Copper-Catalyzed Synthesis of \(N\)-Aryl and \(N\)-Sulfonyl Indoles from 2-Vinylanilines with \(O_2\) as the Terminal Oxidant and TEMPO as Co-Catalyst

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General Information:

All reagents were used out of the bottle as purchased from the supplier without further purification unless otherwise noted. Substrates 1a,e,g were synthesized according to literature procedures.1 Achiral bis(oxazoline) ligand 3 was synthesized according to the procedure reported by Miao et. al.2 1H NMR spectra were recorded in CDCl3 (using 7.26 ppm as internal reference) at 300, 400 or 500 MHz. 13C NMR spectra were recorded in CDCl3 (using 77.0 ppm as internal reference) at 75 MHz unless otherwise noted. 19F NMR spectra were recorded in CDCl3 with α,α,α-trifluorotoluene as an internal reference. IR spectra were taken neat using a Nicolet-Impact 420 FTIR. Wave numbers in cm⁻¹ are reported for characteristic peaks. High resolution mass spectra were obtained at SUNY Buffalo’s mass spec. facility on a ThermoFinnigan MAT XL spectrometer. Melting points are reported as uncorrected.

Synthesis of Aniline Substrates:
Substrates 1b-d,f
Substrates 1b-d,f were synthesized by sulfonylation of the corresponding aniline.

\[
\text{N-(2-(Prop-1-en-2-yl)phenyl)-2-(trimethylsilyl)ethane-1-sulfonamide (1b)}
\]

The aniline (0.5 g, 3.75 mmol, 1 equiv) was dissolved in dry CH₂Cl₂ (7.5 mL, 0.5 M), and the solution was treated with sulfonyl chloride (0.79 g, 4.13 mmol, 1.1 equiv) and pyridine (0.91 mL, 11.3 mmol, 3 equiv). The mixture was stirred at room temperature for 24 h, diluted with H₂O (25 mL) and extracted with CH₂Cl₂ (3 x 25 mL). The combined organic layers were washed with 1M HCl, brine, dried over Na₂SO₄, and concentrated in vacuo. Flash chromatography of the resulting crude mixture on SiO₂ (0-30% EtOAc in hexanes gradient) afforded the sulfonamides in good yields. Substrate 1b was synthesized according to the above procedure using 2-isopropenylaniline and 2-(trimethylsilyl)ethanesulfonyl chloride. Sulfonamide 1b was obtained (0.33 g, 97%) as a yellow oil. 1H NMR (400 MHz, CDCl₃): δ 7.56 (d, J = 8.0 Hz, 1H), 7.25 (t, J = 7.2 Hz, 1H), 7.16 (d, J = 8.0 Hz, 1H), 7.08 (t, J = 7.2 Hz, 1H), 6.83 (bs, 1H), 5.42 (t, J = 1.6 Hz, 1H), 5.02 (t, J = 0.8 Hz, 1H), 2.08 (d, J = 1.6 Hz, 3H), 1.70 (s, 3H).

\[\text{3-Nitro-4-((2-(prop-1-en-2-yl)phenyl)amino)benzenesulfonic acid (1c)}\]

Substrate 1c was synthesized according to the above procedure using 2-isopropenylaniline and p-nitrobenzenesulfonyl chloride. The known sulfonamide 1c was obtained (0.48 g, 99%) as a yellow solid. 1H NMR (400 MHz, CDCl₃): δ 8.27 (d, J = 8 Hz, 2H), 7.94-7.91 (m, 2H), 7.61 (d, J = 8.4 Hz, 1H), 7.26 (t, J = 7.2 Hz, 1H), 7.13-7.04 (m, 2H), 5.28 (t, J = 1.6 Hz, 1H), 4.67 (s, 1H), 1.70 (s, 3H).
N-(2-(Prop-1-en-2-yl)phenyl)methanesulfonamide (1d)

Substrate 1d was synthesized according to the above procedure using 2-isopropenylaniline and methanesulfonyl chloride. The known sulfonamide 1d was obtained (0.3 g, 99%) as a colorless oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.59 (d, $J = 8.0$ Hz, 1H), 7.28 (t, $J = 8.0$ Hz, 1H), 7.18 (d, $J = 7.6$ Hz, 1H), 7.12 (t, $J = 7.6$ Hz, 1H), 6.85 (bs, 1H), 5.42-5.41 (m, 1H), 5.01-5.00 (m, 1H), 3.01 (s, 3H), 2.08-2.07 (m, 3H).

