Acylmonofluoromethylation of Alkenes via Dual NHC/Photoredox Catalysis

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1. General information

General Experimental. Unless otherwise noted, all reactions were carried out under argon atmosphere in a glass tube with magnetic stirring. Analytical thin layer chromatography (TLC) was performed with EM Science silica gel 60 F254 aluminum plates. Visualization was performed under a UV lamp (254 nm). Organic solutions were concentrated by rotary evaporation at 23-35 °C. Purification of products were generally carried out by flash column chromatography with 200-300 mesh silica gel.

Materials. Alkenes **1a-v,** aroyl fluorides **2w, 2x, 2ac, 2ad,** and NHC catalysts **N10-36** were purchased from Leyan.com, Bide Pharmatech Ltd. and Energy Chemical and used as received. NHC catalysts **N1-9** were synthesized as previously methods reported.[1] Anhydrous solvents were purchased from J&K Scientific.

Instrumentation. Photocatalytic reactions were performed in a RLH-18 8-position photo reaction system, which was manufactured by Beijing Rogertech Co. Ltd (Figure S1). Proton nuclear magnetic resonance spectra (^{1}H NMR) spectra, carbon nuclear magnetic resonance spectra (^{13}C NMR) and fluorine nuclear magnetic resonance spectra (^{19}F NMR, decoupled) were recorded at 23 °C on a Bruker 400 spectrometer in $CDCl_3$, or CD_3OD (400 MHz for ^{1}H and 101 MHz for ^{13}C and 376 MHz for ^{19}F), Bruker

[1] Piel, I.; Pawelczyk, M. D.; Hirano, K.; Fröhlich, R.; Glorius, F. A Family of Thiazolium Salt Derived *N*-Heterocyclic Carbenes (NHCs) for Organocatalysis: Synthesis, Investigation and Application in Cross-Benzoin Condensation. *Eur. J. Org. Chem.* **2011**, *2011*, 5474-5484.

500 spectrometer in $CDCl_3$ (500 MHz for ^1H and 126 MHz for ^{13}C) and Bruker 600 spectrometer in $CDCl_3$ or CD_3OD (600 MHz for ^1H and 151 MHz for ^{13}C). Chemical shifts for protons were reported as parts per million in δ scale using solvent residual peak ($CHCl_3$: 7.26 ppm and CD_3OD: 3.31 ppm) or tetramethylsilane (0.00 ppm) as internal standards. Chemical shifts of ^{13}C NMR spectra were reported in ppm from the central peak of $CDCl_3$ (77.16 ppm) and CD_3OD (49.00 ppm) on the δ scale. Data are represented as follows: chemical shift, integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), and coupling constant (*J*, Hz). High resolution mass spectra (HRMS) were obtained on a Micromass QTOF2 Quadrupole/Time-of-Flight Tandem mass spectrometer using electron spray ionization (ESI). GC-MS spectra were recorded on Agilent Intuvo 9000/5977B GC/MS using electron ionization (EI) source. EPR was performed on a Bruker A300.

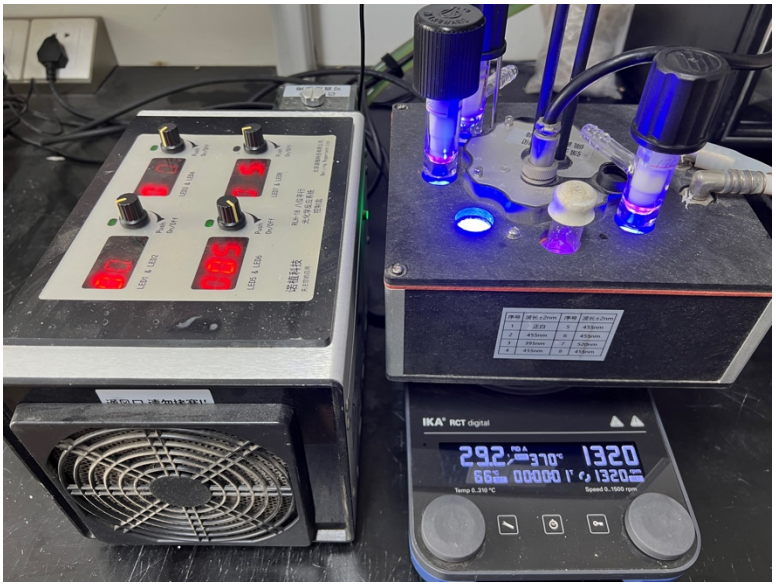
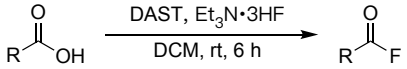


Figure S1. The photoreaction device

2. General procedure (A) for the synthesis of aroyl fluorides from carboxylic acid[2]



To a round-bottom flask was charged with diethylaminodifluorosulfinium tetrafluoroborate (DAST, 6.0 mmol, 1.5 equiv.) and carboxylic acid (4.0 mmol, 1.0 equiv.) in anhydrous DCM (5 mL/mmol substrate) at room temperature. Then Et_3N•3HF (4 mmol, 1.0 equiv.) was added and the reaction mixture was continued stirring at room temperature for 6 h. The reaction was quenched with a 5% $NaHCO_3$ solution and extracted with DCM. The combined organic layers were dried over Na_2SO_4, filtered and dried in vacuo. The crude residue was purified by column chromatography on silica gel to afford the aroyl fluorides.

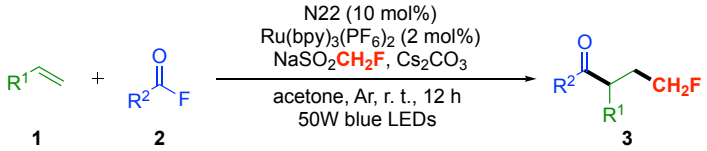
3. General procedure for acyl-monofluoromethylation

(1) General procedure (**B**) for optimizations to preparing product **3a**

[2] Han, J.; Zhou, W.; Zhang, P.-C.; Wang, H.; Zhang, R.; Wu, H.-H.; Zhang, J. Design and Synthesis of WJ-Phos, and Application in Cu-Catalyzed Enantioselective Boroacylation of 1,1-Disubstituted Allenes. *ACS Catal.* **2019**, *9*, 6890-6895.

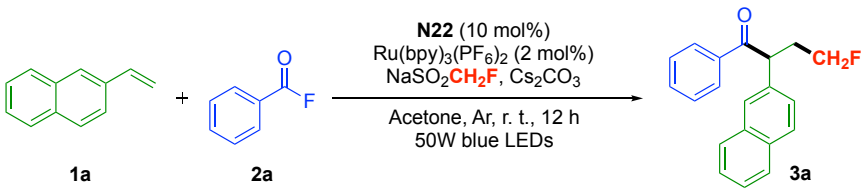
In a glove box, to a glass tube equipped with a magnetic stir bar was added 2-vinylnaphthalene **1a** (0.15 mmol, 1.0 equiv.), benzoyl fluoride **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), NHC catalyst (10 mol%), photocatalysts (2 mol%), base (0.3 mmol, 2.0 equiv.), and solvent (1.5 mL). The tube was tightly sealed and brough out. The reaction was allowed to stir at for 12 h under 50 W blue LED irradiation with argon atmosphere. After that, the mixture was diluted with diethyl ether, washed with water. The combined organic fractions were dried over Na_2SO_4, concentrated under reduced pressure and purified by column chromatography on silica gel (hexane/EtOAc) to afford the desired product **3a**.

(2) General procedure (**C**) for the acylmonofluoromethylation to preparing products **3**



In a glove box, to a glass tube equipped with a stir bar was charged alkenes **1** (0.3 mmol, 1.0 equiv.), acyl fluorides **2** (0.6 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.6 mmol, 2.0 equiv.), NHC catalyst **N22** (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.6 mmol, 2.0 equiv.), and acetone (3 mL). The tube was capped and brought out. The reaction mixture was then stirred at room temperature for 12 h under 50 W blue LED irradiation with argon atmosphere. The mixture was diluted with diethyl ether, washed with water. The combined organic fractions were dried over Na_2SO_4, concentrated under reduced pressure and purified by column chromatography on silica gel (hexane/EtOAc) to afford the desired product **3a-3ar**.

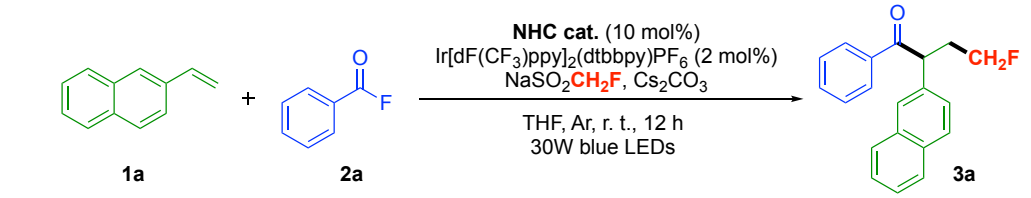
(3) Scale-up synthesis of the product **3a**

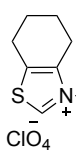


In a glovebox, to a flame-dried 100 mL round-bottom flask were added 2-vinylnaphthalene **1s** (1 mmol, 1.0 equiv.), benzoyl floride **2a** (2.0 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (2.0 mmol, 2.0 equiv.), NHC catalyst **N22** (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), Cs_2CO_3 (2.0 mmol, 2.0 equiv.), and acetone (10 mL). And then resulting suspension stirred at room temperature for 12 h under 50 W blue LED irradiation with argon atmosphere, after which the reaction mixture was diluted with diethyl ether and washed with water. The separated organic layers were dried, concentrated under reduced pressure and the resulting crude material was purified by column chromatography on silica gel (hexane: ethyl acetate = 100: 1) to afford **3a** (195.4 mg) as yellow oil in 67% yield.

4. Optimization studies for the formation of 3a

Table S1. Screening of NHC catalysts.[a]

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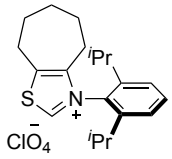
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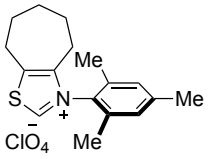
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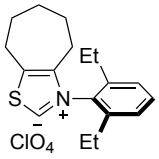
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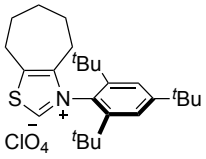
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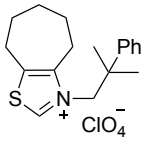
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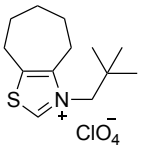
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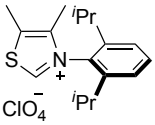
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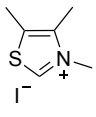
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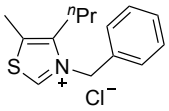
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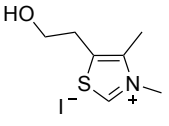
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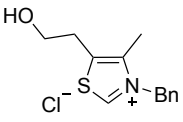
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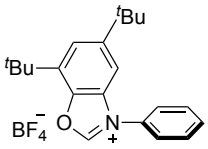
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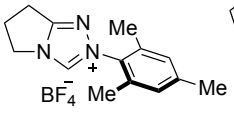
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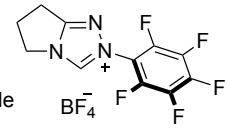
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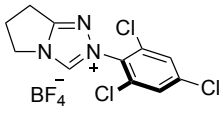
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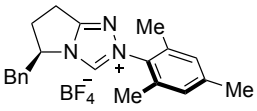
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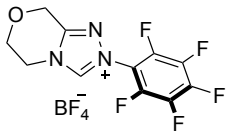
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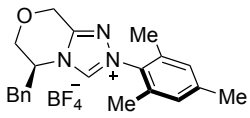
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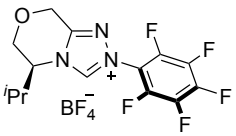
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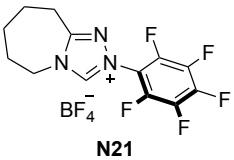
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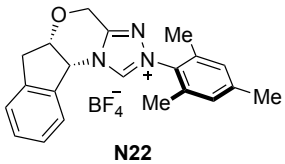
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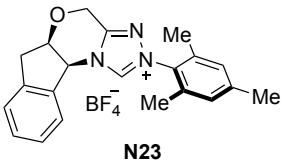
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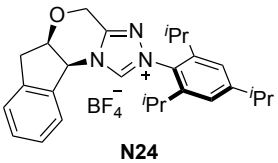
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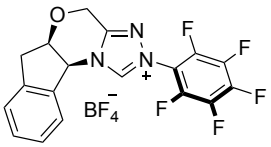
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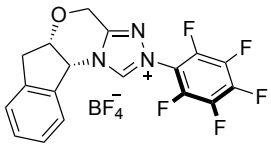
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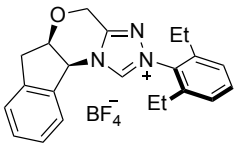
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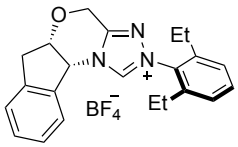
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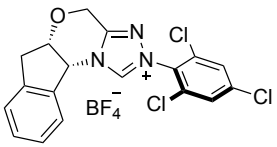
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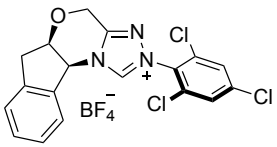
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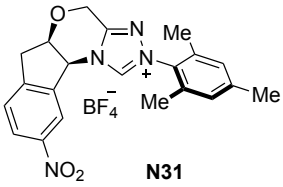
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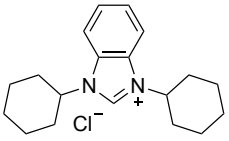
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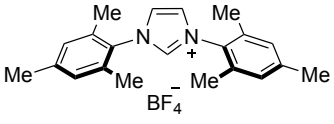
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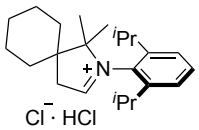
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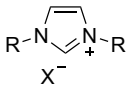
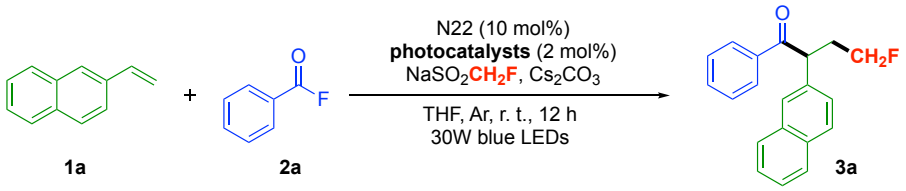

N35: R = Me, X = I
N36: R = cyclohexyl, X = BF_4

Entry	NHC catalysts	Isolated yield
1	N1	11%
2	N2	11%
3	N3	9%
4	N4	11%
5	N5	N. R.[b]
6	N6	10%
7	N7	16%
8	N8	27%
9	N9	14%
10	N10	27%
11	N11	27%
12	N12	27%
13	N13	23%
14	N14	40%
15	N15	34%
16	N16	42%
17	N17	34%
18	N18	29%
19	N19	39%
20	N20	23%
21	N21	31%
22	**N22**	**53%**
23	N23	42%
24	N24	45%
25	N25	44%
26	N26	43%
27	N27	43%
28	N28	45%
29	N29	35%
30	N30	37%
31	N31	41%
32	N32	26%
33	N33	34%
34	N34	28%
35	N35	19%
36	N36	20%

[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), NHC catalyst (10 mol%), $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), THF (1.5 mL), r. t., Ar, 12 h, 30W blue LEDs; [b] N. R. = no reaction

Table S2. Screening of photocatalysts[a]



Entry	Photocatalysts	Isolated yield
1	$Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$	53%
2	$Ir(ppy)_2(dtbbpy)PF_6$	44%
3	$Ir(ppy)_3$	33%
4	$Ir[dF(Me)ppy]_2(phen)PF_6$	45%
5	$Ru(dtbbpy)_3(PF_6)_2$	42%
6	**$Ru(bpy)_3(PF_6)_2$**	**63%**
7	$Ru(phen)_3(PF_6)_2$	47%
8	$Ru(phen)_3Cl_2•H_2O$	47%
9	Mes-$Acr^+ClO_4^-$	N.R.[b]
10	4-CzIPN	38%
11	3CzEPAIPN[c]	49%
12	TBADT	8%
13	Eosin Y	46%
14	Fluorescein	9%
15	Rhodamine B	3%
16	Rhodamine 6G	8%
17	Perylene	18%
18	2,4,6-triphenylpyrylium tetrafluoroborate	2%
19	10-phenyl-10*H*-phenothiazine	4%
20	AQDS[d]	21%
21	$[(^tBu)_2$Mes-PhAcr$]BF_4$	N.R.[b]
22	Rose bengal	46%

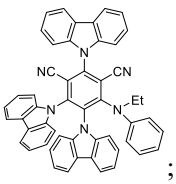
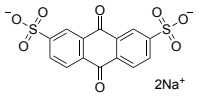
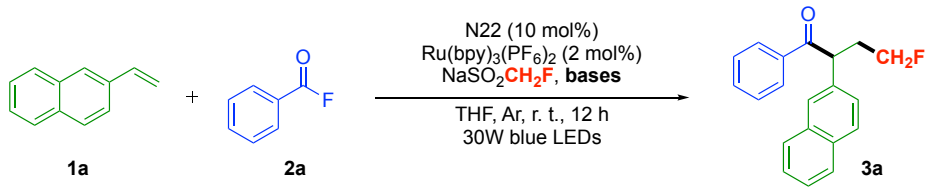
[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), N22 (10 mol%), photocatalyst (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), THF (1.5 mL), r. t., Ar, 12 h, 30W blue LEDs; [b] N. R. = no reaction; [c] 3CzEPAIPN:  ; [d] AQDS: 

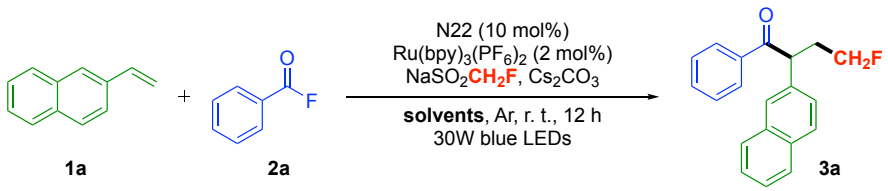
Table S3. Screening of bases[a]



Entry	Bases	Isolated yield
1	Na_2CO_3	42%
2	K_2CO_3	45%
3	Rb_2CO_3	52%
4	**Cs_2CO_3**	**63%**
5	CsOAc	32%
6	CsF	33%
7	KOAc	34%
8	DMAP	5%
9	Et_3N	19%
10	DBU	24%
11	Tetramethylguanidine	10%
12	Proton sponge	48%

[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), N22 (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), bases (0.3 mmol, 2.0 equiv.), THF (1.5 mL), r. t., Ar, 12 h, 30W blue LEDs.

Table S4. Optimization of solvents[a]

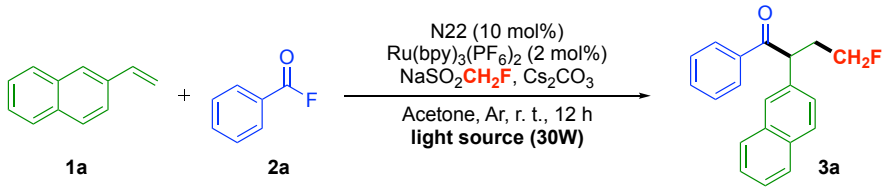


Entry	Solvents	Isolated yield
1	DCM	38%
2	DCE	51%
3	CH_3CN	47%
4	Toluene	31%
5	THF	63%
6	Dioxane	23%
7	DMF	30%
8	DMSO	41%
9	NMP	33%
10	$PhCF_3$	34%
11	CH_3NO_2	12%
12	**Acetone**	**68%**
13	THF: DMF = 3:1	49%

14	THF: Acetone = 1:1	56%
15	THF: Acetone = 3:1	53%
16	THF: Acetone = 1:3	62%

[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), N22 (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), solvent (1.5 mL), r. t., Ar, 12 h, 30W blue LEDs.

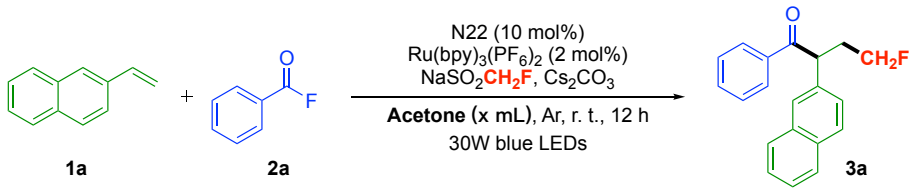
Table S5. Screening of light source[a]



Entry	Light source	Isolated yield
1	**Blue (455 nm)**	**68%**
2	Purple (390 nm)	34%
3	Green (520 nm)	39%
4	CFL	49%

[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), N22 (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), acetone (1.5 mL), r. t., Ar, 12 h, light source (30W).

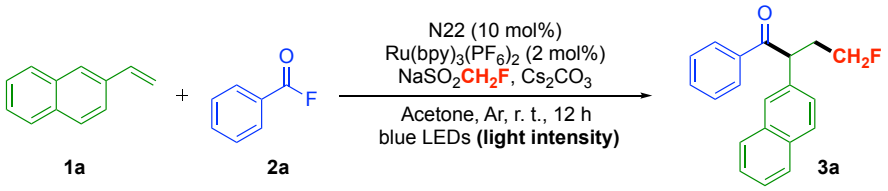
Table S6. Screening of reaction concentration[a]



Entry	Acetone (x mL)	Isolated yield
1	1 mL	62%
2	**1.5 mL**	**68%**
3	2 mL	61%
4	3 mL	57%
5	4 mL	55%

[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), N22 (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), acetone (x mL), r. t., Ar, 12 h, 30W blue LEDs.

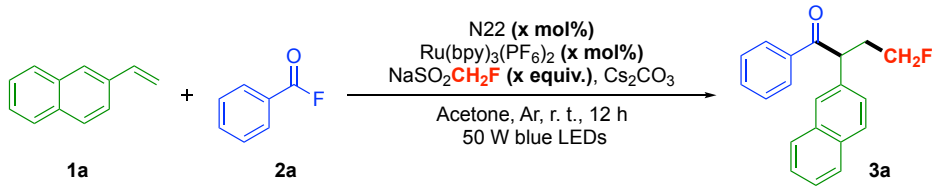
Table S7. Screening of light intensity[a]



Entry	Light intensity	Isolated yield
1	5 W	52%
2	20 W	65%
3	30 W	68%
4	40 W	70%
5	**50 W**	**73%**
6	60 W	71%

[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), N22 (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), acetone (1.5 mL), r. t., Ar, 12 h, blue LEDs.

Table S8. Screening of equivalents of N22, $Ru(bpy)_3(PF_6)_2$ and $NaSO_2CH_2F$[a]



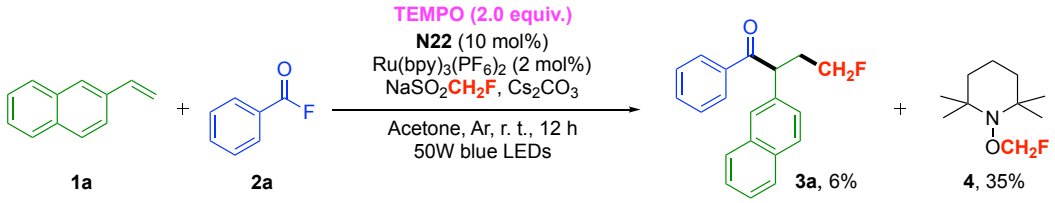
Entry	N22 (x mol%)	$NaSO_2CH_2F$ (x equiv.)	$Ru(bpy)_3(PF_6)_2$ (x mol%)	Isolated yield
1	5	2.0	2	34%
2	20	2.0	2	66%
3	10	1.5	2	60%
4	10	2.5	2	65%
5	10	2.0	1	69%
6	10	2.0	3	68%
7	**10**	**2.0**	**2**	**73%**

[a] Reaction conditions: **1a** (0.15 mmol, 1.0 equiv.), **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (x equiv.), N22 (x mol%), $Ru(bpy)_3(PF_6)_2$ (x mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), acetone (1.5 mL), r. t., Ar, 12 h, blue LEDs.

5. Mechanistic studies

(1) Radical trapping experiment

a. Addition of TEMPO (2.0 equiv.) suppressed the transformation, and the desired product **3a** was obtained in 6% yield. TEMPO-CH_2F **4** adduct was detected in 35% yield by GCMS analysis (Figure S2).



According to the general procedure **C**, 2-vinylnaphthalene **1a** (0.15 mmol, 1.0 equiv.), benzoyl fluoride **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), NHC catalyst **N22** (10 mol%), $Ru(bpy)_2(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), TEMPO (0.3 mmol, 2.0 equiv.) and acetone (1.5 mL) at room temperature for 12 h under 50 W blue LED irradiation with argon atmosphere. The reaction mixtures were analyzed by GCMS with *n*-dodecane as the internal standard.

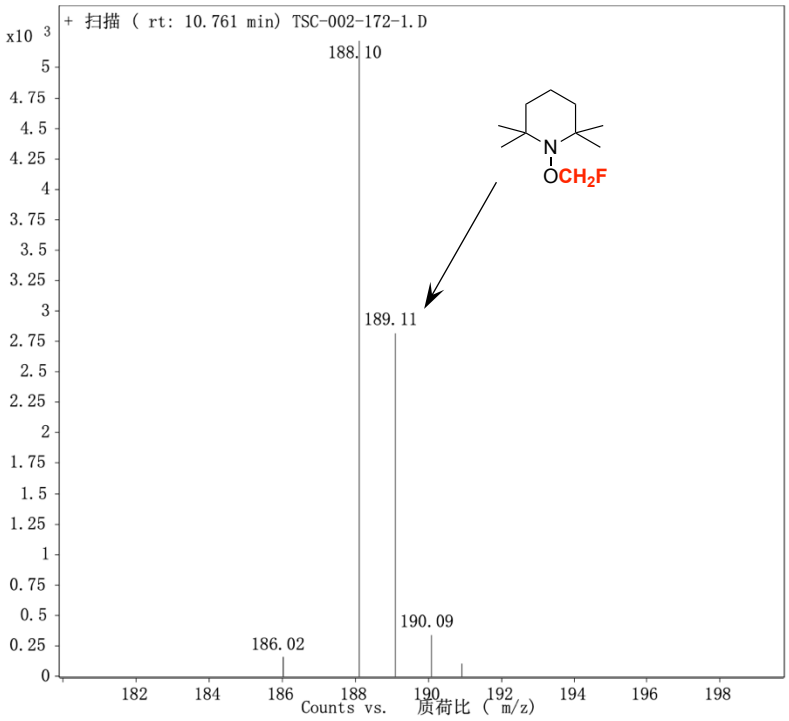
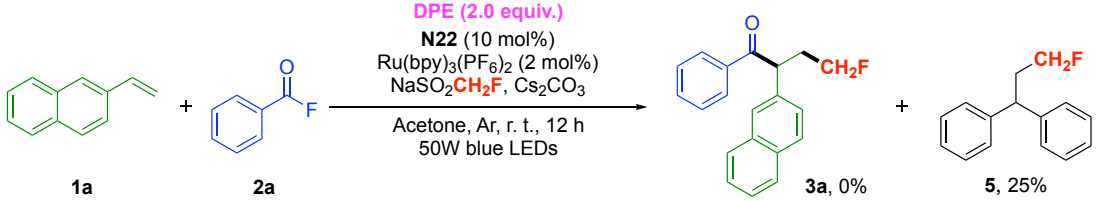


Figure S2. GC result of radical trapping experiment by TEMPO

b. Addition of diphenyl ethylene (DPE, 2.0 equiv.) completely shut down the desired transformation. The DPE trapping adduct **5** was obtained in 25% isolated yield.



According to the general procedure C, 2-vinylnaphthalene **1a** (0.15 mmol, 1.0 equiv.), benzoyl fluoride **2a** (0.3 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.3 mmol, 2.0 equiv.), NHC catalyst **N22** (10 mol%),

$Ru(bpy)_2(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.3 mmol, 2.0 equiv.), DPE (0.3 mmol, 2.0 equiv.) and acetone (1.5 mL) at room temperature for 12 h under 50 W blue LED irradiation with argon atmosphere. The reaction mixtures were analyzed by GCMS with *n*-dodecane as the internal standard, and the product **5** was isolated by chromatography on silica gel (hexane: ethyl acetate = 250: 1) in 25% yield.

(2) EPR experiment

EPR spectra were recorded on a Bruker A300. Microcapillary with inner diameter 1 mm was used for analysis. The EPR instrumental settings was as follows: field sweep, 80G; microwave frequency, 9.85 GHz; microwave power, 2.22×10^{-1} mW; modulation amplitude, 0.8 G; conversion time 40 ms; time constant, 81.92 ms; sweep time 40.96 s; receiver gain, 1×10^4; resolution, 1024 points.

a. Procedure: In glovebox, to an oven-dried reaction tube equipped with $NaSO_2CH_2F$ (0.1 mmol, 1.0 equiv.), $Ru(bpy)_2(PF_6)_2$ (2 mol%), PBN (*N*-benzylidene-*tert*-butylamineoxide) (0.2 mmol, 2.0 equiv.), acetone (1.0 mL) and a stir bar. The reaction mixture was brought out and stirred at room temperature for 30 min under 50 W blue LED irradiation with argon atmosphere and then rapid sampling analyzed by EPR (Figure S3).

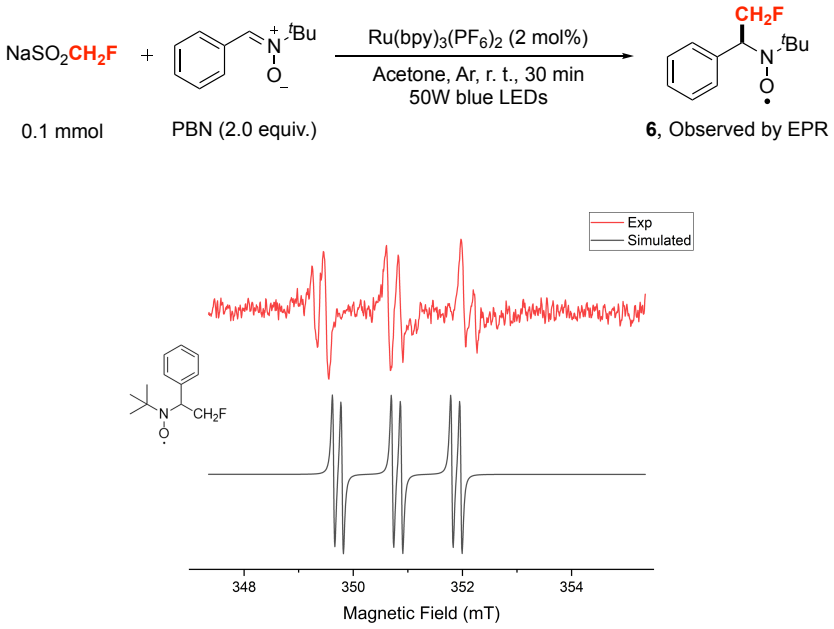


Figure S3. The X-band EPR spectrum (red line) of the radical **6** (a_N = 13.7 G, a_H = 2.1 G, g factor = 2.0064). The DFT simulated spectrum (black line) of the radical **6** based on hyperfine coupling constants of a_N = 12.2 G, a_H = 1.8 G and g factor = 2.0056.

b. Procedure: In glovebox, to an oven-dried reaction tube equipped with styrene (0.1 mmol, 1.0 equiv.), $NaSO_2CH_2F$ (0.1 mmol, 1.0 equiv.), $Ru(bpy)_2(PF_6)_2$ (2 mol%), PBN (*N*-benzylidene-tertbutylamineoxide) (0.2 mmol, 2.0 equiv.), acetone (1.0 mL) and a stir bar. The reaction mixture was brought out and stirred at room temperature for 30 min under 50 W blue LED irradiation with argon atmosphere and then rapid sampling analyzed by EPR (Figure S4).

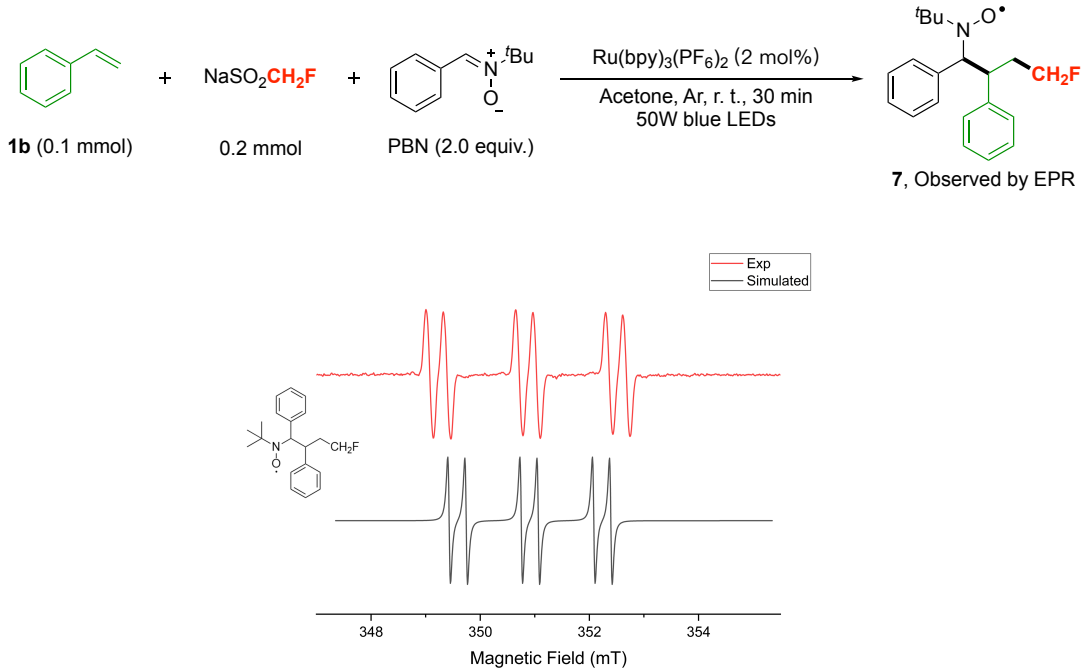
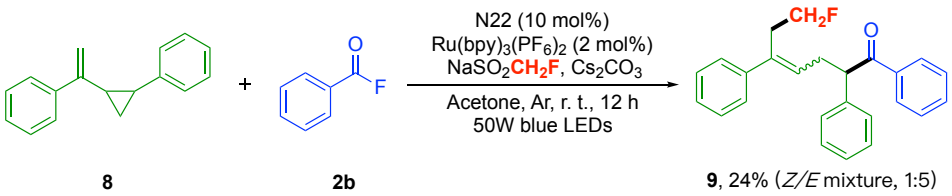


Figure S4. The X-band EPR spectrum (red line) of the radical **7** (a_N = 14.3 G, a_H = 2.8 G, g factor = 2.0062). The DFT simulated spectrum (black line) of radical **7** based on hyperfine coupling constants of a_N = 13.3 G, a_H = 3.2 G and g factor = 2.0058.

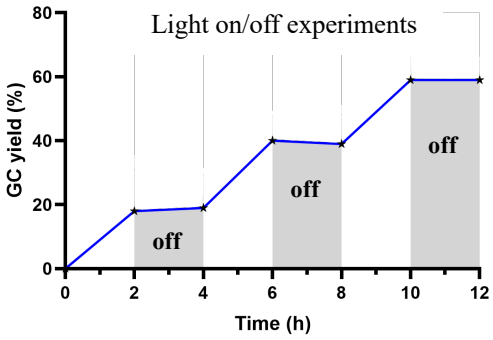
(3) Radical clock experiment

Radical clock probe **8** (0.3 mmol) underwent radical addition, ring-opening and radical cross-coupling, and the expected product **9** was isolated and purified by column chromatography on silica gel (hexane: EtOAc = 50: 1) in 24% yield as a mixture of *Z/E* stereoisomers with a ratio of 1:5. This strongly demonstrated that a radical pathway involved in the difunctionalization process.



(4) Light on/off experiments

Standard reactions were set up parallelly on a 0.3 mmol scale according to the general procedure for the preparation of **3a**. Yield was then determined by GCMS with *n*-dodecane as the internal standard. The reaction was irradiated with blue LEDs and kept in the dark in 2 h intervals at room temperature. The white area represents the light irradiation, while the grey area indicates time light-off. The reaction proceeded smoothly under the irradiation of blue LEDs, but no further transformation was observed without the light irradiation, showcasing that light is a necessary component for this catalytic reaction (Figure S5).

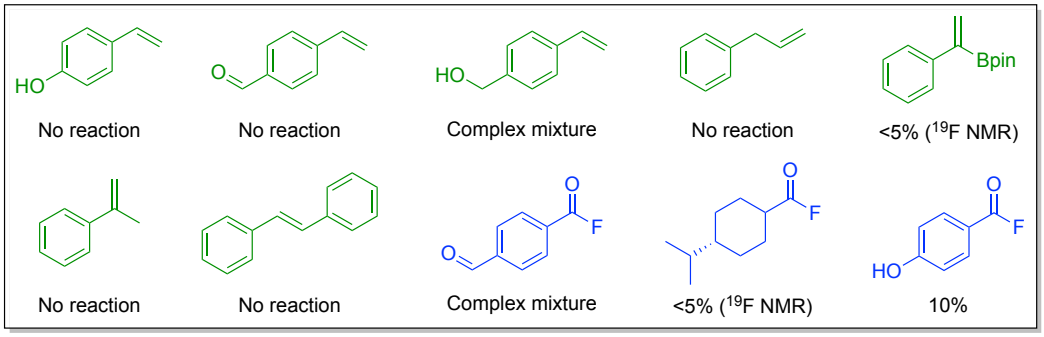


Time (h)	Light on/off	Yield (%)
0	-	0
2	on	18
4	off	19
6	on	40
8	off	39
10	on	59
12	off	59

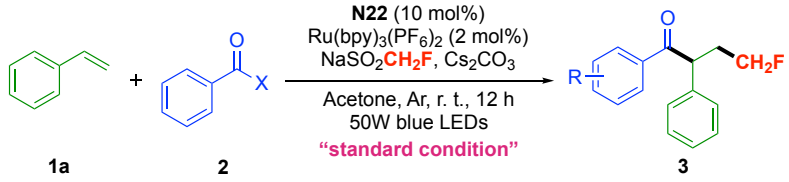
Figure S5. GC yield line chart of compound **3a** during light on-off experiments

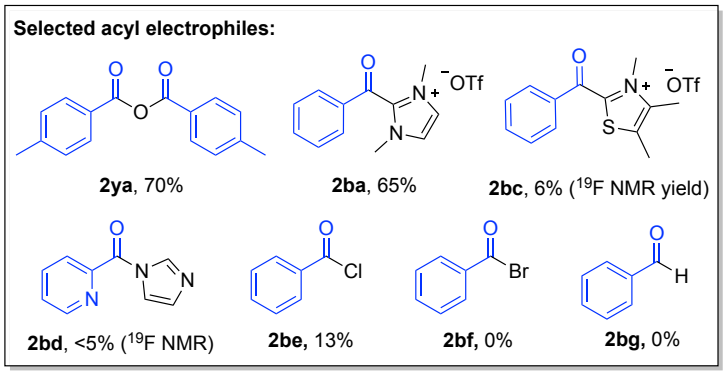
6. Scope studies: less reactive substrates

The following compounds were employed using general procedure **C** and were analyzed by ^{19}F NMR using as an internal standard.



7. Acyl electrophile experiments



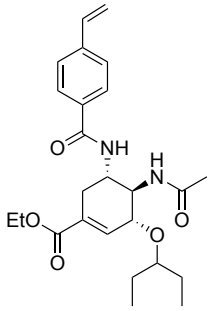


According to the general procedure **C**: In a glove box, to a glass tube equipped with a stir bar was charged styrene **1a** (0.3 mmol, 1.0 equiv.), acyl electrophiles **2** (0.6 mmol, 2.0 equiv.), $NaSO_2CH_2F$ (0.6 mmol, 2.0 equiv.), NHC catalyst **N22** (10 mol%), $Ru(bpy)_3(PF_6)_2$ (2 mol%), Cs_2CO_3 (0.6 mmol, 2.0 equiv.), and acetone (3 mL). The tube was capped and brought out. The reaction mixture was then stirred at room temperature for 12 h under 50 W blue LED irradiation with argon atmosphere. The mixture was

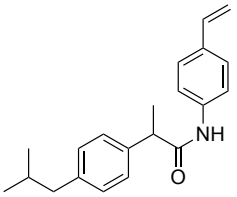
diluted with diethyl ether, washed with water. The combined organic fractions were dried over Na_2SO_4, concentrated under reduced pressure and purified by column chromatography on silica gel (hexane/EtOAc) to afford the desired product.

Acetic anhydride **2ya**, acyl imidazolium salt **2ba** were successfully yield the difunctionalized product of styrene in 70% and 65% isolated yield respectively, which demonstrated that these two compounds were possible intermediate in the transformation process. Meanwhile, acyl thiazolium salt **2bc**, acyl imidazole **2bd** and acyl chloride **2be** showcased a relatively low reaction efficiency, and acyl bromide **2bf** and benzaldehyde **2bg** were not the appropriate substrate to achieve the catalytic reaction.

8. Synthesis of substrates and characterization data

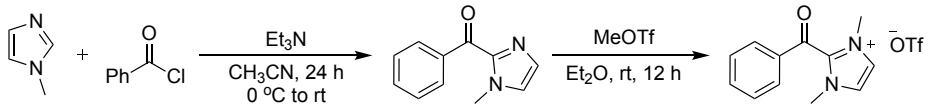


1al: Ethyl (3*R*,4*R*,5*S*)-4-acetamido-3-(pentan-3-yloxy)-5-(4-vinylbenzamido)cyclohex-1-ene-1-carboxylate. A solution of Oseltamivir phosphate (2 mmol, 1.0 equiv.), 4-vinylbenzoic acid (2.4 mmol, 1.2 equiv.), HATU (2.4 mmol, 1.2 equiv.) and Et_3N (8 mmol, 4.0 equiv.) in DCM (30 mL) was stirred at room temperature for 12 h. The reaction mixture was quenched with water and extracted with DCM. The separated organic layers were evaporated to dryness and the resulting residue was purified by column chromatography (hexane: ethyl acetate = 10: 1) to afford compound **1al** as white solid (772 mg, 87% yield). **^{1}H NMR (400 MHz, MeOD-*d*$_4$):** δ 7.75 -7.73 (m, 2H), 7.52 – 7.50 (m, 2H), 6.83 – 6.75 (m, 2H), 5.89 (dd, *J* = 17.6, 0.6 Hz, 1H), 5.35 (dd, *J* = 11.0, 0.6 Hz, 1H), 4.34 – 4.19 (m, 4H), 4.09 – 4.04 (m, 1H), 6.45 (pent. 1H), 2.81 – 2.75 (m, 1H), 2.49 – 2.41 (m, 1H), 1.86 (s, 3H), 1.58 – 1.48 (m, 4H), 1.29 (t, *J* = 7.1 Hz, 3H), 0.94 (t, *J* = 7.4 Hz, 3H), 0.88 (t, *J* = 7.4 Hz, 3H) ppm; **^{13}C NMR (151 MHz, MeOD-*d*$_4$):** δ 174.0, 169.8, 167.5, 142.3, 139.1, 137.2, 134.6, 130.4, 128.7, 127.3, 116.4, 83.9, 77.0, 62.1, 55.9, 50.0, 31.3, 27.4, 26.9, 22.8, 14.5, 9.89, 9.68 ppm.

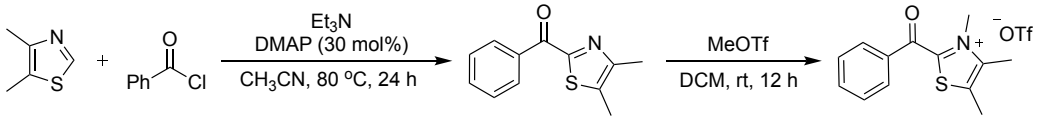


1ao: 2-(4-isobutylphenyl)-N-(4-vinylphenyl)propenamide. A solution of Ibuprofen (2 mmol, 1.0 equiv.), 4-vinylaniline (2.2 mmol, 1.1 equiv.), EDC (4 mmol, 2 equiv.), and DMAP (0.2 mmol, 0.1 equiv.) in DCM (20 mL) was stirred at room temperature for 12 h. The reaction mixture was quenched with water and extracted with DCM. The separated organic layers were evaporated to dryness and the resulting residue was purified by column chromatography (hexane: ethyl acetate = 15: 1) to afford compound **1ad** as white solid (562 mg, 92% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** 7.4 (d, *J* = 8.5 Hz, 2H), 7.31 (d, *J* = 8.5 Hz, 2H), 7.25 (d, *J* = 5.1 Hz, 2H), 7.16 (d, *J* = 7.9 Hz, 2H),

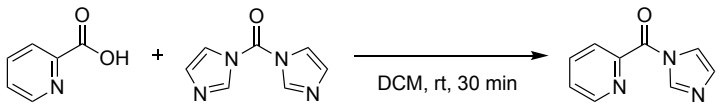
7.03 (brs, 1H), 6.67 – 6.60 (m, 1H), 5.65 (d, *J* = 17.6 Hz, 1H), 5.17 (d, *J* = 10.9 Hz, 1H), 3.69 (q, *J* = 7.1 Hz, 1H), 2.47 (d, *J* = 7.2 Hz, 2H), 1.92 – 1.81 (hept. 1H), 1.58 (s, 3H), 0.92 (s, 3H), 0.90 (s, 3H) ppm.



2ba: 2-Benzoyl-1,3-dimethyl-1*H*-imidazol-3-ium trifluoromethanesulfonate. Following a reported procedure,[3] to a round-bottom flash was added with 1-methylimidazole (5 mmol) and acetonitrile (5 mL). The stirred reaction solution was then cooled to 0 °C and benzoyl chloride (5 mmol) was added by a dropping funnel, followed by the addition of Et_3N (5 mmol). The reaction mixture was continued stirring at room temperature for 24 h. The precipitated solid was filtered off and the solvents was evaporated to dryness. The crude product purified by column chromatography on silica gel (hexane: EtOAc = 15: 1) to give the target compound. To the above product was added diethyl ether and methyl triflate (1.1 equiv.) at room temperature and the reaction was stirred overnight. The resulting white precipitate was filtered off, washed with diethyl ether and dried to afford the corresponding product as a white solid (1.3g, 71% in two steps). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.01 – 8.00 (m, 2H), 7.83 – 7.78 (m, 3H), 7.68 – 7.64 (m, 2H), 3.88 (s, 6H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -78.5 ppm.



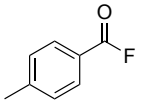
2bc: 2-Benzoyl-3,4,5-trimethylthiazol-3-ium trifluoromethanesulfonate. Following a reported procedure,[4] to a solution of 4,5-dimethylthiazole (5 mmol), DMAP (30 mol%) in CH_3CN (10 mL) was added Et_3N (3 equiv.) and benzoyl chloride (2 equiv.) under Ar atmosphere. The reaction mixture was heated at 80 °C for 24 h. Cooled the mixture to room temperature, diluted with EtOAc and sat. $NaHCO_3$ and extracted with EtOAc. The combined organic layers were concentrated to dryness. The crude product was purified by column chromatography on silica gel (hexane: EtOAc = 7: 1) to yield the target compound. To the above product was added anhydrous DCM and methyl triflate (1.1 equiv.) at room temperature and the reaction was stirred overnight. The solution was concentrated to half of its volume and then Et_2O was added to precipitate a white solid. The solid was filtered off, washed with Et_2O and dried in vacuo to give the title compound as a white solid (990.7 mg, 52%). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.97 -7.95 (m, 2H), 7.71 – 7.67 (m, 1H), 7.53 – 7.49 (m, 2H), 4.15 (s, 3H), 2.54 (s, 3H), 2.52 (s, 3H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -78.5 ppm.



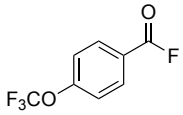
2bd: (1*H*-Imidazol-1-yl) (pyridin-2-yl)methanone. To a solution of picolinic acid (986 mg, 8.0 mmol, 1.0 equiv.) in dry DCM (10 mL) was added *N, N′*-carbonyldiimidazole (1.96 g, 9.6 mmol,

[3] Meng, Q.-Y.; Döben, N.; Studer, A. Cooperative NHC and photoredox catalysis for the synthesis of β-trifluoromethylated alkyl aryl ketones. *Angew. Chem. Int. Ed.* **2020**, *59*, 19956-19960.
[4] Lassalas, P.; Marsais, F.; Hoarau, C. DMAP-catalyzed Regel-type direct C-2 (hetero)aroylation of oxazoles and thiazoles derivatives with acid chlorides. *Synlett*, **2013**, *24*, 2233-2240.

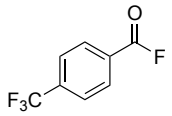
1.2 equiv.) in portions. After strring for 30 mins at room temperature, water was added to the reaction mixture. The separated organic layer was evaporated to dryness and purified by column chromatography on silica gel (hexane: EtOAc = 40: 1) to provide **2bd** as yellow oil (720 mg, 52%). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.82 (s, 1H), 8.64 – 8.63 (m, 1H), 8.11 (d, *J* = 7.9 Hz, 1H), 7.87 – 7.83 (m, 2H), 7.49 – 7.46 (m, 1H), 7.02 – 7.00 (m, 1H) ppm.



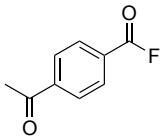
2y: 4-Methylbenzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). Clear oil (209.8 mg, 38% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.93 (d, *J* = 8.2 Hz, 2H), 7.32 (d, *J* = 7.9 Hz, 2H), 2.46 (s, 3H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 17.4 ppm. Spectroscopic data are in accordance with those described in literature.[2]



2z: 4-(Trifluoromethoxy)benzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). Clear oil (316.2 mg, 38% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.11 (d, *J* = 8.9 Hz, 2H), 7.36 (d, *J* = 8.2 Hz, 2H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 18.7, -57.6 ppm. Spectroscopic data are in accordance with those described in literature.[5]



2aa: 4-(Trifluoromethyl)benzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). Clear oil (276.5 mg, 36% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.19 (d, *J* = 8.4 Hz, 2H), 7.81 (d, *J* = 8.2 Hz, 2H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 20.0, -63.5 ppm. Spectroscopic data are in accordance with those described in literature.[6]



2ab: 4-Acetylbenzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). White solid (219.1 mg, 33% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.16 – 8.14 (m, 2H), 8.09 – 8.06 (m, 2H), 2.67 (s, 3H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 20.2 ppm. Spectroscopic data are in accordance with those described in literature.[7]

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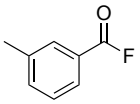
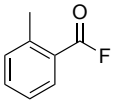
[5] Liang, Y.; Zhao, Z.; Taya. A.; Shibata, N. Acyl Fluorides from Carboxylic Acids, Aldehydes, or Alcohols under Oxidative Fluorination. *Org. Lett.* **2021**, *23*, 847-852.

[6] Wang, Z.; Wang, X.; Nishihara, Y. Nickel-Catalysed Decarbonylative Borylation of Aroyl Fluorides. *Chem. Commun.* **2018**, *54*, 13969-13972.

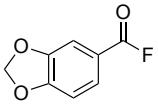
[7] Munoz, S.; Dang, H.; Ispizua-Rodriguez, X.; Mathew, T. Prakash, G. K. S. Direct Access to Acyl Fluorides from Carboxylic Acids Using a Phosphine/Fluoride Deoxyfluorination Reagent System. *Org. Lett.* **2019**, *21*, 1659-1663.



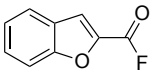
2ae: 3-Methylbenzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). Clear oil (193.2 mg, 35% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.84 (d, *J* = 7.4 Hz, 2H), 7.50 (d, *J* = 7.7 Hz, 1H), 7.41 (t, *J* = 7.6 Hz, 1H), 2.43 (s, 3H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 18.2 ppm. Spectroscopic data are in accordance with those described in literature.[2]



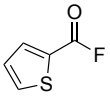
2af: 2-Methylbenzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). Clear oil (182.2 mg, 33% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.01 – 7.99 (m, 1H), 7.57 – 7.53 (m, 1H), 7.35 – 7.31 (m, 2H), 2.66 (d, *J* = 1.8 Hz, 3H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 29.2 ppm. Spectroscopic data are in accordance with those described in literature.[8]



2ag: Benzo[*d*][1,3]dioxole-5-carbonyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). White solid (275.5 mg, 41% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.67 (dd, *J* = 8.2, 1.5 Hz, 1H), 7.42 (d, *J* = 1.6 Hz, 1H), 6.91 – 6.89 (m, 1H), 6.10 (s, 2H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 16.4 ppm. Spectroscopic data are in accordance with those described in literature.[2]



2ah: Benzofuran-2-carbonyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). White solid (249.3 mg, 38% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.77 – 7.74 (m, 2H), 7.64 – 7.62 (m, 1H), 7.58 – 7.54 (m, 1H), 7.40 – 7.36 (m, 1H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 17.4 ppm. Spectroscopic data are in accordance with those described in literature.[9]

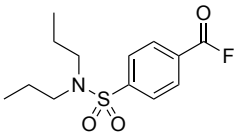


2ai: Thiophene-2-carbonyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). Clear oil (166.2 mg, 33% yield). **^{1}H NMR (400 MHz, $CDCl_3$):**

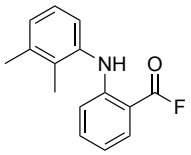
[8] Mavroskoufis, A.; Rajes, K.; Golz, P.; Agrawal, A.; Ruß, V.; Götze, J. P.; Hopkinson, M. N. *N*-Heterocyclic Carbene Catalyzed Photoenolization/Diels–Alder Reaction of Acid Fluorides. *Angew. Chem. Int. Ed.* **2020**, *59*, 3190 -3194.

[9] Malapit, C. A.; Bour, J. R.; Beigham, C. E.; Sanford, M. S. Based-free Nickel-Catalysed Decarbonylative Suzuki-Miyaura Coupling of Acid Fluorides. *Nature*, **2018**, *563*, 100-104.

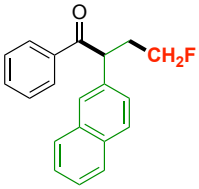
δ 7.95 (dd, *J* = 3.9, 1.2 Hz, 1H), 7.82 – 7.80 (m, 1H), 7.22 – 7.20 (m, 1H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 24.3 ppm. Spectroscopic data are in accordance with those described in literature.[2]



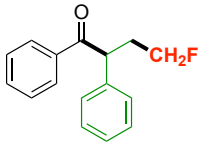
2aq: 4-(*N, N*-dipropylsulfamoyl)benzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). White solid (413.3 mg, 36% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.18 (d, *J* = 8.5 Hz, 2H), 7.96 (d, *J* = 8.0 Hz, 2H), 3.12 (t, *J* = 7.7 Hz, 4H), 1.56 (q, *J* = 7.6 Hz, 4H), 0.87 (t, *J* = 7.4 Hz, 6H) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ 20.2 ppm. Spectroscopic data are in accordance with those described in literature.[5]



2ar: 2-((2,3-Dimethylphenyl)amino)benzoyl fluoride. Prepared according to the general procedure **A** and purified by column chromatography (hexane). Yellow solid (349.9 mg, 36% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.64 (brs, 1H), 7.84 (dd, *J* = 8.1, 1.6 Hz, 1H), 7.36 -7.32 (m, 1H), 7.17 – 7.09 (m, 3H), 6.72 – 6.65 (m, 2H), 2.34 (s, 3H), 2.16 (s, 3H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 159.3 (d, *J* = 337.5 Hz), 151.8 (d, *J* = 10.5 Hz), 138.7, 137.5, 136.9, 133.5, 132.6, 128.2, 126.4, 124.4, 116.6, 113.7 (d, *J* = 3.9 Hz), 104.9 (d, *J* = 52.2), 20.7, 14.1 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ19.9 ppm.

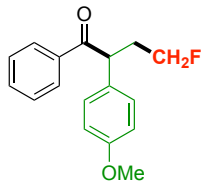


3a: 4-Fluoro-2-(naphthalen-2-yl)-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Colorless oil (63.8 mg, 73% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.03 – 8.00 (m, 2H), 7.82 – 7.77 (m, 4H), 7.48 – 7.42 (m, 4H), 7.39 – 7.35 (m, 2H), 5.02 (t, *J* = 7.4 Hz, 1H), 4.59 – 4.31 (m, 2H), 2.74 – 2.60 (m, 1H), 2.35 – 2.19 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.2, 136.5, 136.1, 133.8, 133.2, 132.7, 129.2, 129.0, 128.7, 127.9, 127.8, 127.5, 126.5, 126.22, 126.18, 81.9 (d, *J* = 164.4 Hz), 49.2 (d, *J* = 3.0 Hz), 34.5 (d, *J* = 19.6 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{20}H_{17}FONa$ $[M+Na]^+$: 315.1156; found: 315.1149.

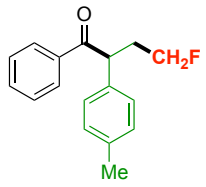


3b: 4-Fluoro-1,2-diphenylbutan-1-one. Prepared according to the general procedure **C** and

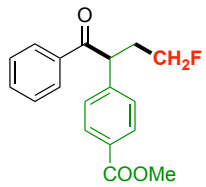
purified by column chromatography (hexane: ethyl acetate = 100: 1). Colorless oil (51.4 mg, 71% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.92 (d, *J* = 7.3 Hz, 2H), 7.44 – 7.40 (m, 1H), 7.34 – 7.31 (m, 2H), 7.26 – 7.25 (m, 4H), 7.20 – 7.14 (m, 1H), 4.80 (t, *J* = 7.4Hz, 1H), 4.50 – 4.22 (m, 2H), 2.60 – 2.46 (m, 1H), 2.20 – 2.04 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.2, 138.6, 136.5, 133.2, 129.3, 128.9, 128.7, 128.5, 127.5, 81.9 (d, *J* = 164.6 Hz), 49.1 (d, *J* = 3.2 Hz), 34.5 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{16}H_{15}FONa$ $[M+Na]^+$: 265.0999; found: 265.0999.



3c: 4-Fluoro-2-(4-methoxyphenyl)-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Colorless oil (37.6 mg, 46% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.96 (d, *J* = 7.7 Hz, 2H), 7.50 – 7.46 (m, 1H), 7.40 – 7.37 (m, 2H), 7.23 (d, *J* = 8.3 Hz, 2H), 6.84 (d, *J* = 8.3 Hz, 2H), 4.80 (t, *J* = 7.3 Hz, 1H), 4.56 – 4.28 (m, 2H), 3.75 (s, 3H), 2.62 – 2.48 (m, 1H), 2.22 – 2.07 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.4, 158.9, 136.5, 136.6, 133.1, 130.5, 129.5, 128.9, 128.7, 114.7, 81.9 (d, *J* = 164.3 Hz), 55.3, 48.2 (d, *J* = 3.0 Hz), 34.5 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{17}FO_2Na$ $[M+Na]^+$: 295.1105; found: 295.1110.

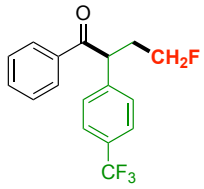


3d: 4-fluoro-1-phenyl-2-(*p*-tolyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (52.9 mg, 69% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.97 (d, *J* = 7.6 Hz, 2H), 7.50 – 7.46 (m, 1H), 7.40 – 7.36 (m, 2H), 7.20 (d, *J* = 8.0 Hz, 2H), 7.11 (d, *J* = 7.9 Hz, 2H), 4.82 (t, *J* = 7.4 Hz, 1H), 4.56 – 4.29 (m, 2H), 2.64 – 2.49 (m, 1H), 2.29 (s, 3H), 2.24 – 2.08 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.4, 137.2, 136.6, 135.5, 133.1, 130.0, 128.9, 128.6, 128.3, 81.9 (d, *J* = 164.4 Hz), 48.7 (d, *J* = 3.3 Hz), 34.5 (d, *J* = 19.3 Hz), 21.1 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{18}FONa$ $[M+Na]^+$: 279.1156; found: 279.1159.

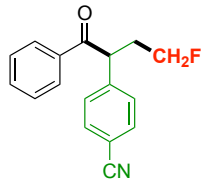


3e: Methyl-4-(4-fluoro-1-oxo-1-phenylbutan-2-yl)benzoate. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (62.8 mg, 70% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.99 – 7.93 (m, 4H), 7.51 – 7.47 (m, 1H),

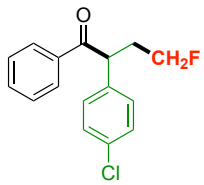
7.41 – 7.36 (m, 4H), 4.92 (t, J = 7.3 Hz, 1H), 4.56 – 4.26 (m, 2H), 3.87 (s, 3H), 2.68 – 2.54 (m, 1H), 2.25 – 2.09 (m, 1H) ppm; **^{13}C NMR (101 MHz, CDCl$_3$):** δ 198.6, 166.8, 143.8, 136.3, 133.4, 130.5, 129.4, 128.9, 128.8, 128.5, 81.6 (d, J = 165.1 Hz), 52.2, 49.1 (d, J = 3.1 Hz), 34.4 (d, J = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{18}H_{17}FO_3Na$ $[M+Na]^+$: 323.1054; found: 323.1048.



3f: 4-Fluoro-1-phenyl-2-(4-(trifluoromethyl)phenyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (64.1 mg, 69% yield). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 7.97 – 7.95 (m, 2H), 7.58 (d, J = 8.2 Hz, 2H), 7.54 – 7.50 (m, 1H), 7.47 – 7.40 (m, 4H), 5.00 (t, J = 7.4 Hz, 1H), 4.57 – 4.27 (m, 2H), 2.69 – 2.55 (m, 1H), 2.26 – 2.10 (m, 1H) ppm; **^{13}C NMR (101 MHz, CDCl$_3$):** δ 198.6, 142.6, 136.2, 133.6, 130.1, 129.8 (q, J = 32.8 Hz), 129.2, 128.9, 126.2 (q, J = 3.7 Hz), 124.1 (q, J = 273.2 Hz), 81.6 (d, J = 165.2 Hz), 48.8 (d, J = 2.9 Hz), 34.5 (d, J = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -62.6, -221.5 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{14}F_4ONa$ $[M+Na]^+$: 333.0873; found: 333.0872.

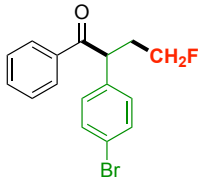


3g: 4-(4-Fluoro-1-oxo-1-phenylbutan-2-yl)benzonitrile. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 30: 1). Yellow oil (52.1 mg, 65% yield). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 7.94 – 7.92 (m, 2H), 7.62 – 7.60 (m, 2H), 7.55 – 7.51 (m, 1H), 7.46 – 7.40 (m, 4H), 4.94 (t, J = 7.4 Hz, 1H), 4.56 – 4.25 (m, 2H), 2.68 – 2.54 (m, 1H), 2.24 – 2.08 (m, 1H) ppm; **^{13}C NMR (101 MHz, CDCl$_3$):** δ 198.2, 144.0, 136.0, 133.7, 133.0, 129.3, 128.9, 128.8, 118.6, 111.6, 81.4 (d, J = 165.5 Hz), 48.9 (d, J = 2.9 Hz), 34.4 (d, J = 19.6 Hz) ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{15}FNO$ $[M+H]^+$: 268.1132; found: 268.1136.

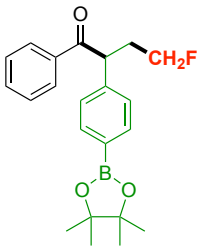


3h: 2-(4-Chlorophenyl)-4-fluoro-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (40.1 mg, 48% yield). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 7.94 (d, J = 7.4 Hz, 2H), 7.52 – 7.49 (m, 1H), 7.41 – 7.38 (m, 2H), 7.29 – 7.24 (m, 4H), 4.84 (t, J = 7.4 Hz, 1H), 4.56 – 4.26 (m, 2H), 2.64 –

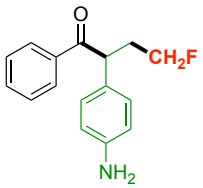
2.49 (m, 1H), 2.21 – 2.06 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.9, 137.0, 136.3, 133.5, 133.4, 129.8, 129.5, 128.9, 128.8, 81.7 (d, *J* = 164.8 Hz), 48.3 (d, *J* = 3.2 Hz), 34.4 (d, *J* = 19.3 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{16}H_{14}FClONa$ $[M+Na]^+$: 299.0609; found: 299.0605.



3i: 2-(4-Bromophenyl)-4-fluoro-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (63.2 mg, 66% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.94 (d, *J* = 7.6 Hz, 2H), 7.53 – 7.49 (m, 1H), 7.44 – 7.38 (m, 4H), 7.20 (d, *J* = 8.4 Hz, 2H), 4.83 (t, *J* = 7.4 Hz, 1H), 4.56 – 4.26 (m, 2H), 2.64 – 2.49 (m, 1H), 2.24 – 1.99 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.8, 137.6, 136.2, 133.4, 132.4, 130.2, 128.9, 128.8, 121.6, 81.6 (d, *J* = 164.9 Hz), 48.4 (d, *J* = 3.2 Hz), 34.4 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{16}H_{14}FBrONa$ $[M+Na]^+$: 343.0104; found: 343.0115.

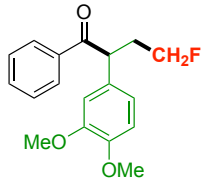


3j: 4-Fluoro-1-phenyl-2-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (60.5 mg, 55% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.95 – 7.93 (m, 2H), 7.75 (d, *J* = 8.0 Hz, 2H), 7.49 – 7.45 (m, 1H), 7.38 – 7.31 (m, 4H), 4.85 (t, *J* = 7.3 Hz, 1H), 4.55 – 4.27 (m, 2H), 2.66 – 2.51 (m, 1H), 2.24 – 2.08 (m, 1H), 1.31 (s, 12H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.0, 141.8, 136.5, 135.7, 133.2, 128.9, 128.7 (overlapped), 127.9, 84.0, 81.8 (d, *J* = 164.4 Hz), 49.4 (d, *J* = 3.2 Hz), 34.4 (d, *J* = 19.6 Hz), 24.98, 24.95 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{22}H_{26}BFO_3Na$ $[M+Na]^+$: 391.1851; found: 391.1848.

