Supporting Information for:

Silver-Mediated Trifluoromethylation of Arenes using $TMSCF_3$

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General Procedures

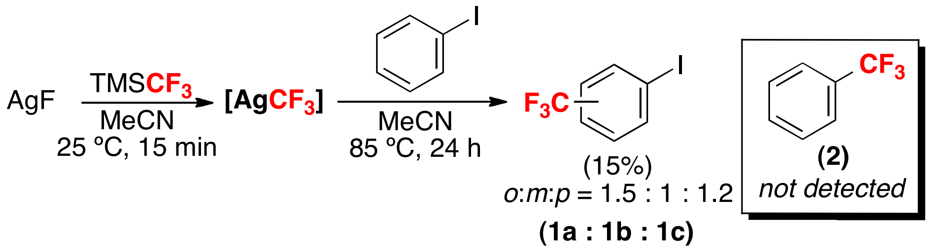
NMR spectra were obtained on a Varian Inova 400 (399.96 MHz for ^1H; 376.34 MHz for ^{19}F; 100.57 MHz for ^{13}C) or a MR400 (400.53 MHz for ^1H: 376.87 MHz for ^{19}F; 100.71 MHz for ^{13}C) spectrometer. ^1H and ^{13}C chemical shifts are reported in parts per million (ppm) relative to TMS, with the residual solvent peak used as an internal reference. ^{19}F NMR spectra are referenced based on the internal standard 4-fluoroanisole, which appears at –125.00 ppm. ^1H and ^{19}F multiplicities are reported as follows: singlet (s), doublet (d), quartet (q) and multiplet (m).

Materials and Methods

AgF, AgOTf, and 4-fluoroanisole were obtained from Matrix Scientific. Benzene and potassium fluoride were obtained from EMD. Rupert's reagent ($TMSCF_3$) was obtained from Oakwood Products. $AgNO_3$, 1,2-Dimethoxybenzene, 1,3-dimethoxybenzene, 1,4-dichlorobenzene, anisole, iodobenzene, and naphthalene were obtained from Sigma Aldrich. 1,4-Dimethoxybenzene and *o*-xylenes were obtained from TCI America. Trifluorotoluene and *m*-xylenes were obtained from Acros. 1,2-Dichloroethane, *p*-xylene, thiophene, *N*-methylpyrrole and mesitylene were obtained from Alfa Aesar. $CDCl_3$ was obtained from Cambridge Isotope Laboratories. Authentic samples of the aryl–CF_3 products were purchased from commercial sources unless otherwise stated. Dichloroethane, xylenes, and dimethoxybenzene derivatives were distilled from CaH_2. Benzene was distilled from Na and benzophenone. Anisole, *N*-methylpyrrole, mesitylene, and thiophene were distilled from Na. Other chemicals were used as received. All syntheses were conducted using standard Schlenk techniques or in a nitrogen atmosphere glovebox unless otherwise stated.

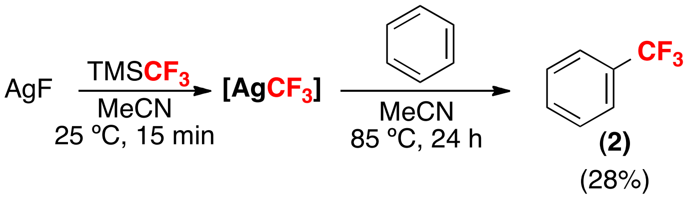
Experimental Details

Reaction of Ag–CF$_3$ with PhI



In a glovebox, AgF (10.3 mg, 0.081 mmol, 1 equiv) was weighed into a 4 mL vial and dissolved in MeCN (0.2 mL). TMSCF$_3$ (12 µL, 0.081 mmol, 1 equiv) was added, and the reaction was stirred at 25 °C for 15 min.[1] Iodobenzene (180 µL, 1.62 mmol, 20 equiv) was added to the reaction mixture. The vial was sealed with a Teflon-lined cap and removed from the glovebox. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with MeCN (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy in MeCN, showing a combined 15% yield of the three isomeric products. The ^{19}F NMR spectroscopic data matched that of authentic samples of all three isomers (*o*-isomer (Alfa Aesar): s, –62.7 ppm; *m*-isomer (Matrix Scientific): s, –62.9 ppm; *p*-isomer (Matrix Scientific), s, –63.0 ppm).

Reaction of Ag–CF$_3$ with Benzene



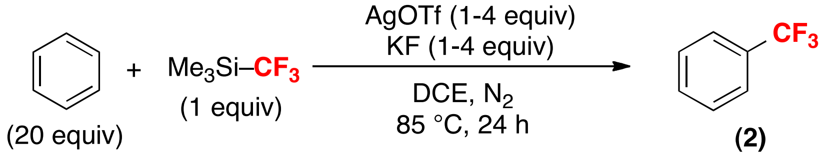
In a glovebox, AgF (10.3 mg, 0.081 mmol, 1 equiv) was weighed into a 4 mL vial and dissolved in MeCN (0.2 mL). TMSCF$_3$ (12 µL, 0.081 mmol, 1 equiv) was added, and the reaction was stirred at 25 °C for 15 min.[1] Benzene (144 µL, 1.62 mmol, 20 equiv) was added to the reaction mixture. The vial was sealed with a Teflon-lined cap and removed from the glovebox. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with MeCN (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy in

MeCN, showing 28% yield of trifluorotoluene. The ^{19}F NMR spectroscopic data matched that obtained of an authentic sample of trifluorotoluene (Acros, s, –63.3 ppm).

Trifluoromethylation of C_6H_6 Reaction Optimization (Variation of Equiv of AgOTf/KF)

In a glovebox, AgOTf (1-4 equiv, 0.081-0.324 mmol) and KF (1-4 equiv, 0.081-0.324 mmol) were weighed into a 4 mL vial and dissolved in DCE (0.2 mL). Benzene (144 μL, 1.62 mmol, 20 equiv) and $TMSCF_3$ (12 μL, 0.081 mmol, 1 equiv) were added. The vial was sealed with a Teflon-lined cap and removed from the glovebox. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with DCE (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy in DCE. In all cases, ^{19}F NMR spectroscopic data matched that obtained for an authentic sample of trifluorotoluene in DCE. The results of these experiments are reported in **Table S1**.

Table S1. Trifluoromethylation of C_6H_6 with Different Equivalent of AgOTf/KF

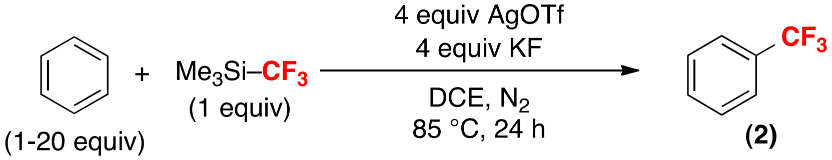


entry	AgOTf/KF (equiv)	Yield (%)
1	1	22
2	2	68
3	3	74
4	4	87

Trifluoromethylation of C_6H_6 Reaction Optimization (Variation of Equiv of Benzene)

In a glovebox, AgOTf (83.2 mg, 0.324 mmol, 4 equiv) and KF (18.8 mg, 0.324 mmol, 4 equiv) were weighed into a 4 mL vial and dissolved in DCE (0.2 mL). Benzene and $TMSCF_3$ (12 µL, 0.081 mmol, 1 equiv) were added. The vial was sealed with a Teflon-lined cap and removed from the glovebox. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with DCE (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy in DCE. The ^{19}F NMR spectroscopic data matched that obtained for an authentic sample of trifluorotoluene in DCE. The results of these experiments are reported in **Table S2**.

Table S2. Trifluoromethylation of C_6H_6 with Different Equivalents of C_6H_6



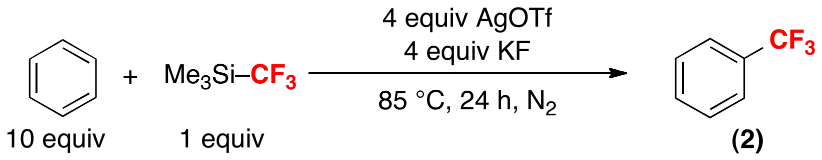
Entry	C_6H_6 (equiv)	Yield (%)
1	1	17
2	5	49
3	10	75
4	20	87

This reaction was also conducted using benzene as the limiting reagent (12 µL, 0.081 mmol, 1 equiv) and an excess of $TMSCF_3$ (60 µL, 0.4 mmol, 5 equiv). Under these conditions, the yield of the reaction was 53%.

Trifluoromethylation of C_6H_6 Reaction Optimization (Variation of Solvent)

In a glovebox, AgOTf (83.2 mg, 0.324 mmol, 4 equiv) and KF (18.8 mg, 0.324 mmol, 4 equiv) were weighed into a 4 mL vial and dissolved in the appropriate solvent (0.2 mL). Benzene (72 µL, 0.81 mmol, 10 equiv) and $TMSCF_3$ (12 µL, 0.081 mmol, 1 equiv) were added. The vial was sealed with a Teflon-lined cap and removed from the glovebox. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with DCE (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy. The ^{19}F NMR spectroscopic data matched that obtained for an authentic sample of trifluorotoluene. The results of these experiments are reported in **Table S3**.

Table S3. Trifluoromethylation of C_6H_6 with Different Solvents

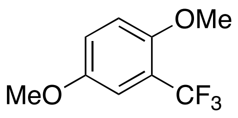


(2)

entry	solvent	yield (%)
1	diglyme	3
2	pentane	4
3	NMP	7
4	DMA	10
5	MeCN	20
6	THF	27
7	Et_2O	35
8	dioxane	48
9	ethyl acetate	57
10	DCE	75

General Procedure for Preparation of Authentic Samples of Previously Unreported Benzotrifluorides

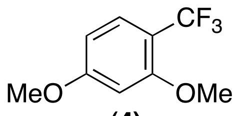
The authentic samples were synthesized following a literature procedure.[2] In a glovebox, $[Cu(OTf)]_2 \bullet C_6H_6$ (60.4 mg, 0.12 mmol, 0.6 equiv), 1,10-phenanthroline (43 mg, 0.24 mmol, 1.2 equiv), K_3PO_4 (127 mg, 0.6 mmol, 3 equiv), KF (58.1 mg, 1.0 mmol, 5 equiv), Ag_2CO_3 (55.2 mg, 0.2 mmol, 1 equiv), DMF (2.0 mL) and $TMSCF_3$ (0.15 mL, 0.1 mmol, 5 equiv) were added to a 20 mL reaction vial that was equipped with a stir bar. In a second vial, boronic acid (0.2 mmol, 1 equiv) was dissolved in DMF (2.0 mL). Both vials were sealed with rubber septa and removed from the glovebox. The first vial was heated to 45 ºC, and the solution of boronic acid was then added to over 2 h by using a syringe pump under N_2 atmosphere. After addition of the boronic acid solution, the reaction mixture was heated at 45 ºC for another 2 h. The reaction was cooled to 0 ºC, and water (10 mL) was added. The resulting mixture was extracted with diethyl ether, and the combined organic extracts were washed with water (3 x 50 mL) and brine (1 x 50 mL) and then dried over magnesium sulfate. The solvent was removed by rotary evaporation, and the products were purified by column chromatography on silica gel using pentane as the eluent.



(3)

1,4-Dimethoxy-2-(trifluoromethyl)benzene

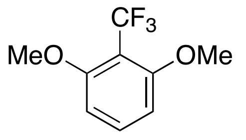
The general procedure was followed using 2,5-dimethoxyphenylboronic acid (36.4 mg, 0.2 mmol, 1 equiv) as the substrate. The product was obtained as colorless liquid (R_F = 0.13 in pentanes). ^{1}H NMR ($CDCl_3$, 25 °C): δ 7.12 (s, 1H), 7.02 (d, J = 9.2 Hz, 1H), 6.94 (d, J = 9.2 Hz, 1H), 3.86 (s, 3H), 3.79 (s, 3H). ^{13}C NMR ($CDCl_3$, 25 °C): δ 153.10, 151.67, 123.56 (q, J = 271.0 Hz), 119.54 (q, J = 30.8 Hz), 118.23, 113.72, 112.96 (q, J = 5.5 Hz), 56.71, 56.03. ^{19}F NMR ($CDCl_3$, 25 °C): δ –62.44 (s, 3F). HRMS EI (m/z): $[M]^+$ calcd for $C_9H_9F_3O_2$, 206.0555; found, 206.0563.



(4)

1,3-Dimethoxy-4-(trifluoromethyl)benzene

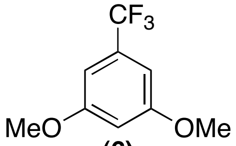
The general procedure was followed using 2,4-dimethoxyphenylboronic acid (36.4 mg, 0.2 mmol, 1 equiv) as the substrate. The product was obtained as colorless liquid (R_F = 0.1 in pentanes). ^{1}H NMR ($CDCl_3$, 25 °C): δ 7.48 (d, J = 8.7 Hz, 1H), 6.52 (s, 1H), 6.49 (d, J = 8.7 Hz, 1H), 3.87 (s, 3H), 3.84 (s, 3H). ^{13}C NMR ($CDCl_3$, 25 °C): δ 163.80, 159.01, 128.41 (q, J = 5.4 Hz), 124.12 (q, J = 270.6 Hz), 111.70 (q, J = 31.1 Hz), 103.84, 99.51, 55.96, 55.65. ^{19}F NMR ($CDCl_3$, 25 °C): δ –61.32 (s, 3F). HRMS EI (m/z): $[M]^+$ calcd for $C_9H_9F_3O_2$, 206.0555; found, 206.0559.



(5)

1,3-Dimethoxy-2-(trifluoromethyl)benzene

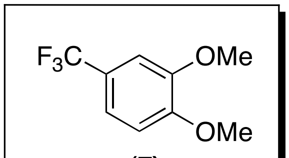
The general procedure was followed using 2,6-dimethoxyphenylboronic acid (36.4 mg, 0.2 mmol, 1 equiv) as the substrate. The product was obtained as a light yellow viscous solid (R_F = 0.13 in pentanes). ^{1}H NMR ($CDCl_3$, 25 °C): δ 7.38 (t, J = 8.8 Hz, 1H), 6.61 (d, J = 8.8 Hz, 2H), 3.86 (s, 6H). ^{13}C NMR ($CDCl_3$, 25 °C): δ 159.44, 133.11, 127.30, 124.22 (q, J = 275.5 Hz), 104.96, 56.50. ^{19}F NMR ($CDCl_3$, 25 °C): δ –54.97 (s, 3F). HRMS EI (m/z): $[M]^+$ calcd for $C_9H_9F_3O_2$, 206.0555; found, 206.0555.



(6)

1,3-Dimethoxy-5-(trifluoromethyl)benzene

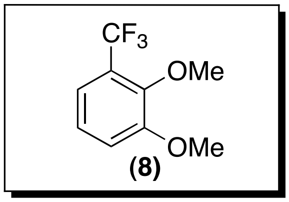
The general procedure was followed using 3,5-dimethoxyphenylboronic acid (36.4 mg, 0.2 mmol, 1 equiv) as the substrate. The product was obtained as colorless liquid (R_F = 0.23 in pentanes). ^{1}H NMR ($CDCl_3$, 25 °C): δ 6.74 (s, 2H), 6.60 (s, 1H), 3.82 (s, 6H). ^{13}C NMR ($CDCl_3$, 25 °C): δ 161.16, 132.53 (q, J = 32.3 Hz), 124.05 (q, J = 272.3 Hz), 103.76, 103.42 (q, J = 3.9 Hz), 55.67. ^{19}F NMR ($CDCl_3$, 25 °C): δ –62.96 (s, 3F). HRMS EI (m/z): [M]+ calcd for $C_9H_9F_3O_2$, 206.0555; found, 206.0554.