(E,Z)-4-Methyl-N-(2-(1-phenylprop-1-en-1-yl)phenyl)benzenesulfonamide (1f)

Substrate 1f was synthesized according to the above procedure using 2-(1-phenylprop-1-en-1-yl)aniline and p-toluenesulfonyl chloride. Sulfonamide 1f was obtained (0.14 g, 88%) as a colorless oil in a 3:2 Z:E ratio. Product characterized as a mixture of isomers. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.74 (d, $J = 7.6$ Hz, 1H), 7.57 (d, $J = 8.4$ Hz, 0.6H), 7.46 (d, $J = 8.8$ Hz, 2H), 7.37 (d, $J = 8.4$ Hz, 1.3H), 7.32-7.07 (m, 13H), 7.00-6.93 (m, 4H), 6.54 (bs, 1H), 6.42 (bs, 0.6H), 6.38 (q, $J = 7.2$ Hz, 1H), 5.42 (q, $J = 7.2$ Hz, 0.6H), 2.38 (s, 2H), 2.36 (s, 3H), 1.77 (d, $J = 6.8$ Hz, 2H), 1.47 (d, $J = 7.2$ Hz, 3H); $^{13}$C NMR (75 Hz, CDCl$_3$) $\delta$ 143.6, 143.5, 139.6, 138.1, 137.0, 136.1, 134.6, 134.0, 129.5, 129.4, 128.9, 128.7, 128.6, 127.7, 127.7, 127.4, 127.2, 127.2, 125.9, 124.9, 124.2, 121.7, 119.0, 21.5, 15.4, 15.3; IR (neat): 3326. 3057, 1491, 1396, 1336, 1166, 1090, 918, 760, 667 cm$^{-1}$; HRMS (ESI) calcd for [M+Na]$^+$ C$_{22}$H$_{21}$O$_2$NNaS: 386.1199, found: 386.1185.

Substrates 1h-j

Substrates 1h-j were synthesized using a procedure reported by Buchwald et al. The ArB(OH)$_2$ (0.28 g, 2.26 mmol, 1.2 equiv), Cu(OAc)$_2$ (0.07 g, 0.38 mmol, 0.2 equiv) and myristic acid (0.172 g, 0.75 mmol, 0.4 equiv) were dissolved in toluene (3.8 mL, 0.5M) in a 100 mL round bottom flask. The reaction was stirred and 2,6-lutidine (0.22 mL, 1.88 mmol, 1 equiv) and the corresponding aniline (0.26 mL, 1.88 mmol, 1 equiv) were added. The reaction was stirred at room temperature with the flask uncapped and open to air for 24 h. The reaction was filtered through a SiO$_2$ plug with ether (100 mL) and the filtrate was condensed. Crude mixtures were purified via flash chromatography on SiO$_2$ (0-10% Et$_2$O in hexanes gradient) to afford the anilines in high yields.

N-(4-Fluorophenyl)-2-(prop-1-en-2-yl)aniline (1h)

Substrate 1h was synthesized according to the above procedure using 2-isopropenylaniline and 4-fluorophenylboronic acid. Aniline 1h was obtained (0.22 g, 65%) as a yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.18-7.15 (m, 3H), 7.07-6.97 (m, 4H), 6.92-6.87 (m, 1H), 5.80 (bs, 1H), 5.32 (q, $J = 2.2$ Hz, 1H), 5.08 (t, $J = 1.6$ Hz, 1H), 2.09 (d, $J = 2.4$ Hz, 3H); $^{13}$C NMR (75 Hz,
CDCl$_3$ δ 158.1 (d, $J_{CF} = 239.3$), 143.8, 140.2, 139.3, 139.3, 132.8, 127.8, 120.7, 120.5 (d, $J_{CF} = 45.8$), 116.1, 116.0 (d, $J_{CF} = 5.7$ Hz), 115.7, 24.0; $^{19}$F NMR (282 MHz, CDCl$_3$): δ -123.1; IR (neat): 3407, 3076, 2968, 1575, 1508, 1450, 1310, 1218, 821, 757 cm$^{-1}$; HRMS (EI) calcd for [M]$^+$ C$_{15}$H$_{14}$FN: 227.1098, found: 227.1105.