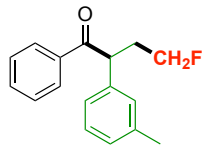


3k: 2-(4-Aminophenyl)-4-fluoro-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 10: 1). Yellow oil (40.7 mg, 53% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.97 – 7.94 (m, 2H), 7.49 – 7.45 (m, 1H), 7.39 – 7.35 (m, 2H), 7.09 – 7.07 (m, 2H), 6.63 – 6.60 (m, 2H), 4.73 (t, *J* = 7.4 Hz, 1H), 4.55 – 4.29

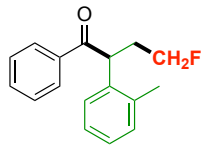
(m, 2H), 3.48 (brs, 2H), 2.59 – 2.44 (m, 1H), 2.21 – 2.04 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.6, 145.5, 136.7, 133.0, 129.4, 128.9, 128.6, 128.3, 115.9, 82.0 (d, *J* = 163.9 Hz), 48.3 (d, *J* = 3.1 Hz), 34.4 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{16}H_{17}FNO$ $[M+H]^+$: 258.1289; found: 258.1282.



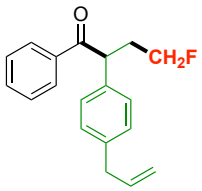
3l: 2-(3,4-Dimethoxyphenyl)-4-fluoro-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 20: 1). Yellow oil (50.5 mg, 56% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.97 – 7.7.95 (m, 2H), 7.50 – 7.46 (m, 1H), 7.40 – 7.36 (m, 2H), 6.87 – 6.85 (m, 1H), 6.80 – 6.78 (m, 2H), 4.78 (t, *J* = 7.4 Hz, 1H), 4.55 – 4.30 (m, 2H), 3.84 (s, 3H), 3.82 (s, 3H), 2.61 – 2.47 (m, 1H), 2.23 – 2.07 (m, 2H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.4, 149.5, 148.4, 136.6, 133.1, 130.9, 128.8, 128.6, 121.0, 111.6, 111.0, 81.9 (d, *J* = 164.3 Hz), 56.0, 55.9, 48.6 (d, *J* = 3.1 Hz), 34.4 (d, *J* = 19.3 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{18}H_{20}FO_3$ $[M+]^+$: 303.1391; found: 303.1399.



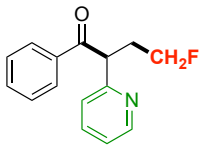
3m: 4-Fluoro-1-phenyl-2-(*m*-tolyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (45.1 mg, 59% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.00 – 7.97 (m, 2H), 7.51 – 7.46 (m, 1H), 7.41 – 7.37 (m, 2H), 7.22 – 7.18 (m, 1H), 7.13 – 7.11 (m, 2H), 7.04 – 7.02 (m, 1H), 4.82 (t, *J* = 7.4 Hz, 1H), 4.55 – 4.29 (m, 2H), 2.64 – 2.50 (m, 1H), 2.31 (s, 3H), 2.23 – 2.09 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.3, 139.0, 138.5, 136.6, 133.1, 129.1, 128.9, 128.7, 128.3, 125.6, 81.9 (d, *J* = 164.4 Hz), 49.0 (d, *J* = 3.1 Hz), 34.5 (d, *J* = 19.4 Hz), 21.5 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{17}FONa$ $[M+Na]^+$: 279.1156; found: 279.1151.



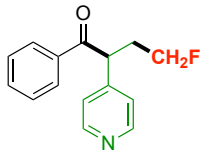
3n: 4-Fluoro-1-phenyl-2-(*o*-tolyl)butan-1-one. Prepared according to the general procedure and purified **C** by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (41.3 mg, 54% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.85 (d, *J* = 7.6 Hz, 2H), 7.49 – 7.45 (m, 1H), 7.38 – 7.35 (m, 2H), 7.22 (d, *J* = 7.2 Hz, 1H), 7.15 – 7.05 (m, 3H), 4.99 (t, *J* = 7.1 Hz, 1H); 4.57 – 4.33 (m, 2H), 2.67 – 2.57 (m, 1H), 2.55 (s, 3H), 2.14 – 1.99 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 200.0, 137.5, 136.9, 135.6, 133.0, 131.3, 128.7, 128.6, 127.4, 126.9, 82.2 (d, *J* = 163.9 Hz), 45.4 (d, *J* = 2.8 Hz), 34.2 (d, *J* = 19.7 Hz), 19.7 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -219.7 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{17}FONa$ $[M+Na]^+$: 279.1156; found: 279.1154.



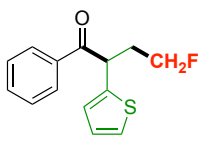
3o: 2-(4-Allylphenyl)-4-fluoro-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (47.6 mg, 56% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.98 – 7.96 (m, 2H), 7.50 – 7.46 (m, 1H), 7.40 – 7.37 (m, 2H), 7.25 – 7.23 (m, 2H), 7.13 (d, *J* = 8.1 Hz, 2H), 5.97 – 5.86 (m, 1H), 5.07 – 5.06 (m, 1H), 5.03 – 5.02 (m, 1H), 4.83 (t, *J* = 7.4 Hz, 1H), 4.55 – 4.28 (m, 2H), 3.33 (d, *J* = 6.8 Hz, 2H), 2.64 – 2.49 (m, 1H), 2.24 – 2.08 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.3, 139.3, 137.2, 136.6, 136.3, 133.1, 129.4, 128.9, 128.7, 128.5, 116.1, 81.9 (d, *J* = 164.3 Hz), 48.7 (d, *J* = 3.3 Hz), 39.9, 34.5 (d, *J* = 19.3 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{19}H_{19}FONa$ $[M+Na]^+$: 305.1312; found: 305.1304.



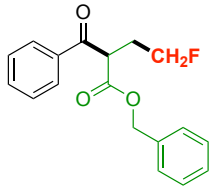
3p: 4-Fluoro-1-phenyl-2-(pyridin-2-yl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 10: 1). Yellow oil (47.3 mg, 65% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.55 (m, 1H), 8.04 – 8.02 (m, 2H), 7.64 – 7.60 (m, 1H), 7.51 – 7.47 (m, 1H), 7.41 – 7.37 (m, 2H), 7.30 (d, *J* = 7.8 Hz, 1H), 7.15 – 7.12 (m, 1H), 5.10 (t, *J* = 7.3 Hz, 1H), 4.59 – 4.34 (m, 2H), 2.74 – 2.59 (m, 1H), 2.39 – 2.20 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.3, 158.7, 150.1, 137.3, 136.5, 133.3, 129.1, 128.7, 122.9, 122.3, 82.0 (d, *J* = 165.4 Hz), 52.0 (d, *J* = 3.4 Hz), 33.4 (d, *J* = 19.6 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -220.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{15}H_{15}FNO$ $[M+H]^+$: 244.1132; found: 244.1123.



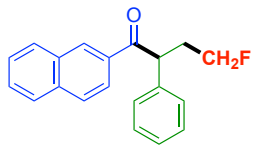
3q: 4-Fluoro-1-phenyl-2-(pyridin-4-yl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 10: 1). Yellow oil (49.7 mg, 68% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.55 (d, *J* = 5.5 Hz, 2H), 7.95 – 7.93 (m, 2H), 7.56 – 7.52 (m, 1H), 7.44 – 7.40 (m, 2H), 7.29 (d, *J* = 5.9 Hz, 2H), 4.88 (t, *J* = 7.3 Hz, 1H), 4.57 – 4.27 (m, 2H), 2.68 – 2.54 (m, 1H), 2.24 – 2.09 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.0, 150.3, 148.1, 136.0, 133.8, 128.9, 128.8, 123.8, 81.4 (d, *J* = 165.6 Hz), 48.4 (d, *J* = 2.9 Hz), 34.2 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{15}H_{15}FNO$ $[M+H]^+$: 244.1132; found: 244.1126.



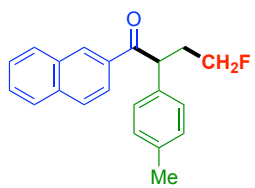
3r: 4-Fluoro-1-phenyl-2-(thiophen-2-yl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (43.1 mg, 58% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.03 – 8.01 (m, 2H), 7.56 – 7.52 (m, 1H), 7.46 – 7.42 (m, 2H), 7.21 – 7.19 (m, 1H), 6.96 – 6.92 (m, 2H), 5.19 (t, *J* = 7.4 Hz, 1H), 4.58 – 4.36 (m, 2H), 2.66 – 2.51 (m, 1H), 2.33 – 2.18 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.1, 140.6, 136.1, 133.5, 128.9, 128.8, 127.2, 126.4, 125.5, 81.6 (d, *J* = 164.9 Hz), 43.6 (d, *J* = 3.4 Hz), 35.3(d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.6 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{14}H_{13}FOSNa$ $[M+Na]^+$: 271.0563; found: 271.0566.



3s: Benzyl-2-benzoyl-4-fluorobutanoate. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (31.3 mg, 35% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.00 – 7.97 (m, 2H), 7.61 – 7.57 (m, 1H), 7.48 – 7.44 (m, 2H), 7.30 – 7.28 (m, 3H), 7.21 – 7.18 (m, 2H), 5.13 (s, 2H), 4.66 (t, *J* = 7.0 Hz, 1H), 4.62 – 4.44 (m, 2H), 2.48 – 2.43 (m, 1H), 2.41 – 2.37 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 194.6, 169.4, 136.0, 135.3, 133.9, 128.94, 128.90, 128.7, 128.5, 128.2, 81.7 (d, *J* = 165.9 Hz), 67.5, 49.9 (d, *J* = 3.2 Hz), 29.9 (d, *J* = 19.5 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -220.7 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{18}H_{175}FO_3Na$ $[M+Na]^+$: 323.1054; found: 323.1051.

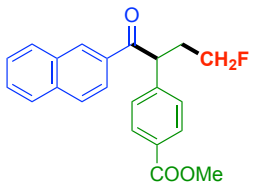


3t: 4-Fluoro-1-(naphthalen-2-yl)-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (44.4 mg, 51% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.51 (s, 1H), 8.03 – 8.01 (m, 1H), 7.91 (d, *J* = 8.0 Hz, 1H), 7.83 – 7.81 (m, 2H), 7.58 – 7.49 (m, 2H), 7.39 – 7.37 (m, 2H), 7.33 – 7.29 (m, 2H), 7.23 – 7.19 (m, 1H), 5.02 (t, *J* = 7.4 Hz, 1H), 4.61 – 4.33 (m, 2H), 2.72 – 2.58 (m, 1H), 2.31 – 2.16 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.2, 138.7, 135.6, 133.9, 132.6, 130.8, 129.8, 129.3, 128.7, 128.53, 128.49, 127.8, 127.5, 126.8, 124.6, 82.0 (d, *J* = 164.4 Hz), 49.2 (d, *J* = 3.2 Hz), 34.6 (d, *J* = 19.5 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{20}H_{17}FONa$ $[M+Na]^+$: 315.1156; found: 315.1149.

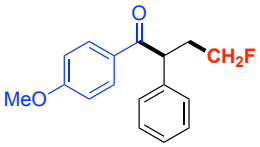


3u: 4-Fluoro-1-(naphthalen-2-yl)-2-(*p*-tolyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil

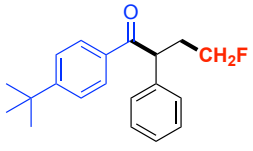
(40.5 mg, 44% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.50 (s, 1H), 8.02 – 8.00 (m, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.82 – 7.80 (m, 2H), 7.57 – 7.49 (m, 2H), 7.26 – 7.24 (m, 2H), 7.11 (d, *J* = 7.9 Hz, 2H), 4.97 (t, *J* = 7.3 Hz, 1H), 4.59 – 4.32 (m, 2H), 2.70 – 2.55 (m, 1H), 2.26 (s, 3H), 2.24 – 2.13 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.3, 137.2, 135.64, 135.59, 133.9, 132.6, 130.7, 130.0, 129.8, 128.6, 128.5, 128.3, 127.8, 126.8, 124.6, 82.0 (d, *J* = 164.1 Hz), 48.8 (d, *J* = 3.0 Hz), 34.5 (d, *J* = 19.3 Hz), 21.1 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{20}H_{19}FONa$ $[M+Na]^+$: 329.1312; found: 329.1315.



3v: Methyl-4-(4-fluoro-1-(naphthalen-2-yl)-1-oxobutan-2-yl)benzoate. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 30: 1). Yellow oil (47.4 mg, 45% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.48 (s, 1H), 8.01 – 7.97 (m, 3H), 7.91 (d, *J* = 8.0 Hz, 1H), 7.84 – 7.81 (m, 2H), 7.59 – 7.50 (m, 2H), 7.47 – 7.45 (m, 2H), 5.09 (t, *J* = 7.3 Hz, 1H), 4.61 – 4.31 (m, 2H), 3.87 (s, 3H), 2.75 – 2.60 (m, 1H), 2.31 – 2.16 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.6, 166.8, 143.9, 135.7, 133.6, 132.5, 130.8, 130.6, 129.8, 129.5, 128.9, 128.7, 128.5, 127.8, 127.0, 124.4, 81.7 (d, *J* = 165.0 Hz), 52.3, 49.1 (d, *J* = 3.1 Hz), 34.5 (d, *J* = 19.5 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{22}H_{19}FO_3Na$ $[M+Na]^+$: 373.1210; found: 373.1206.

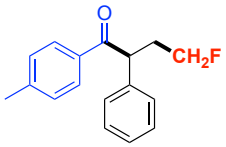


3w: 4-Fluoro-1-(4-methoxyphenyl)-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (50.5 mg, 62% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.98 – 7.94 (m, 2H), 7.32 – 7.28 (m, 4H), 7.23 – 7.19 (m, 1H), 6.88 – 6.84 (m, 2H), 4.80 (t, *J* = 7.4 Hz, 1H), 4.54 – 4.27 (m, 2H), 3.82 (s, 3H), 2.64 – 2.49 (m, 1H), 2.22 – 2.08 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 197.7, 165.5, 139.1, 131.3, 129.5, 129.2, 128.4, 127.4, 113.9, 82.0 (d, *J* = 164.2 Hz), 55.6, 48.7 (d, *J* = 3.0 Hz), 34.6 (d, *J* = 19.6 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{17}FO_2Na$ $[M+Na]^+$: 295.1105; found: 295.1105.

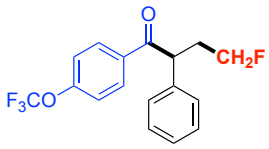


3x: 1-(4-(*tert*-Butyl)phenyl)-4-fluoro-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (64.3 mg, 72% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.94 – 7.91 (m, 2H), 7.42 – 7.39 (m, 2H), 7.34 – 7.29 (m, 4H), 7.24 – 7.20 (m, 1H), 4.84 (t, *J* = 7.4 Hz, 1H), 4.54 – 4.27 (m, 2H), 2.64 – 2.50 (m, 1H),

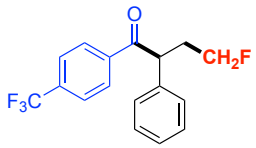
2.22 – 2.09 (m, 1H), 1.29 (s, 9H) ppm; **^{13}C NMR (101 MHz, CDCl$_3$):** δ 198.8, 156.9, 138.9, 133.9, 129.2, 128.9, 128.5, 127.4, 125.7, 82.0 (d, *J* = 164.2 Hz), 48.9 (d, *J* = 3.4 Hz), 35.2, 34.6 (d, *J* = 19.4 Hz), 31.1 ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{20}H_{23}FONa$ $[M+Na]^+$: 361.1625; found: 321.1620.



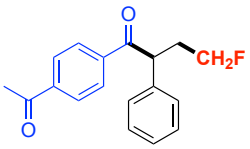
3y: 4-Fluoro-2-phenyl-1-(*p*-tolyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (52.0 mg, 68% yield). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 7.87 (d, J = 8.2 Hz, 2H), 7.32 – 7.27 (m, 4H), 7.23 – 7.16 (m, 3H), 4.83 (t, *J* = 7.4 Hz, 1H), 4.55 – 4.27 (m, 2H), 2.65 – 2.50 (m, 1H), 2.34 (s, 3H), 2.24 – 2.08 (m, 1H) ppm; **^{13}C NMR (101 MHz, CDCl$_3$):** δ 198.8, 144.0, 138.8, 134.0, 129.4, 129.2, 129.1, 128.4, 127.4, 81.9 (d, *J* = 164.4 Hz), 48.9 (d, *J* = 3.2 Hz), 34.5 (d, *J* = 19.5 Hz), 21.7 ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{18}FO$ $[M+H]^+$: 257.1336; found: 257.1329.



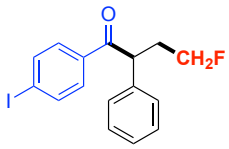
3z: 4-Fluoro-2-phenyl-1-(4-(trifluoromethoxy)phenyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (33.2 mg, 32% yield). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 8.01 (d, *J* = 8.7 Hz, 2H), 7.34 – 7.28 (m, 4H), 7.26 – 7.19 (m, 3H), 4.80 (t, *J* = 7.3 Hz, 1H), 4.82 – 4.27 (m, 2H), 2.65 – 2.51 (m, 1H), 2.24 – 2.08 (m, 1H) ppm; **^{13}C NMR (101 MHz, CDCl$_3$):** δ 197.6, 152.6, 138.2, 134.7, 131.0, 129.4, 128.4, 127.7, 120.40, 120.36 (d, *J* = 259.9 Hz), 81.7 (d, *J* = 163.9 Hz), 49.3 (d, *J* = 3.3 Hz), 34.5 (d, *J* = 19.3 Hz) ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -57.6 (s, 3F), -221.3 (s, 1F) ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{14}F_4O_2Na$ $[M+Na]^+$: 349.0822; found: 349.0816.



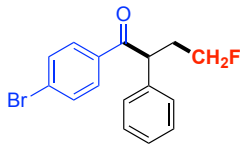
3aa: 4-Fluoro-2-phenyl-1-(4-(trifluoromethyl)phenyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 50: 1). Yellow oil (32.3 mg, 35% yield). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 8.05 (d, *J* = 8.2 Hz, 2H), 7.64 (d, *J* =8.3 Hz, 2H), 7.34 – 7.24 (m, 5H), 4.82 (t, *J* = 7.3 Hz, 1H), 4.57 – 4.28 (m, 2H), 2.67. – 2.53 (m, 1H), 2.25 – 2.09 (m, 1H) ppm; **^{13}C NMR (151 MHz, CDCl$_3$):** δ 198.3, 139.2, 137.9, 134.3 (q, *J* = 32.6 Hz), 129.5, 129.2, 128.5, 127.8, 125.8 (q, *J* = 3.6 Hz), 123.6 (q, *J* = 272.6 Hz), 81.7 (d, *J* = 1634.1 Hz), 49.6 (d, *J* = 2.8 Hz), 34.3 (d, *J* = 19.1 Hz) ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -63.2 (s, 3F), -221.6 (s, 1F) ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{15}F_4O$ $[M+H]^+$: 311.1054; found: 311.1043.



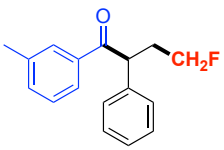
3ab: 1-(4-Acetylphenyl)-4-fluoro-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 30: 1). Yellow oil (45.9 mg, 54% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.03 – 8.01 (m, 2H), 7.95 – 7.93 (m, 2H), 7.33 -7.22 (m, 5H), 4.84 (t, *J* = 7.3 Hz, 1H), 4.58 – 4.28 (m, 2H), 2.67 – 2.53 (m, 4H), 2.25 – 2.09 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.7, 197.5, 140.1, 139.8, 138.0, 129.4, 129.1, 128.54, 128.49, 127.7, 81.7 (d, *J* = 164.7 Hz), 49.7 (d, *J* = 3.1 Hz), 34.3 (d, *J* = 19.4 Hz), 27.0 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{18}H_{18}FO_2$ $[M+H]^+$: 285.1285; found: 285.1290.



3ac: 4-Fluoro-1-(4-iodophenyl)-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (41.5 mg, 38% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.76 – 7.73 (m, 2H), 7.67 – 7.35 (m, 2H), 7.33 – 7.27 (m, 4H), 7.25 – 7.01 (m, 1H), 4.76 (t, *J* = 7.3 Hz, 1H), 4.55 – 4.26 (m, 2H), 2.64 – 2.49 (m, 1H), 2.22 – 2.07 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.5, 138.2, 138.0, 135.7, 130.3, 129.4, 128.4, 127.7, 101.2, 81.8 (d, *J* = 164.4 Hz), 49.2 (d, *J* = 3.0 Hz), 34.3 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.5 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{16}H_{14}FIONa$ $[M+Na]^+$: 390.9966; found: 390.9955.

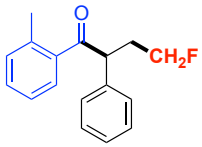


3ad: 1-(4-Bromophenyl)-4-fluoro-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (38.6 mg, 40% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.83 – 7.80 (m, 2H), 7.53 – 7.50 (m, 2H), 7.33 – 7.27 (m, 4H), 7.25 – 7.21 (m, 1H), 4.77 (t, *J* = 7.3 Hz, 1H), 4.55 – 4.27 (m, 2H), 2.64 – 2.50 (m, 1H), 2.23 – 2.07 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.2, 138.2, 135.2, 132.0, 130.4, 129.4, 128.41, 128.38, 127.7, 81.8 (d, *J* = 164.4 Hz), 49.2 (d, *J* = 3.1 Hz), 34.4 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.5 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{16}H_{14}FBrONa$ $[M+Na]^+$: 343.0104; found: 343.0099.

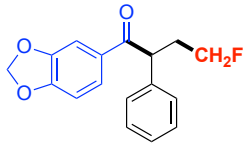


3ae: 4-Fluoro-2-phenyl-1-(*m*-tolyl)butan-1-one. Prepared according to the general procedure **C**

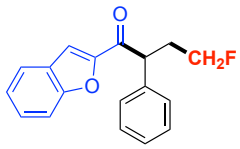
and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (46.7 mg, 61% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.78 – 7.75 (m, 2H), 7.32 – 7.19 (m, 7H), 4.84 (t, *J* = 7.4 Hz, 1H), 4.55 – 4.28 (m, 2H), 2.65 – 2.50 (m, 1H), 2.35 (s, 3H), 2.25 – 2.09 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.5, 138.7, 138.5, 136.6, 134.0, 139.4, 129.2, 128.52, 128.46, 127.4, 126.2, 81.9 (d, *J* = 164.4 Hz), 49.1 (d, *J* = 3.4 Hz), 34.5 (d, *J* = 19.5 Hz), 21.5 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{18}FO$ $[M+H]^+$: 257.1336; found: 257.1339.



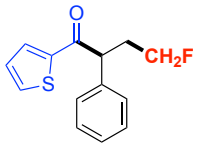
3af: 4-Fluoro-2-phenyl-1-(*o*-tolyl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (48.2 mg, 63% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.59 (d, *J* = 7.7 Hz, 1H), 7.30 – 7.13 (m, 8H), 4.69 (t, *J* = 7.4 Hz, 1H), 4.58 – 4.30 (m, 2H), 2.70 – 2.55 (m, 1H), 2.31 (s, 3H), 2.25 – 2.09 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 203.3, 138.4, 138.2, 137.8, 131.8, 131.1, 129.1, 128.6, 128.2, 127.5, 125.6, 82.0 (d, *J* = 164.7 Hz), 52.1 (d, *J* = 3.1 Hz), 33.9 (d, *J* = 19.6 Hz), 20.9 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{18}FO$ $[M+H]^+$: 257.1336; found: 257.1346.



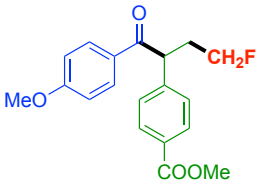
3ag: 1-(Benzo[*d*][1,3]dioxol-5-yl)-4-fluoro-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 50: 1). Yellow oil (46.5 mg, 66% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.59 (dd, *J* = 8.2, 1.7 Hz, 1H), 7.44 (d, *J* = 1.7 Hz, 1H), 7.33 – 7.28 (m, 4H), 7.24 – 7.20 (m, 1H), 6.77 (d, *J* = 8.2 Hz, 1H), 5.99 (s, 2H), 4.75 (t, *J* = 7.4 Hz, 1H), 4.54 – 4.26 (m, 2H), 2.63 – 2.48 (m, 1H), 2.24 – 2.05 (m, 1H) ppm; **^{13}C NMR (126 MHz, $CDCl_3$):** δ 197.3, 151.9, 148.3, 138.9, 131.3, 129.3, 128.4, 127.5, 125.3, 108.7, 108.0, 102.0, 81.9 (d, *J* = 164.2 Hz), 48.9 (d, *J* = 3.0 Hz), 34.6 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{17}H_{15}FO_3Na$ $[M+Na]^+$: 309.0897; found: 309.0900.



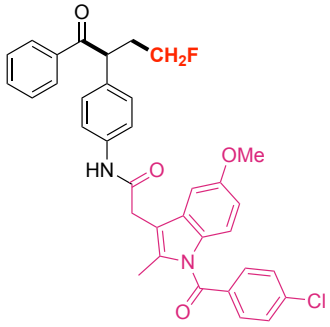
3ah: 1-(Benzofuran-2-yl)-4-fluoro-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 50: 1). Yellow oil (25.0 mg, 30% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.63 (d, *J* = 7.9 Hz, 1H), 7.54 – 7.50 (m, 2H), 7.45 – 7.38 (m, 3H), 7.32 (t, *J* = 7.6 Hz, 2H), 7.25. (t, *J* = 7.9 Hz, 2H), 4.78 (t, *J* = 7.5 Hz, 1H), 4.58 – 4.29 (m, 2H), 2.70 – 2.56 (m, 1H), 2.30 – 2.14 (m, 1H) ppm; **^{13}C NMR (101MHz, $CDCl_3$):** δ 190.0, 155.8, 152.1, 137.9, 129.2, 128.6, 128.5, 127.7, 127.1, 124.0, 123.4, 114.3, 112.6, 81.7 (d, *J* = 164.4 Hz), 49.8 (d, *J* = 3.2 Hz), 33.6 (d, *J* = 19.6 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{18}H_{16}FO_2$ $[M+H]^+$: 283.1129; found: 283.1124.



3ai: 4-Fluoro-2-phenyl-1-(thiophen-2-yl)butan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 50: 1). Yellow oil (34.1 mg, 46% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.73 – 7.72 (m, 1H), 7.58 – 7.56 (m, 1H), 7.37 – 7.30 (m, 4H), 7.26 – 7.23 (m, 1H), 7.05 – 7.03 (m, 1H), 4.67 (t, *J* = 7.4 Hz, 1H), 4.56 – 4.27 (m, 2H), 2.66 – 2.51 (m, 1H), 2.25 – 2.10 (m, 1H) ppm; **^{13}C NMR (101MHz, $CDCl_3$):** δ 192.1, 143.8, 138.6, 134.1, 132.9, 129.2, 128.4, 128.3, 127.6, 81.8 (d, *J* = 164.7 Hz), 50.6 (d, *J* = 3.1 Hz), 34.3 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.5 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{14}H_{13}FOSNa$ $[M+Na]^+$: 271.0563; found: 271.0560.

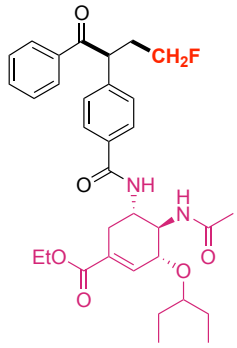


3aj: Methyl-4-(4-fluoro-1-(4-methoxyphenyl)-1-oxobutan-2-yl)benzoate. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (36.8 mg, 37% yield). **^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.98 – 7.92 (m, 4H), 7.40 – 7.38 (m, 2H), 6.88 – 6.85 (m, 2H), 4.87 (t, *J* = 7.4 Hz, 1H), 4.54 – 4.27 (m, 2H), 3.88 (m, 3H), 3.82 (m, 3H), 2.65 – 2.53 (m, 1H), 2.22 – 2.09 (m, 1H) ppm; **^{13}C NMR (126 MHz, $CDCl_3$):** δ 197.1, 166.9, 163.8, 144.3, 131.3, 130.5, 129.33, 129.27, 128.5, 114.0, 81.8 (d, *J* = 164.7 Hz), 55.6, 52.3, 48.7 (d, *J* = 3.0 Hz), 34.4 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.3 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{19}H_{19}FO_4Na$ $[M+Na]^+$: 353.1160; found: 353.1161.

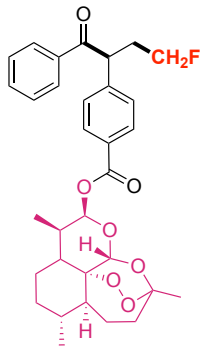


3ak: 2-(1-(4-Chlorobenzoyl)-5-methoxy-2-methyl-1*H*-indol-3-yl)-*N*-(4-(4-fluoro-1-oxo-1-phenylbutan-2-yl)phenyl)acetamide. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). White solid (127.3 mg, 71% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.91 (d, *J* = 8.2 Hz, 2H), 7.64 (d, *J* = 8.1 Hz, 2H), 7.48 – 7.45 (m, 3H), 7.37 – 7.32 (m, 5H), 7.21 (d, *J* = 8.3 Hz, 2H), 6.91 – 6.84 (m, 2H), 6.71 – 6.68 (m, 1H), 4.79 (t, *J* = 7.3 Hz, 1H), 4.52 – 4.23 (m, 2H), 3.78 (s, 3H), 3.76 (s, 2H), 2.59 – 2.45 (m, 1H), 2.41 (s, 3H), 2.19 – 2.02 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.0, 168.4, 168.3, 156.5, 139.8, 136.8, 136.7, 134.7, 133.5, 133.2, 131.3, 131.0, 130.2, 129.4, 129.0, 128.8, 128.7, 120.9, 115.3, 112.5, 112.3, 100.8, 81.7 (d, *J* = 164.5 Hz), 55.9, 48.5 (d, *J* = 3.0 Hz), 34.3 (d, *J* = 19.5 Hz), 33.4, 13.4 ppm; **^{19}F**

NMR (376 MHz, $CDCl_3$): δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{35}H_{30}ClFN_2O_4K$ $[M+K]^+$: 635.1510; found: 635.1494.

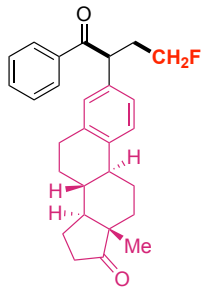


3al: Ethyl (3*R*,4*R*,5*S*)-4-acetamido-5-(4-((*S*)-4-fluoro-1-oxo-1-phenylbutan-2-yl)benzamido)-3-(pentan-3-yloxy)cyclohex-1-ene-1-carboxylate. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 5: 1). White solid (88.9 mg, 51% yield, 1:0.72 dr). **^{1}H NMR (400 MHz, MeOD-*d*$_4$, contained a isomer):** δ 8.32 – 7.98 (m, 2.5H), 7.77 – 7.70 (m, 2H), 7.54 – 7.37 (m, 4.4H), 6.83 – 6.80 (m, 1H), 5.02 (t, *J* = 7.3 Hz, 1H), 4.65 – 4.47 (m, 1H), 4.45 – 4.35 (m, 1H), 4.32 – 4.17 (m, 5H), 4.09 – 4.00 (m, 1H), 3.46 – 3.40 (m, 1H), 2.81 – 2.71 (m, 1H), 2.65 – 2.51 (m, 1H), 2.48 – 2.37 (m, 1H), 2.22 – 2.16 (m, 1H), 2.09 – 1.93 (m, 1H), 1.86 – 1.82 (m, 3H),1.52 – 1.47 (m, 3H), 1.31 – 1.29 (m, 4H), 0.95 – 0.84 (m, 6H) ppm; Data of one isomer: **^{13}C NMR (126 MHz, MeOD-*d*$_4$):** δ 200.41, 173.99, 169.77, 167.46, 144.1, 139.1, 137.6, 134.4, 130.8, 130.37, 129.7, 129.5, 129.1, 128.7, 83.87, 82.6 (d, *J* = 164.1 Hz), 76.94, 62.1, 55.9, 50.1 (d, *J* = 4.0 Hz), 49.97, 35.3 (d, *J* = 19.5 Hz), 31.17, 27.3, 26.8, 22.79, 14.4, 9.8, 9.6 ppm; Data of the other isomer: **^{13}C NMR (126 MHz, MeOD-*d*$_4$):** δ 200.39, 174.03, 169.91, 167.49, 144.1, 139.1, 137.6, 134.7, 130.8, 130.42, 129.8, 129.5, 129.1, 128.7, 83.89, 82.5 (d, *J* = 165.1 Hz), 76.99, 62.1, 55.9, 50.1 (d, *J* = 4.0 Hz), 50.0, 35.3 (d, *J* = 19.5 Hz), 31.24, 28.1, 26.9, 22.81, 14.4, 9.8, 9.6 ppm; **^{19}F NMR (376 MHz, MeOD-*d*$_4$):** δ -221.57, -221.6, -222.0 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{34}H_{41}FN_2O_6Na$ $[M+Na]^+$: 603.2841; found: 603.2844.

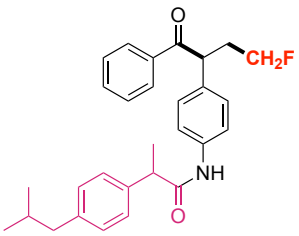


3am: (5*aS*,6*R*,9*R*,10*R*,12*R*,12a*R*)-3,6,9-trimethyldecahydro-12*H*-3,12-epoxy[1,2]dioxepino[4,3-i]isochromen-10-yl 4-(4-fluoro-1-oxo-1-phenylbutan-2-yl)benzoate. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 7: 1). White solid (54.6 mg, 33% yield, dr = 1:1). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.06 (d, *J* = 7.9 Hz, 2H), 7.94 (d, *J* = 7.8 Hz, 2H), 7.52 – 7.48 (m, 1H), 7.41 – 7.38 (m, 4H), 5.96 (d, *J* = 9.8 Hz, 1H), 5.49 (s, 1H), 4.92 (t, *J* = 7.3 Hz, 1H), 4.57 – 4.26 (m, 2H), 2.74 – 2.57 (m, 2H), 2.42 – 2.34 (m, 1H), 2.24 – 2.11 (m, 1H),

2.05 – 2.01 (m, 1H), 1.92 – 1.88 (m, 1H), 1.82 – 1.63 (m, 3H), 1.51 – 1.43 (m, 2H), 1.40 (s, 3H), 1.33 – 1.28 (m, 2H), 1.07 – 1.01 (m, 1H), 0.97 (d, J = 5.9 Hz, 3H), 0.88 (d, J = 6.7 Hz, 3H) ppm; Data of one isomer: **^{13}C NMR (151 MHz, CDCl$_3$):** δ 198.63, 165.0, 144.2, 136.29, 133.47, 131.14, 128.94, 128.89, 128.8, 128.5, 104.6, 92.7, 91.7, 81.7 (d, J = 164.7 Hz), 80.30, 51.7, 49.2 (d, J = 3.3 Hz), 45.4, 37.4, 36.4, 34.4 (d, J = 19.3 Hz), 34.2, 32.1, 36.1, 24.7, 22.2, 20.4, 12.4 ppm; Data of the other isomer: **^{13}C NMR (151 MHz, CDCl$_3$):** 198.58, 165.0, 144.2, 136.26, 133.46, 131.11, 128.94, 128.91, 128.8, 128.5, 104.6, 92.7, 91.7, 81.7 (d, J = 164.7 Hz), 80.28, 51.7, 49.1 (d, J = 3.3 Hz), 45.4, 37.4, 36.4, 34.4 (d, J = 19.3 Hz), 34.2, 31.7, 26.1, 24.7, 22.2, 20.4, 14.3 ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -221.39, -221.43 ppm. **HRMS** *m/z* (ESI): calcd. for $C_{32}H_{37}FO_7Na$ $[M+Na]^+$: 575.2416; found: 575.2409.

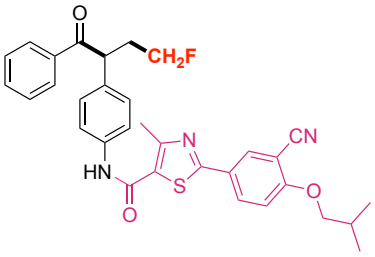


3an: (8*R*,9*S*,13*S*,14*S*)-3-((*S*)-4-fluoro-1-oxo-1-phenylbutan-2-yl)-13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17*H*-cyclopenta[a]phenanthren-17-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 7: 1). White solid (60.1 mg, 48% yield, dr = 1:1). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 7.99 (d, J = 7.6 Hz, 2H), 7.51 – 7.48 (m, 1H), 7.42 – 7.38 (m, 2H), 7.23 – 7.20 (m, 1H), 7.11 – 7.08 (m, 1H), 7.01 (d, J = 6.0 Hz, 1H), 4.80 (t, J = 7.3 Hz, 1H), 4.54 – 4.30 (m, 2H), 2.87 – 2.84 (m, 2H), 2.63 – 2.46 (m, 2H), 2.40 – 2.32 (m, 1H), 2.26 – 1.92 (m, 7H), 1.66 – 1.52 (m, 3H), 1.46 – 1.38 (m, 2H), 0.89 (s, 1.5H), 0.88 (s, 1.5H) ppm; Data of one isomer: **^{13}C NMR (101 MHz, CDCl$_3$):** 221.0, 199.32, 139.0, 137.45, 136.6, 135.9, 133.1, 130.01, 129.0, 128.67, 126.2, 126.0, 82.0 (d, J = 164.3 Hz), 50.6, 48.5 (d, J = 2.2 Hz), 48.1, 44.4, 38.1, 35.96, 34.57 (d, J = 19.7 Hz), 31.7, 29.44, 26.54, 25.7, 21.7, 13.9 ppm; Data of the other isomer: **^{13}C NMR (101 MHz, CDCl$_3$):** 221.0, 199.30, 139.0, 137.42, 136.6, 135.9, 133.1, 130.05, 129.0, 128.71, 126.2, 125.97, 82.0 (d, J = 164.3 Hz), 50.6, 48.5 (d, J = 2.2 Hz), 48.1, 44.4, 38.1, 36.0, 34.59 (d, J = 19.3 Hz), 32.0, 29.49, 26.53, 25.7, 22.8, 14.3 ppm; **^{19}F NMR (376 MHz, CDCl$_3$):** δ -221.2 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{28}H_{32}FO_2$ $[M+H]^+$: 419.2381; found: 419.2384.

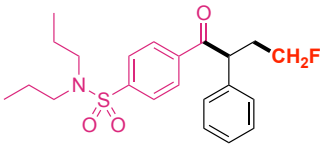


3ao: *N*-(4-(4-fluoro-1-oxo-1-phenylbutan-2-yl)phenyl)-2-(4-isobutylphenyl)propanamide. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 6). Yellow oil (70.6 mg, 53% yield). **^{1}H NMR (400 MHz, CDCl$_3$):** δ 7.92 (d, J = 7.7 Hz, 2H), 7.48 – 7.44 (m, 1H), 7.37 – 7.34 (m, 4H), 7.23 – 7.19 (m, 4H), 7.12 (d, J = 8.1 Hz, 2H), 7.11 (s, 1H), 4.79 (t, J = 7.3 Hz, 1H), 4.53 – 4.24 (m, 2H), 3.66 (q, J = 7.1 Hz, 1H), 2.60 – 2.48 (m, 1H), 2.45 (d, J = 7.2 Hz, 2H), 2.24 – 2.06 (m, 1H), 1.89 – 1.79 (m, 1H), 1.55 (d, J = 7.1 Hz, 3H), 0.90 (s, 3H),

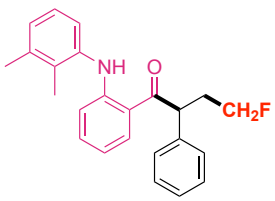
0.89 (s, 3H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.1, 172.8, 141.3, 138.0, 137.2, 136.4, 134.2, 133.2, 130.0, 129.0, 128.9, 128.7, 127.5, 120.4, 81.8 (d, *J* = 164.4 Hz), 48.5 (d, *J* = 3.1 Hz), 47.8, 45.1, 34.3 (d, *J* = 19.4 Hz), 30.3, 22.5, 18.5 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.4 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{29}H_{32}FNO_2Na$ $[M+Na]^+$: 468.2309; found: 468.2301.



3ap: 2-(3-Cyano-4-isobutoxyphenyl)-*N*-(4-(4-fluoro-1-oxo-1-phenylbutan-2-yl)phenyl)-4-methylthiazole-5-carboxamide. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). White solid (121.8 mg, 73% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.04 – 8.03 (m, 1H), 8.01 – 7.94 (m, 3H), 7.79 (brs, 1H), 7.56 – 7.54 (m, 2H), 7.50 – 7.47 (m, 1H), 7.40 – 7.36 (m, 2H), 7.31 – 7.29 (m, 2H), 6.98 – 6.96 (d, *J* = 8.9 Hz, 1H), 4.85 (t, *J* = 7.3 Hz, 1H), 4.55 – 4.28 (m, 2H), 3.87 (d, *J* = 6.5 Hz, 2H), 2.71 (s, 3H), 2.64 – 2.49 (m, 1H), 2.23 – 2.09 (m, 2H), 1.07 (s, 3H), 1.05 (s, 3H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.1, 165.0, 162.5, 159.9, 157.2, 136.8, 136.4, 135.0, 133.3, 132.6, 131.9, 129.2, 128.9, 128.7, 125.8, 125.7, 121.2, 115.6, 112.7, 102.8, 81.8 (d, *J* = 164.7 Hz), 75.8, 48.5 (d, *J* = 3.0 Hz), 34.4 (d, *J* = 19.6 Hz), 28.2, 19.1, 17.5 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.2 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{32}H_{30}FN_3O_3SNa$ $[M+Na]^+$: 578.1884; found: 578.1882.

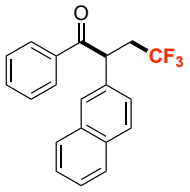


3aq: 4-(4-Fluoro-2-phenylbutanoyl)-*N, N*-dipropylbenzenesulfonamide. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 30: 1). Yellow oil (51.1 mg, 42% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.04 (d, *J* = 8.5 Hz, 2H), 7.80 (d, *J* = 8.5 Hz, 2H), 7.35 – 7.25 (m, 5H), 4.81 (t, *J* = 7.3 Hz, 1H), 4.59 – 4.28 (m, 2H), 3.05 (t, *J* = 7.7 Hz, 4H), 2.66 – 2.52 (m, 1H), 2.25 – 2.09 (m, 1H), 1.57 – 1.47 (m. 4H), 0.84 (t, *J* = 7.4 Hz, 6H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 198.2, 144.1, 139.3, 137.8, 129.5, 129.4, 128.5, 127.8, 127.3, 81.6 (d, *J* = 164.1 Hz), 50.1, 49.7 (d, *J* = 3.0 Hz), 34.3 (d, *J* = 19.5 Hz), 22.1, 11.3 ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.6 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{22}H_{28}FNO_3SK$ $[M+K]^+$: 444.1406; found: 444.1393.

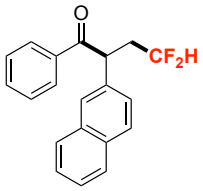


3ar: 1-(2-((2,3-Dimethylphenyl)amino)phenyl)-4-fluoro-2-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100:

1). Yellow oil (44.8 mg, 41% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 10.4 (brs, 1H), 7.91 (dd, *J* = 8.2, 1.3 Hz, 1H), 7.38 – 7.31 (m, 4H), 7.24 – 7.21 (m, 1H), 7.18 – 7.07 (m, 3H), 7.03 – 7.01 (m, 1H), 6.75 – 6.73 (m, 1H), 6.60 – 6.56 (m, 1H), 4.94 (t, *J* = 7.4 Hz, 1H), 4.57 – 4.29 (m, 2H), 2.66 – 2.52 (m, 1H), 2.32 (s, 3H), 2.27 – 2.20 (m, 1H), 2.16 (s, 3H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 201.7, 150.2, 139.6, 138.5, 138.4, 134.6, 132.6, 132.0, 129.2, 128.3, 127.3, 127.1, 126.0, 123.4, 117.7, 115.8, 114.5, 82.1 (d, *J* = 164.0 Hz), 49.1 (d, *J* = 2.9 Hz), 34.9 (d, *J* = 19.4 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -221.0 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{24}H_{25}FNO$ $[M+H]^+$: 362.1915; found: 362.1887.

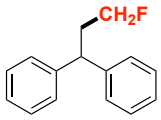


3as: 4,4,4-Trifluoro-2-(naphthalen-2-yl)-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Colorless oil (24.1 mg, 37% yield, 0.2 mmol scale). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.03 – 8.01 (m, 2H), 7.84 – 7.77 (m, 4H), 7.49 – 7.38 (m, 6H), 5.10 (dd, *J* = 5.7, 5.1 Hz, 1H), 3.49 – 3.35 (m, 1H), 2.72 – 2.59 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 196.8, 135.8, 134.9, 133.7, 133.5, 132.8, 129.5, 129.0, 128.8, 128.0, 127.8, 127.4, 126.7, 126.54 (d, *J* = 274.7 Hz), 126.50, 125.7, 47.4 (q, *J* = 2.4 Hz), 37.5 (q, *J* = 28.2 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -64.5 ppm. Spectroscopic data are in accordance with those described in literature.[10]

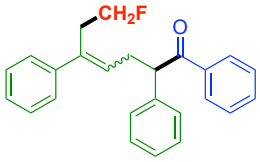


3at: 4,4-Difluoro-2-(naphthalen-2-yl)-1-phenylbutan-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Colorless oil (31.6 mg, 51% yield, 0.2 mmol scale). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.02 – 8.00 (m, 2H), 7.84 – 7.77 (m, 4H), 7.49 – 7.43 (m, 4H), 7.40 – 7.36 (m, 2H), 5.10 (tt, *J* = 56.7, 4.8 Hz, 1H), 4.99 (t, J = 7.4 Hz, 1H), 2.95 – 2.80 (m, 1H), 2.54 – 2.39 (m, 1H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 197.8, 135.9, 135.3, 133.7, 133.4, 132.7, 129.5, 129.0, 128.8, 127.9, 127.8, 127.3, 126.7, 126.4, 125.8, 116.3 (t, *J* = 238.8 Hz), 47.9 (t, *J* = 5.5 Hz), 38.1 (t, *J* = 21.7 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -115.8 (d, $^2J_{F\text{-}F}$ = 284.8 Hz, 1F), -117.7 (d, $^2J_{F\text{-}F}$ = 284.8 Hz, 1F) ppm.

[10] Li, J.-L.; Liu, Y.-Q.; Zou, W.-L.; Zeng, R.; Zhang, X.; Liu, Y.; Han, B.; He, Y.; Leng, H.-J.; Li, Q.-Z. Radical Acylfluoroalkylation of Olefins through N-Heterocyclic Carbene Organocatalysis. *Angew. Chem. Int. Ed.* **2020**, *59*, 1863-1870.

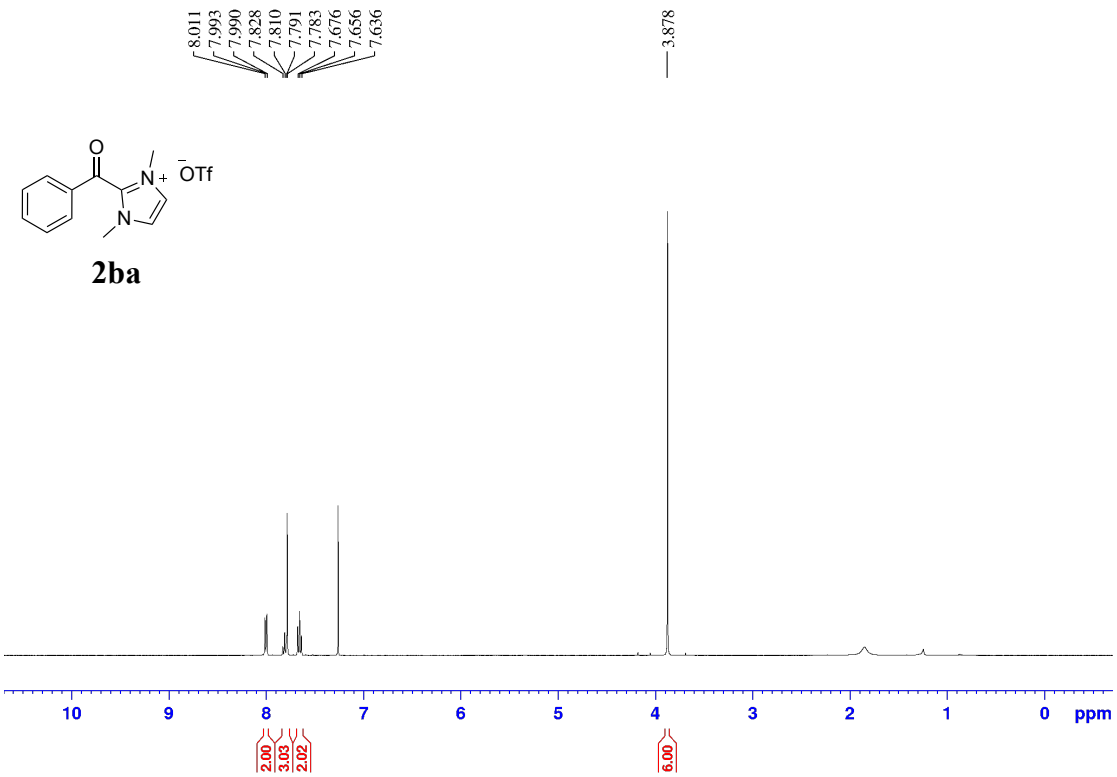


5: (3-Fluoropropane-1,1-diyl)dibenzene. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 100: 1). Yellow oil (16.2 mg, 25% yield). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.24 – 7.16 (m, 8H), 7.14 – 7.10 (m, 2H), 4.37 (t, *J* = 6.0 Hz, 1H), 4.25 (t, *J* = 6.0 Hz, 1H), 4.10 (t, *J* = 8.0 Hz, 1H), 2.42 – 2.31 (m, 2H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 144.0, 128.7, 128.0, 126.6, 82.2 (d, *J* = 165.3 Hz), 46.5 (d, *J* = 5.2 Hz), 36.2 (d, *J* = 19.9 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -220.8 ppm; **HRMS** *m/z* (ESI): calcd. for $C_{15}H_{14}F$ $[M+H]^+$: 215.1231; found: 215.1232.



9: 7-Fluoro-1,2,5-triphenylhept-4-en-1-one. Prepared according to the general procedure **C** and purified by column chromatography (hexane: ethyl acetate = 50: 1). Yellow oil (25.8 mg, 24% yield, *Z/E* = 1:5). The *Z/E* ratio is based on ^{1}H-NMR and NOE analysis. **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.97 – 7.95 (m, 2H), 7.90 – 7.88 (m, 0.4H), 7.49 – 7.46 (m, 1H + 0.2H), 7.40 – 7.21 (m, 12H + 2H), 6.99 – 6.97 (m, 0.4H), 5.73 (t, *J* = 7.5 Hz, 1H), 5.51 (t, *J* = 7.3 Hz, 0.2 H), 4.68 (t, *J* = 7.3 Hz, 1H), 4.50 (t, *J* = 7.3 Hz, 0.2H), 4.42 – 4.16 (m, 2H + 0.4H), 3.11 – 3.04 (m, 1H), 2.93 – 2.73 (m, 3H + 0.2H), 2.68 – 2.59 (m, 0.4H), 2.55 – 2.47 (m, 0.2H) ppm; **^{13}C NMR (101 MHz, $CDCl_3$):** δ 199.4, 142.3, 139.2, 136.74, 136.69, 133.1, 129.2, 129.1, 128.9, 128.7, 128.5, 128.4, 127.4, 127.2, 126.5, 82.2 (d, *J* = 168.5 Hz), 54.1, 33.3, 31.3 (d, *J* = 21.0 Hz) ppm; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -215.3, -217.7 (minor) ppm; **HRMS** *m/z* (ESI): calcd. for $C_{25}H_{23}FONa$ $[M+Na]^+$: 381.1625; found: 381.1632.

9. Spectra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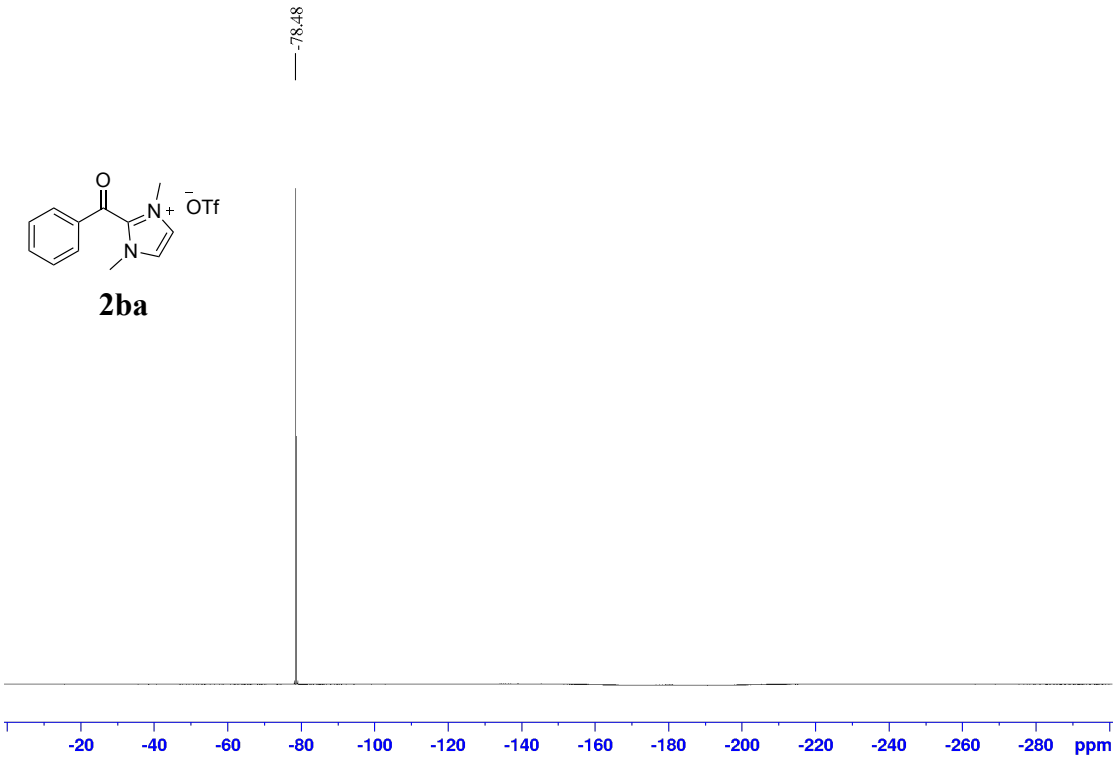
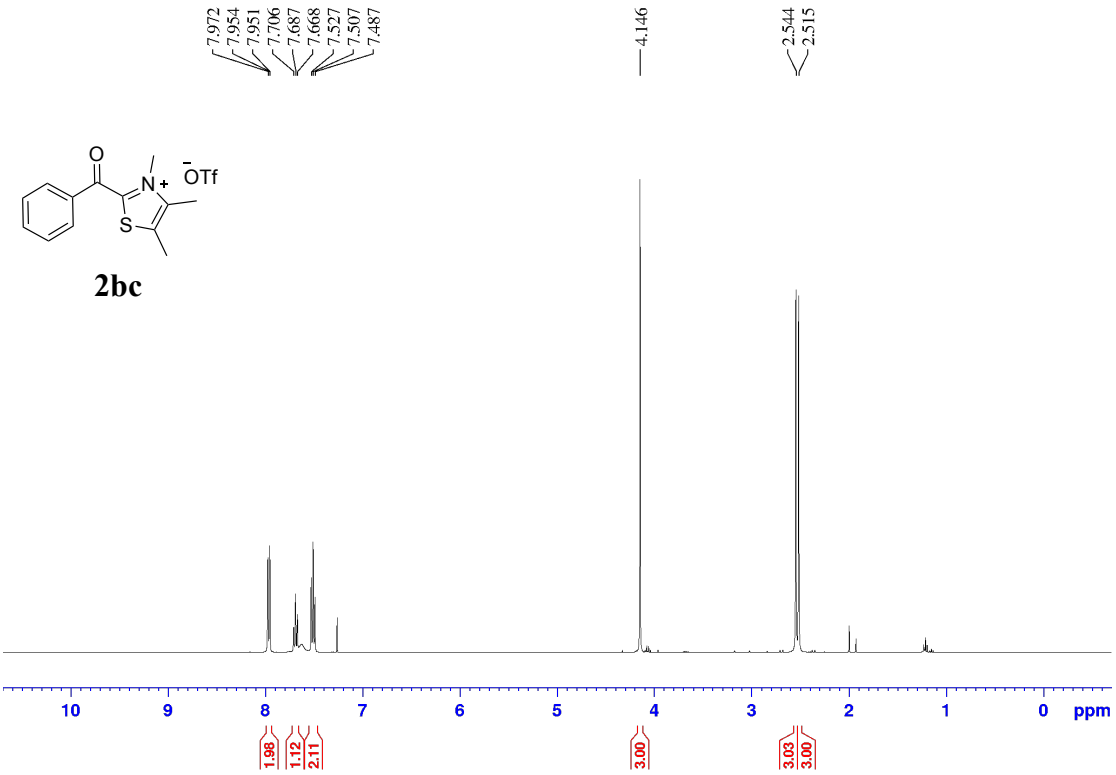
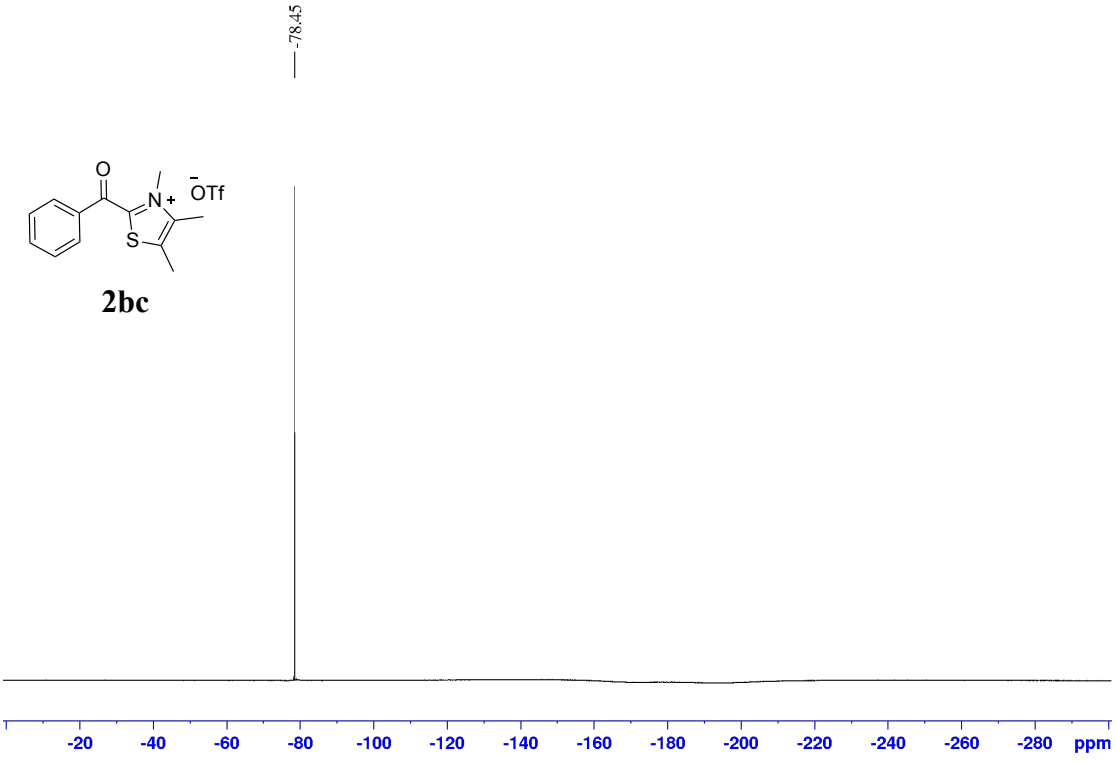
7.993
7.990
7.828
7.810
7.791
7.783
7.676
7.656
7.636
3.878
OTf
2ba
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
3.03
2.02
6.00


-78.48
OTf
2ba
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.972
7.954
7.951
7.706
7.687
7.668
7.527
7.507
7.487
4.146
2.544
2.515
O
N+
OTf
S
10
9
8
7
6
5
4
3
2
1
0
ppm
1.98
1.12
2.11
3.00
3.03
3.00

2bc


-78.45
O
N+
OTf
S
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm

2bc


8.815
8.643
8.641
8.639
8.631
8.629
8.628
8.117
8.097
7.865
7.861
7.846
7.842
7.825
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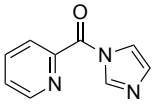
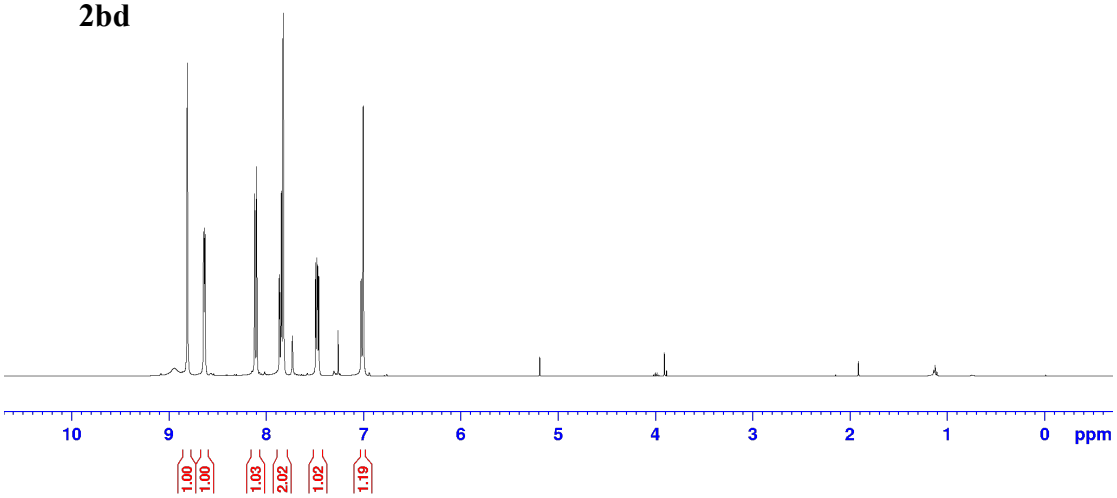
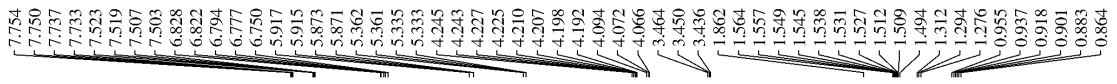
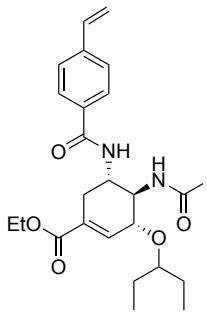
7.480
7.477
7.472
7.470
7.461
7.458
7.023
7.004
7.002



2bd

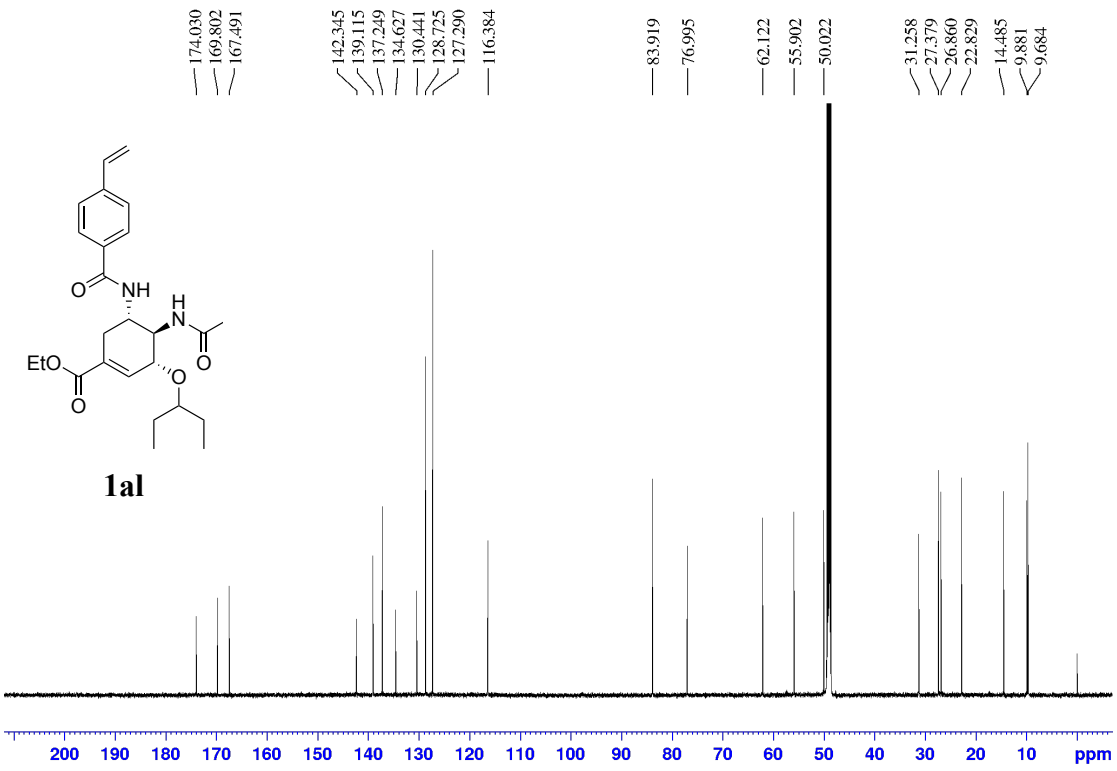

10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.00
1.03
2.02
1.02
1.19


7.754
7.750
7.737
7.733
7.523
7.519
7.507
7.503
6.828
6.822
6.794
6.777
6.750
5.917
5.915
5.873
5.871
5.362
5.361
5.335
5.333
4.245
4.243
4.227
4.225
4.210
4.207
4.198
4.192
4.094
4.072
4.066
3.464
3.450
3.436
1.862
1.564
1.557
1.549
1.545
1.538
1.531
1.527
1.512
1.509
1.494
1.312
1.294
1.276
0.955
0.937
0.918
0.901
0.883
0.864