(7)

1,2-Dimethoxy-4-(trifluoromethyl)benzene

The general procedure was followed using 3,4-dimethoxyphenylboronic acid (36.4 mg, 0.2 mmol, 1 equiv) as the substrate. The product was obtained as colorless liquid (R_F = 0.1 in pentanes). ^{1}H NMR ($CDCl_3$, 25 °C): δ 7.18 (d, J = 8.4 Hz, 1H), 7.05 (s, 1H), 6.88 (d, J = 8.4 Hz, 1H), 3.89 (s, 6H). ^{13}C NMR ($CDCl_3$, 25 °C): δ 151.66, 149.12, 124.40 (q, J = 271.5 Hz), 122.97 (q, J = 32.9 Hz), 118.40 (q, J = 3.6 Hz), 110.65, 108.06 (q, J = 3.6 Hz), 56.04, 56.02. ^{19}F NMR ($CDCl_3$, 25 °C): δ –61.67 (s, 3F). HRMS EI (m/z): $[M]^+$ calcd for $C_9H_9F_3O_2$, 206.0555; found, 206.0559.



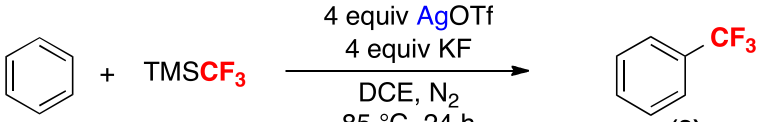
(8)

1,2-Dimethoxy-3-(trifluoromethyl)benzene

The general procedure was followed using 2,3-dimethoxyphenylboronic acid (36.4 mg, 0.2 mmol, 1 equiv) as the substrate. The product was obtained as colorless liquid (R_F = 0.12 in pentanes). ^{1}H NMR ($CDCl_3$, 25 °C): δ 7.17-7.08 (multiple peaks, 3H), 3.91 (s, 3H), 3.90 (s, 3H). ^{13}C NMR ($CDCl_3$, 25 °C): δ 153.62, 147.72 (q, J = 1.9 Hz), 124.72 (q, J = 30.4 Hz), 123.92, 123.68 (q, J = 273.6 Hz), 118.16 (q, J = 5.1 Hz), 116.24, 61.50, 56.15. ^{19}F NMR ($CDCl_3$, 25 °C): δ –61.36 (s, 3F). HRMS EI (m/z): [M]+ calcd for $C_9H_9F_3O_2$, 206.0555; found, 206.0559.

General Procedure for Trifluoromethylation of Arenes

In a glovebox, AgOTf (83.2 mg, 0.324 mmol, 4 equiv) and KF (18.8 mg, 0.324 mmol, 4 equiv) were weighed into a 4 mL vial and dissolved in DCE (0.2 mL). The aromatic substrate and $TMSCF_3$ (12 μL, 0.081 mmol, 1 equiv) were then added. The vial was sealed with a Teflon-lined cap and removed from the glovebox. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with DCE (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy in DCE to determine the yield. GCMS analyses were performed on a Shimadzu GCMS-QP5000 gas chromatograph mass spectrometer. The products were separated on a 30 m length×0.25 mm i.d., RESTEK XTI-5 column coated with a 0.25 μm film. The GC oven temperature program was as follows: 30 ºC hold 10 min, ramp 20 ºC/min to 250 ºC, and hold for 3 min. Helium was employed as the carrier gas, with a constant column flow of 1.5 mL/min. The injector temperature was held constant at 250 ºC.

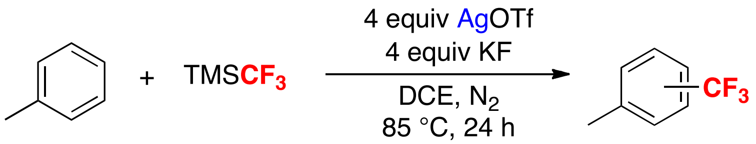


(2)

(87%)

The general procedure was followed using 20 equiv of benzene. The ^{19}F NMR spectroscopic data matched that obtained for an authentic sample of trifluorotoluene (Acros, s, –63.3 ppm). Trifluorotoluene was formed in 87% yield as determined by ^{19}F NMR spectroscopic analysis of the crude reaction mixture.

This reaction was also conducted on 0.5 mmol and 1 mmol scale. For the 0.5 mmol scale reaction, AgOTf (514 mg, 2 mmol, 4 equiv), KF (116 mg, 2 mmol, 4 equiv), $TMSCF_3$ (73.8 μL, 0.5 mmol, 1 equiv), benzene (0.89 mL, 10 mmol, 20 equiv) and DCE (1.25 mL) were used. The yield of the reaction was 84%. For the 1 mmol scale reaction, AgOTf (1028 mg, 4 mmol, 4 equiv), KF (232 mg, 4 mmol, 4 equiv), $TMSCF_3$ (147.7 μL, 1 mmol, 1 equiv), benzene (1.78 mL, 20 mmol, 20 equiv) and DCE (2.5 mL) were used. The reaction was conducted in a 20 mL vial, and the yield was 87%.

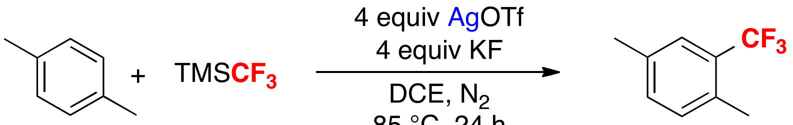


(81%)

o : *m* : *p* = 1.4 : 1 : 2.7

(9a : 9b : 9c)

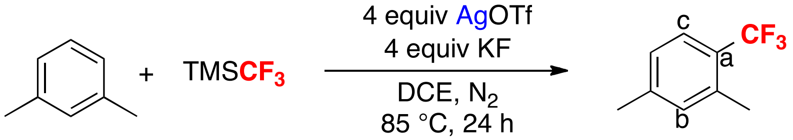
The general procedure was followed using 10 equiv of toluene. The ^{19}F NMR spectroscopic data matched that of authentic samples of all three isomers (*o*-isomer, (Matrix Scientific): s, –62.7 ppm; *m*-isomer (Matrix Scientific): s, –62.4 ppm; *p*-isomer (Alfa Aesar), s, –61.7 ppm). The trifluoromethylated products were formed in 81% combined yield with an *o* : *m* : *p* ratio of 1.4 : 1 : 2.7 as determined by ^{19}F NMR spectroscopic analysis of the crude reaction mixture.



(10)

(76%)

The general procedure was followed using 10 equiv of *p*-xylenes. ^{19}F NMR analysis of the crude reaction mixture showed that 1,4-dimethyl-2-(trifluoromethyl)benzene was formed in 76% yield. The product showed a ^{19}F NMR signal at –61.6 ppm in DCE (lit. –61.6 ppm in $CDCl_3$).[3] The identity of the product was further confirmed by GCMS analysis, where the product peak was observed at 11.8 min. The mass spectrum of the product is provided in the spectral data below.



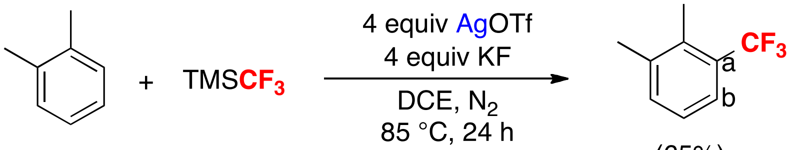
(76%)

a : b : c = 5.2 : 3.5 : 1

(11a : 11b : 11c)

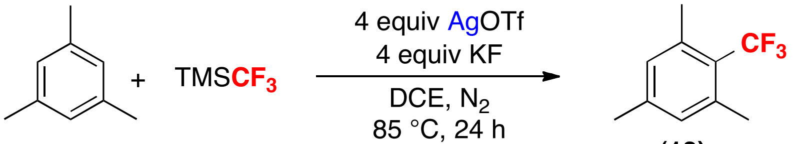
The general procedure was followed using 10 equiv of *m*-xylenes. ^{19}F NMR analysis of the crude reaction mixture showed that the mono-trifluoromethylated product was formed in 76% yield as a mixture of 3 isomers. These products showed ^{19}F NMR signals in DCE at –61.2 ppm (a isomer, lit. –61.2 ppm in $CDCl_3$),[3] –54.1 ppm (b isomer, lit. –54.1 ppm in $CDCl_3$),[3] and –62.6 ppm (c isomer, lit. –62.6 ppm in $CDCl_3$).[3] The identity of the products was further confirmed by

GCMS analysis, where the product peaks were observed at 11.6 min, 11.9 min and 12.2 min. The mass spectra of the products are provided in the spectral data below.



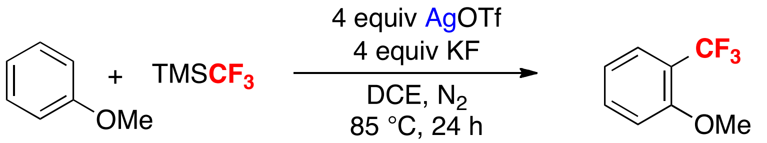
(65%)
a : b = 1.4 : 1
(12a : 12b)

The general procedure was followed using 10 equiv of *ortho*-xylenes. ^{19}F NMR analysis of the crude reaction mixture showed that the mono-trifluoromethylated product was formed was in 65% yield as a 1.4 : 1 mixture of the a and b isomers. These products showed ^{19}F NMR signals in DCE at –60.4 ppm (a isomer, lit. –60.4 ppm in $CDCl_3$)[3] and –62.3 ppm (b isomer). The ^{19}F NMR spectroscopic data of b isomer matched that of an authentic sample (SynQuest Laboratories). The identity of the products was further confirmed by GCMS analysis, where the product peaks were observed at 12.3 min and 12.4 min. The mass spectra of the products are provided in the spectral data below.



(13)
(78%)

The general procedure was followed using 10 equiv of mesitylene. ^{19}F NMR analysis of the crude reaction mixture showed that 1,3,5-trimethyl-2-(trifluoromethyl)benzene was formed in 78% yield. The product showed a ^{19}F NMR signal at –53.7 ppm in DCE (lit. –55 ppm in $CDCl_3$).[4] The identity of the product was further confirmed by GCMS analysis, where the product peak was observed at 14.0 min. The mass spectrum of the product is provided in the spectral data below.

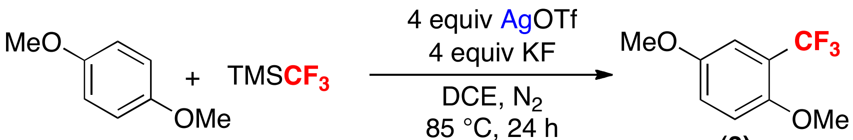


(87%)

o : *m* : *p* = 2.7 : 1 : 1.2

(14a : 14b : 14c)

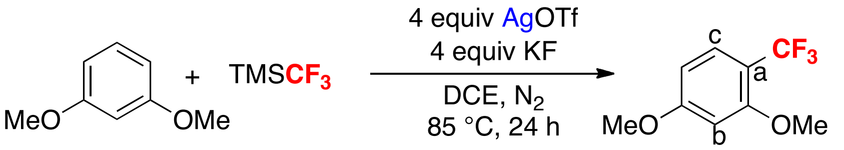
The general procedure was followed using 10 equiv of anisole. The ^{19}F NMR spectroscopic data matched that of authentic samples of all three isomers (*o*-isomer (Alfa Aesar): s, –62.5 ppm; *m*-isomer (Matrix Scientific): s, –62.8 ppm; *p*-isomer (SynQuest Laboratories), s, –61.5 ppm). The trifluoromethylated products were formed in 87% combined yield with an *o* : *m* : *p* ratio of 2.7 : 1 : 1.2 as determined by ^{19}F NMR spectroscopic analysis of the crude reaction mixture.



(3)

(88%)

The general procedure was followed using 20 equiv of 1,4-dimethoxybenzene. The ^{19}F NMR spectroscopic data matched that of the authentic samples of prepared above. 1,4-Dimethoxy-2-trifluoromethylbenzene was formed in 81% yield as determined by ^{19}F NMR spectroscopic analysis of the crude reaction mixture.

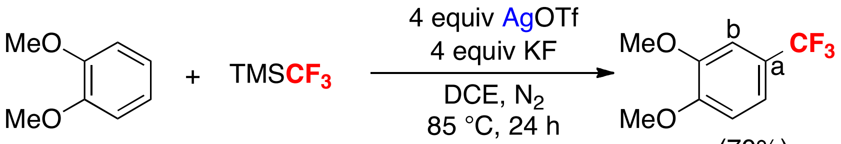


(85%)

a : b : c = 13 : 7.3 : 1

(4 : 5 : 6)

The general procedure was followed using 10 equiv of 1,3-dimethoxybenzene. The ^{19}F NMR spectroscopic data matched that of the authentic samples of prepared above. The three isomeric mono-trifluoromethylated products were formed in 85% yield with an a : b : c ratio of 13 : 7.3 : 1 as determined by ^{19}F NMR spectroscopic analysis of the crude reaction mixture.

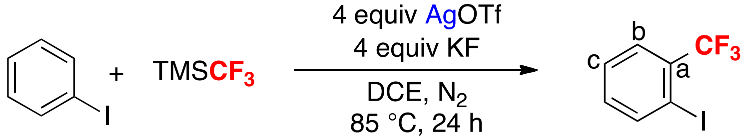


(70%)

a : b = 4 : 1

(7 : 8)

The general procedure was followed using 10 equiv of 1,2-dimethoxybenzene. The ^{19}F NMR spectroscopic data matched that of the authentic samples of prepared above. The three isomeric mono-trifluoromethylated products were formed in 71% yield with an a : b ratio of 4 : 1 as determined by ^{19}F NMR spectroscopic analysis of the crude reaction mixture.

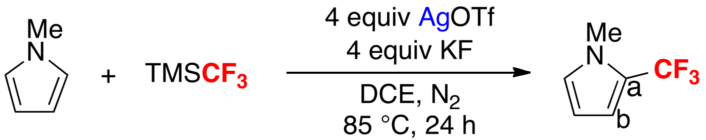


(46%)

a : b : c = 1.7 : 1.2 : 1

(1a : 1b : 1c)

The general procedure was followed using 20 equiv of iodobenzene. The ^{19}F NMR spectroscopic data matched that of authentic samples of all three isomers (*o*-isomer (Alfa Aesar): s, –62.7 ppm; *m*-isomer (Matrix Scientific): s, –62.9 ppm; *p*-isomer (Matrix Scientific), s, –63.0 ppm). The trifluoromethylated products were obtained in 46% combined yield with an *o* : *m* : *p* ratio of 1.7 : 1.2 : 1 as determined by ^{19}F NMR analysis of the crude reaction mixture.