N-(4-Methoxyphenyl)-2-(prop-1-en-2-yl)aniline (1i)$^7$
Substrate 1i was synthesized according to the above procedure using 2-isoproponylaniline and 4-methoxyphenylboronic acid. The known aniline 1i was obtained (0.18 g, 79%) as a yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): δ 7.12-7.01 (m, 5H), 6.88-6.79 (m, 3H), 5.74 (bs, 1H), 5.32 (s, 1H), 5.09 (s, 1H), 3.80 (s, 1H), 2.09 (s, 3H).

N-(4-methoxyphenyl)-2-vinylaniline (1j)$^7$
Substrate 1j was synthesized according to the above procedure using 2-vinylaniline and 4-methoxyphenylboronic acid. The known aniline 1j was obtained (0.24 g, 62%) as a yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): δ 7.41 (d, $J = 8$ Hz, 1H), 7.15 (t, $J = 6.8$ Hz, 1H), 7.04 (d, $J = 7.6$ Hz, 1H), 7.00-6.97 (m, 2H), 6.92-6.85 (m, 4H), 5.68 (dd, $J = 17.6$, 1.6 Hz, 1H), 5.41 (bs, 1H), 5.33 (dd, $J = 10.4$, 1.6 Hz, 1H), 3.80 (s, 3H).

Representative Procedure for the Cu(eh)$_2$ / TEMPO-Catalyzed Aerobic Intramolecular C-H Amination

3-Methyl-1-tosyl-1H-indole (2a)$^1$
To an oven dried 100 mL round bottom flask was charge with 1a (50 mg, 0.174 mmol, 1 equiv), Cu(eh)$_2$ (9 mg, 0.026 mmol, 0.15 equiv), TEMPO (5 mg, 0.035 mmol, 0.2 equiv) and toluene (1.74 mL, 0.1M). The flask was purged with O$_2$, put under an O$_2$ atmosphere using an O$_2$ balloon and stirred for 24 h at 120 °C. Filtration of the cooled reaction mixture through a pad of silica gel with ethyl acetate (100 mL), and subsequent evaporation of the solvent in vacuo afforded crude mixture. Flash chromatography of the resulting crude mixture on silica gel (0-20% ethyl acetate in hexanes gradient) afforded the known indole 2a (36 mg, 71% yield) as an off-white solid. $^1$H NMR (400 MHz, CDCl$_3$): δ 7.99 (d, $J = 8.4$ Hz, 1H), 7.74 (d, $J = 8.0$ Hz, 2H), 7.45 (d, $J = 7.2$ Hz, 1H), 7.34-7.29 (m, 2H), 7.26-7.22 (m, 1H), 7.19 (d, $J = 8.4$ Hz, 2H), 2.32 (s, 3H), 2.24 (d, $J = 0.8$ Hz, 3H).

3-Methyl-3-((2,2,6,6-tetramethylpiperidin-1-yl)peroxy)-1-tosylindoline (2aa)
The TEMPO-peroxide product 2aa was obtained (15 mg, 20% yield) as an off-white solid. $^1$H NMR (400 MHz, CDCl$_3$): δ 7.66-7.61 (m, 3H), 7.40 (t, $J = 7.2$ Hz, 1H), 7.32-7.22 (m, 5H), 6.98
(d, J = 8.1 Hz, 1H), 5.73 (d, J = 9.6 Hz, 1H), 4.81 (d, J = 9.6 Hz, 1H), 2.60 (s, 3H), 2.43 (s, 3H), 1.58-1.25 (m, 9H), 1.13 (s, 3H), 0.96 (s, 3H), 0.67 (s, 3H); $^{13}$C NMR (75 Hz, CDCl$_3$) δ 143.6, 141.4, 137.1, 136.1, 132.1, 130.8, 129.2, 128.9, 128.8, 128.2, 84.9, 59.9, 39.8, 33.0, 32.0, 30.0, 29.7, 21.6, 20.3, 20.2, 16.9; IR (neat): 2973, 2928, 2871, 1697, 1347, 1165, 1141, 1024, 869, 814, 686, 660 cm$^{-1}$; HRMS (ESI) calcd for [M+H]$^+$ C$_{25}$H$_{35}$O$_4$N$_2$S: 459.2312, found: 459.2301.

