Direct Synthesis of Quinazolines through Copper-Catalyzed Reaction of Aniline-Derived Benzamidines

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Experimental Section

General Methods. IR spectra were determined on a JASCO FT/IR-4100 spectrometer. Exact mass (HRMS) spectra were recorded on JMS-HX/HX 110A mass spectrometer. ^{1}H NMR spectra were recorded using a JEOL AL-500 spectrometer at 500 MHz frequency. Chemical shifts are reported in δ (ppm) relative to Me_4Si (in $CDCl_3$) as internal standard. ^{13}C NMR spectra were recorded using a JEOL AL-500 and referenced to the residual $CHCl_3$ signal. Melting points were measured by a hot stage melting points apparatus (uncorrected). For column chromatography, Wakosil C-300 was employed.

5-Fluoro-2-iodobenzoic acid and **1a** is commercially available.
5-Methyl-2-iodosylbenzoic acid,[1] 5-nitro-2-iodosylbenzoic acid,[1] compounds **1b**,[2] **1c**,[3] **1d**,[4] **1e**,[5] **1f**,[6] **1g**,[6] **1j**,[7] **1l**,[6] **1m**,[8] **2a**,[9] **2b**,[10] and **2c-f**[11] were prepared according to the literatures.
Compounds **1h**, **1i**, **1k**,[12] 5-nitro2-iodobenzoic acid,[13] and **2g–i**[11] were synthesized based on the reported procedures for synthesis of related compounds.

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General Procedure for Synthesis of *N*-Phenylbenzamidine: *N*-(4-*tert*-Butylphenyl)benzamidine (1h). The mixture of 4-(*t*-butyl)aniline (1.85 mL, 11.6 mmol), benzonitrile (1.00 g, 9.70 mmol), and $AlCl_3$ (1.27 g, 9.70 mmol) in a pressure flask was reacted at 120 °C for 45 min, and then taken out of the oil bath. Ice water was added to the vigorously stirred hot mixture. After aqueous saturated NaOH was added to this mixture until the pH reached 14, it was extracted with $CHCl_3$ (3 times). The extract was dried over $MgSO_4$ and concentrated under reduced pressure. The

residue was recrystallized from $CHCl_3$–hexane to give pure **1h** (1.79 g, 71% from benzonitrile): colorless crystals: 174–176 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.33 (s, 9H, CMe_3), 4.85 (br s, 2H, 2 × NH), 6.92 (d, *J* = 8.0 Hz, 2H, Ar), 7.36 (d, *J* = 8.0 Hz, 2H, Ar), 7.41-7.47 (m, 3H, Ar), 7.87 (d, *J* = 6.3 Hz, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 31.5 (3C), 34.2, 121.0 (2C), 126.3 (2C), 126.7 (2C), 128.5 (2C), 130.4, 136.0, 145.6, 147.0, 154.6. *Anal.* Calcd for $C_{17}H_{20}BrN_2$: C, 80.91; H, 7.99; N, 11.10. Found: C, 81.00; H, 7.93; N, 11.03.

***N*-(3-Bromophenyl)benzamidine (1i).** By a procedure described for the preparation of amidine **1h**, benzonitrile (1 g, 9.70 mmol) was converted into **1i** (1.24 g, 47% from benzonitrile) by the reaction with 3-bromoaniline (1.27 mL, 11.6 mmol): colorless crystals; mp 123–125 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.90 (br s, 2H, 2 × NH), 6.90 (d, *J* = 6.9 Hz, 1H, Ar), 7.15-7.22 (m, 3H, Ar), 7.42-7.50 (m, 3H, Ar), 7.82 (d, *J* = 5.7 Hz, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 120.5, 123.0, 124.7, 126.0, 126.8 (2C), 128.6 (2C), 130.81, 130.83, 135.3, 151.2, 155.2. *Anal.* Calcd for $C_{13}H_{11}BrN_2$: C, 56.75; H, 4.03; N, 10.18. Found: C, 56.75; H, 4.06; N, 10.10.

***N*-Phenyl-4-(trifluoromethyl)benzamidine (1k)** By a procedure described for the preparation of amidine **1h**, 4-(trifluoromethyl)benzonitrile (1.30 mL, 9.70 mmol) was converted into **1k** [1.24 g, 48% from 4-(trifluoromethyl)benzonitrile] by the reaction with aniline (1.06 mL, 11.6 mmol): colorless crystals; mp 157–159 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.89 (br s, 2H, 2 × NH), 6.98 (d, *J* = 7.4 Hz, 2H, Ar), 7.09 (t, *J* = 7.4 Hz, 1H, Ar), 7.37 (dd, *J* = 7.4, 7.4 Hz, 2H, Ar), 7.70 (d, *J* = 8.0 Hz, 2H, Ar), 7.99 (d, *J* = 8.0 Hz, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 121.3 (2C), 122.8, 123.8 (q, *J* = 272.3 Hz), 125.5 (q, *J* = 3.6 Hz, 2C), 127.2 (2C), 129.6 (2C), 132.4 (q, *J* = 32.4 Hz), 139.2, 149.3, 153.3. *Anal.* Calcd for $C_{14}H_{11}F_3N_2$: C, 66.63; H, 4.20; N, 10.60. Found: C, 63.38; H, 4.17; N, 10.56.

General Procedure for Synthesis of 5-Methyl-1-[(triisopropylsilyl)ethynyl]-1*H*-1λ^3-benzo[*d*][1,2]iodoxol-3-one (2g). To the stirred suspension of 5-methyl-2-iodosylbenzoic acid (1.05 g, 3.79 mmol) in CH_3CN was added dropwise trimethylsilyltriflate (0.75 mL, 4.17 mmol) at room temperature under argon. After (trimethylsilyl)(triisopropylsilyl)acetylene (1.06 mL, 4.17 mmol) was added dropwise to the reaction mixture at room temperature, it was stirred at this temperature for 15 min. Then pyridine (0.34 mL, 4.17 mmol) was added dropwise. After 20 min, the solvent was removed under reduced pressure. The residue was extracted with CH_2Cl_2, washed with 1 N HCl and aqueous saturated $NaHCO_3$, and dried over $MgSO_4$. Concentration under reduced pressure gave an yellow solid, which was recrystallized from CH_3CN to give **2g** (1.0 g, 59%) as colorless crystals: mp 189–191 °C; IR (neat) 1619 (CO) cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.09-1.22 (m, 21H, 3 × *i*-Pr), 2.52 (s, 3H, CMe), 7.59 (dd, *J* = 8.6, 2.0 Hz, 1H, Ar), 8.13 (d, *J* = 8.6 Hz, 1H, Ar), 8.24 (d, *J* = 2.0 Hz, 1H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.2 (3C), 18.5 (6C), 20.7, 64.6, 111.8, 113.8, 125.8, 131.2, 133.0, 135.6, 142.5, 166.6. *Anal.* Calcd for $C_{19}H_{27}IO_2Si$: C, 51.58; H, 6.15. Found: C, 51.34; H, 6.00.

5-Fluoro-1-[(triisopropylsilyl)ethynyl]-1*H*-1λ^3-benzo[*d*][1,2]iodoxol-3-one (2h). A mixture of 5-fluoro-2-iodobenzoinc acid (1.0 g, 3.76 mmol) and $NaIO_4$ (0.84 g, 3.95 mmol) in 30% (v/v) aqueous AcOH (7 mL) was stirred under reflux for 4 h. The mixture was diluted with cold water (20 mL). The precipitate was collected by filtration, washed with ice water and acetone, and air-dried in the dark to give 5-fluoro-2-iodosylbenzoic acid (1.01 g, 94%), which was used without further purification. To the stirred suspension of 5-fluoro-2-iodosylbenzoic acid (0.5 g, 1.77 mmol) in CH_3CN was added dropwise trimethylsilyltriflate (0.34 mL, 1.95 mmol) at room temperature under argon. After (trimethylsilyl)(triisopropylsilyl)acetylene (0.50 mL, 1.95 mmol) was added dropwise to the reaction mixture at room temperature, it was stirred at room temperature for 15 min. Then pyridine (0.16 mL, 1.95 mmol) was added dropwise. After 20 min, the solvent was removed under reduced pressure. The residue was extracted with CH_2Cl_2, washed with 1 N HCl and aqueous saturated $NaHCO_3$, and dried over $MgSO_4$. Concentration under reduced pressure gave an yellow solid, which was recrystallized from CH_3CN to give **2h** (0.59 g, 75%) as colorless crystals: mp 181–183 °C; IR (neat) 1623 (CO) cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.08-1.25 (m, 21H, 3 × *i*-Pr), 7.46-7.50 (m, 1H, Ar), 8.09-8.11 (m, 1H, Ar), 8.24 (dd, *J* = 9.2, 4.0 Hz, 1H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.2 (3C), 18.5 (6C), 64.1, 108.0 (d, *J* = 6.0 Hz), 114.8-114.9 (m), 119.3 (d, *J* = 24.0 Hz), 122.2 (d, *J* = 25.2 Hz), 127.8, 134.2-134.3 (m), 165.1 (d, *J* = 7.2 Hz), 165.5 (d, *J* = 253.1 Hz). *Anal.* Calcd for $C_{18}H_{24}FIO_2Si$: C, 48.43; H, 5.42. Found: C, 48.33; H, 5.34.

5-Nitro-1-[(triisopropylsilyl)ethynyl]-1*H*-1λ^3-benzo[*d*][1,2]iodoxol-3-one (2i). By a procedure described for the preparation of benziodoxolone derivative **2g**, 5-nitro-2-iodosylbenzoic acid (2.0 g, 6.47 mmol) was converted into **2i** (1.84 g, 60%): colorless crystals; mp 201–203 °C; IR (neat) 1624 (CO) cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.20-1.30 (m, 21H, 3 × *i*-Pr), 8.52 (dd, *J* = 9.2, 2.3 Hz, 1H, Ar), 8.63 (d, *J* = 9.2 Hz, 1H, Ar), 9.06 (dd, *J* = 2.3 Hz, 1H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.3 (3C), 18.5 (6C), 63.0, 115.0, 123.0, 126.5, 128.2, 129.2, 134.5, 150.7, 166.7. *Anal.* Calcd for $C_{18}H_{24}INO_4Si$: C, 45.67; H, 5.11; N, 2.96. Found: C, 45.60; H, 4.93; N, 2.97.

General Procedure for Quinazoline Synthesis through Copper-Catalyzed Domino C–H Alkynylation and Cyclization: Synthesis of 2-Phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4a). A mixture of **1a** (25.0 mg, 0.13 mmol), CuBr (3.7 mg, 0.03 mmol), **2i** (90.4 mg, 0.19 mmol), K_2CO_3 (17.6 mg, 0.13 mmol), and MS4Å (300 mg) in benzene was stirred at 80 °C for 1 h. The reaction mixture was concentrated under reduced pressure and purified by column chromatography over silica gel with hexane–EtOAc (50:1) to give **4a** (29.8 mg, 62 %) as a colorless oil: ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.03 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.15-1.26 (m, 3H, 3 × CH), 2.99 (s, 2H, CH_2), 7.42-7.56 (m, 4H, Ar), 7.78-7.84 (m, 1H, Ar), 8.00-8.05 (m, 1H, Ar), 8.12 (d, *J* = 8.0 Hz, 1H, Ar), 8.32-8.64 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (3C), 18.6 (6C), 19.4, 122.8, 125.1, 126.3, 128.4 (2C) 128.5, (2C), 129.4, 130.2, 133.2, 138.5, 150.6, 159.5, 172.8; MS (FAB) *m/z* (%): 377 (MH^+, 100), 333 (60); HRMS (FAB) calcd for $C_{24}H_{33}N_2Si$ (MH^+): 377.2413; found: 377.2422.

6-Fluoro-2-phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4e). By a procedure described for the preparation of **4a**, **1b** (27.3 mg, 0.13 mmol) was converted into **4e** (26.0 mg, 52%) as a pale yellow solid: mp 72–74 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.04 (d, *J* = 6.9 Hz, 18H, 6 × CMe), 1.17-1.25 (m, 3H, 3 × CH), 2.91 (s, 2H, CH_2), 7.46-7.53 (m, 3H, Ar), 7.57-7.61 (m, 1H, Ar), 7.71 (dd, *J* = 9.2, 2.9 Hz, 1H, Ar), 8.04 (dd, *J* = 9.2, 5.2 Hz, 1H, Ar), 8.59-8.61 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (3C), 18.6 (6C), 19.5, 108.7 (d, *J* = 22.8 Hz), 123.1 (d, *J* = 8.4 Hz), 123.3 (d, *J* = 25.2 Hz), 128.4 (2C), 128.5 (2C), 130.3, 132.0 (d, *J* = 8.4 Hz), 138.2, 147.7, 159.2 (d, 2.4 Hz), 160.0 (d, *J* = 248.3 Hz), 172.3 (d, *J* = 4.8 Hz); MS (FAB) *m/z* (%): 395 (MH^+, 100), 351 (80); HRMS (FAB) calcd for $C_{24}H_{32}FN_2Si$ (MH^+): 395.2319; found: 395.2310.

6-Chloro-2-phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4f). By a procedure described for the preparation of **4a**, **1c** (29.4 mg, 0.13 mmol) was converted into **4f** (24.2 mg, 46%) as a pale yellow solid: mp 74–76 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.04 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.16-1.24 (m, 3H, 3 × CH), 2.93 (s, 2H, CH_2), 7.47-7.53 (m, 3H, Ar), 7.75 (dd, *J* = 9.2, 2.3 Hz, 1H, Ar), 7 96 (d, *J* = 9.2 Hz, 1H, Ar), 8.08 (d, *J* = 2.3 Hz, 1H, Ar), 8.59-8.61 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (3C), 18.5 (6C), 19.6, 123.3, 124.2, 128.5 (4C), 130.5, 131.1, 131.7, 134.0, 138.1, 149.1, 159.8, 172.2; MS (FAB) *m/z* (%): 411 (MH^+, 100), 367 (80); HRMS (FAB) calcd for $C_{24}H_{32}ClN_2Si$ (MH^+): 411.2023; found: 411.2024.

6-Bromo-2-phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4g). By a procedure described for the preparation of **4a**, **1d** (35.1 mg, 0.13 mmol) was converted into **4g** (28.4 mg, 49%) as a pale yellow solid: mp 76–78 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.04 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.16-1.25 (m, 3H, 3 × CH), 2.93 (s, 2H, CH_2), 7.47-7.53 (m, 3H, Ar), 7.86-7.90 (m, 2H, Ar), 8.25 (d, *J* = 2.3 Hz, 1H, Ar), 8.59-8.61 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (3C), 18.5 (6C), 19.7, 119.6, 123.8, 127.6, 128.5 (4C), 130.5, 131.2, 136.6, 138.1, 149.3, 159.8, 172.1; MS (FAB) *m/z* (%): 457 (MH^+, ^{81}Br, 100), 455 (MH^+, ^{79}Br, 100), 413 (80), 411 (80); HRMS (FAB) calcd for $C_{24}H_{32}BrN_2Si$ (MH^+, ^{79}Br): 455.1513; found: 455.1516.

6-Iodo-2-phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4h). By a procedure described for the preparation of **4a**, **1e** (40.9 mg, 0.13 mmol) was converted into **4h** (36.6 mg, 57%) as a pale yellow solid: mp 97–99 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.04 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.16-1.23 (m, 3H, 3 × CH), 2.93 (s, 2H, CH_2), 7.48-7.53 (m, 3H, Ar), 7.75 (d, *J* = 8.6 Hz, 1H, Ar), 8.03 (dd, *J* = 8.6, 1.7 Hz, 1H, Ar), 8.48 (d, *J* = 1.7 Hz, 1H, Ar), 8.60 (dd, *J* = 7.7, 1.4 Hz, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.6 (3C), 18.5 (6C), 19.8, 90.9, 124.4, 128.5 (4C), 130.5, 131.2, 134.3 (d, *J* = 8.4 Hz), 138.1, 141.8, 149.6, 159.9, 171.8; MS (FAB) *m/z* (%): 503 (MH^+, 100), 459 (75); HRMS (FAB) calcd for $C_{24}H_{32}IN_2Si$ (MH^+): 503.1379; found: 503.1374.

6-Methyl-2-phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4i). By a procedure described for the preparation of **4a**, **1f** (26.8 mg, 0.13 mmol) was converted into **4i** (30.0 mg, 60%) as a pale yellow solid: mp 78–79 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.04 (d, *J* = 7.4 Hz, 18H, 6 × CMe),

1.16-1.25 (m, 3H, 3 × CH), 2.56 (s, 3H, CMe), 2.95 (s, 2H, CH_2), 7.44-7.52 (m, 3H, Ar), 7.64 (dd, *J* = 8.6, 1.7 Hz, 1H, Ar), 7.86-7.88 (m, 1H, Ar), 7.92 (d, *J* = 8.6 Hz, 1H, Ar), 8.59-8.68 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.6 (3C), 18.6 (6C), 19.3, 21.9, 122.7, 124.1, 128.35 (2C), 128.40 (2C), 129.1, 130.0, 135.3, 136.1, 138.7, 149.1, 158.9, 172.0; MS (FAB) *m/z* (%): 391 (MH^+, 100), 347 (50); HRMS (FAB) calcd for $C_{25}H_{35}N_2Si$ (MH^+): 391.2569; found: 391.2575.

6-Methoxy-2-phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4j). By a procedure described for the preparation of **4a**, **1g** (28.8 mg, 0.13 mmol) was converted into **4j** (31.6 mg, 61%) as a pale yellow solid; mp 92–93 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.05 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.17-1.27 (m, 3H, 3 × CH), 2.93 (s, 2H, CH_2), 3.96 (s, 3H, OMe), 7.34 (d, *J* = 2.9 Hz, 1H, Ar), 7.44-7.52 (m, 4H, Ar), 7.95 (d, *J* = 9.2 Hz, 1H, Ar), 8.28-8.60 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.6 (3C), 18.6 (6C), 19.4, 55.6, 103.1, 123.4, 125.5, 128.1 (2C), 128.4 (2C), 129.8, 130.9, 138.7, 146.5, 157.5, 157.9, 170.9; MS (FAB) *m/z* (%): 407 (MH^+, 100), 363 (60); HRMS (FAB) calcd for $C_{25}H_{35}N_2OSi$ (MH^+): 407.2519; found: 407.2509.

6-*tert*-Butyl-2-phenyl-4-[(triisopropylsilyl)methyl]quinazoline (4k). By a procedure described for the preparation of **4a**, **1h** (32.1 mg, 0.13 mmol) was converted into **4k** (37 mg, 67%) as a colorless oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.04 (d, *J* = 6.9 Hz, 18H, 6 × CMe), 1.16-1.25 (m, 3H, 3 × CH), 1.44 (s, 9H, CMe_3), 3.00 (s, 2H, CH_2), 7.45-7.52 (m, 3H, Ar), 7.91 (dd, *J* = 8.9, 2.0 Hz, 1H, Ar), 7.96 (d, *J* = 8.9 Hz, 1H, Ar), 8.04 (d, *J* = 2.0 Hz, 1H, Ar), 8.59-8.62 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.6 (3C), 18.6 (6C), 19.4, 31.2 (3C), 35.2, 120.2, 122.4, 128.4 (2C), 128.9 (3C), 130.0, 132.0, 138.7, 149.0, 149.1, 159.1, 172.4; MS (FAB) *m/z* (%): 433 (MH^+, 100); HRMS (FAB) calcd for $C_{28}H_{41}N_2Si$ (MH^+): 433.3039; found: 433.3031.

Mixture of 5-Bromo- and 7-Bromo-2-phenyl-4-[(triisopropylsilyl)methyl]quinazolines (4l). By a procedure described for the preparation of **4a**, **1i** (35.1 mg, 0.13 mmol) was converted into **4l** (27.7 mg, 48%, 3.7:1 inseparable mixture) as a colorless oil: ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.99 (d, *J* = 7.4 Hz, 14.2H, 6 × CMe), 1.03 (d, *J* = 7.4 Hz, 3.8H, 6 × CMe), 1.16-1.25 (m, 3H, 3 × CH), 2.94 (s, 0.4H, CH_2), 3.72 (s, 1.6H, CH_2), 7.47-7.62 (m, 4H, Ar), 7.82 (d, *J* = 7.4 Hz, 0.8H, Ar), 7.96 (d, *J* = 8.6 Hz, 0.2H, Ar), 7.99 (d, *J* = 9.2 Hz, 0.8H, Ar), 8.21 (d, *J* = 1.7 Hz, 0.2H, Ar), 8.58-8.61 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (0.6C), 11.6 (2.4C), 18.5 (1.3C), 18.7 (4.7C), 19.6 (0.2C), 23.1 (0.8C), 119.2 (0.8C), 121.4 (0.2C), 122.7 (0.8C), 126.5 (0.2C), 127.7 (0.2C), 128.5 (2C), 128.6 (2C), 129.8 (0.2C), 130.1 (0.8C), 130.6 (1C), 131.8 (0.2C), 132.6 (0.8C), 133.8 (0.8C), 137.5 (0.8C), 138.1 (0.2C), 151.5 (0.2C), 153.3 (0.8C), 158.4 (0.8C), 160.4 (0.2C), 172.9 (0.8C), 173.1 (0.2C); MS (FAB) *m/z* (%): 457 (MH^+, ^{81}Br, 75), 455 (MH^+, ^{79}Br, 75), 413 (100), 411 (100); HRMS (FAB) calcd for $C_{24}H_{32}BrN_2Si$ (MH^+, ^{79}Br): 455.1513; found: 455.1509.

Mixture of 5-Methoxy- and 7-Methoxy-2-phenyl-4-[(triisopropylsilyl)methyl]quinazolines (4m). By a procedure described for the preparation of **4a**, **1j** (28.8 mg, 0.13 mmol) was converted into **4m** (40.1 mg, 77%, 1.25:1 inseparable mixture) as a colorless solid: mp 66–68 °C; ^{1}H NMR

(500 MHz, $CDCl_3$) δ 1.00-1.04 (m, 18H, 6 × CMe), 1.16-1.25 (m, 3H, 3 × CH), 2.90 (s, 0.9H, CH_2), 3.46 (s, 1.1H, CH_2), 3.98 (s, 3H, OMe), 6.84 (d, *J* = 7.4 Hz, 0.55H, Ar), 7.14 (dd, *J* = 8.9, 2.6 Hz, 0.45H, Ar), 7.32 (d, *J* = 2.6 Hz, 0.45H, Ar), 7.45-7.52 (m, 3H, Ar), 7.59-7.60 (m, 0.55H, Ar), 7.95-7.68 (m, 0.55H, Ar), 7.99 (d, *J* = 8.9 Hz, 0.45H, Ar), 8.59-8.62 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.47 (1.5C), 11.52 (1.5C), 18.56 (3C), 18.64 (3C), 19.3 (0.5C), 27.7 (0.5C), 55.4 (0.5C), 55.7 (0.5C), 105.6 (0.5C), 107.0 (0.5C), 115.7 (0.5C), 118.1 (0.5C), 119.2 (0.5C), 121.8 (0.5C), 126.6 (0.5C), 128.36 (1C), 128.40 (1C), 128.44 (1C), 128.5 (1C), 130.11 (0.5C) 130.14 (0.5C), 132.9 (0.5C), 138.3 (0.5C), 138.7 (0.5C), 153.1 (0.5C), 153.2 (0.5C), 157.2 (0.5C), 159.1 (0.5C), 160.1 (0.5C), 163.4 (0.5C), 171.6 (0.5C), 172.8 (0.5C); MS (FAB) *m/z* (%): 407 (MH^+, 100), 363 (60); HRMS (FAB) calcd for $C_{25}H_{35}N_2OSi$ (MH^+): 407.2519; found: 407.2513.

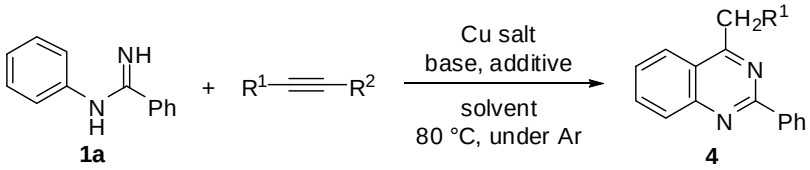
2-[4-(Trifluoromethyl)phenyl]-4-[(triisopropylsilyl)methyl]quinazoline (4n). By a procedure described for the preparation of **4a**, **1k** (33.7 mg, 0.13 mmol) was converted into **4n** (28.6 mg, 50%) as a colorless solid: mp 64–66 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 1.03 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.13-1.26 (m, 3H, 3 × CH), 3.00 (s, 2H, CH_2), 7.56-7.60 (m, 1H, Ar), 7.76 (d, *J* = 8.6 Hz, 2H, Ar), 7.83-7.87 (m, 1H, Ar), 8.04 (d, *J* = 8.0 Hz, 1H, Ar), 8.15 (d, *J* = 8.0 Hz, 1H, Ar), 8.74 (d, *J* = 8.6 Hz, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (3C), 18.5 (6C), 19.5, 123.0, 124.1 (q, *J* = 272.3 Hz), 125.2, 125.4 (q, *J* = 3.6 Hz), 126.9, 128.7 (2C), 129.5, 131.7 (q, *J* = 32.4 Hz, 2C), 133.5, 141.9, 150.5, 158.1, 173.3; MS (FAB) *m/z* (%): 445 (MH^+, 80), 401 (100); HRMS (FAB) calcd for $C_{25}H_{32}F_3N_2Si$ (MH^+): 445.2287; found: 445.2285.