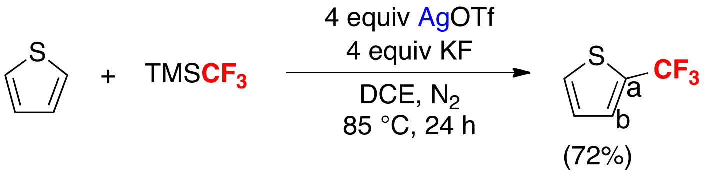


(44%)

a : b = >20 : 1

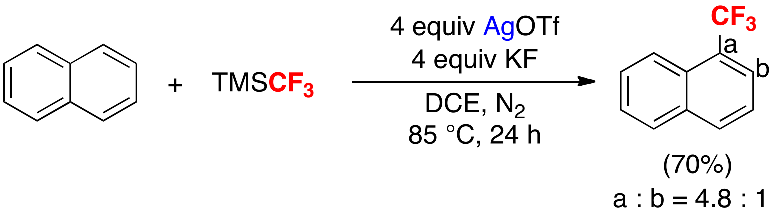
(15a : 15b)

The general procedure was followed using 20 equiv of *N*-methylpyrrole. ^{19}F NMR analysis of the crude reaction mixture showed that the mono-trifluoromethylated product was formed in 44% total yield as a >20:1 mixture of the a and b isomers. These products showed ^{19}F NMR signals in DCE at –58.8 ppm (a isomer, lit. –58.3 ppm in $CDCl_3$)[5] and –56.8 ppm (b isomer, lit. –56.6 in $CDCl_3$).[5] The identity of the products was further confirmed by GCMS analysis, where the product peaks were observed at 3.7 min and 4.1 min. The mass spectra of the products are provided in the spectral data below.



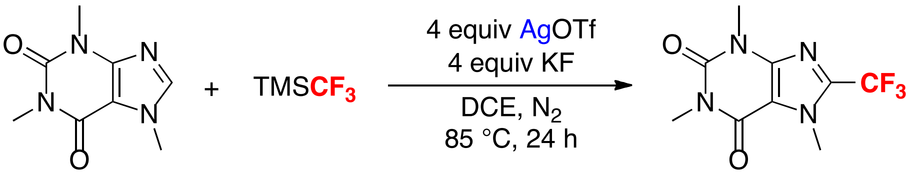
(16a : 16b)

The general procedure was followed using 10 equiv of thiophene. ^{19}F NMR analysis of the crude reaction mixture showed that the mono-trifluoromethylated product was formed in 72% total yield as an 8:1 mixture of the a and b isomers. These products showed ^{19}F NMR signals in DCE at –55.1 ppm (a isomer, lit. –55.1 ppm in thiophene)[6] and –59.4 ppm (b isomer, lit. –59.5 in thiophene).[6] The identity of the products was further confirmed by GCMS analysis, where the product peaks were observed at 3.3 min and 3.5 min. The mass spectra of the products are provided in the spectral data below.



(17a : 17b)

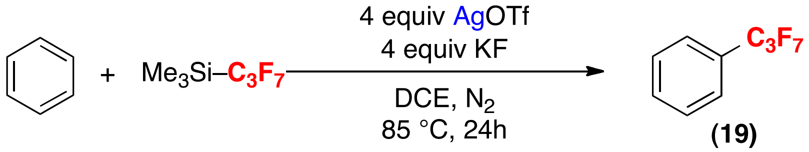
The general procedure was followed using 5 equiv of naphthalene. ^{19}F NMR analysis of the crude reaction mixture showed that the mono-trifluoromethylated product was formed in 70% total yield as an 4.8 : 1 mixture of the a and b isomers. These products showed ^{19}F NMR signals in DCE at –59.9 ppm (a isomer, lit. –60.1 ppm in $CDCl_3$)[7] and –62.4 ppm (b isomer, lit. –62.1 in $CDCl_3$).[2] The identity of the products was further confirmed by GCMS analysis, where the product peaks were observed at 15.7 min and 15.8 min. The mass spectra of the products are provided in the spectral data below.



(18)
(42%)

The general procedure was followed using 5 equiv of caffeine. ^{19}F NMR analysis of the crude reaction mixture showed that the trifluoromethylated product was formed in 42% yield. The product showed ^{19}F NMR signals in DCE at –62.5 ppm (lit. –62.7 ppm in $CDCl_3$).[8] The identity of the product was further confirmed by GCMS analysis. The GC oven temperature program was as follows: start at 100 ºC, ramp 15 ºC/min to 250 ºC, and hold for 10 min. The product peak was observed at 6.5 min. The mass spectra of the products are provided in the spectral data below.

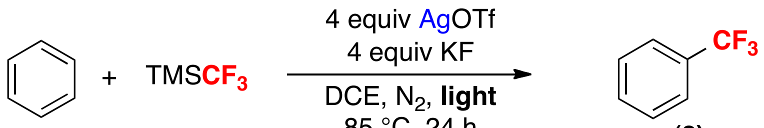
Heptafluoropropylation of Arenes



(19)
(60%)

In a glovebox, AgOTf (83.2 mg, 0.324 mmol, 4 equiv) and KF (18.8 mg, 0.324 mmol, 4 equiv) were weighed into a 4 mL vial and dissolved in DCE (0.2 mL). Benzene (144 μL, 1.62 mmol, 20 equiv) was added to the reaction mixture. The vial was removed from the glovebox. In the air, $TMSC_3F_7$ (16.4 μL, 0.081 mmol, 1 equiv) was added, and the vial was sealed with a Teflon-lined cap. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with DCE (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy in DCE to determine the yield. ^{19}F NMR analysis of the crude reaction mixture showed that heptafluoropropyl-benzene was formed in 60%. The product was identified by comparison to literature ^{19}F NMR data: observed δ –80.4 ppm (t, J = 9.8 Hz, 3F), –111.8 ppm (q, J = 9.8 Hz, 2F), –126.6 ppm (s, 2F) in DCE; lit. –80.2 ppm (t, J = 9 Hz, 3F), –111.5 ppm (q, J = 9 Hz, 2F), –126.5 ppm (s, 2F) in $CDCl_3$.[9] The identity of the product was further confirmed by GCMS analysis, where the product peak was observed at 5.0 min. The mass spectrum of the product is provided in the spectral data below.

Trifluoromethylation of C_6H_6 under Light



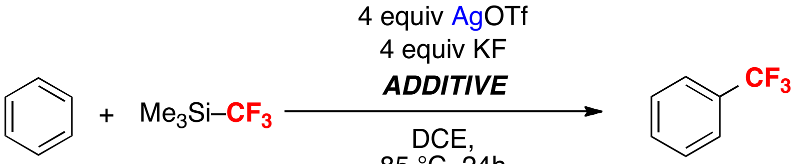
(2)
(75%)

In a glovebox, AgOTf (83.2 mg, 0.324 mmol, 4 equiv) and KF (18.8 mg, 0.324 mmol, 4 equiv) were weighed into a 4 mL vial and dissolved in DCE (0.2 mL). Benzene (144 μL, 1.62 mmol, 20 equiv) and $TMSCF_3$ (12 μL, 0.081 mmol, 1 equiv) were added. The vial was sealed with a Teflon-lined cap and removed from the glovebox. A 26-watt fluorescent light source was placed 5 cm from the reaction, and the reaction was heated in a clear oil bath at 85 °C for 24 h. The resulting dark brown mixture was cooled to room temperature and diluted with DCE (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy, showing 75% yield of trifluorotoluene.

Trifluoromethylation of C_6H_6 Reaction with Additives

In a glovebox, AgOTf (83.2 mg, 0.324 mmol, 4 equiv) and KF (18.8 mg, 0.324 mmol, 4 equiv) were weighed into a 4 mL vial and dissolved in DCE (0.2 mL). Benzene (144 µL, 1.62 mmol, 20 equiv), additive (0.2 equiv or 1 equiv), and $TMSCF_3$ (12 µL, 0.081 mmol, 1 equiv) were added. The vial was sealed with a Teflon-lined cap and removed from the glovebox. The reaction was heated at 85 °C for 24 h with exclusion of light. The resulting dark brown mixture was cooled to room temperature and diluted with DCE (1 mL). 4-Fluoroanisole (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy. The results of these experiments are reported in **Table S4**.

Table S4. Trifluoromethylation of C_6H_6 with Additives



(2)

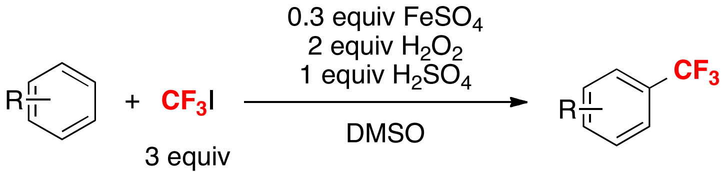
entry	additive	yield (%)
1	20 mol % AIBN	77
2	1 equiv AIBN	57
3	1 equiv nitrobenzene	85
4	1 equiv TEMPO	7

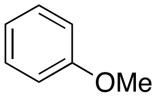
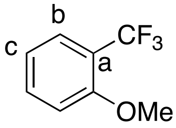
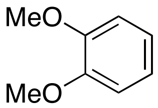
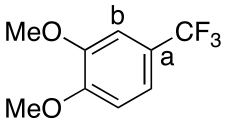
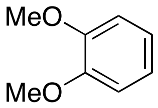
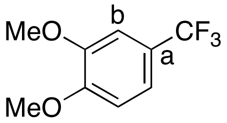
Radical Trifluoromethylation

The radical trifluoromethylation reactions were performed following a literature procedure.[10] In air, anisole (109 μL, 1.0 mmol) or veratrole (127 μL, 1.0 mmol), DMSO (2.0 mL), a DMSO solution of H_2SO_4 (0.5 M, 2.0 mL), a DMSO solution of CF_3I (3.0 M, 1.0 mL) and an aqueous solution of $FeSO_4$ (1 M, 0.3 mL) were combined in a 20 mL vial. A 30% aqueous solution of H_2O_2 (0.2 mL) was added drop-wise at the rate of 0.04 mL/min using a syringe pump. After the addition of H_2O_2, the mixture was stirred at 45 °C for 20 min. After cooling to room temperature, 2,2,2-trifluoroethanol (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy. The results of these experiments are reported in **Table S5**.

This reaction was also heated to 85°C for 20 min after the addition of H_2O_2. The result is shown at **Table S5**, entry 3.

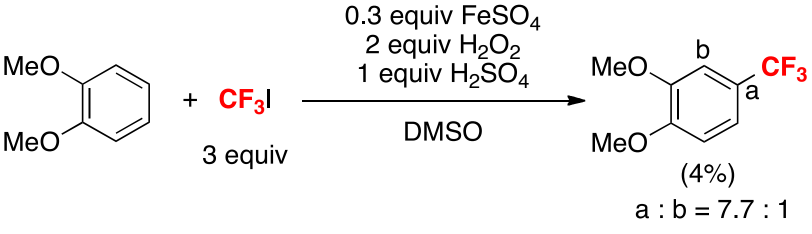
Table S5. Radical Trifluoromethylation



entry	substrate	major product	NMR yield (%)	isomer ration
1			26	a : b : c = 7.5 : 1 : 5 **(14a : 14b : 14c)**
2			60	a : b = 9.8 : 1 **(7 : 8)**
3[a]			67	a : b = 10.2 : 1 **(7 : 8)**

[a] Reaction was heated at 85 ºC.

Radical Trifluoromethylation in DCE



(7 : 8)

The radical trifluoromethylation reactions were performed following a modified literature procedure.[10] In air, veratrole (127 μL, 1.0 mmol), DCE (2.0 mL), a DCE solution of H_2SO_4 (0.5 M, 2.0 mL), a DMSO solution of CF_3I (3.0 M, 1.0 mL) and an aqueous solution of $FeSO_4$ (1 M, 0.3 mL) were combined in a 20 mL vial. A 30% aqueous solution of H_2O_2 (0.2 mL) was added drop-wise at the rate of 0.04 mL/min using a syringe pump. After the addition of H_2O_2, the mixture was stirred at 45 °C for 20 min. After cooling to room temperature, 2,2,2-trifluoroethanol (1 equiv) was added as an internal standard, and the reaction was analyzed by ^{19}F NMR spectroscopy.

References:

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[1] Tyrra, W. E.; Naumann, D. *J. Fluorine Chem.* **2004**, *125*, 823.

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[10] Kino, T.; Nagase, Y.; Ohtsuka, Y.; Yamamoto, K.; Uraguchi, D.; Tokuhisa, K.; Yamakawa, T. *J. Fluorine Chem.* **2010**, *131*, 98.

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Archive directory:

Sample directory:

FidFile:

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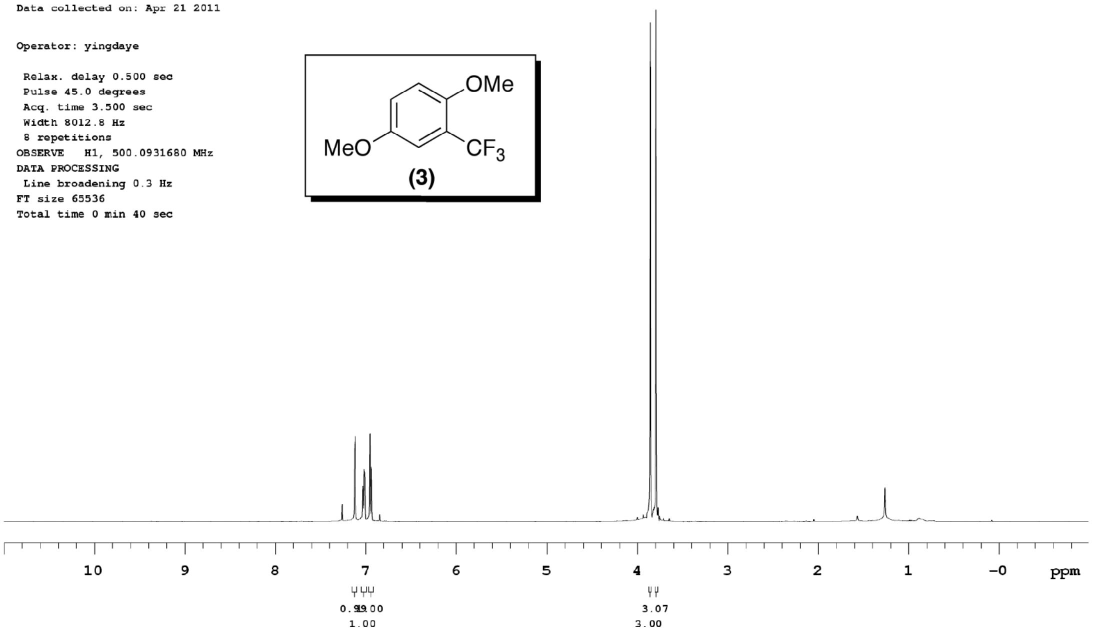
Solvent: cdcl3
Data collected on: Apr 21 2011

Operator: yingdaye

Relax. delay 0.500 sec
Pulse 45.0 degrees
Acq. time 3.500 sec
Width 8012.8 Hz
8 repetitions
OBSERVE H1, 500.0931680 MHz
DATA PROCESSING
Line broadening 0.3 Hz
FT size 65536
Total time 0 min 40 sec



(3)

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Sample directory:

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Solvent: cdcl3
Data collected on: Apr 21 2011