Possible Mechanistic Pathway to 2aa
The following scheme shows a possible rationale for product 2aa. After N-radical addition to the alkene (see Scheme 2 in manuscript), oxygen can trap the benzylic radical. Reduction by [Cu(I)] and protonation can give a peroxide intermediate that undergoes either Cu-catalyzed or thermal homolysis to an alkoxy radical that can then be trapped by TEMPO to yield 2aa.

3-Methyl-1-((2-(trimethylsilyl)ethyl)sulfonyl)-1H-indole (2b)
The indole 2b was obtained (27 mg, 55% yield) as a colorless oil. $^1$H NMR (400 MHz, CDCl$_3$): δ 7.87 (d, J = 7.6 Hz, 1H), 7.56 (d, J = 7.6 Hz, 1H), 7.35-7.30 (m, 2H), 7.21 (s, 1H), 3.15-3.10 (m, 2H), 2.30 (d, J = 1.2 Hz, 3H), 0.90-0.84 (m, 2H), -0.05 (s, 9H); $^{13}$C NMR (75 Hz, CDCl$_3$) δ 135.4, 131.5, 124.6, 123.6, 122.8, 119.5, 117.1, 113.1, 50.3, 9.9, 9.6, -2.2; IR (neat): 2954, 2922, 1448, 1365, 1273, 1252, 1174, 1158, 1121, 1001, 972, 860, 841, 756, 680 cm$^{-1}$; HRMS (EI) calcd for [M]$^+$ C$_{14}$H$_{21}$O$_2$NSSi: 295.1057, found: 295.1057.
3-Methyl-1-((4-nitrophenyl)sulfonyl)-1H-indole (2c)

The known indole 2c was obtained (25 mg, 51% yield) as a yellow solid. $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 8.24 (d, J = 9.0 Hz, 2H), 8.03-7.96 (m, 3H), 7.46 (d, J = 8.1 Hz, 1H), 7.37-7.28 (m, 3H), 2.25 (s, 3H).

3-Methyl-1-(methylsulfonyl)-1H-indole (2d)

The known indole 2d was obtained (25 mg, 50% yield) as a white solid. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.90 (d, J = 8.0 Hz, 1H), 7.56 (d, J = 7.6 Hz, 1H), 7.39-7.31 (m, 2H), 7.20 (s, 1H), 3.03 (s, 3H), 2.30 (s, 3H).

3-Phenyl-1-tosyl-1H-indole (2e)

The known indole 2e was obtained (36 mg, 73% yield) as a pale yellow solid. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.06 (d, J = 8.0 Hz, 1H), 7.82-7.77 (m, 3H), 7.70 (s, 1H), 7.61 (d, J = 8.0 Hz, 2H), 7.47 (t, J = 7.4 Hz, 2H), 7.39-7.35 (m, 2H), 7.30-7.22 (m, 3H), 2.34 (s, 3H).

2-Methyl-3-phenyl-1-tosyl-1H-indole (2f)

The known indole 2f was obtained (11 mg, 22% yield) from a 3:2 Z:E ratio of alkene isomers as an off-white solid. Obtained a 22% yield of unreacted (Z)-isomer after reaction. $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 8.26 (d, J = 8.1 Hz, 1H), 7.72 (d, J = 8.1 Hz, 2H), 7.46-7.19 (m, 10H), 2.60 (s, 3H), 2.37 (s, 3H).