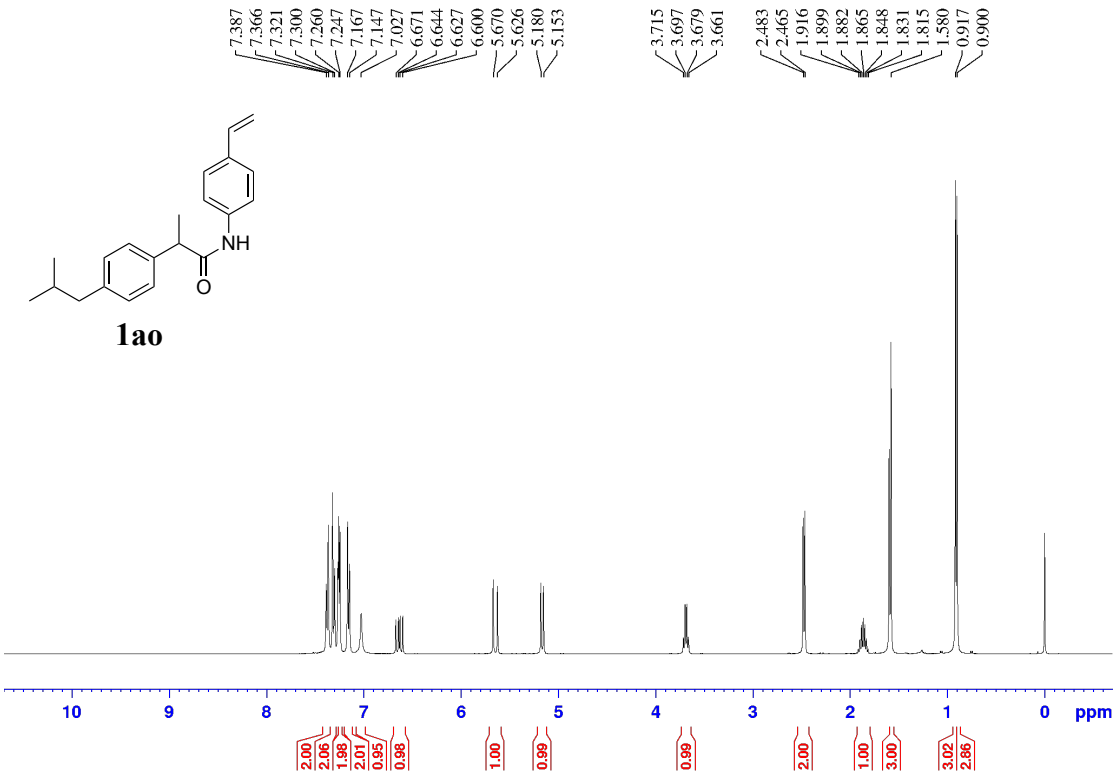


1al

10
9
8
7
6
5
4
3
2
1
0
ppm
2.02
2.05
2.00
1.00
1.02
4.10
1.03
1.03
1.01
1.01
3.00
3.06
3.12
3.04
3.05


174.030
169.802
167.491
142.345
139.115
137.249
134.627
130.441
128.725
127.290
116.384
83.919
76.995
62.122
55.902
50.022
31.258
27.379
26.860
22.829
14.485
9.881
9.684
O
NH
H
N
O
EtO
O
O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

1al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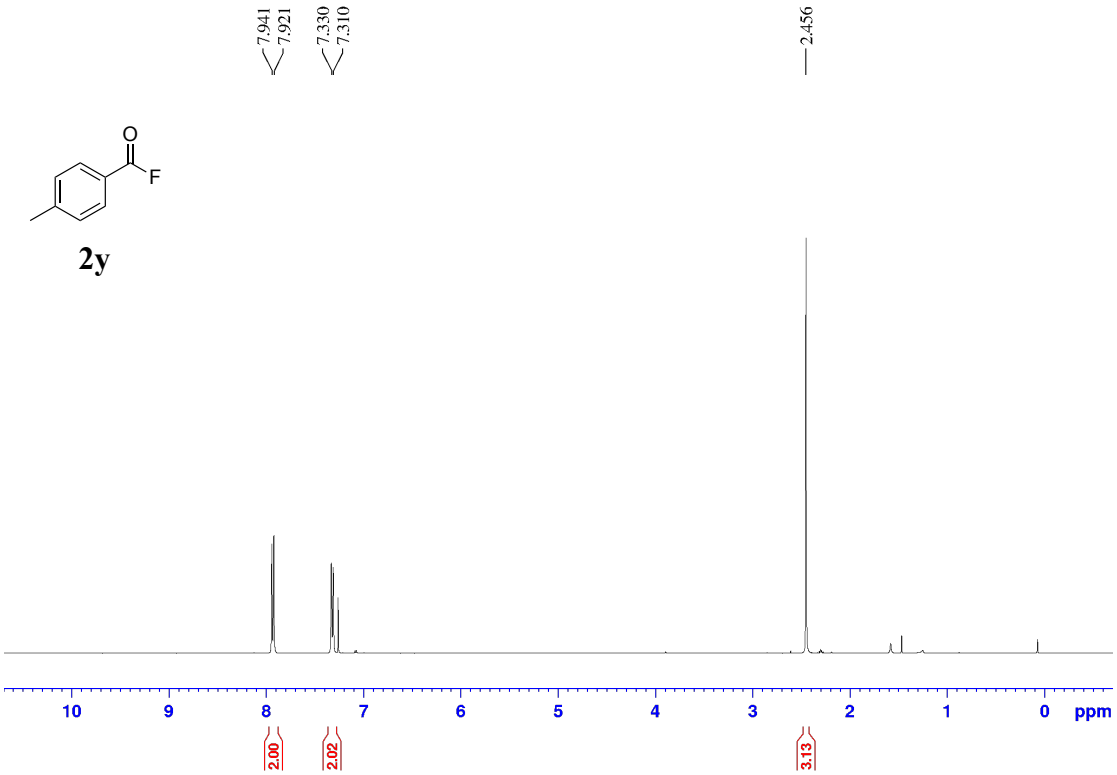
7.366
7.321
7.300
7.260
7.247
7.167
7.147
7.027
6.671
6.644
6.627
6.600
5.670
5.626
5.180
5.153
3.715
3.697
3.679
3.661
2.483
2.465
1.916
1.899
1.882
1.865
1.848
1.831
1.815
1.580
0.917
0.900
NH
O
10 9 8 7 6 5 4 3 2 1 0 ppm
2.00
2.06
1.98
2.01
0.95
0.98
1.00
0.99
0.99
2.00
1.00
3.00
3.02
2.86

1ao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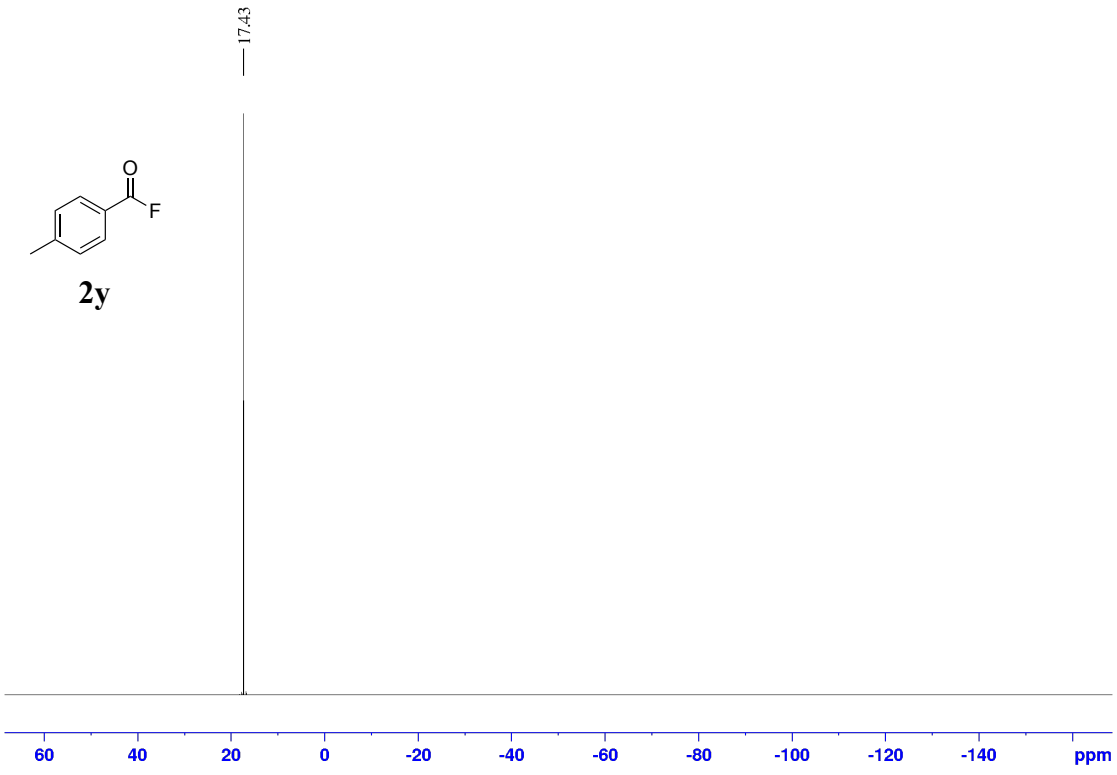
7.330
7.310
2.456
O
F
2y
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.02
3.13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20
0
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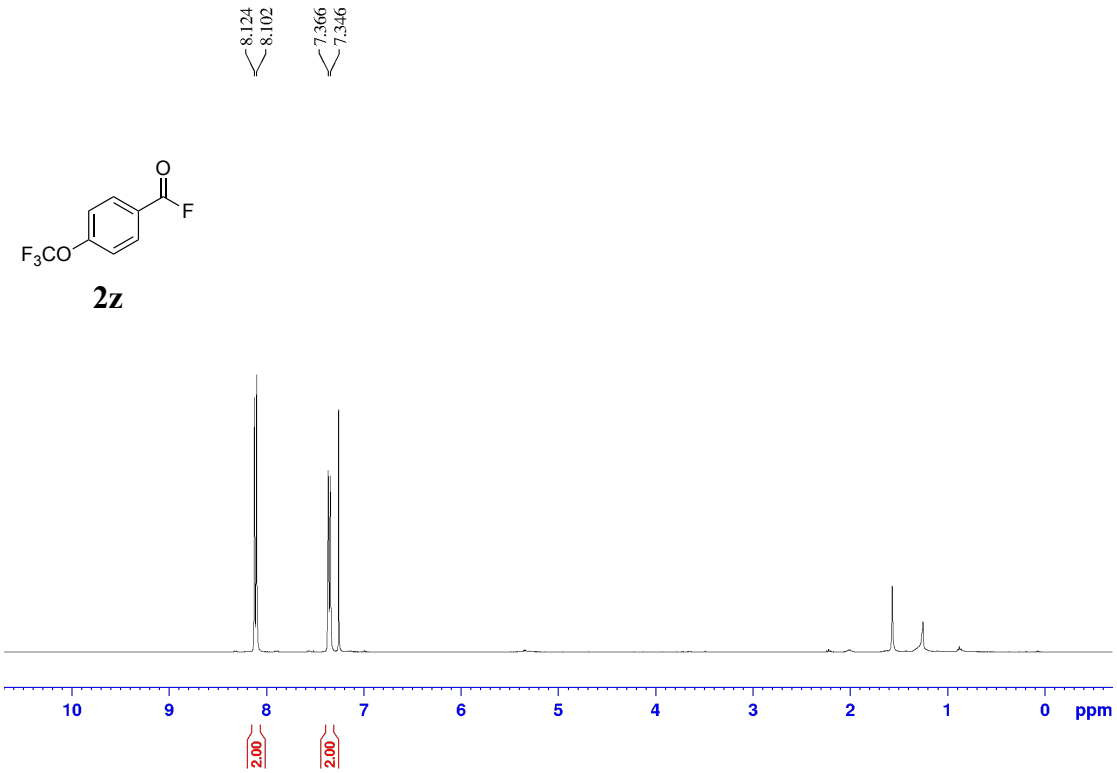
-40
-60
-80
-100
-120
-140
ppm


8.124
8.102
7.366
7.346
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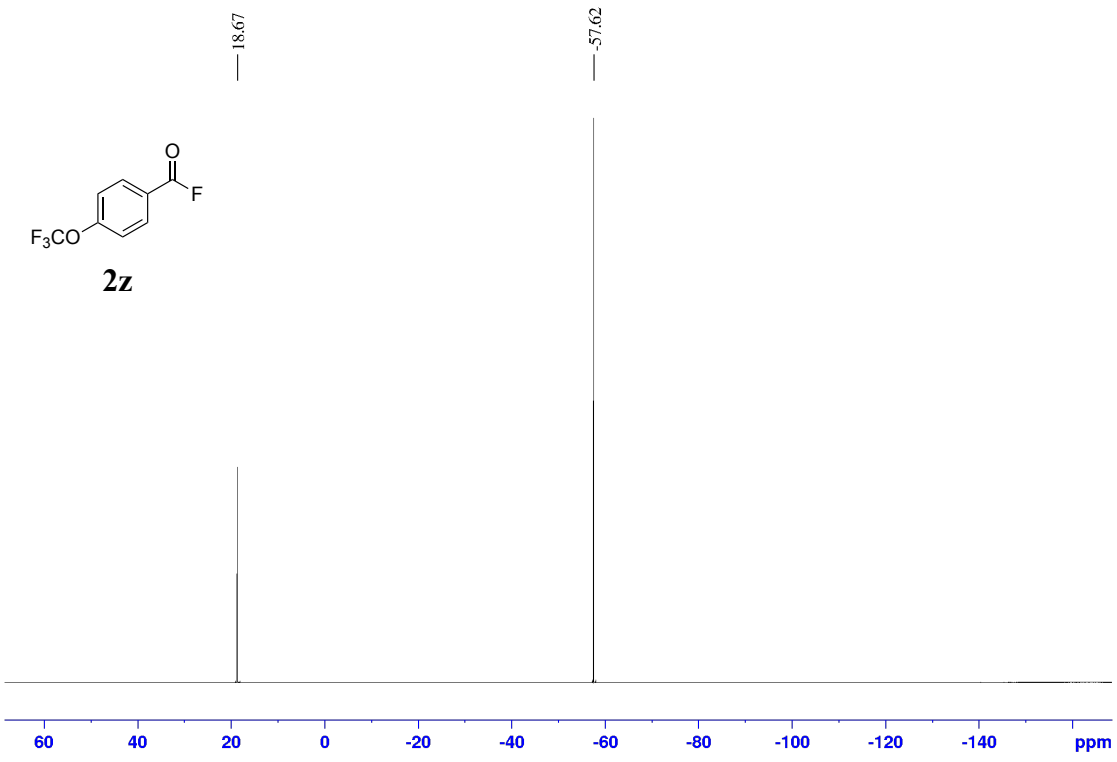
F
F3CO
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.00

2z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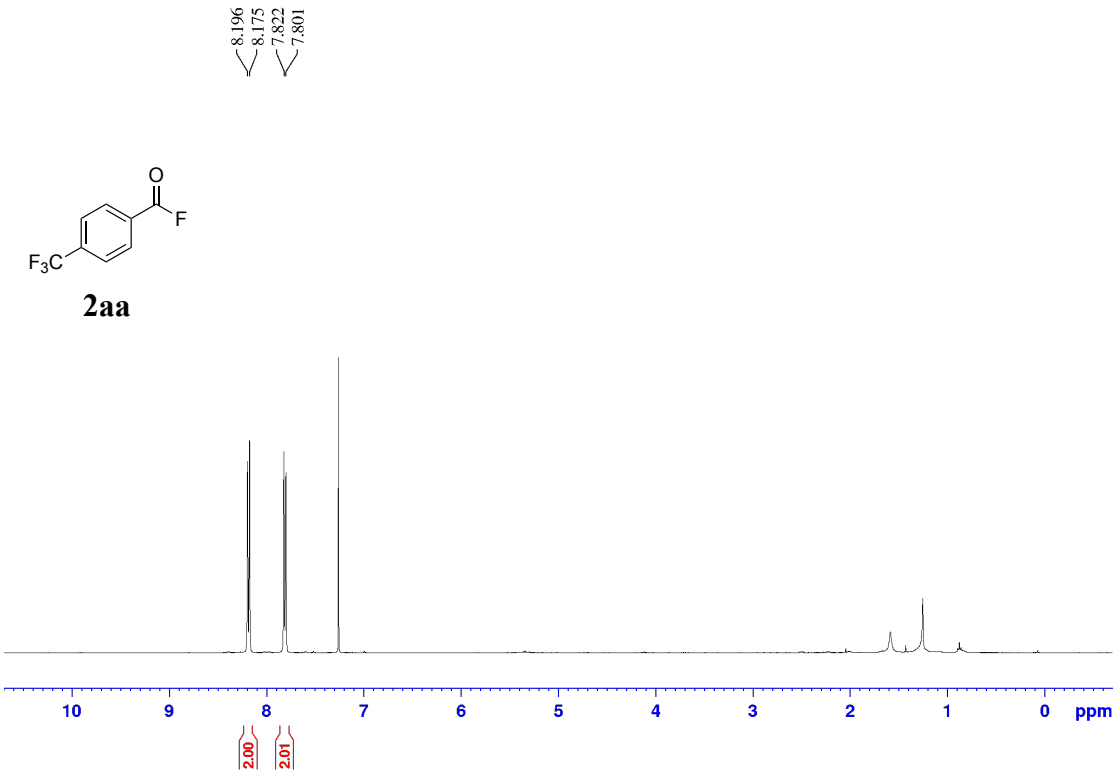
-57.62
O
F
F3CO
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm

2z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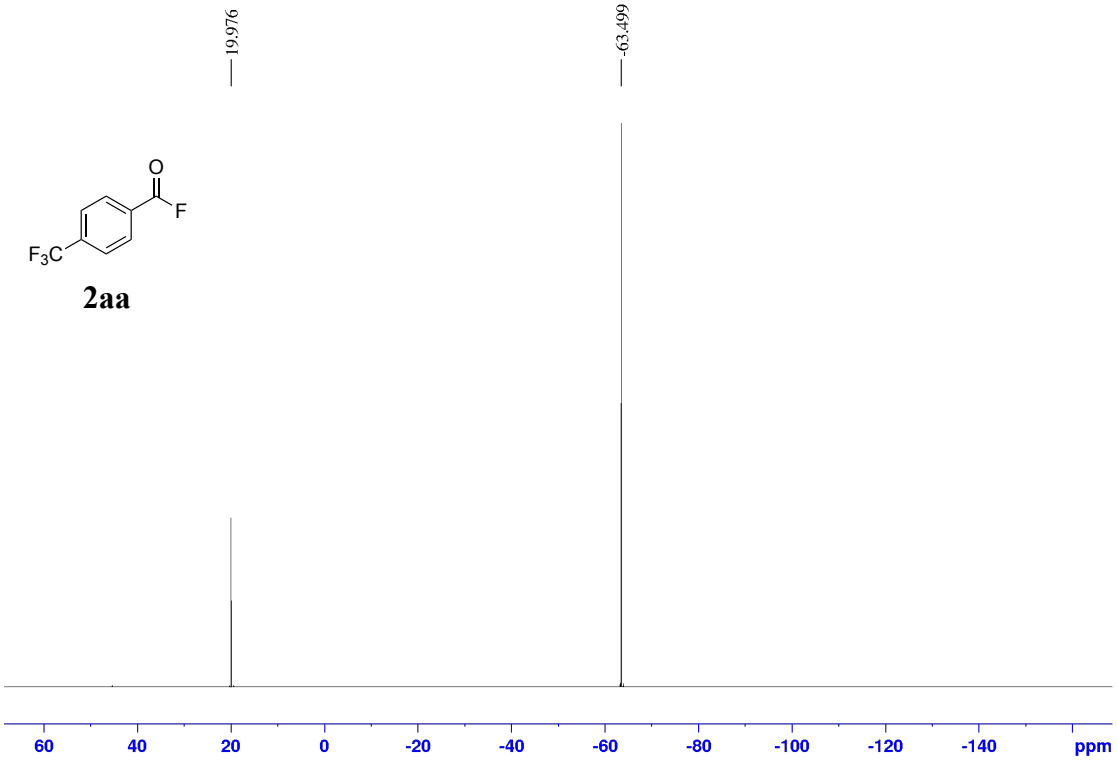
7.822
7.801
O
F
F3C
2aa
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.01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F3C
2aa
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20
0
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-40
-60
-80
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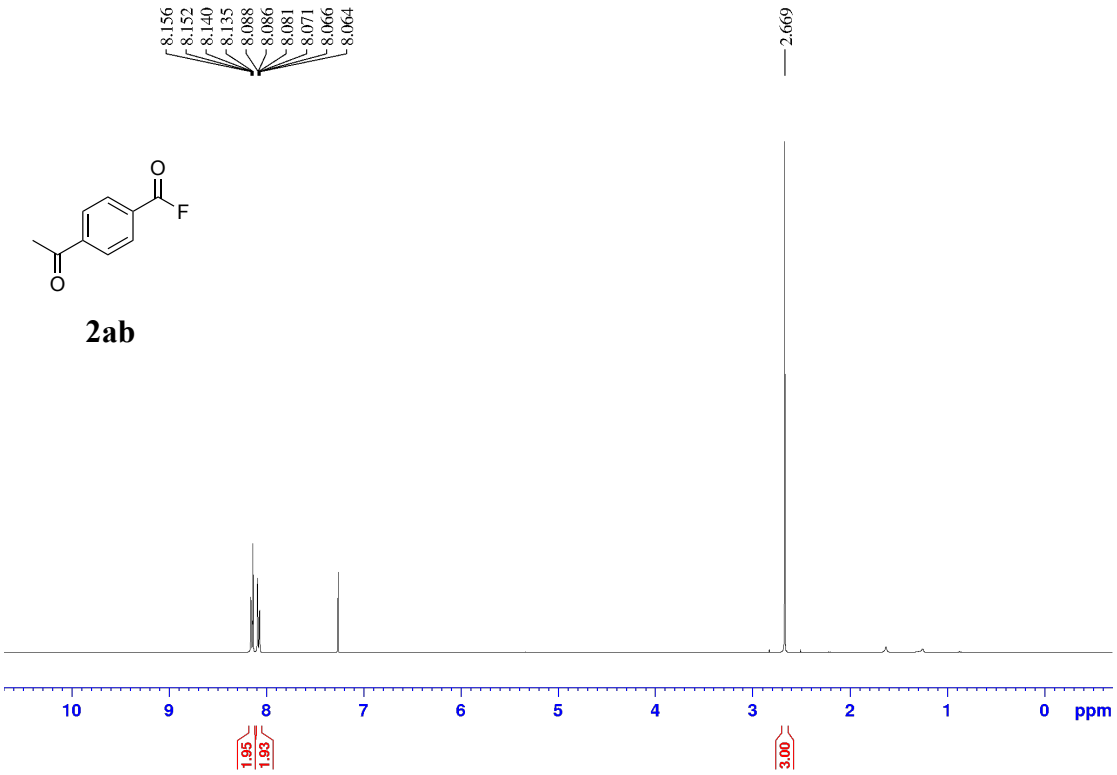
-120
-140
ppm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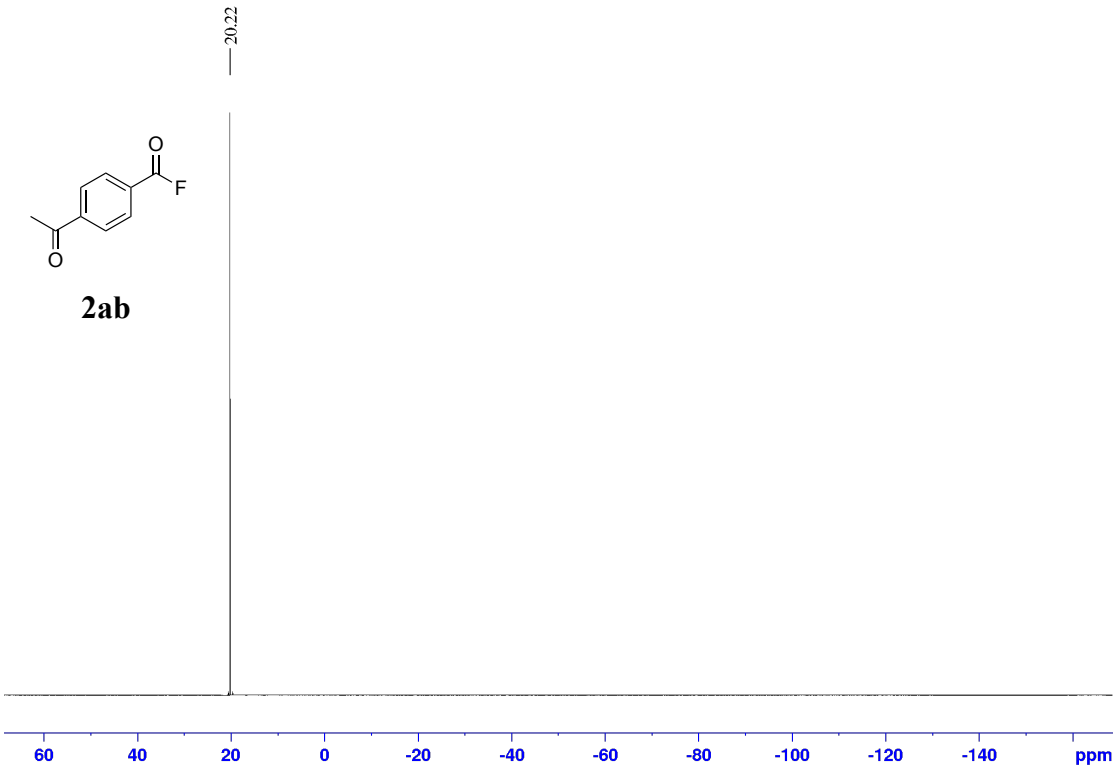
8.152
8.140
8.135
8.088
8.086
8.081
8.071
8.066
8.064
2.669
O
F
O
10
9
8
7
6
5
4
3
2
1
0
ppm
1.95
1.93
3.00

2ab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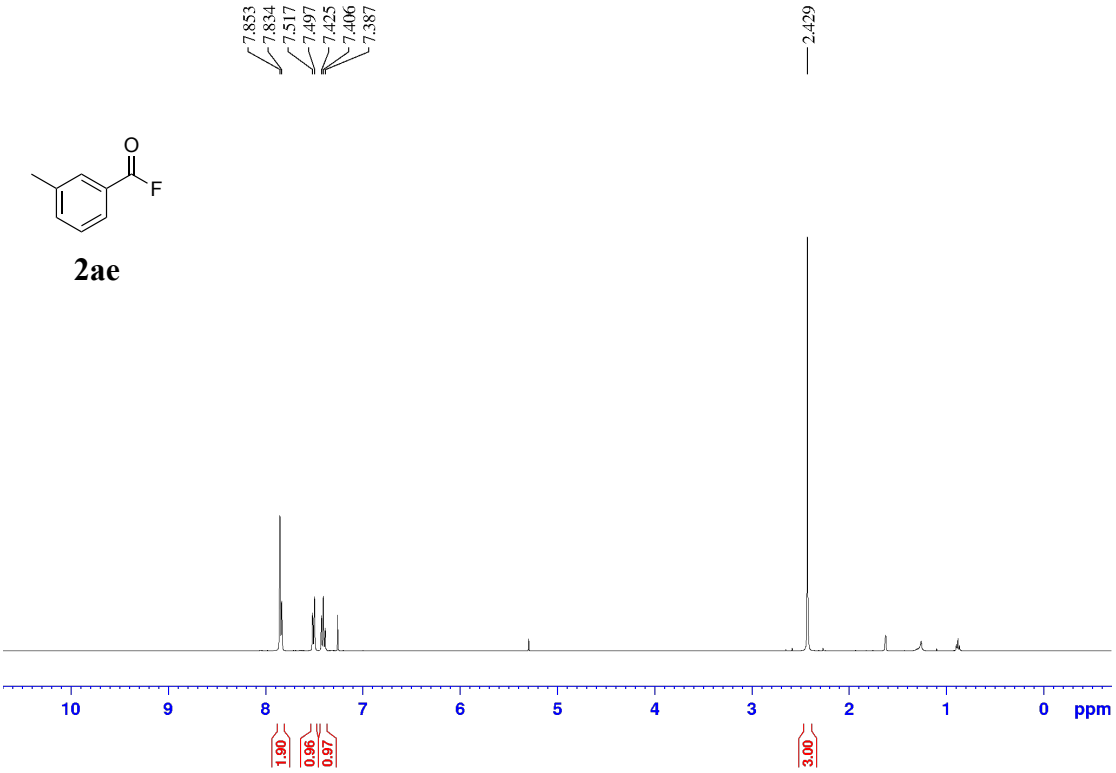
O
F
O
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm

2ab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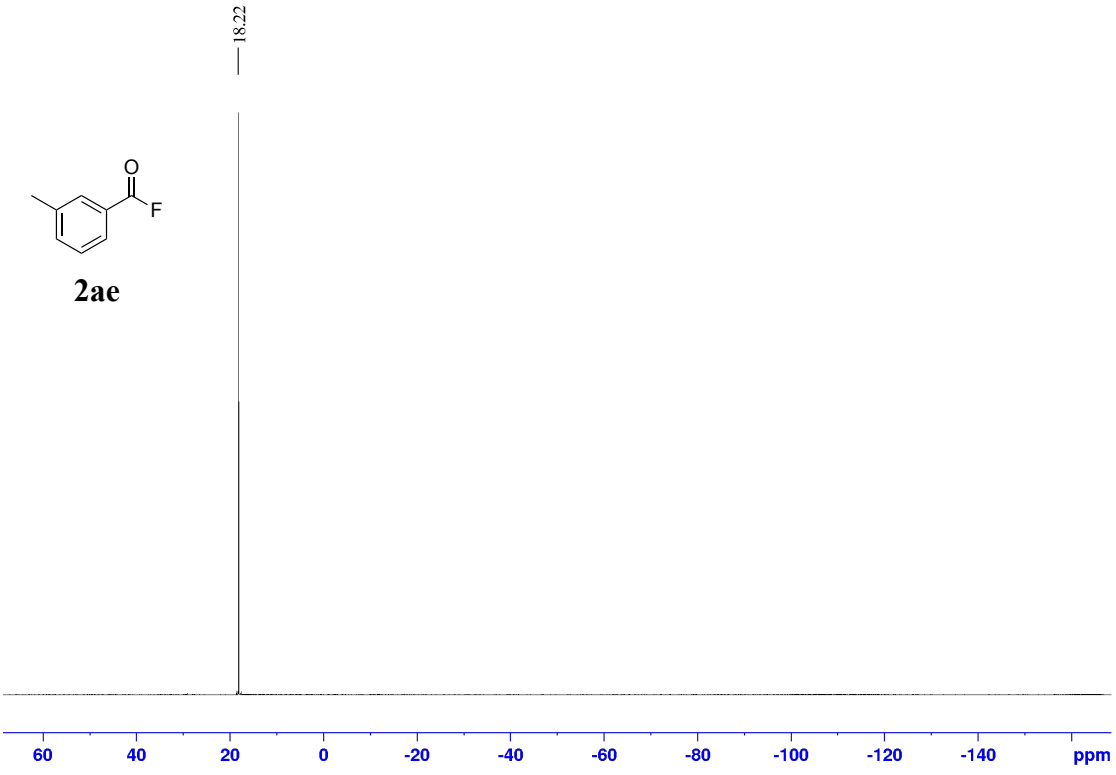
7.834
7.517
7.497
7.425
7.406
7.387
2.429
O
F
2ae
10
9
8
7
6
5
4
3
2
1
0
ppm
1.90
0.96
0.97
3.00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F
2ae
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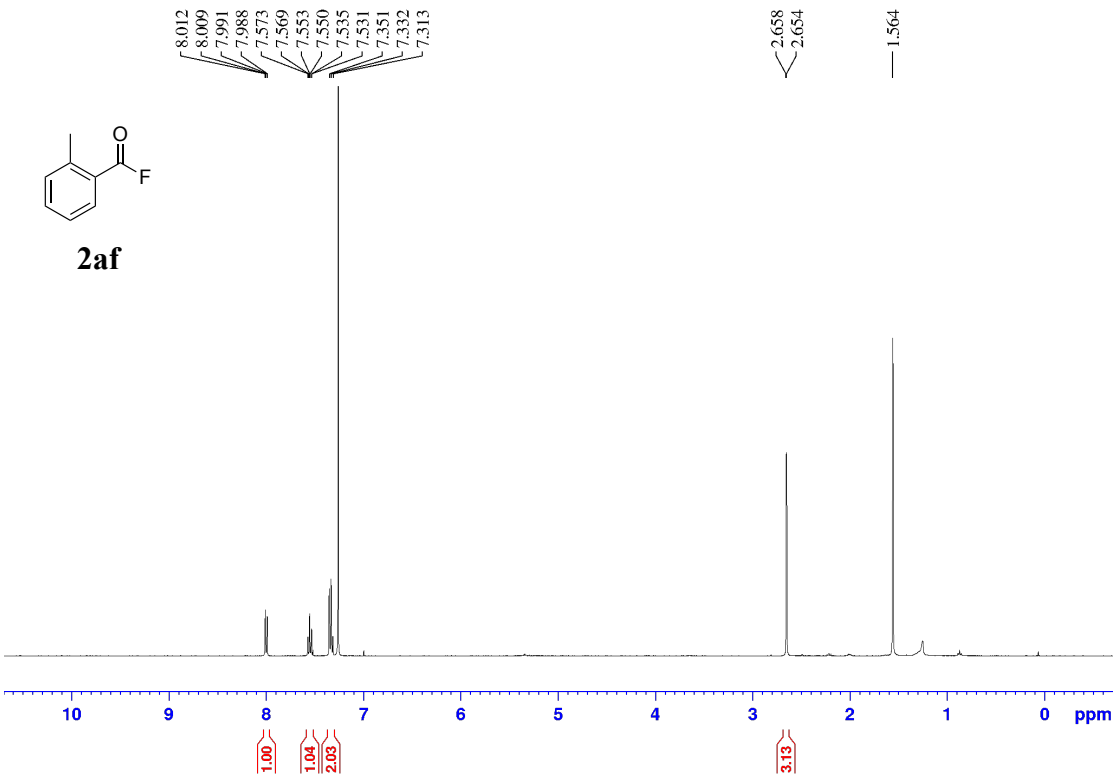
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm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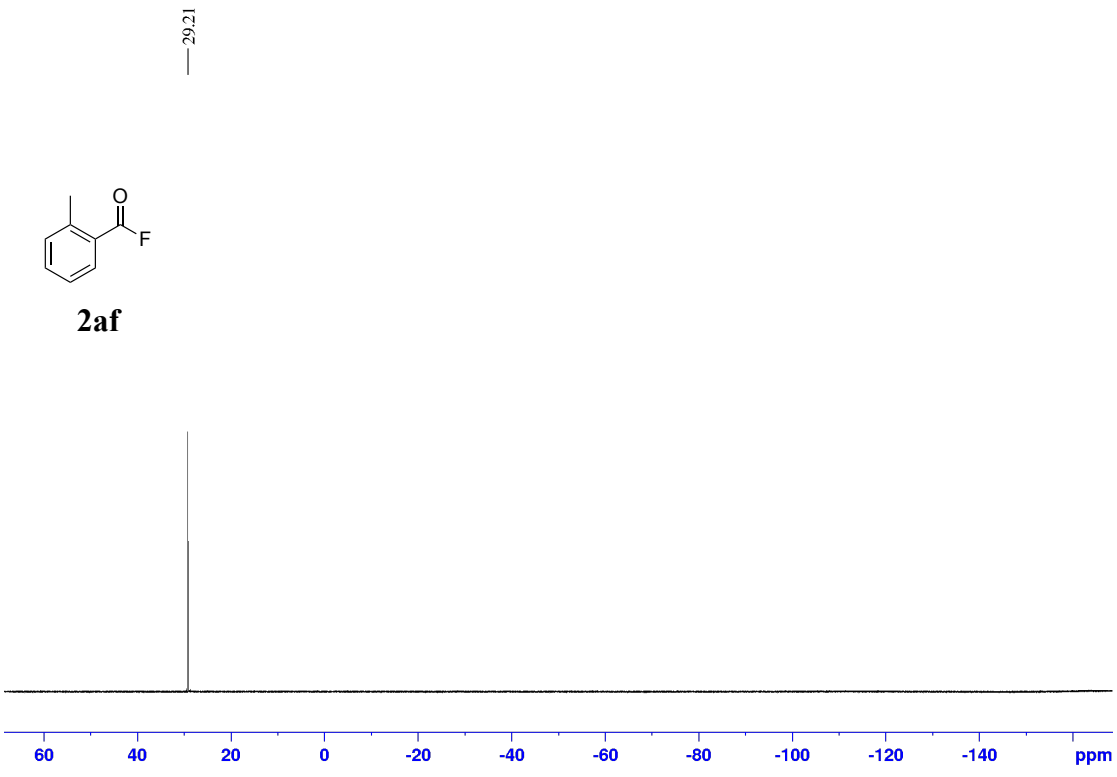
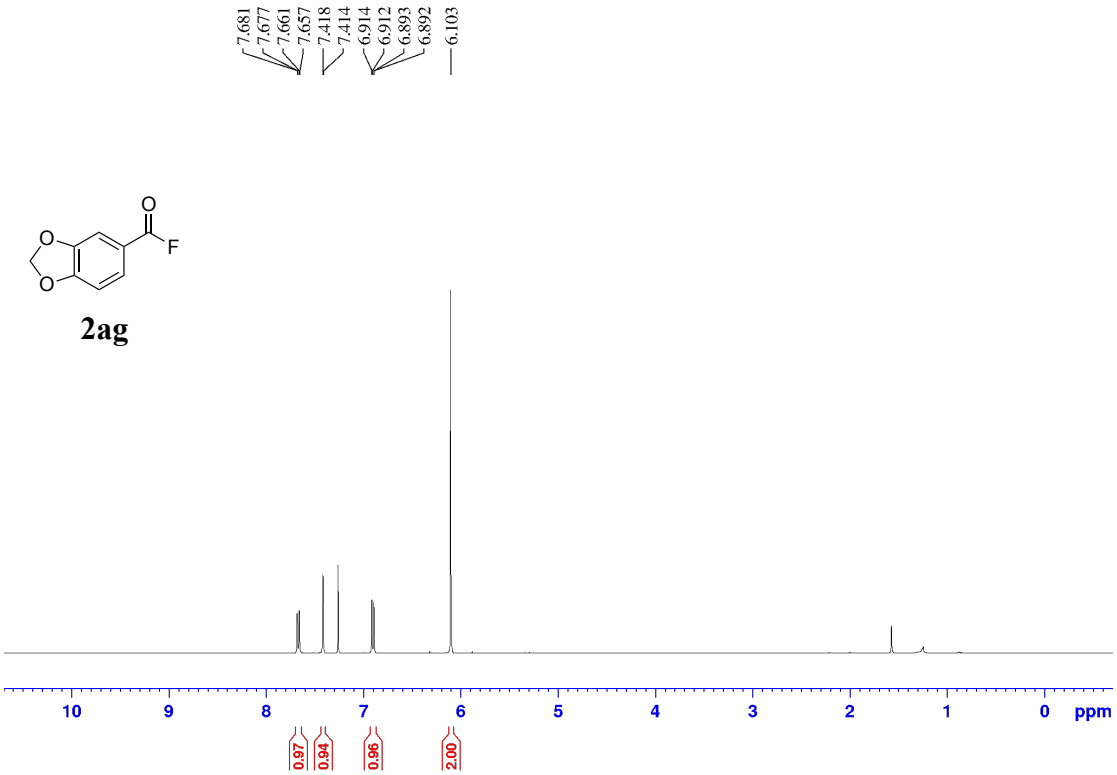
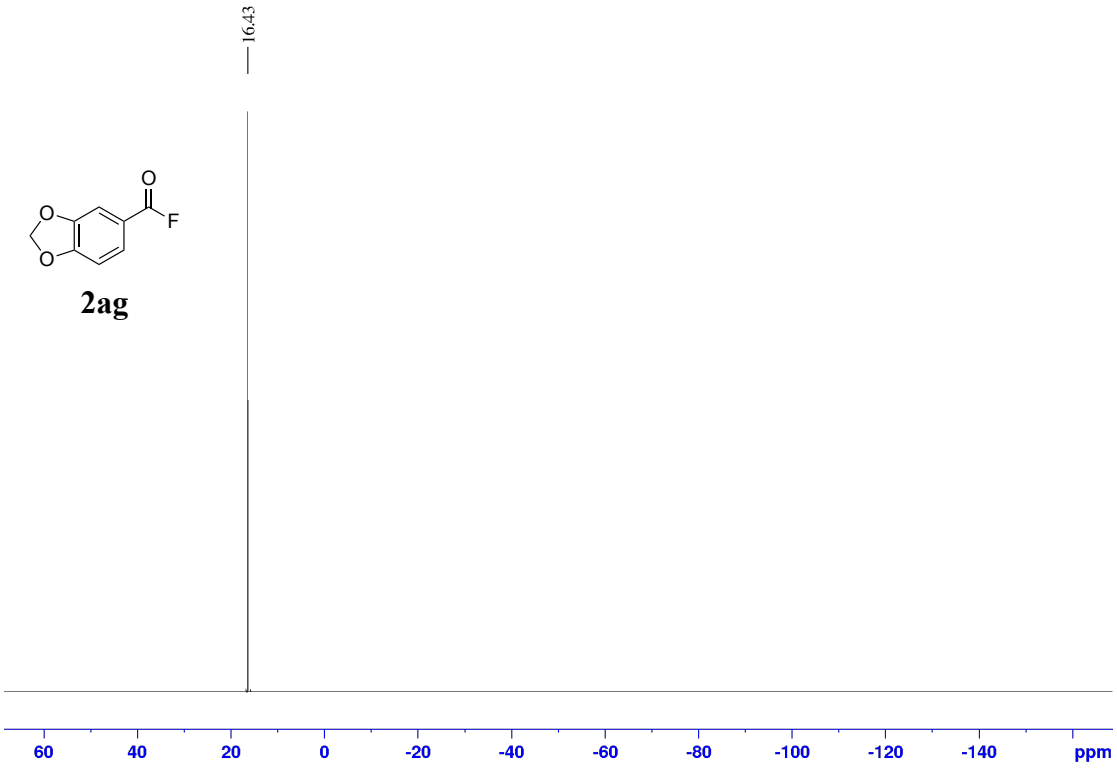
7.988
7.573
7.569
7.553
7.550
7.535
7.531
7.351
7.332
7.313
2.658
2.654
1.564
O
F
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.04
2.03
3.13

2af

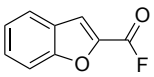

29.21
O
F
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm

2af

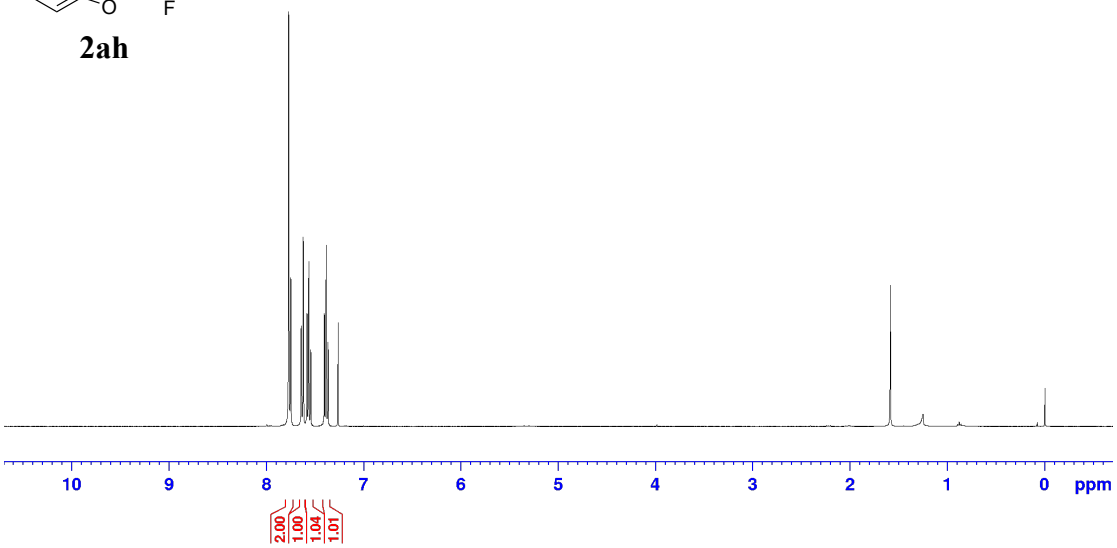

7.681
7.677
7.661
7.657
7.418
7.414
6.914
6.912
6.893
6.892
6.103
O
O
O
F
2ag
10
9
8
7
6
5
4
3
2
1
0
ppm
0.97
0.94
0.96
2.00


16.43
O
O
O
F
2ag
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm

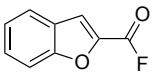

7.768
7.767
7.763
7.748
7.746
7.743
7.642
7.640
7.638
7.620
7.618
7.616
7.581
7.578
7.564
7.560
7.557
7.542
7.539
7.402
7.400
7.384
7.382
7.380
7.365
7.362


O
O
F

2ah


10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
1.00
1.04
1.01

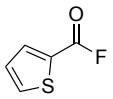

17.37


O
O
F

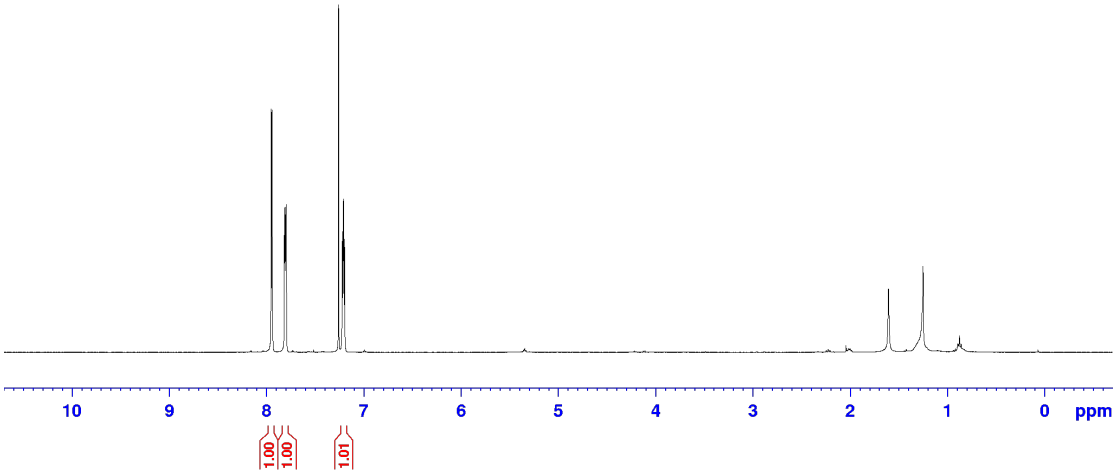
2ah

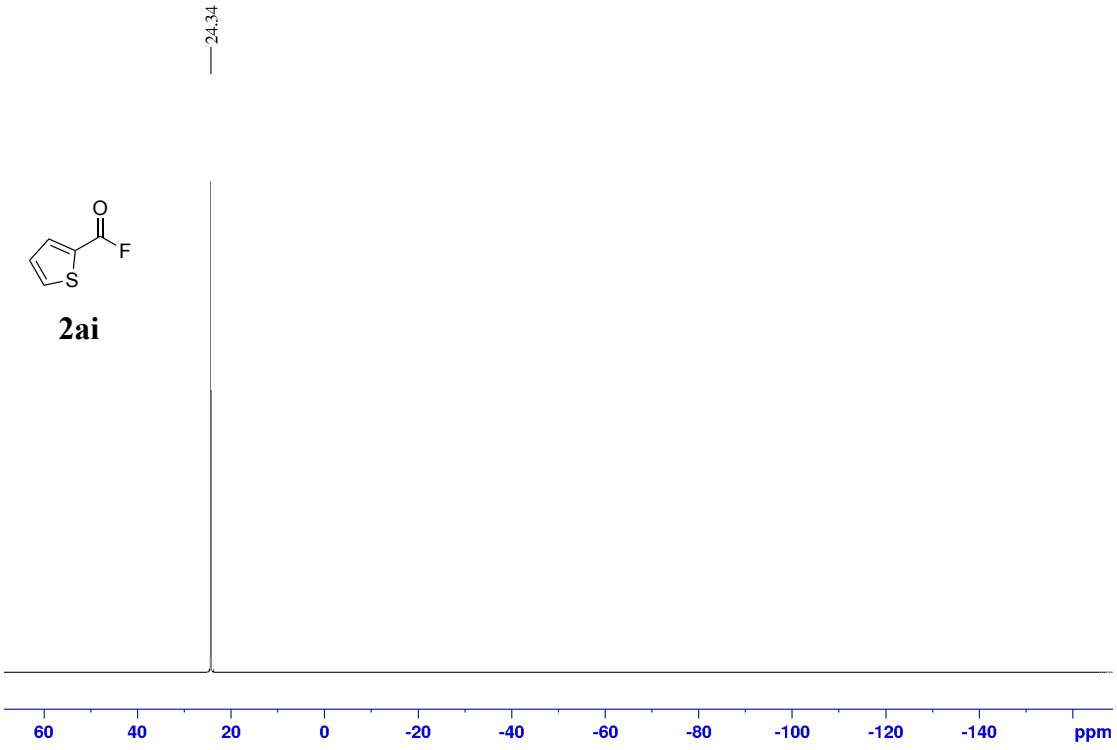
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm


7.954
7.951
7.944
7.941
7.818
7.814
7.812
7.809
7.805
7.802
7.800
7.797
7.224
7.219
7.214
7.211
7.209
7.206
7.202
7.196


O
F
S

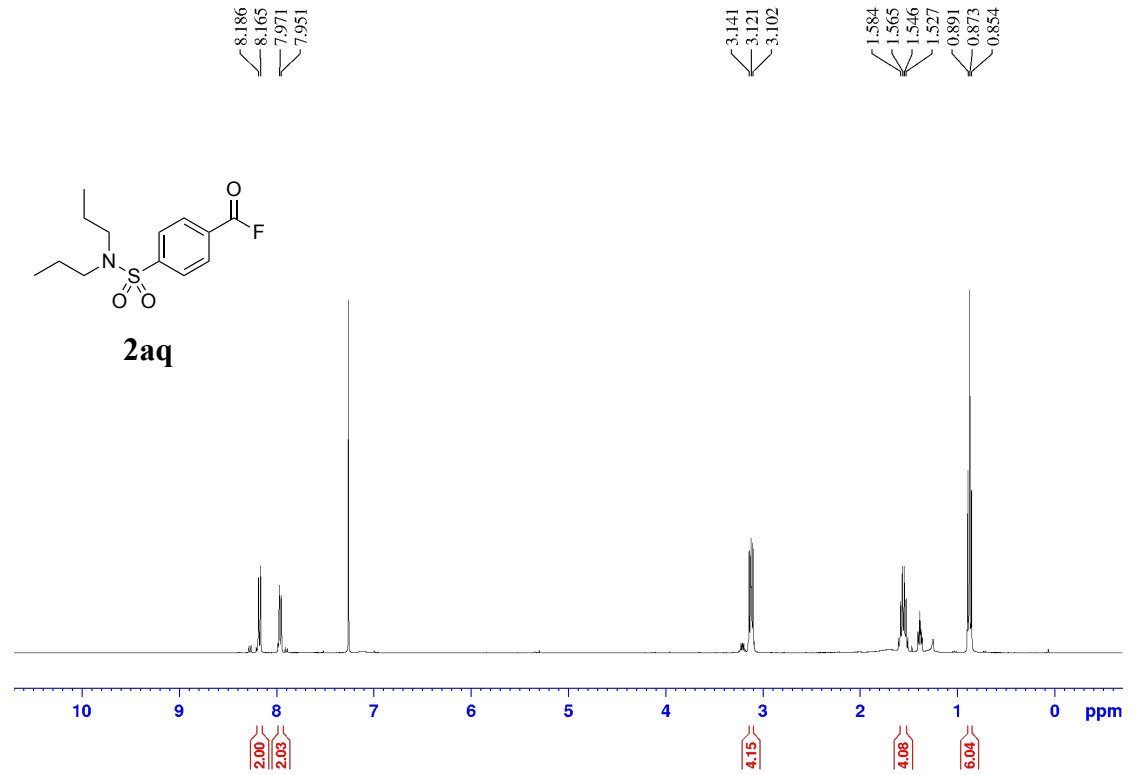
2ai


10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.00
1.01

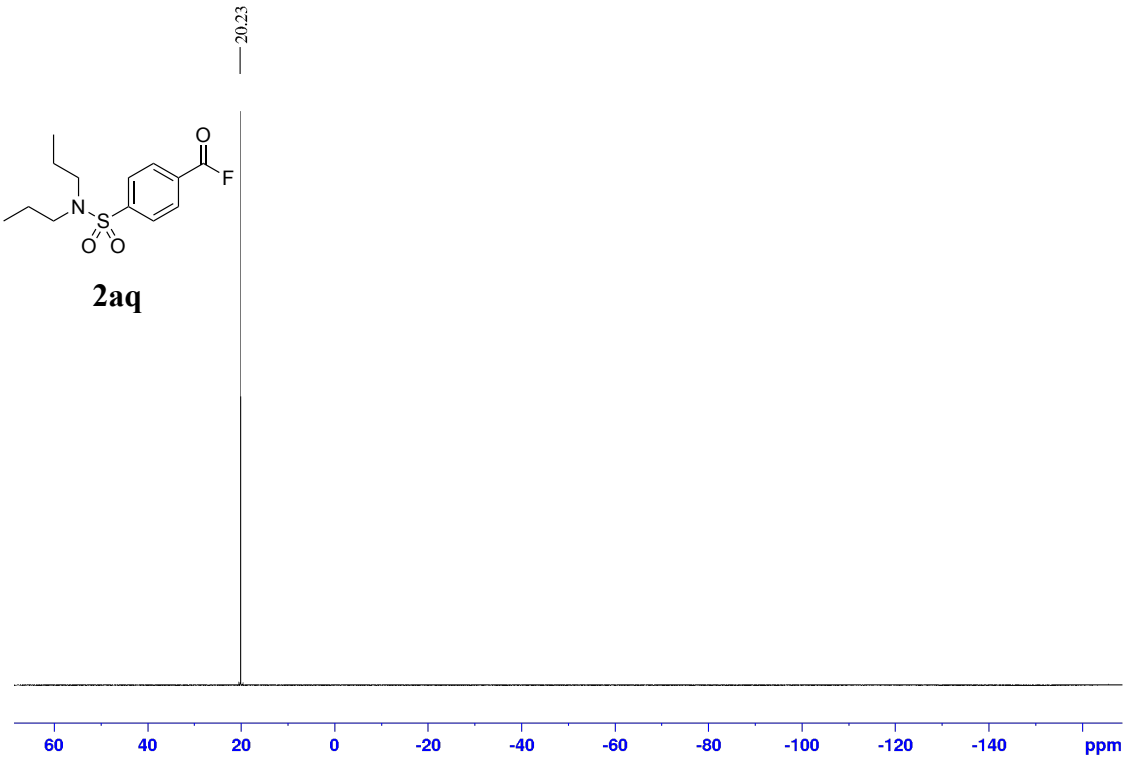

24.34
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm

O
F
S

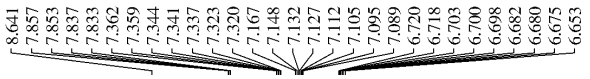
2ai

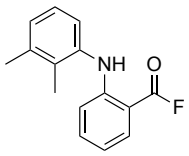

8.186
8.165
7.971
7.951
3.141
3.121
3.102
1.584
1.565
1.546
1.527
0.891
0.873
0.854
O
F
N
S
O
O
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.03
4.15
4.08
6.04

2aq

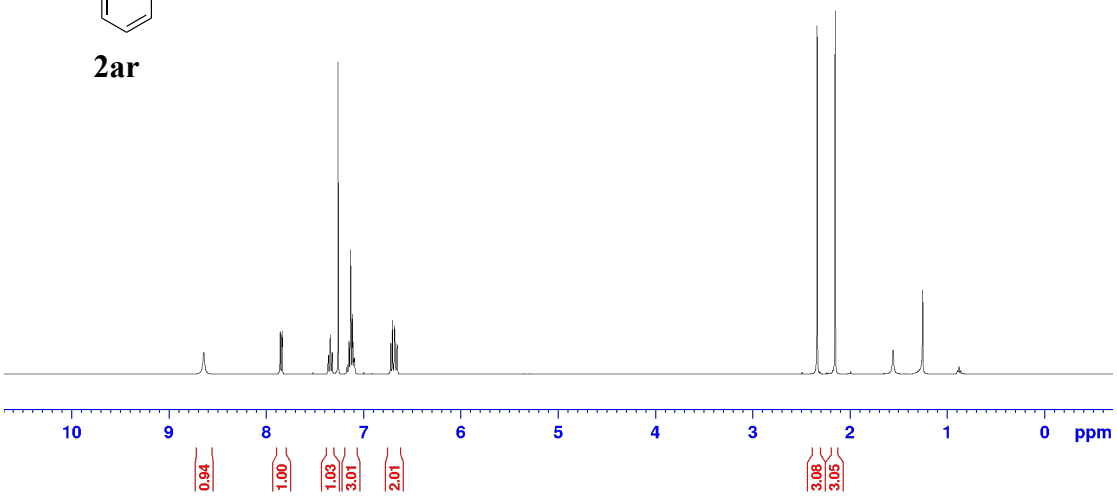

20.23
O
F
N
S
O
O
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm

2aq

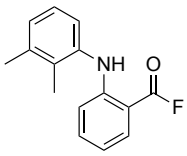

8.641
7.857
7.853
7.837
7.833
7.362
7.359
7.344
7.341
7.337
7.323
7.320
7.167
7.148
7.132
7.127
7.112
7.105
7.095
7.089
6.720
6.718
6.703
6.700
6.698
6.682
6.680
6.675
6.653
2.341
2.155


NH
O
F

2ar

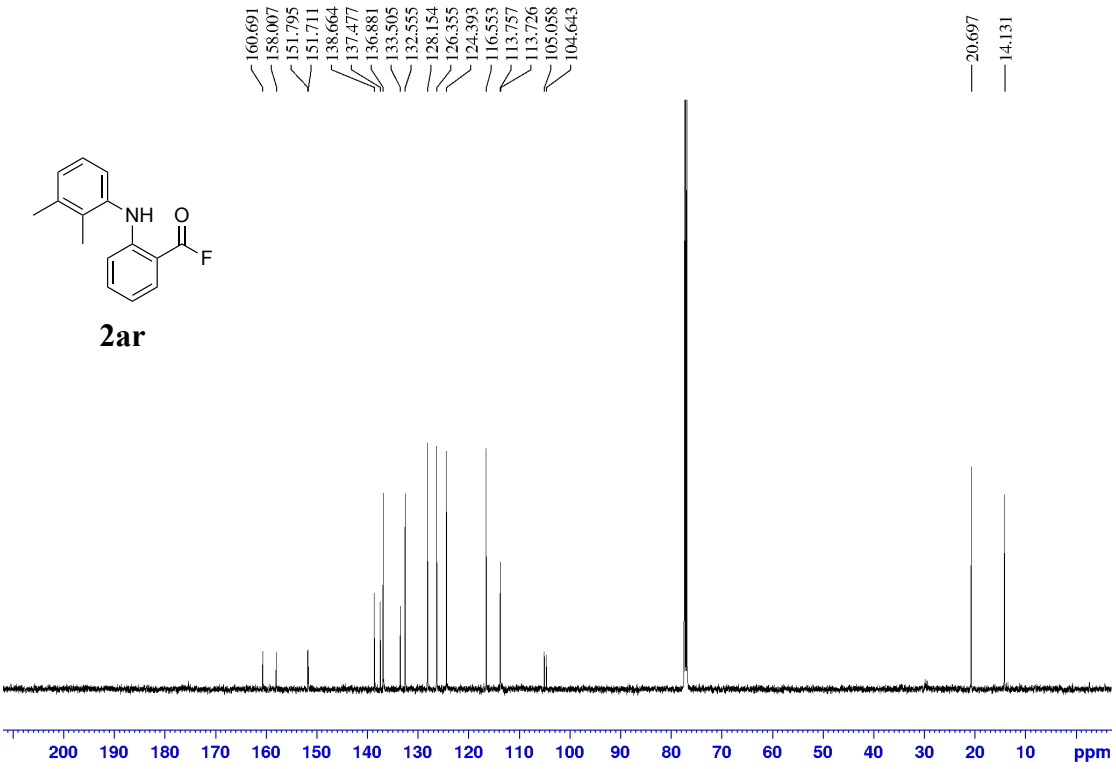

10
9
8
7
6
5
4
3
2
1
0
ppm
0.94
1.00
1.03
3.01
2.01
3.08
3.05


19.91

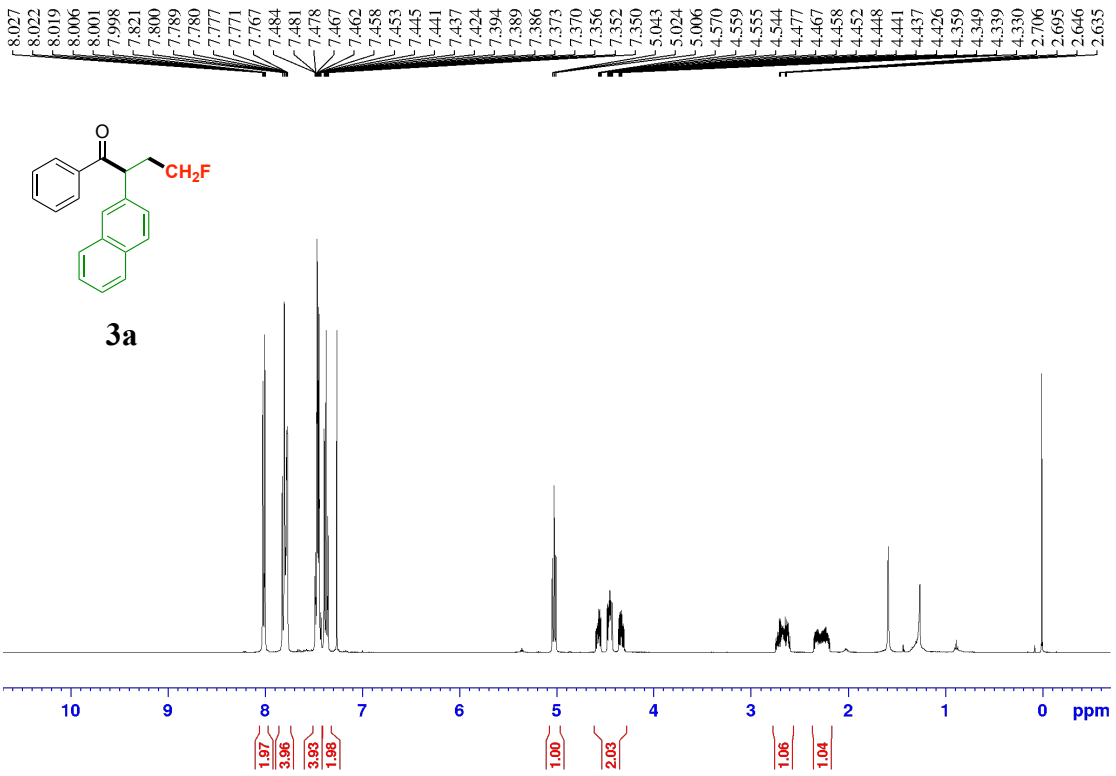

NH
O
F

2ar

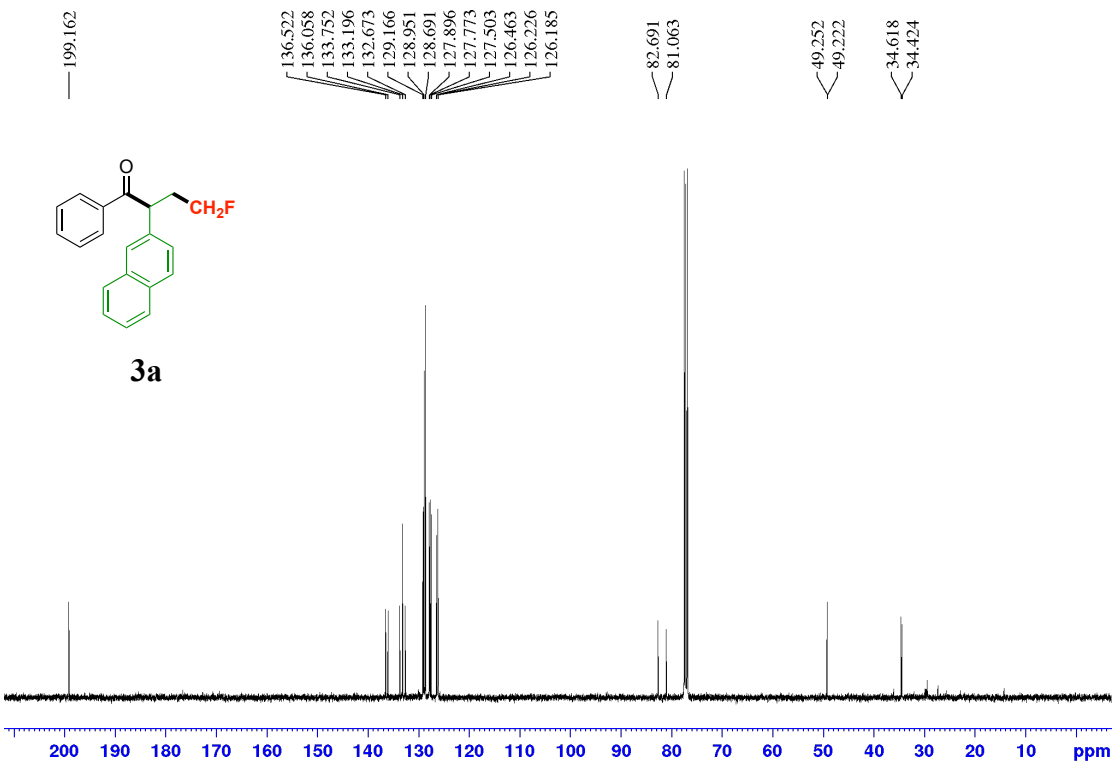
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
ppm


160.691
158.007
151.795
151.711
138.664
137.477
136.881
133.505
132.555
128.154
126.355
124.393
116.553
113.757
113.726
105.058
104.643
20.697
14.131
NH
O
F
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