Operator: yingdaye

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Acq. time 2.045 sec
Width 32051.3 Hz
640 repetitions
OBSERVE C13, 125.7485074 MHz
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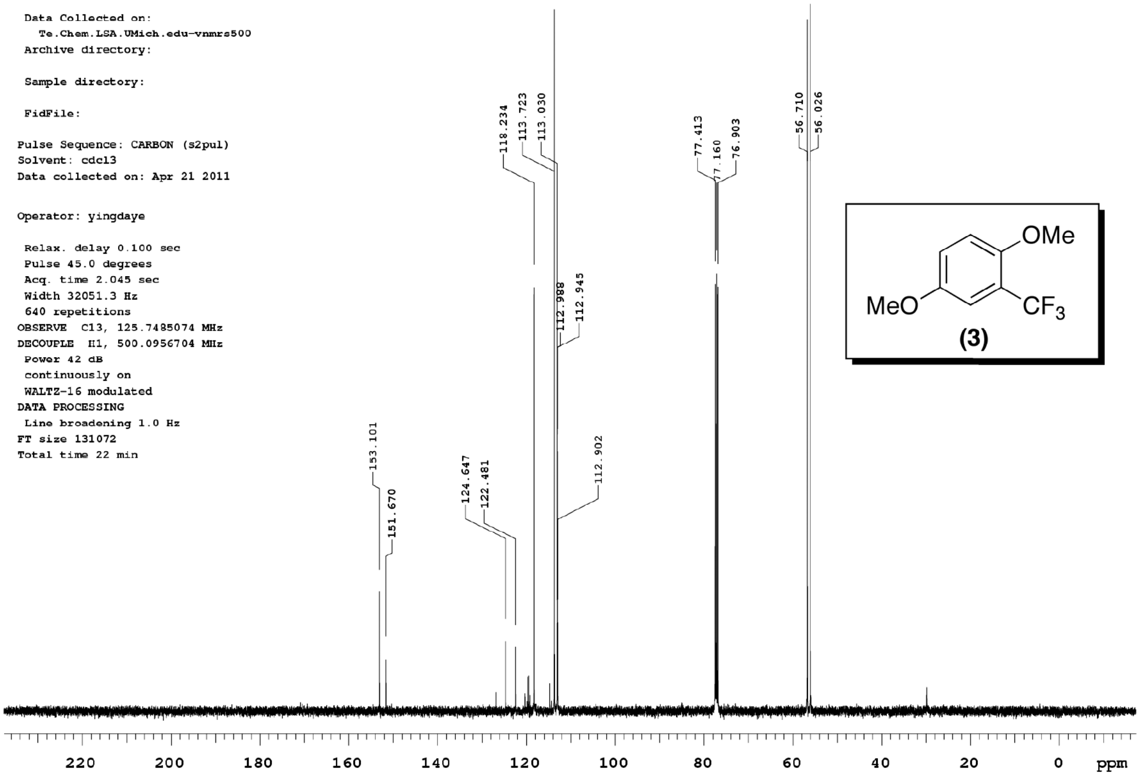
Power 42 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 22 min



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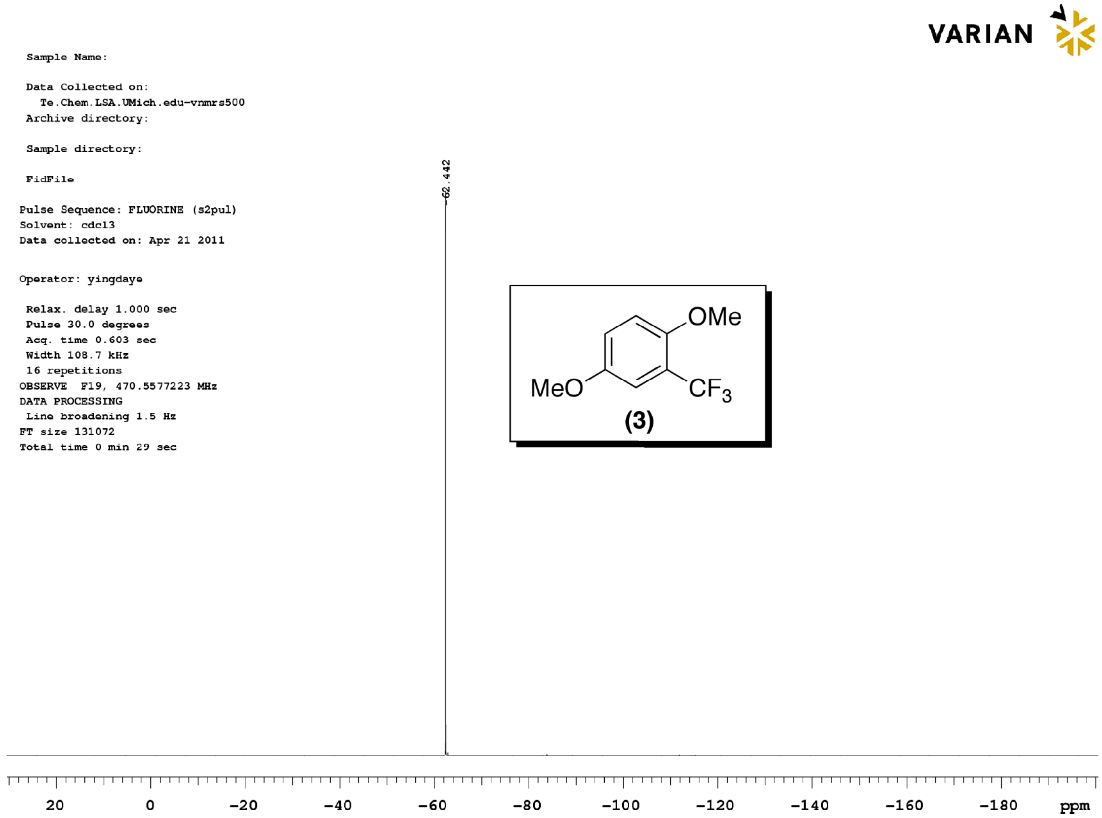

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Archive directory:

Sample directory:

FidFile

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Solvent: cdcl3
Data collected on: Apr 21 2011

Operator: yingdaye

Relax. delay 1.000 sec
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Acq. time 0.603 sec
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DATA PROCESSING
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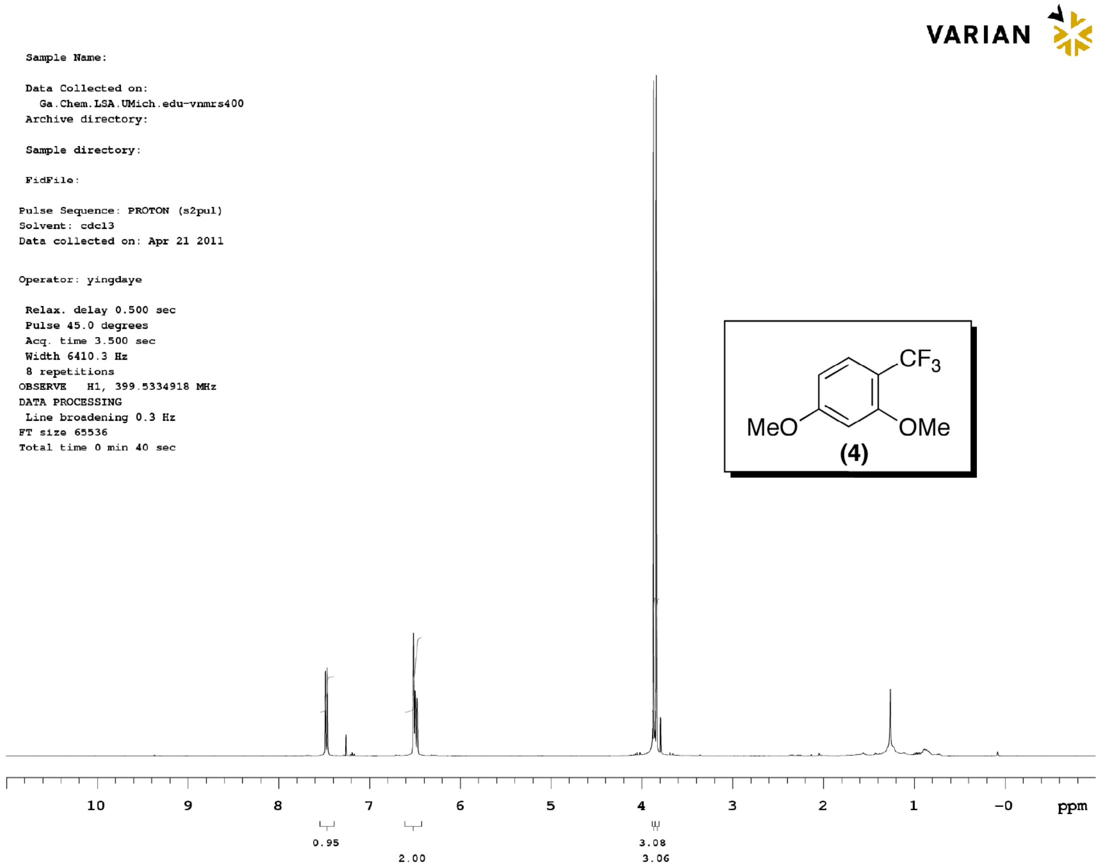
Total time 0 min 29 sec

(3)



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Archive directory:

Sample directory:

FidFile:

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Solvent: cdcl3
Data collected on: Apr 21 2011

Operator: yingdaye

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8 repetitions
OBSERVE H1, 399.5334918 MHz
DATA PROCESSING
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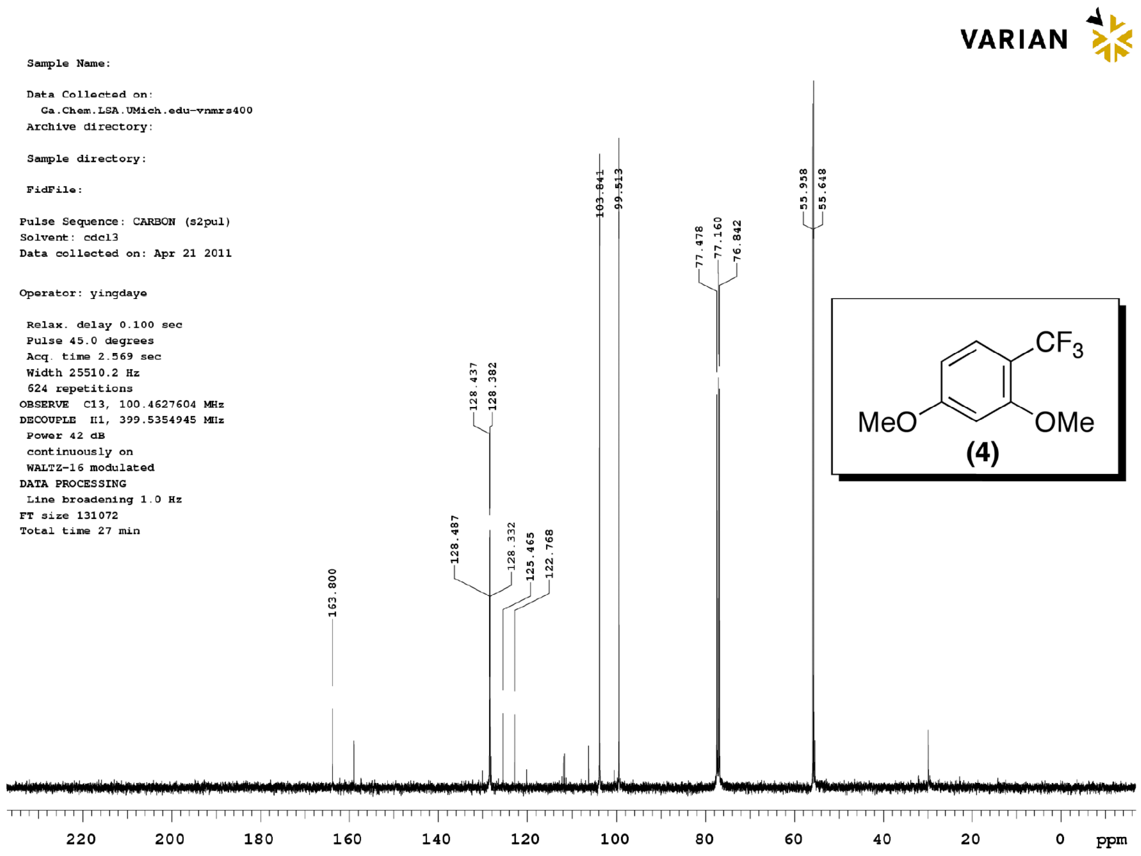
FT size 65536
Total time 0 min 40 sec

(4)



Sample Name:

Data Collected on:
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Archive directory:

Sample directory:

FidFile:

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Solvent: cdcl3
Data collected on: Apr 21 2011

Operator: yingdaye

Relax. delay 0.100 sec
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Acq. time 2.569 sec
Width 25510.2 Hz
624 repetitions
OBSERVE C13, 100.4627604 MHz
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FT size 131072
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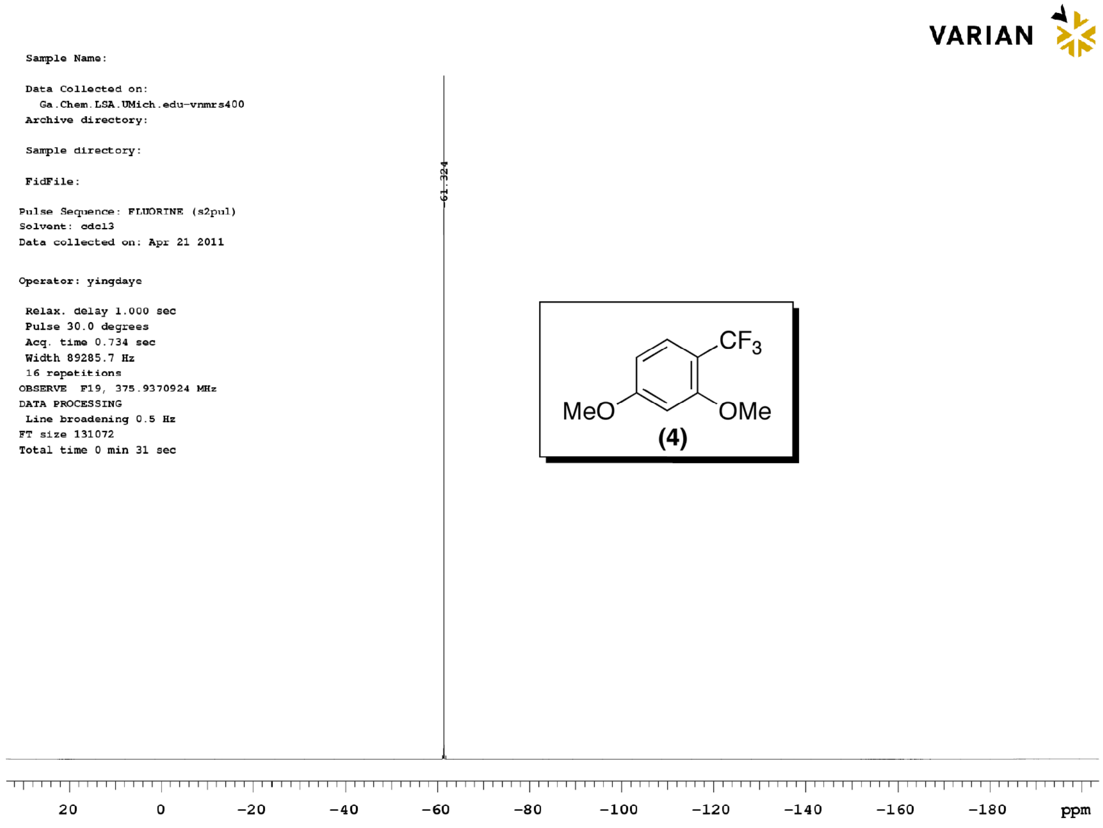