2-(4-methoxyphenyl)-4-[(triisopropylsilyl)methyl]quinazoline (4o). By a procedure described for the preparation of **4a**, **1l** (28.8 mg, 0.13 mmol) was converted into **4o** (31.4 mg, 61%) as a colorless solid: mp 69–71 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 1.03 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.15-1.26 (m, 3H, 3 × CH), 2.96 (s, 2H, CH_2), 3.89 (s, 3H, OMe), 7.01-7.04 (m, 2H, Ar), 7.47-7.51 (m, 1H, Ar), 7.77-7.80 (m, 1H, Ar), 7.98 (d, *J* = 8.0 Hz, 1H, Ar), 8.09 (d, *J* = 8.6 Hz, 1H, Ar) 8.56-8.59 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (3C), 18.6 (6C), 19.3, 55.3, 113.8 (2C), 122.6, 125.1, 125.8, 129.2, 130.1 (2C), 131.3, 133.1, 150.7, 159.3, 161.5, 172.6; MS (FAB) *m/z* (%): 407 (MH^+, 100), 363 (55); HRMS (FAB) calcd for $C_{25}H_{35}N_2OSi$ (MH^+): 407.2519; found: 407.2531.

2-(Thiophen-2-yl)-4-[(triisopropylsilyl)methyl]quinazoline (4p). By a procedure described for the preparation of **4a**, **1m** (25.8 mg, 0.13 mmol) was converted into **4p** (22.2 mg, 46%) as a colorless oil: ^1H NMR (500 MHz, $CDCl_3$) δ 1.03 (d, *J* = 7.4 Hz, 18H, 6 × CMe), 1.15-1.26 (m, 3H, 3 × CH), 2.93 (s, 2H, CH_2), 7.17 (dd, *J* = 4.9, 3.7 Hz, 1H, Ar), 7.47-7.51 (m, 2H, Ar), 7.77-7.81 (m, 1H, Ar), 7.95 (d, *J* = 8.6 Hz, 1H, Ar), 8.07-8.09 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 11.5 (3C), 18.6 (6C), 19.1, 122.7, 125.2, 126.0, 128.1, 128.6, 129.0, 129.4, 133.4, 144.8, 150.5, 156.6, 173.1; MS (FAB) *m/z* (%): 383 (MH^+, 100), 339 (65); HRMS (FAB) calcd for $C_{22}H_{31}N_2SSi$ (MH^+): 383.1977; found: 383.1979.

4-Methyl-2-phenylquinazoline (5). To a stirred solution of **4a** (79 mg, 0.21 mmol) in THF (0.87 mL) and AcOH (0.044 mL) was added dropwise TBAF (1.0 mol/L in THF; 0.315 mL, 0.315 mmol) at room temperature. After stirring the mixture at this temperature for 4.5 h, the mixture was concentrated under reduced pressure. The residue was purified by column chromatography over alumina with hexane–EtOAc (30:1) to give **5** (35 mg, 76%) as a colorless solid: mp 85–87 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.00 (s, 3H, CMe), 7.47-7.57 (m, 4H, Ar), 7.82-7.85 (m, 1H, Ar), 8.06 (d, J = 8.6 Hz, 2H, Ar), 8.61-8.63 (m, 2H, Ar); ^{13}C NMR (125 MHz, $CDCl_3$) δ 22.0, 123.0, 124.9, 126.8, 128.5 (4C), 129.2, 130.3, 133.5, 138.3, 150.4, 160.2, 168.2; MS (FAB) *m/z* (%): 221 (MH^+, 100); HRMS (FAB) calcd for $C_{15}H_{13}N$ (MH^+): 221.1087; found: 221.1084.

Table S1. Selected Results of Reaction Optimization

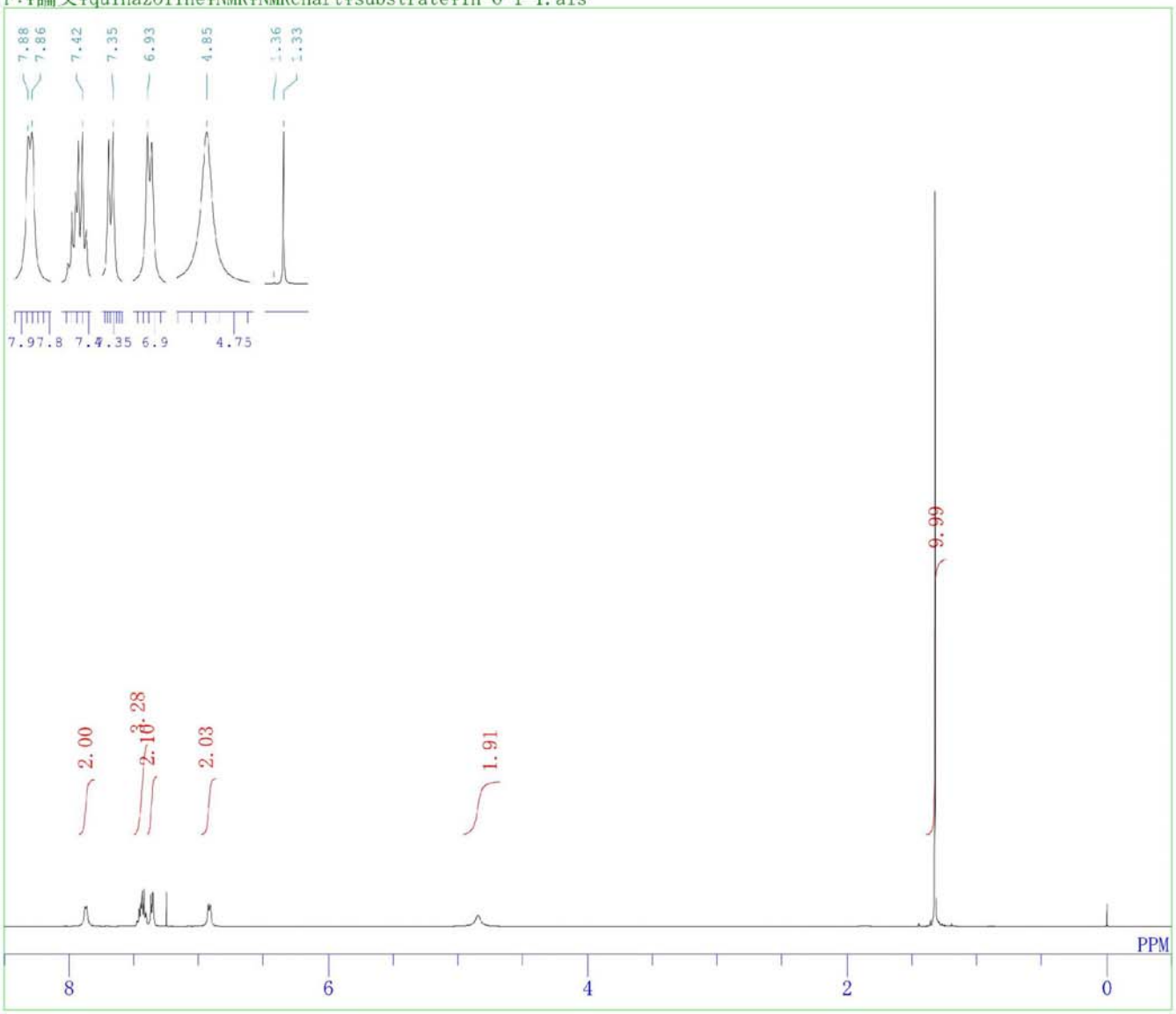


entry	catalyst/reagent (equiv)	base (1 equiv)	additive (equiv)	solvent	R^1	R^2	results
1	$Cu(OTf)_2$ (1.1)	–	–	DMF	TIPS	H	isomerization
2	$Cu(OAc)_2$ (1.1)	–	–	DMF	TIPS	H	isomerization
3	CuCl (1.1)	–	–	DMF	TIPS	H	no reaction
4	CuBr (1.1)	–	–	DMF	TIPS	H	no reaction
5	$Cu(OTf)_2$ (1.1)	–	–	DMF	$C(Me)_2OH$	H	isomerization
6	$Cu(OAc)_2$ (1.1)	–	–	DMF	$C(Me)_2OH$	H	isomerization
7	CuCl (1.1)	–	–	DMF	$C(Me)_2OH$	H	no reaction
8	CuBr (1.1)	–	–	DMF	$C(Me)_2OH$	H	no reaction
9	$Cu(OAc)_2$ (1.1)	–	CsF (2)	DMF	Ph	TMS	isomerization
10	$Cu(OAc)_2$ (1.1)	–	TBAF (2)	DMF	Ph	TMS	isomerization
11	$Cu(OAc)_2$ (1.1)	–	–	DMF	Ph	TMS	isomerization
16	$Cu(OAc)_2$ (0.5)	–	AcOH (5)	DMSO	Ph	H	isomerization
17	$Cu(OAc)_2$ (0.5)	–	AcOH (5)	DMSO	Ph	TMS	isomerization
18	$Cu(OAc)_2$ (0.2)	K_2CO_3	–	toluene	TIPS	Br	**4a** (<16%)[a]
19	$Cu(OAc)_2$ (0.2)	K_2CO_3	AgOTf (0.2)	toluene	TIPS	Br	**4a** (<5%)[a]
19	CuOAc (0.2)	K_2CO_3	–	toluene	TIPS	Br	**4a** (<5%)[a]
20	$Cu(OTf)_2$ (0.2)	K_2CO_3	–	toluene	TIPS	Br	no reaction
21	$CuBr_2$ (0.2)	K_2CO_3	–	toluene	TIPS	Br	no reaction
22	$CuCl_2$ (0.2)	K_2CO_3	–	toluene	TIPS	Br	no reaction
23	CuOTf (0.2)	K_2CO_3	–	toluene	TIPS	Br	no reaction
24	CuBr (0.2)	K_2CO_3	–	toluene	TIPS	Br	**4a** (<38%)[a]
25	CuCl (0.2)	K_2CO_3	–	toluene	TIPS	Br	**4a** (<7%)[a]
26	CuI (0.2)	K_2CO_3	–	toluene	TIPS	Br	**4a** (<19%)[a]
27	CuBr (0.2)	K_2CO_3	AgOTf (0.2)	toluene	TIPS	Br	complex mixture
28	CuBr (0.2)	K_2CO_3	–	dioxane	TIPS	Br	trace
29	CuBr (0.2)	K_2CO_3	–	DMF	TIPS	Br	**4a** (<5%)[a]
30	CuBr (0.2)	K_2CO_3	–	benzene	TIPS	Br	**4a** (<47%)[a]
31	CuBr (0.2)	K_2CO_3	–	xylene	TIPS	Br	**4a** (<34%)[a]
32	CuBr (0.2)	K_2CO_3	–	CH_2Cl_2	TIPS	Br	**4a** (<24%)[a]
33	CuBr (0.2)	K_2CO_3	–	EtCN	TIPS	Br	**4a** (<5%)[a]
34	CuBr (0.2)	K_2CO_3	–	DME	TIPS	Br	**4a** (<6%)[a]
35	CuBr (0.2)	Na_2CO_3	–	benzene	TIPS	Br	**4a** (<12%)[a]
36	CuBr (0.2)	Cs_2CO_3	–	benzene	TIPS	Br	**4a** (<22%)[a]
37	CuBr (0.2)	$NaHCO_3$	–	benzene	TIPS	Br	**4a** (<40%)[a]
38	CuBr (0.2)	KOAc	–	benzene	TIPS	Br	trace
39	CuBr (0.2)	CsOAc	–	benzene	TIPS	Br	trace
40	CuBr (0.5)	CsOAc	–	benzene	TIPS	Br	**4a** (<33%)[a]
41	CuBr (1.0)	CsOAc	–	benzene	TIPS	Br	**4a** (<34%)[a]
42	CuBr (1.5)	CsOAc	–	benzene	TIPS	Br	**4a** (<46%)[a]

[a] Containing some inseparable impurities.

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥1h-0-1-1.als



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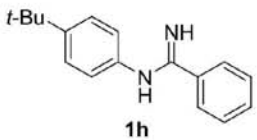
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	38



1h

single_pulse

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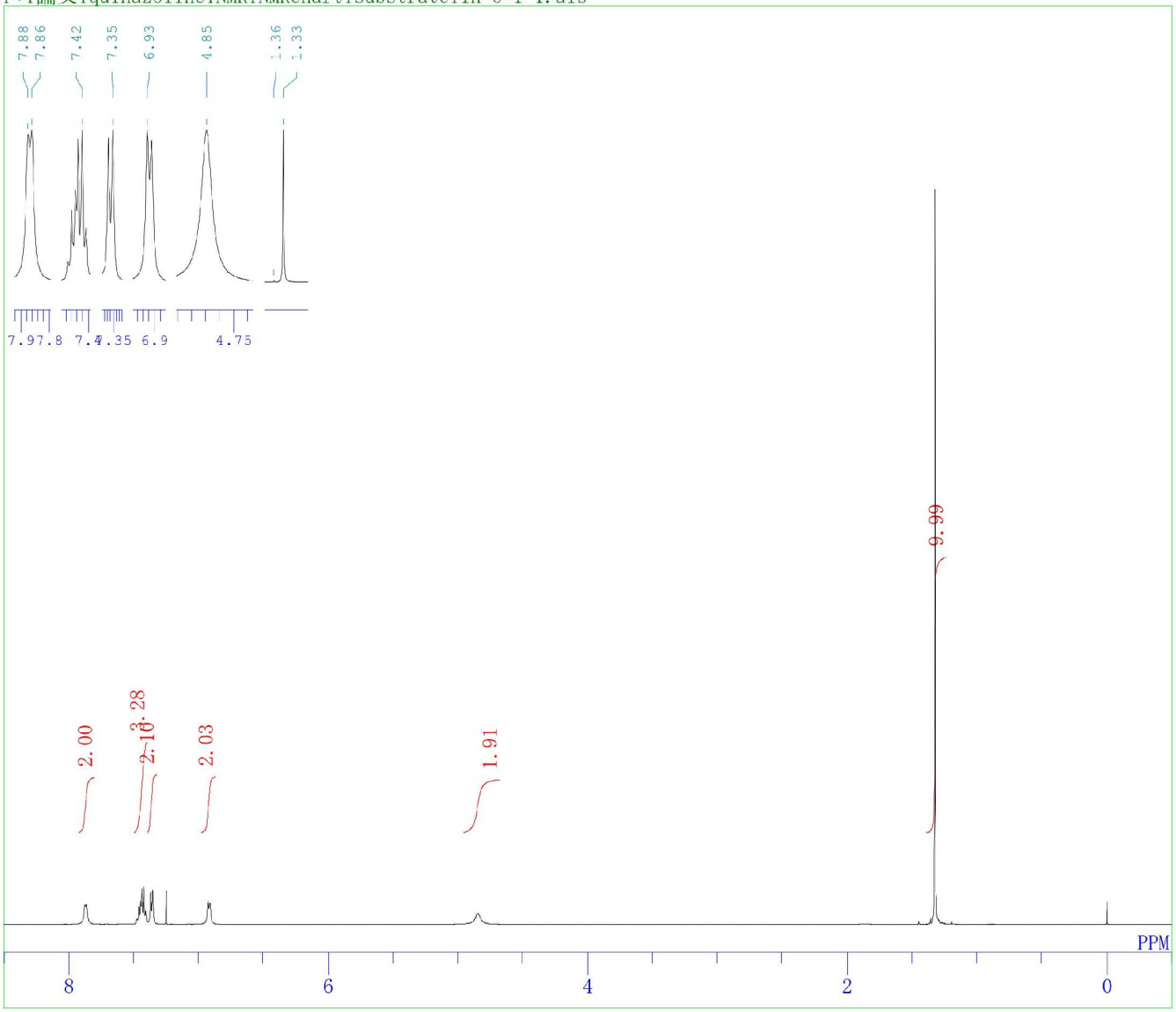

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OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
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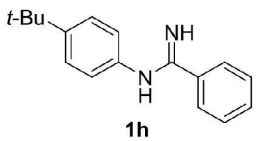
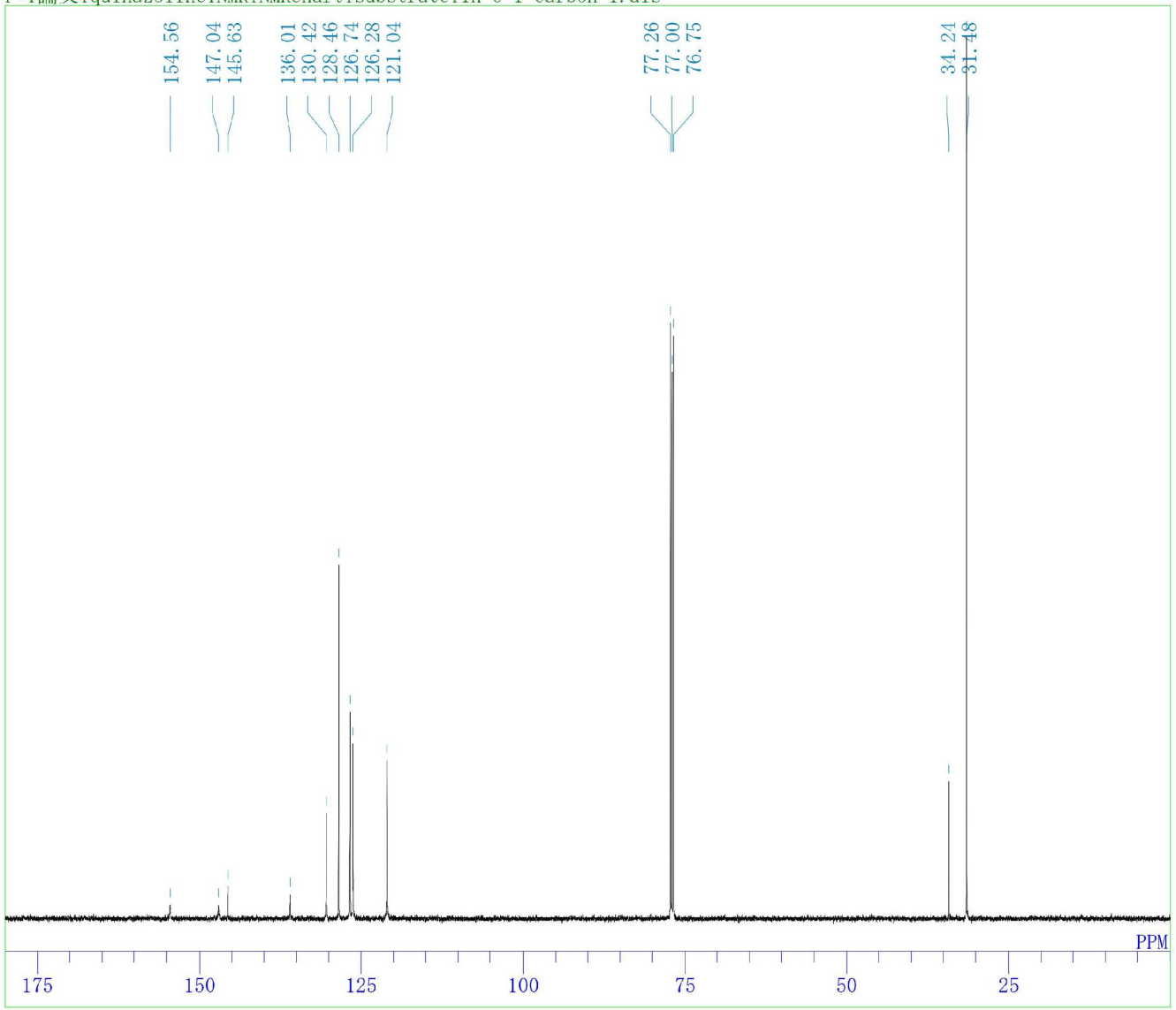
CTEMP	24.8 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	38



1h

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥1h-O-1-carbon-1.als



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POINT	26214
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PD	2.0000 sec
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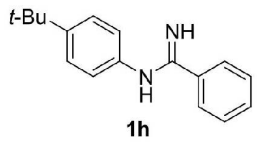
RGAIN	58



1h

single_pulse

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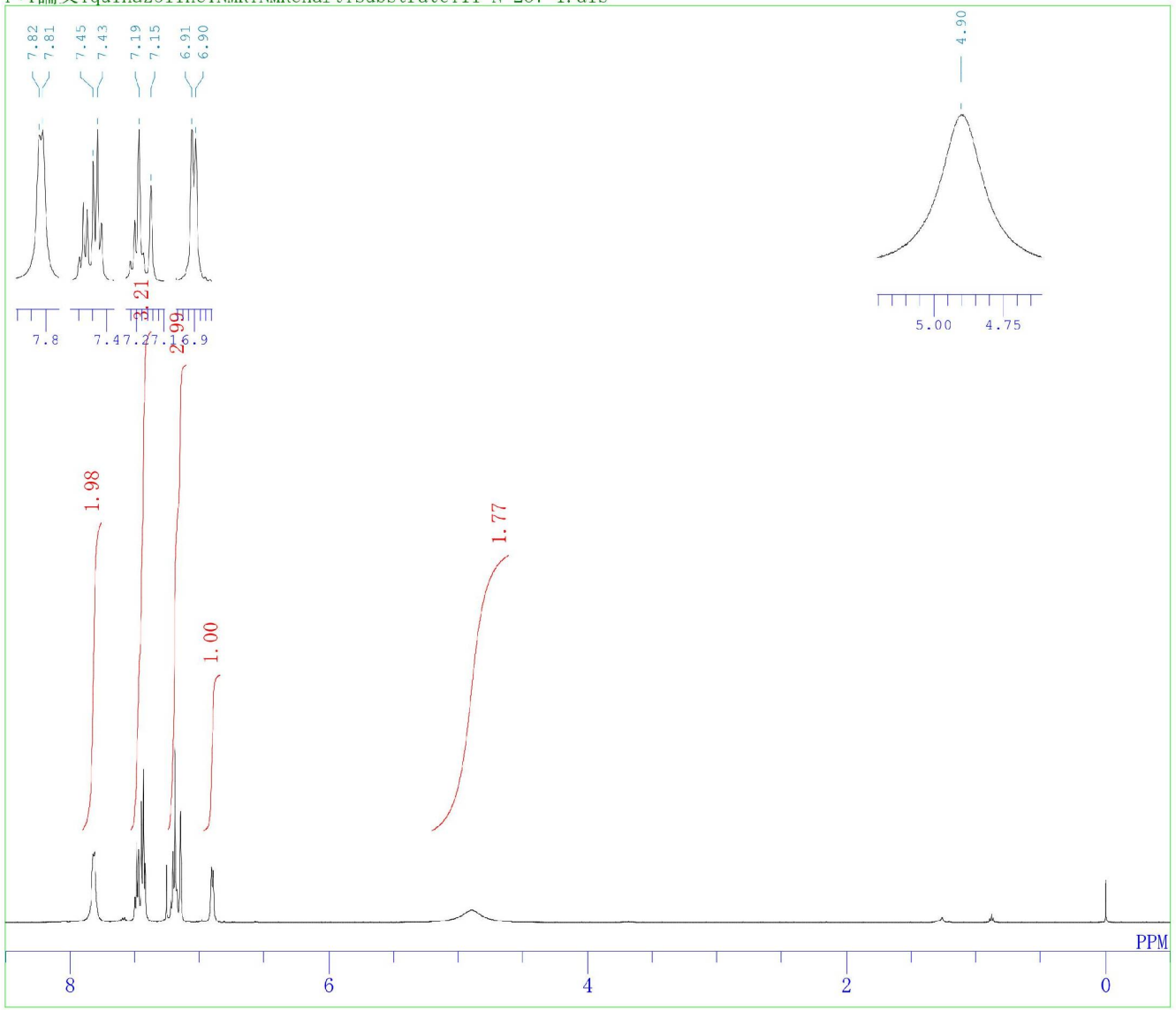