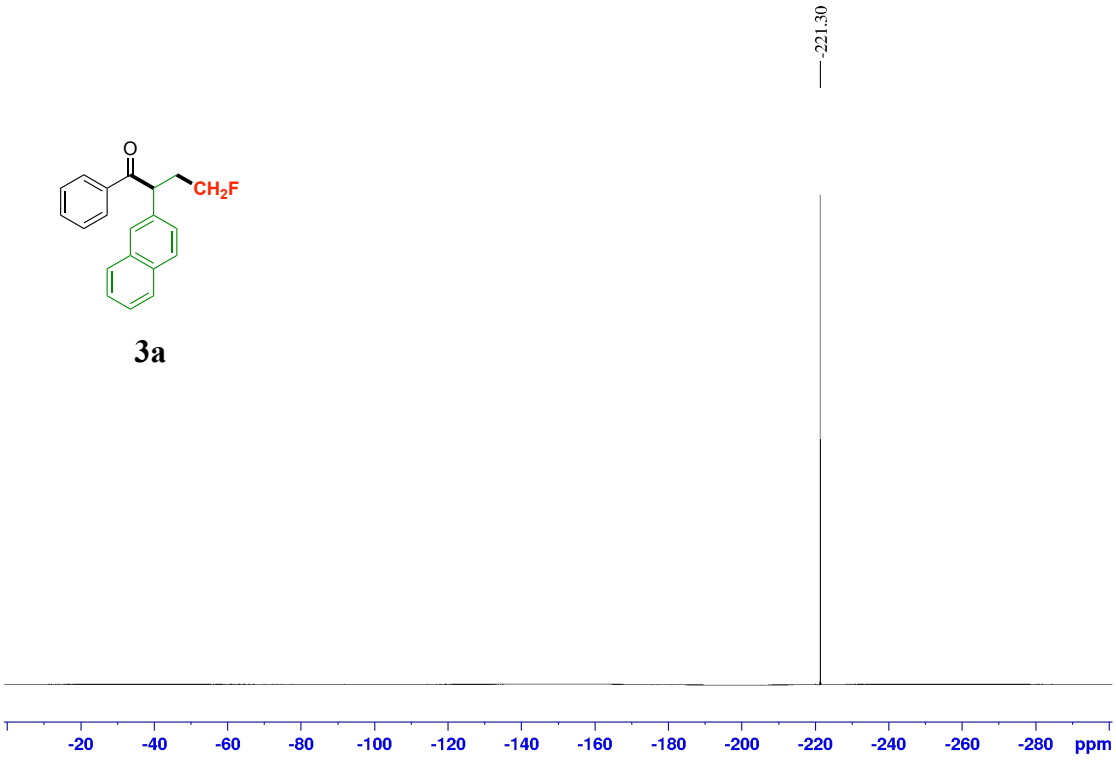
2ar


8.027
8.022
8.019
8.006
8.001
7.998
7.821
7.800
7.789
7.780
7.777
7.771
7.767
7.484
7.481
7.478
7.467
7.462
7.458
7.453
7.445
7.441
7.437
7.424
7.394
7.389
7.386
7.373
7.370
7.356
7.352
7.350
5.043
5.024
5.006
4.570
4.559
4.555
4.544
4.477
4.467
4.458
4.452
4.448
4.441
4.437
4.426
4.359
4.349
4.339
4.330
2.706
2.695
2.646
2.635
O
CH2F
10 9 8 7 6 5 4 3 2 1 0 ppm
1.97
3.96
3.93
1.98
1.00
2.03
1.06
1.04

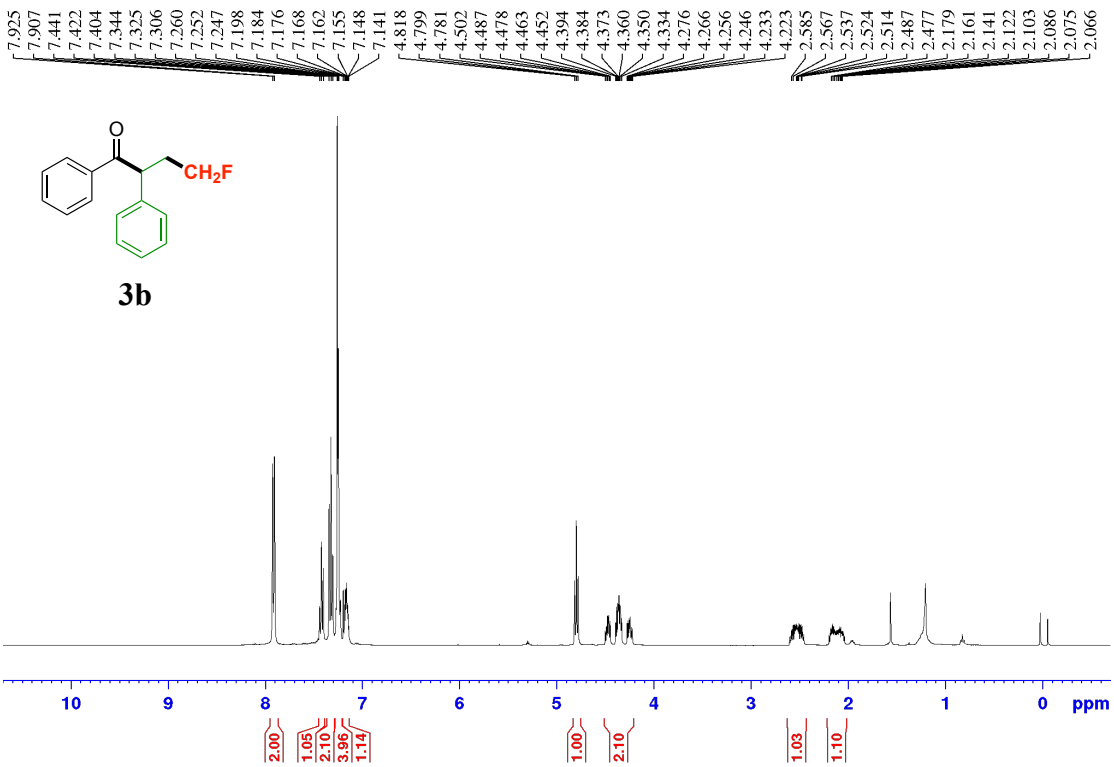
3a

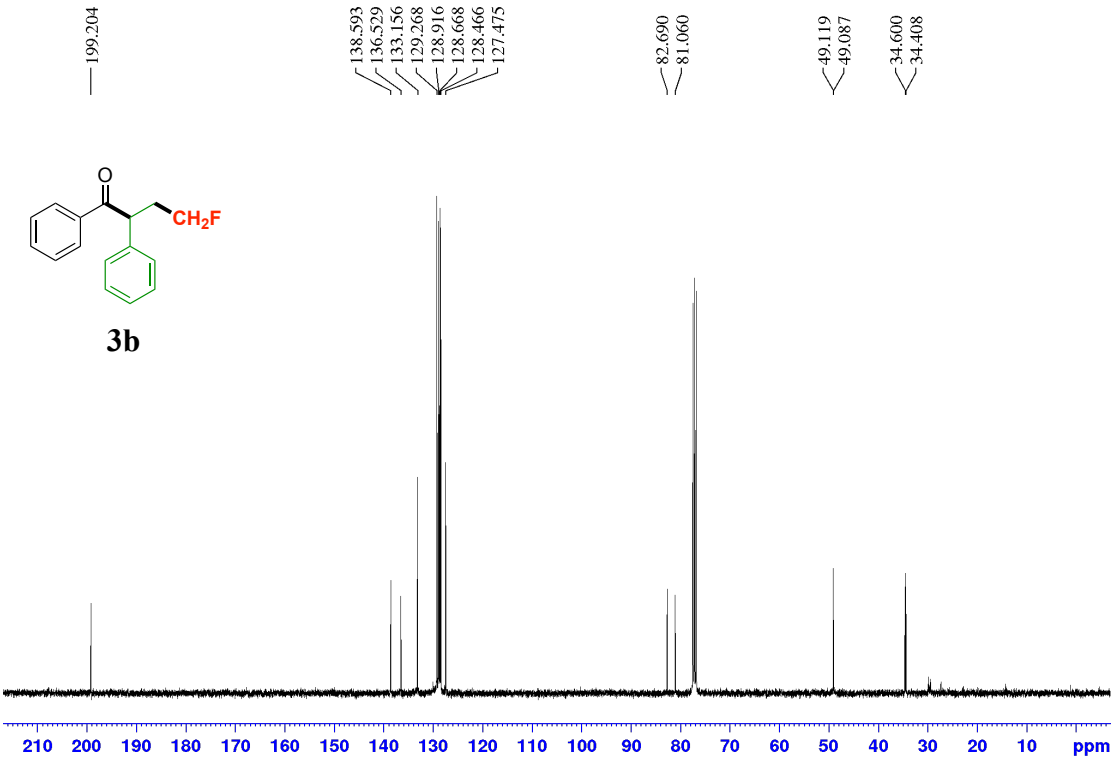

199.162
136.522
136.058
133.752
133.196
132.673
129.166
128.951
128.691
127.896
127.773
127.503
126.463
126.226
126.185
82.691
81.063
49.252
49.222
34.618
34.424
O
CH2F
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

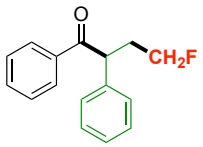
3a


-221.30
O
CH2F
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3a

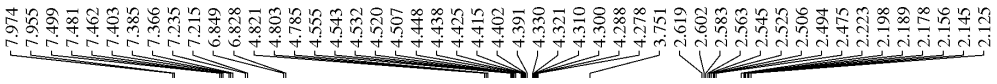

7.925
7.907
7.441
7.422
7.404
7.344
7.325
7.306
7.260
7.252
7.247
7.198
7.184
7.176
7.168
7.162
7.155
7.148
7.141
4.818
4.799
4.781
4.502
4.487
4.478
4.463
4.452
4.394
4.384
4.373
4.360
4.350
4.334
4.276
4.266
4.256
4.246
4.233
4.223
2.585
2.567
2.537
2.524
2.514
2.487
2.477
2.179
2.161
2.141
2.122
2.103
2.086
2.075
2.066
O
CH2F
3b
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
1.05
2.10
3.96
1.14
1.00
2.10
1.03
1.10

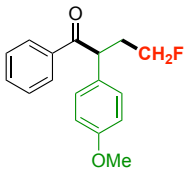

199.204
138.593
136.529
133.156
129.268
128.916
128.668
128.466
127.475
82.690
81.060
49.119
49.087
34.600
34.408
O
CH2F
3b
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F

3b

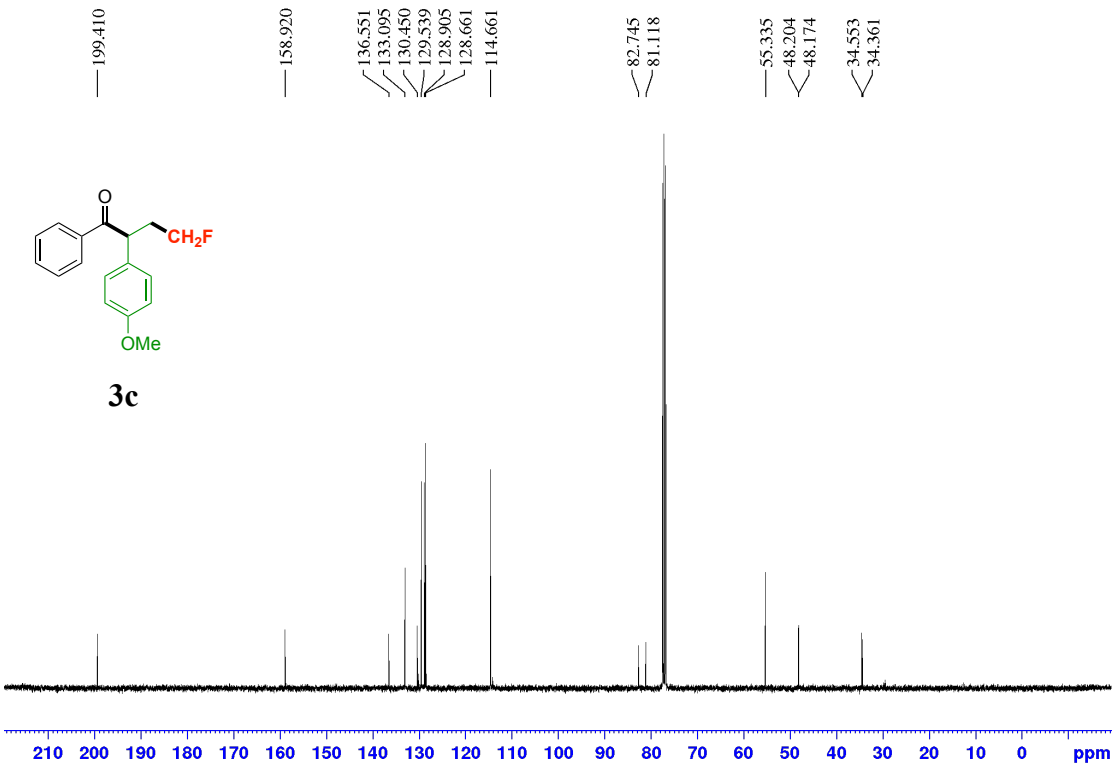
-221.33
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.974
7.955
7.499
7.481
7.462
7.403
7.385
7.366
7.235
7.215
6.849
6.828
4.821
4.803
4.785
4.555
4.543
4.532
4.520
4.507
4.448
4.438
4.425
4.415
4.402
4.391
4.330
4.321
4.310
4.300
4.288
4.278
3.751
2.619
2.602
2.583
2.563
2.545
2.525
2.506
2.494
2.475
2.223
2.198
2.189
2.178
2.156
2.145
2.125

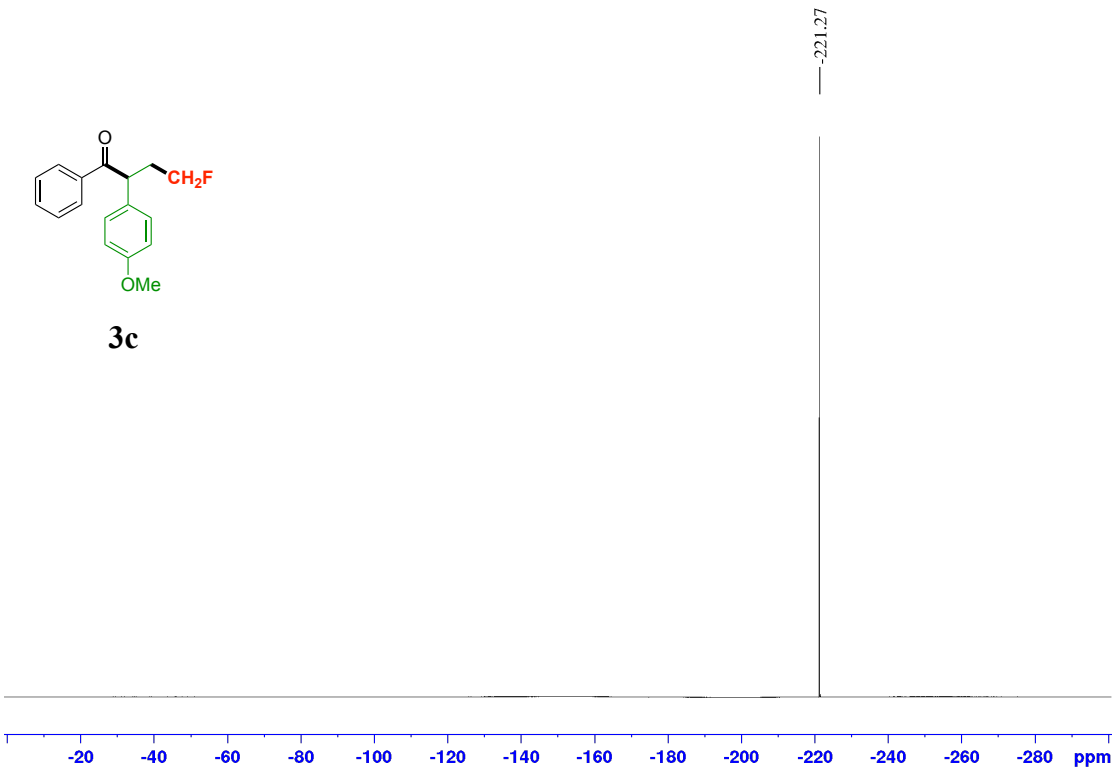

O
CH2F
OMe

3c

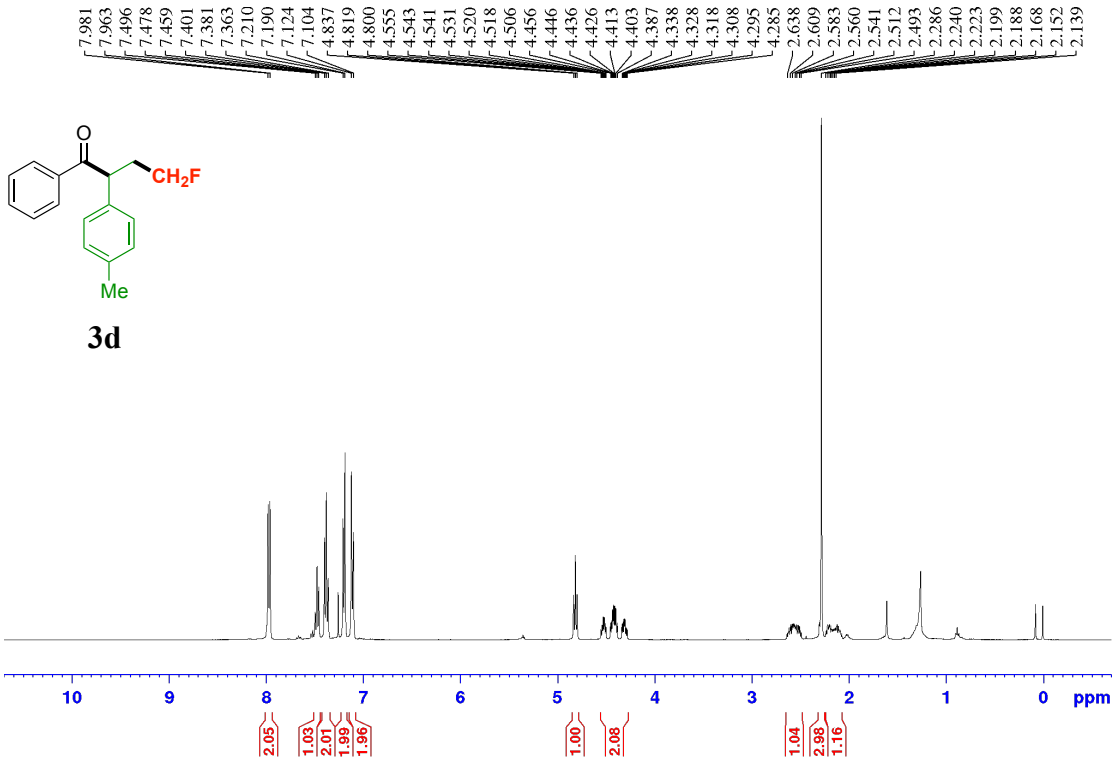
10
9
8
7
6
5
4
3
2
1
ppm
2.00
1.09
2.07
1.93
2.06
1.00
2.08
2.99
1.04
1.08

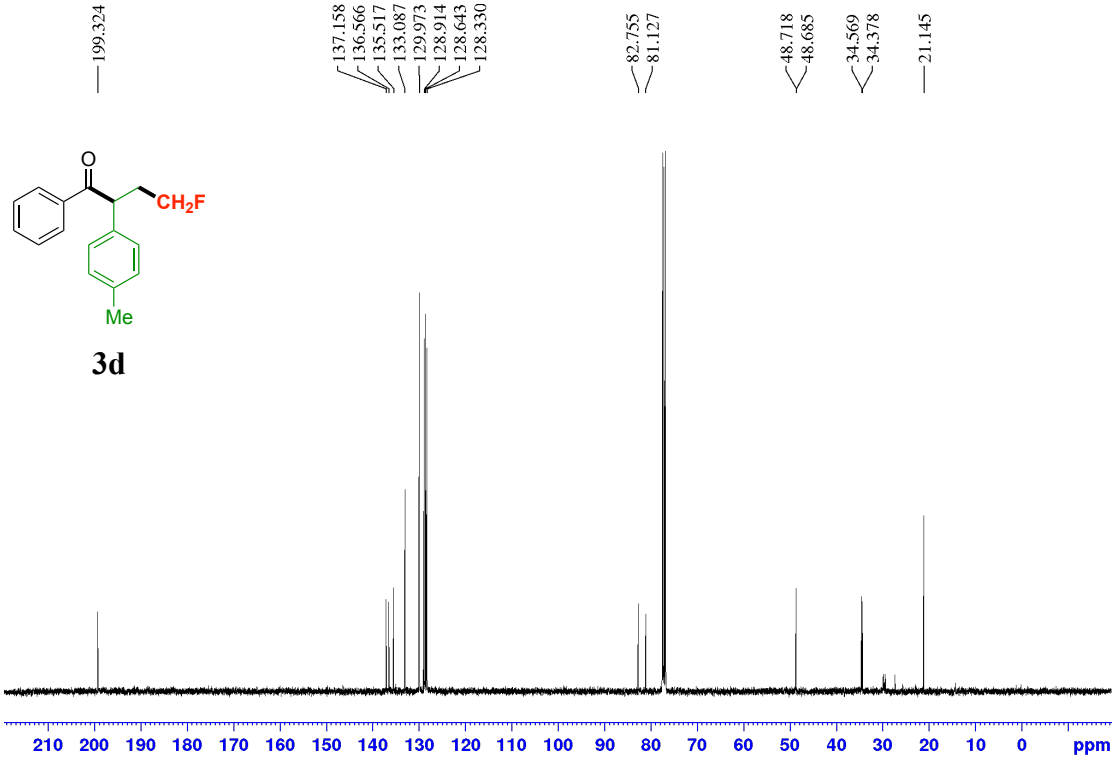

199.410
158.920
136.551
133.095
130.450
129.539
128.905
128.661
114.661
82.745
81.118
55.335
48.204
48.174
34.553
34.361
O
CH2F
OMe
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

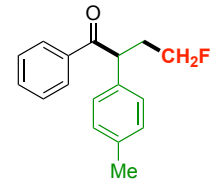
3c


-221.27
O
CH2F
OMe
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3c

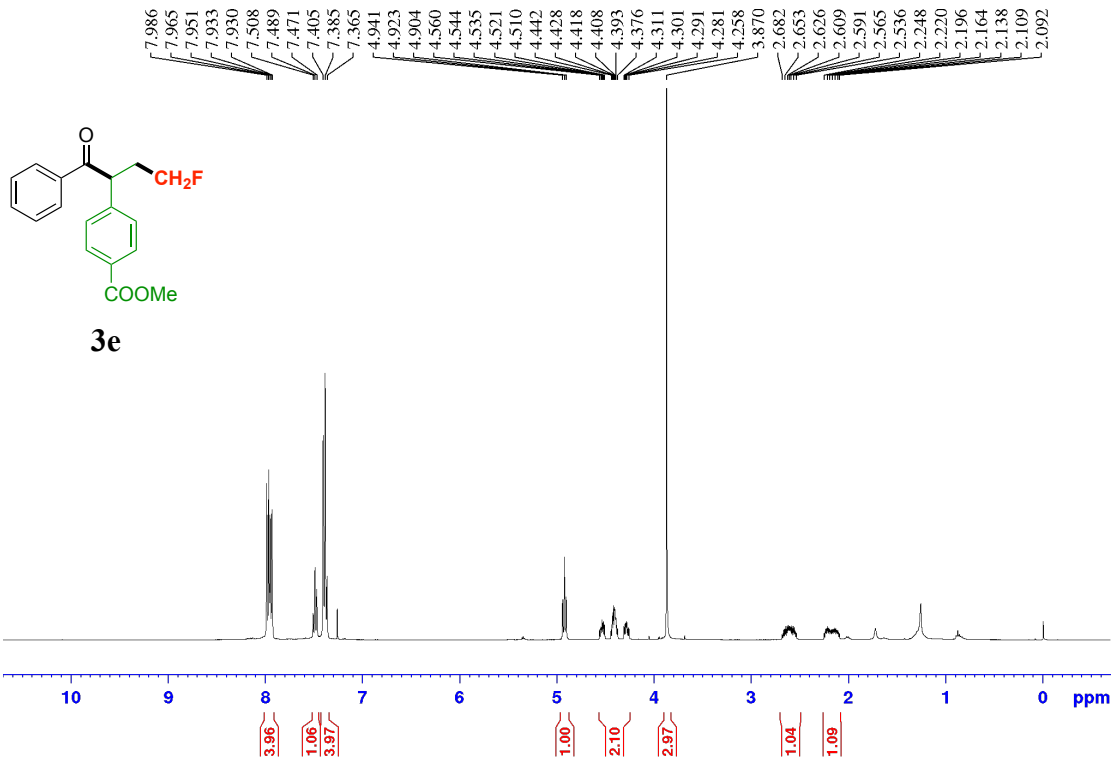

7.981
7.963
7.496
7.478
7.459
7.401
7.381
7.363
7.210
7.190
7.124
7.104
4.837
4.819
4.800
4.555
4.543
4.541
4.531
4.520
4.518
4.506
4.456
4.446
4.436
4.426
4.413
4.403
4.387
4.338
4.328
4.318
4.308
4.295
4.285
2.638
2.609
2.583
2.560
2.541
2.512
2.493
2.286
2.240
2.223
2.199
2.188
2.168
2.152
2.139
O
CH2F
Me
3d
10
9
8
7
6
5
4
3
2
1
0
ppm
2.05
1.03
2.01
1.99
1.96
1.00
2.08
1.04
2.98
1.16


199.324
137.158
136.566
135.517
133.087
129.973
128.914
128.643
128.330
82.755
81.127
48.718
48.685
34.569
34.378
21.145
O
CH2F
Me
3d
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


O
CH2F
Me

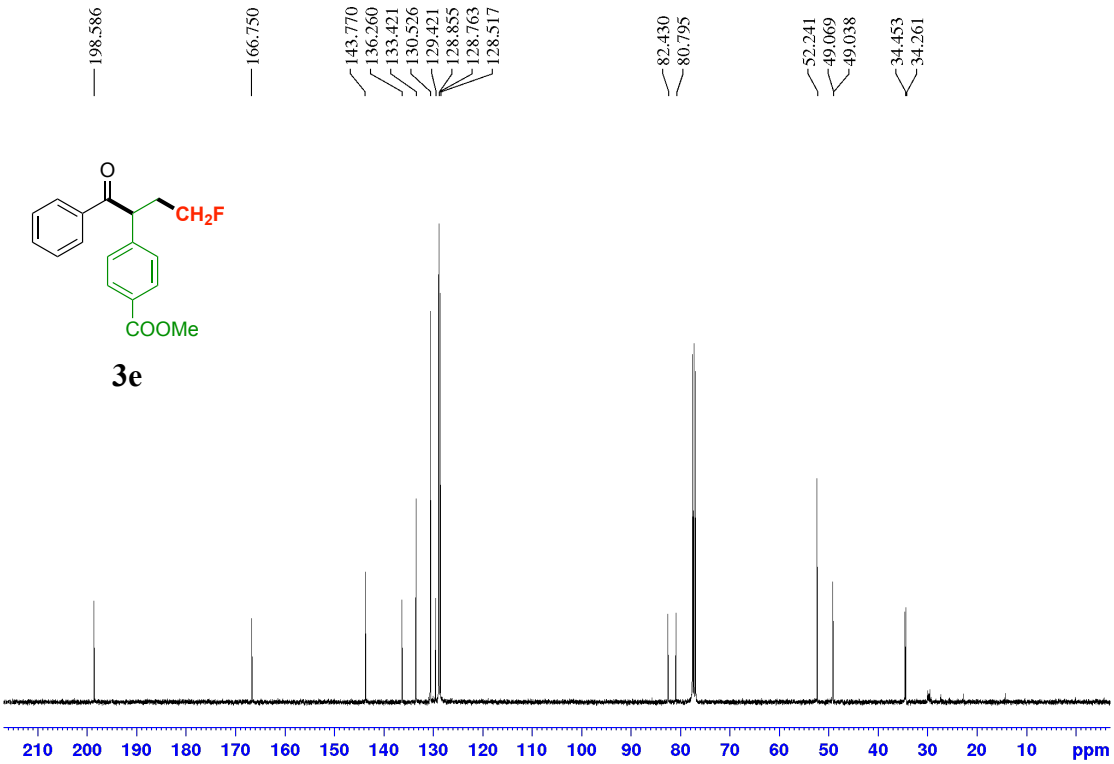
3d

221.33
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm

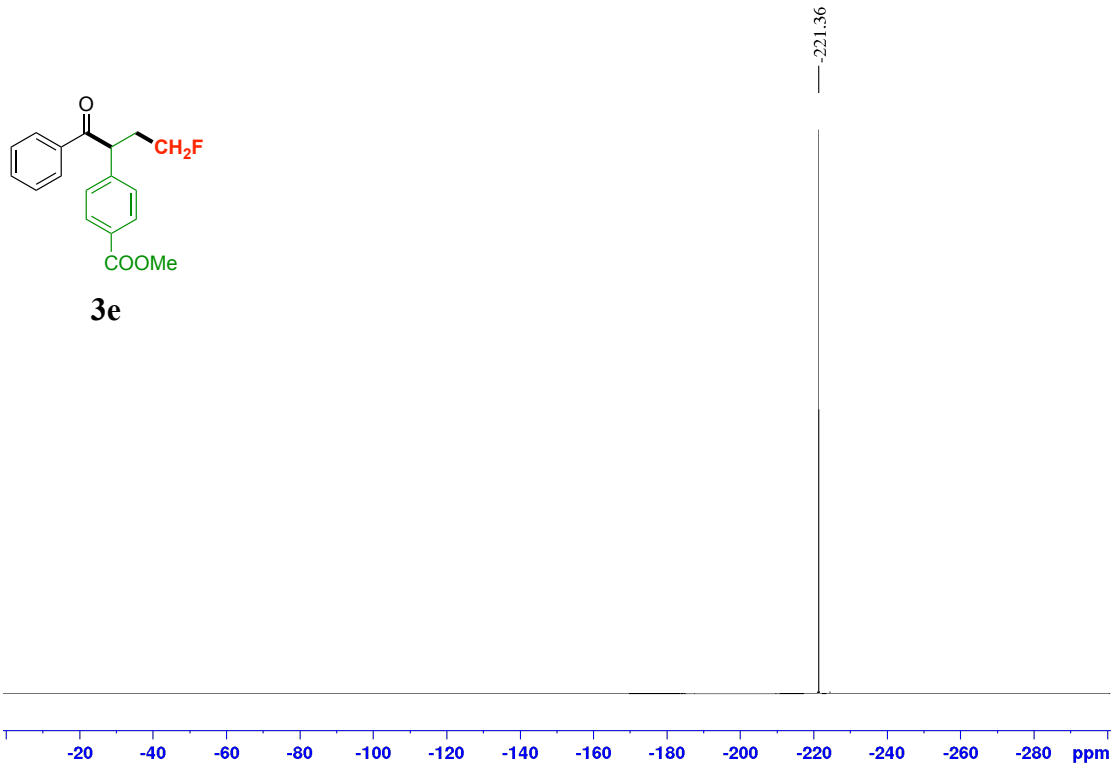

7.986
7.965
7.951
7.933
7.930
7.508
7.489
7.471
7.405
7.385
7.365
4.941
4.923
4.904
4.560
4.544
4.535
4.521
4.510
4.442
4.428
4.418
4.408
4.393
4.376
4.311
4.301
4.291
4.281
4.258
3.870
2.682
2.653
2.626
2.609
2.591
2.565
2.536
2.248
2.220
2.196
2.164
2.138
2.109
2.092
10
9
8
7
6
5
4
3
2
1
0
ppm
3.96
1.06
3.97
1.00
2.10
2.97
1.04
1.09

O
CH2F
COOMe

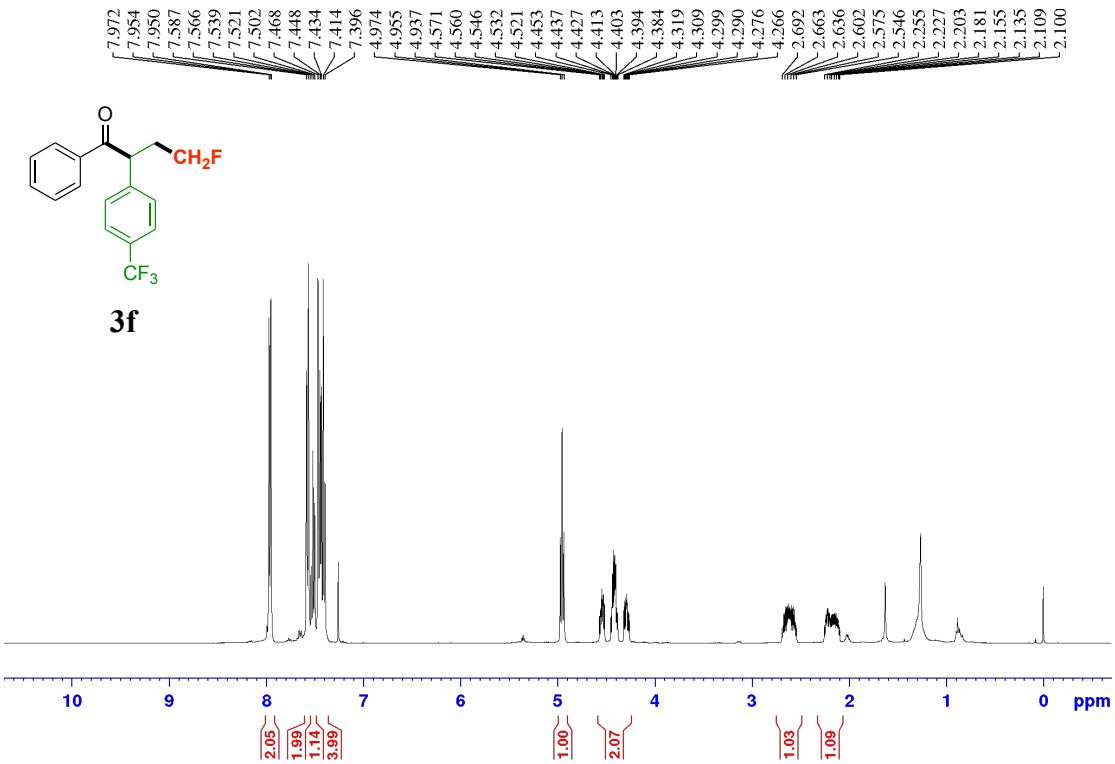
3e

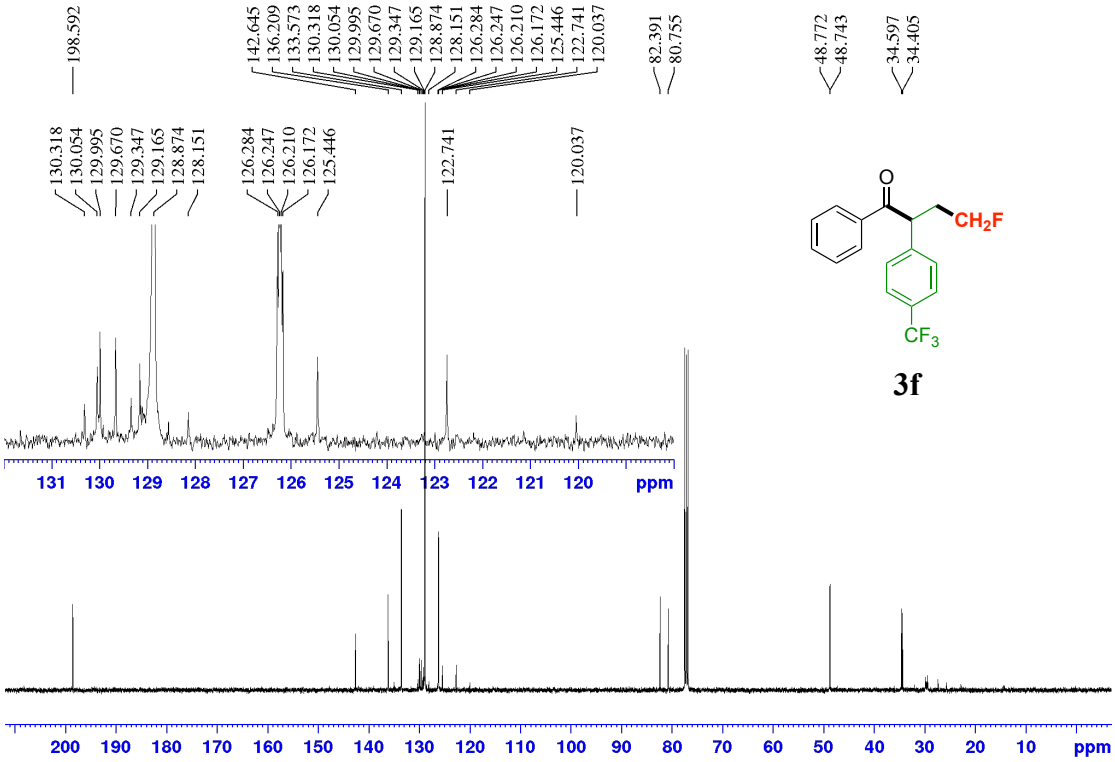

198.586
166.750
143.770
136.260
133.421
130.526
129.421
128.855
128.763
128.517
82.430
80.795
52.241
49.069
49.038
34.453
34.261
O
CH2F
COOMe
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

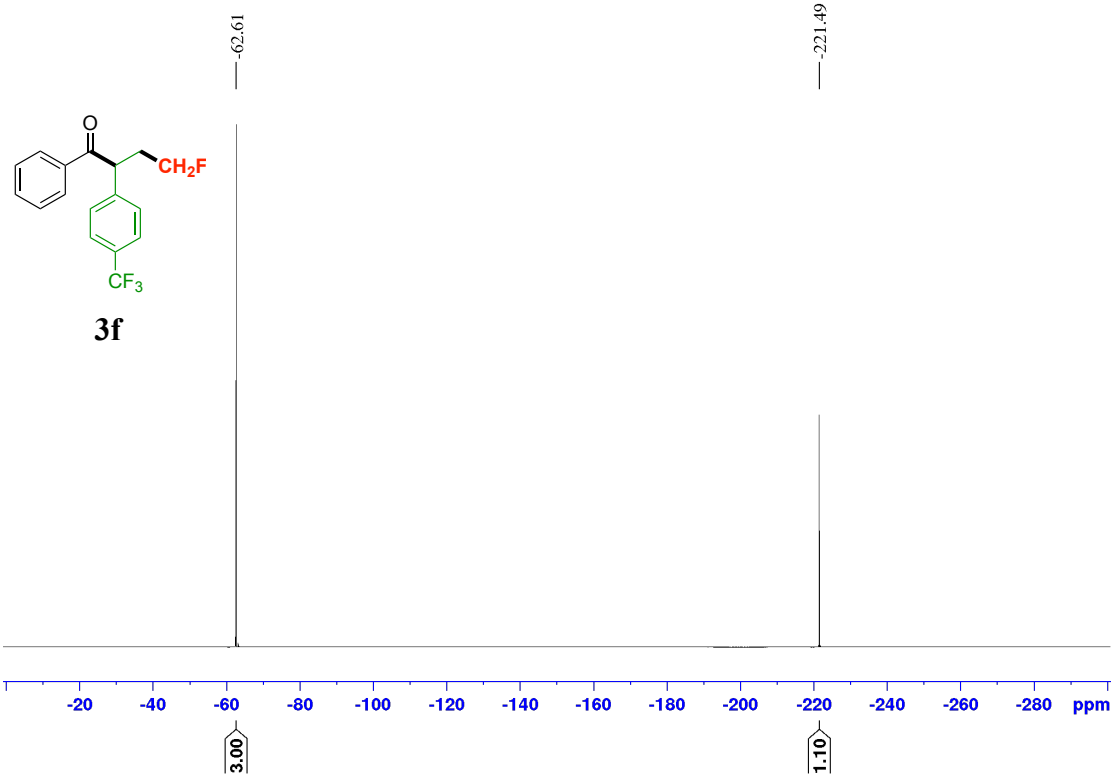
3e


-221.36
O
CH2F
COOMe
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

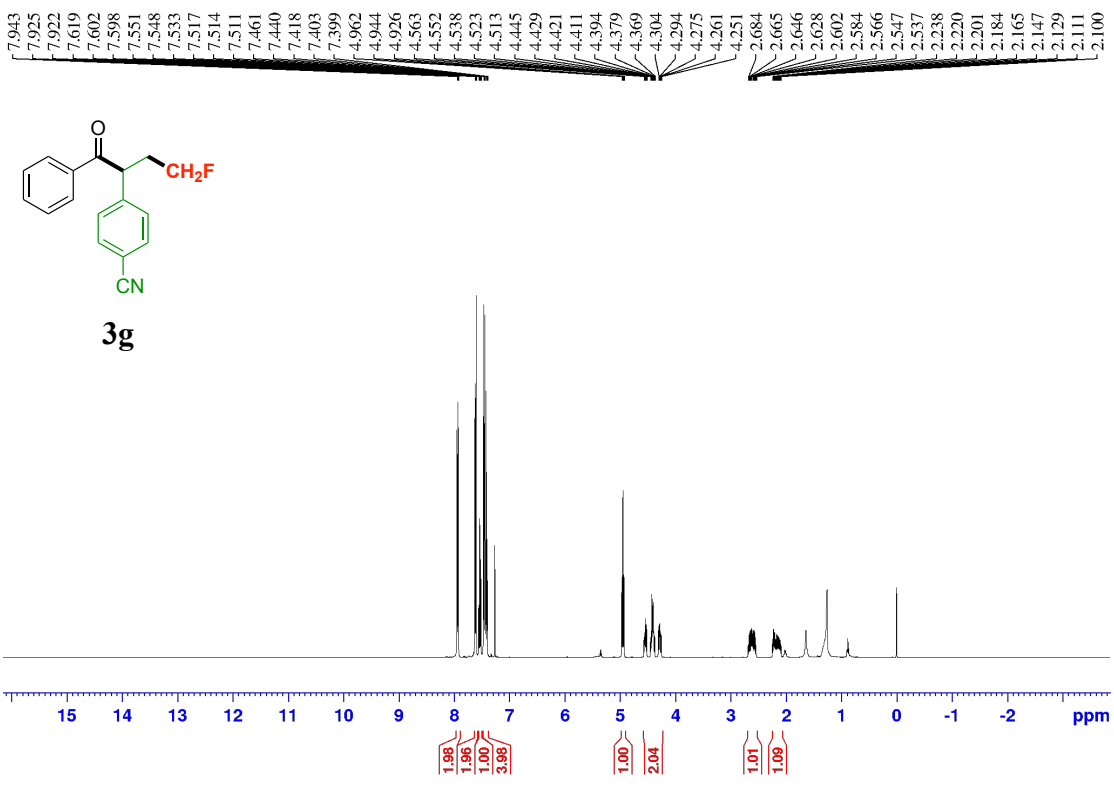
3e


7.972
7.954
7.950
7.587
7.566
7.539
7.521
7.502
7.468
7.448
7.434
7.414
7.396
4.974
4.955
4.937
4.571
4.560
4.546
4.532
4.521
4.453
4.437
4.427
4.413
4.403
4.394
4.384
4.319
4.309
4.299
4.290
4.276
4.266
2.692
2.663
2.636
2.602
2.575
2.546
2.255
2.227
2.203
2.181
2.155
2.135
2.109
2.100
O
CH2F
CF3
3f
10
9
8
7
6
5
4
3
2
1
0
ppm
2.05
1.99
1.14
3.99
1.00
2.07
1.03
1.09

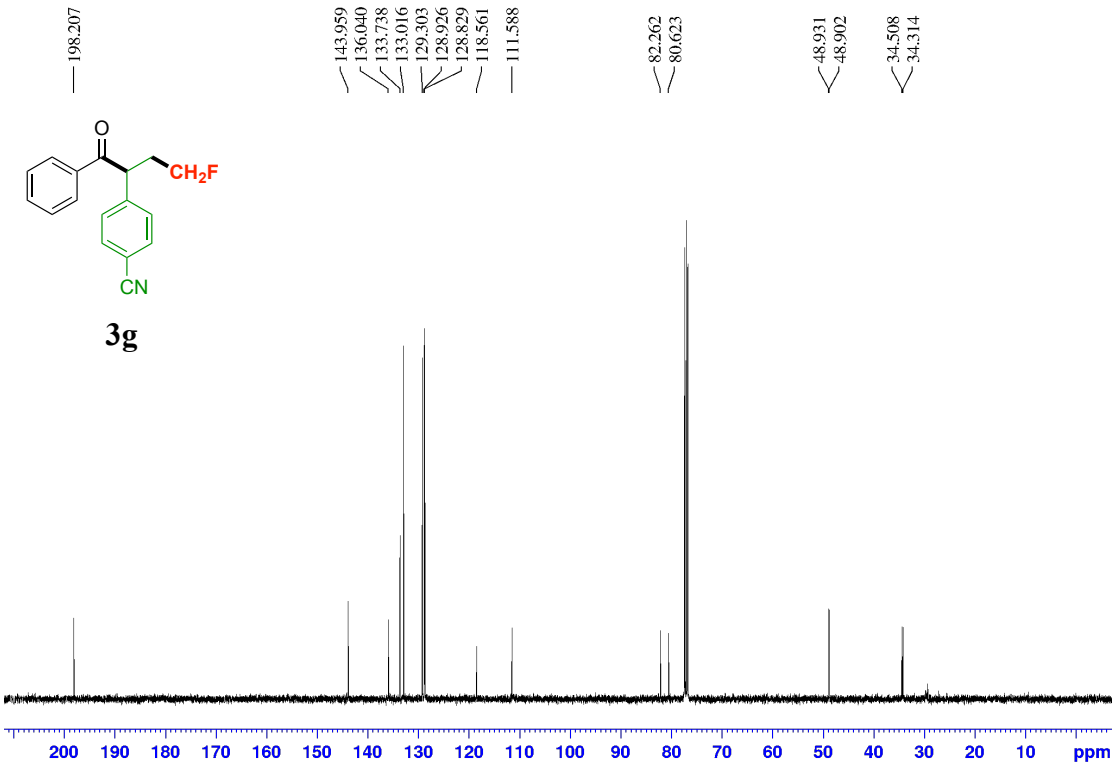

198.592
142.645
136.209
133.573
130.318
130.054
129.995
129.670
129.347
129.165
128.874
128.151
126.284
126.247
126.210
126.172
125.446
122.741
120.037
82.391
80.755
48.772
48.743
34.597
34.405
O
CH2F
CF3
3f
131
130
129
128
127
126
125
124
123
122
121
120
ppm
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


-62.61
-221.49
O
CH2F
CF3
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm
3.00
1.10

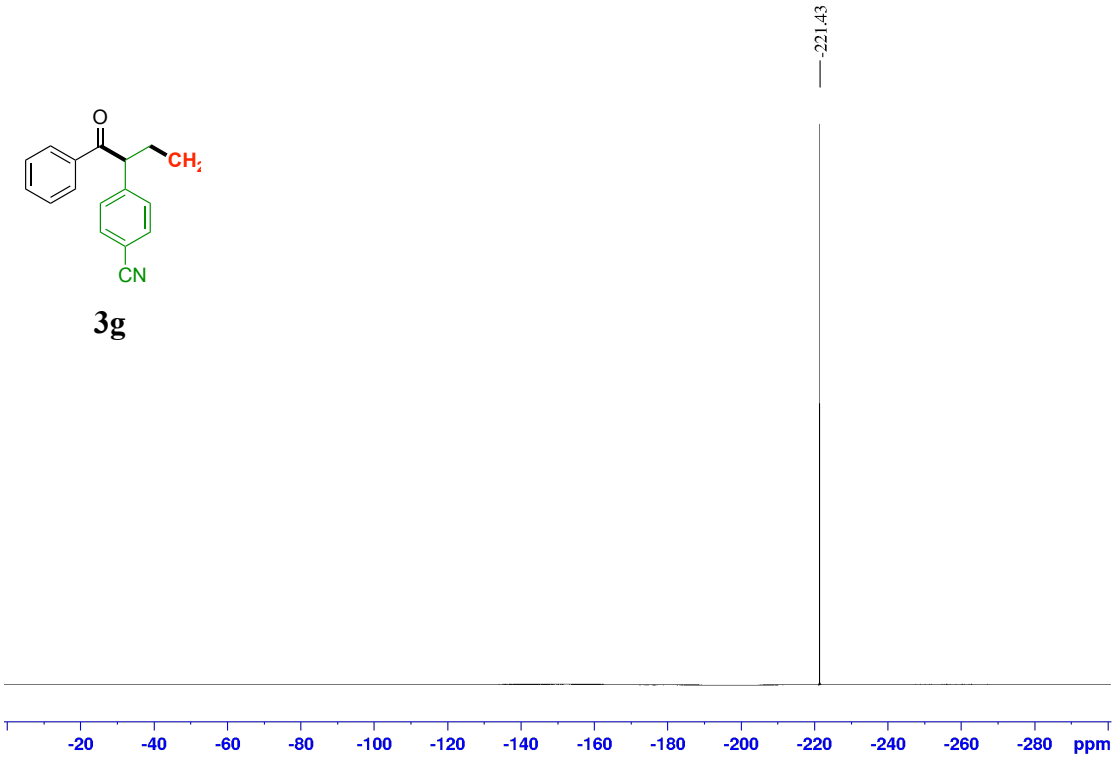
3f


7.943 7.925 7.922 7.619 7.602 7.598 7.551 7.548 7.533 7.517 7.514 7.511 7.461 7.440 7.418 7.403 7.399 4.962 4.944 4.926 4.563 4.552 4.538 4.523 4.513 4.445 4.429 4.421 4.411 4.394 4.379 4.369 4.304 4.294 4.275 4.261 4.251 2.684 2.665 2.646 2.628 2.602 2.584 2.566 2.547 2.537 2.238 2.220 2.201 2.184 2.165 2.147 2.129 2.111 2.100
O
CH2F
CN
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 ppm
1.98 1.96 1.00 3.98 1.00 2.04 1.01 1.09

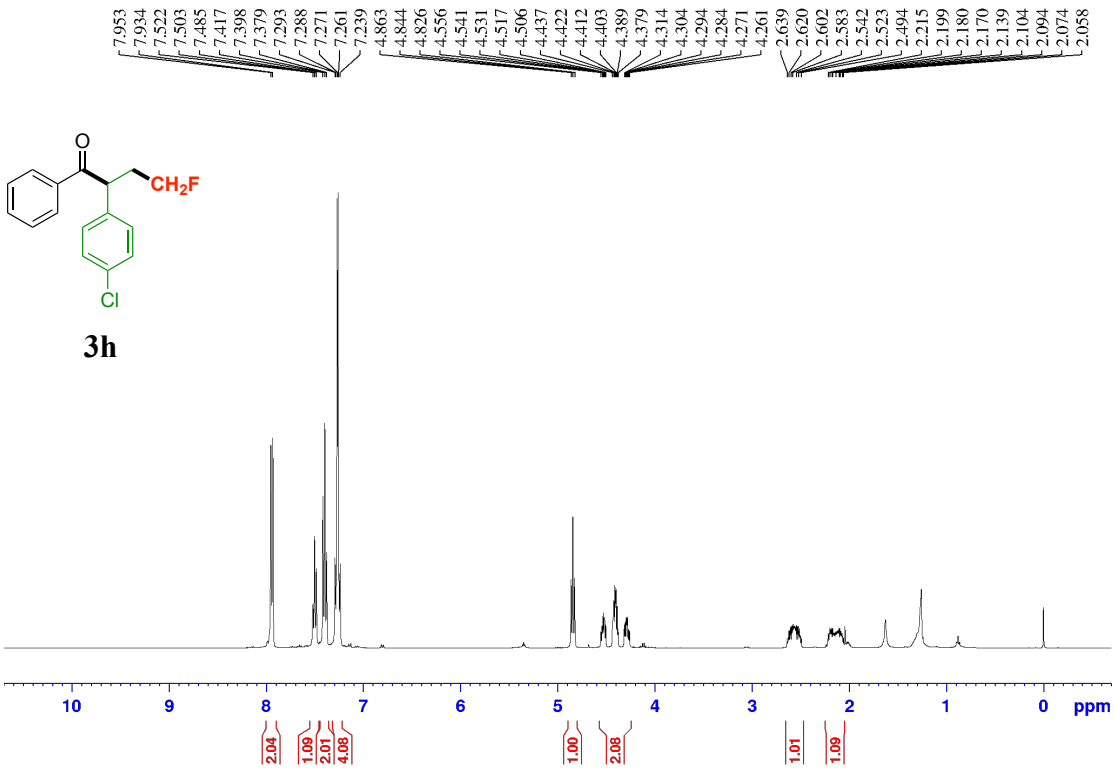
3g

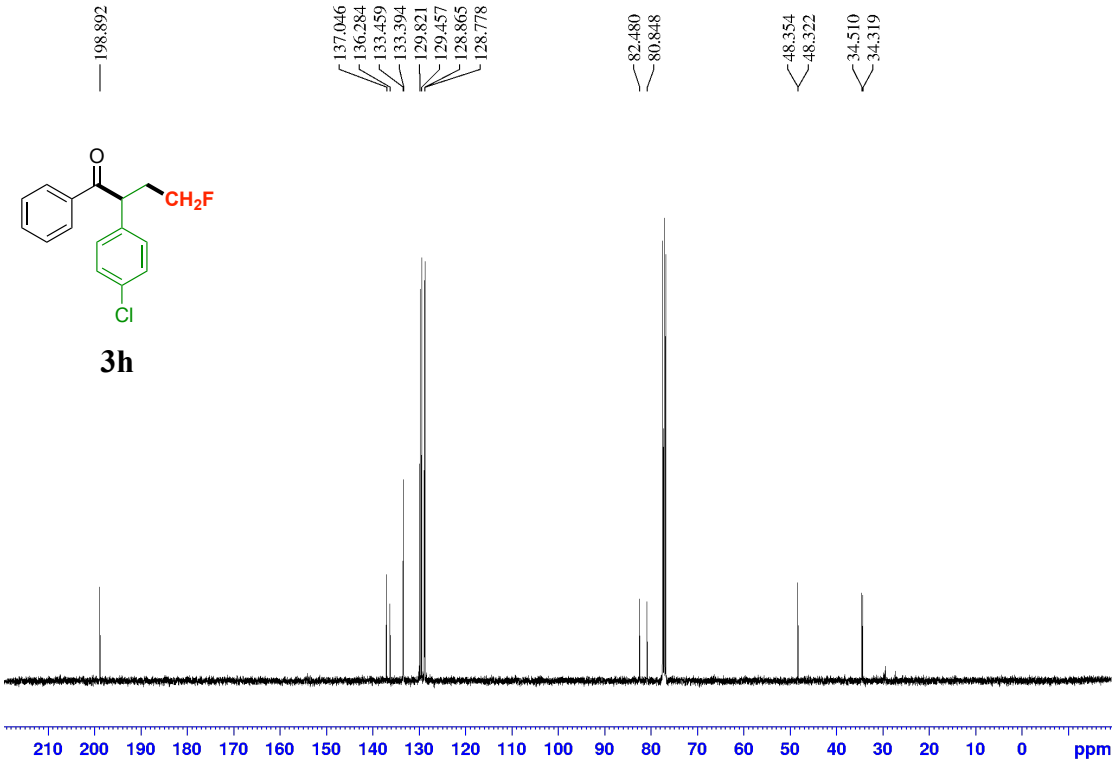

198.207
143.959
136.040
133.738
133.016
129.303
128.926
128.829
118.561
111.588
82.262
80.623
48.931
48.902
34.508
34.314
O
CH2F
CN
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

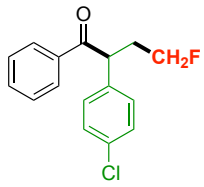
3g


-221.43
O
CH2
CN
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3g

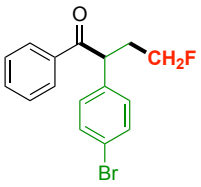

7.953
7.934
7.522
7.503
7.485
7.417
7.398
7.379
7.293
7.288
7.271
7.261
7.239
4.863
4.844
4.826
4.556
4.541
4.531
4.517
4.506
4.437
4.422
4.412
4.403
4.389
4.379
4.314
4.304
4.294
4.284
4.271
4.261
2.639
2.620
2.602
2.583
2.542
2.523
2.494
2.215
2.199
2.180
2.170
2.139
2.104
2.094
2.074
2.058
O
CH2F
Cl
3h
10
9
8
7
6
5
4
3
2
1
0
ppm
2.04
1.09
2.01
4.08
1.00
2.08
1.01
1.09


198.892
137.046
136.284
133.459
133.394
129.821
129.457
128.865
128.778
82.480
80.848
48.354
48.322
34.510
34.319
O
CH2F
Cl
3h
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm



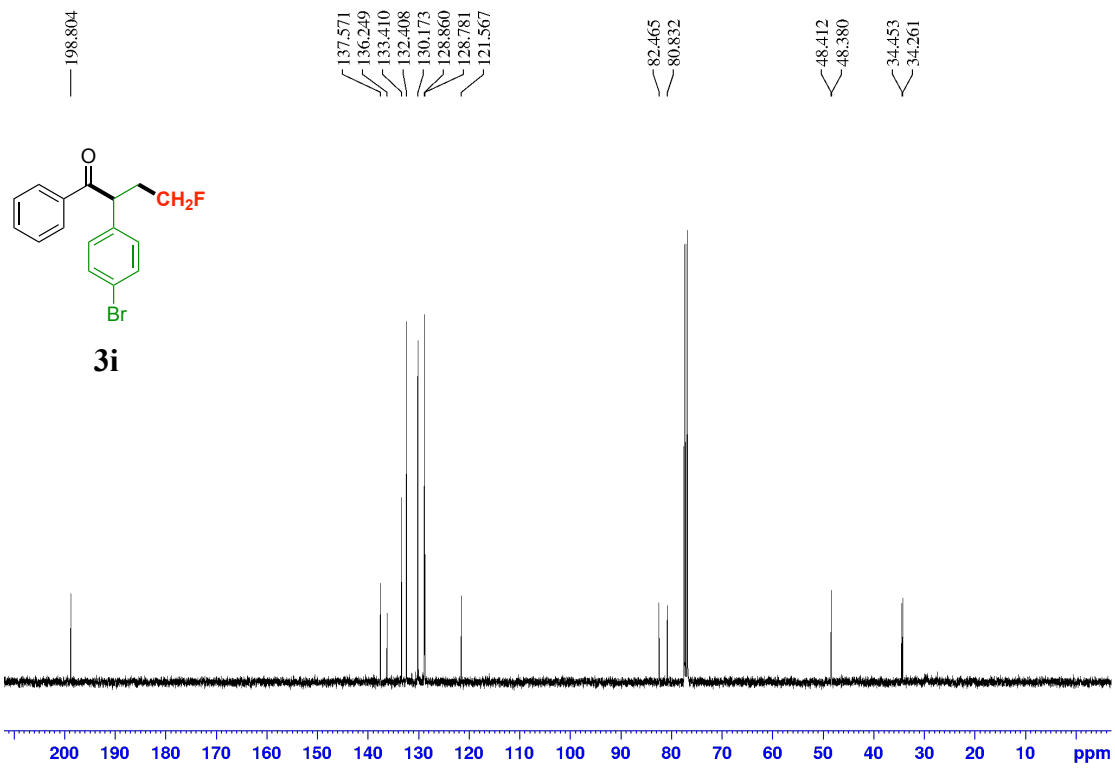
3h

-221.42
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm

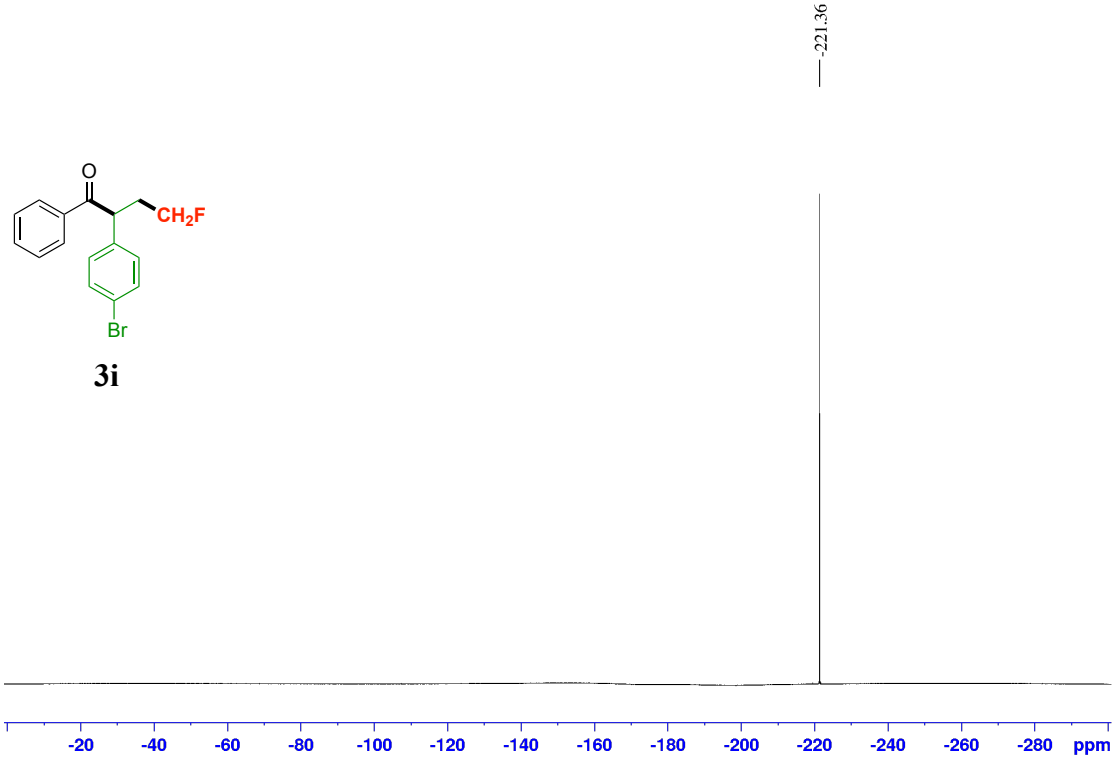


3i

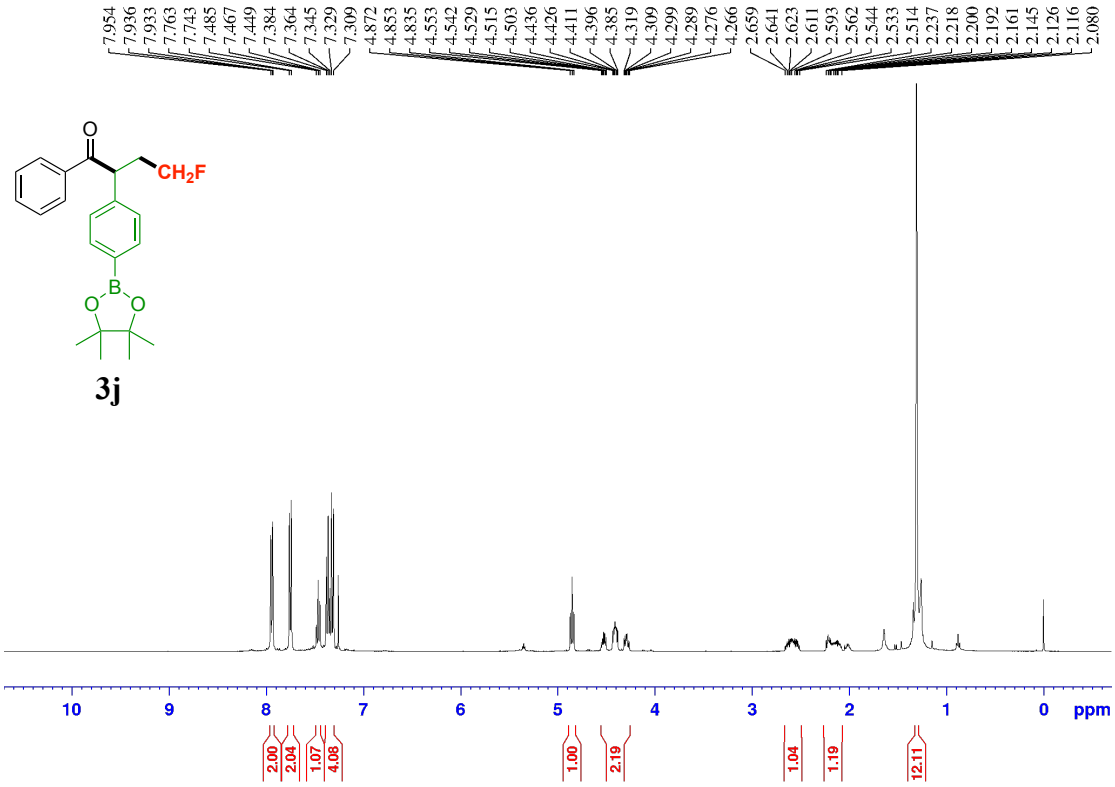
7.953
7.934
7.525
7.507
7.488
7.445
7.424
7.400
7.381
7.208
7.187
4.852
4.834
4.815
4.557
4.533
4.508
4.433
4.414
4.381
4.315
4.286
4.263
2.639
2.610
2.583
2.541
2.512
2.494
2.242
2.215
2.179
2.103
2.093
2.046
1.993
10
9
8
7
6
5
4
3
2
1
0
ppm
1.94
1.08
3.94
2.00
1.00
2.09
1.01
1.20