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Sample directory:

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Solvent: cdcl3
Data collected on: Apr 21 2011

Operator: yingdaye

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Width 89285.7 Hz
16 repetitions
OBSERVE F19, 375.9370924 MHz
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 0 min 31 sec

VARIAN

Sample Name:

Data Collected on:
Te.Chem.LSA.UMich.edu-vnmrs500
Archive directory:

Sample directory:

FidFile:

Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 27 2011

Temp. -10.0 C / 263.1 K
Operator: yingdaye

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Pulse 45.0 degrees
Acq. time 3.500 sec
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8 repetitions
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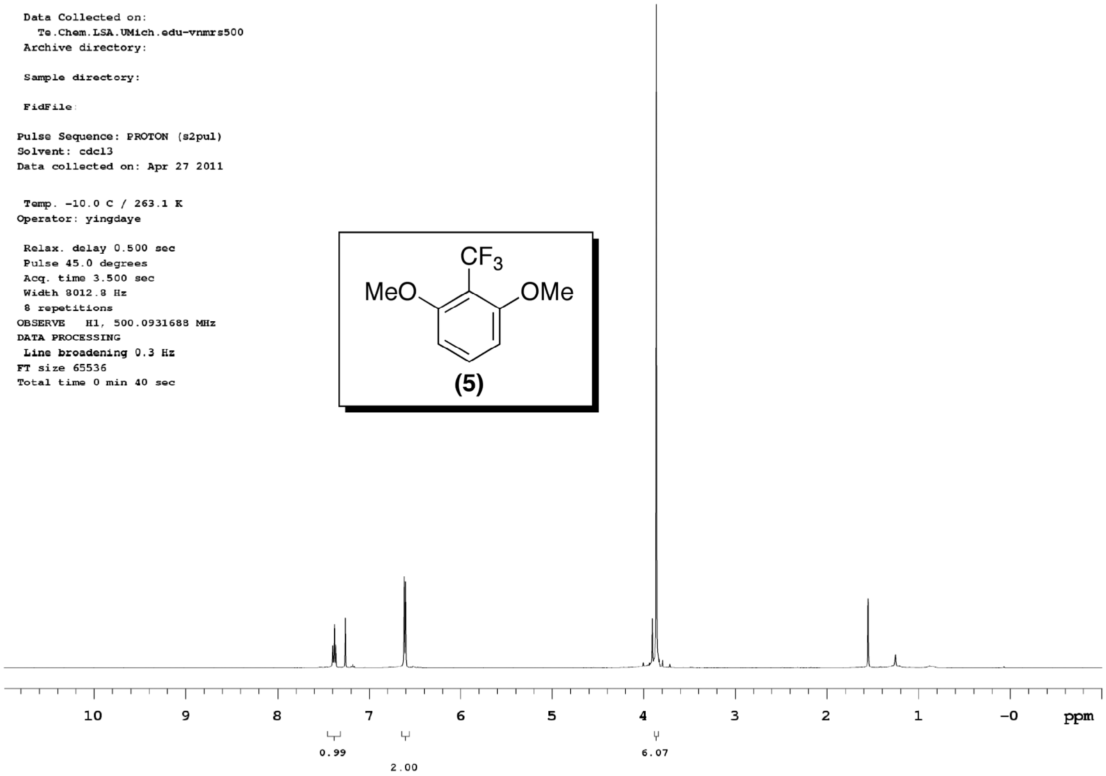
DATA PROCESSING
Line broadening 0.3 Hz
FT size 65536
Total time 0 min 40 sec



VARIAN

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Te.Chem.LSA.UMich.edu-vnmrs500
Archive directory:

Sample directory:

FidFile:

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Solvent: cdcl3
Data collected on: Apr 27 2011

Temp. -10.0 C / 263.1 K
Operator: yingdaye

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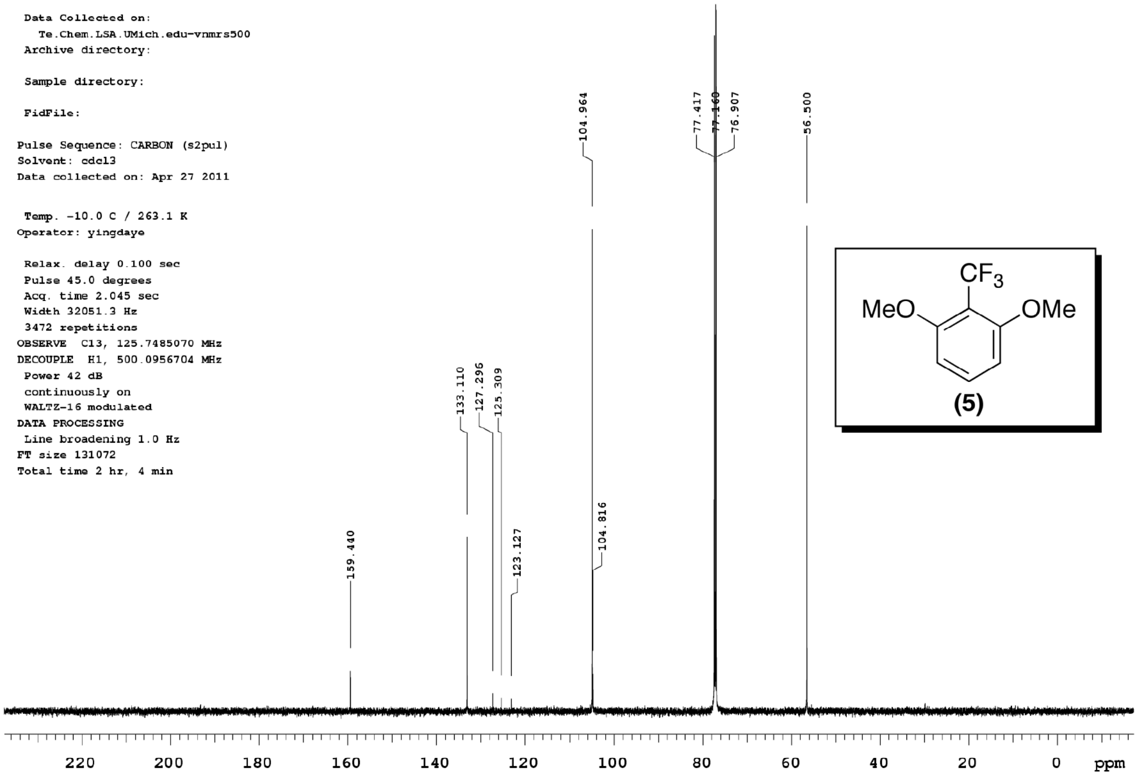
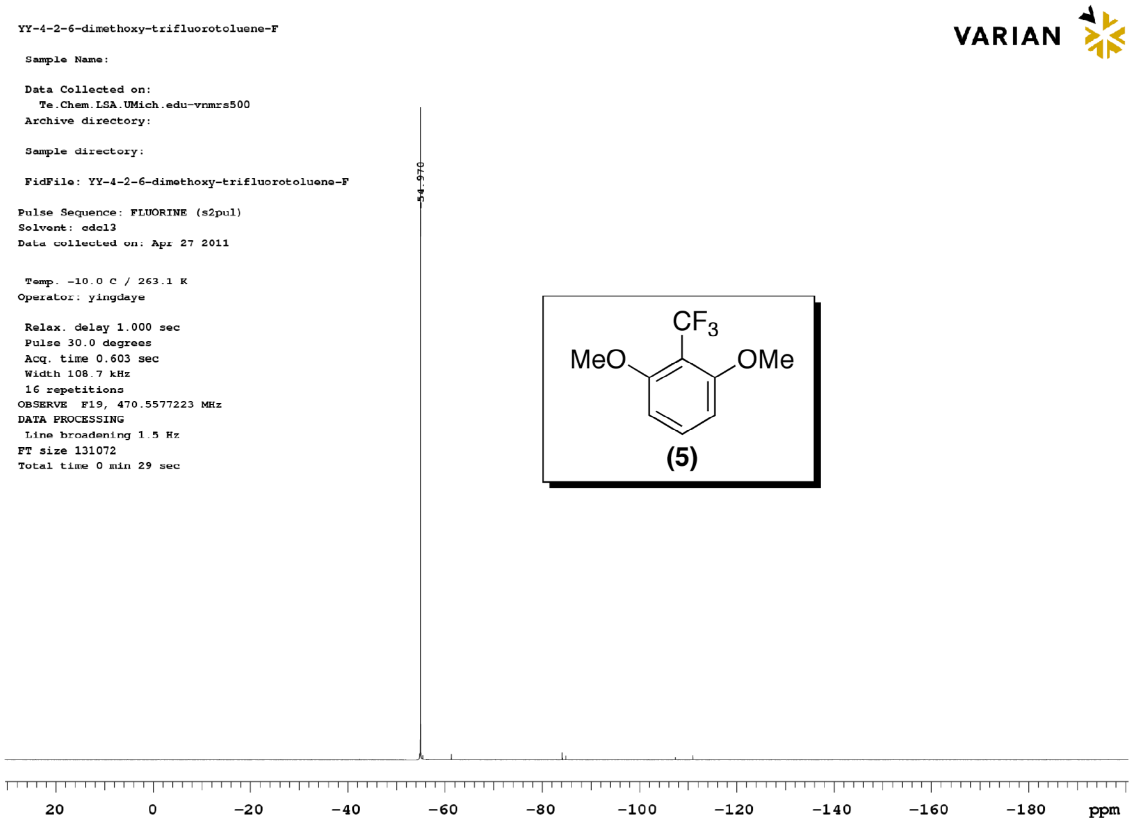
Pulse 45.0 degrees
Acq. time 2.045 sec
Width 32051.3 Hz
3472 repetitions
OBSERVE C13, 125.7485070 MHz
DECOUPLE H1, 500.0956704 MHz
Power 42 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 2 hr, 4 min

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YY-4-2-6-dimethoxy-trifluorotoluene-F

 Sample Name:

 Data Collected on:
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 Archive directory:

 Sample directory:

 FidFile: YY-4-2-6-dimethoxy-trifluorotoluene-F

Pulse Sequence: FLUORINE (s2pul)
Solvent: cdcl3
Data collected on: Apr 27 2011

 Temp. -10.0 C / 263.1 K
Operator: yingdaye

 Relax. delay 1.000 sec
 Pulse 30.0 degrees
 Acq. time 0.603 sec
 Width 108.7 kHz
 16 repetitions
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DATA PROCESSING
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FT size 131072
Total time 0 min 29 sec
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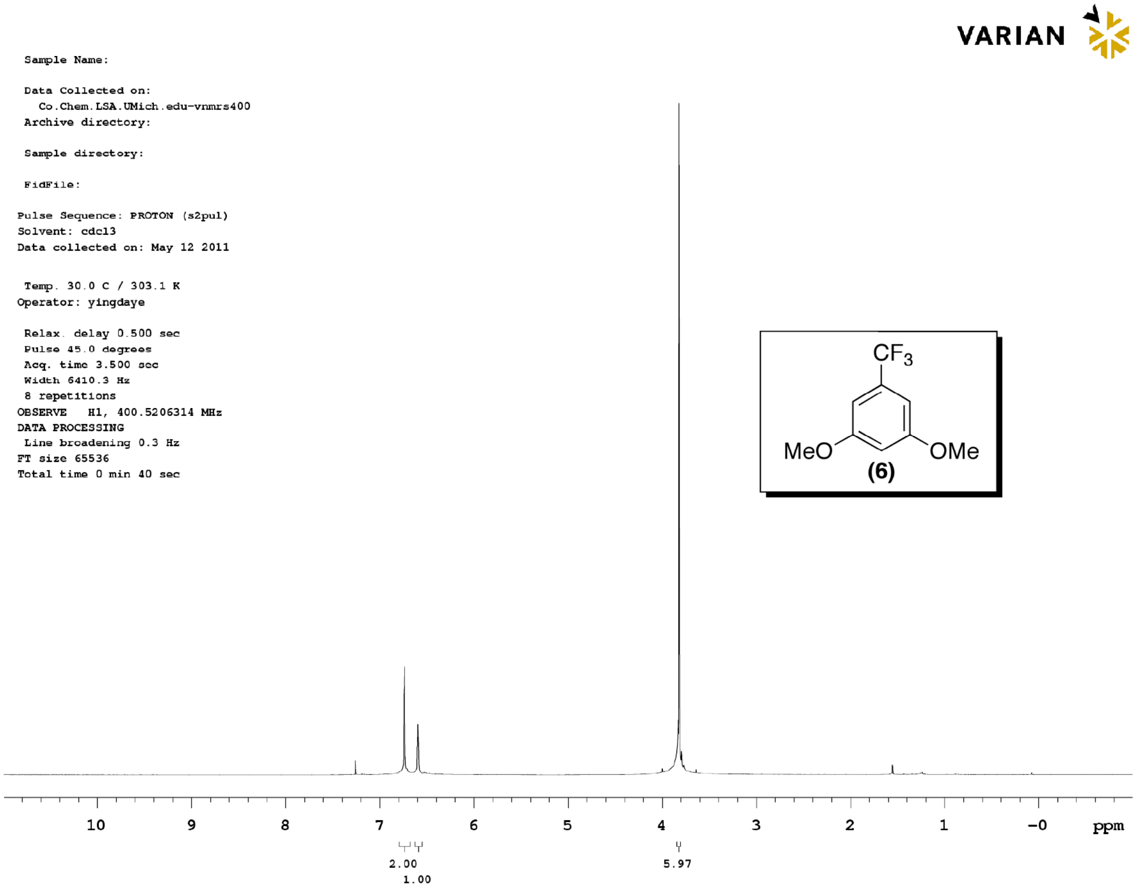
(5)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Archive directory:

Sample directory:

FidFile:

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Solvent: cdcl3
Data collected on: May 12 2011