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OBFIN	6.01 Hz
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FREQU	7507.39 Hz
SCANS	8
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PD	5.0000 sec
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IRNUC	1H
CTEMP	24.3 c
SLVNT	CDCL3
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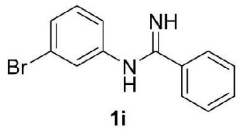
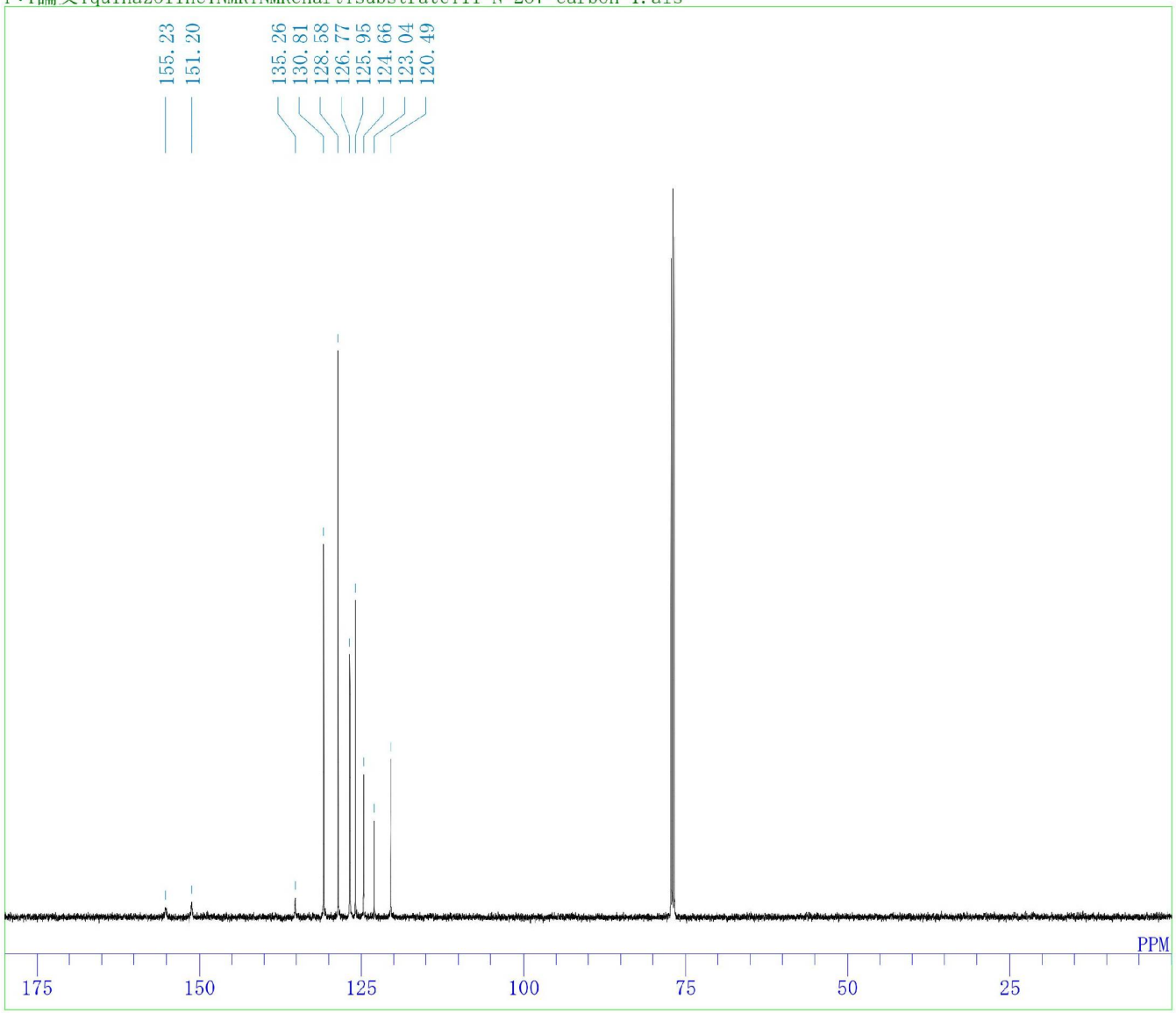
RGAIN	42



1i

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥1i-N-287-carbon-1.als



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OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
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PD	2.0000 sec
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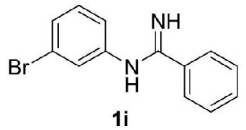
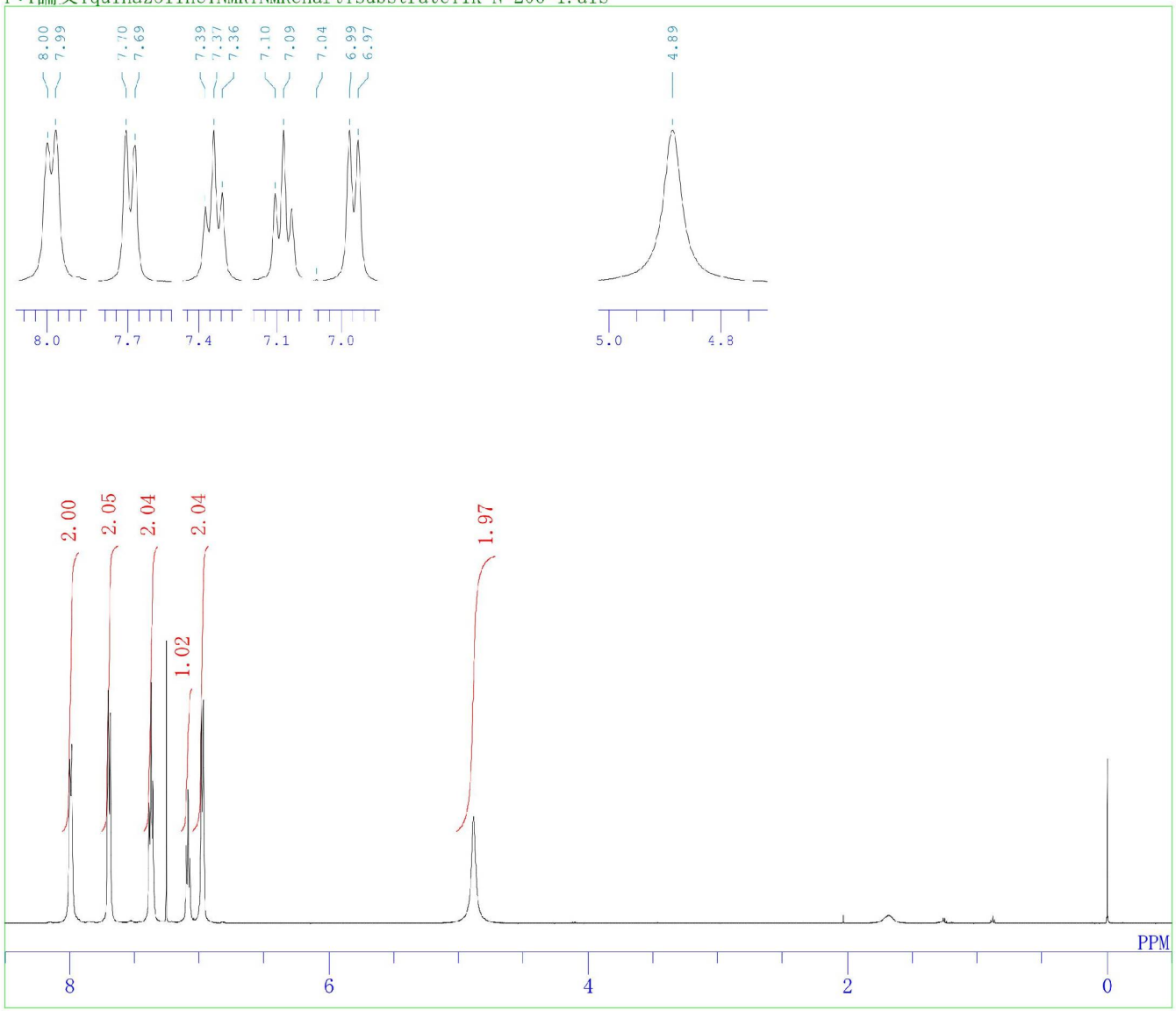


1i

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥1k-N-206-1.als



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OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
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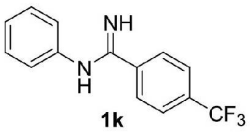
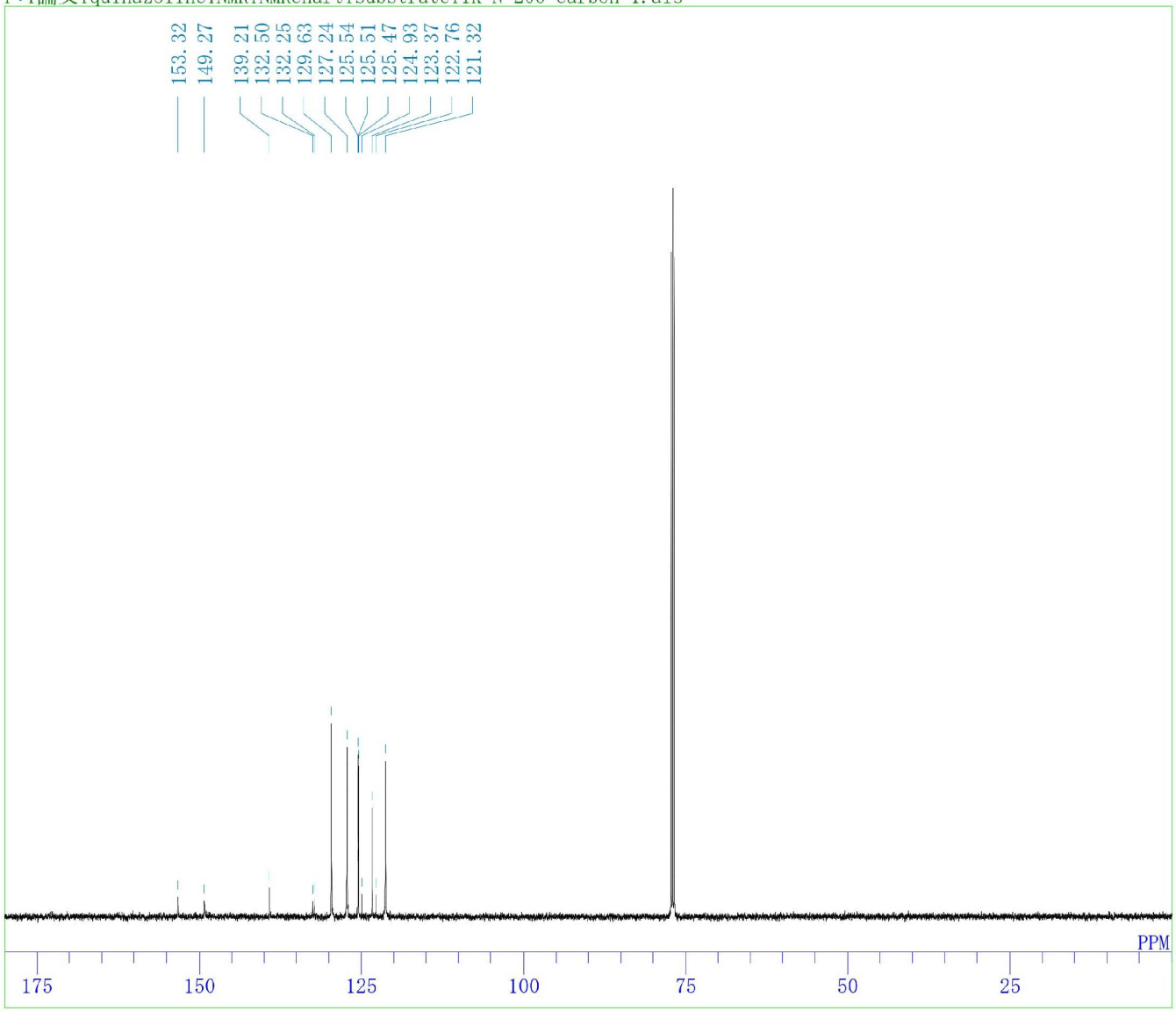
IRNUC	1H
CTEMP	25.9 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	44



1k

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥1k-N-206-carbon-1.als



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OBFIN	4.21 Hz
POINT	26214
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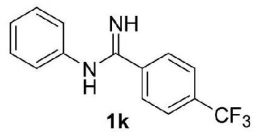
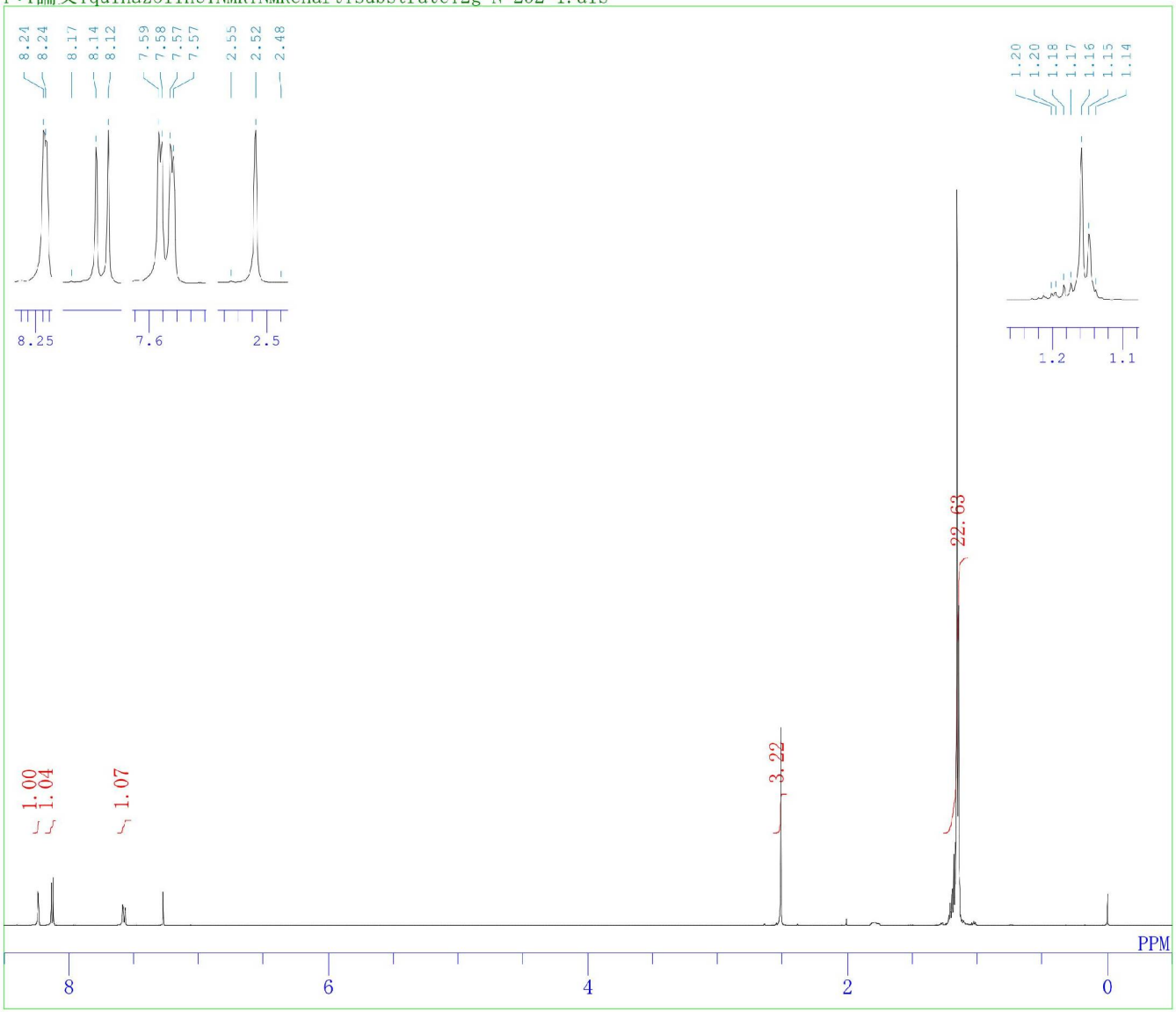
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.4 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	58



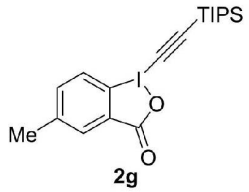
1k

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥2g-N-252-1.als



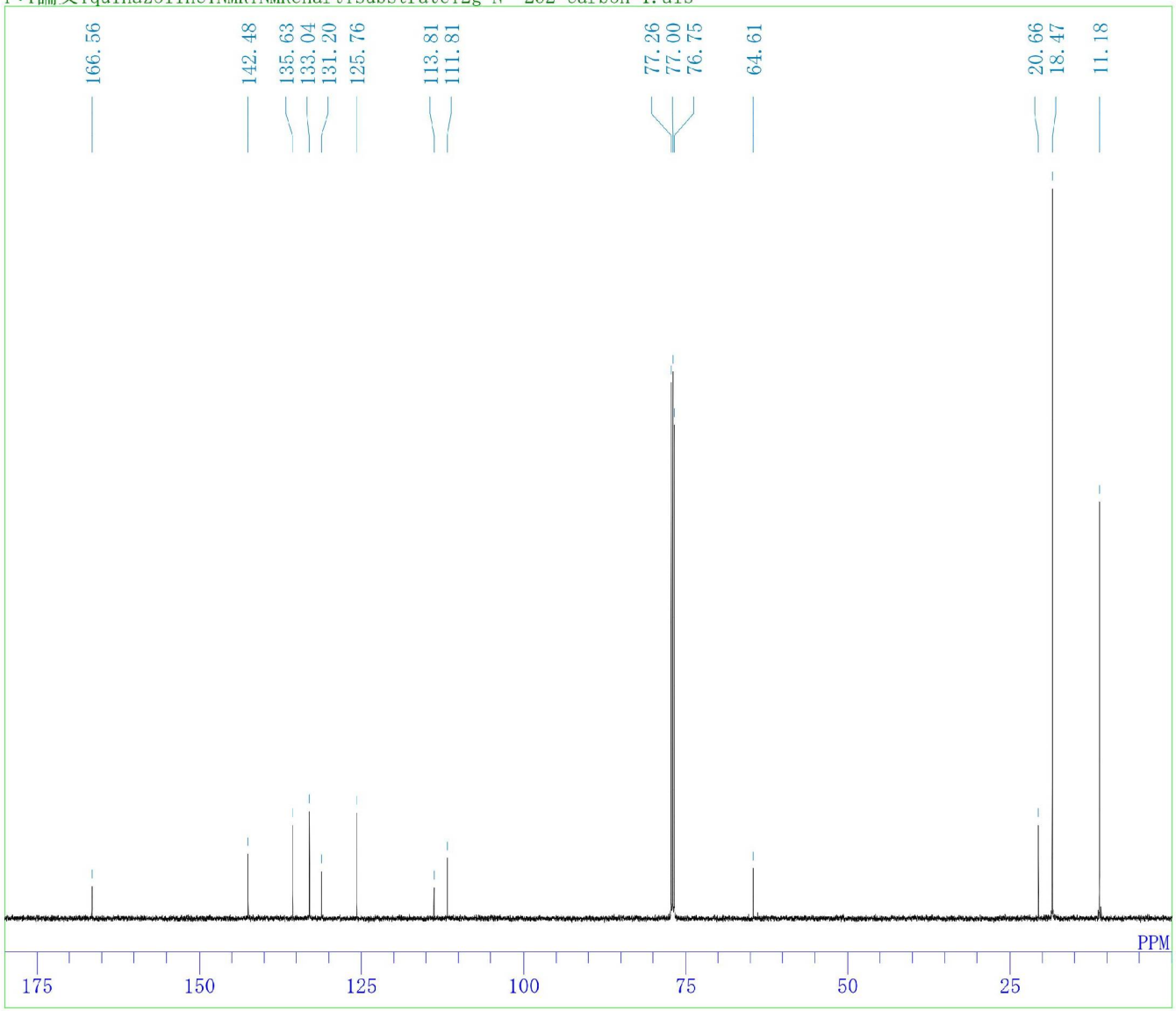
DFILE	2g-N-252-1.als
COMNT	single_pulse
DATIM	12-03-2010 13:45:35
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	25.7 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	40



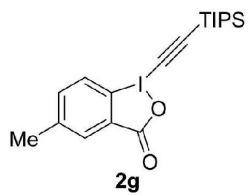
2g

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥2g-N -252-carbon-1.als



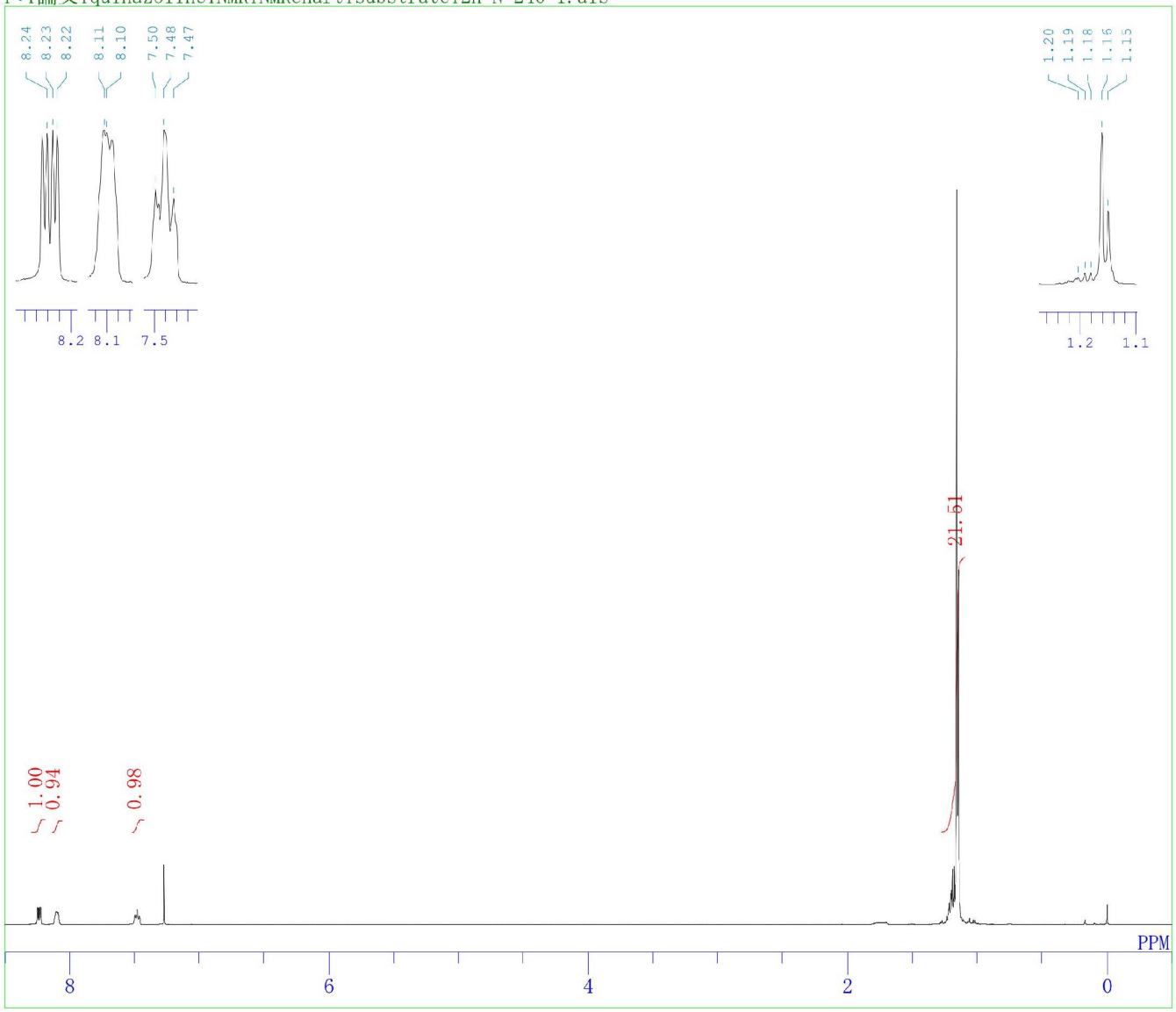
DFILE	2g-N -252-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	12-03-2010 14:33:32
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.2 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	60



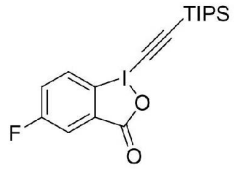
2g

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥2h-N-246-1.als



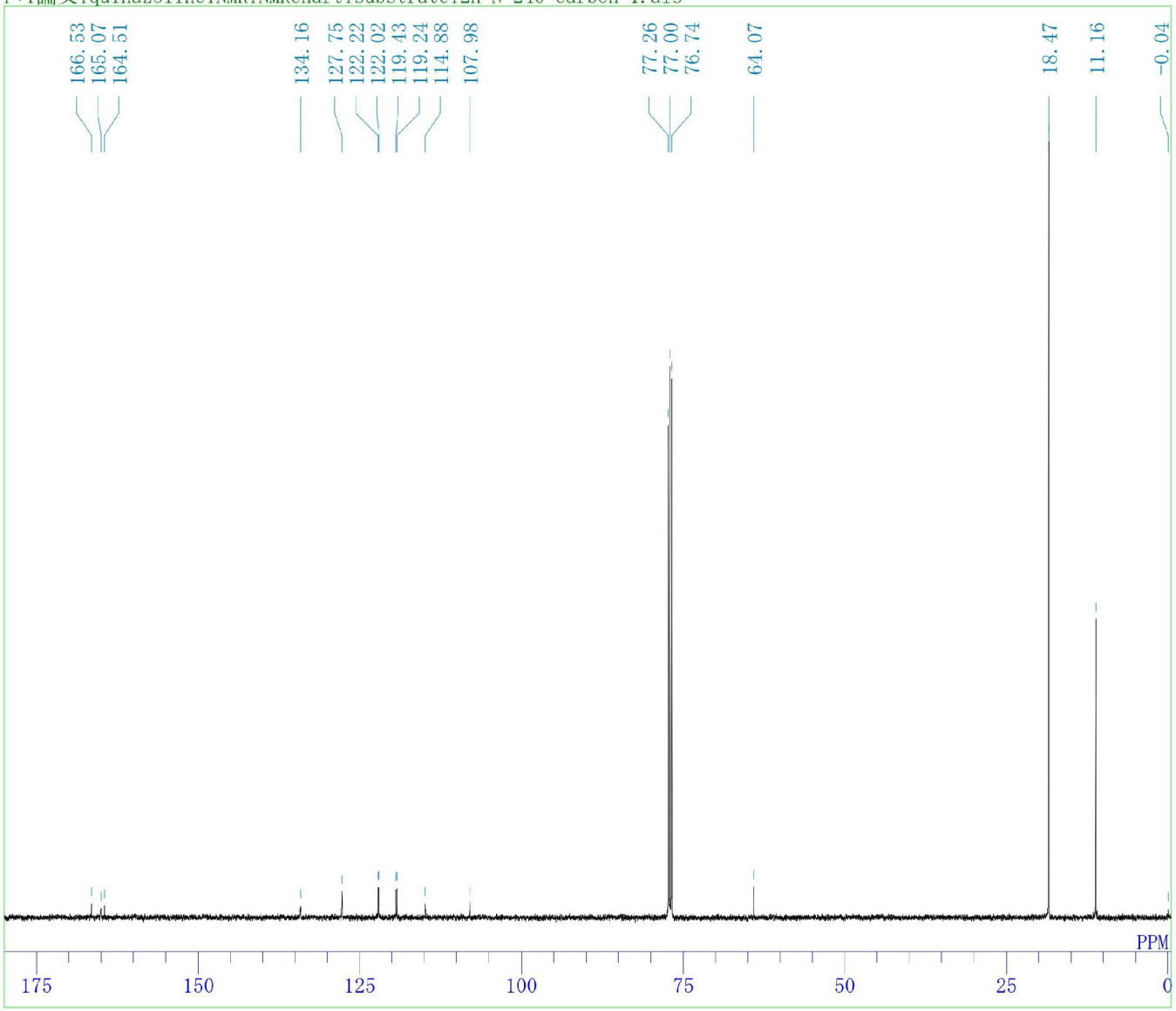
DFILE	2h-N-246-1.als
COMNT	single_pulse
DATIM	12-03-2010 10:49:22
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	24.5 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	42