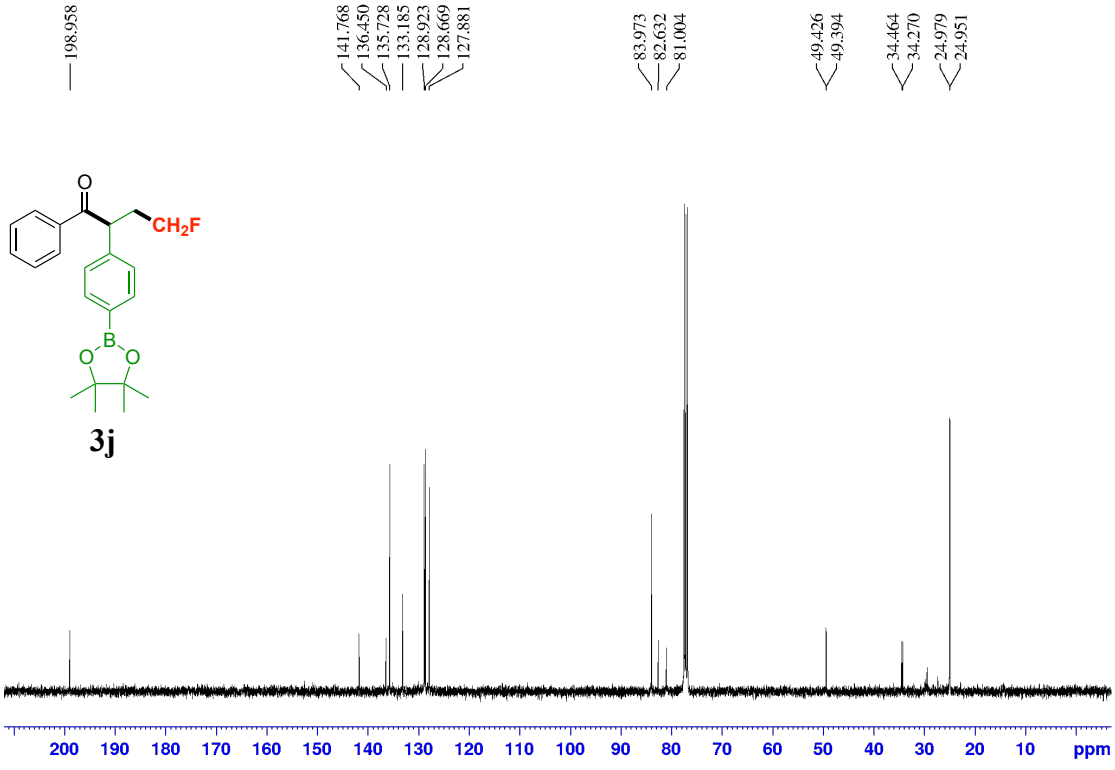

198.804
137.571
136.249
133.410
132.408
130.173
128.860
128.781
121.567
82.465
80.832
48.412
48.380
34.453
34.261
O
CH2F
Br
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

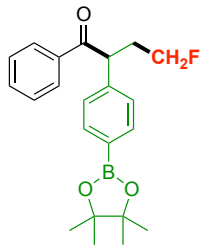
3i


-221.36
O
CH2F
Br
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3i

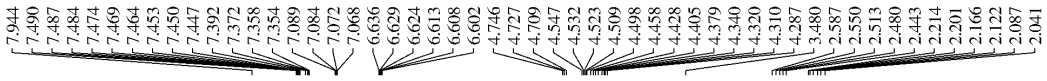

7.954
7.936
7.933
7.763
7.743
7.485
7.467
7.449
7.384
7.364
7.345
7.329
7.309
4.872
4.853
4.835
4.553
4.542
4.529
4.515
4.503
4.436
4.426
4.411
4.396
4.385
4.319
4.309
4.299
4.289
4.276
4.266
2.659
2.641
2.623
2.611
2.593
2.562
2.544
2.533
2.514
2.237
2.218
2.200
2.192
2.161
2.145
2.126
2.116
2.080
O
CH2F
B
O
O
3j
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.04
1.07
4.08
1.00
2.19
1.04
1.19
12.11

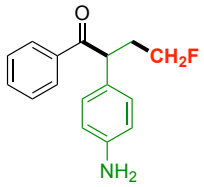

198.958
141.768
136.450
135.728
133.185
128.923
128.669
127.881
83.973
82.632
81.004
49.426
49.394
34.464
34.270
24.979
24.951
O
CH2F
B
O
O
3j
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F
B
O
O

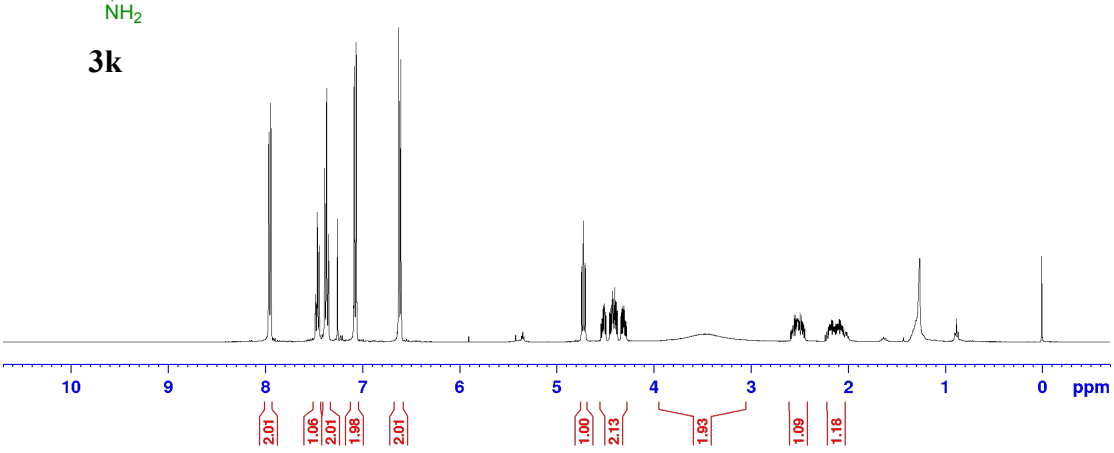
3j

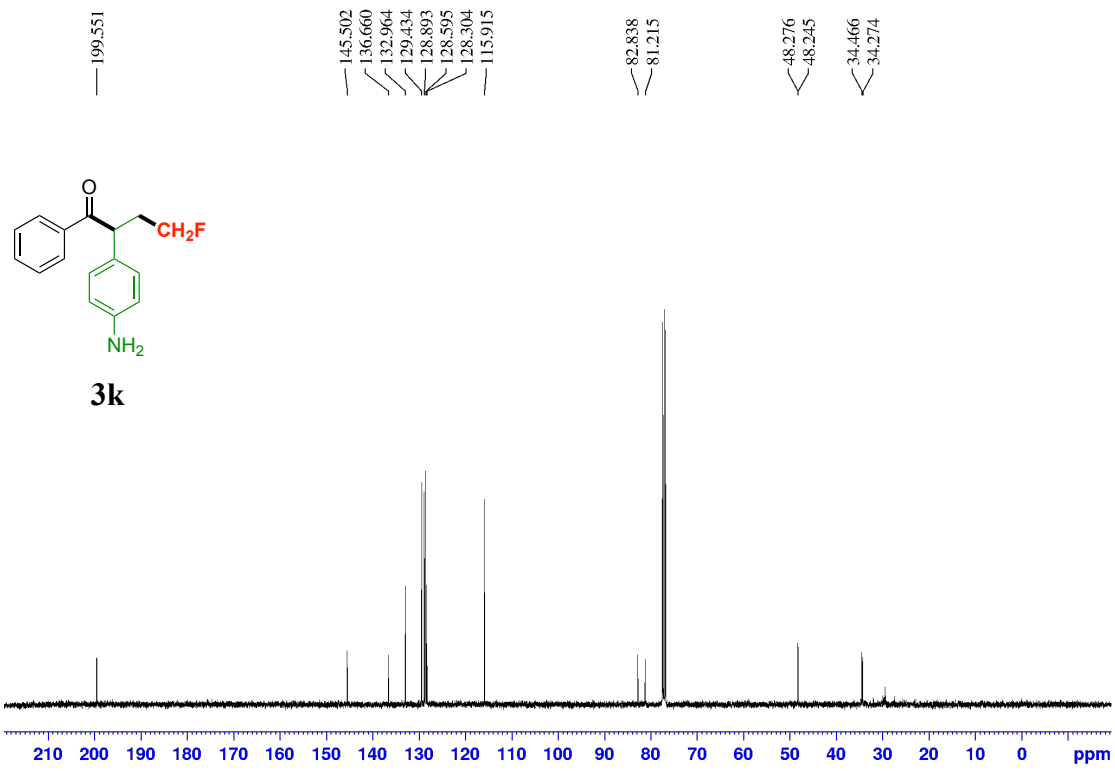
-221.36
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.944
7.490
7.487
7.484
7.474
7.469
7.464
7.453
7.450
7.447
7.392
7.372
7.358
7.354
7.089
7.084
7.072
7.068
6.636
6.629
6.624
6.613
6.608
6.602
4.746
4.727
4.709
4.547
4.532
4.523
4.509
4.498
4.458
4.428
4.405
4.379
4.340
4.320
4.310
4.287
3.480
2.587
2.550
2.513
2.480
2.443
2.214
2.201
2.166
2.122
2.087
2.041

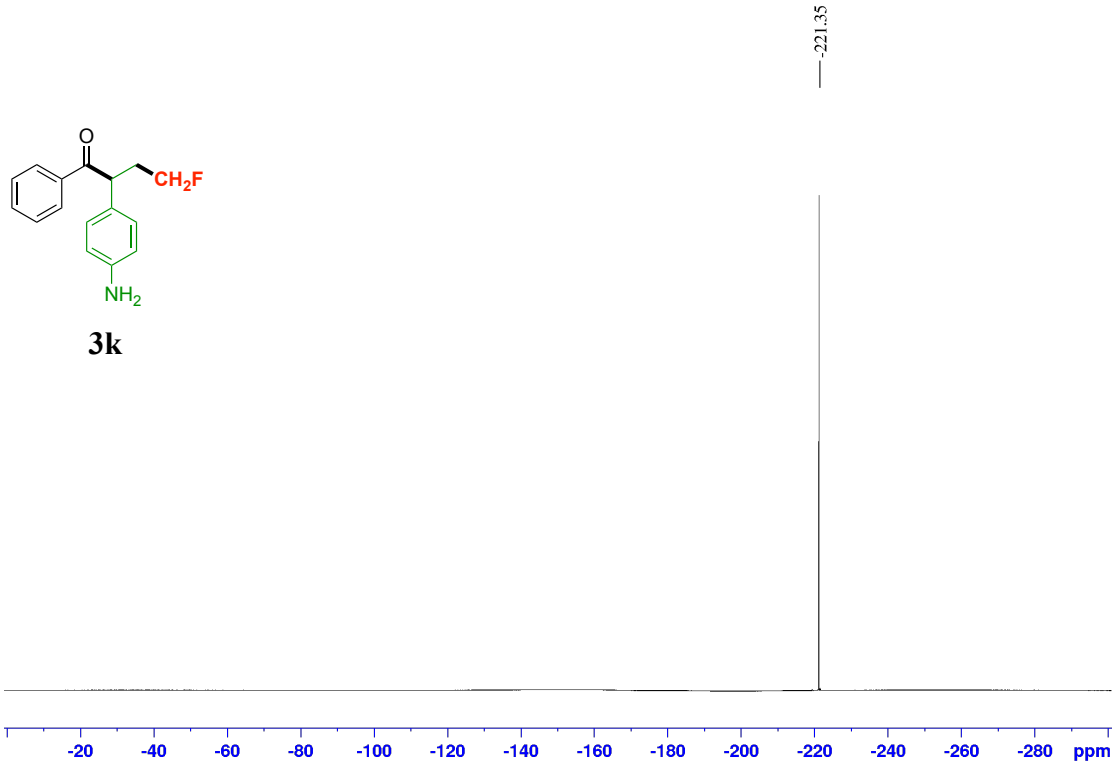

O
CH2F
NH2

3k

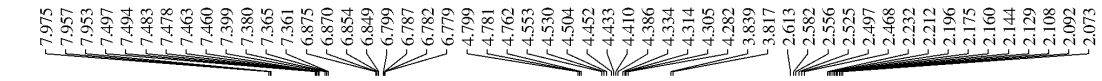

10
9
8
7
6
5
4
3
2
1
0
ppm
2.01
1.06
2.01
1.98
2.01
1.00
2.13
1.93
1.09
1.18

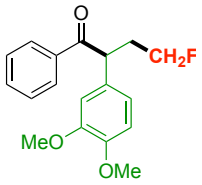

199.551
145.502
136.660
132.964
129.434
128.893
128.595
128.304
115.915
82.838
81.215
48.276
48.245
34.466
34.274
O
CH2F
NH2
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

3k


-221.35
O
CH2F
NH2
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

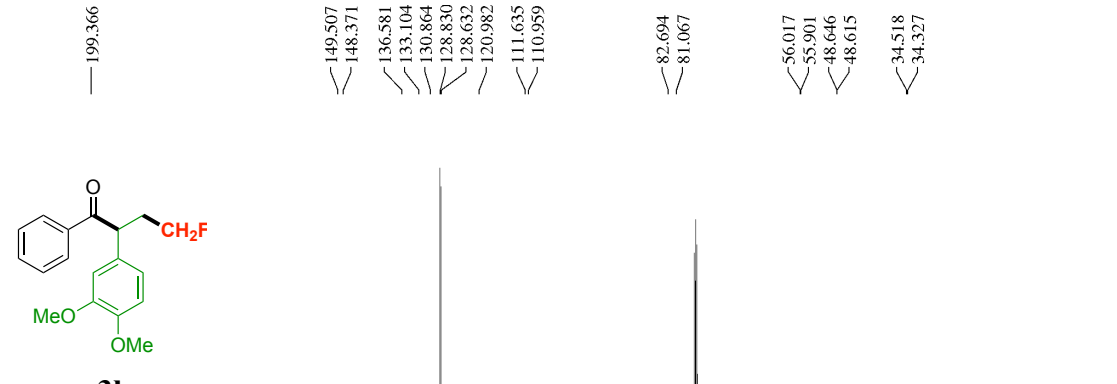
3k


7.975
7.957
7.953
7.497
7.494
7.483
7.478
7.463
7.460
7.399
7.380
7.365
7.361
6.875
6.870
6.854
6.849
6.799
6.787
6.782
6.779
4.799
4.781
4.762
4.553
4.530
4.504
4.452
4.433
4.410
4.386
4.334
4.314
4.305
4.282
3.839
3.817
2.613
2.582
2.556
2.525
2.497
2.468
2.232
2.212
2.196
2.175
2.160
2.144
2.129
2.108
2.092
2.073


O
CH2F
MeO
OMe

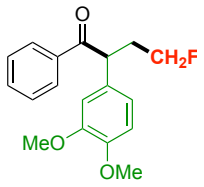
3l

10
9
8
7
6
5
4
3
2
1
0
ppm
2.03
1.06
1.98
1.02
1.97
1.00
2.09
2.97
2.91
1.03
1.13


199.366
149.507
148.371
136.581
133.104
130.864
128.830
128.632
120.982
111.635
110.959
82.694
81.067
56.017
55.901
48.646
48.615
34.518
34.327
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

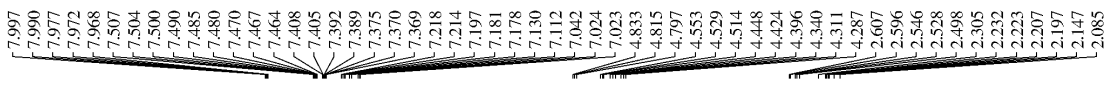
O
CH2F
MeO
OMe

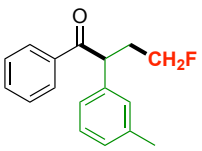
3l


O
CH2F
MeO
OMe

3l

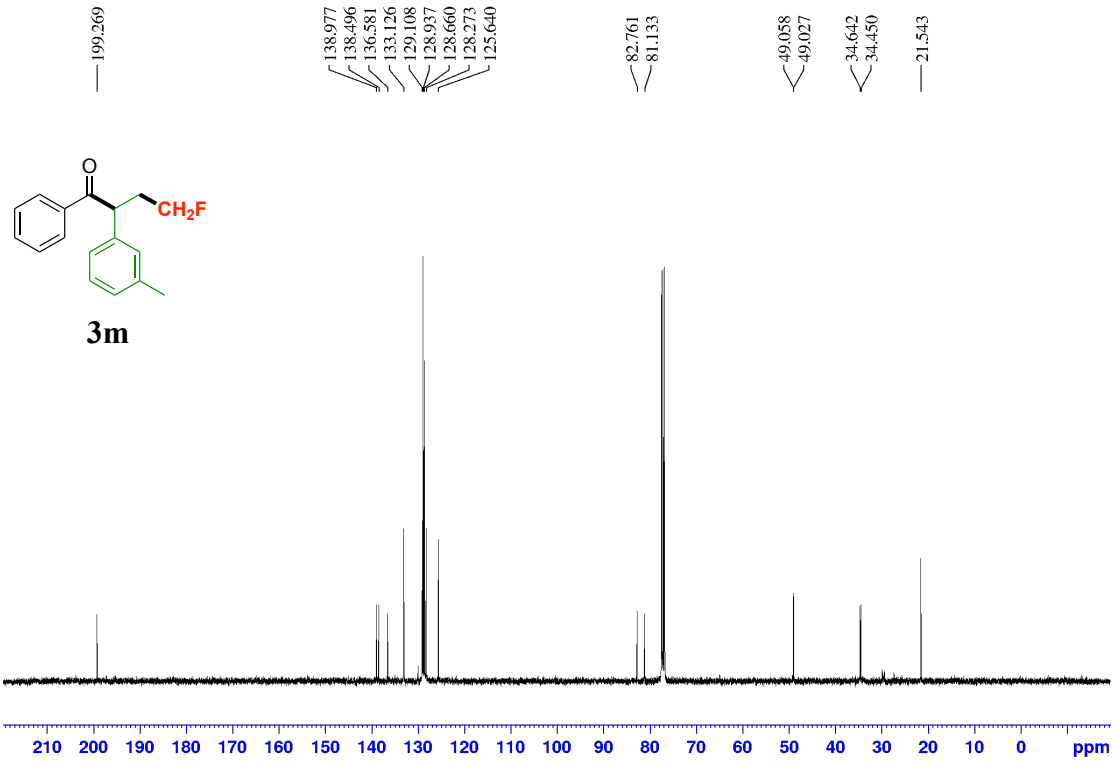
-221.40
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.997
7.990
7.977
7.972
7.968
7.507
7.504
7.500
7.490
7.485
7.480
7.470
7.467
7.464
7.408
7.405
7.392
7.389
7.375
7.370
7.369
7.218
7.214
7.197
7.181
7.178
7.130
7.112
7.042
7.024
7.023
4.833
4.815
4.797
4.553
4.529
4.514
4.448
4.424
4.396
4.340
4.311
4.287
2.607
2.596
2.546
2.528
2.498
2.305
2.232
2.223
2.207
2.197
2.147
2.085

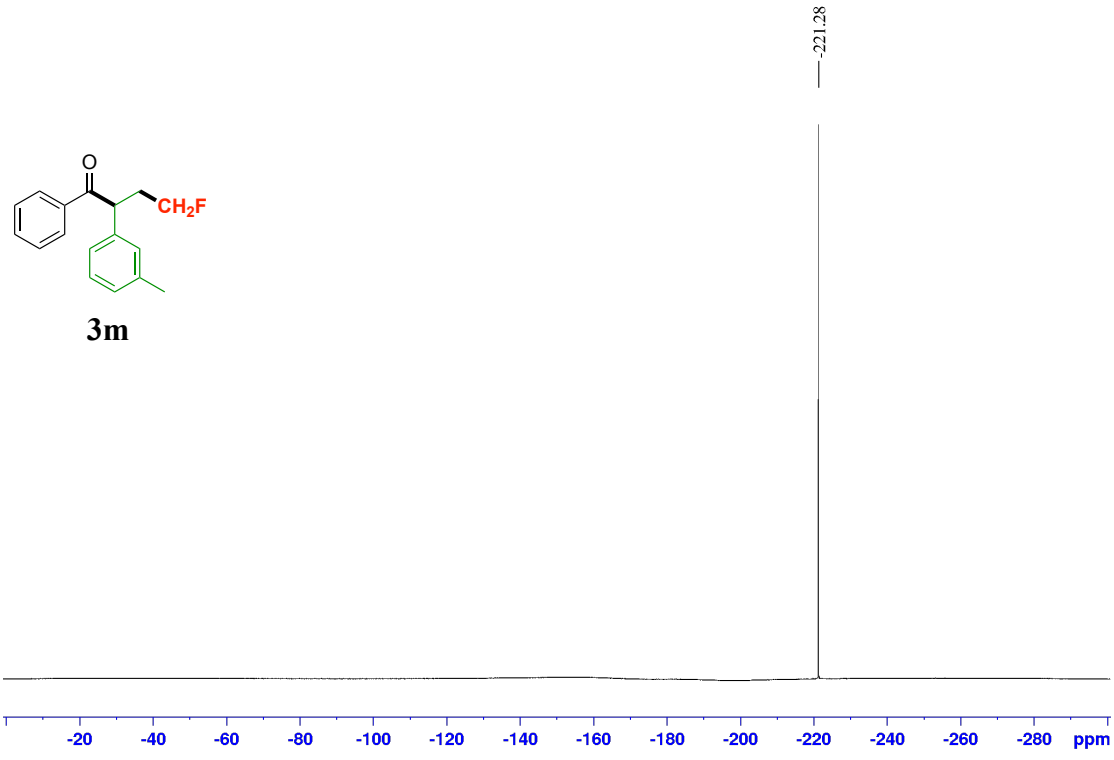

O
CH2F

3m

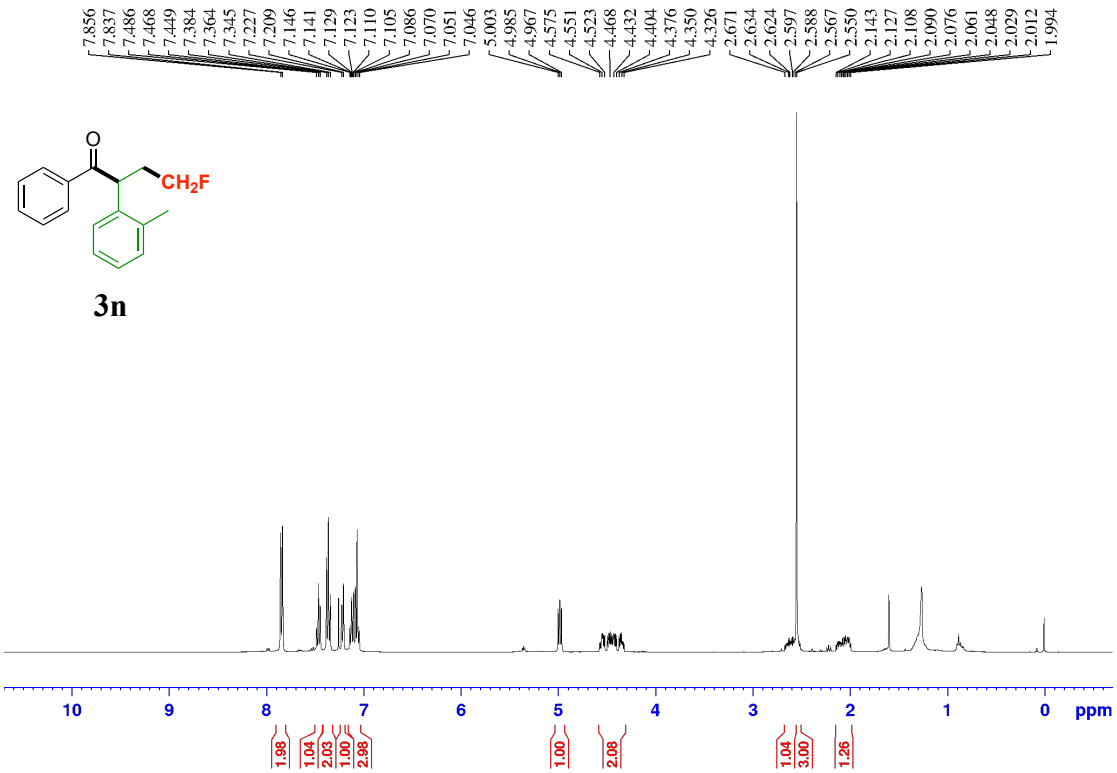
10
9
8
7
6
5
4
3
2
1
0
ppm
2.05
1.03
1.98
1.06
1.96
0.97
1.00
2.07
1.06
3.01
1.12

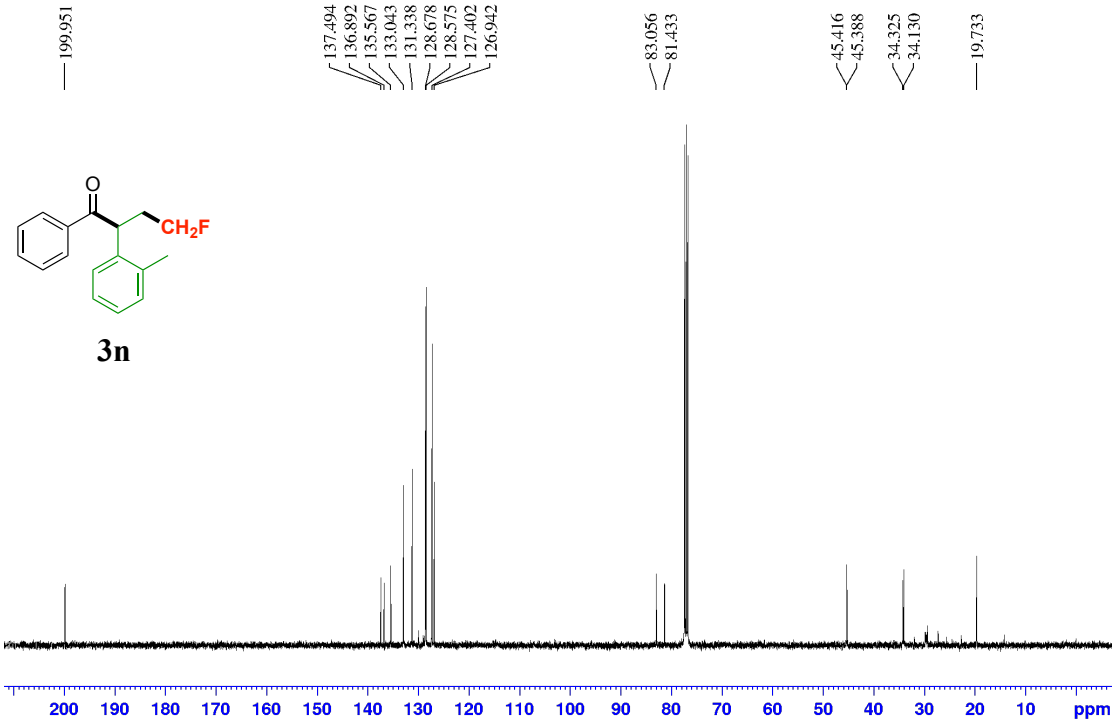

199.269
138.977
138.496
136.581
133.126
129.108
128.937
128.660
128.273
125.640
82.761
81.133
49.058
49.027
34.642
34.450
21.543
O
CH2F
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

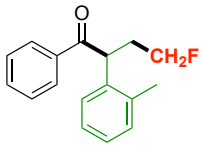
3m


-221.28
O
CH2F
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3m

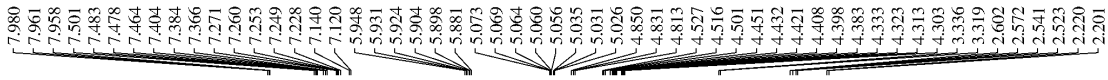

7.856
7.837
7.486
7.468
7.449
7.384
7.364
7.345
7.227
7.209
7.146
7.141
7.129
7.123
7.110
7.105
7.086
7.070
7.051
7.046
5.003
4.985
4.967
4.575
4.551
4.523
4.468
4.432
4.404
4.376
4.350
4.326
2.671
2.634
2.624
2.597
2.588
2.567
2.550
2.143
2.127
2.108
2.090
2.076
2.061
2.048
2.029
2.012
1.994
O
CH2F
3n
10
9
8
7
6
5
4
3
2
1
0
ppm
1.98
1.04
2.03
1.00
2.98
1.00
2.08
1.04
3.00
1.26


199.951
137.494
136.892
135.567
133.043
131.338
128.678
128.575
127.402
126.942
83.056
81.433
45.416
45.388
34.325
34.130
19.733
O
CH2F
3n
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm



3n

-219.72
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm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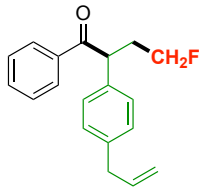
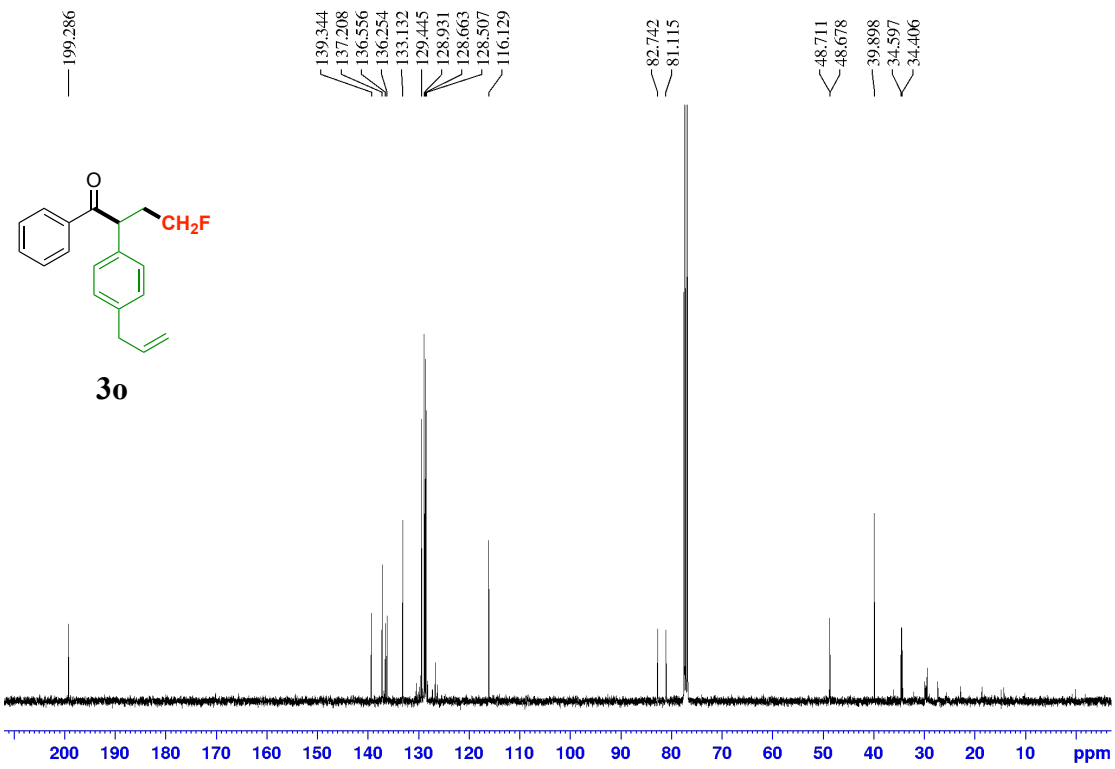
7.961
7.958
7.501
7.483
7.478
7.464
7.404
7.384
7.366
7.271
7.260
7.253
7.249
7.228
7.140
7.120
5.948
5.931
5.924
5.904
5.898
5.881
5.073
5.069
5.064
5.060
5.056
5.035
5.031
5.026
4.850
4.831
4.813
4.527
4.516
4.501
4.451
4.432
4.421
4.408
4.398
4.383
4.333
4.323
4.313
4.303
3.336
3.319
2.602
2.572
2.541
2.523
2.220
2.201

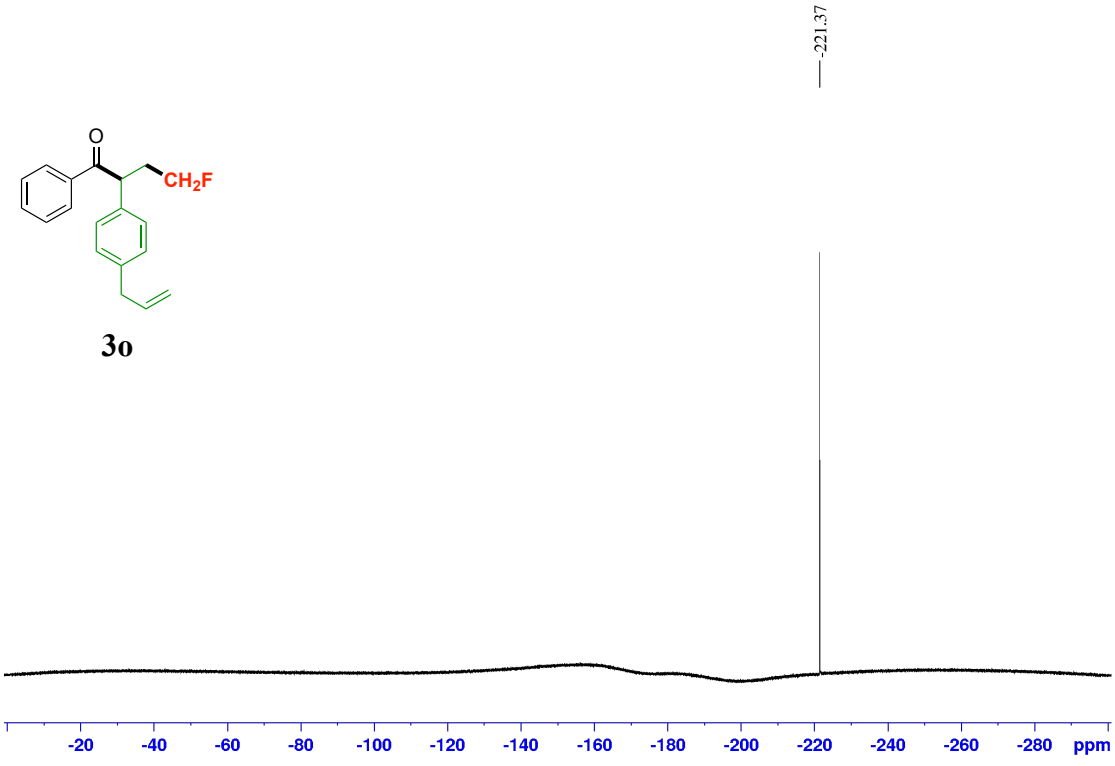


3o

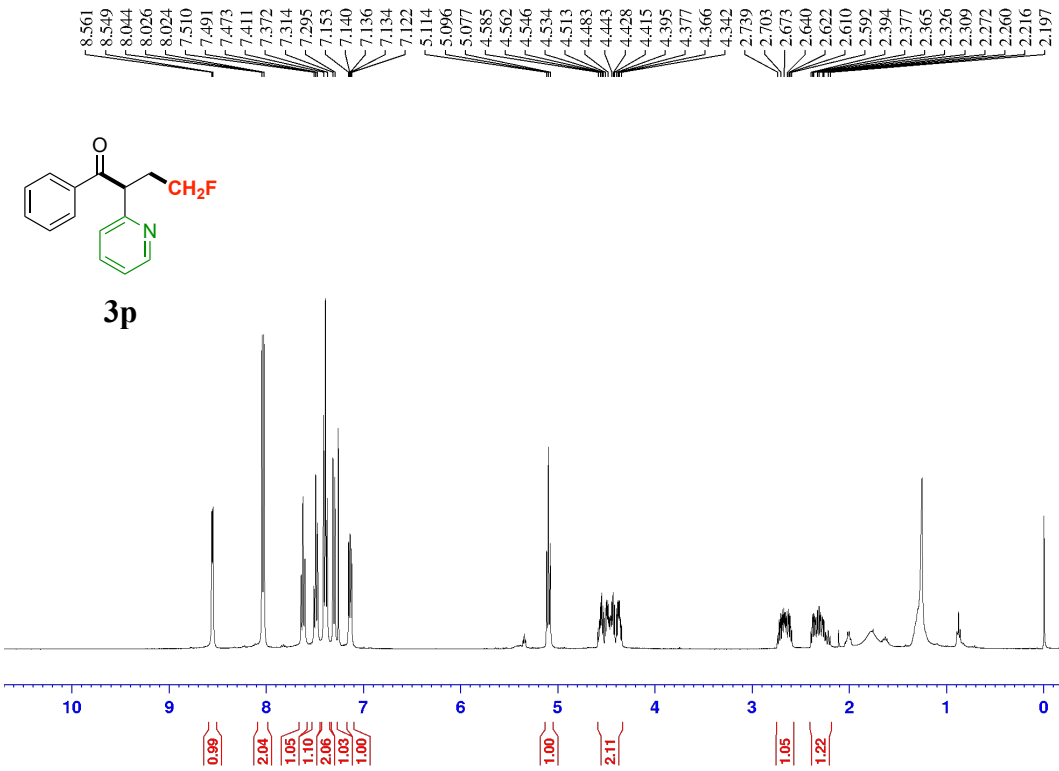
10
9
8
7
6
5
4
3
2
1
0
ppm
2.14
1.15
2.15
2.16
1.96
0.95
1.01
0.92
1.00
2.34
1.98
1.19
1.26


199.286
139.344
137.208
136.556
136.254
133.132
129.445
128.931
128.663
128.507
116.129
82.742
81.115
48.711
48.678
39.898
34.597
34.406
O
CH2F
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

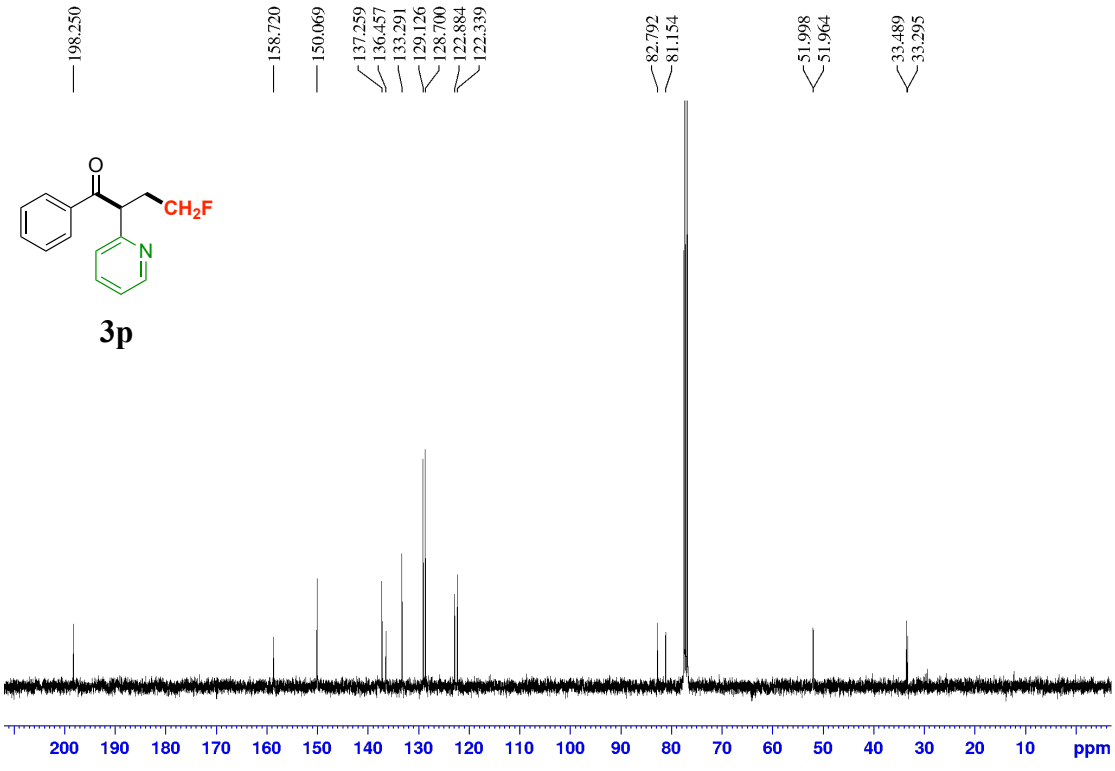
3o


-221.37
O
CH2F
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

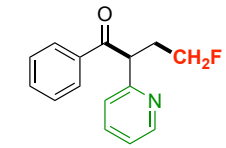
3o


8.561
8.549
8.044
8.026
8.024
7.510
7.491
7.473
7.411
7.372
7.314
7.295
7.153
7.140
7.136
7.134
7.122
5.114
5.096
5.077
4.585
4.562
4.546
4.534
4.513
4.483
4.443
4.428
4.415
4.395
4.377
4.366
4.342
2.739
2.703
2.673
2.640
2.622
2.610
2.592
2.394
2.377
2.365
2.326
2.309
2.272
2.260
2.216
2.197
O
CH2F
N
10
9
8
7
6
5
4
3
2
1
0
ppm
0.99
2.04
1.05
1.10
2.06
1.03
1.00
1.00
2.11
1.05
1.22

3p

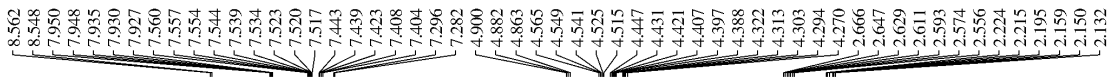

198.250
158.720
150.069
137.259
136.457
133.291
129.126
128.700
122.884
122.339
82.792
81.154
51.998
51.964
33.489
33.295
O
CH2F
N
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

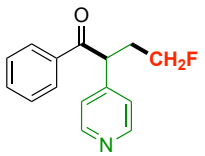
3p


O
CH2F
N

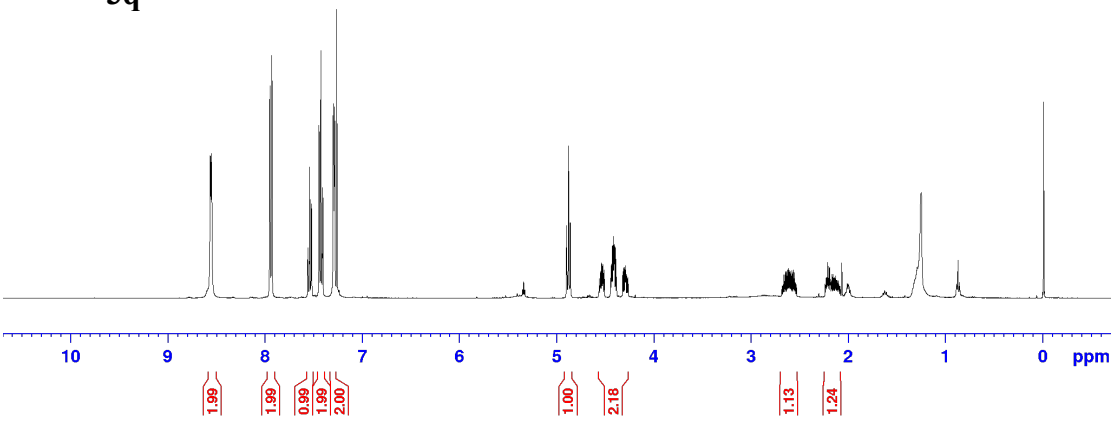
3p

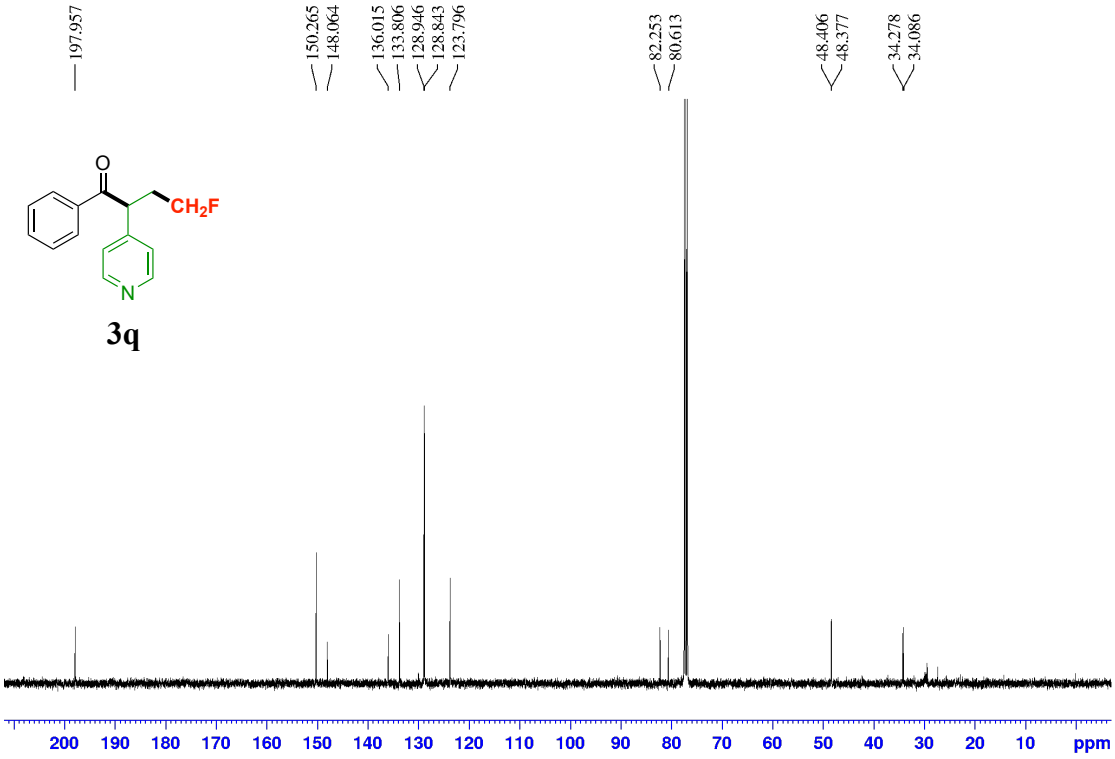
-220.32
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


8.562
8.548
7.950
7.948
7.935
7.930
7.927
7.560
7.557
7.554
7.544
7.539
7.534
7.523
7.520
7.517
7.443
7.439
7.423
7.408
7.404
7.296
7.282
4.900
4.882
4.863
4.565
4.549
4.541
4.525
4.515
4.447
4.431
4.421
4.407
4.397
4.388
4.322
4.313
4.303
4.294
4.270
2.666
2.647
2.629
2.611
2.593
2.574
2.556
2.224
2.215
2.195
2.159
2.150
2.132

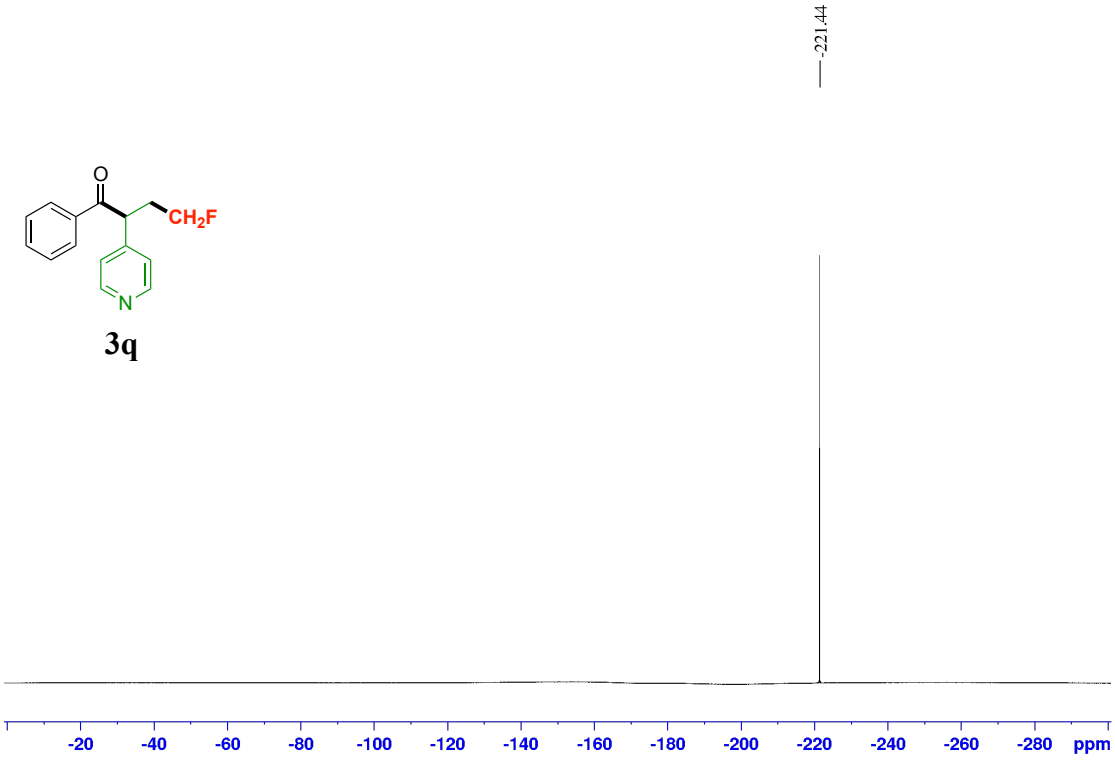

O
CH2F
N

3q

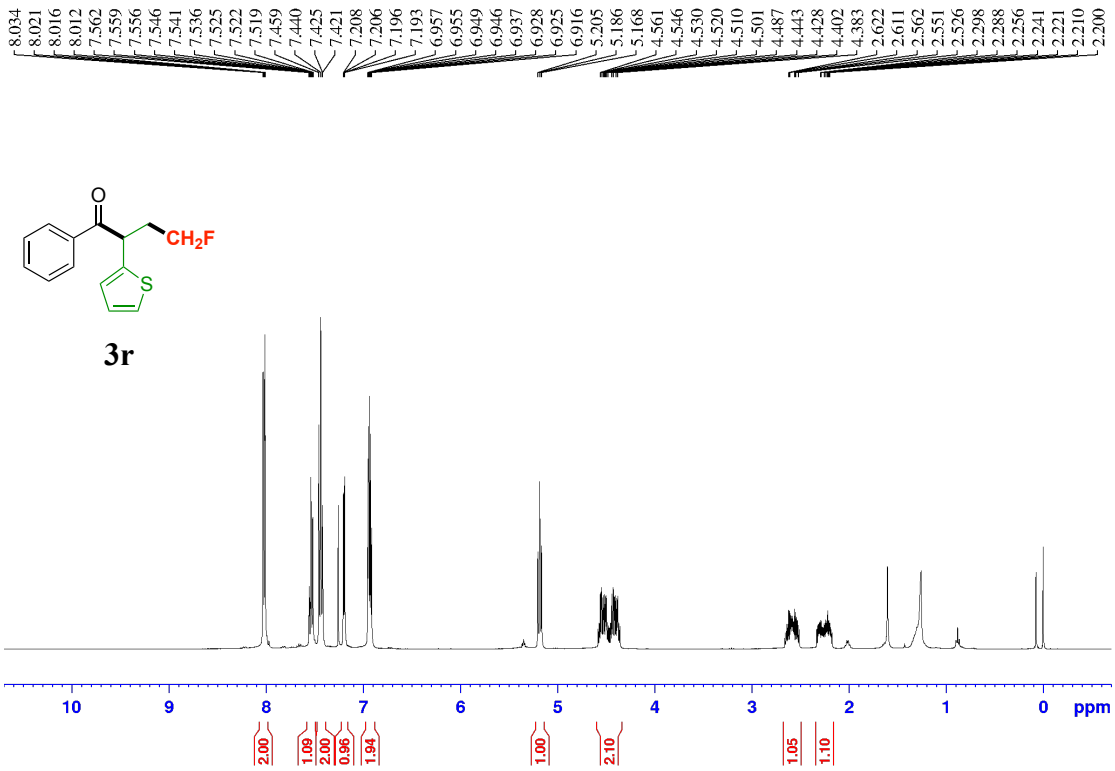

10
9
8
7
6
5
4
3
2
1
0
ppm
1.99
1.99
0.99
1.99
2.00
1.00
2.18
1.13
1.24

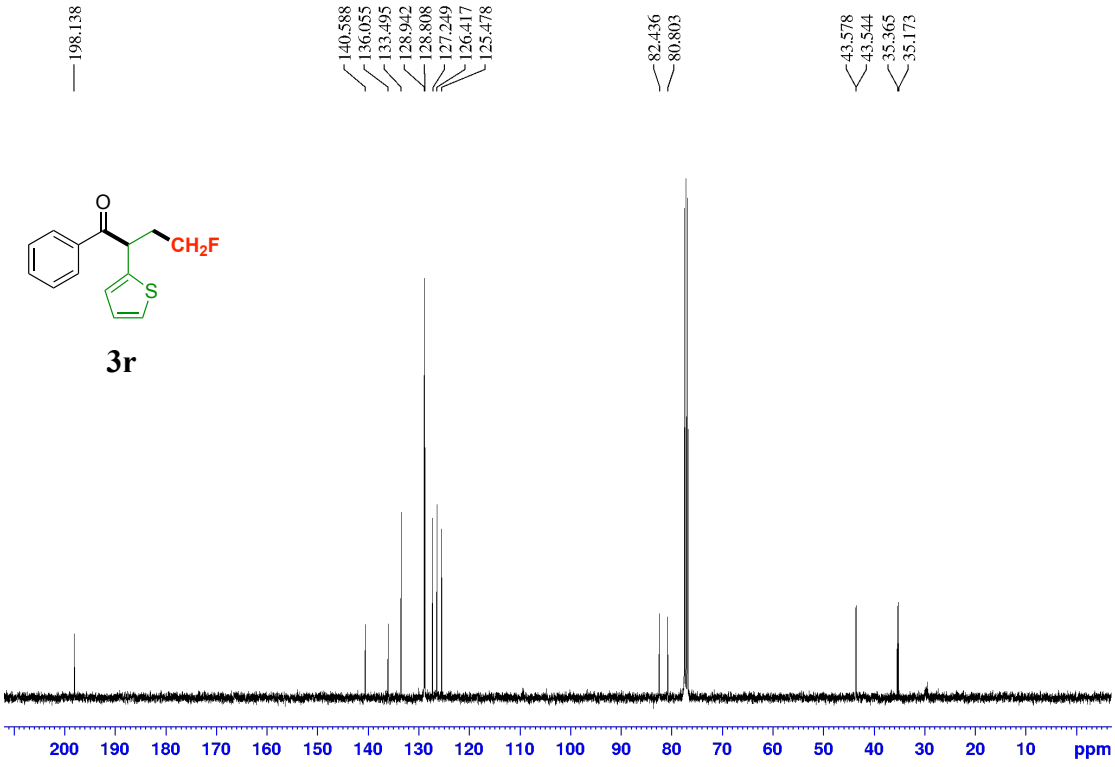

197.957
150.265
148.064
136.015
133.806
128.946
128.843
123.796
82.253
80.613
48.406
48.377
34.278
34.086
O
CH2F
N
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

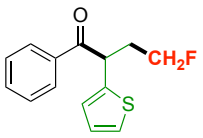
3q


-221.44
O
CH2F
N
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3q

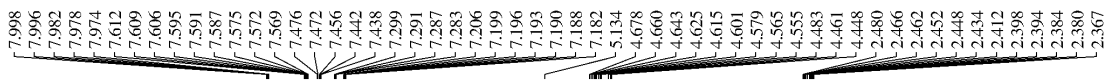

8.034
8.021
8.016
8.012
7.562
7.559
7.556
7.546
7.541
7.536
7.525
7.522
7.519
7.459
7.440
7.425
7.421
7.208
7.206
7.196
7.193
6.957
6.955
6.949
6.946
6.937
6.928
6.925
6.916
5.205
5.186
5.168
4.561
4.546
4.530
4.520
4.510
4.501
4.487
4.443
4.428
4.402
4.383
2.622
2.611
2.562
2.551
2.526
2.298
2.288
2.256
2.241
2.221
2.210
2.200
O
CH2F
S
3r
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
1.09
2.00
0.96
1.94
1.00
2.10
1.05
1.10

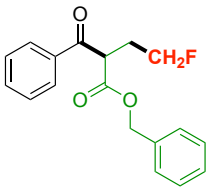

198.138
140.588
136.055
133.495
128.942
128.808
127.249
126.417
125.478
82.436
80.803
43.578
43.544
35.365
35.173
O
CH2F
S
3r
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F
S

3r

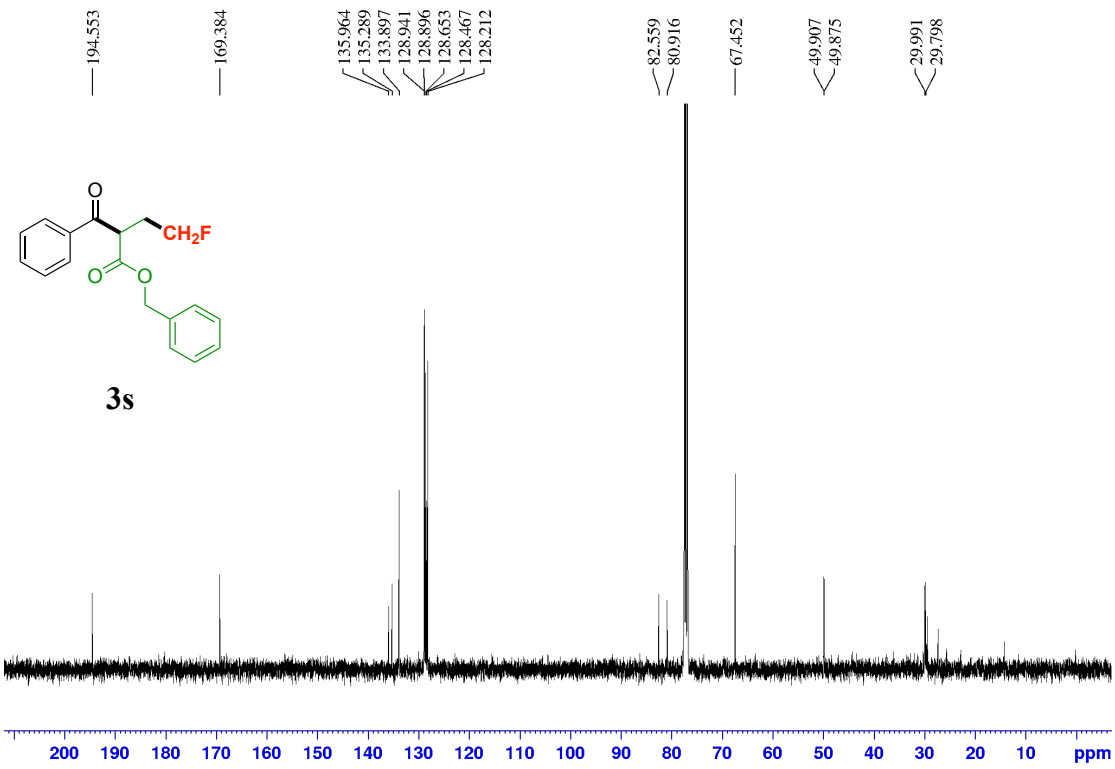
-221.60
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.998
7.996
7.982
7.978
7.974
7.612
7.609
7.606
7.595
7.591
7.587
7.575
7.572
7.569
7.476
7.472
7.456
7.442
7.438
7.299
7.291
7.287
7.283
7.206
7.199
7.196
7.193
7.190
7.188
7.182
5.134
4.678
4.660
4.643
4.625
4.615
4.601
4.579
4.565
4.555
4.483
4.461
4.448
2.480
2.466
2.462
2.452
2.448
2.434
2.412
2.398
2.394
2.384
2.380
2.367

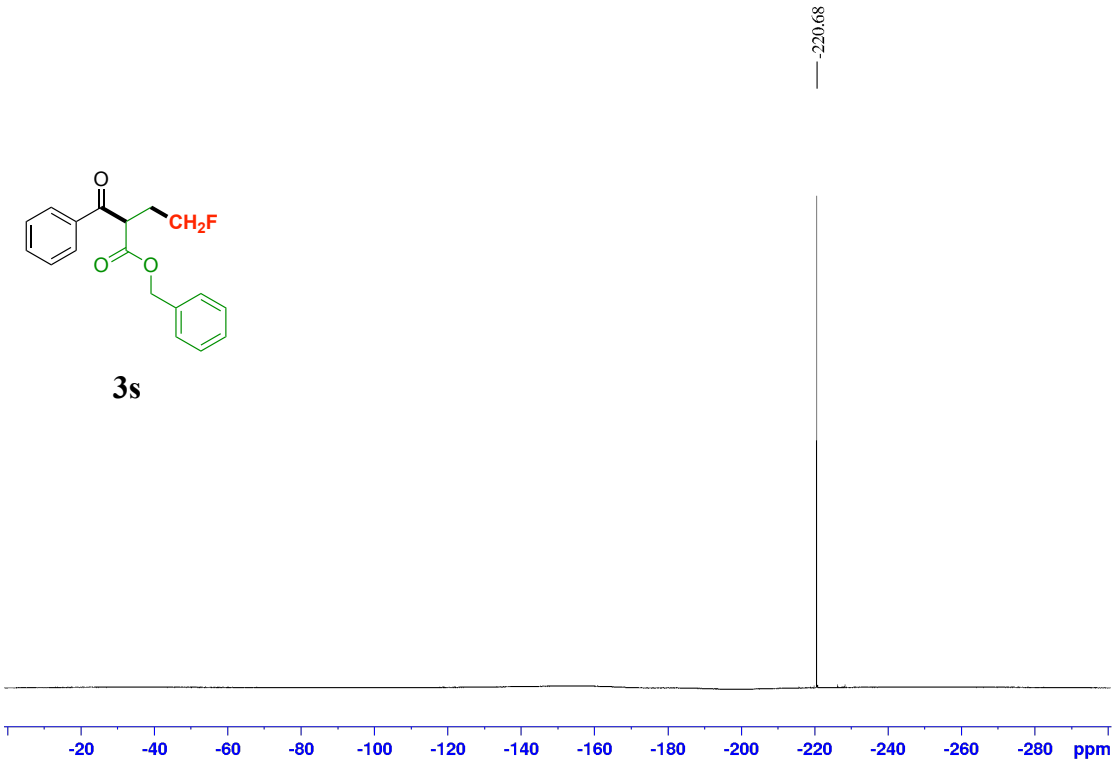

O
CH2F
O
O

3s

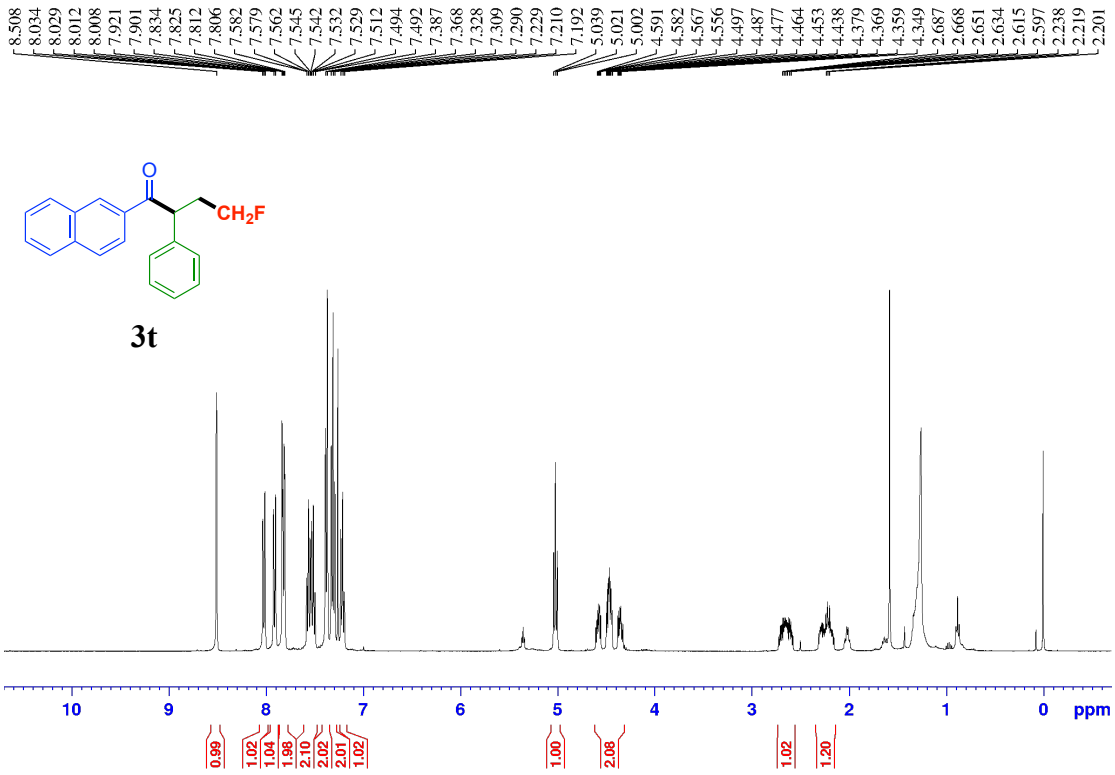
10
9
8
7
6
5
4
3
2
1
0
ppm
1.95
1.10
2.09
3.04
1.92
1.92
1.00
1.99
1.01
0.94


194.553
169.384
135.964
135.289
133.897
128.941
128.896
128.653
128.467
128.212
82.559
80.916
67.452
49.907
49.875
29.991
29.798
O
CH2F
O
O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3s


-220.68
O
CH2F
O
O
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3s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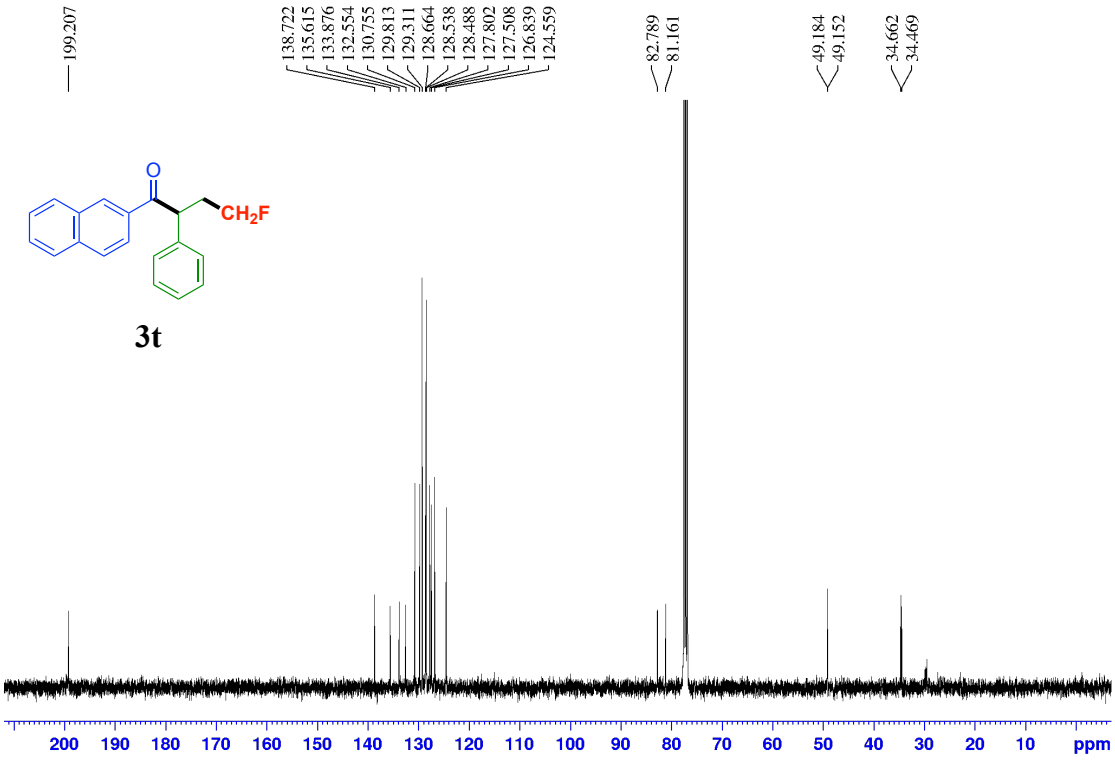
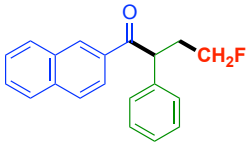
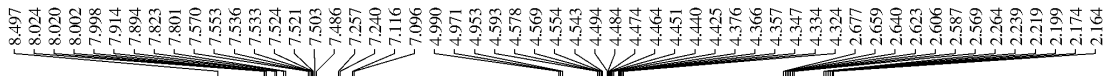
8.034
8.029
8.012
8.008
7.921
7.901
7.834
7.825
7.812
7.806
7.582
7.579
7.562
7.545
7.542
7.532
7.529
7.512
7.494
7.492
7.387
7.368
7.328
7.309
7.290
7.229
7.210
7.192
5.039
5.021
5.002
4.591
4.582
4.567
4.556
4.497
4.487
4.477
4.464
4.453
4.438
4.379
4.369
4.359
4.349
2.687
2.668
2.651
2.634
2.615
2.597
2.238
2.219
2.201
O
CH2F
3t
10
9
8
7
6
5
4
3
2
1
0
ppm
0.99
1.02
1.04
1.98
2.10
2.02
2.01
1.02
1.00
2.08
1.02
1.20