 Temp. 30.0 C / 303.1 K
Operator: yingdaye

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 Pulse 45.0 degrees
 Acq. time 3.500 sec
 Width 6410.3 Hz
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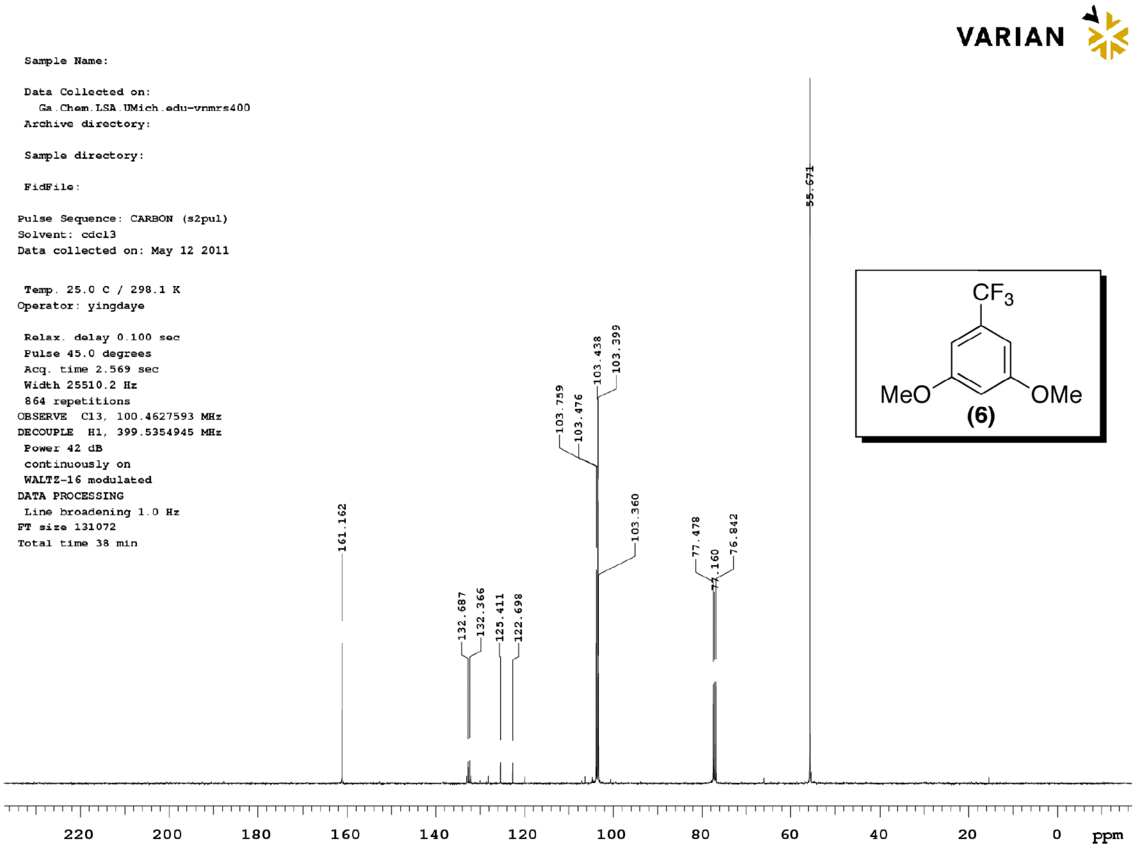
(6)



Sample Name:

Data Collected on:
Ga.Chem.LSA.UMich.edu-vnmrs400
Archive directory:

Sample directory:

FidFile:

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Solvent: cdcl3
Data collected on: May 12 2011

Temp. 25.0 C / 298.1 K
Operator: yingdaye

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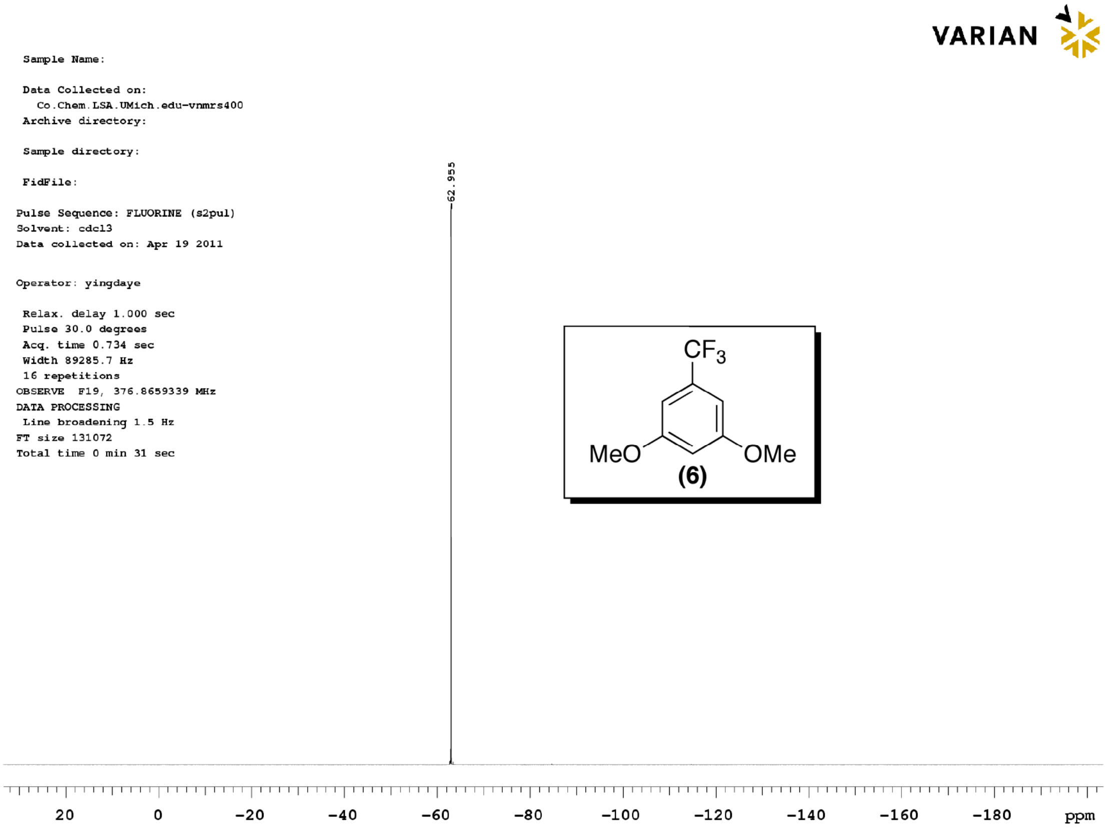
Pulse 45.0 degrees
Acq. time 2.569 sec
Width 25510.2 Hz
864 repetitions
OBSERVE C13, 100.4627593 MHz
DECOUPLE H1, 399.5354945 MHz
Power 42 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 38 min



Sample Name:

Data Collected on:
Co.Chem.LSA.UMich.edu-vnmrs400
Archive directory:

Sample directory:

FidFile:

Pulse Sequence: FLUORINE (s2pul)
Solvent: cdcl3
Data collected on: Apr 19 2011

Operator: yingdaye

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 0.734 sec
Width 89285.7 Hz
16 repetitions
OBSERVE F19, 376.8659339 MHz
DATA PROCESSING
Line broadening 1.5 Hz
FT size 131072
Total time 0 min 31 sec

Sample Name:

Data Collected on:
Sn.Chem.LSA.UMich.edu-inova500
Archive directory:

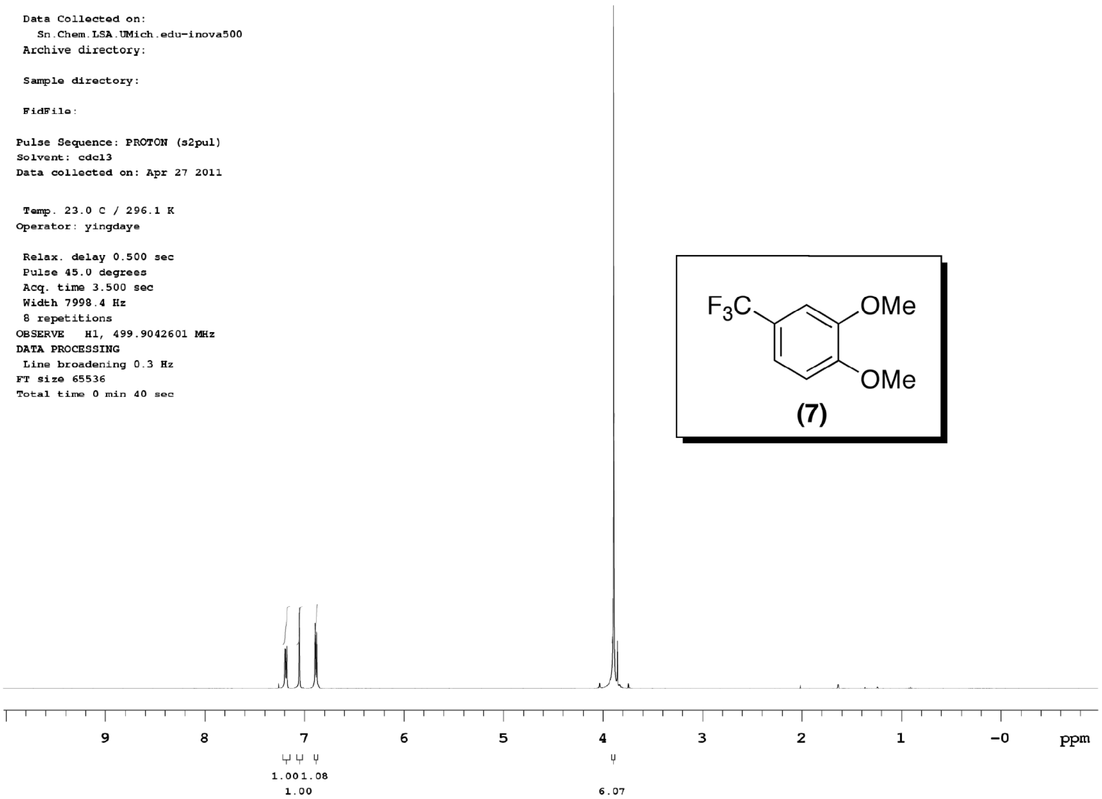
Sample directory:

FidFile:

Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 27 2011

Temp. 23.0 C / 296.1 K
Operator: yingdaye

Relax. delay 0.500 sec
Pulse 45.0 degrees
Acq. time 3.500 sec
Width 7998.4 Hz
8 repetitions
OBSERVE H1, 499.9042601 MHz
DATA PROCESSING
Line broadening 0.3 Hz
FT size 65536
Total time 0 min 40 sec



Sample Name:

Data Collected on:
Sn.Chem.LSA.UMich.edu-inova500
Archive directory:

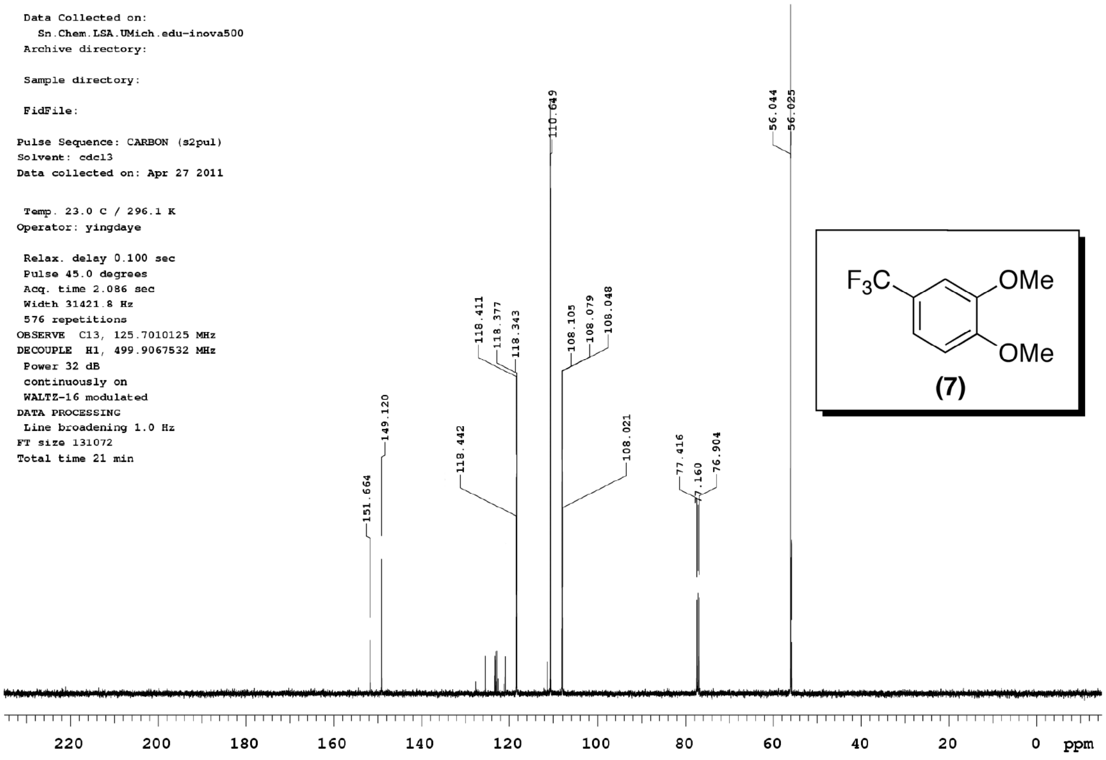
Sample directory:

FidFile:

Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Apr 27 2011

Temp. 23.0 C / 296.1 K
Operator: yingdaye

Relax. delay 0.100 sec
Pulse 45.0 degrees
Acq. time 2.086 sec
Width 31421.8 Hz
576 repetitions
OBSERVE C13, 125.7010125 MHz
DECOUPLE H1, 499.9067532 MHz
Power 32 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 21 min



VARIAN

Sample Name:

Data Collected on:
Co.Chem.LSA.UMich.edu-vnmrs400
Archive directory:

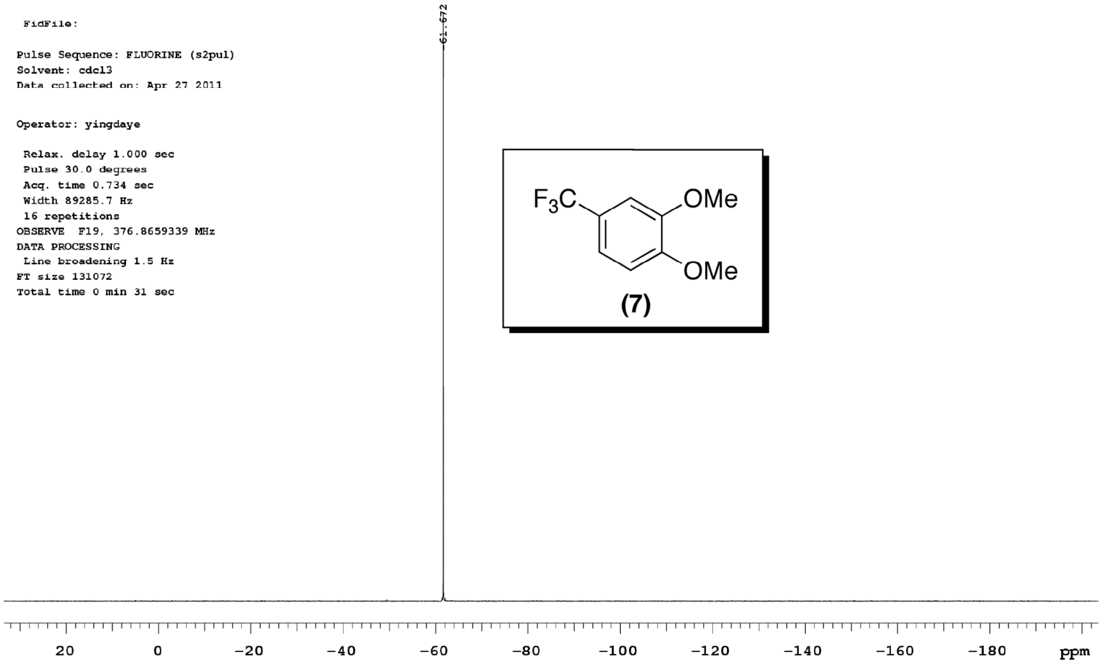
Sample directory:

FidFile:

Pulse Sequence: FLUORINE (s2pul)
Solvent: cdcl3
Data collected on: Apr 27 2011

Operator: yingdaye

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 0.734 sec
Width 89285.7 Hz
16 repetitions
OBSERVE F19, 376.8659339 MHz
DATA PROCESSING
Line broadening 1.5 Hz
FT size 131072
Total time 0 min 31 sec



(7)

VARIAN

Sample Name:

Data Collected on:
Te.Chem.LSA.UMich.edu-vnmrs500
Archive directory:

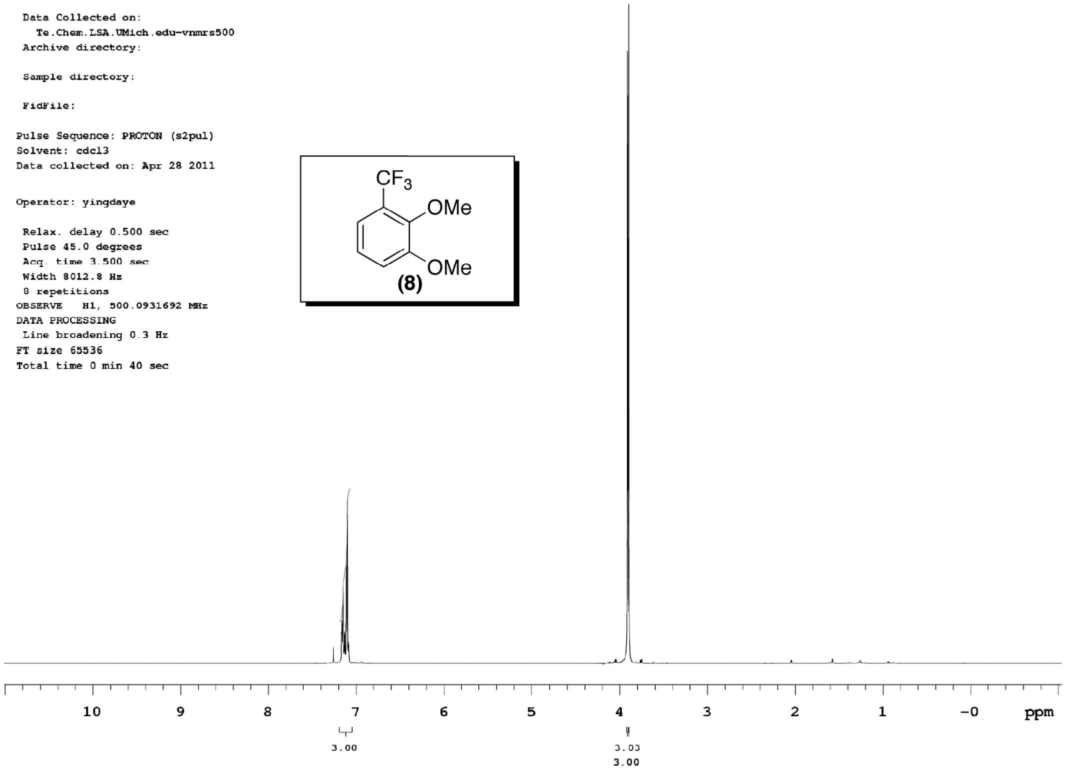
Sample directory:

FidFile:

Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 28 2011

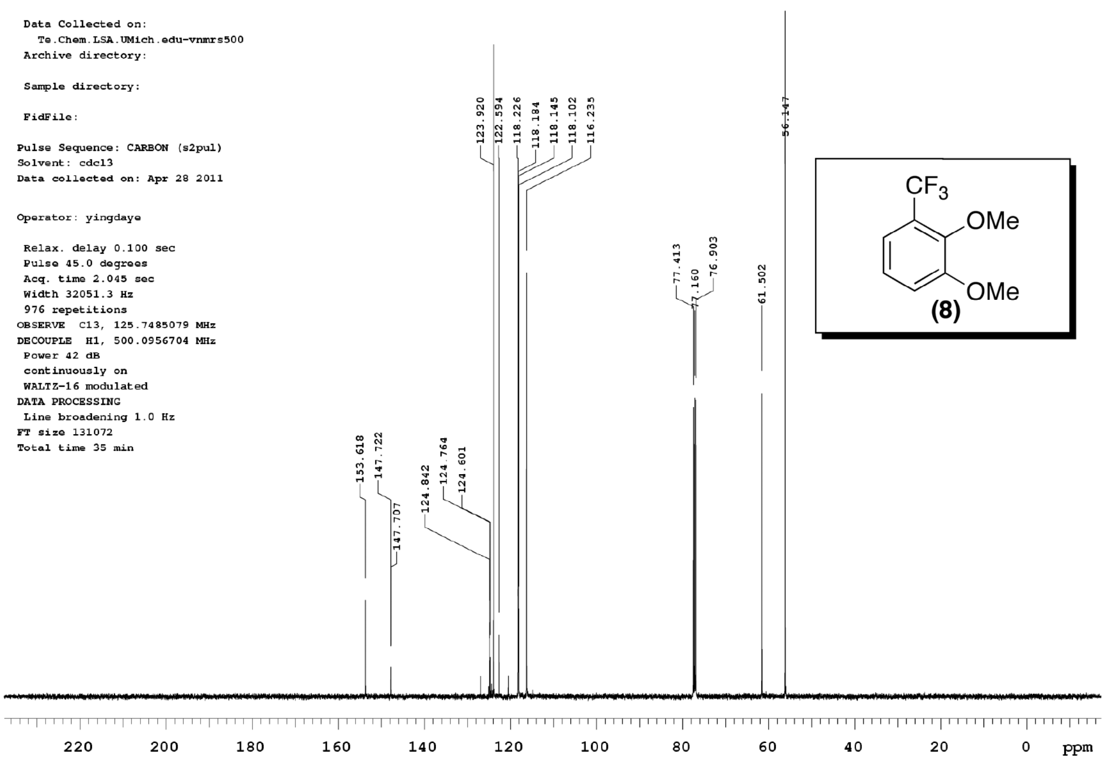
Operator: yingdaye

Relax. delay 0.500 sec
Pulse 45.0 degrees
Acq. time 3.500 sec
Width 8012.8 Hz
8 repetitions
OBSERVE H1, 500.0931692 MHz
DATA PROCESSING
Line broadening 0.3 Hz
FT size 65536
Total time 0 min 40 sec



(8)

VARIAN


Sample Name:

Data Collected on:
Te.Chem.LSA.UMich.edu-vnmrs500
Archive directory:

Sample directory:

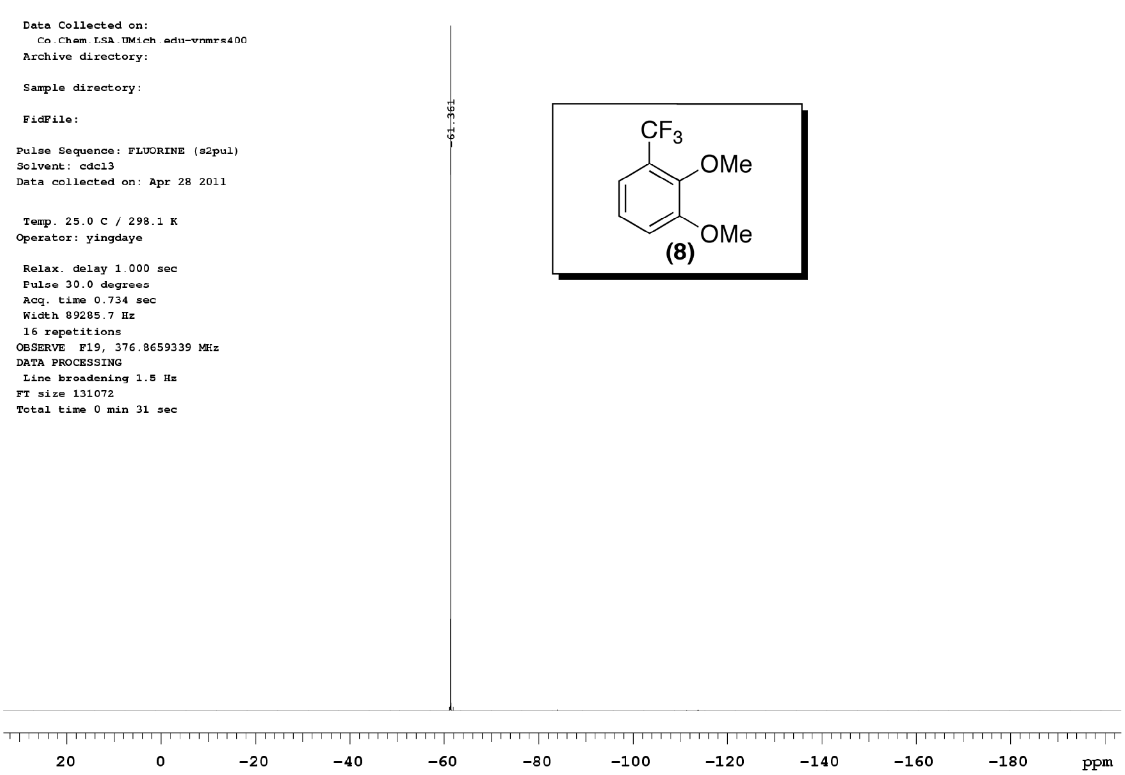
FidFile:

Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Apr 28 2011

Operator: yingdaye

Relax. delay 0.100 sec
Pulse 45.0 degrees
Acq. time 2.045 sec
Width 32051.3 Hz
976 repetitions
OBSERVE C13, 125.7485079 MHz
DECOUPLE H1, 500.0956704 MHz
Power 42 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 35 min

VARIAN


Sample Name:

Data Collected on:
Co.Chem.LSA.UMich.edu-vnmrs400
Archive directory:

Sample directory:

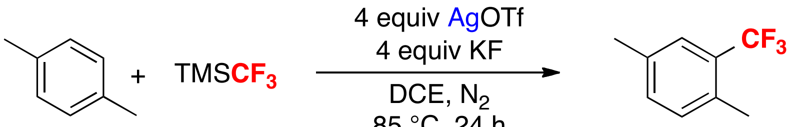
FidFile:

Pulse Sequence: FLUORINE (s2pul)
Solvent: cdcl3
Data collected on: Apr 28 2011

Temp. 25.0 C / 298.1 K
Operator: yingdaye

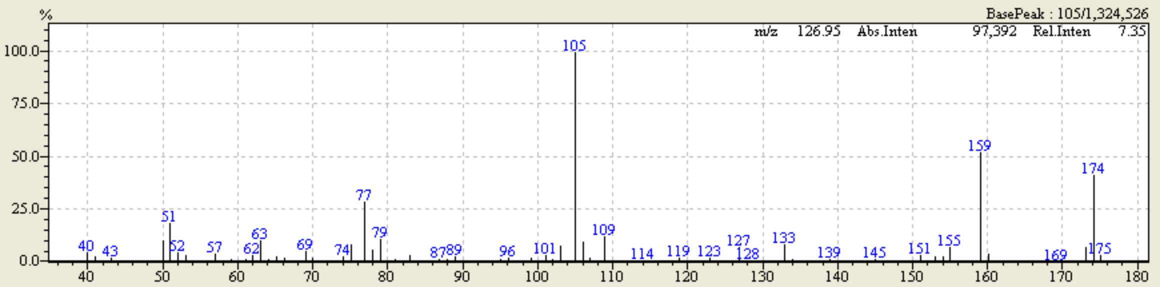
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 0.734 sec
Width 89285.7 Hz
16 repetitions
OBSERVE F19, 376.8659339 MHz
DATA PROCESSING
Line broadening 1.5 Hz
FT size 131072
Total time 0 min 31 sec

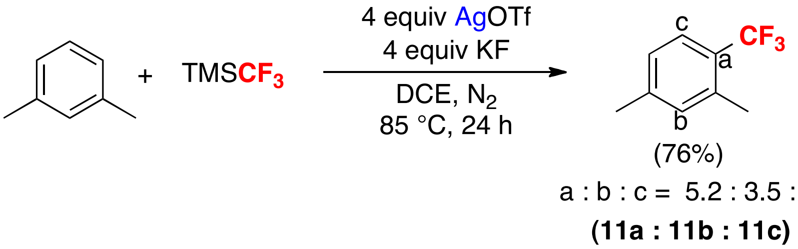
GCMS Data for Trifluoromethylation Reactions



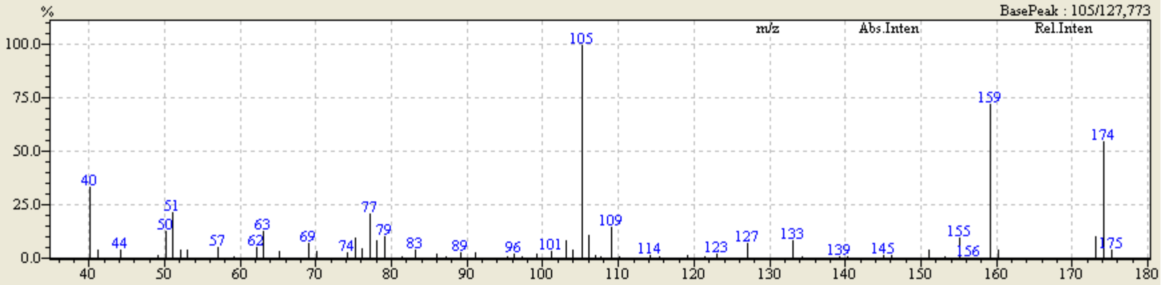
(10)
(76%)

Retention time: 11.8 min

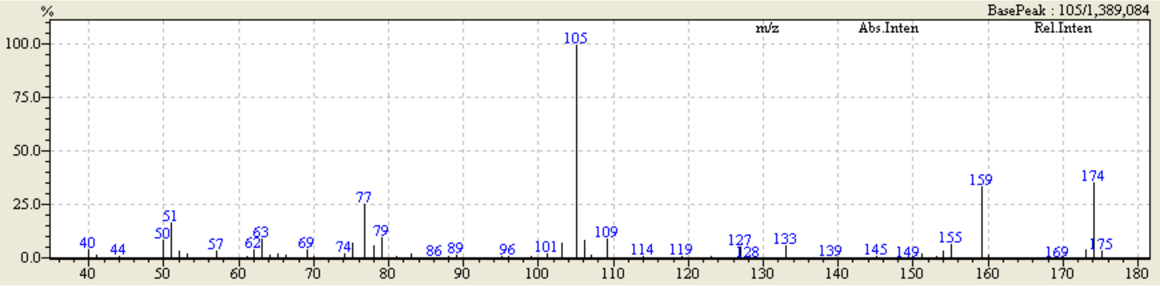




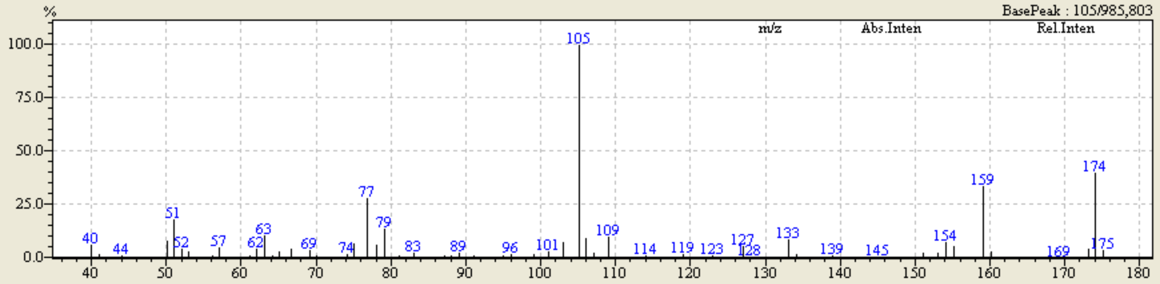
Retention time: 11.6 min

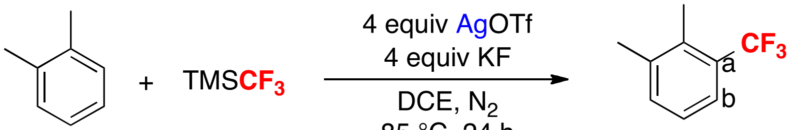


Retention time: 11.9 min



Retention time: 12.2 min



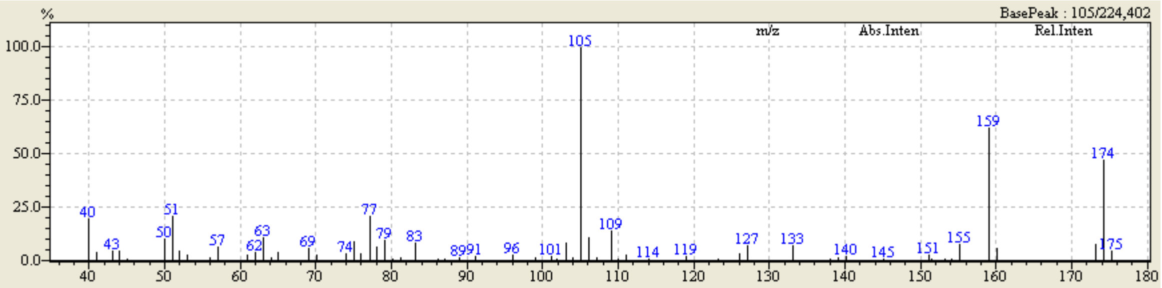


(65%)