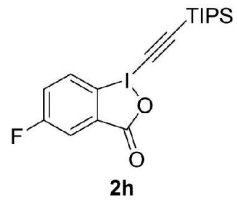
2h

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥2h-N-246-carbon-1.als



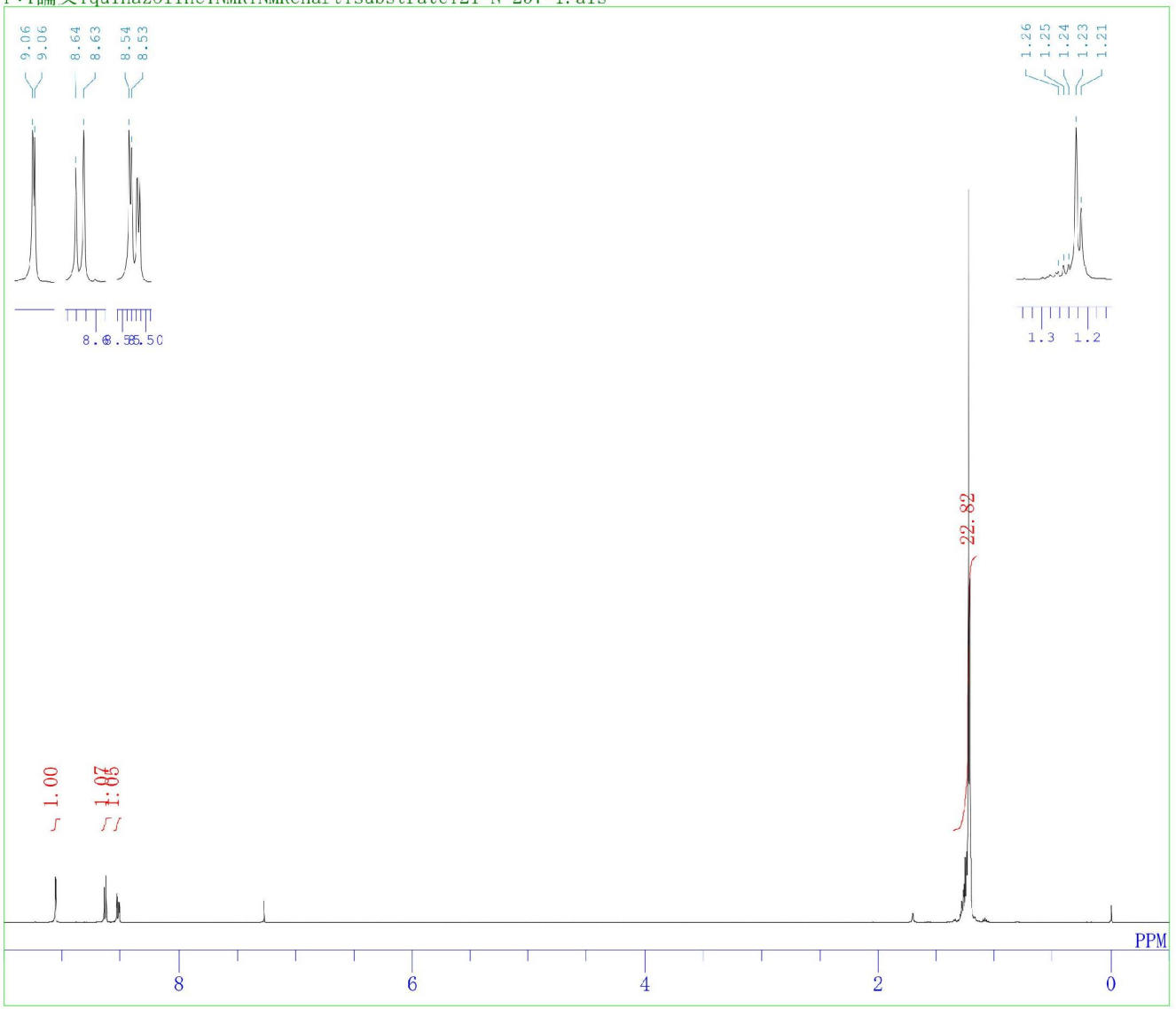

```
DFILE   2h-N-246-carbon-1.als
COMNT   single pulse decoupled gated NOE
DATIM   12-03-2010 11:37:27
OBNUC   13C
EXMOD   single_pulse_dec
OBFRQ         125.77 MHz
OBSET           7.87 KHz
OBFIN           4.21 Hz
POINT          26214
FREQU       31446.06 Hz
SCANS           1000
ACQTM         0.8336 sec
PD            2.0000 sec
PW1             3.50 usec
IRNUC   1H
CTEMP          25.3 c
SLVNT   CDCL3
EXREF          77.00 ppm
BF              1.20 Hz
RGAIN             58
```



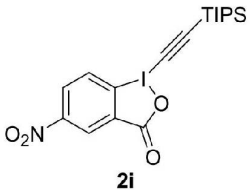
2h

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥2i-N-257-1.als



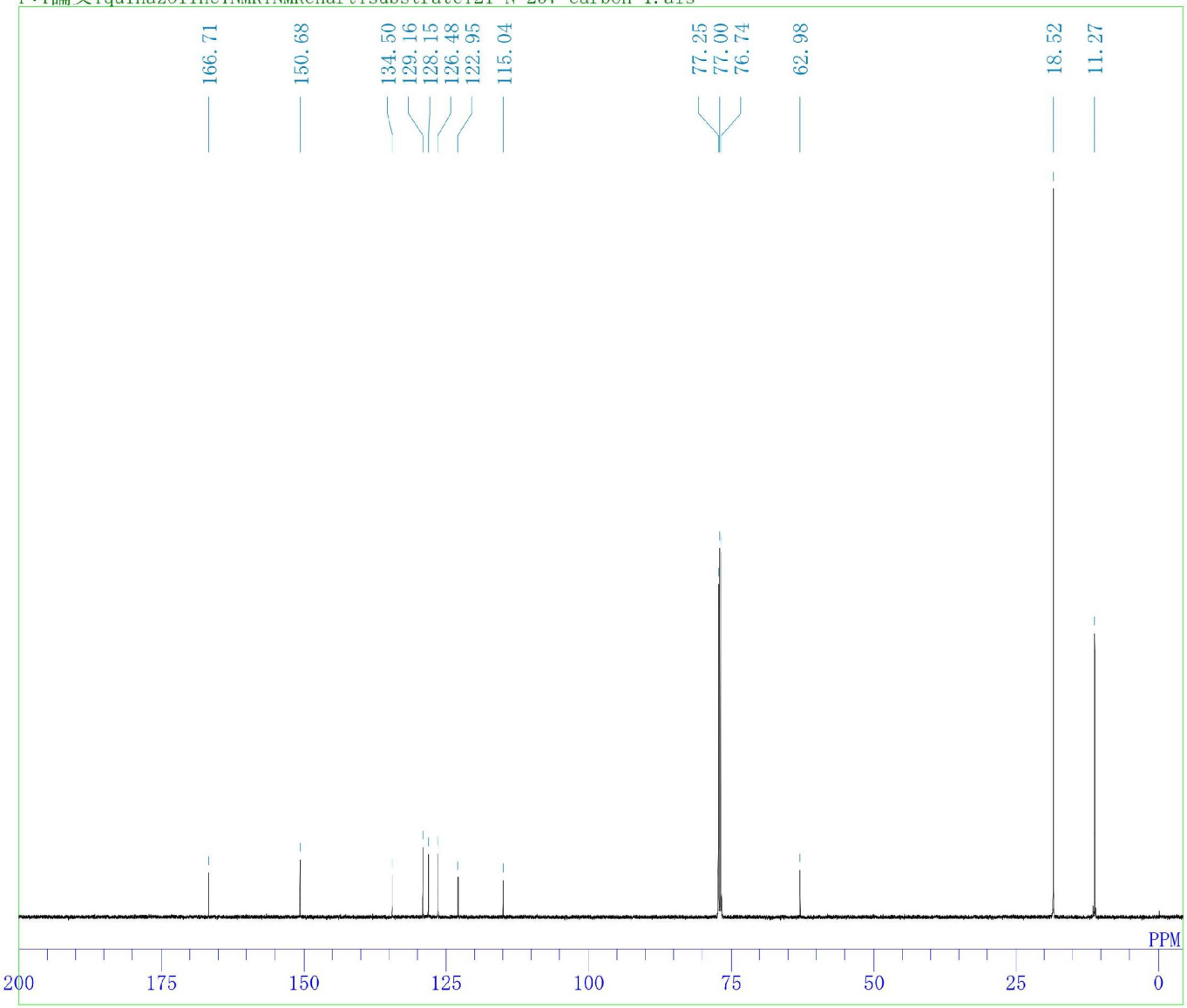
DFILE	2i-N-257-1.als
COMNT	single_pulse
DATIM	12-03-2010 16:54:51
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	26.1 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	38



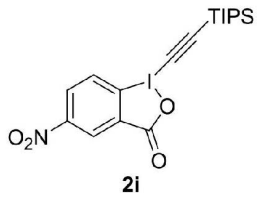
2i

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥substrate¥2i-N-257-carbon-1.als



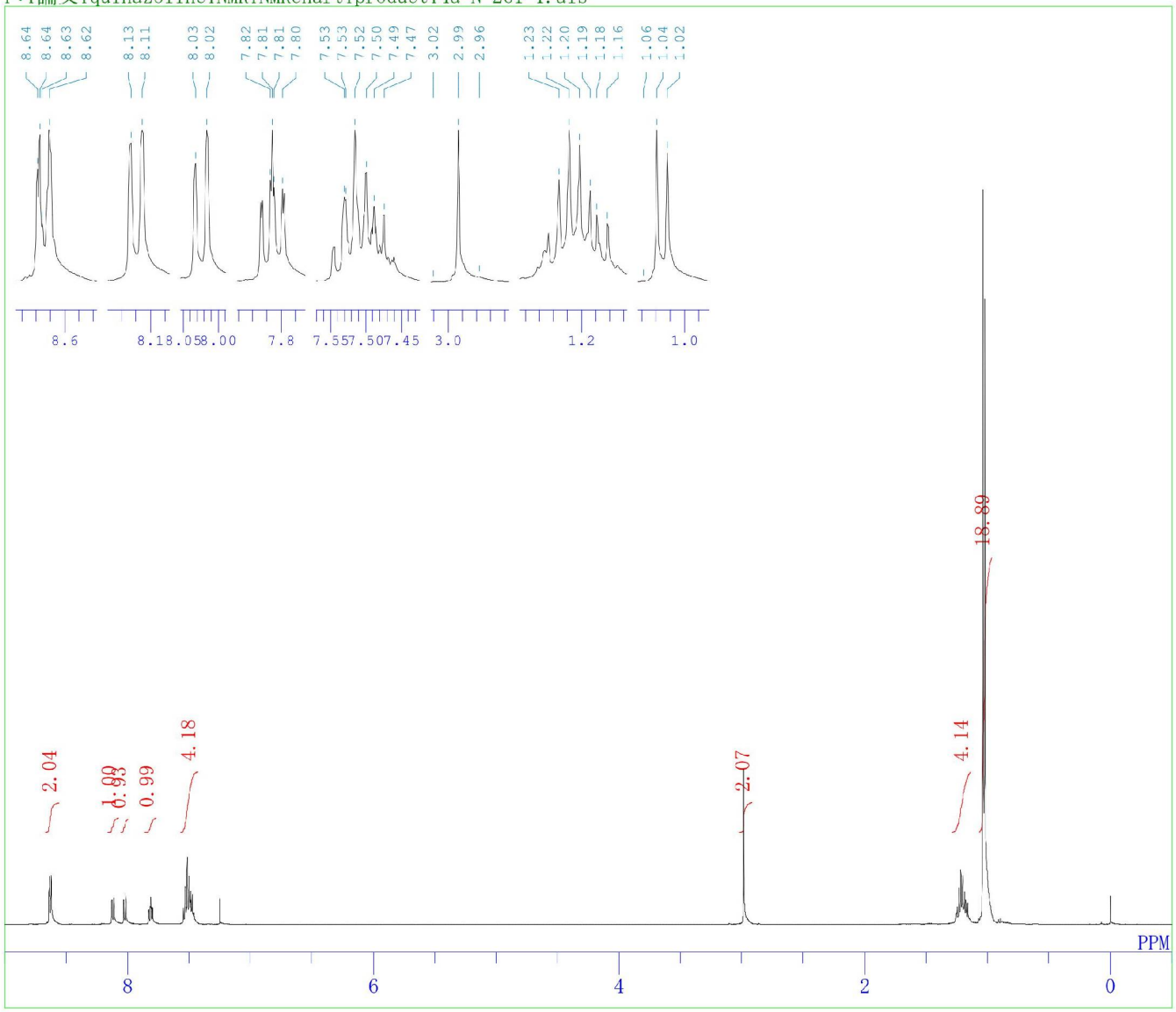
DFILE	2i-N-257-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	12-03-2010 17:42:50
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.5 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	60



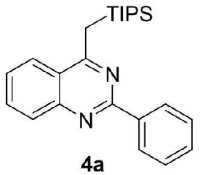
2i

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4a-N-261-1.als



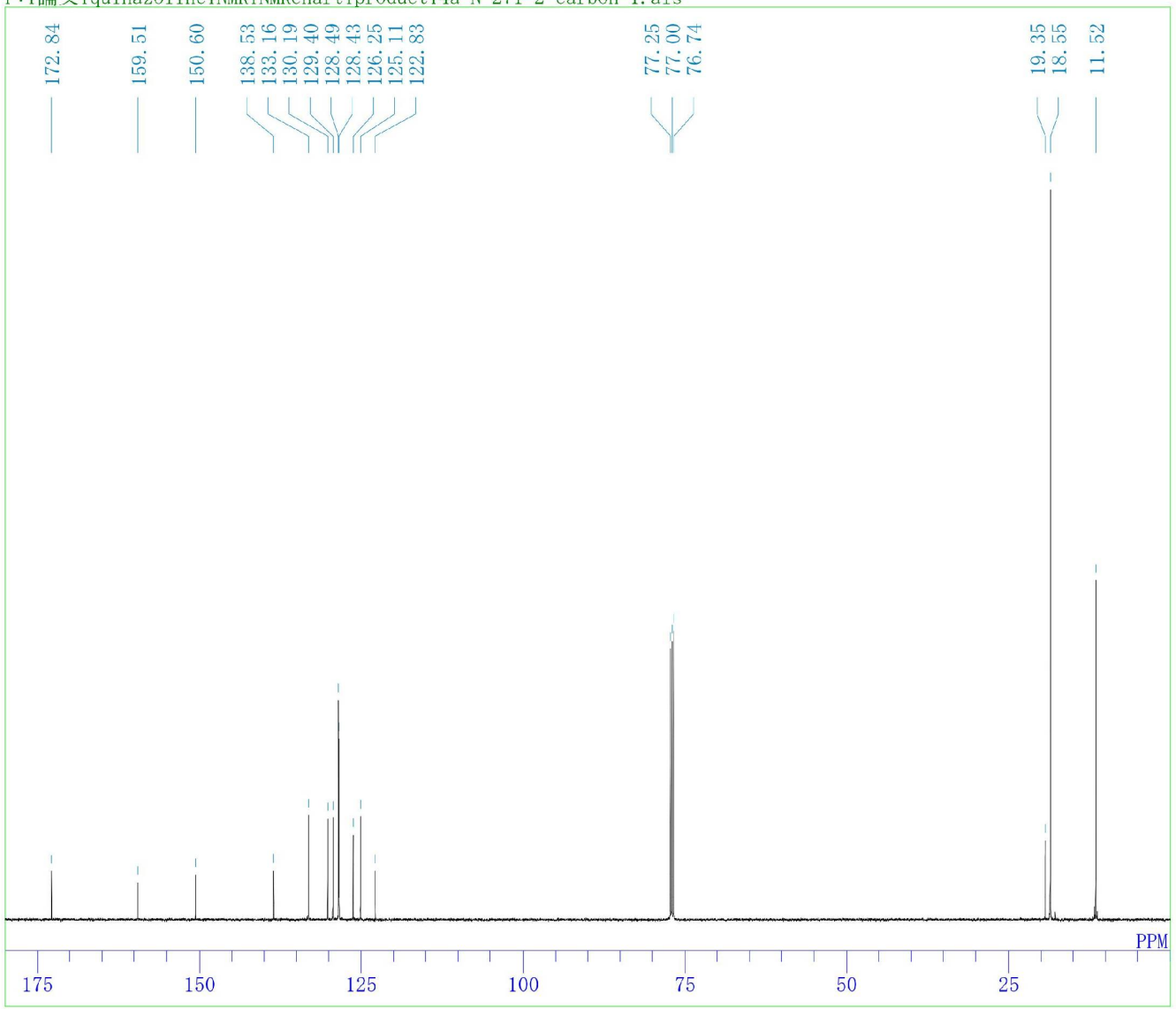
DFILE	4a-N-261-1.als
COMNT	single_pulse
DATIM	26-01-2010 19:04:48
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	25.4 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	38



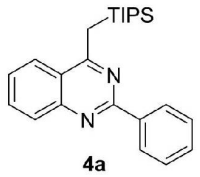
4a

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4a-N-271-2-carbon-1.als



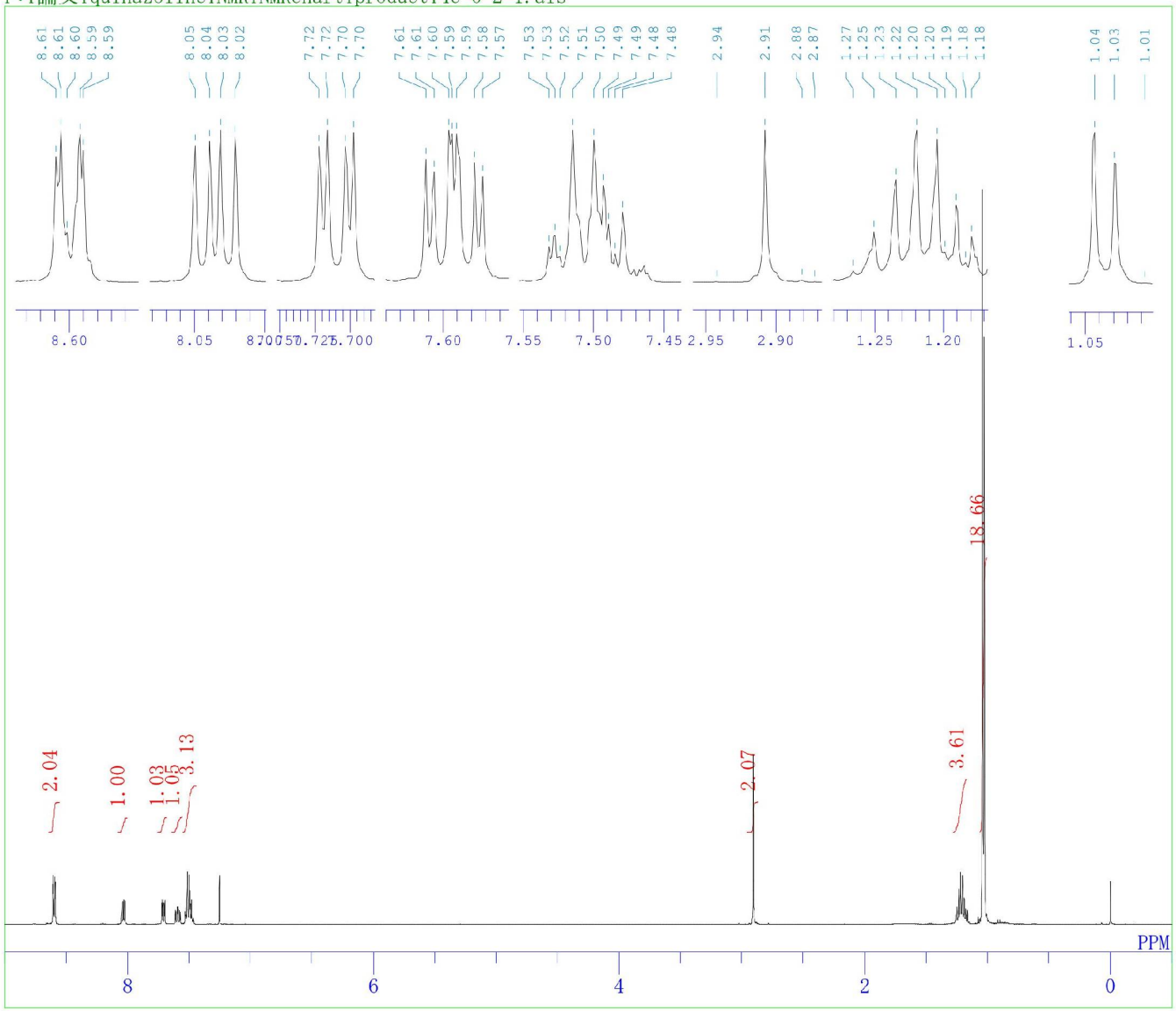
DFILE	4a-N-271-2-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	15-03-2010 09:11:38
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.6 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	50



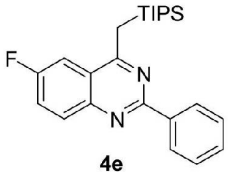
4a

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4e-O-2-1.als



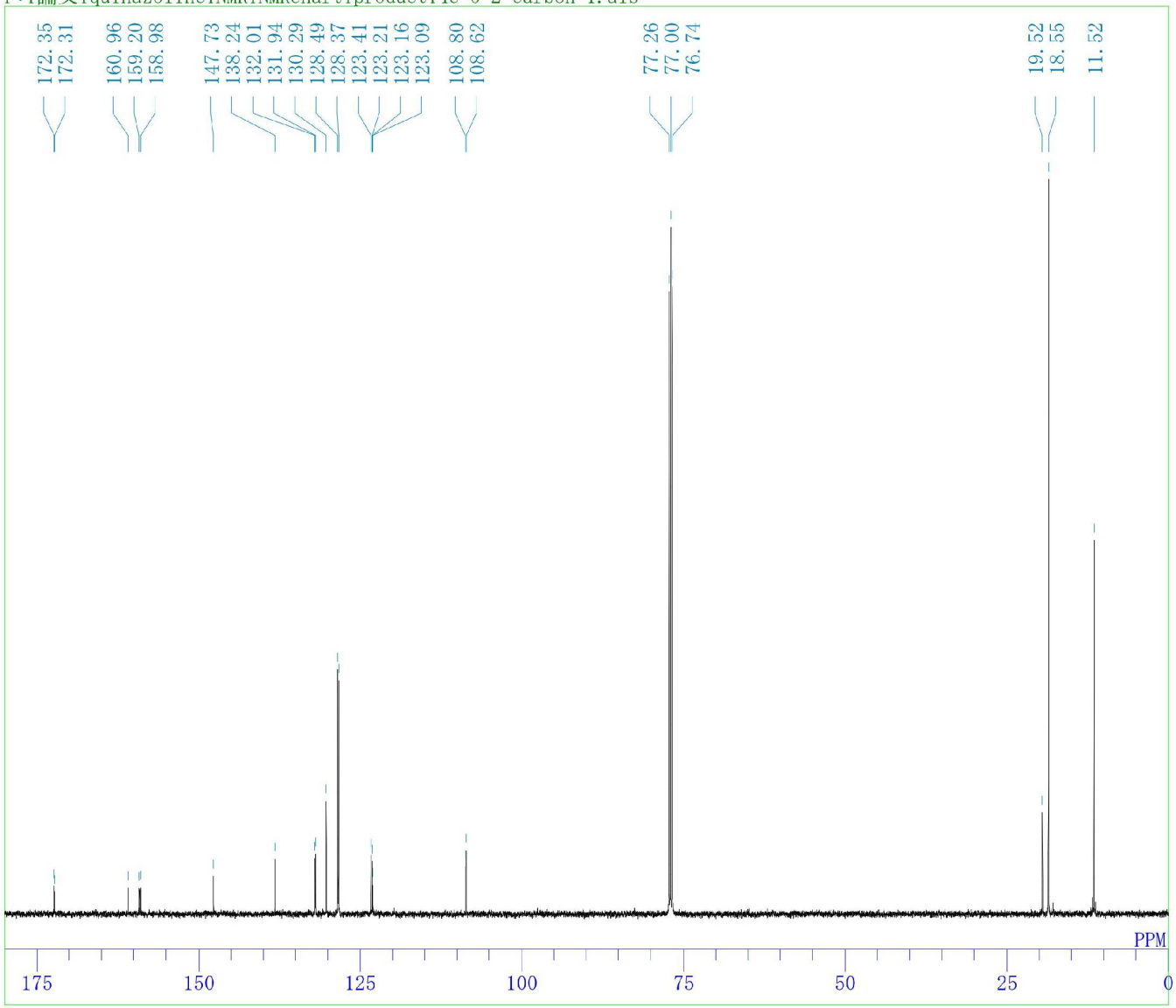
DFILE 4e-O-2-1.als
COMNT single_pulse
DATIM 25-02-2010 12:18:41
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 25.6 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 40



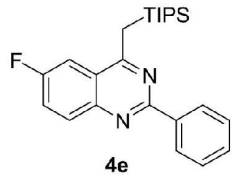
4e

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4e-O-2-carbon-1.als



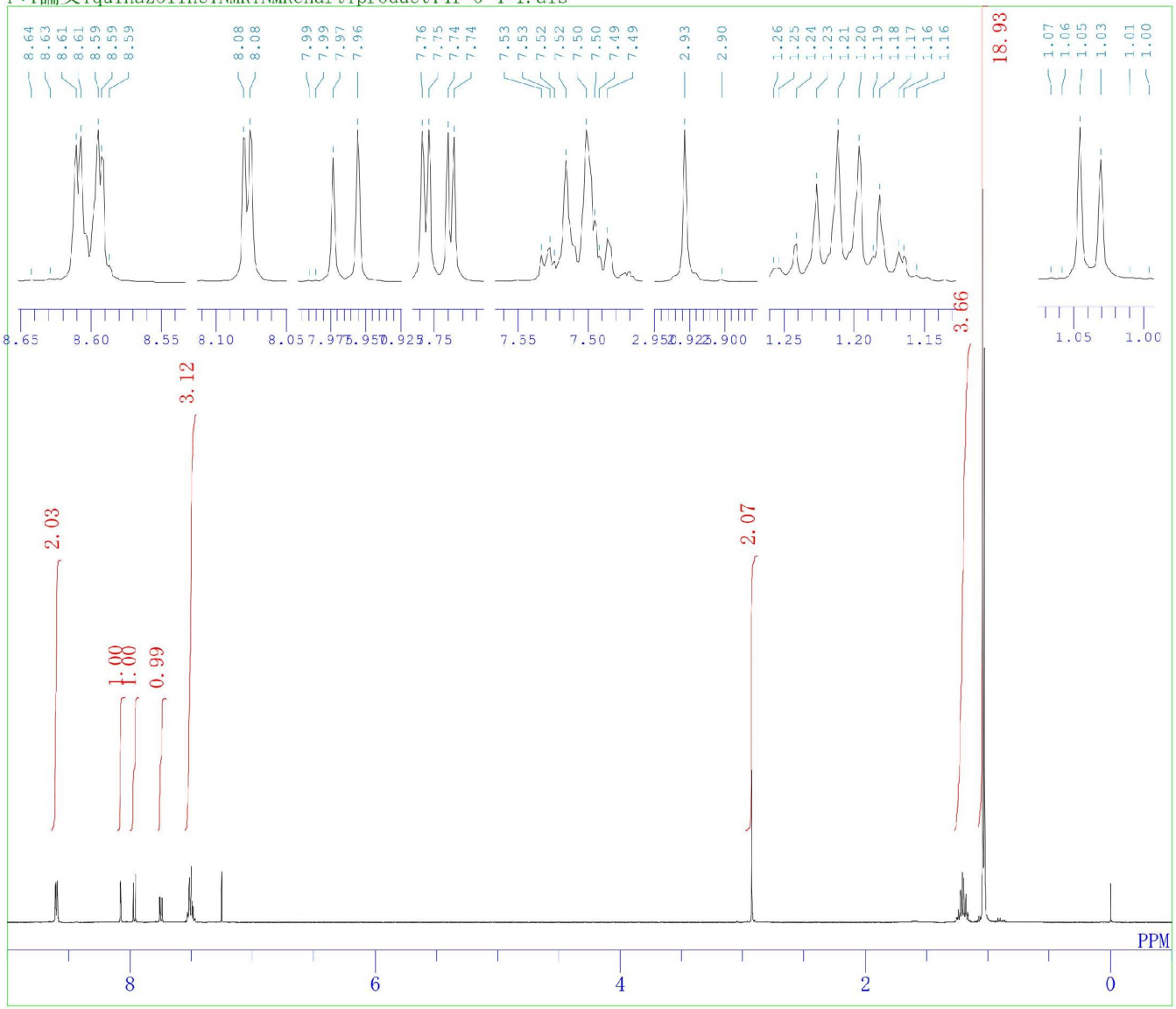
DFILE	4e-O-2-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	25-02-2010 13:06:42
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	25.8 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	56



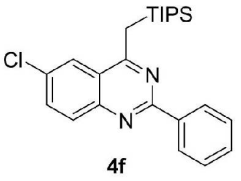
4e

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4f-0-4-1.als



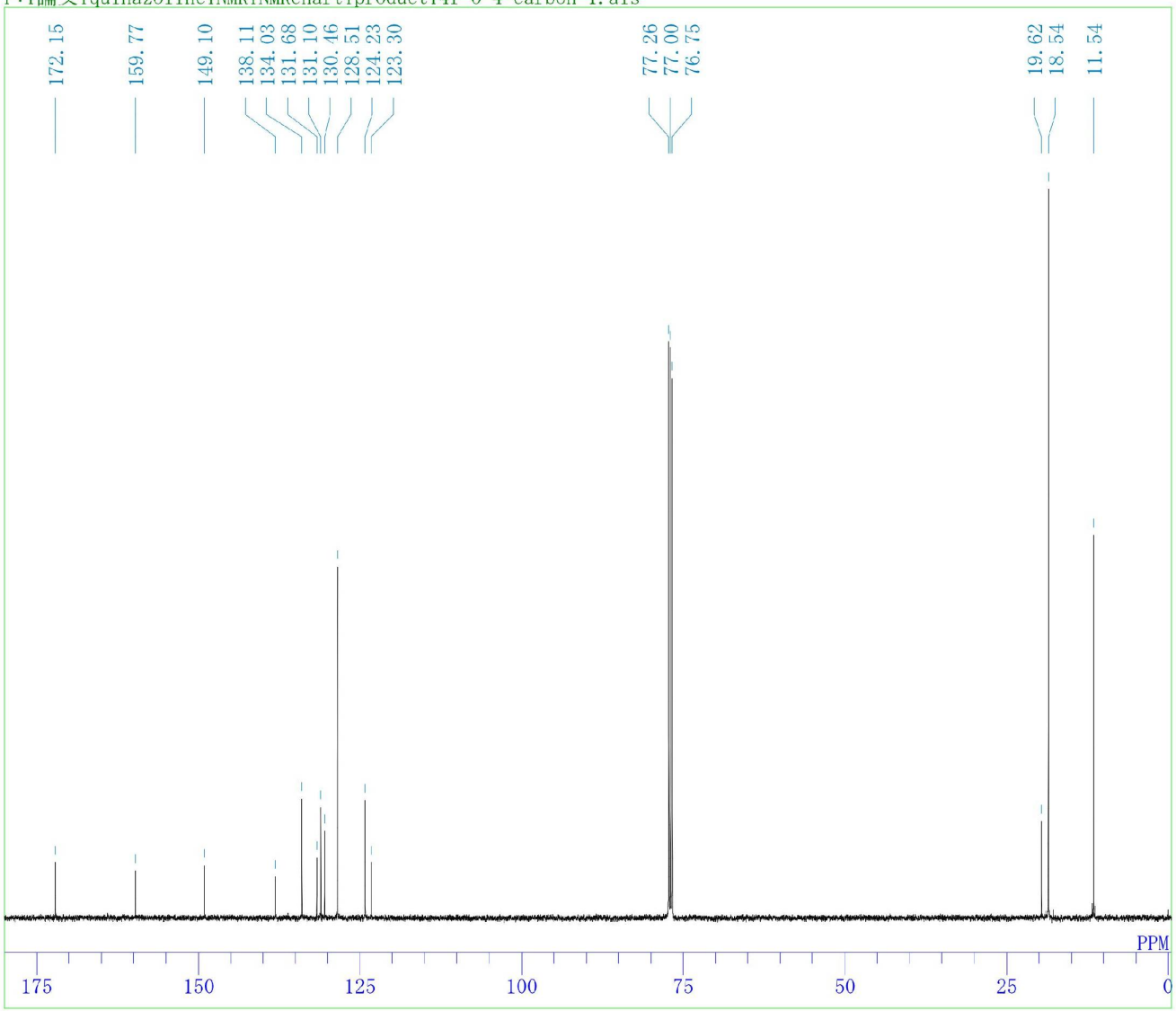
DFILE 4f-0-4-1.als
COMNT single_pulse
DATIM 25-02-2010 19:49:17
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 25.3 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 40



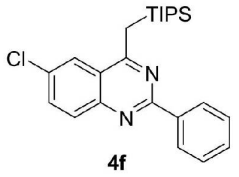
4f

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4f-O-4-carbon-1.als



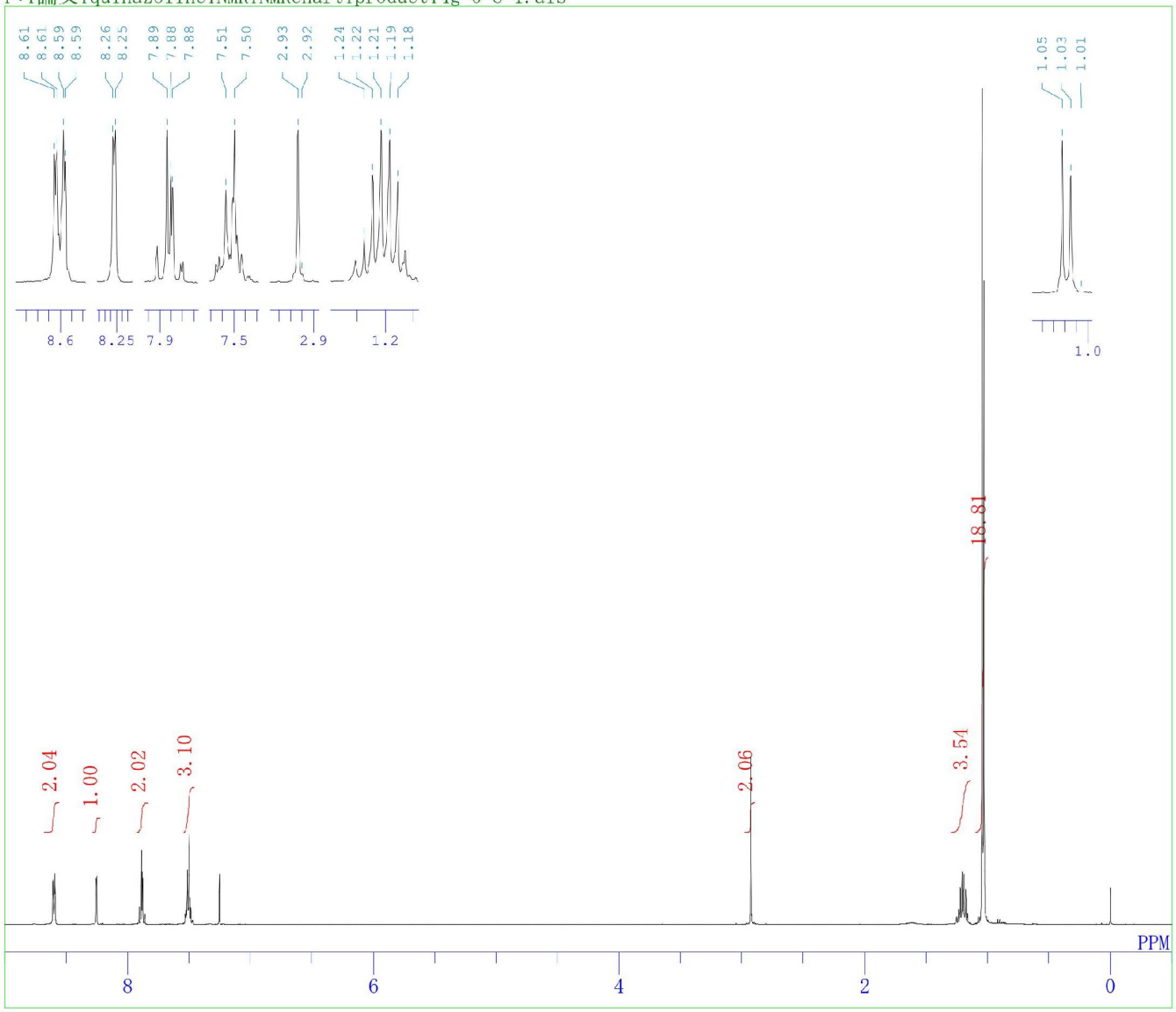
DFILE 4f-O-4-carbon-1.als
COMNT single pulse decoupled gated NOE
DATIM 25-02-2010 20:37:23
OBNUC 13C
EXMOD single_pulse_dec
OBFRQ 125.77 MHz
OBSET 7.87 KHz
OBFIN 4.21 Hz
POINT 26214
FREQU 31446.06 Hz
SCANS 1000
ACQTM 0.8336 sec
PD 2.0000 sec
PW1 3.50 usec
IRNUC 1H
CTEMP 25.7 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 1.20 Hz
RGAIN 56



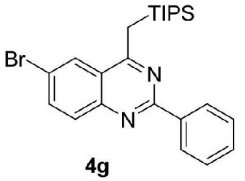
4f

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4g-O-8-1.als



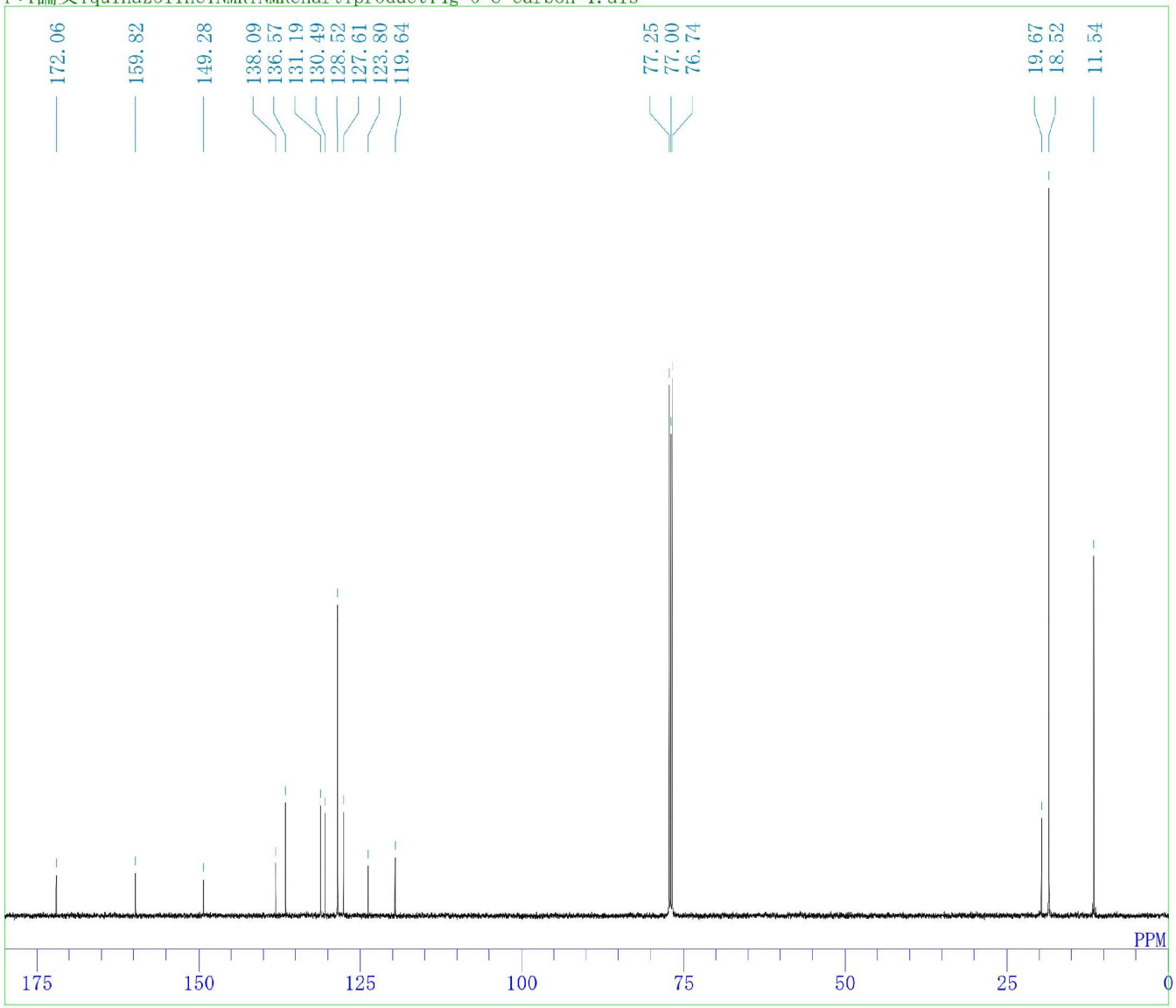
DFILE 4g-O-8-1.als
COMNT single_pulse
DATIM 01-03-2010 08:02:12
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 25.7 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 40



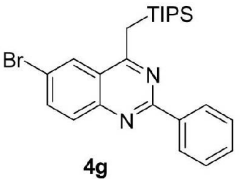
4g

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4g-O-8-carbon-1.als



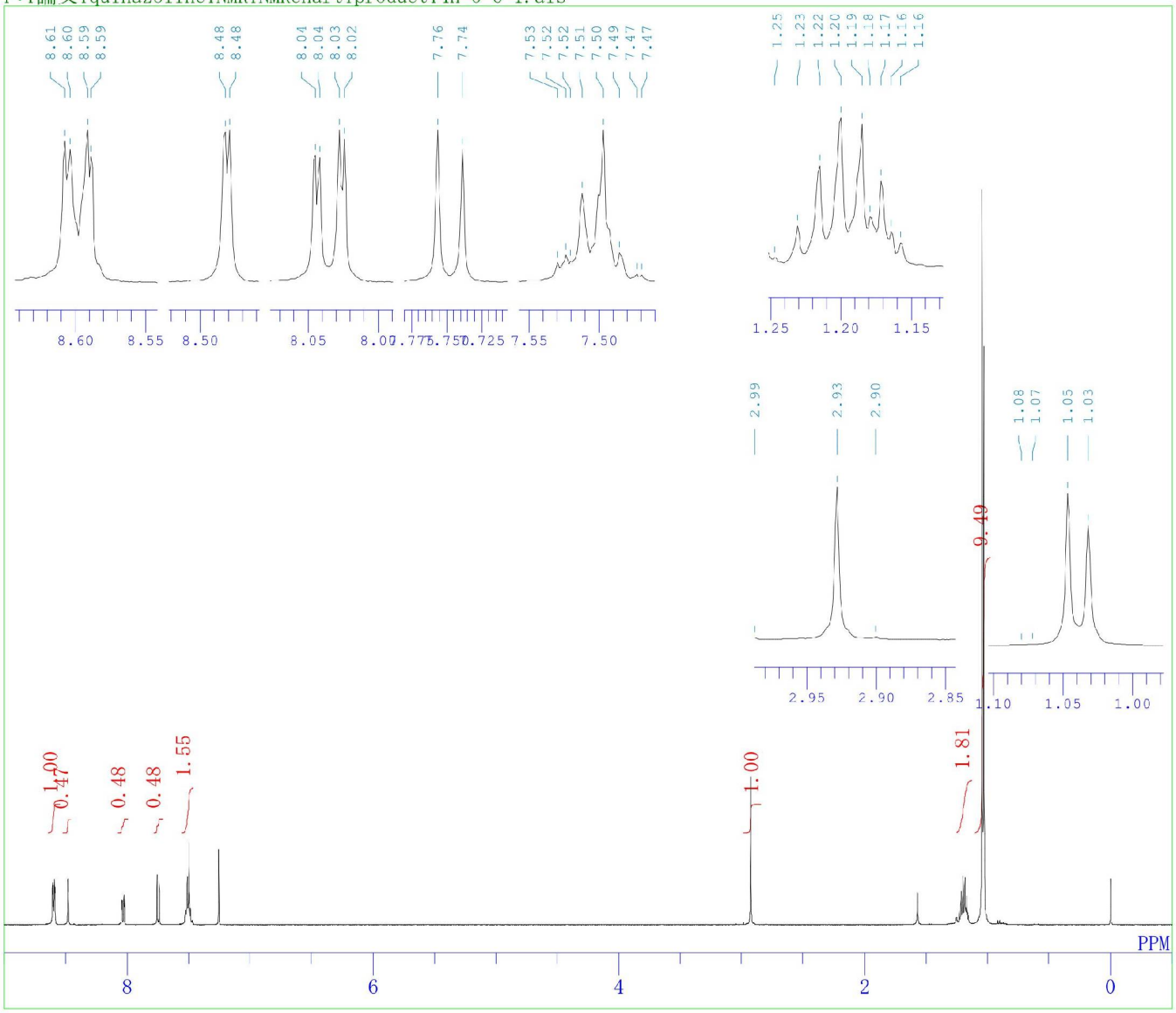

```
DFILE   4g-O-8-carbon-1.als
COMNT   single pulse decoupled gated NOE
DATIM   01-03-2010 08:50:20
OBNUC   13C
EXMOD   single_pulse_dec
OBFRQ         125.77 MHz
OBSET           7.87 KHz
OBFIN           4.21 Hz
POINT          26214
FREQU       31446.06 Hz
SCANS           1000
ACQTM         0.8336 sec
PD            2.0000 sec
PW1             3.50 usec
IRNUC   1H
CTEMP            25.6 c
SLVNT   CDCL3
EXREF           77.00 ppm
BF              1.20 Hz
RGAIN             56
```



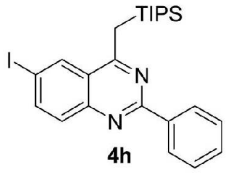
4g

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4h-O-6-1.als



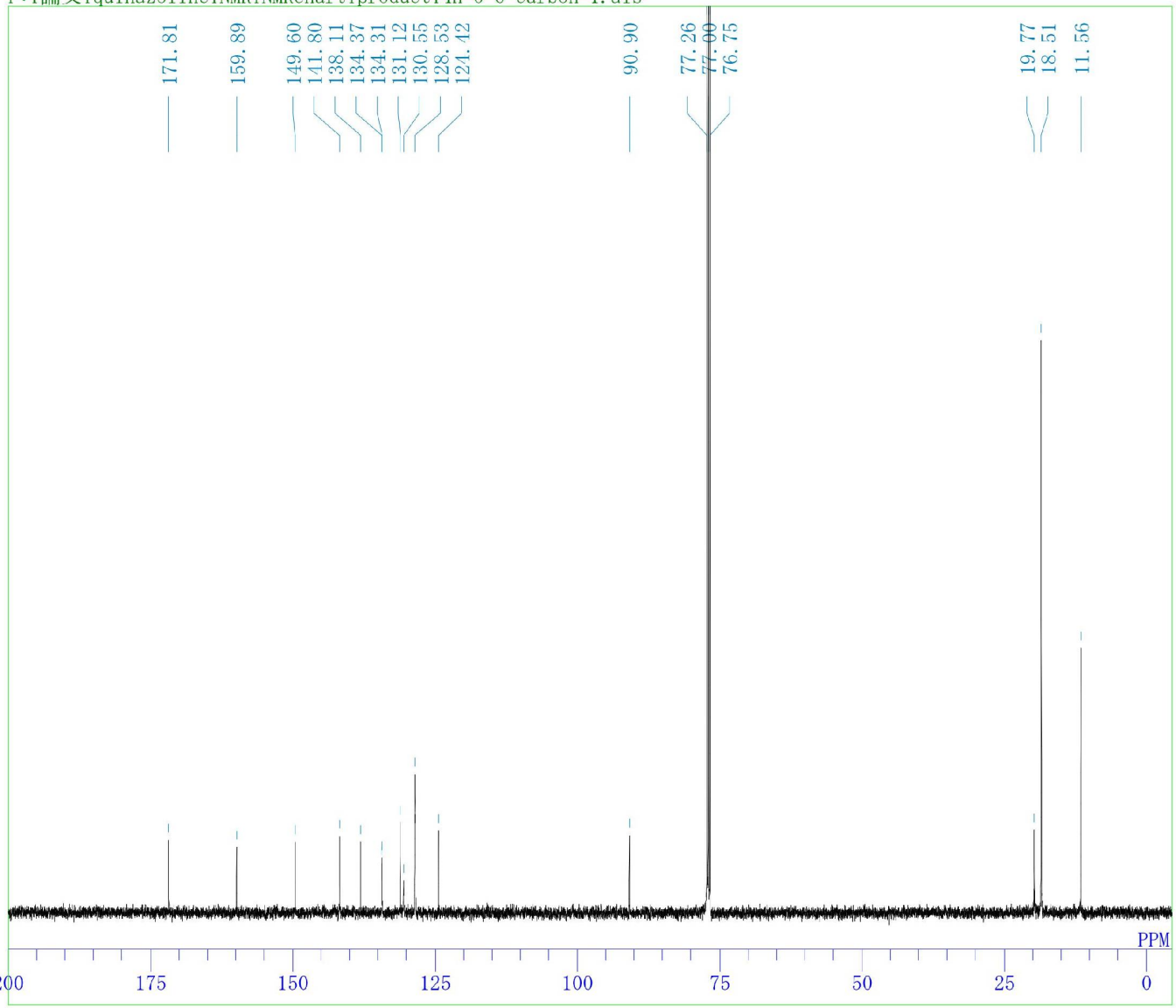
DFILE 4h-O-6-1.als
COMNT single_pulse
DATIM 26-02-2010 19:46:09
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 25.6 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 48