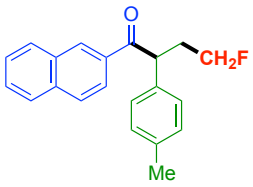

199.207
138.722
135.615
133.876
132.554
130.755
129.813
129.311
128.664
128.538
128.488
127.802
127.508
126.839
124.559
82.789
81.161
49.184
49.152
34.662
34.469
O
CH2F
3t
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F

3t

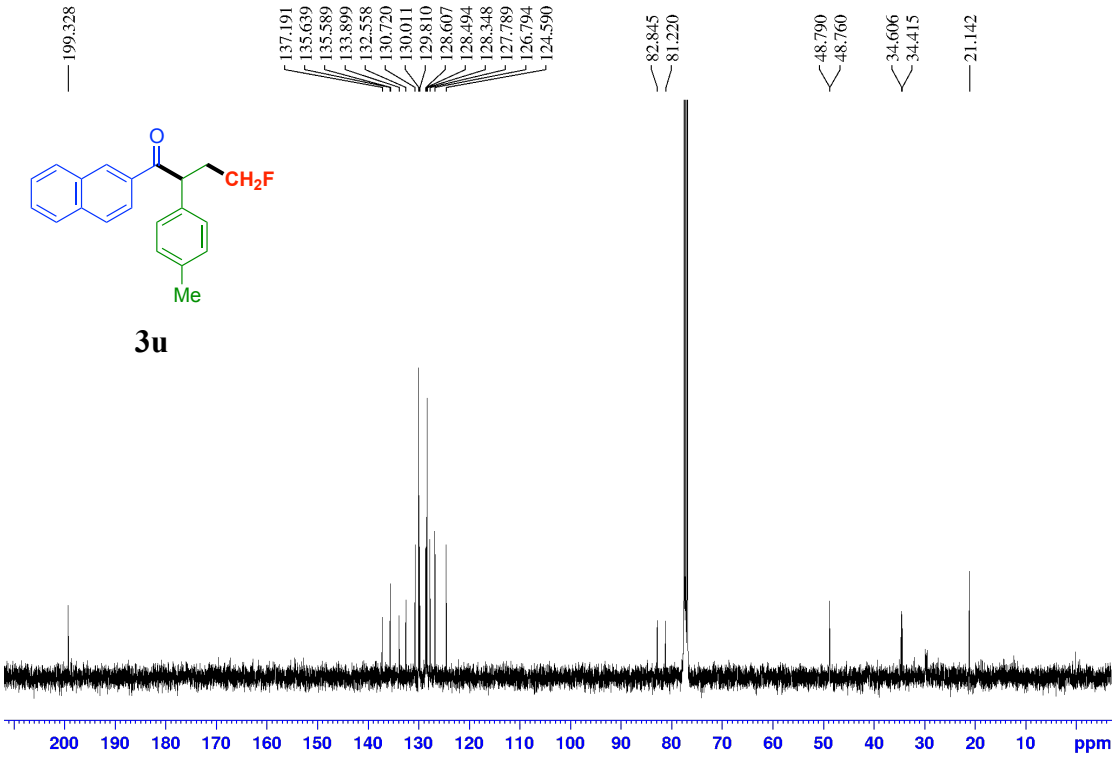
-221.27
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


8.497
8.024
8.020
8.002
7.998
7.914
7.894
7.823
7.801
7.570
7.553
7.536
7.533
7.524
7.521
7.503
7.486
7.257
7.240
7.116
7.096
4.990
4.971
4.953
4.593
4.578
4.569
4.554
4.543
4.494
4.484
4.474
4.464
4.451
4.440
4.425
4.376
4.366
4.357
4.347
4.334
4.324
2.677
2.659
2.640
2.623
2.606
2.587
2.569
2.264
2.239
2.219
2.199
2.174
2.164

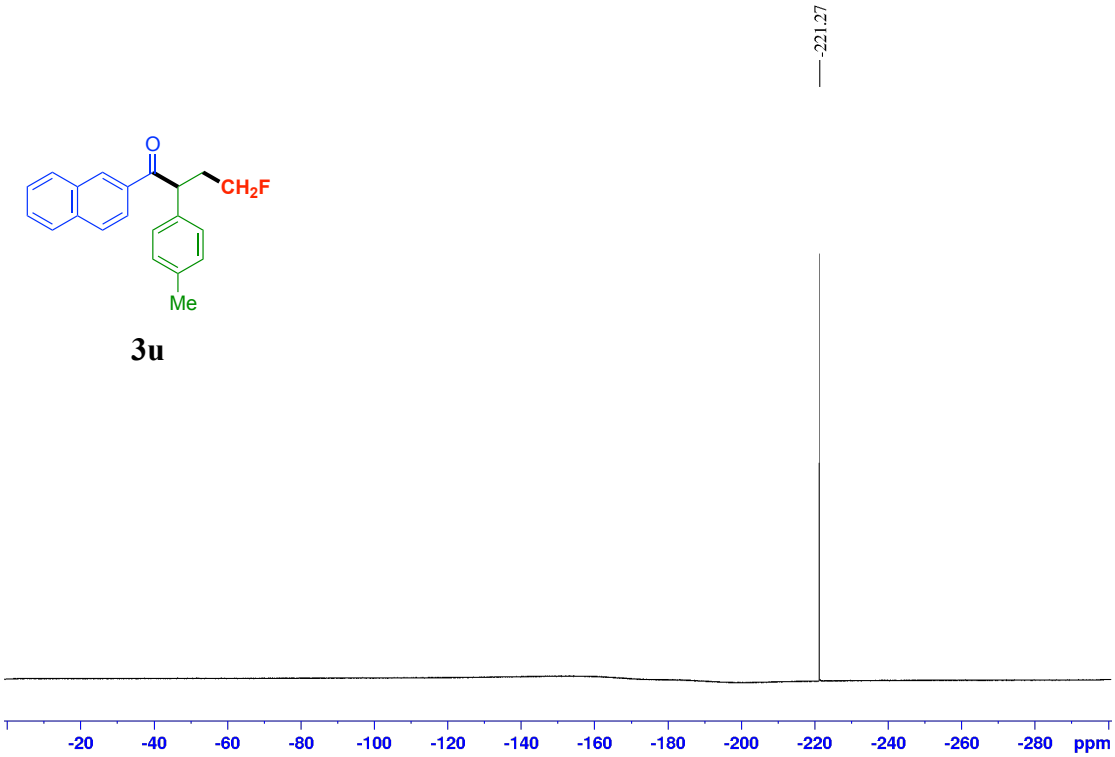

O
CH2F
Me

3u

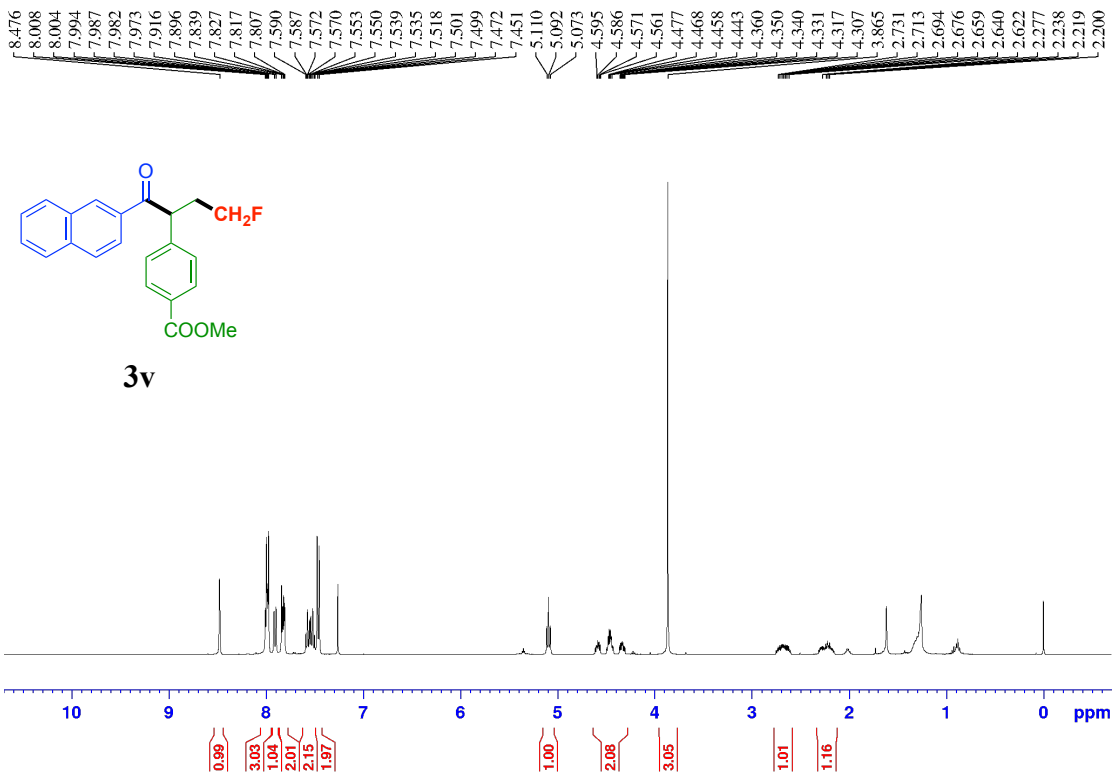
10
9
8
7
6
5
4
3
2
1
0
ppm
0.99
1.04
1.05
2.03
2.08
2.19
1.92
1.00
2.11
1.05
3.09
1.06

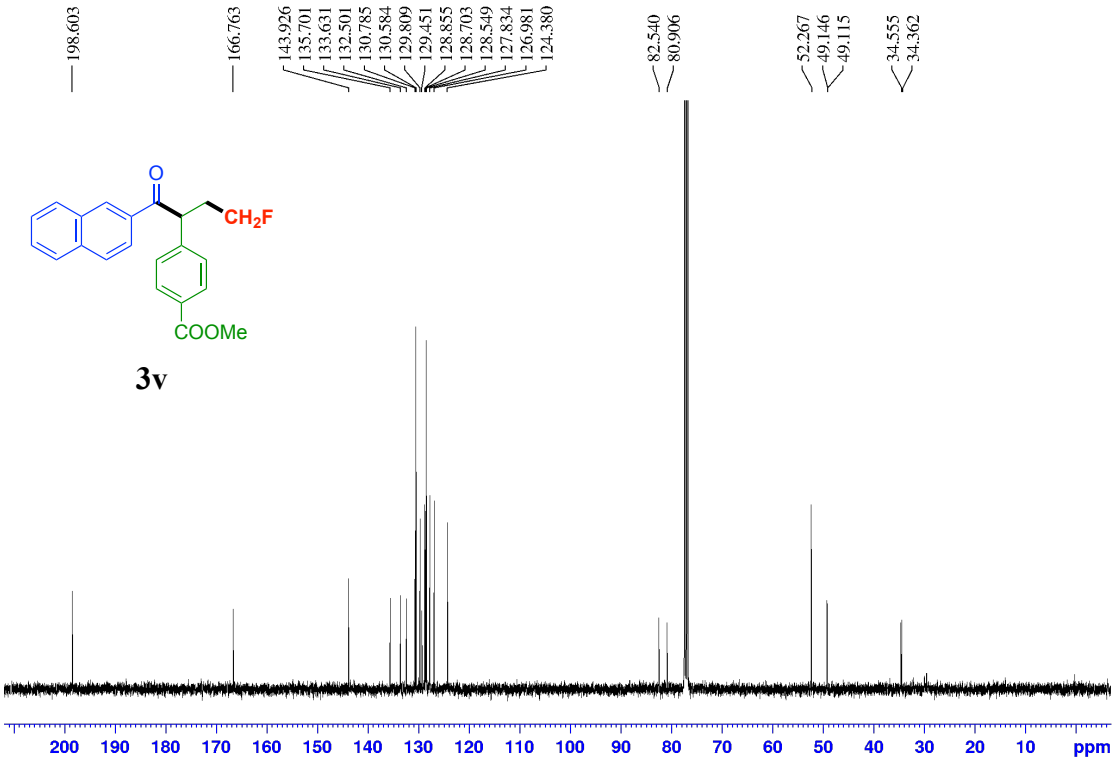

199.328
137.191
135.639
135.589
133.899
132.558
130.720
130.011
129.810
128.607
128.494
128.348
127.789
126.794
124.590
82.845
81.220
48.790
48.760
34.606
34.415
21.142
O
CH2F
Me
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

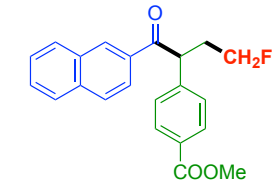
3u


-221.27
O
CH2F
Me
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3u


8.476
8.008
8.004
7.994
7.987
7.982
7.973
7.916
7.896
7.839
7.827
7.817
7.807
7.590
7.587
7.572
7.570
7.553
7.550
7.539
7.535
7.518
7.501
7.499
7.472
7.451
5.110
5.092
5.073
4.595
4.586
4.571
4.561
4.477
4.468
4.458
4.443
4.360
4.350
4.340
4.331
4.317
4.307
3.865
2.731
2.713
2.694
2.676
2.659
2.640
2.622
2.277
2.238
2.219
2.200
O
CH2F
COOMe
3v
10
9
8
7
6
5
4
3
2
1
0
ppm
0.99
3.03
1.04
2.01
2.15
1.97
1.00
2.08
3.05
1.01
1.16

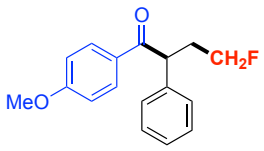

198.603
166.763
143.926
135.701
133.631
132.501
130.785
130.584
129.809
129.451
128.855
128.703
128.549
127.834
126.981
124.380
82.540
80.906
52.267
49.146
49.115
34.555
34.362
O
CH2F
COOMe
3v
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F
COOMe

3v

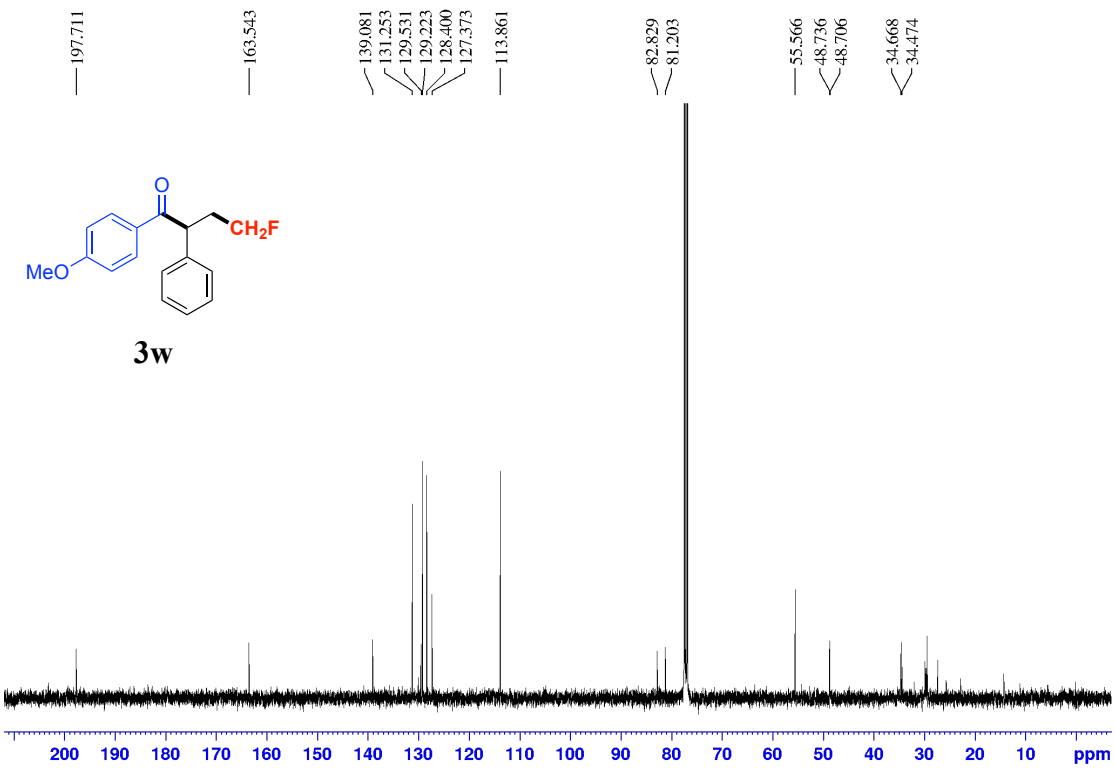
-221.33
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.979
7.972
7.967
7.954
7.949
7.942
7.323
7.310
7.302
7.297
7.282
7.276
7.234
7.227
7.212
7.205
7.191
6.877
6.870
6.865
6.852
6.848
6.841
4.819
4.800
4.782
4.547
4.524
4.509
4.498
4.445
4.426
4.416
4.394
4.379
4.327
4.298
4.275
3.815
2.640
2.621
2.603
2.584
2.566
2.541
2.523
2.493
2.219
2.191
2.161
2.145
2.125
2.095
2.079

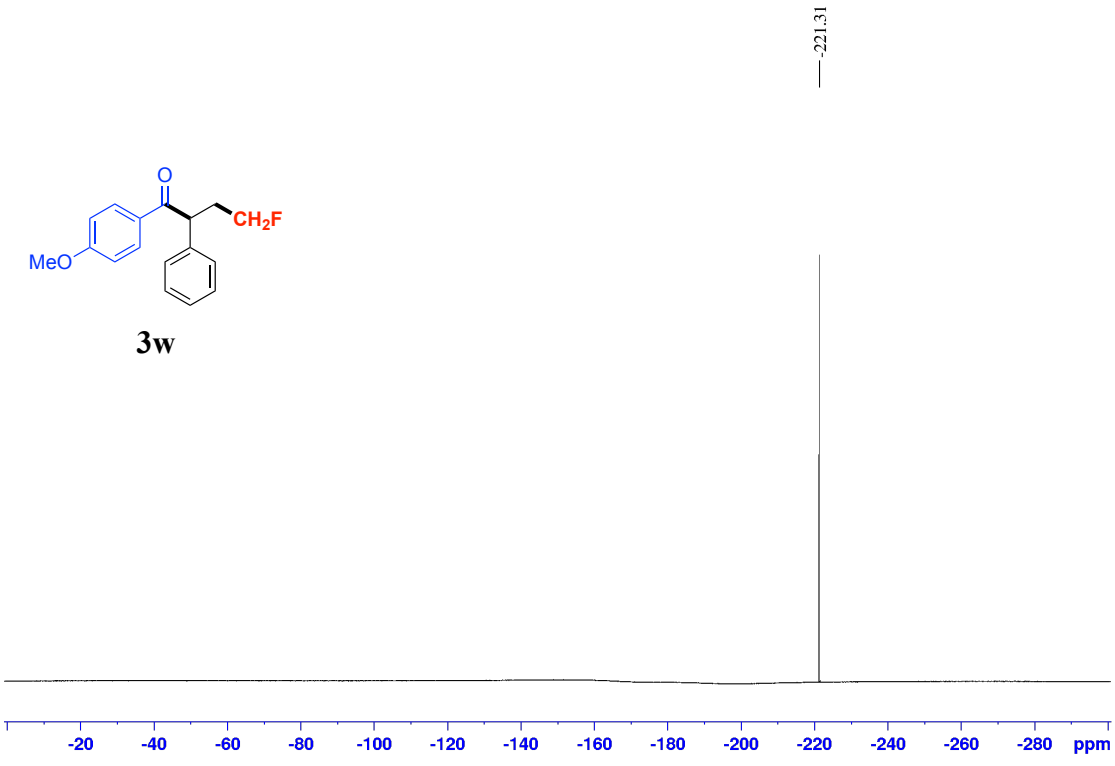

O
CH2F
MeO

3w

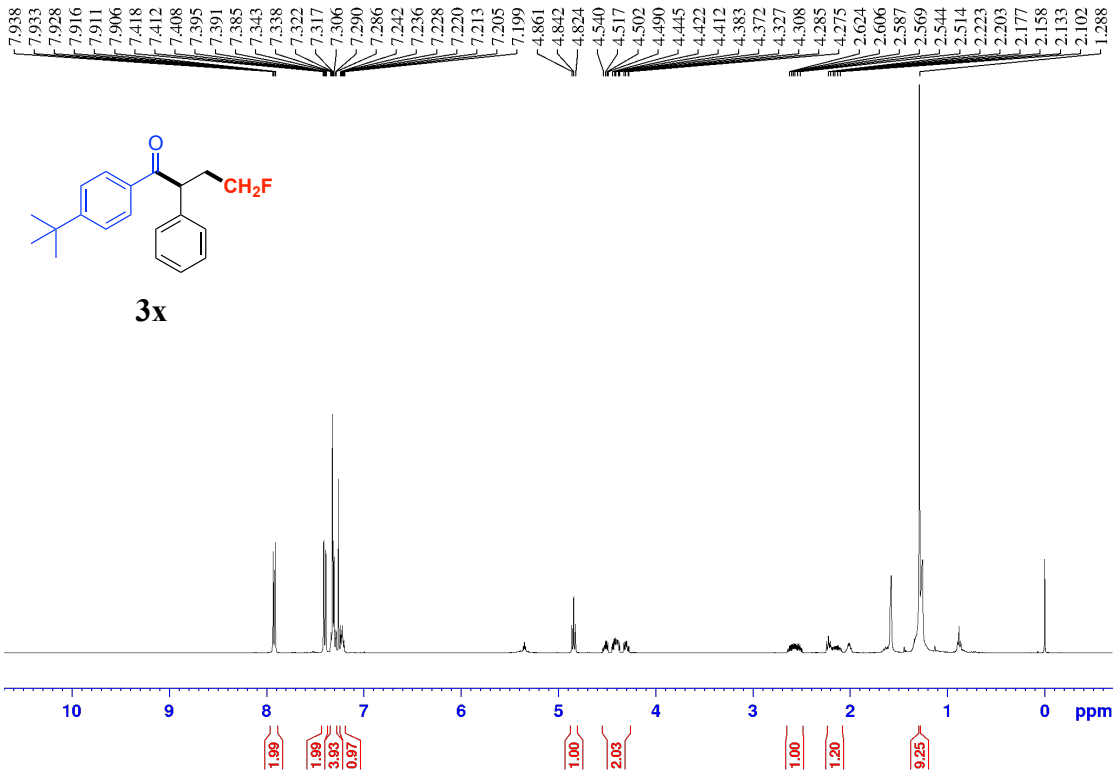
10
9
8
7
6
5
4
3
2
1
0
ppm
2.02
3.98
1.02
1.99
1.00
2.07
3.10
1.00
1.28

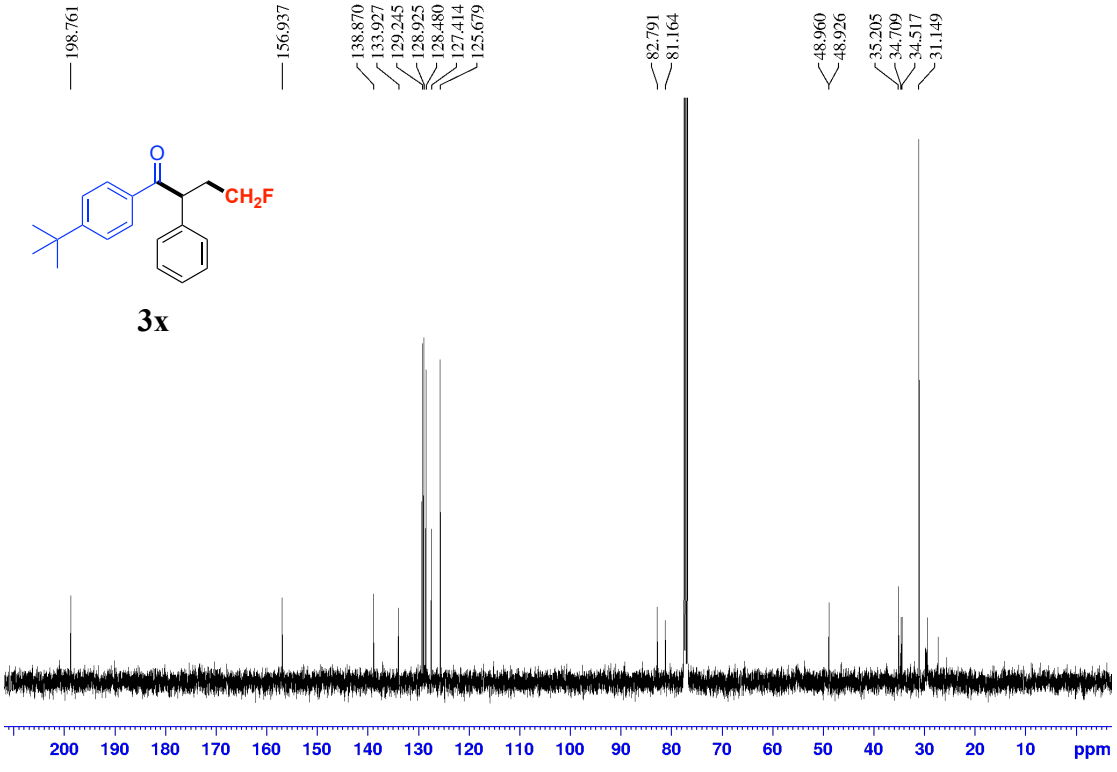

197.711
163.543
139.081
131.253
129.531
129.223
128.400
127.373
113.861
82.829
81.203
55.566
48.736
48.706
34.668
34.474
O
CH2F
MeO
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

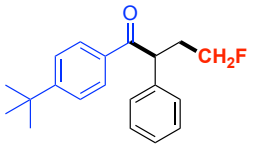
3w


-221.31
O
CH2F
MeO
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3w

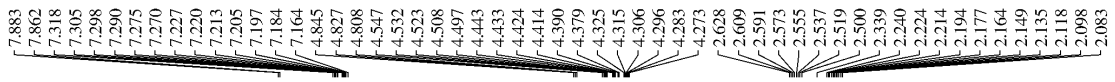

7.938
7.933
7.928
7.916
7.911
7.906
7.418
7.412
7.408
7.395
7.391
7.385
7.343
7.338
7.322
7.317
7.306
7.290
7.286
7.242
7.236
7.228
7.220
7.213
7.205
7.199
4.861
4.842
4.824
4.540
4.517
4.502
4.490
4.445
4.422
4.412
4.383
4.372
4.327
4.308
4.285
4.275
2.624
2.606
2.587
2.569
2.544
2.514
2.223
2.203
2.177
2.158
2.133
2.102
1.288
O
CH2F
3x
10
9
8
7
6
5
4
3
2
1
0
ppm
1.99
1.99
3.93
0.97
1.00
2.03
1.00
1.20
9.25

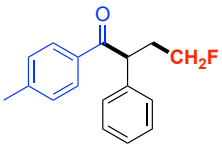

198.761
156.937
138.870
133.927
129.245
128.925
128.480
127.414
125.679
82.791
81.164
48.960
48.926
35.205
34.709
34.517
31.149
O
CH2F
3x
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F

3x

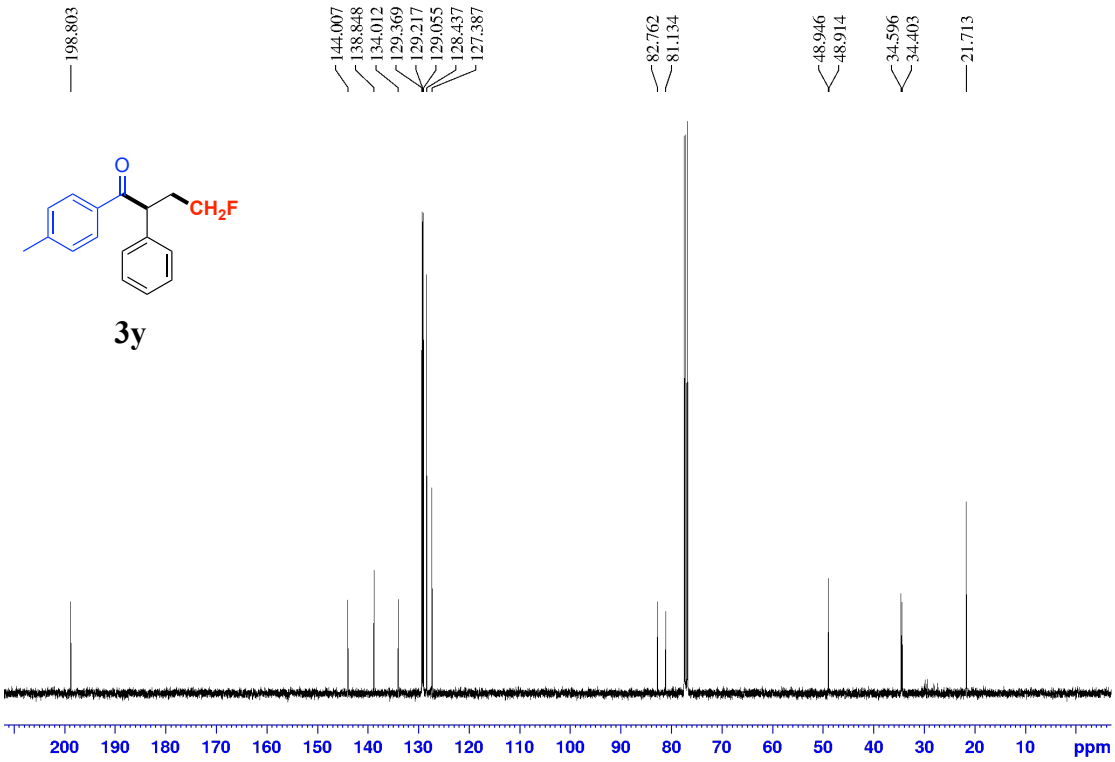
-221.30
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.883
7.862
7.318
7.305
7.298
7.290
7.275
7.270
7.227
7.220
7.213
7.205
7.197
7.184
7.164
4.845
4.827
4.808
4.547
4.532
4.523
4.508
4.497
4.443
4.433
4.424
4.414
4.390
4.379
4.325
4.315
4.306
4.296
4.283
4.273
2.628
2.609
2.591
2.573
2.555
2.537
2.519
2.500
2.339
2.240
2.224
2.214
2.194
2.177
2.164
2.149
2.135
2.118
2.098
2.083

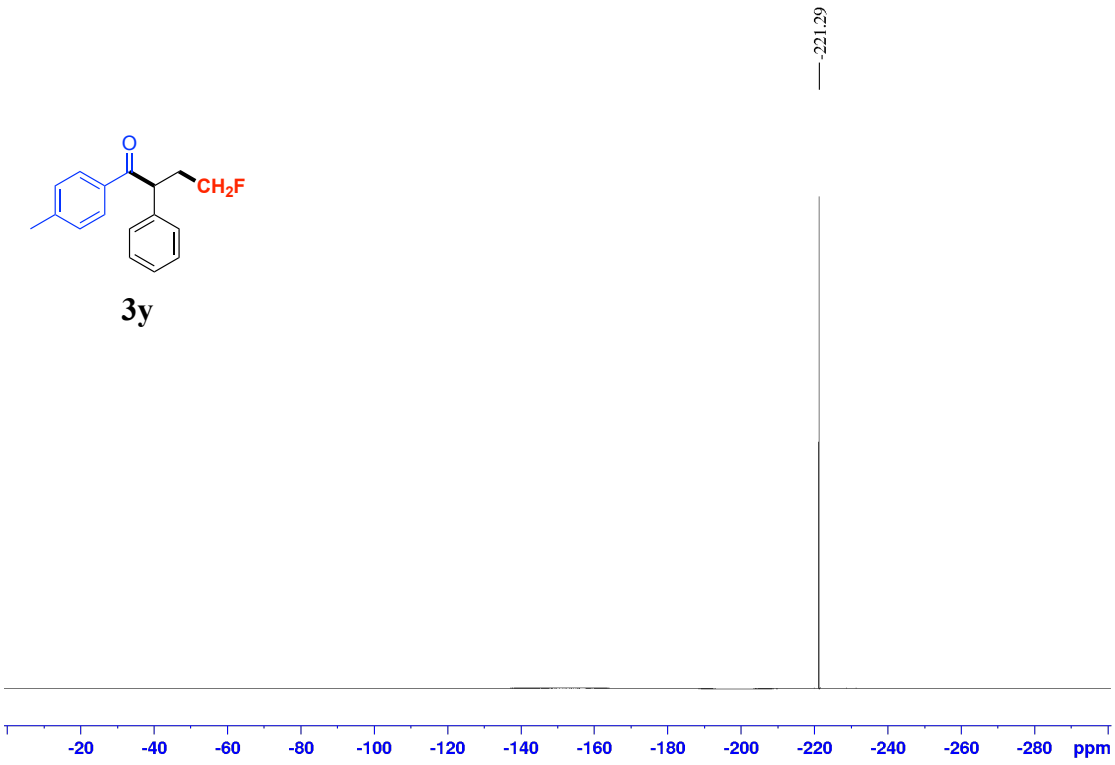

O
CH2F

3y

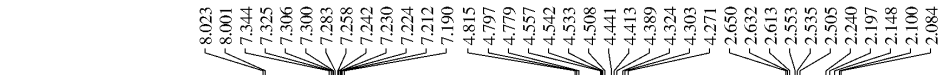
10
9
8
7
6
5
4
3
2
1
0
ppm
1.97
3.91
2.92
1.00
2.04
1.02
3.00
1.11

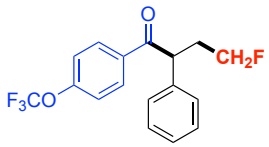

198.803
144.007
138.848
134.012
129.369
129.217
129.055
128.437
127.387
82.762
81.134
48.946
48.914
34.596
34.403
21.713
O
CH2F
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3y

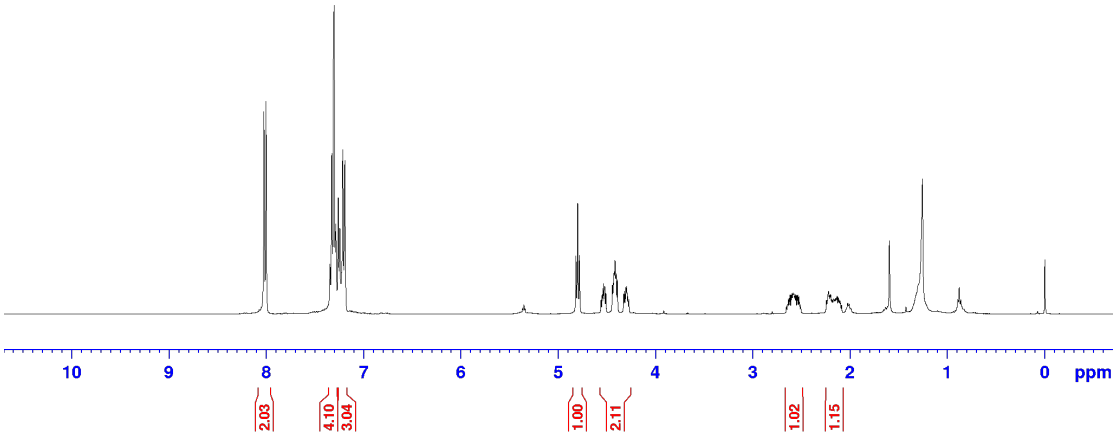

-221.29
O
CH2F
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

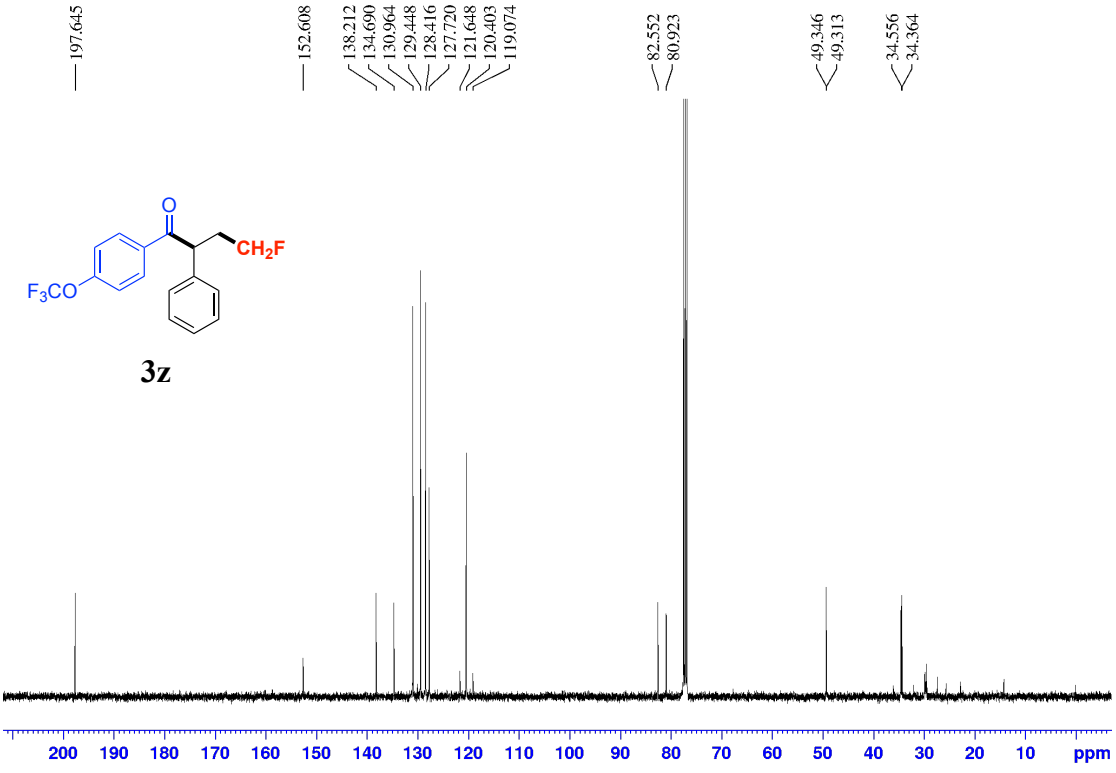
3y


8.023
8.001
7.344
7.325
7.306
7.300
7.283
7.258
7.242
7.230
7.224
7.212
7.190
4.815
4.797
4.779
4.557
4.542
4.533
4.508
4.441
4.413
4.389
4.324
4.303
4.271
2.650
2.632
2.613
2.553
2.535
2.505
2.240
2.197
2.148
2.100
2.084


O
CH2F
F3CO

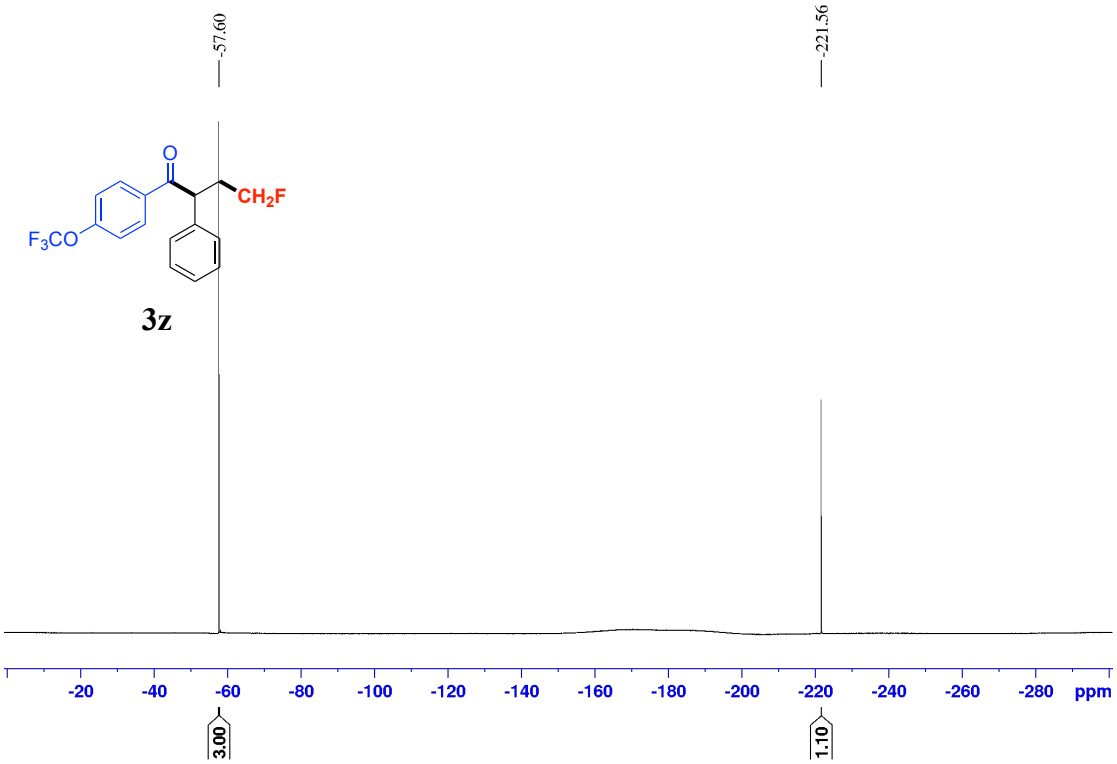
3z


10
9
8
7
6
5
4
3
2
1
0
ppm
2.03
4.10
3.04
1.00
2.11
1.02
1.15

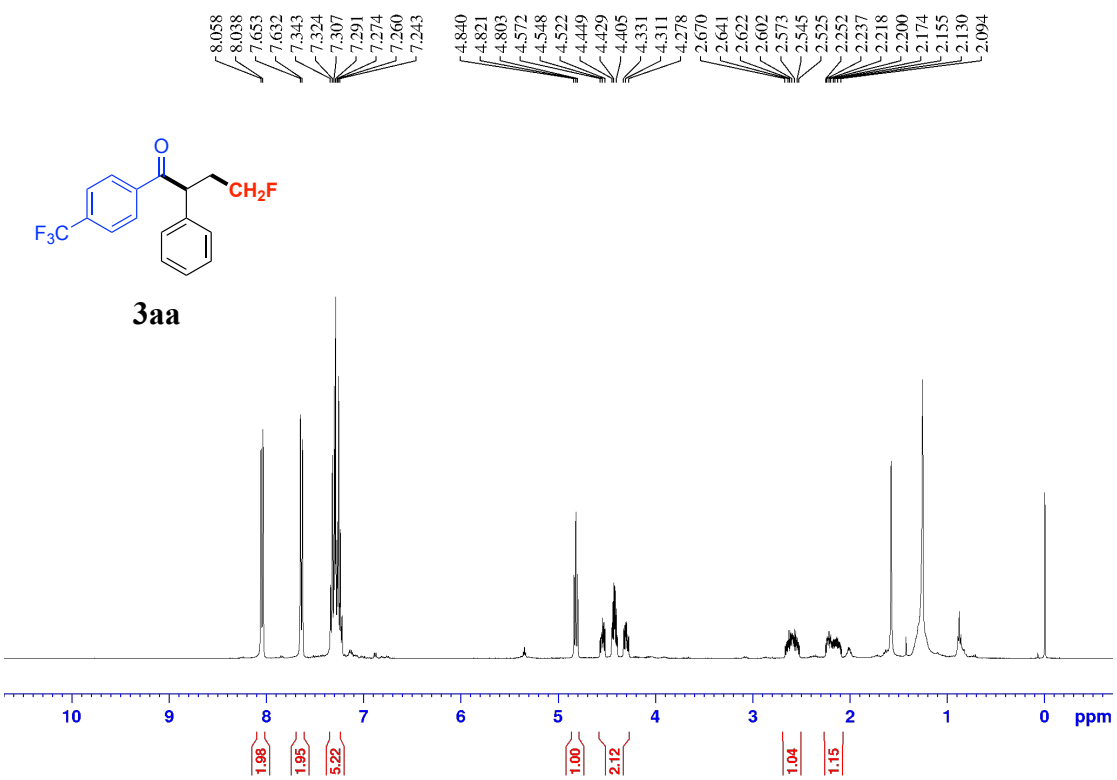

197.645
152.608
138.212
134.690
130.964
129.448
128.416
127.720
121.648
120.403
119.074
82.552
80.923
49.346
49.313
34.556
34.364
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

O
CH2F
F3CO

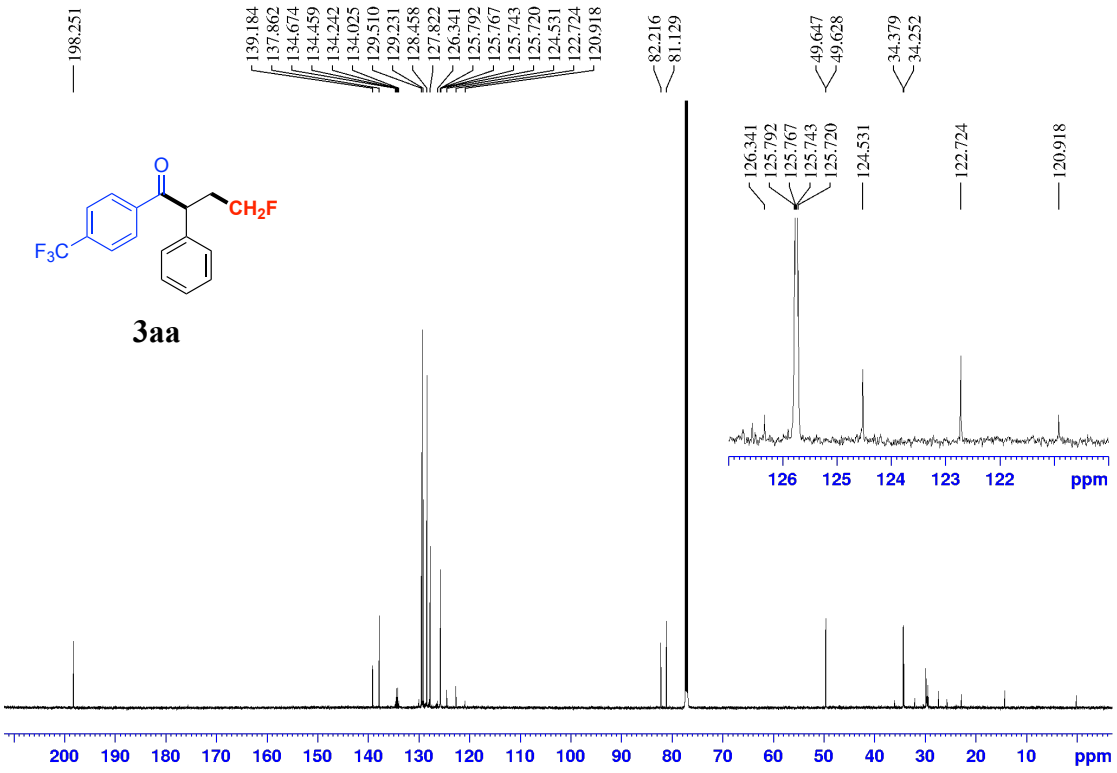
3z

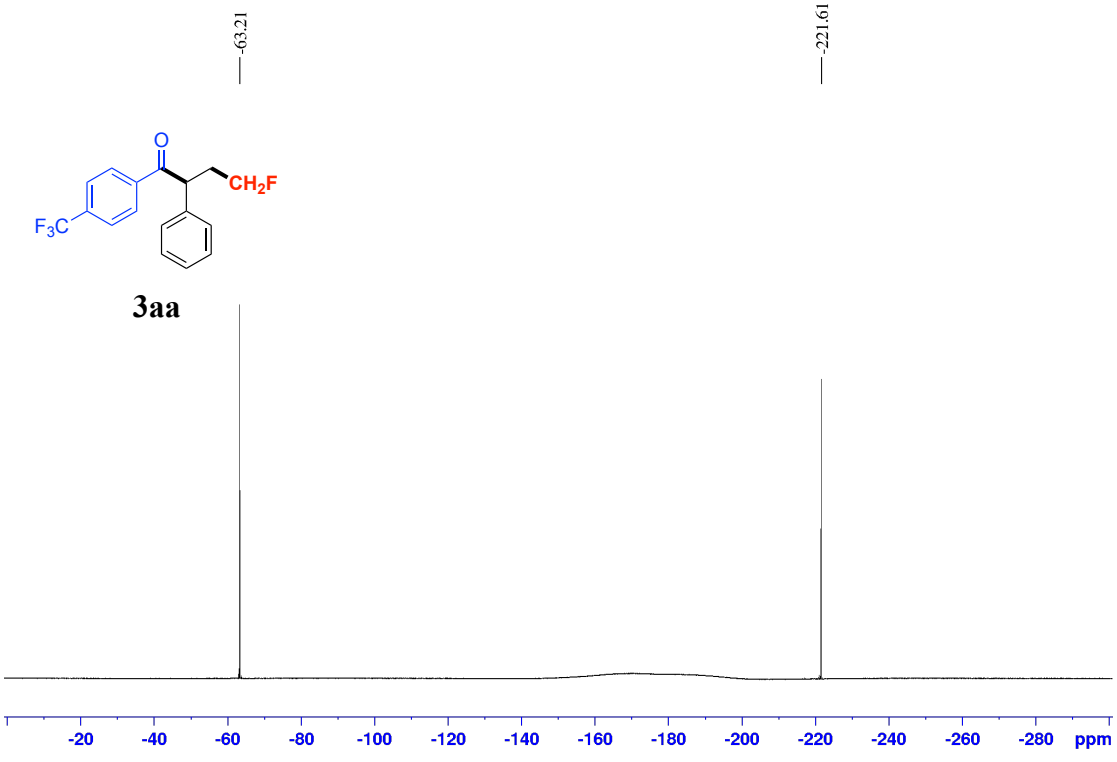

-57.60
-221.56
O
CH2F
F3CO
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm
3.00
1.10

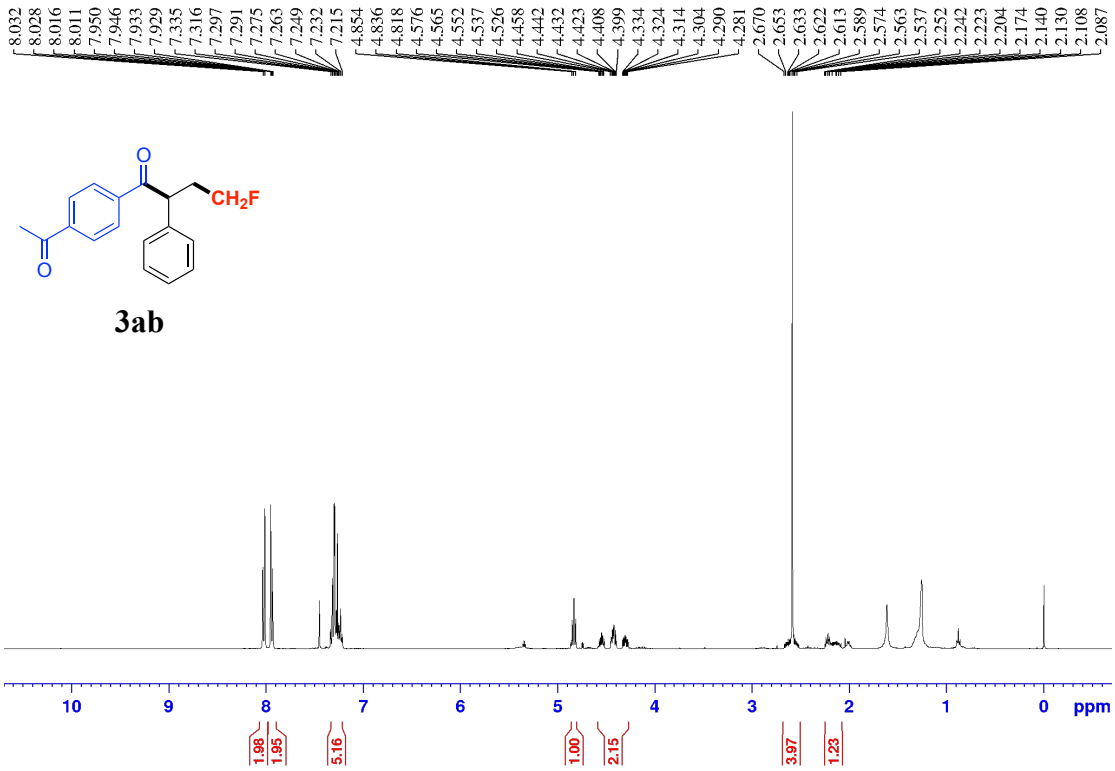
3z

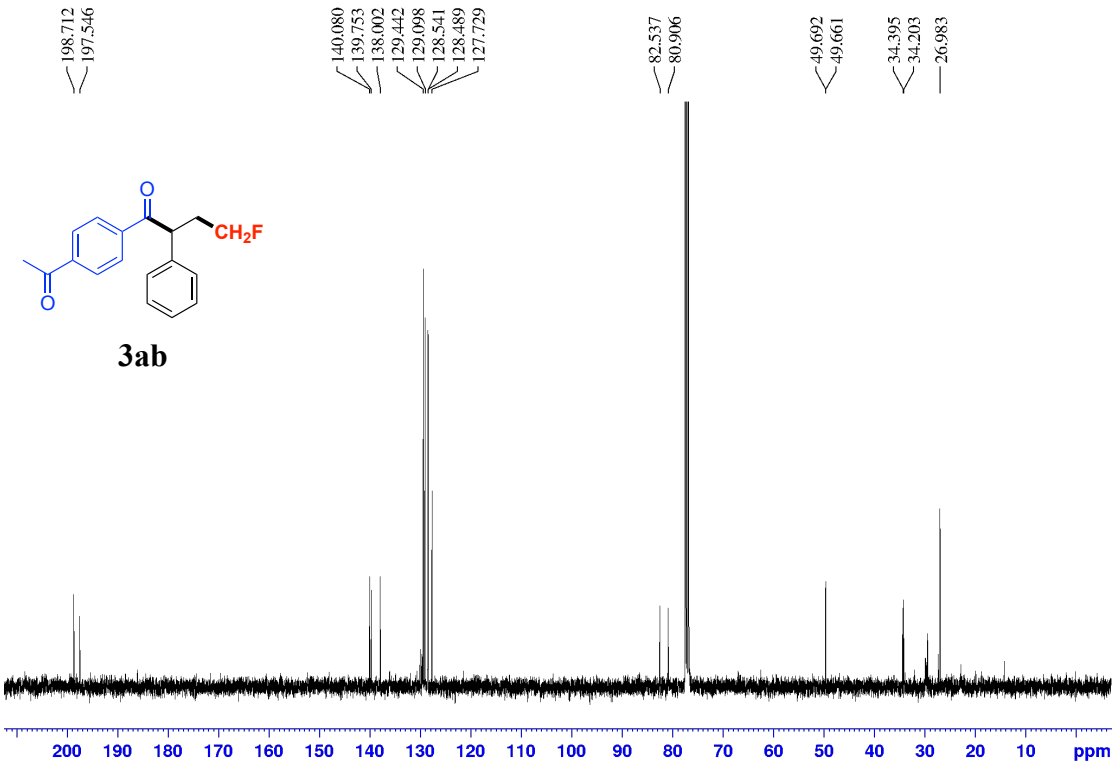

8.058
8.038
7.653
7.632
7.343
7.324
7.307
7.291
7.274
7.260
7.243
4.840
4.821
4.803
4.572
4.548
4.522
4.449
4.429
4.405
4.331
4.311
4.278
2.670
2.641
2.622
2.602
2.573
2.545
2.525
2.252
2.237
2.218
2.200
2.174
2.155
2.130
2.094
O
CH2F
F3C
10
9
8
7
6
5
4
3
2
1
0
ppm
1.98
1.95
5.22
1.00
2.12
1.04
1.15

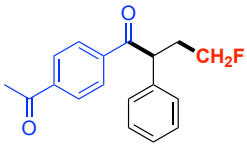
3aa


198.251
139.184
137.862
134.674
134.459
134.242
134.025
129.510
129.231
128.458
127.822
126.341
125.792
125.767
125.743
125.720
124.531
122.724
120.918
82.216
81.129
49.647
49.628
34.379
34.252
126.341
125.792
125.767
125.743
125.720
124.531
122.724
120.918
126 125 124 123 122 ppm
O
CH2F
F3C
3aa
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


-63.21
-221.61
O
CH2F
F3C
3aa
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

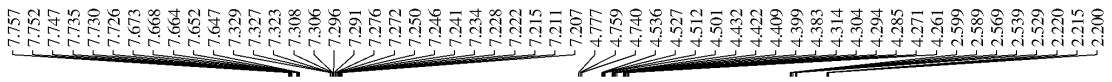

8.032
8.028
8.016
8.011
7.950
7.946
7.933
7.929
7.335
7.316
7.297
7.291
7.275
7.263
7.249
7.232
7.215
4.854
4.836
4.818
4.576
4.565
4.552
4.537
4.526
4.458
4.442
4.432
4.423
4.408
4.399
4.334
4.324
4.314
4.304
4.290
4.281
2.670
2.653
2.633
2.622
2.613
2.589
2.574
2.563
2.537
2.252
2.242
2.223
2.204
2.174
2.140
2.130
2.108
2.087
O
CH2F
O
3ab
10
9
8
7
6
5
4
3
2
1
0
ppm
1.98
1.95
5.16
1.00
2.15
3.97
1.23

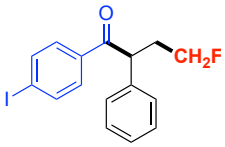

198.712
197.546
140.080
139.753
138.002
129.442
129.098
128.541
128.489
127.729
82.537
80.906
49.692
49.661
34.395
34.203
26.983
O
CH2F
O
3ab
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm



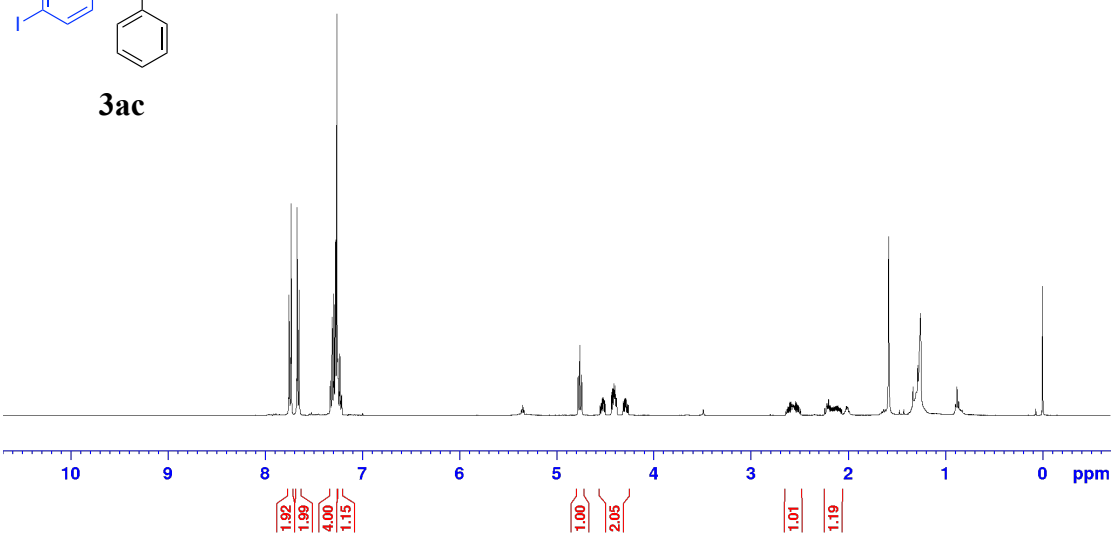
3ab

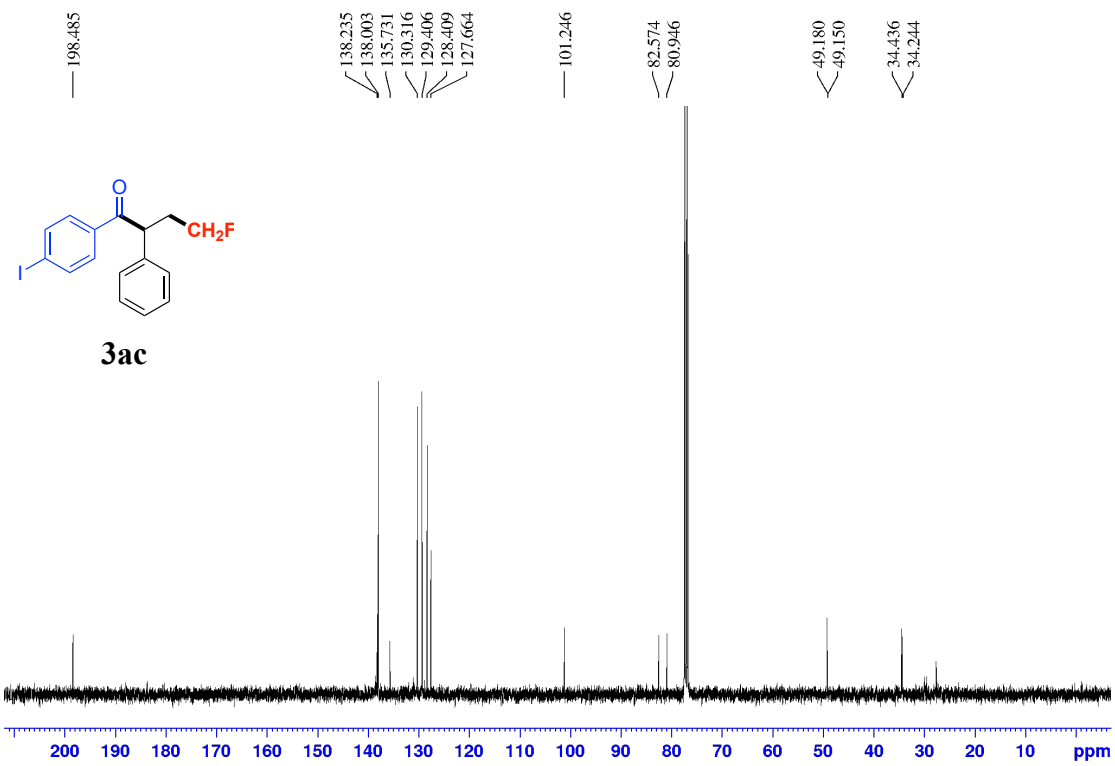
-221.30
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.757
7.752
7.747
7.735
7.730
7.726
7.673
7.668
7.664
7.652
7.647
7.329
7.327
7.323
7.308
7.306
7.296
7.291
7.276
7.272
7.250
7.246
7.241
7.234
7.228
7.222
7.215
7.211
7.207
4.777
4.759
4.740
4.536
4.527
4.512
4.501
4.432
4.422
4.409
4.399
4.383
4.314
4.304
4.294
4.285
4.271
4.261
2.599
2.589
2.569
2.539
2.529
2.220
2.215
2.200

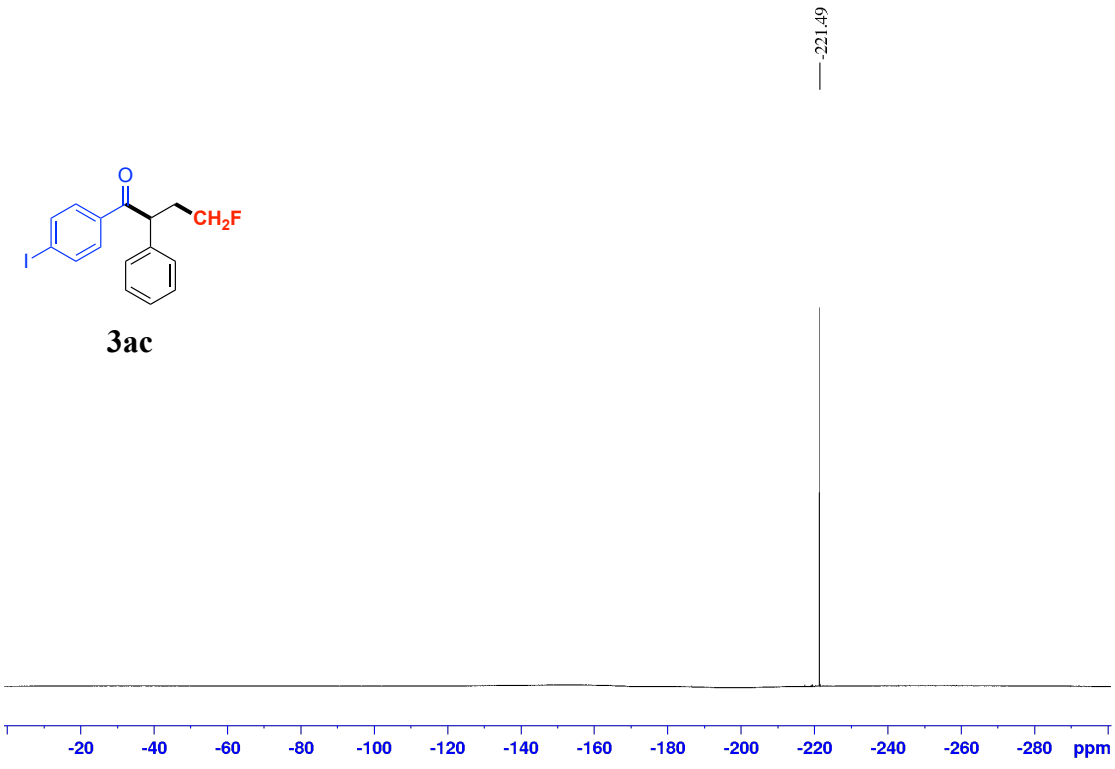


3ac

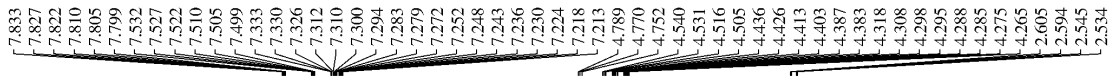

10
9
8
7
6
5
4
3
2
1
0
ppm
1.92
1.99
4.00
1.15
1.00
2.05
1.01
1.19

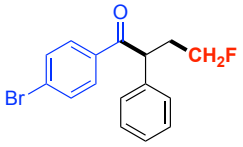

198.485
138.235
138.003
135.731
130.316
129.406
128.409
127.664
101.246
82.574
80.946
49.180
49.150
34.436
34.244
O
CH2F
I
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3ac