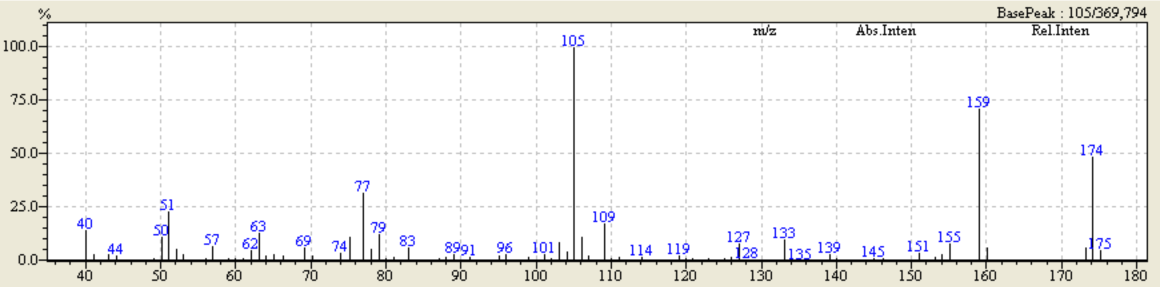
a : b = 1.4 : 1

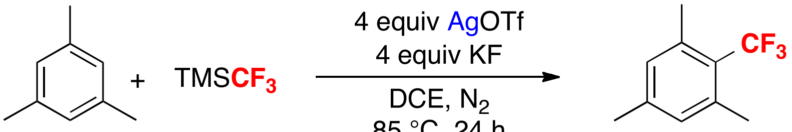
(12a : 12b)

Retention time: 12.3 min



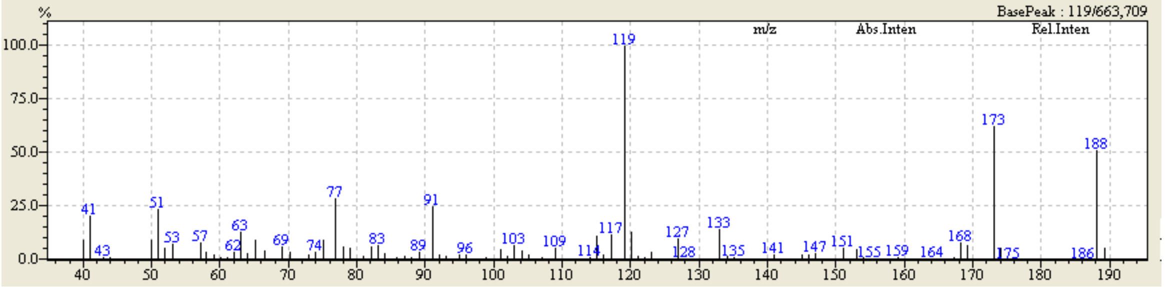
Retention time: 12.4 min

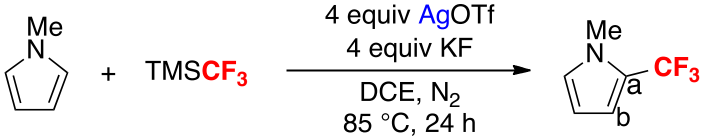




(13)
(78%)

Retention time: 14.0 min



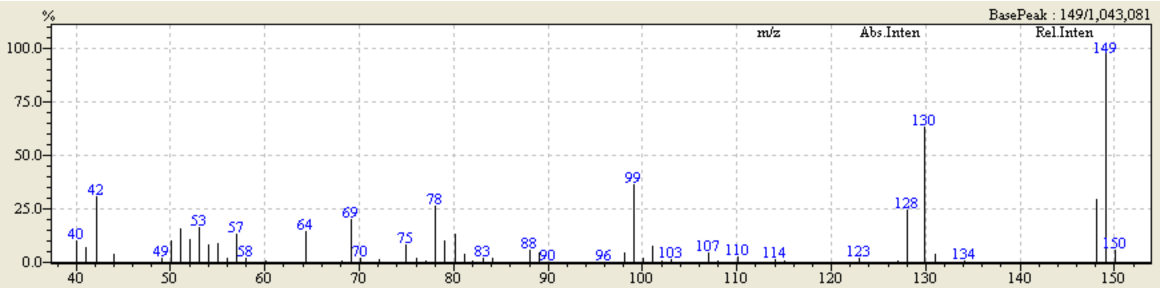


(44%)

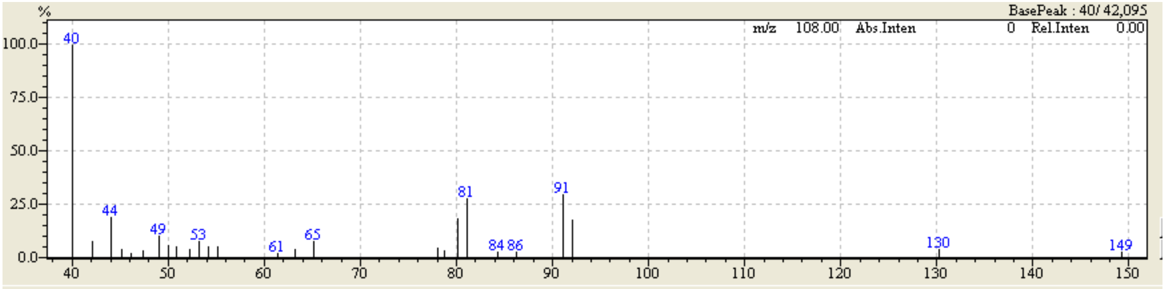
a : b = >20 : 1

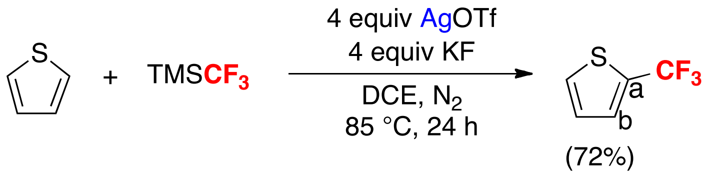
(15a : 15b)

Retention time: 3.7 min



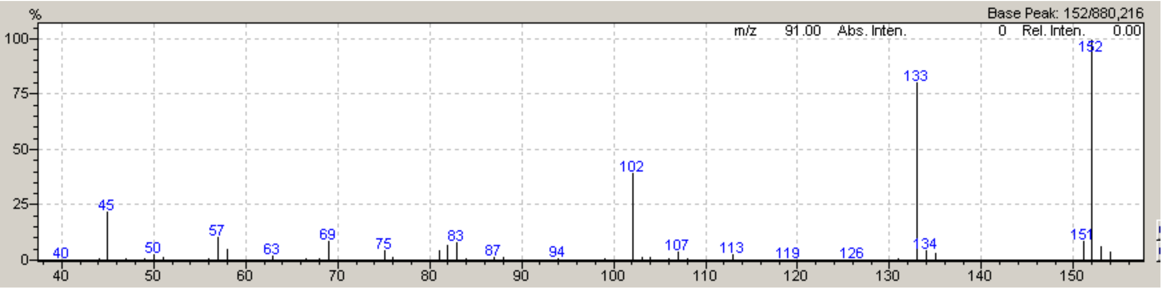
Retention time: 4.1 min



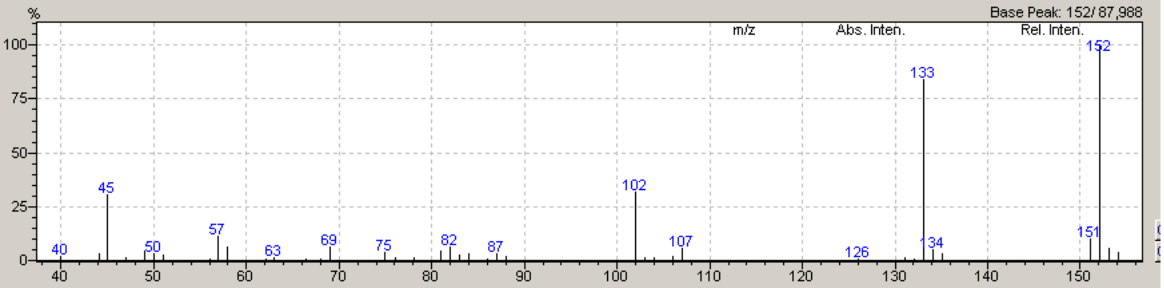


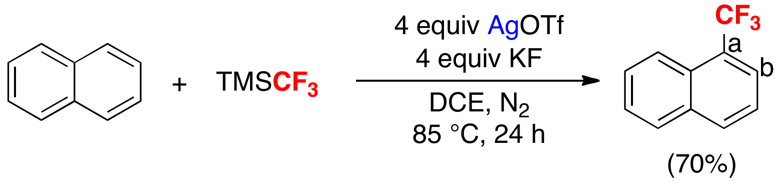
(72%)
a : b = 8 : 1
(16a : 16b)

Retention time: 3.3 min



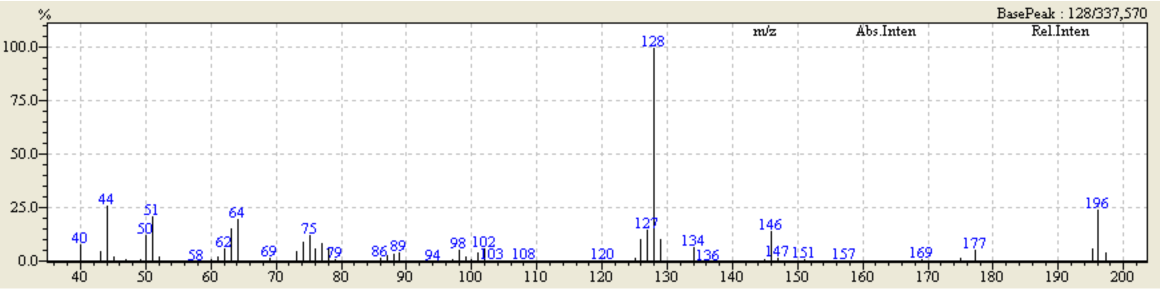
Retention time 3.5 min



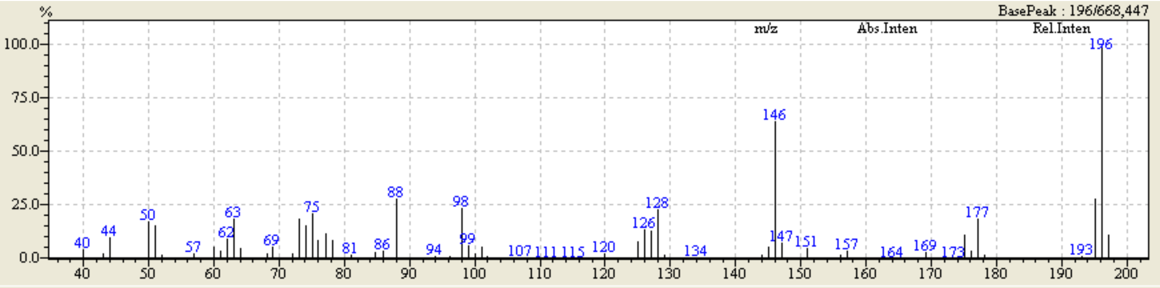


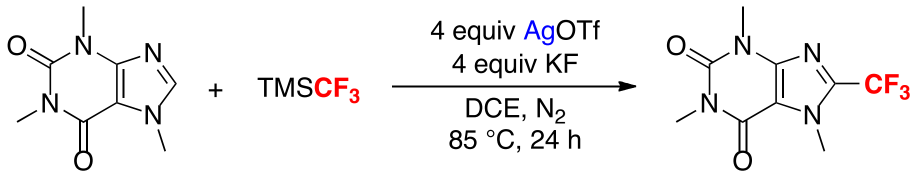
(70%)
a : b = 4.8 : 1
(17a : 17b)

Retention time: 15.7 min



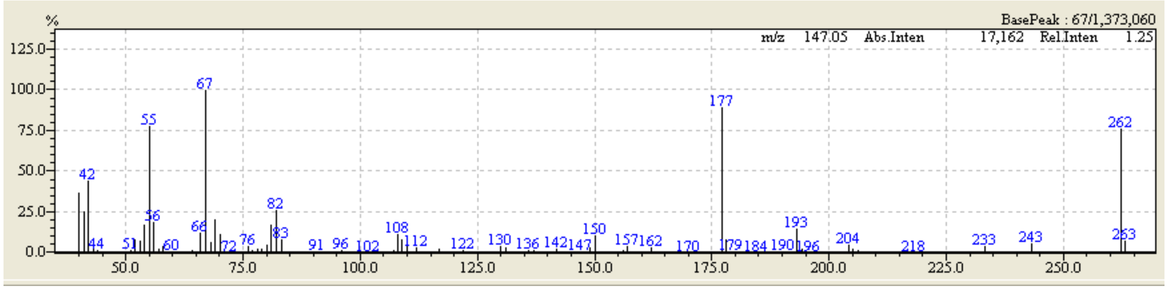
Retention time: 15.8 min

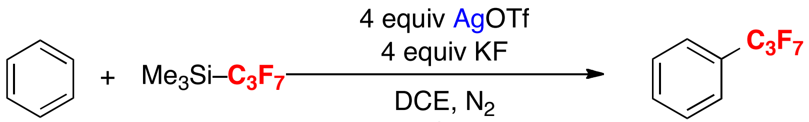




(18)
(42%)

Retention time: 6.5 min





(19)

(60%)

Retention time: 5.0 min