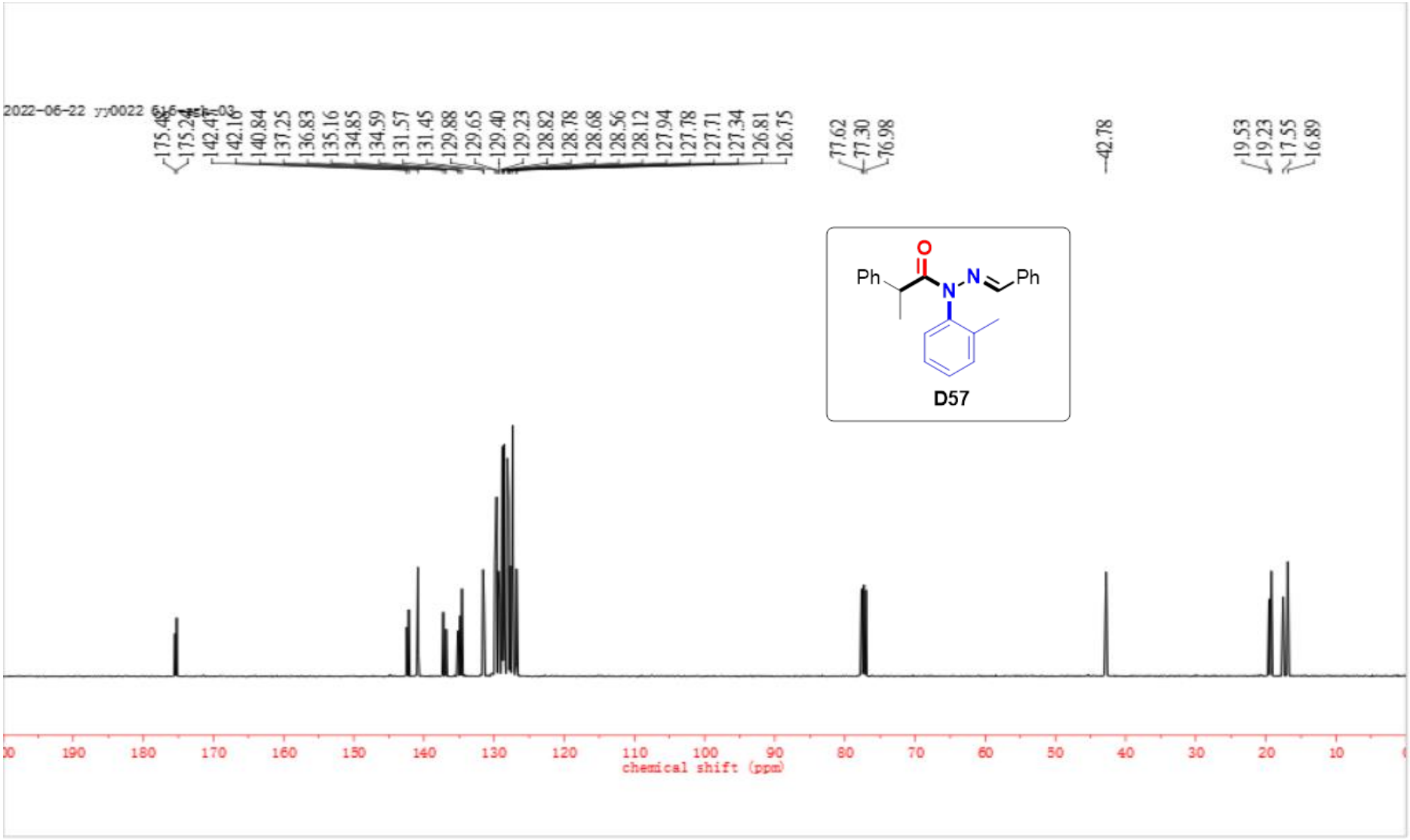

2022-6-20 yy0022 616-zgh-1
7.4908
7.4724
7.2816
7.2646
7.2486
7.2293
7.1562
7.1415
6.9283
6.9088
5.0945
5.0770
2.3286
1.5947
1.5771
Ph
O
N
N
Ph
D55
4.00
7.00
2.00
2.00
1.00
3.00
3.00
chemical shift (ppm)

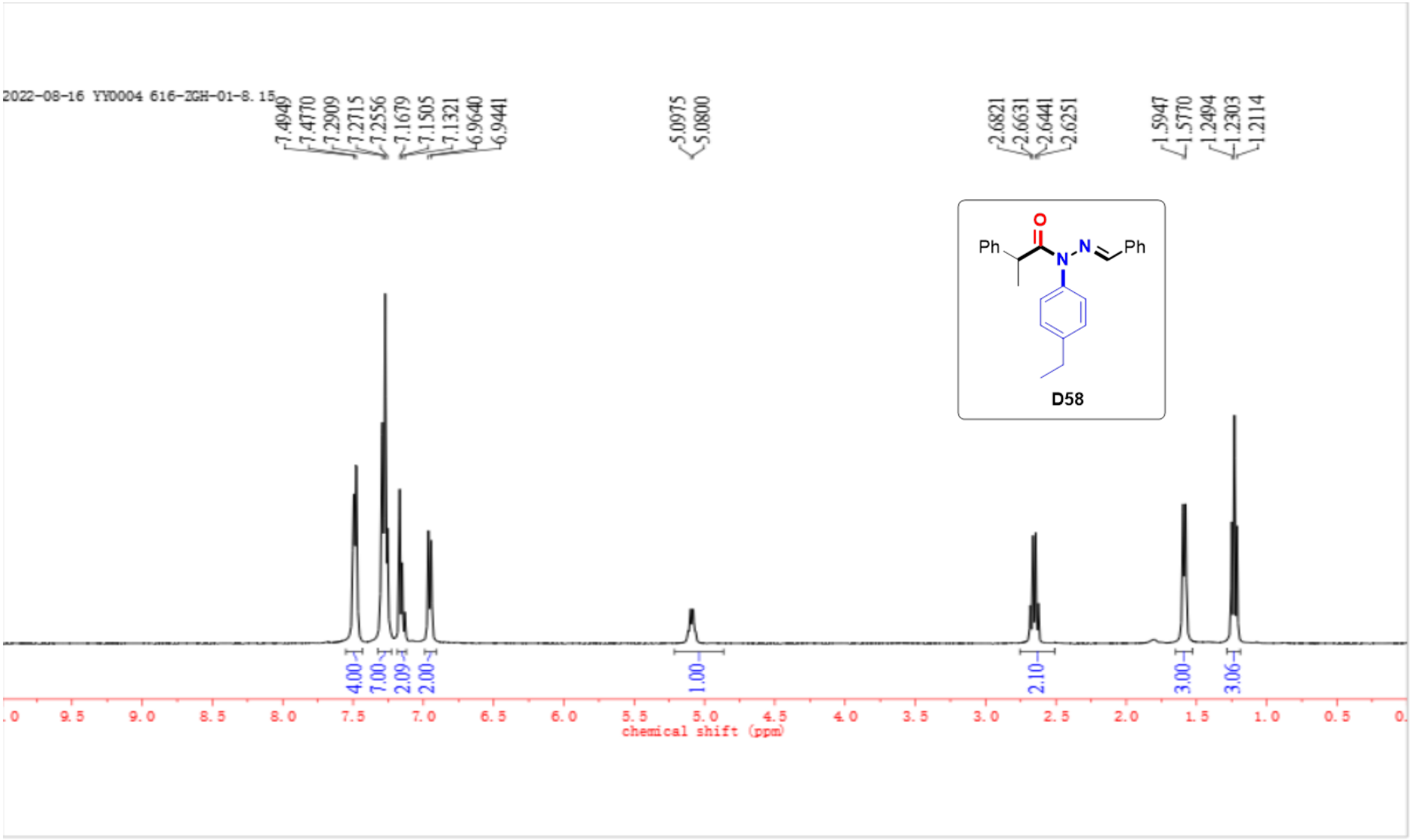

2022-6-20 yy0022 616-zgh-1
175.81
142.71
141.45
139.27
134.63
133.60
130.95
129.86
128.97
128.82
128.73
127.89
127.34
126.75
77.79
77.47
77.15
43.05
21.45
19.71
Ph
O
N
N
Ph
D55
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

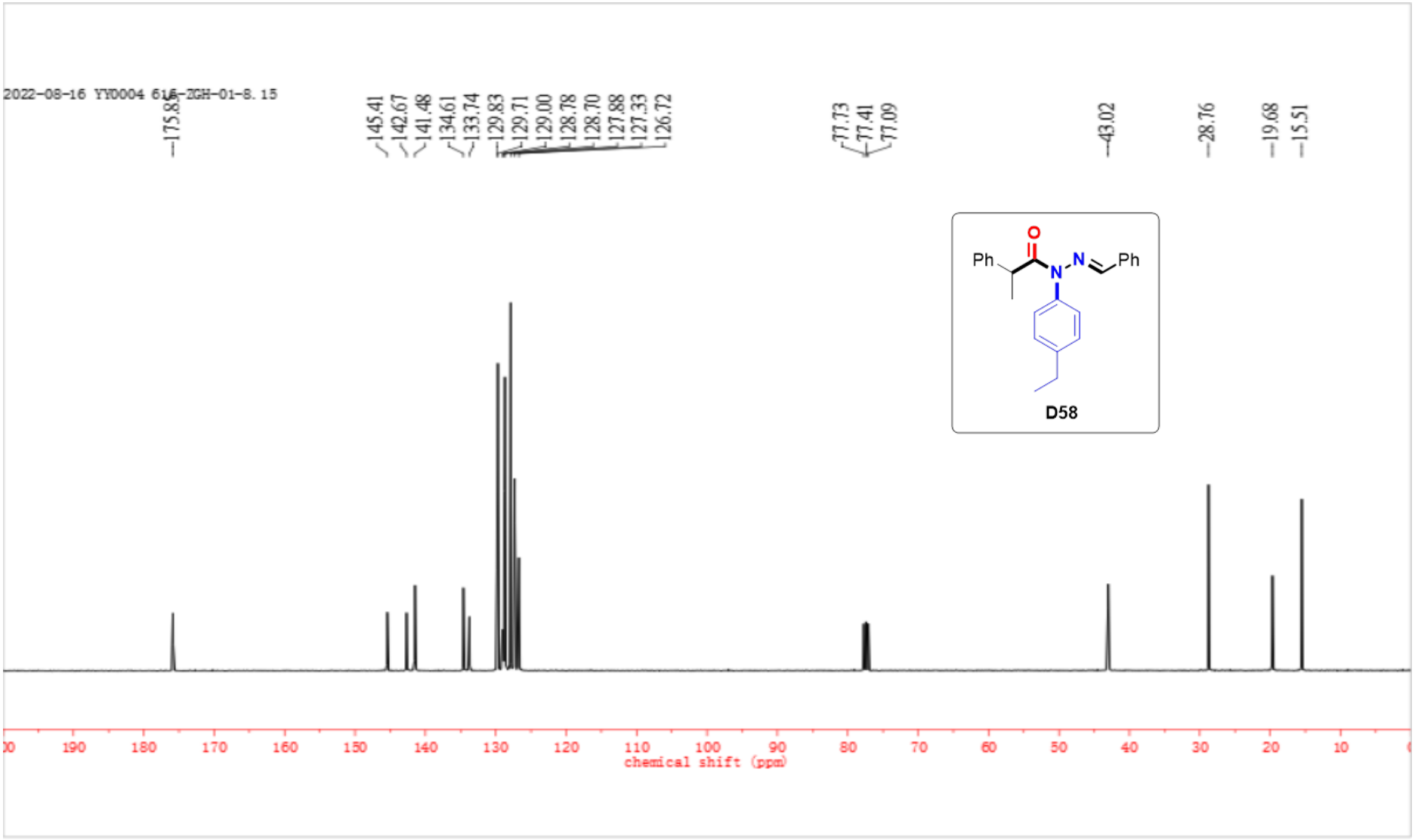

2022-06-22 yy0022 616-zgh-03
7.5002
7.4830
7.3587
7.3395
7.3197
7.2965
7.2831
7.2786
7.2650
7.2019
7.1806
7.1615
7.1408
6.8628
6.8412
5.0971
5.0800
2.3206
1.6011
1.5837
Ph
O
N
N
Ph
D56
4.00
6.00
3.00
2.00
1.00
3.00
3.00
chemical shift (ppm)

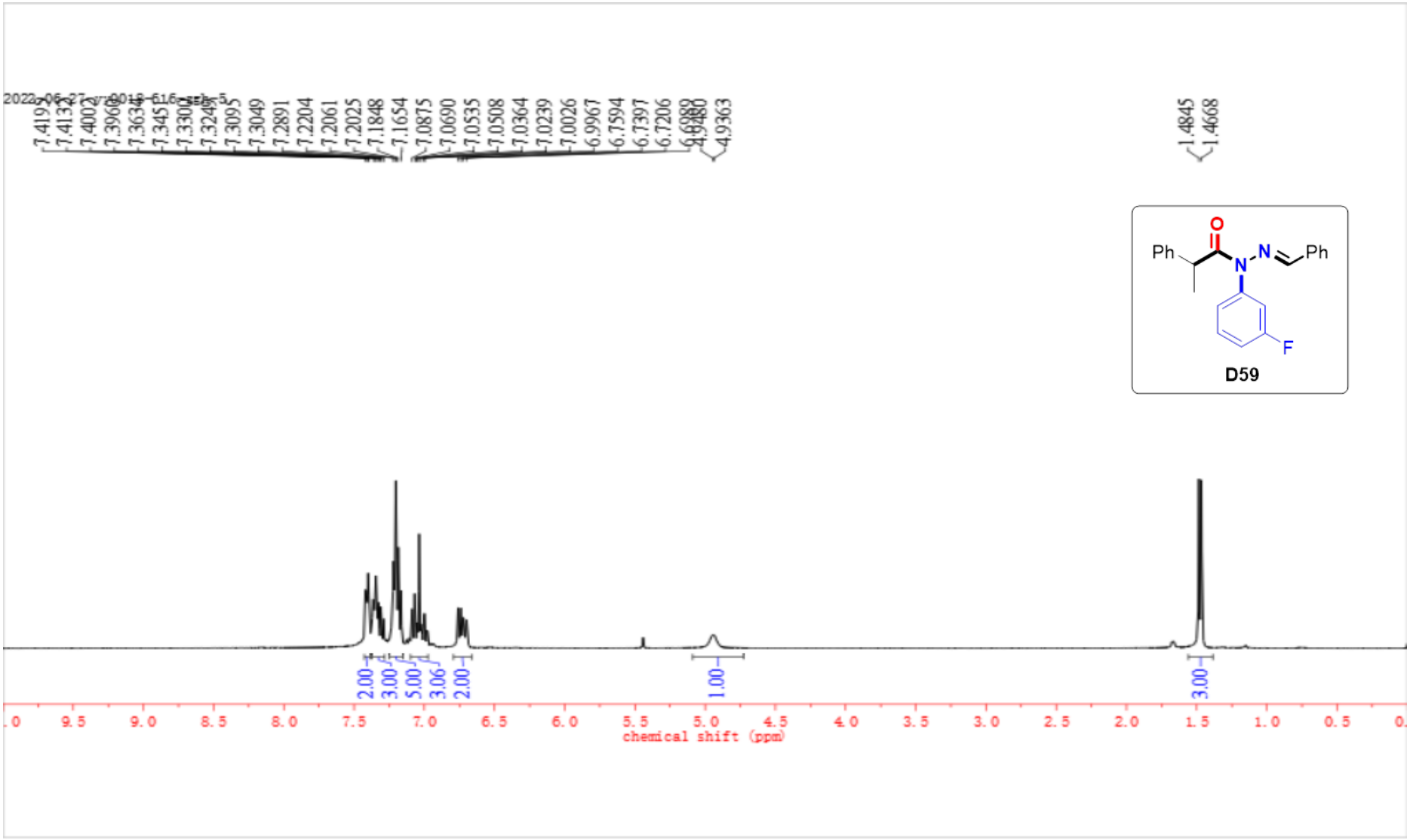

2022-06-22 yy0022 616-zgh-02
175.76
142.62
141.60
140.33
136.24
134.56
130.15
130.02
129.87
129.67
128.79
128.71
127.88
127.33
126.73
126.13
77.71
77.39
77.07
42.99
21.45
19.64
O
Ph
N
N
Ph
D56
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

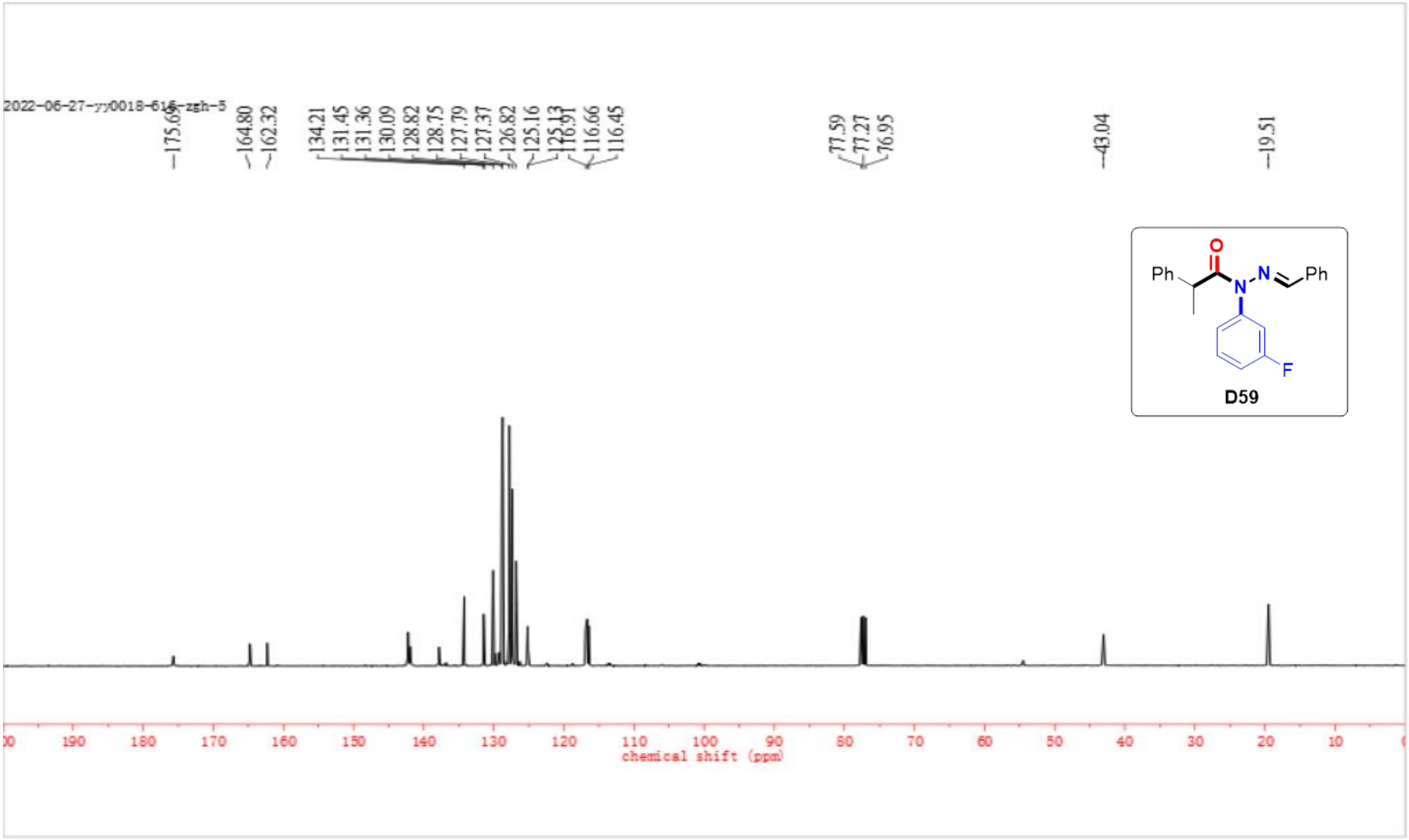

7.4514
7.4467
7.4314
7.4278
7.4182
7.4151
7.4042
7.3981
7.3951
7.3871
7.2421
7.2272
7.2130
7.2087
7.1961
7.1829
7.1651
7.1564
7.1457
7.1332
7.0742
7.0556
6.9979
6.9888
6.9846
6.9752
6.8932
5.0328
5.0150
1.9978
1.5427
1.5177
1.5096
1.5000
1.4918
Ph
N
N
Ph
O
D57
4.00
8.00
1.14
0.60
0.92
0.40
1.00
1.20
1.62
2.76
chemical shift (ppm)

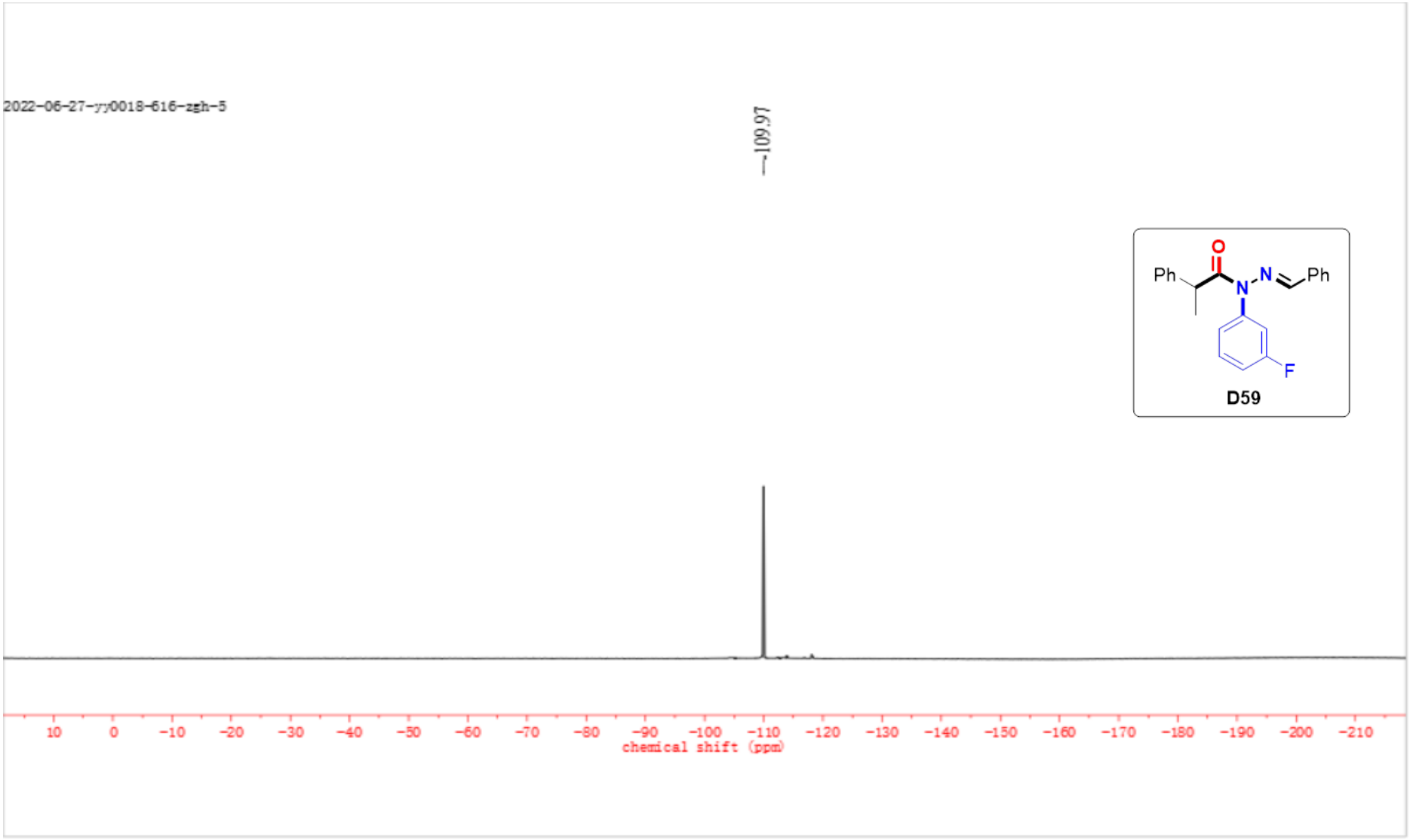

2022-06-22 yy0022
175.48
175.24
142.47
142.16
140.84
137.25
136.83
135.16
134.85
134.59
131.57
131.45
129.88
129.65
129.40
129.23
128.82
128.78
128.68
128.56
128.12
127.94
127.78
127.71
127.34
126.81
126.75
77.62
77.30
76.98
42.78
19.53
19.23
17.55
16.89
Ph
O
N
N
Ph
D57
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

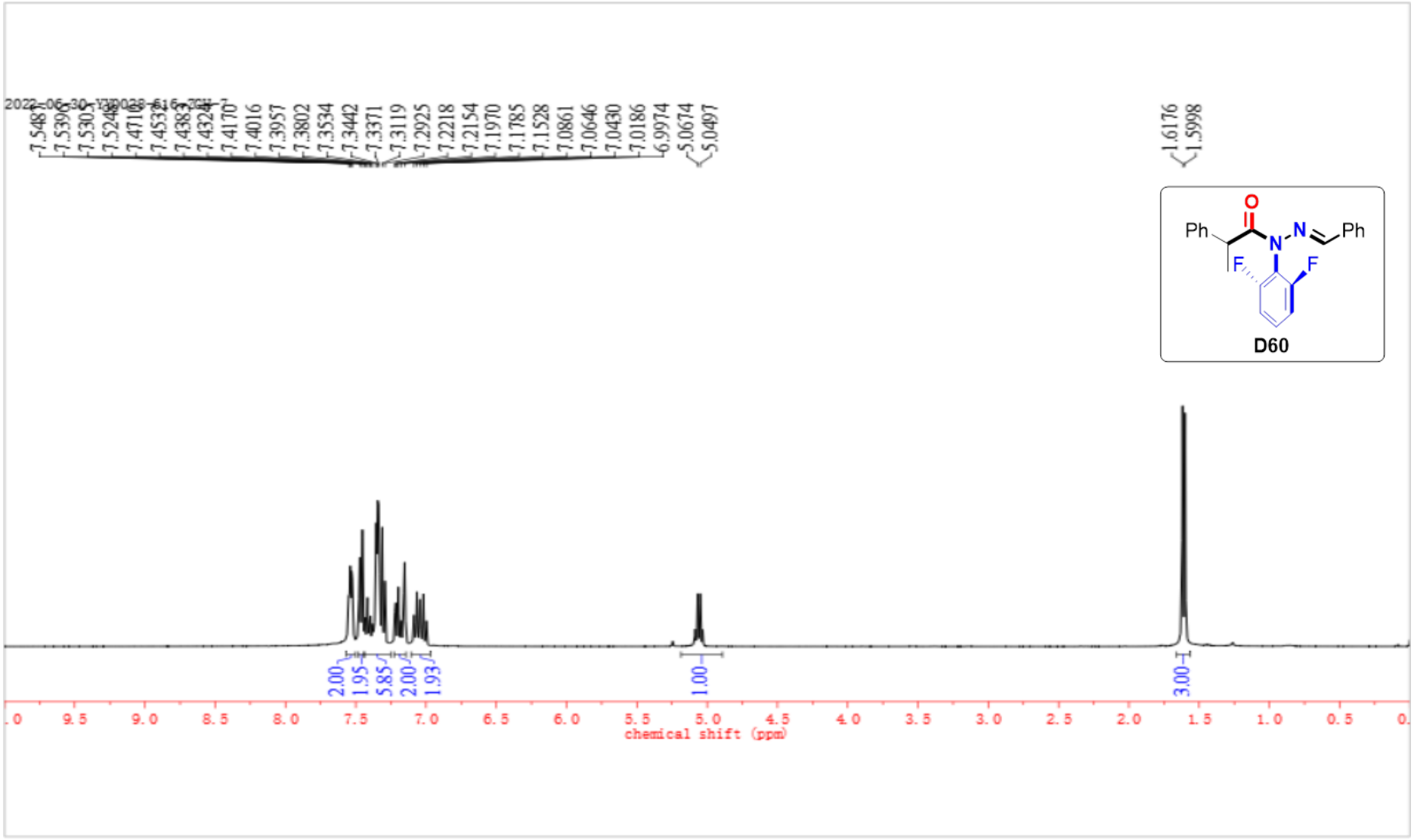

2022-08-16 YYD004 616-ZGH-01-8.15
7.4949
7.4770
7.2909
7.2715
7.2556
7.1679
7.1505
7.1321
6.9640
6.9441
5.0975
5.0800
2.6821
2.6631
2.6441
2.6251
1.5947
1.5770
1.2494
1.2303
1.2114
Ph
O
N
N
Ph
D58
4.00
7.00
2.09
2.00
1.00
2.10
3.00
3.06
chemical shift (ppm)

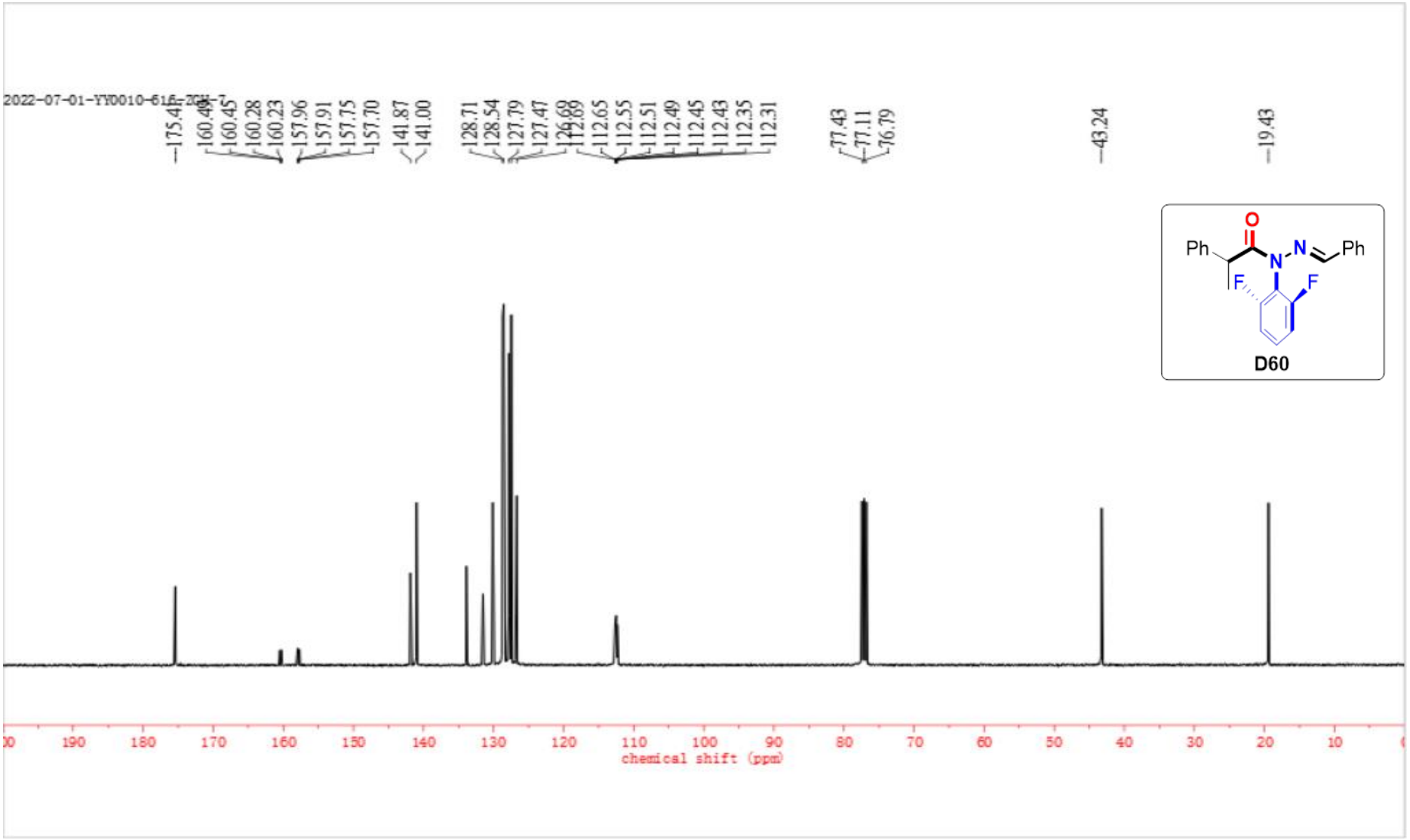

2022-08-16 YYD004 616-2GH-01-8.15
175.83
145.41
142.67
141.48
134.61
133.74
129.83
129.71
129.00
128.78
128.70
127.88
127.33
126.72
77.73
77.41
77.09
43.02
28.76
19.68
15.51
Ph
N
N
Ph
O
D58
chemical shift (ppm)

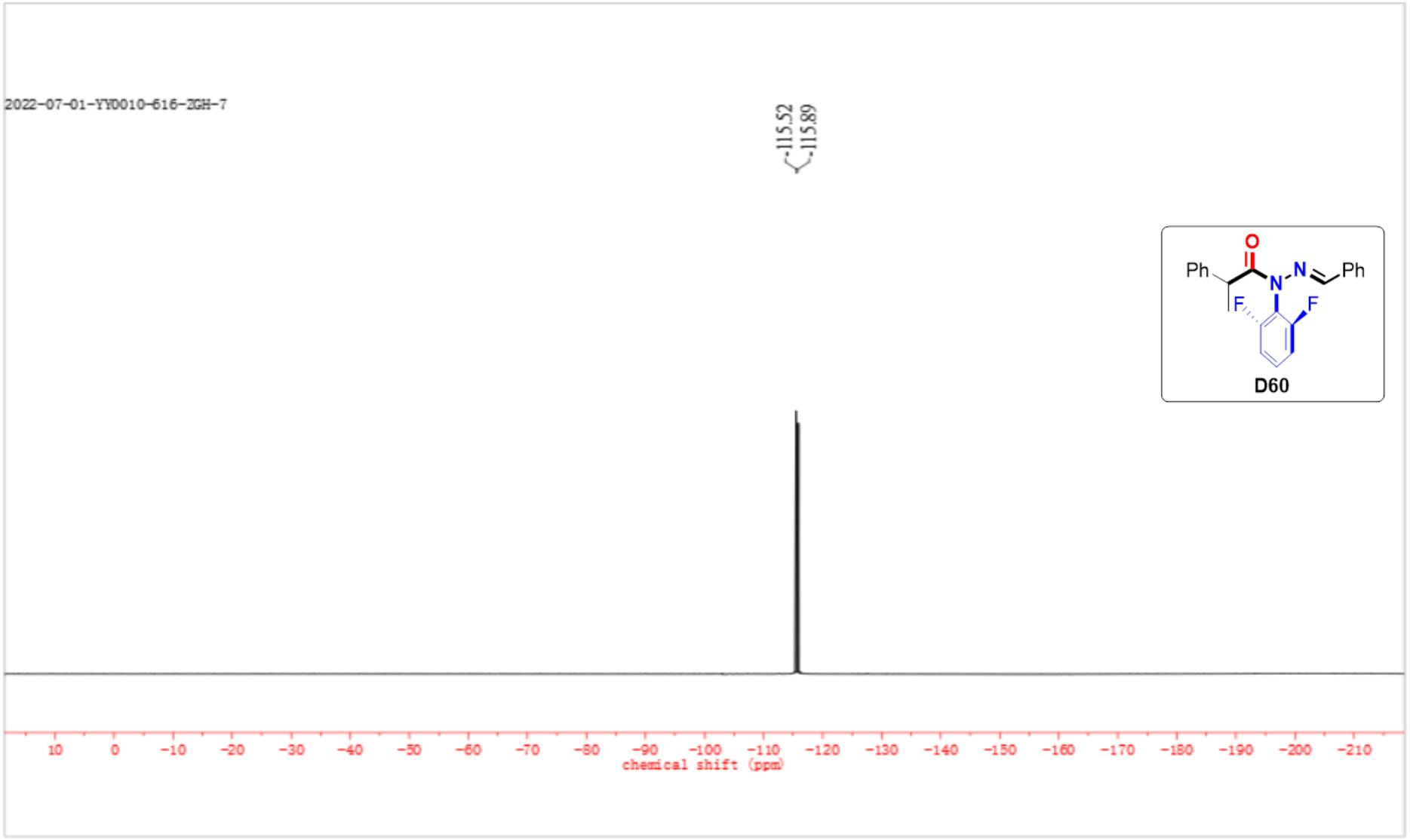

7.4195
7.4132
7.4002
7.3960
7.3634
7.3455
7.3300
7.3249
7.3095
7.3049
7.2891
7.2204
7.2061
7.2025
7.1848
7.1654
7.0875
7.0690
7.0535
7.0508
7.0364
7.0239
7.0026
6.9967
6.7594
6.7397
6.7206
6.6988
4.9480
4.9363
1.4845
1.4668
Ph
O
N
N
Ph
F
D59
2.00
3.00
5.00
3.06
2.00
1.00
3.00
chemical shift (ppm)

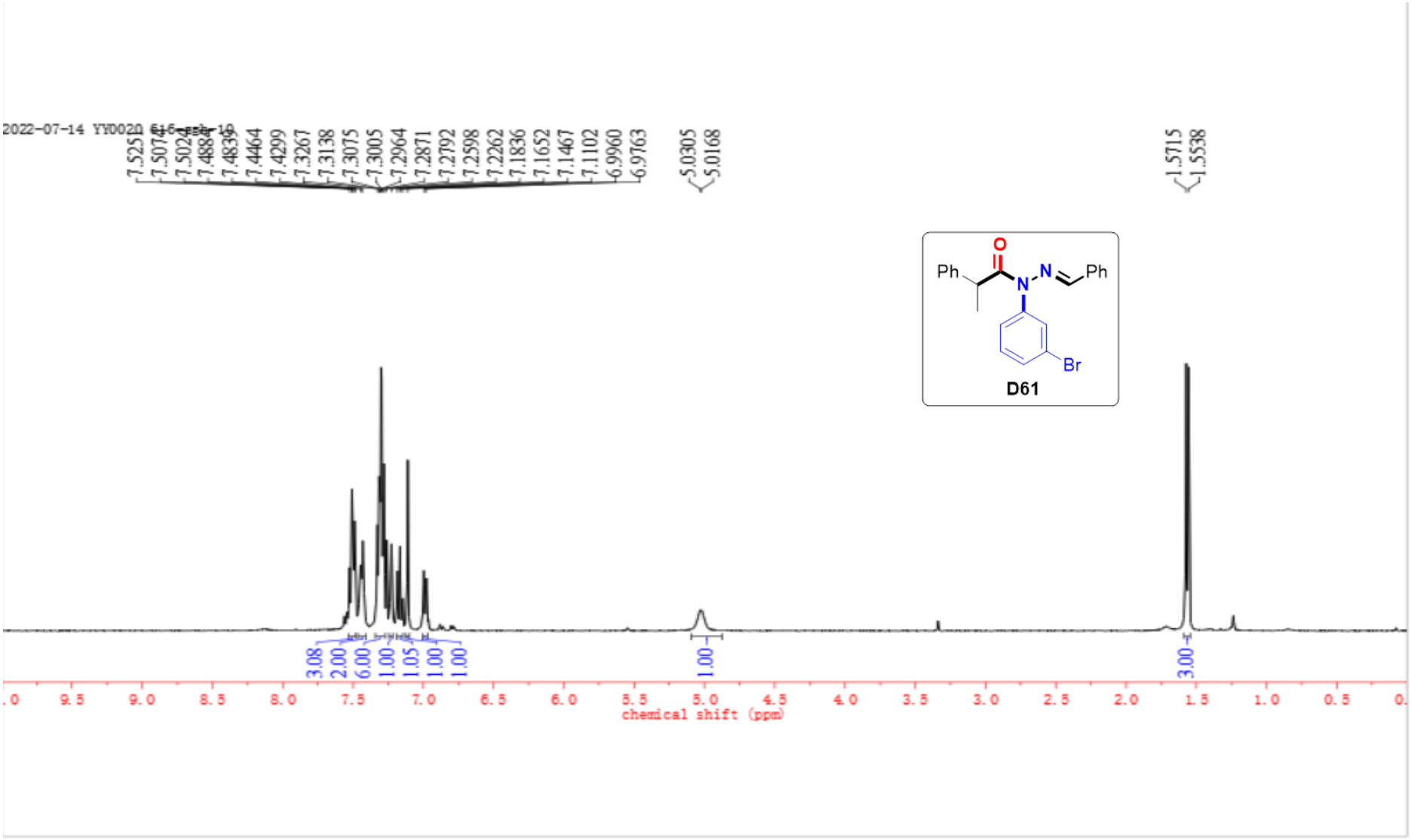

2022-06-27-yy0018-616-zgh-5
175.69
164.80
162.32
134.21
131.45
131.36
130.09
128.82
128.75
127.79
127.37
126.82
125.16
125.13
116.91
116.66
116.45
77.59
77.27
76.95
43.04
19.51
O
Ph
N
N
Ph
F
D59
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

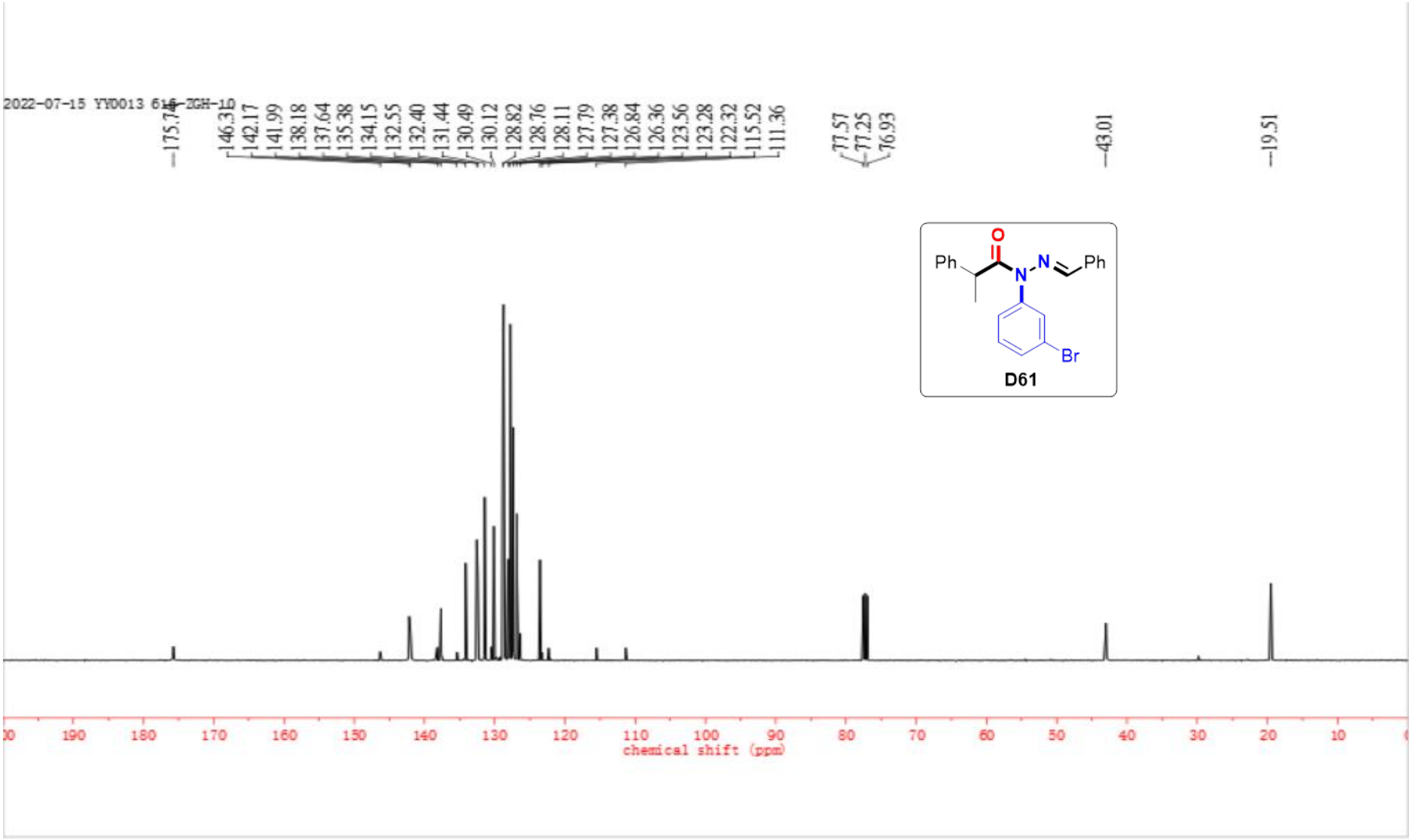

2022-06-27-yy0018-616-zgh-5
-109.97
O
Ph
N
N
Ph
F
D59
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

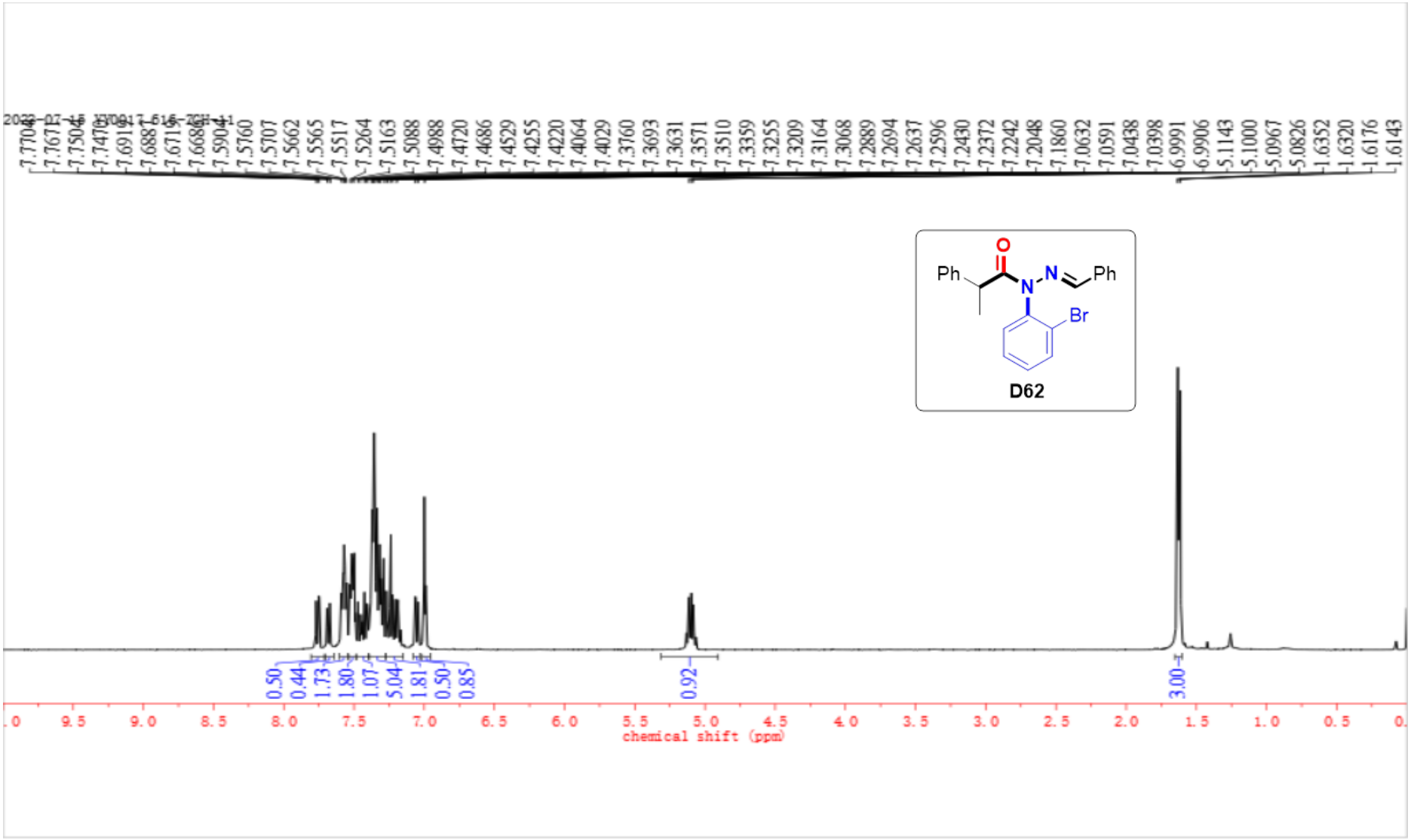

7.5487
7.5396
7.5303
7.5248
7.4716
7.4532
7.4383
7.4324
7.4170
7.4016
7.3957
7.3802
7.3534
7.3442
7.3371
7.3119
7.2925
7.2218
7.2154
7.1970
7.1785
7.1528
7.0861
7.0646
7.0430
7.0186
6.9974
5.0674
5.0497
1.6176
1.5998
Ph
O
N
N
Ph
F
F
D60
2.00
1.95
5.85
2.00
1.93
1.00
3.00
chemical shift (ppm)

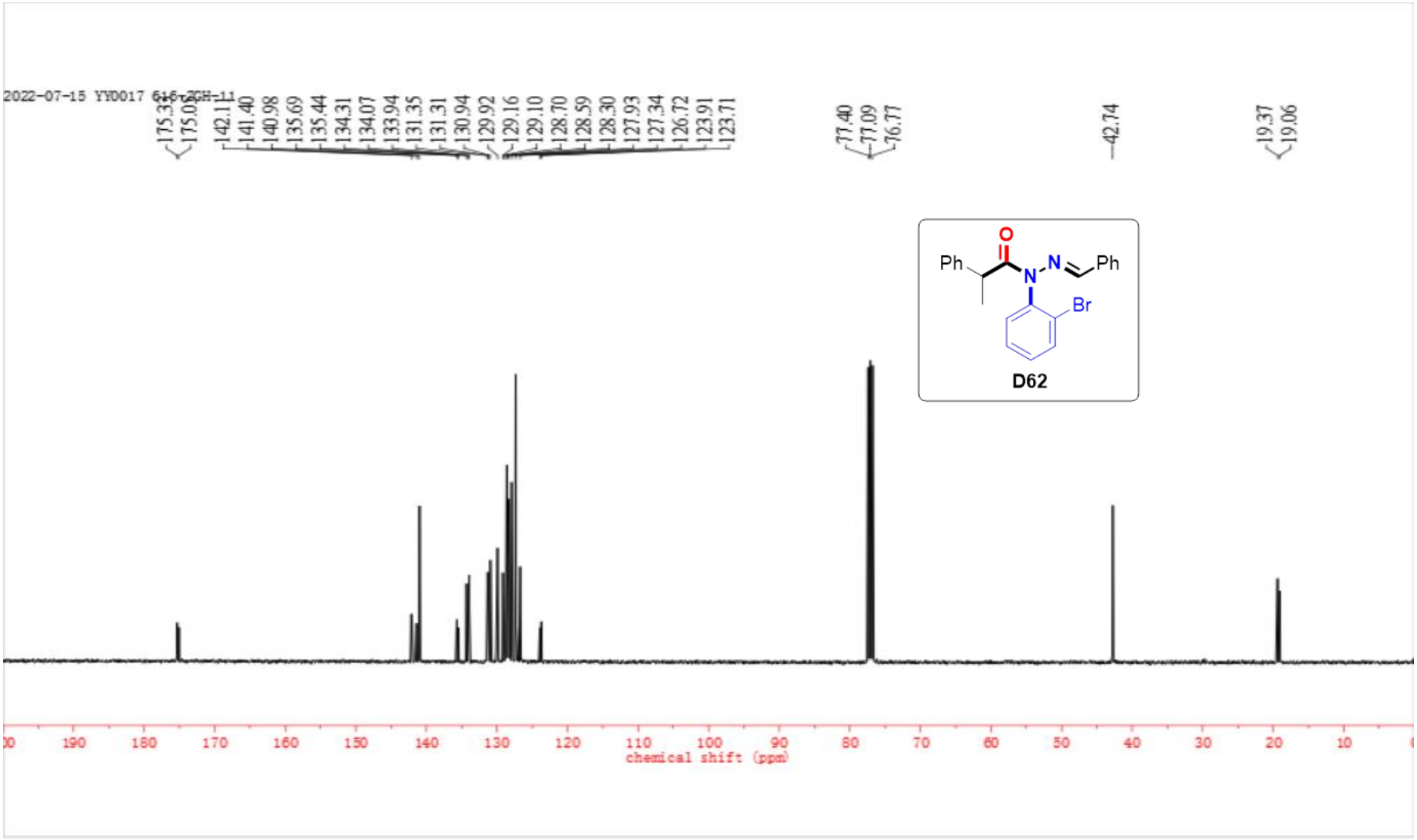

2022-07-01-YYD010-616-2GH-1
175.41
160.49
160.45
160.28
160.23
157.96
157.91
157.75
157.70
141.87
141.00
128.71
128.54
127.79
127.47
126.69
112.89
112.65
112.55
112.51
112.49
112.45
112.43
112.35
112.31
77.43
77.11
76.79
43.24
19.43
Ph
O
N
N
Ph
F
F
D60
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

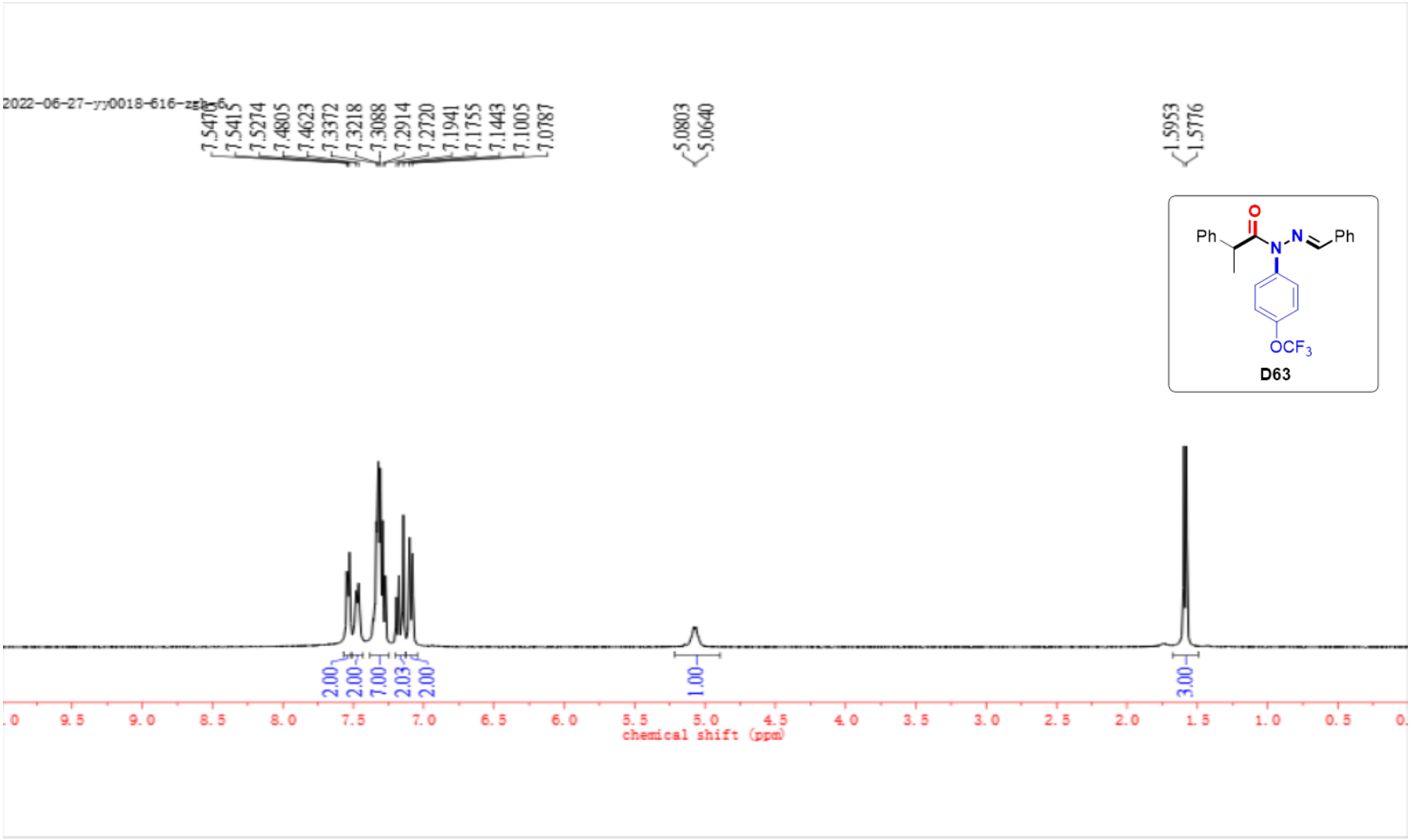

2022-07-01-YYD010-616-2GH-7
-115.52
-115.89
O
Ph
N
N
Ph
F
F
D60
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

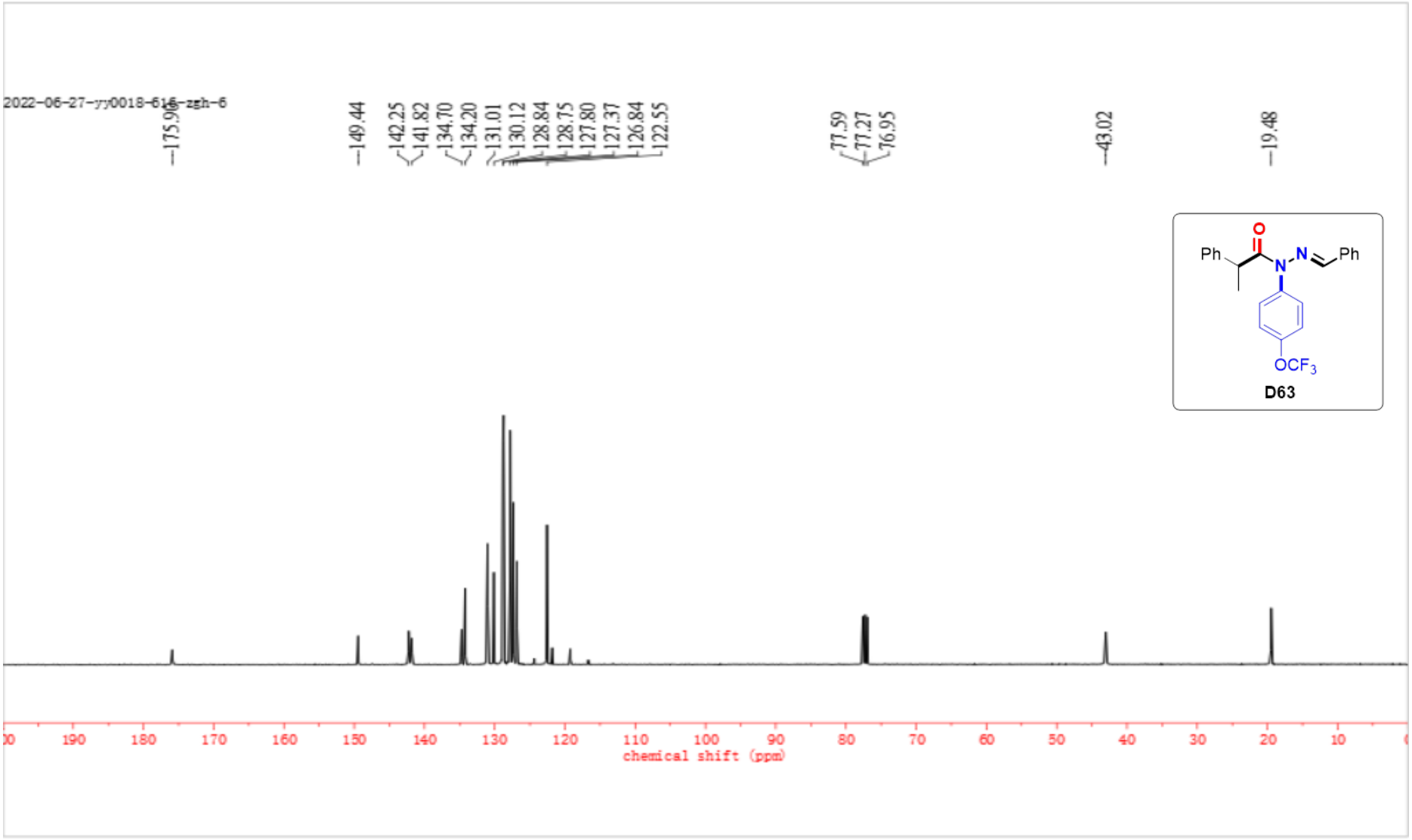

2022-07-14 YYD020
7.5251
7.5074
7.5024
7.4884
7.4839
7.4464
7.4299
7.3267
7.3138
7.3075
7.3005
7.2964
7.2871
7.2792
7.2598
7.2262
7.1836
7.1652
7.1467
7.1102
6.9960
6.9763
5.0305
5.0168
1.5715
1.5538
Ph
O
N
N
Ph
Br
D61
3.08
2.00
6.00
1.00
1.05
1.00
1.00
1.00
3.00
chemical shift (ppm)

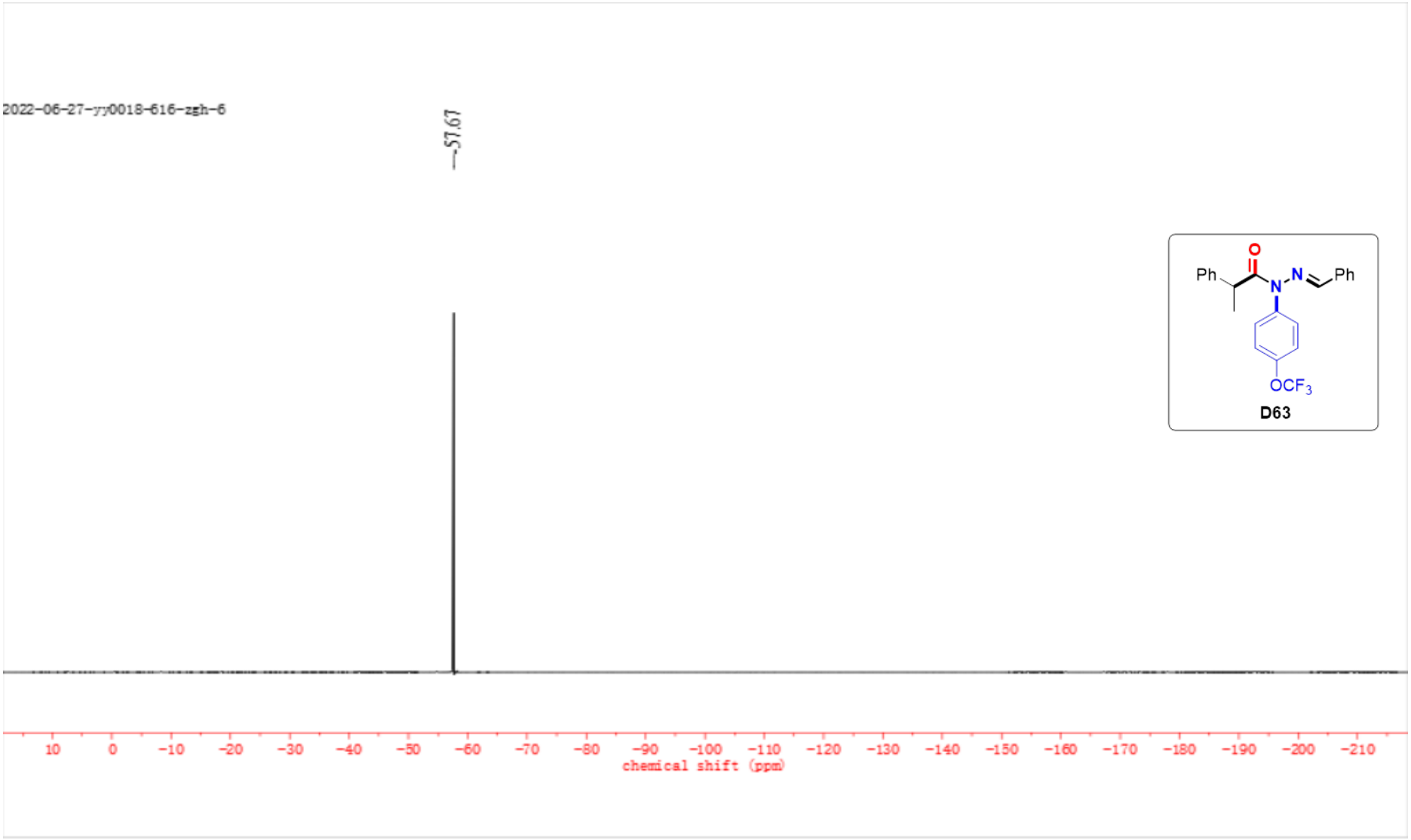

2022-07-15 YYD013 6
175.74
146.31
142.17
141.99
138.18
137.64
135.38
134.15
132.55
132.40
131.44
130.49
130.12
128.82
128.76
128.11
127.79
127.38
126.84
126.36
123.56
123.28
122.32
115.52
111.36
77.57
77.25
76.93
43.01
19.51
Ph
N
N
Ph
O
Br
D61
chemical shift (ppm)

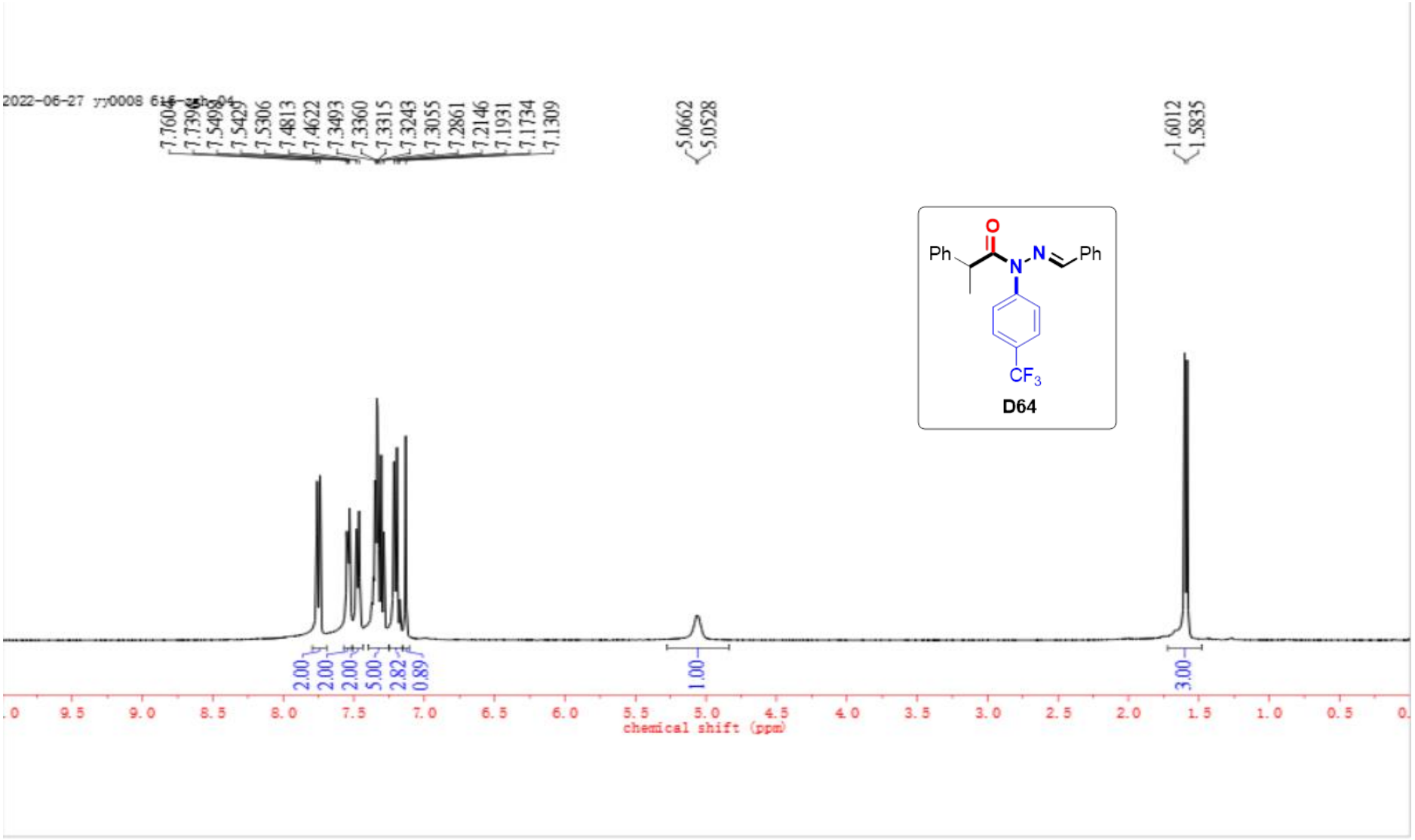

Ph
O
N
N
Ph
Br
D62
0.50
0.44
1.73
1.80
1.07
5.04
1.81
0.50
0.85
0.92
3.00
chemical shift (ppm)

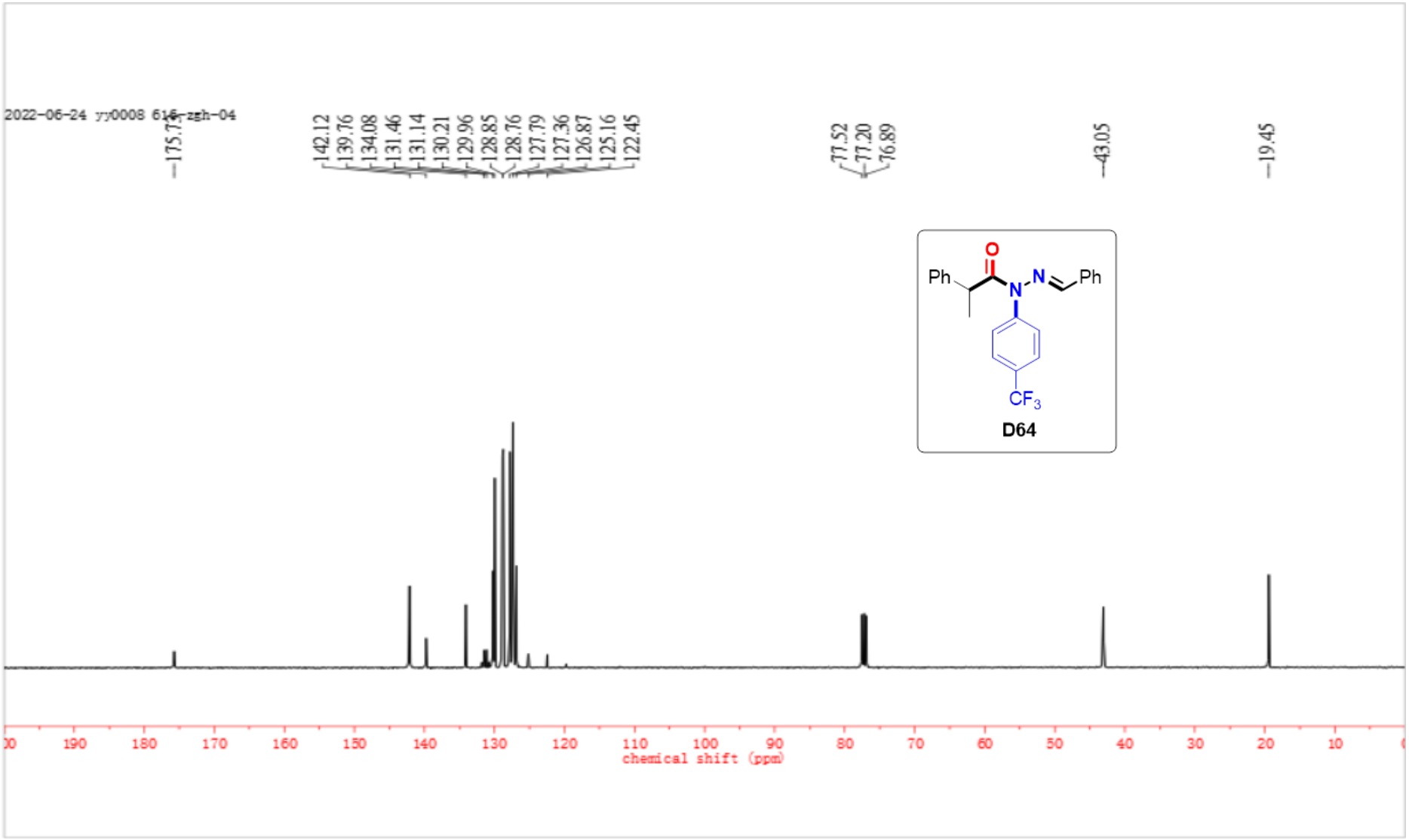

2022-07-15 YW0017 616-ZGH-11
175.33
175.03
142.11
141.40
140.98
135.69
135.44
134.31
134.07
133.94
131.35
131.31
130.94
129.92
129.16
129.10
128.70
128.59
128.30
127.93
127.34
126.72
123.91
123.71
77.40
77.09
76.77
42.74
19.37
19.06
Ph
O
N
N
Ph
Br
D62
chemical shift (ppm)

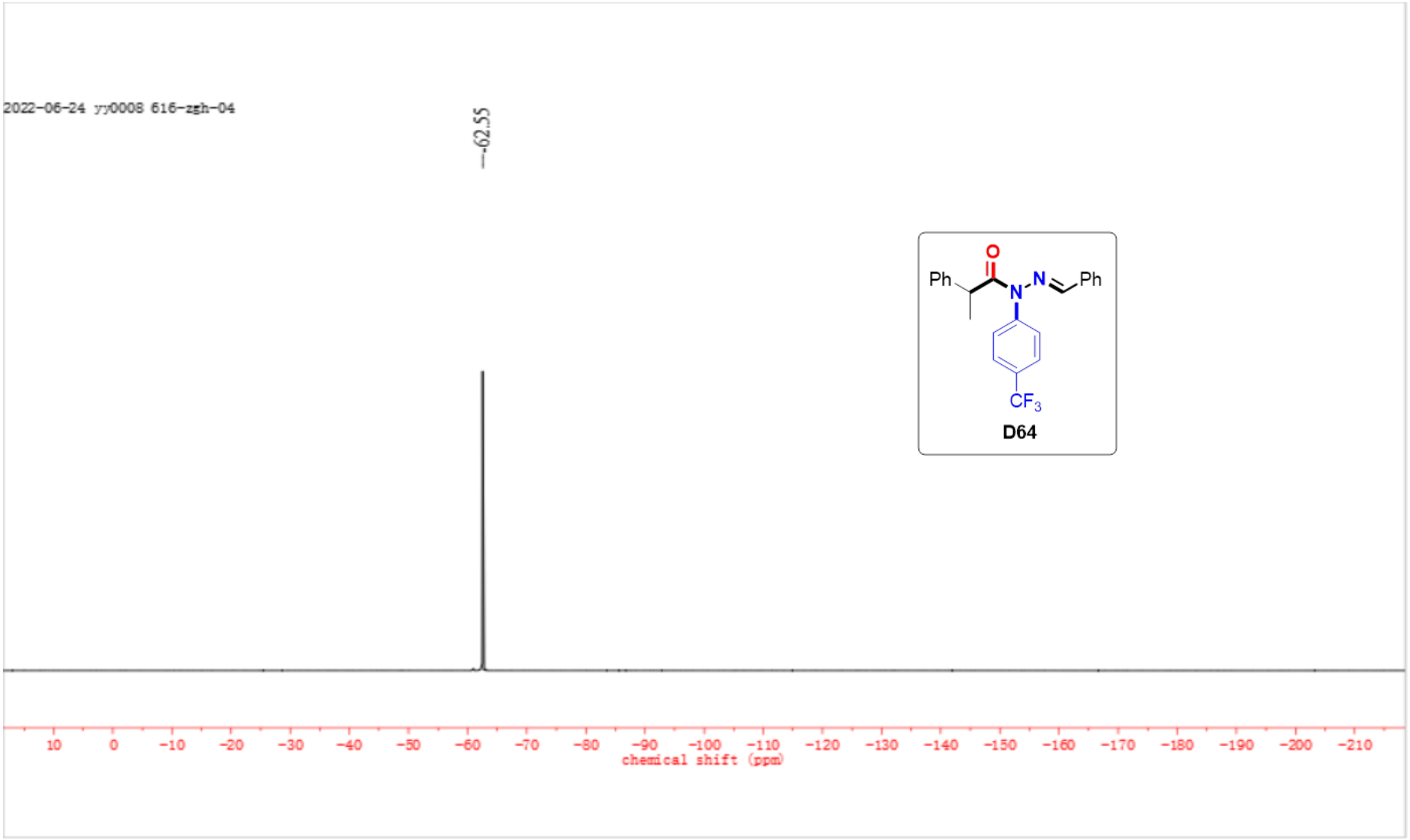

2022-06-27-yy0018-616-zgh-6
7.5470
7.5415
7.5274
7.4805
7.4623
7.3372
7.3218
7.3088
7.2914
7.2720
7.1941
7.1755
7.1443
7.1005
7.0787
5.0803
5.0640
1.5953
1.5776
Ph
N
N
Ph
O
OCF3
D63
2.00
2.00
7.00
2.03
2.00
1.00
3.00
chemical shift (ppm)

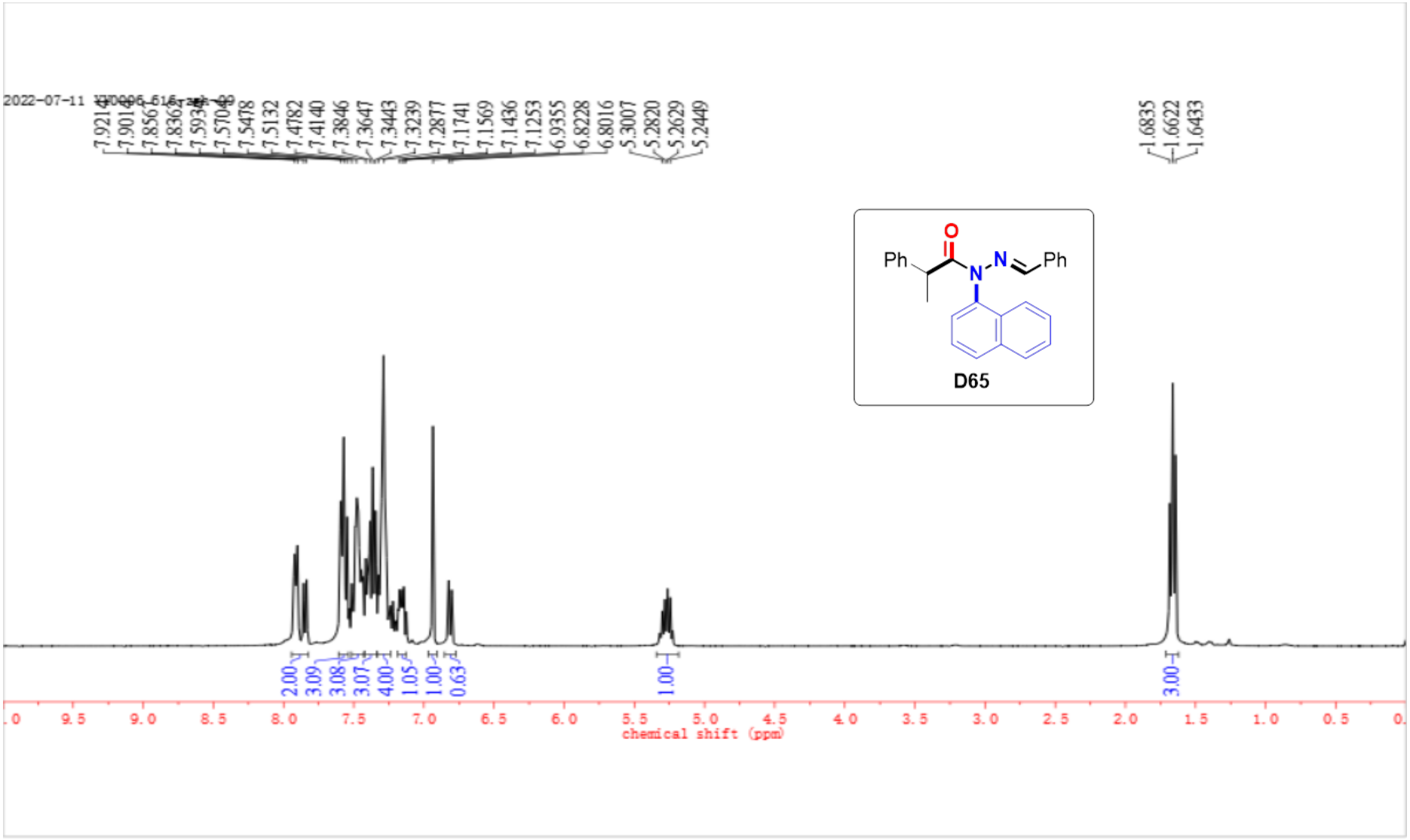

2022-06-27-yy0018-616-zgh-6
175.96
149.44
142.25
141.82
134.70
134.20
131.01
130.12
128.84
128.75
127.80
127.37
126.84
122.55
77.59
77.27
76.95
43.02
19.48
Ph
N
N
Ph
O
OCF3
D63
chemical shift (ppm)

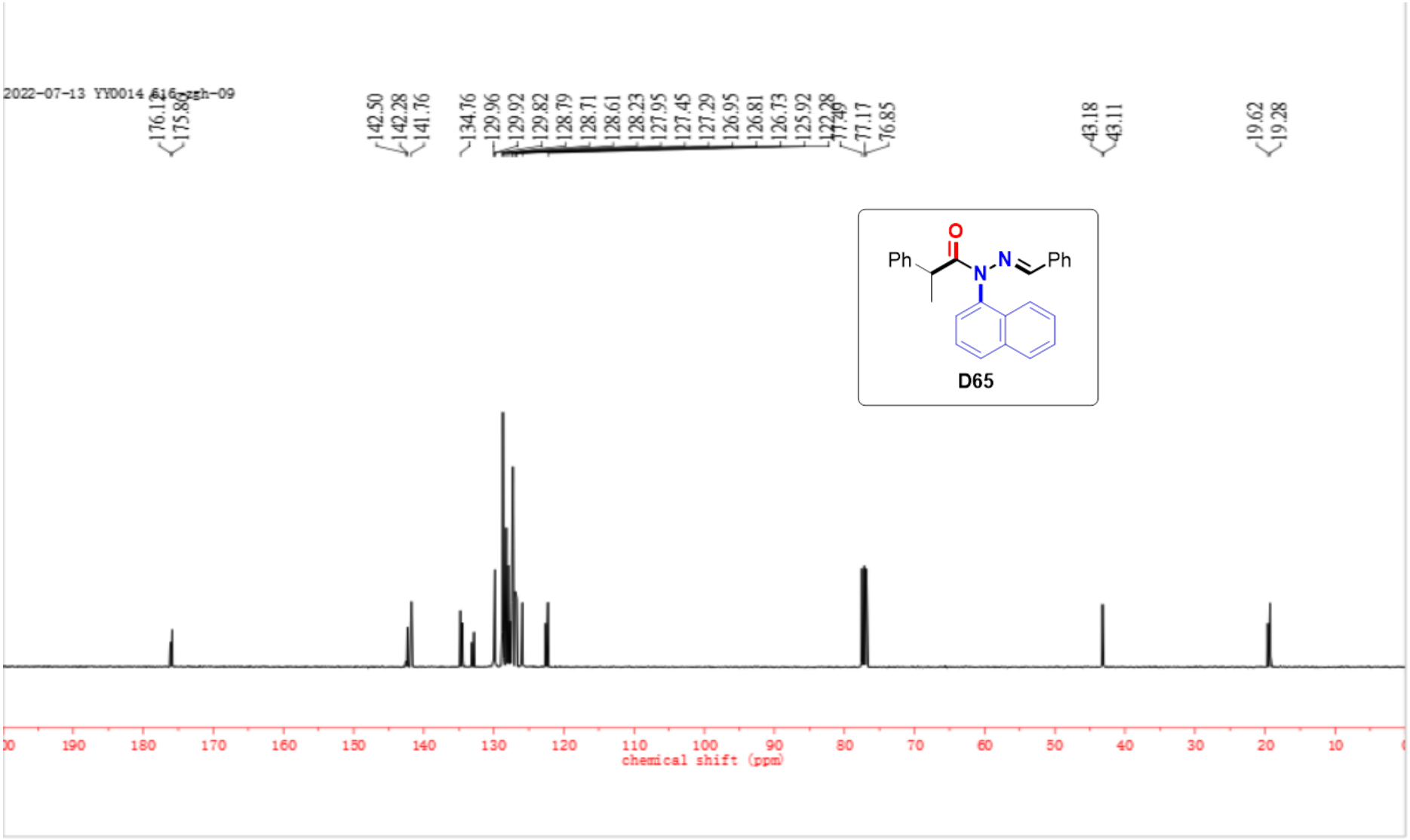

2022-06-27-yy0018-616-zgh-6
-57.67
Ph
O
N
N
Ph
OCF3
D63
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

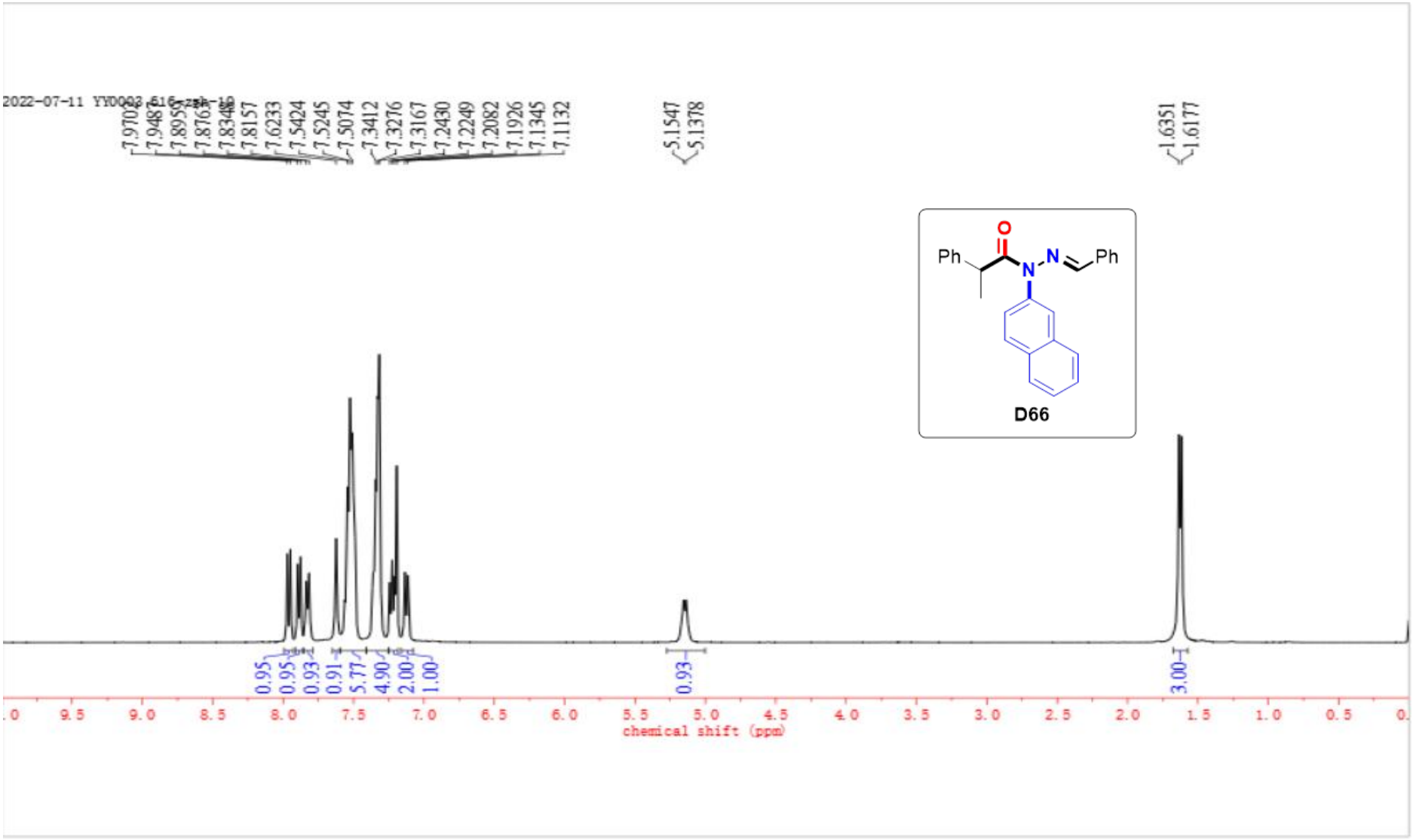

2022-06-27 yy0008 616-nh-04
7.7604
7.7396
7.5498
7.5429
7.5306
7.4813
7.4622
7.3493
7.3360
7.3315
7.3243
7.3055
7.2861
7.2146
7.1931
7.1734
7.1309
5.0662
5.0528
1.6012
1.5835
Ph
O
N
N
Ph
CF3
D64
2.00
2.00
2.00
5.00
2.82
0.89
1.00
3.00
chemical shift (ppm)

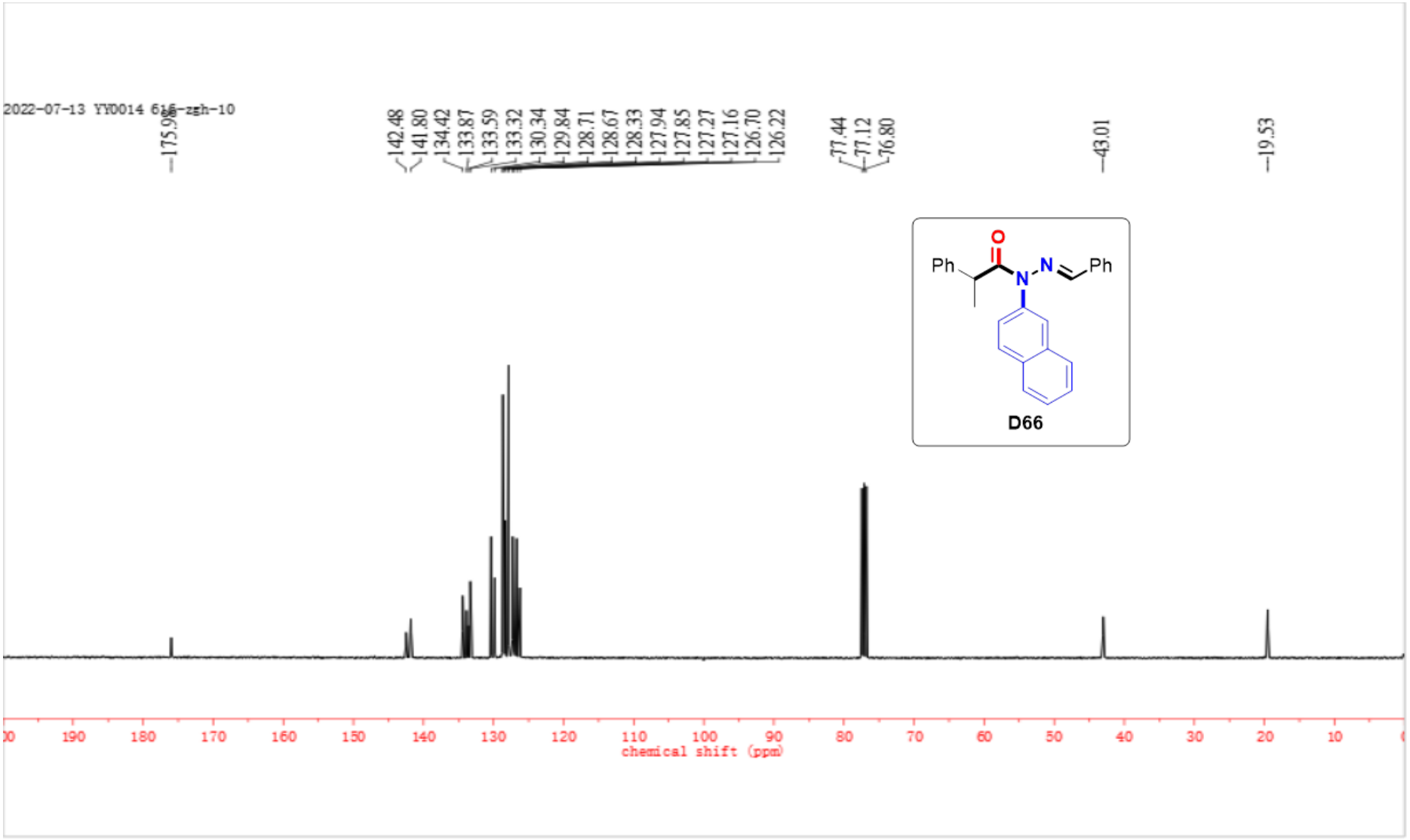

2022-06-24 yy0008 616-zgh-04
175.73
142.12
139.76
134.08
131.46
131.14
130.21
129.96
128.85
128.76
127.79
127.36
126.87
125.16
122.45
77.52
77.20
76.89
43.05
19.45
Ph
O
N
N
Ph
CF3
D64
chemical shift (ppm)

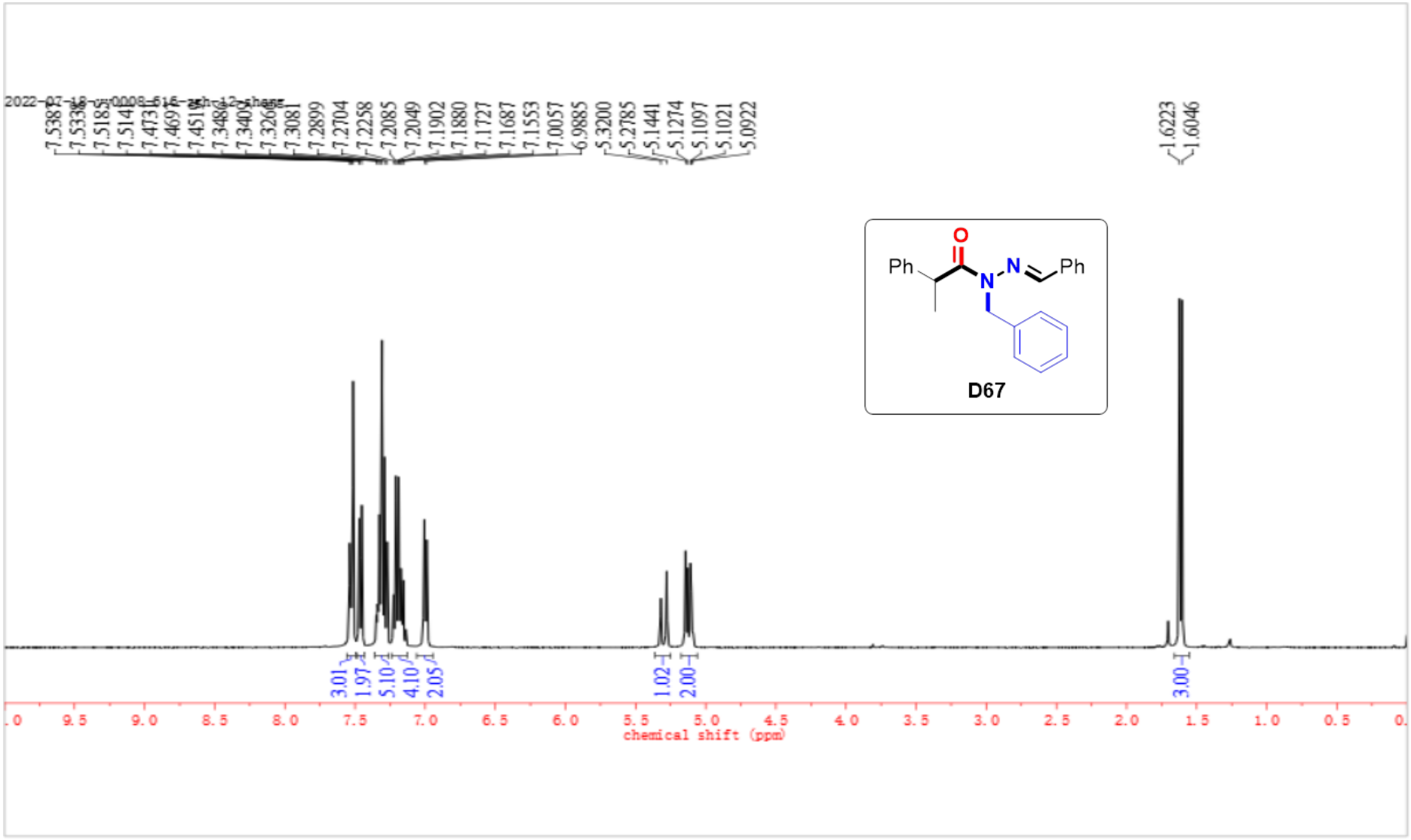

2022-06-24 yy0008 616-zgh-04
-62.55
O
Ph
N
N
Ph
CF3
D64
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
chemical shift (ppm)

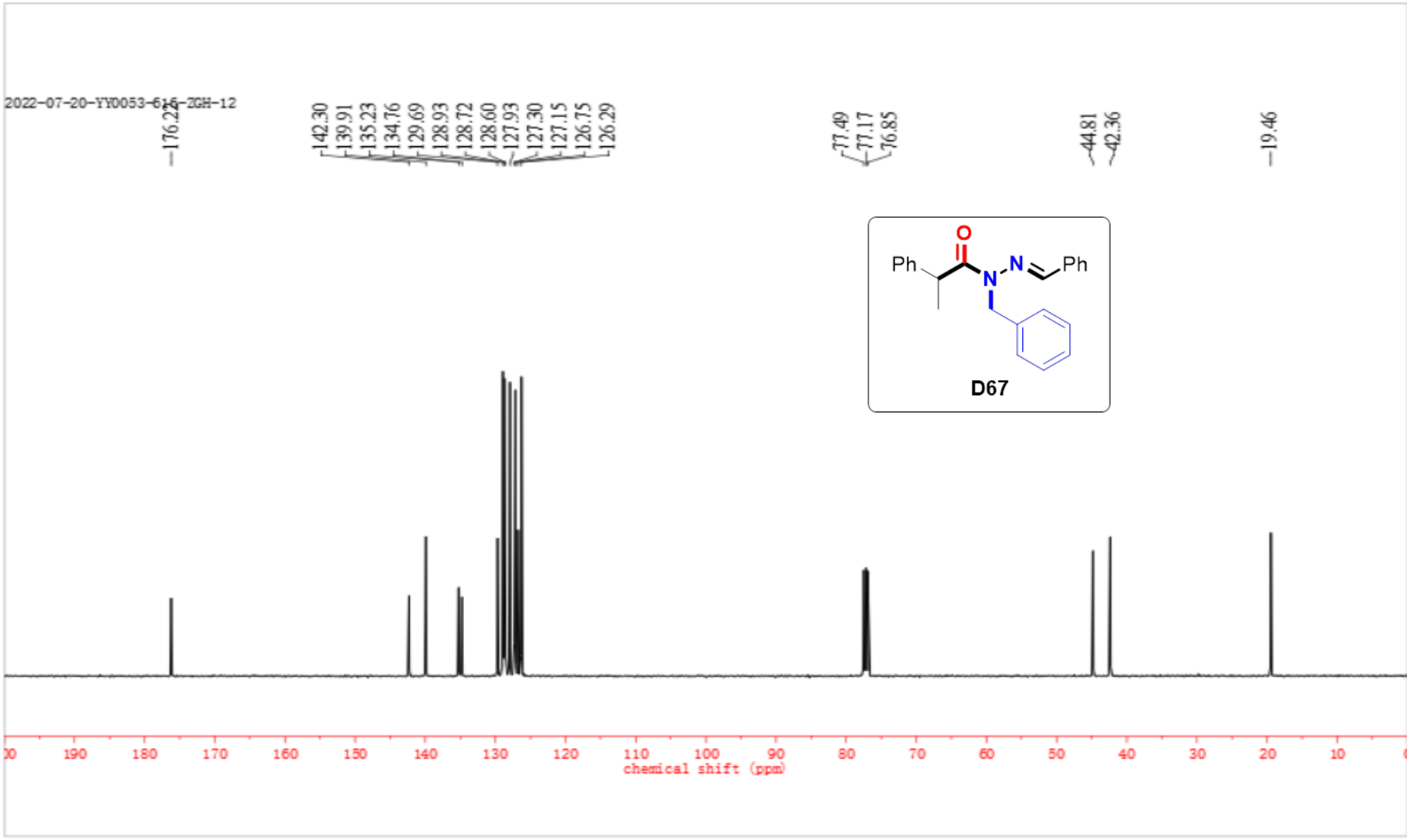

2022-07-11
7.9214
7.9016
7.8567
7.8362
7.5934
7.5704
7.5478
7.5132
7.4782
7.4140
7.3846
7.3647
7.3443
7.3239
7.2877
7.1741
7.1569
7.1436
7.1253
6.9355
6.8228
6.8016
5.3007
5.2820
5.2629
5.2449
1.6835
1.6622
1.6433
Ph
O
N
N
Ph
D65
2.00
3.09
3.08
3.07
4.00
1.05
1.00
0.63
1.00
3.00
chemical shift (ppm)

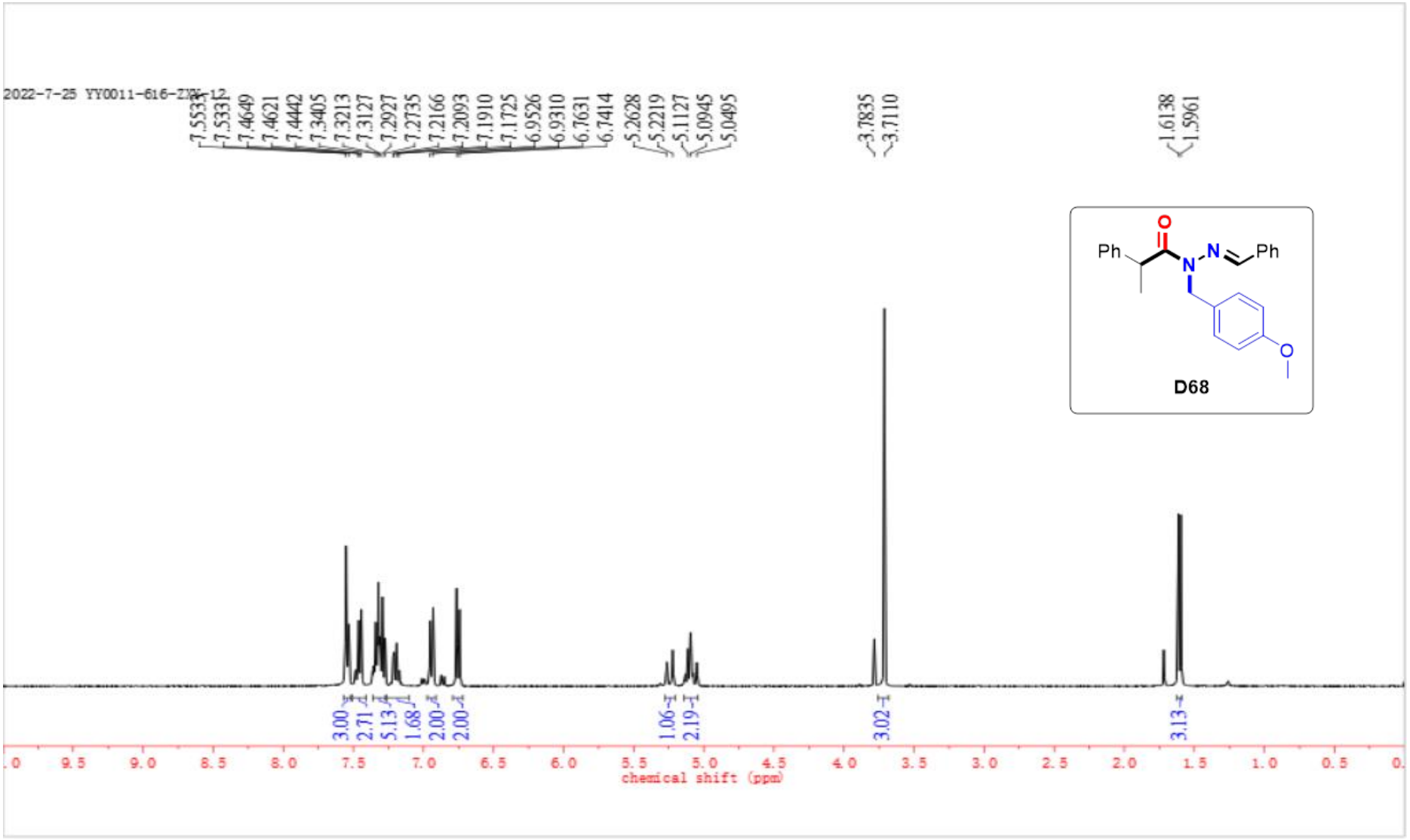

2022-07-13 YY0014 s16-zgh-09
176.12
175.80
142.50
142.28
141.76
134.76
129.96
129.92
129.82
128.79
128.71
128.61
128.23
127.95
127.45
127.29
126.95
126.81
126.73
125.92
122.28
77.17
76.85
43.18
43.11
19.62
19.28
O
Ph
N
N
Ph
D65
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

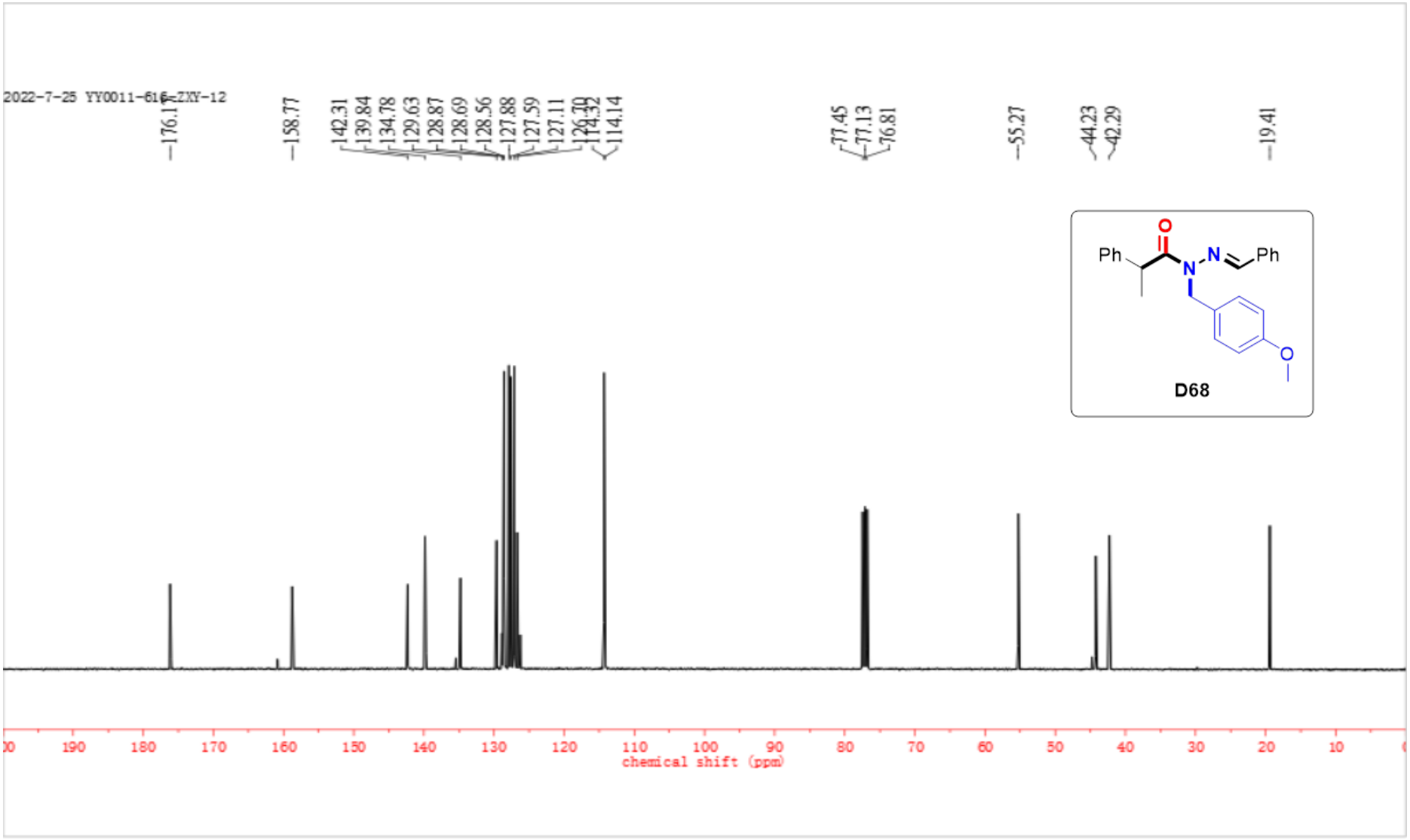

2022-07-11 YY0002-516-zsh-1b
7.9702
7.9487
7.8959
7.8763
7.8348
7.8157
7.6233
7.5424
7.5245
7.5074
7.3412
7.3276
7.3167
7.2430
7.2249
7.2082
7.1926
7.1345
7.1132
5.1547
5.1378
1.6351
1.6177
Ph
O
N
N
Ph
D66
0.95
0.95
0.93
0.91
5.77
4.90
2.00
1.00
0.93
3.00
chemical shift (ppm)

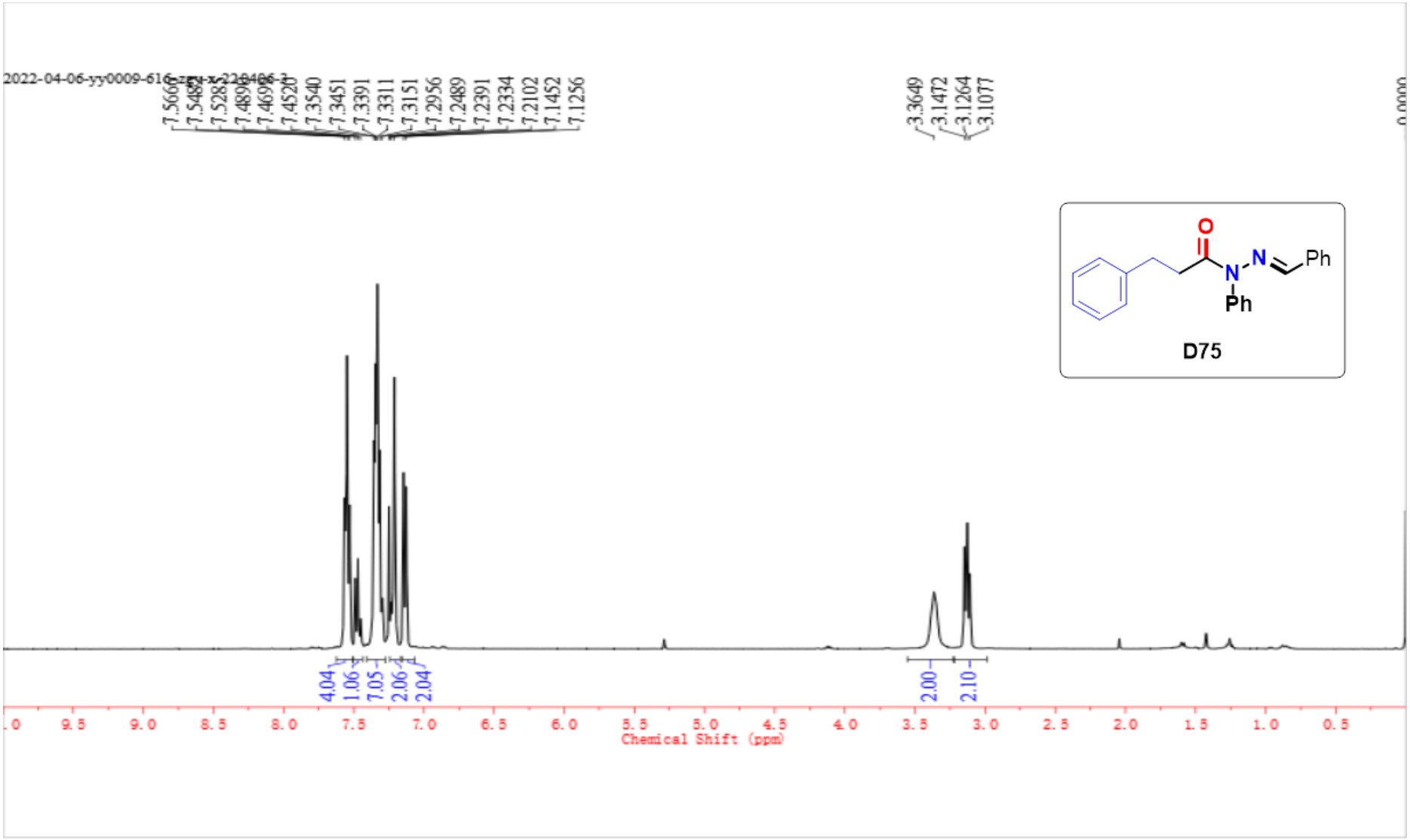

2022-07-13 YYD014 6i6-zgh-10
175.98
142.48
141.80
134.42
133.87
133.59
133.32
130.34
129.84
128.71
128.67
128.33
127.94
127.85
127.27
127.16
126.70
126.22
77.44
77.12
76.80
43.01
19.53
Ph
O
N
N
Ph
D66
chemical shift (ppm)

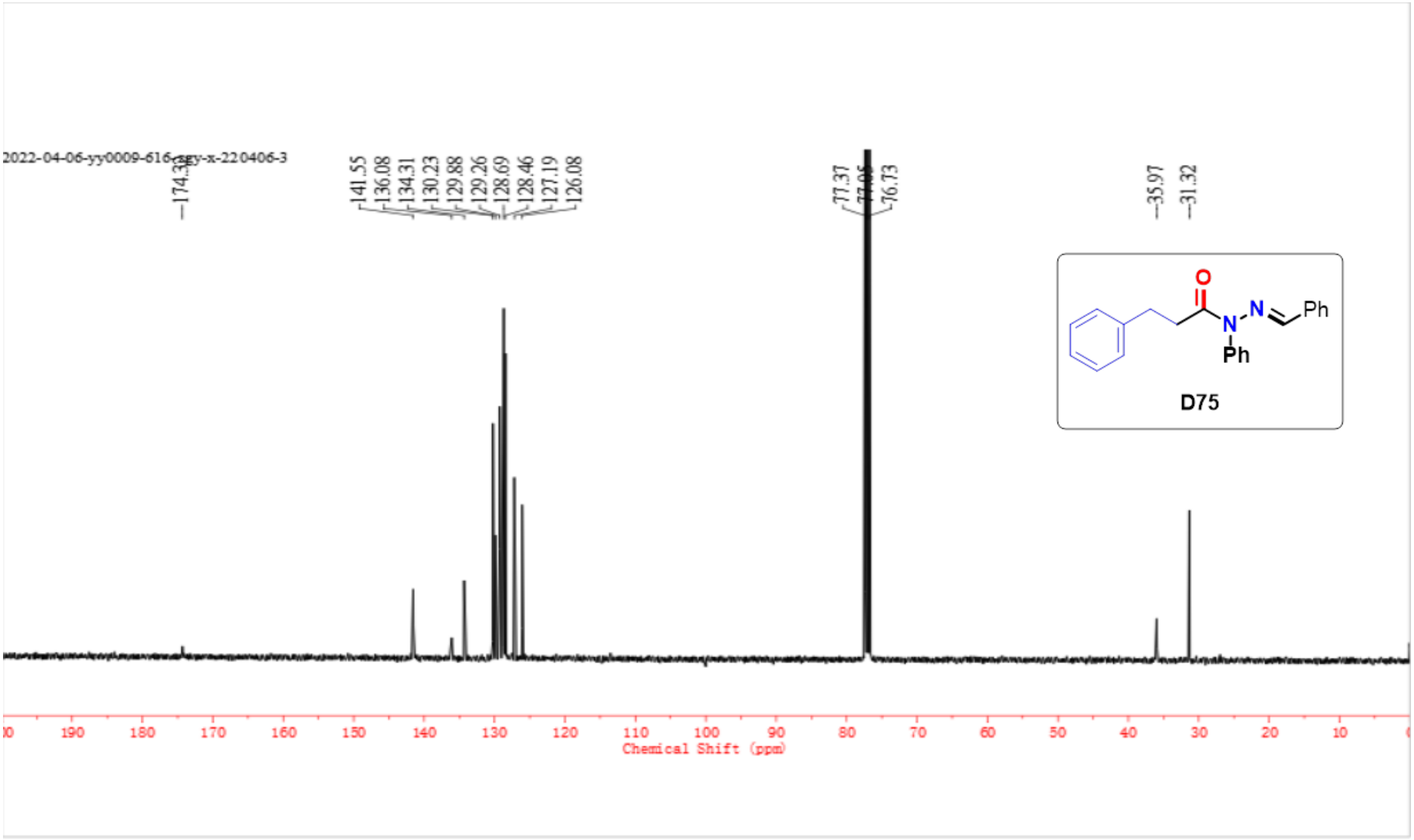

7.5387
7.5336
7.5185
7.5141
7.4731
7.4697
7.4515
7.3484
7.3409
7.3268
7.3081
7.2899
7.2704
7.2258
7.2085
7.2049
7.1902
7.1880
7.1727
7.1687
7.1553
7.0057
6.9885
5.3200
5.2785
5.1441
5.1274
5.1097
5.1021
5.0922
1.6223
1.6046
Ph
O
N
N
Ph
D67
3.01
1.97
5.10
4.10
2.05
1.02
2.00
3.00
chemical shift (ppm)

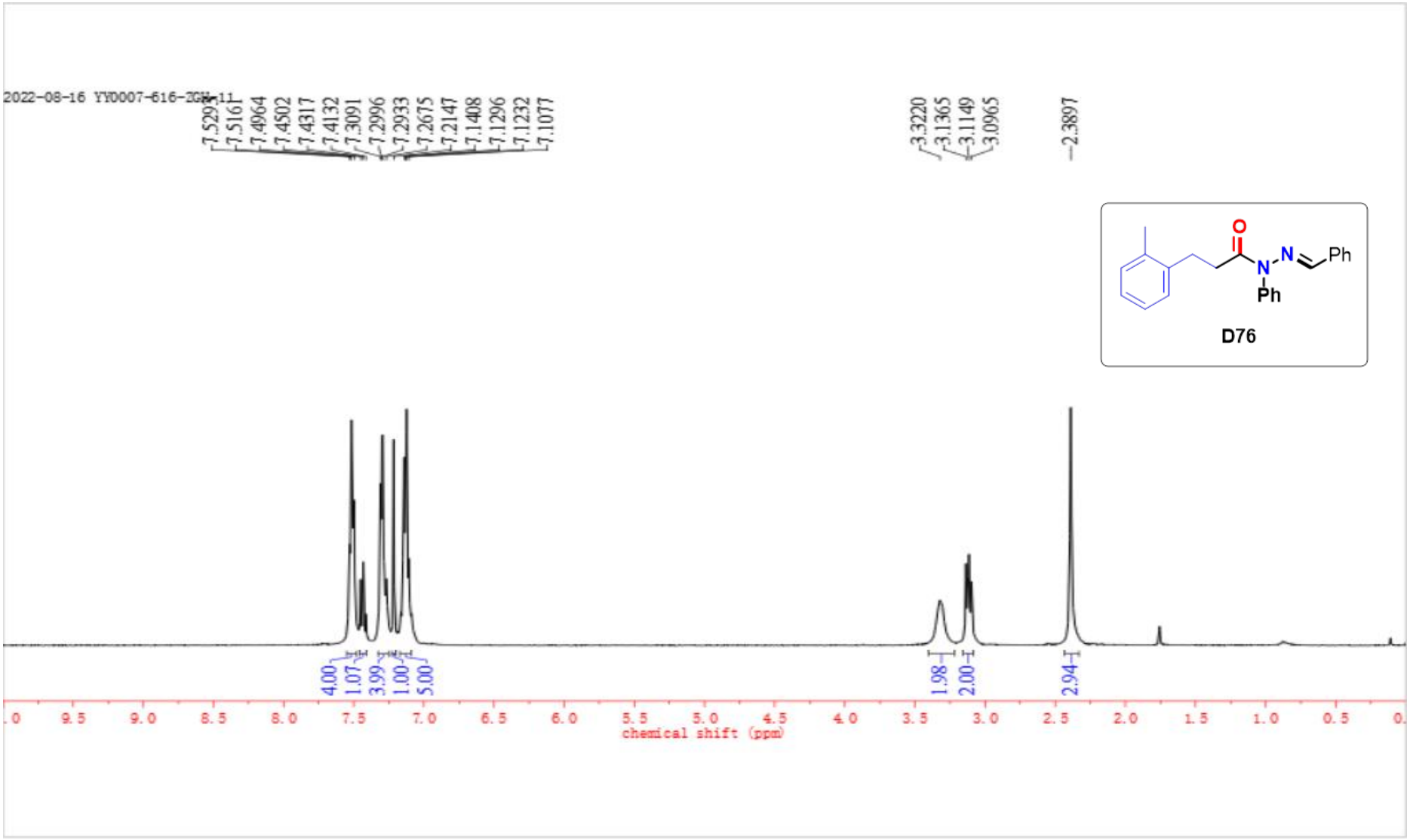

2022-07-20-YYD053-616-2GH-12
176.22
142.30
139.91
135.23
134.76
129.69
128.93
128.72
128.60
127.93
127.30
127.15
126.75
126.29
77.49
77.17
76.85
44.81
42.36
19.46
O
Ph
N
N
Ph
D67
chemical shift (ppm)

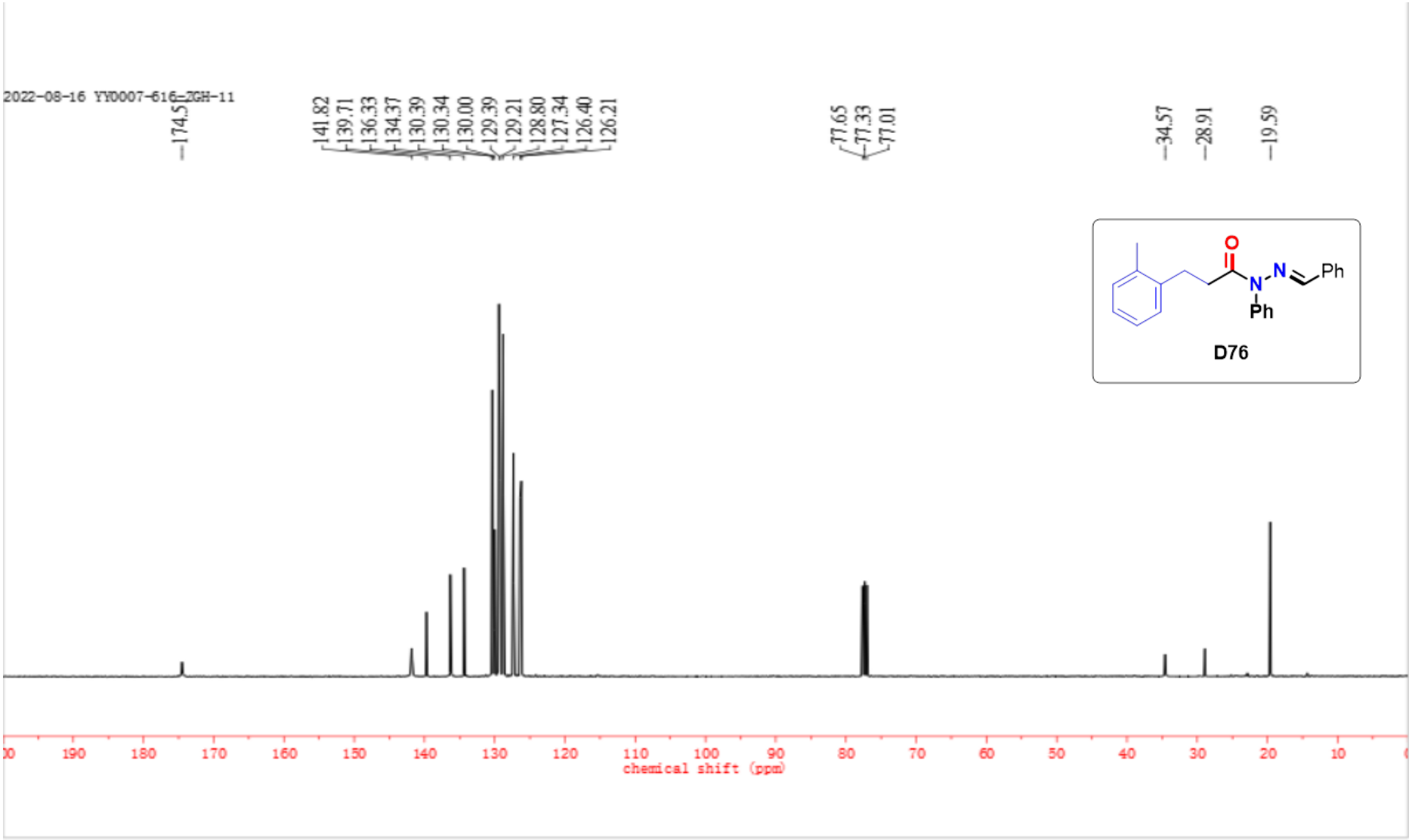

2022-7-25 YY0011-616-ZJK-12
7.5533
7.5331
7.4649
7.4621
7.4442
7.3405
7.3213
7.3127
7.2927
7.2735
7.2166
7.2093
7.1910
7.1725
6.9526
6.9310
6.7631
6.7414
5.2628
5.2219
5.1127
5.0945
5.0495
3.7835
3.7110
1.6138
1.5961
3.00
2.71
5.13
1.68
2.00
2.00
1.06
2.19
3.02
3.13
chemical shift (ppm)
Ph
N
N
Ph
O
O
D68

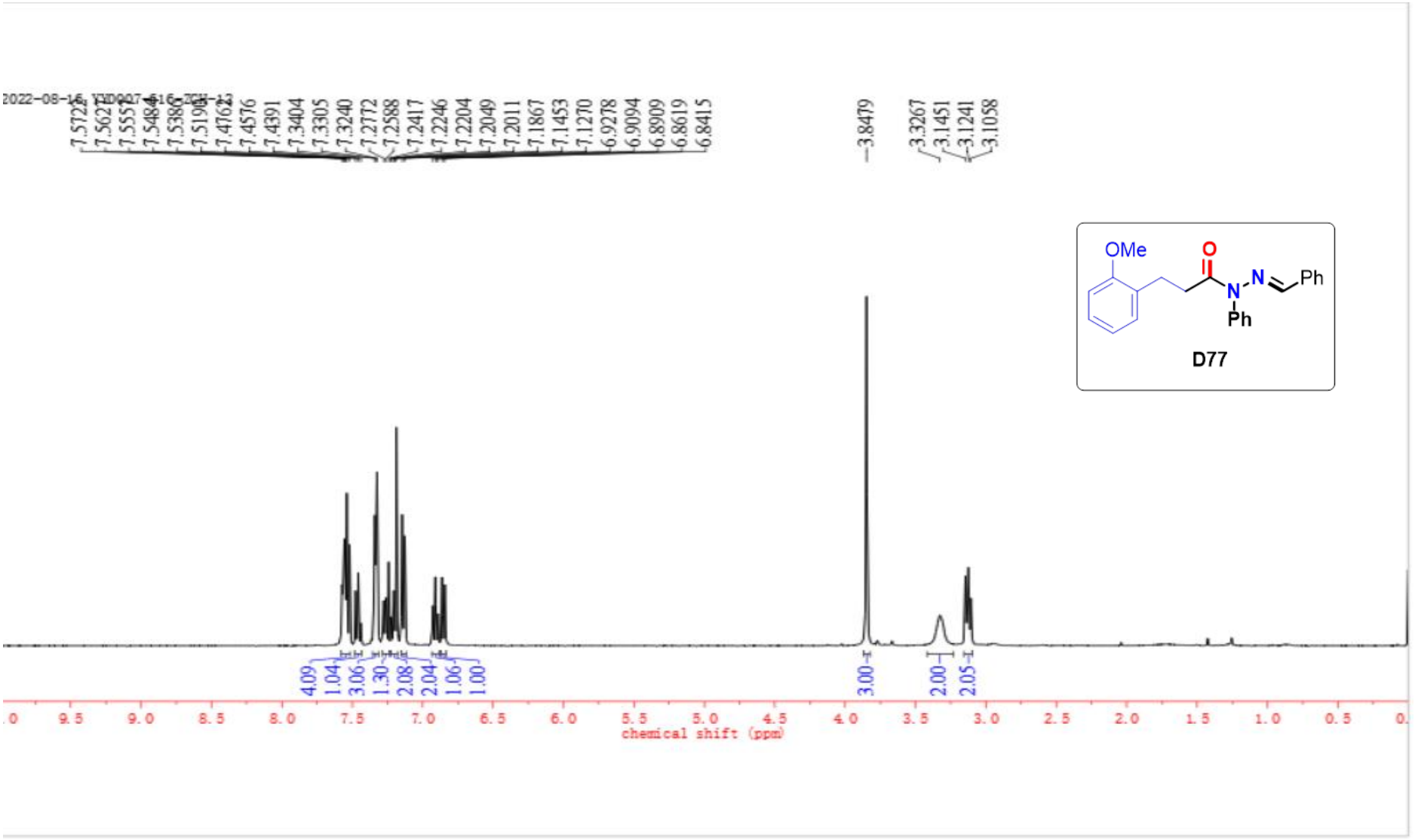

2022-7-25 YY0011-616-ZXY-12
176.17
158.77
142.31
139.84
134.78
129.63
128.87
128.69
128.56
127.88
127.59
127.11
114.32
114.14
77.45
77.13
76.81
55.27
44.23
42.29
19.41
Ph
O
N
N
Ph
O
D68
chemical shift (ppm)

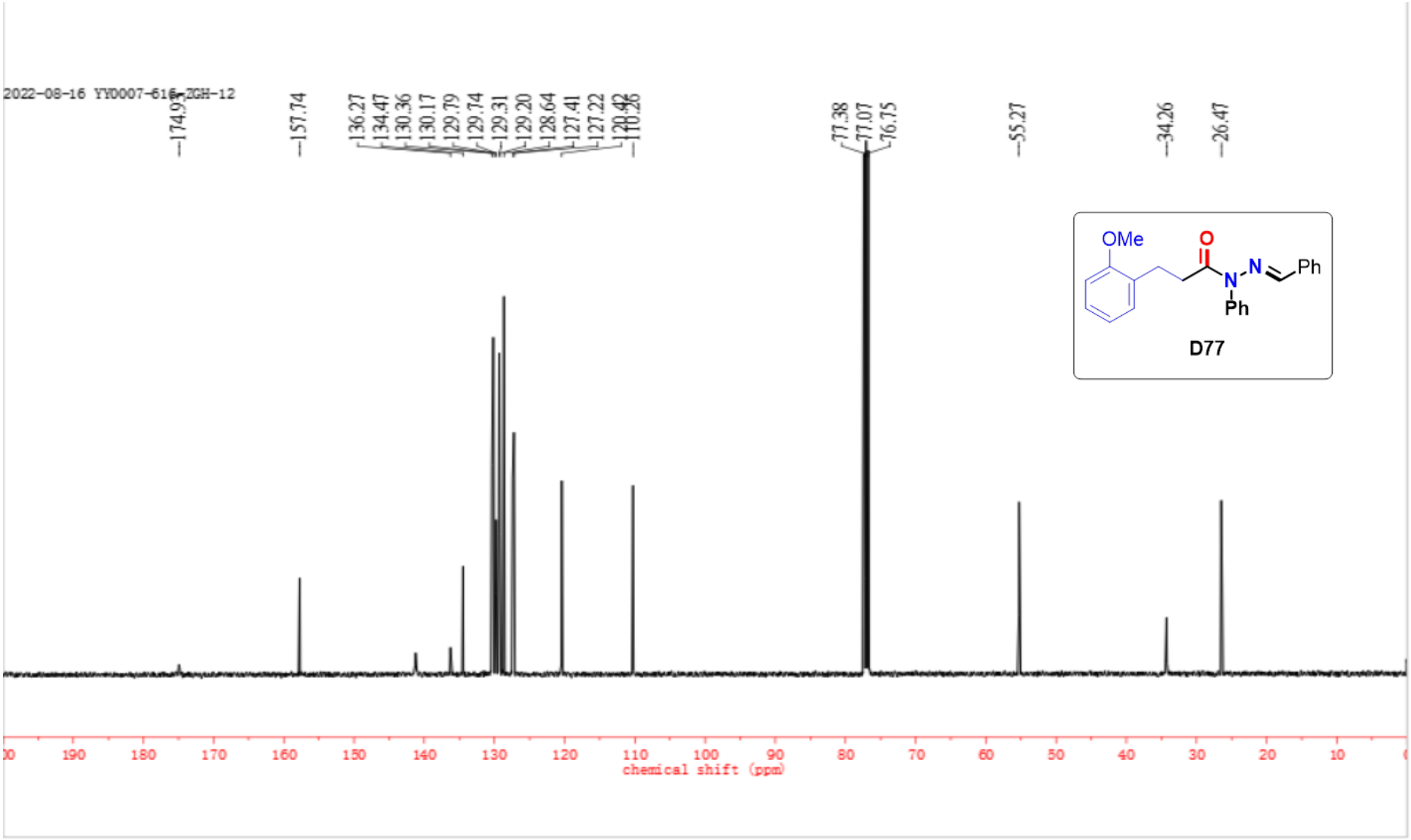

2022-04-06-yy0009-616-zzy-x-220406-1
7.5666
7.5482
7.5285
7.4896
7.4698
7.4520
7.3540
7.3451
7.3391
7.3311
7.3151
7.2956
7.2489
7.2391
7.2334
7.2102
7.1452
7.1256
3.3649
3.1472
3.1264
3.1077
0.0000
O
N
N
Ph
Ph
D75
4.04
1.06
7.05
2.06
2.04
2.00
2.10
Chemical Shift (ppm)

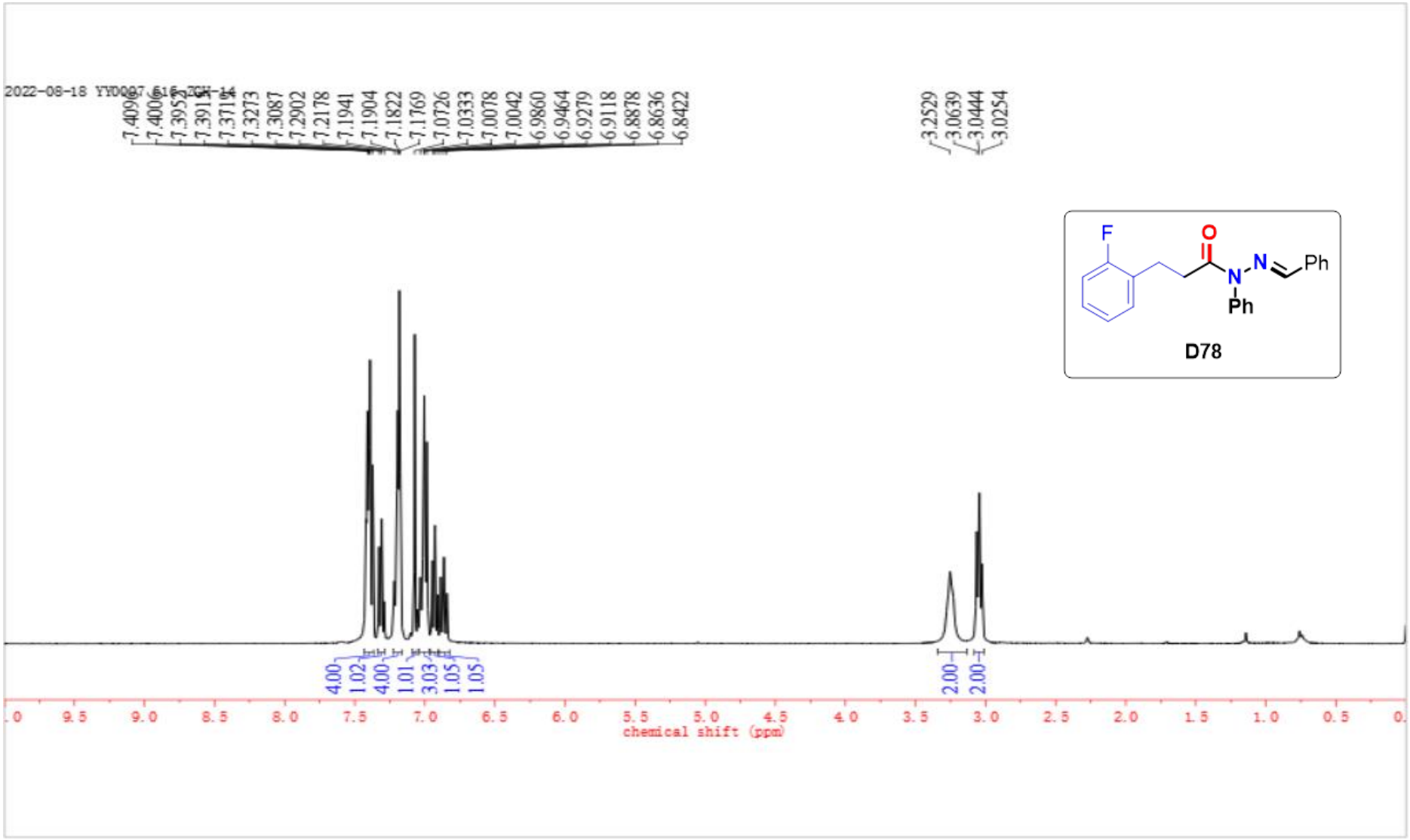

2022-04-06-yy0009-616-qgy-x-220406-3
174.38
141.55
136.08
134.31
130.23
129.88
129.26
128.69
128.46
127.19
126.08
77.37
77.05
76.73
35.97
31.32
O
N
N
Ph
Ph
D75
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Chemical Shift (ppm)

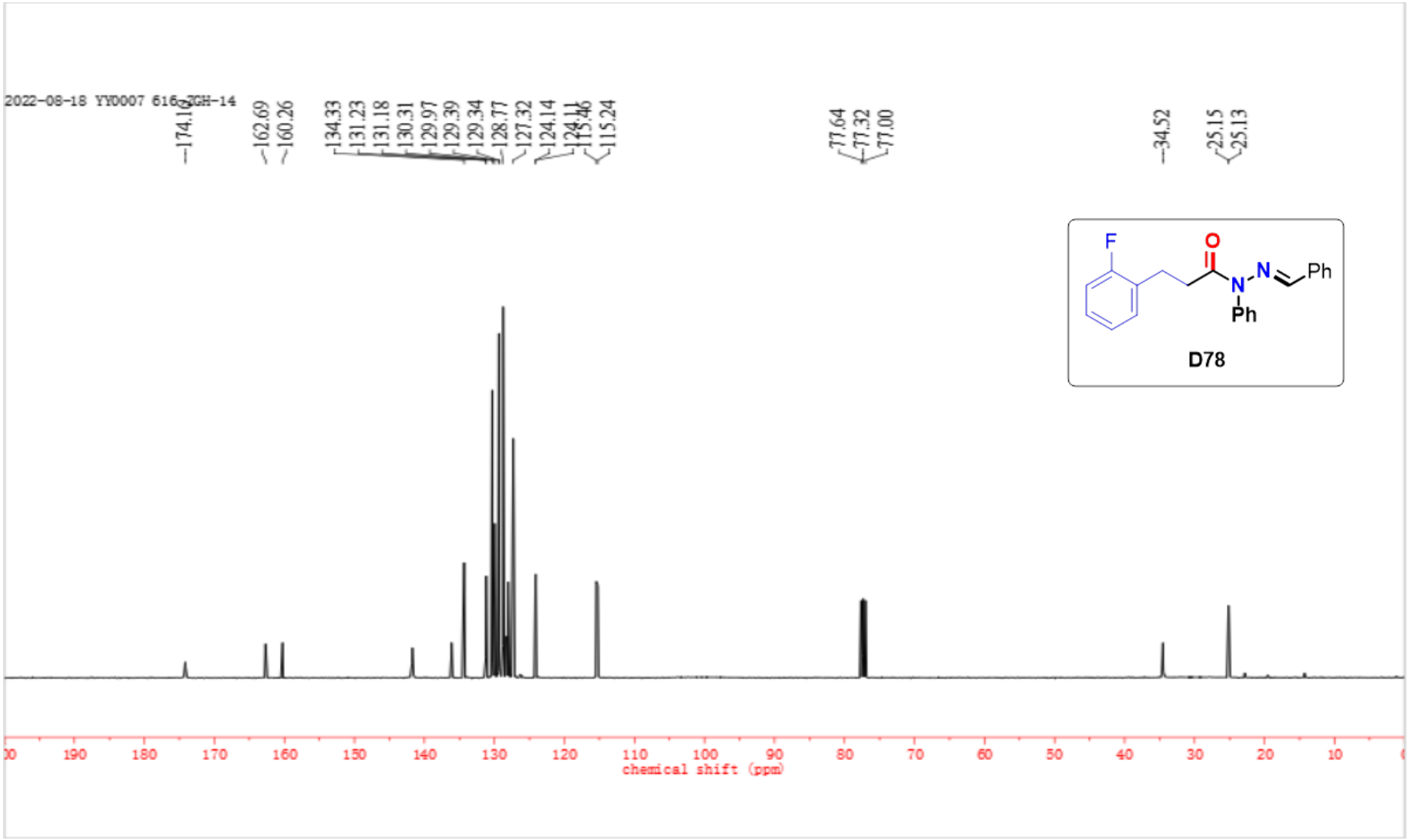

2022-08-16 YYD007-616-2GH-11
7.5293
7.5161
7.4964
7.4502
7.4317
7.4132
7.3091
7.2996
7.2933
7.2675
7.2147
7.1408
7.1296
7.1232
7.1077
3.3220
3.1365
3.1149
3.0965
2.3897
O
N
N
Ph
Ph
Ph
D76
4.00
1.07
3.99
1.00
5.00
1.98
2.00
2.94
chemical shift (ppm)

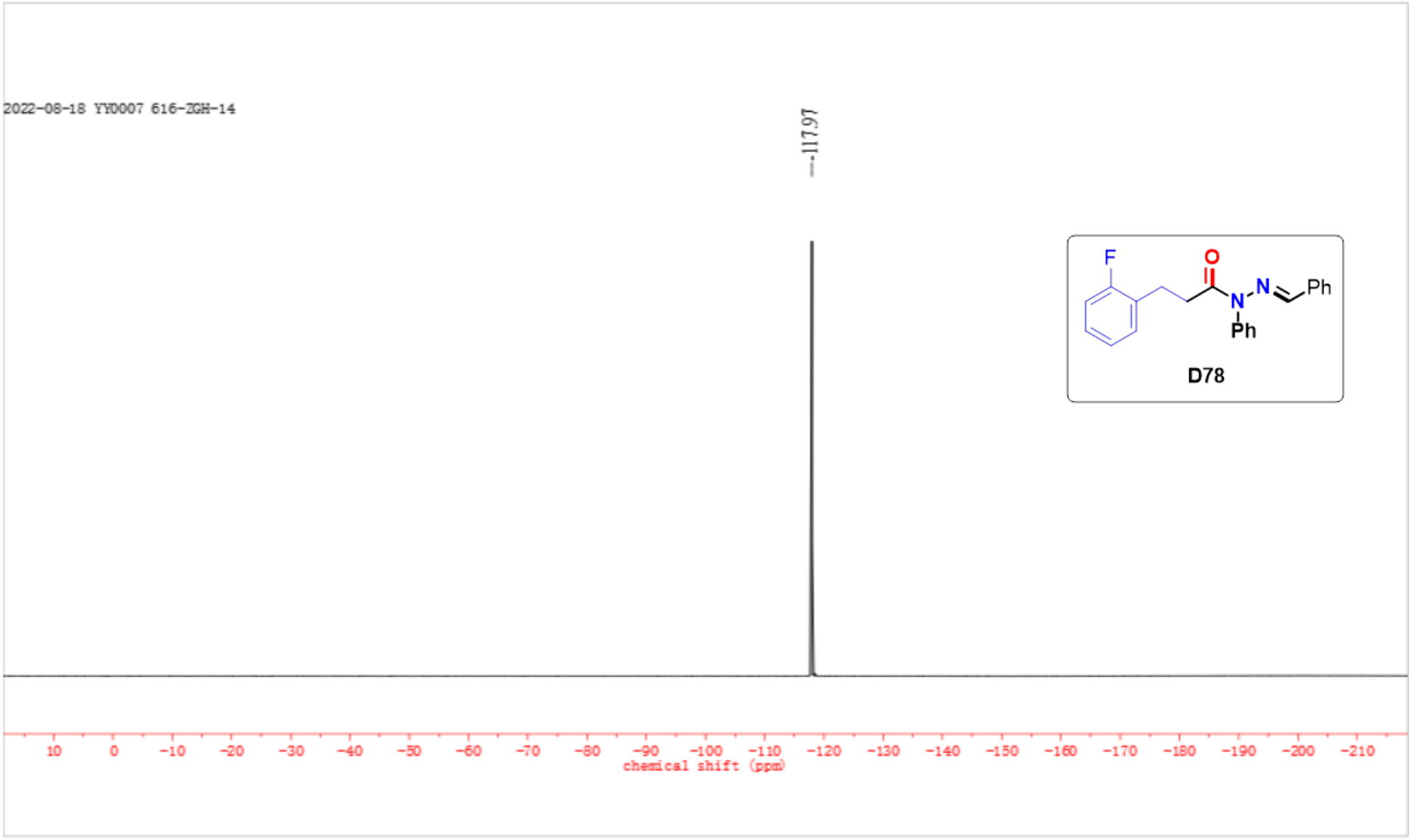

2022-08-16 YY0007-616-ZGH-11
174.51
141.82
139.71
136.33
134.37
130.39
130.34
130.00
129.39
129.21
128.80
127.34
126.40
126.21
77.65
77.33
77.01
34.57
28.91
19.59
O
N
N
Ph
Ph
D76
chemical shift (ppm)

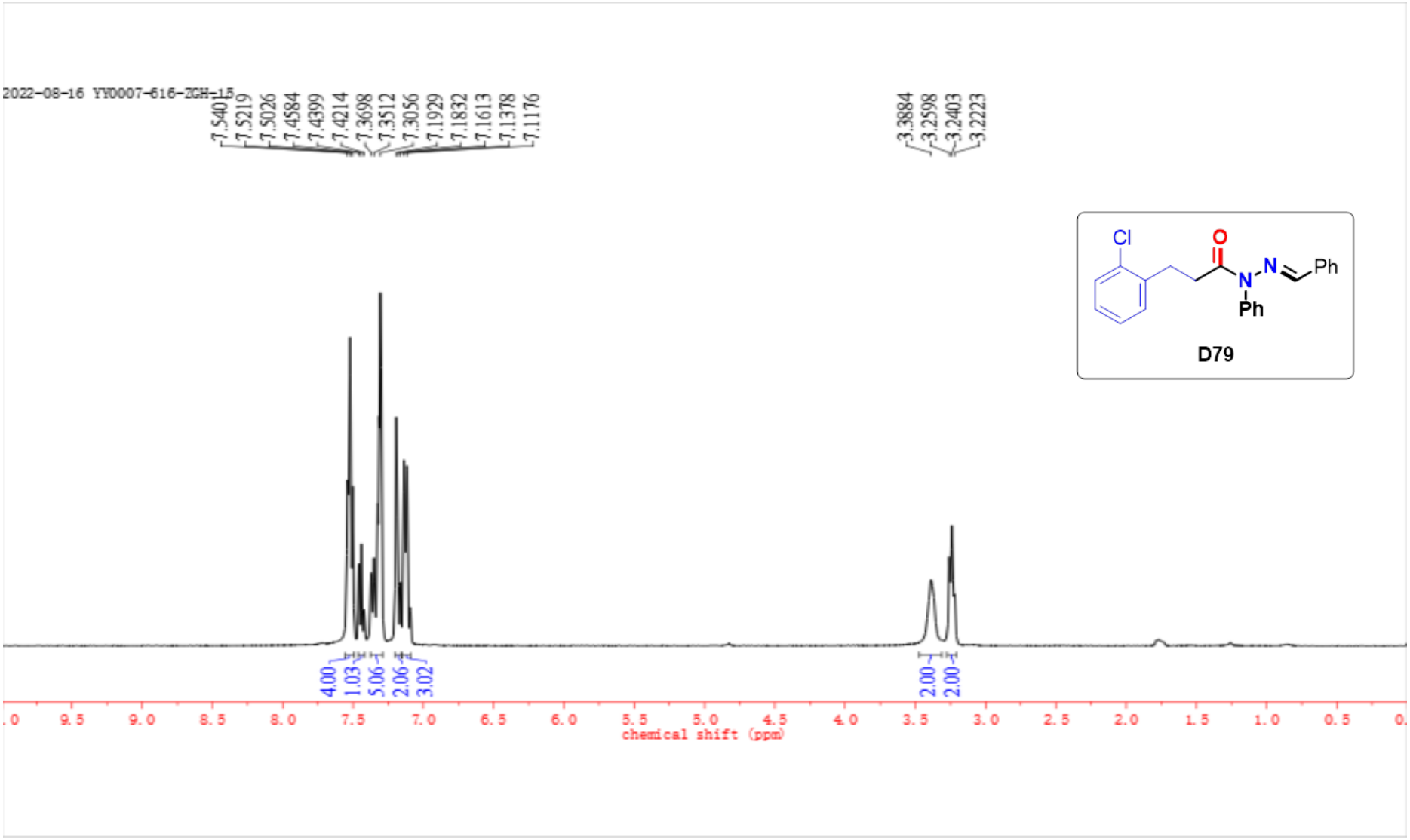

7.5722
7.5627
7.5557
7.5484
7.5386
7.5194
7.4762
7.4576
7.4391
7.3404
7.3305
7.3240
7.2772
7.2588
7.2417
7.2246
7.2204
7.2049
7.2011
7.1867
7.1453
7.1270
6.9278
6.9094
6.8909
6.8619
6.8415
3.8479
3.3267
3.1451
3.1241
3.1058
OMe
O
N
N
Ph
Ph
D77
4.09
1.04
3.06
1.30
2.08
2.04
1.06
1.00
3.00
2.00
2.05
chemical shift (ppm)

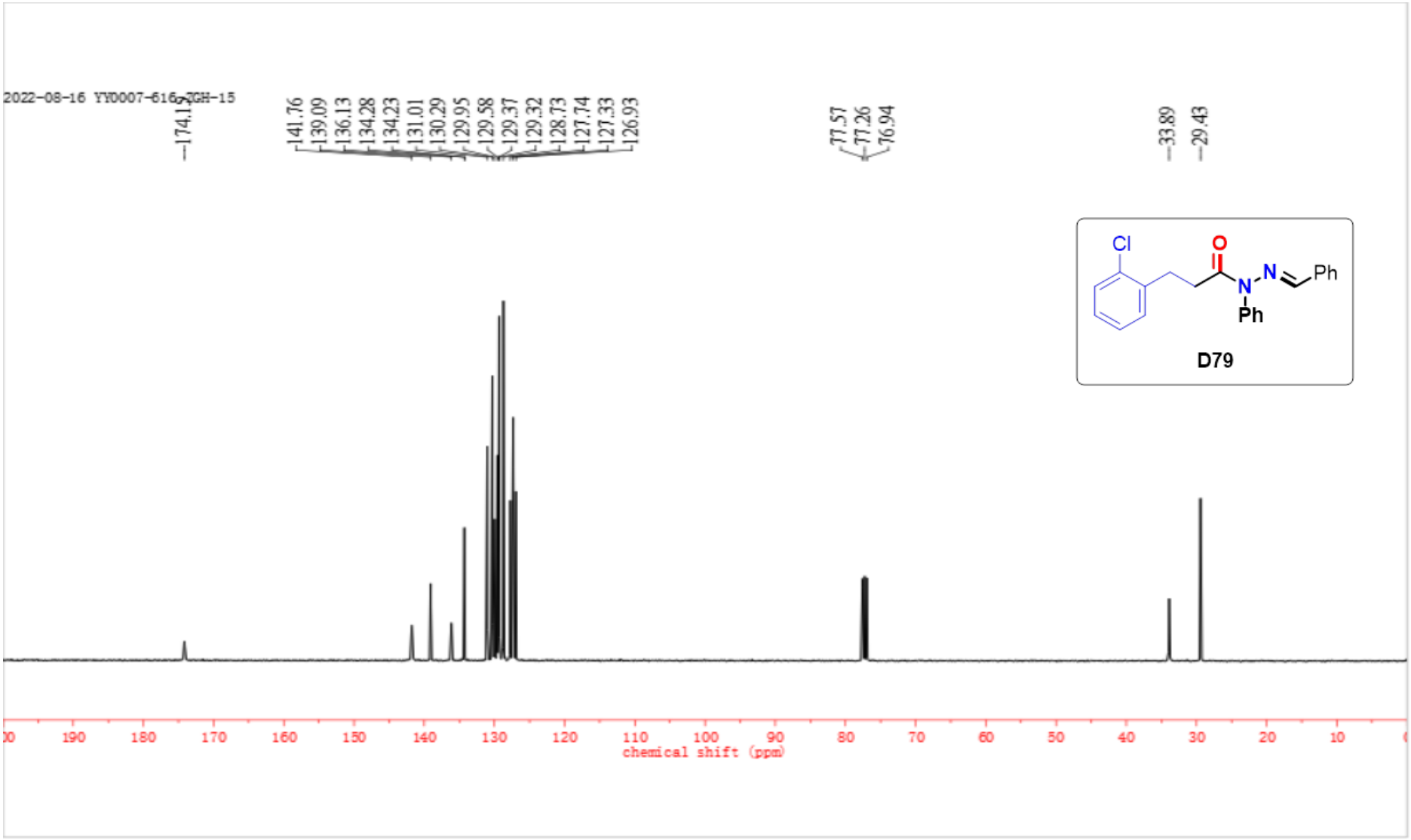

2022-08-16 YYD007-616-ZGH-12
174.93
157.74
136.27
134.47
130.36
130.17
129.79
129.74
129.31
129.20
128.64
127.41
127.22
120.42
110.26
77.38
77.07
76.75
55.27
34.26
26.47
OMe
O
N
N
Ph
Ph
D77
chemical shift (ppm)

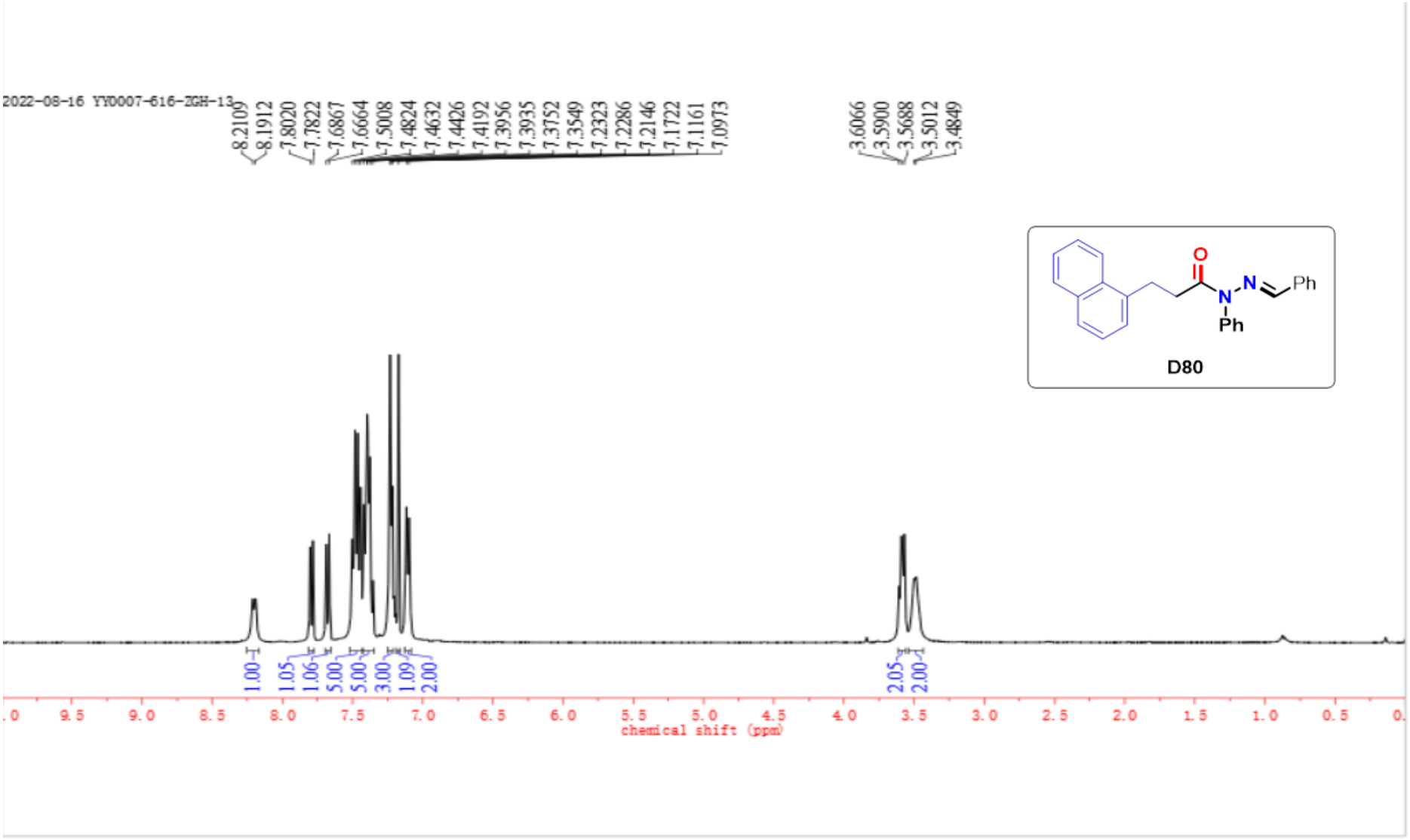

2022-08-18 YYD007
7.4096
7.4006
7.3952
7.3915
7.3714
7.3273
7.3087
7.2902
7.2178
7.1941
7.1904
7.1822
7.1769
7.0726
7.0333
7.0078
7.0042
6.9860
6.9464
6.9279
6.9118
6.8878
6.8636
6.8422
3.2529
3.0639
3.0444
3.0254
F
O
N
N
Ph
Ph
D78
4.00
1.02
4.00
1.01
3.03
1.05
1.05
2.00
2.00
chemical shift (ppm)

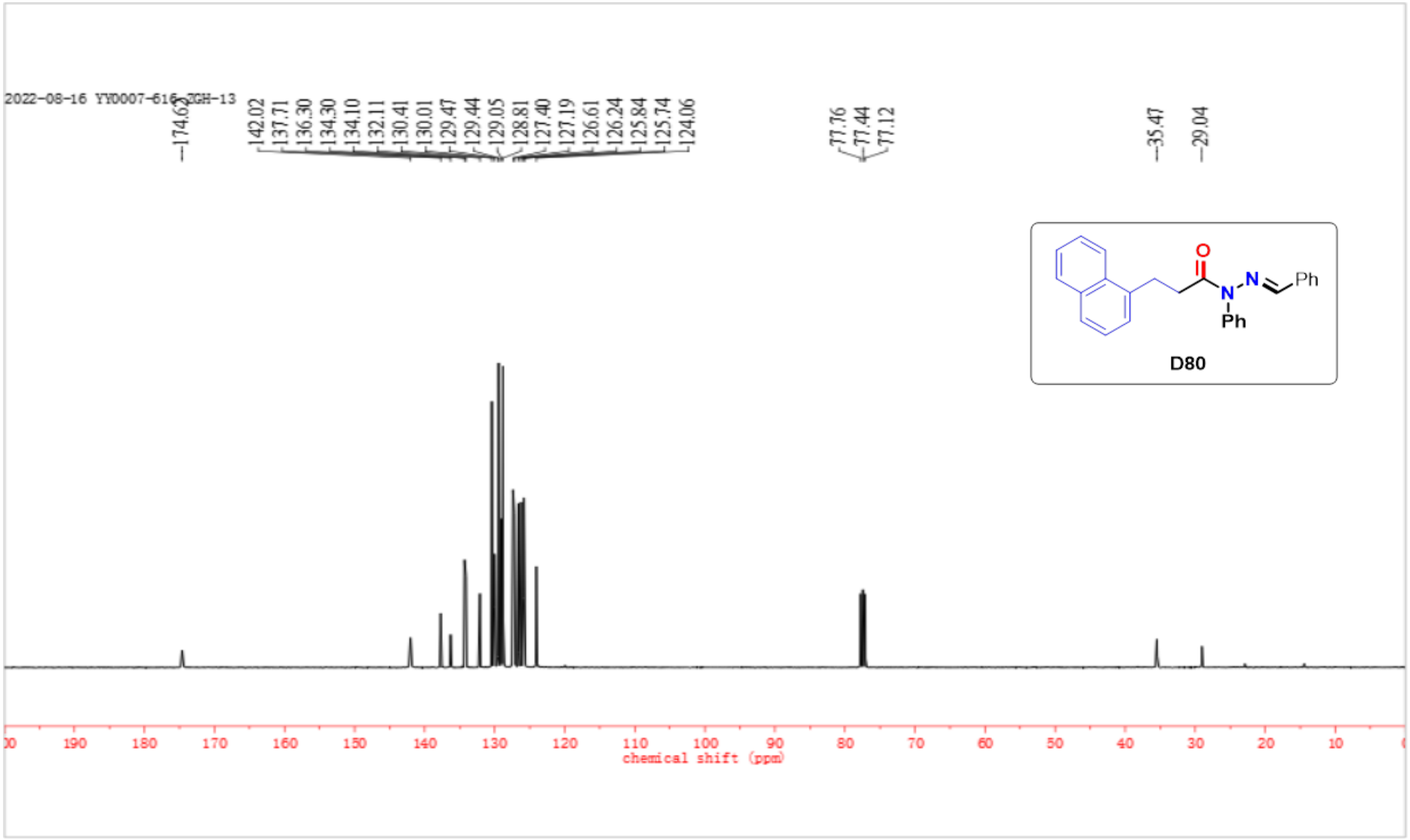

2022-08-18 YYD007 616-2GH-14
174.16
162.69
160.26
134.33
131.23
131.18
130.31
129.97
129.39
129.34
128.77
127.32
124.14
124.11
115.46
115.24
77.64
77.32
77.00
34.52
25.15
25.13
F
O
N
N
Ph
Ph
D78
chemical shift (ppm)

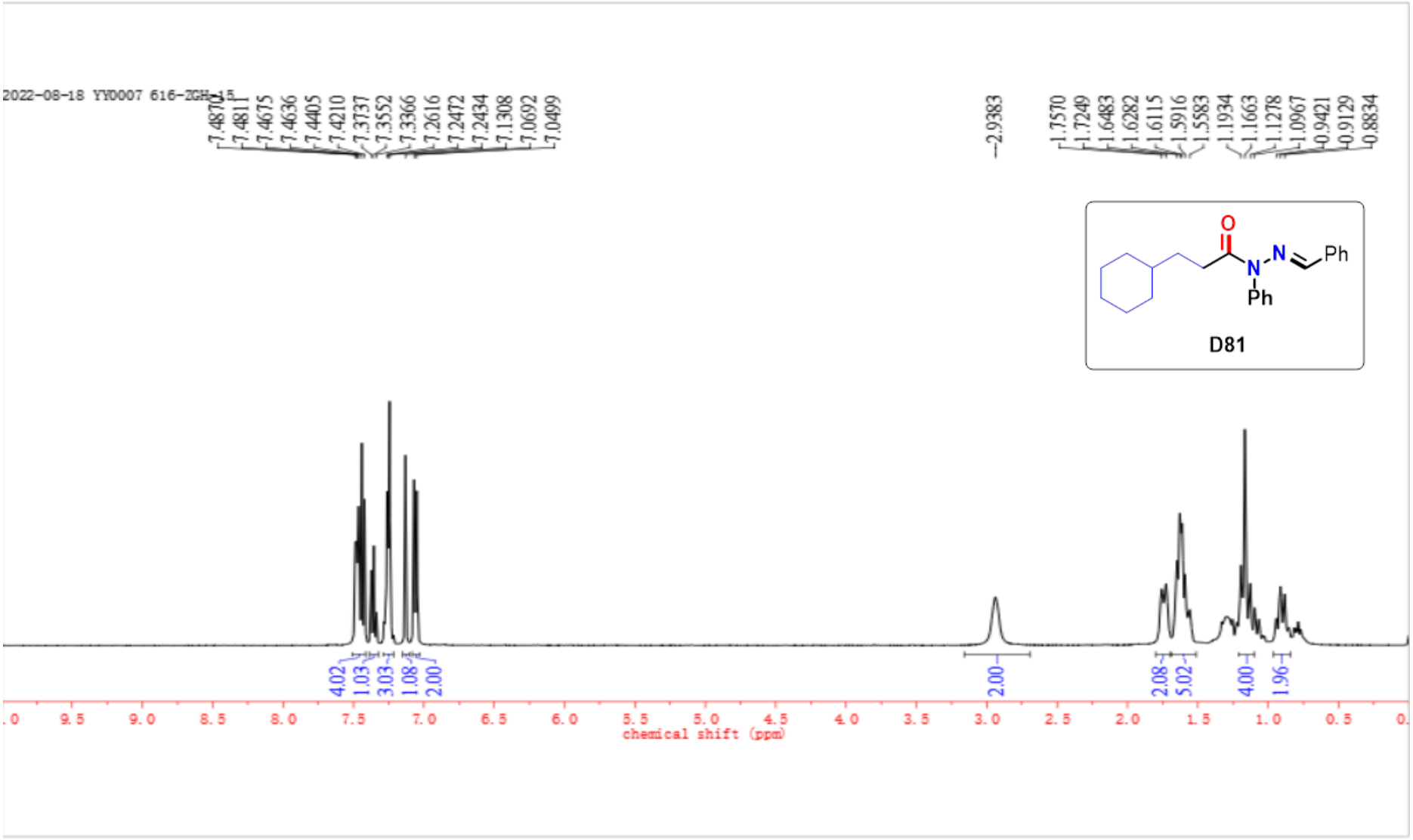

2022-08-18 YYD007 616-ZGH-14
-117.97
F
O
N
N
Ph
Ph
D78
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

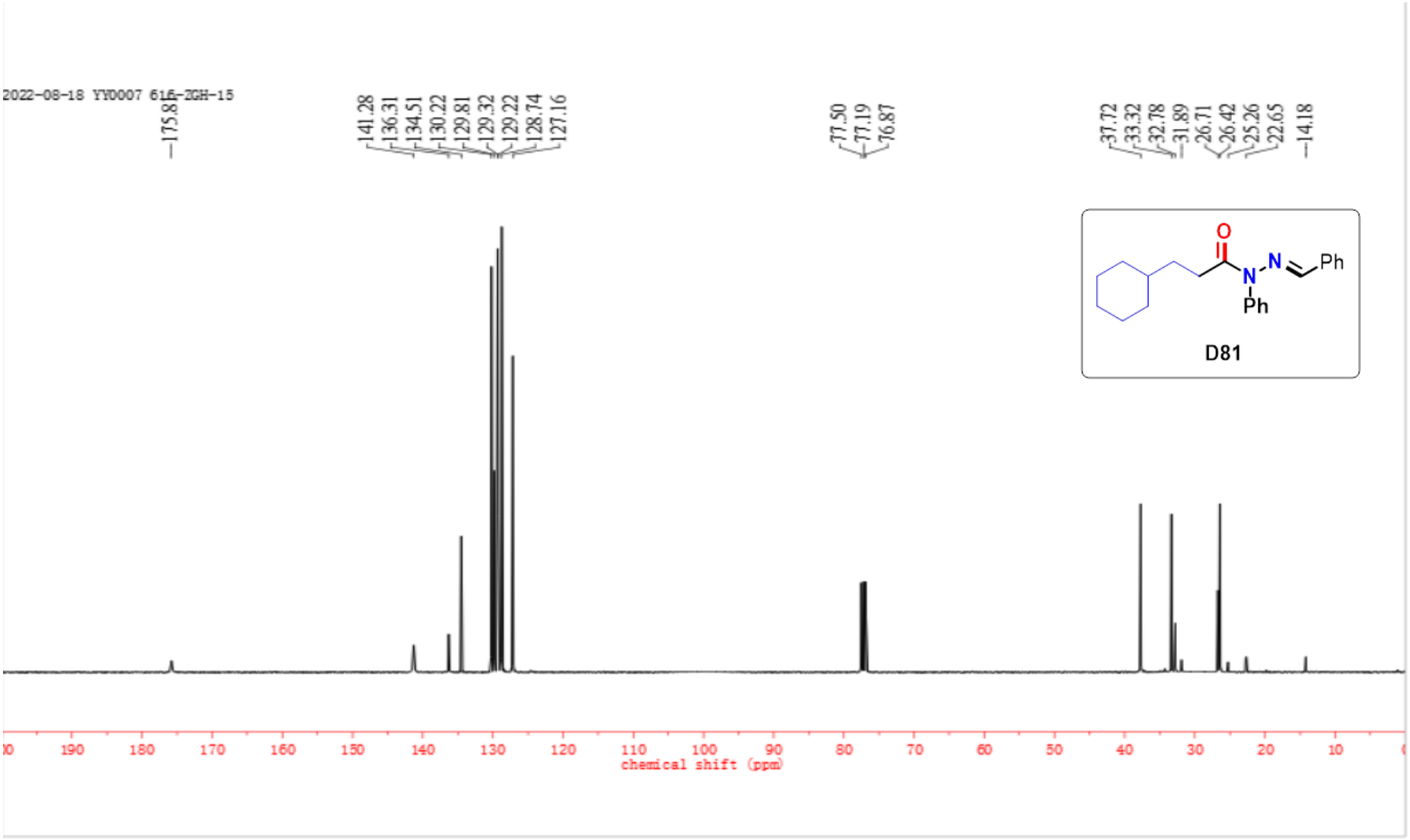

2022-08-16 YYD007-616-ZGH-15
7.5401
7.5219
7.5026
7.4584
7.4399
7.4214
7.3698
7.3512
7.3056
7.1929
7.1832
7.1613
7.1378
7.1176
3.3884
3.2598
3.2403
3.2223
Cl
O
N
N
Ph
Ph
D79
4.00
1.03
5.06
2.06
3.02
2.00
2.00
chemical shift (ppm)

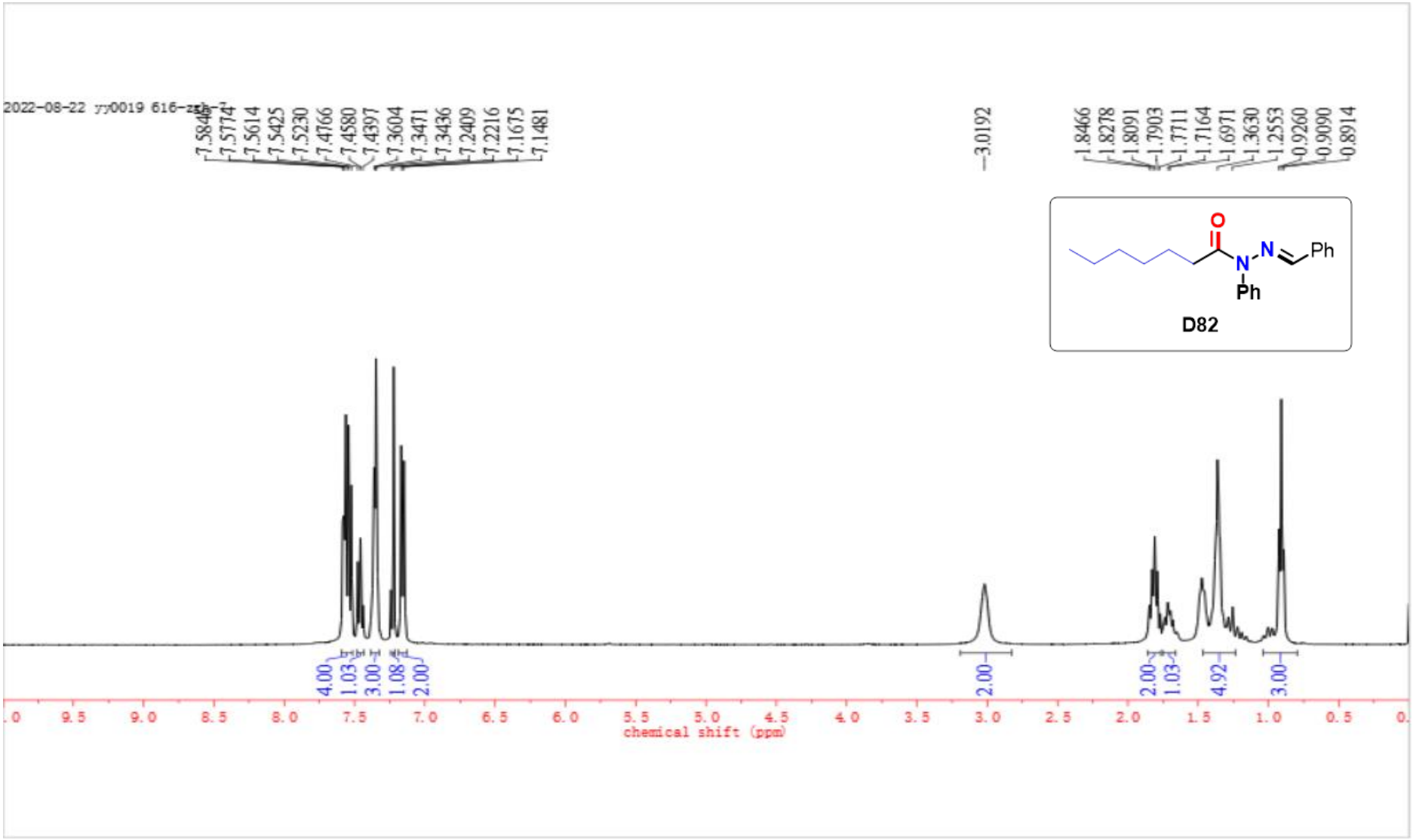

2022-08-16 YY0007-616-ZGH-15
174.15
141.76
139.09
136.13
134.28
134.23
131.01
130.29
129.95
129.58
129.37
129.32
128.73
127.74
127.33
126.93
77.57
77.26
76.94
33.89
29.43
Cl
O
N
N
Ph
Ph
D79
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

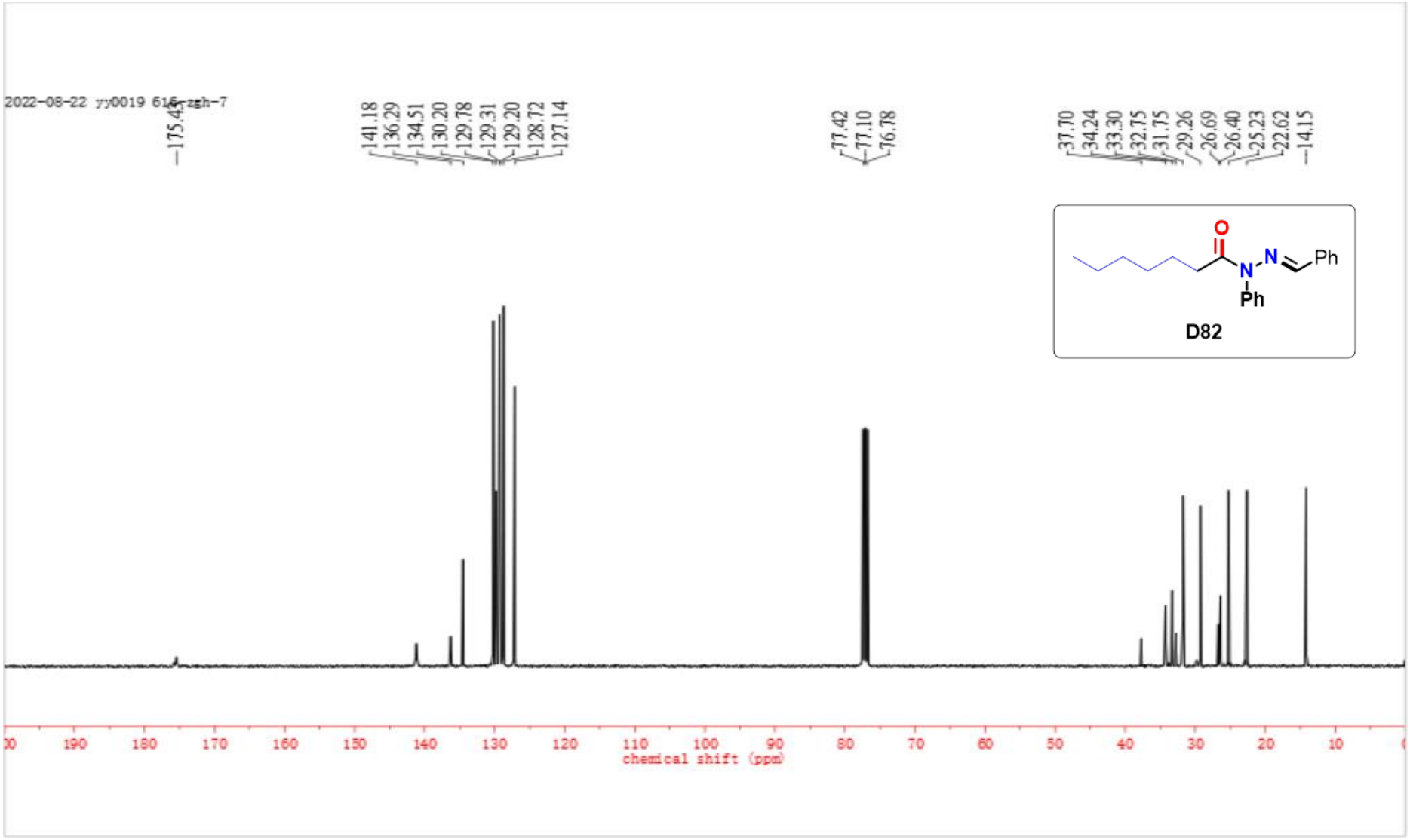

2022-08-16 YY0007-616-ZGH-13
8.2109
8.1912
7.8020
7.7822
7.6867
7.6664
7.5008
7.4824
7.4632
7.4426
7.4192
7.3956
7.3935
7.3752
7.3549
7.2323
7.2286
7.2146
7.1722
7.1161
7.0973
3.6066
3.5900
3.5688
3.5012
3.4849
O
N
N
Ph
Ph
D80
1.00
1.05
1.06
5.00
5.00
3.00
1.09
2.00
2.05
2.00
chemical shift (ppm)

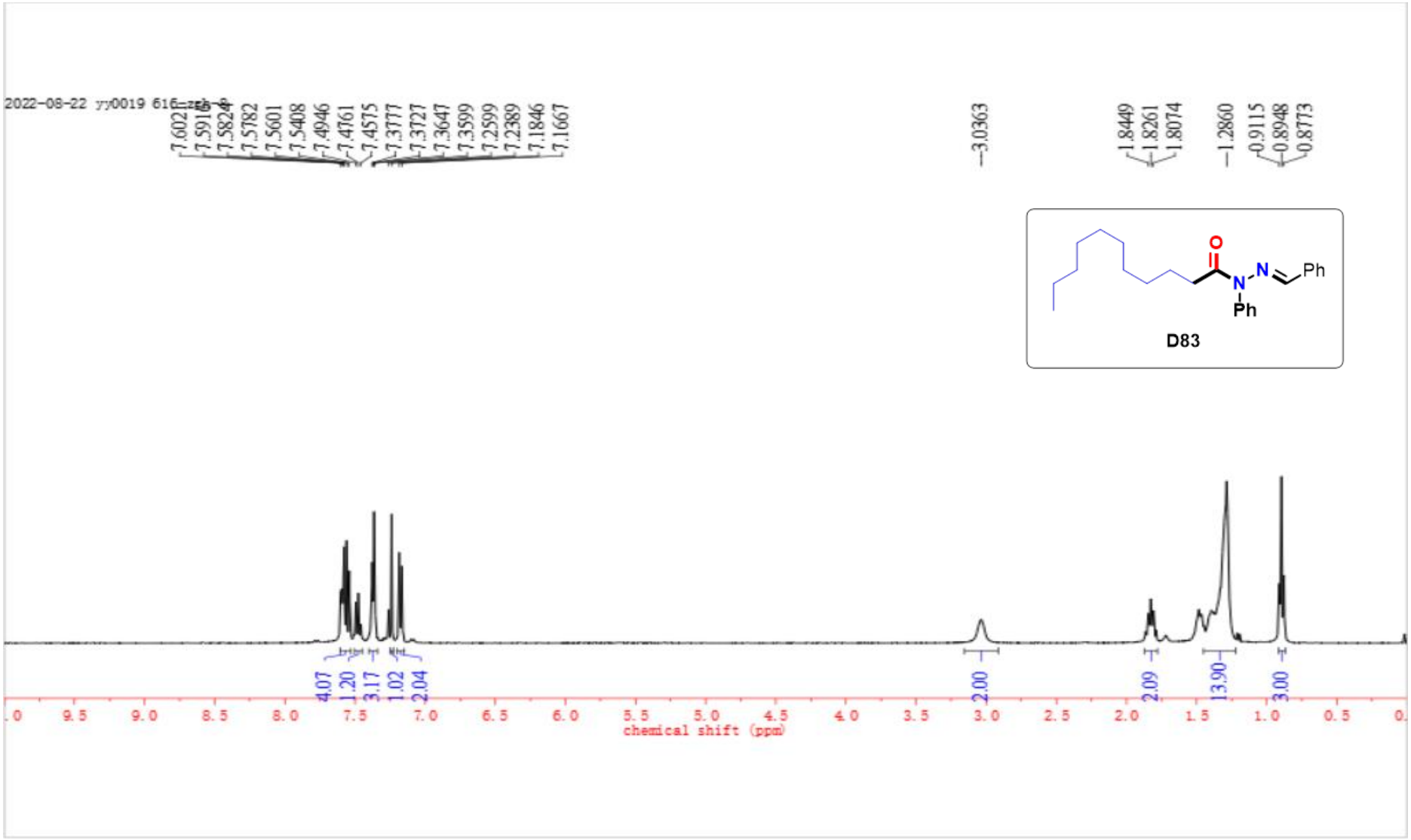

2022-08-16 YYD007-616-2GH-13
174.62
142.02
137.71
136.30
134.30
134.10
132.11
130.41
130.01
129.47
129.44
129.05
128.81
127.40
127.19
126.61
126.24
125.84
125.74
124.06
77.76
77.44
77.12
35.47
29.04
O
N
N
Ph
Ph
D80
chemical shift (ppm)

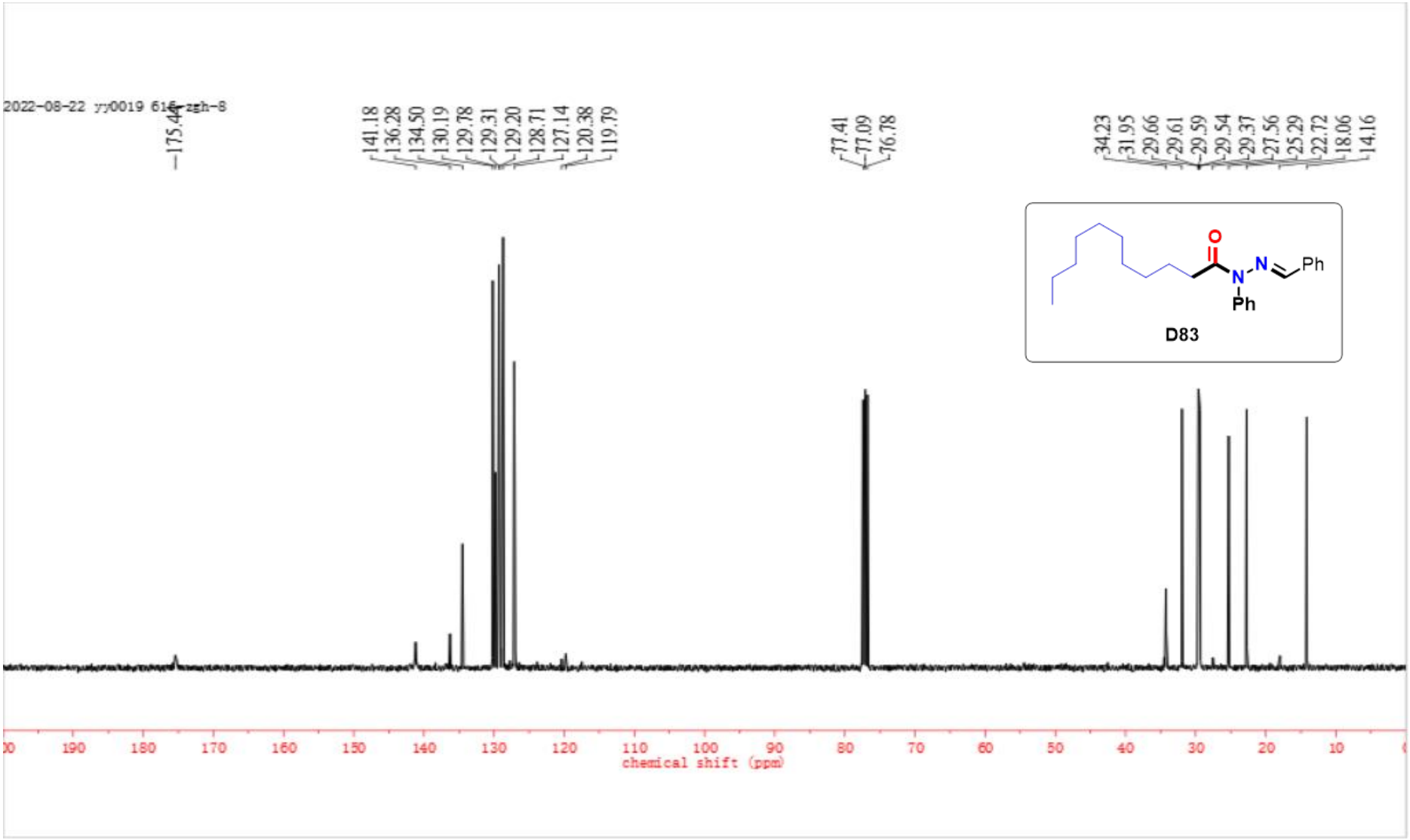

2022-08-18 YYD007 616-ZGH-1H
7.4870
7.4811
7.4675
7.4636
7.4405
7.4210
7.3737
7.3552
7.3366
7.2616
7.2472
7.2434
7.1308
7.0692
7.0499
2.9383
1.7570
1.7249
1.6483
1.6282
1.6115
1.5916
1.5583
1.1934
1.1663
1.1278
1.0967
0.9421
0.9129
0.8834
O
N
N
Ph
Ph
D81
4.02
1.03
3.03
1.08
2.00
2.00
2.08
5.02
4.00
1.96
chemical shift (ppm)

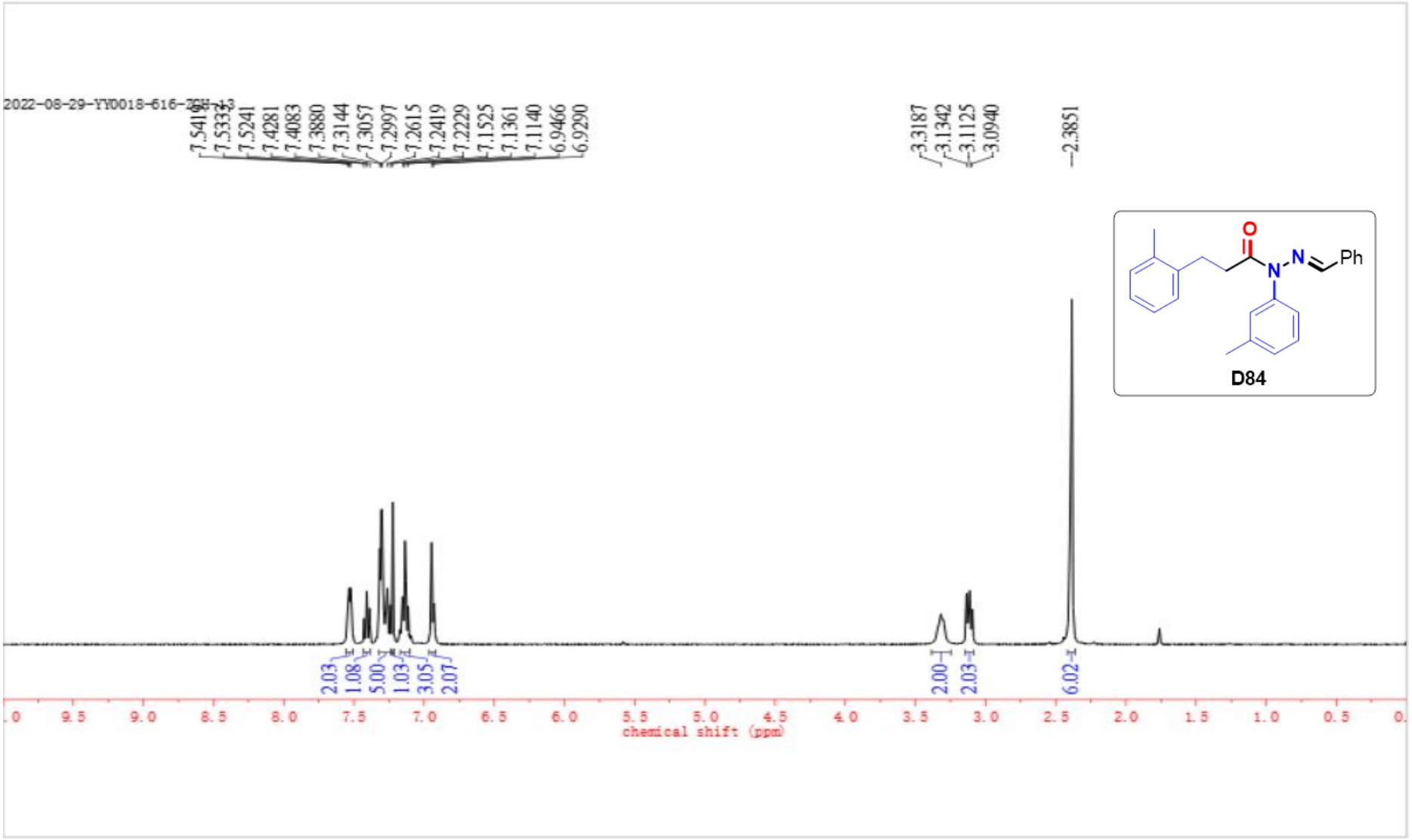

2022-08-18 YYD007 616-ZGH-15
175.81
141.28
136.31
134.51
130.22
129.81
129.32
129.22
128.74
127.16
77.50
77.19
76.87
37.72
33.32
32.78
31.89
26.71
26.42
25.26
22.65
14.18
O
N
N
Ph
Ph
D81
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

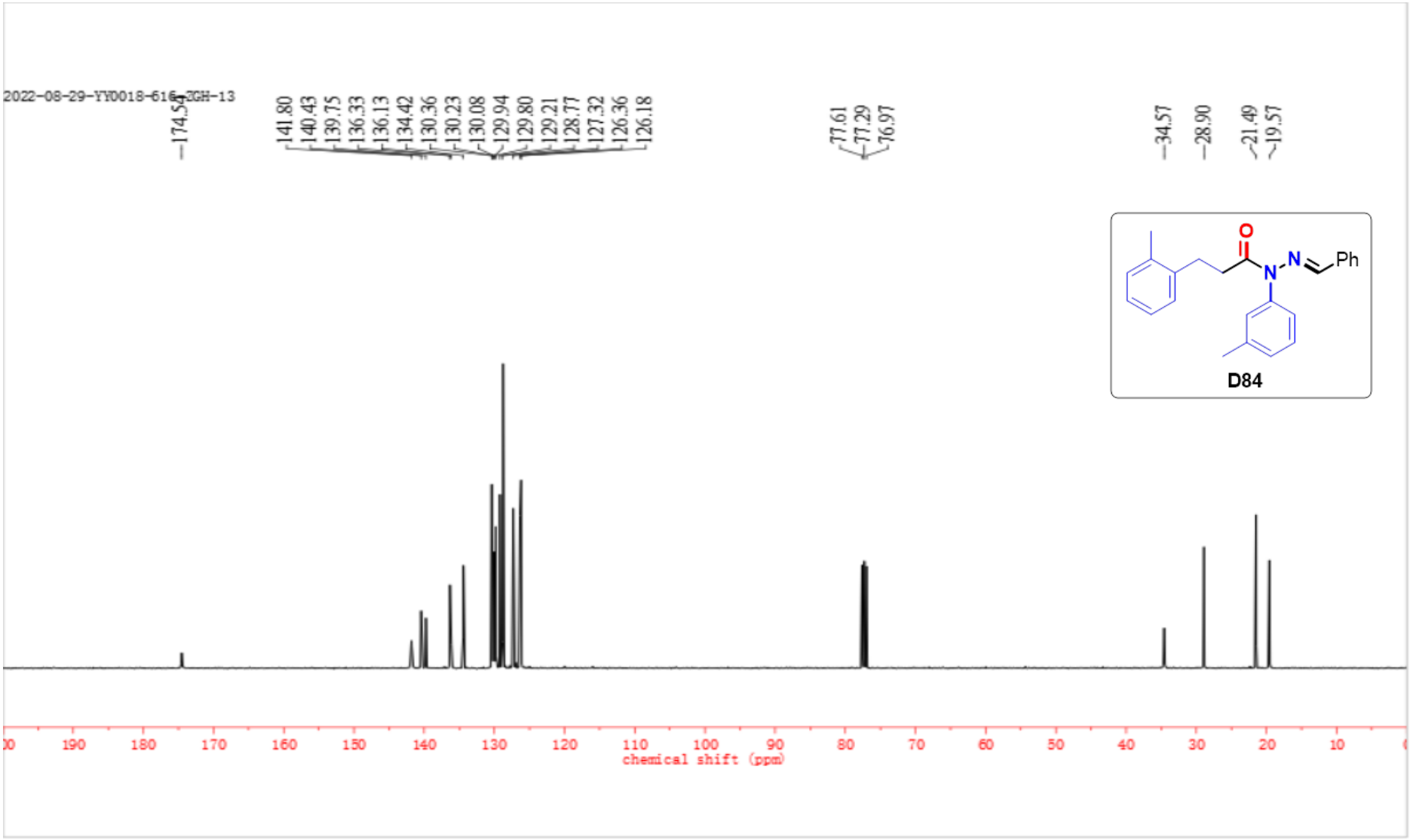

2022-08-22 yy0019 616-za
7.5840
7.5774
7.5614
7.5425
7.5230
7.4766
7.4580
7.4397
7.3604
7.3471
7.3436
7.2409
7.2216
7.1675
7.1481
3.0192
1.8466
1.8278
1.8091
1.7903
1.7711
1.7164
1.6971
1.3630
1.2553
0.9260
0.9090
0.8914
O
N
N
Ph
Ph
D82
4.00
1.03
3.00
1.08
2.00
2.00
2.00
1.03
4.92
3.00
chemical shift (ppm)

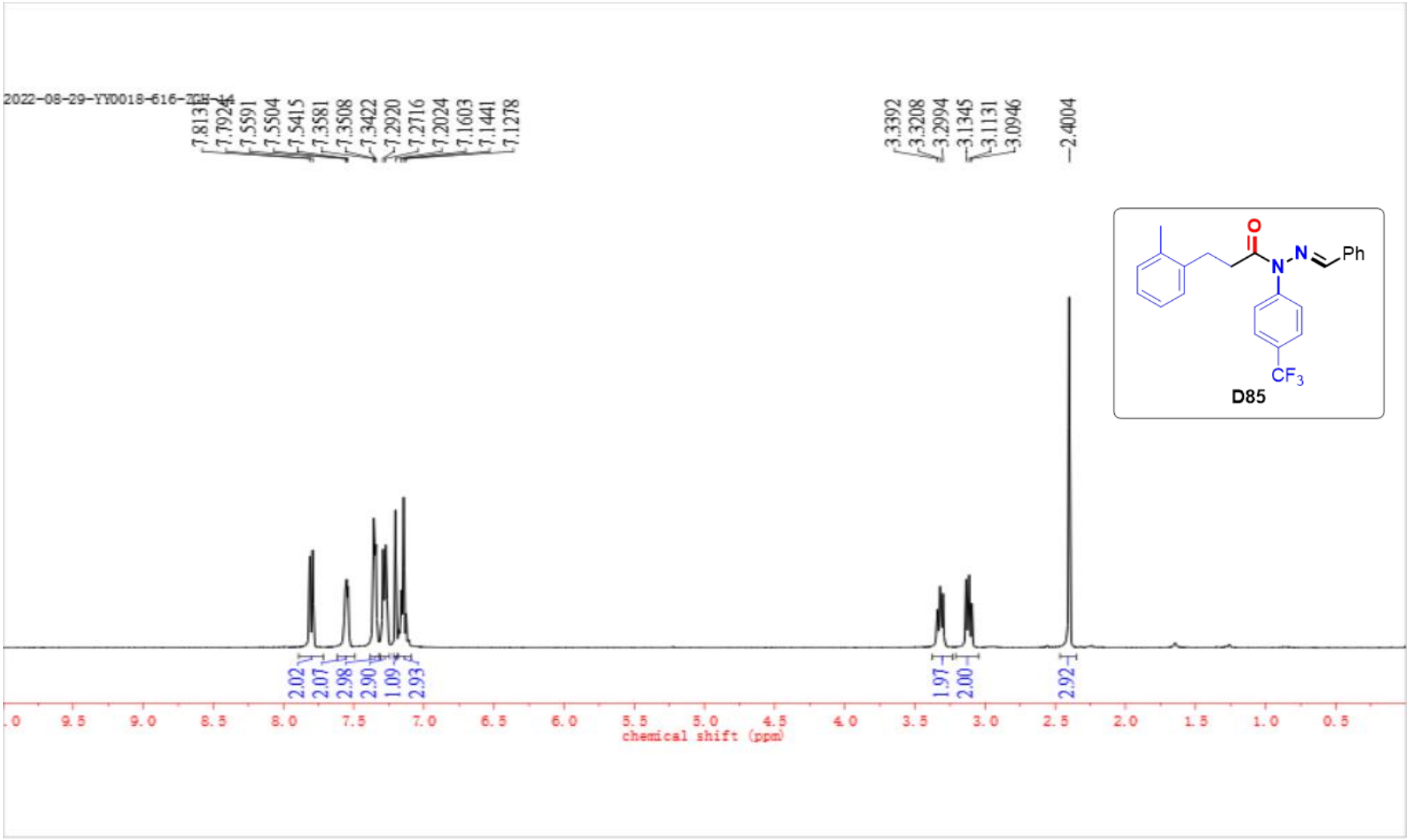

2022-08-22 yy0019 616-zgh-7
175.43
141.18
136.29
134.51
130.20
129.78
129.31
129.20
128.72
127.14
77.42
77.10
76.78
37.70
34.24
33.30
32.75
31.75
29.26
26.69
26.40
25.23
22.62
14.15
O
N
N
Ph
Ph
D82
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

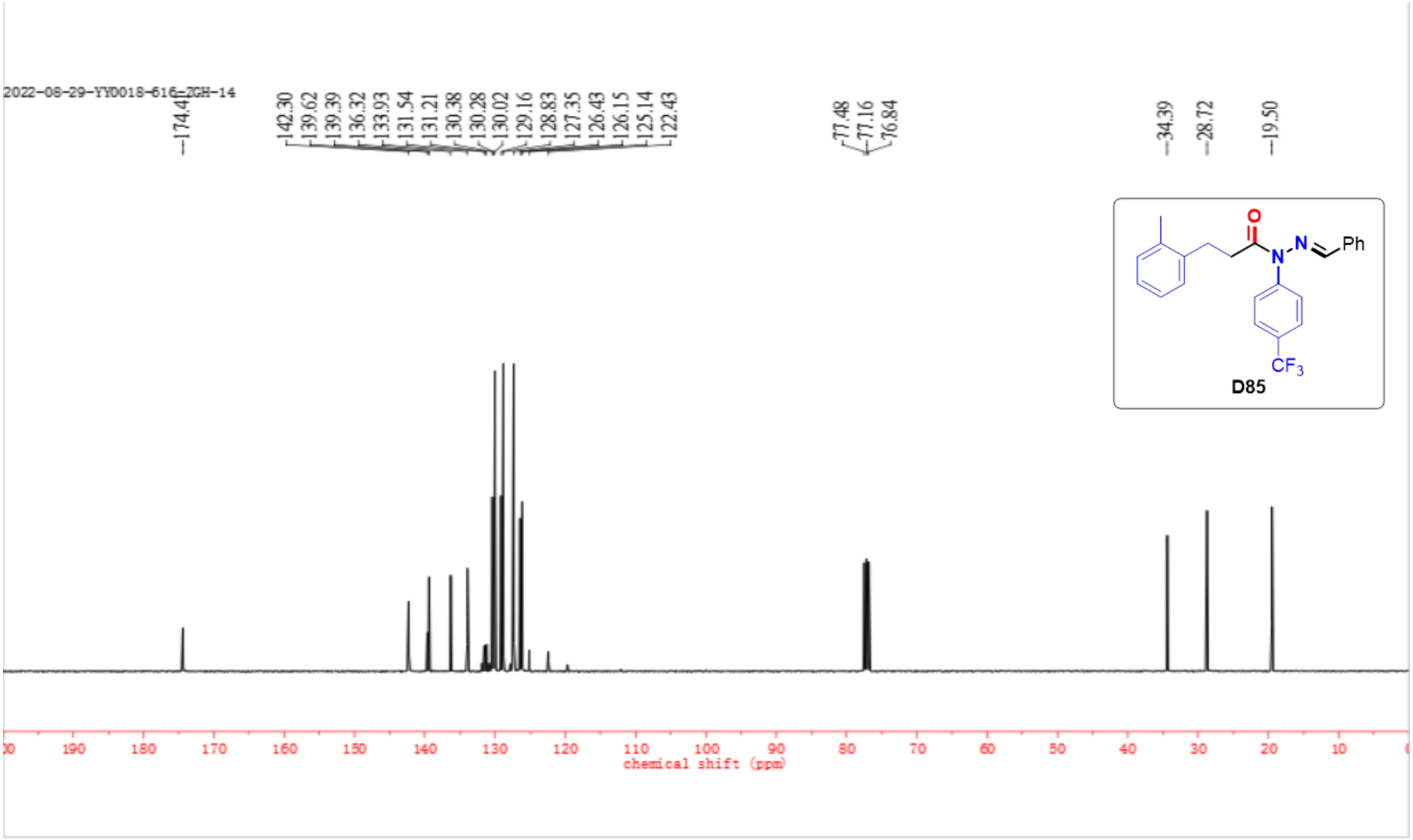

2022-08-22 yy0019 616
7.6021
7.5918
7.5824
7.5782
7.5601
7.5408
7.4946
7.4761
7.4575
7.3777
7.3727
7.3647
7.3599
7.2599
7.2389
7.1846
7.1667
3.0363
1.8449
1.8261
1.8074
1.2860
0.9115
0.8948
0.8773
O
N
N
Ph
Ph
D83
4.07
1.20
3.17
1.02
2.04
2.00
2.09
13.90
3.00
chemical shift (ppm)

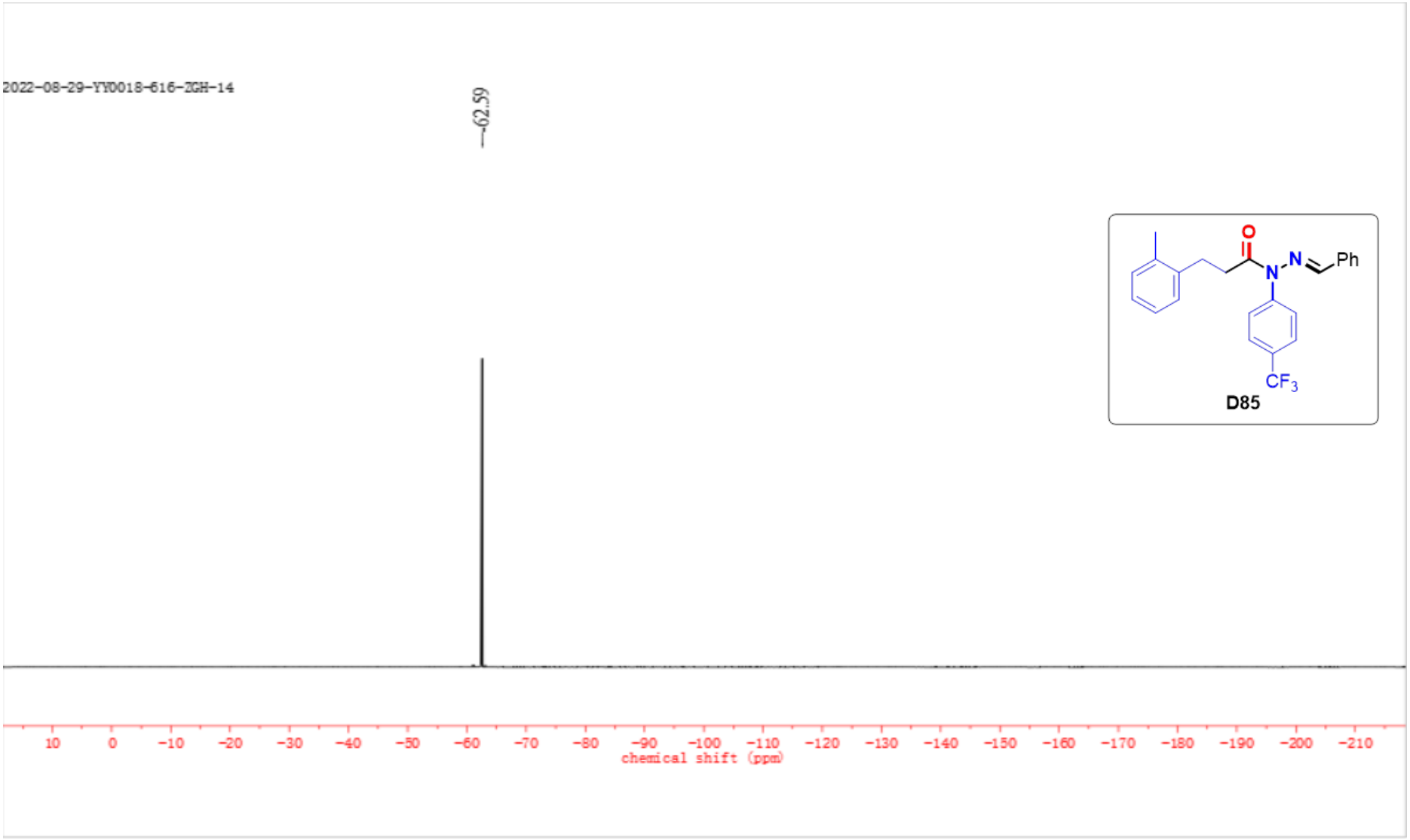

2022-08-22 yy0019 61f zgh-8
175.44
141.18
136.28
134.50
130.19
129.78
129.31
129.20
128.71
127.14
120.38
119.79
77.41
77.09
76.78
34.23
31.95
29.66
29.61
29.59
29.54
29.37
27.56
25.29
22.72
18.06
14.16
O
N
N
Ph
Ph
D83
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

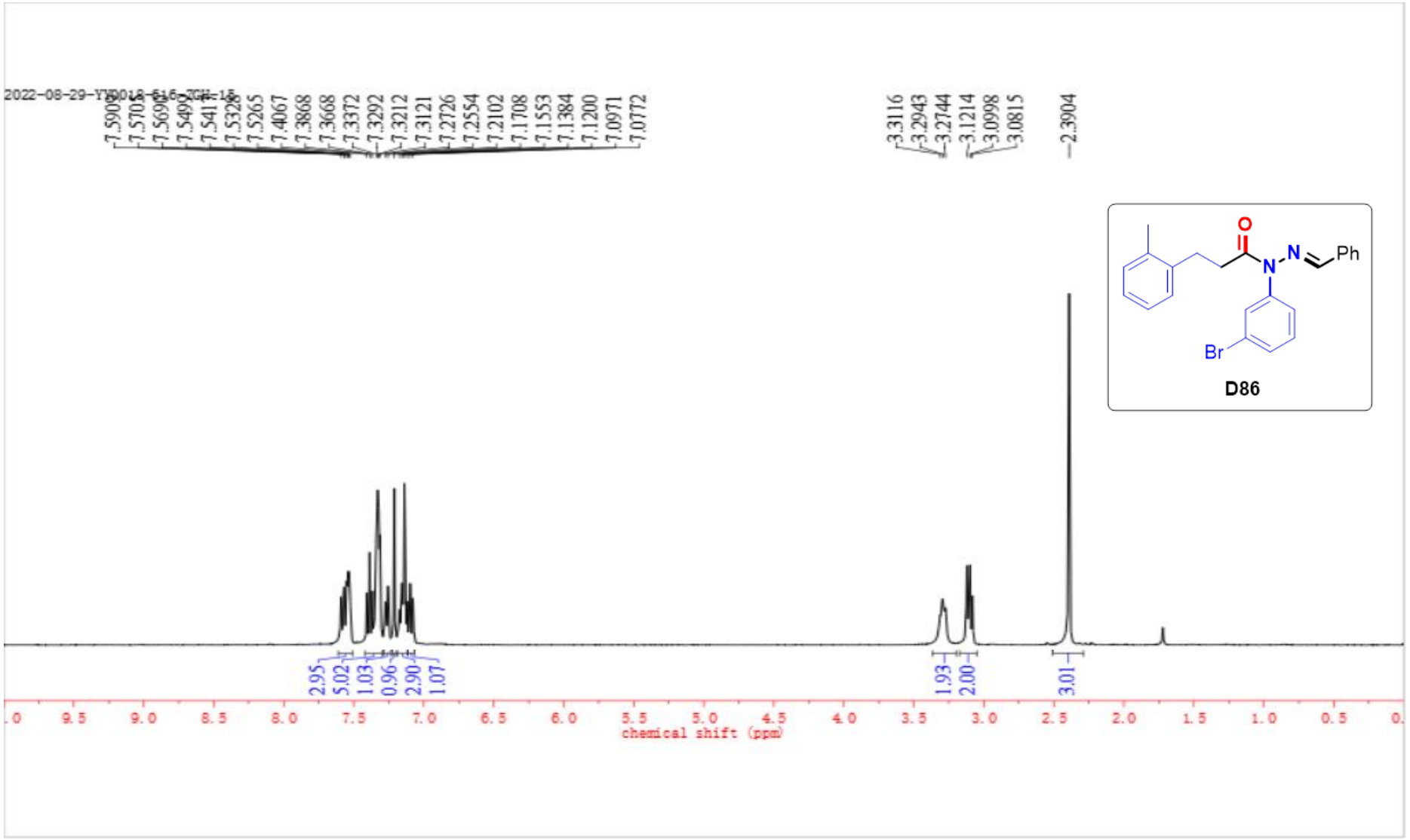

2022-08-29-YY0018-616-
7.5419
7.5332
7.5241
7.4281
7.4083
7.3880
7.3144
7.3057
7.2997
7.2615
7.2419
7.2229
7.1525
7.1361
7.1140
6.9466
6.9290
3.3187
3.1342
3.1125
3.0940
2.3851
O
N
N
Ph
D84
2.03
1.08
5.00
1.03
3.05
2.07
2.00
2.03
6.02
chemical shift (ppm)

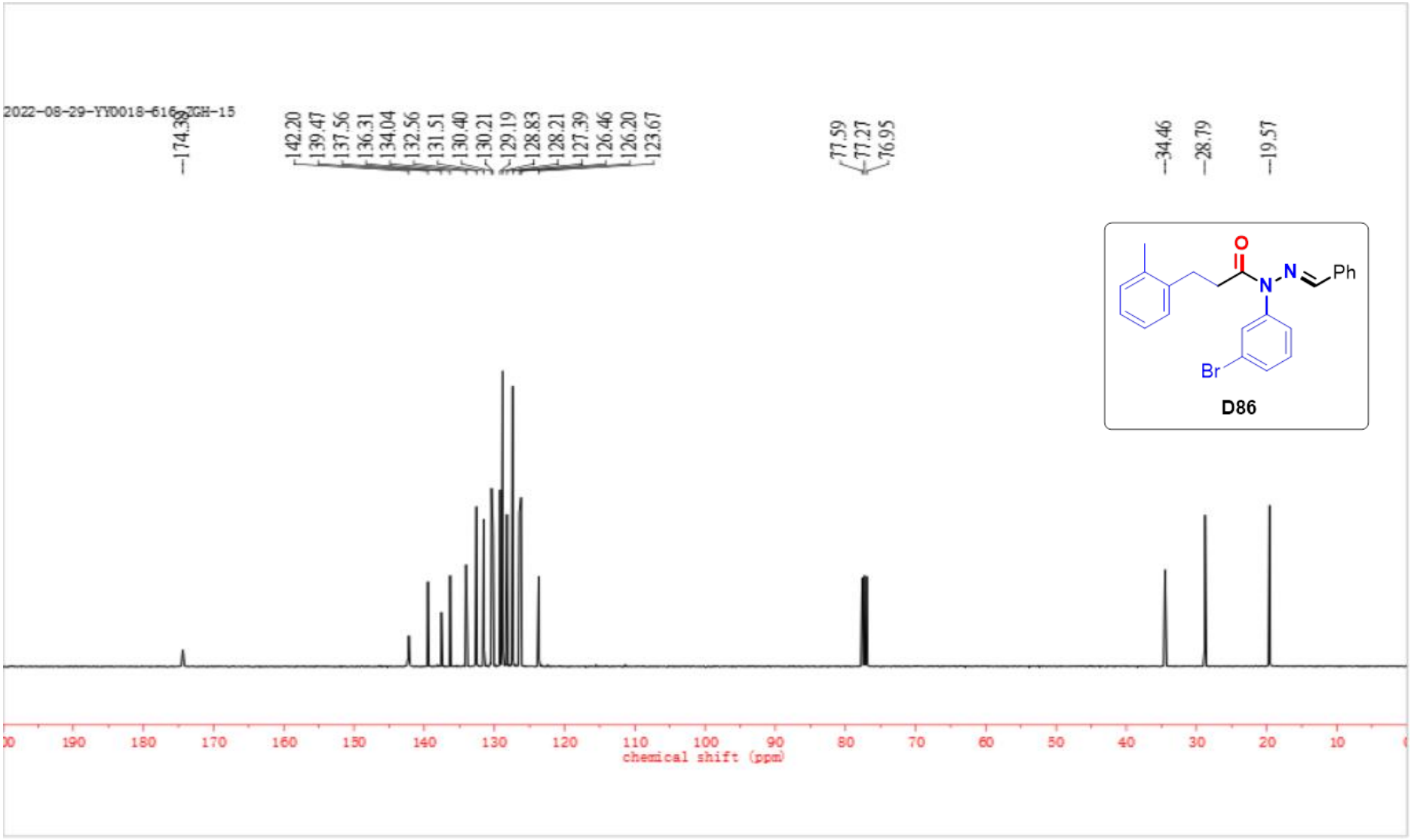

2022-08-29-YY0018-616-ZGH-13
174.54
141.80
140.43
139.75
136.33
136.13
134.42
130.36
130.23
130.08
129.94
129.80
129.21
128.77
127.32
126.36
126.18
77.61
77.29
76.97
34.57
28.90
21.49
19.57
O
N
N
Ph
D84
chemical shift (ppm)

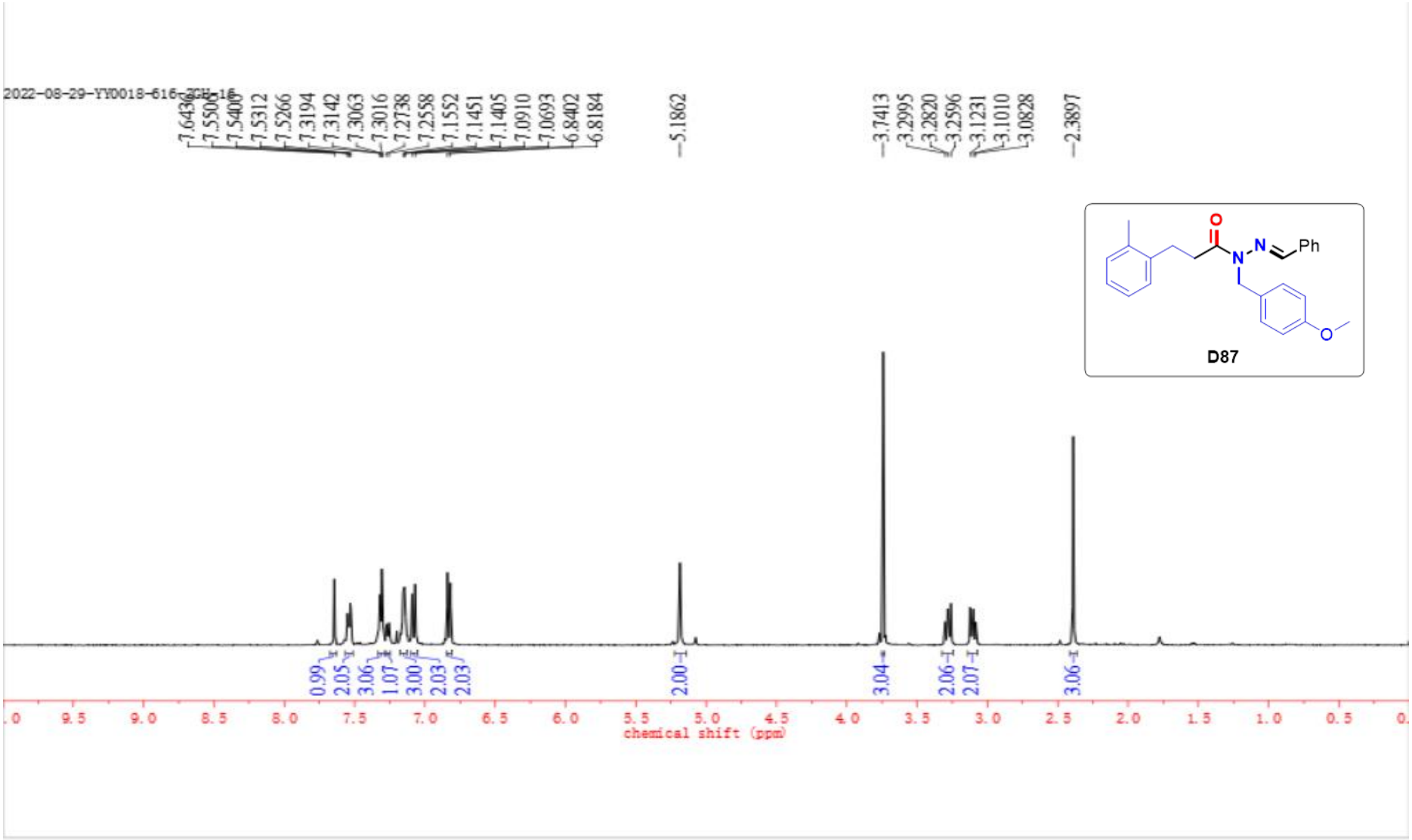

2022-08-29-YY0018-616-ZH-4
7.8136
7.7924
7.5591
7.5504
7.5415
7.3581
7.3508
7.3422
7.2920
7.2716
7.2024
7.1603
7.1441
7.1278
3.3392
3.3208
3.2994
3.1345
3.1131
3.0946
2.4004
2.02
2.07
2.98
2.90
1.09
2.93
1.97
2.00
2.92
chemical shift (ppm)
O
N
N
Ph
CF3
D85

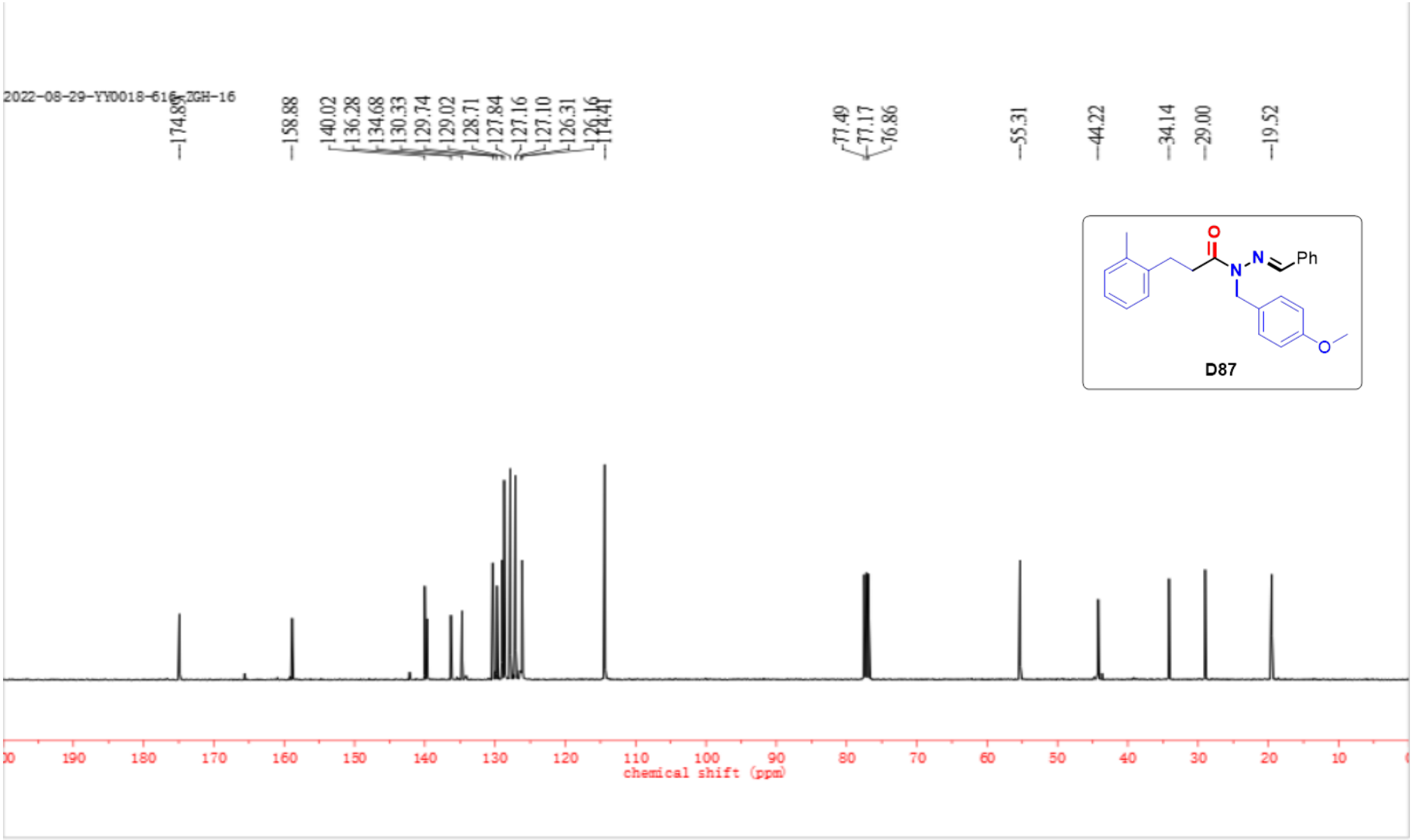

2022-08-29-YYD018-616-ZGH-14
174.41
142.30
139.62
139.39
136.32
133.93
131.54
131.21
130.38
130.28
130.02
129.16
128.83
127.35
126.43
126.15
125.14
122.43
77.48
77.16
76.84
34.39
28.72
19.50
O
N
N
Ph
CF3
D85
chemical shift (ppm)

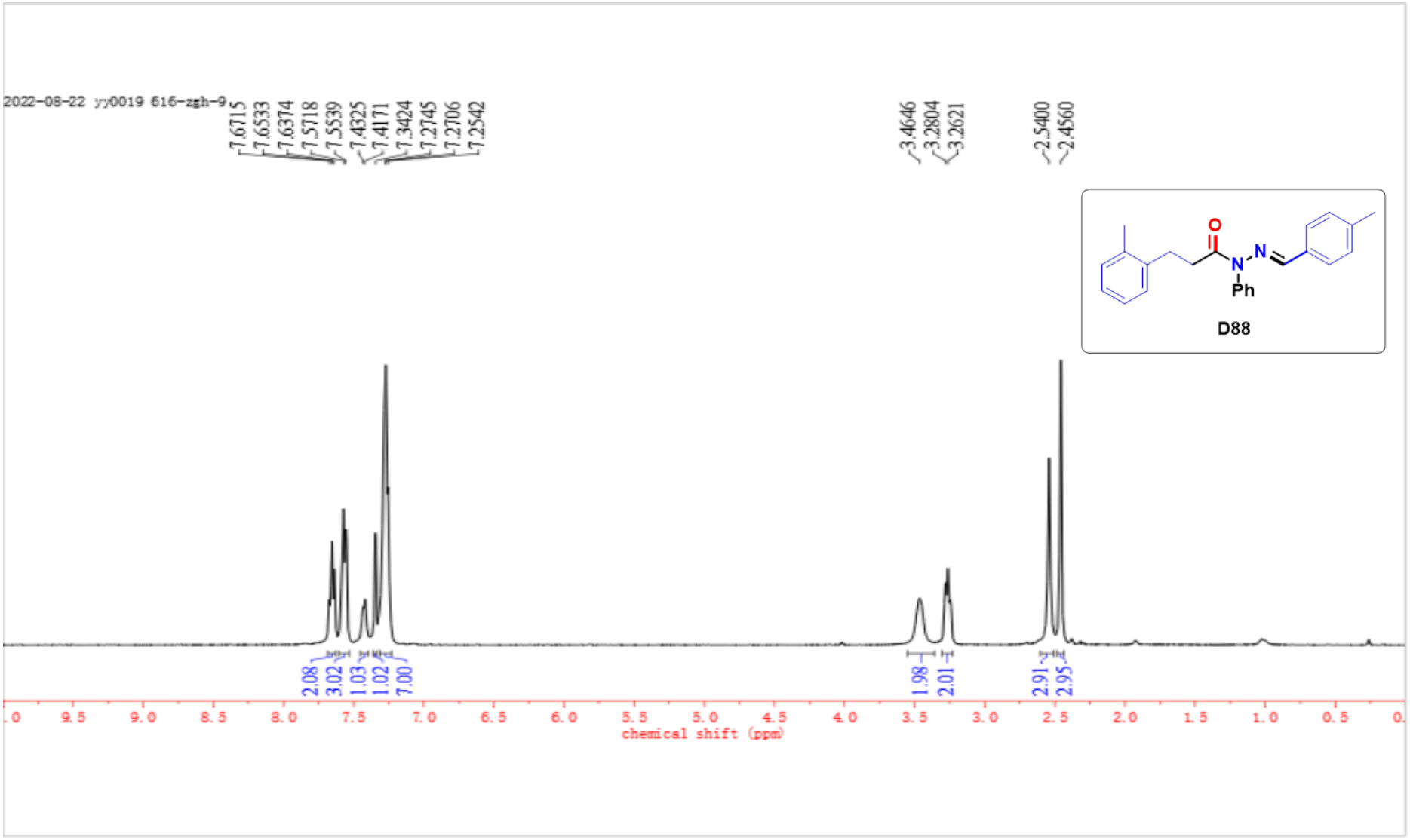

2022-08-29-YYD018-616-ZGH-14
-62.59
O
N
N
Ph
CF3
D85
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
chemical shift (ppm)

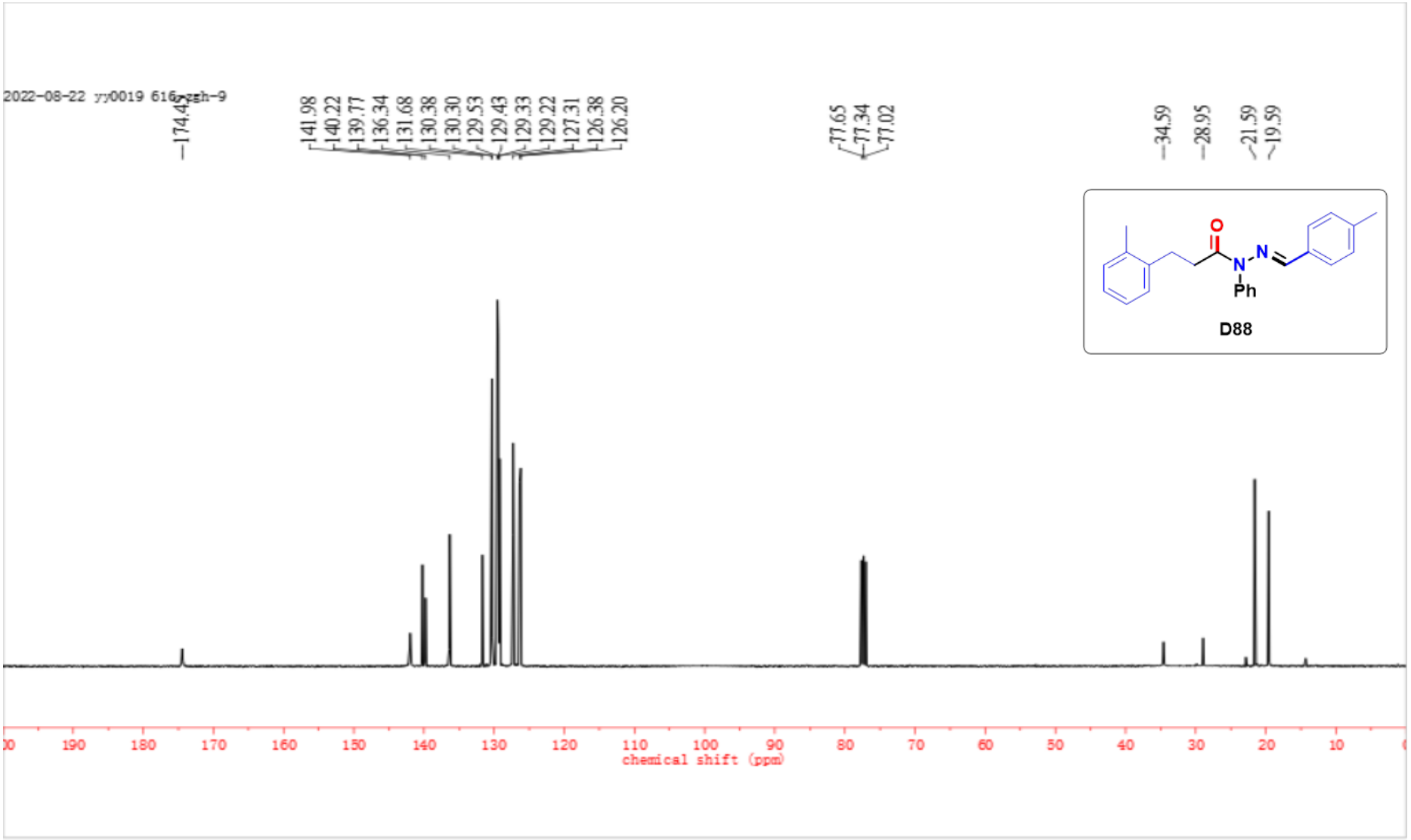

7.5903
7.5703
7.5696
7.5492
7.5417
7.5328
7.5265
7.4067
7.3868
7.3668
7.3372
7.3292
7.3212
7.3121
7.2726
7.2554
7.2102
7.1708
7.1553
7.1384
7.1200
7.0971
7.0772
3.3116
3.2943
3.2744
3.1214
3.0998
3.0815
2.3904
O
N
N
Ph
Br
D86
2.95
5.02
1.03
0.96
2.90
1.07
1.93
2.00
3.01
chemical shift (ppm)

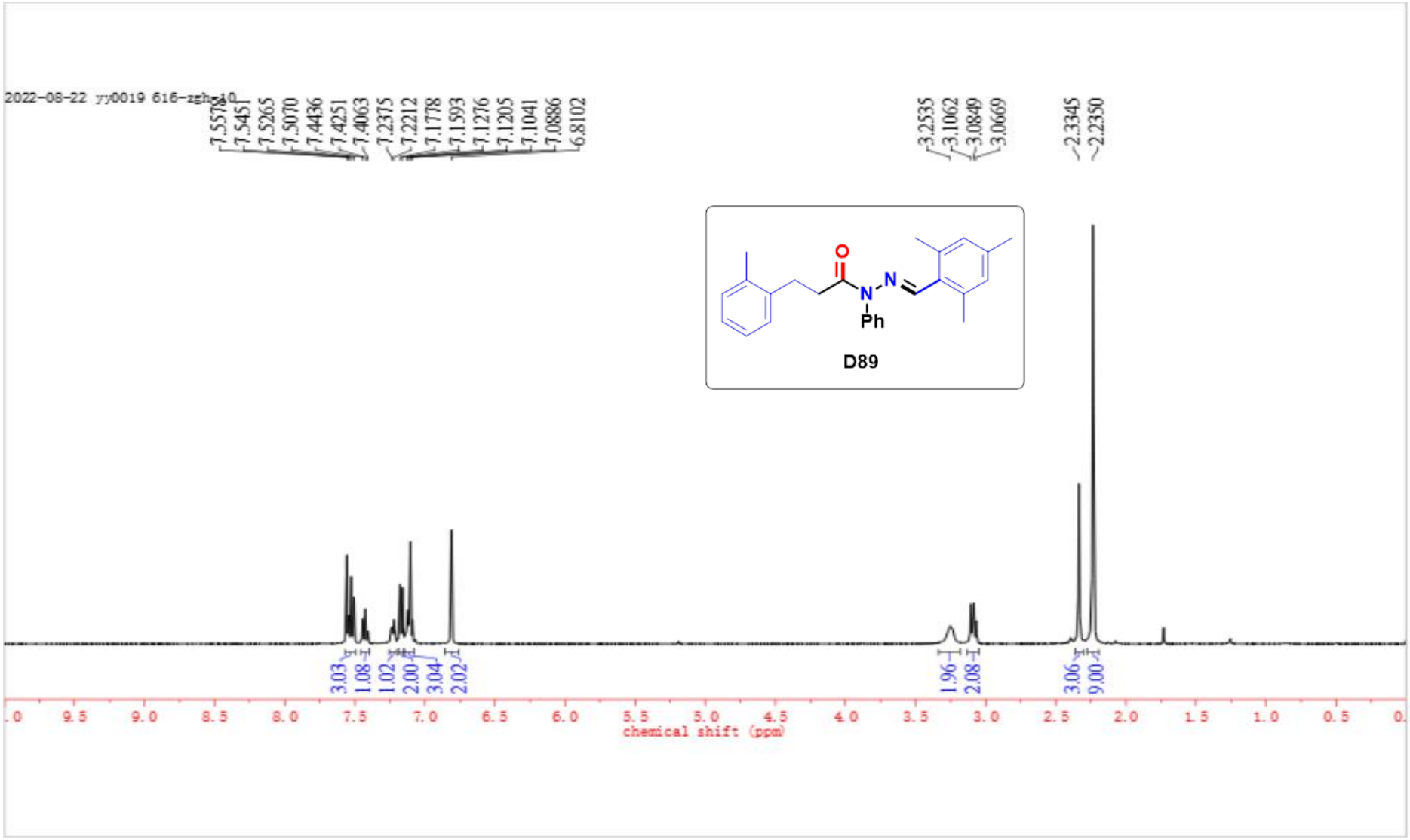

2022-08-29-YYD018-616-ZGH-15
174.39
142.20
139.47
137.56
136.31
134.04
132.56
131.51
130.40
130.21
129.19
128.83
128.21
127.39
126.46
126.20
123.67
77.59
77.27
76.95
34.46
28.79
19.57
O
N
N
Ph
Br
D86
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
chemical shift (ppm)

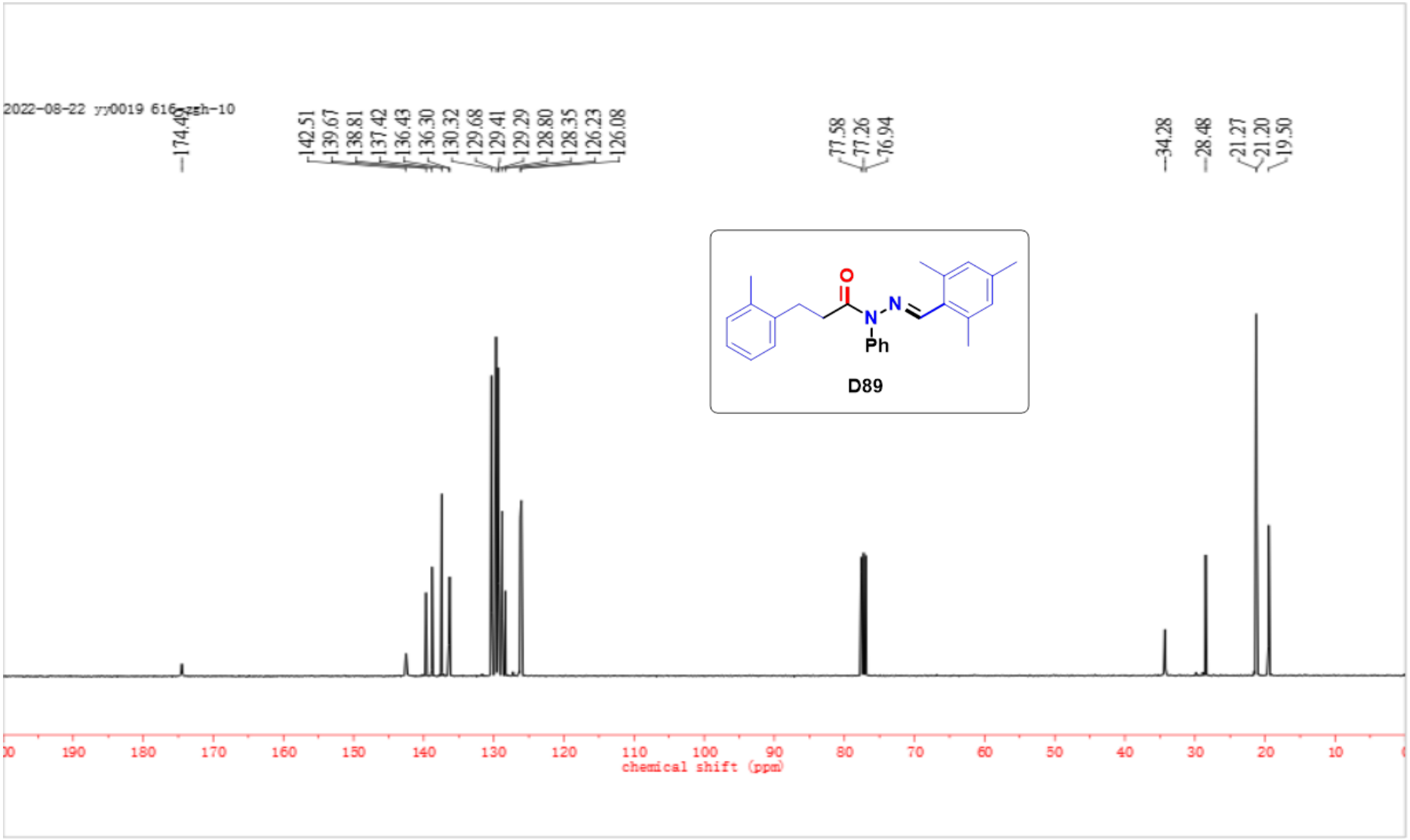

2022-08-29-YY0018-616-1H-16
7.6436
7.5506
7.5400
7.5312
7.5266
7.3194
7.3142
7.3063
7.3016
7.2738
7.2558
7.1552
7.1451
7.1405
7.0910
7.0693
6.8402
6.8184
5.1862
3.7413
3.2995
3.2820
3.2596
3.1231
3.1010
3.0828
2.3897
O
N
N
Ph
O
D87
0.99
2.05
3.06
1.07
3.00
2.03
2.03
2.00
3.04
2.06
2.07
3.06
chemical shift (ppm)

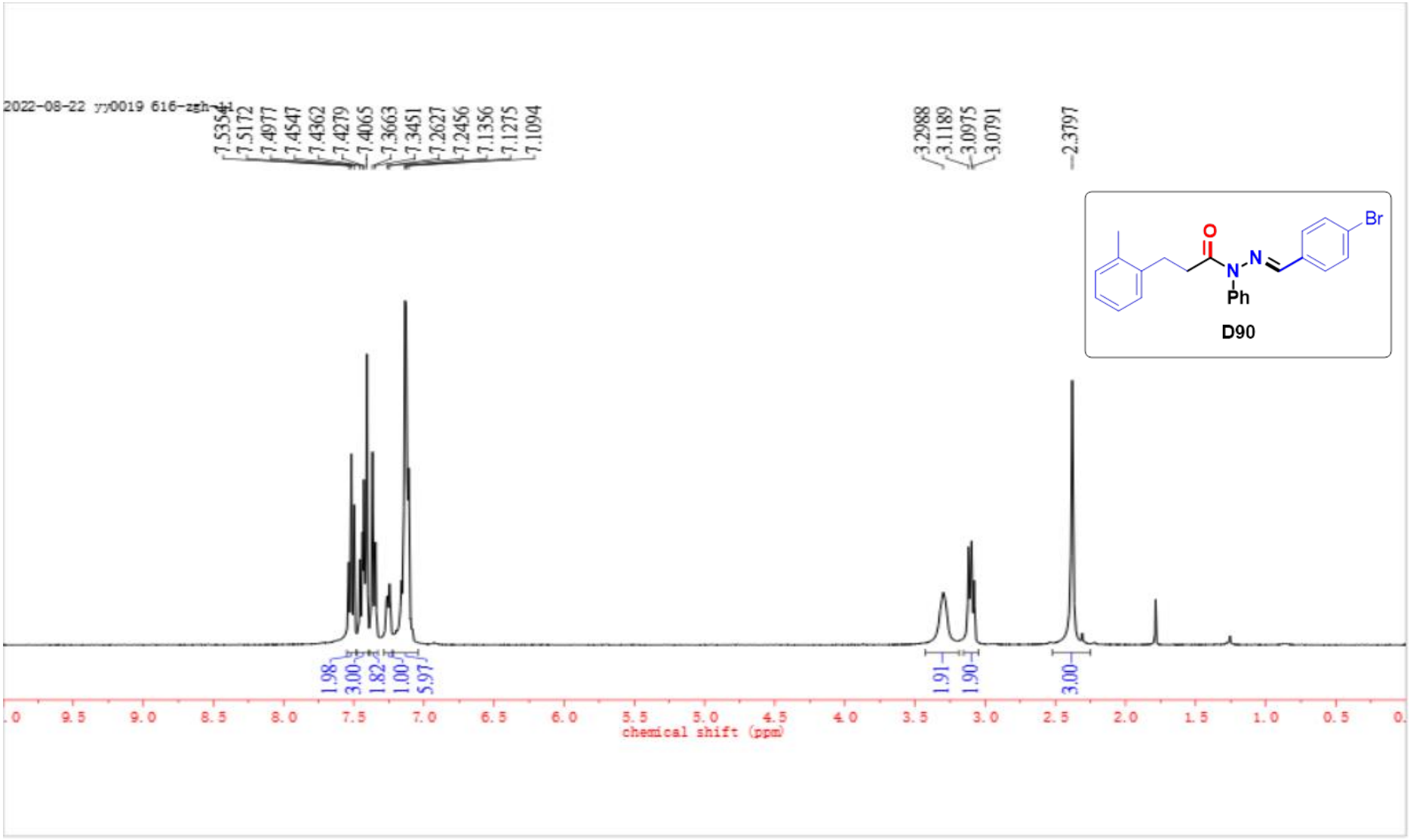

2022-08-29-YYD018-616-ZGH-16
174.89
158.88
140.02
136.28
134.68
130.33
129.74
129.02
128.71
127.84
127.16
127.10
126.31
114.41
77.49
77.17
76.86
55.31
44.22
34.14
29.00
19.52
O
N
N
Ph
O
D87
chemical shift (ppm)

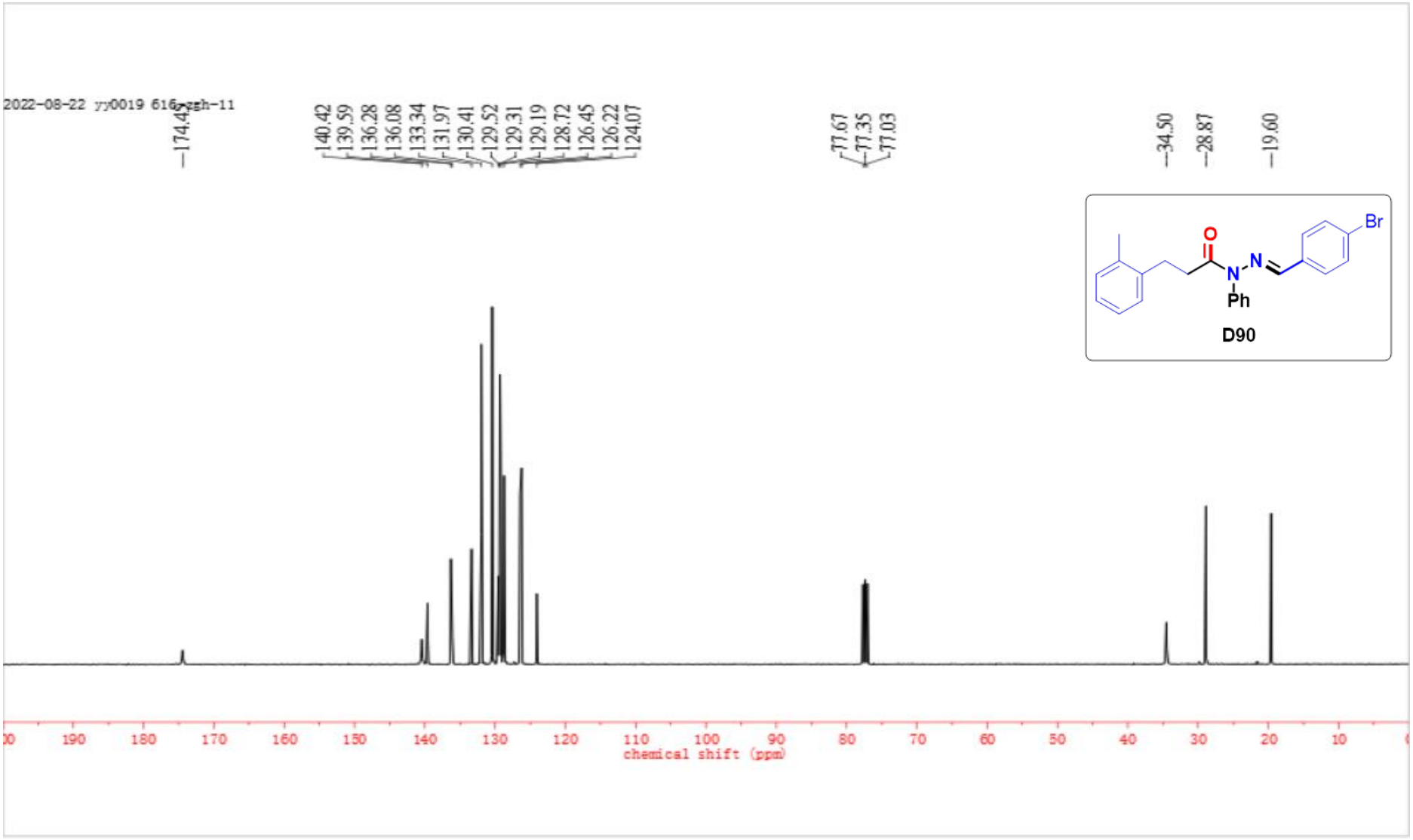

2022-08-22 yy0019 616-zgh-9
7.6715
7.6533
7.6374
7.5718
7.5539
7.4325
7.4171
7.3424
7.2745
7.2706
7.2542
3.4646
3.2804
3.2621
2.5400
2.4560
O
N
N
Ph
D88
2.08
3.02
1.03
1.02
7.00
1.98
2.01
2.91
2.95
chemical shift (ppm)

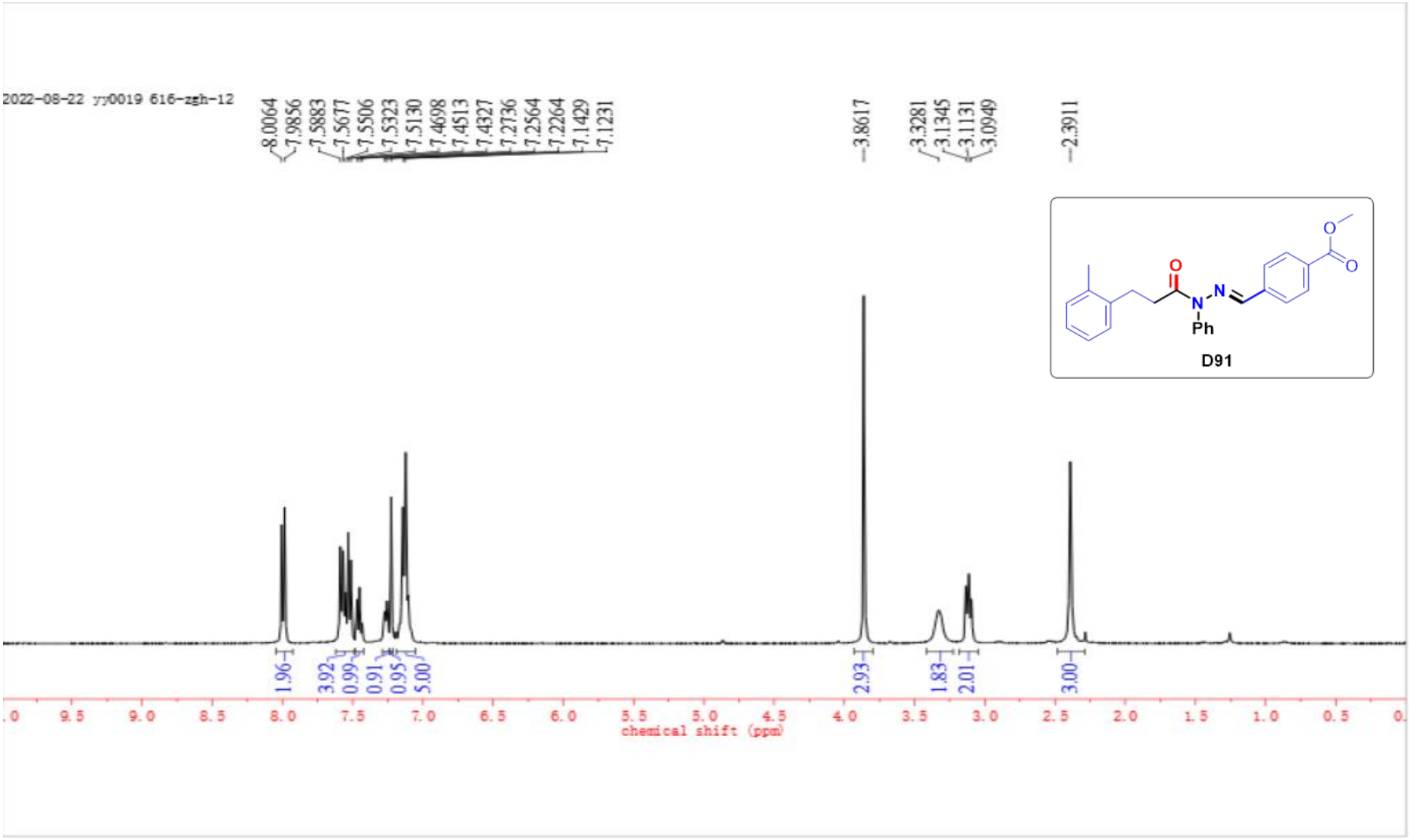

2022-08-22 yy0019 616_zgh-9
174.45
141.98
140.22
139.77
136.34
131.68
130.38
130.30
129.53
129.43
129.33
129.22
127.31
126.38
126.20
77.65
77.34
77.02
34.59
28.95
21.59
19.59
O
N
N
Ph
D88
chemical shift (ppm)

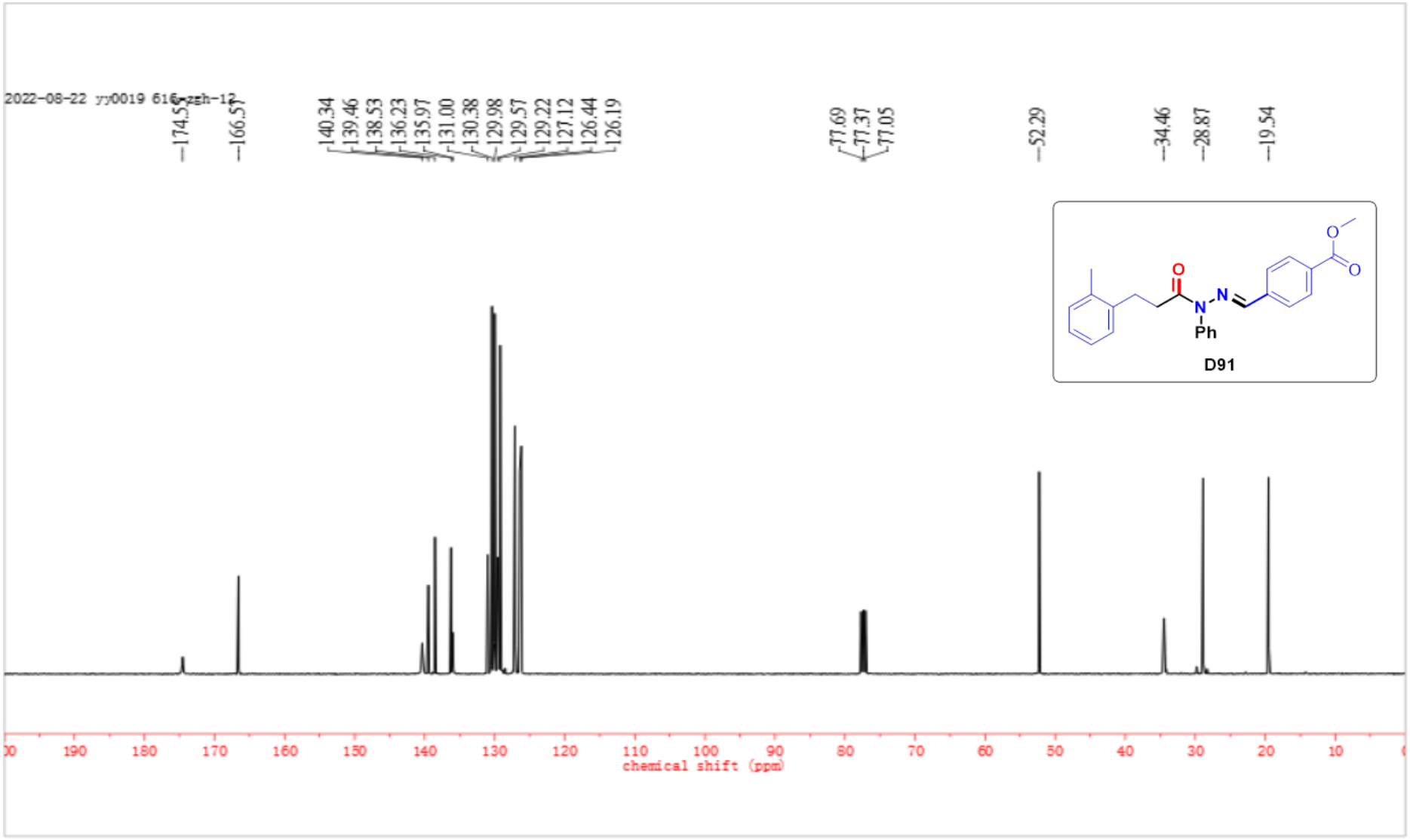

2022-08-22 yy0019 616-zgh-1D
7.5578
7.5451
7.5265
7.5070
7.4436
7.4251
7.4063
7.2375
7.2212
7.1778
7.1593
7.1276
7.1205
7.1041
7.0886
6.8102
3.2535
3.1062
3.0849
3.0669
2.3345
2.2350
O
N
N
Ph
D89
3.03
1.08
1.02
2.00
3.04
2.02
1.96
2.08
3.06
9.00
chemical shift (ppm)

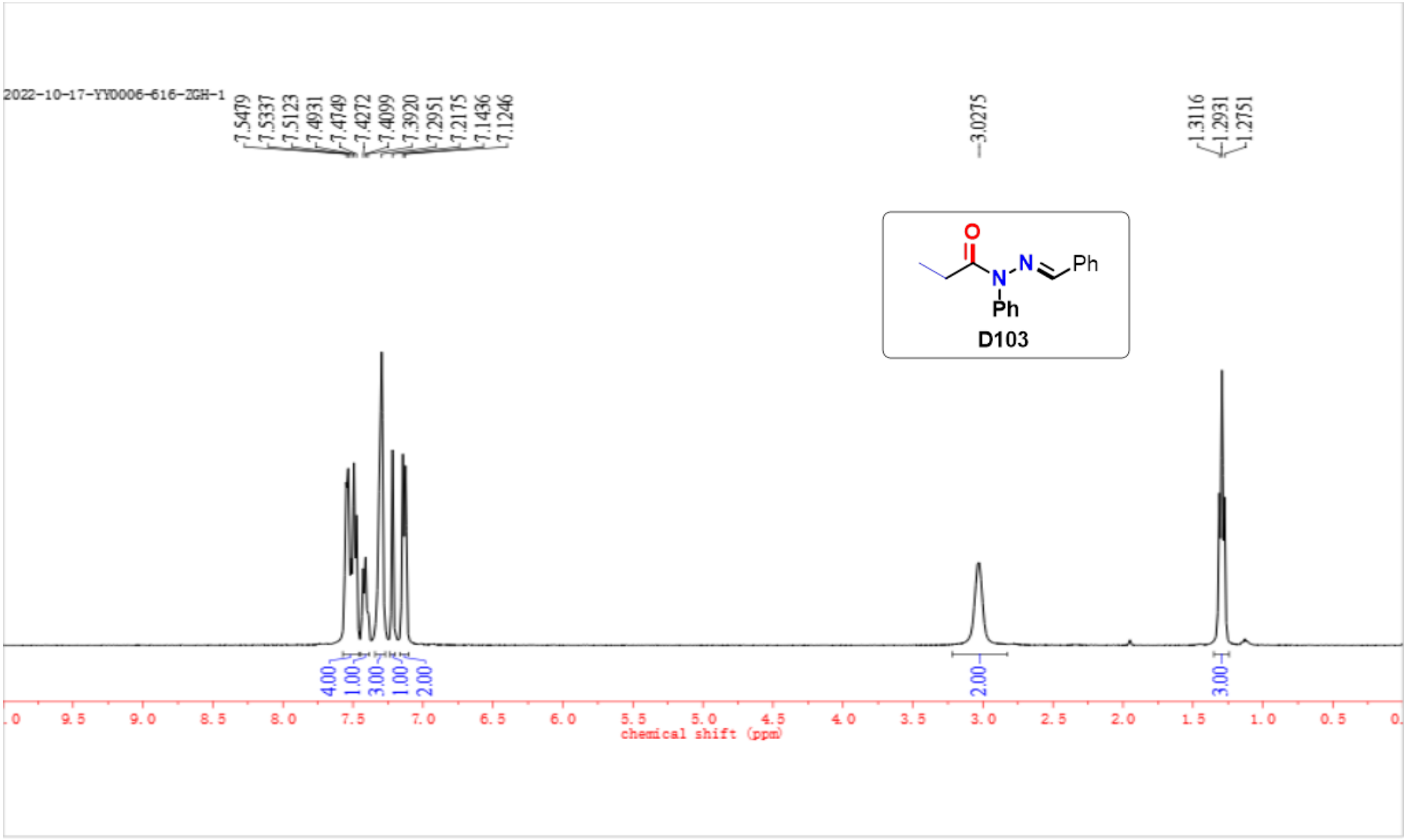

2022-08-22 yy0019 616 zgh-10
174.49
142.51
139.67
138.81
137.42
136.43
136.30
130.32
129.68
129.41
129.29
128.80
128.35
126.23
126.08
77.58
77.26
76.94
34.28
28.48
21.27
21.20
19.50
O
N
N
Ph
D89
chemical shift (ppm)

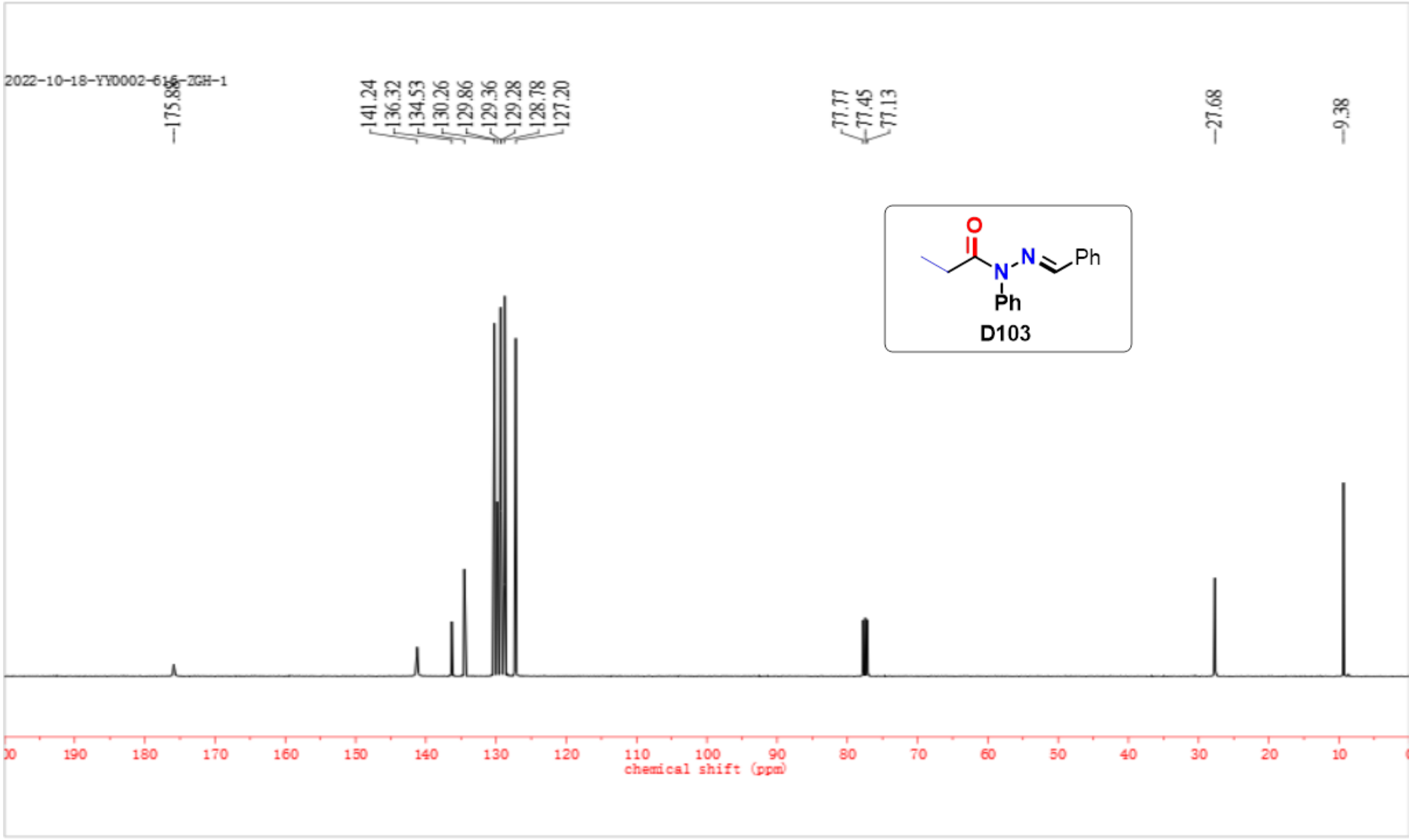

2022-08-22 yy0019 616-zgh-1
7.5354
7.5172
7.4977
7.4547
7.4362
7.4279
7.4065
7.3663
7.3451
7.2627
7.2456
7.1356
7.1275
7.1094
3.2988
3.1189
3.0975
3.0791
2.3797
Br
O
N
N
Ph
D90
1.98
3.00
1.82
1.00
5.97
1.91
1.90
3.00
chemical shift (ppm)


2022-08-22 yy0019 616 ygh-11
174.42
140.42
139.59
136.28
136.08
133.34
131.97
130.41
129.52
129.31
129.19
128.72
126.45
126.22
124.07
77.67
77.35
77.03
34.50
28.87
19.60
Br
O
N
N
Ph
D90
chemical shift (ppm)


2022-08-22 yy0019 616-zgh-12
8.0064
7.9856
7.5883
7.5677
7.5506
7.5323
7.5130
7.4698
7.4513
7.4327
7.2736
7.2564
7.2264
7.1429
7.1231
3.8617
3.3281
3.1345
3.1131
3.0949
2.3911
O
O
N
N
Ph
O
D91
1.96
3.92
0.99
0.91
0.95
5.00
2.93
1.83
2.01
3.00
chemical shift (ppm)


2022-08-22 yy0019 616-zgh-1H
174.55
166.57
140.34
139.46
138.53
136.23
135.97
131.00
130.38
129.98
129.57
129.22
127.12
126.44
126.19
77.69
77.37
77.05
52.29
34.46
28.87
19.54
O
O
N
N
Ph
O
D91
chemical shift (ppm)


2022-10-17-YYD006-616-ZGH-1
7.5479
7.5337
7.5123
7.4931
7.4749
7.4272
7.4099
7.3920
7.2951
7.2175
7.1436
7.1246
3.0275
1.3116
1.2931
1.2751
O
N
N
Ph
Ph
D103
4.00
1.00
3.00
1.00
2.00
2.00
3.00
chemical shift (ppm)


2022-10-18-YYD002-616-2GH-1
175.88
141.24
136.32
134.53
130.26
129.86
129.36
129.28
128.78
127.20
77.77
77.45
77.13
27.68
9.38
O
N
N
Ph
Ph
D103
chemical shift (ppm)