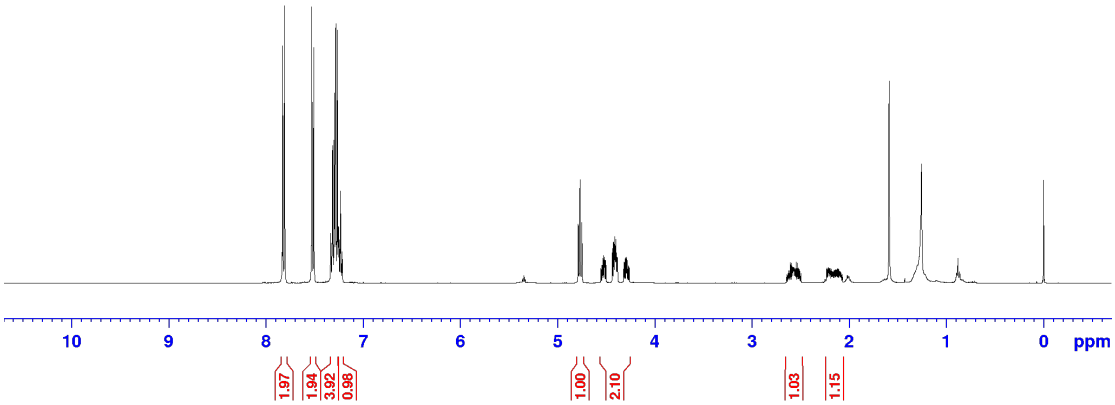

-221.49
O
CH2F
I
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

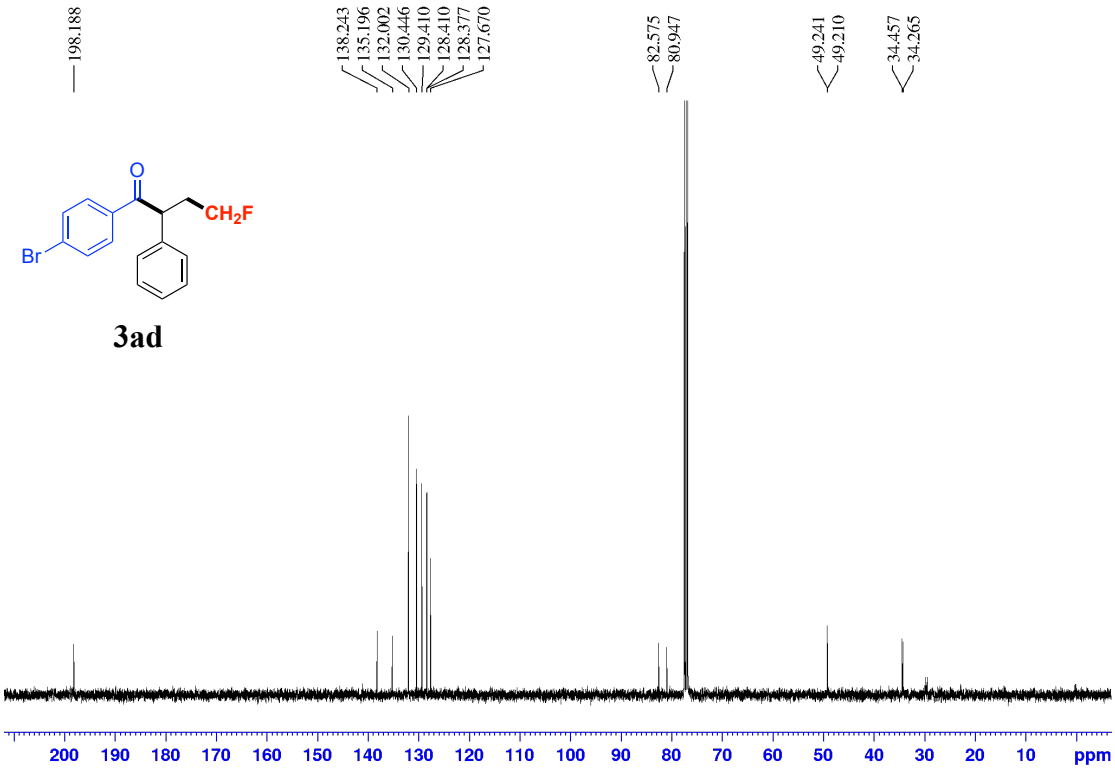
3ac


7.833
7.827
7.822
7.810
7.805
7.799
7.532
7.527
7.522
7.510
7.505
7.499
7.333
7.330
7.326
7.312
7.310
7.300
7.294
7.283
7.279
7.272
7.252
7.248
7.243
7.236
7.230
7.224
7.218
7.213
4.789
4.770
4.752
4.540
4.531
4.516
4.505
4.436
4.426
4.413
4.403
4.387
4.383
4.318
4.308
4.298
4.295
4.288
4.285
4.275
4.265
2.605
2.594
2.545
2.534


O
CH2F
Br

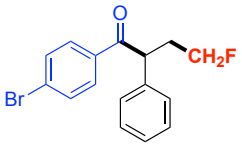
3ad


10
9
8
7
6
5
4
3
2
1
0
ppm
1.97
1.94
3.92
0.98
1.00
2.10
1.03
1.15


198.188
138.243
135.196
132.002
130.446
129.410
128.410
128.377
127.670
82.575
80.947
49.241
49.210
34.457
34.265
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

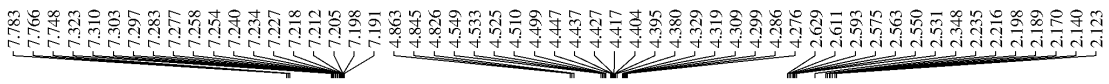
O
CH2F
Br

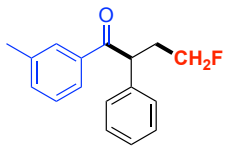
3ad


O
CH2F
Br

3ad

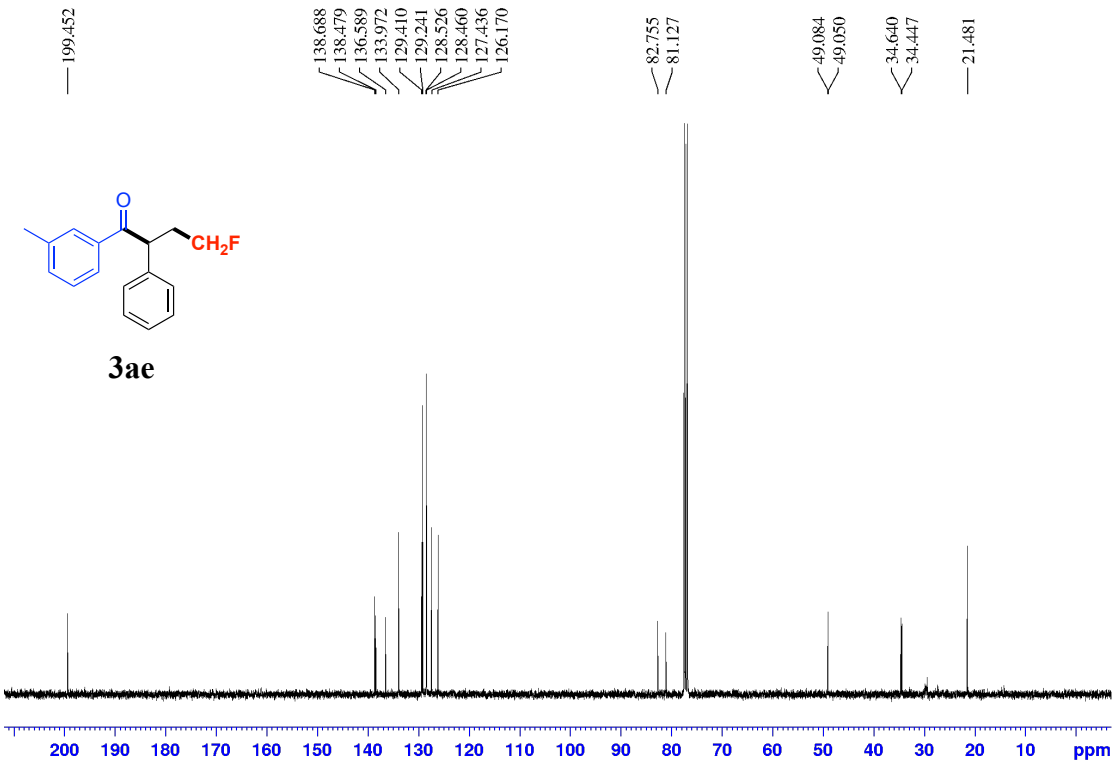
-221.51
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.783
7.766
7.748
7.323
7.310
7.303
7.297
7.283
7.277
7.258
7.254
7.240
7.234
7.227
7.218
7.212
7.205
7.198
7.191
4.863
4.845
4.826
4.549
4.533
4.525
4.510
4.499
4.447
4.437
4.427
4.417
4.404
4.395
4.380
4.329
4.319
4.309
4.299
4.286
4.276
2.629
2.611
2.593
2.575
2.563
2.550
2.531
2.348
2.235
2.216
2.198
2.189
2.170
2.140
2.123

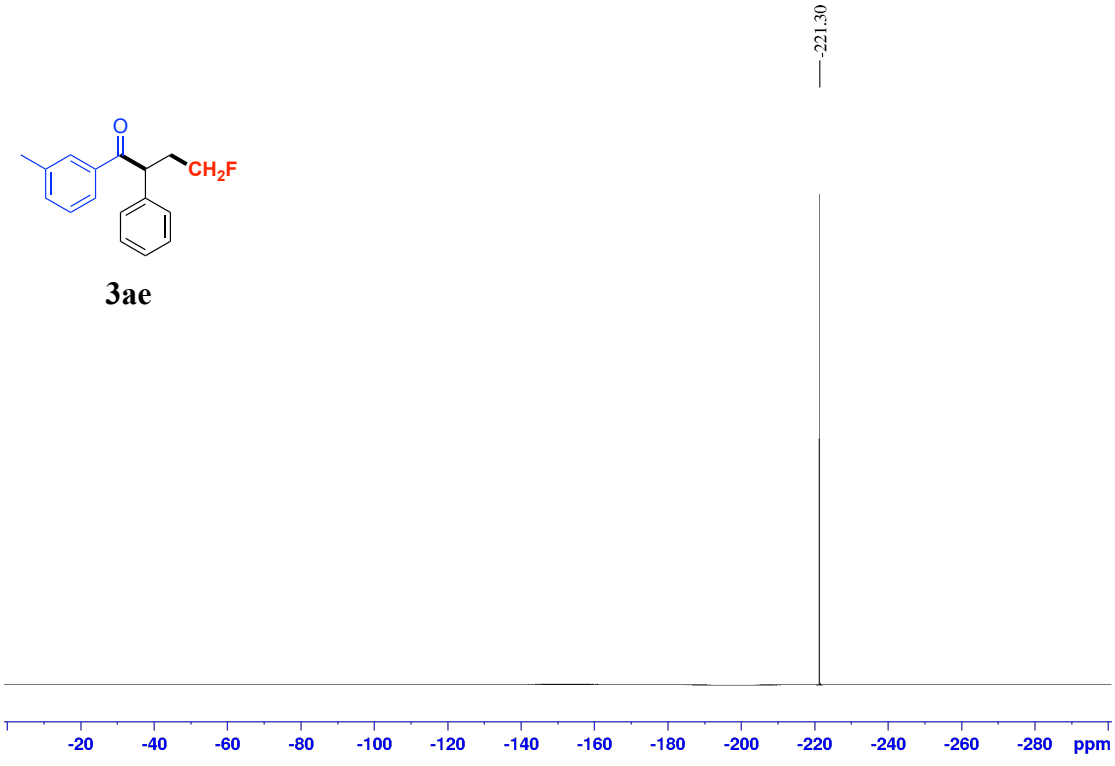

O
CH2F

3ae

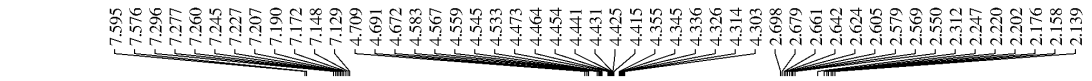
10
9
8
7
6
5
4
3
2
1
0
ppm
1.99
7.08
1.00
2.04
1.02
2.96
1.12

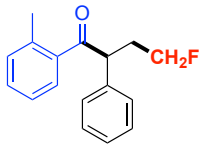

199.452
138.688
138.479
136.589
133.972
129.410
129.241
128.526
128.460
127.436
126.170
82.755
81.127
49.084
49.050
34.640
34.447
21.481
O
CH2F
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3ae


-221.30
O
CH2F
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

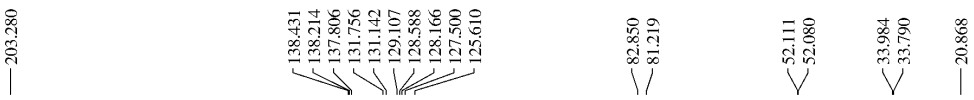
3ae

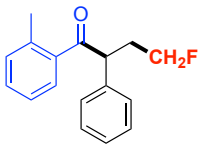

7.595
7.576
7.296
7.277
7.260
7.245
7.227
7.207
7.190
7.172
7.148
7.129
4.709
4.691
4.672
4.583
4.567
4.559
4.545
4.533
4.473
4.464
4.454
4.441
4.431
4.425
4.415
4.355
4.345
4.336
4.326
4.314
4.303
2.698
2.679
2.661
2.642
2.624
2.605
2.579
2.569
2.550
2.312
2.247
2.220
2.202
2.176
2.158
2.139


O
CH2F

3af

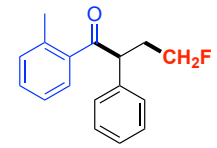
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
8.08
1.00
2.06
1.03
2.96
1.15


203.280
138.431
138.214
137.806
131.756
131.142
129.107
128.588
128.166
127.500
125.610
82.850
81.219
52.111
52.080
33.984
33.790
20.868


O
CH2F

3af

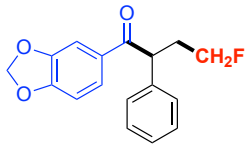
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm



3af

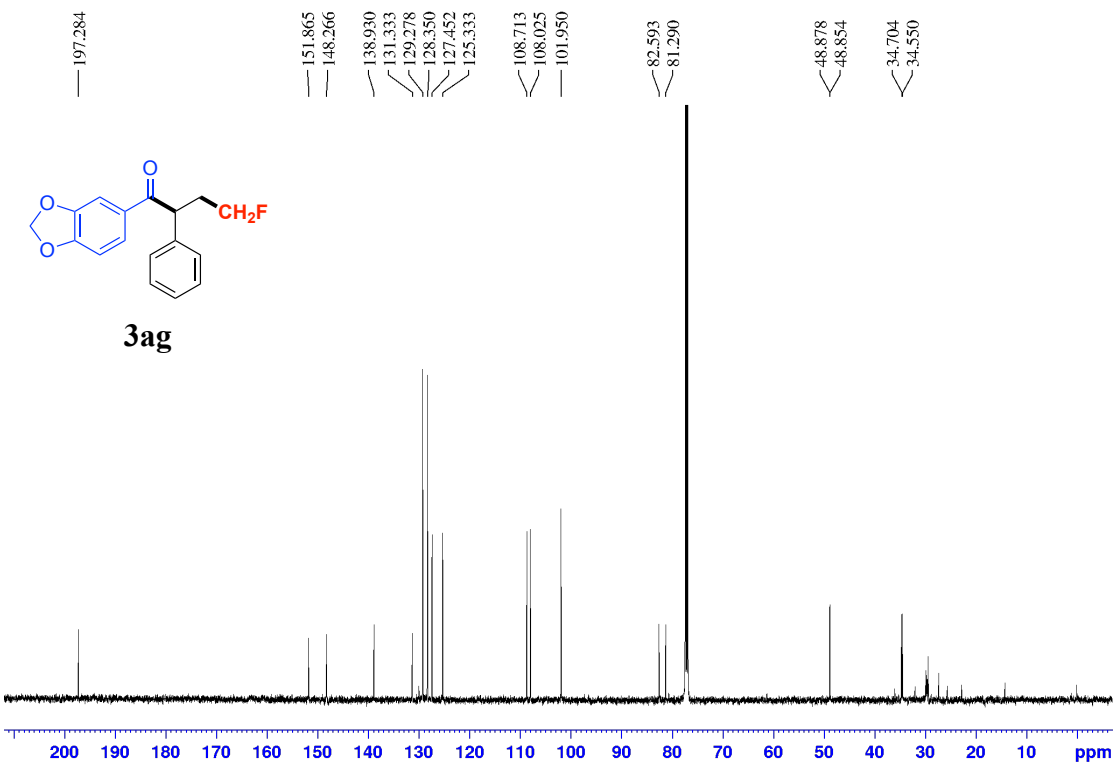
-221.27
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.607
7.603
7.587
7.582
7.440
7.436
7.329
7.309
7.303
7.295
7.282
7.243
7.236
7.228
7.222
7.216
7.207
7.200
6.780
6.759
5.986
4.770
4.752
4.734
4.539
4.516
4.500
4.489
4.435
4.406
4.382
4.371
4.317
4.298
4.288
4.265
2.627
2.608
2.590
2.571
2.553
2.536
2.517
2.499
2.480
2.216
2.200
2.180
2.160
2.140
2.121
2.104
2.084
2.069
2.046

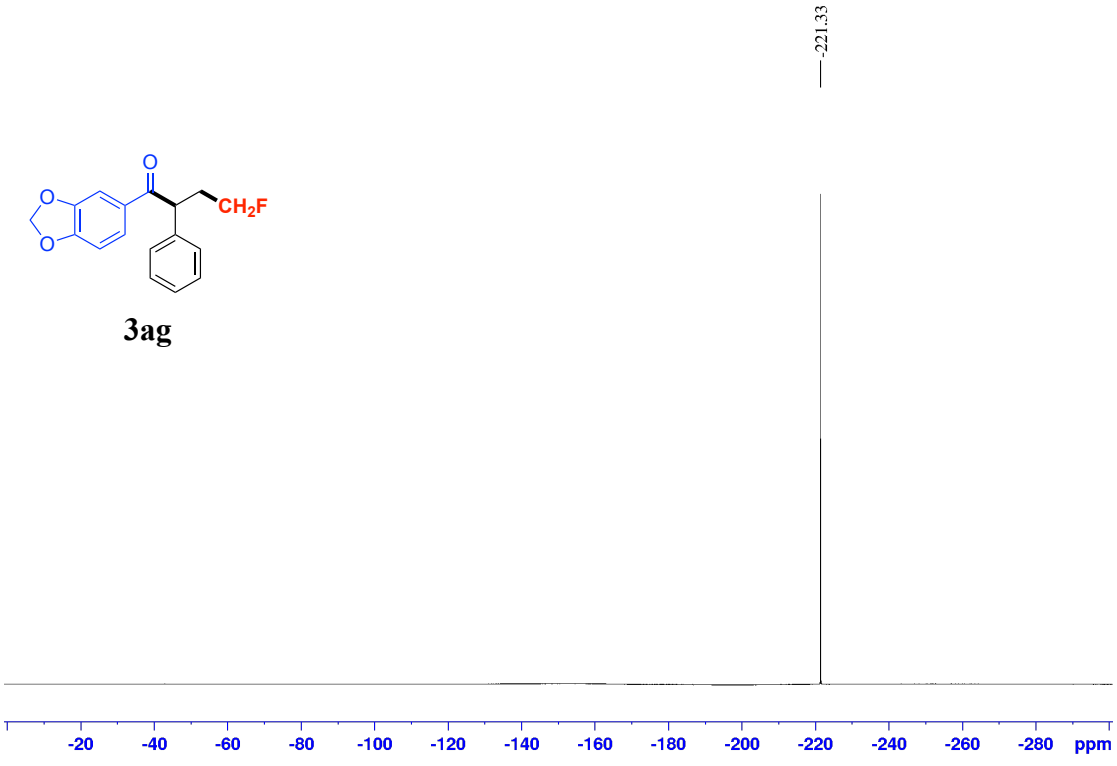


3ag

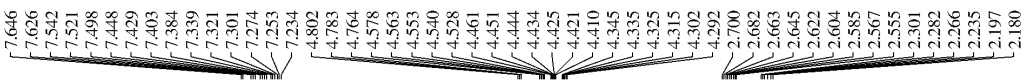
10
9
8
7
6
5
4
3
2
1
0
ppm
1.01
0.97
3.91
0.92
0.96
1.99
1.00
2.05
1.01
1.06

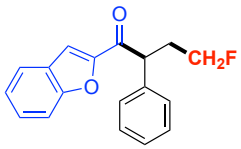

197.284
151.865
148.266
138.930
131.333
129.278
128.350
127.452
125.333
108.713
108.025
101.950
82.593
81.290
48.878
48.854
34.704
34.550
O
O
O
CH2F
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3ag

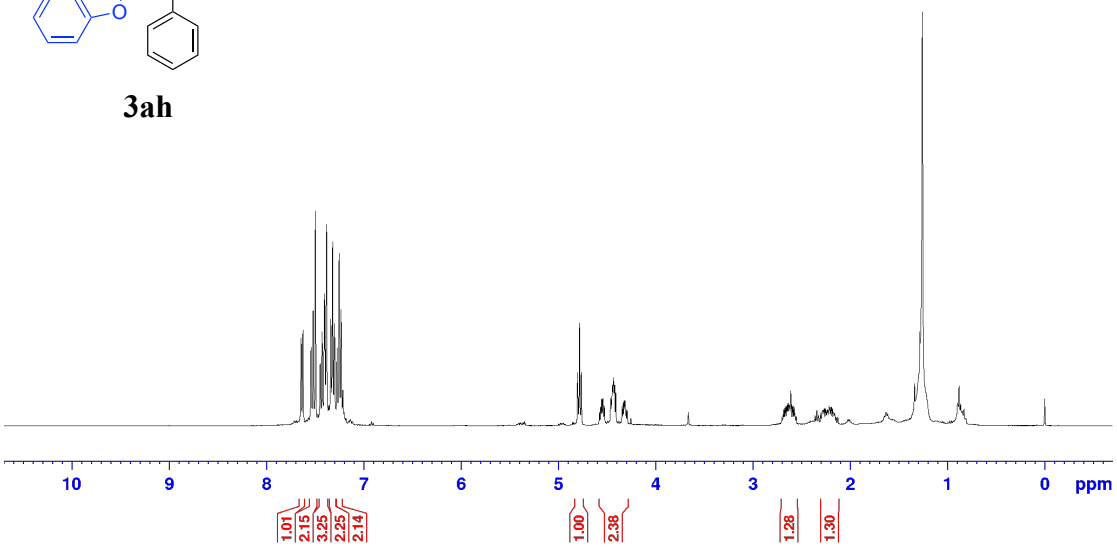

-221.33
O
O
O
CH2F
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

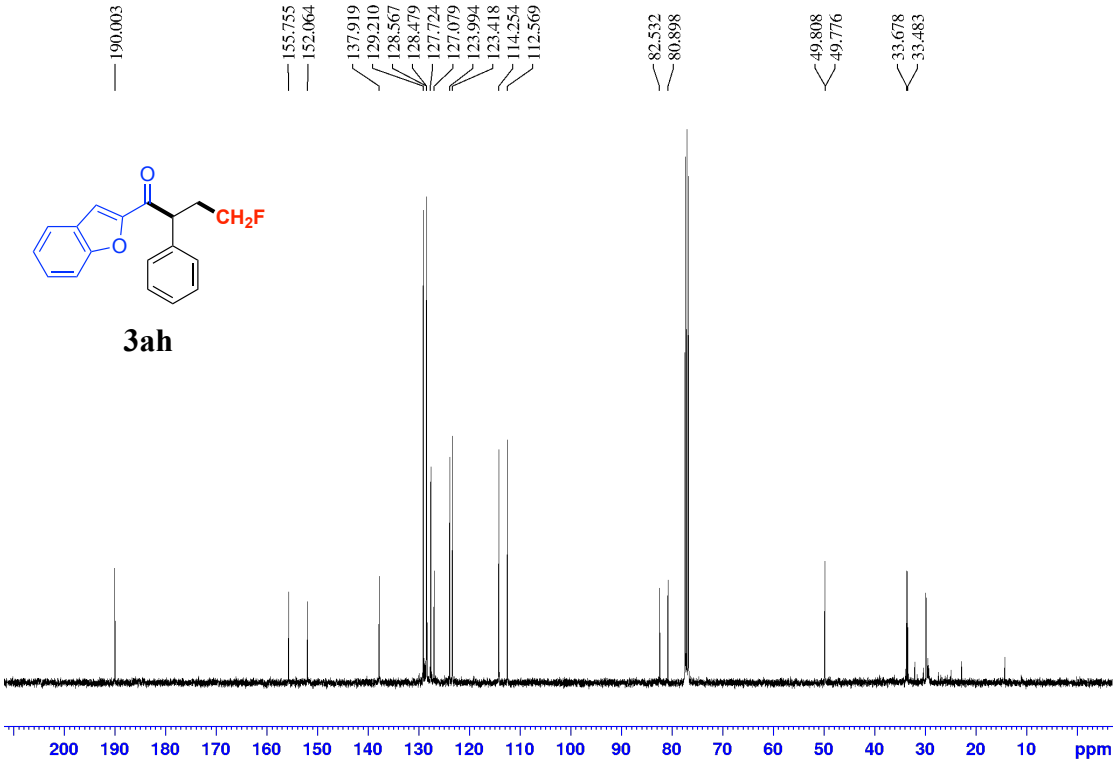
3ag


7.646
7.626
7.542
7.521
7.498
7.448
7.429
7.403
7.384
7.339
7.321
7.301
7.274
7.253
7.234
4.802
4.783
4.764
4.578
4.563
4.553
4.540
4.528
4.461
4.451
4.444
4.434
4.425
4.421
4.410
4.345
4.335
4.325
4.315
4.302
4.292
2.700
2.682
2.663
2.645
2.622
2.604
2.585
2.567
2.555
2.301
2.282
2.266
2.235
2.197
2.180


O
O
CH2F

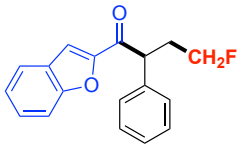
3ah


10
9
8
7
6
5
4
3
2
1
0
ppm
1.01
2.15
3.25
2.25
2.14
1.00
2.38
1.28
1.30


190.003
155.755
152.064
137.919
129.210
128.567
128.479
127.724
127.079
123.994
123.418
114.254
112.569
82.532
80.898
49.808
49.776
33.678
33.483
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

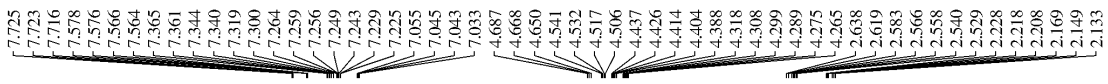
O
O
CH2F

3ah



3ah

-221.30
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.725
7.723
7.716
7.578
7.576
7.566
7.564
7.365
7.361
7.344
7.340
7.319
7.300
7.264
7.259
7.256
7.249
7.243
7.229
7.225
7.055
7.045
7.043
7.033
4.687
4.668
4.650
4.541
4.532
4.517
4.506
4.437
4.426
4.414
4.404
4.388
4.318
4.308
4.299
4.289
4.275
4.265
2.638
2.619
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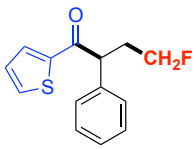
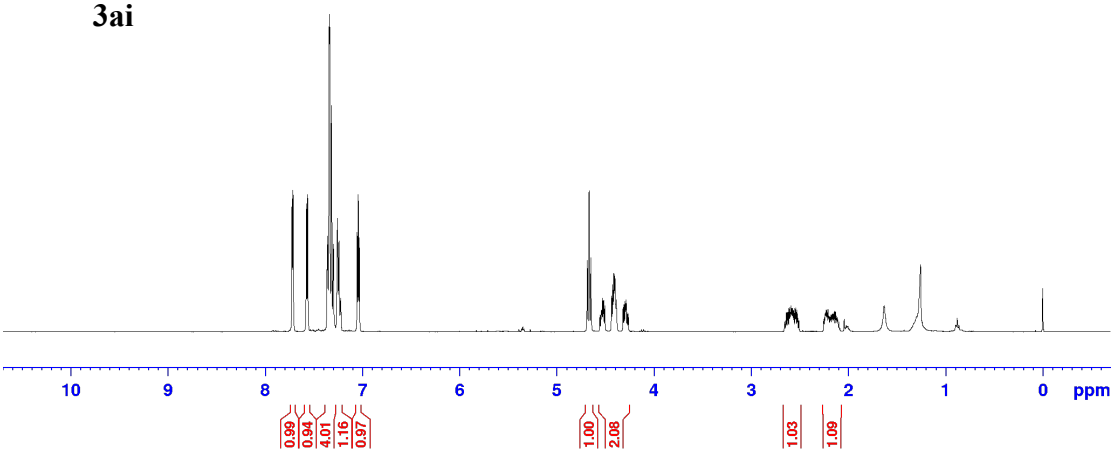
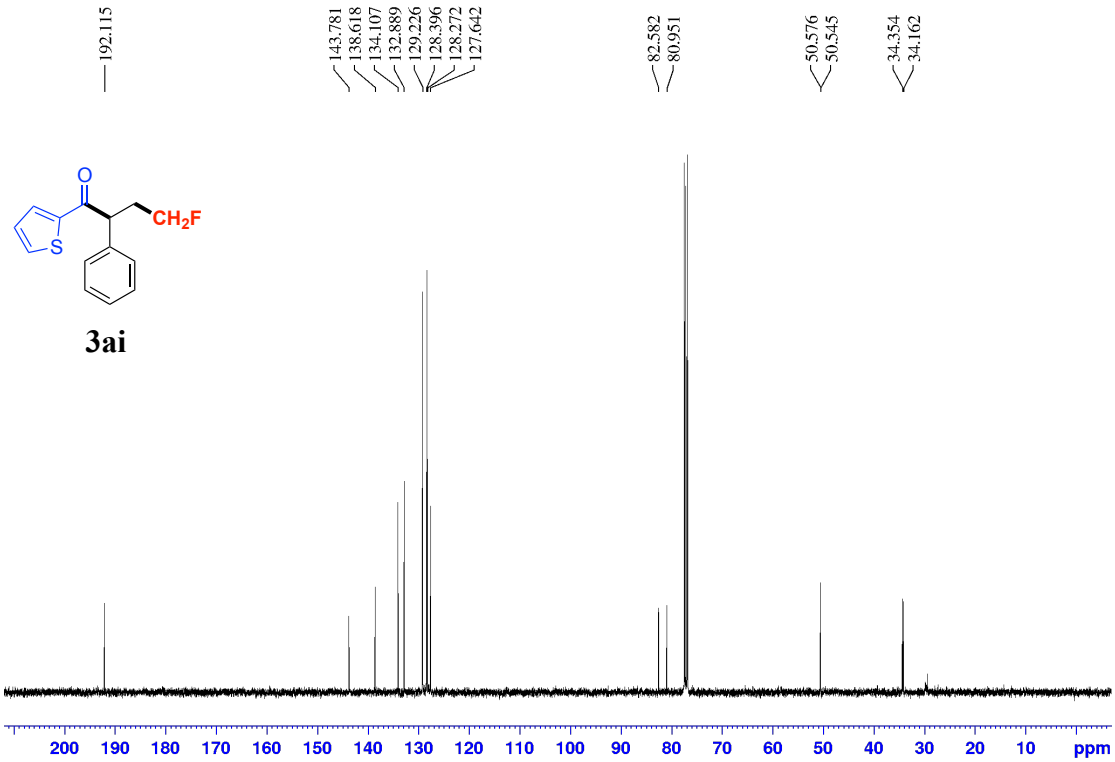
2.228
2.218
2.208
2.169
2.149
2.133

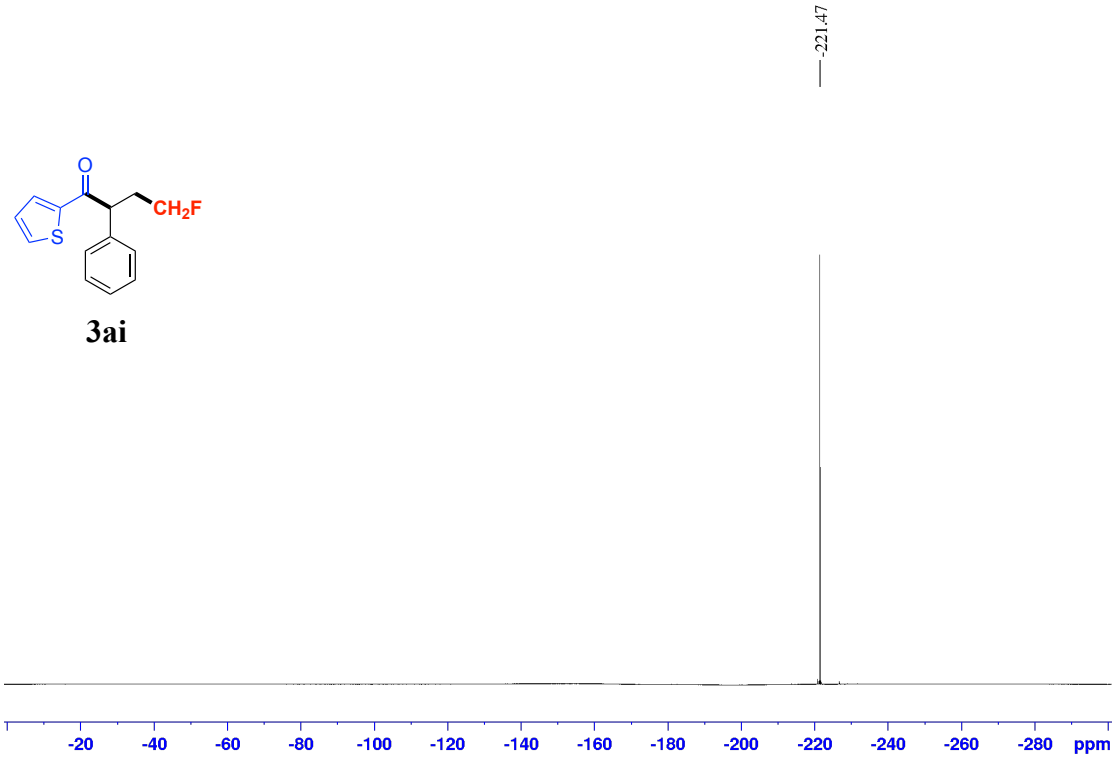


3ai

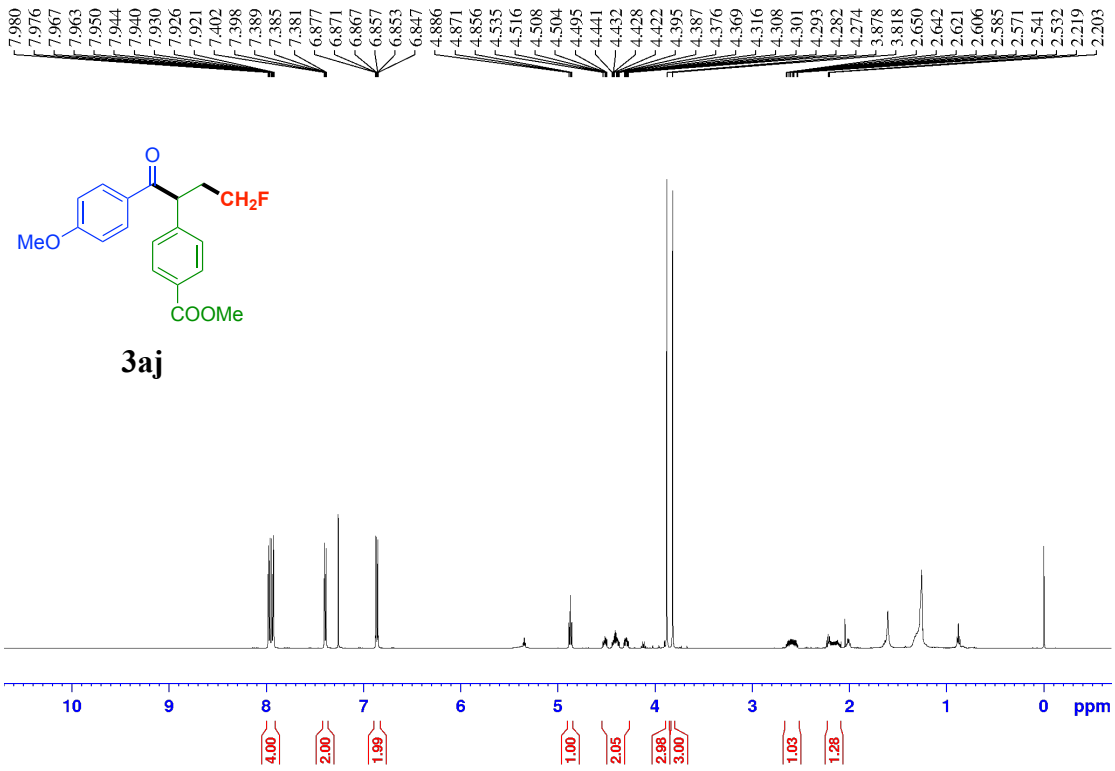

10
9
8
7
6
5
4
3
2
1
0
ppm
0.99
0.94
4.01
1.16
0.97
1.00
2.08
1.03
1.09

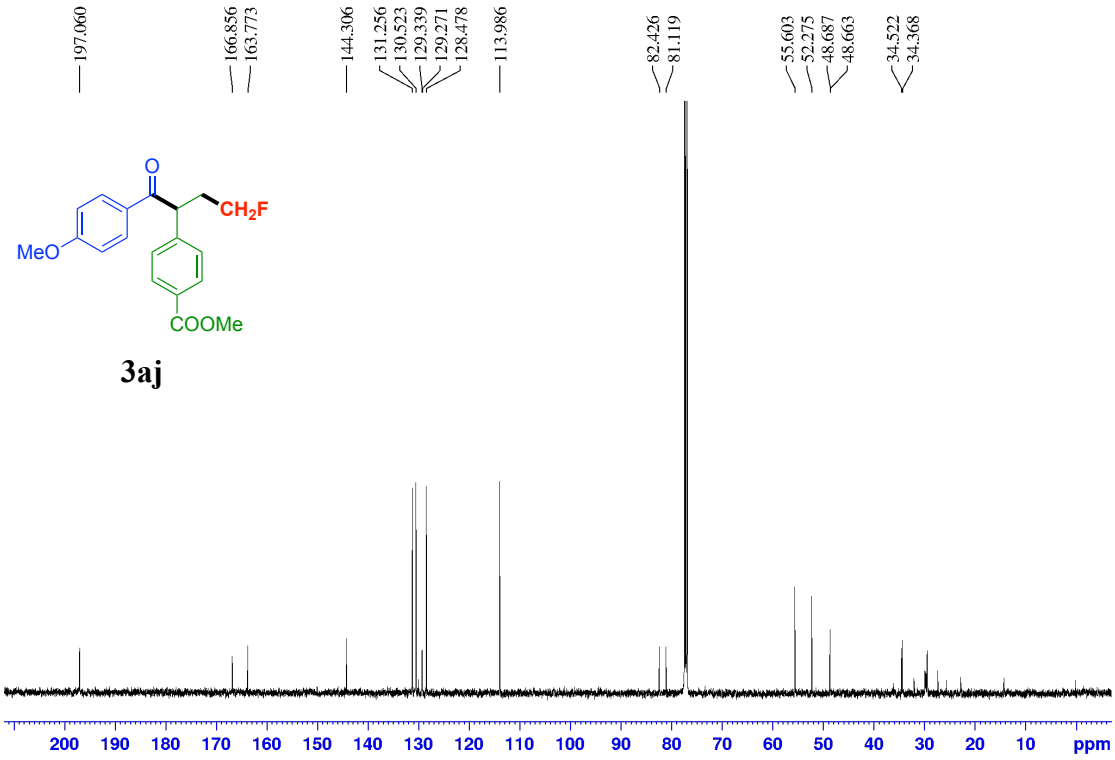

192.115
143.781
138.618
134.107
132.889
129.226
128.396
128.272
127.642
82.582
80.951
50.576
50.545
34.354
34.162
O
CH2F
S
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3ai


-221.47
O
CH2F
S
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3ai


7.980
7.976
7.967
7.963
7.950
7.944
7.940
7.930
7.926
7.921
7.402
7.398
7.389
7.385
7.381
6.877
6.871
6.867
6.857
6.853
6.847
4.886
4.871
4.856
4.535
4.516
4.508
4.504
4.495
4.441
4.432
4.428
4.422
4.395
4.387
4.376
4.369
4.316
4.308
4.301
4.293
4.282
4.274
3.878
3.818
2.650
2.642
2.621
2.606
2.585
2.571
2.541
2.532
2.219
2.203
O
CH2F
MeO
COOMe
3aj
10
9
8
7
6
5
4
3
2
1
0
ppm
4.00
2.00
1.99
1.00
2.05
2.98
3.00
1.03
1.28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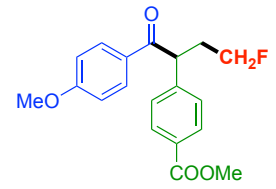
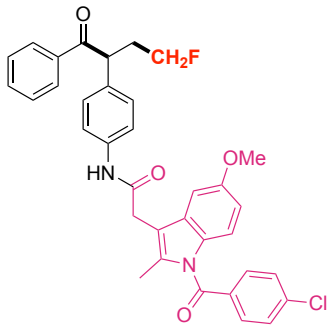
166.856
163.773
144.306
131.256
130.523
129.339
129.271
128.478
113.986
82.426
81.119
55.603
52.275
48.687
48.663
34.522
34.368
O
CH2F
MeO
COOMe
3aj
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F
MeO
COOMe

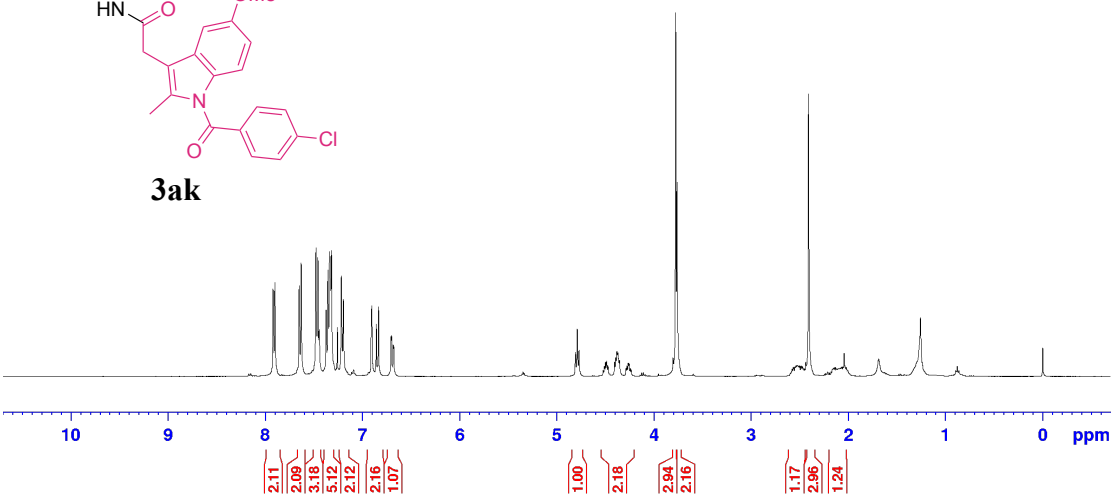
3aj

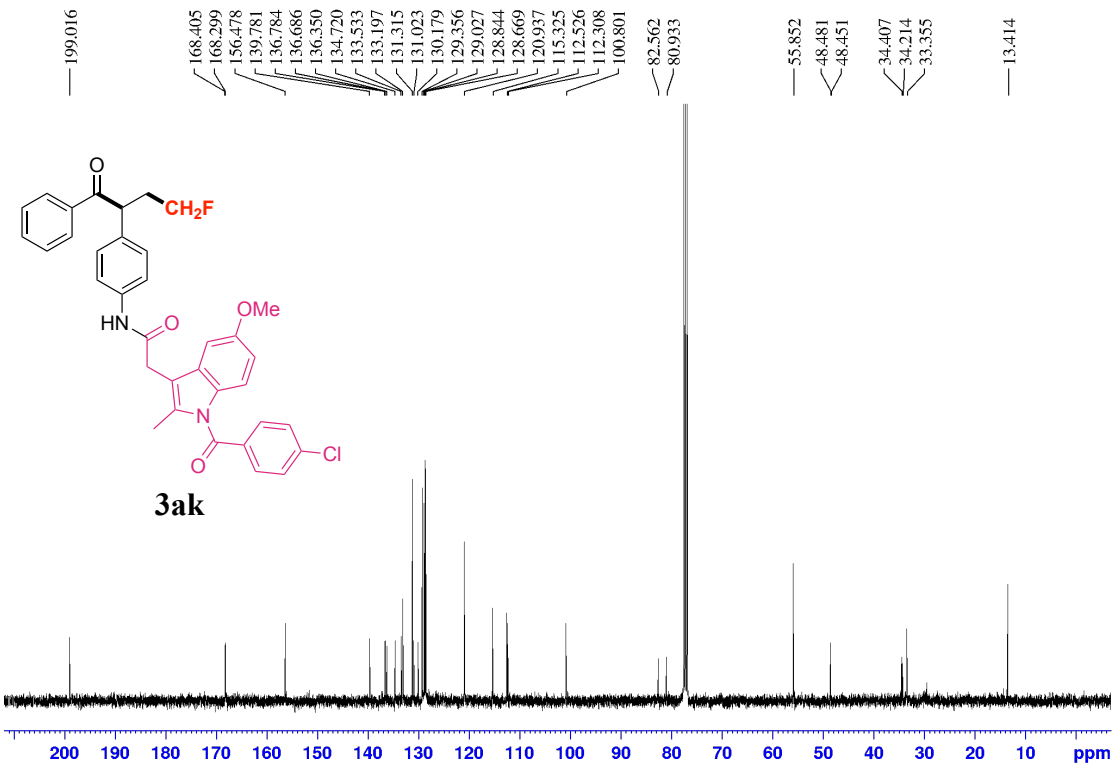
-221.30
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.920
7.900
7.651
7.631
7.479
7.458
7.446
7.374
7.355
7.338
7.320
7.217
7.197
6.908
6.903
6.858
6.835
6.706
6.701
6.683
6.679
4.807
4.789
4.771
4.509
4.498
4.486
4.473
4.404
4.394
4.381
4.372
4.354
4.286
4.277
4.265
4.256
4.244
3.776
3.762
2.577
2.559
2.539
2.508
2.499
2.480
2.469
2.450
2.408
2.141
2.130
2.064
2.054
2.042
2.019

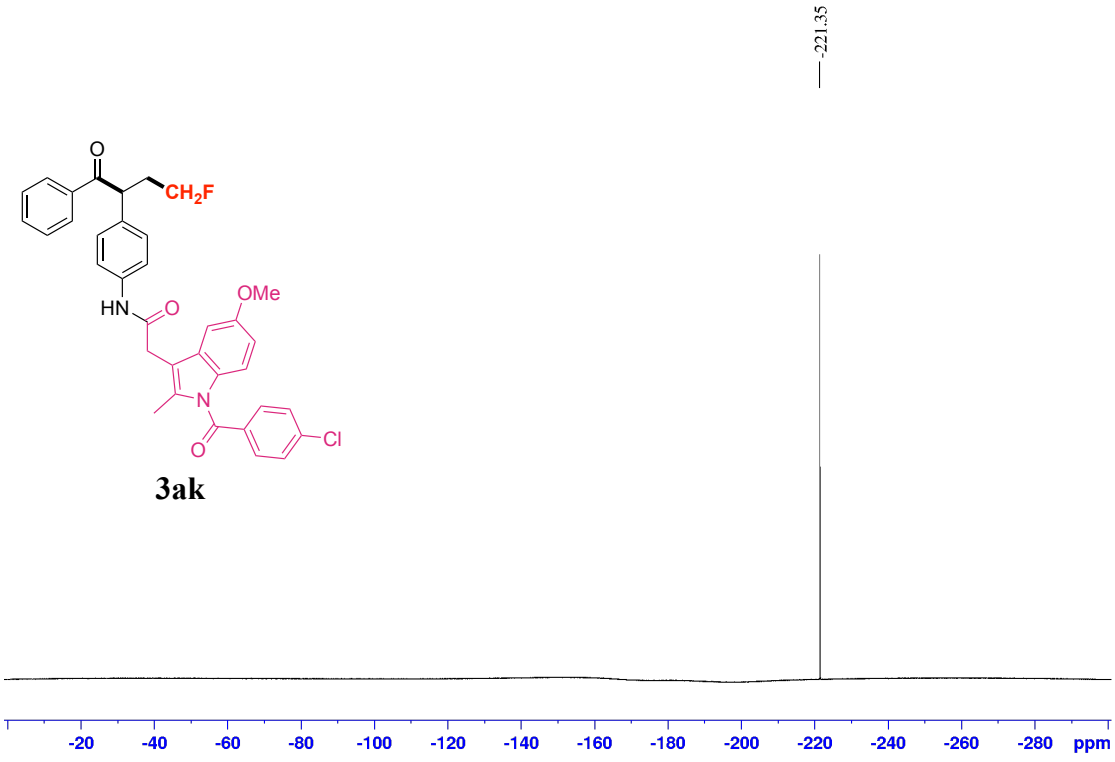

O
CH2F
HN
O
OMe
N
O
Cl

3ak

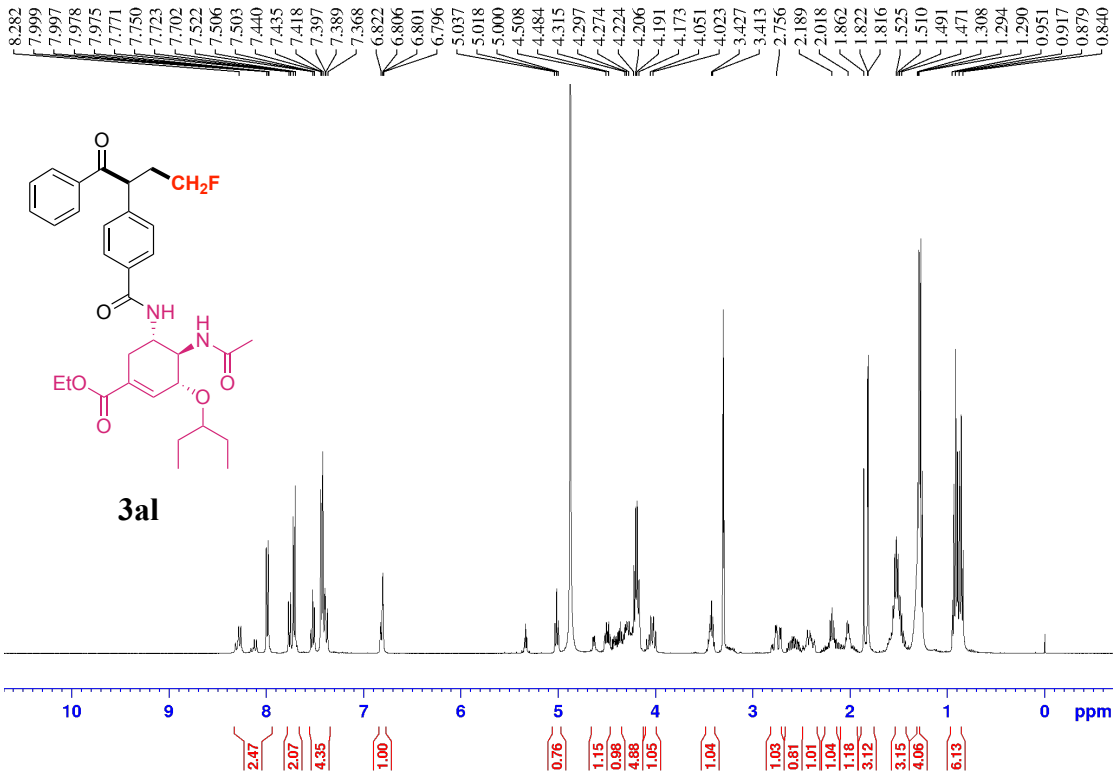

10
9
8
7
6
5
4
3
2
1
0
ppm
2.11
2.09
3.18
5.12
2.12
2.16
1.07
1.00
2.18
2.94
2.16
1.17
2.96
1.24

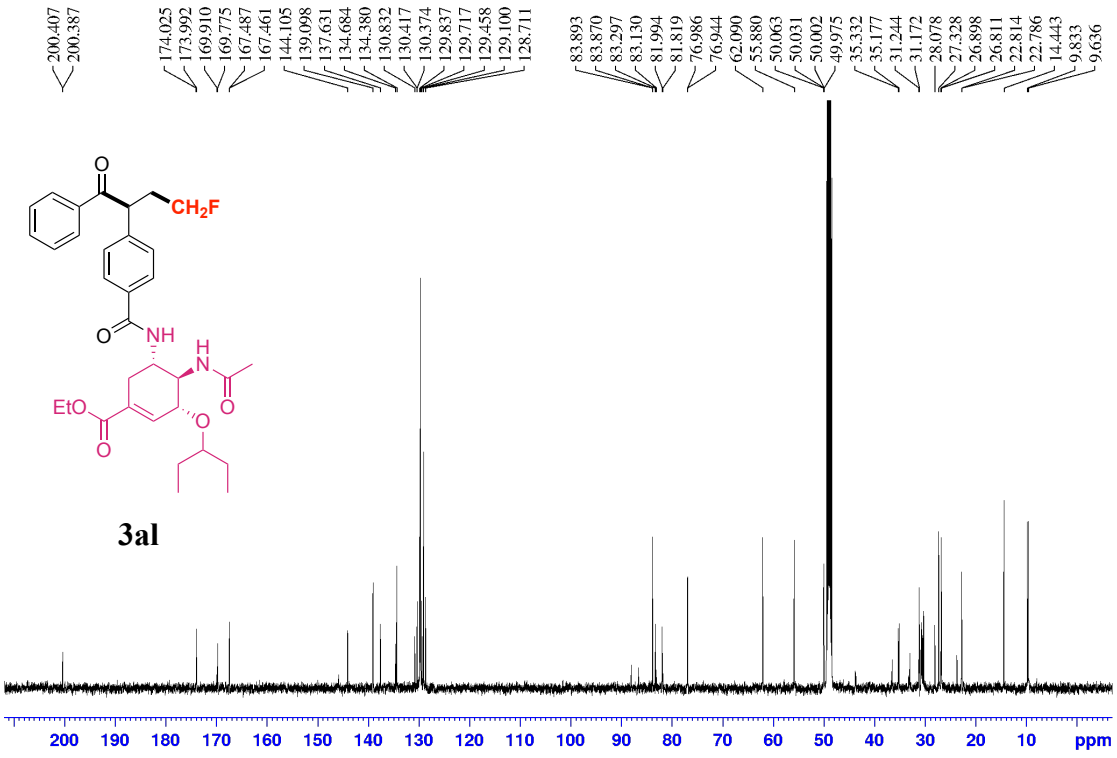

199.016
168.405
168.299
156.478
139.781
136.784
136.686
136.350
134.720
133.533
133.197
131.315
131.023
130.179
129.356
129.027
128.844
128.669
120.937
115.325
112.526
112.308
100.801
82.562
80.933
55.852
48.481
48.451
34.407
34.214
33.355
13.414
O
CH2F
HN
O
OMe
N
O
Cl
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

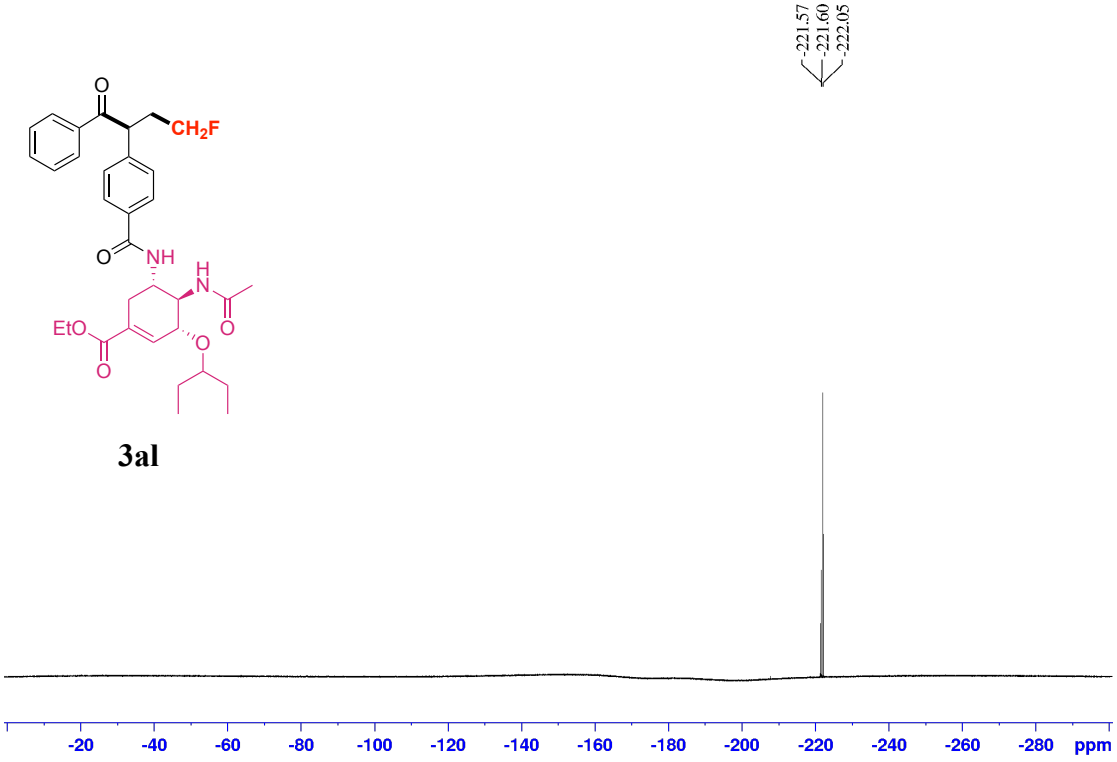
3ak


-221.35
O
CH2F
HN
O
OMe
N
O
Cl
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

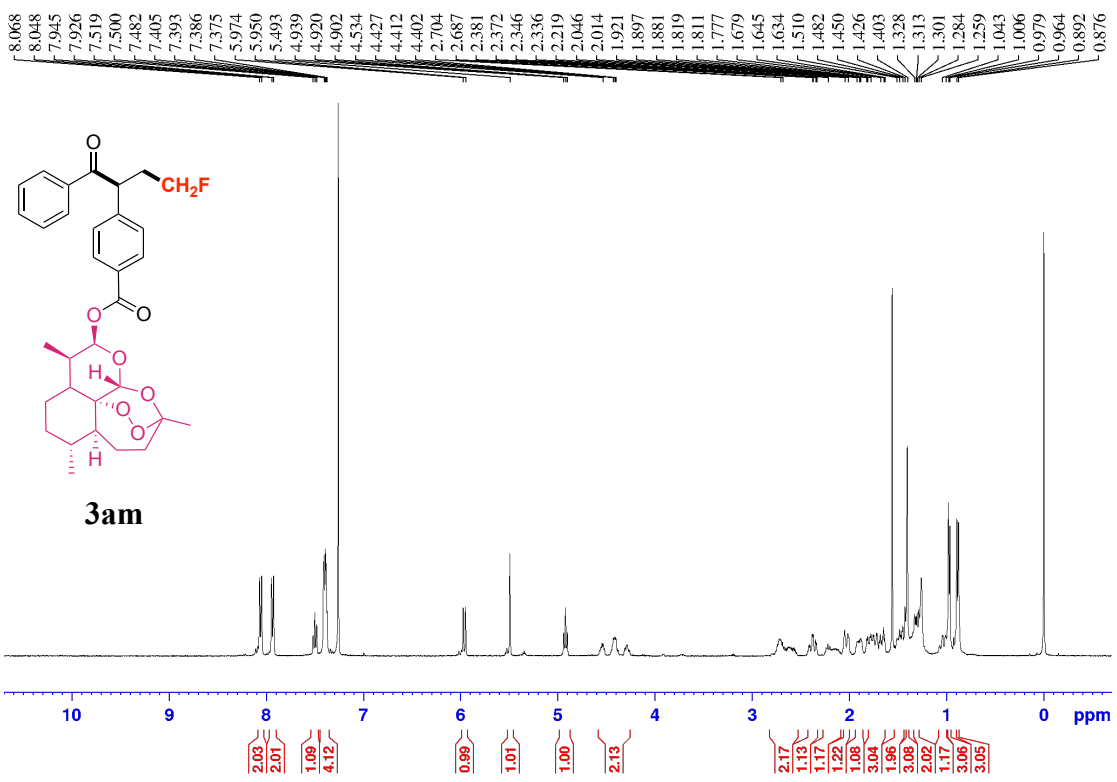
3ak


8.282
7.999
7.997
7.978
7.975
7.771
7.750
7.723
7.702
7.522
7.506
7.503
7.440
7.435
7.418
7.397
7.389
7.368
6.822
6.806
6.801
6.796
5.037
5.018
5.000
4.508
4.484
4.315
4.297
4.274
4.224
4.206
4.191
4.173
4.051
4.023
3.427
3.413
2.756
2.189
2.018
1.862
1.822
1.816
1.525
1.510
1.491
1.471
1.308
1.294
1.290
0.951
0.917
0.879
0.840
CH2F
NH
H
N
EtO
O
3al
10
9
8
7
6
5
4
3
2
1
0
ppm
2.47
2.07
4.35
1.00
0.76
1.15
0.98
4.88
1.05
1.04
1.03
0.81
1.01
1.04
1.18
3.12
3.15
4.06
6.13


200.407
200.387
174.025
173.992
169.910
169.775
167.487
167.461
144.105
139.098
137.631
134.684
134.380
130.832
130.417
130.374
129.837
129.717
129.458
129.100
128.711
83.893
83.870
83.297
83.130
81.994
81.819
76.986
76.944
62.090
55.880
50.063
50.031
50.002
49.975
35.332
35.177
31.244
31.172
28.078
27.328
26.898
26.811
22.814
22.786
14.443
9.833
9.636
CH2F
NH
H
N
EtO
O
3al
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


-221.57
-221.60
-222.05
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm

3al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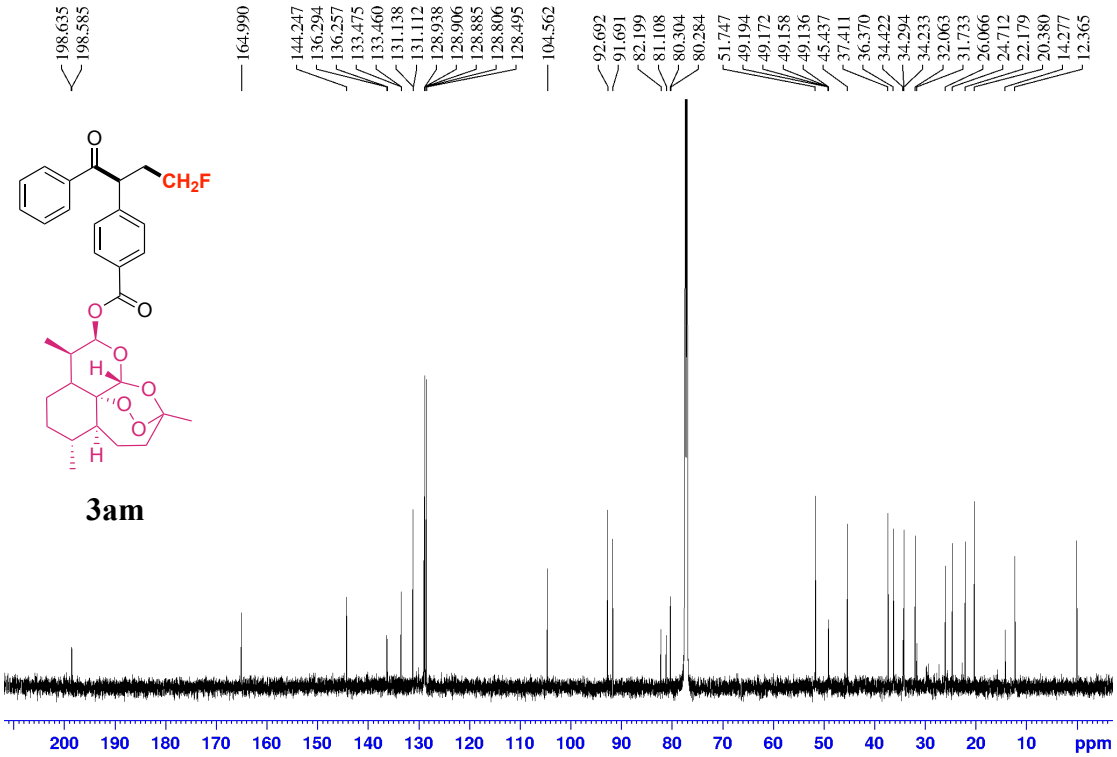
8.048
7.945
7.926
7.519
7.500
7.482
7.405
7.393
7.386
7.375
5.974
5.950
5.493
4.939
4.920
4.902
4.534
4.427
4.412
4.402
2.704
2.687
2.381
2.372
2.346
2.336
2.219
2.046
2.014
1.921
1.897
1.881
1.819
1.811
1.777
1.679
1.645
1.634
1.510
1.482
1.450
1.426
1.403
1.328
1.313
1.301
1.284
1.259
1.043
1.006
0.979
0.964
0.892
0.876
10
9
8
7
6
5
4
3
2
1
0
ppm
2.03
2.01
1.09
4.12
0.99
1.01
1.00
2.13
2.17
1.13
1.17
1.22
1.08
3.04
1.96
3.08
2.02
1.17
3.06
3.05

3am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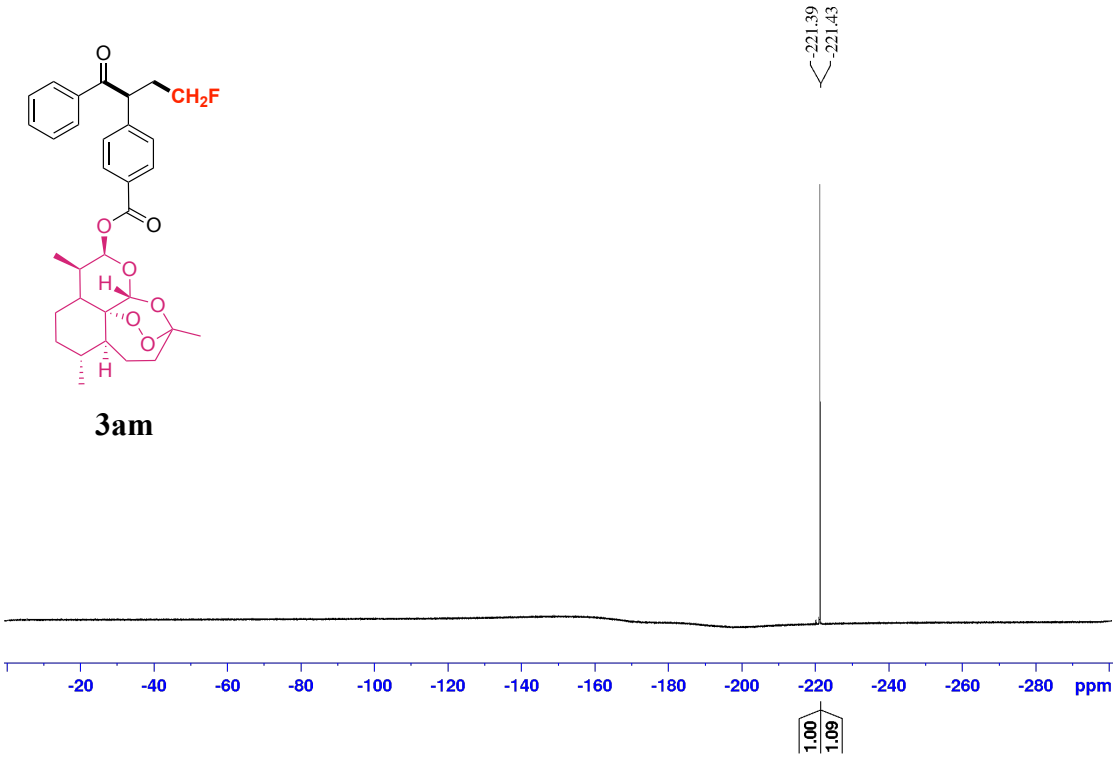
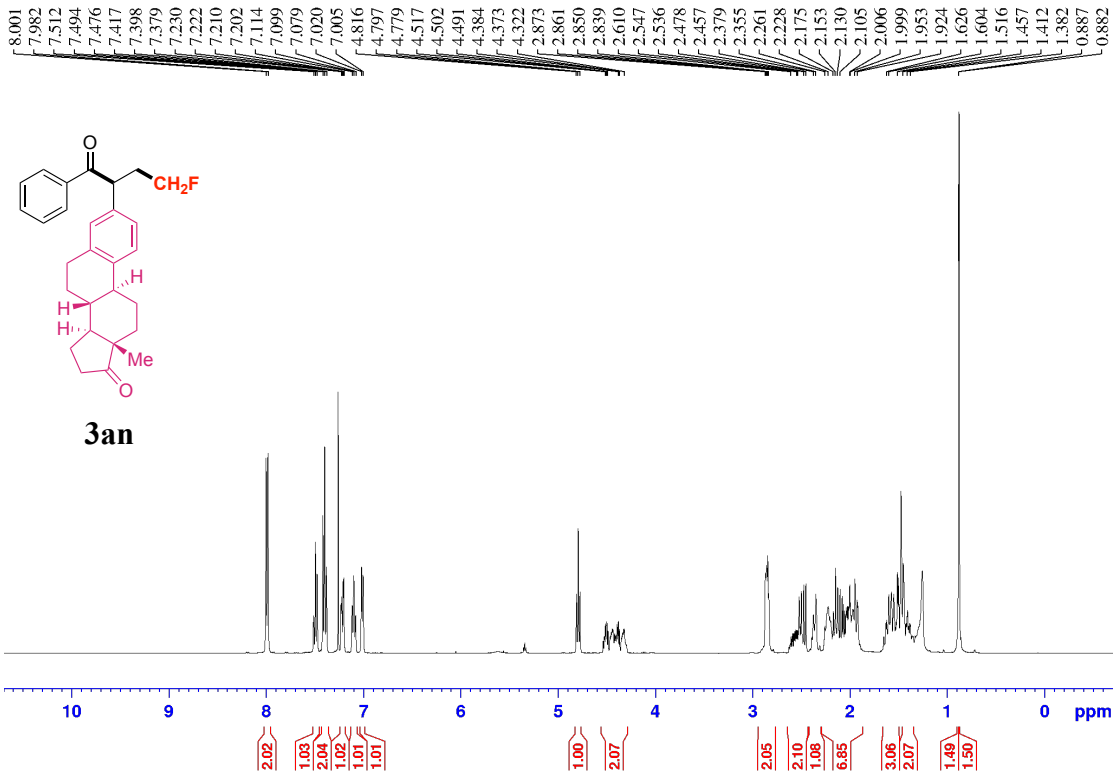
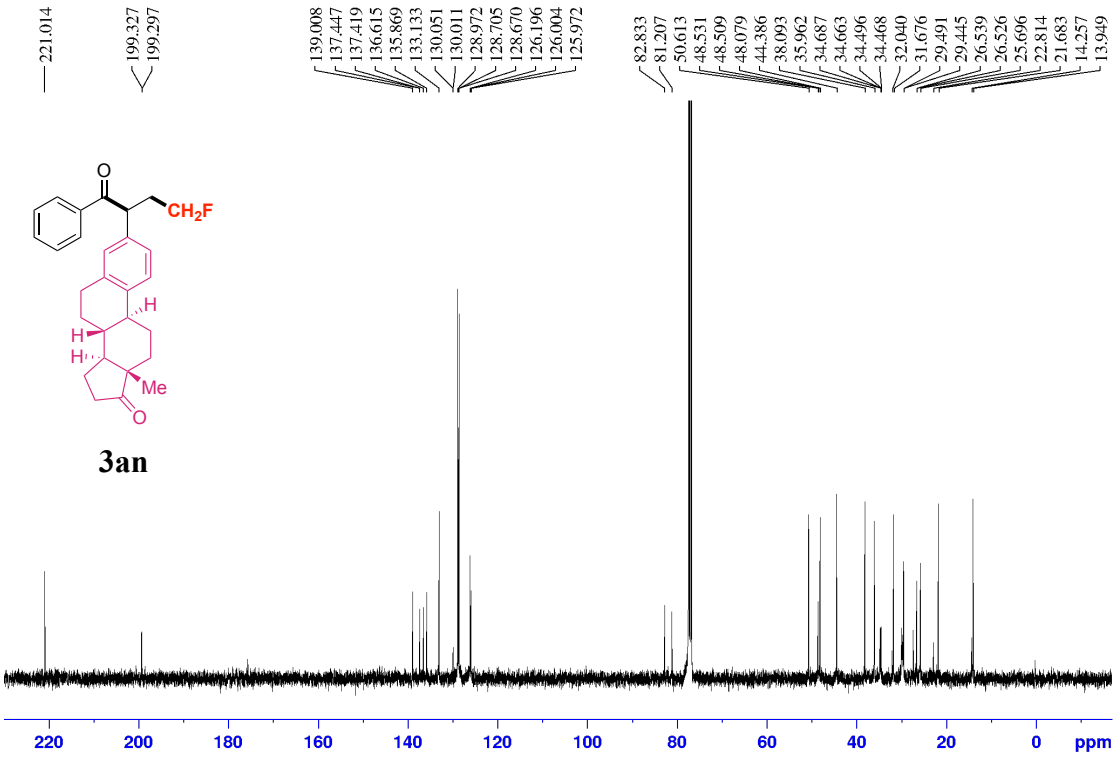
198.585
164.990
144.247
136.294
136.257
133.475
133.460
131.138
131.112
128.938
128.906
128.885
128.806
128.495
104.562
92.692
91.691
82.199
81.108
80.304
80.284
51.747
49.194
49.172
49.158
49.136
45.437
37.411
36.370
34.422
34.294
34.233
32.063
31.733
26.066
24.712
22.179
20.380
14.277
12.365
CH2F
O
O
O
H
O
O
O
O
H
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

3am


-221.39
-221.43
CH2F
O
O
O
H
O
O
O
O
H
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm
1.00
1.09

3am


8.001
7.982
7.512
7.494
7.476
7.417
7.398
7.379
7.230
7.222
7.210
7.202
7.114
7.099
7.079
7.020
7.005
4.816
4.797
4.779
4.517
4.502
4.491
4.384
4.373
4.322
2.873
2.861
2.850
2.839
2.610
2.547
2.536
2.478
2.457
2.379
2.355
2.261
2.228
2.175
2.153
2.130
2.105
2.006
1.999
1.953
1.924
1.626
1.604
1.516
1.457
1.412
1.382
0.887
0.882
O
CH2F
H
H
H
Me
O
3an
10
9
8
7
6
5
4
3
2
1
0
ppm
2.02
1.03
2.04
1.02
1.01
1.01
1.00
2.07
2.05
2.10
1.08
6.85
3.06
2.07
1.49
1.50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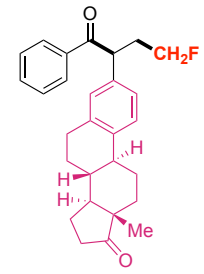
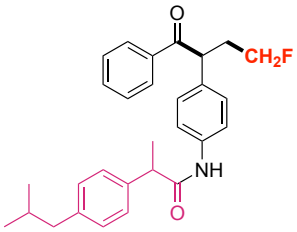
199.327
199.297
139.008
137.447
137.419
136.615
135.869
133.133
130.051
130.011
128.972
128.705
128.670
126.196
126.004
125.972
82.833
81.207
50.613
48.531
48.509
48.079
44.386
38.093
35.962
34.687
34.663
34.496
34.468
32.040
31.676
29.491
29.445
26.539
26.526
25.696
22.814
21.683
14.257
13.949
O
CH2F
H
H
H
Me
O
3an
220
200
180
160
140
120
100
80
60
40
20
0
ppm


O
CH2F
H
H
H
Me
O

3an

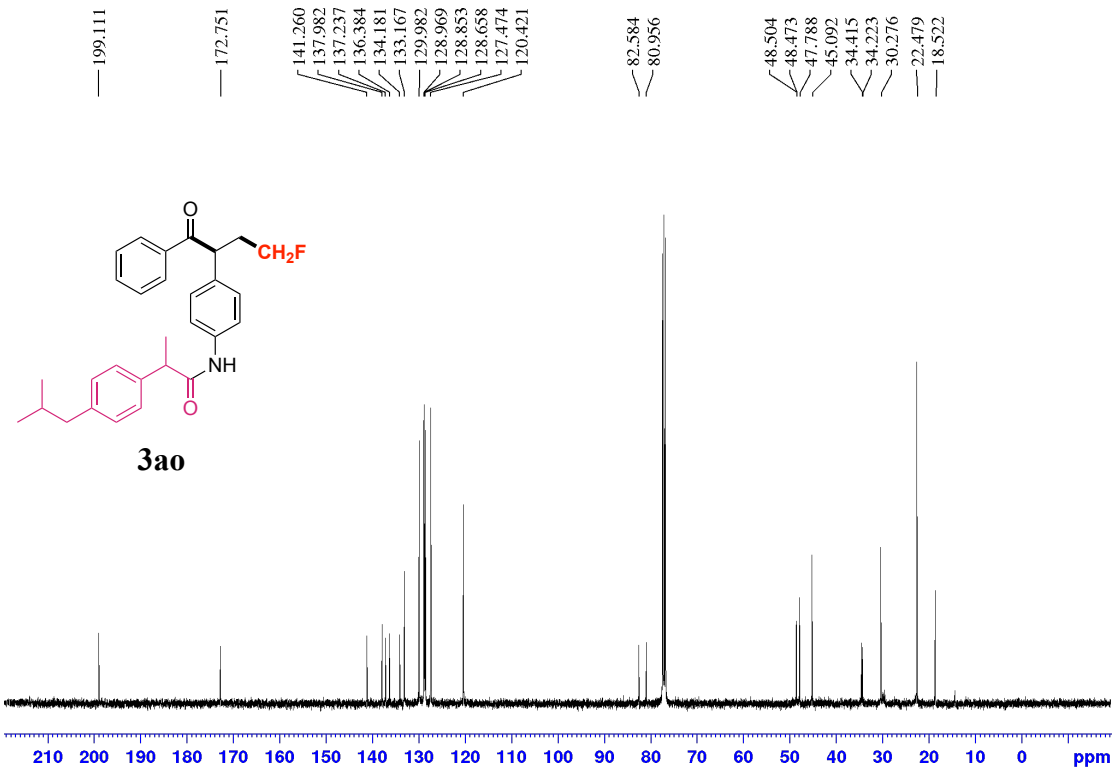
-221.22
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


7.928
7.909
7.481
7.463
7.445
7.372
7.356
7.352
7.338
7.228
7.211
7.190
7.134
7.114
7.107
4.805
4.787
4.769
4.513
4.502
4.489
4.477
4.410
4.392
4.383
4.370
4.359
4.294
4.284
4.273
4.263
4.251
3.684
3.666
3.648
3.631
2.562
2.532
2.511
2.484
2.461
2.443
2.153
2.137
2.070
2.059
1.878
1.861
1.844
1.827
1.811
1.559
1.541
0.902
0.885

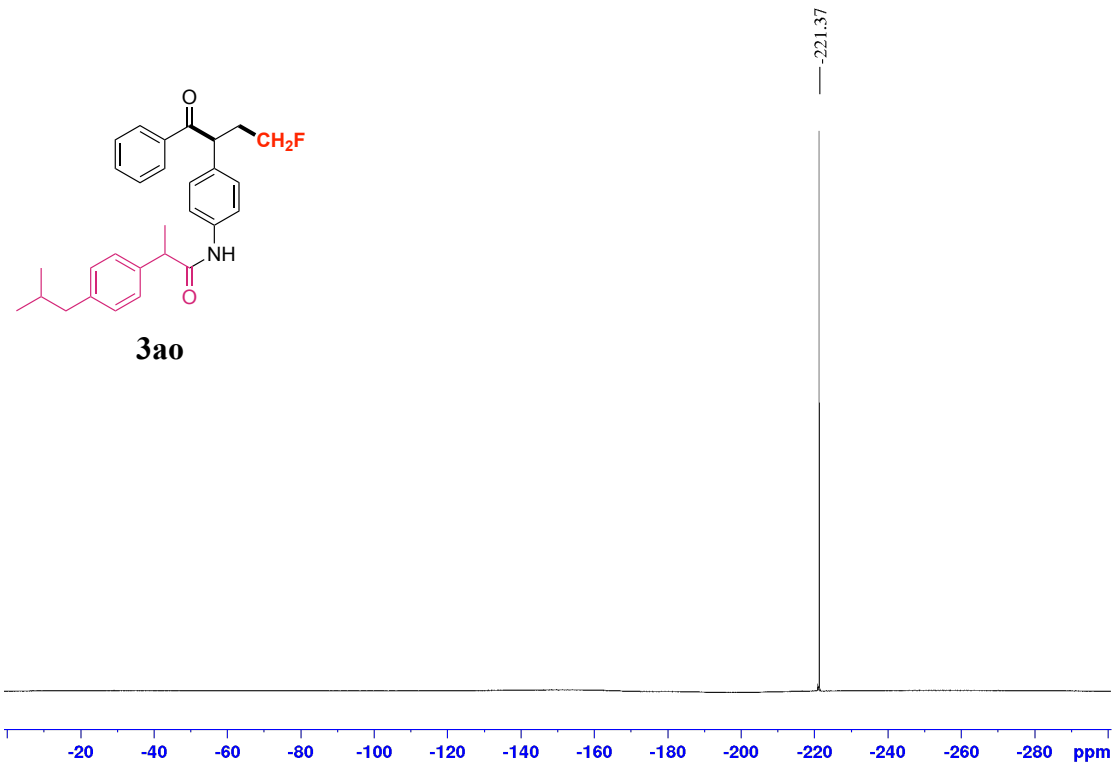

O
CH2F
NH
O

3ao

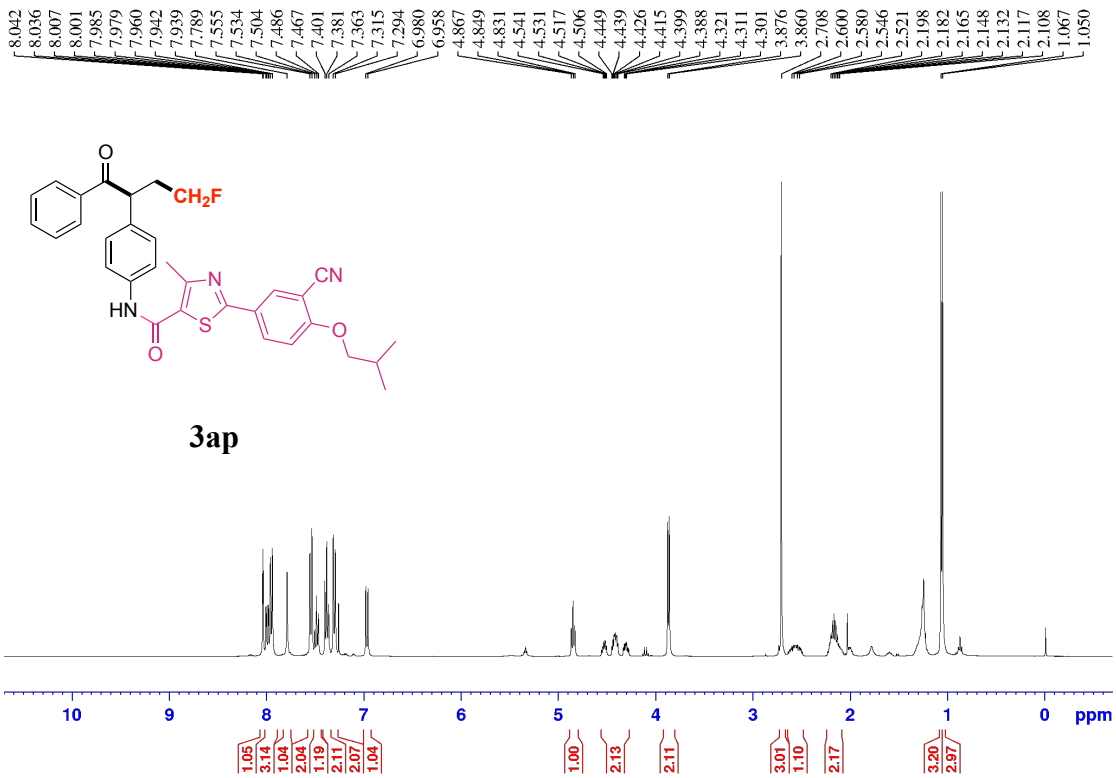
10
9
8
7
6
5
4
3
2
1
0
ppm
2.04
1.05
4.02
4.08
2.08
0.96
1.00
2.07
1.03
0.99
2.05
1.04
1.11
3.01
3.07
2.98

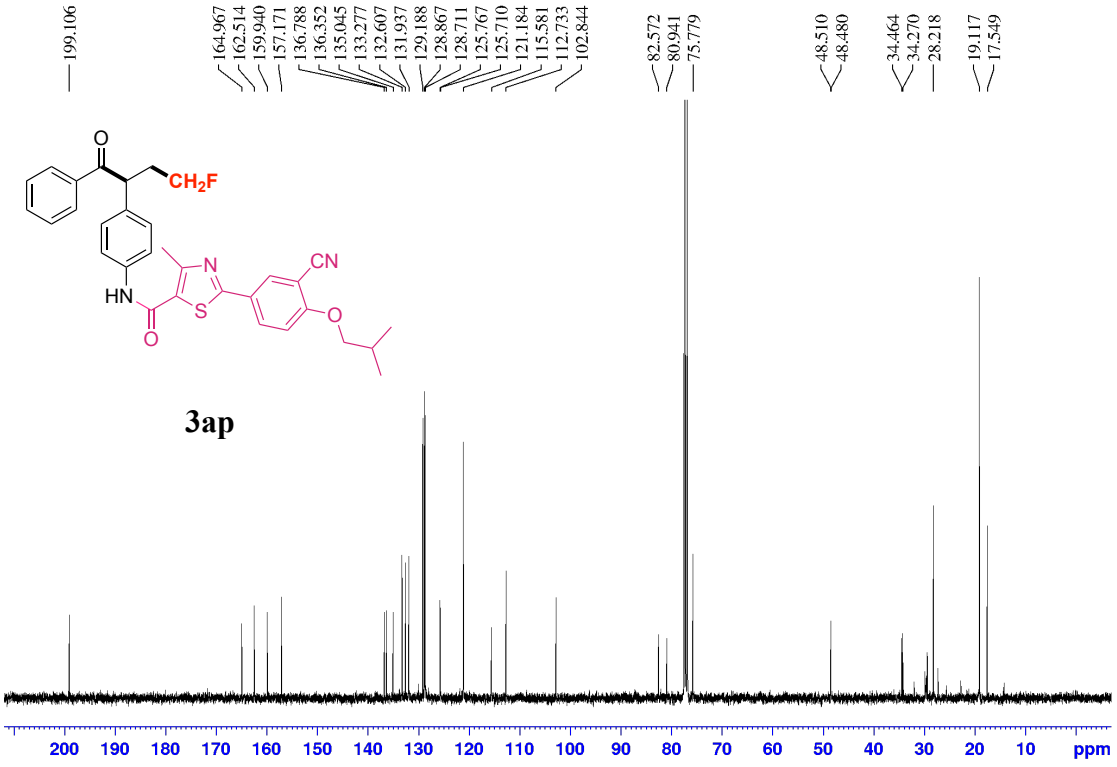

199.111
172.751
141.260
137.982
137.237
136.384
134.181
133.167
129.982
128.969
128.853
128.658
127.474
120.421
82.584
80.956
48.504
48.473
47.788
45.092
34.415
34.223
30.276
22.479
18.522
O
CH2F
NH
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

3ao


-221.37
O
CH2F
NH
O
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

3ao


8.042
8.036
8.007
8.001
7.985
7.979
7.960
7.942
7.939
7.789
7.555
7.534
7.504
7.486
7.467
7.401
7.381
7.363
7.315
7.294
6.980
6.958
4.867
4.849
4.831
4.541
4.531
4.517
4.506
4.449
4.439
4.426
4.415
4.399
4.388
4.321
4.311
4.301
3.876
3.860
2.708
2.600
2.580
2.546
2.521
2.198
2.182
2.165
2.148
2.132
2.117
2.108
1.067
1.050
O
CH2F
HN
O
N
S
CN
O
3ap
10
9
8
7
6
5
4
3
2
1
0
ppm
1.05
3.14
1.04
2.04
1.19
2.11
2.07
1.04
1.00
2.13
2.11
3.01
1.10
2.17
3.20
2.97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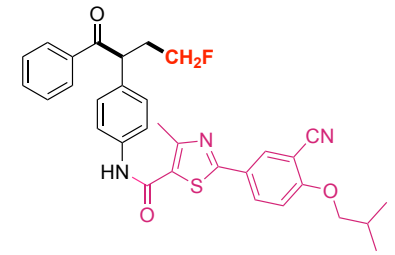
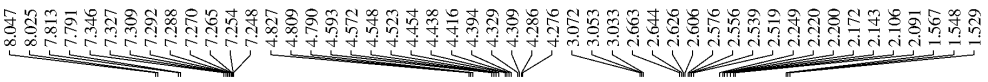
164.967
162.514
159.940
157.171
136.788
136.352
135.045
133.277
132.607
131.937
129.188
128.867
128.711
125.767
125.710
121.184
115.581
112.733
102.844
82.572
80.941
75.779
48.510
48.480
34.464
34.270
28.218
19.117
17.549
O
CH2F
HN
O
N
S
CN
O
3ap
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O
CH2F
HN
O
N
S
CN
O

3ap

-221.24
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


8.047
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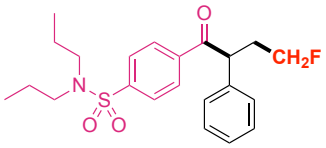
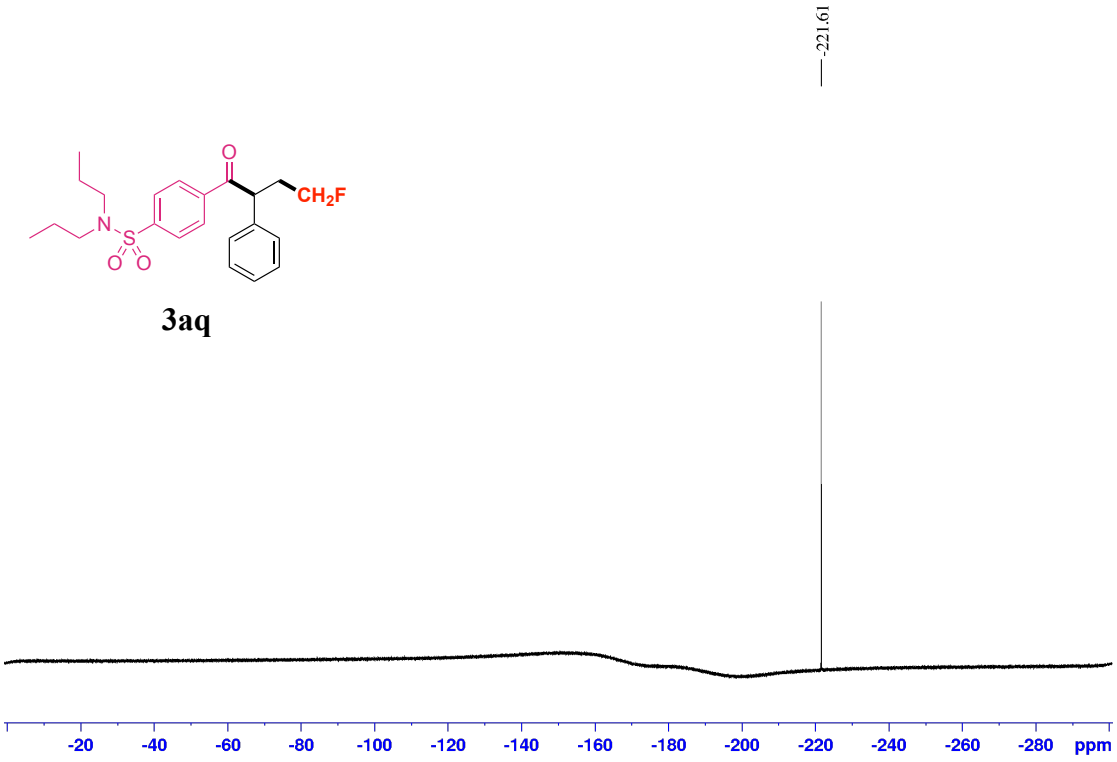
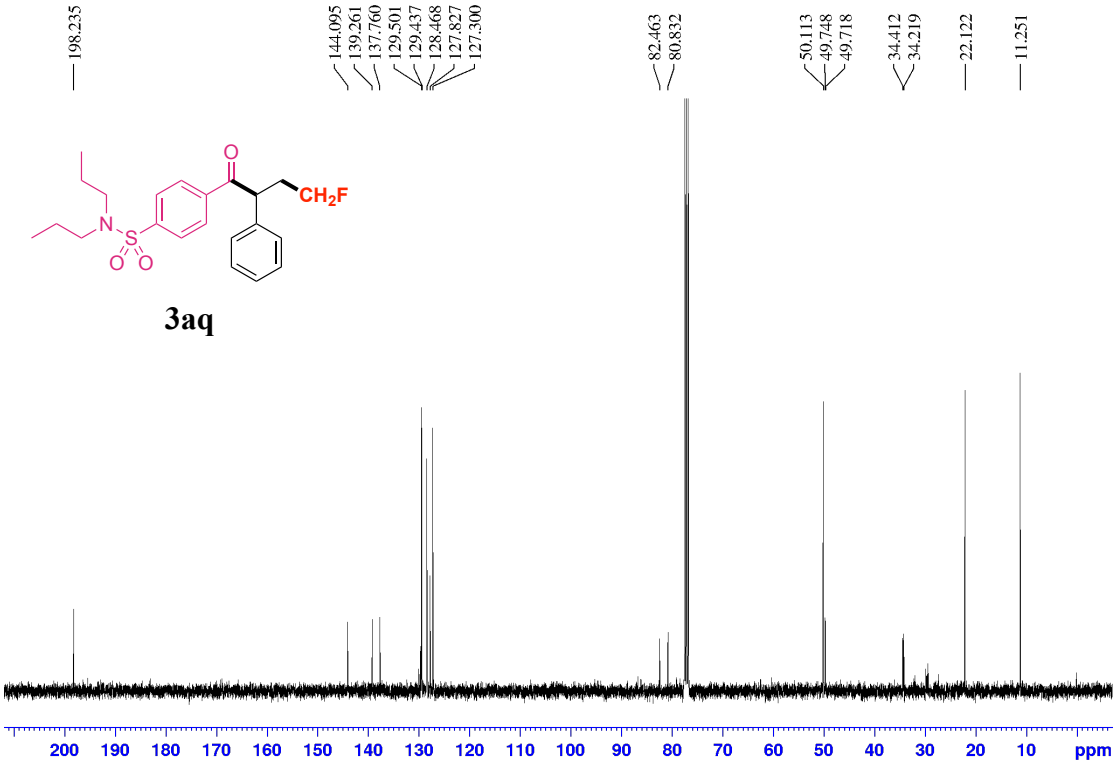
7.813
7.791
7.346
7.327
7.309
7.292
7.288
7.270
7.265
7.254
7.248
4.827
4.809
4.790
4.593
4.572
4.548
4.523
4.454
4.438
4.416
4.394
4.329
4.309
4.286
4.276
3.072
3.053
3.033
2.663
2.644
2.626
2.606
2.576
2.556
2.539
2.519
2.249
2.220
2.200
2.172
2.143
2.106
2.091
1.567
1.548
1.529

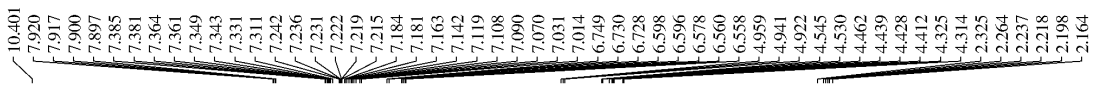

O
CH2F
N
S
O
O

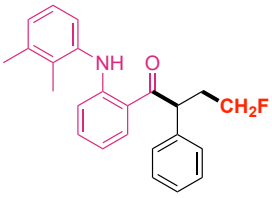
3aq

10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
1.97
5.25
1.00
2.30
4.06
1.00
1.15
4.09
6.05


-221.61
CH2F
3aq
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm

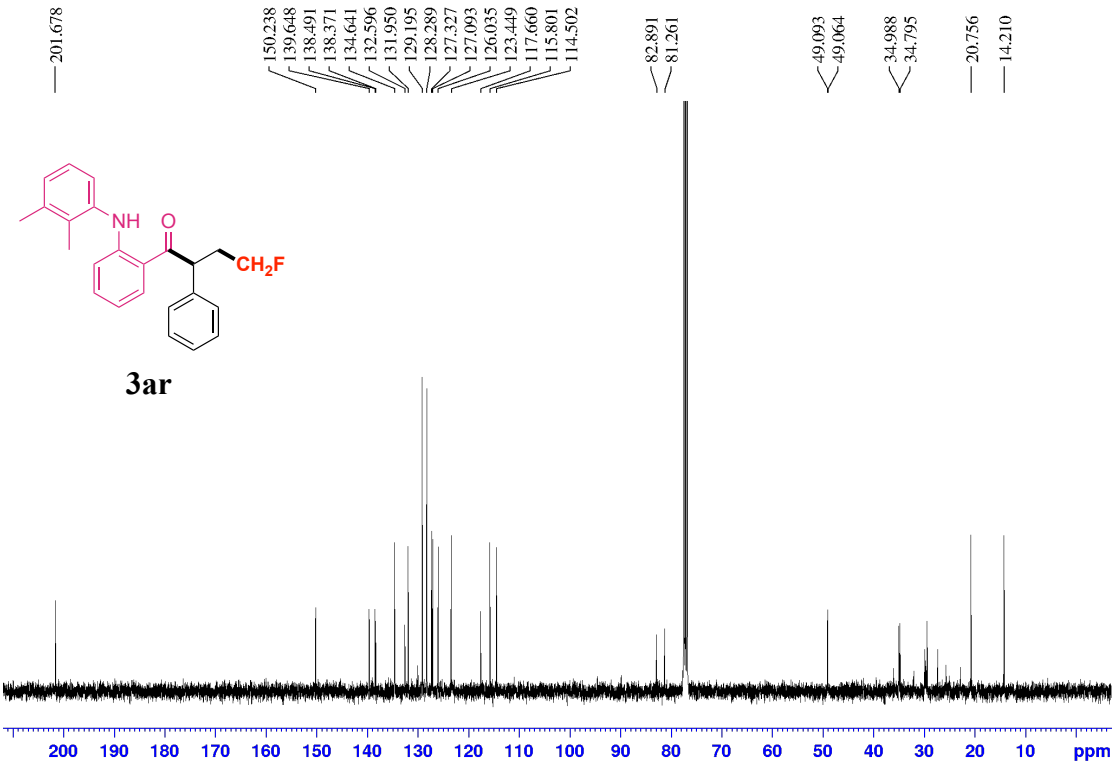

198.235
144.095
139.261
137.760
129.501
129.437
128.468
127.827
127.300
82.463
80.832
50.113
49.748
49.718
34.412
34.219
22.122
11.251
CH2F
3aq
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


10.401
7.920
7.917
7.900
7.897
7.385
7.381
7.364
7.361
7.349
7.343
7.331
7.311
7.242
7.236
7.231
7.222
7.219
7.215
7.184
7.181
7.163
7.142
7.119
7.108
7.090
7.070
7.031
7.014
6.749
6.730
6.728
6.598
6.596
6.578
6.560
6.558
4.959
4.941
4.922
4.545
4.530
4.462
4.439
4.428
4.412
4.325
4.314
2.325
2.264
2.237
2.218
2.198
2.164


NH
O
CH2F

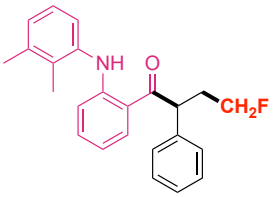
3ar

10
9
8
7
6
5
4
3
2
1
0
ppm
0.99
1.02
4.13
0.92
3.16
0.97
1.02
1.01
1.00
2.07
1.14
3.16
1.07
2.97


201.678
150.238
139.648
138.491
138.371
134.641
132.596
131.950
129.195
128.289
127.327
127.093
126.035
123.449
117.660
115.801
114.502
82.891
81.261
49.093
49.064
34.988
34.795
20.756
14.210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

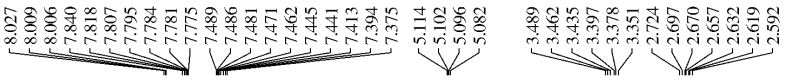
NH
O
CH2F

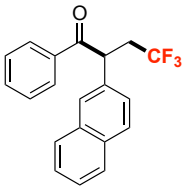
3ar


NH
O
CH2F

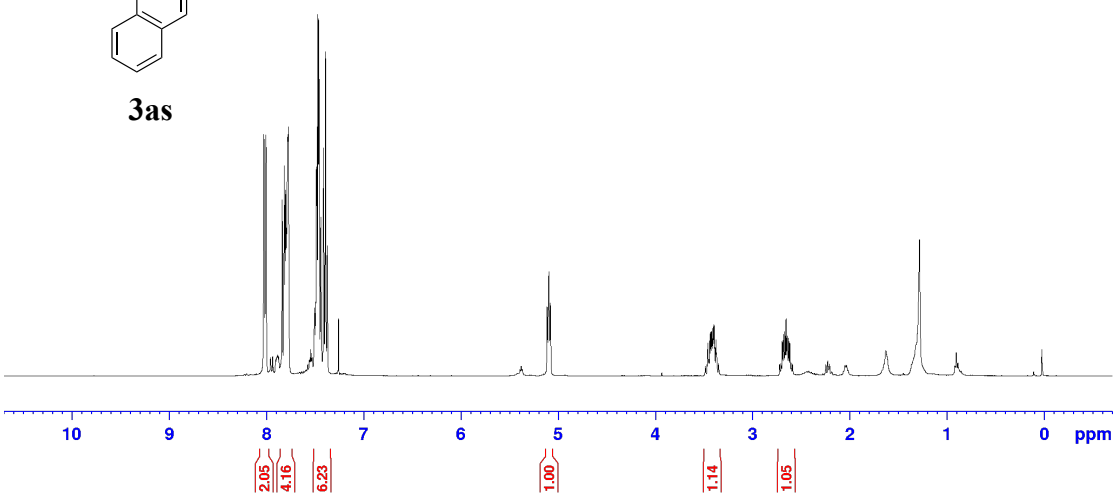
3ar

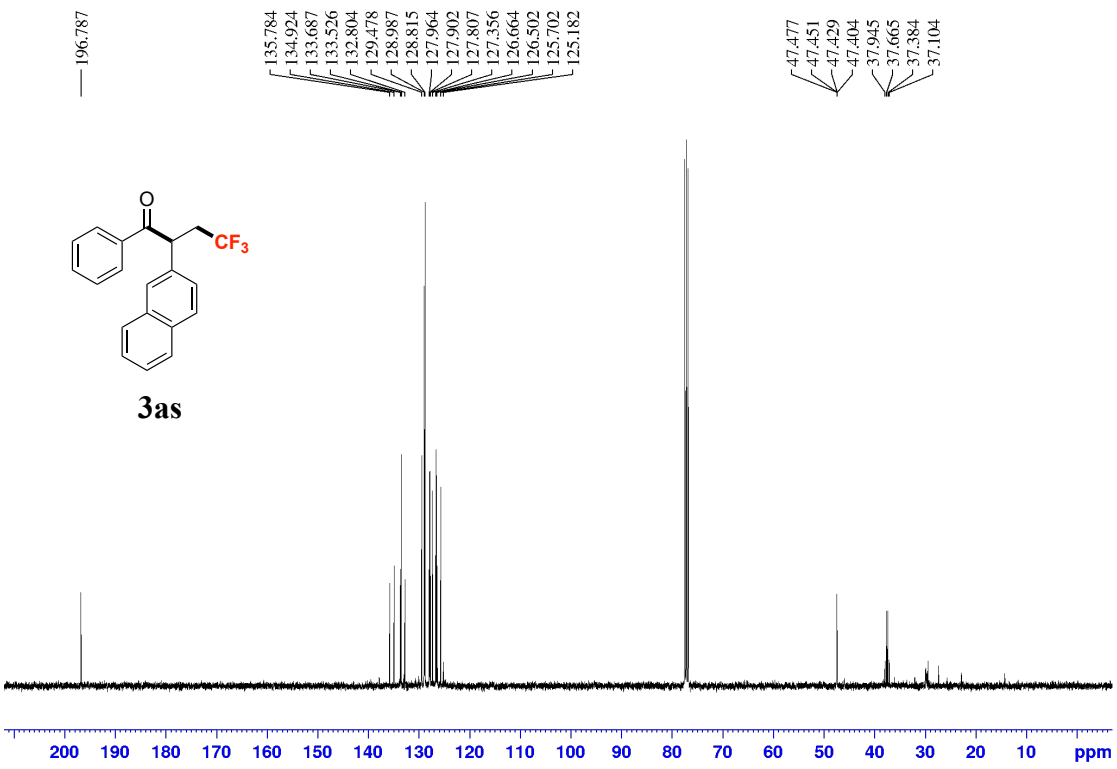
-221.02
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm


8.027
8.009
8.006
7.840
7.818
7.807
7.795
7.784
7.781
7.775
7.489
7.486
7.481
7.471
7.462
7.445
7.441
7.413
7.394
7.375
5.114
5.102
5.096
5.082
3.489
3.462
3.435
3.397
3.378
3.351
2.724
2.697
2.670
2.657
2.632
2.619
2.592

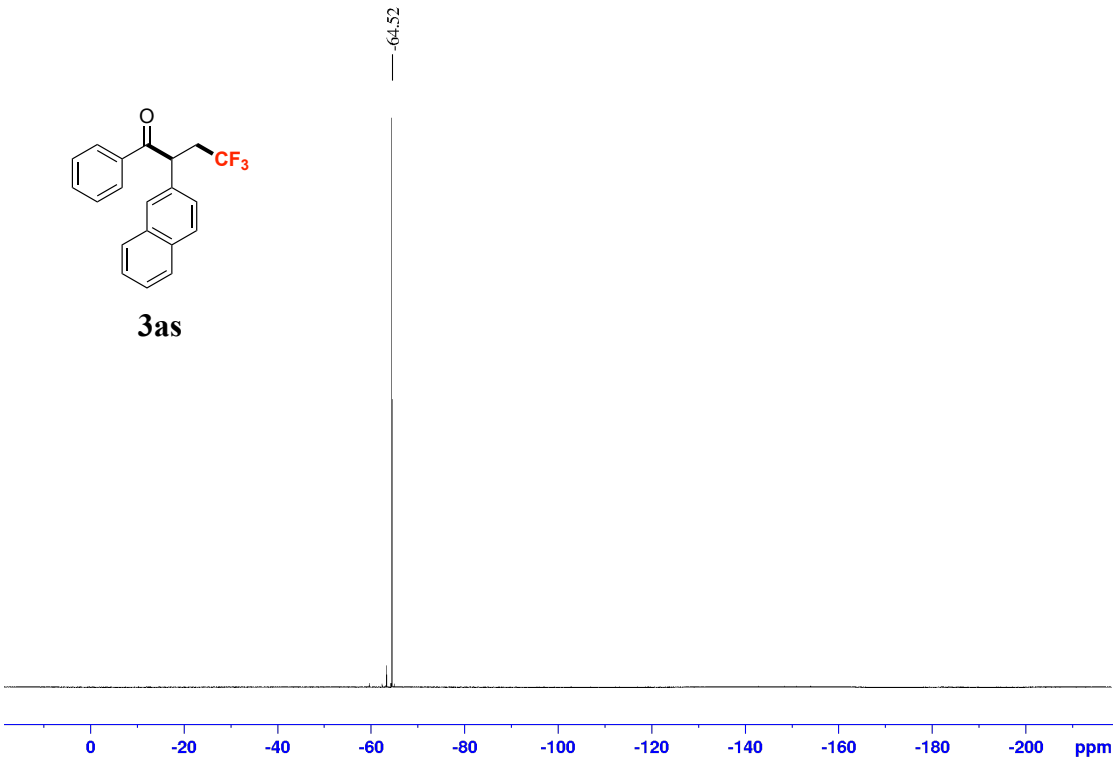

O
CF3

3as

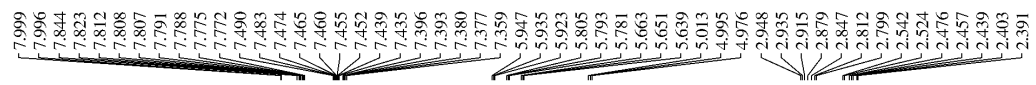

10
9
8
7
6
5
4
3
2
1
0
ppm
2.05
4.16
6.23
1.00
1.14
1.05


196.787
135.784
134.924
133.687
133.526
132.804
129.478
128.987
128.815
127.964
127.902
127.807
127.356
126.664
126.502
125.702
125.182
47.477
47.451
47.429
47.404
37.945
37.665
37.384
37.104
O
CF3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3as


-64.52
O
CF3
0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 ppm

3as


7.999
7.996
7.844
7.823
7.812
7.808
7.807
7.791
7.788
7.775
7.772
7.490
7.483
7.474
7.465
7.460
7.455
7.452
7.439
7.435
7.396
7.393
7.380
7.377
7.359
5.947
5.935
5.923
5.805
5.793
5.781
5.663
5.651
5.639
5.013
4.995
4.976
2.948
2.935
2.915
2.879
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2.812
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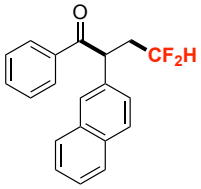
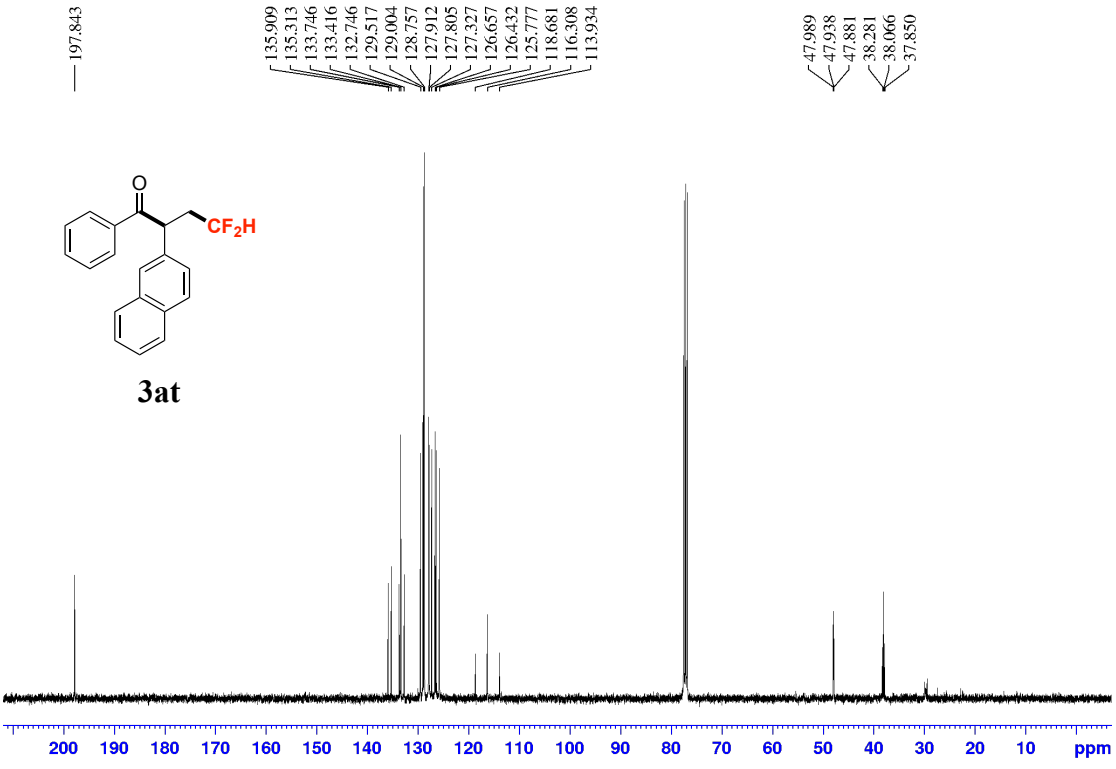
2.542
2.524
2.476
2.457
2.439
2.403
2.391


O
CF2H

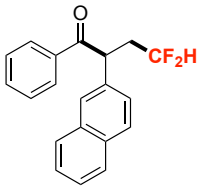
3at

10
9
8
7
6
5
4
3
2
1
ppm
2.07
4.09
4.03
1.87
1.06
1.00
1.02
1.07


197.843
135.909
135.313
133.746
133.416
132.746
129.517
129.004
128.757
127.912
127.805
127.327
126.657
126.432
125.777
118.681
116.308
113.934
47.989
47.938
47.881
38.281
38.066
37.850
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

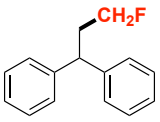
O
CF2H

3at


O
CF2H

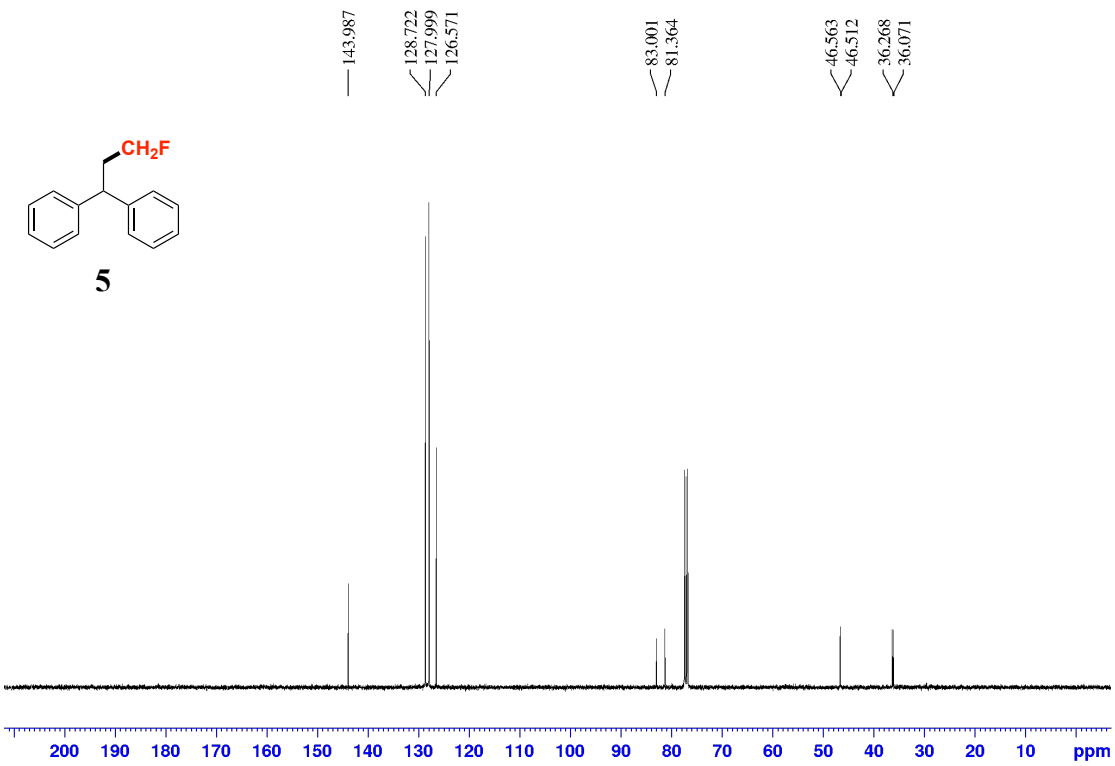
3at

-115.42
-116.17
-117.27
-118.03
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm

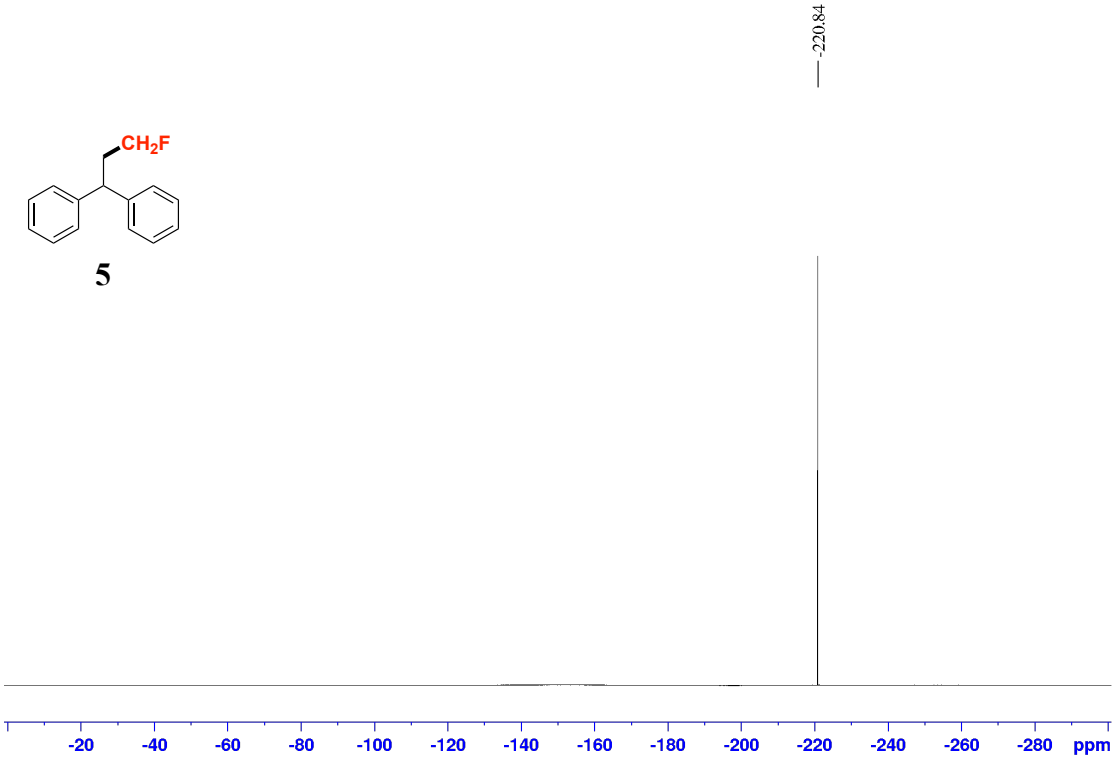

CH2F

5

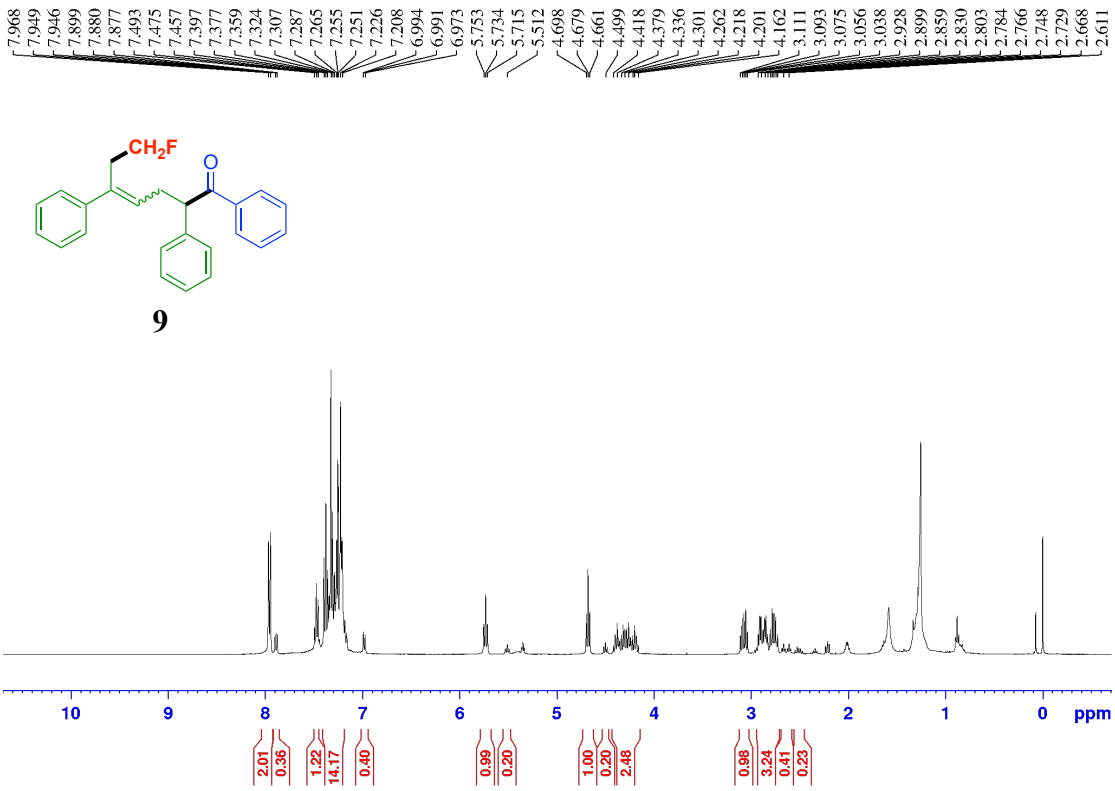
7.239
7.220
7.202
7.185
7.168
7.165
7.139
7.135
7.132
7.118
7.113
7.105
7.101
7.097
4.386
4.371
4.356
4.268
4.253
4.238
4.116
4.097
4.077
2.418
2.402
2.398
2.387
2.383
2.368
2.357
2.342
2.338
2.327
2.323
2.307
10
9
8
7
6
5
4
3
2
1
0
ppm
8.18
1.96
1.01
1.02
1.00
2.08


143.987
128.722
127.999
126.571
83.001
81.364
46.563
46.512
36.268
36.071
CH2F
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

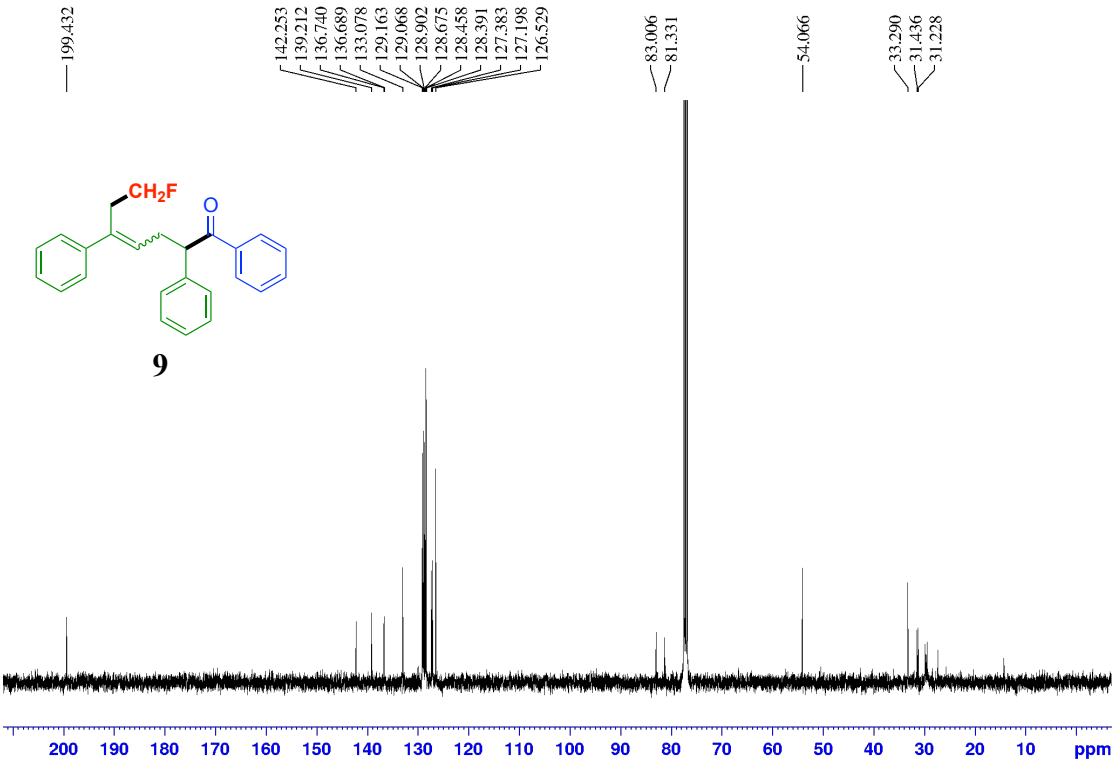
5


-220.84
CH2F
-20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 ppm

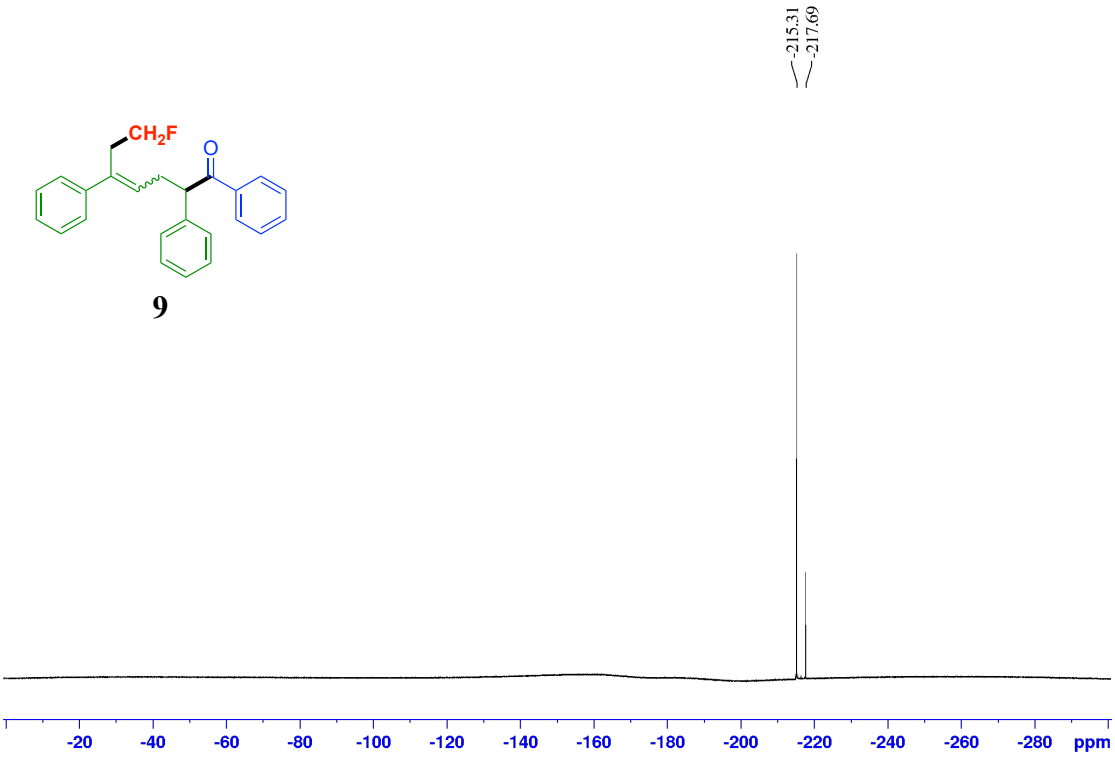
5


7.968
7.949
7.946
7.899
7.880
7.877
7.493
7.475
7.457
7.397
7.377
7.359
7.324
7.307
7.287
7.265
7.255
7.251
7.226
7.208
6.994
6.991
6.973
5.753
5.734
5.715
5.512
4.698
4.679
4.661
4.499
4.418
4.379
4.336
4.301
4.262
4.218
4.201
4.162
3.111
3.093
3.075
3.056
3.038
2.928
2.899
2.859
2.830
2.803
2.784
2.766
2.748
2.729
2.668
2.611
CH2F
O
10
9
8
7
6
5
4
3
2
1
0
ppm
2.01
0.36
1.22
14.17
0.40
0.99
0.20
1.00
0.20
2.48
0.98
3.24
0.41
0.23

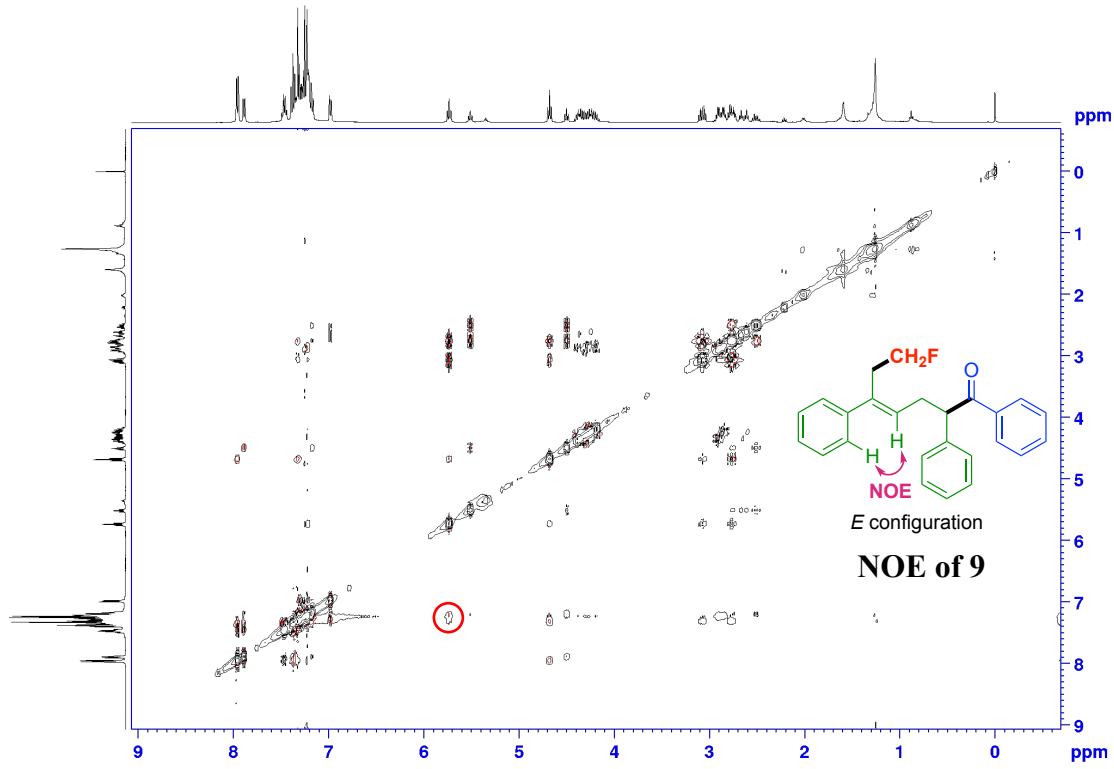
9


199.432
142.253
139.212
136.740
136.689
133.078
129.163
129.068
128.902
128.675
128.458
128.391
127.383
127.198
126.529
83.006
81.331
54.066
33.290
31.436
31.228
CH2F
O
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

9


-215.31
-217.69
CH2F
O
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
ppm

9


ppm
0
1
2
3
4
5
6
7
8
9
CH2F
O
H
H
NOE
E configuration

NOE of 9