When reaction was run with exclusively the (E)-isomer the product was obtained in a 43% yield. When the (Z)-isomer was run it was determined to be unreactive under the reaction conditions.
3-Methyl-1-phenyl-1H-indole (2g)

The known indole 2g was obtained (41 mg, 82% yield) as a yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.63 (d, J = 8.0 Hz, 1H), 7.56 (d, J = 7.6 Hz, 1H), 7.50-7.47 (m, 4H), 7.32-7.29 (m, 1H), 7.25-7.14 (m, 3H), 2.40 (d, J = 1.2 Hz, 3H)

1-(4-Fluorophenyl)-3-methyl-1H-indole (2h)

The known indole 2h was obtained (40 mg, 81% yield) as a yellow oil. $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.63 (d, J = 6.6 Hz, 1H), 7.47-7.41 (m, 3H), 7.25-7.16 (m, 4H), 7.08 (s, 1H), 2.40 (s, 3H).

1-(4-Methoxyphenyl)-3-methyl-1H-indole (2i)

The known indole 2i was obtained (42 mg, 85% yield) as a yellow oil. $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.62 (d, J = 7.2 Hz, 1H), 7.44 (d, J = 6.6 Hz, 1H), 7.39 (d, J = 7.2 Hz, 2H), 7.21-7.13 (m, 2H), 7.07 (s, 1H), 7.02 (d, J = 7.2 Hz, 2H), 3.88 (s, 3H), 2.39 (d, J = 1.2 Hz, 3H).

1-(4-Methoxyphenyl)-1H-indole (2j)

The known indole 2j was obtained (27 mg, 55% yield) as a yellow oil. $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.70 (d, J = 8.4 Hz, 1H), 7.47 (d, J = 8.4 Hz, 1H), 7.41 (d, J = 6.6 Hz, 2H), 7.29 (d, J = 3 Hz, 1H), 7.22-7.15 (m, 2H), 7.04 (d, J = 6.9 Hz, 2H), 6.67 (d, J = 2.4 Hz, 1H), 3.89 (s, 3H).
Representative Procedure for the One-Pot Chan-Lam Coupling / C-H Amination

3-Methyl-1-phenyl-1H-indole (2g)

PhB(OH)$_2$ (0.15 g, 1.2 mmol, 1.2 equiv), Cu(OAc)$_2$ (0.036 g, 0.2 mmol, 0.2 equiv) and myristic acid (0.091 g, 0.4 mmol, 0.4 equiv) were dissolved in toluene (2 mL, 0.5M). The reaction was stirred, 2,6-lutidine (0.12 mL, 1 mmol, 1 equiv) and 2-isopropylaniline (0.14 mL, 1 mmol, 1 equiv) were added. The reaction was stirred at room temperature exposed to air for 24 h. TEMPO (0.031 g, 0.2 mmol, 0.2 equiv) and toluene (8 mL, 0.1M overall) were then added. The flask was purged with O$_2$, put under an O$_2$ atmosphere using an O$_2$ balloon and stirred for 24 h at 120 ℃. Filtration of the cooled reaction mixture through a pad of silica gel with ethyl acetate (100 mL), and subsequent evaporation of the solvent in vacuo afforded crude mixtures. Flash chromatography of the resulting crude mixture on silica gel (0-5% diethyl ether in hexanes gradient) afforded the known indole 2g (0.11 g, 53% yield) as a yellow liquid.

3-Methyl-1-(p-tolyl)-1H-indole (1k)

The known indole 2k was obtained (0.12 g, 54% yield) as a yellow oil from the one-pot reaction using p-tolylboronic acid. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.63 (d, J = 7.2 Hz, 1H), 7.52 (d, J = 8.0 Hz, 1H), 7.37 (d, J = 8.4 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H), 7.24-7.15 (m, 2H), 7.12 (s, 1H), 2.43 (s, 3H), 2.39 (d, J = 1.2 Hz, 3H).

3-Methyl-1-(4-(trifluoromethoxy)phenyl)-1H-indole (2l)

The indole 2l was obtained (0.12 g, 42% yield) as a yellow oil from the one-pot reaction using 4-(trifluoromethoxy)phenyl boronic acid. $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.63 (d, J = 7.8 Hz, 1H),
7.54-7.49 (m, 3H), 7.35 (d, \(J = 8.7\) Hz, 2H), 7.27-7.17 (m, 2H), 7.10 (s, 1H), 2.39 (s, 3H); \(^{13}\)C NMR (75 Hz, CDCl\(_3\)) \(\delta\) 146.7, 138.6, 135.9, 129.9, 125.2, 125.0, 122.7, 122.3, 120.1, 119.3, 118.8, 113.4, 110.1, 110.0, 9.5; \(^{19}\)F NMR (282 MHz, CDCl\(_3\)) \(\delta\) -59.0; IR (neat):2922, 1607, 1513, 1457, 1260, 1222, 1167, 740 cm\(^{-1}\); HRMS (EI) calcd for [M]\(^+\) C\(_{16}H_{12}F_3ON: 291.0856, \)found: 291.0866.