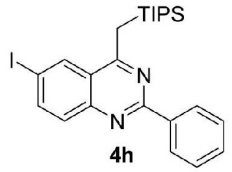
4h

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4h-O-6-carbon-1.als



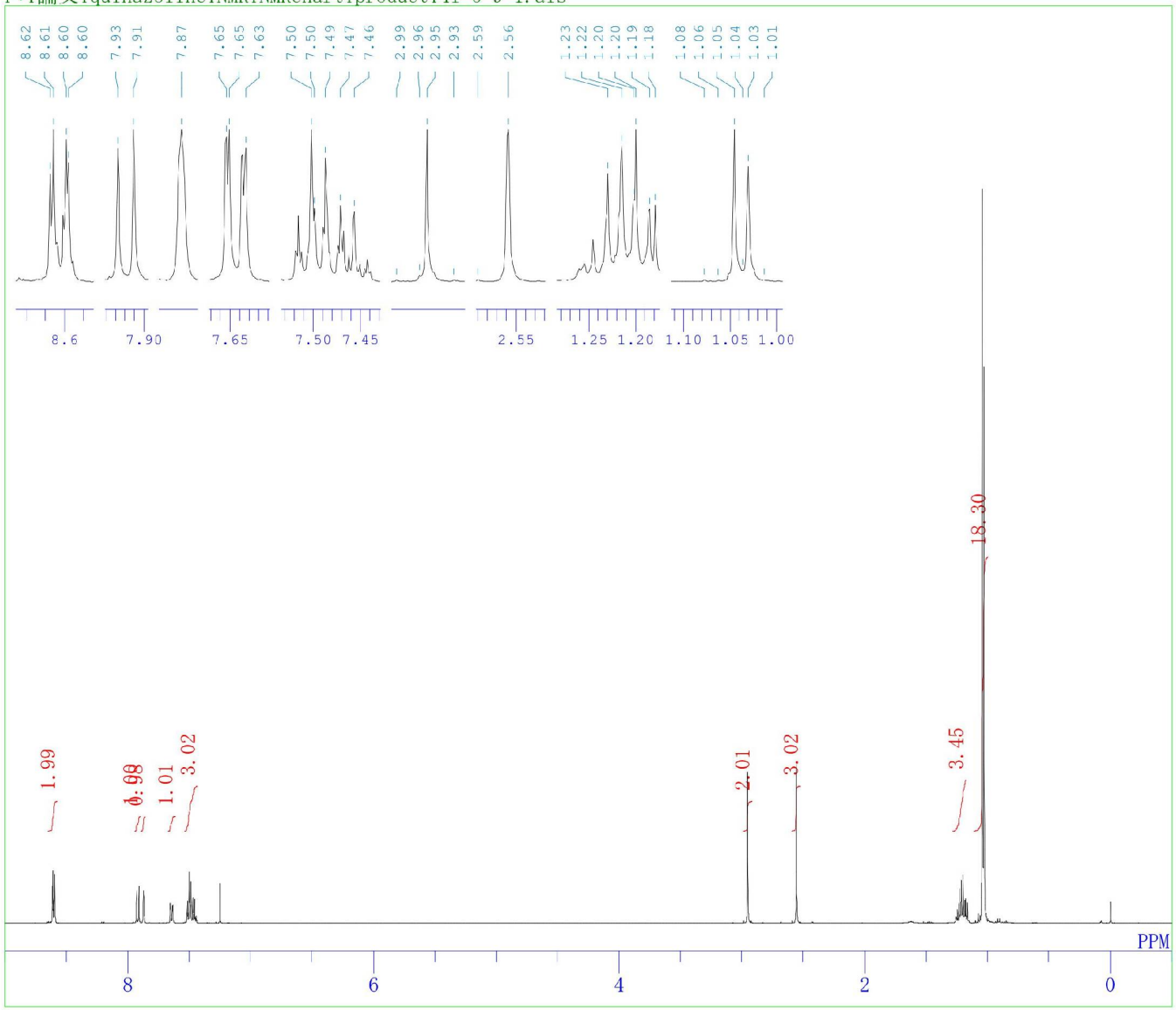

```
DFILE   4h-O-6-carbon-1.als
COMNT   single pulse decoupled gated NOE
DATIM   26-02-2010 20:34:09
OBNUC   13C
EXMOD   single_pulse_dec
OBFRQ         125.77 MHz
OBSET           7.87 KHz
OBFIN           4.21 Hz
POINT          26214
FREQU       31446.06 Hz
SCANS           1000
ACQTM         0.8336 sec
PD            2.0000 sec
PW1             3.50 usec
IRNUC   1H
CTEMP            25.2 c
SLVNT   CDCL3
EXREF           77.00 ppm
BF              1.20 Hz
RGAIN             58
```



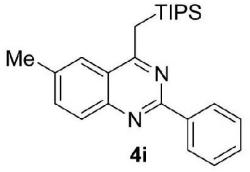
4h

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4i-O-9-1.als



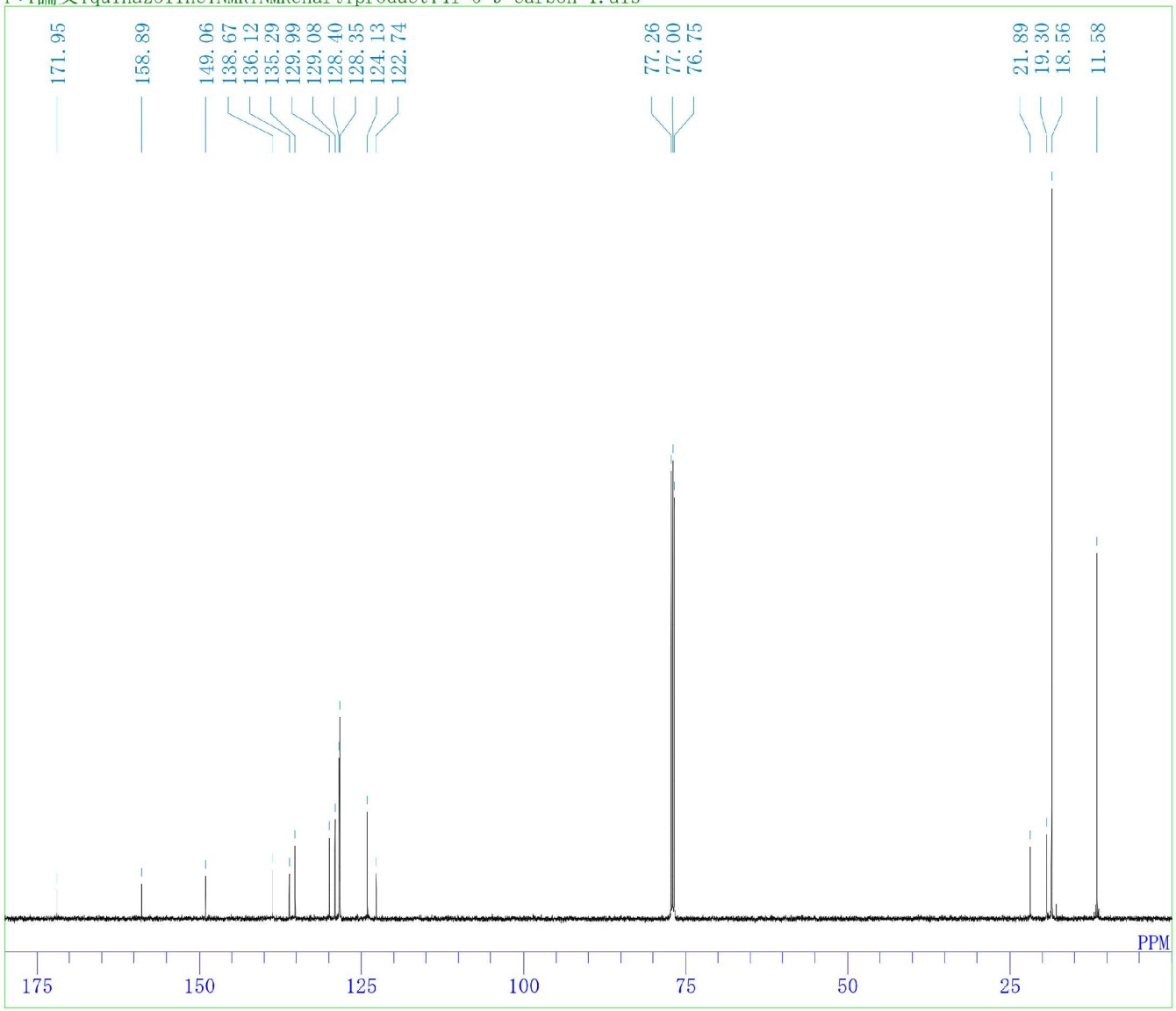
DFILE 4i-O-9-1.als
COMNT single_pulse
DATIM 26-02-2010 13:52:11
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 28.6 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 38



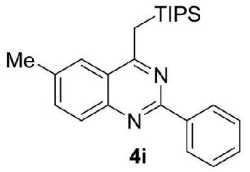
4i

single pulse decoupled gated NOE

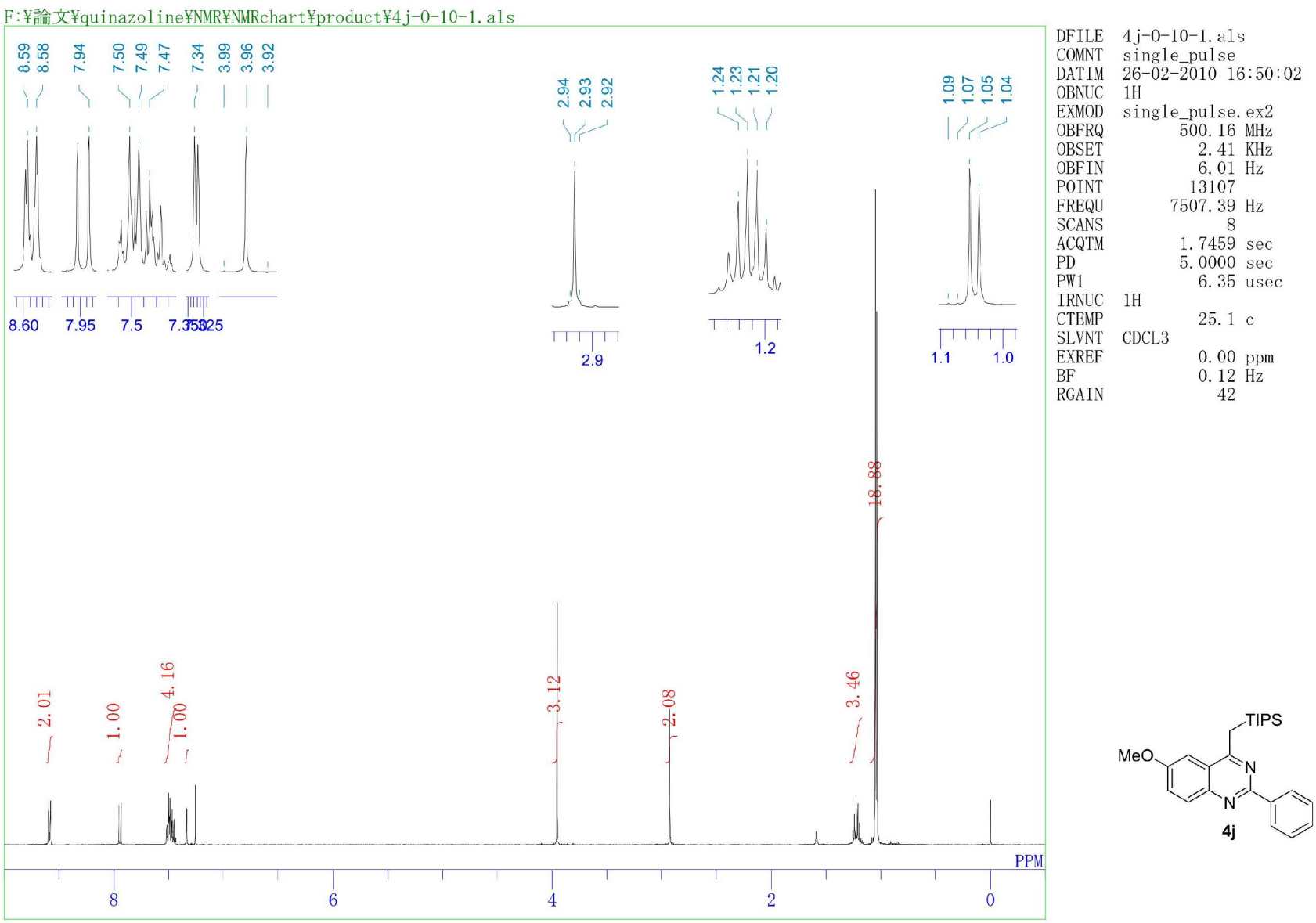
F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4i-O-9-carbon-1.als



DFILE	4i-O-9-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	26-02-2010 14:40:02
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.7 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	60



4i

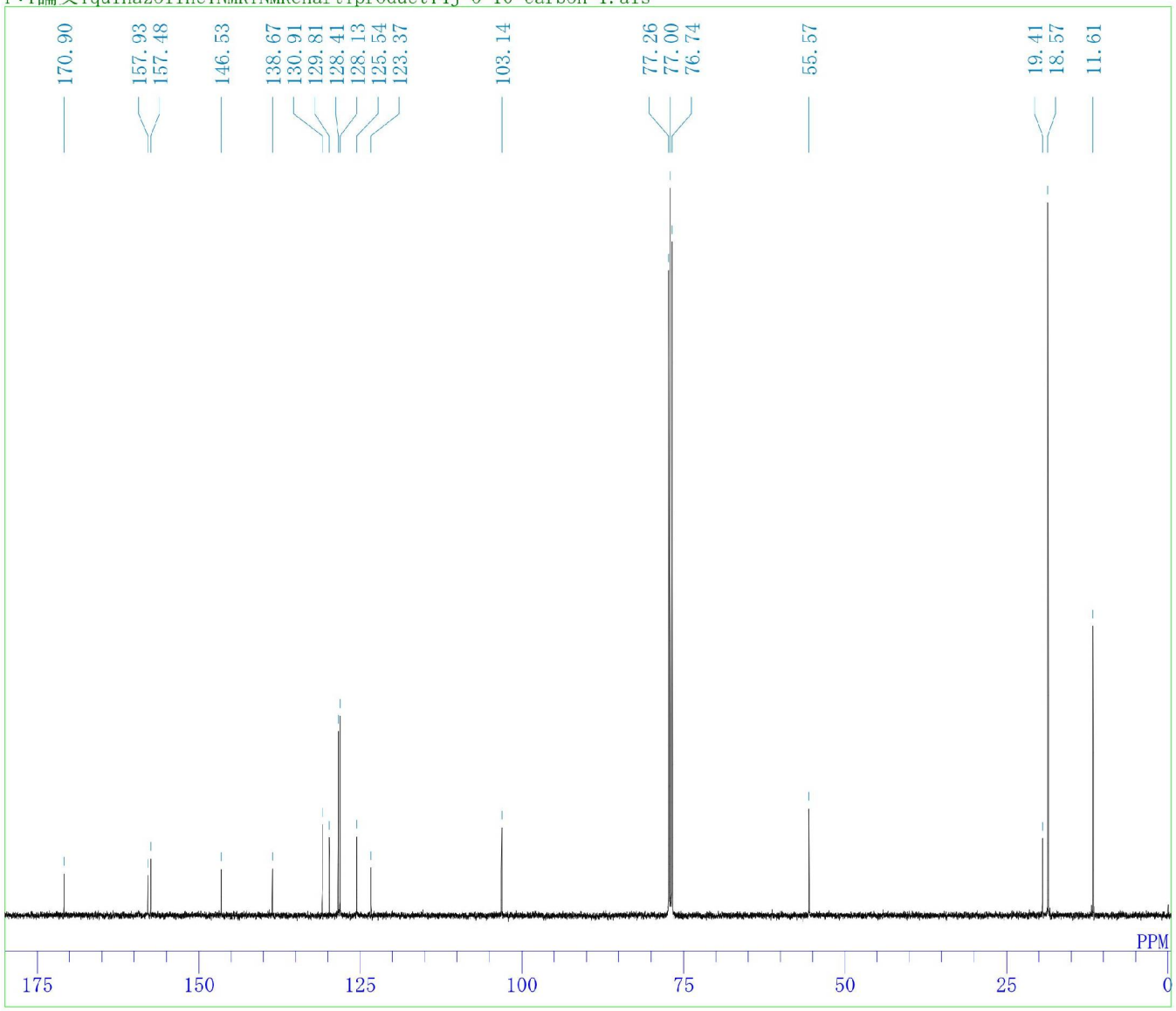


DFILE 4j-O-10-1.als
COMNT single_pulse
DATIM 26-02-2010 16:50:02
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 25.1 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 42

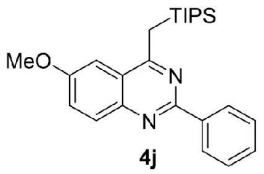
4j

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4j-O-10-carbon-1.als



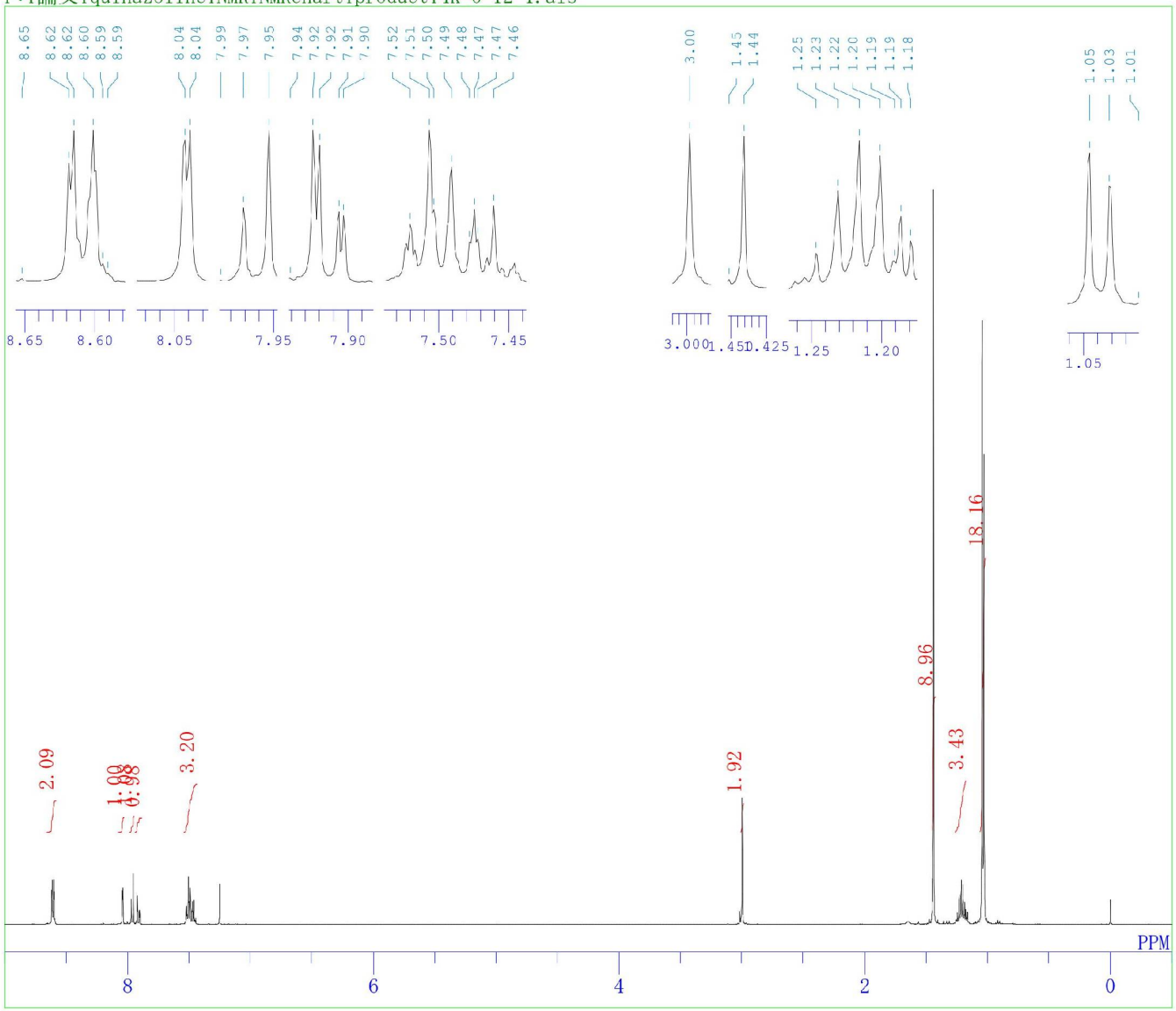
DFILE	4j-O-10-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	26-02-2010 17:38:34
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.2 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	58



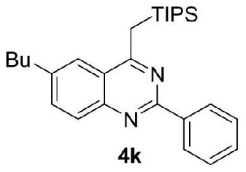
4j

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4k-O-12-1.als



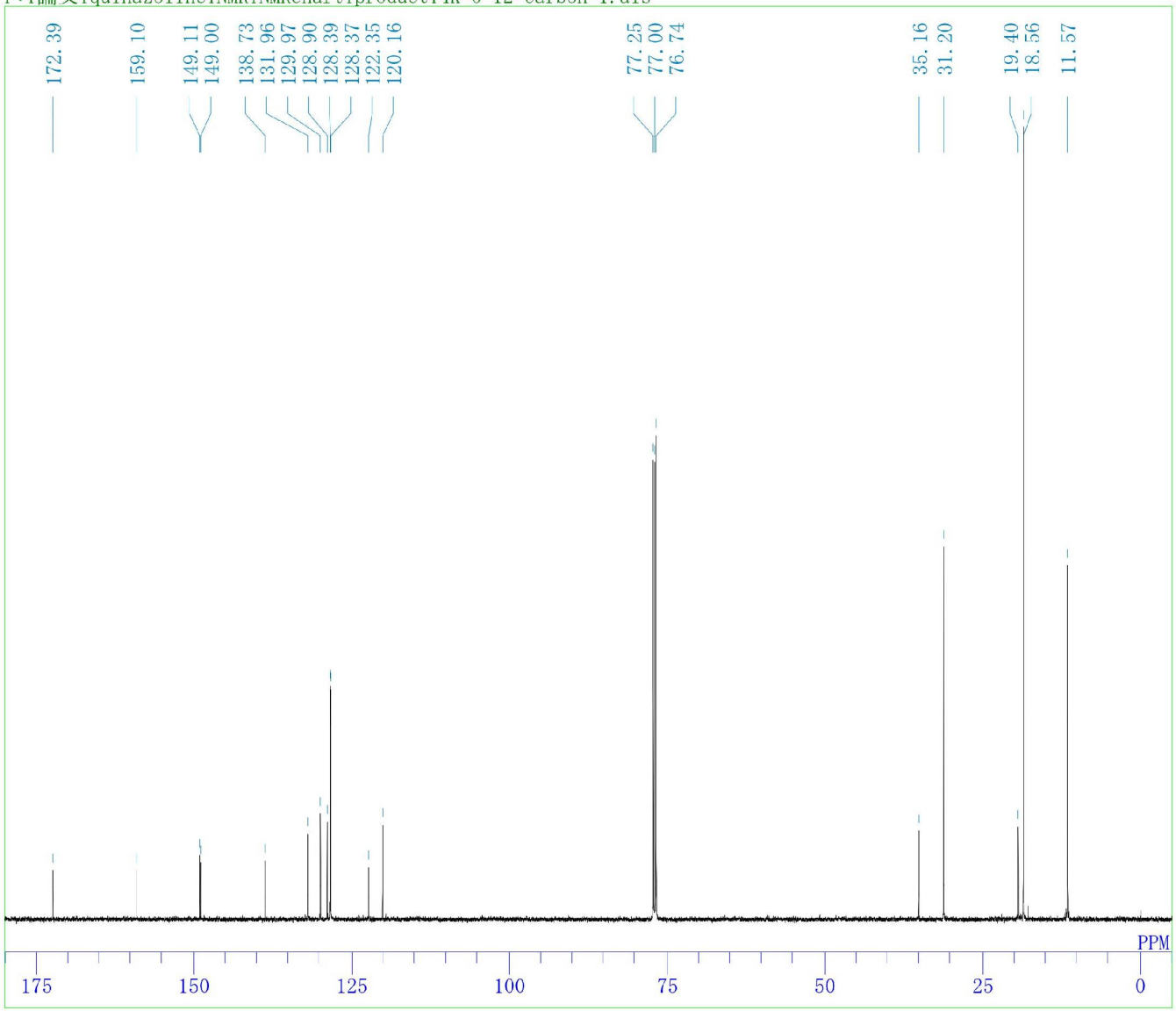
DFILE	4k-O-12-1.als
COMNT	single_pulse
DATIM	01-03-2010 13:49:58
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	25.6 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	36



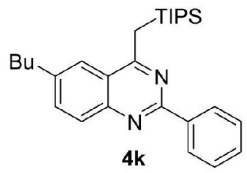
4k

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4k-O-12-carbon-1.als



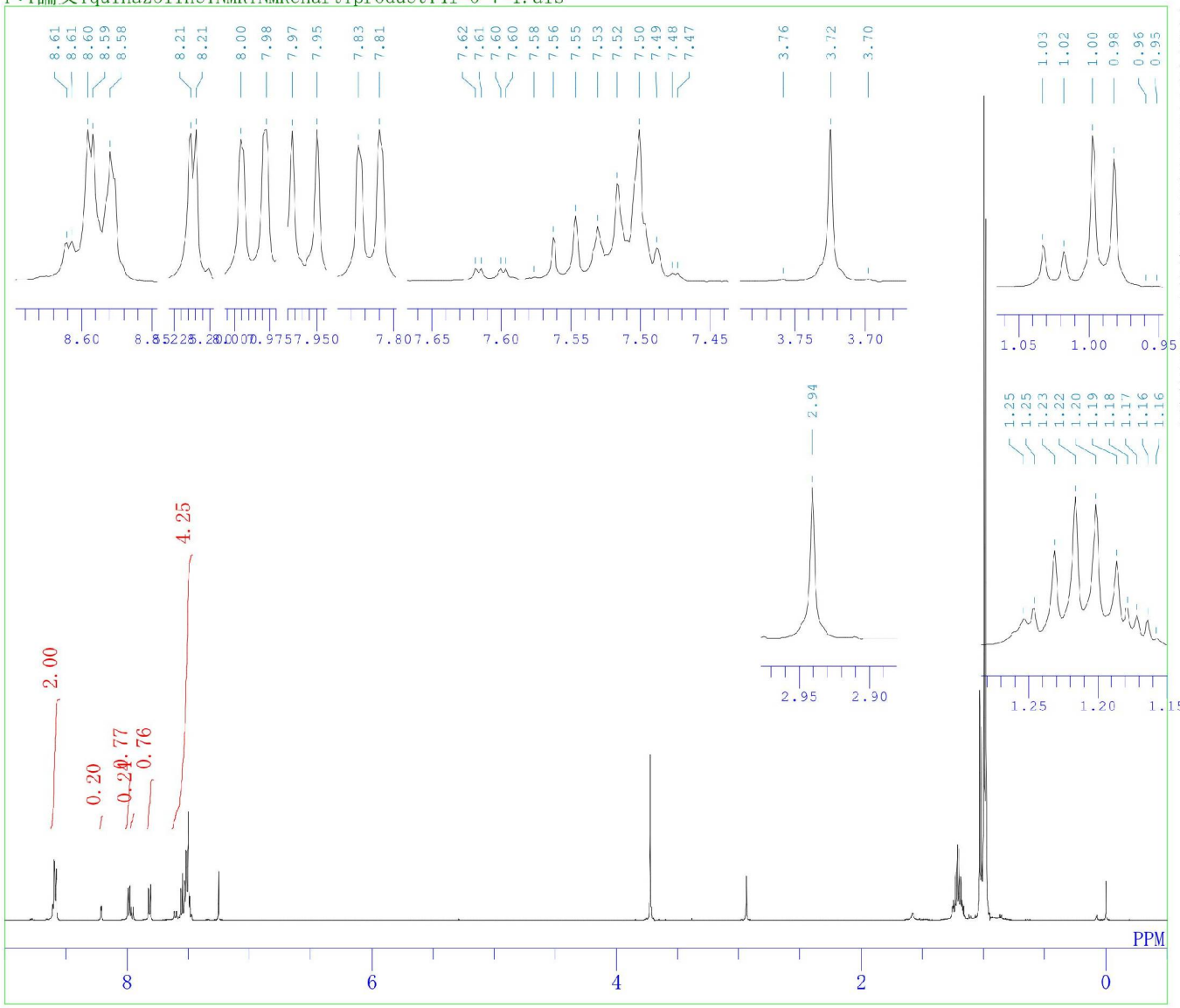
DFILE	4k-O-12-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	01-03-2010 14:38:01
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.6 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	58



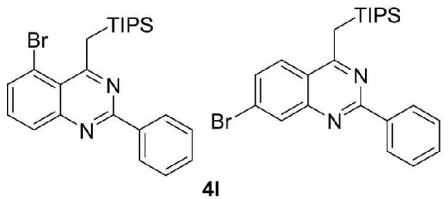
4k

single_pulse

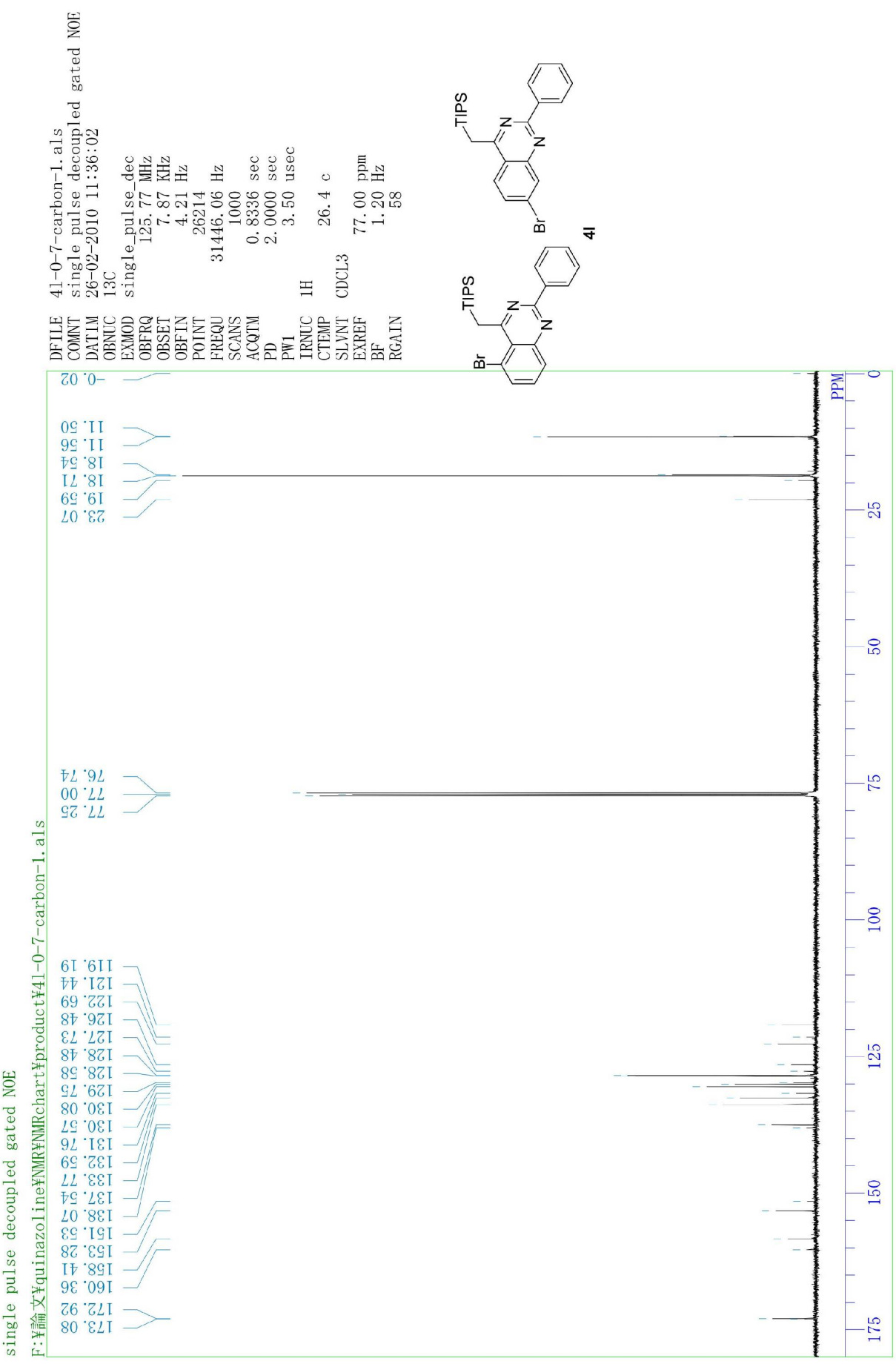
F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4l-O-7-1.als

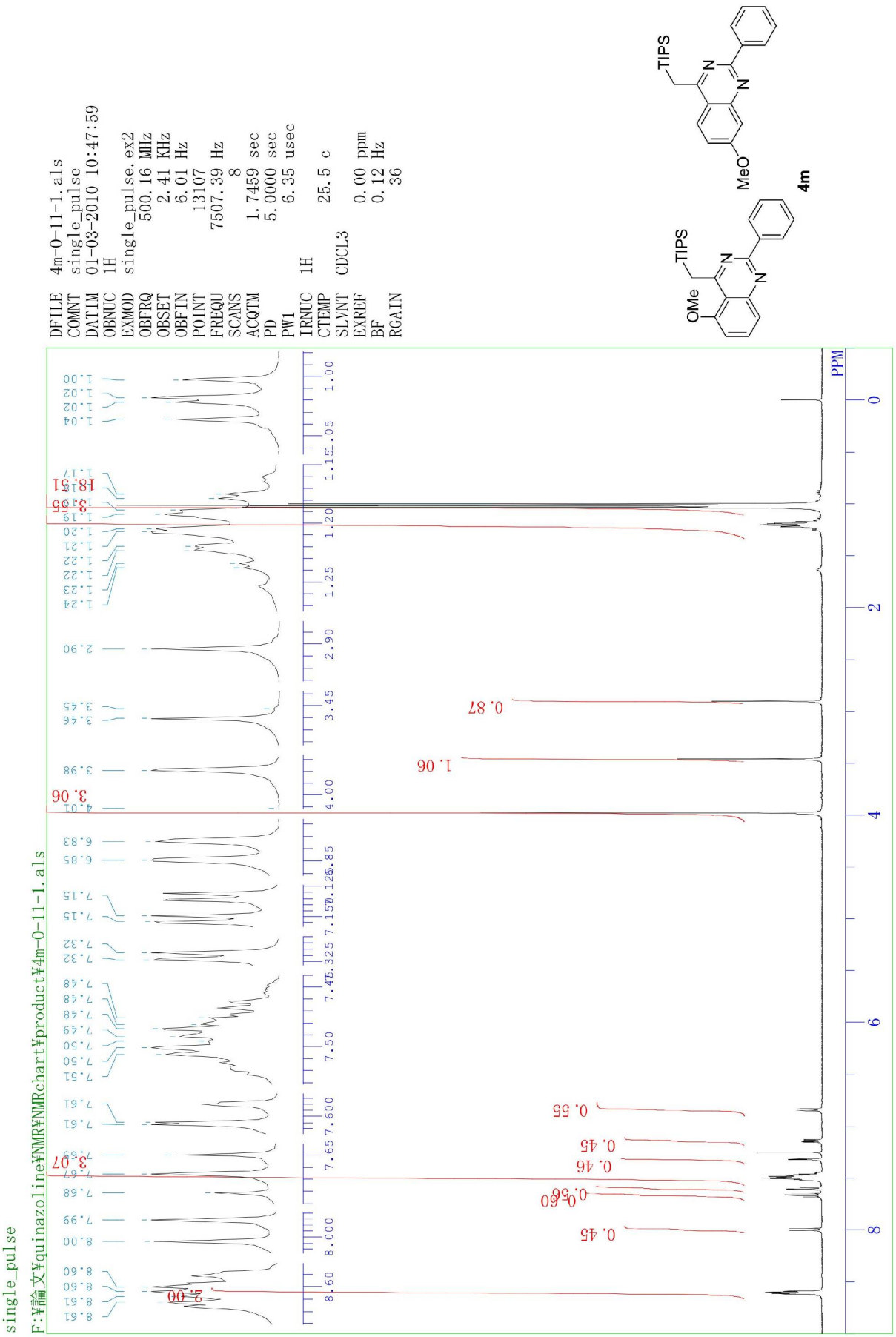


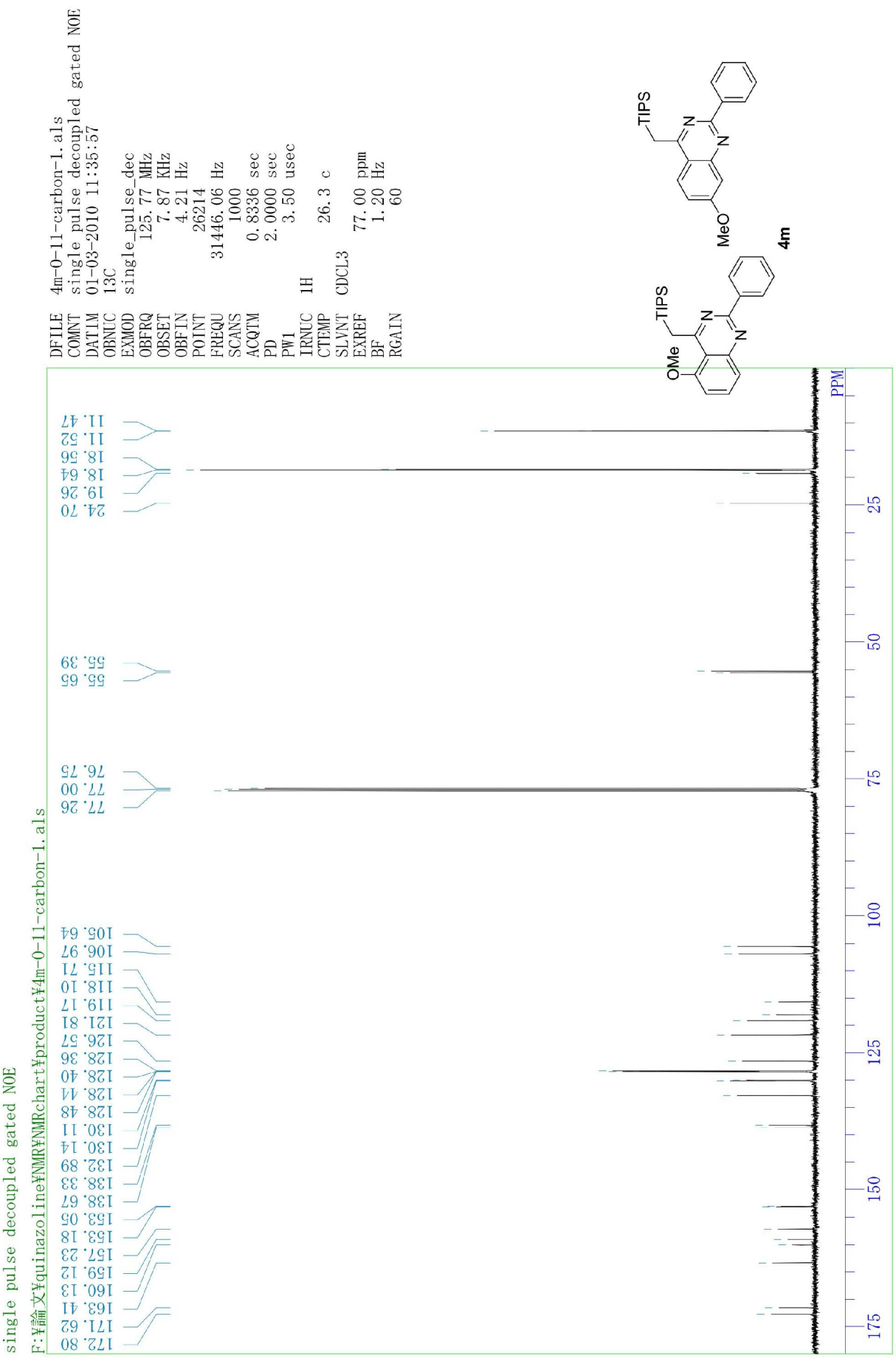
DFILE 4l-O-7-1.als
COMNT single_pulse
DATIM 26-02-2010 10:48:02
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 25.0 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 40



4l

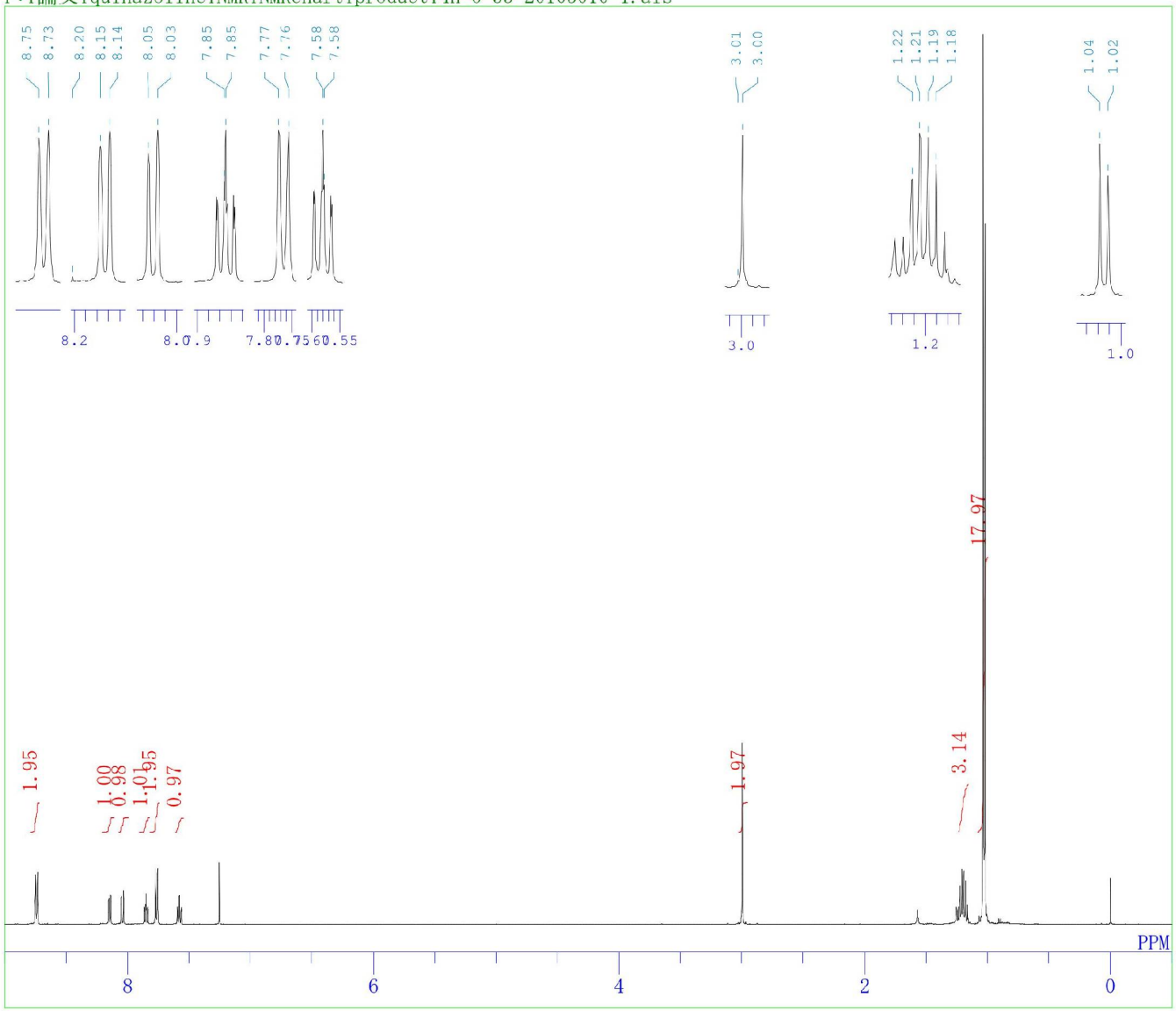

single pulse decoupled gated NOE
F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥41-0-7-carbon-1.als
DFILE 41-0-7-carbon-1.als
COMNT single pulse decoupled gated NOE
DATIM 26-02-2010 11:36:02
OBNUC 13C
EXMOD single_pulse_dec
OBFRQ 125.77 MHz
OBSET 7.87 KHz
OBFIN 4.21 Hz
POINT 26214
FREQU 31446.06 Hz
SCANS 1000
ACQTM 0.8336 sec
PD 2.0000 sec
PW1 3.50 usec
IRNUC 1H
CTEMP 26.4 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 1.20 Hz
RGAIN 58
TIPS
Br
N
N
41
PPM


single_pulse
F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4m-O-11-1.als
DFILE 4m-O-11-1.als
COMNT single_pulse
DATIM 01-03-2010 10:47:59
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 25.5 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 36
TIPS
OMe
N
N
TIPS
MeO
N
N
4m
PPM

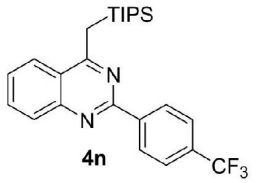

single pulse decoupled gated NOE
F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4m-O-11-carbon-1.als
DFILE 4m-O-11-carbon-1.als
COMNT single pulse decoupled gated NOE
DATIM 01-03-2010 11:35:57
OBNUC 13C
EXMOD single_pulse_dec
OBFRQ 125.77 MHz
OBSET 7.87 KHz
OBFIN 4.21 Hz
POINT 26214
FREQU 31446.06 Hz
SCANS 1000
ACQTM 0.8336 sec
PD 2.0000 sec
PW1 3.50 usec
IRNUC 1H
CTEMP 26.3 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 1.20 Hz
RGAIN 60
172.80
171.62
163.41
160.13
159.12
157.23
153.18
153.05
138.67
138.33
132.89
130.14
130.11
128.48
128.44
128.40
128.36
126.57
121.81
119.17
118.10
115.71
106.97
105.64
77.26
77.00
76.75
55.65
55.39
24.70
19.26
18.64
18.56
11.52
11.47
PPM
175
150
125
100
75
50
25
TIPS
N
N
MeO
4m
TIPS
OMe
N
N

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4n-O-33-20103010-1.als



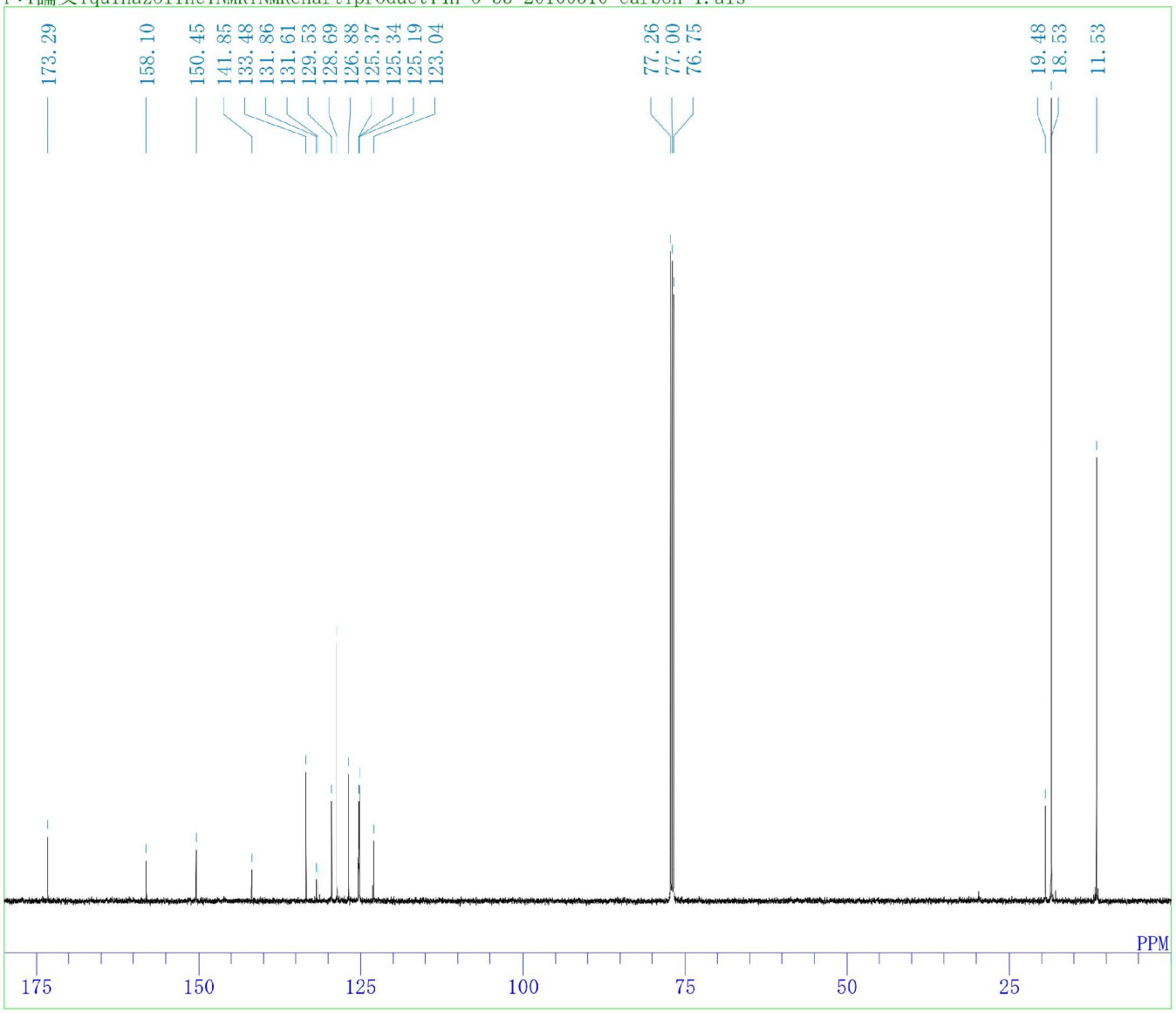
DFILE 4n-O-33-20103010-1.als
COMNT single_pulse
DATIM 10-03-2010 14:48:26
OBNUC 1H
EXMOD single_pulse.ex2
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 13107
FREQU 7507.39 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 6.35 usec
IRNUC 1H
CTEMP 27.5 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 40



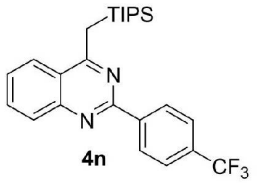
4n

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4n-O-33-20100310-carbon-1.als



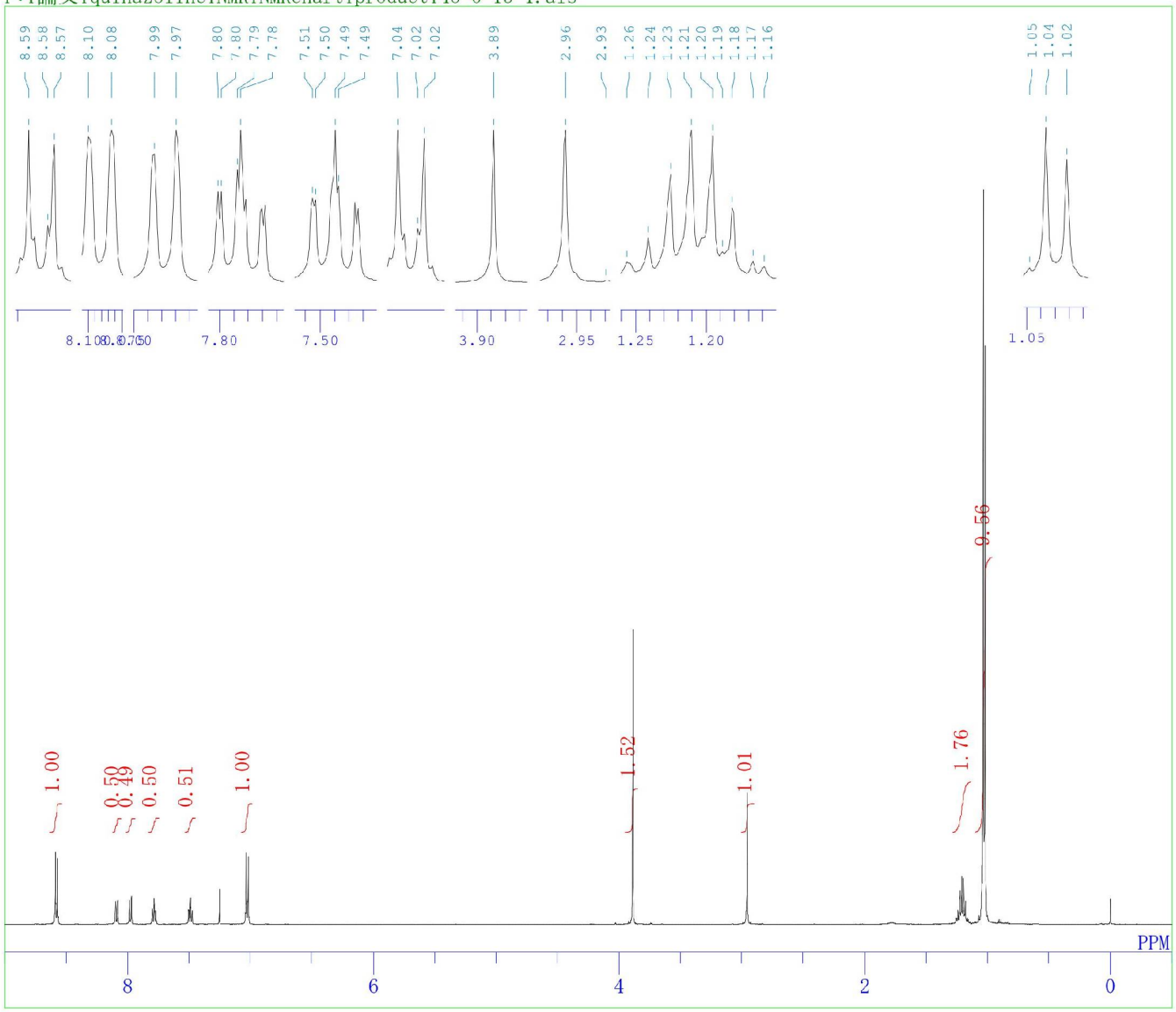
DFILE	4n-O-33-20100310-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	12-03-2010 08:28:25
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	24.1 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	60



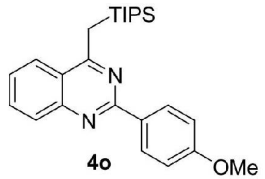
4n

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4o-O-15-1.als



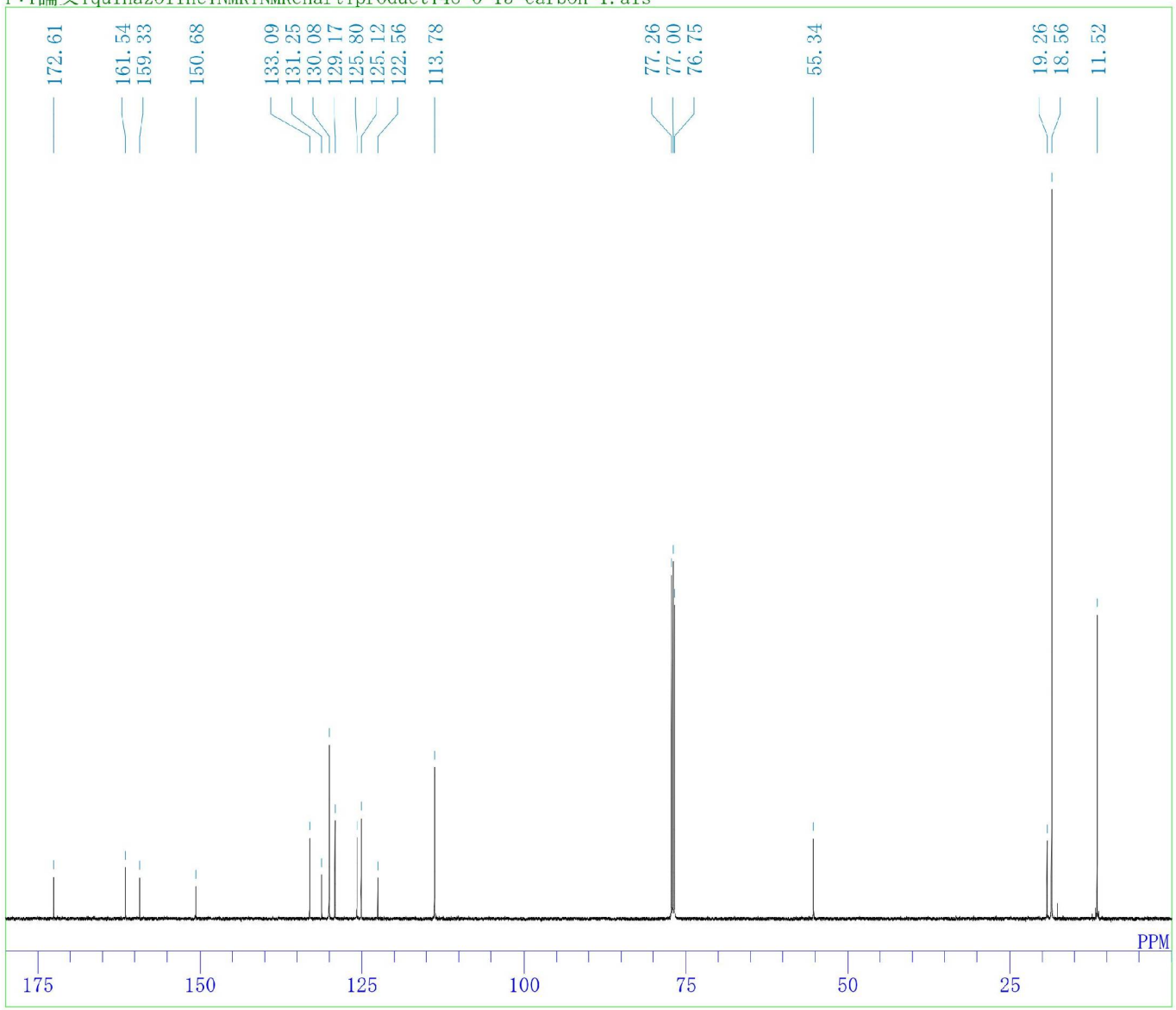
DFILE	4o-O-15-1.als
COMNT	single_pulse
DATIM	02-03-2010 07:52:46
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	25.9 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	36



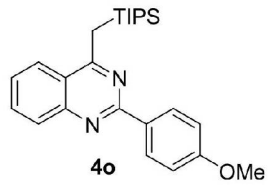
4o

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4o-O-15-carbon-1.als



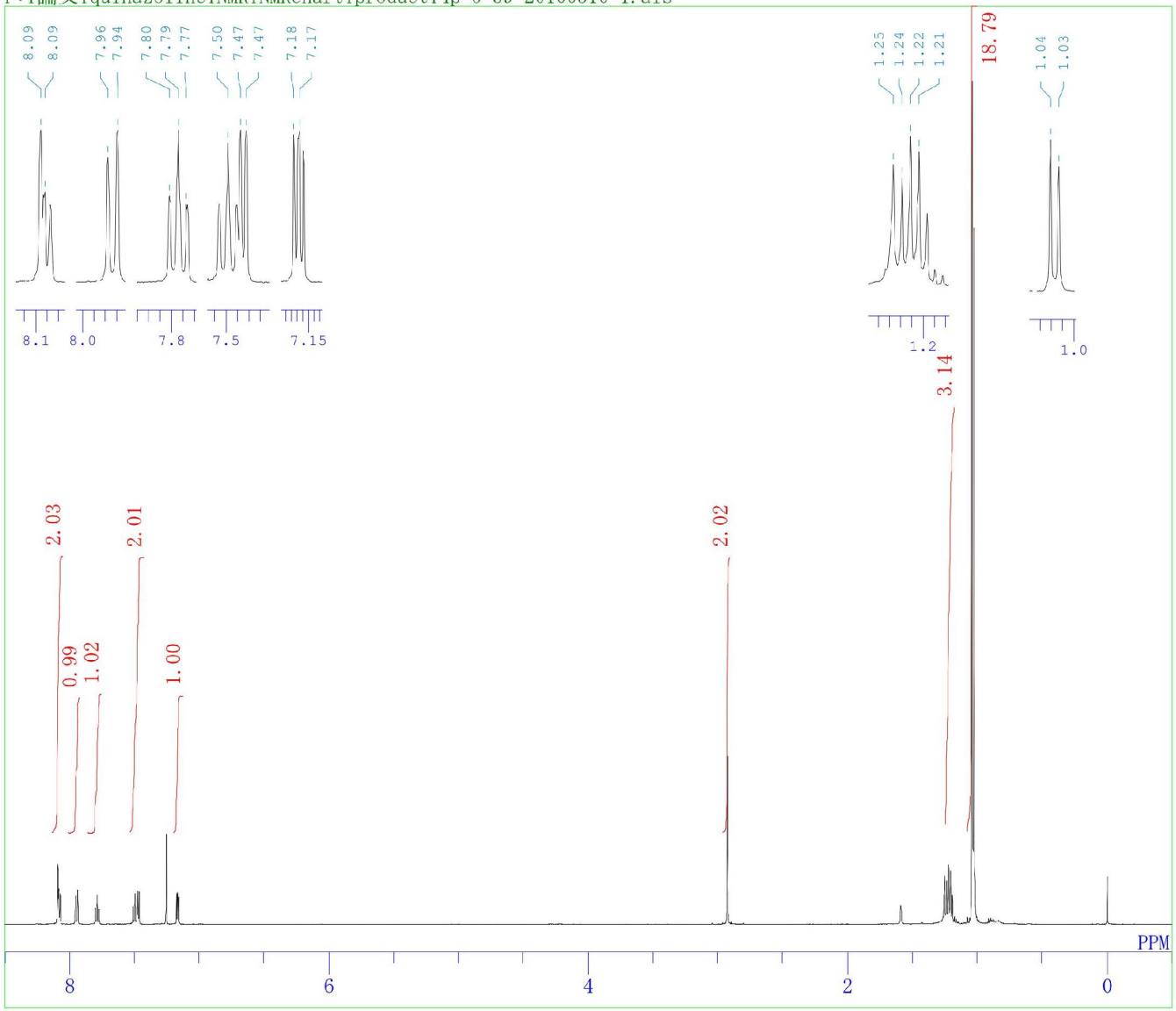

```
DFILE   4o-O-15-carbon-1.als
COMNT   single pulse decoupled gated NOE
DATIM   02-03-2010 08:40:44
OBNUC   13C
EXMOD   single_pulse_dec
OBFRQ         125.77 MHz
OBSET           7.87 KHz
OBFIN           4.21 Hz
POINT          26214
FREQU       31446.06 Hz
SCANS           1000
ACQTM         0.8336 sec
PD            2.0000 sec
PW1             3.50 usec
IRNUC   1H
CTEMP           26.5 c
SLVNT   CDCL3
EXREF           77.00 ppm
BF              1.20 Hz
RGAIN             60
```



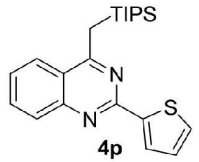
4o

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4p-O-39-20100310-1.als



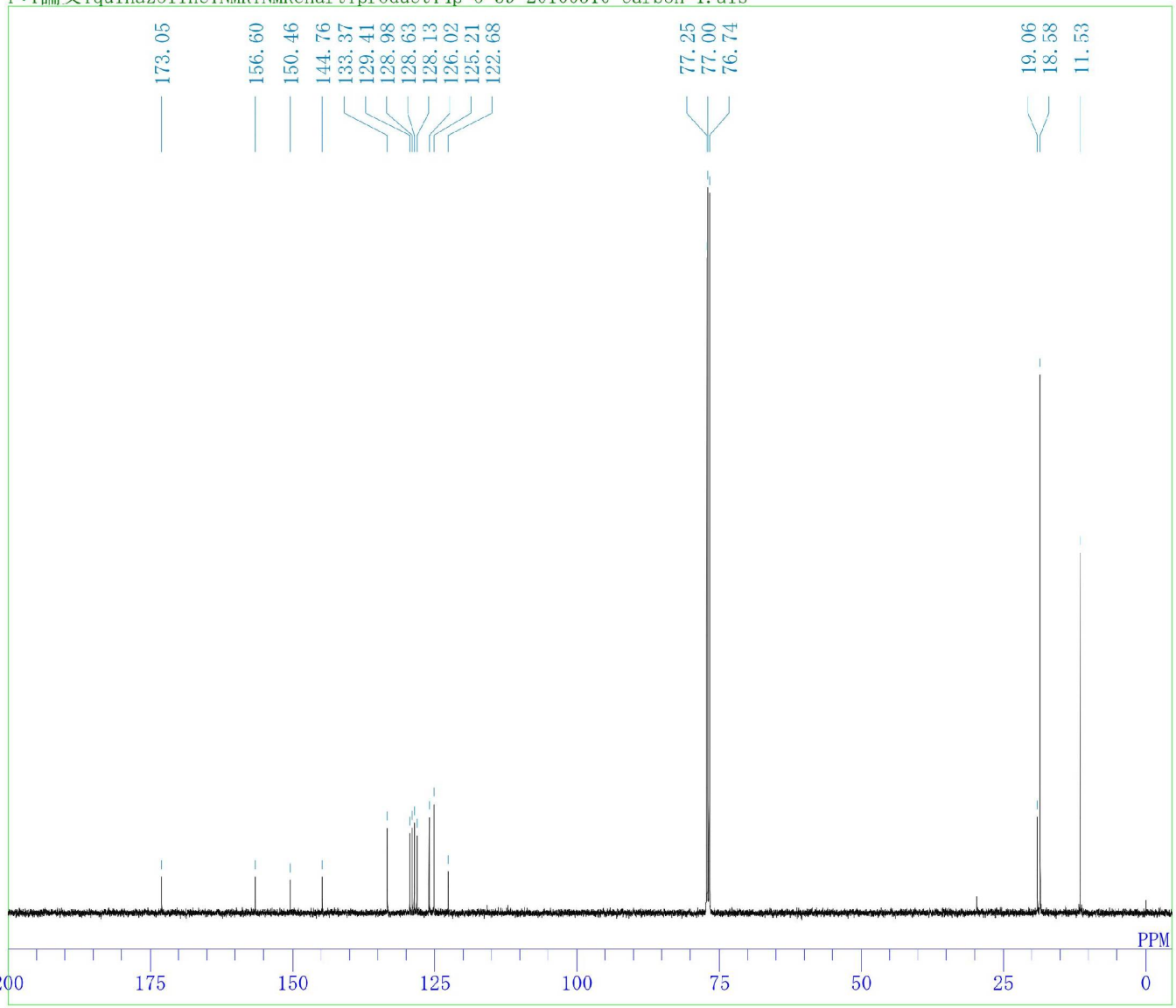
DFILE	4p-O-39-20100310-1.als
COMNT	single_pulse
DATIM	10-03-2010 14:53:31
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	26.7 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	42



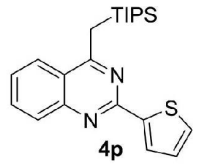
4p

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥4p-O-39-20100310-carbon-1.als



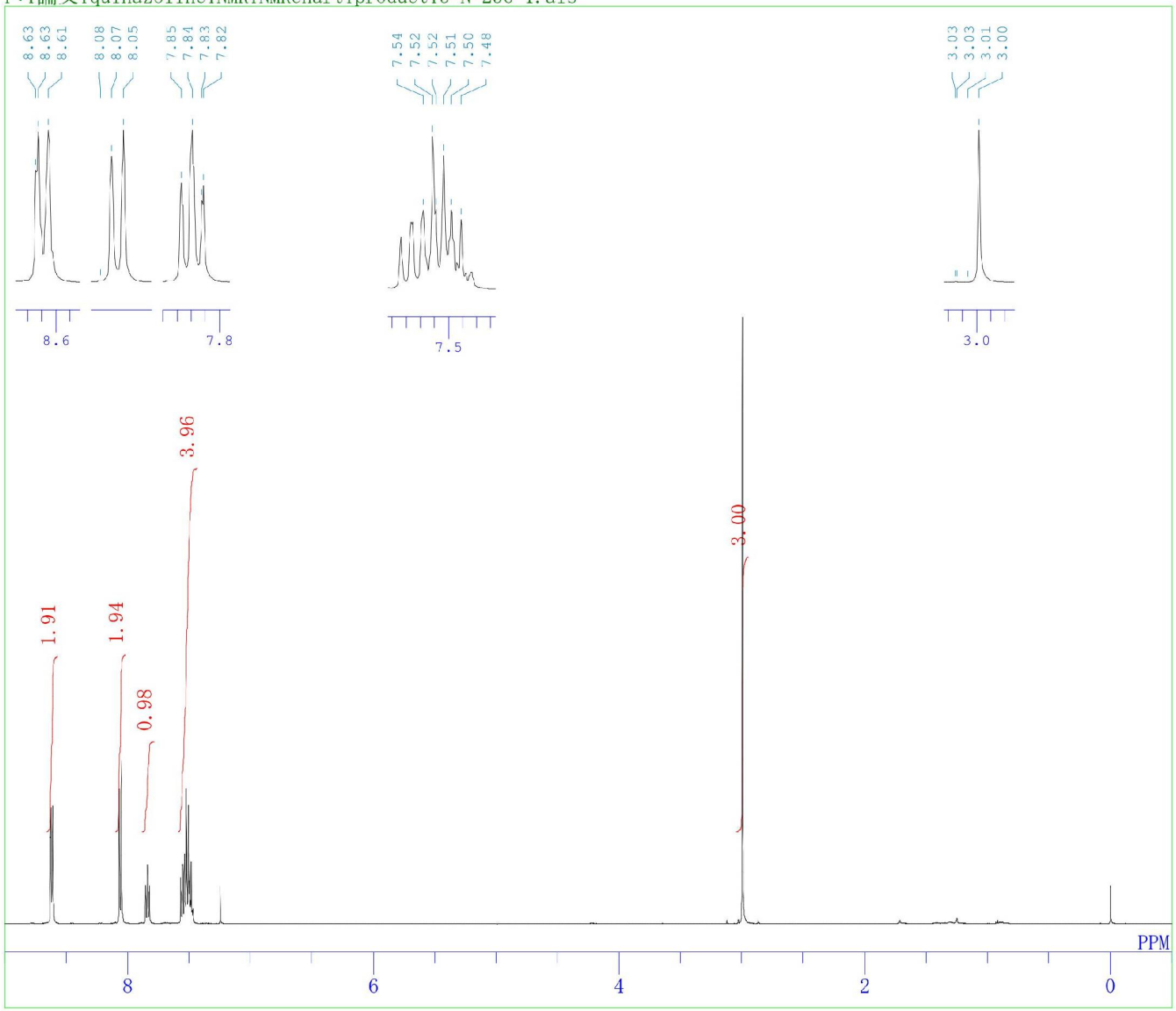
DFILE	4p-O-39-20100310-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	10-03-2010 15:41:38
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	1000
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	25.8 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	60



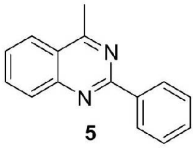
4p

single_pulse

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥5-N-236-1.als



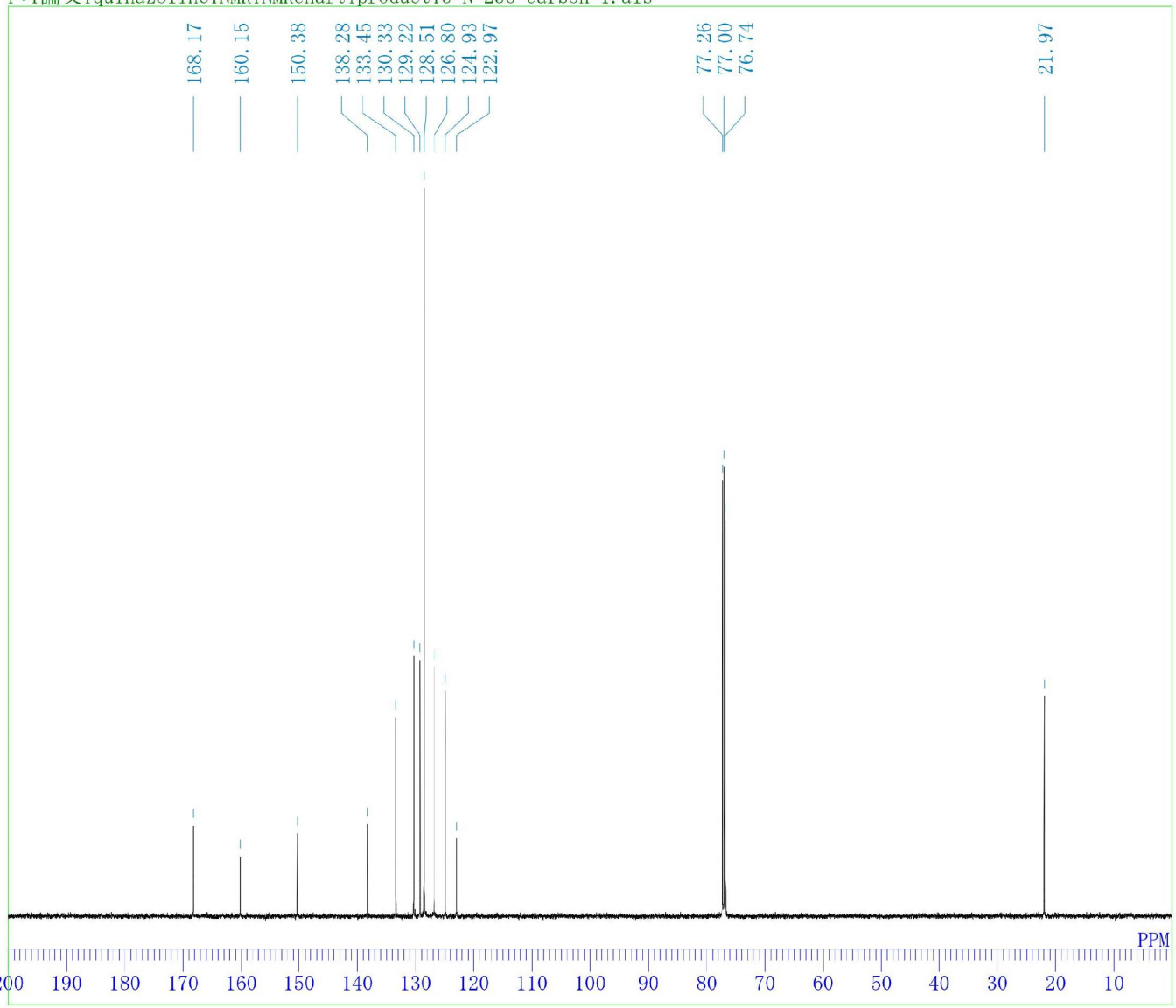
DFILE	5-N-236-1.als
COMNT	single_pulse
DATIM	08-12-2009 17:17:31
OBNUC	1H
EXMOD	single_pulse.ex2
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.39 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	6.35 usec
IRNUC	1H
CTEMP	25.1 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	40



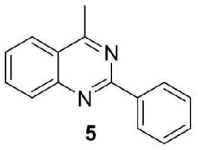
5

single pulse decoupled gated NOE

F:¥論文¥quinazoline¥NMR¥NMRchart¥product¥5-N-236-carbon-1.als



DFILE	5-N-236-carbon-1.als
COMNT	single pulse decoupled gated NOE
DATIM	08-12-2009 18:00:43
OBNUC	13C
EXMOD	single_pulse_dec
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	26214
FREQU	31446.06 Hz
SCANS	900
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.50 usec
IRNUC	1H
CTEMP	26.3 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	1.20 Hz
RGAIN	60



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