**1',3-Dimethyl-1'H-1,5'-biindole (2m)**

The indole 2m was obtained (0.1 g, 39% yield) as a brownish solid from the one-pot reaction using N-methylindole-5-boronic acid. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.69 (d, \(J = 2.0\) Hz, 1H), 7.66-7.63 (m, 1H), 7.51-7.49 (m, 1H), 7.42 (d, \(J = 8.8\) Hz, 1H), 7.35-7.32 (m, 1H), 7.20-7.15 (m, 4H), 6.54 (dd, \(J = 2.8, 0.8\) Hz, 1H), 3.86 (s, 3H), 2.42 (d, \(J = 1.2\) Hz, 3H); \(^{13}\)C NMR (75 Hz, CDCl\(_3\)) \(\delta\) 136.9, 135.2, 132.3, 130.2, 129.2, 128.8, 126.6, 121.9, 119.2, 119.2, 118.9, 116.8, 111.5, 110.4, 109.8, 101.2, 33.0, 9.6; IR (neat): 3048, 2914, 1572, 1497, 1458, 1350, 1236, 801, 757, 740, 722 cm\(^{-1}\); HRMS (EI) calcd for [M]\(^+\) C\(_{18}H_{16}N_2: 260.1305, \)found: 260.1308.

**References**

$^1$H and $^{13}$C Spectra

twl-3-21pp
Sample Name:
Data Collected on:
mar208.chem.berkeley.edu-mercury208
Archive directory:
Sample directory:
Field: PROTON
Pulse Sequence: PROTON (2p0p)
Solvent: DMSO
Data collected on: May 13 2014
Temp. 29.6 °C / 298.1 K
Operator: Chealer
Relax. delay 1.000 sec
Pulse 45.0 degrees
Acc. time 1.700 sec
Ex. time 0.020 sec
888 repetitions
Observ. H 399.073846 MHz
FID time 15.0 sec
Total time 0 min 23 sec

$^{13}$C Spectra

twl-3-10 carbon
Sample Name:
Data Collected on:
mar208.chem.berkeley.edu-mercury208
Archive directory:
Sample directory:
Field: CARBON
Pulse Sequence: CARBON (2p0p)
Solvent: DMSO
Data collected on: May 13 2014
Temp. 29.5 °C / 298.6 K
Operator: Chealer
Relax. delay 1.000 sec
Pulse 45.0 degrees
Acc. time 1.700 sec
Ex. time 0.020 sec
888 repetitions
Observ. H 399.073846 MHz
DECOUPLER H 399.073846 MHz
Proton decoupler
WALTZ-16 modulated
DATA PROCESSING
FID time 15.0 sec
Total time 0 min 23 sec
TEMPO-capture product

Sample Name:
Data Collected on: cmm.caehe.srlab.sfu.ca
Archive directory:
Sample directory:

File: PROTON
Pulse Sequence: PROTON (52ps)
Sweep width: 7000 Hz
Data collected on: Jun 23 2016

Temp: 25.6 °C / 298.1 K
Operator: Chantal
Relax delay: 1.000 sec
Pulse 90.0 degree
Acc. time 1.706 sec
Widt 3000.12 Hz
Shift value: 6.000 ppm

Spectrum:

TEMPA-capture product

Sample Name:
Data Collected on: cmm.caehe.srlab.sfu.ca
Archive directory:
Sample directory:

File: CARBON
Pulse Sequence: CARBON (52ps)
Sweep width: 7000 Hz
Data collected on: Jun 24 2016

Temp: 29.7 °C / 296.9 K
Operator: Chantal
Relax delay: 1.000 sec
Pulse 90.0 degree
Acc. time 1.706 sec
Widt 3000.12 Hz
Shift value: 6.000 ppm

Spectrum: