

Supplementary Material

Synthesis of multi-substituted allenes from organoalane reagents and propargyl esters by nickel-catalyzed

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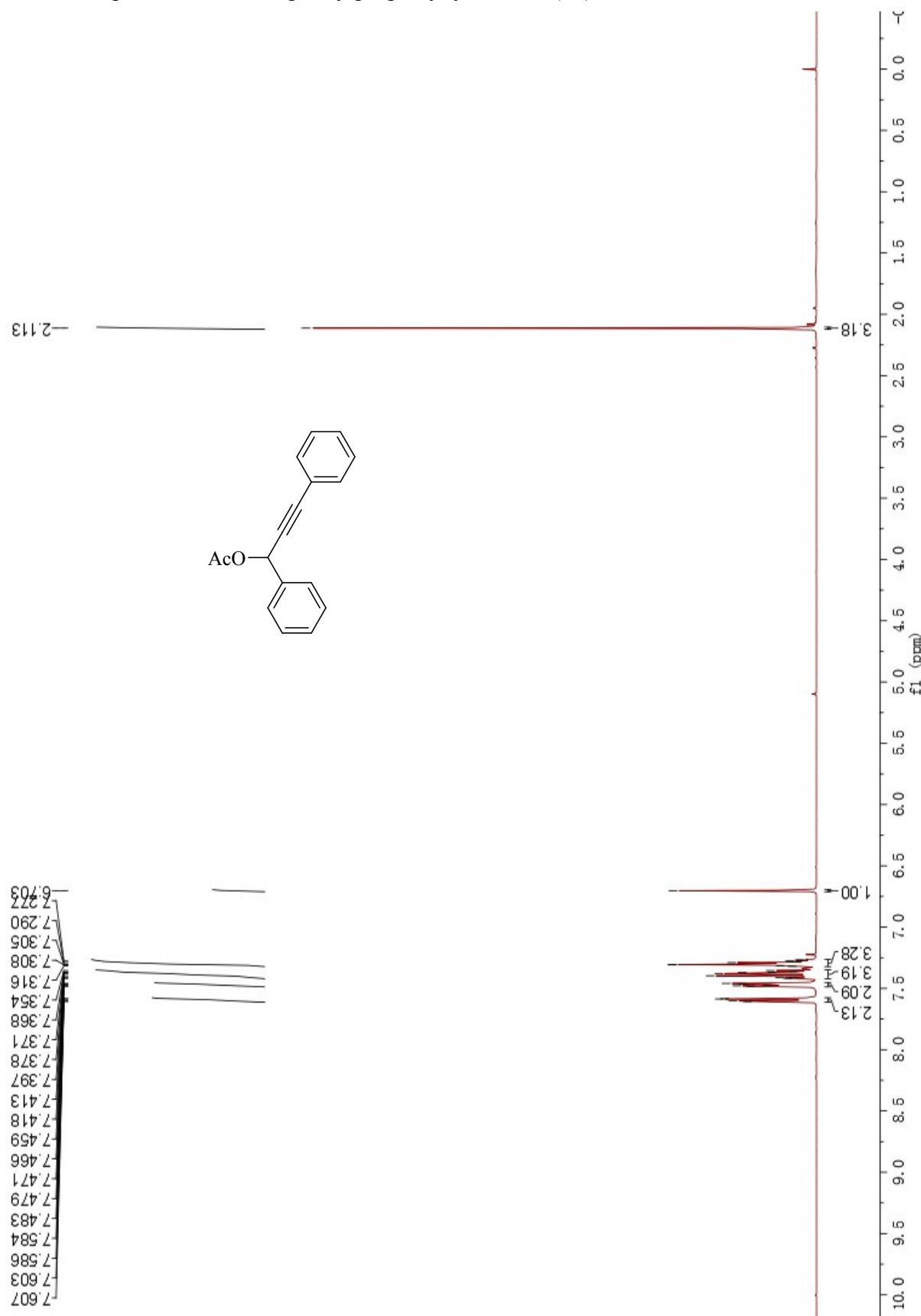
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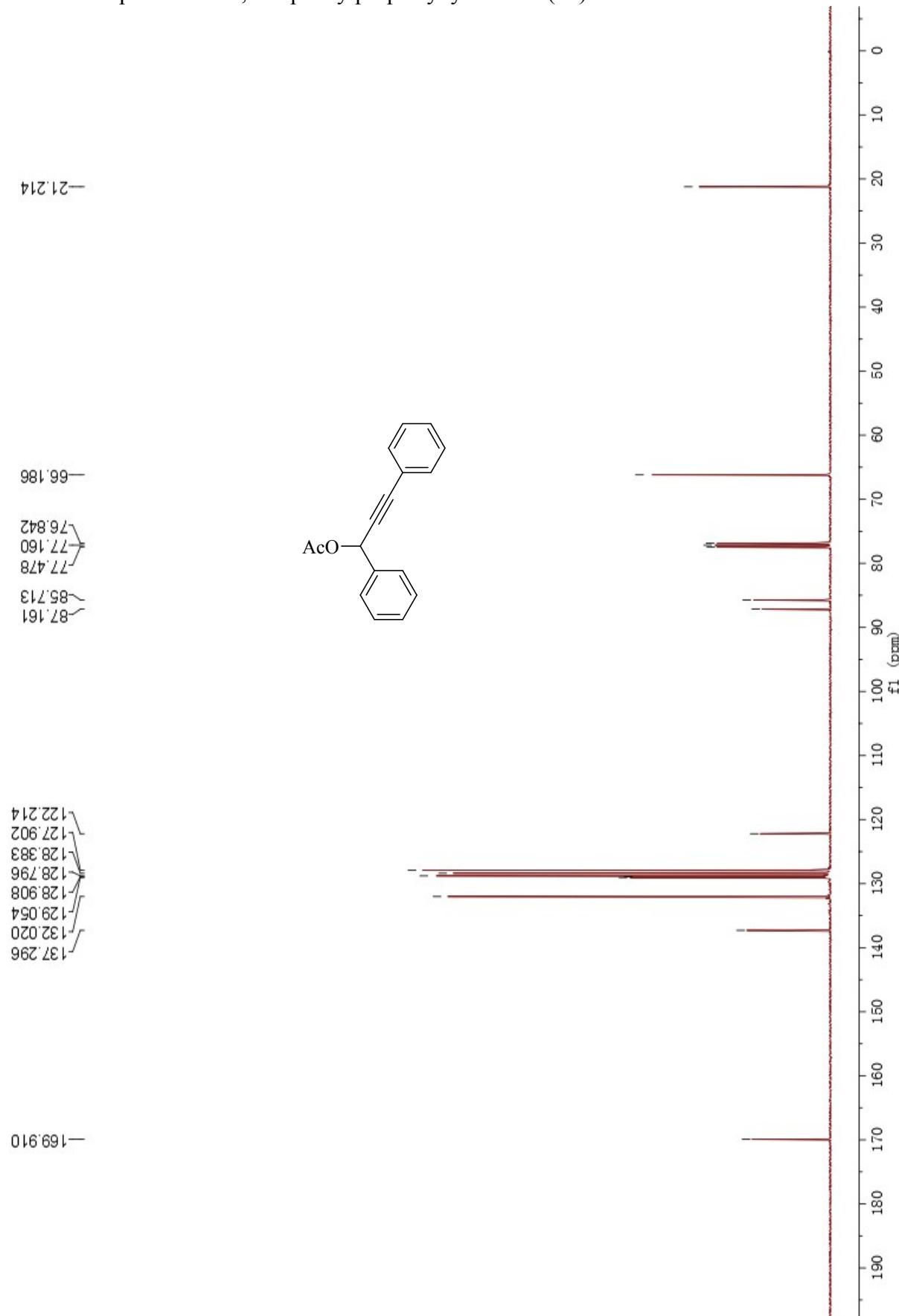
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¹H and ¹³C NMR Spectra of new Propargyl acetates

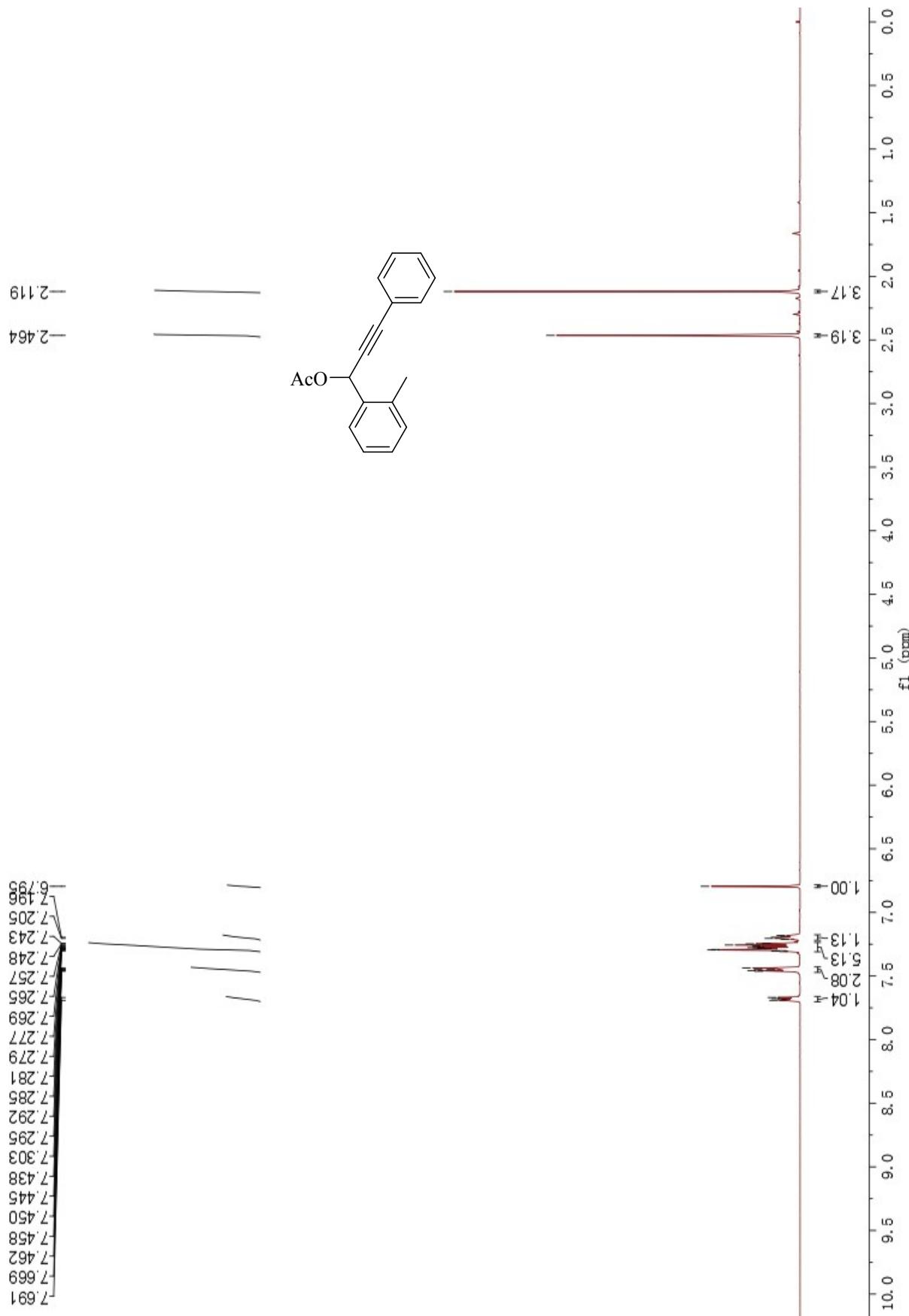
¹H NMR Spectrum of 1,3-Diphenylprop-2-ynyl acetate (**1a**)



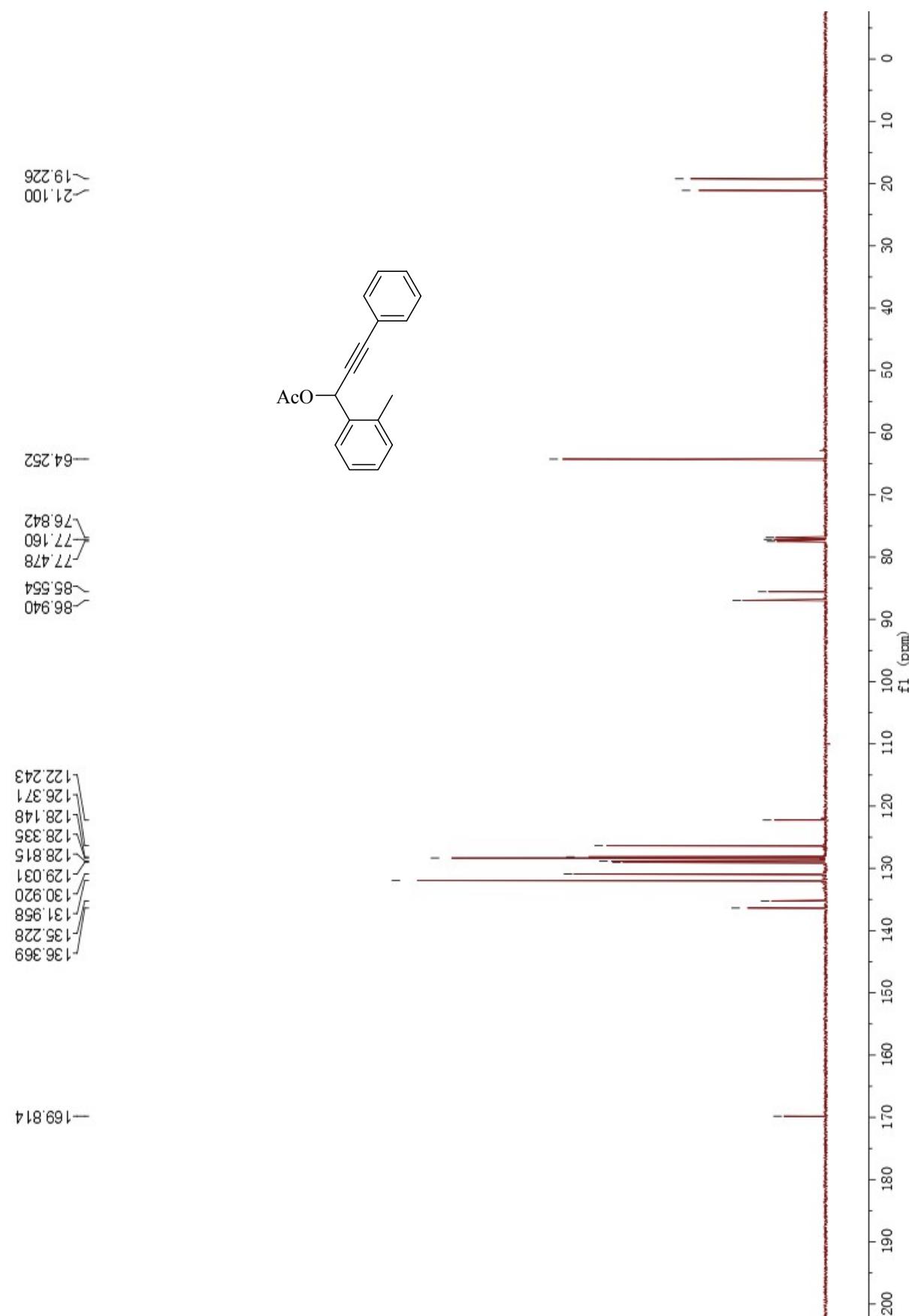
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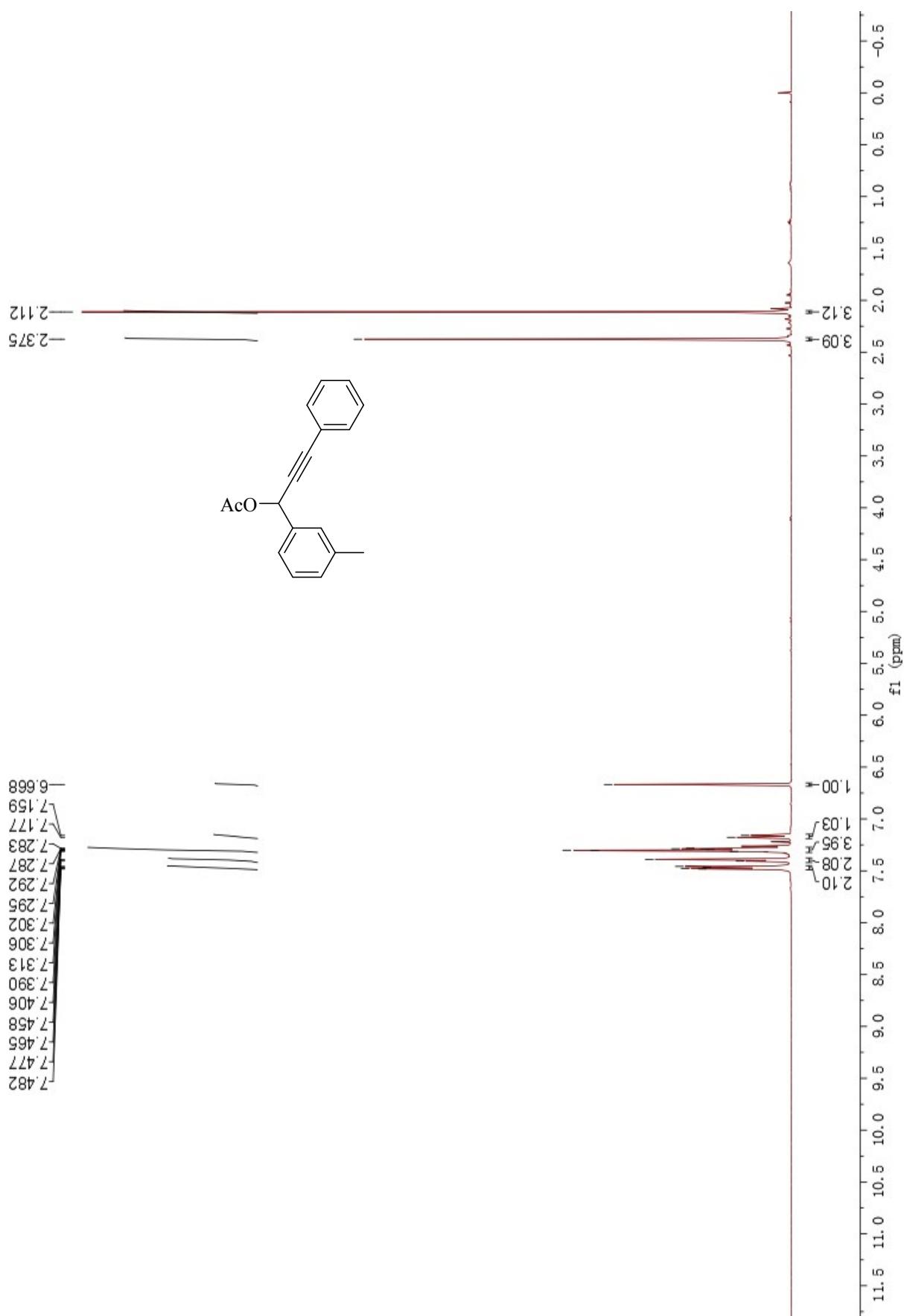
¹H NMR Spectrum of 3-Phenyl-1-*o*-tolylprop-2-ynyl acetate (**1b**)



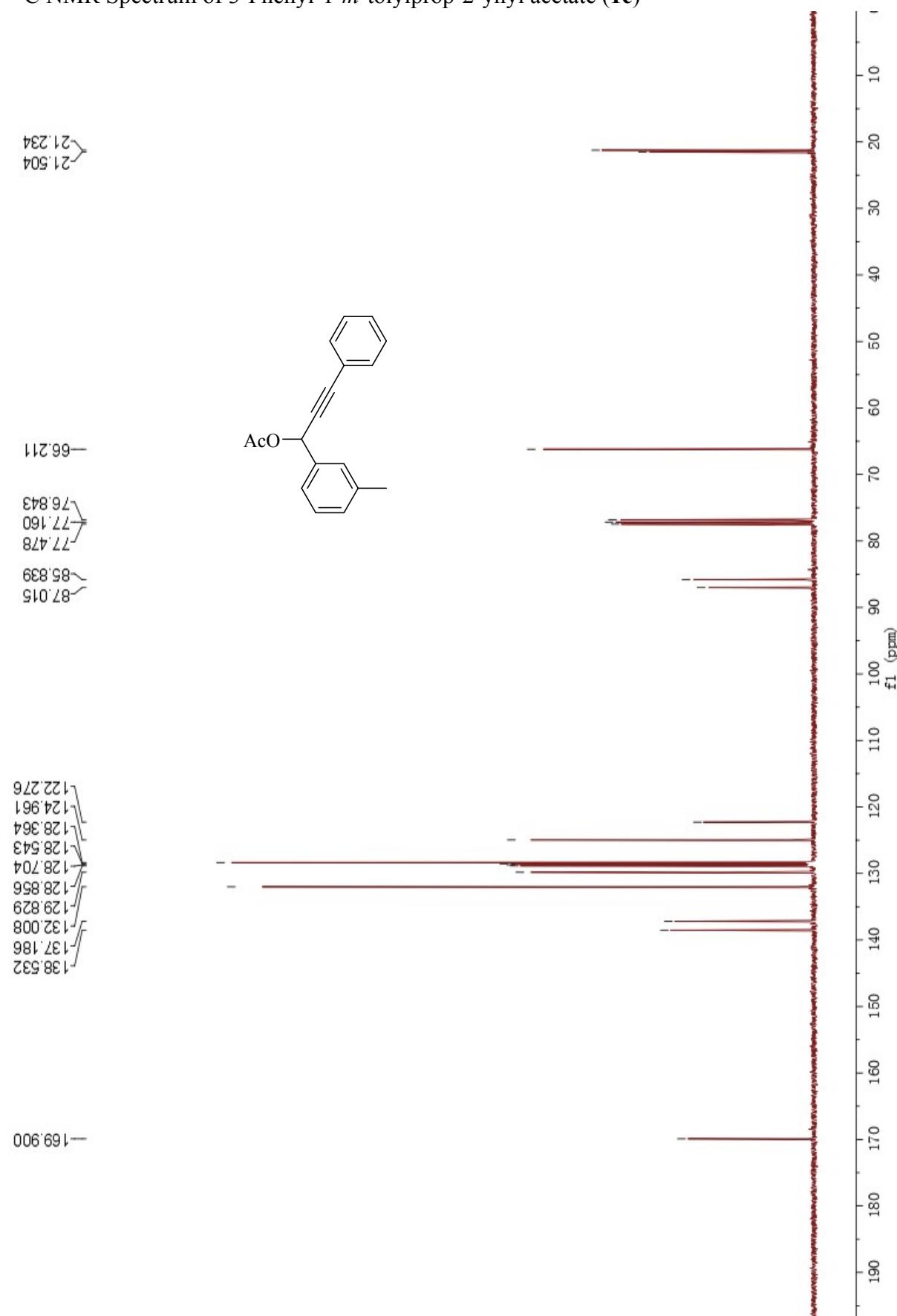
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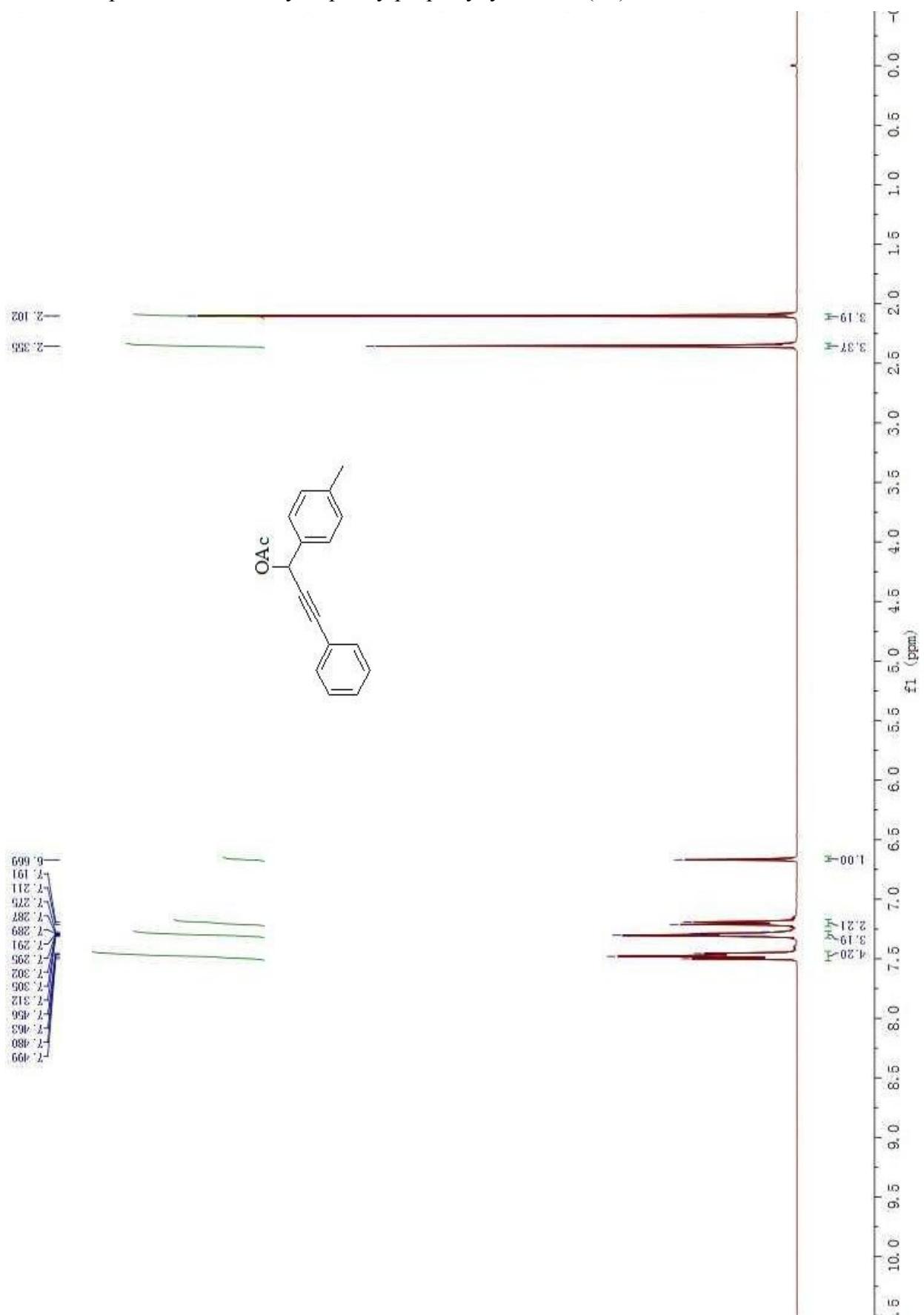
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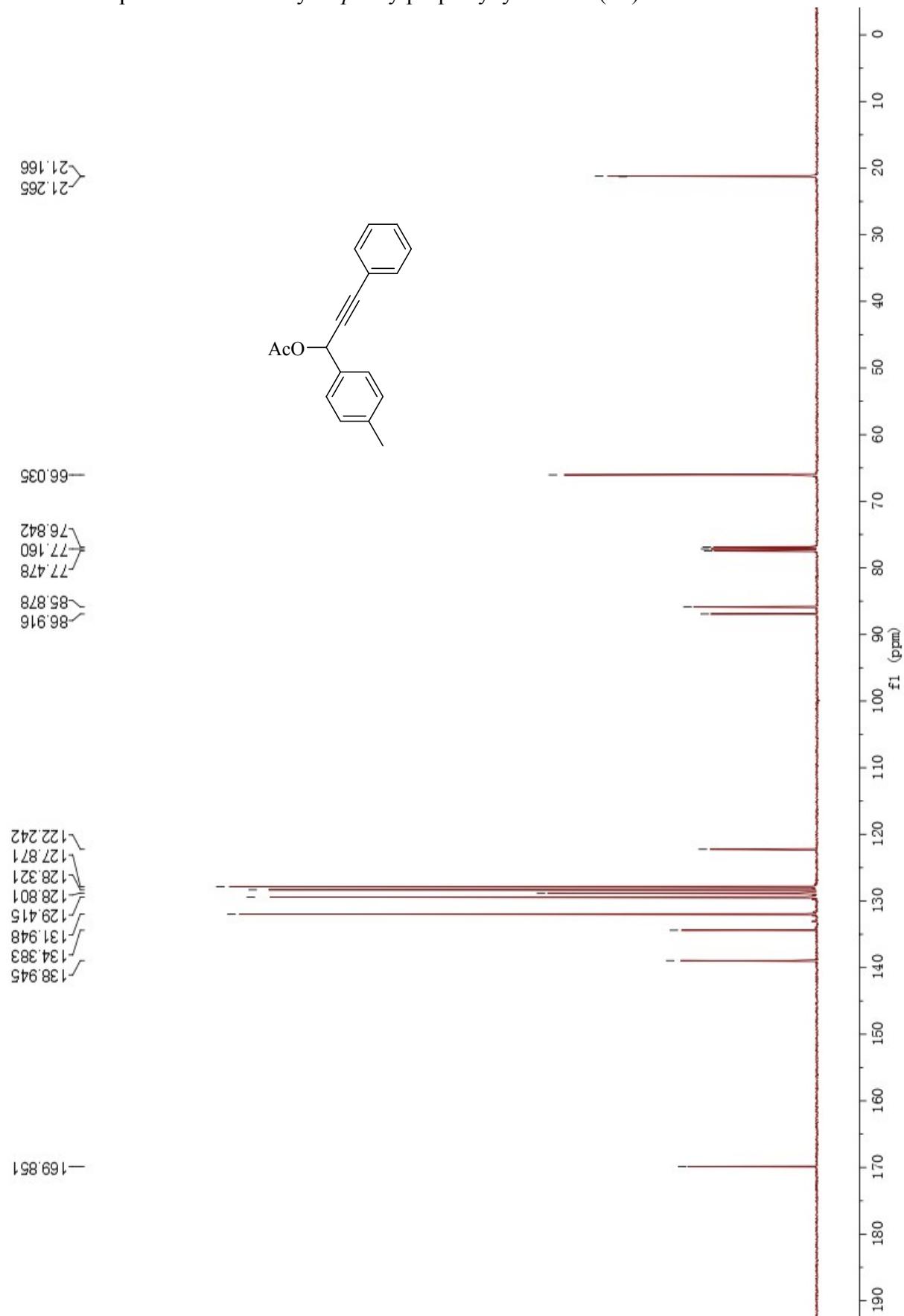
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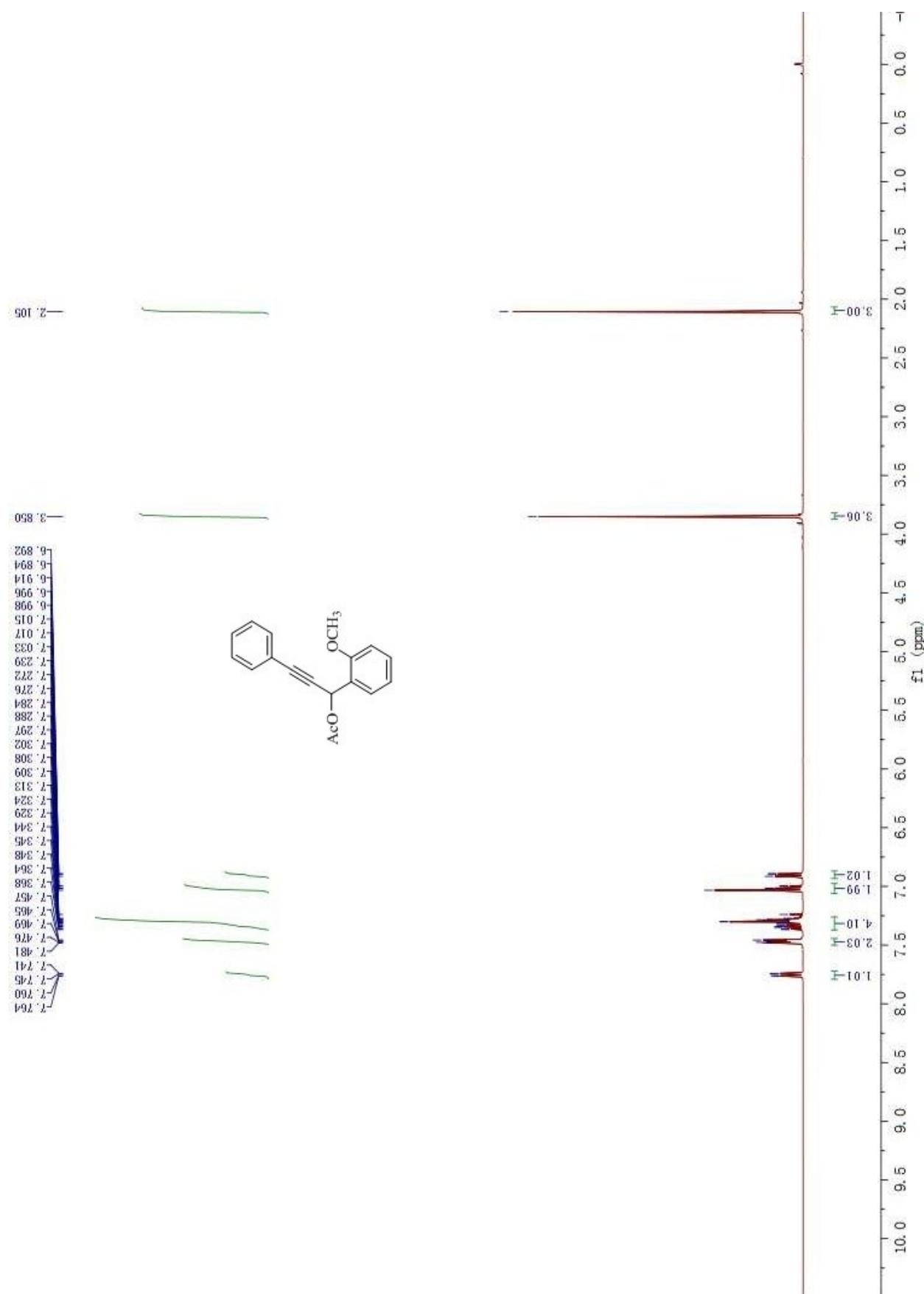
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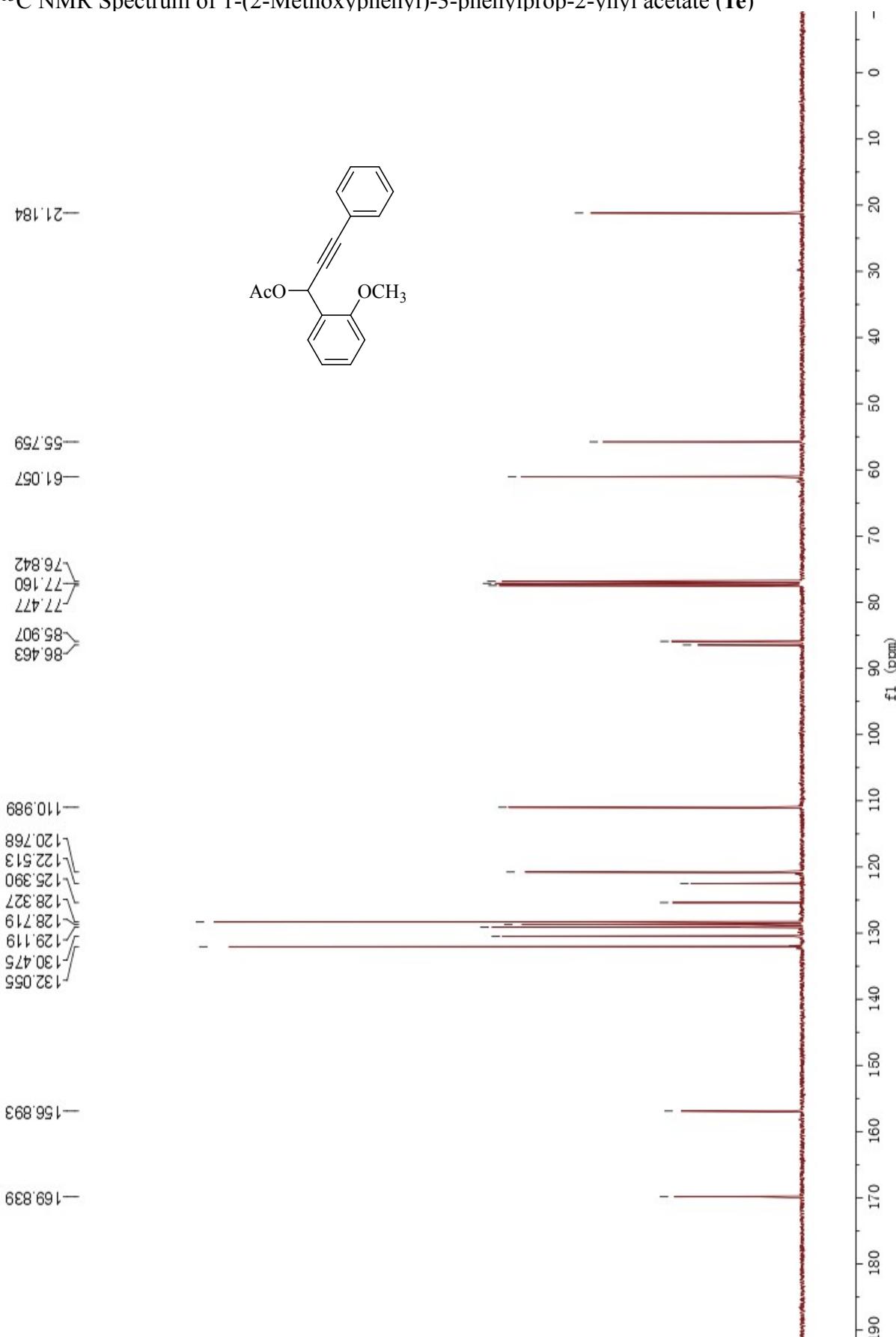
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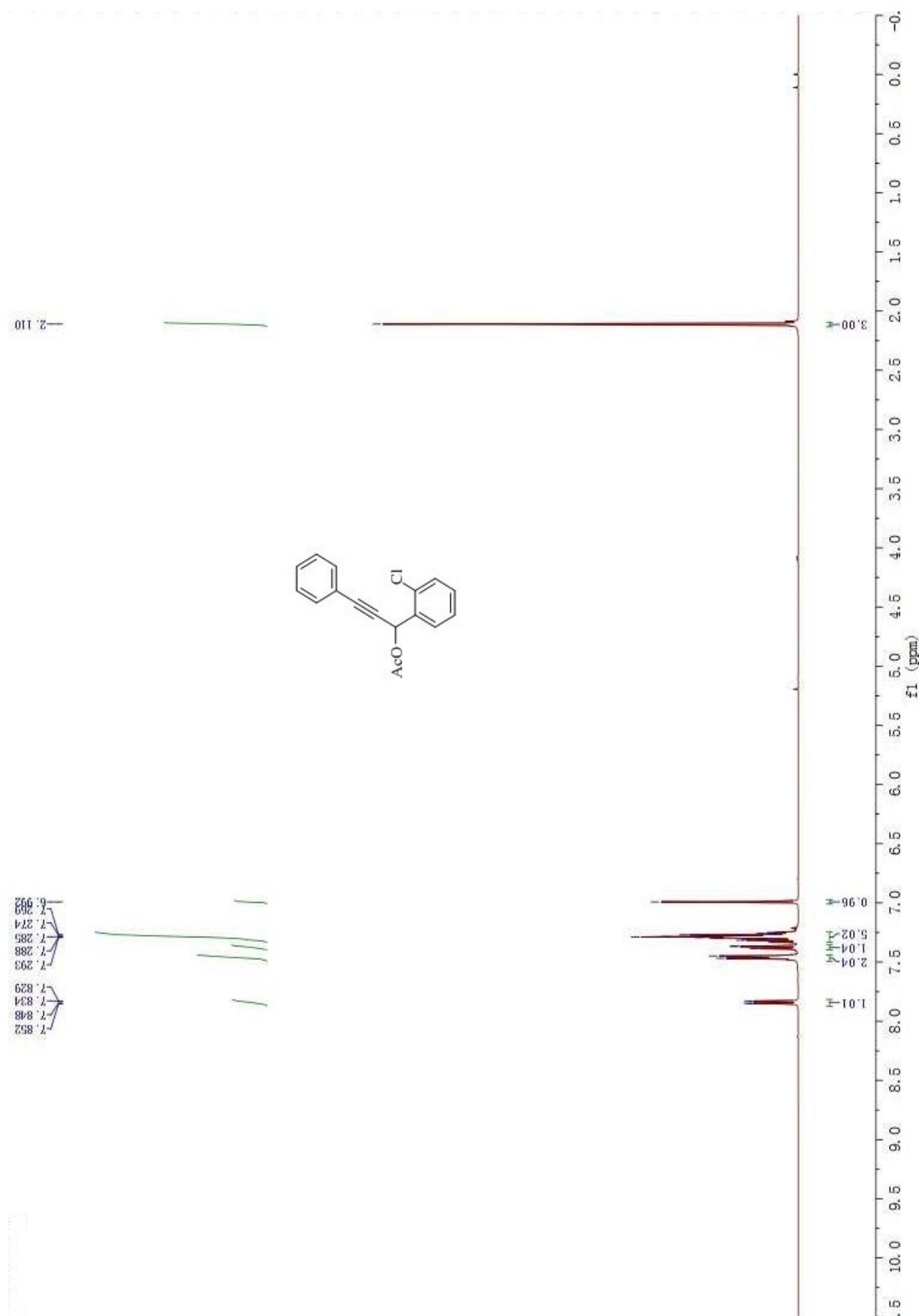
¹H NMR Spectrum of 1-(2-Methoxyphenyl)-3-phenylprop-2-ynyl acetate (**1e**)



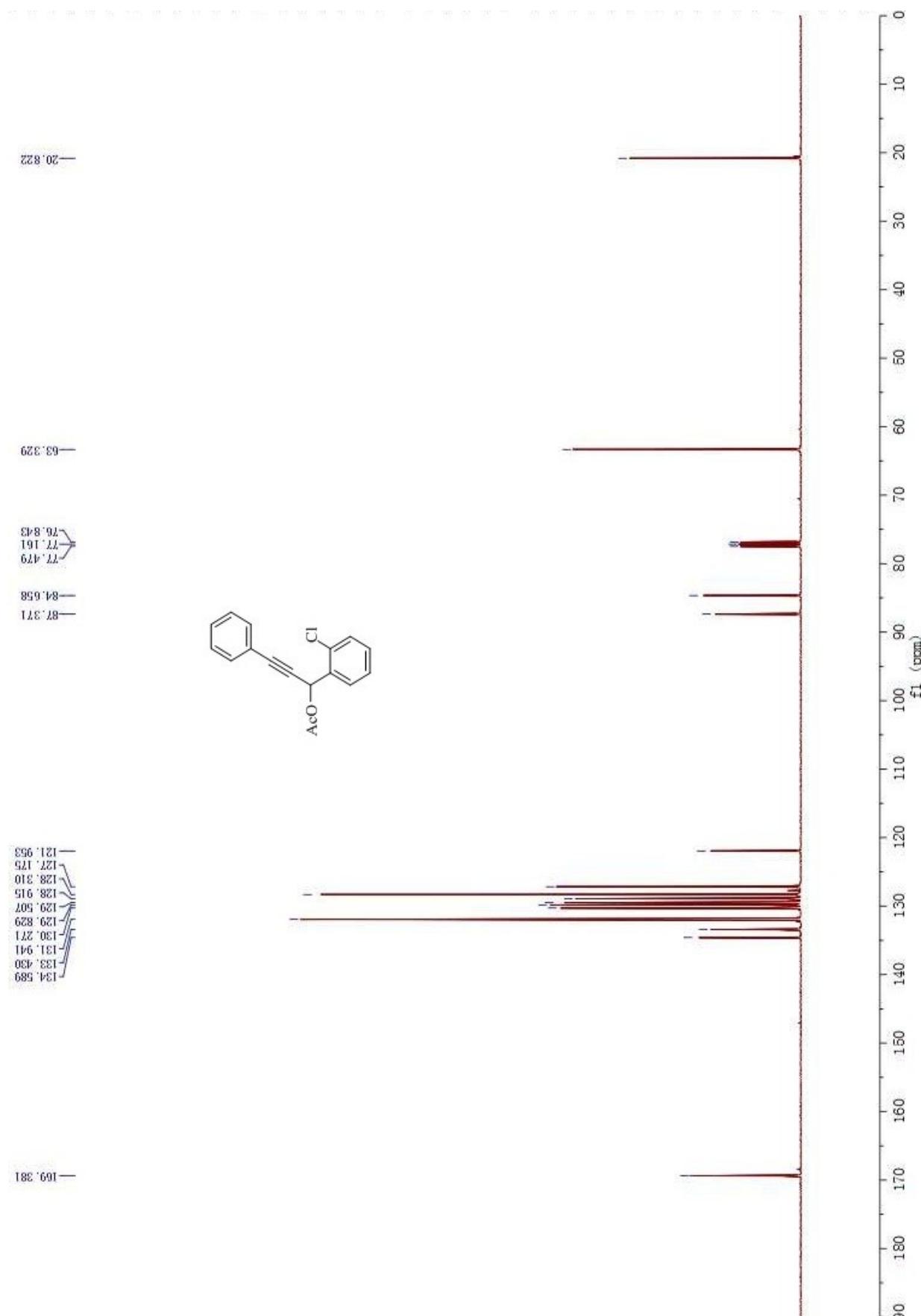
¹³C NMR Spectrum of 1-(2-Methoxyphenyl)-3-phenylprop-2-ynyl acetate (**1e**)



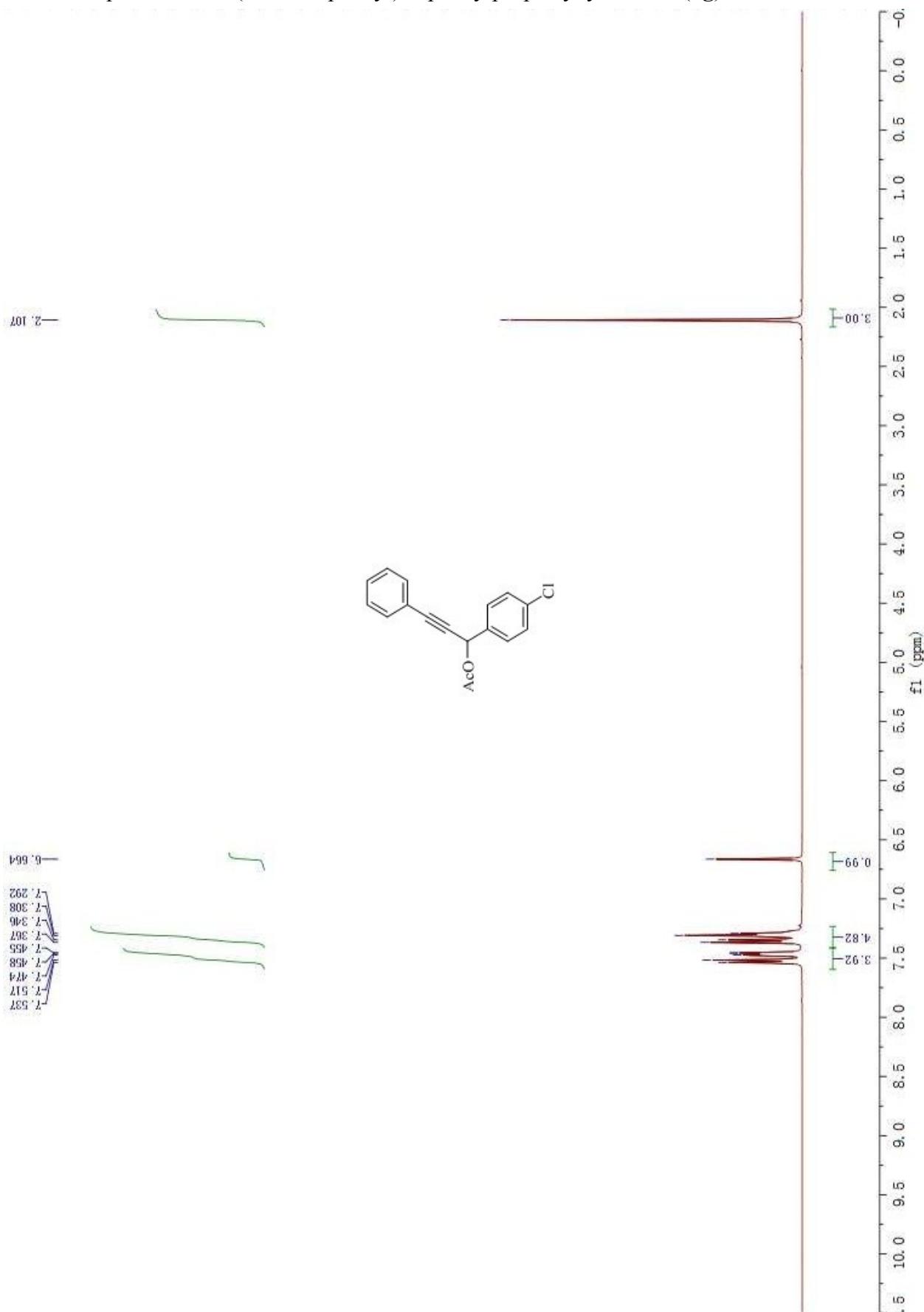
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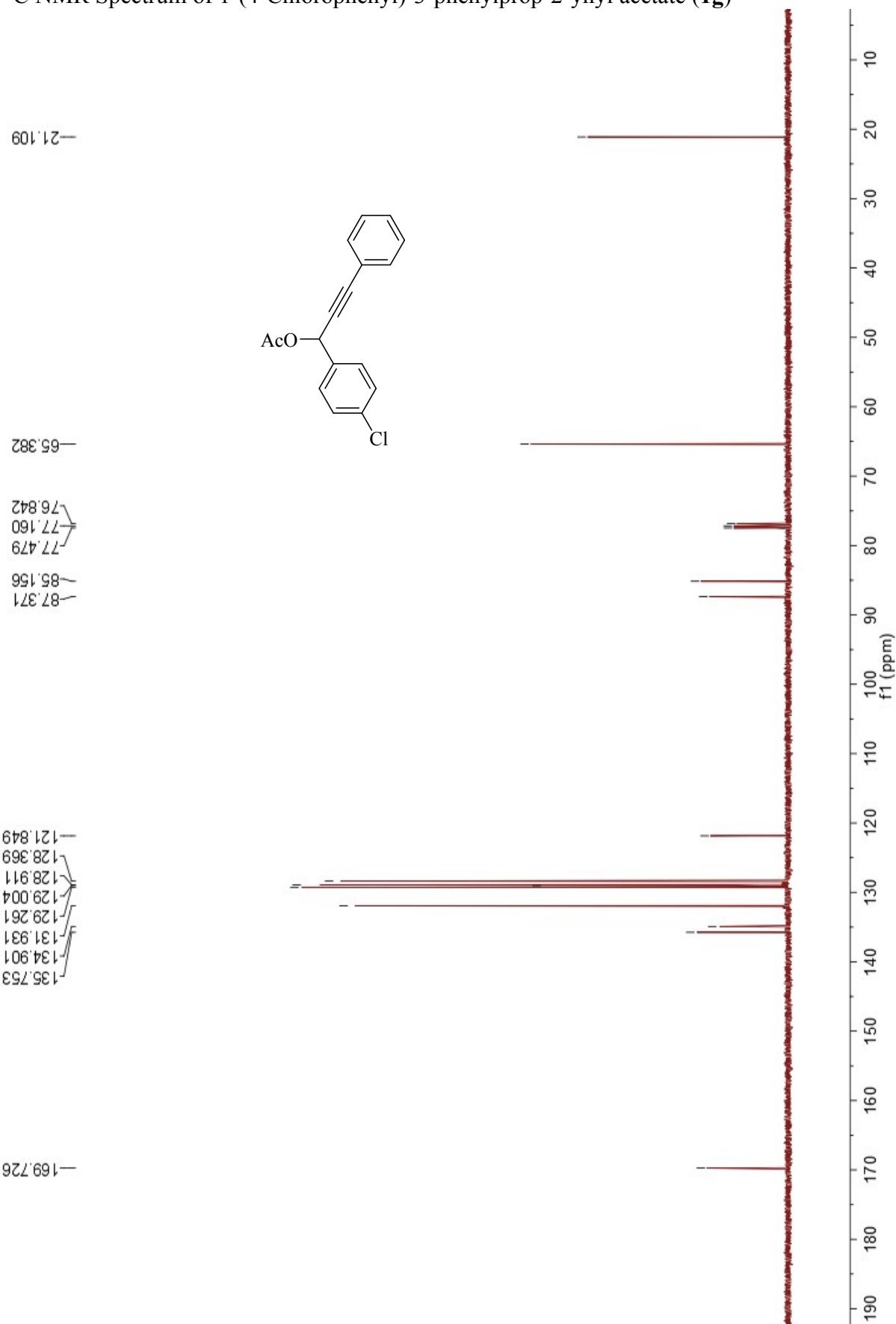
¹³C NMR Spectrum of 1-(2-Chlorophenyl)-3-phenylprop-2-ynyl acetate (**1f**)



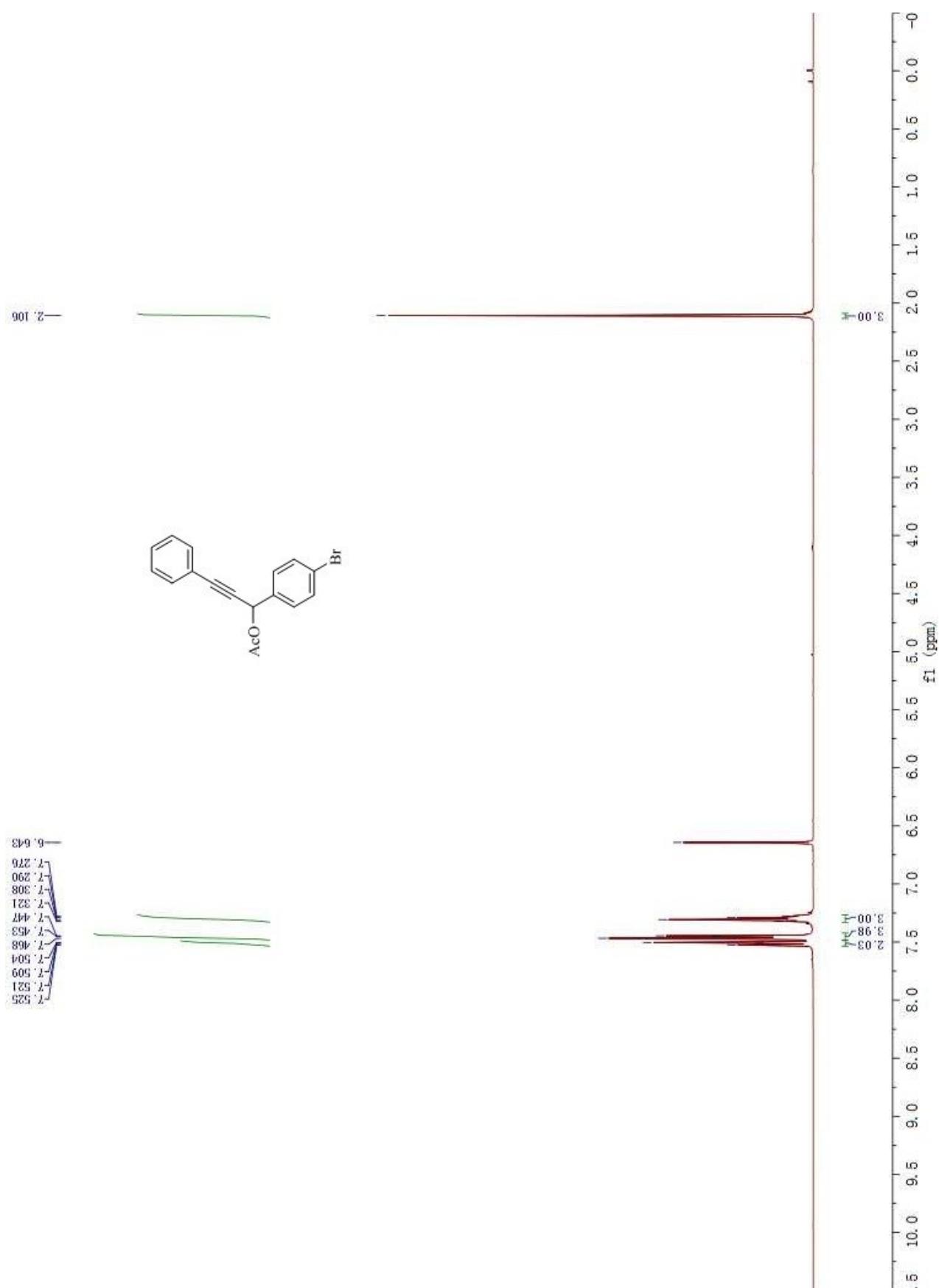
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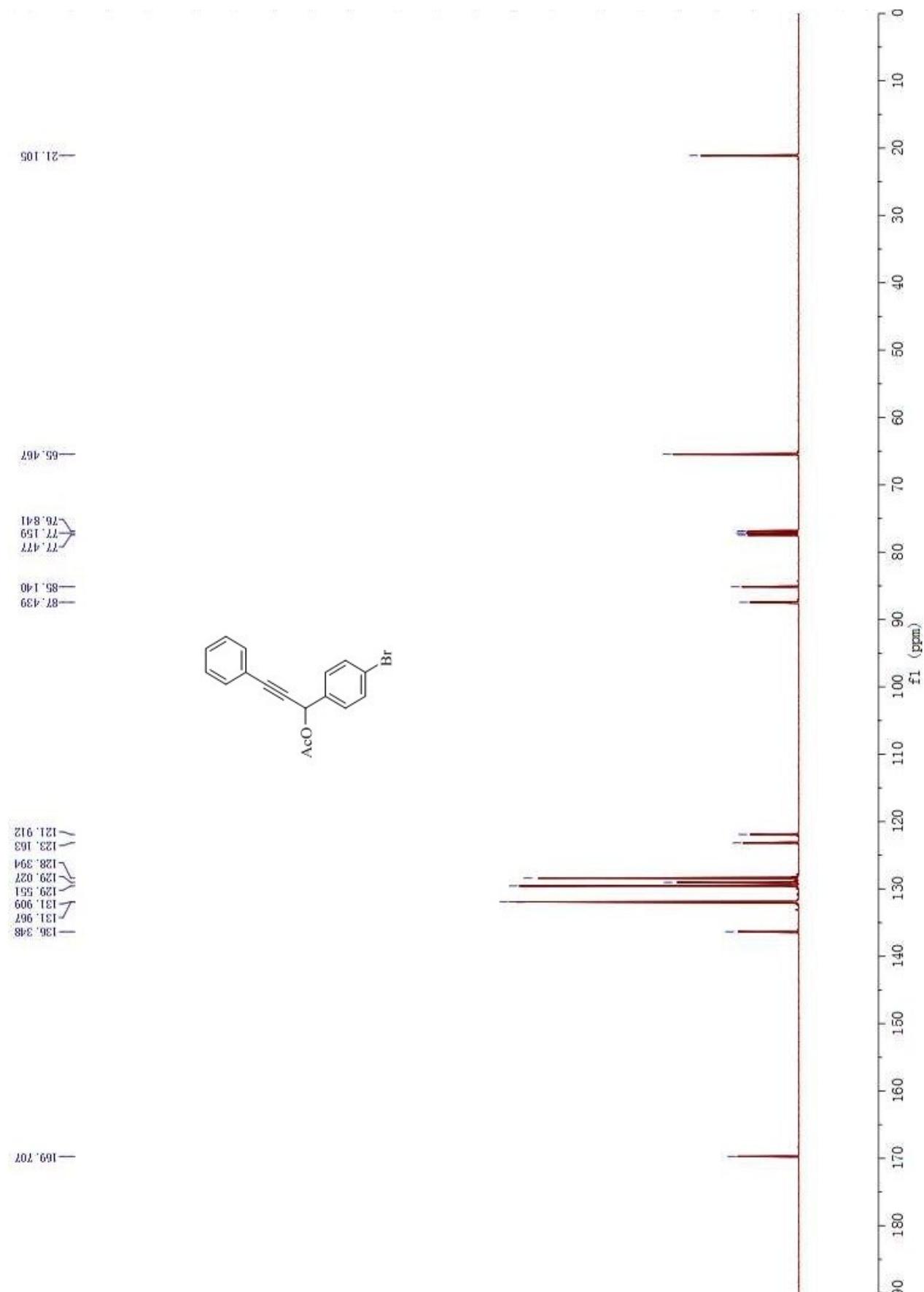
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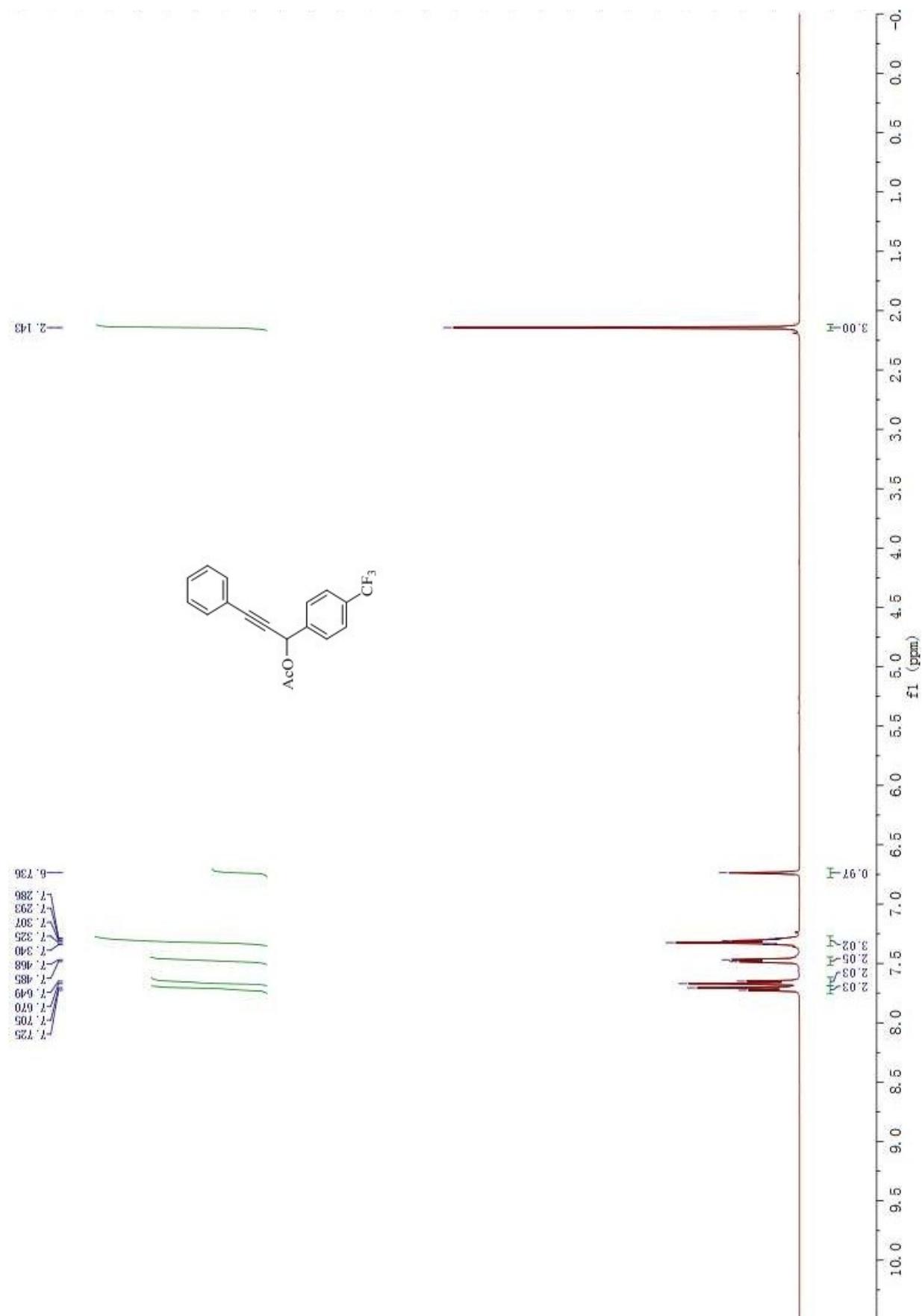
¹H NMR Spectrum of 1-(4-bromophenyl)-3-phenylprop-2-ynyl acetate (**1h**)



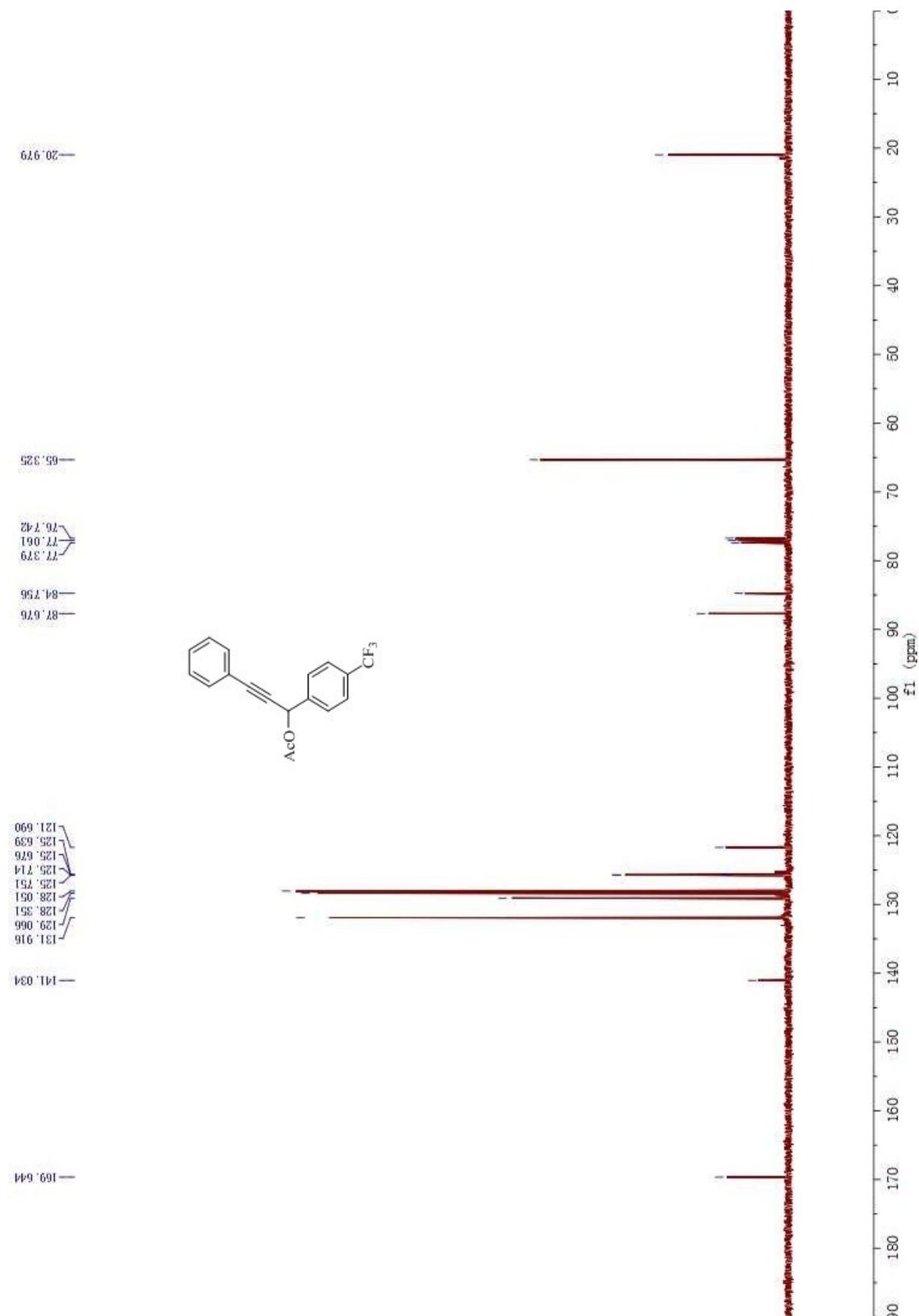
¹³C NMR Spectrum of 1-(4-bromophenyl)-3-phenylprop-2-ynyl acetate (**1h**)



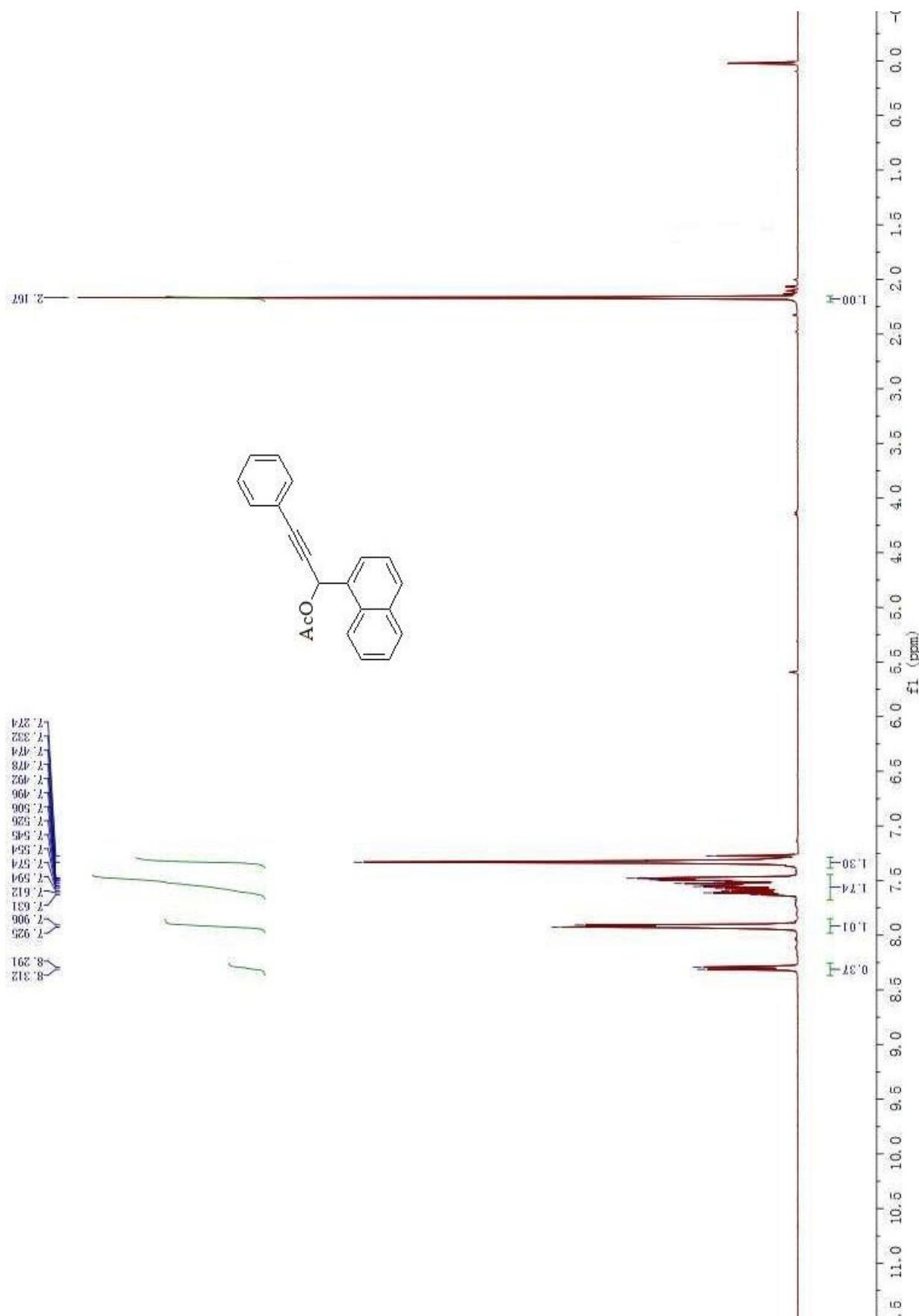
¹H NMR Spectrum of 3-Phenyl-1-(4-(trifluoromethyl)phenyl)prop-2-ynyl acetate (**1i**)



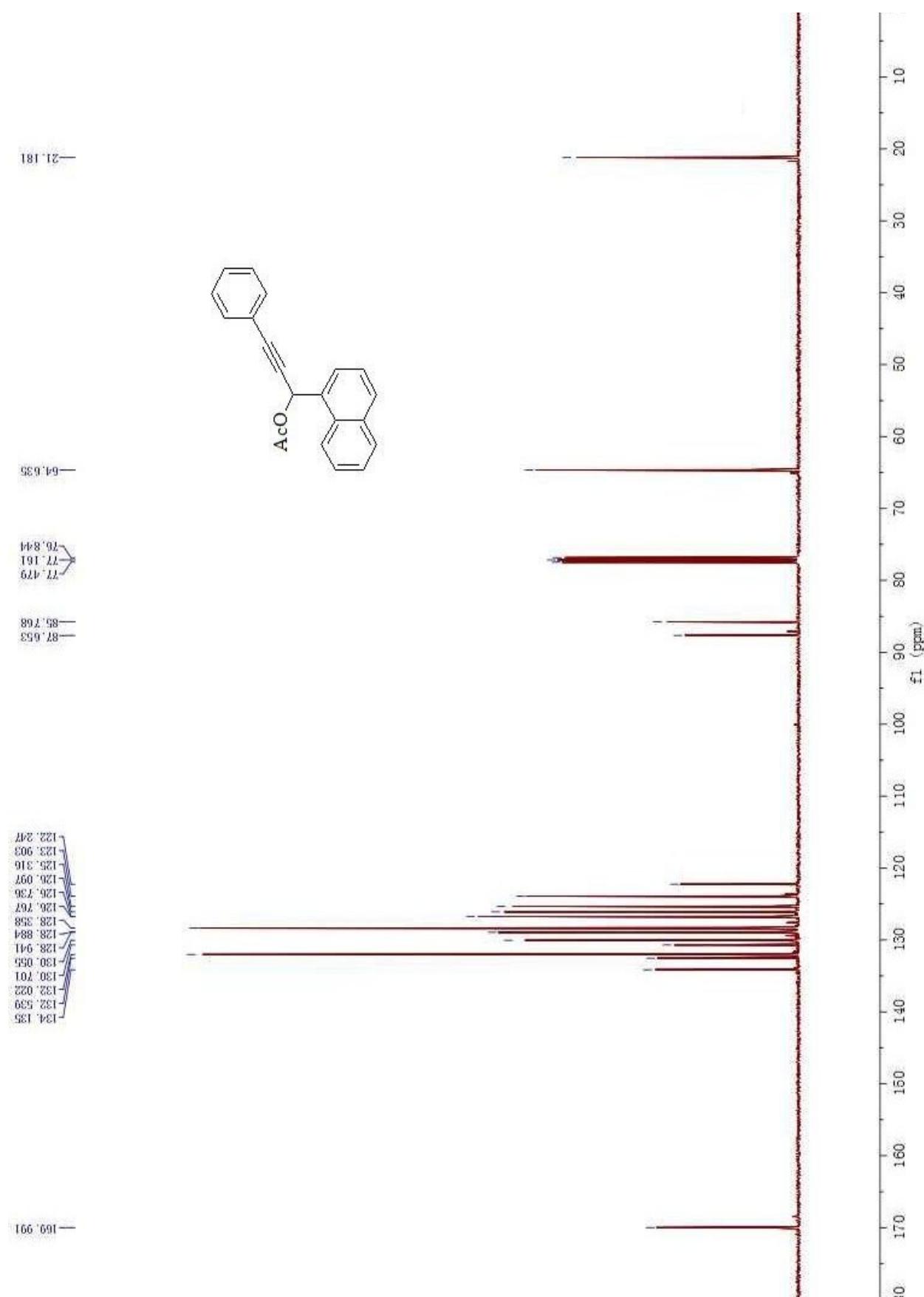
¹³C NMR Spectrum of 3-Phenyl-1-(4-(trifluoromethyl)phenyl)prop-2-ynyl acetate (**1i**)



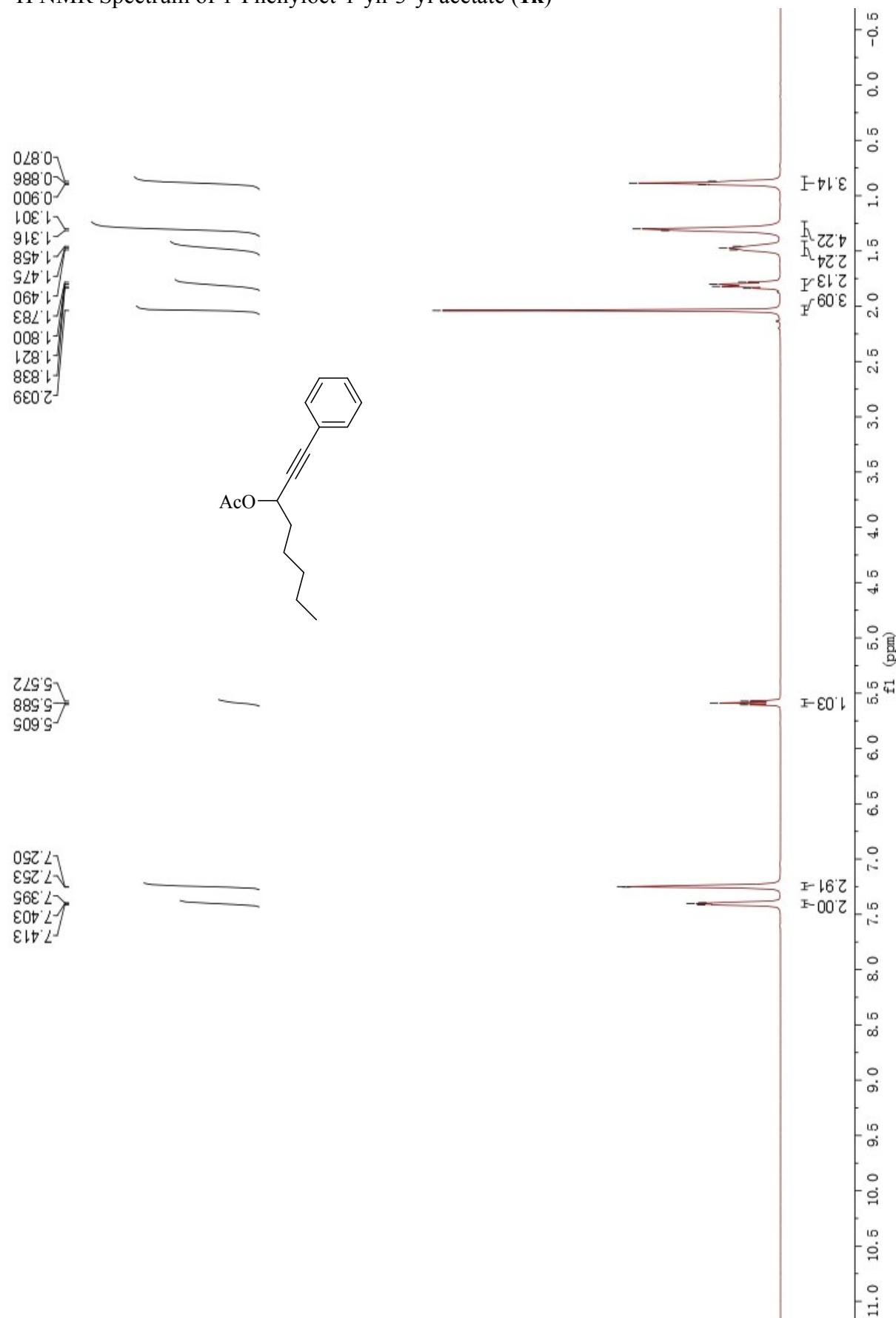
¹H NMR Spectrum of 1-(Naphthalen-1-yl)-3-phenylprop-2-ynyl acetate (**1j**)



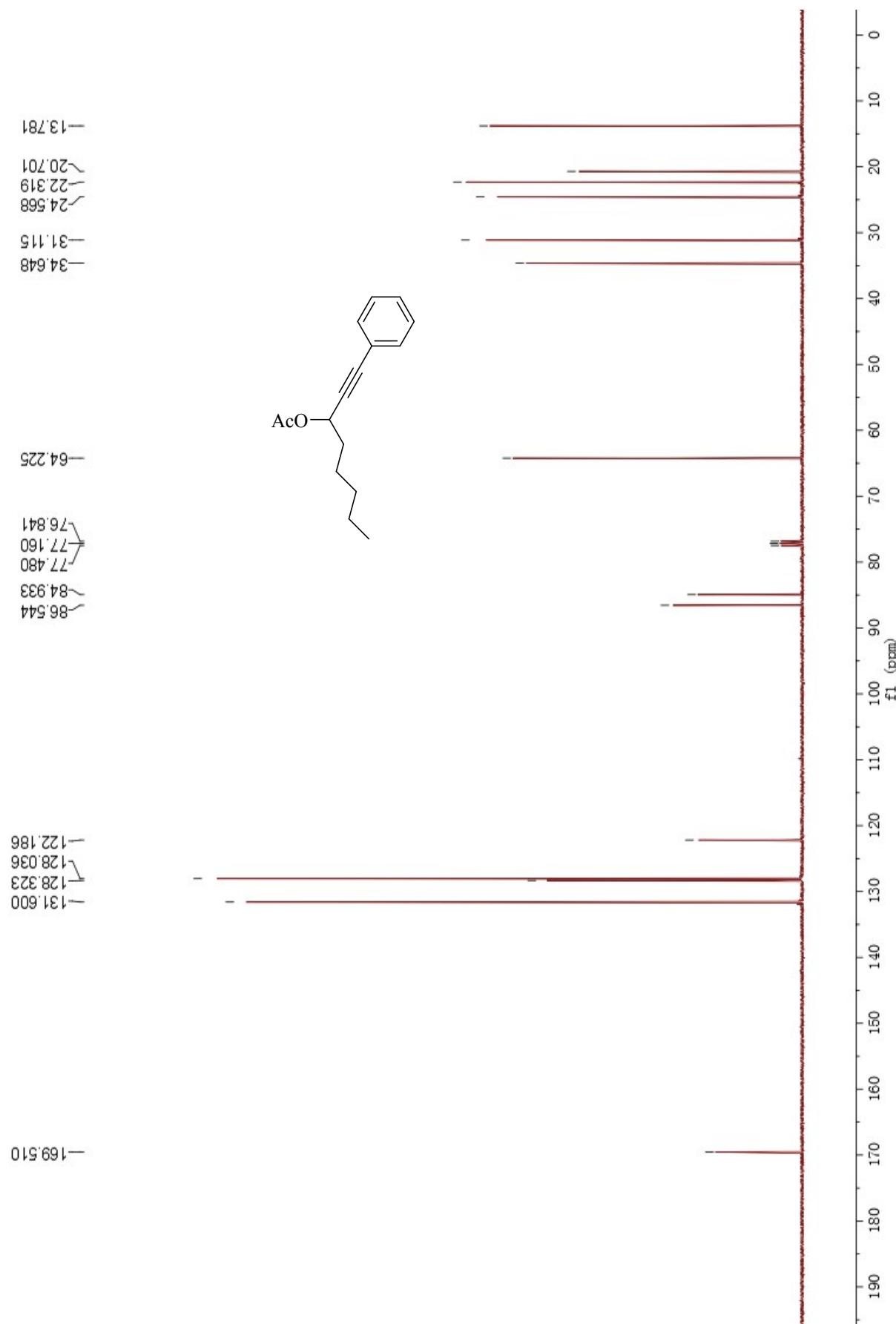
¹³C NMR Spectrum of 1-(Naphthalen-1-yl)-3-phenylprop-2-ynyl acetate (**1j**)



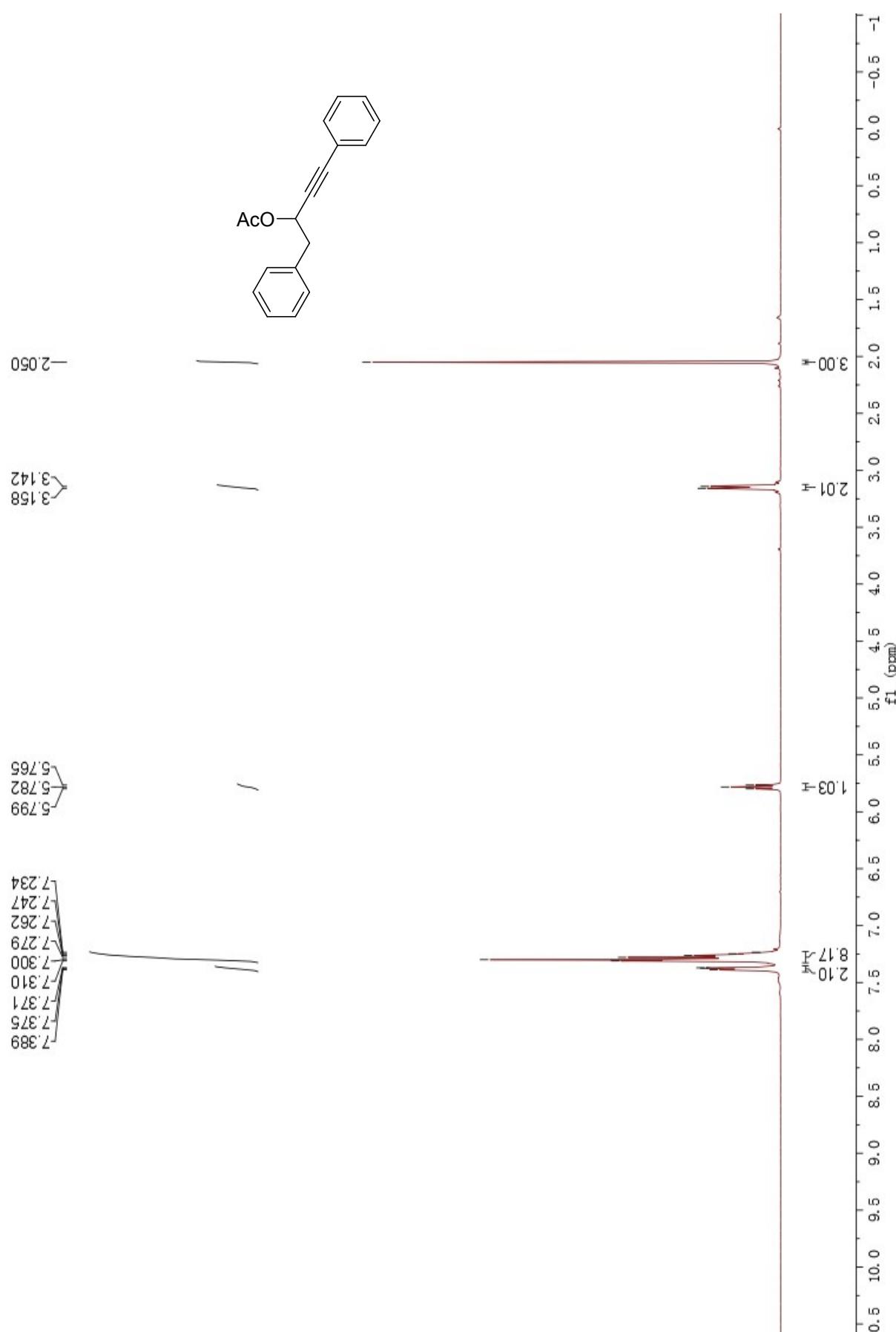
¹H NMR Spectrum of 1-Phenyl-1-yn-3-yl acetate (**1k**)



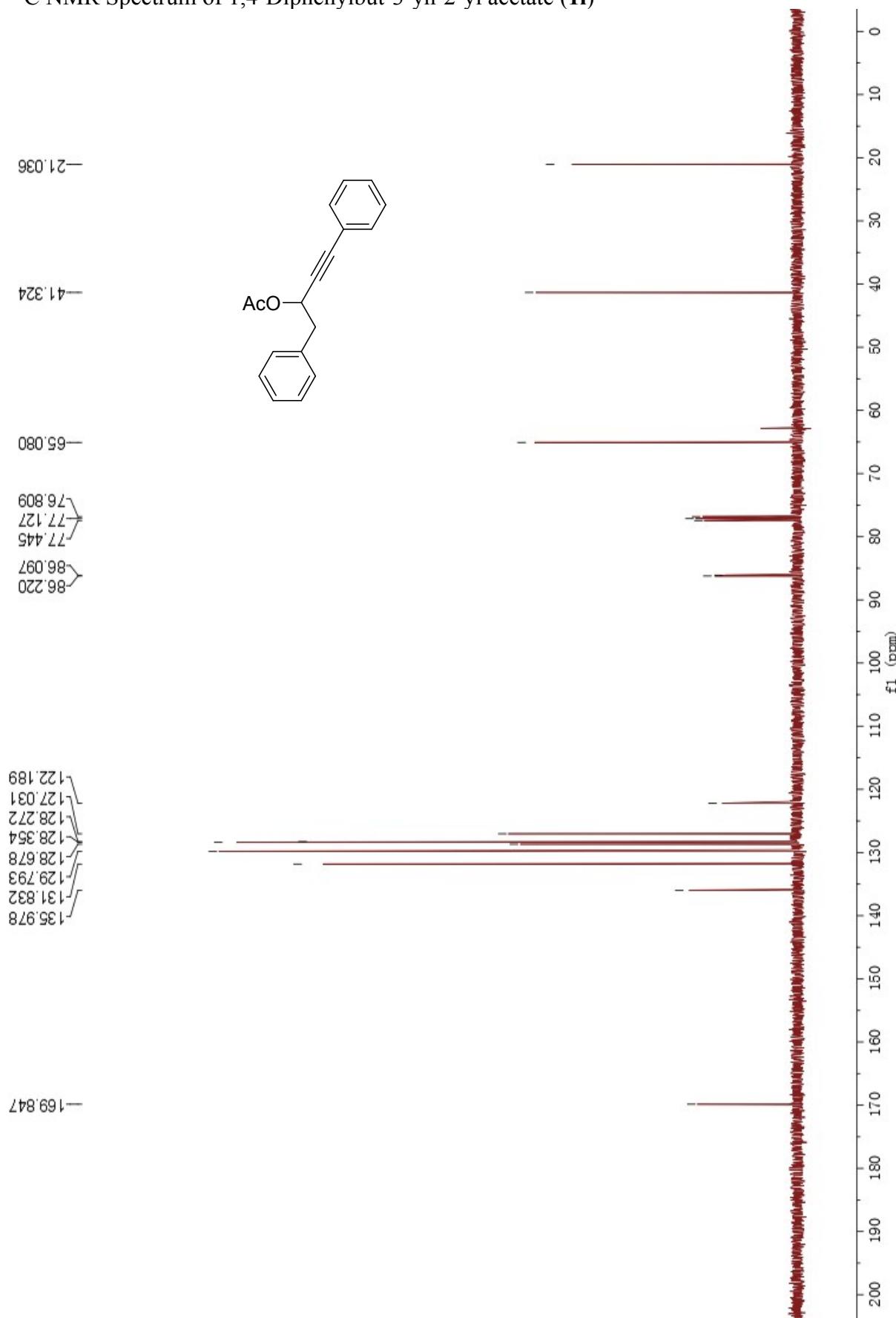
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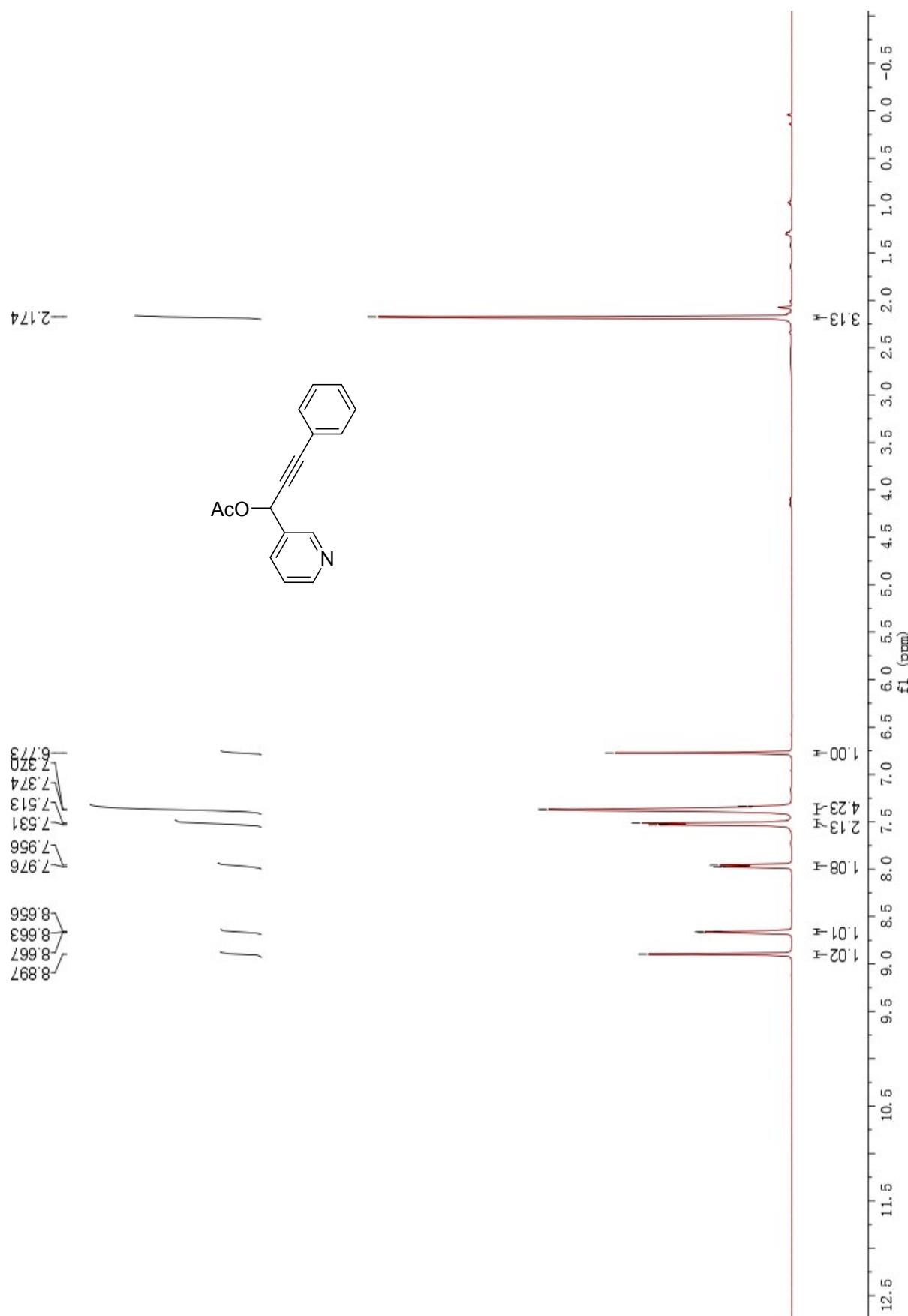
¹H NMR Spectrum of 1,4-Diphenylbut-3-yn-2-yl acetate (**1l**)



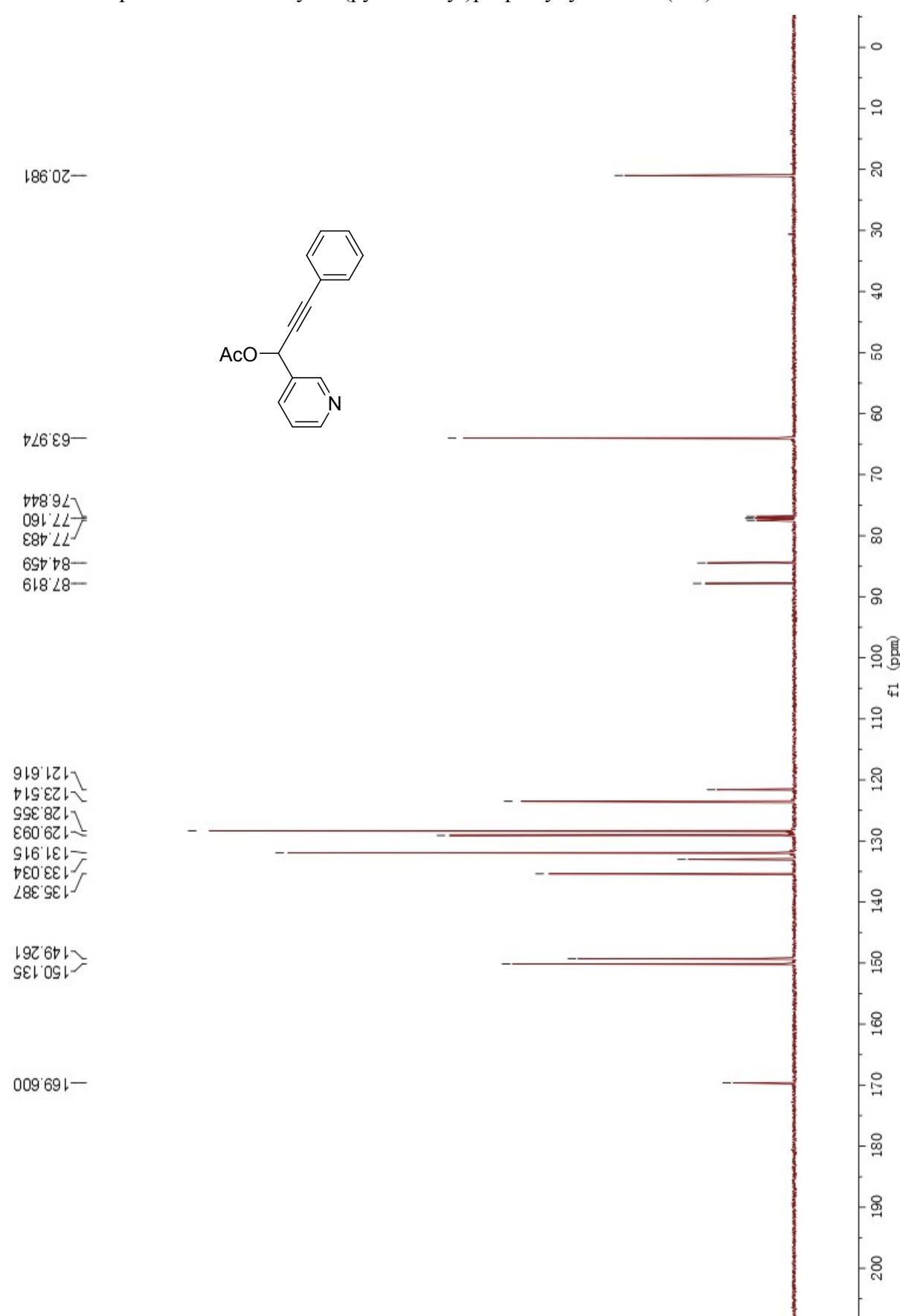
^{13}C NMR Spectrum of 1,4-Diphenylbut-3-yn-2-yl acetate (**1l**)



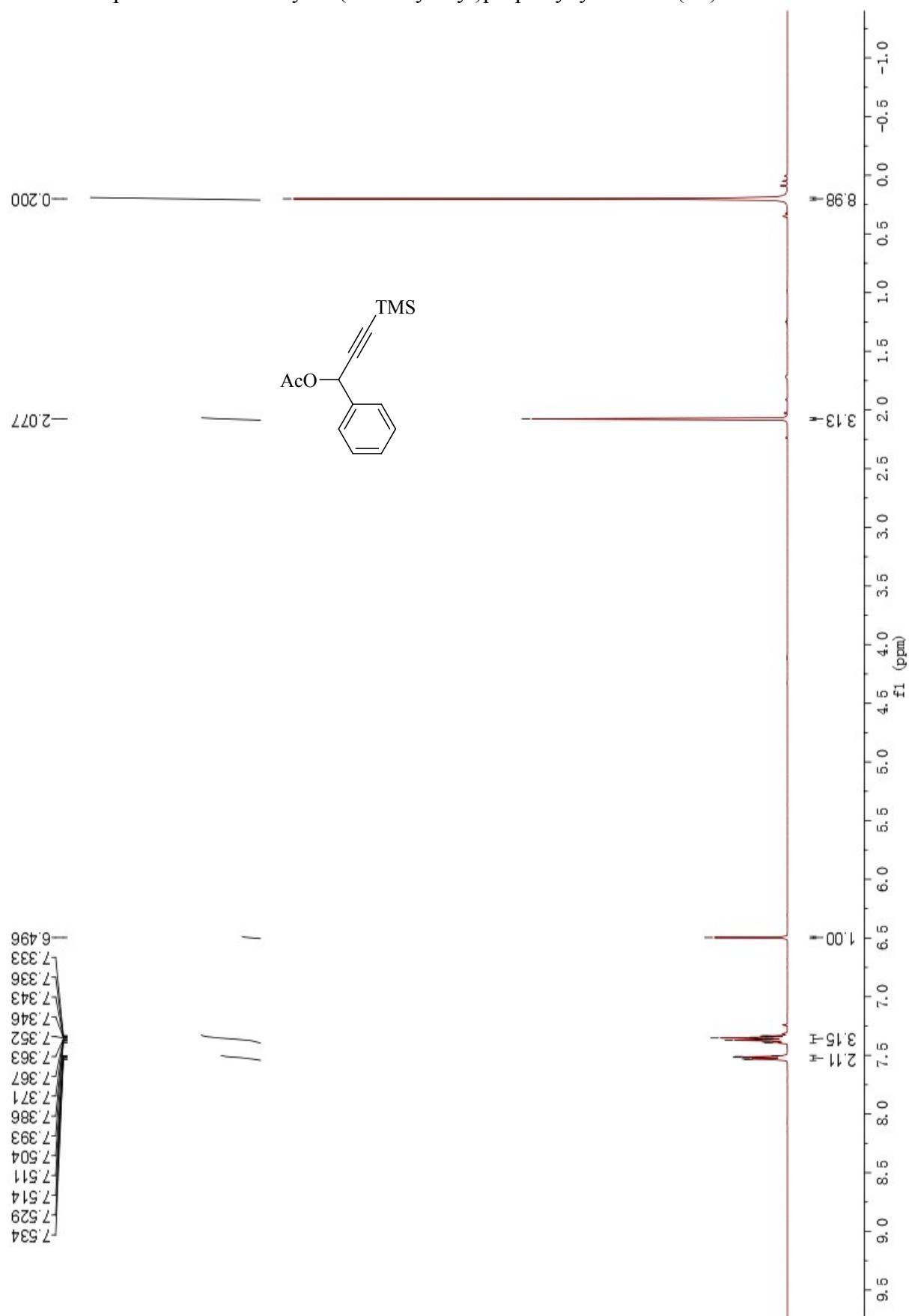
¹H NMR Spectrum of 3-Phenyl-1-(pyridin-3-yl)prop-2-ynyl acetate (**1m**)



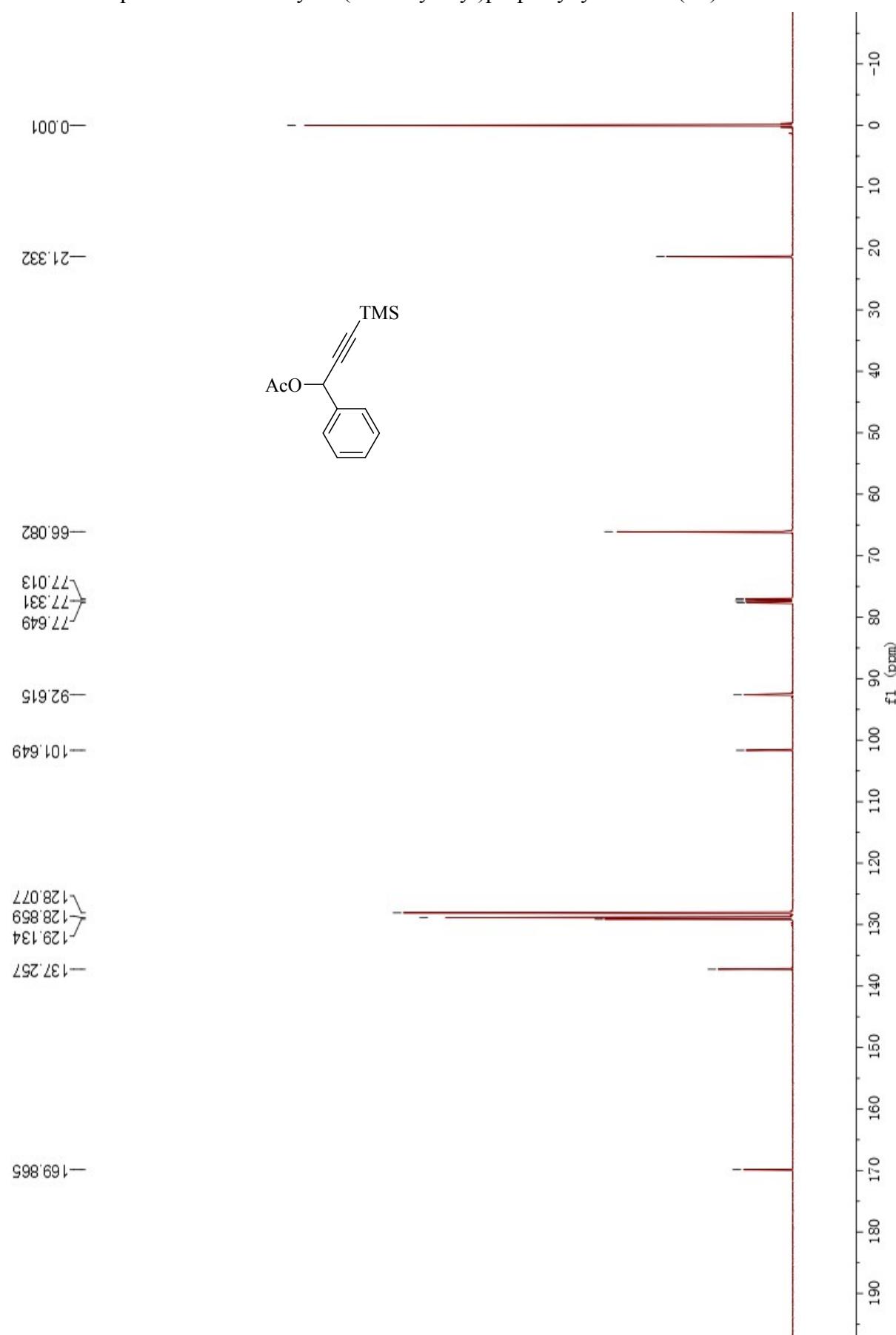
¹³C NMR Spectrum of 3-Phenyl-1-(pyridin-3-yl)prop-2-ynyl acetate (**1m**)



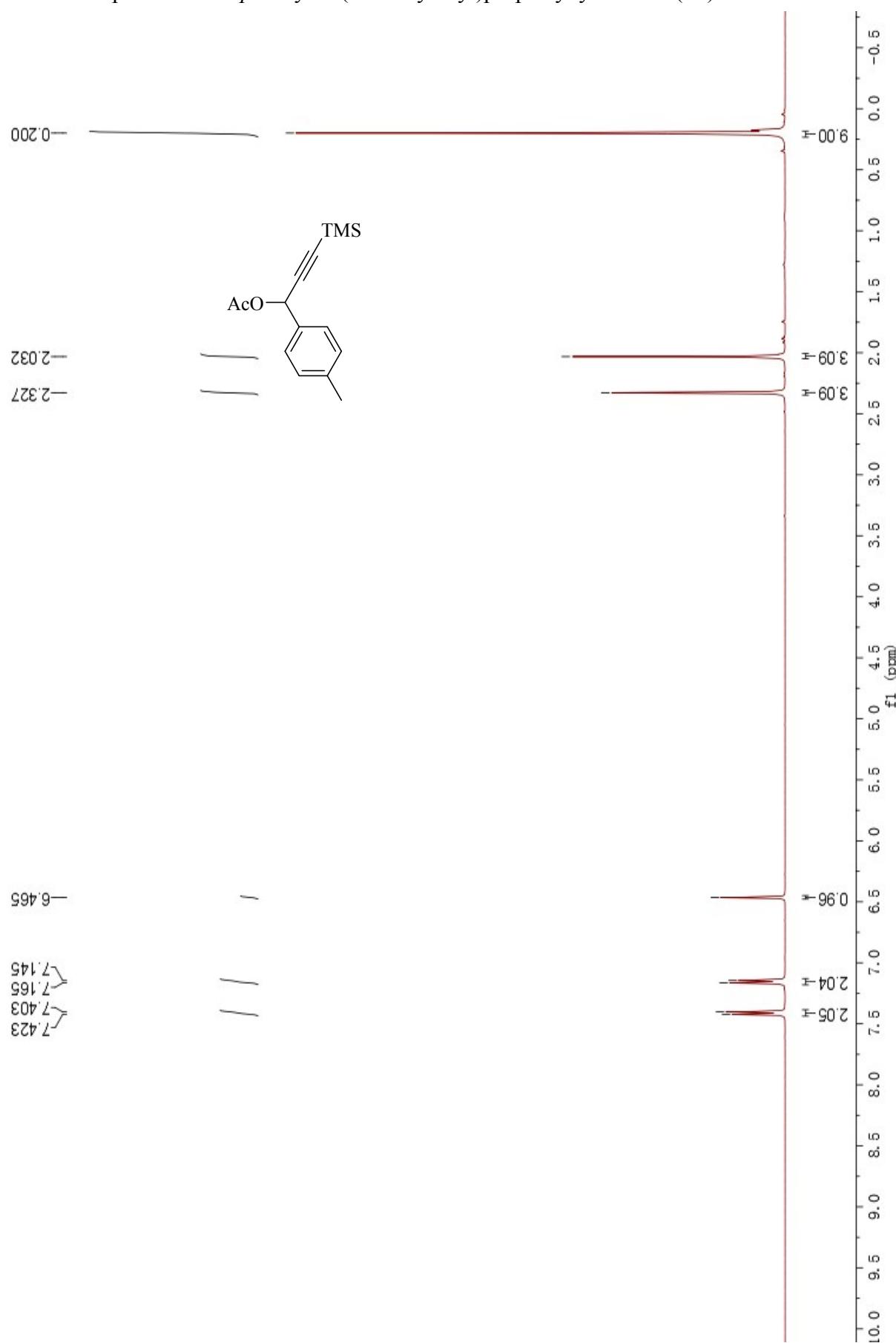
¹H NMR Spectrum of 1-Phenyl-3-(trimethylsilyl)prop-2-ynyl acetate (**1n**)



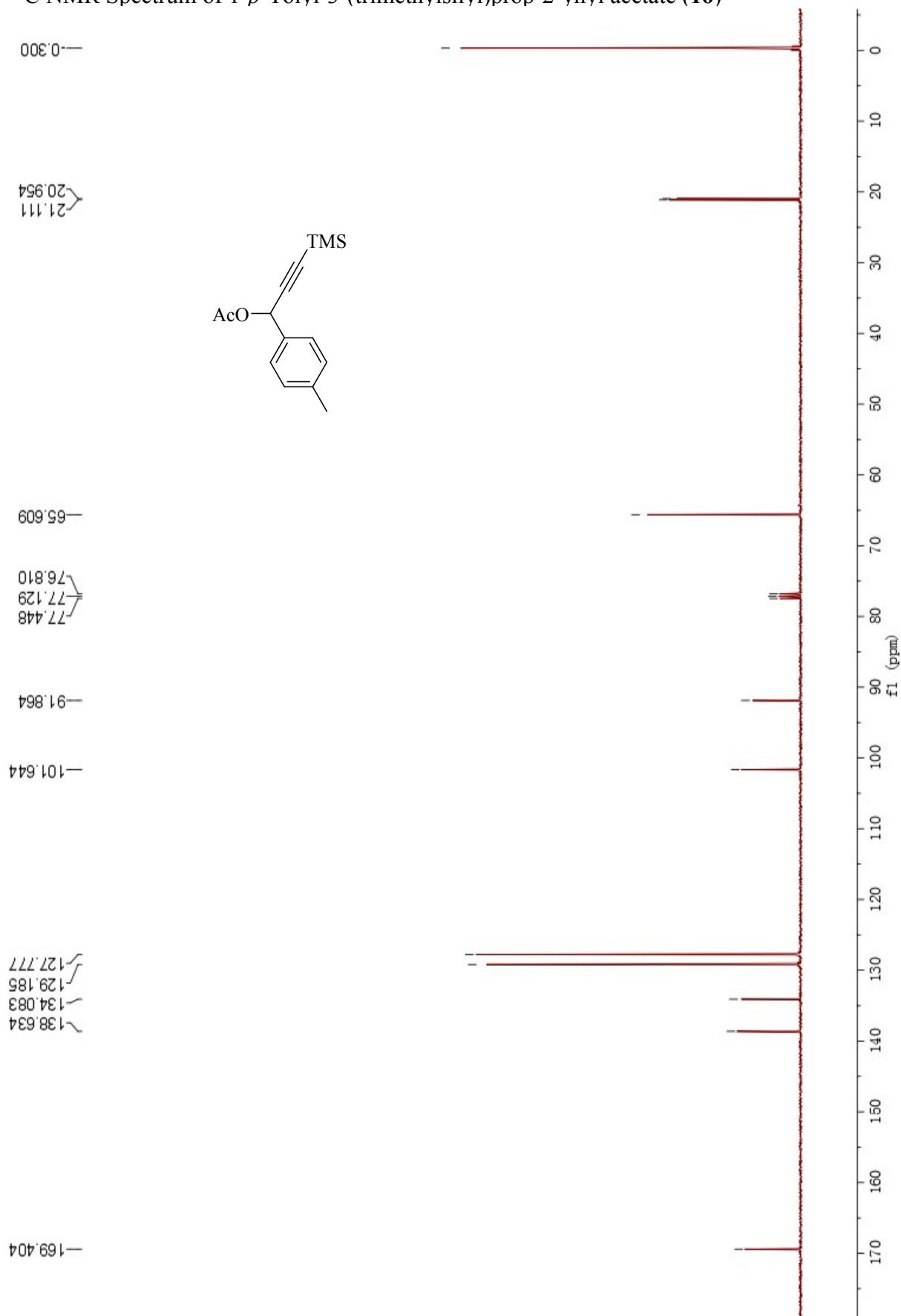
¹³C NMR Spectrum of 1-Phenyl-3-(trimethylsilyl)prop-2-ynyl acetate (**1n**)

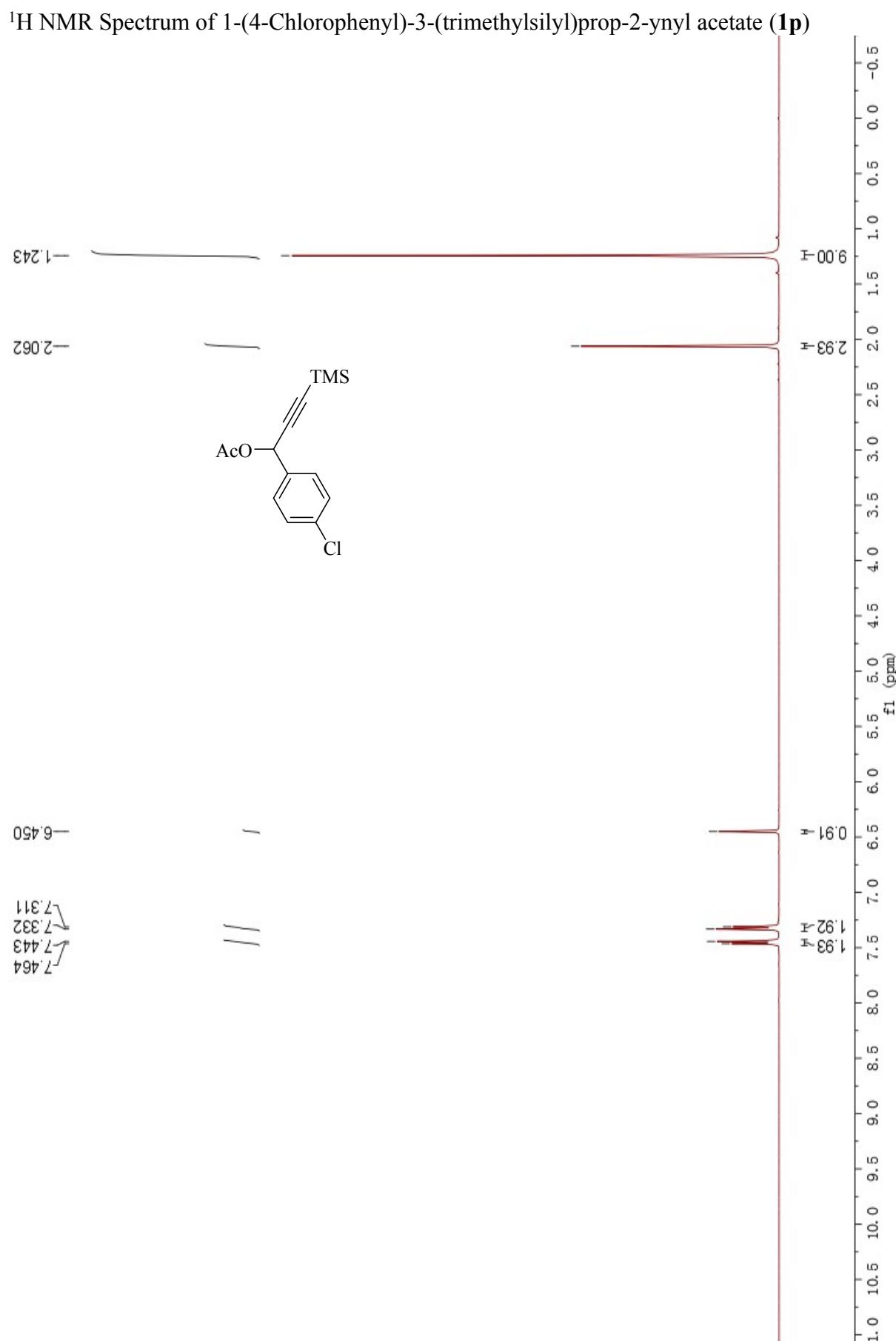


¹H NMR Spectrum of 1-*p*-Tolyl-3-(trimethylsilyl)prop-2-ynyl acetate (**1o**)

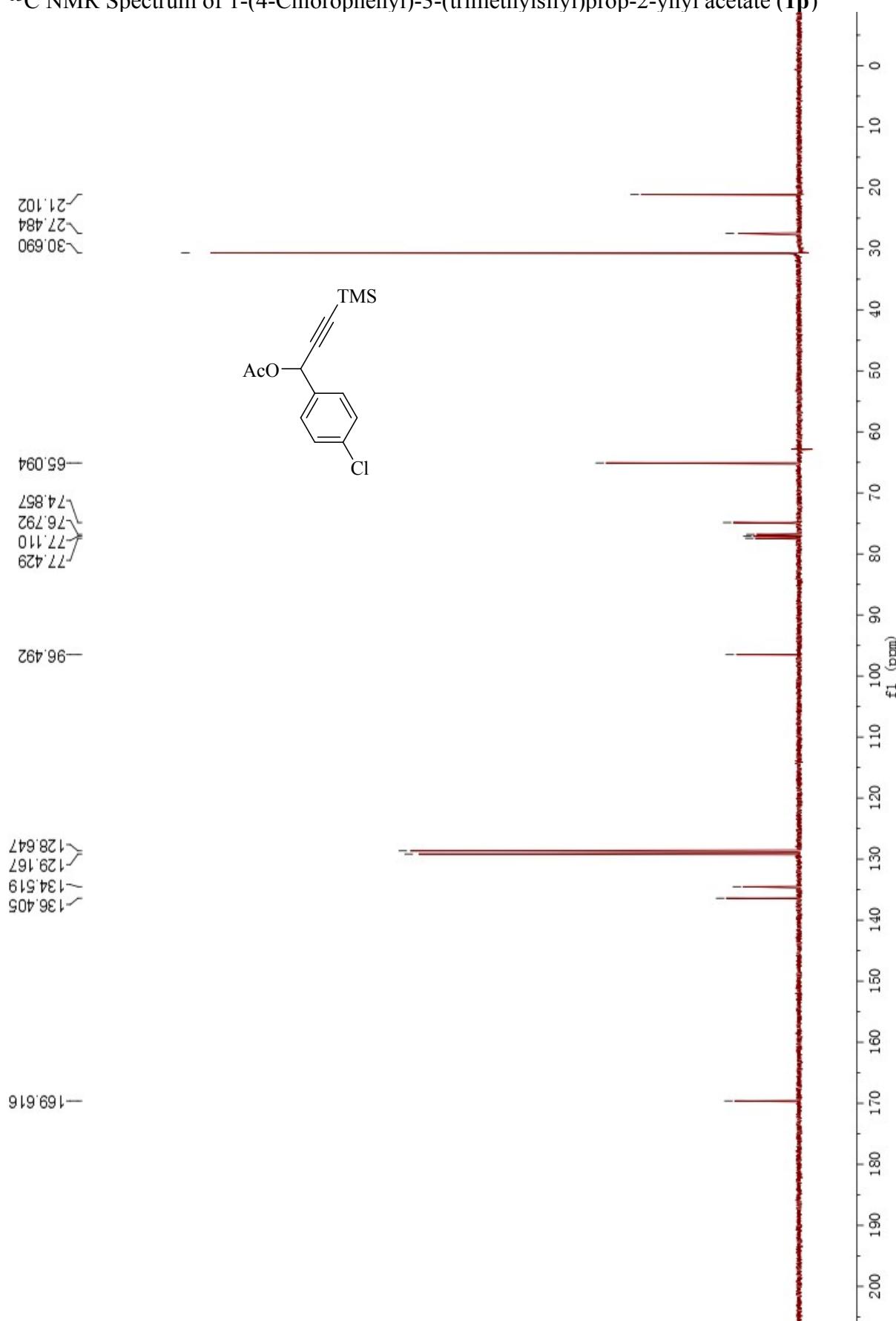


¹³C NMR Spectrum of 1-*p*-Tolyl-3-(trimethylsilyl)prop-2-ynyl acetate (**1o**)

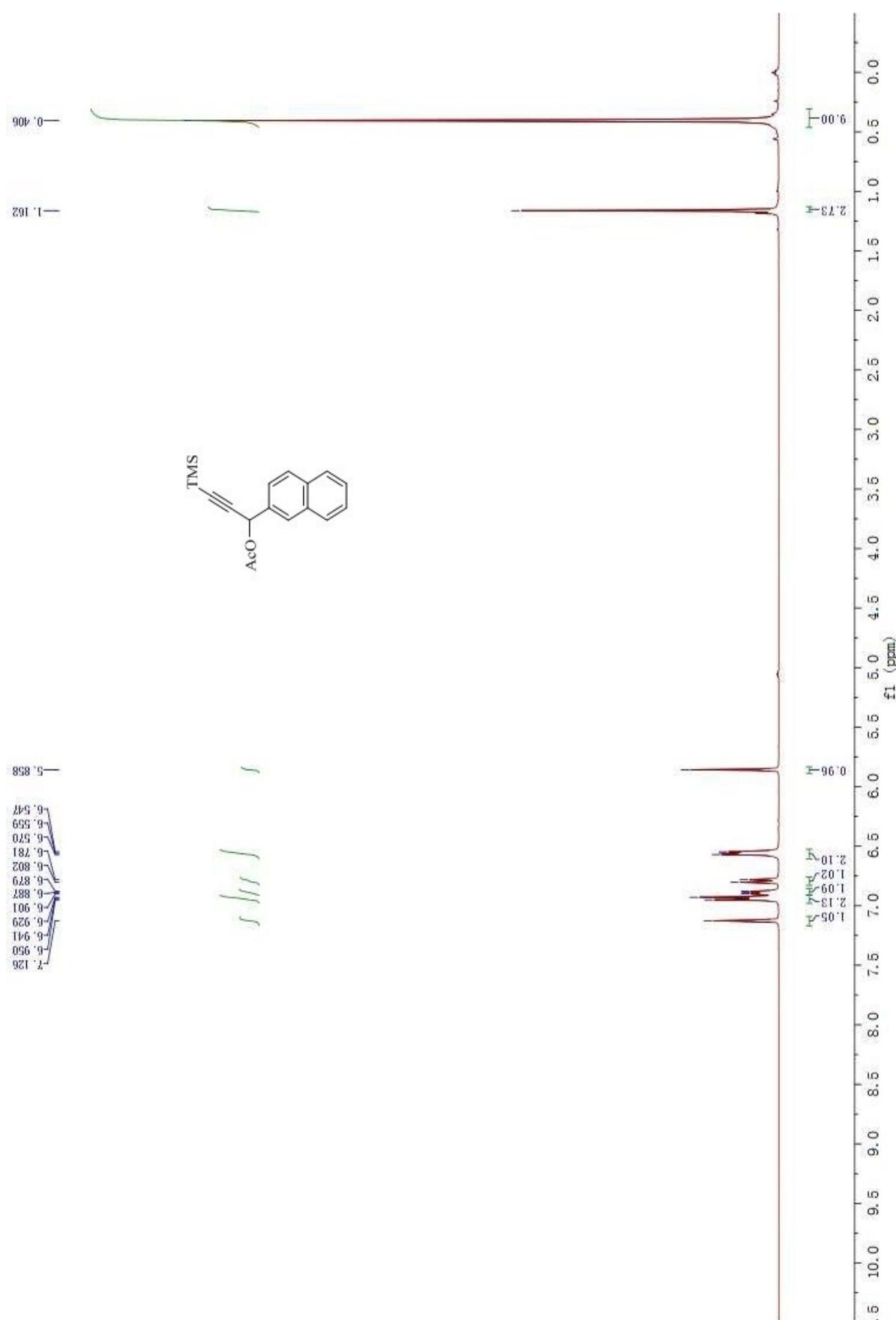




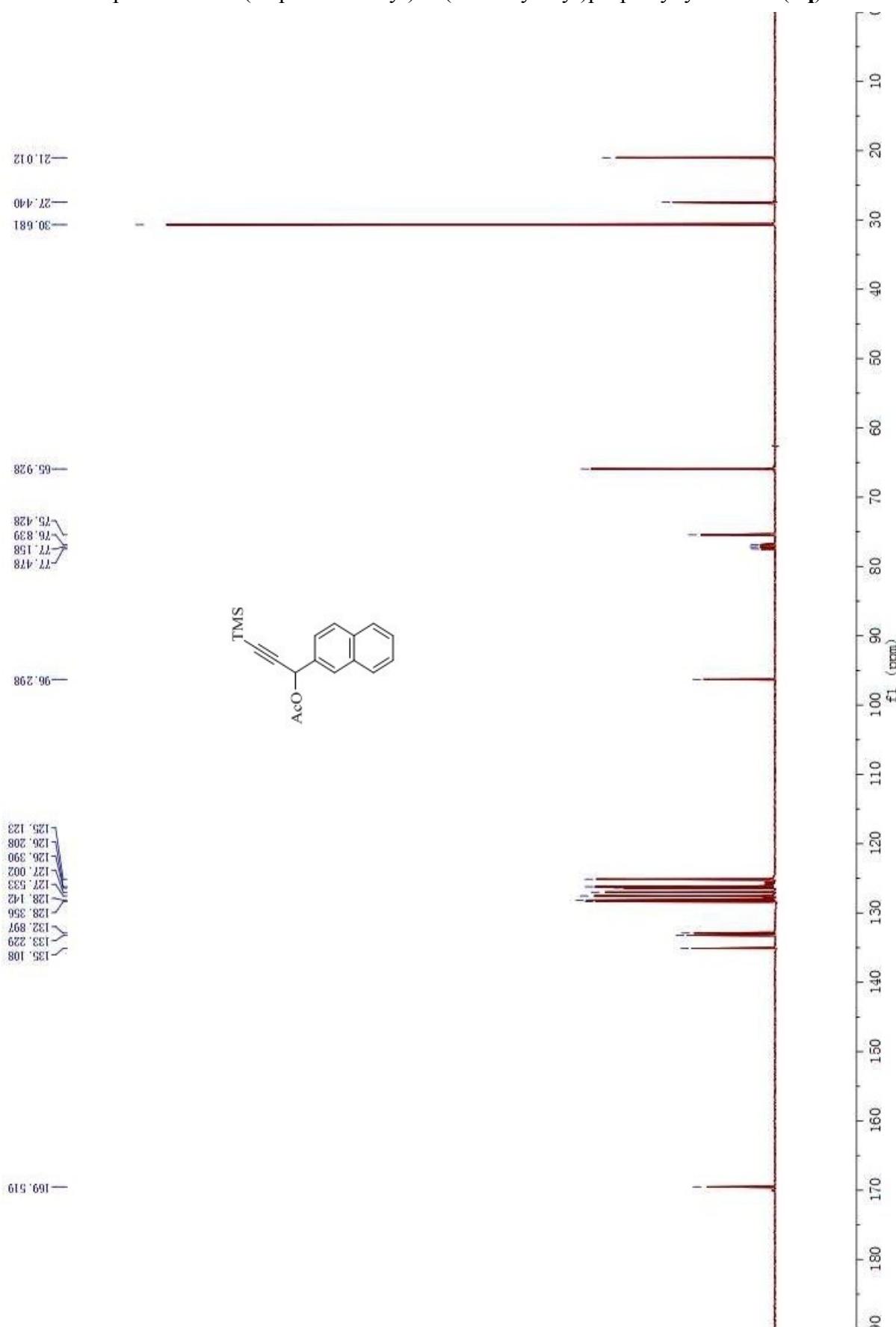
^{13}C NMR Spectrum of 1-(4-Chlorophenyl)-3-(trimethylsilyl)prop-2-ynyl acetate (**1p**)



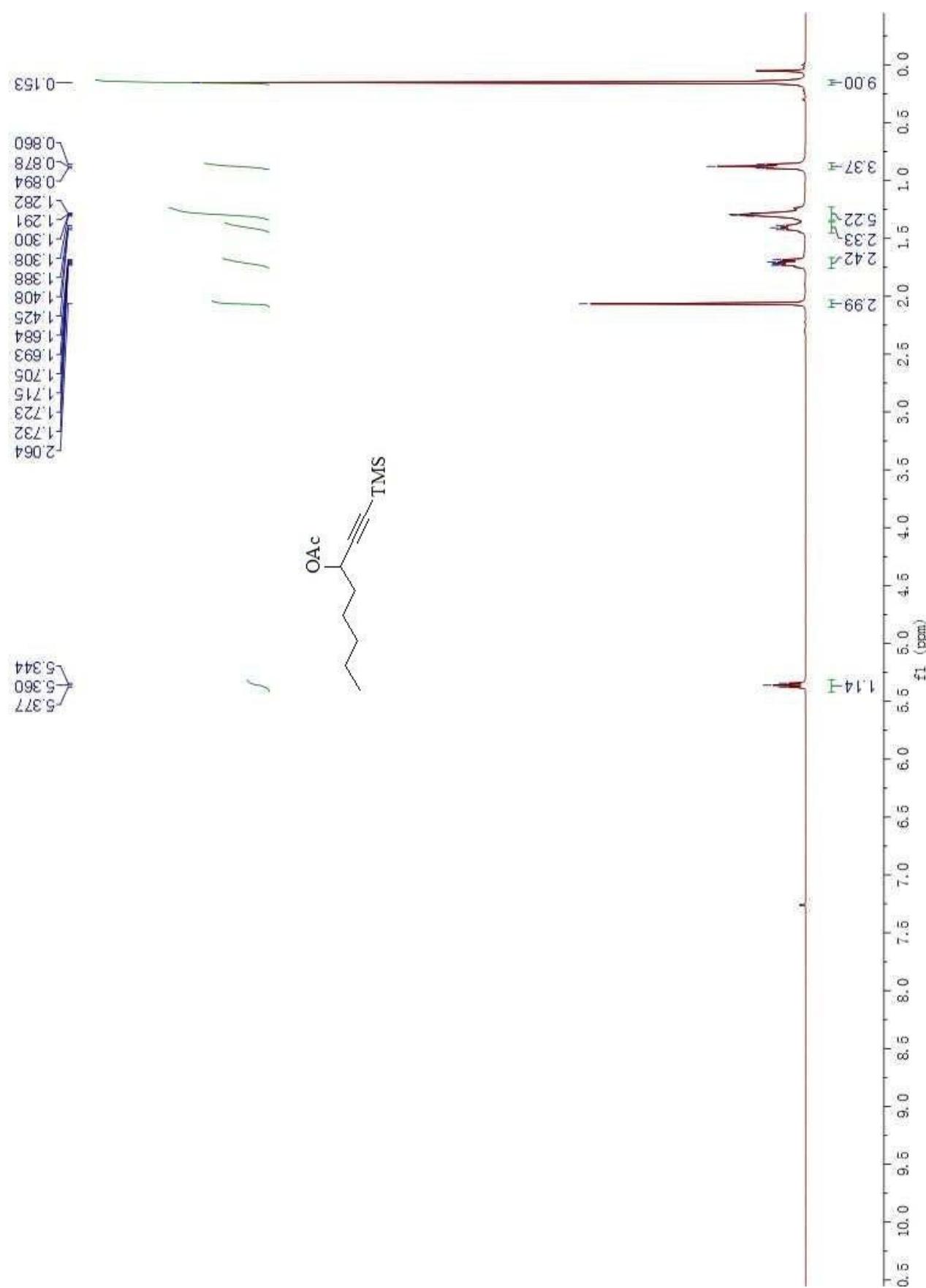
¹H NMR Spectrum of 1-(Naphthalen-2-yl)-3-(trimethylsilyl)prop-2-ynyl acetate (**1q**)



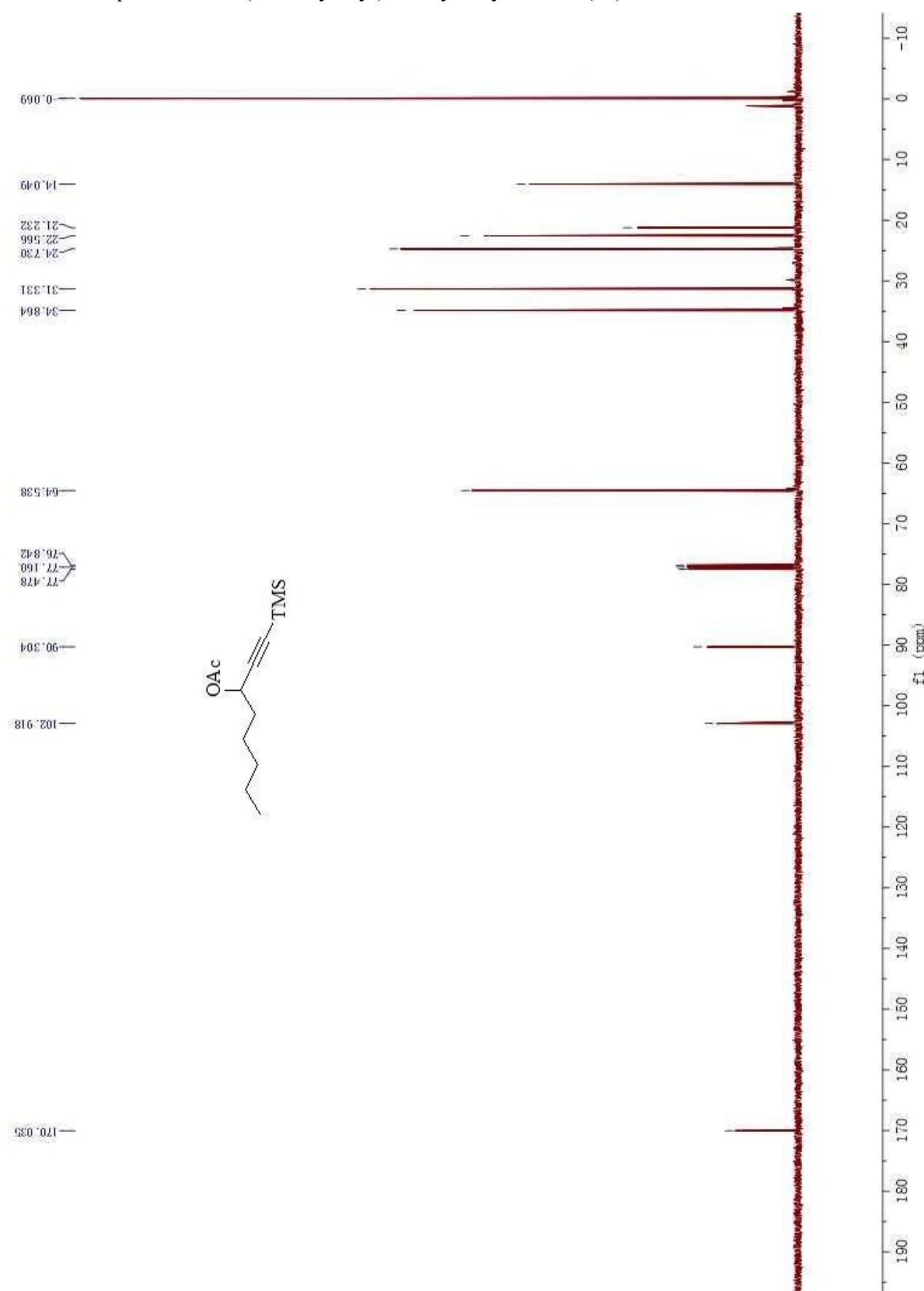
¹³C NMR Spectrum of 1-(Naphthalen-2-yl)-3-(trimethylsilyl)prop-2-ynyl acetate (**1q**)



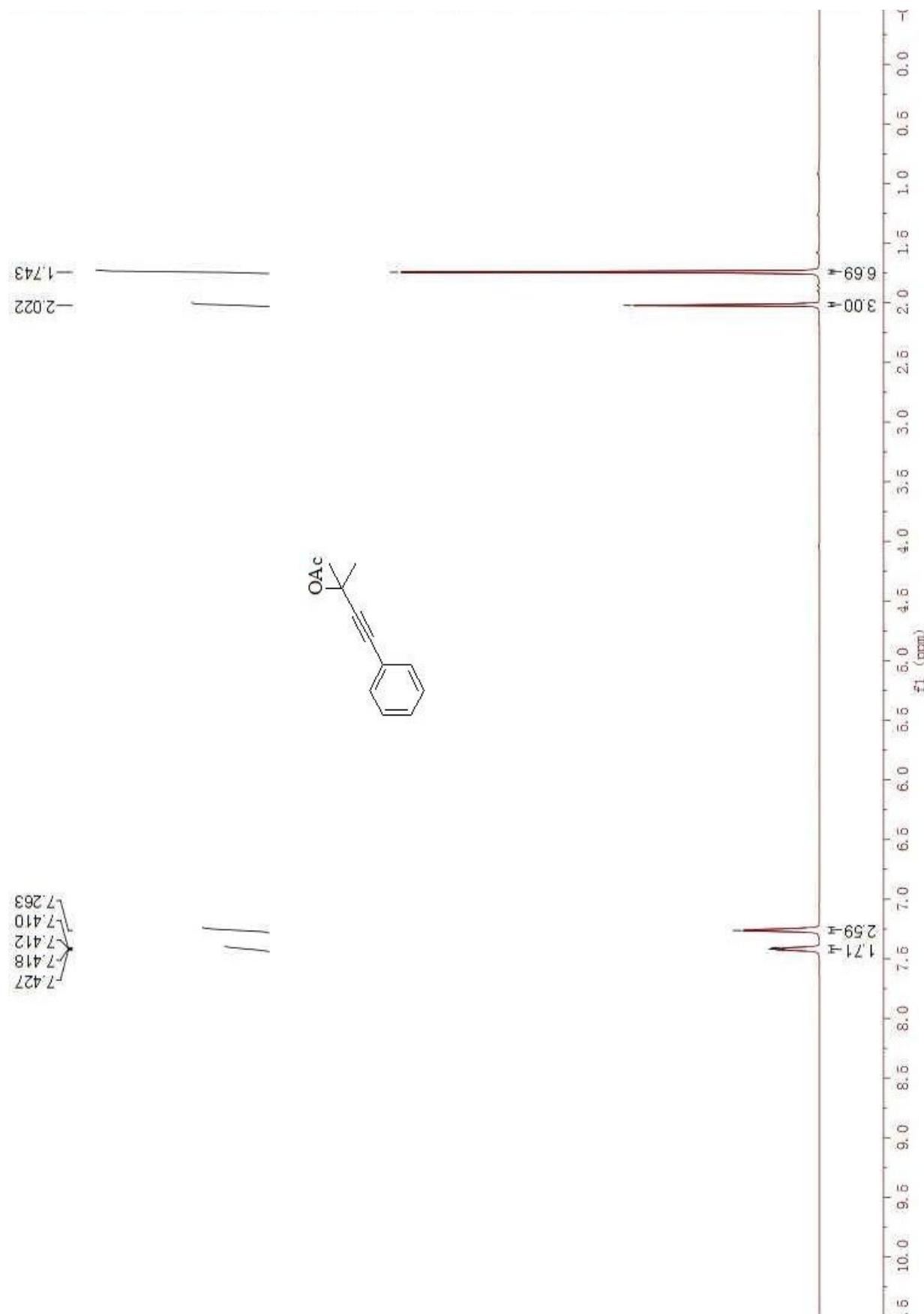
¹H NMR Spectrum of 1-(trimethylsilyl)oct-1-yn-3-yl acetate (**1r**)



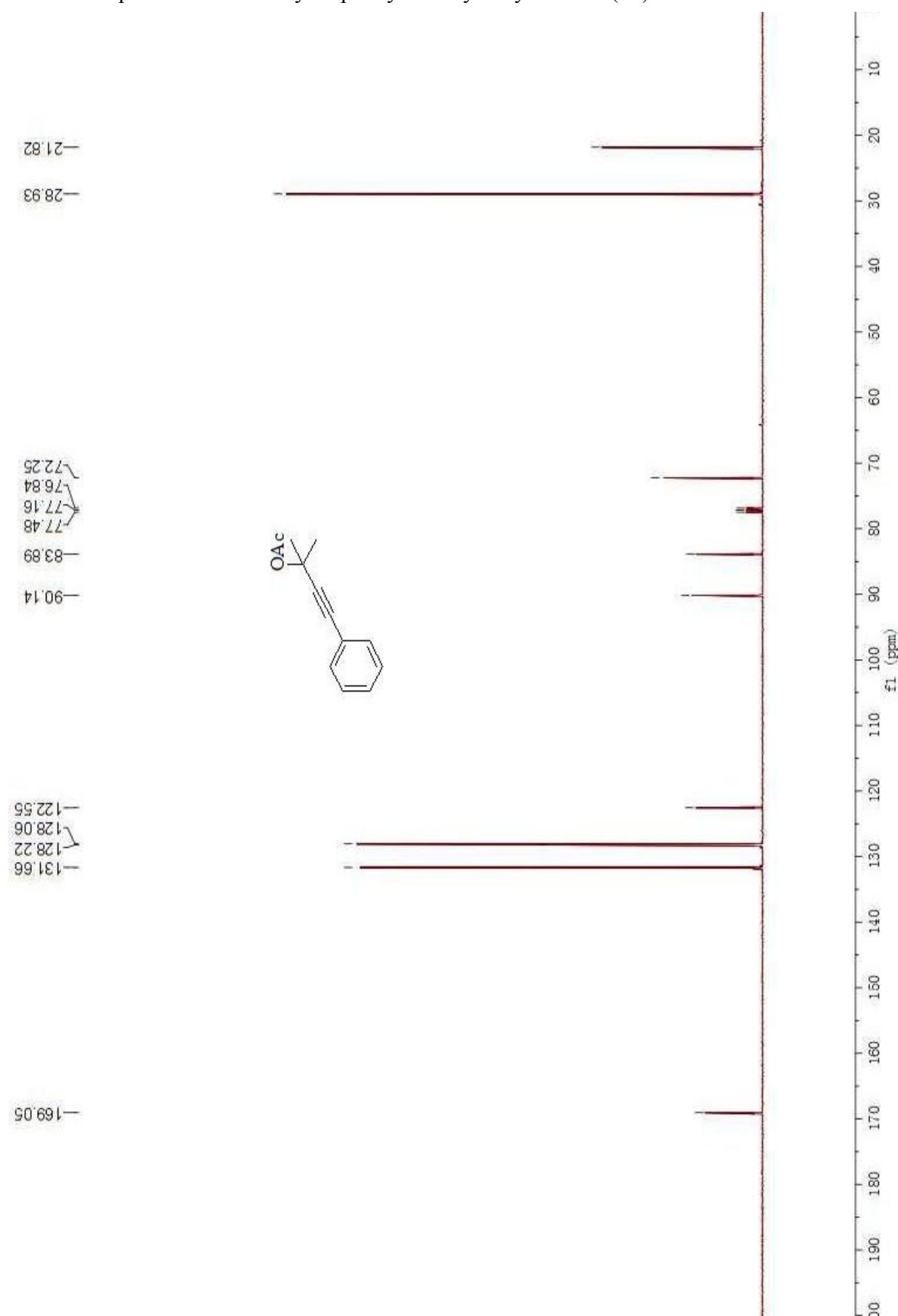
¹³C NMR Spectrum of 1-(trimethylsilyl)oct-1-yn-3-yl acetate (**1r**)



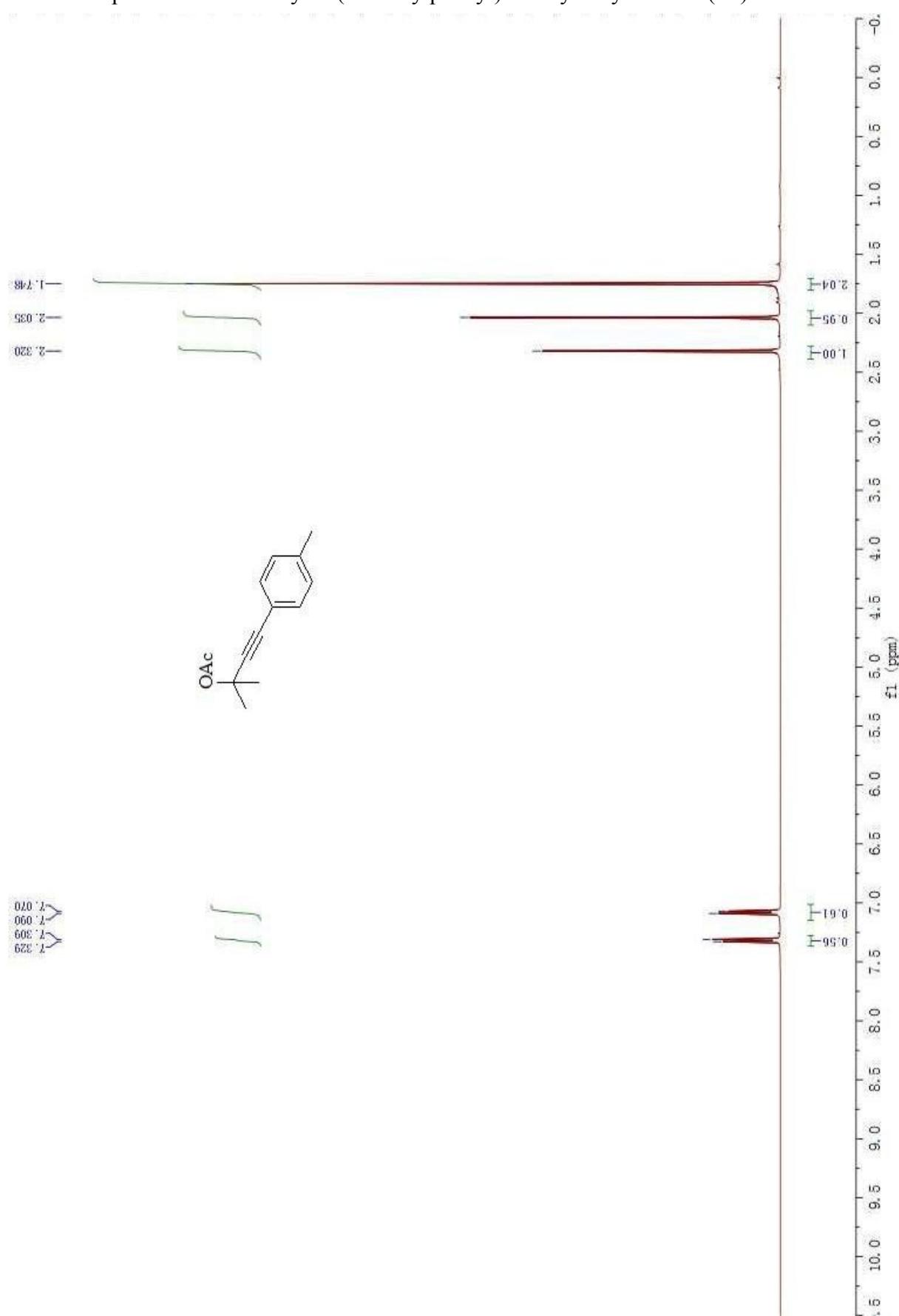
¹H NMR Spectrum of 2-methyl-4-phenylbut-3-yn-2-yl acetate (**4a**)



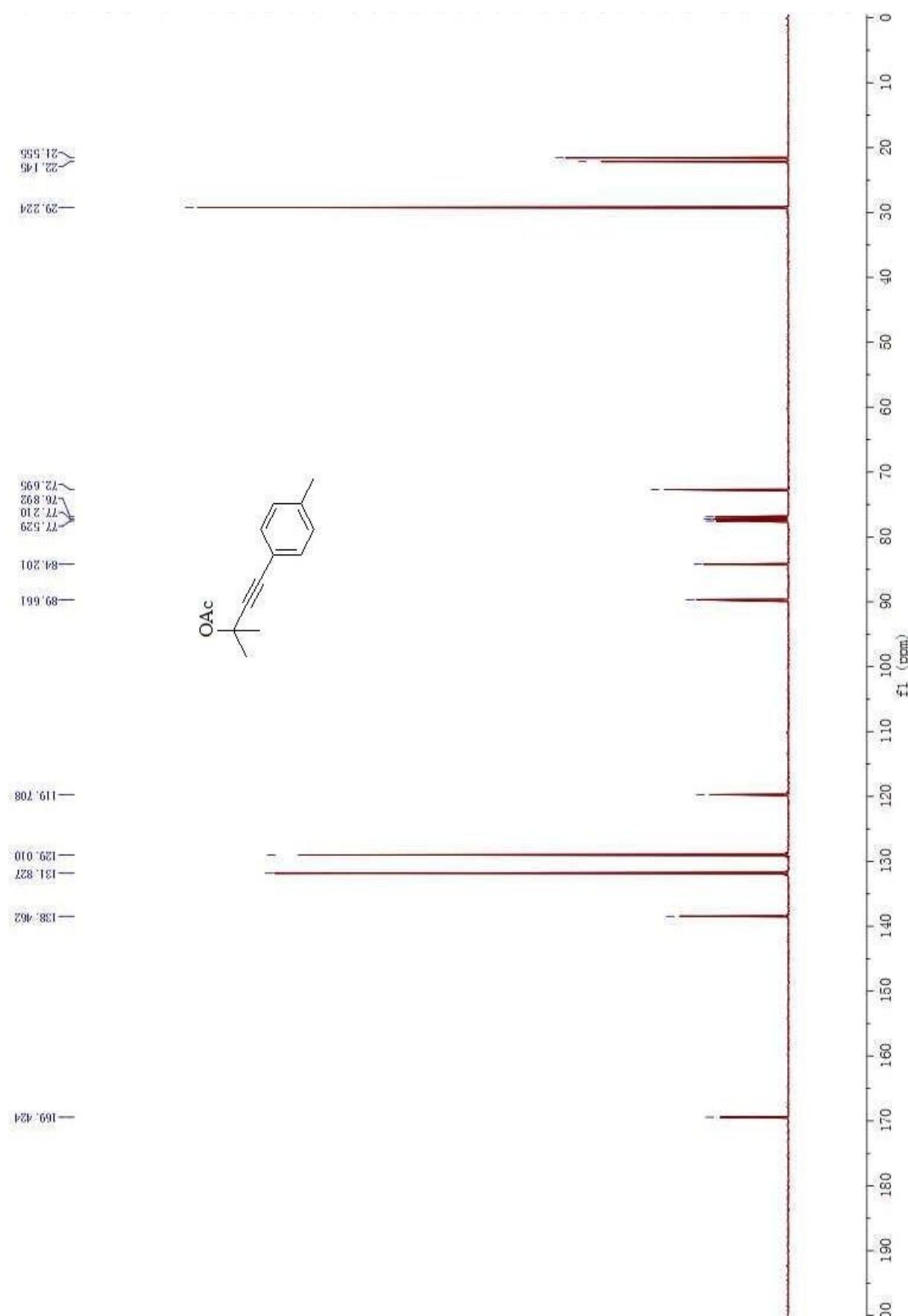
¹³C NMR Spectrum of 2-methyl-4-phenylbut-3-yn-2-yl acetate (**4a**)



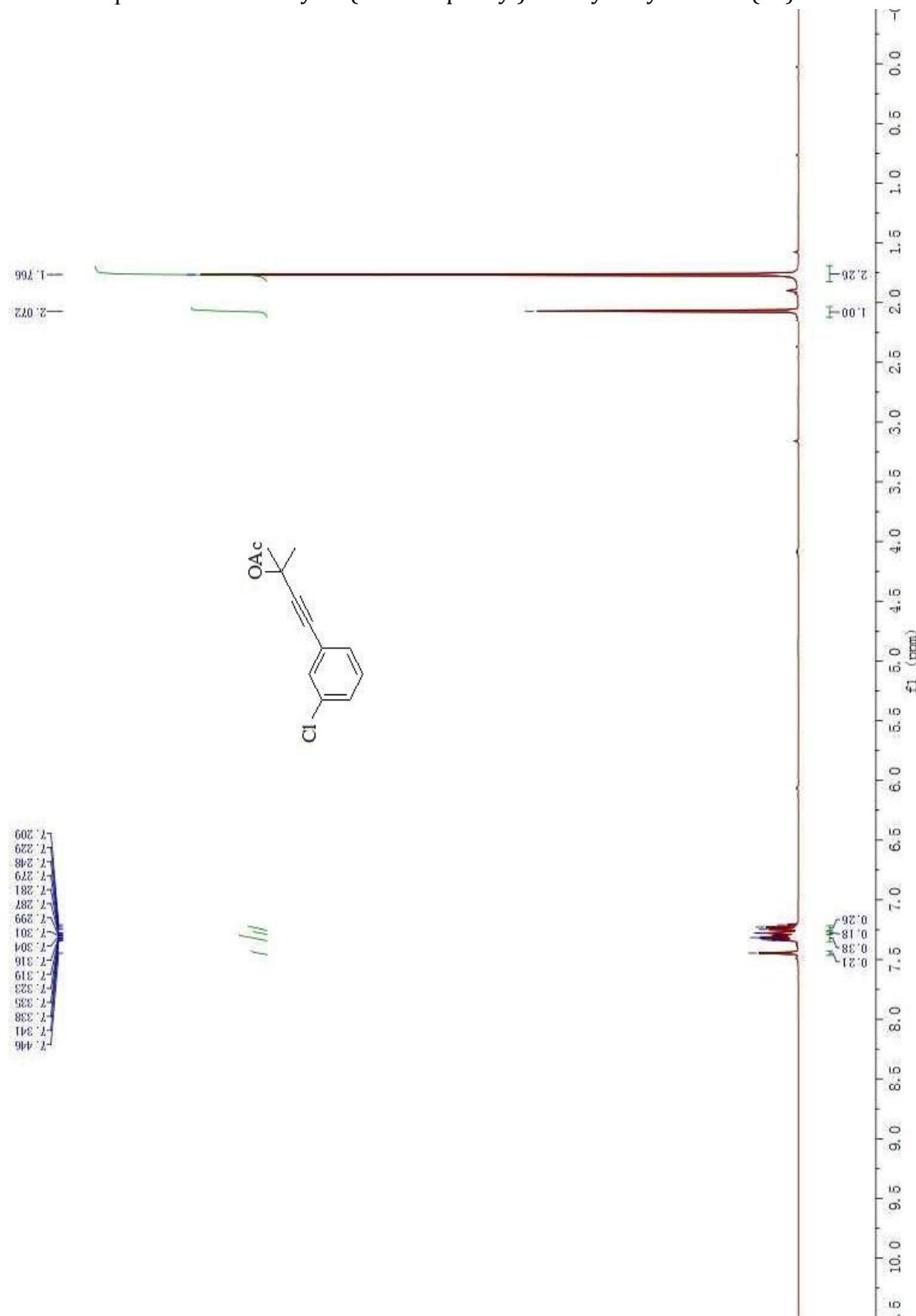
¹H NMR Spectrum of 2-Methyl-4-(4-methylphenyl)but-3-yn-2-yl acetate (**4b**)



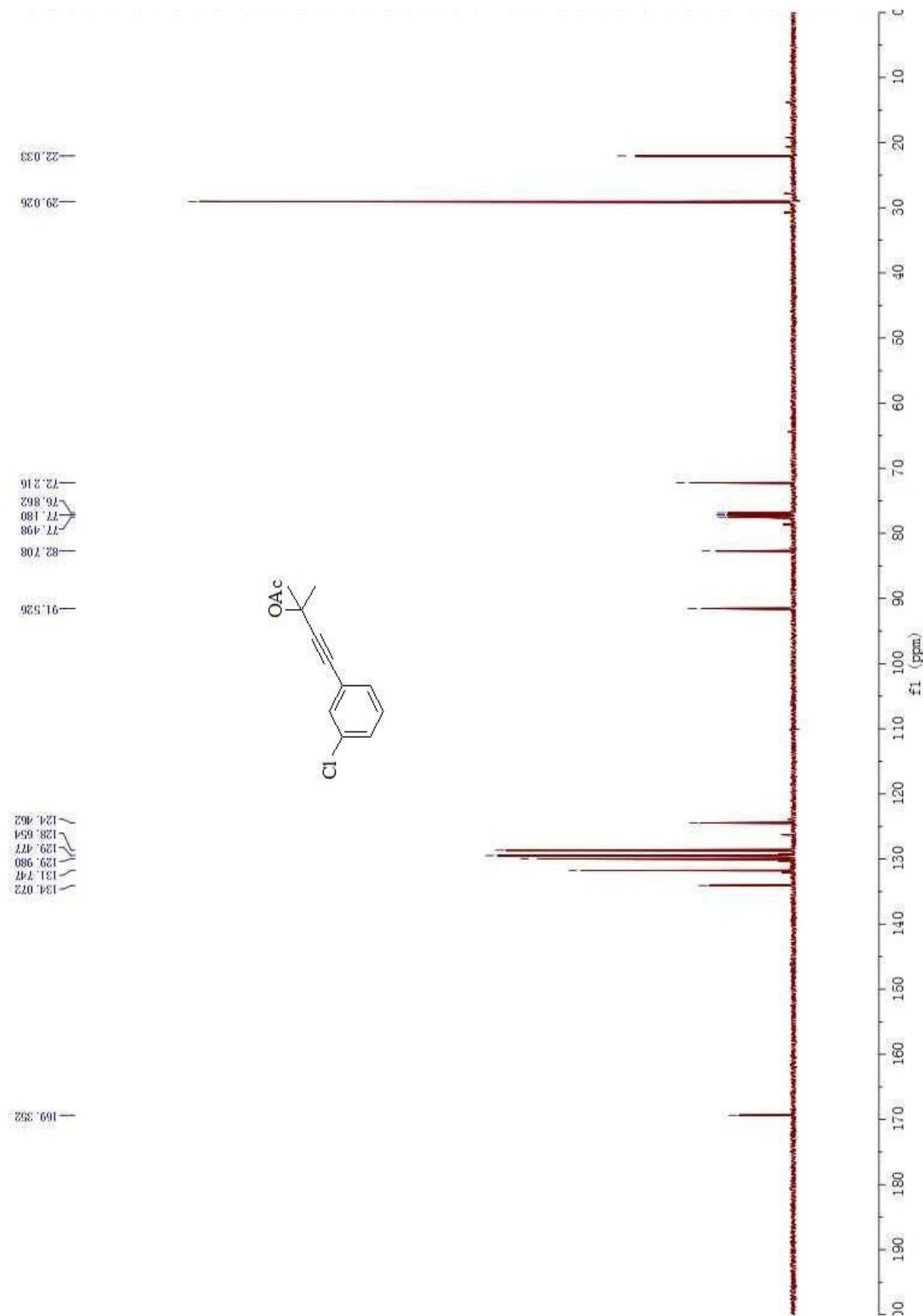
¹³C NMR Spectrum of 2-Methyl-4-(4-methylphenyl)but-3-yn-2-yl acetate (**4b**)



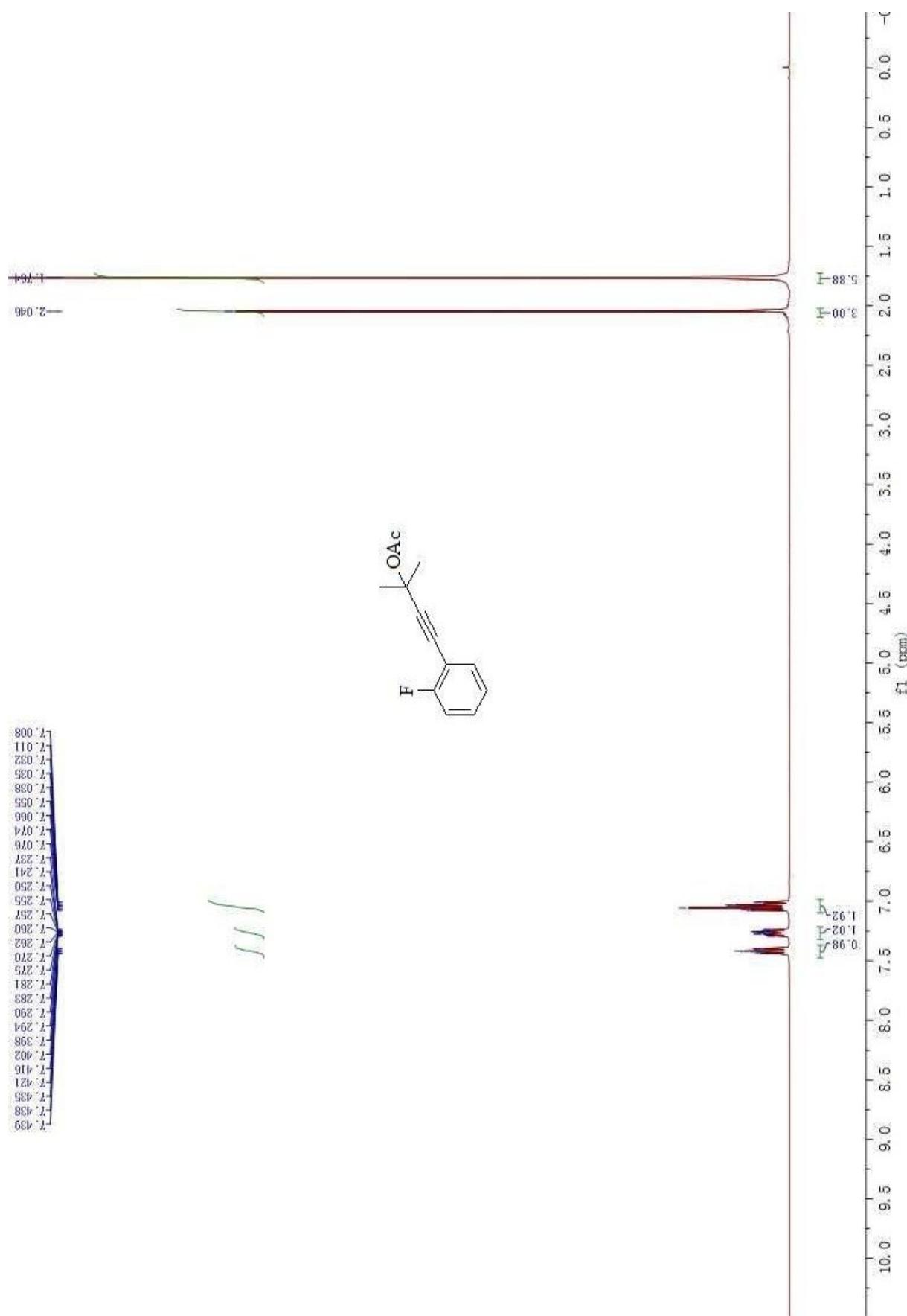
¹H NMR Spectrum of 2-Methyl-4-(3-chlorophenyl)but-3-yn-2-yl acetate (**4c**)



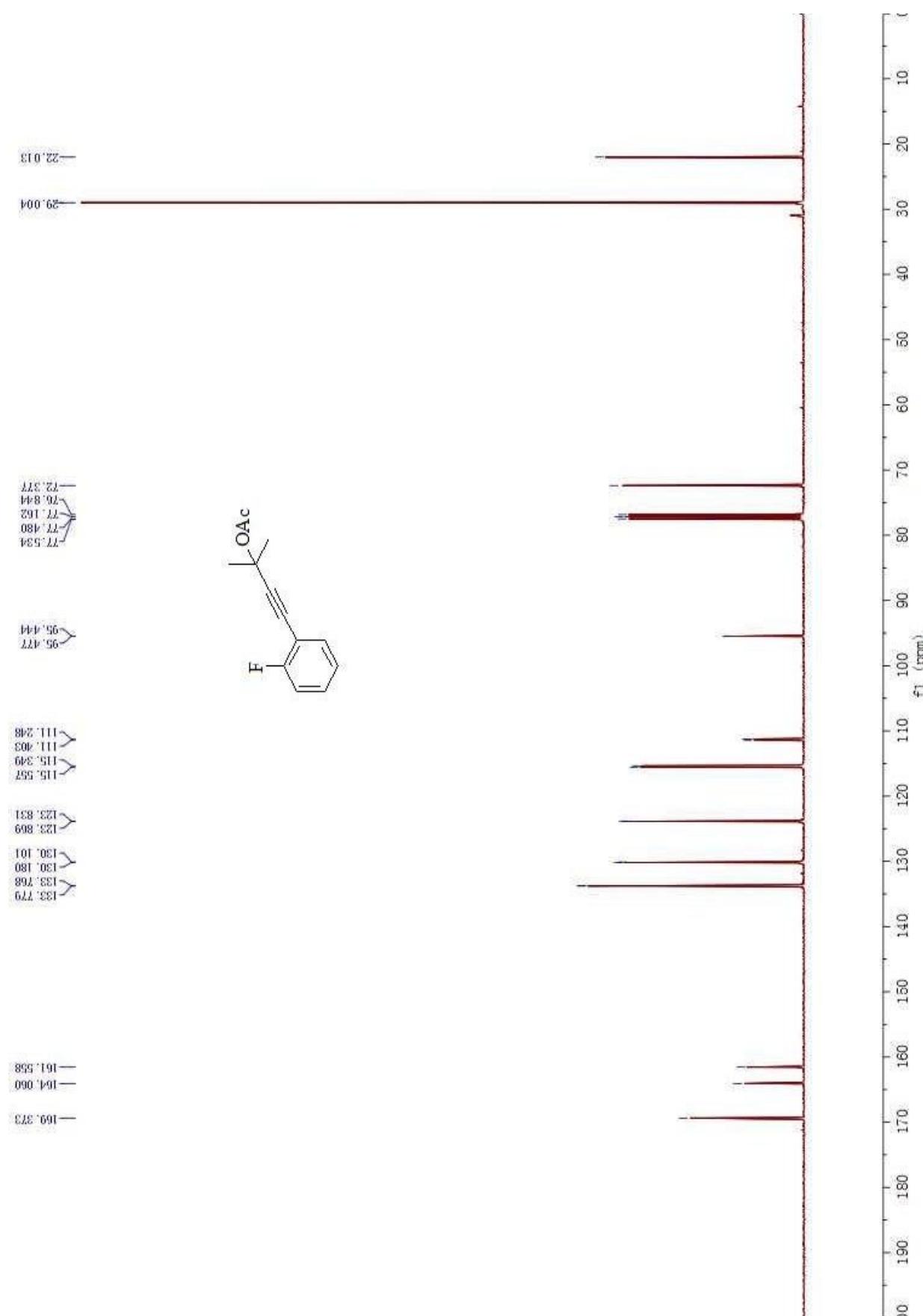
¹³C NMR Spectrum of 2-Methyl-4-(3-chlorophenyl)but-3-yn-2-yl acetate (**4c**)



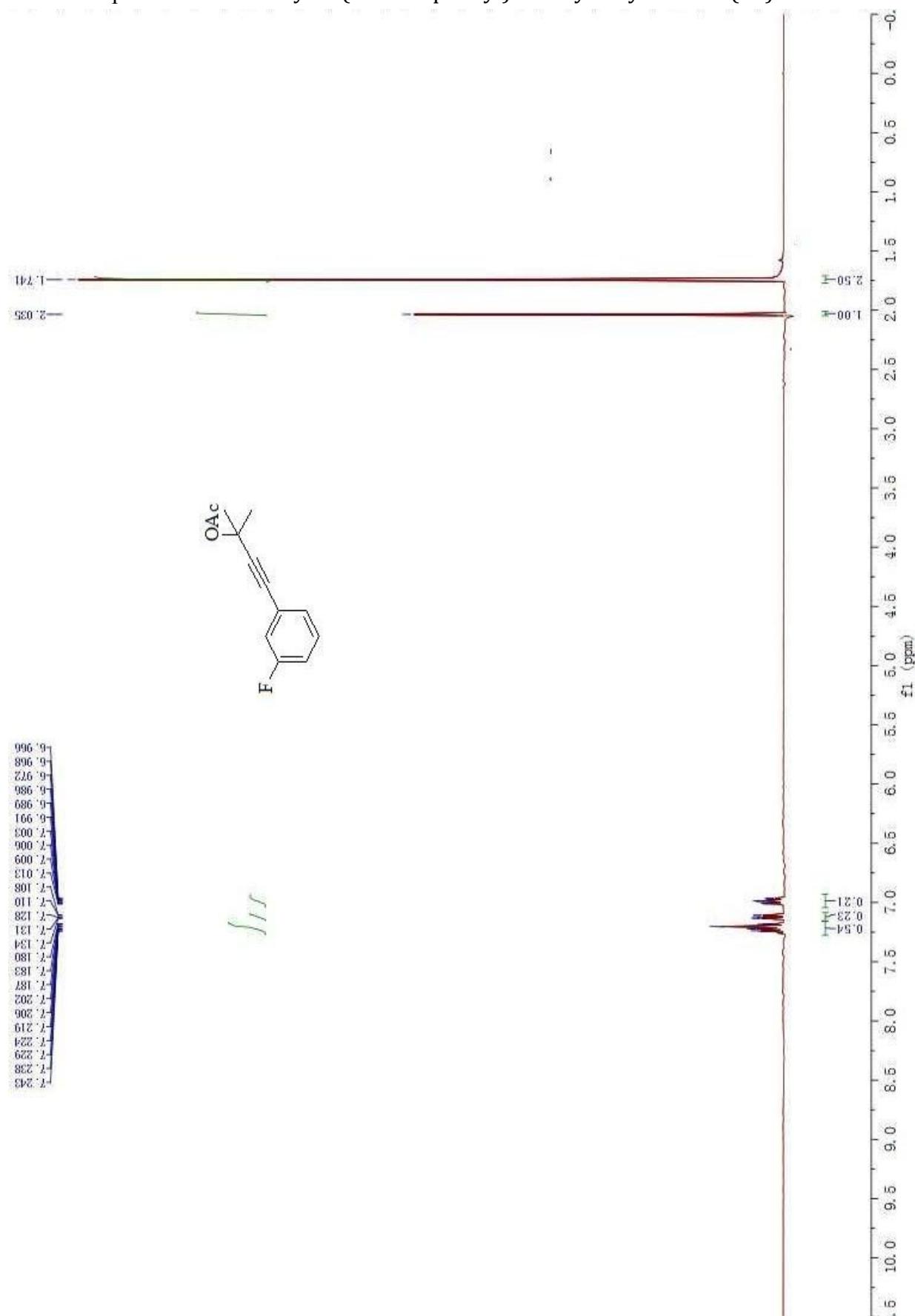
¹H NMR Spectrum of 2-Methyl-4-(2-fluorophenyl)but-3-yn-2-yl acetate (**4d**):



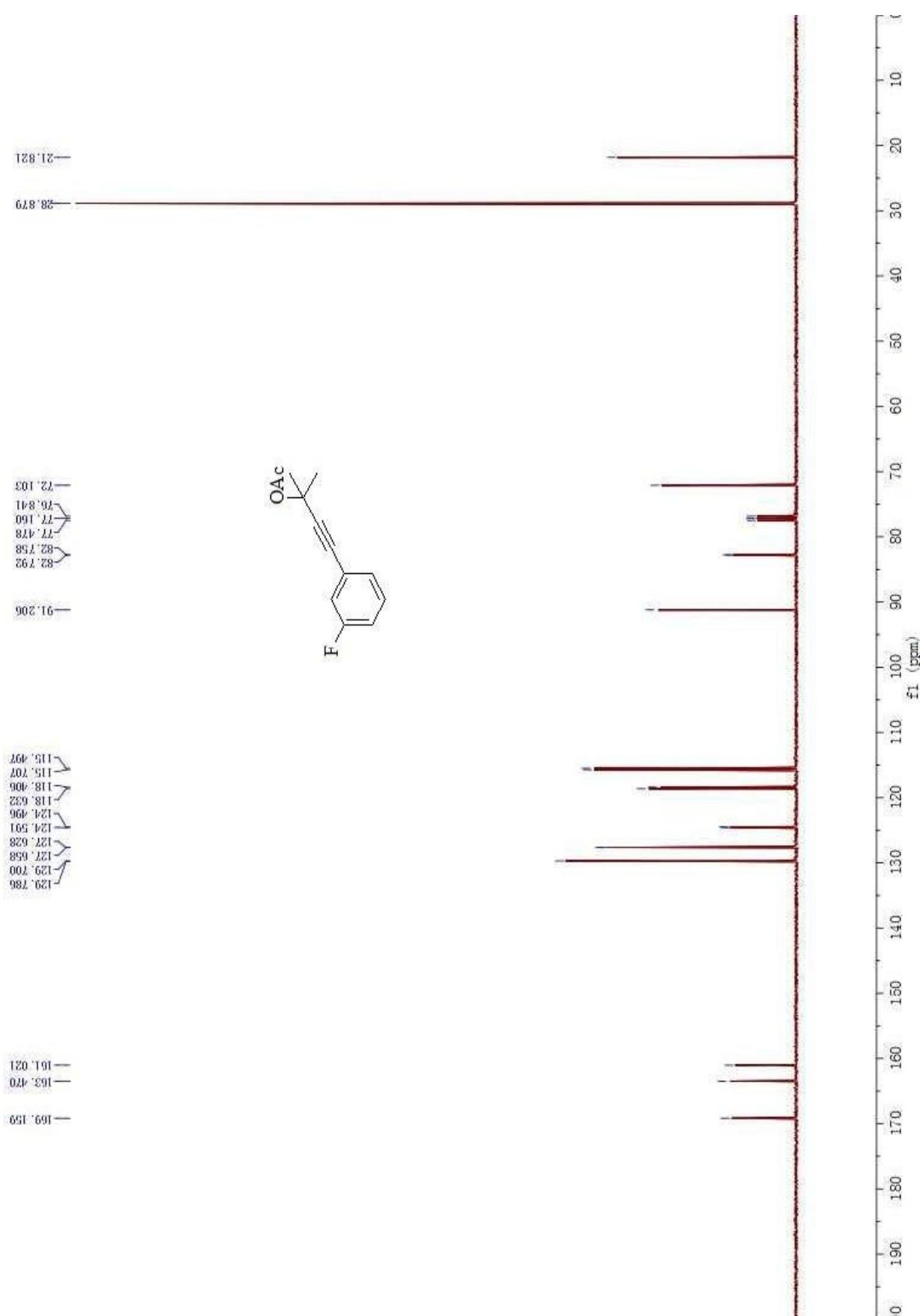
¹³C NMR Spectrum of 2-Methyl-4-(2-fluorophenyl)but-3-yn-2-yl acetate (**4d**):



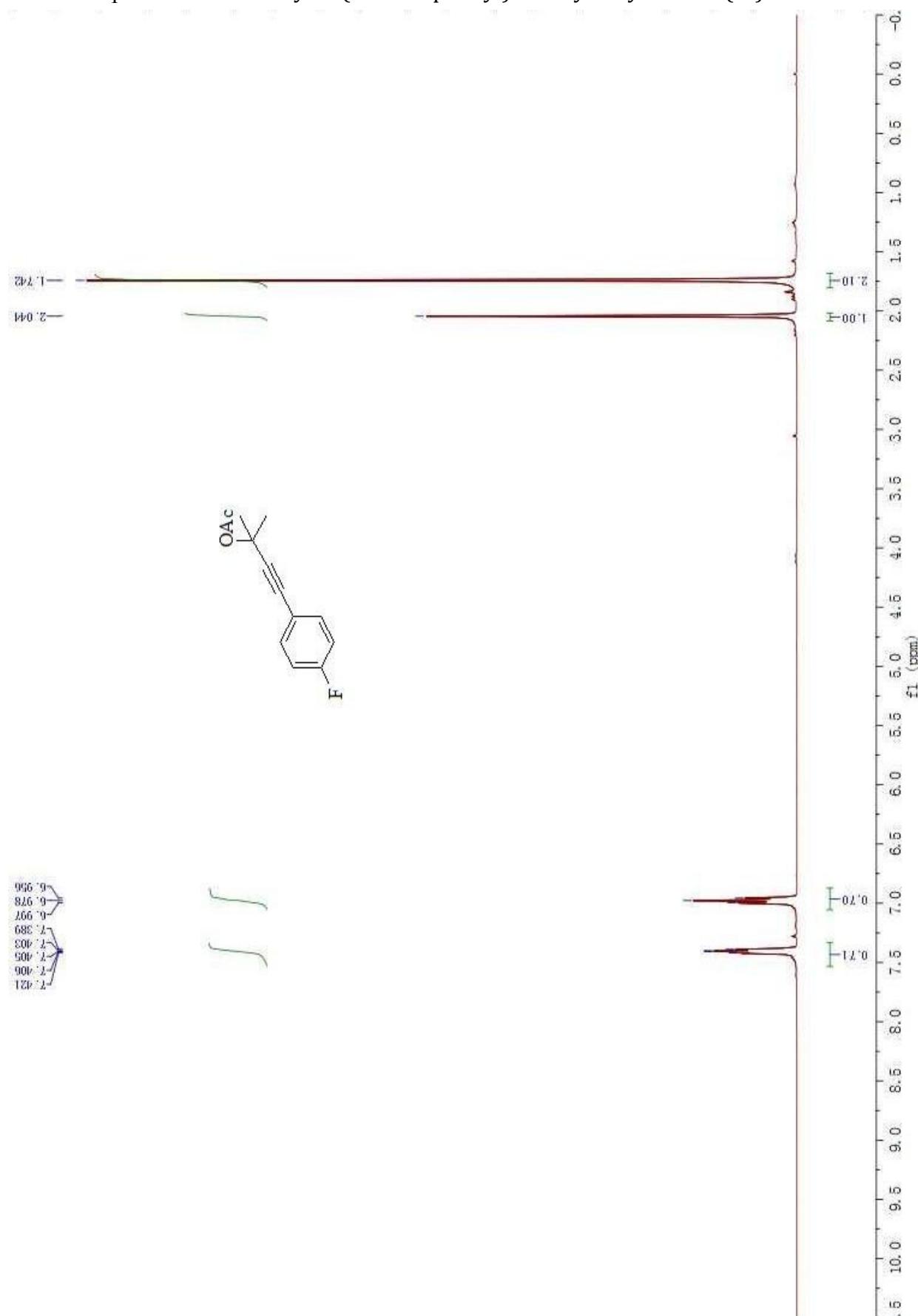
¹H NMR Spectrum of 2-Methyl-4-(3-fluorophenyl)but-3-yn-2-yl acetate (**4e**)



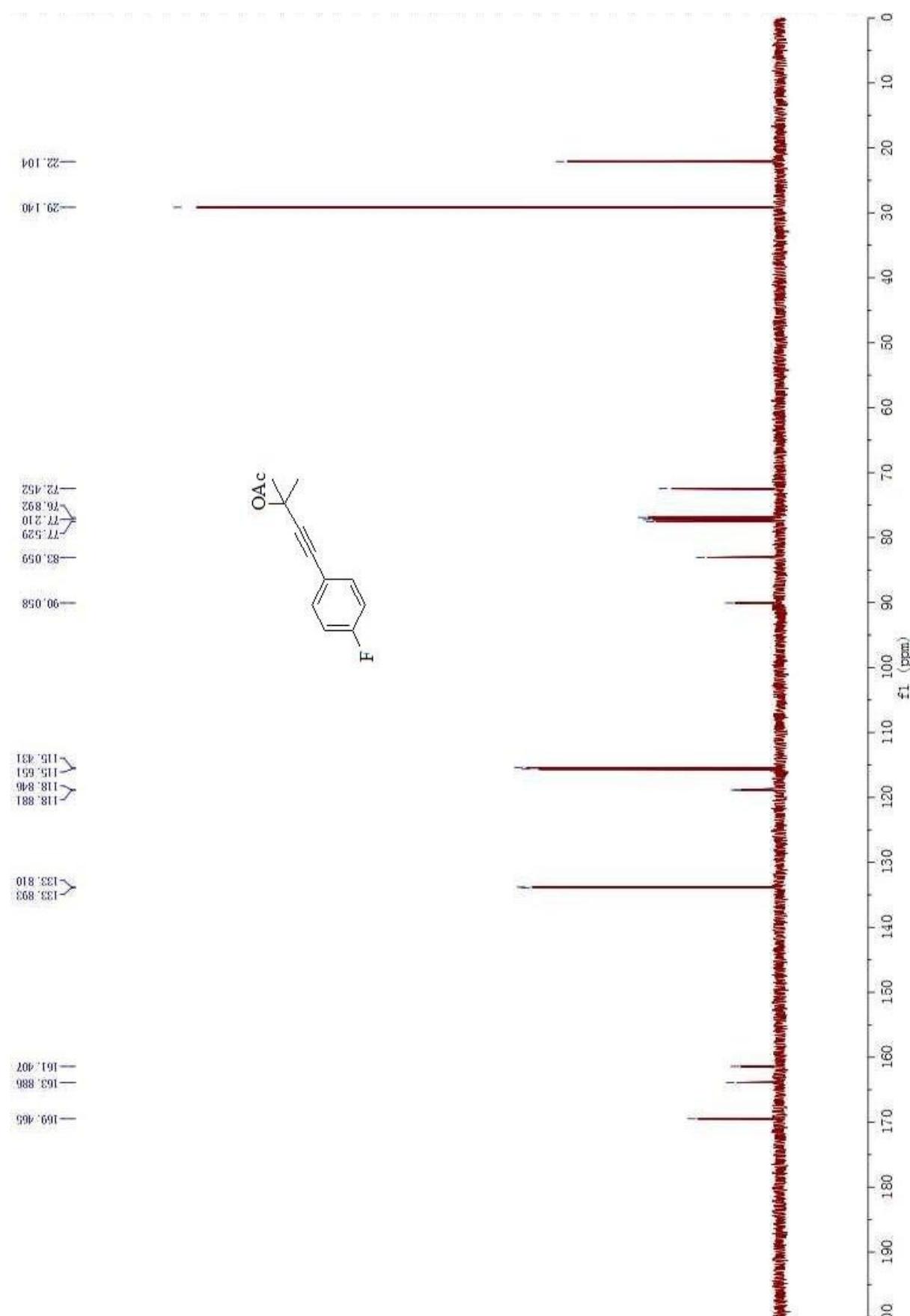
¹³C NMR Spectrum of 2-Methyl-4-(3-fluorophenyl)but-3-yn-2-yl acetate (**4e**)



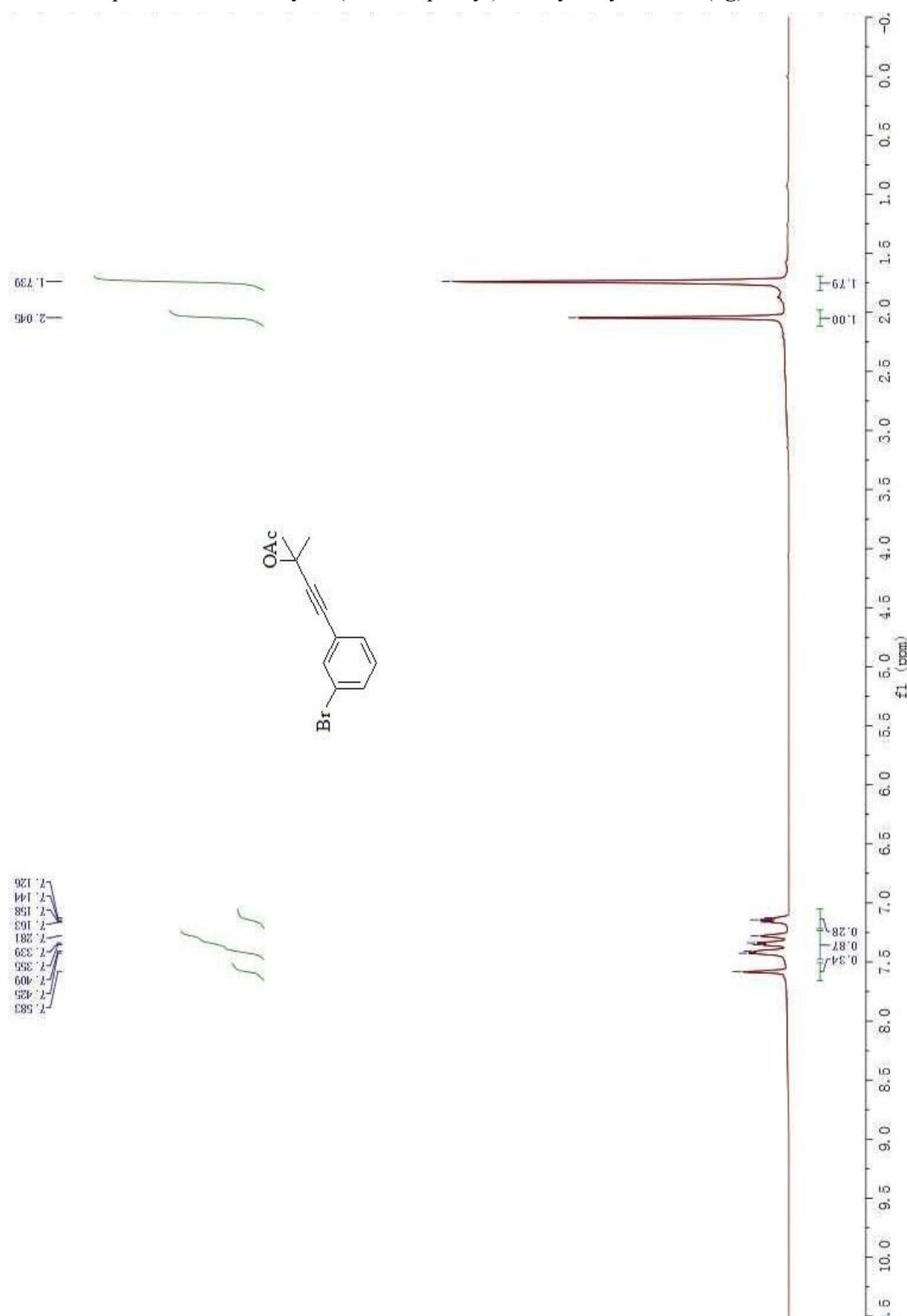
¹H NMR Spectrum of 2-Methyl-4-(4-fluorophenyl)but-3-yn-2-yl acetate(**4f**)



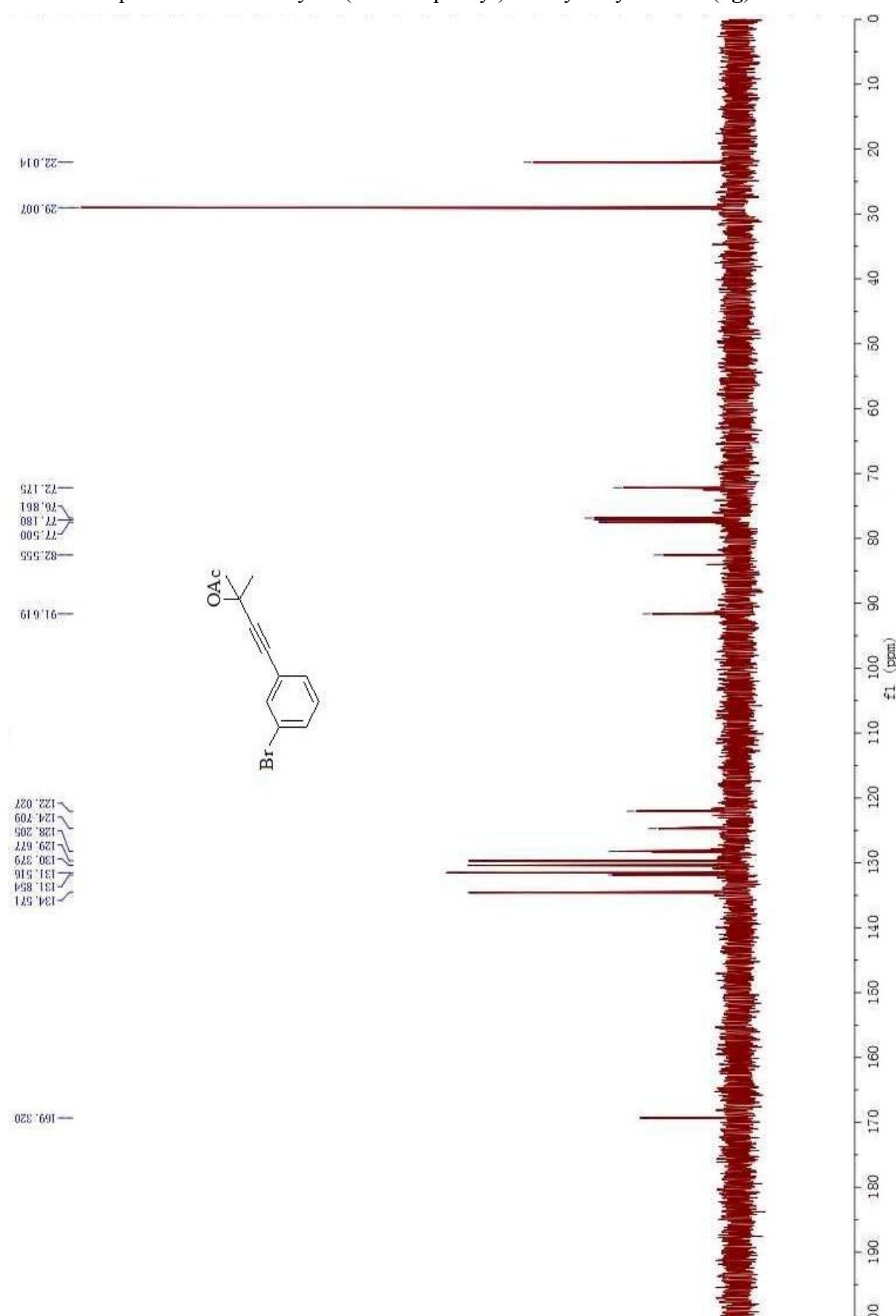
¹³C NMR Spectrum of 2-Methyl-4-(4-fluorophenyl)but-3-yn-2-yl acetate(**4f**)



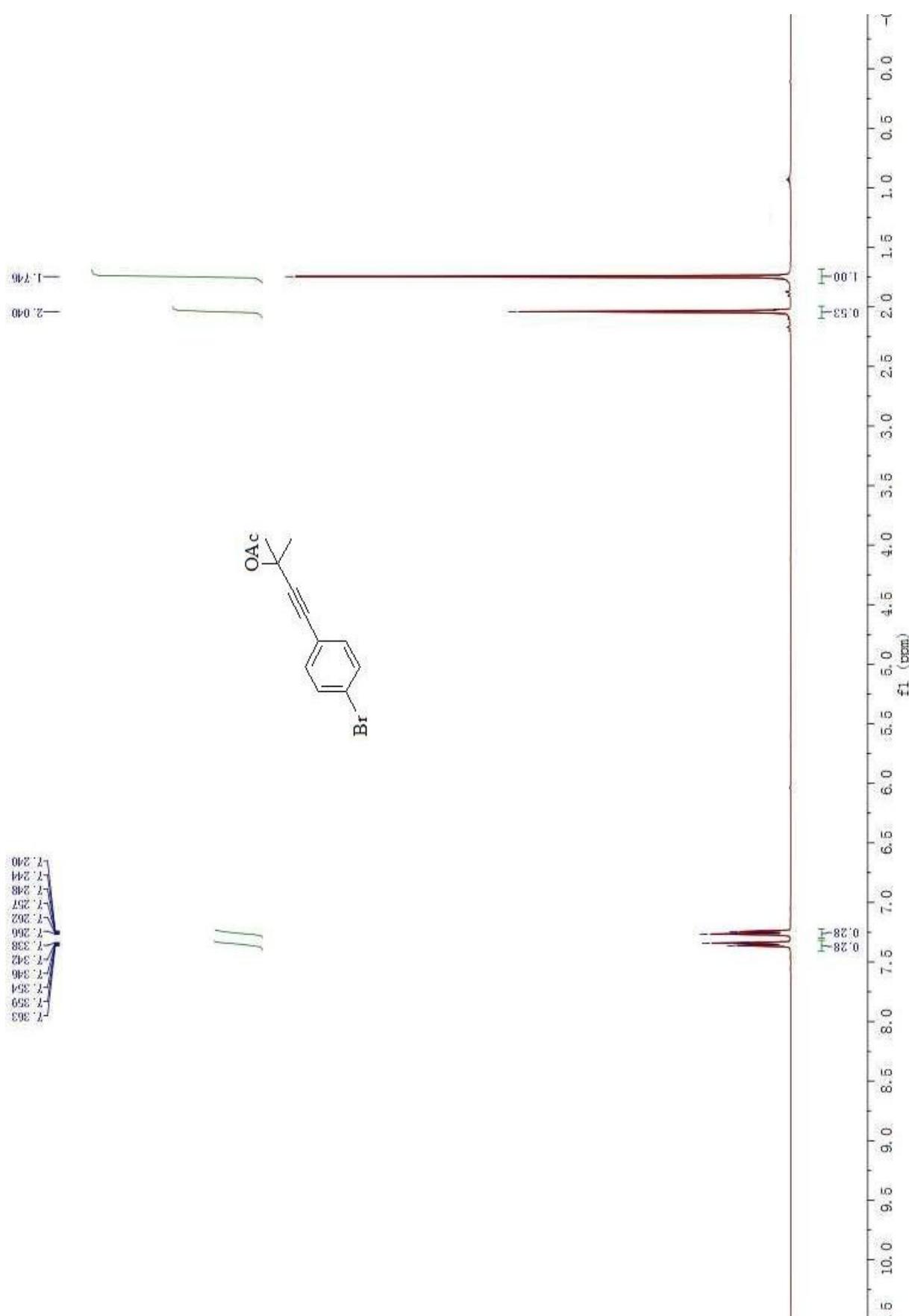
¹H NMR Spectrum of 2-Methyl-4-(3-bromophenyl)but-3-yn-2-yl acetate (**4g**)



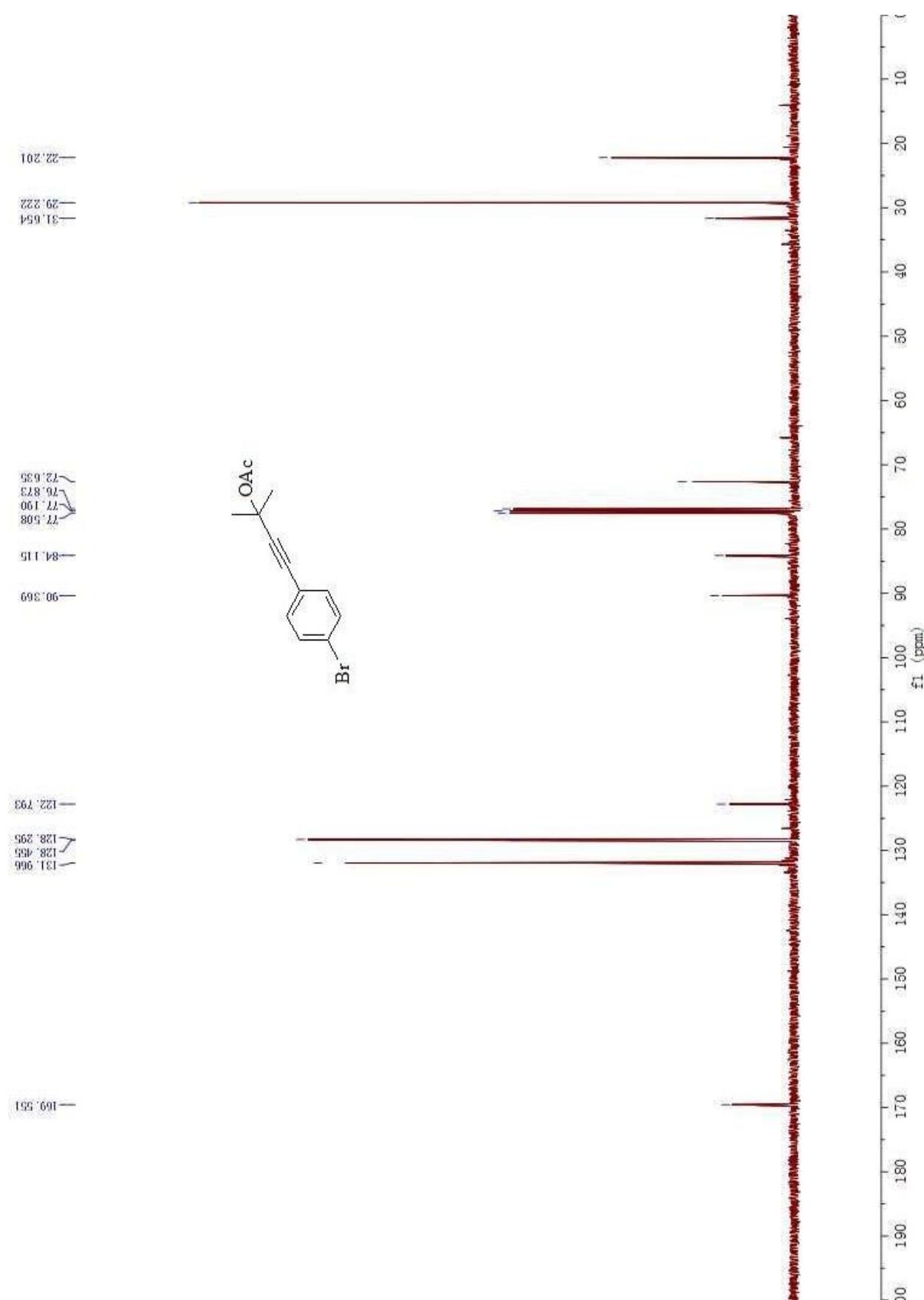
¹³C NMR Spectrum of 2-Methyl-4-(3-bromophenyl)but-3-yn-2-yl acetate (**4g**)



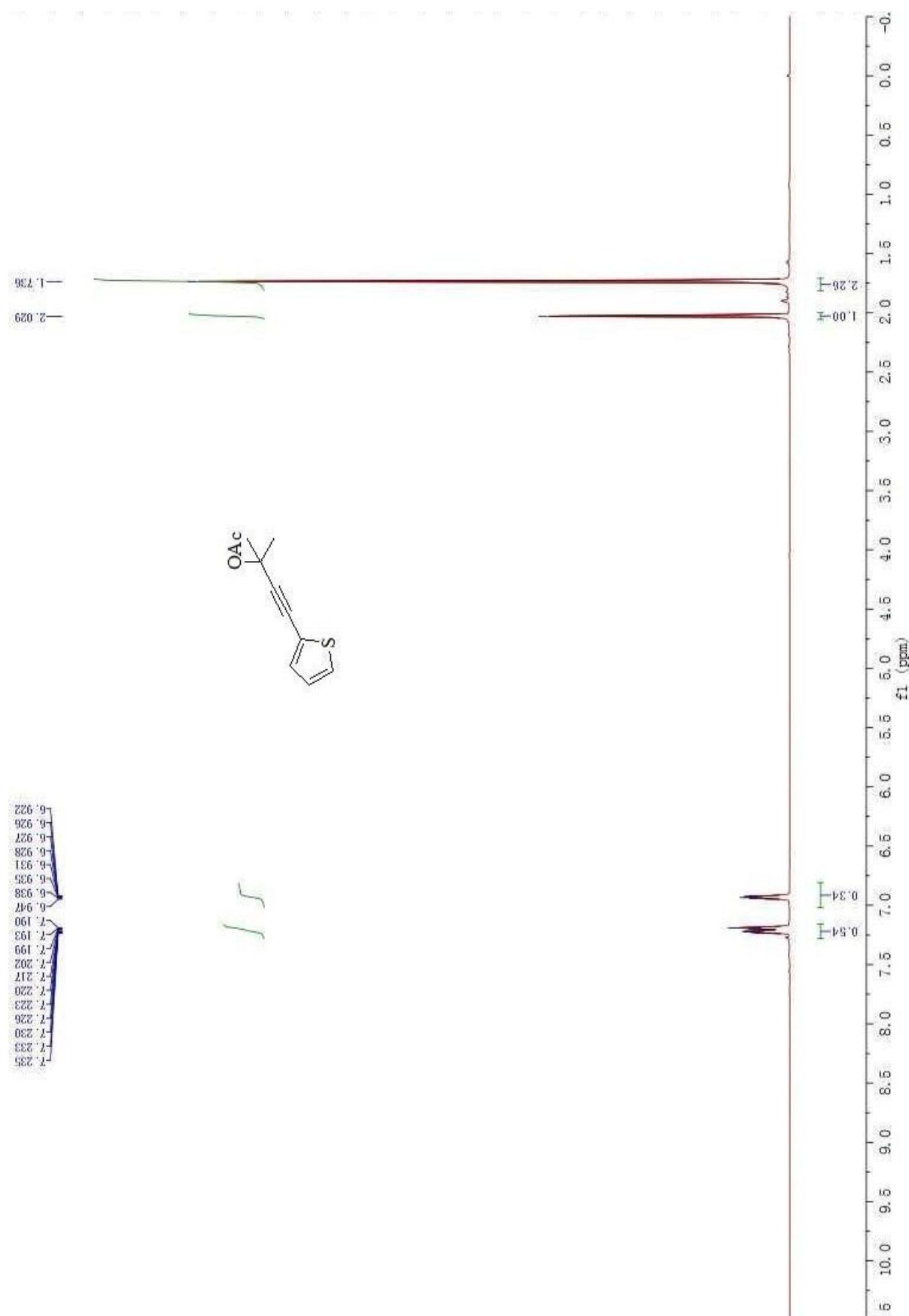
¹H NMR Spectrum of 2-Methyl-4-(4-bromophenyl)but-3-yn-2-yl acetate (**4h**)



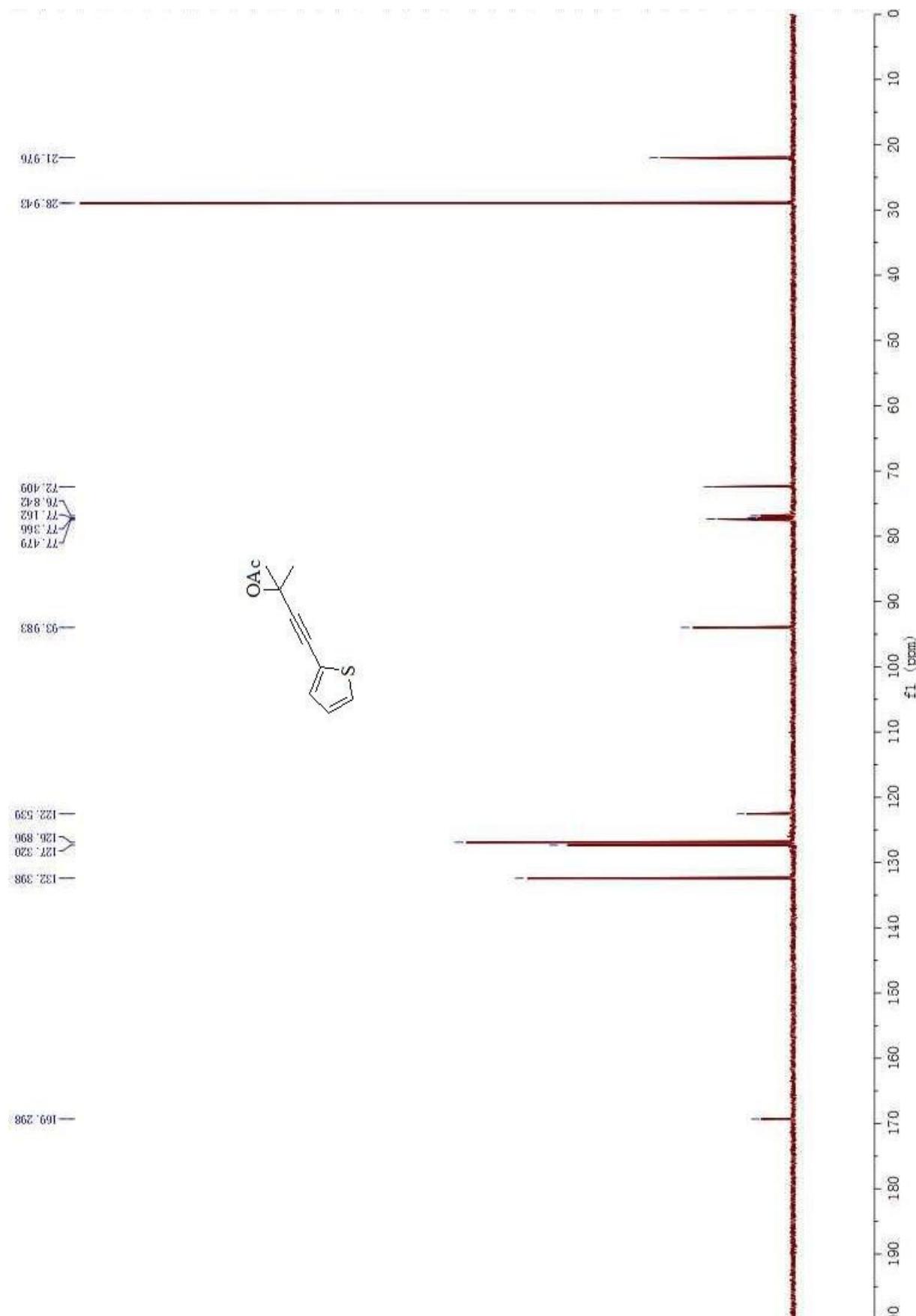
¹³C NMR Spectrum of 2-Methyl-4-(4-bromophenyl)but-3-yn-2-yl acetate (**4h**)



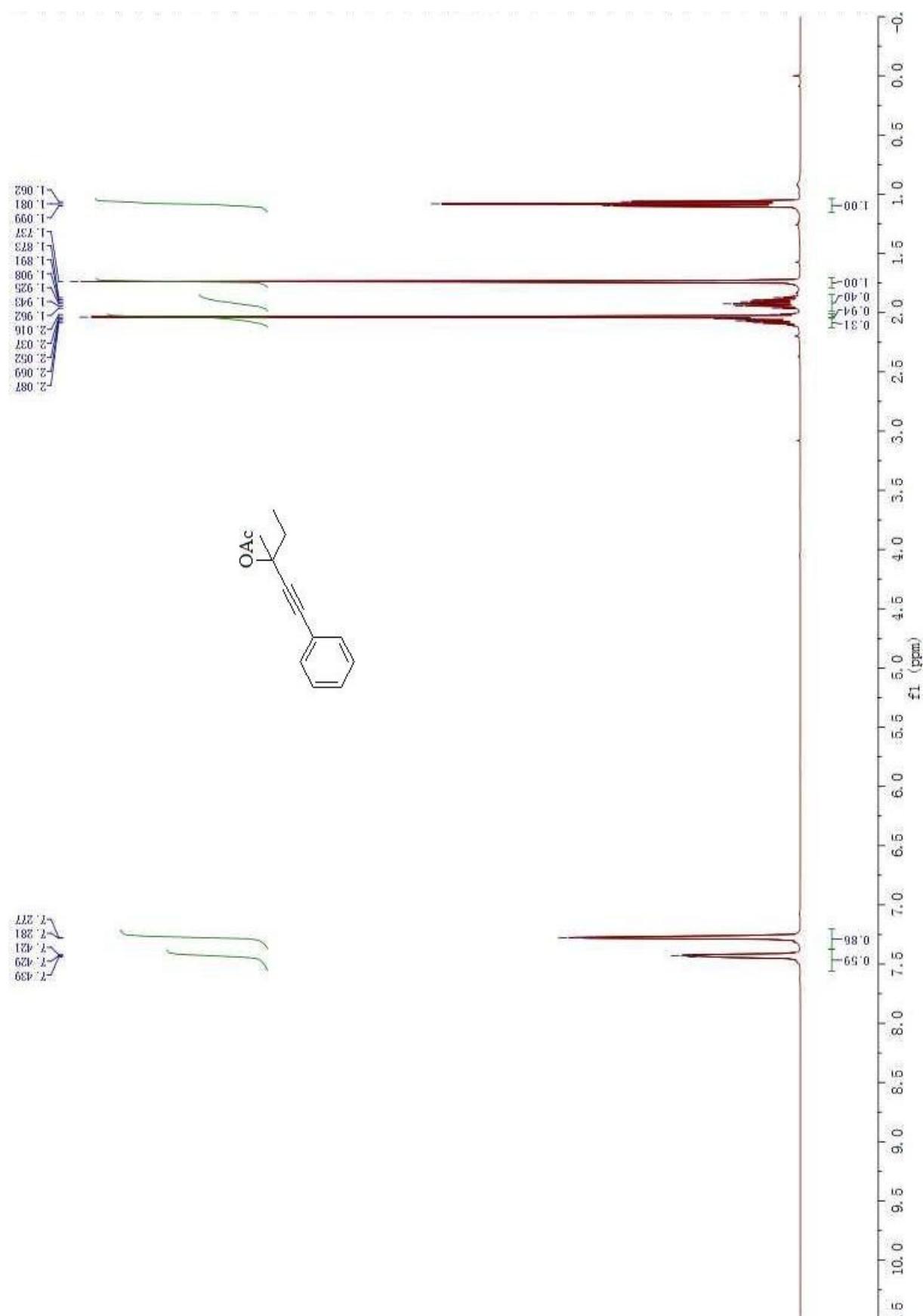
¹H NMR Spectrum of 2-Methyl-4-thienylbut-3-yn-2-yl acetate (**4i**)



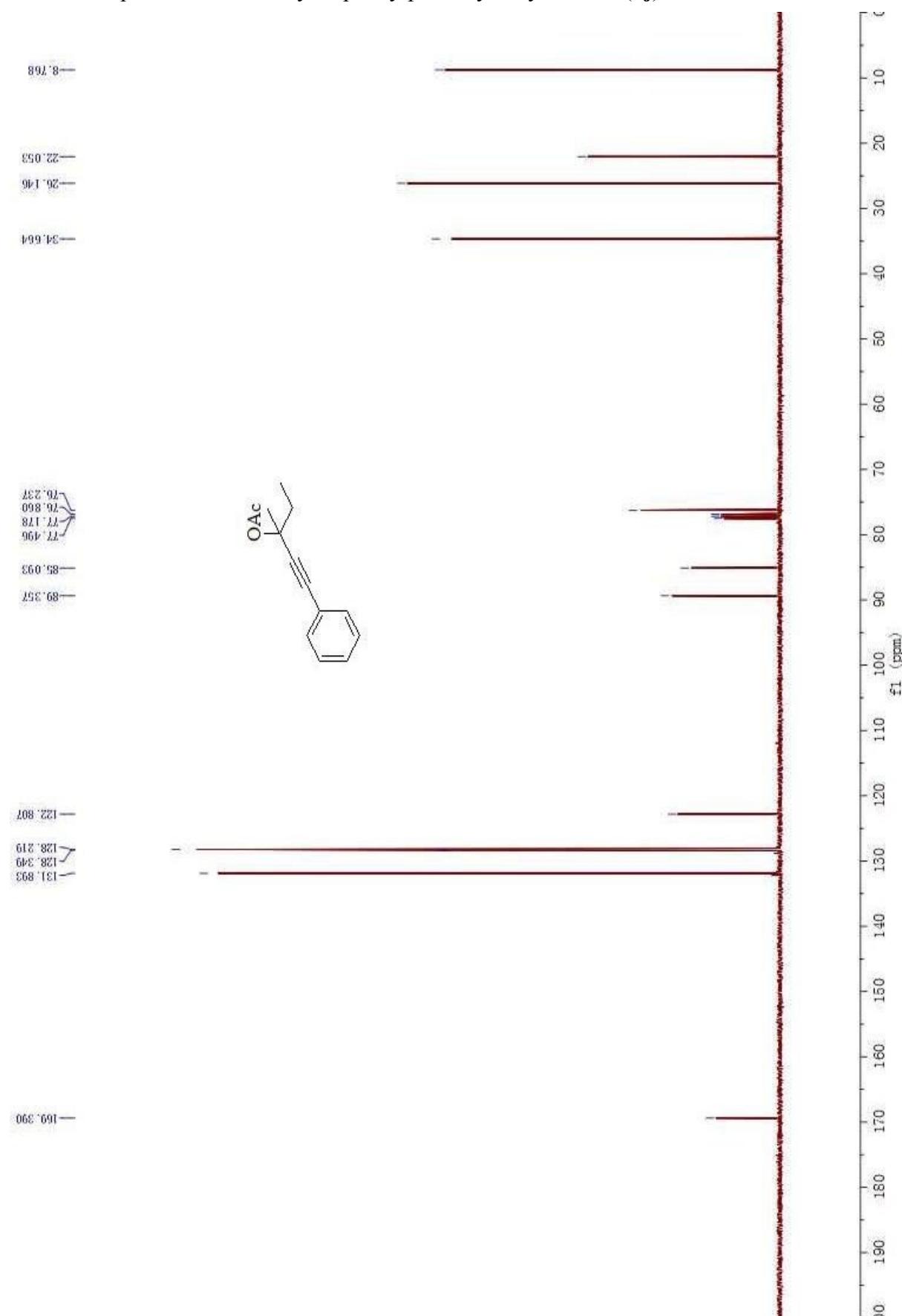
¹³C NMR Spectrum of 2-Methyl-4-thienylbut-3-yn-2-yl acetate (**4i**)



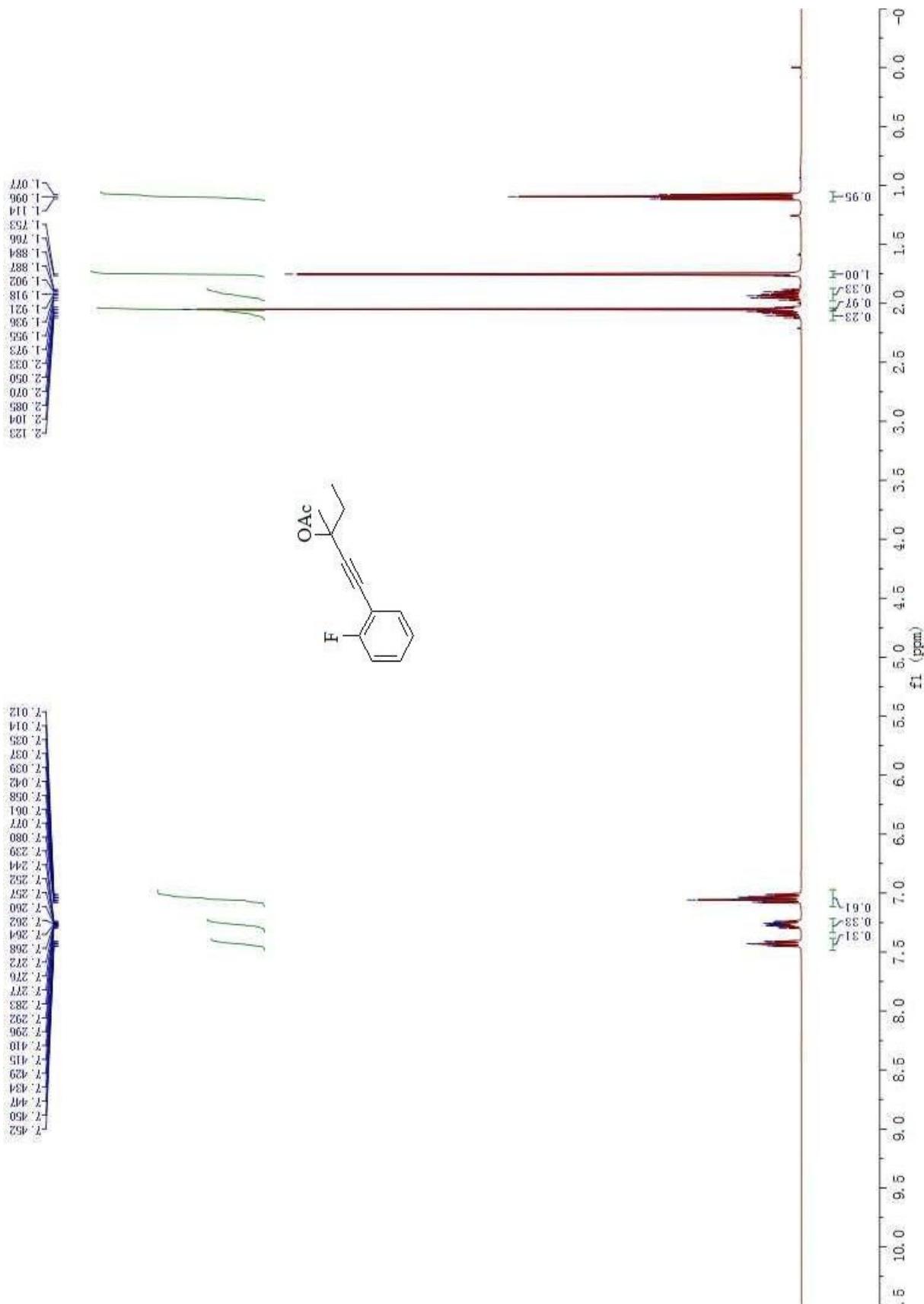
¹H NMR Spectrum of 3-methyl-1-phenylpent-1-yn-3-yl acetate (**4j**)



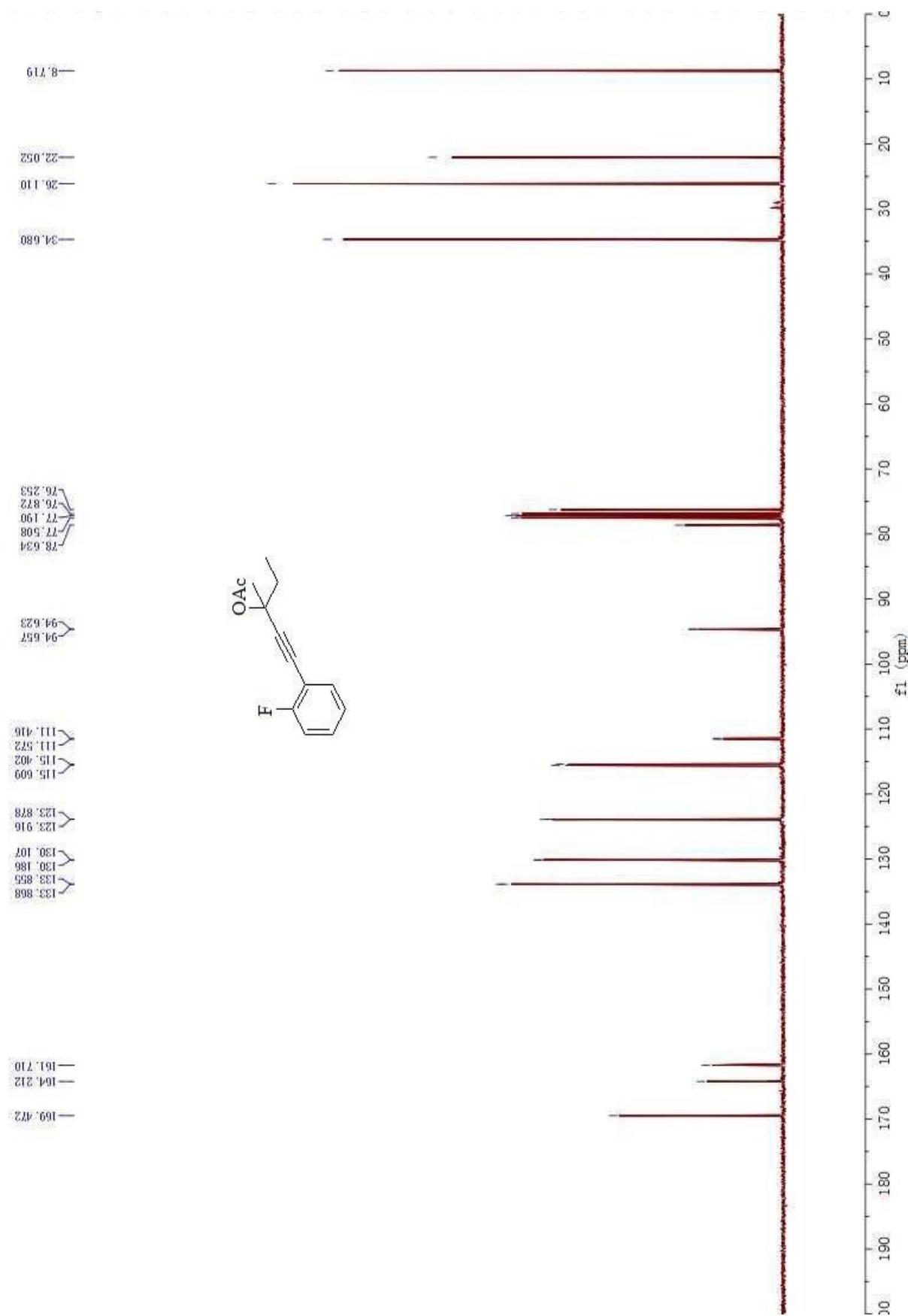
^{13}C NMR Spectrum of 3-methyl-1-phenylpent-1-yn-3-yl acetate (**4j**)



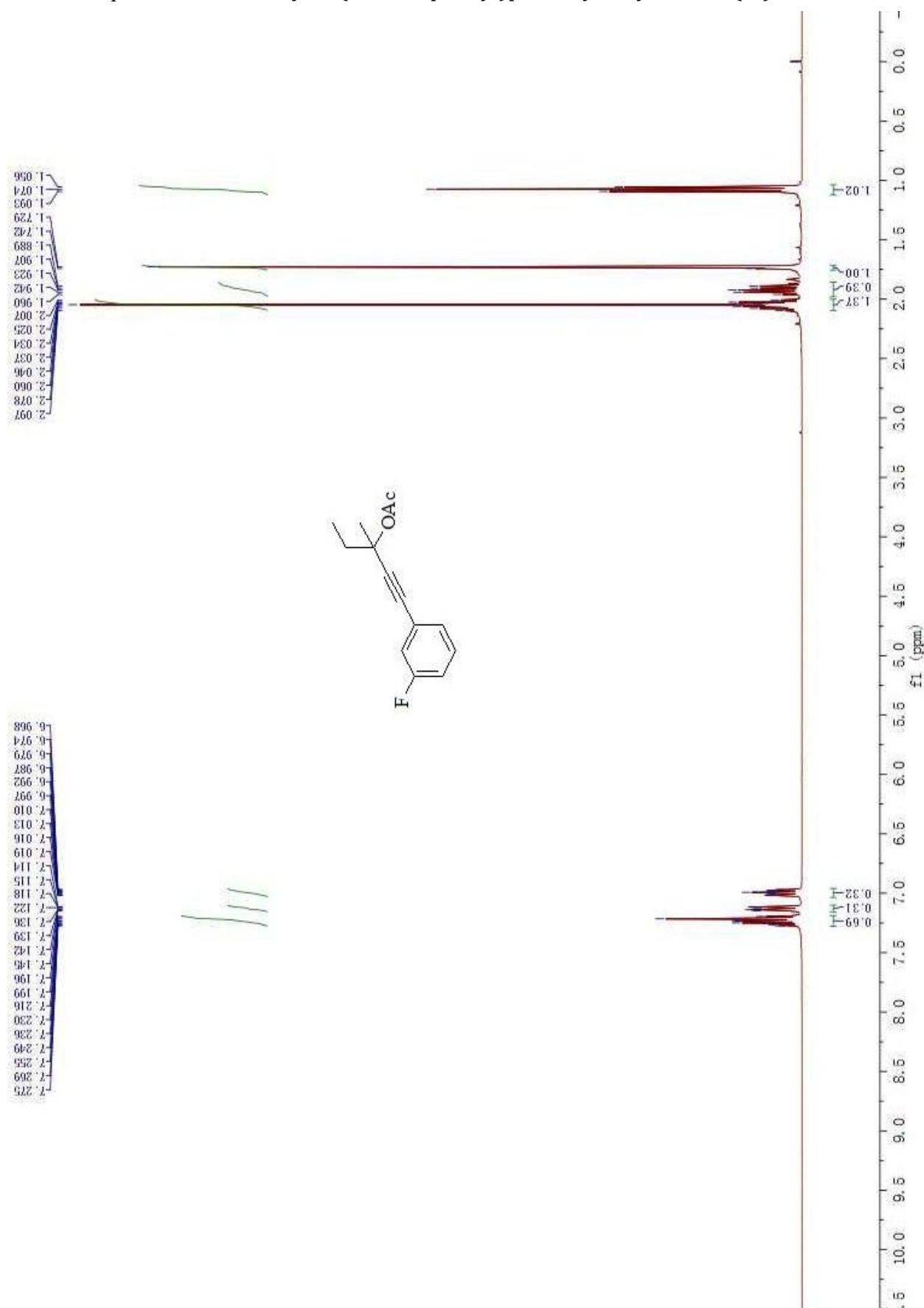
¹H NMR Spectrum of 3-methyl-1-(2-fluorophenyl)pent-1-yn-3-yl acetate (**4k**):



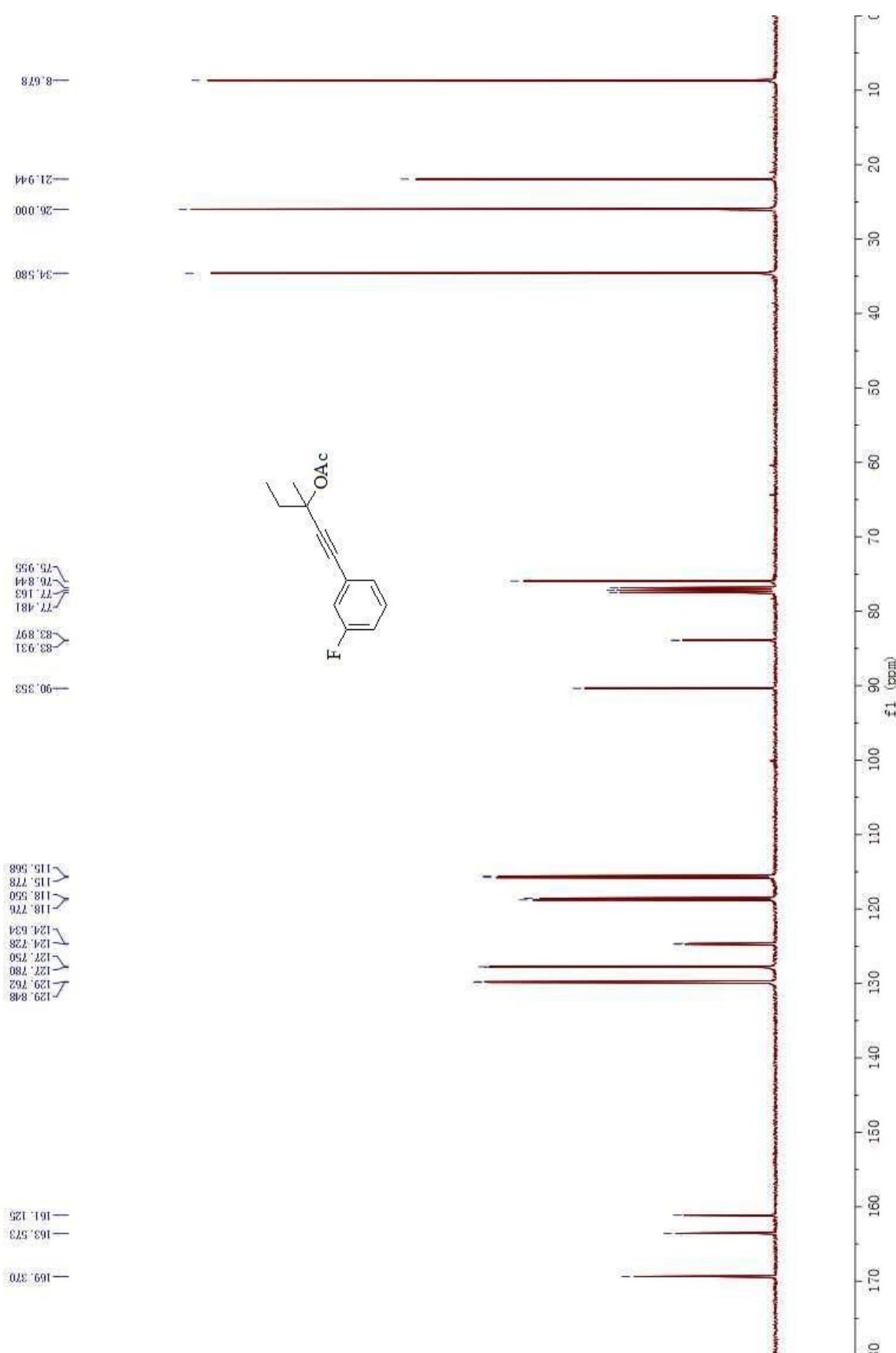
¹³C NMR Spectrum of 3-methyl-1-(2-fluorophenyl)pent-1-yn-3-yl acetate (**4k**)



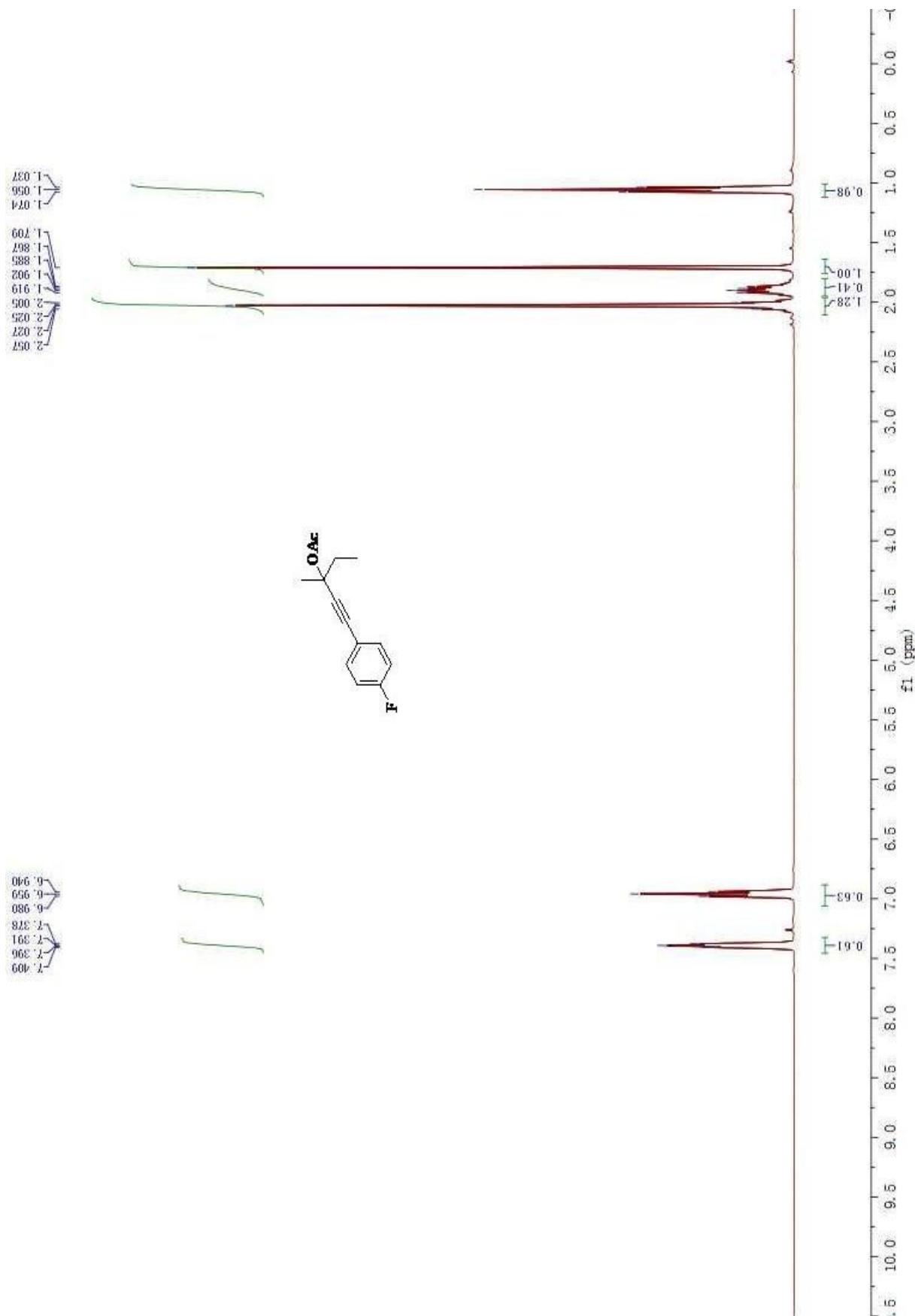
¹H NMR Spectrum of 3-methyl-1-(3-fluorophenyl)pent-1-yn-3-yl acetate(**4l**)



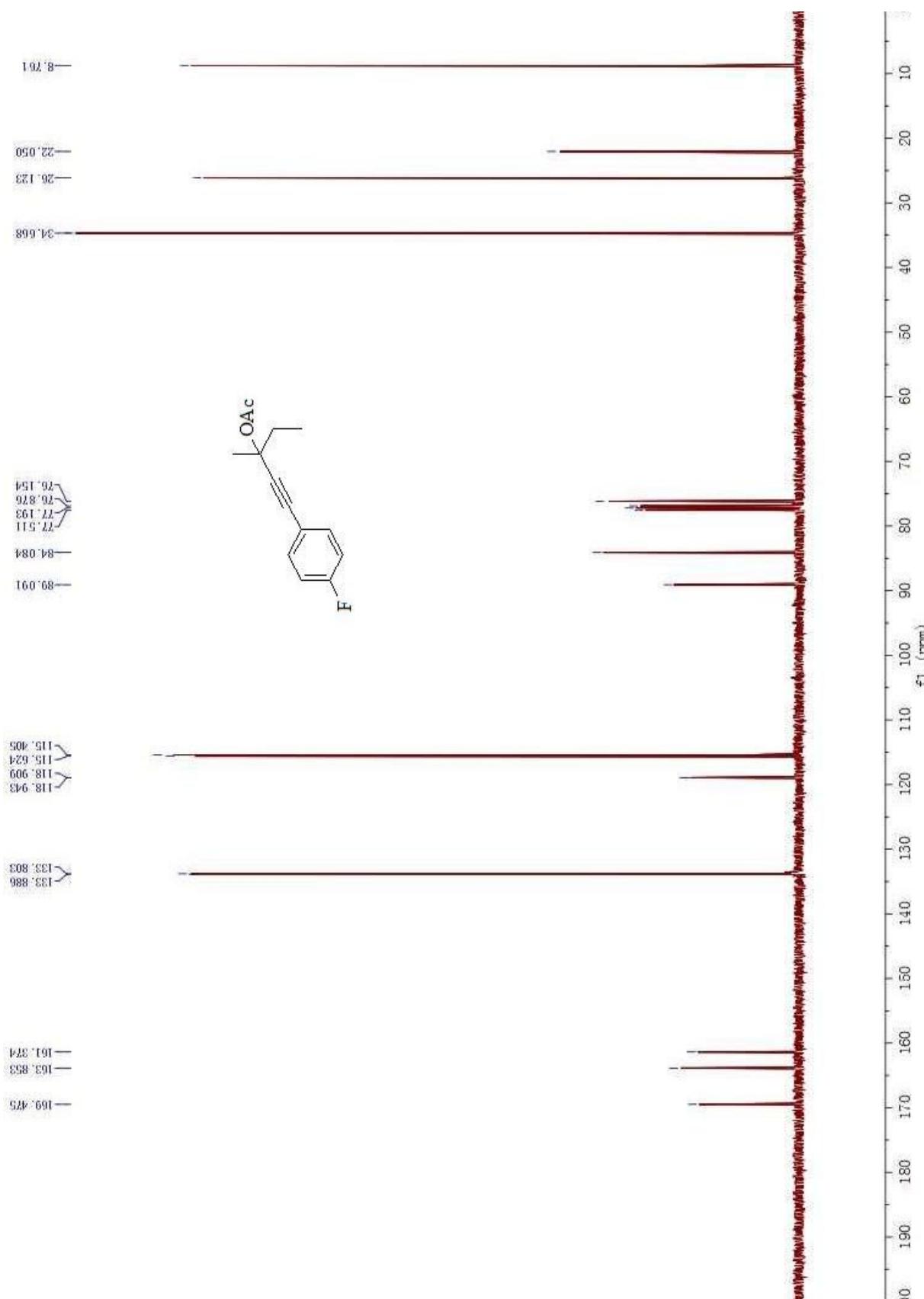
¹³C NMR Spectrum of 3-methyl-1-(3-fluorophenyl)pent-1-yn-3-yl acetate(**4l**)



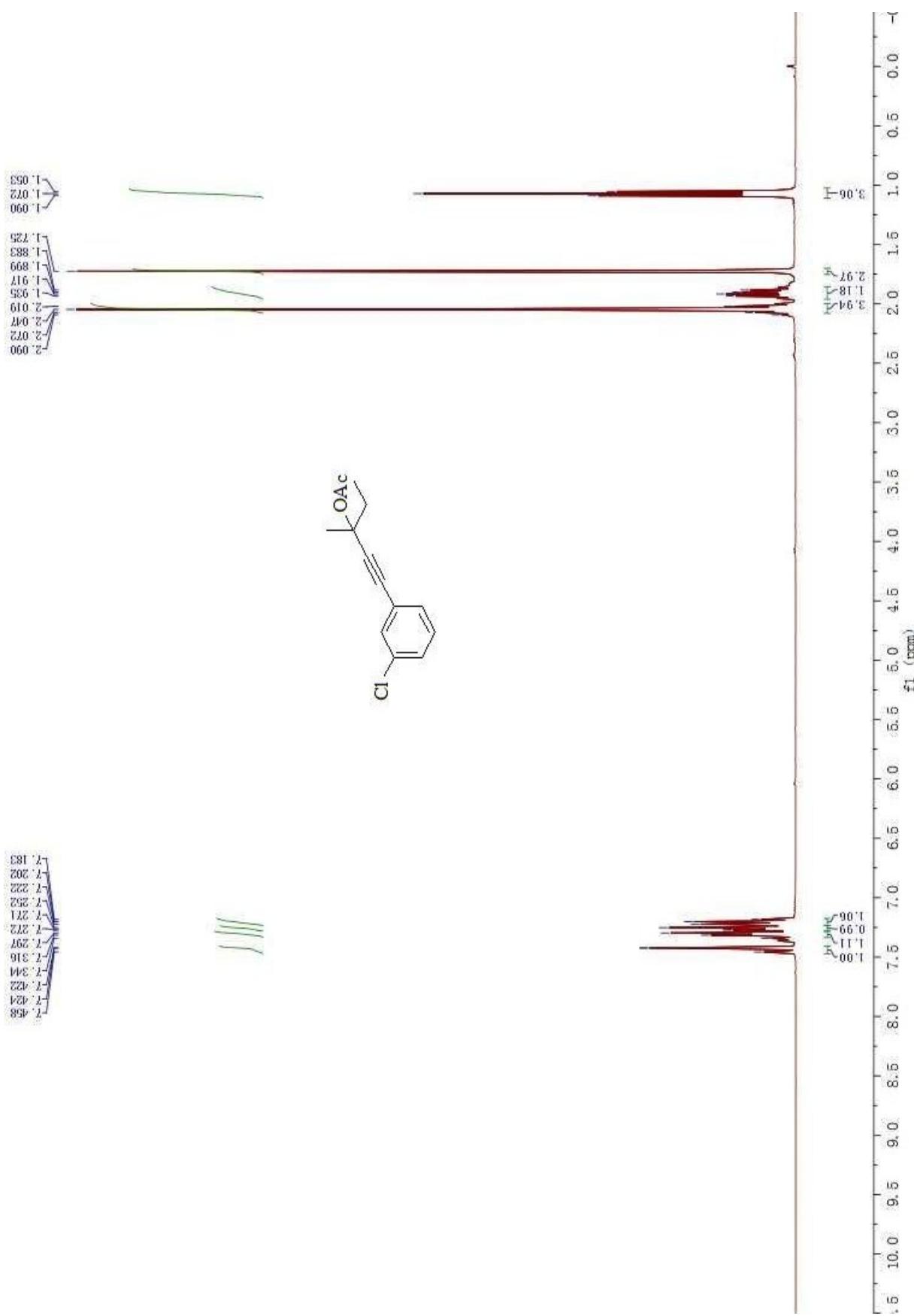
¹H NMR Spectrum of 3-methyl-1-(4-fluorophenyl)pent-1-yn-3-yl acetate (**4m**):



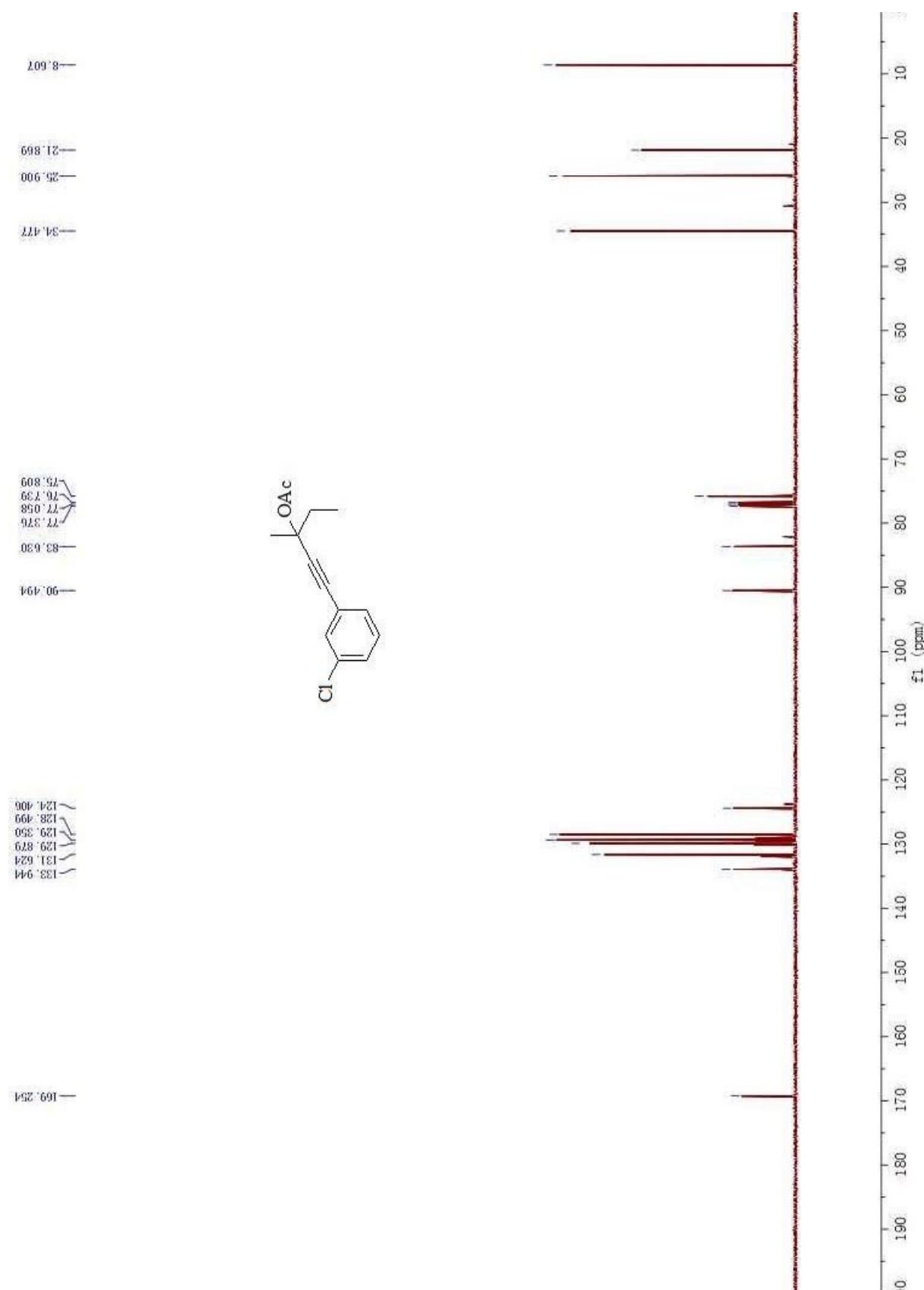
¹³C NMR Spectrum of 3-methyl-1-(4-fluorophenyl)pent-1-yn-3-yl acetate (**4m**):



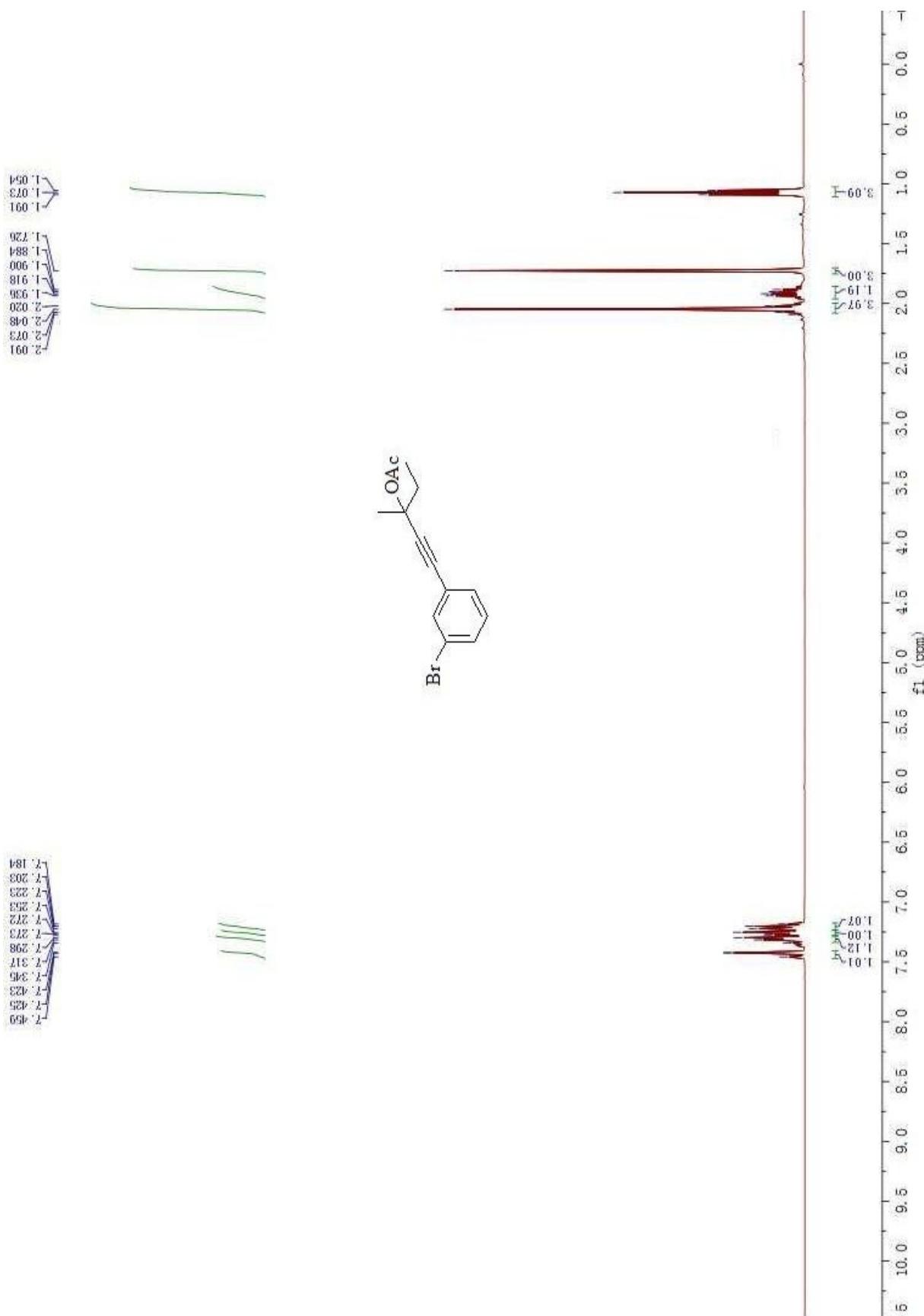
¹H NMR Spectrum of 3-methyl-1-(3-chlorophenyl)pent-1-yn-3-yl acetate (**4n**):



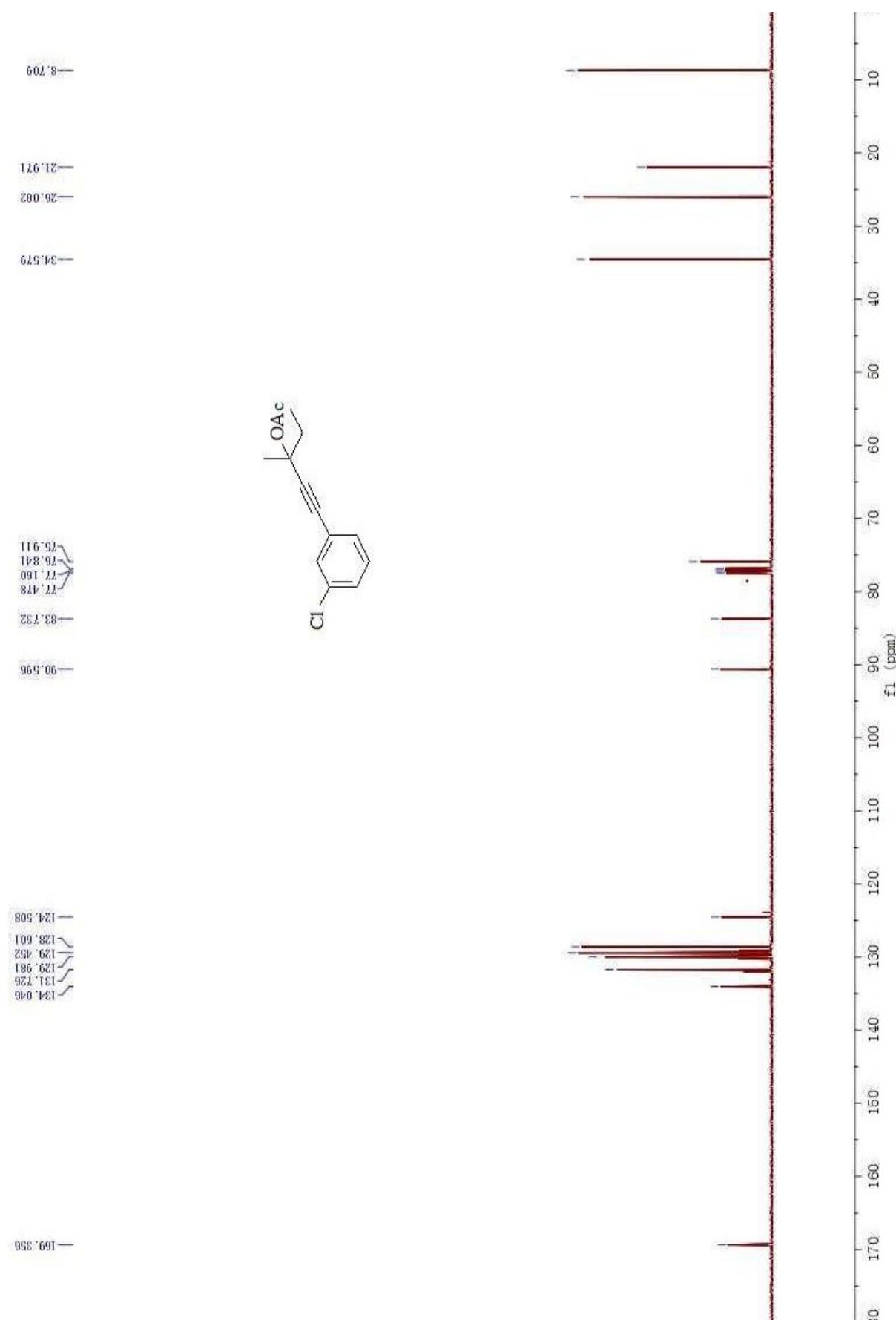
¹³C NMR Spectrum of 3-methyl-1-(3-chlorophenyl)pent-1-yn-3-yl acetate (**4n**):



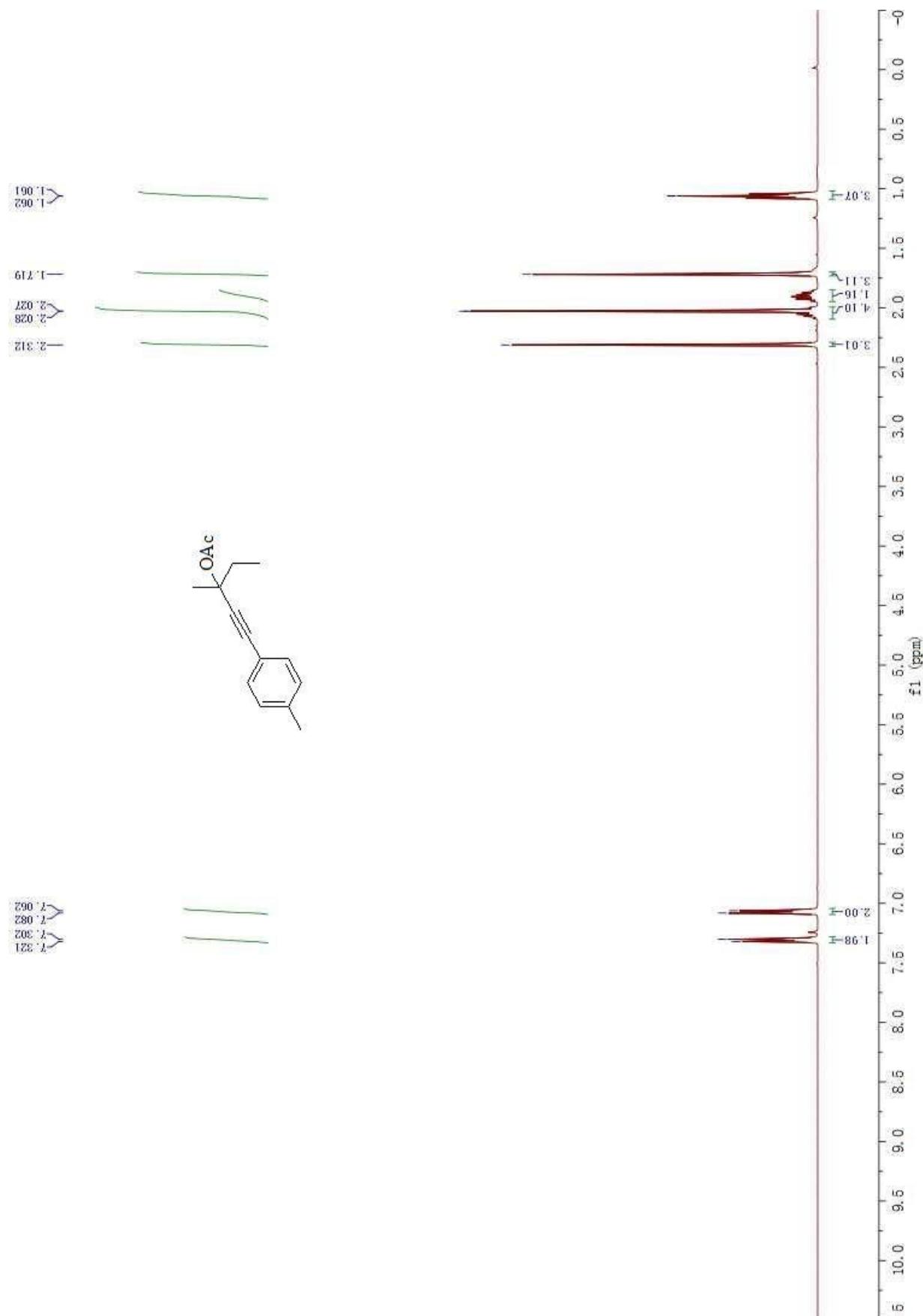
¹H NMR Spectrum of 3-methyl-1-(3-bromophenyl)pent-1-yn-3-yl acetate (**4o**):



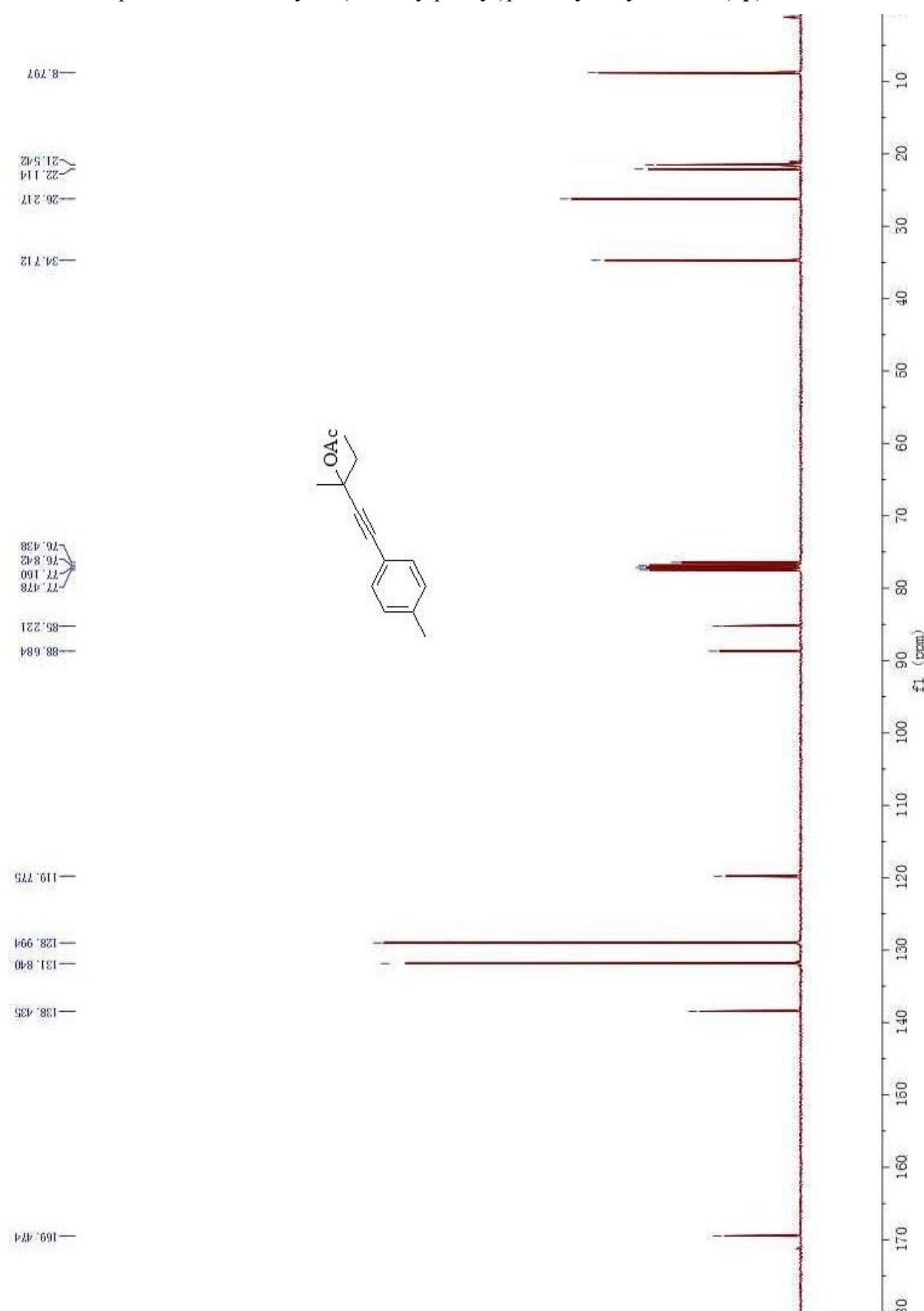
¹³C NMR Spectrum of 3-methyl-1-(3-bromophenyl)pent-1-yn-3-yl acetate (**4o**):



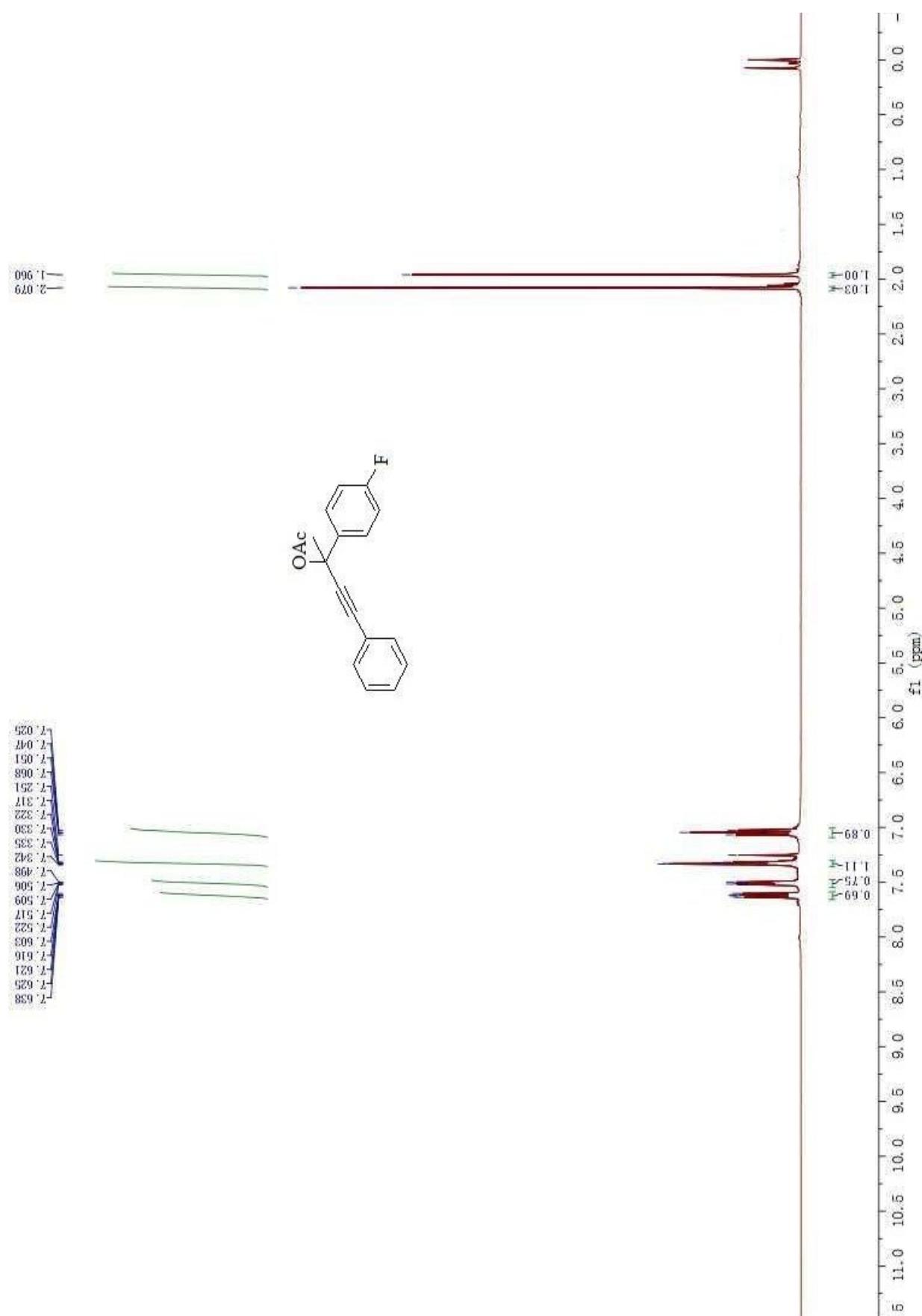
¹H NMR Spectrum of 3-methyl-1-(4-methylphenyl)pent-1-yn-3-yl acetate (**4p**):



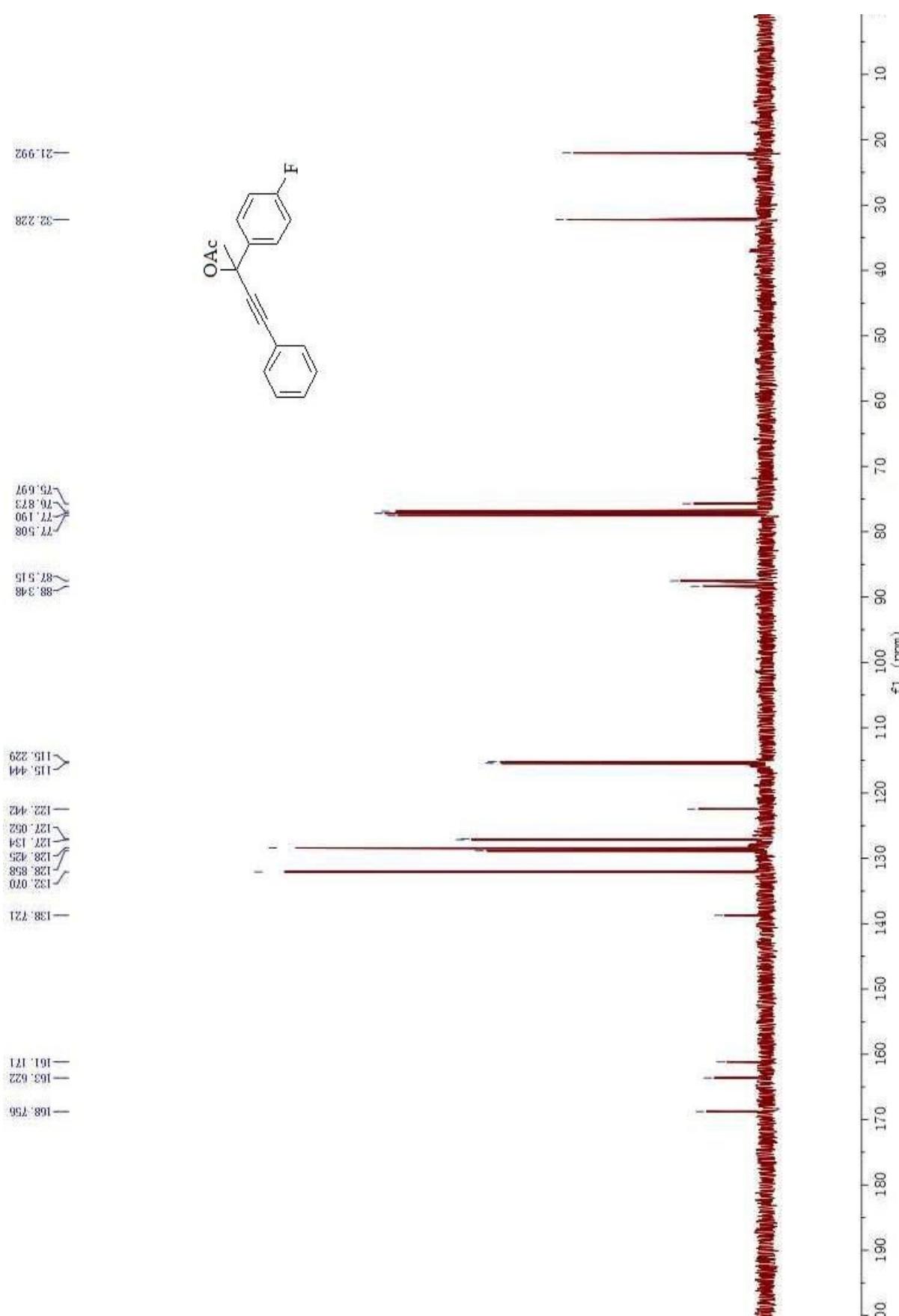
¹³C NMR Spectrum of 3-methyl-1-(4-methylphenyl)pent-1-yn-3-yl acetate (**4p**):



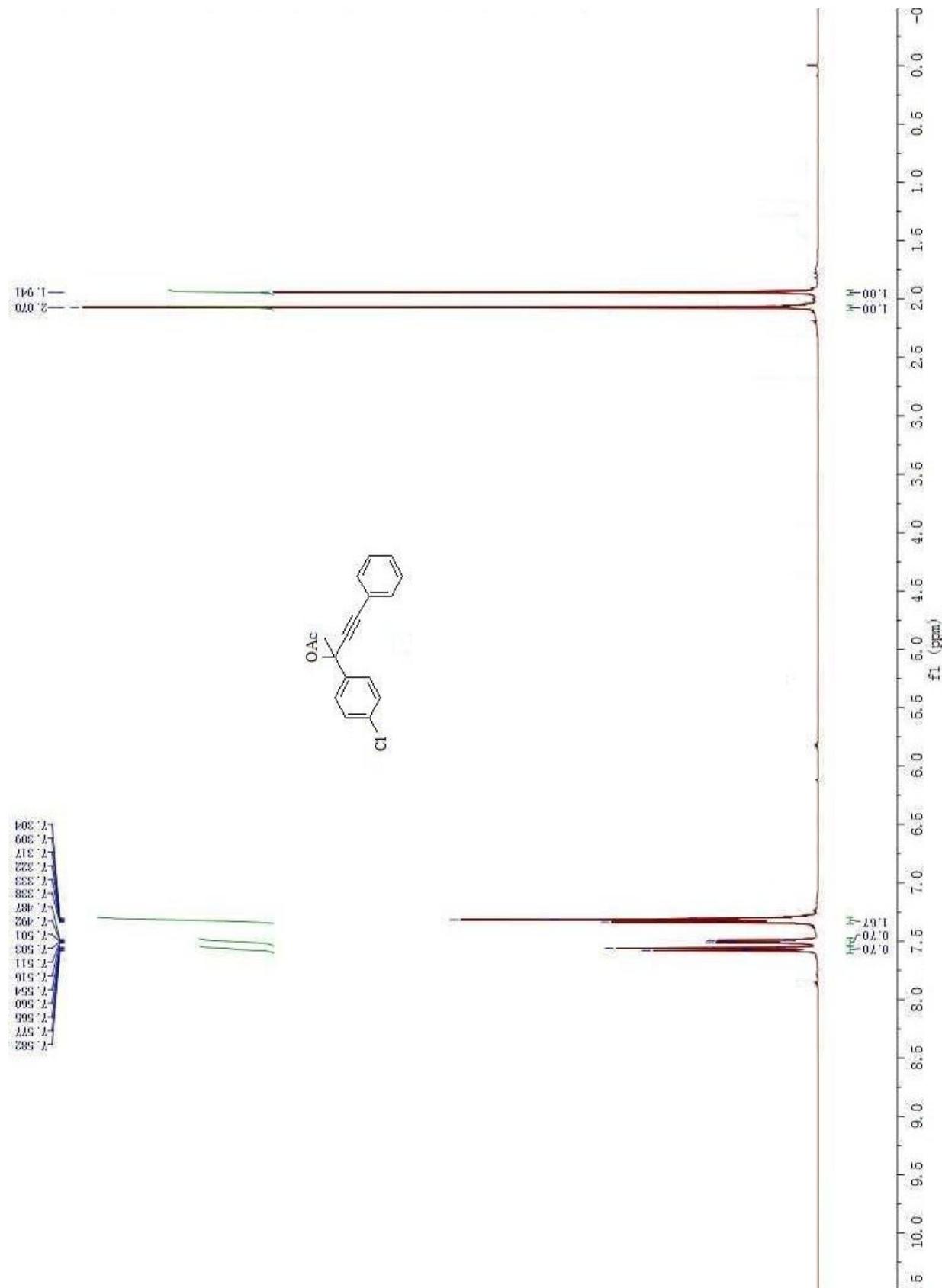
¹H NMR Spectrum of 4-(4-fluorophenyl)-2-phenylbut-3-yn-2-yl acetate(**4q**):



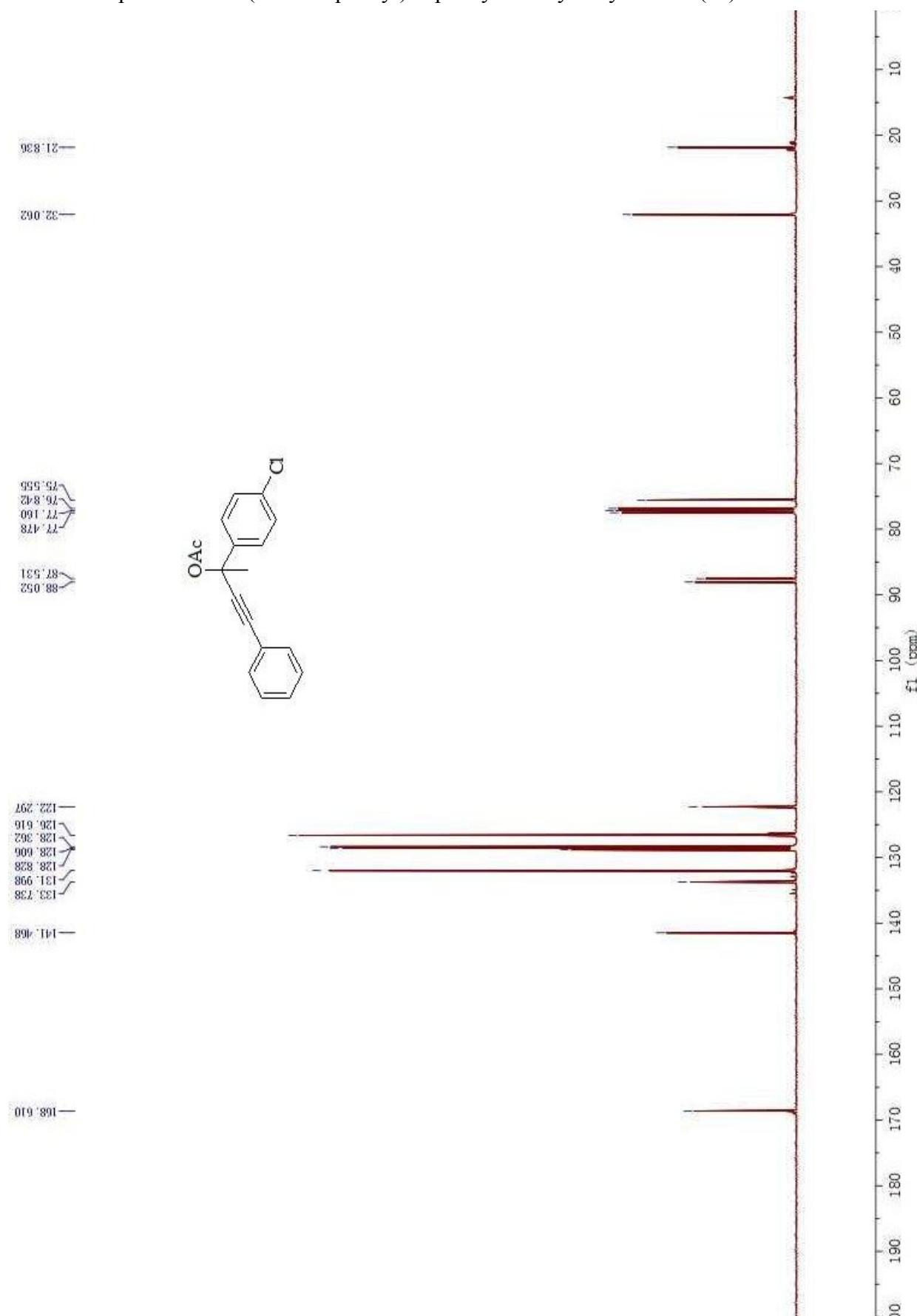
¹³C NMR Spectrum of 4-(4-fluorophenyl)-2-phenylbut-3-yn-2-yl acetate(**4q**):



¹H NMR Spectrum of 4-(4-chlorophenyl)-2-phenylbut-3-yn-2-yl acetate(**4r**):

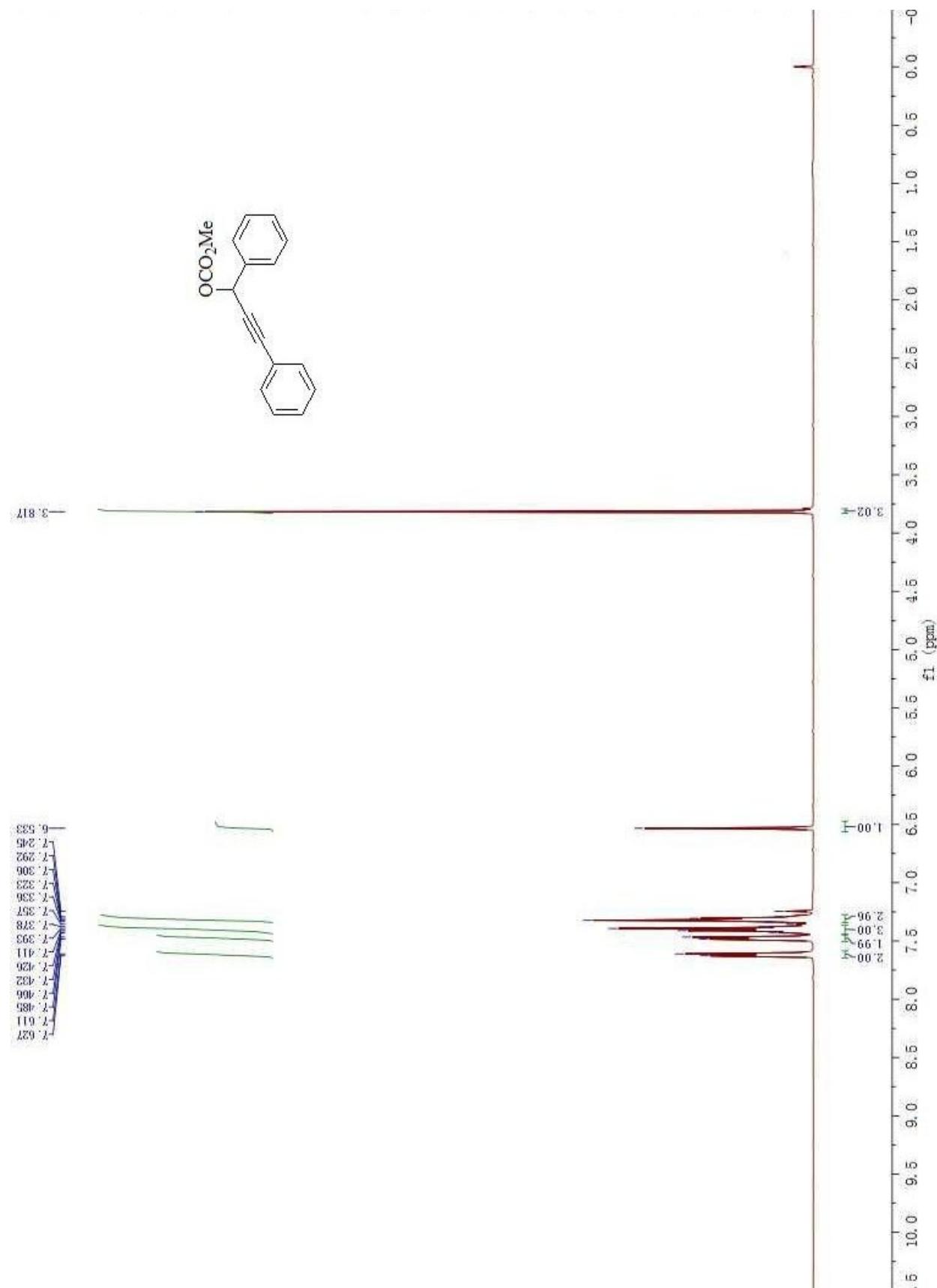


¹³C NMR Spectrum of 4-(4-chlorophenyl)-2-phenylbut-3-yn-2-yl acetate(**4r**):

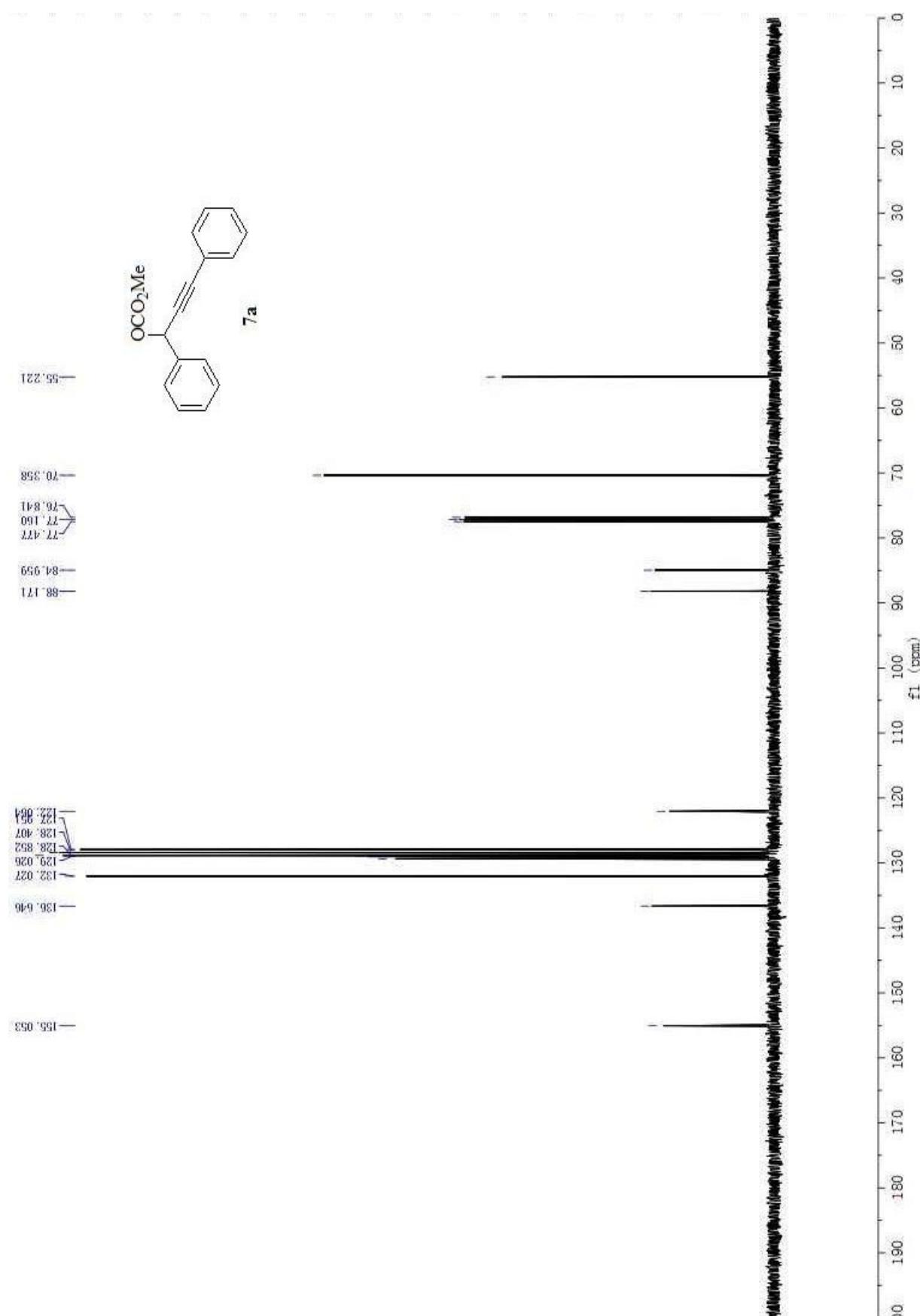


II. ^1H and ^{13}C NMR Spectra of Propargyl carbonate 7(a,b).

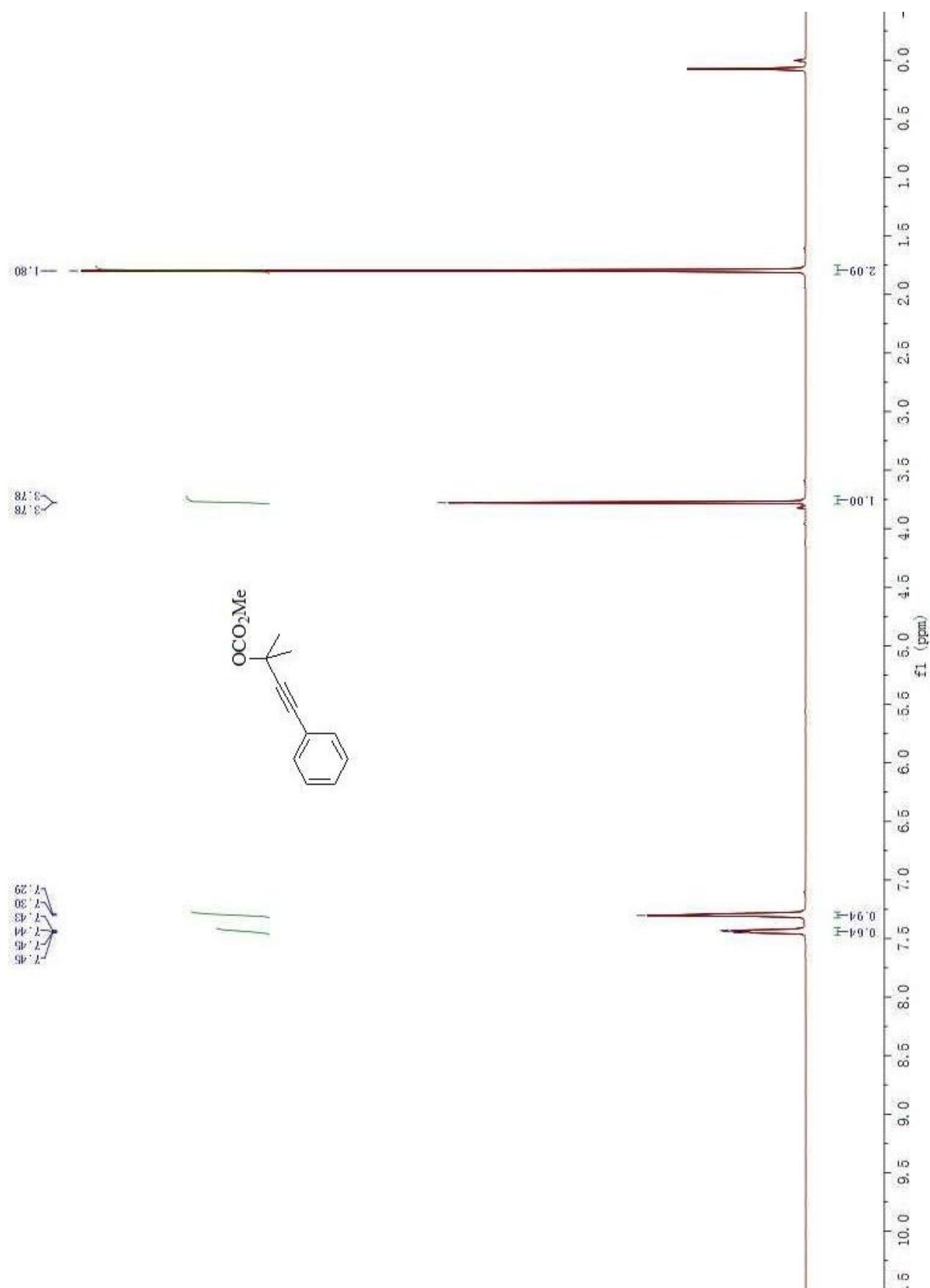
¹H NMR Spectrum of 1,3-Diphenylprop-2-ynyl methyl carbonate (**7a**)



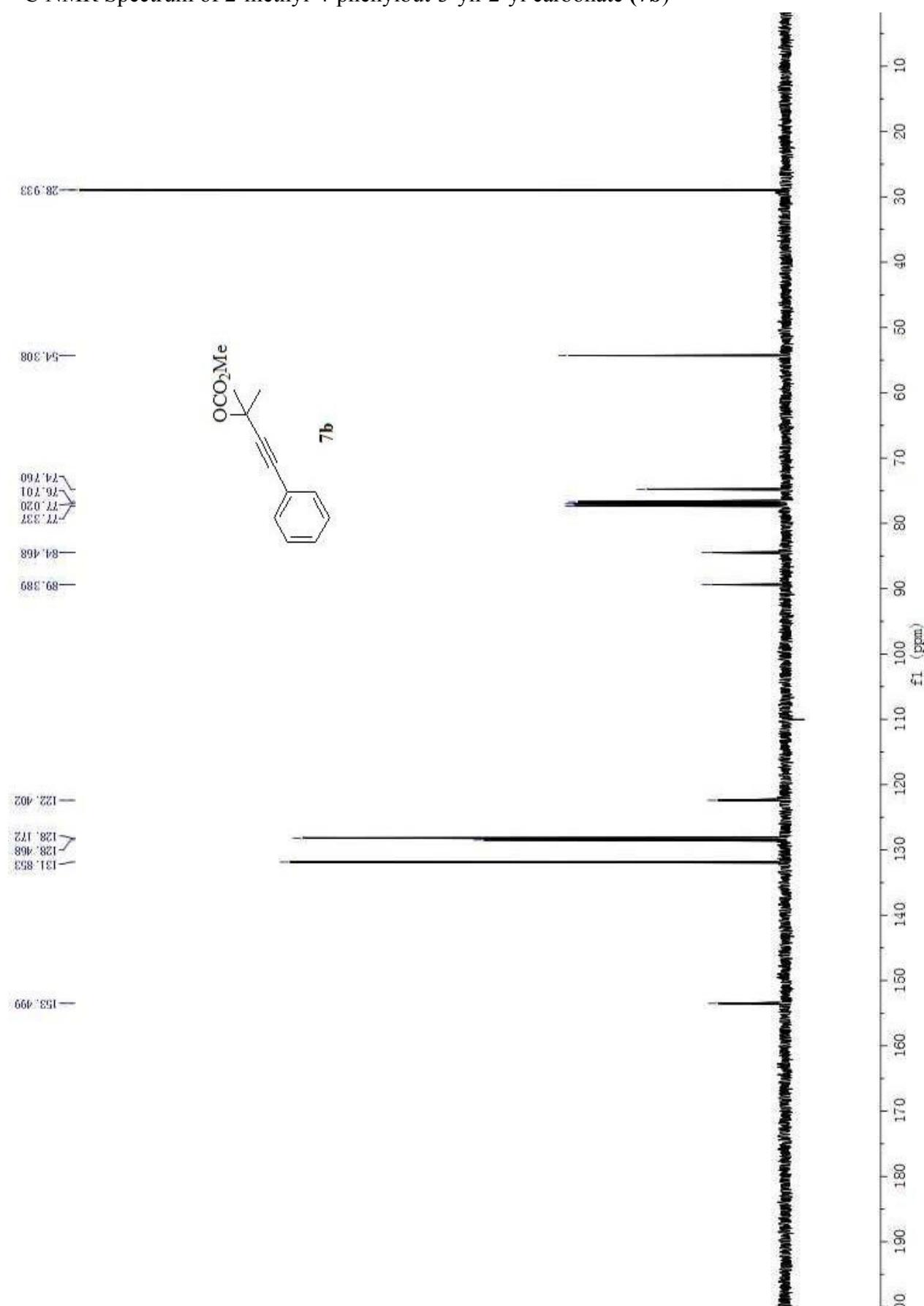
¹³C NMR Spectrum of 1,3-Diphenylprop-2-ynyl methyl carbonate (**7a**)



¹H NMR Spectrum of 2-methyl-4-phenylbut-3-yn-2-yl carbonate (**7b**)

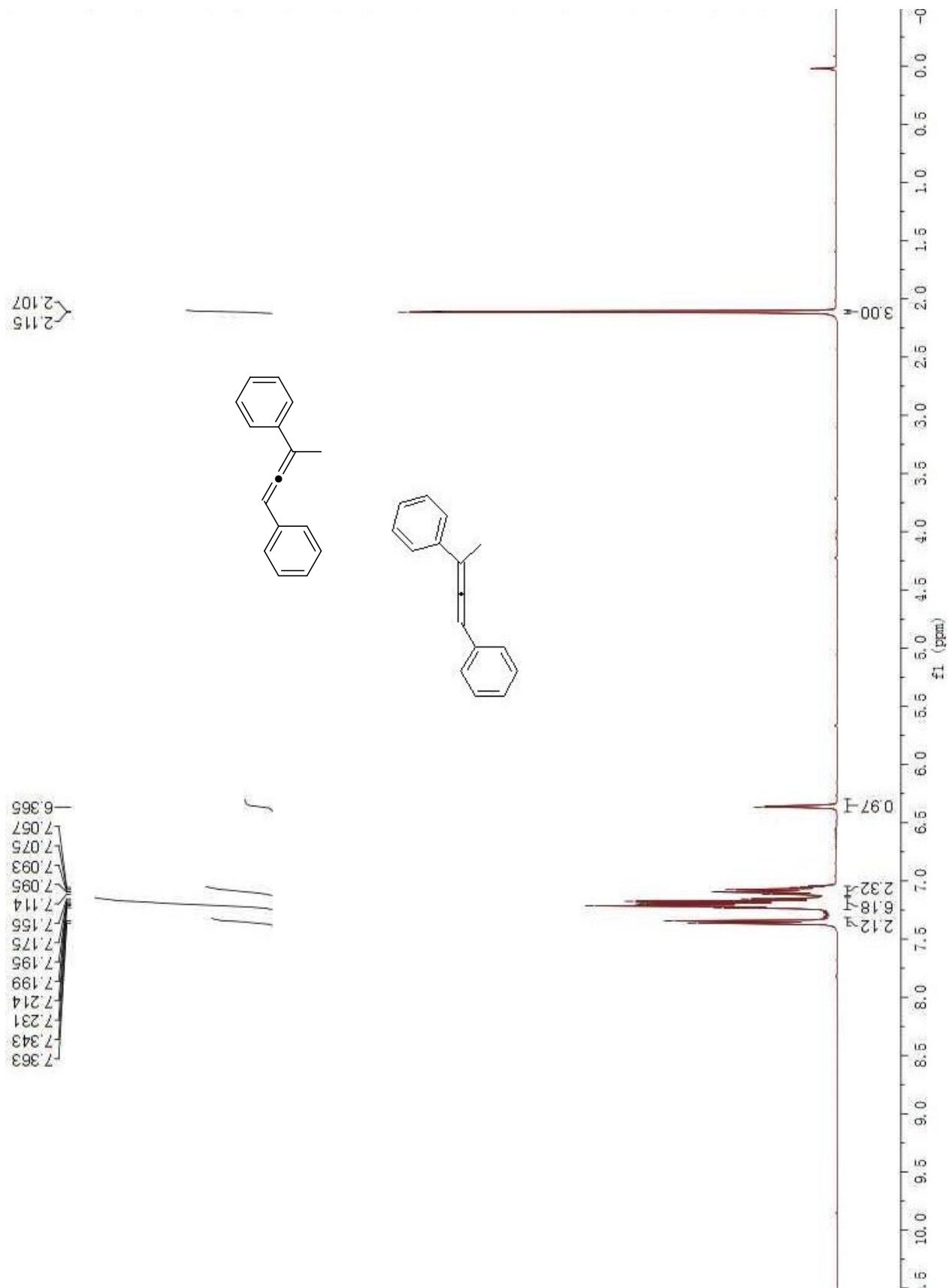


¹³C NMR Spectrum of 2-methyl-4-phenylbut-3-yn-2-yl carbonate (**7b**)

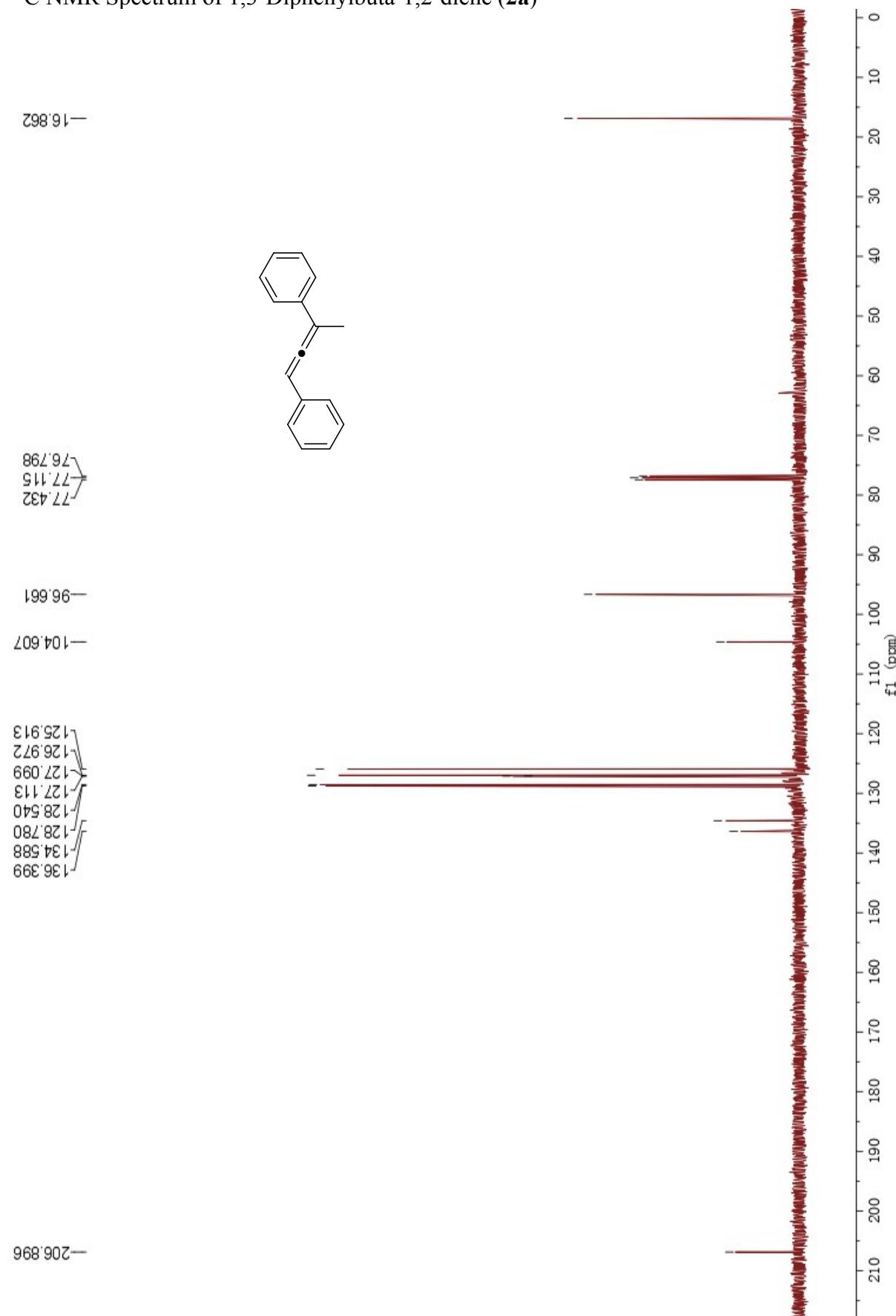


III. ^1H and ^{13}C NMR Spectra of Coupling Products

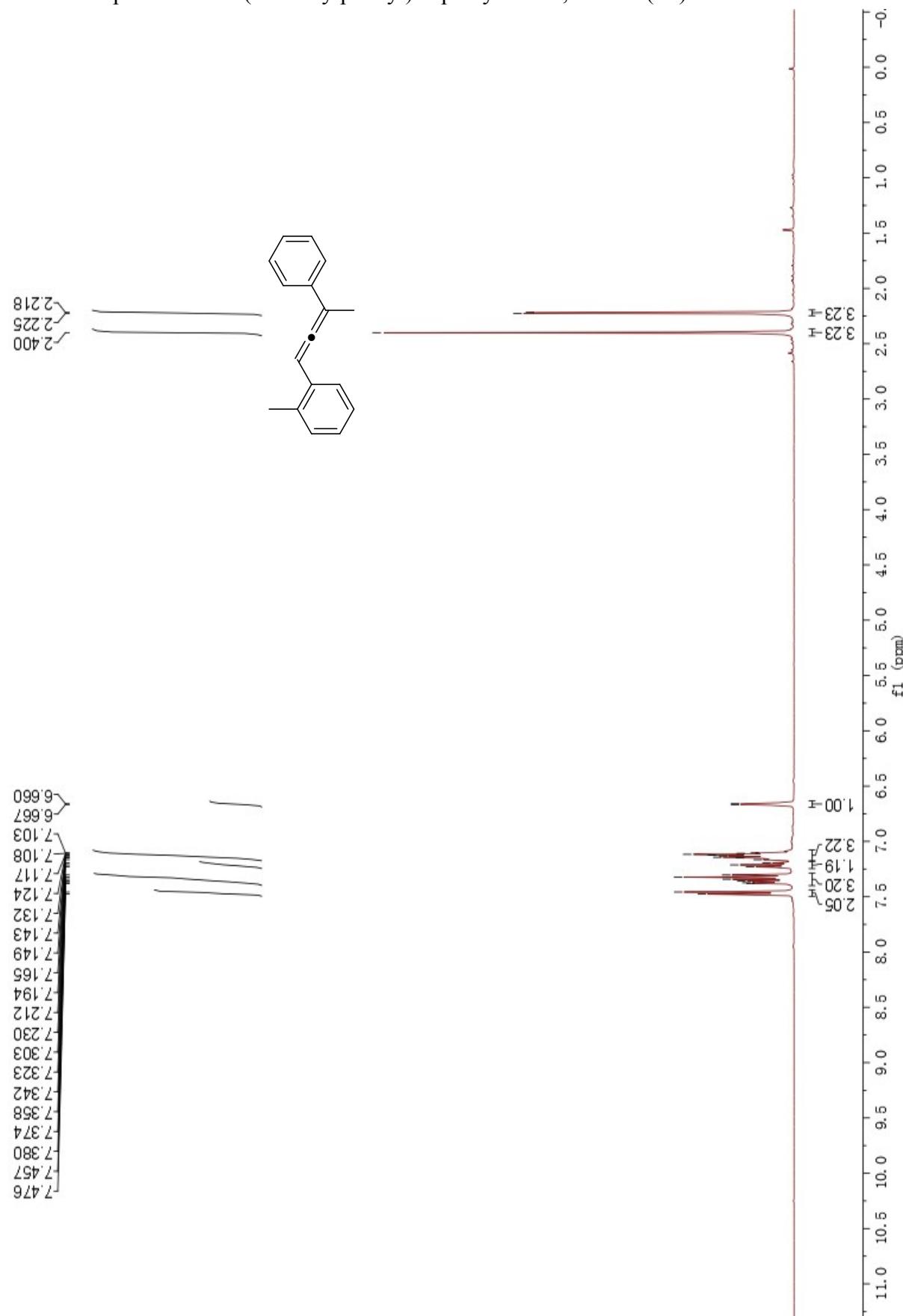
^1H NMR Spectrum of 1,3-Diphenylbuta-1,2-diene (**2a**)



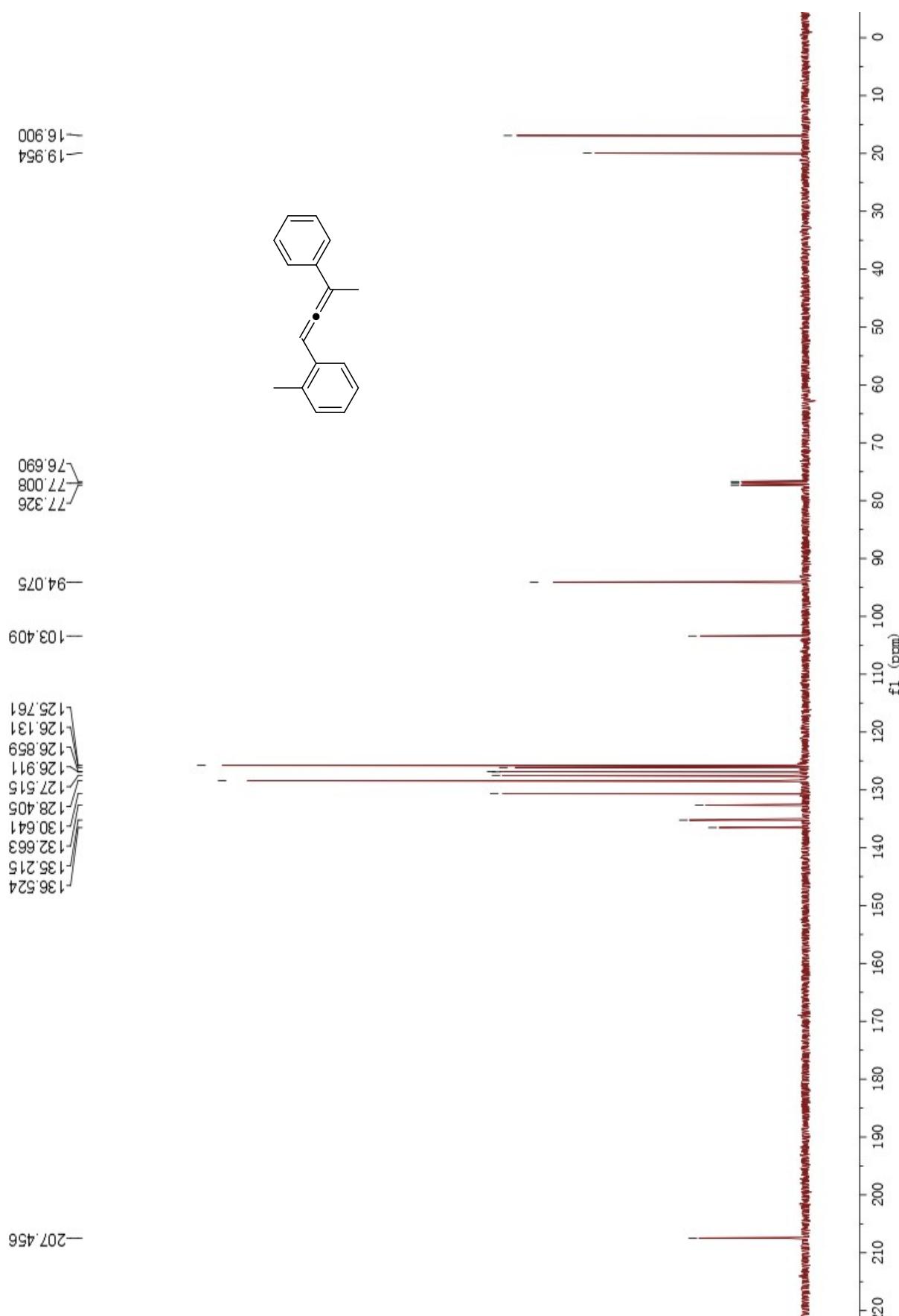
^{13}C NMR Spectrum of 1,3-Diphenylbuta-1,2-diene (**2a**)



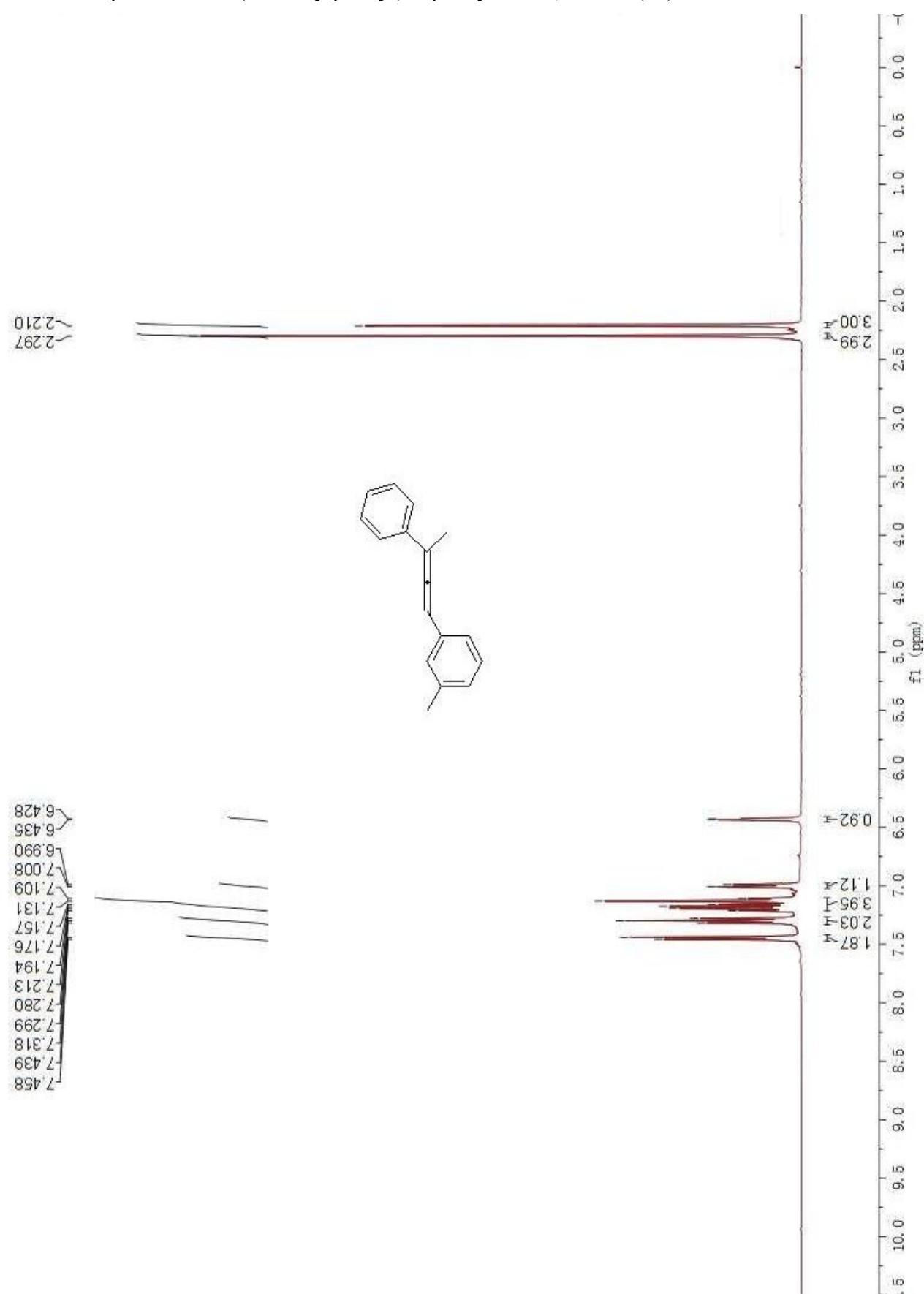
¹H NMR Spectrum of 1-(2-Methylphenyl)-3-pethylbuta-1,2-diene (**2b**)



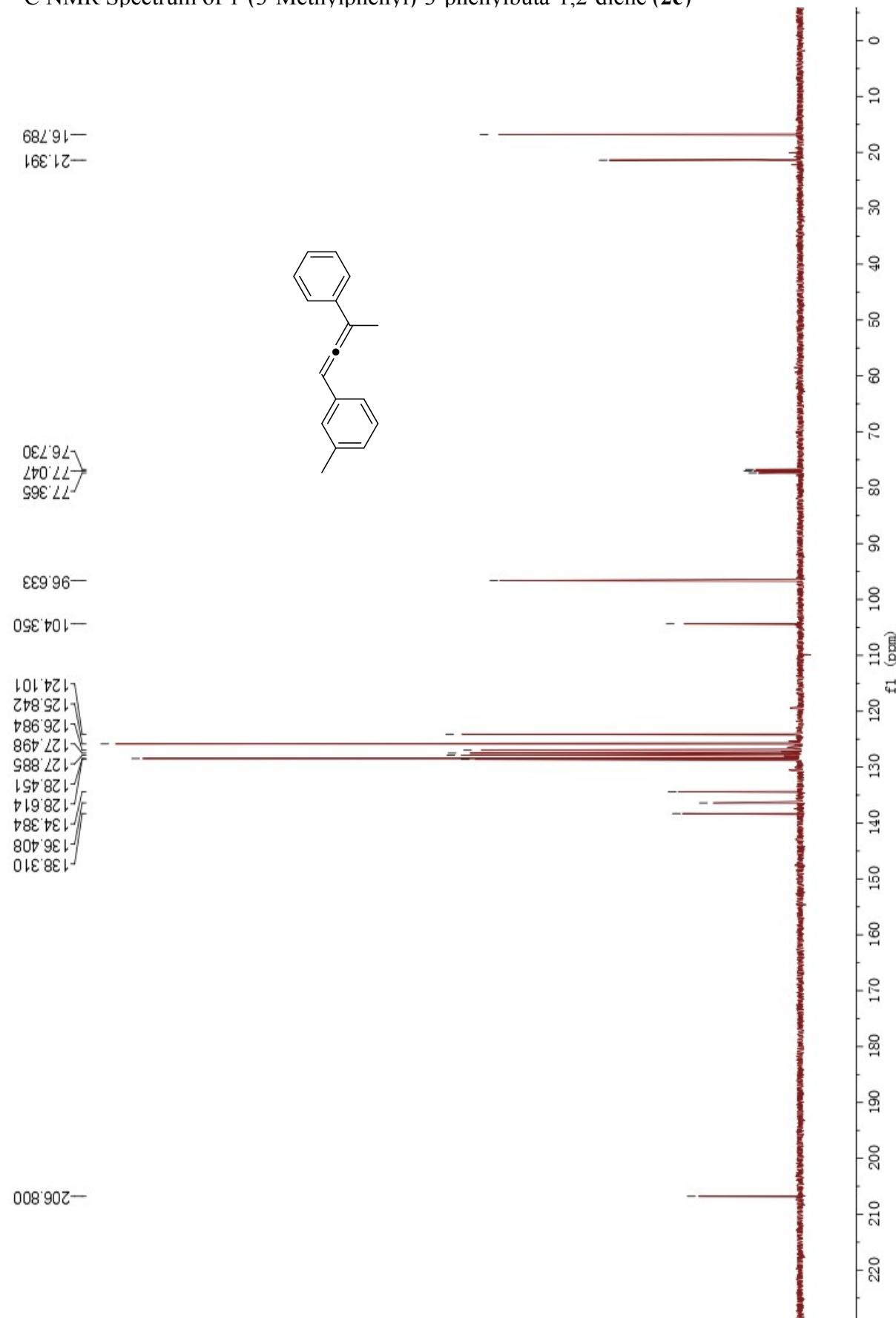
¹³C NMR Spectrum of 1-(2-Methylphenyl)-3-pethylbuta-1,2-diene (**2b**)



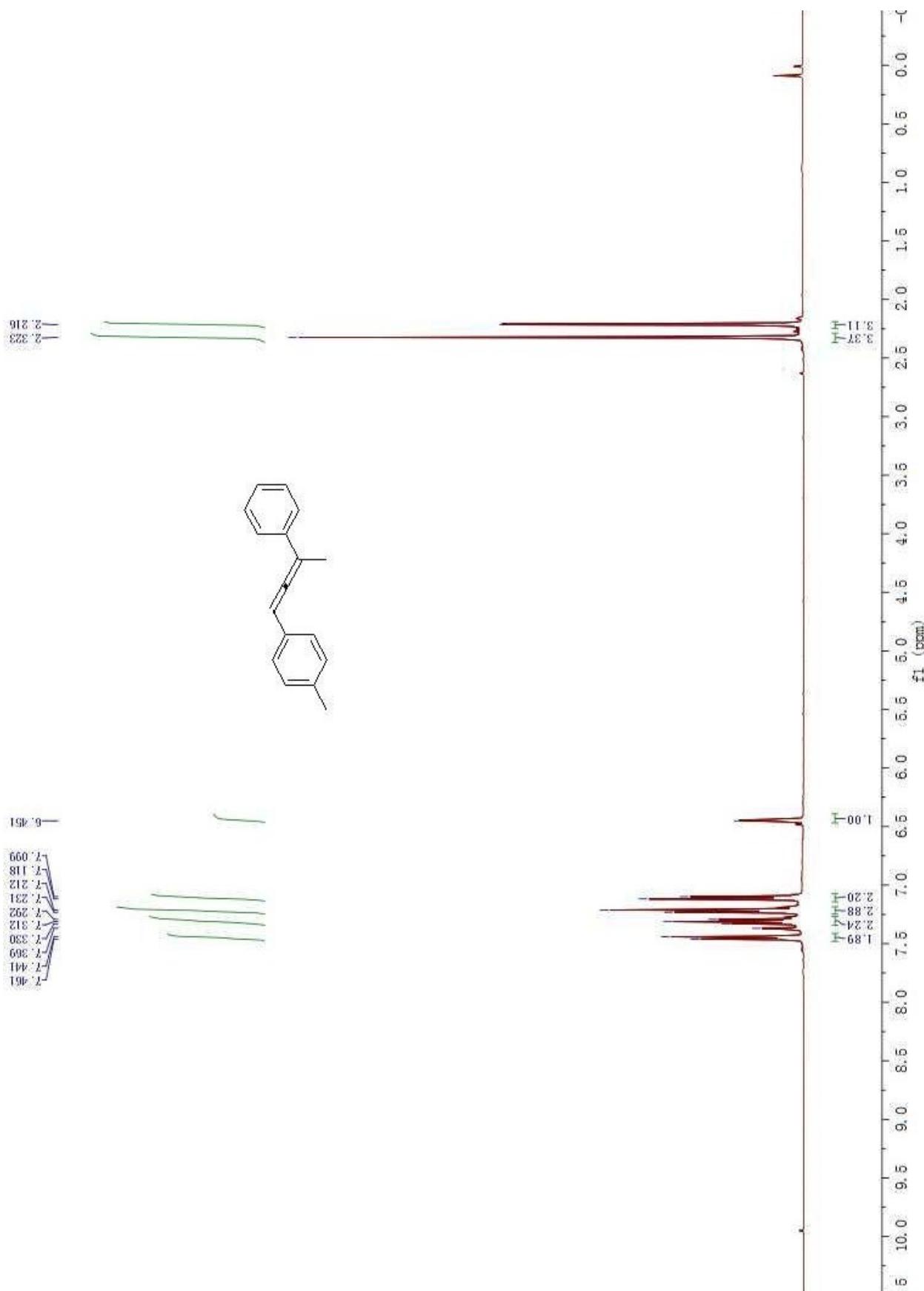
¹H NMR Spectrum of 1-(3-Methylphenyl)-3-phenylbuta-1,2-diene (**2c**)



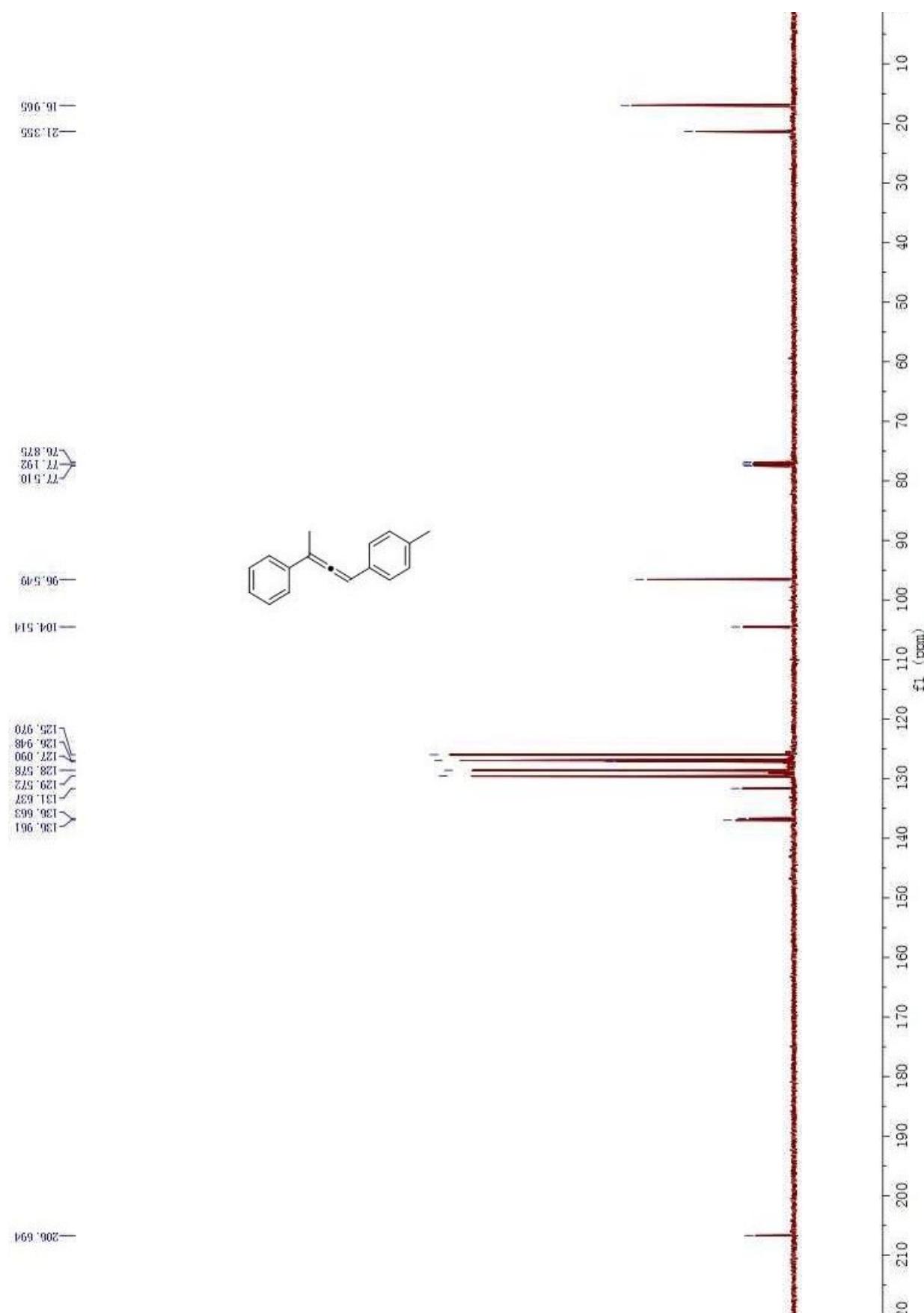
¹³C NMR Spectrum of 1-(3-Methylphenyl)-3-phenylbuta-1,2-diene (**2c**)



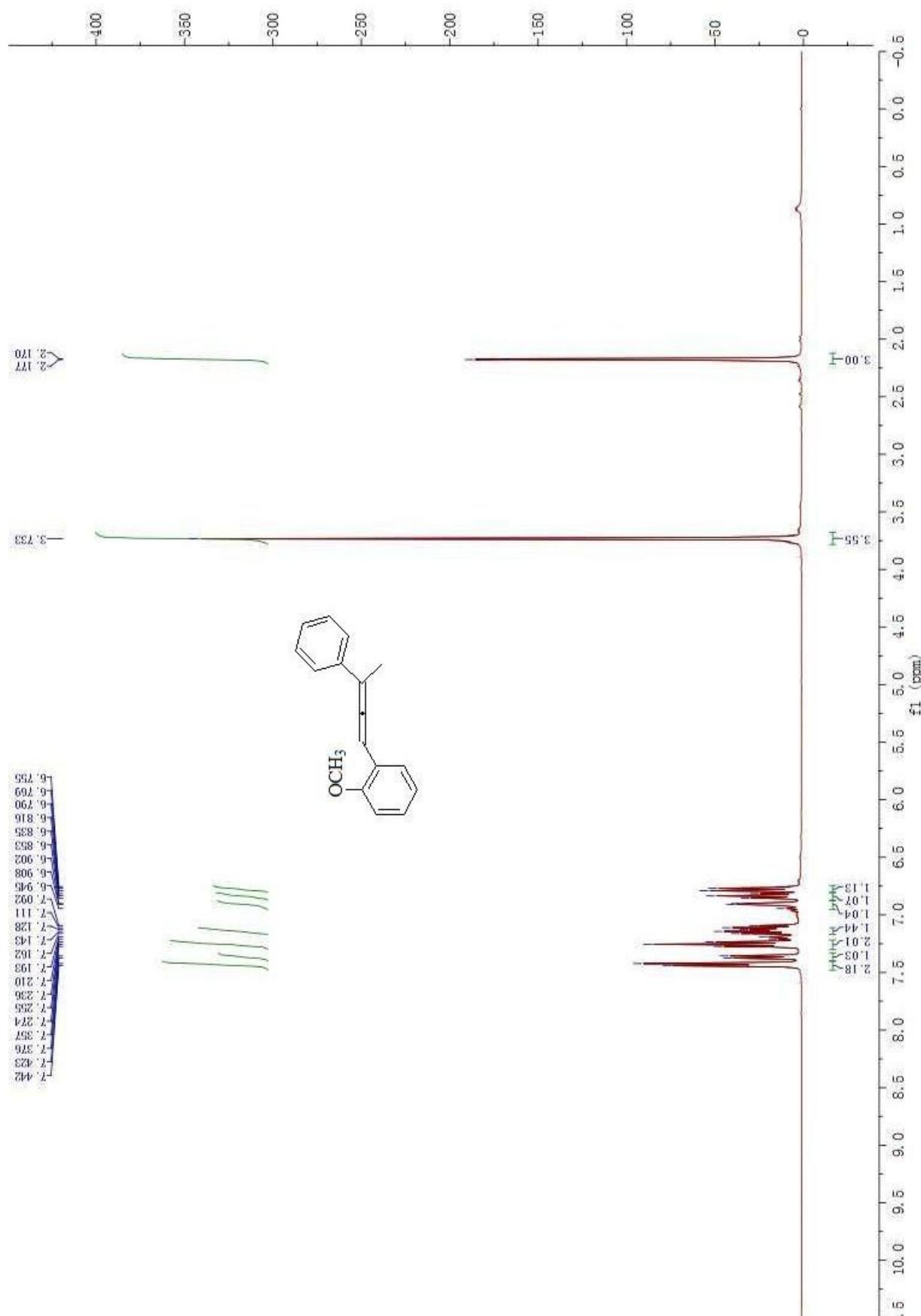
¹H NMR Spectrum of 1-(4-Methylphenyl)-3-phenylbuta-1,2-diene (**2d**)



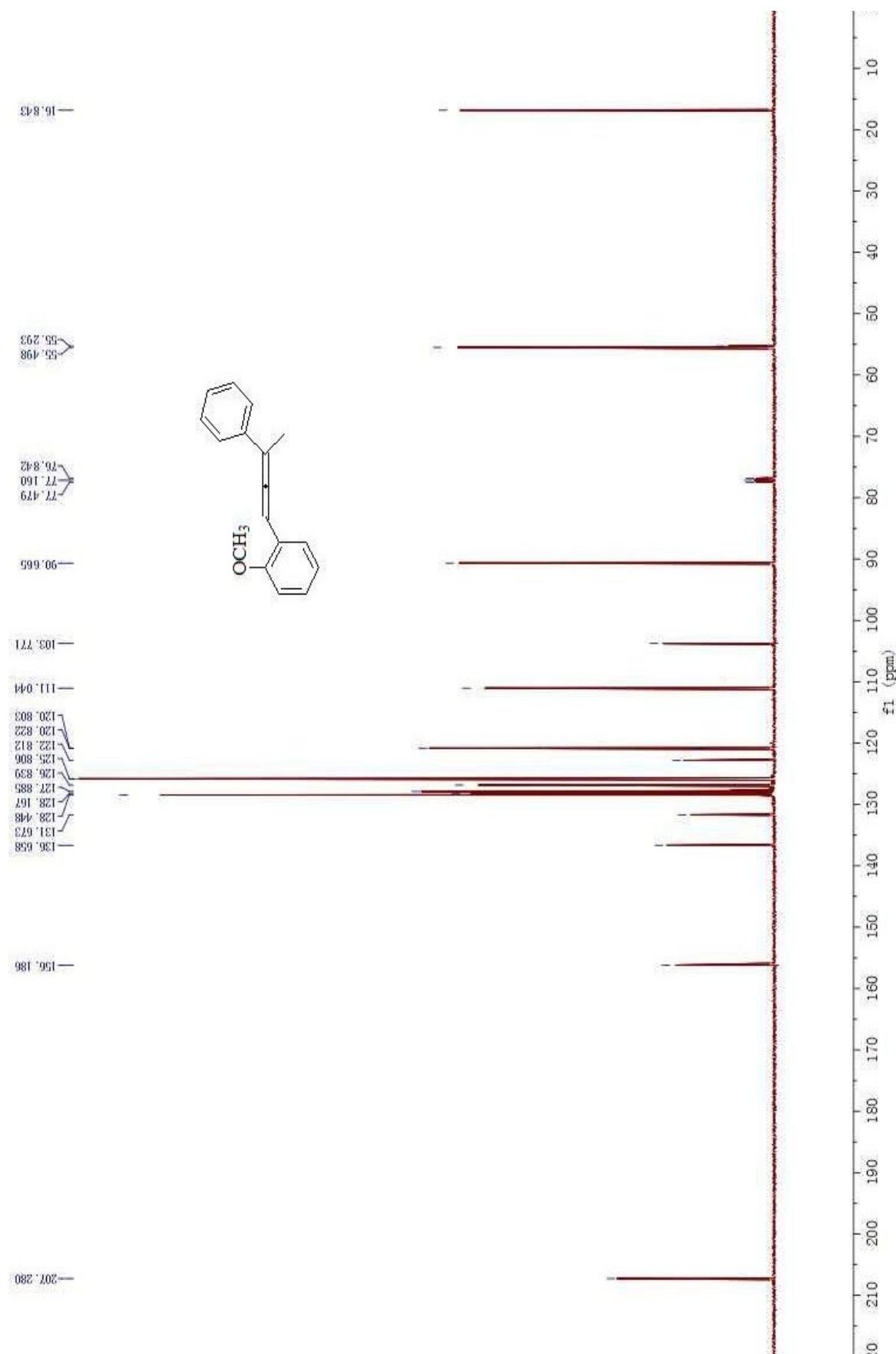
¹³C NMR Spectrum of 1-(4-Methylphenyl)-3-phenylbuta-1,2-diene (**2d**)



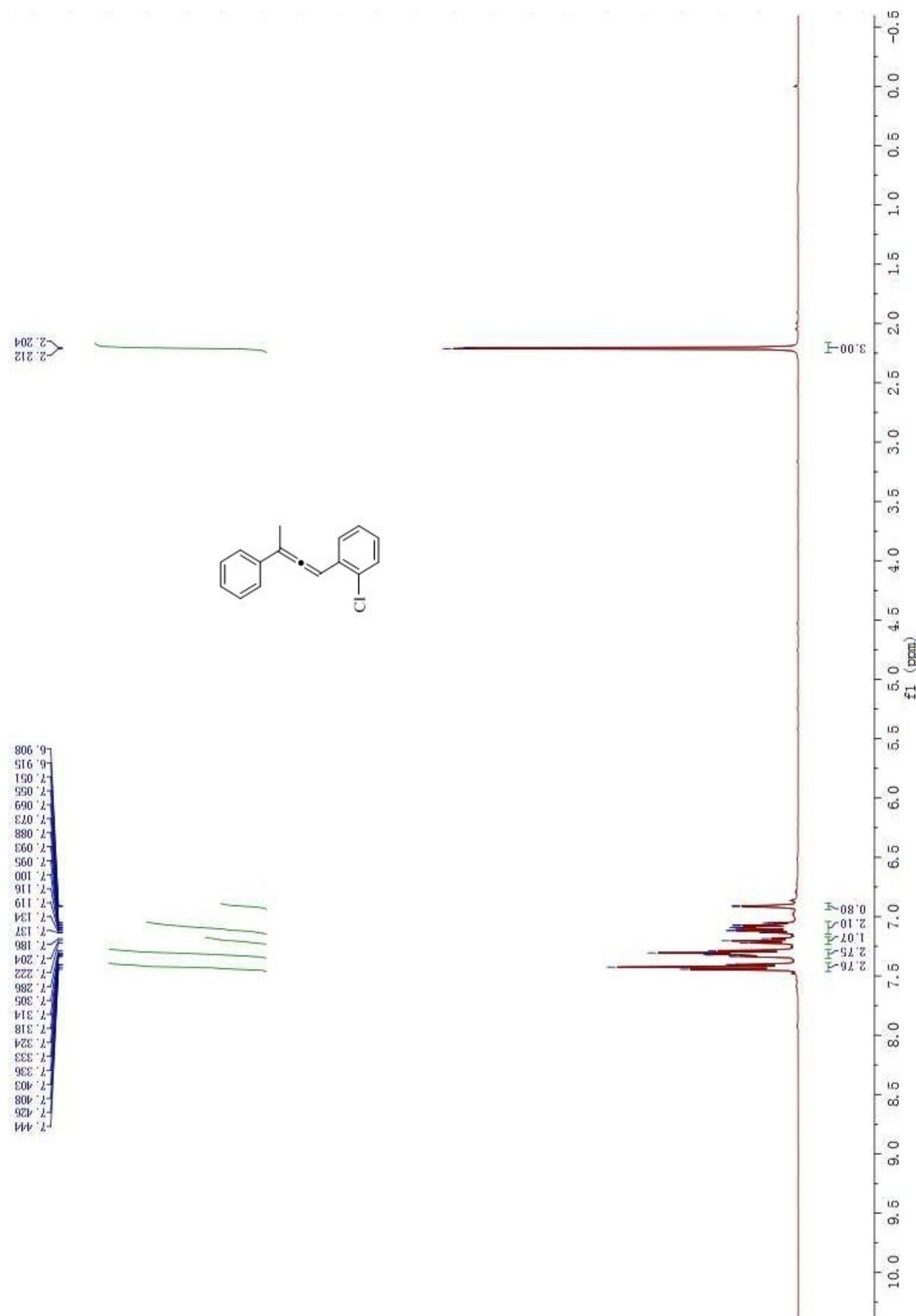
¹H NMR Spectrum of 1-(2-Methoxyphenyl)-3-phenylbuta-1,2-diene (**2e**)



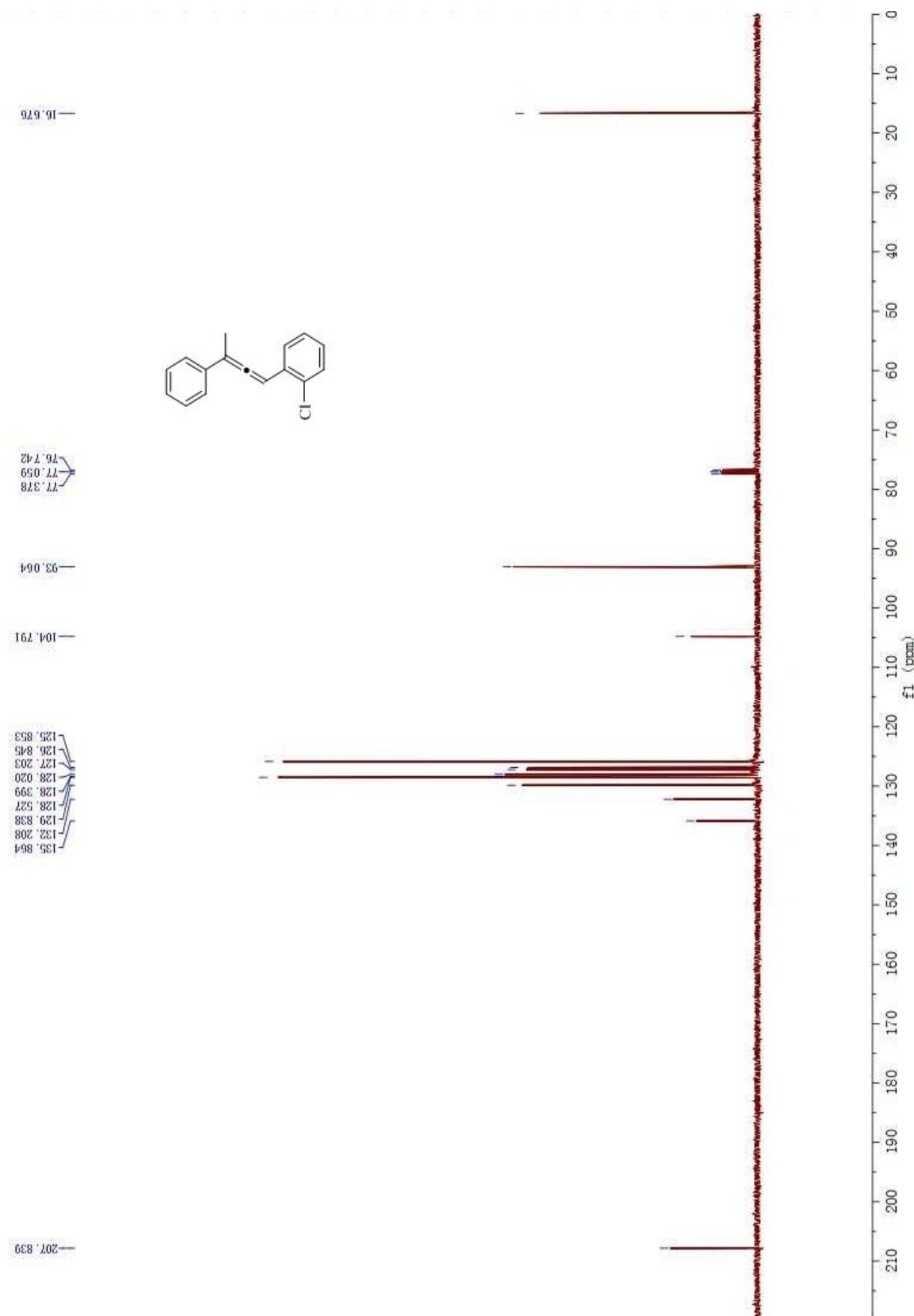
¹³C NMR Spectrum of 1-(2-Methoxyphenyl)-3-phenylbuta-1,2-diene (**2e**)



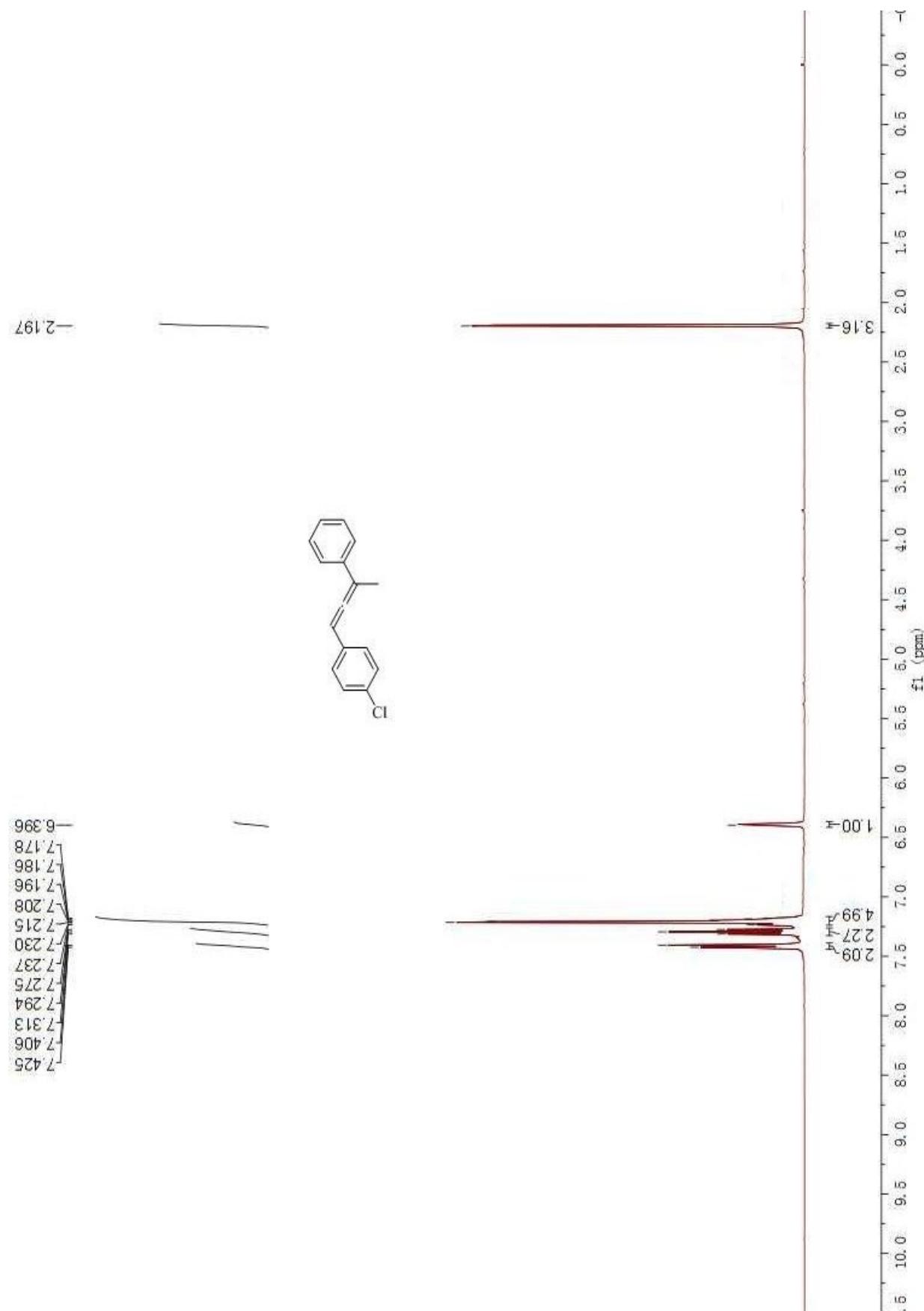
¹H NMR Spectrum of 1-(2-Chlorophenyl)-3-phenylbuta-1,2-diene (**2f**)



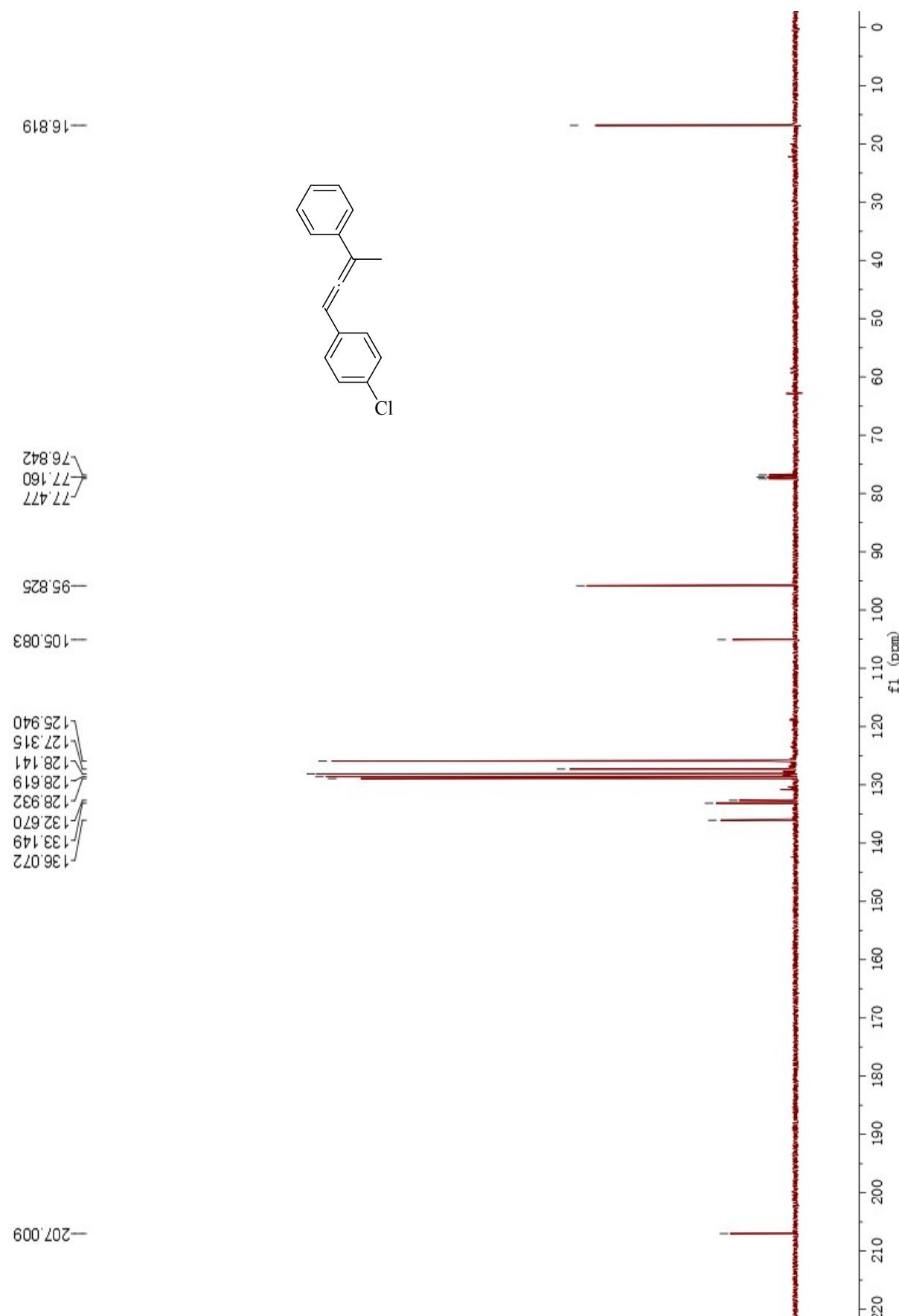
¹³C NMR Spectrum of 1-(2-Chlorophenyl)-3-phenylbuta-1,2-diene (**2f**)



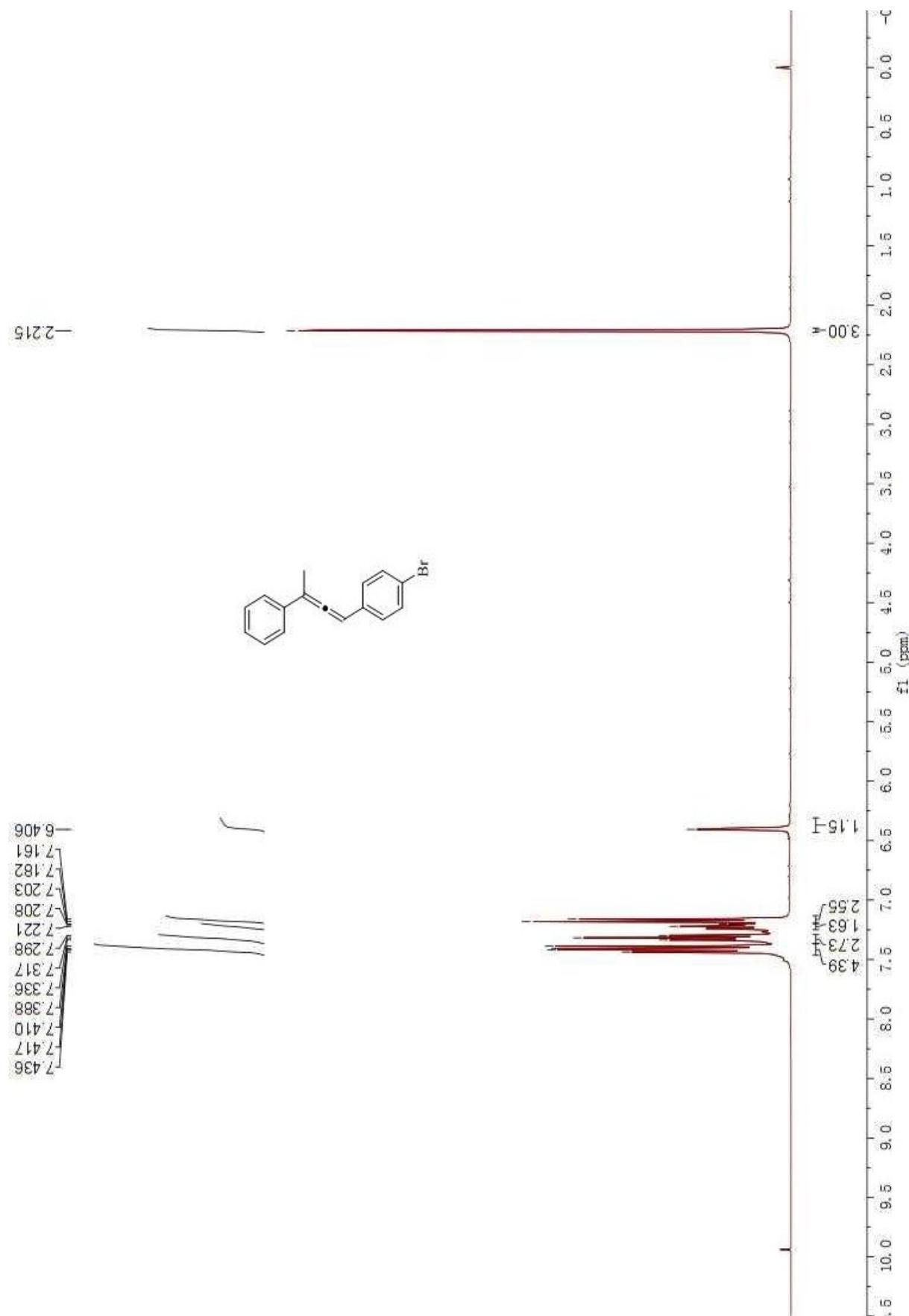
¹H NMR Spectrum of 1-(4-Chlorophenyl)-3-phenylbuta-1,2-diene (**2g**)



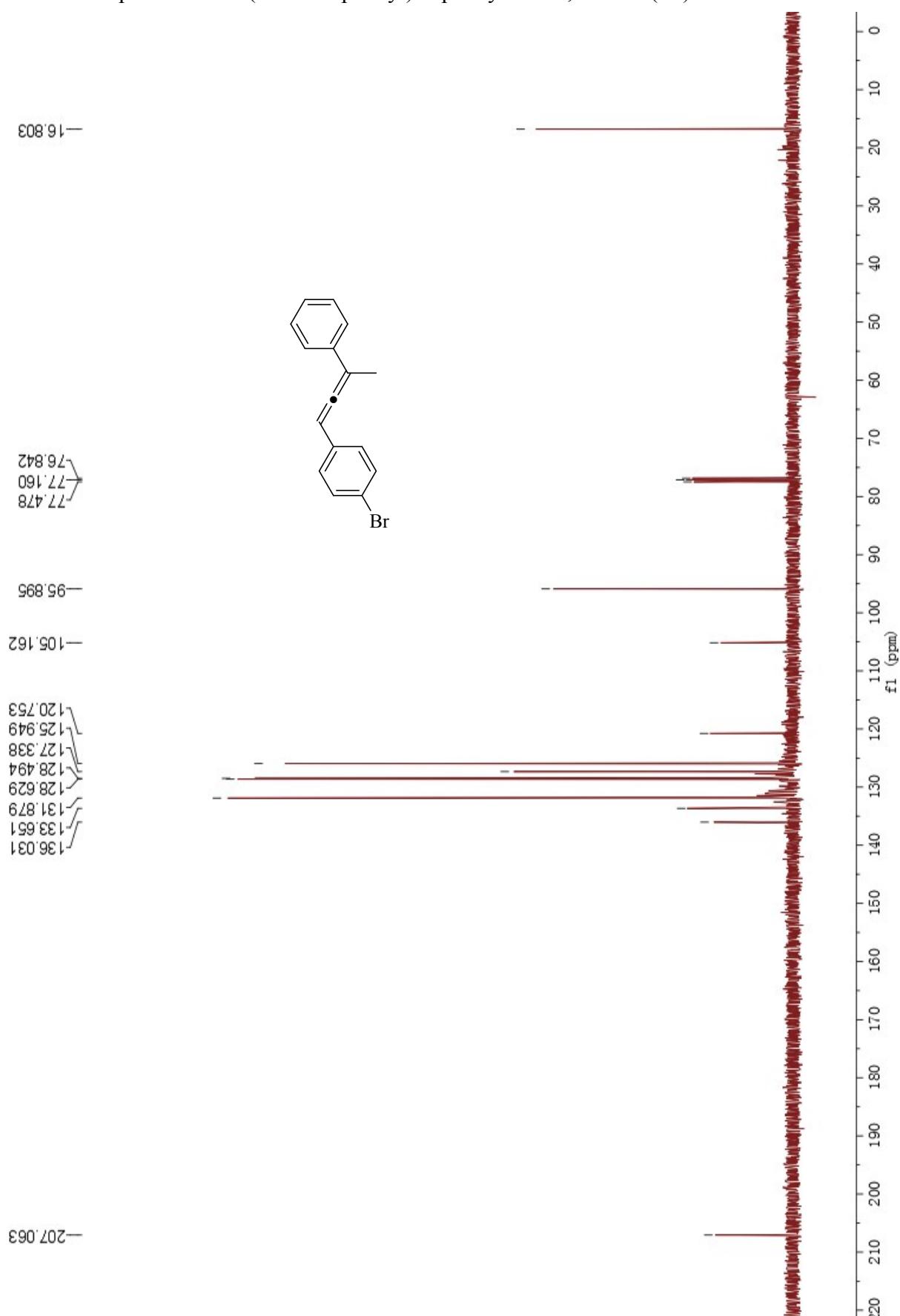
¹³C NMR Spectrum of 1-(4-Chlorophenyl)-3-phenylbuta-1,2-diene (**2g**)



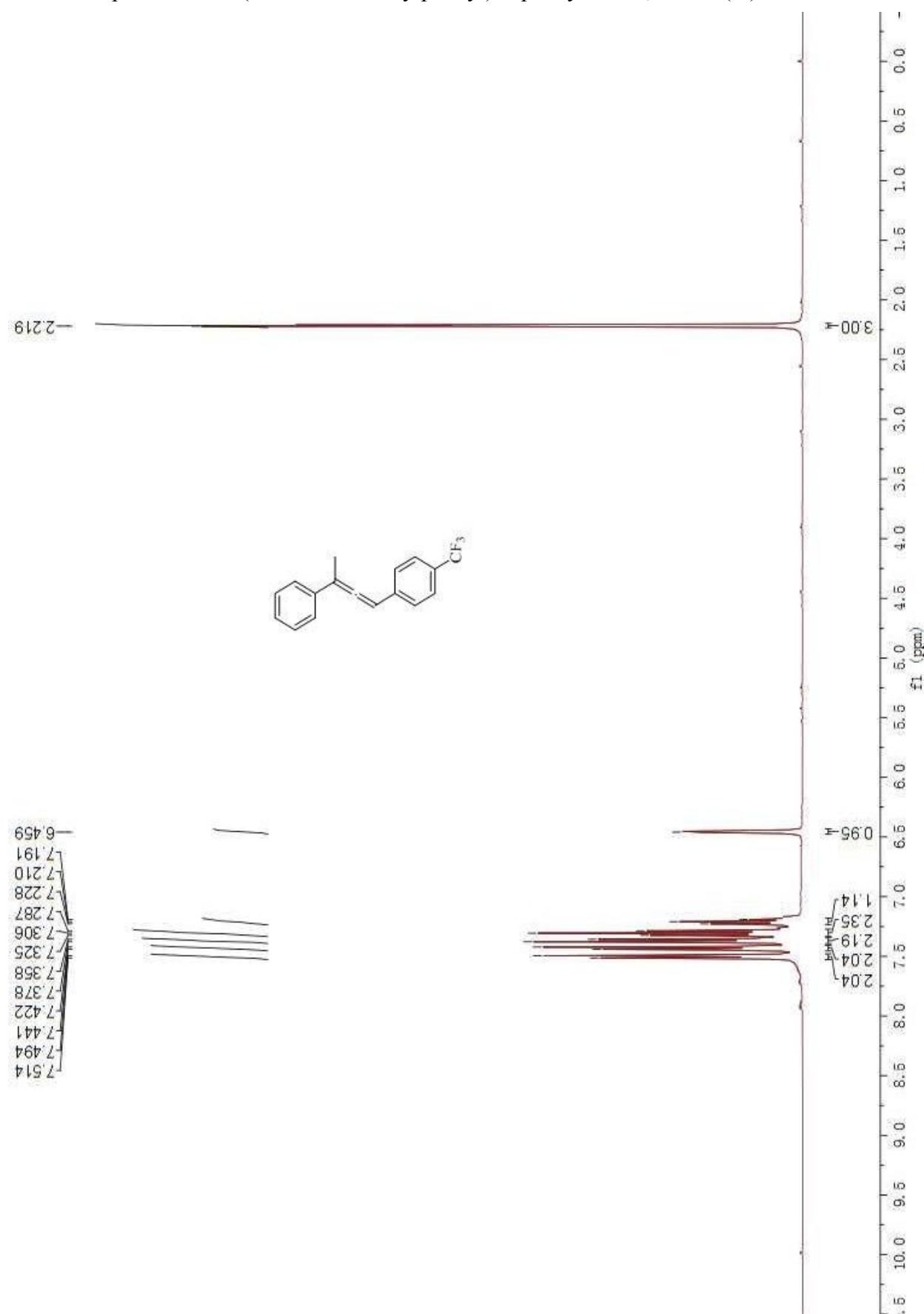
¹H NMR Spectrum of 1-(4-Bromophneyl)-3-phenylbuta-1,2-diene (**2h**)



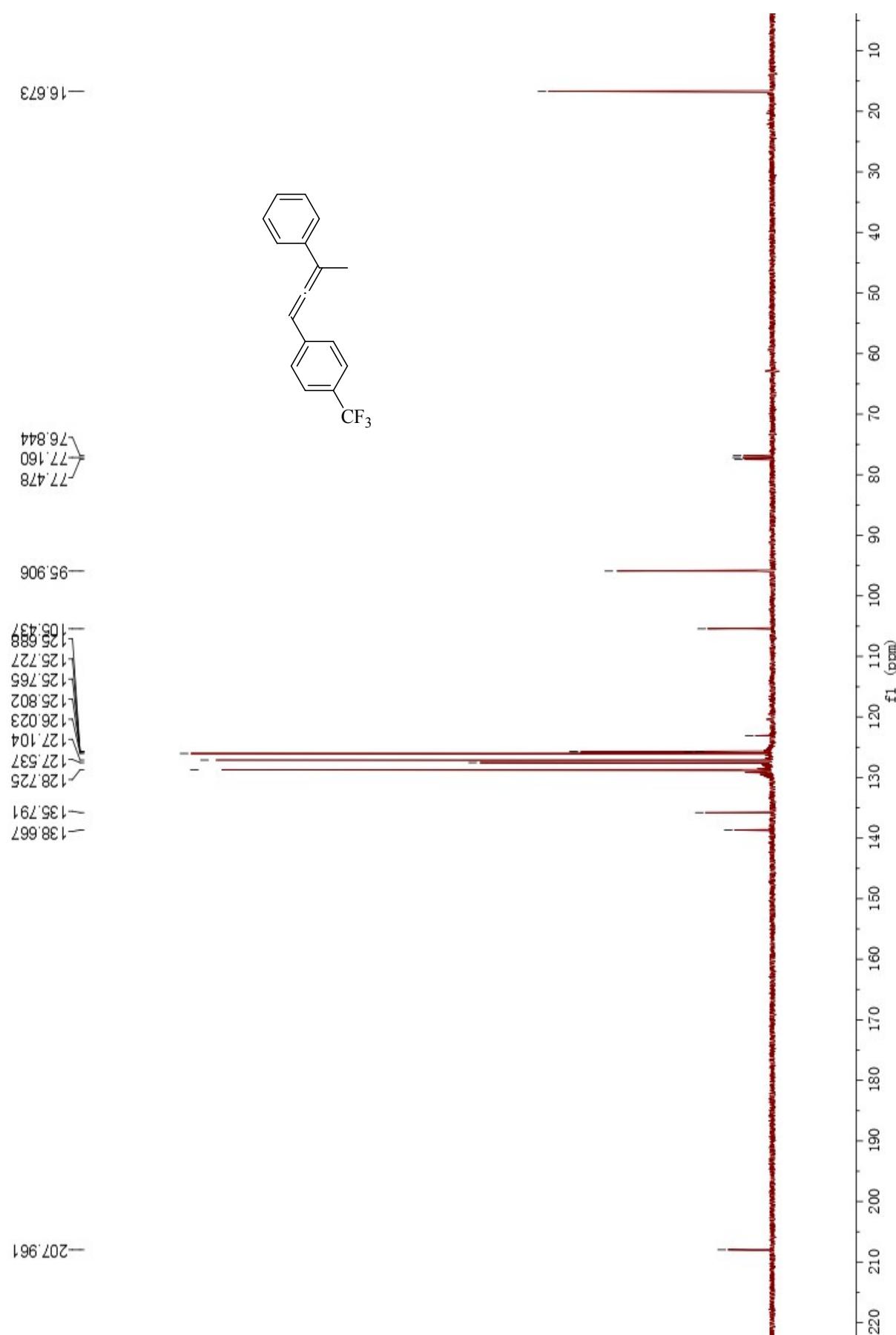
¹³C NMR Spectrum of 1-(4-Bromophnyl)-3-phenylbuta-1,2-diene (**2h**)



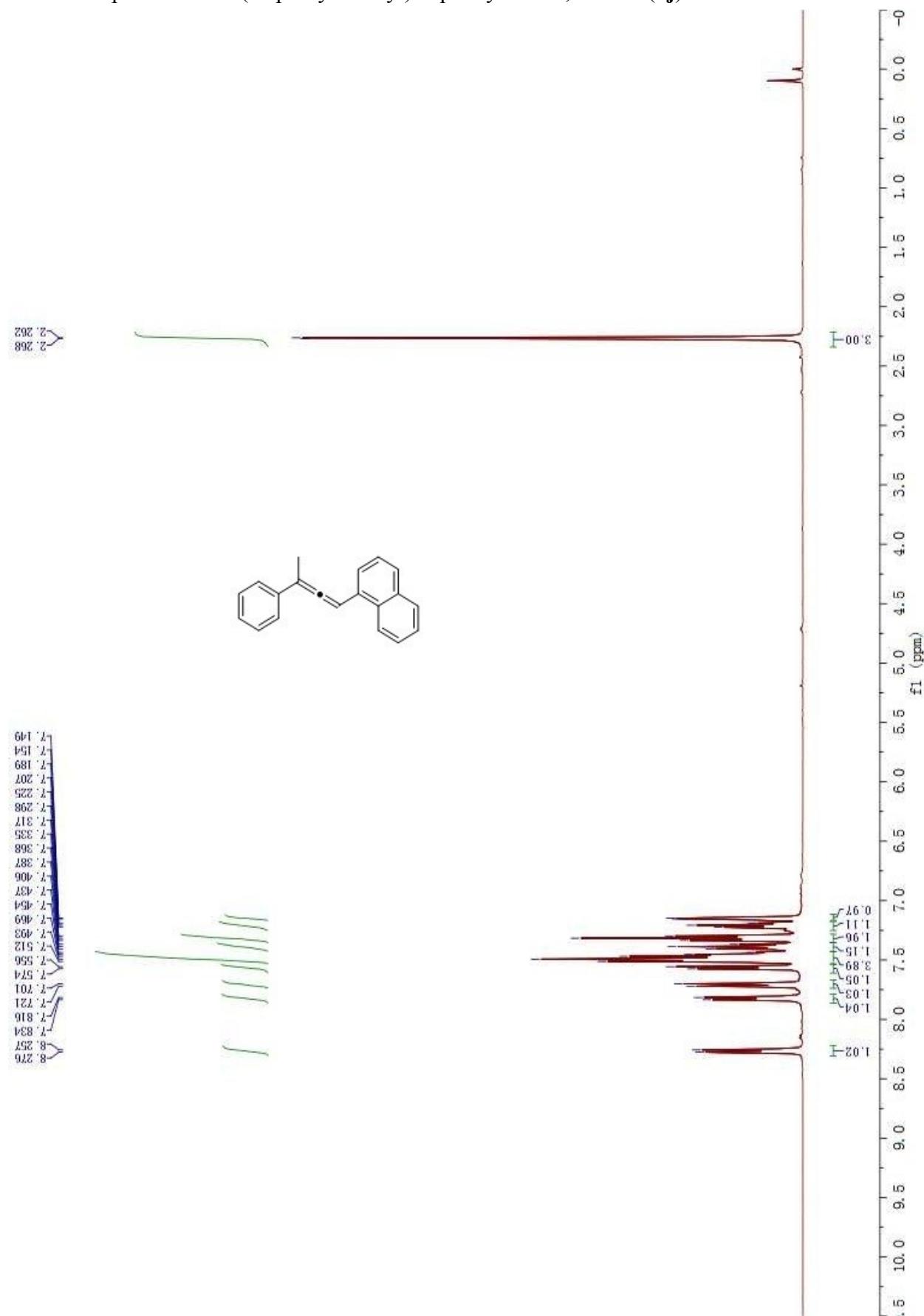
¹H NMR Spectrum of 1-(4-Trifluoromethylphenyl)-3-phenylbuta-1,2-diene(**2i**)



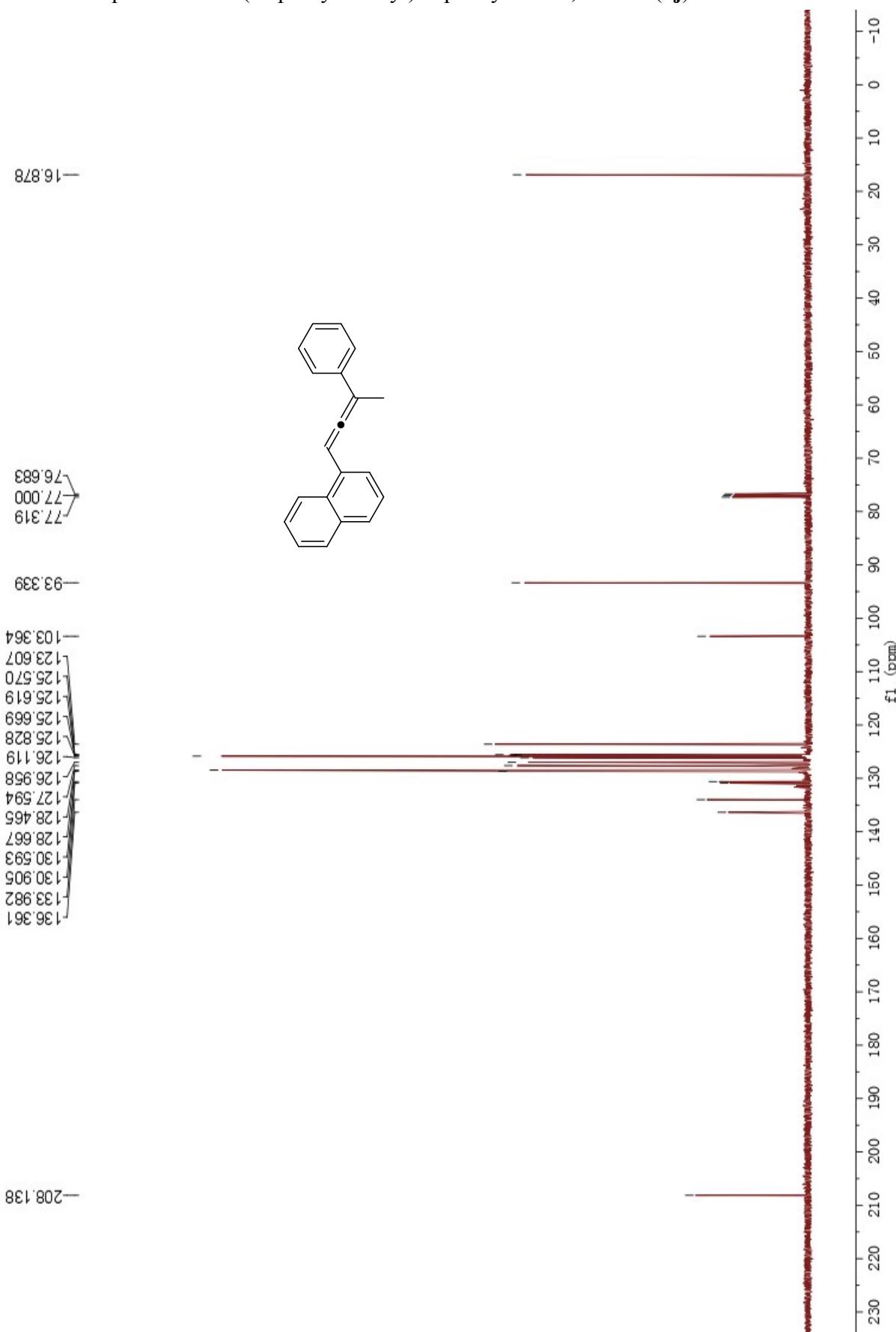
¹³C NMR Spectrum of 1-(4-Trifluoromethylphenyl)-3-phenylbuta-1,2-diene(**2i**)



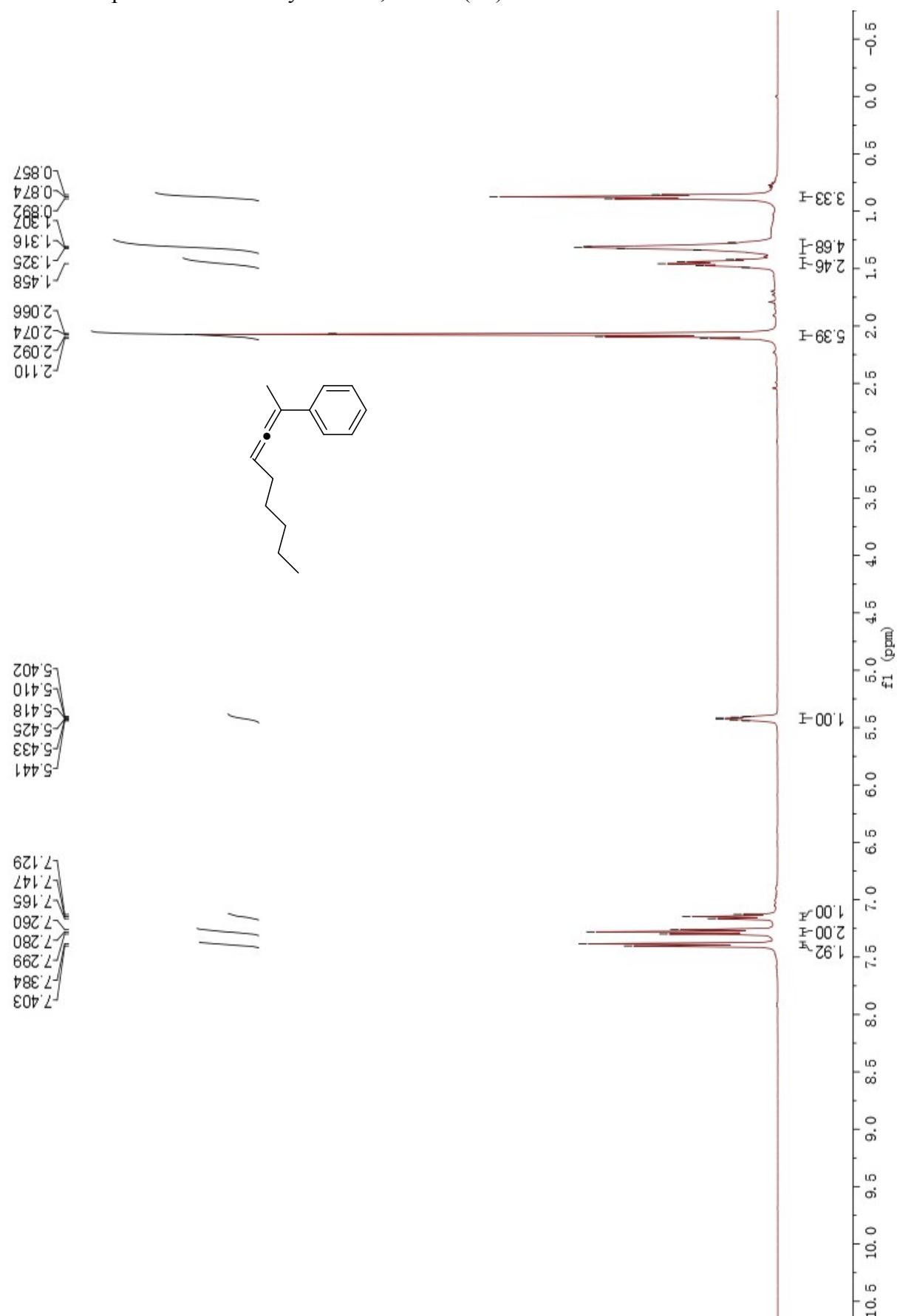
¹H NMR Spectrum of 1-(Naphthylen-1-yl)-3-phenylbuta-1,2-diene (**2j**)



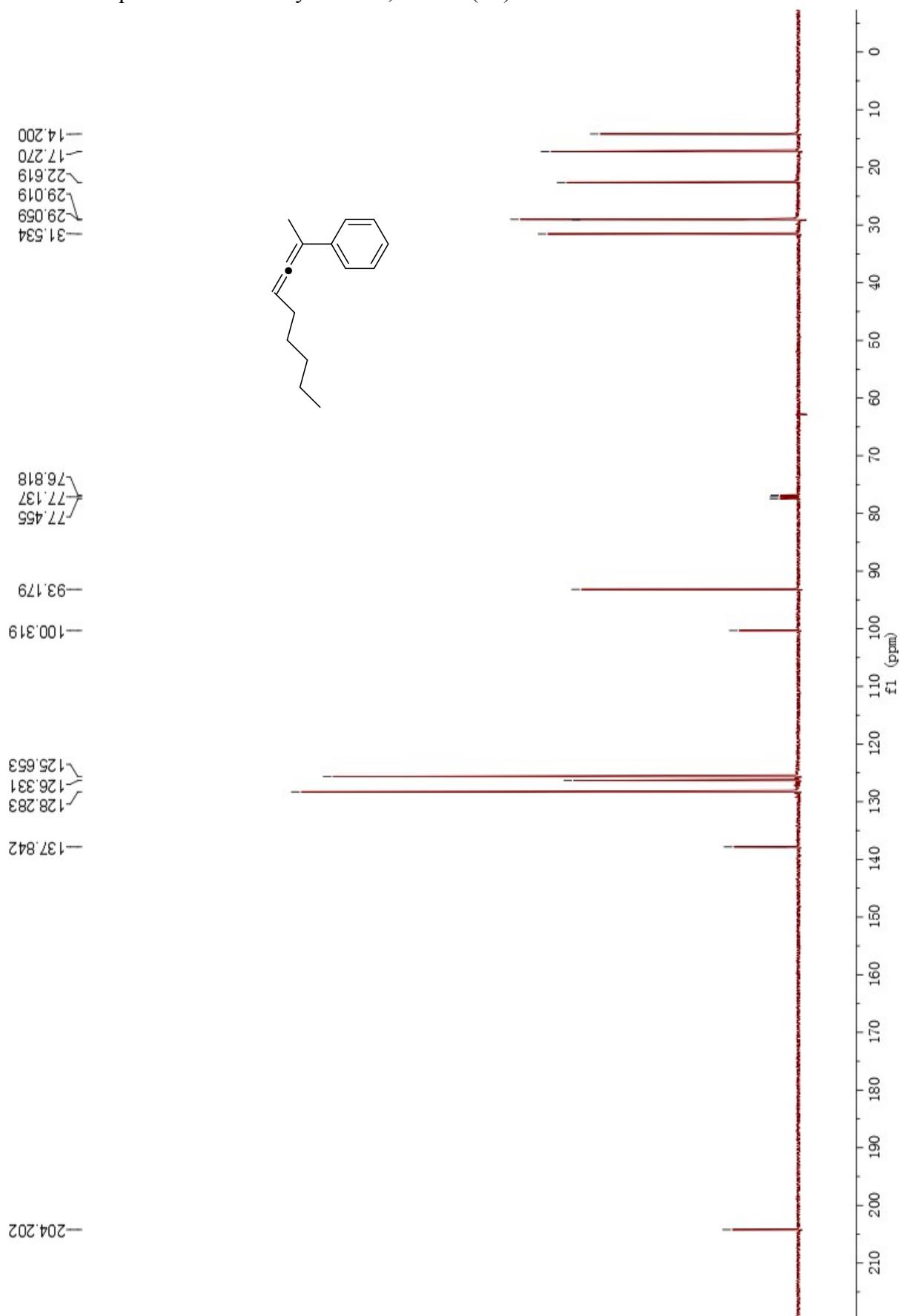
¹³C NMR Spectrum of 1-(Naphthylen-1-yl)-3-phenylbuta-1,2-diene (**2j**)



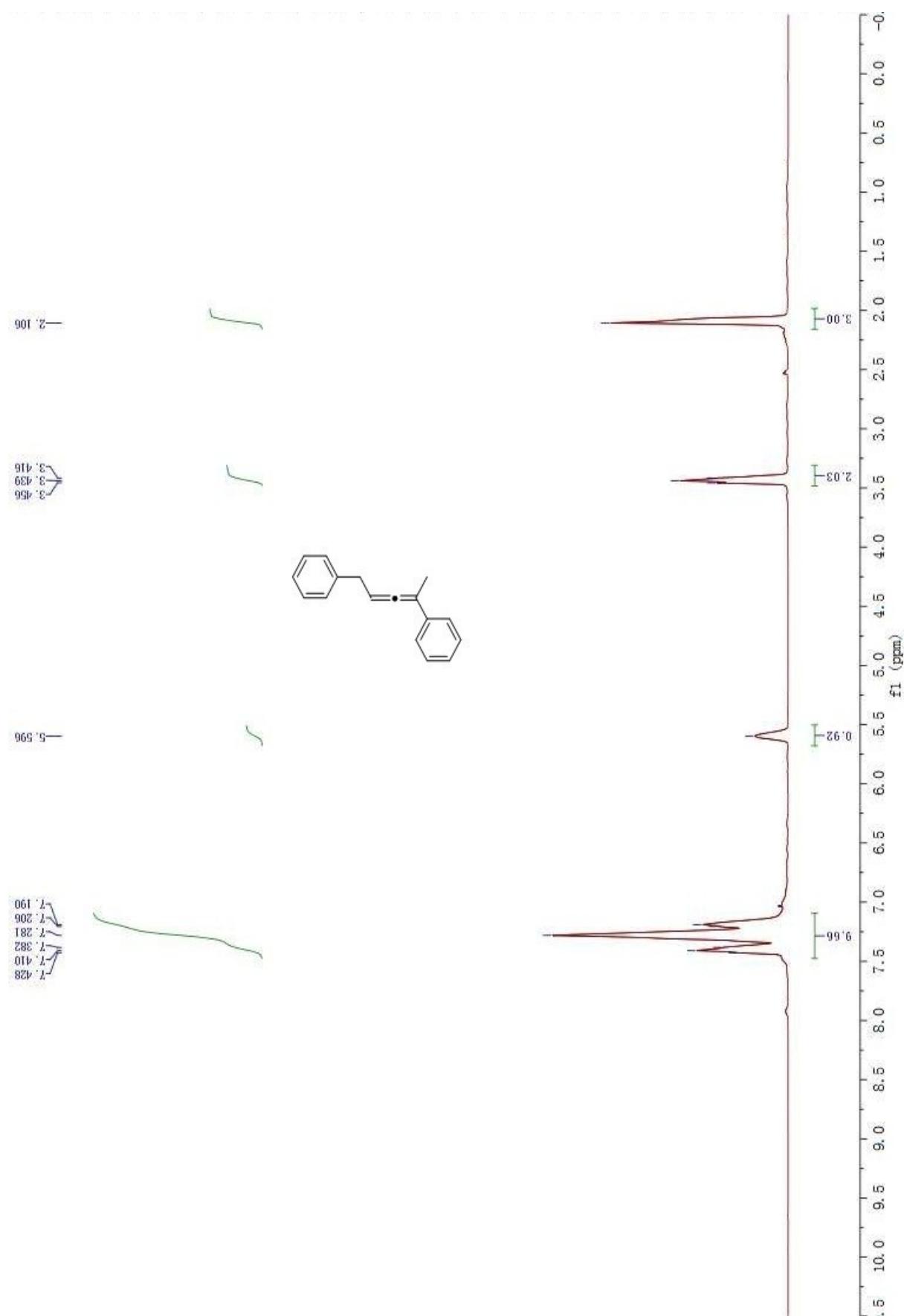
¹H NMR Spectrum of 2-Phenyl-nona-2,3-diene (**2k**)



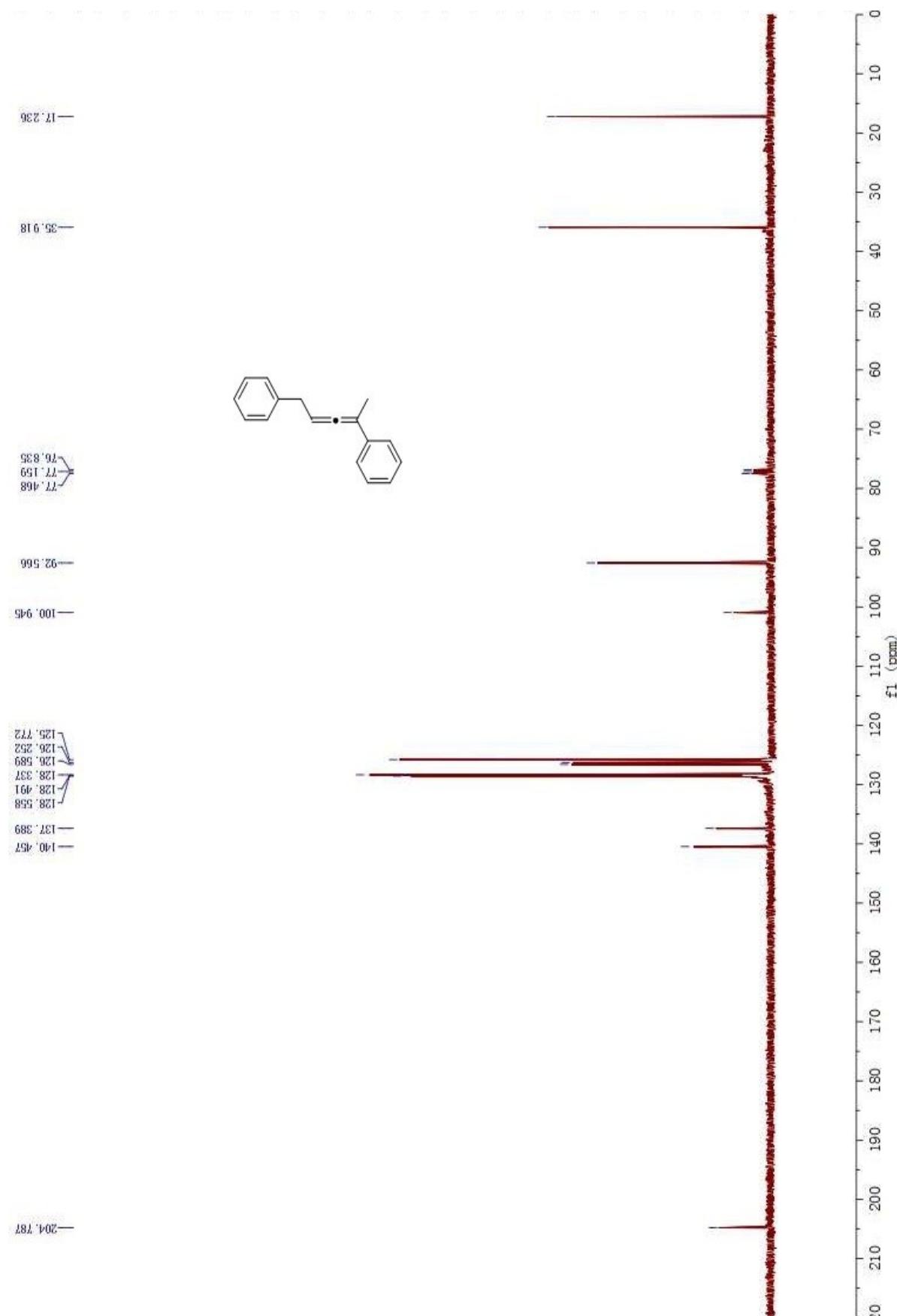
¹³C NMR Spectrum of 2-Phenyl-nona-2,3-diene (**2k**)



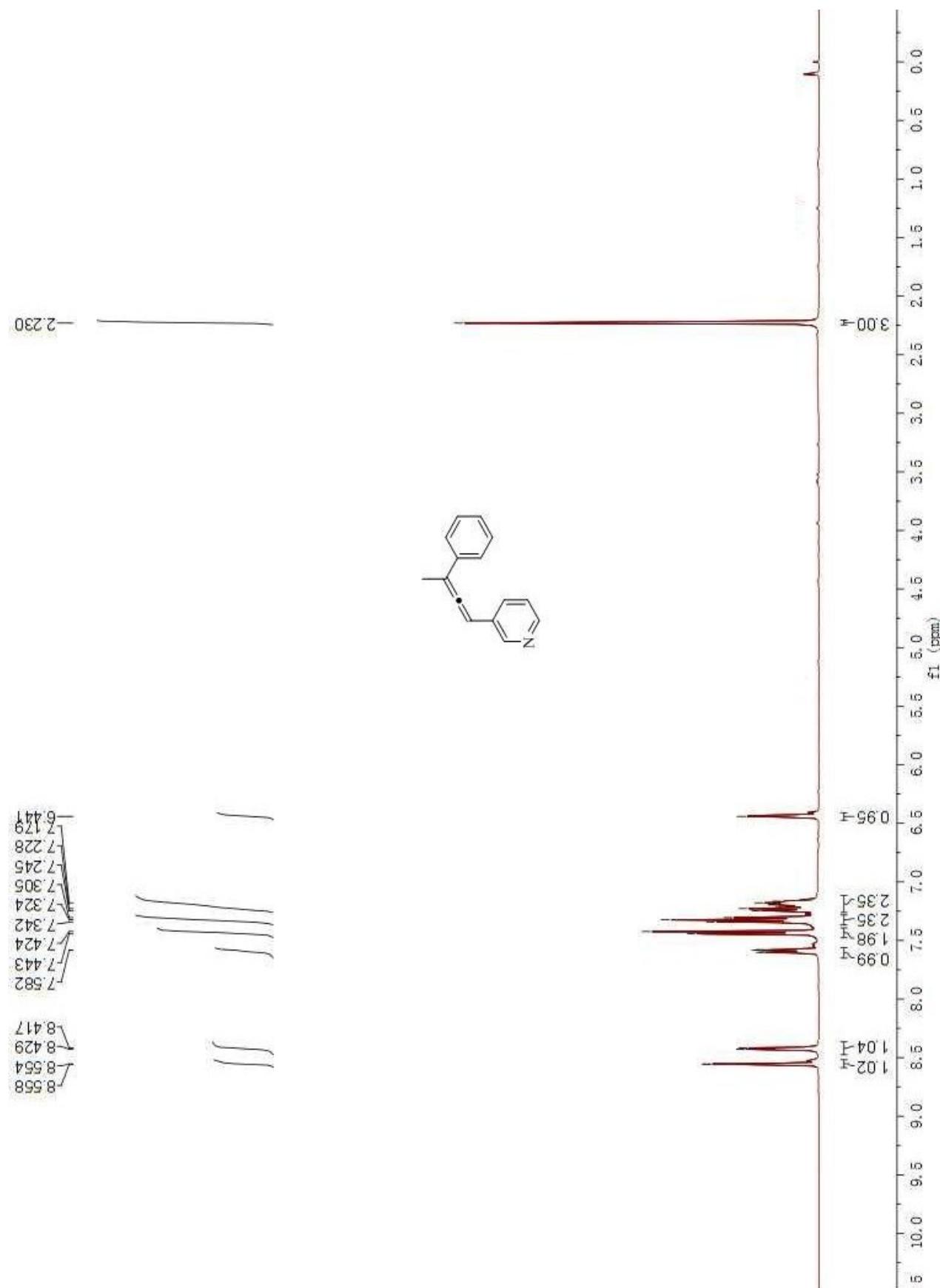
¹H NMR Spectrum of 1,4-diphenylpenta-2,3-diene (**2l**)



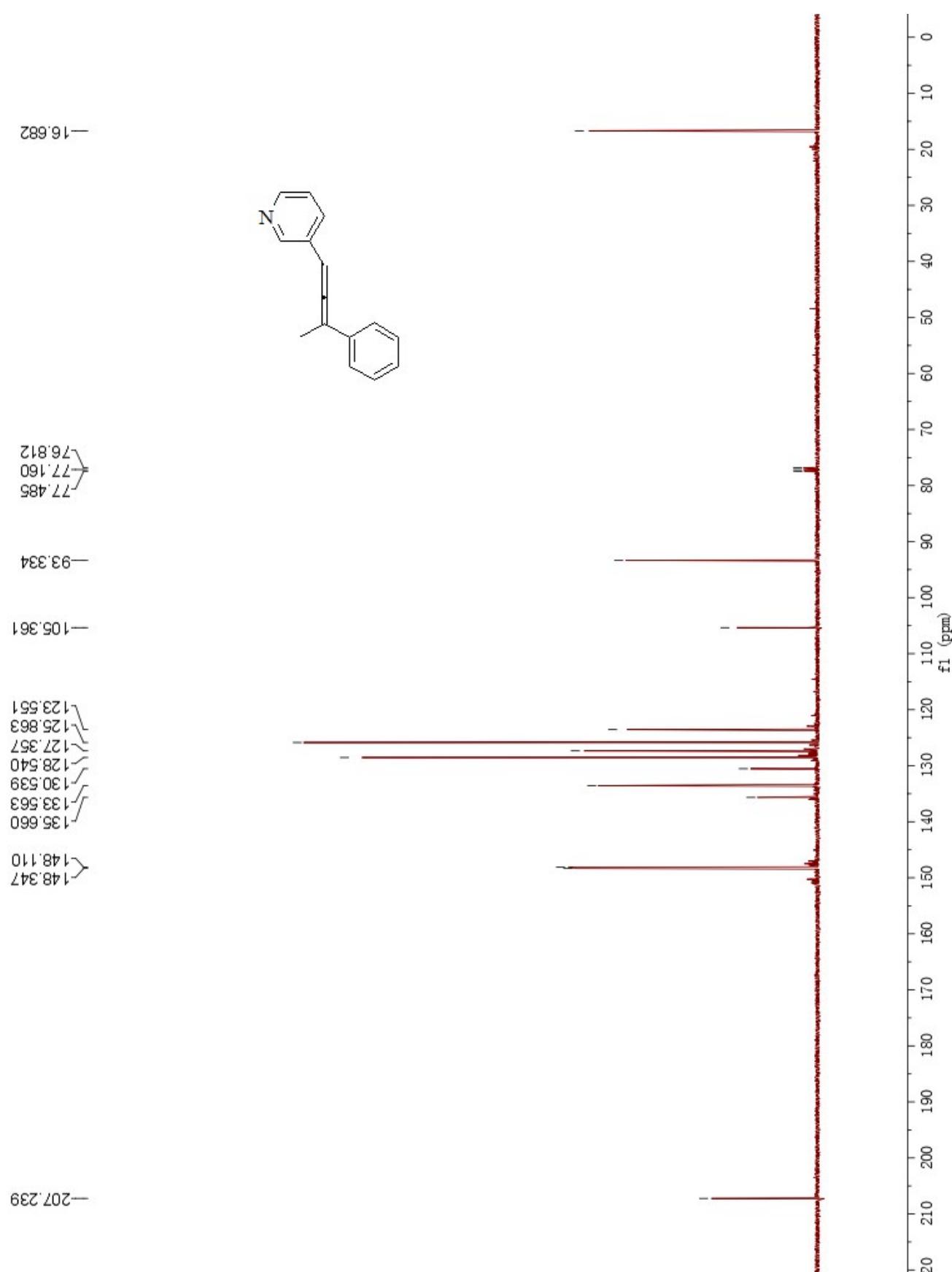
¹³C NMR Spectrum of 1,4-diphenylpenta-2,3-diene (**2l**)



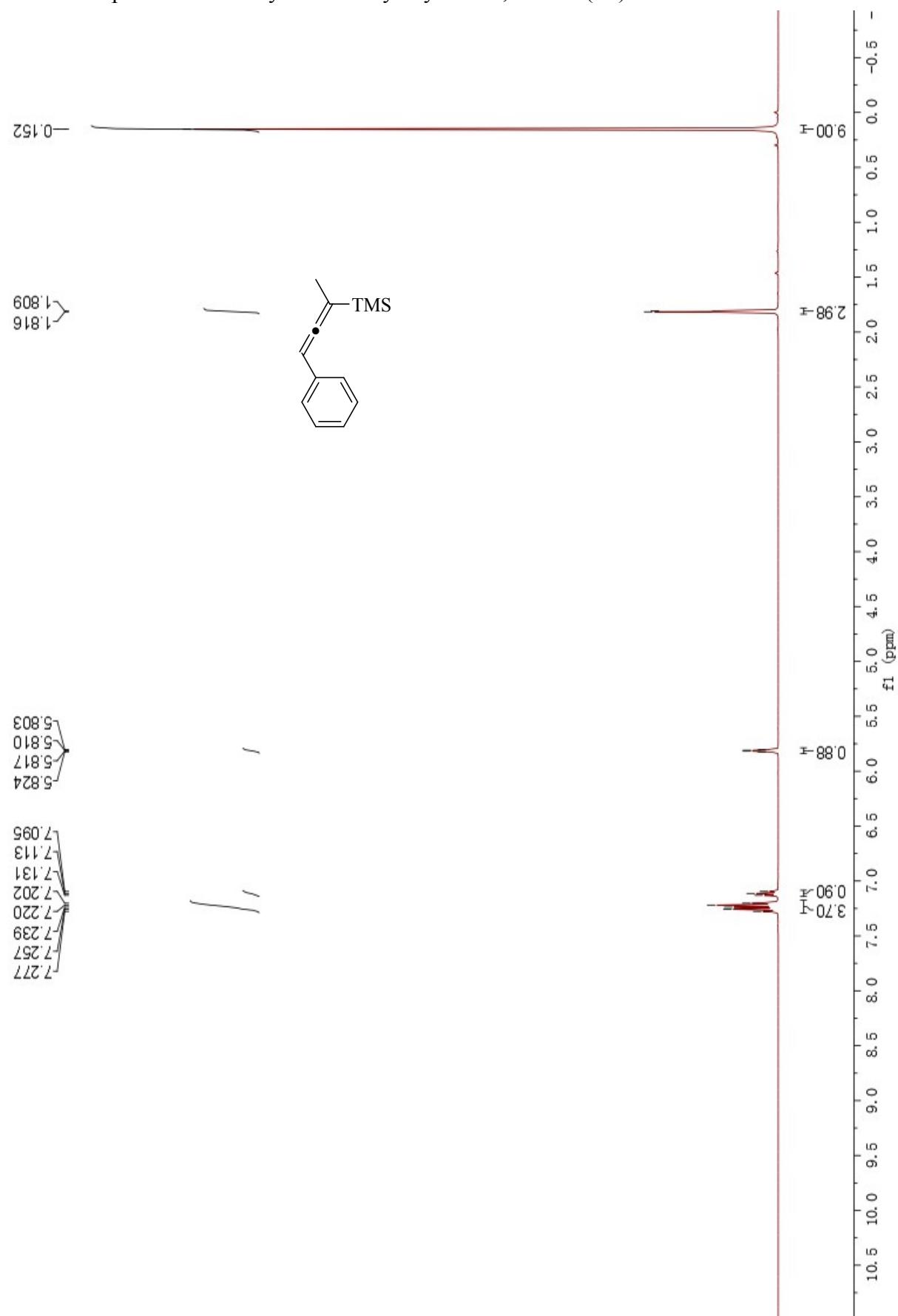
¹H NMR Spectrum of 3-(3-phenylbuta-1,2-dienyl)pyridine(**2m**)



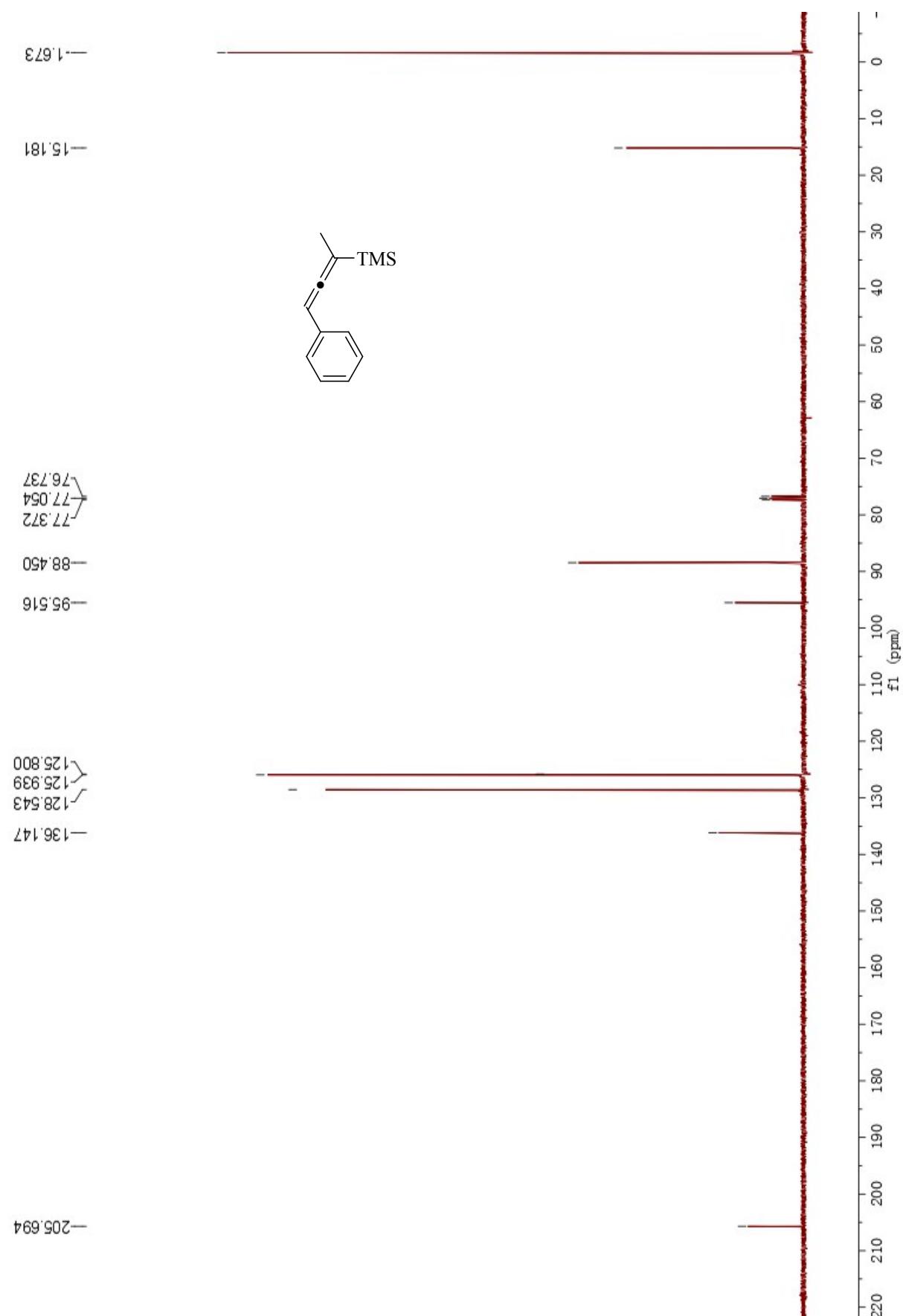
^{13}C NMR Spectrum of 3-(3-phenylbuta-1,2-dienyl)pyridine(**2m**)



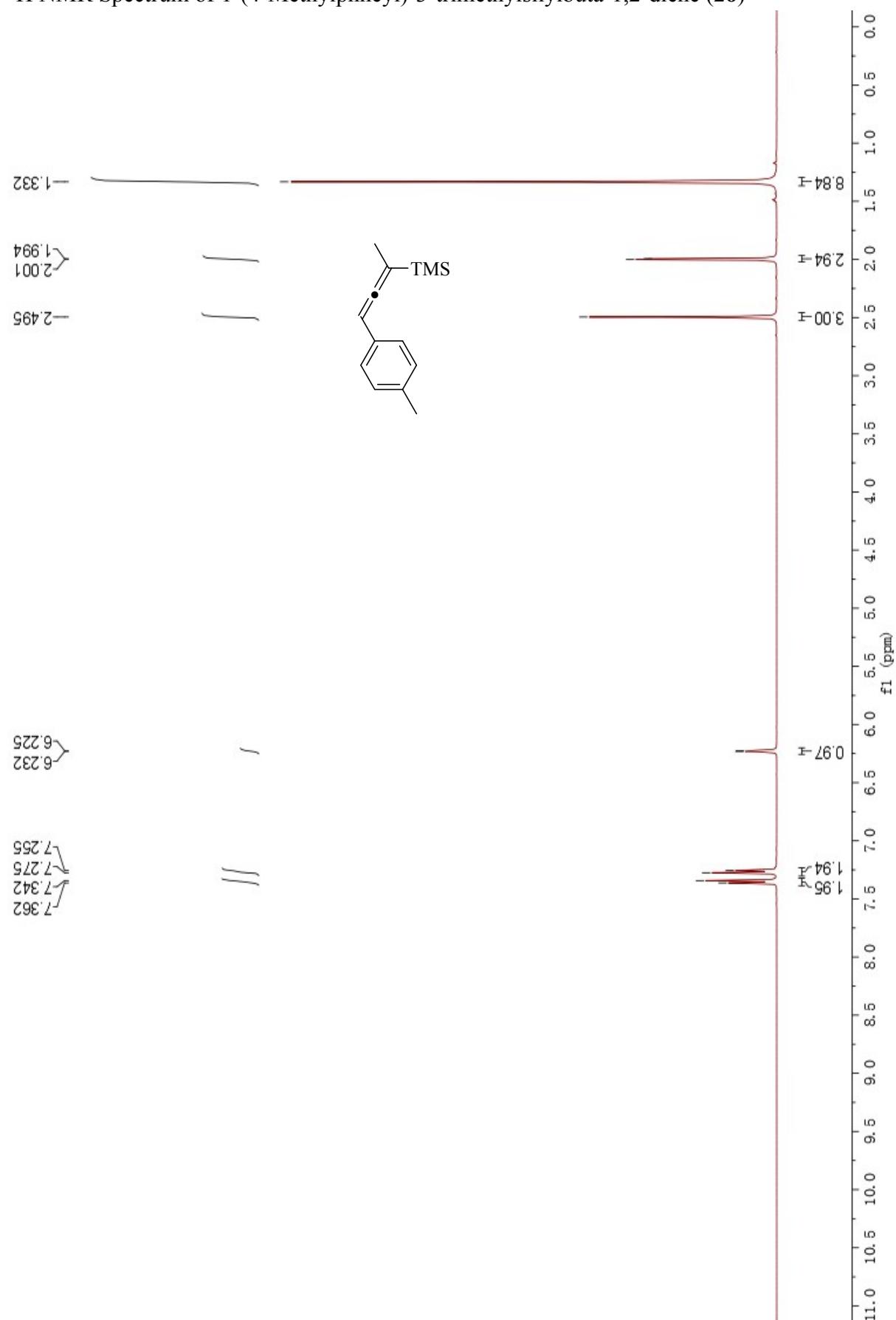
¹H NMR Spectrum of Phenyl-3-trimethylsilylbuta-1,2-diene (**2n**)



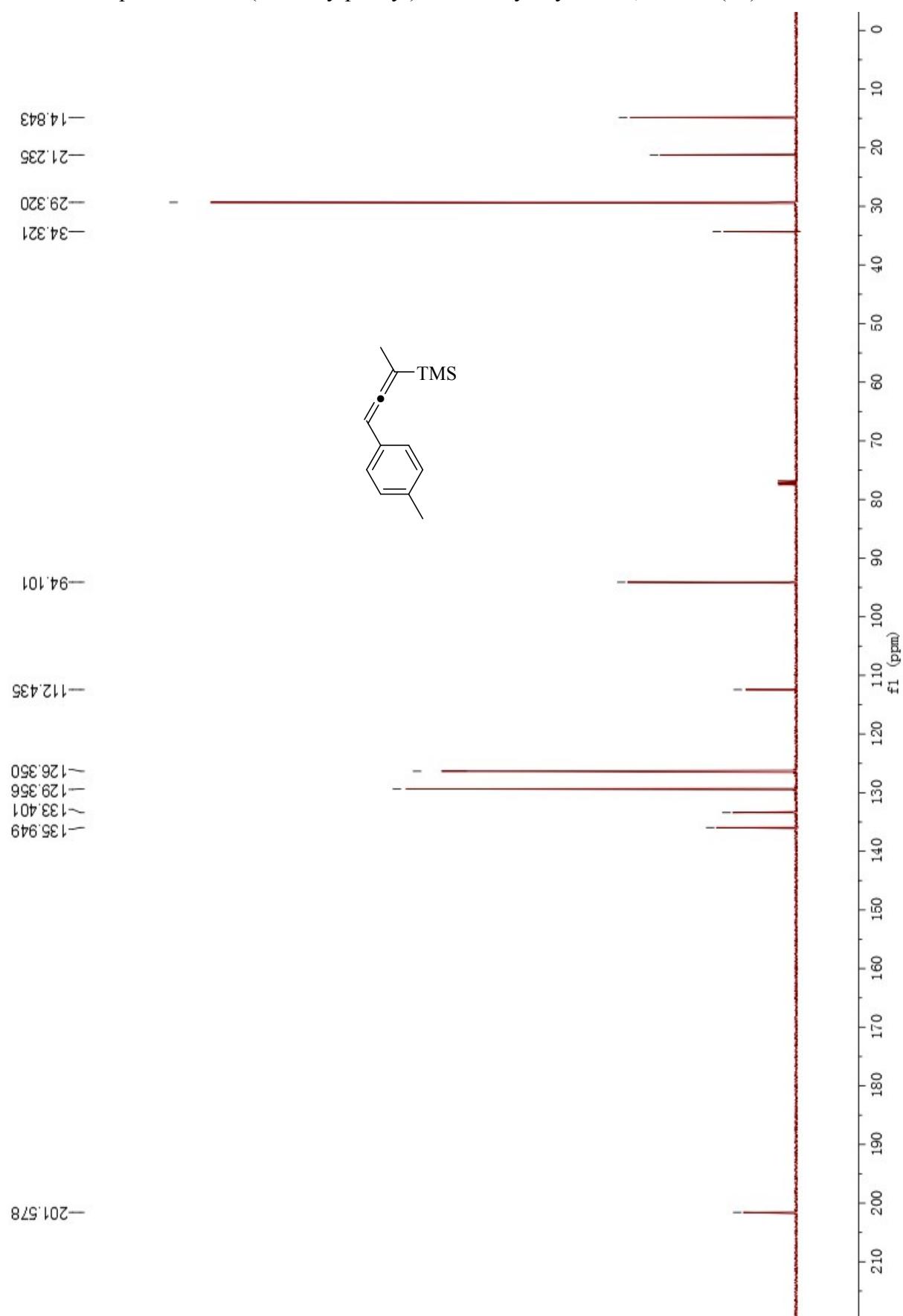
¹³C NMR Spectrum of Phenyl-3-trimethylsilylbuta-1,2-diene (**2n**)



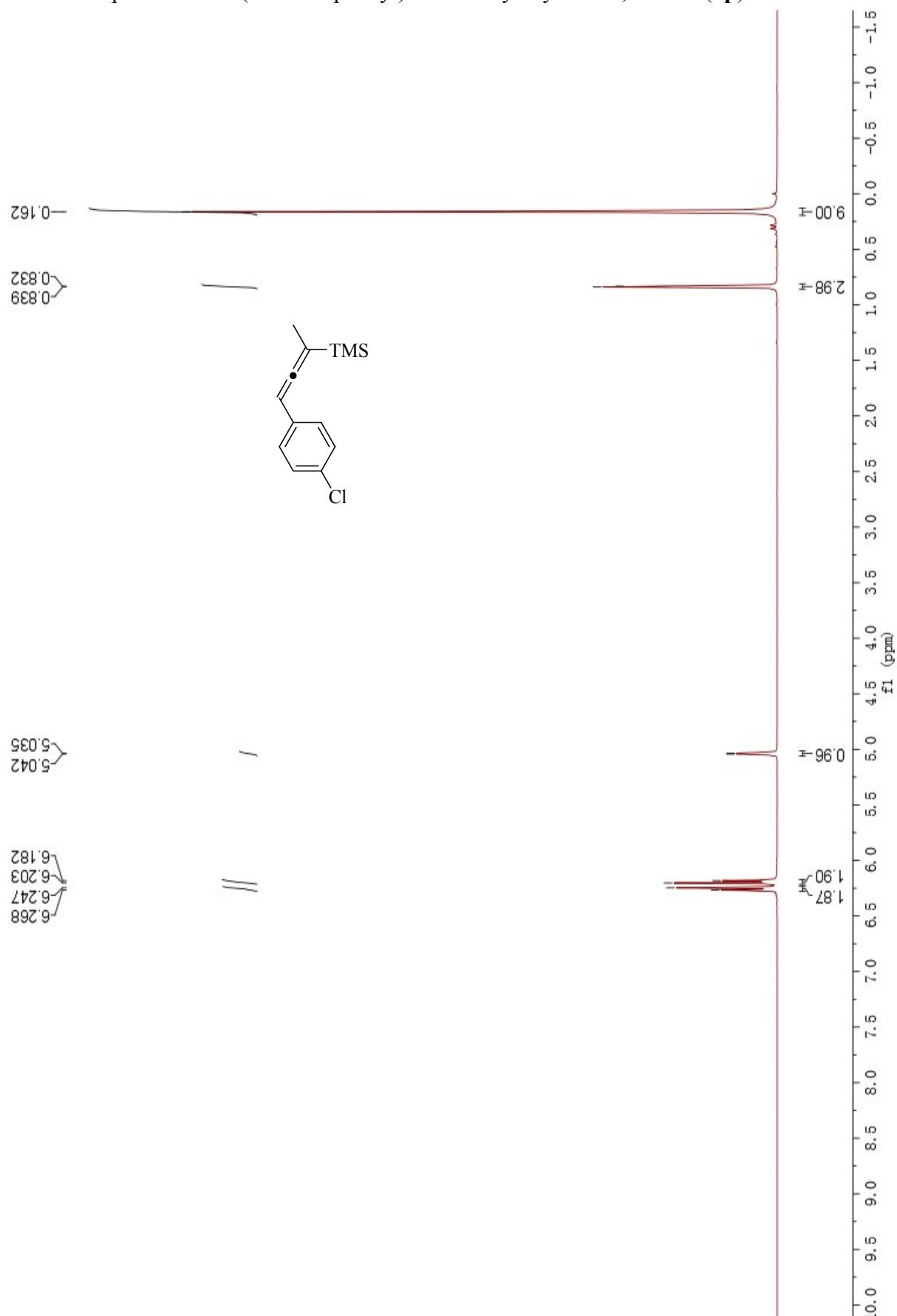
¹H NMR Spectrum of 1-(4-Methylphneyl)-3-trimethylsilylbuta-1,2-diene (**2o**)



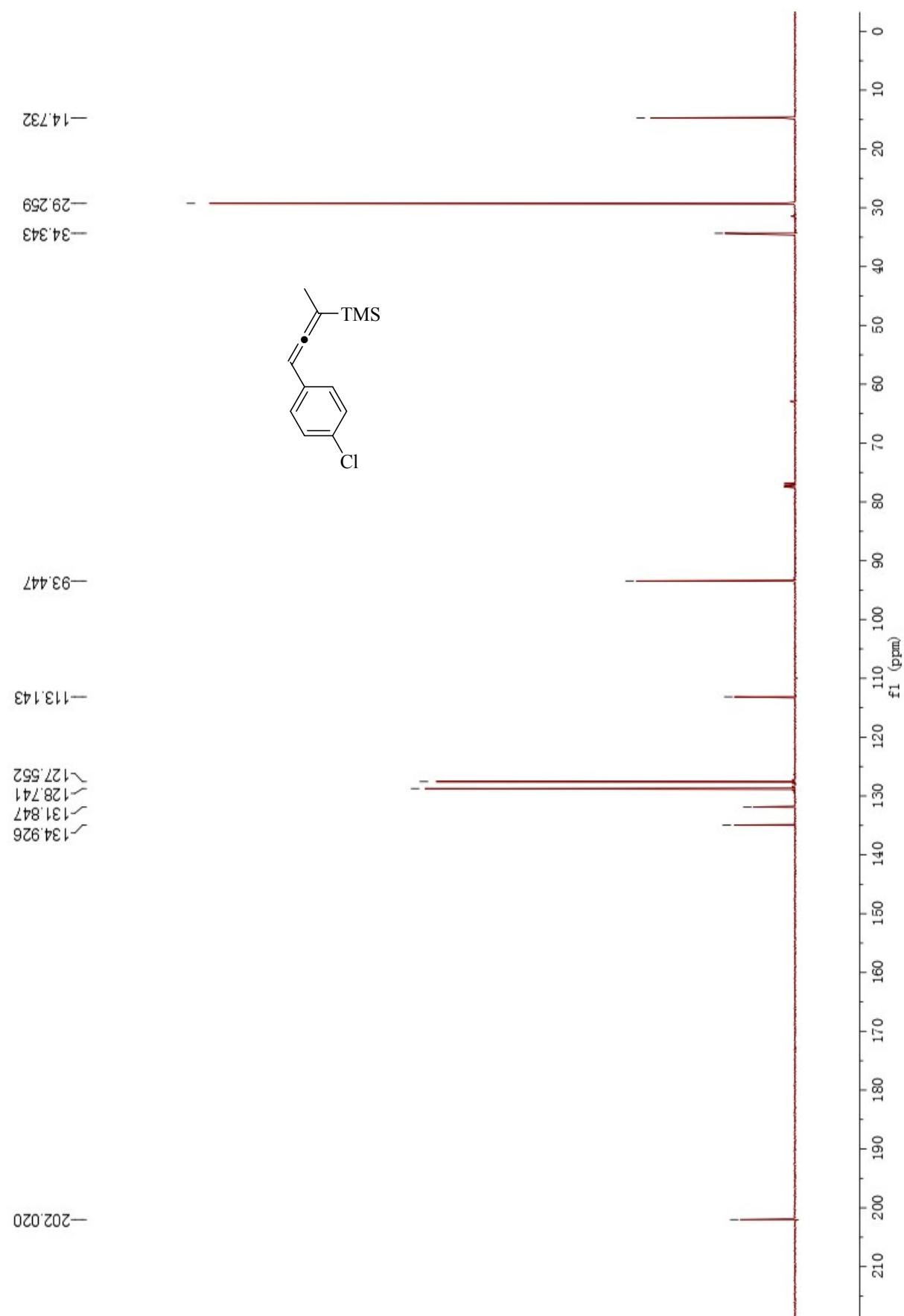
^{13}C NMR Spectrum of 1-(4-Methylphneyl)-3-trimethylsilylbuta-1,2-diene (**2o**)



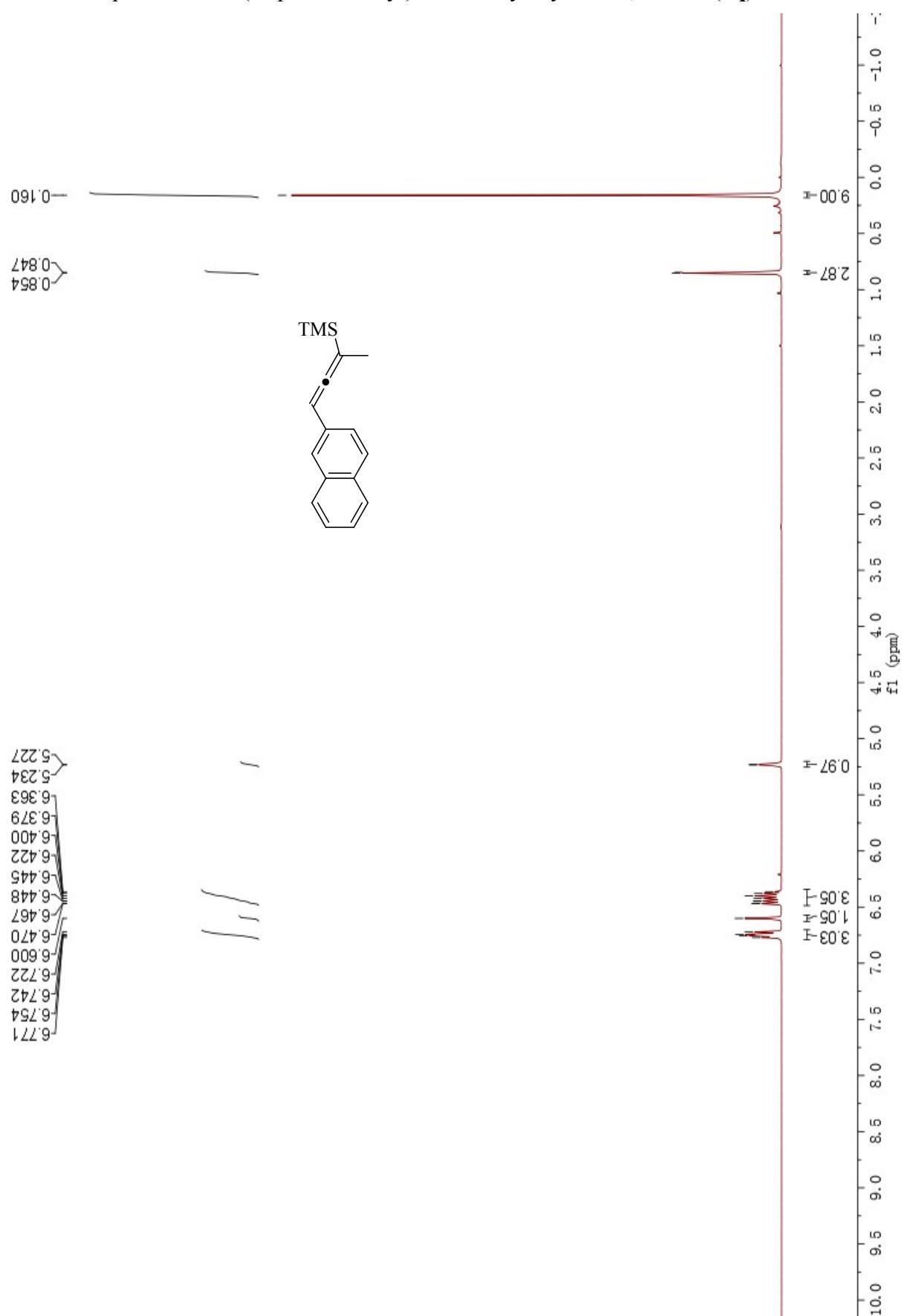
¹H NMR Spectrum of 1-(4-Chlorophenyl)-3-trimethylsilylbuta-1,2-diene (**2p**)



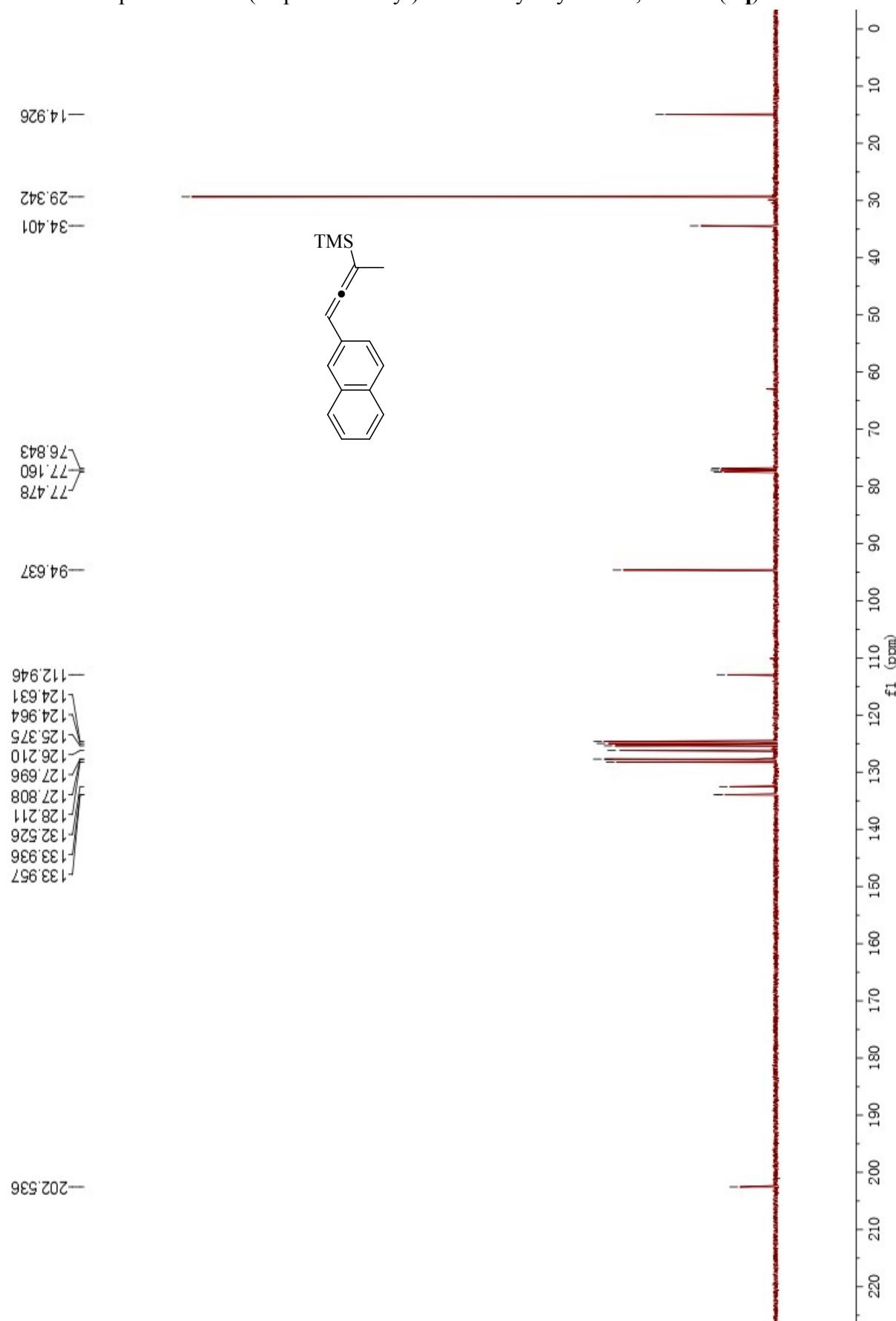
^{13}C NMR Spectrum of 1-(4-Chlorophenyl)-3-trimethylsilylbuta-1,2-diene (**2p**)



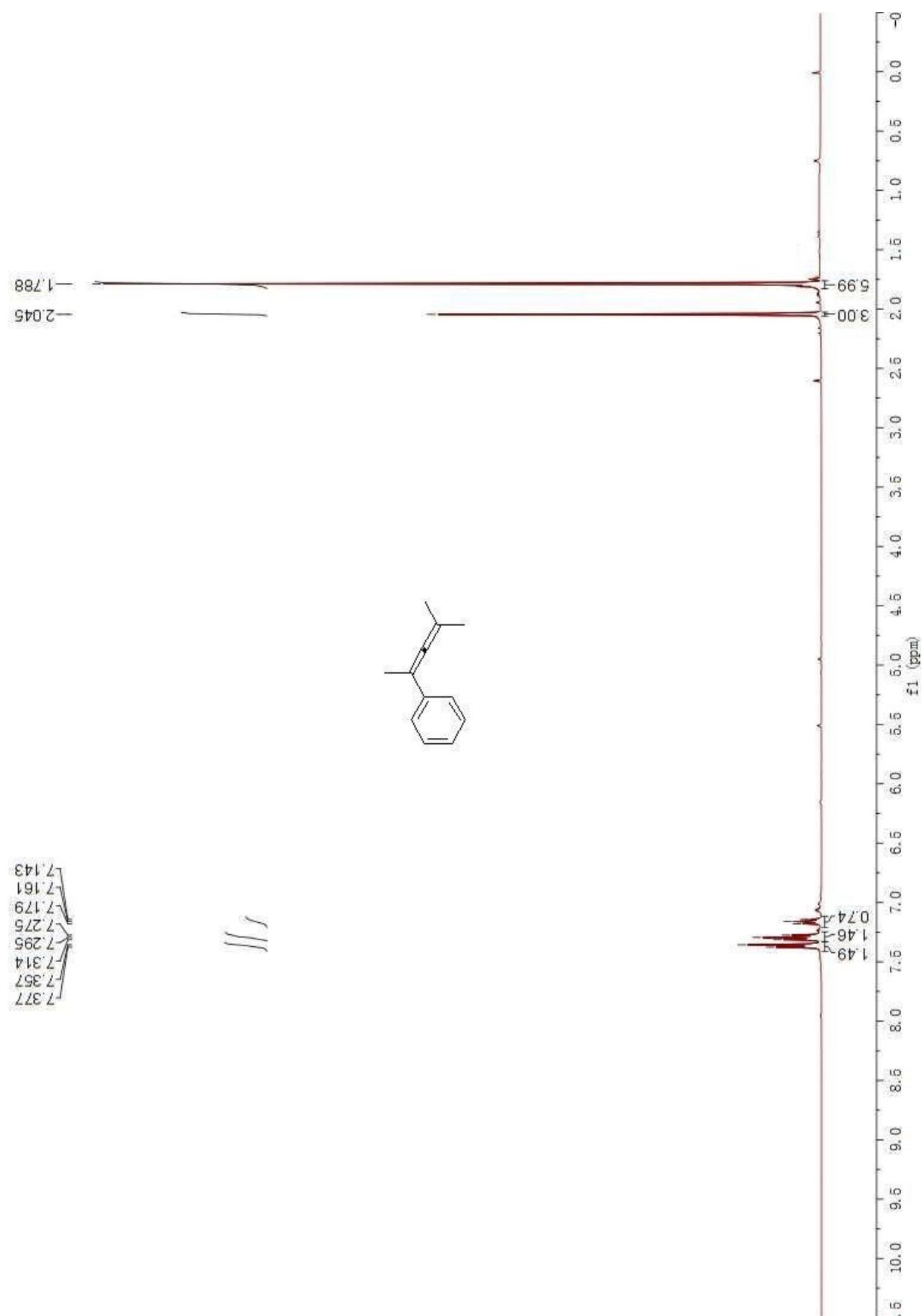
¹H NMR Spectrum of 3-(Naphthalen-2-yl)-3-trimethylsilylbuta-1,2-diene (**2q**)



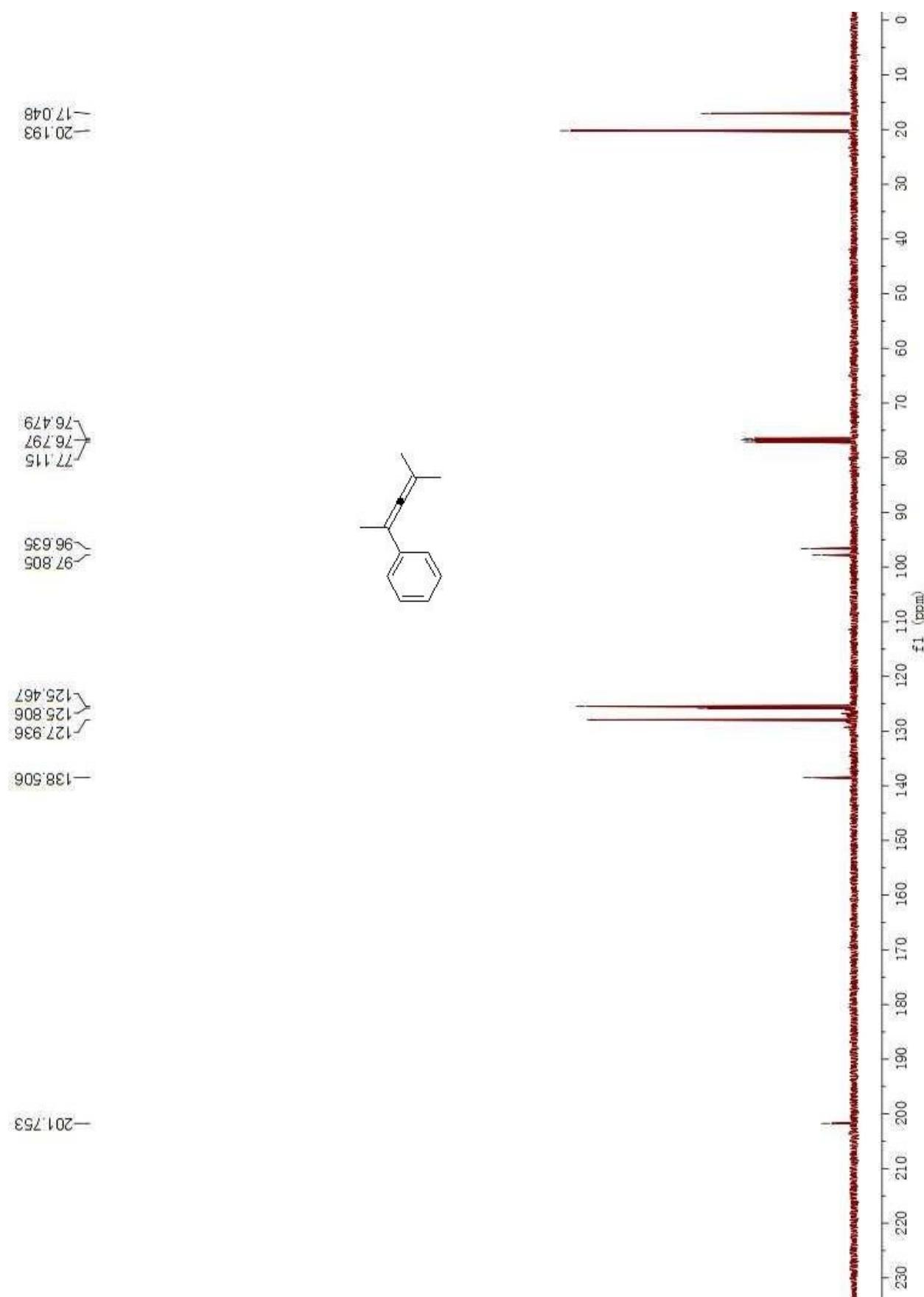
¹³C NMR Spectrum of 3-(Naphthalen-2-yl)-3-trimethylsilylbuta-1,2-diene (**2q**)



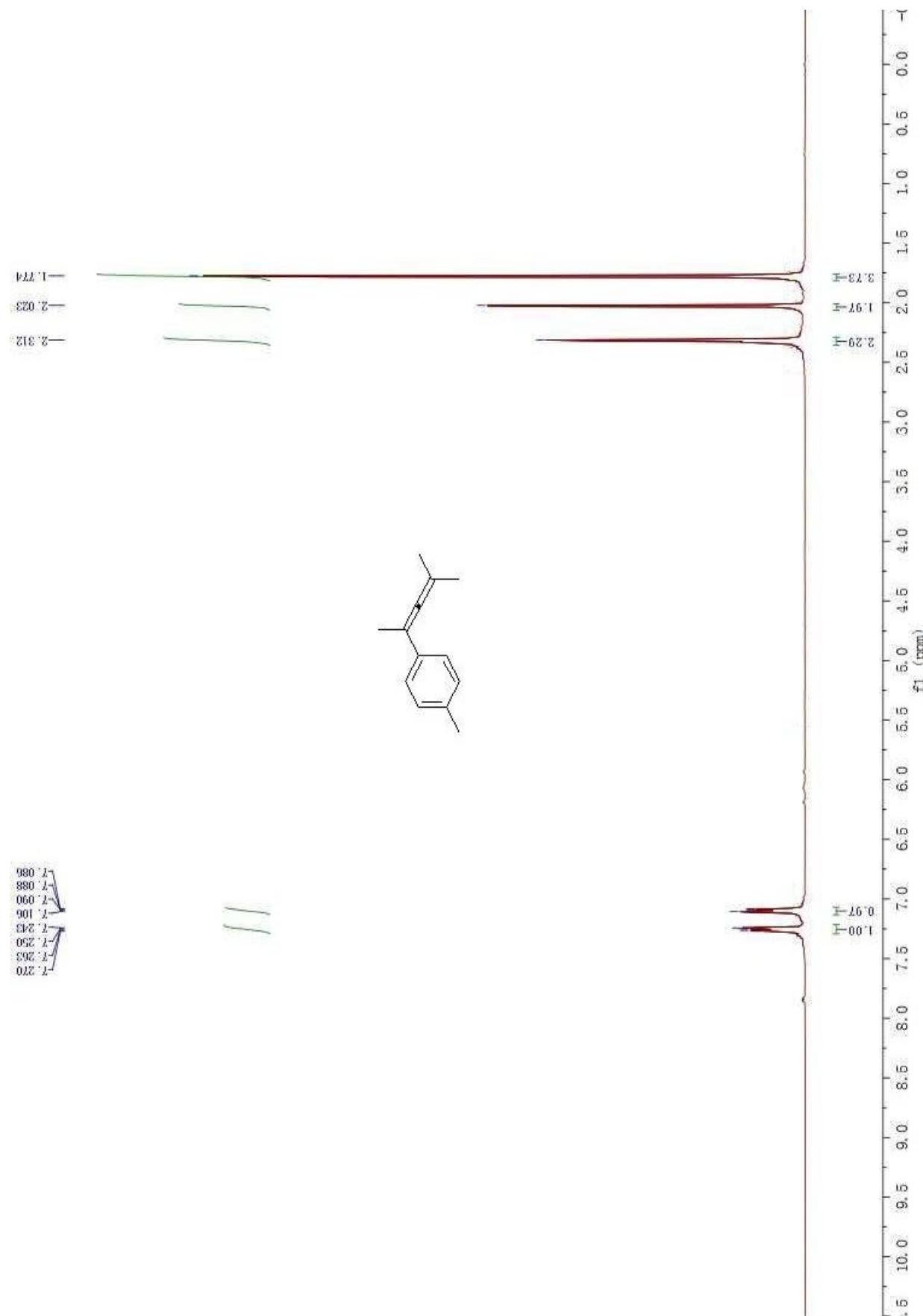
¹H NMR Spectrum of 1-(4-methylpenta-2,3-dien-2-yl)benzene (**5a**)



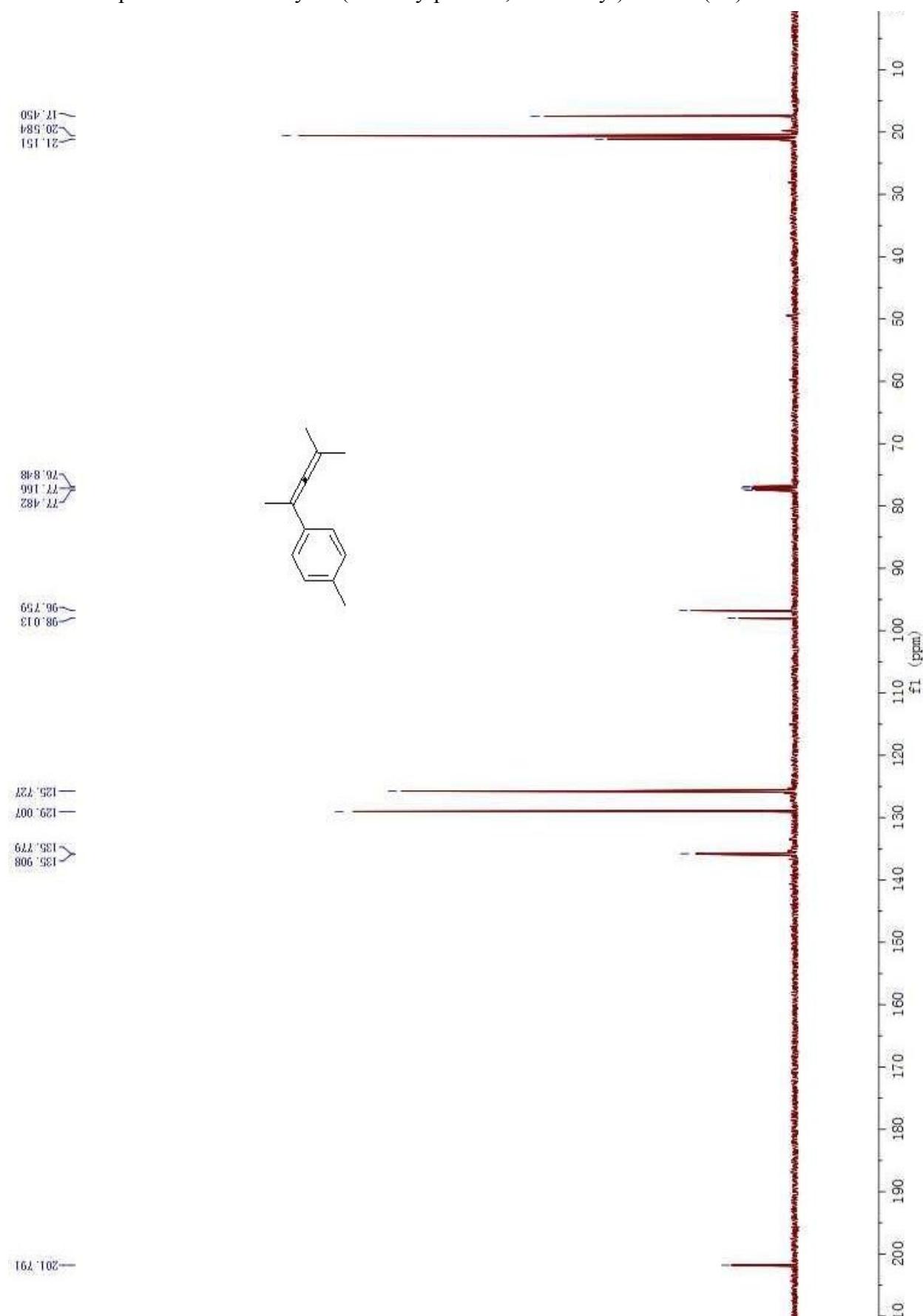
¹³C NMR Spectrum of 1-(4-methylpenta-2,3-dien-2-yl)benzene (**5a**)



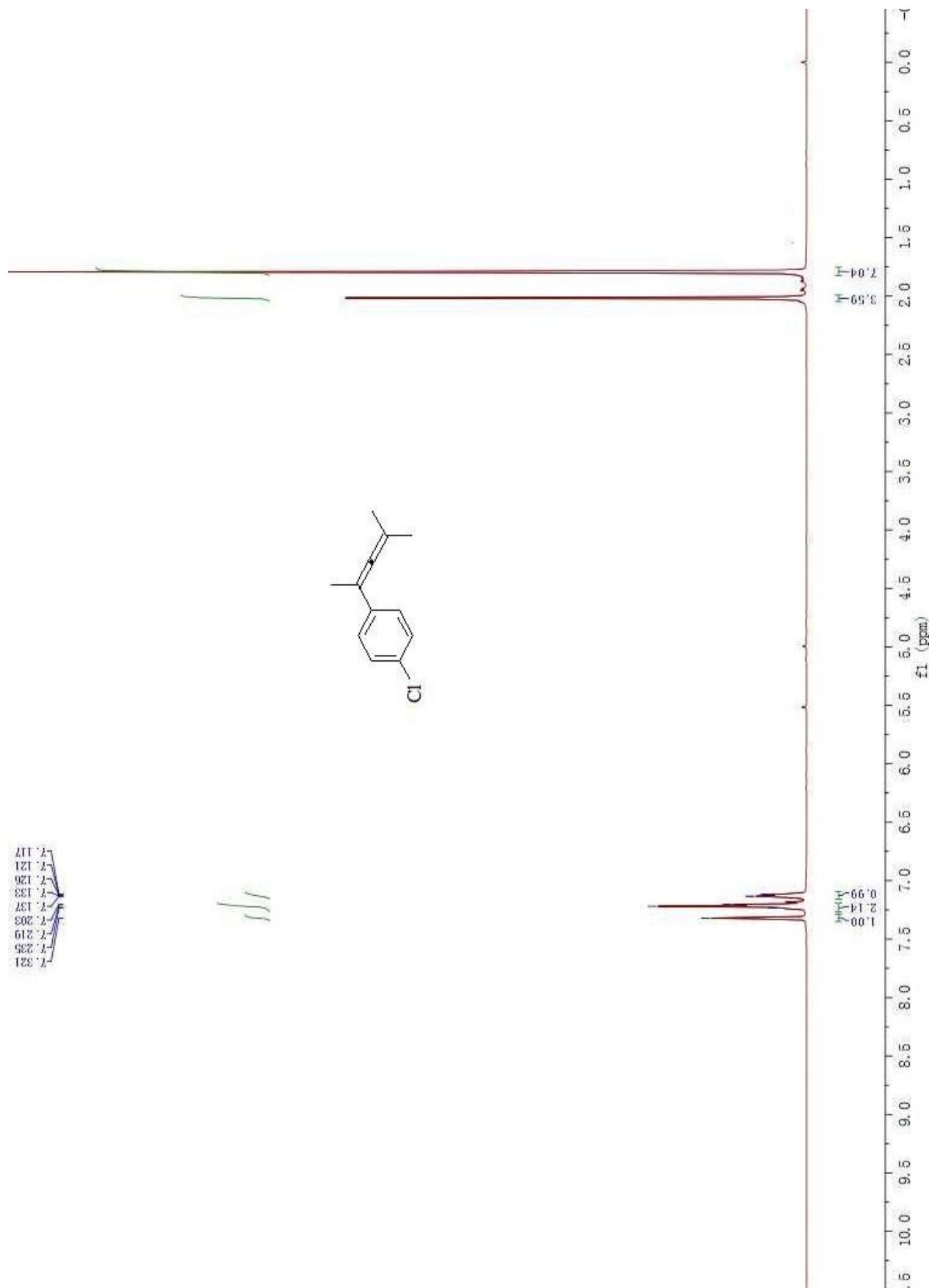
¹H NMR Spectrum of 1-methyl-4-(4-methylpenta-2,3-dien-2-yl)benzene(**5b**)



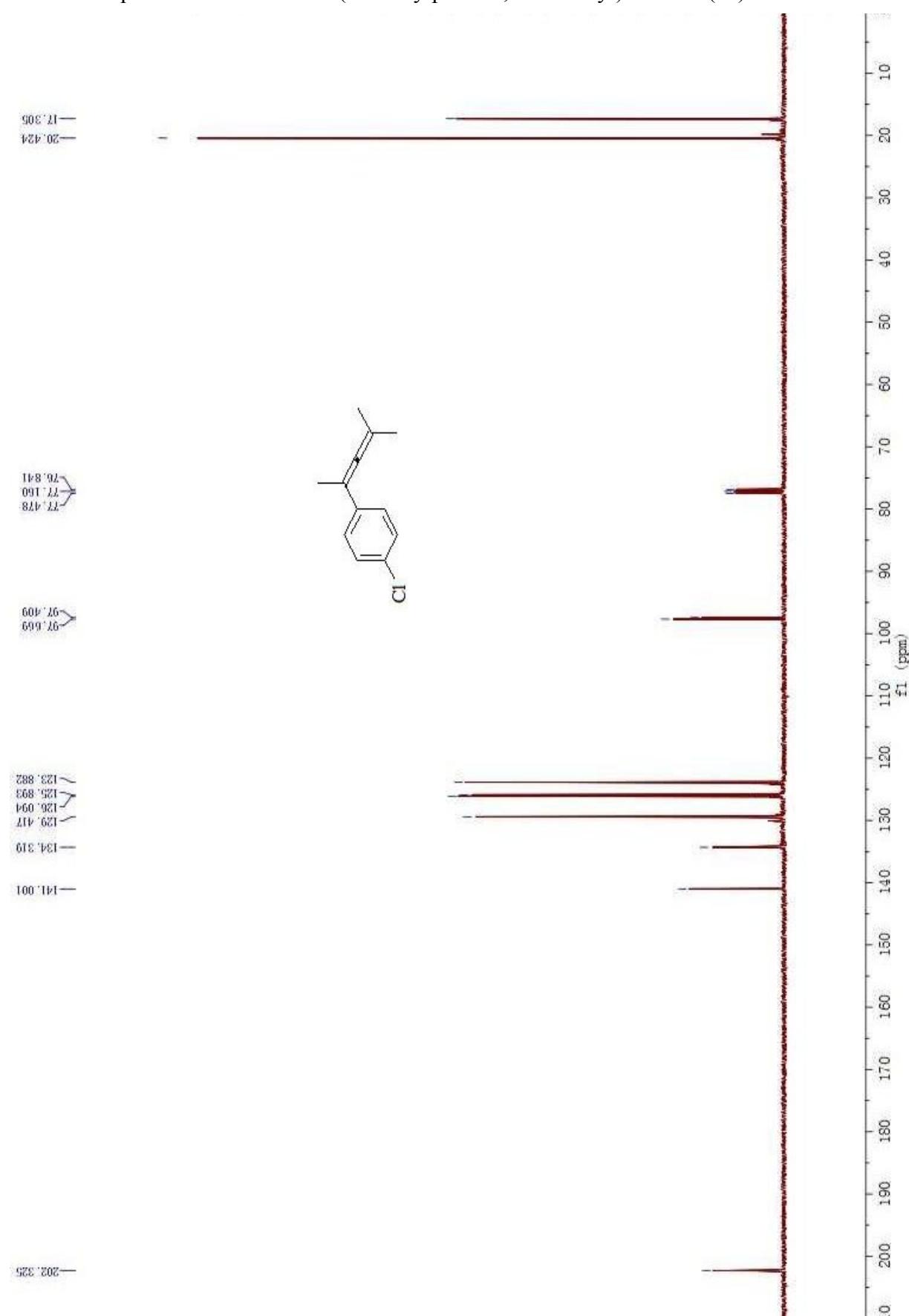
¹³C NMR Spectrum of 1-methyl-4-(4-methylpenta-2,3-dien-2-yl)benzene(**5b**)



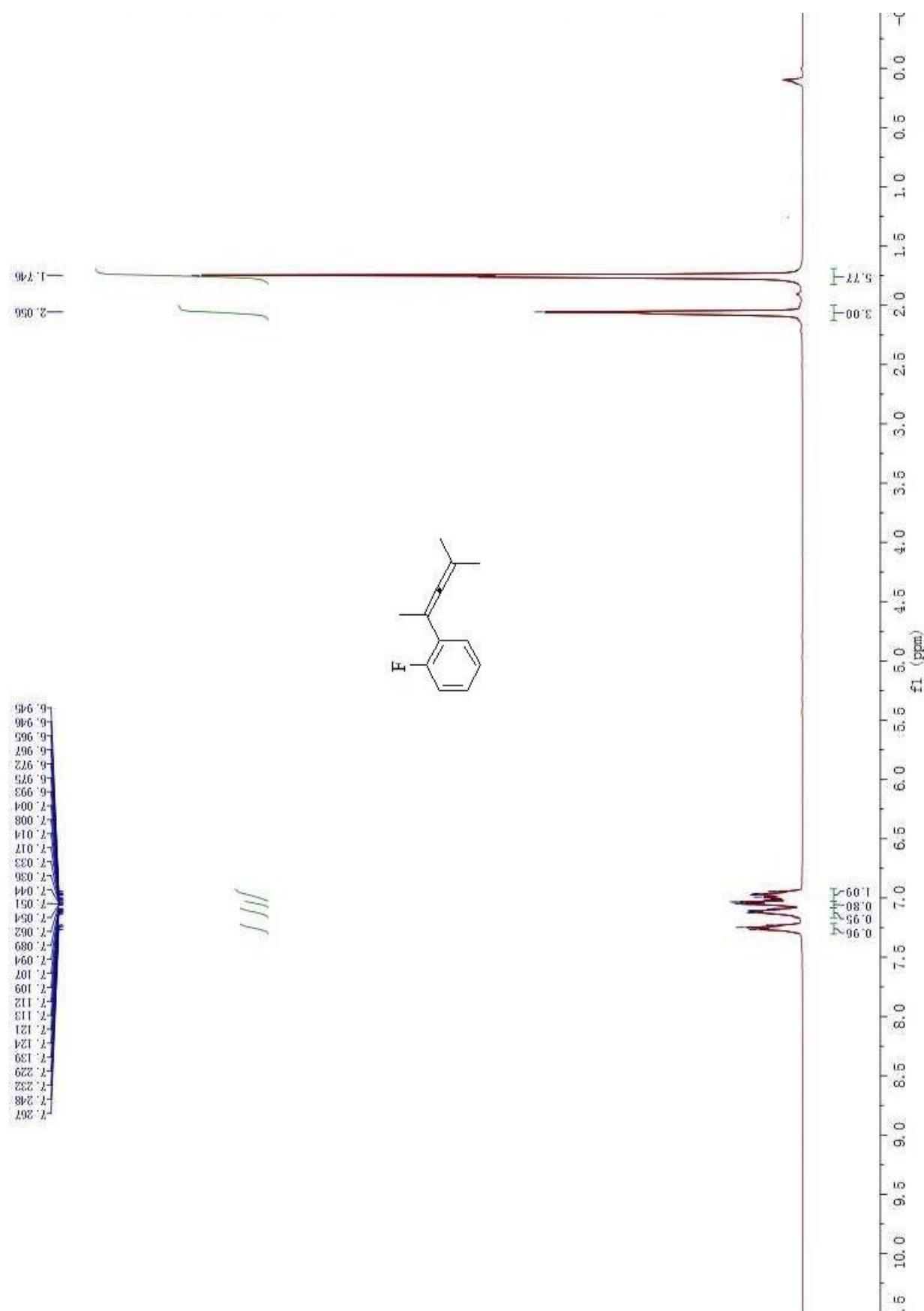
¹H NMR Spectrum of 1-chloro-3-(4-methylpenta-2,3-dien-2-yl)benzene (**5c**)



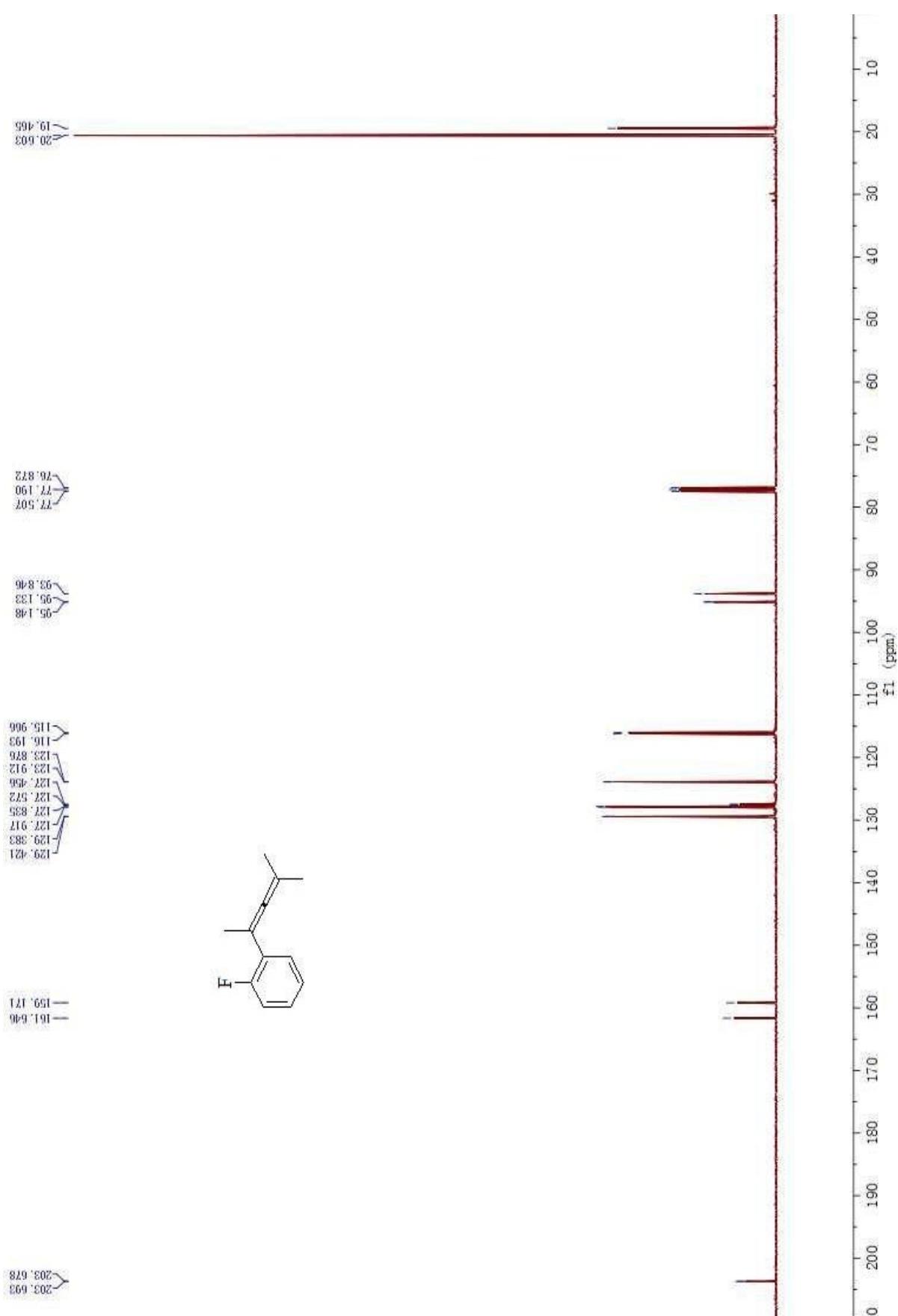
^{13}C NMR Spectrum of 1-chloro-3-(4-methylpenta-2,3-dien-2-yl)benzene (**5c**)



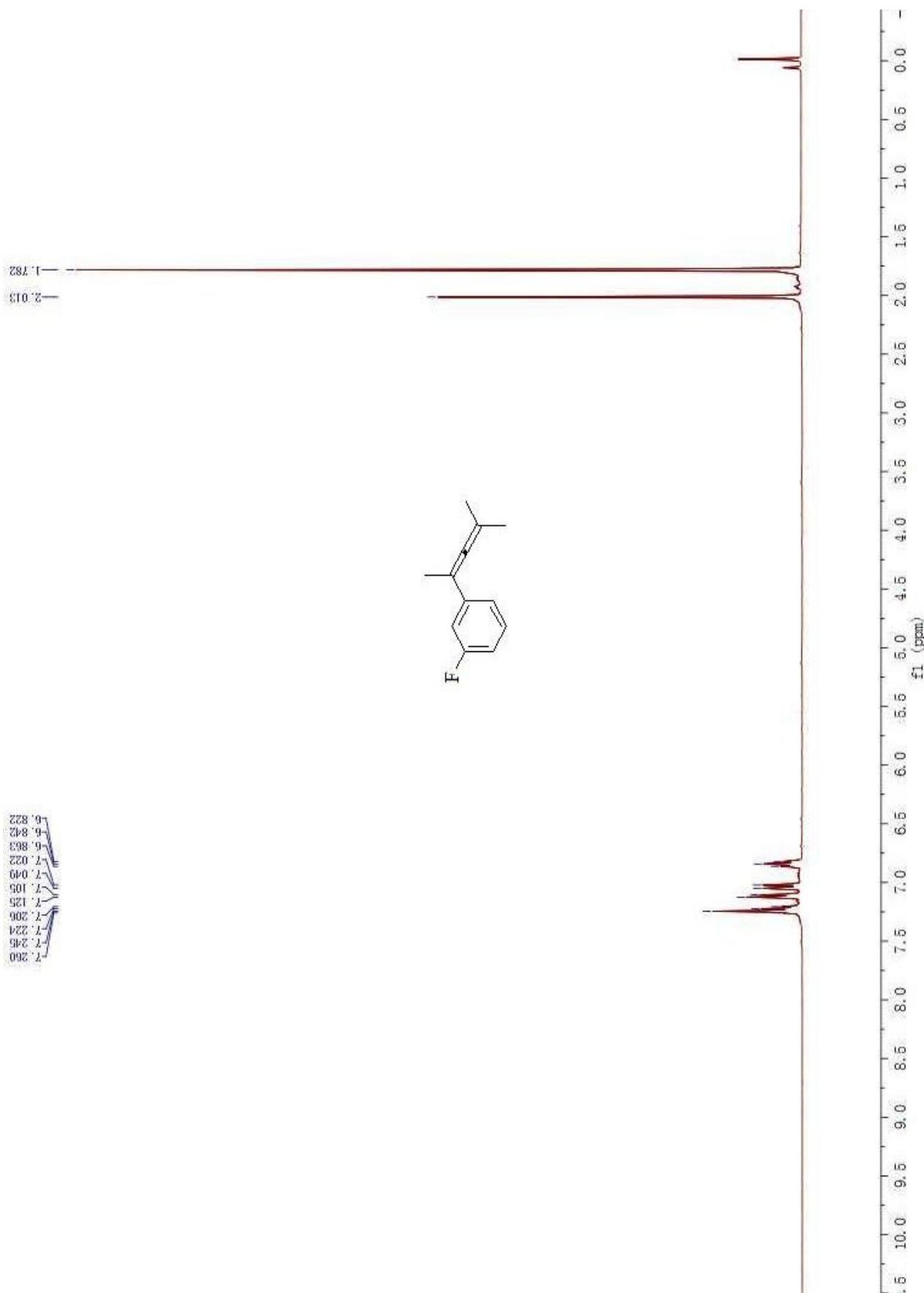
¹H NMR Spectrum of 1-flouro-2-(4-methylpenta-2,3-dien-2-yl)benzene (**5d**)



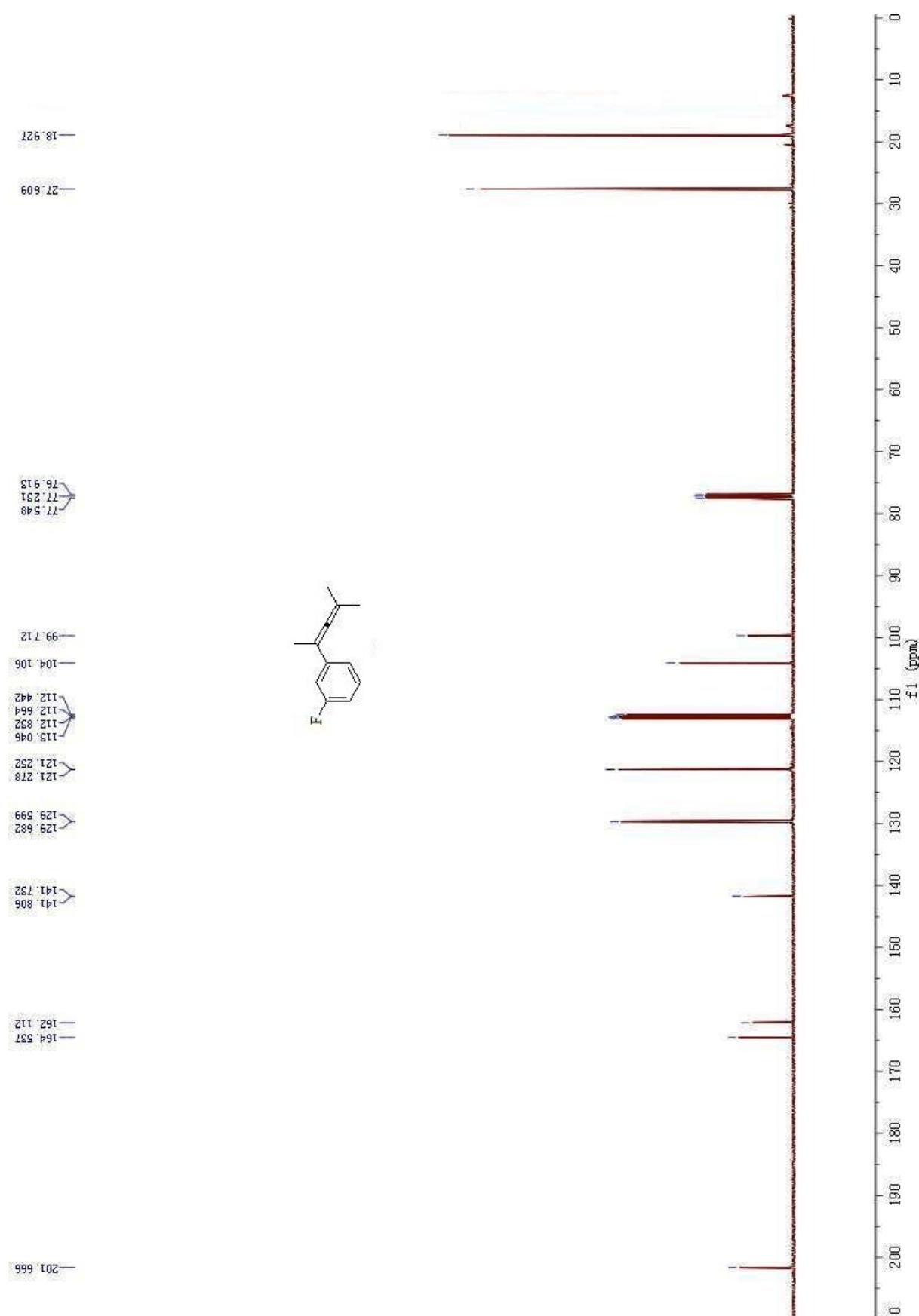
¹³C NMR Spectrum of 1-flouro-2-(4-methylpenta-2,3-dien-2-yl)benzene (**5d**)



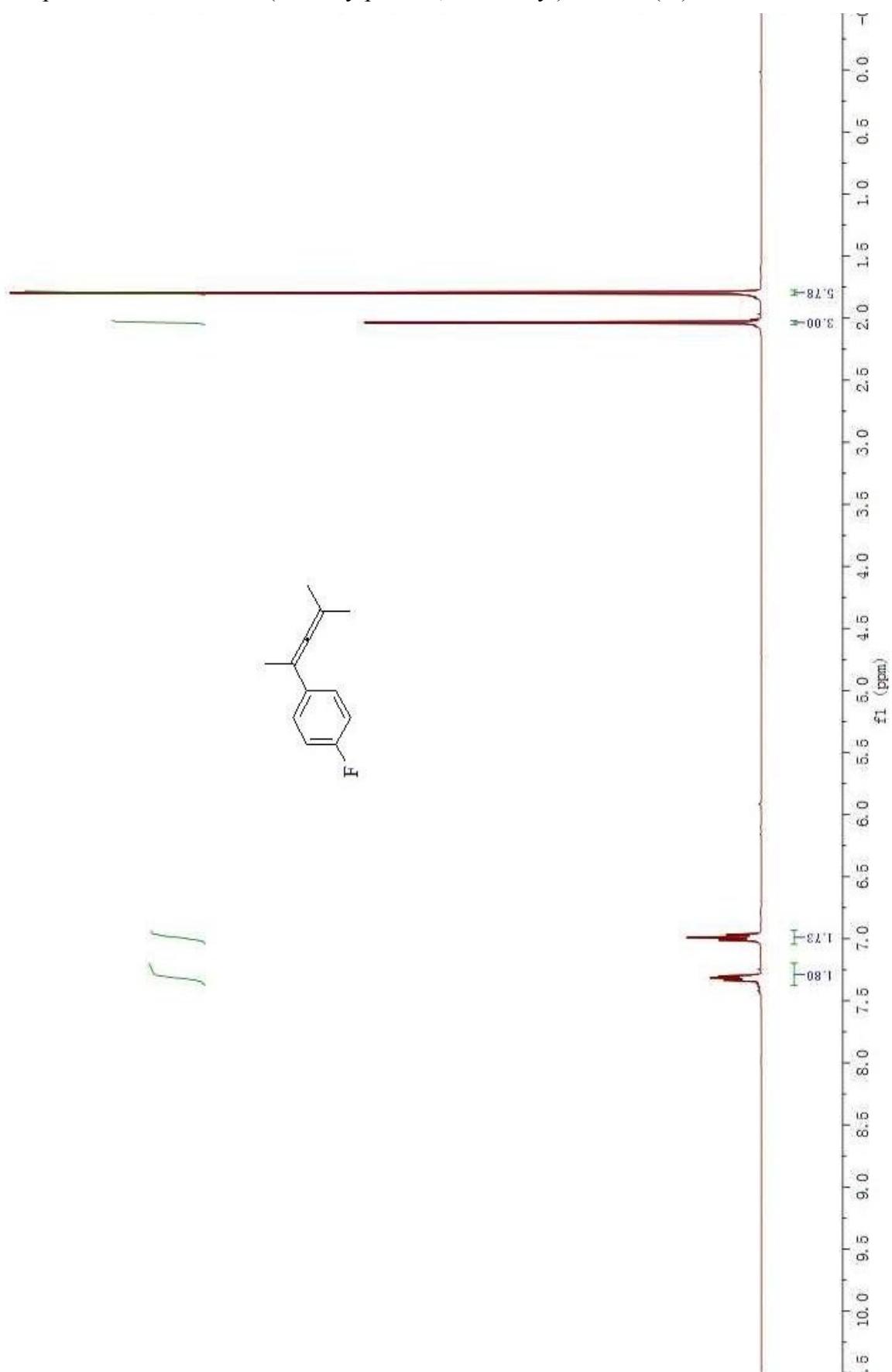
¹H NMR Spectrum of 1-flouro-3-(4-methylpenta-2,3-dien-2-yl)benzene (**5e**)



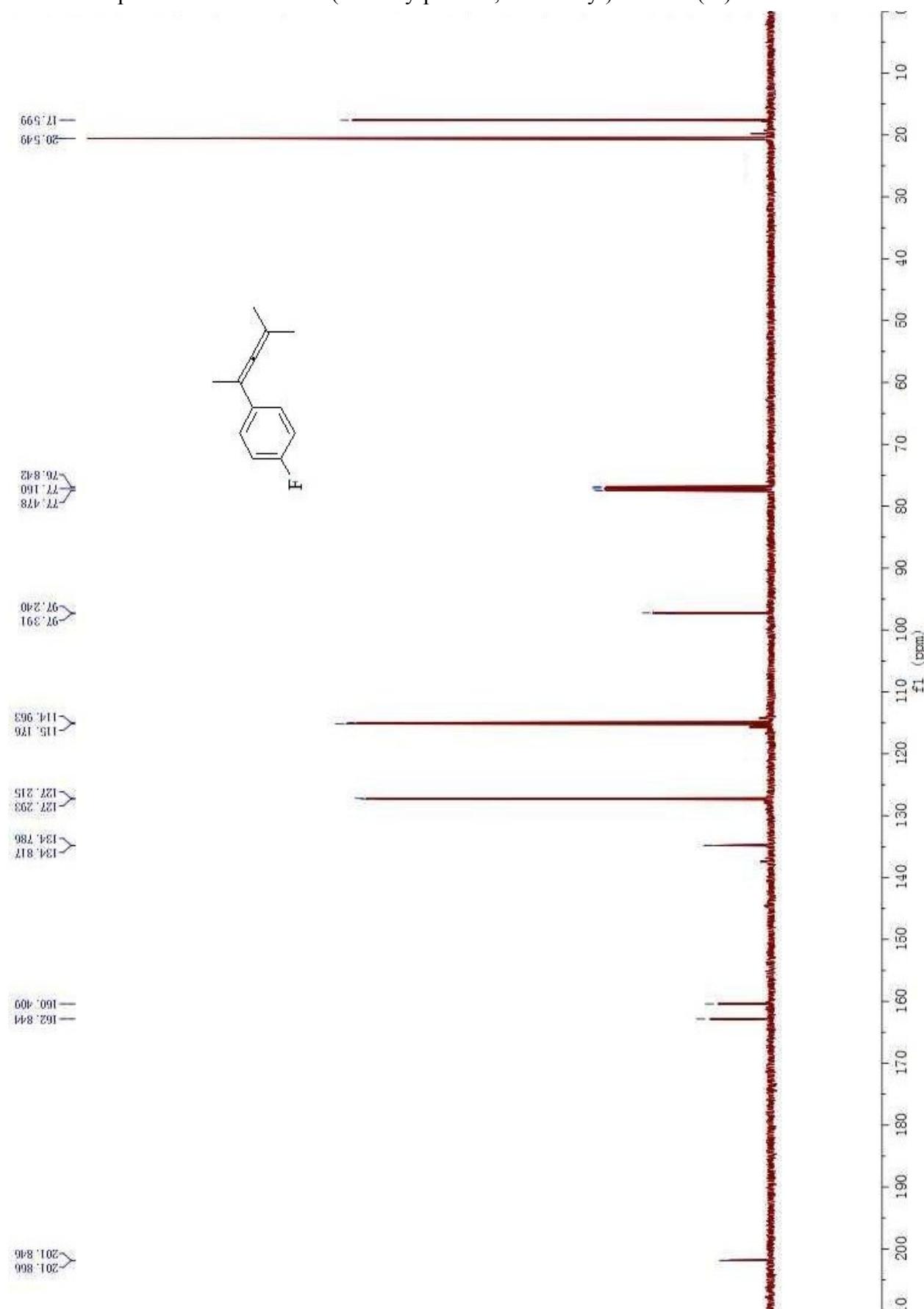
¹³C NMR Spectrum of 1-flouro-3-(4-methylpenta-2,3-dien-2-yl)benzene (**5e**):



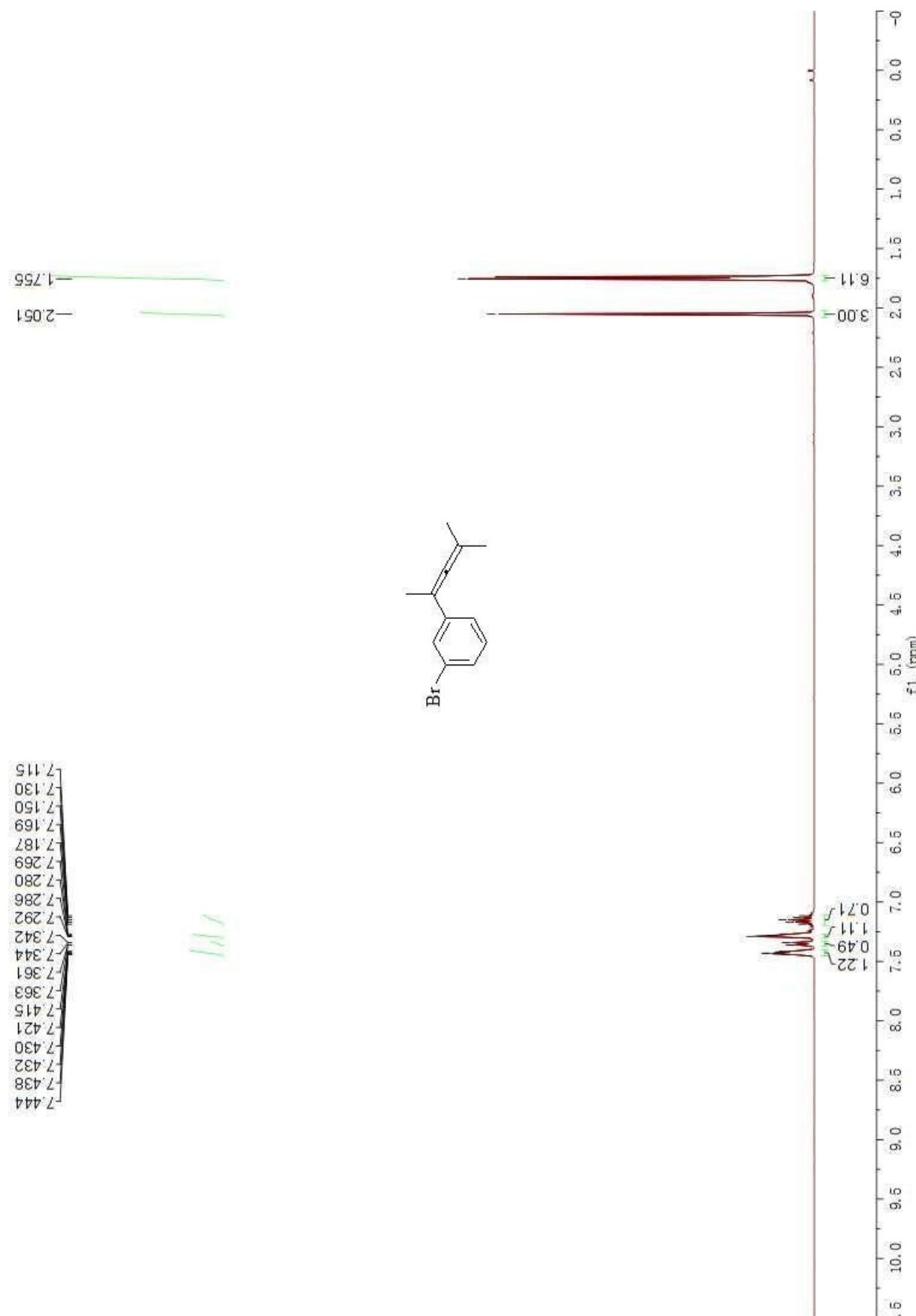
¹H NMR Spectrum of 1-fluoro-4-(4-methylpenta-2,3-dien-2-yl)benzene (**5f**)



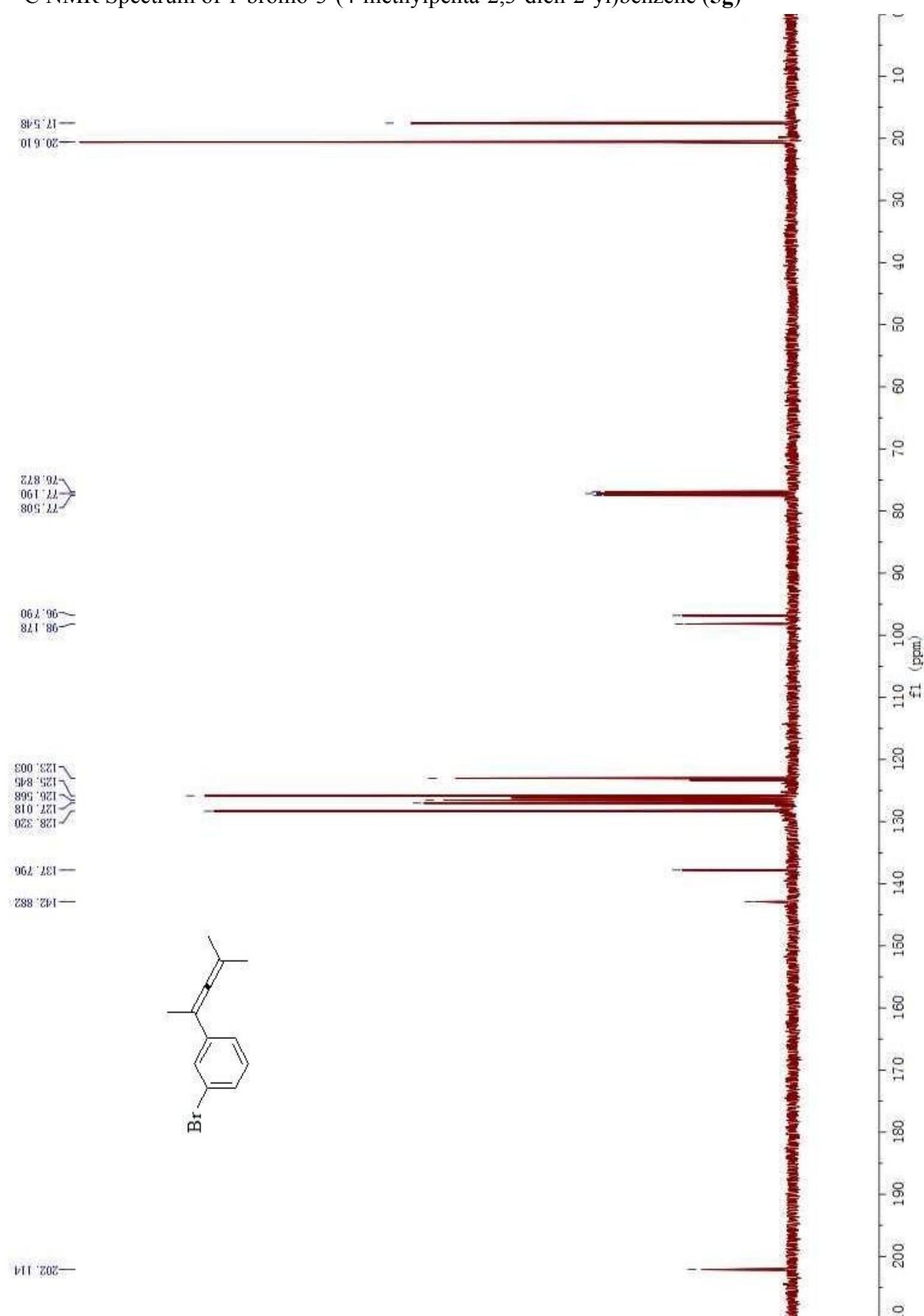
¹³C NMR Spectrum of 1-fluoro-4-(4-methylpenta-2,3-dien-2-yl)benzene (**5f**)



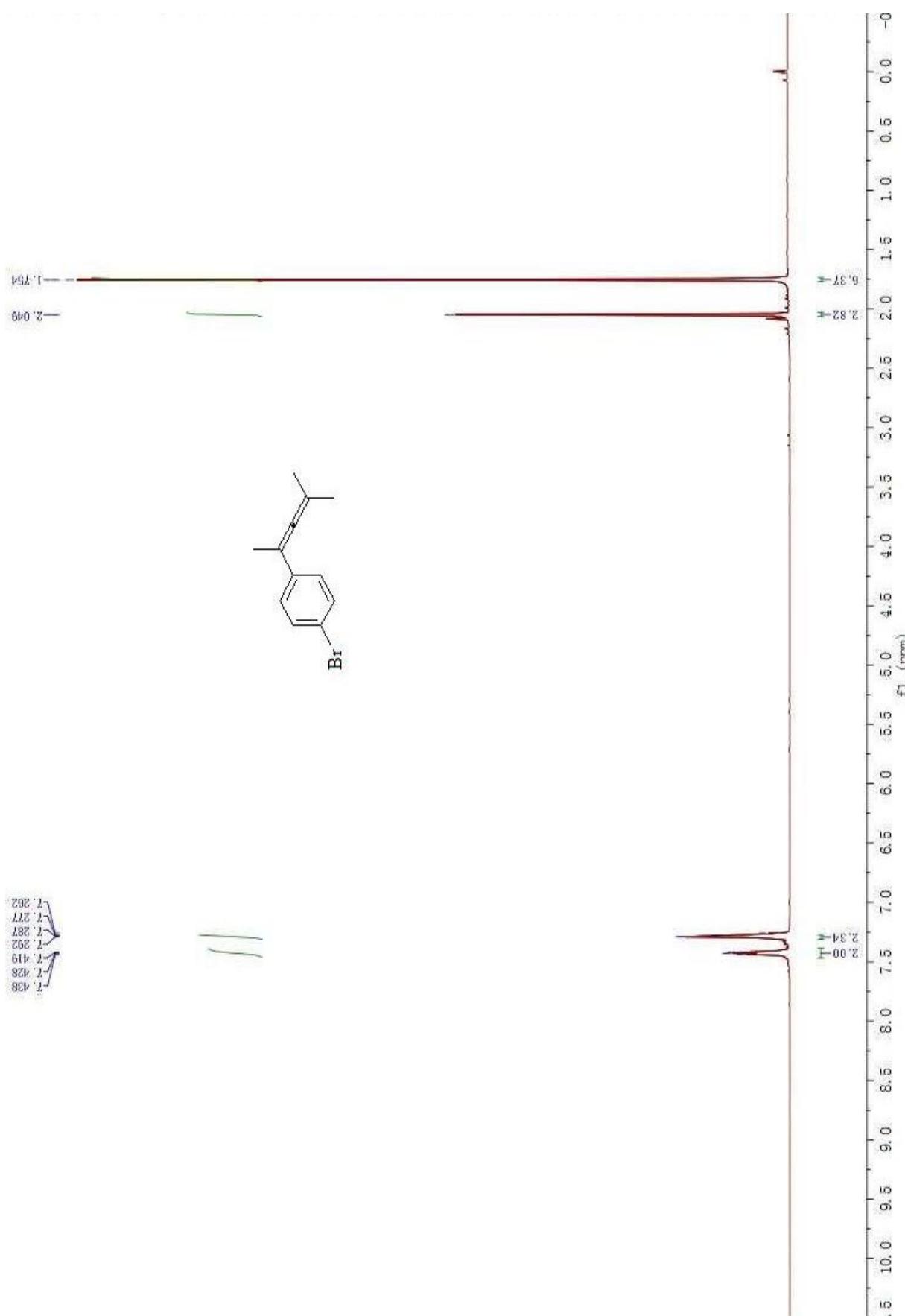
¹H NMR Spectrum of 1-bromo-3-(4-methylpenta-2,3-dien-2-yl)benzene (**5g**)



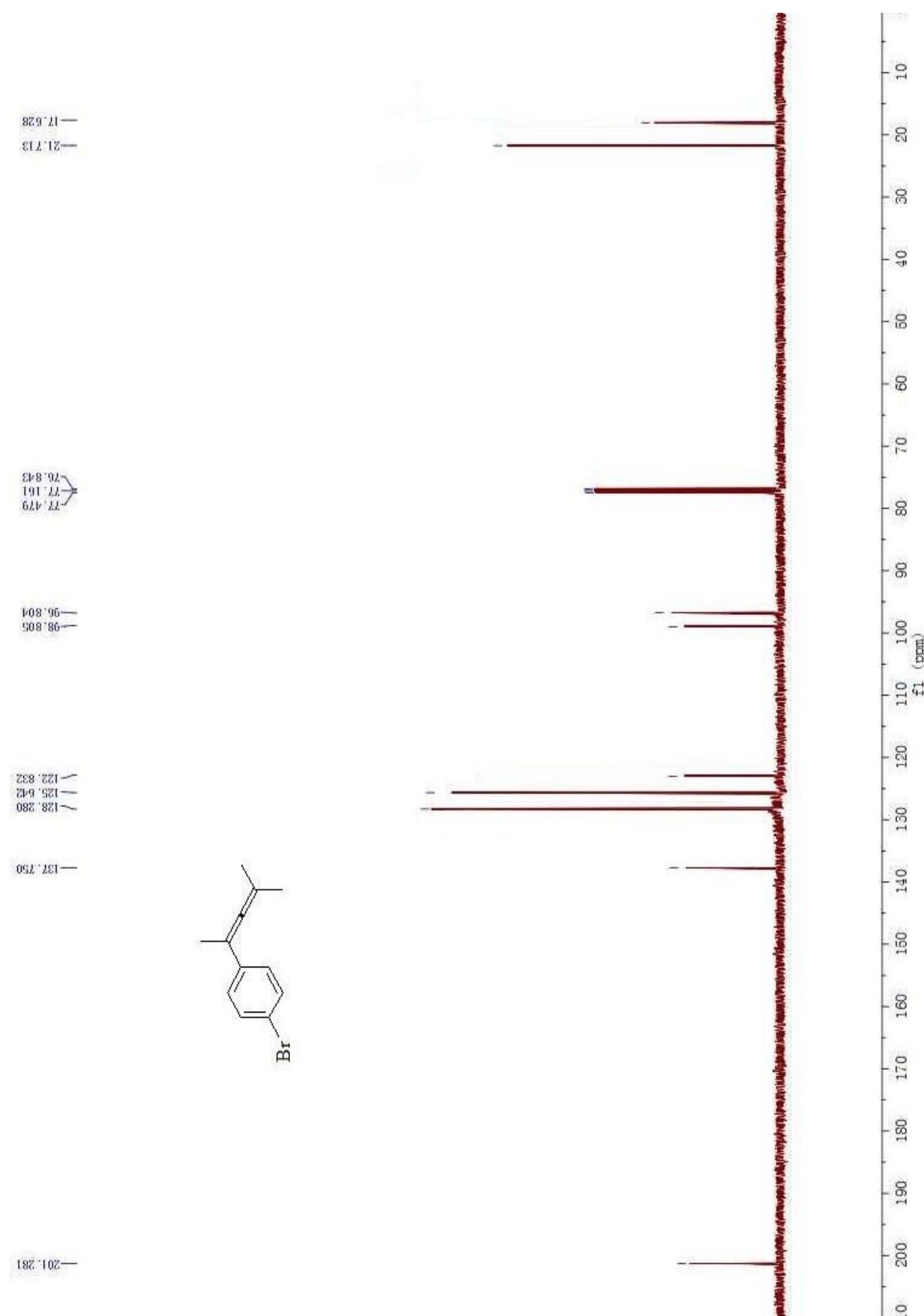
¹³C NMR Spectrum of 1-bromo-3-(4-methylpenta-2,3-dien-2-yl)benzene (**5g**)



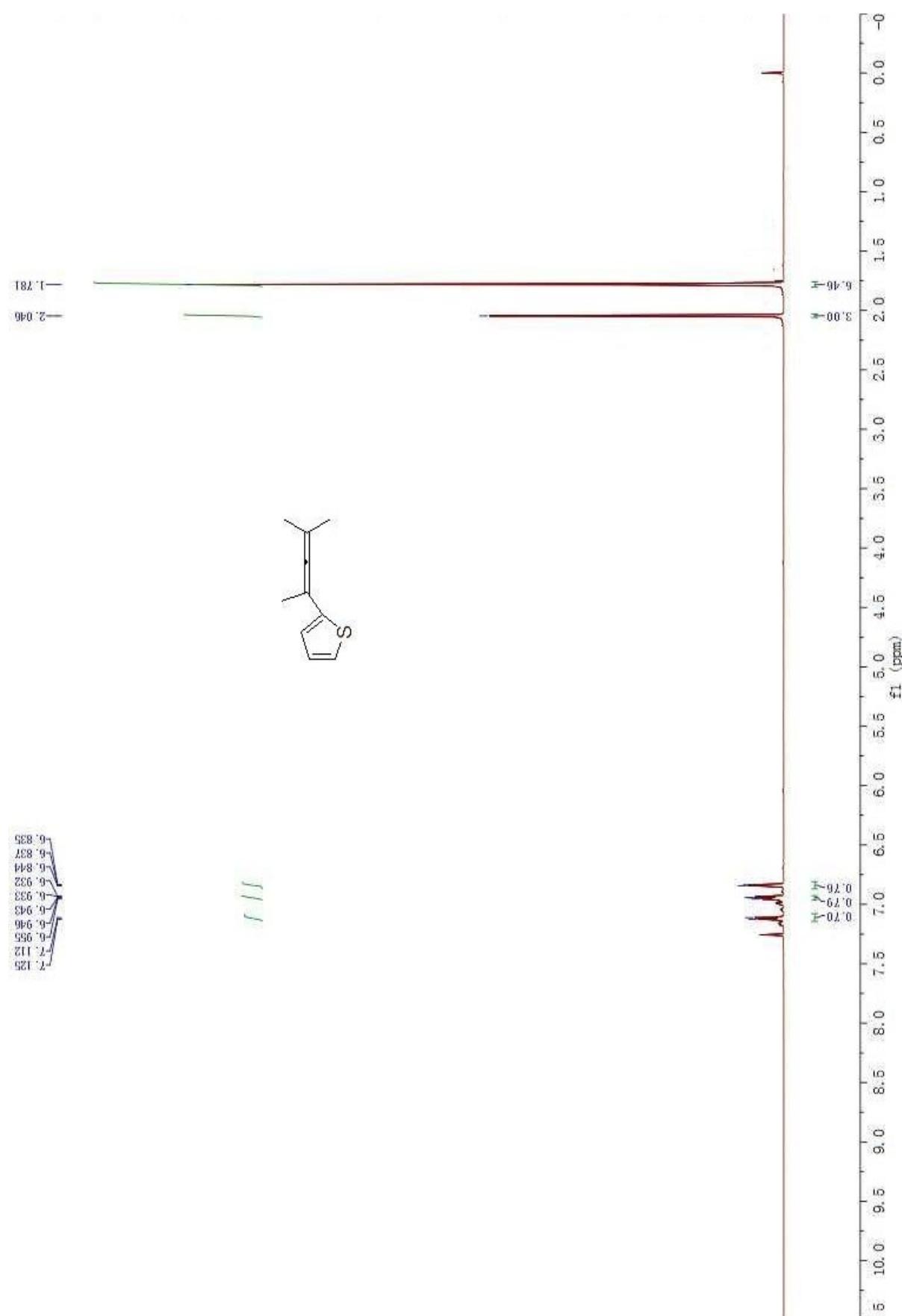
¹H NMR Spectrum of 1-bromo-4-(4-methylpenta-2,3-dien-2-yl)benzene (**5h**)



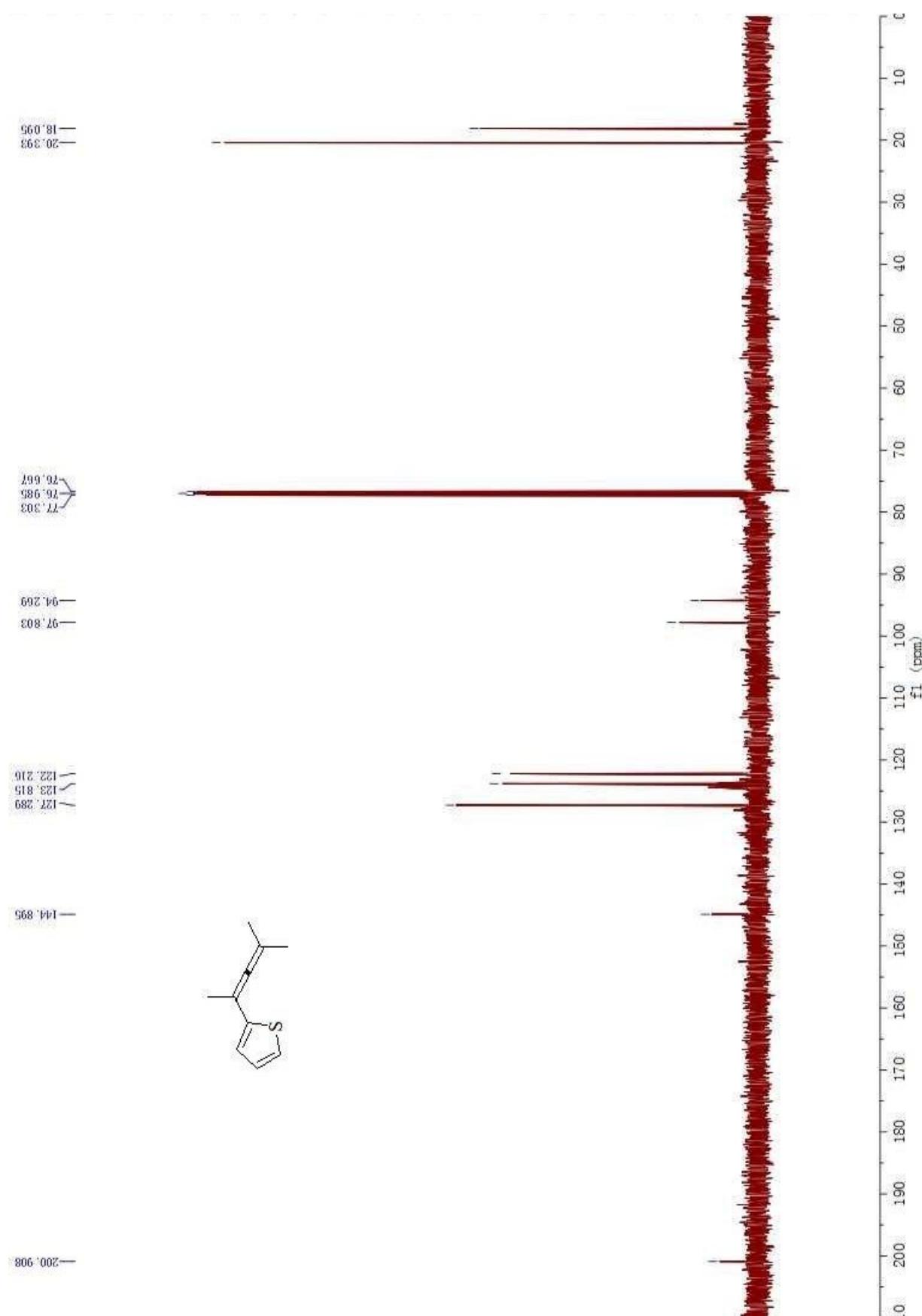
^{13}C NMR Spectrum of 1-bromo-4-(4-methylpenta-2,3-dien-2-yl)benzene (**5h**)



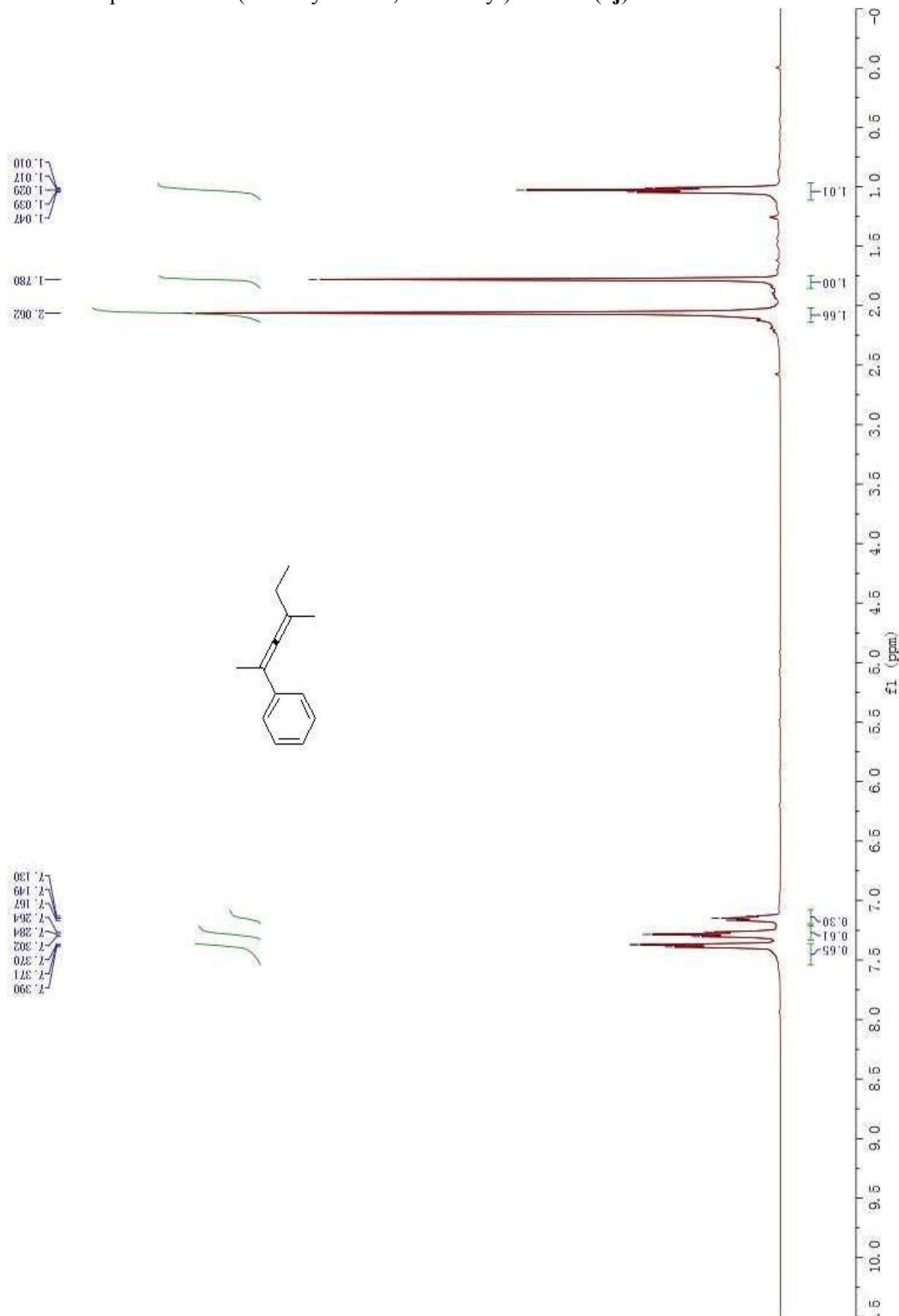
¹H NMR Spectrum of 2-(4-methylpenta-2,3-dien-2-yl)thiophene (**5i**)



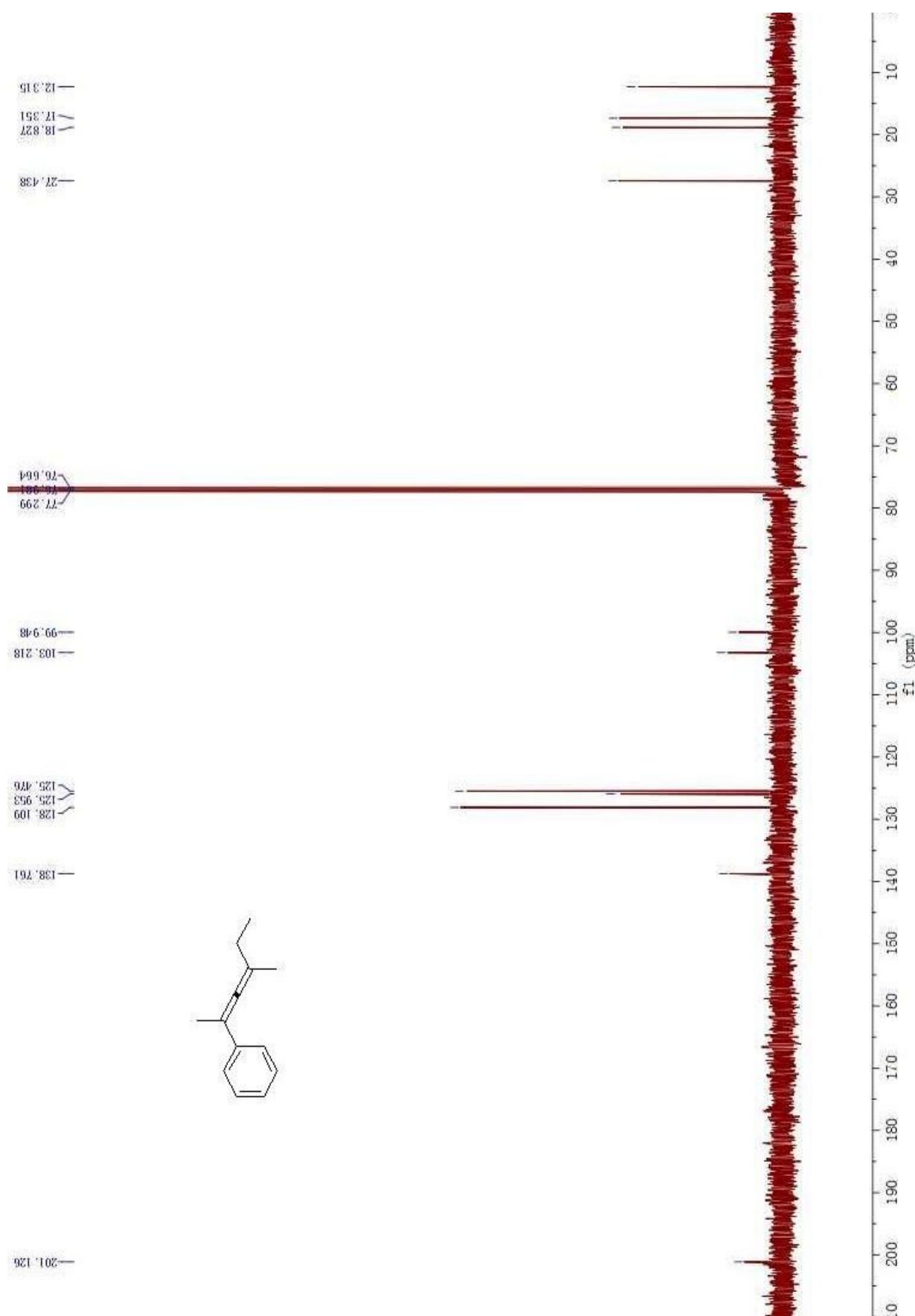
¹³C NMR Spectrum of 2-(4-methylpenta-2,3-dien-2-yl)thiophene (**5i**)



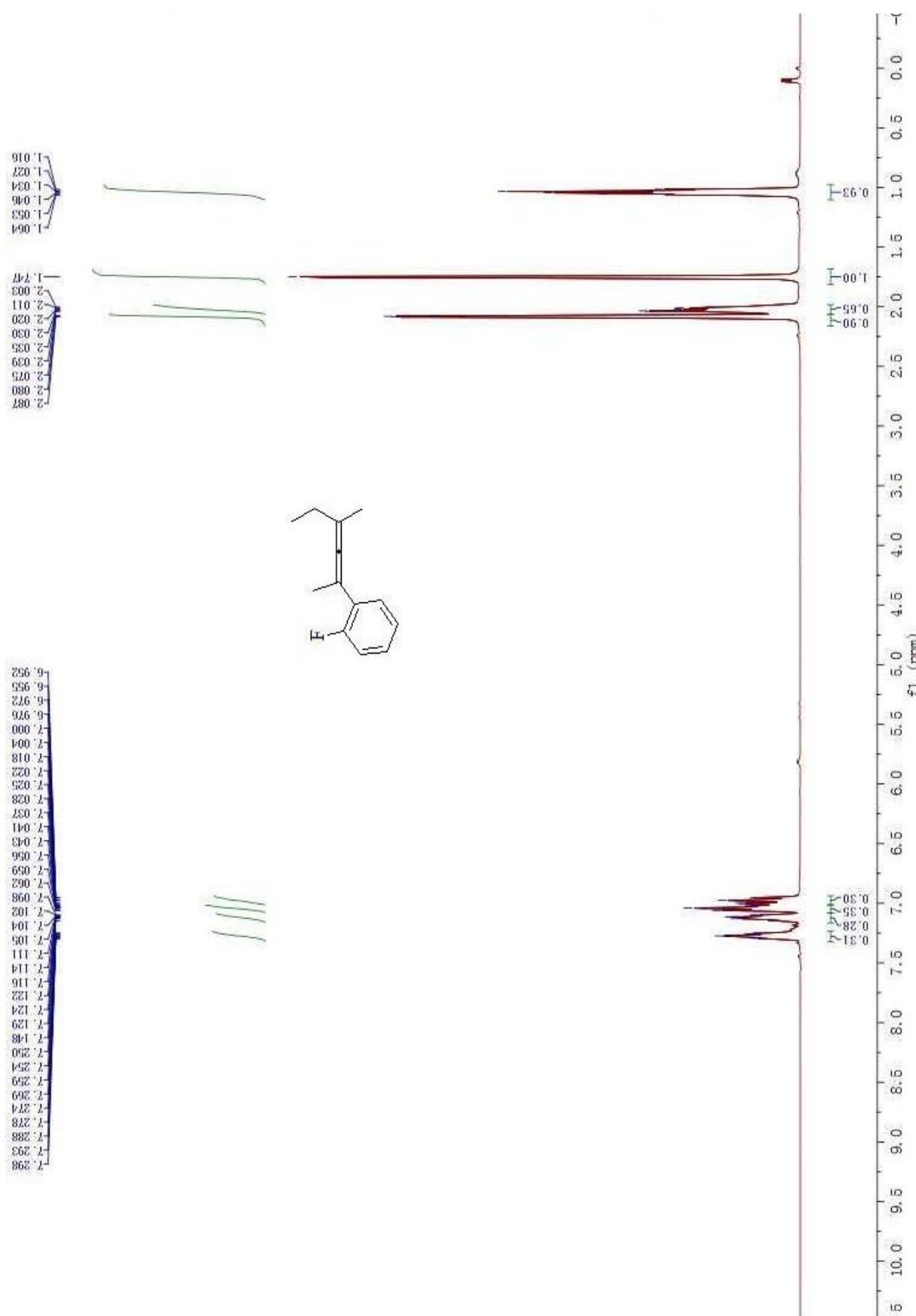
¹H NMR Spectrum of 1-(4-methylhexa-2,3-dien-2-yl)benzene (**5j**)



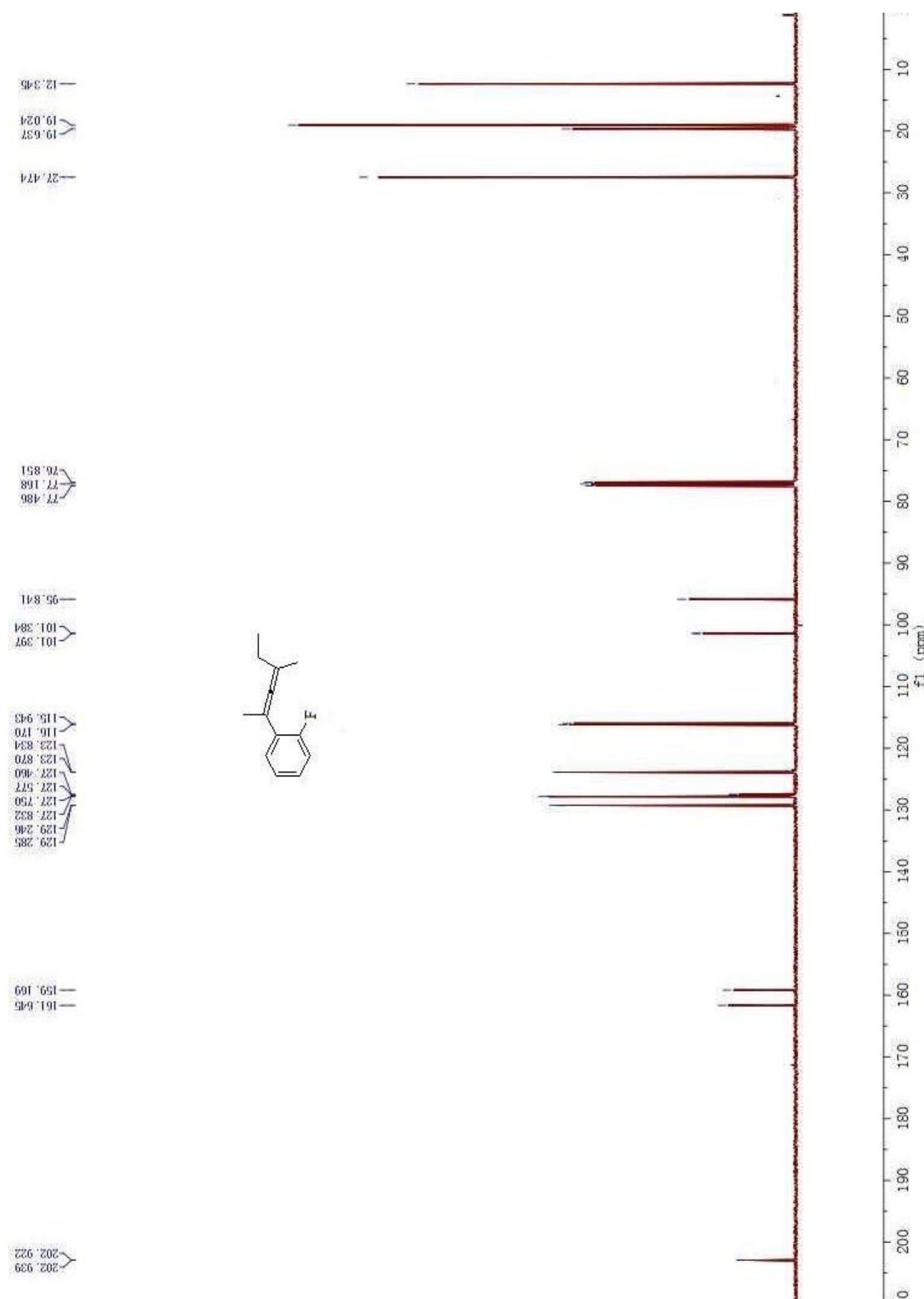
¹³C NMR Spectrum of 1-(4-methylhexa-2,3-dien-2-yl)benzene (**5j**)



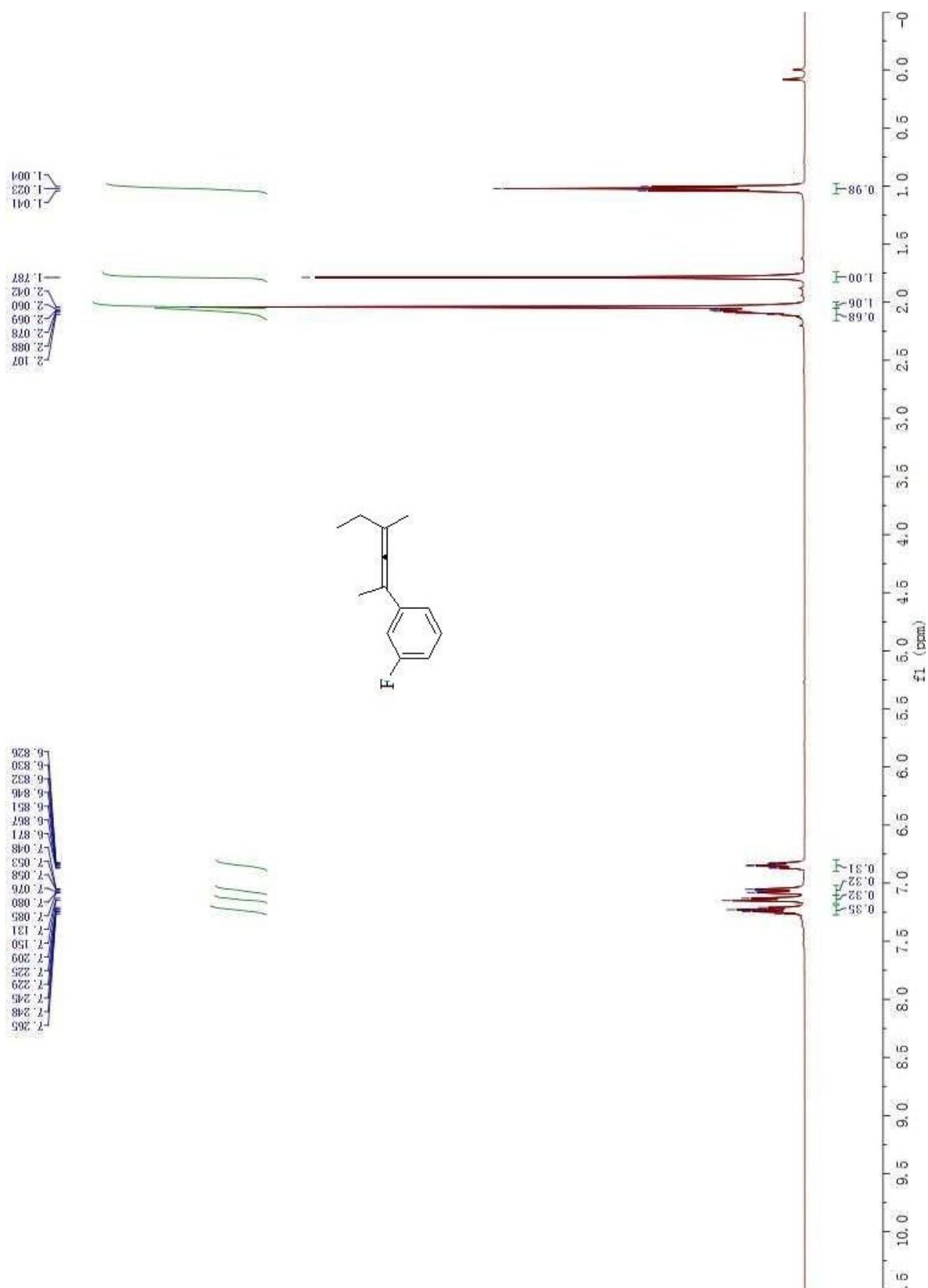
¹H NMR Spectrum of 1-fluoro-2-(4-methylhexa-2,3-dien-2-yl)benzene (**5k**)



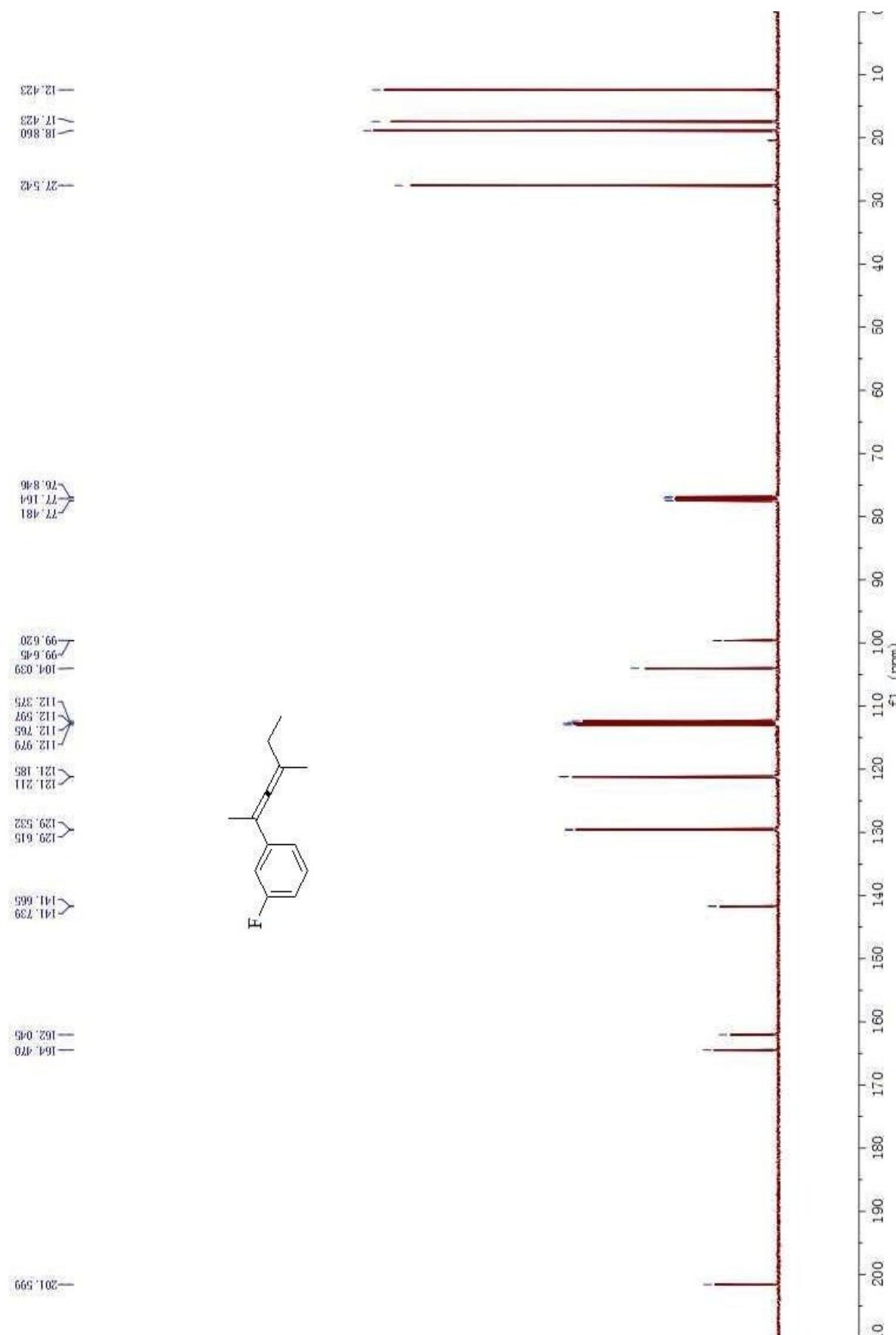
¹³C NMR Spectrum of 1-fluoro-2-(4-methylhexa-2,3-dien-2-yl)benzene (**5k**)



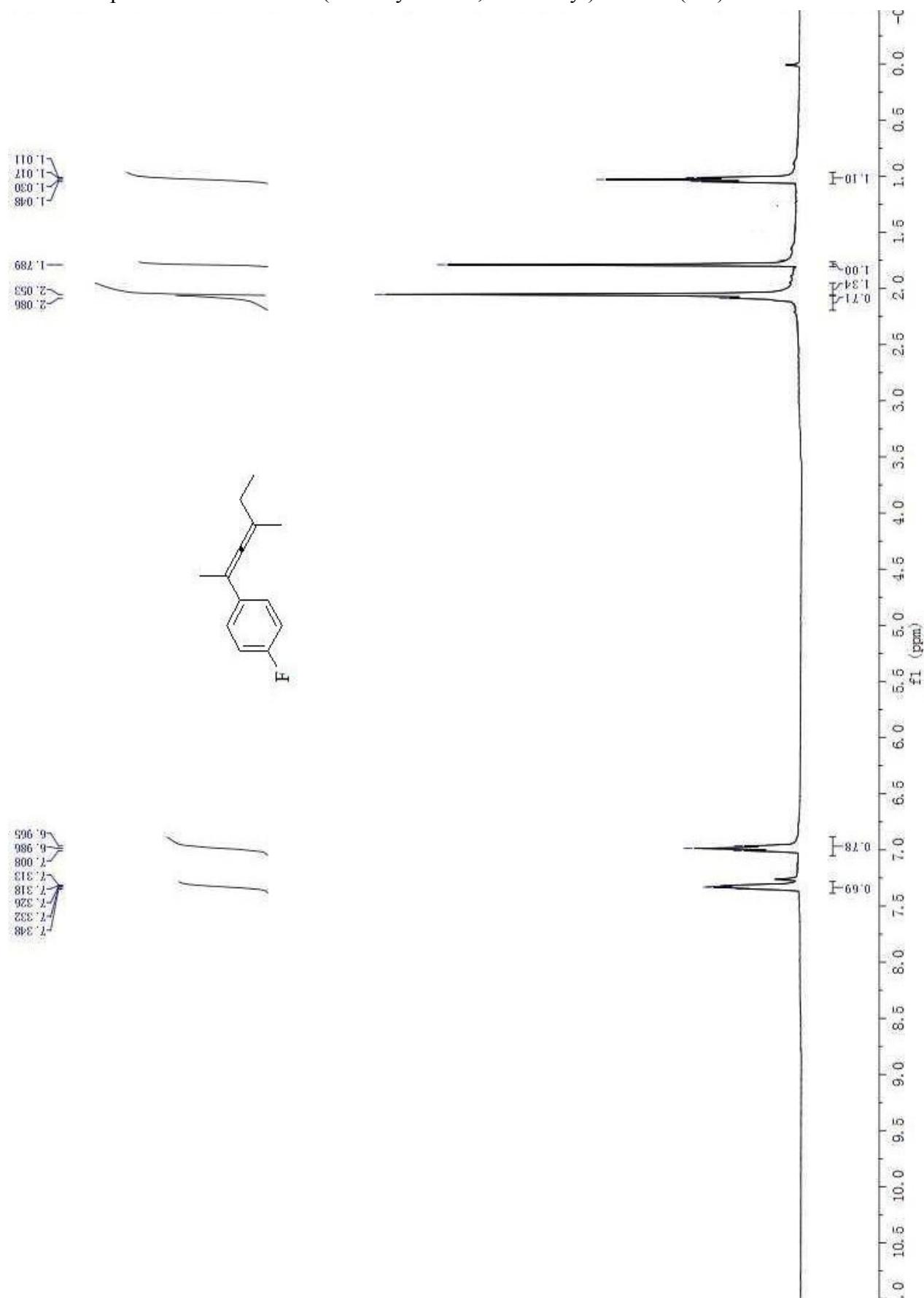
¹H NMR Spectrum of 1-fluoro-3-(3-methylhexa-2,3-dien-2-yl)benzene (**5l**)



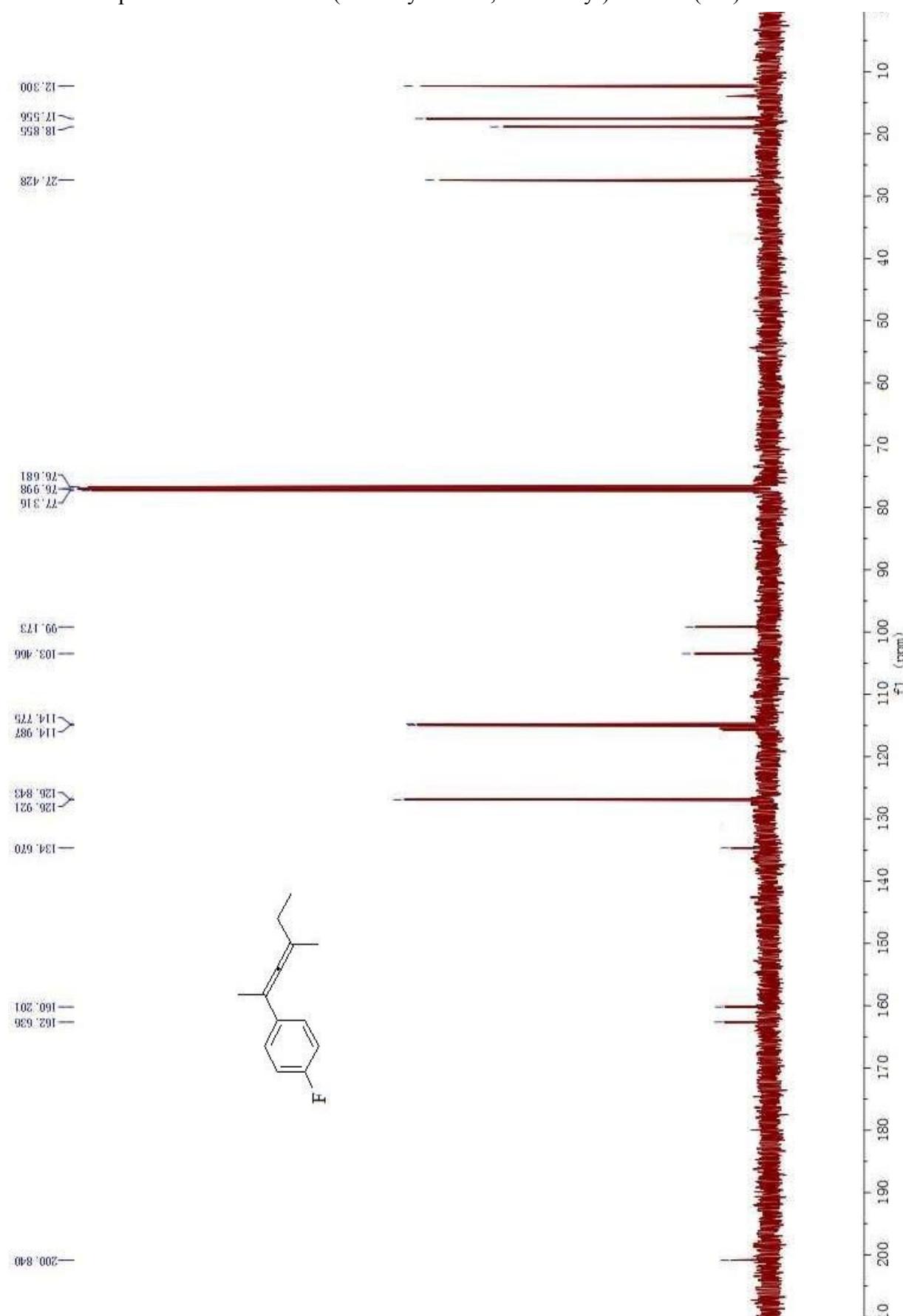
¹³C NMR Spectrum of 1-fluoro-3-(3-methylhexa-2,3-dien-2-yl)benzene (**5l**)



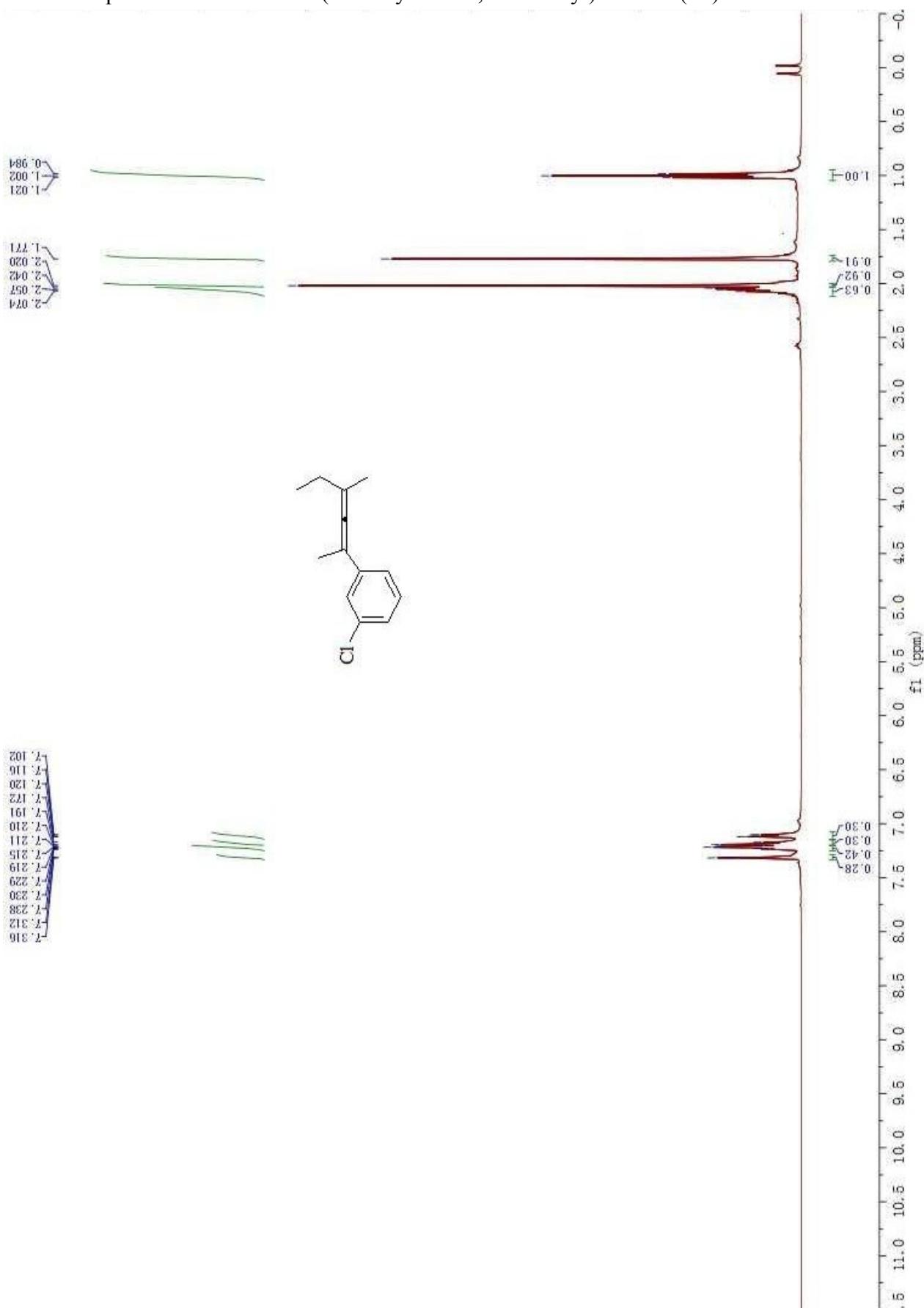
¹H NMR Spectrum of 1-fluoro-4-(4-methylhexa-2,3-dien-2-yl)benzene (**5m**)



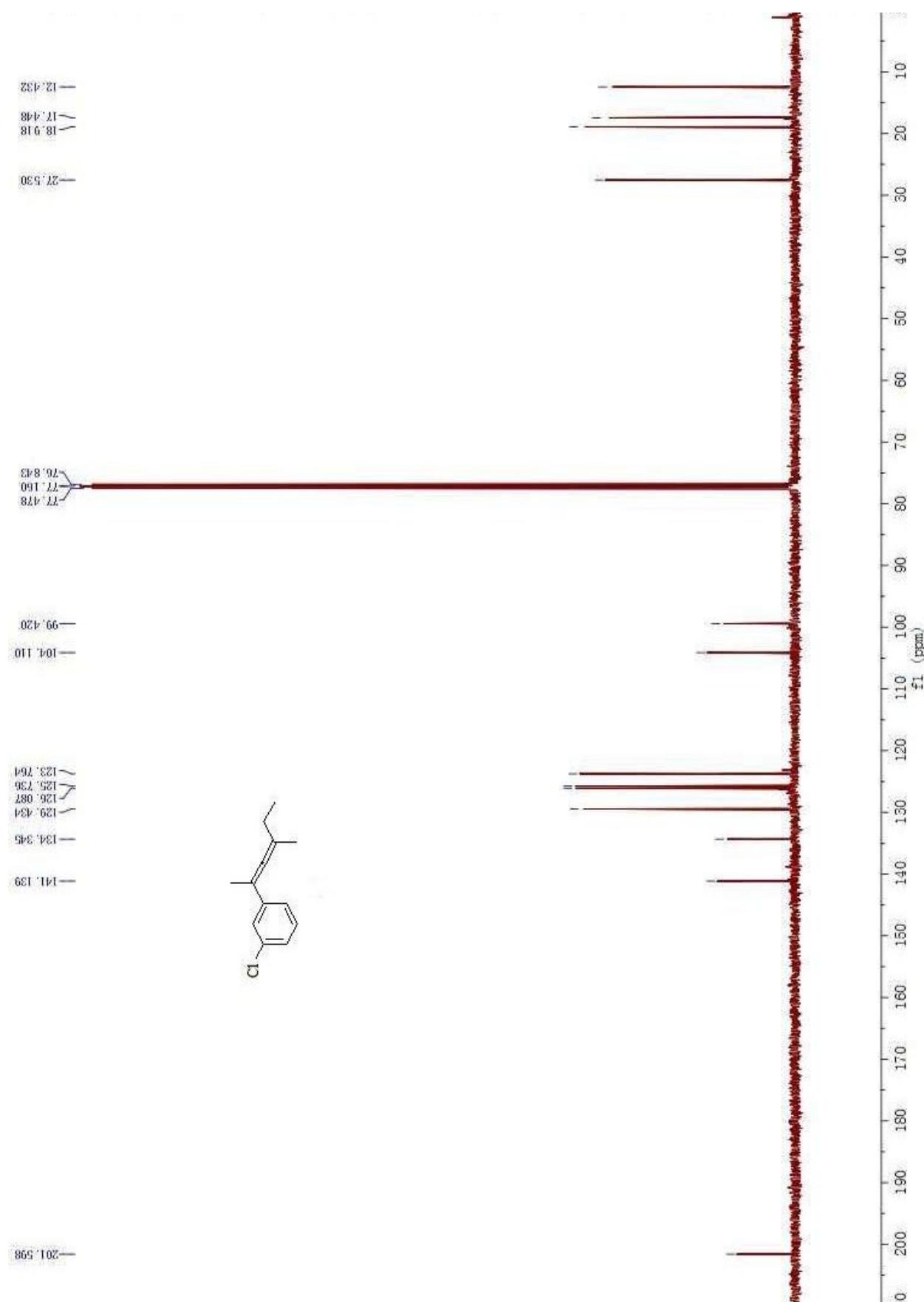
¹³C NMR Spectrum of 1-fluoro-4-(4-methylhexa-2,3-dien-2-yl)benzene (**5m**)



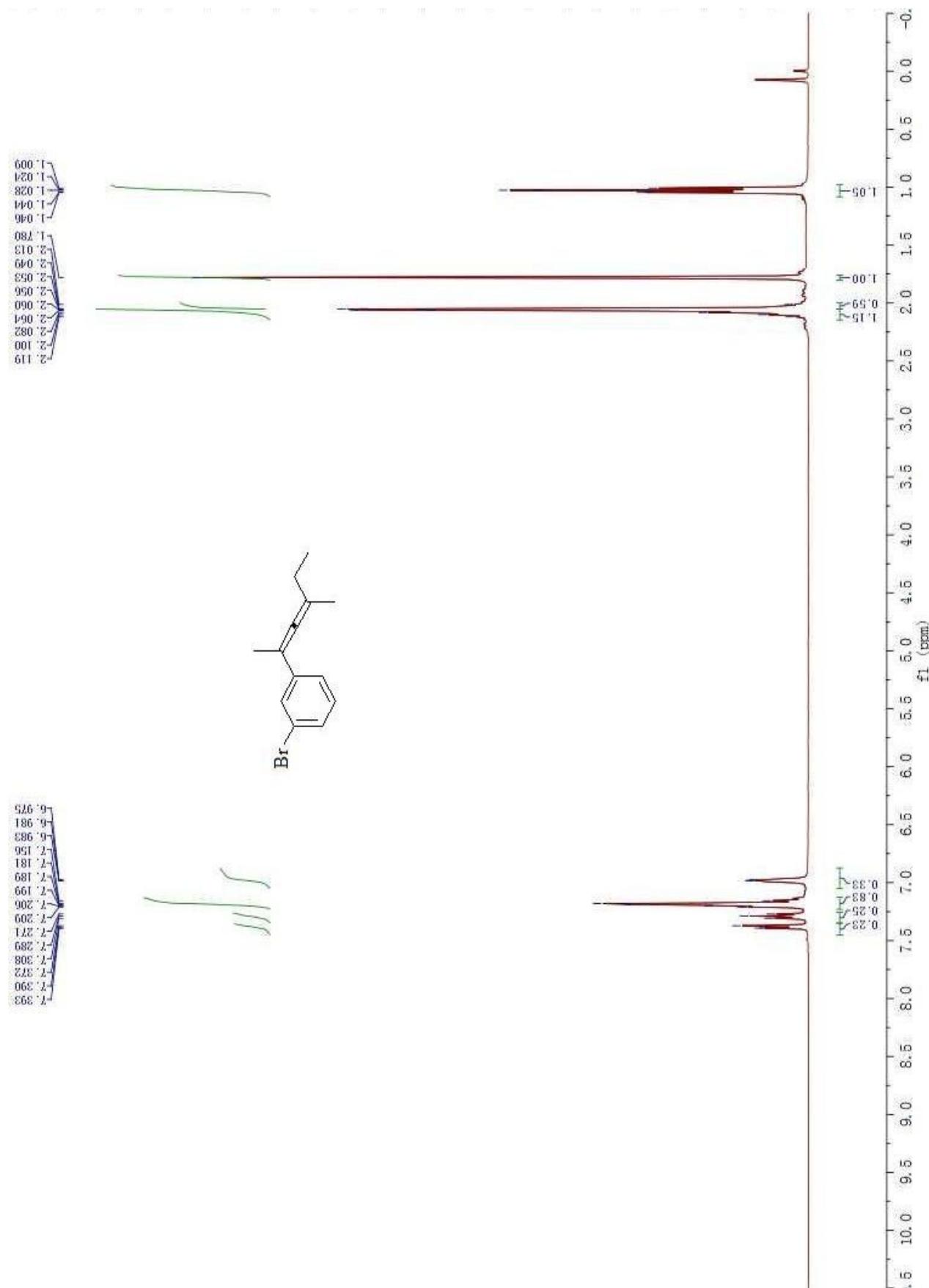
¹H NMR Spectrum of 1-chloro-3-(4-methylhexa-2,3-dien-2-yl)benzene (**5n**)



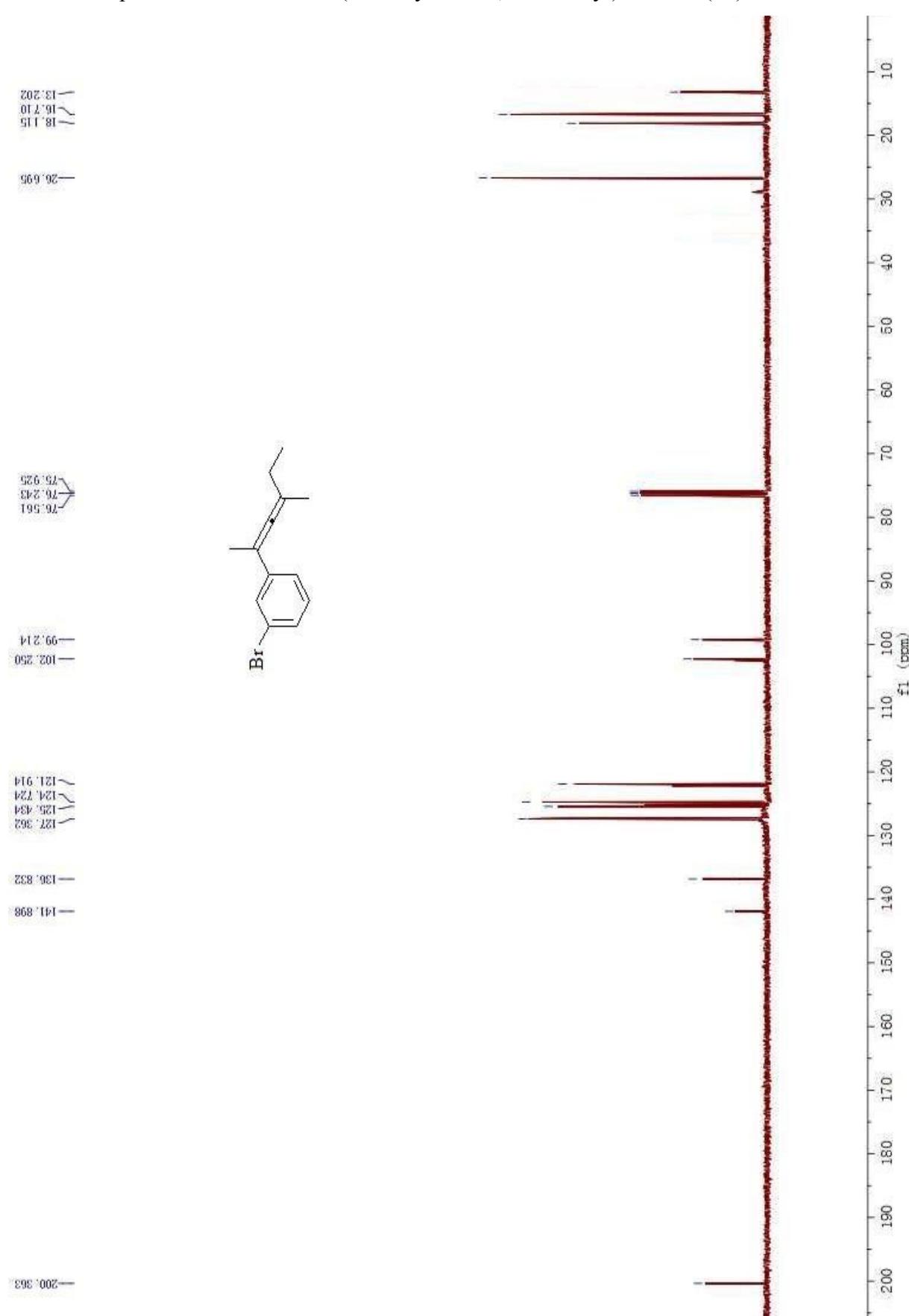
¹³C NMR Spectrum of 1-chloro-3-(4-methylhexa-2,3-dien-2-yl)benzene (**5n**)



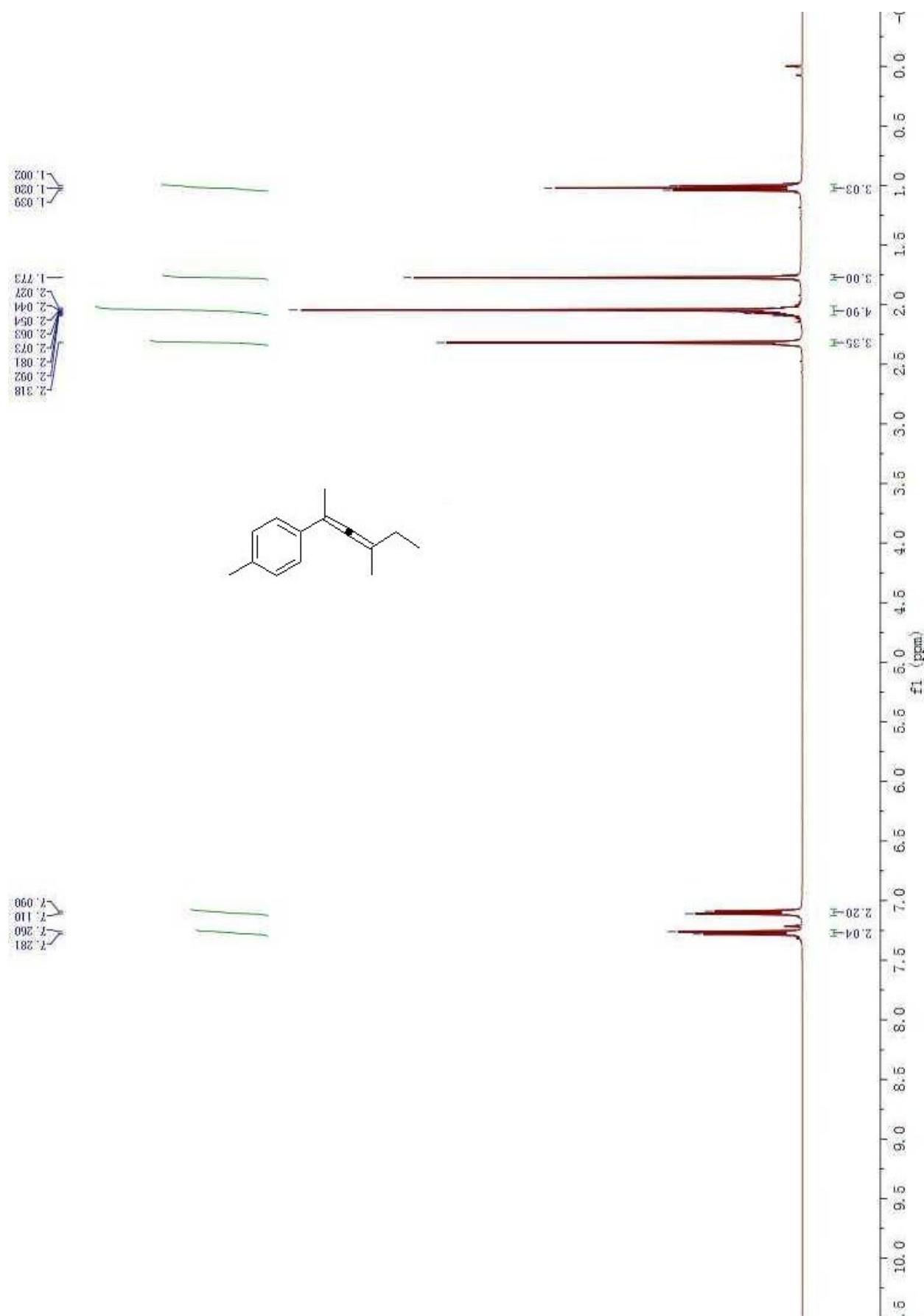
¹H NMR Spectrum of 1-bromo-3-(4-methylhexa-2,3-dien-2-yl)benzene (**5o**)



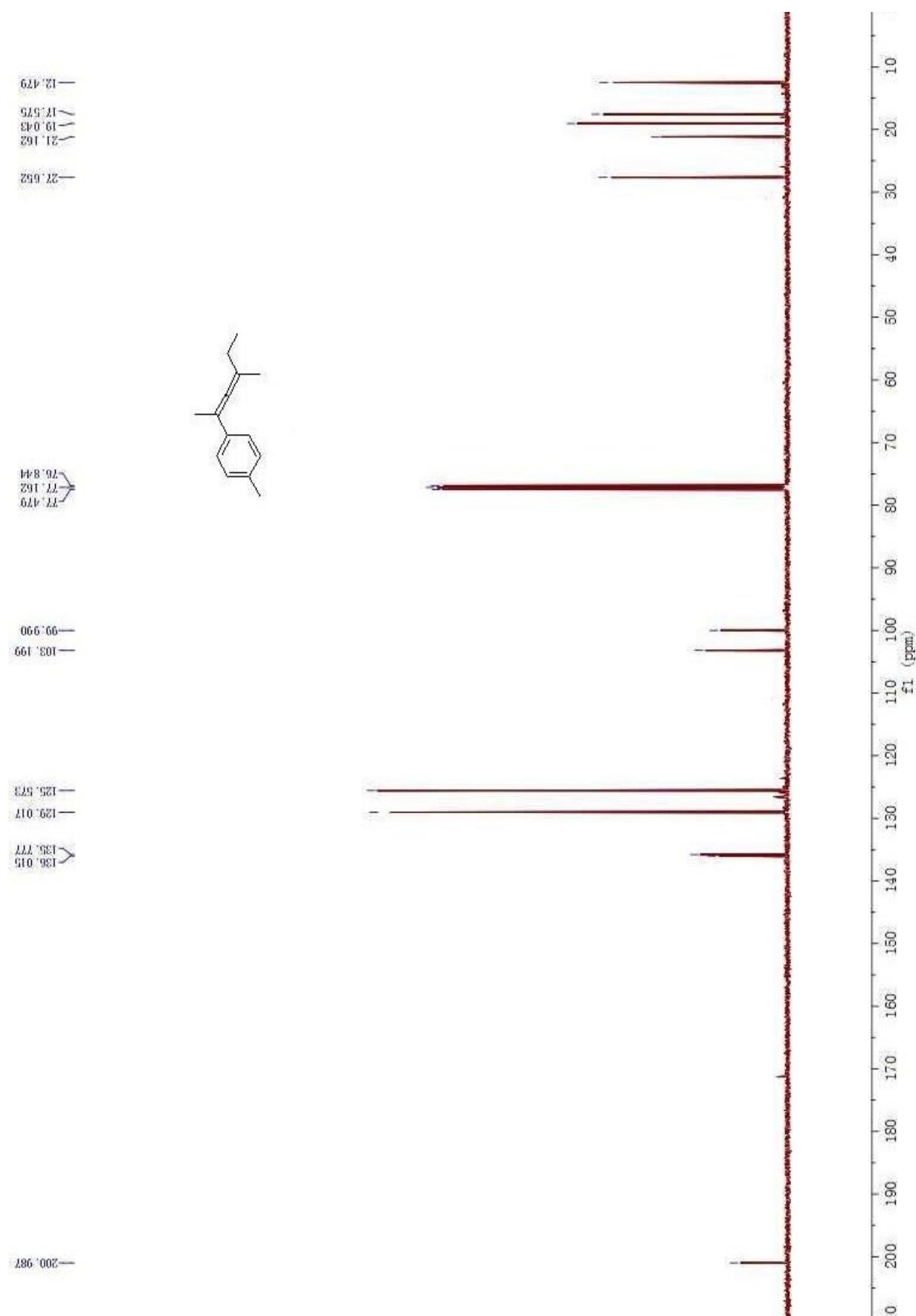
¹³C NMR Spectrum of 1-bromo-3-(4-methylhexa-2,3-dien-2-yl)benzene (**5o**)



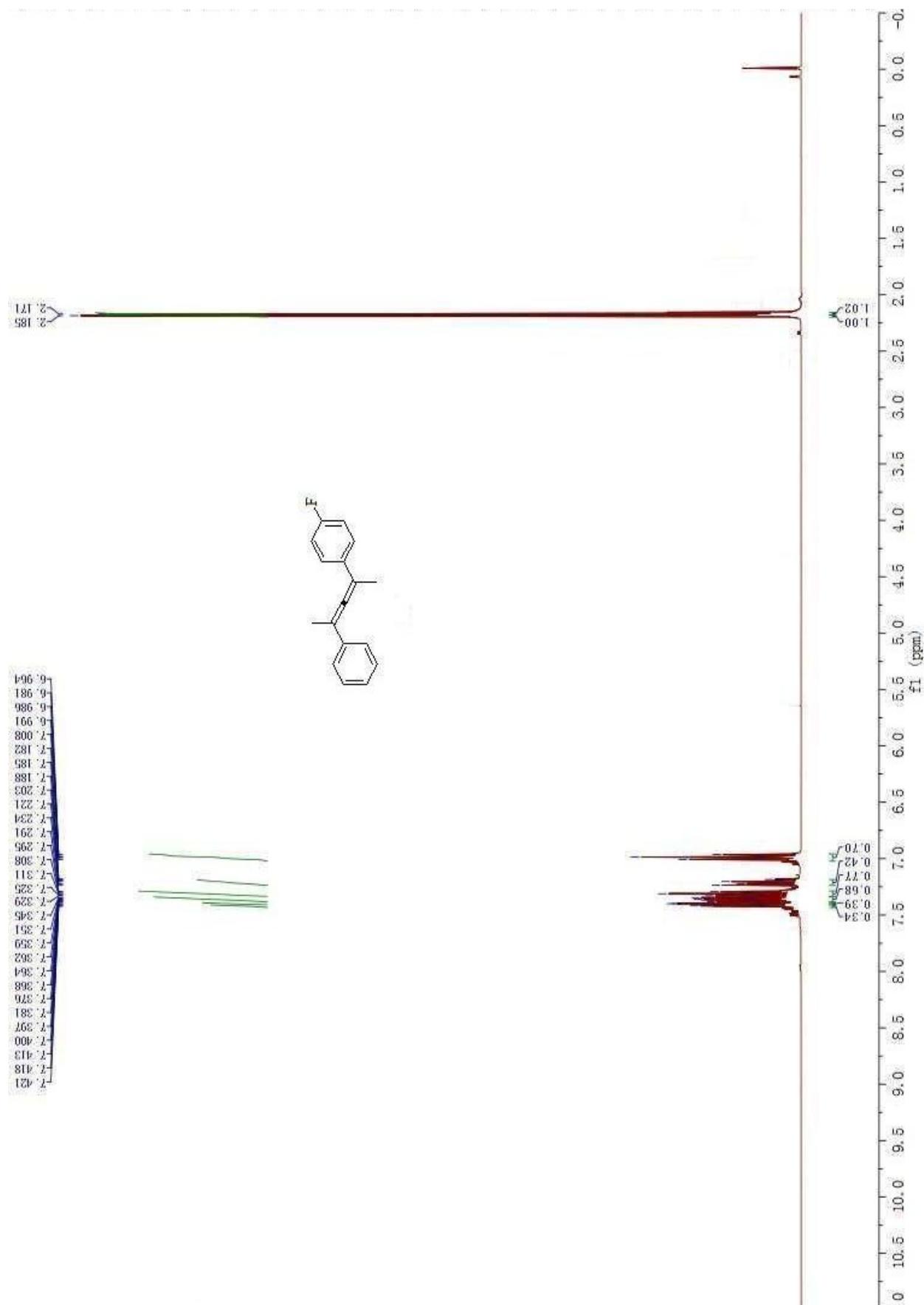
¹H NMR Spectrum of 1-methyl-4-(4-methylpenta-2,3-dien-2-yl)benzene(**5p**)



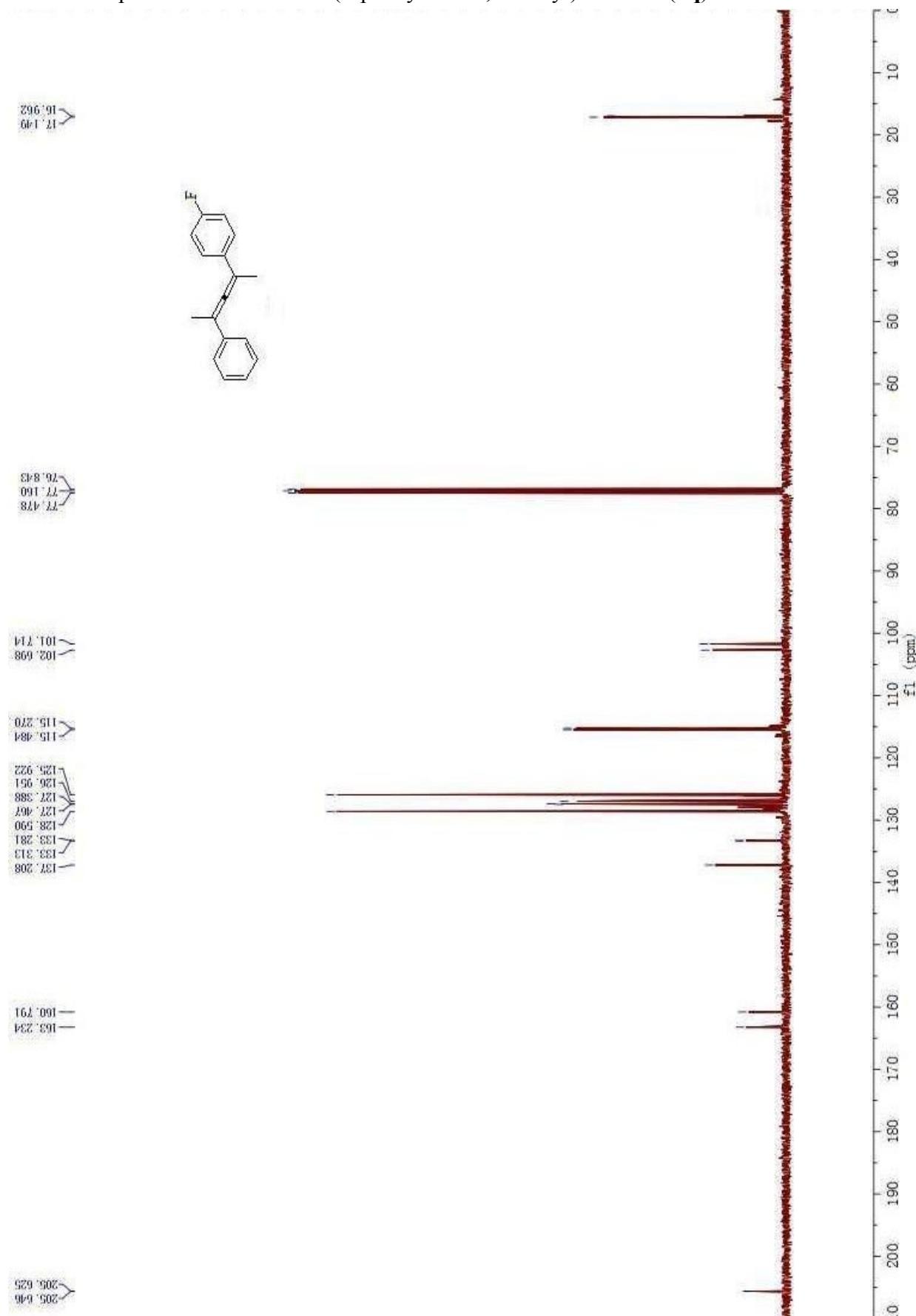
¹³C NMR Spectrum of 1-methyl-4-(4-methylpenta-2,3-dien-2-yl)benzene(**5p**)



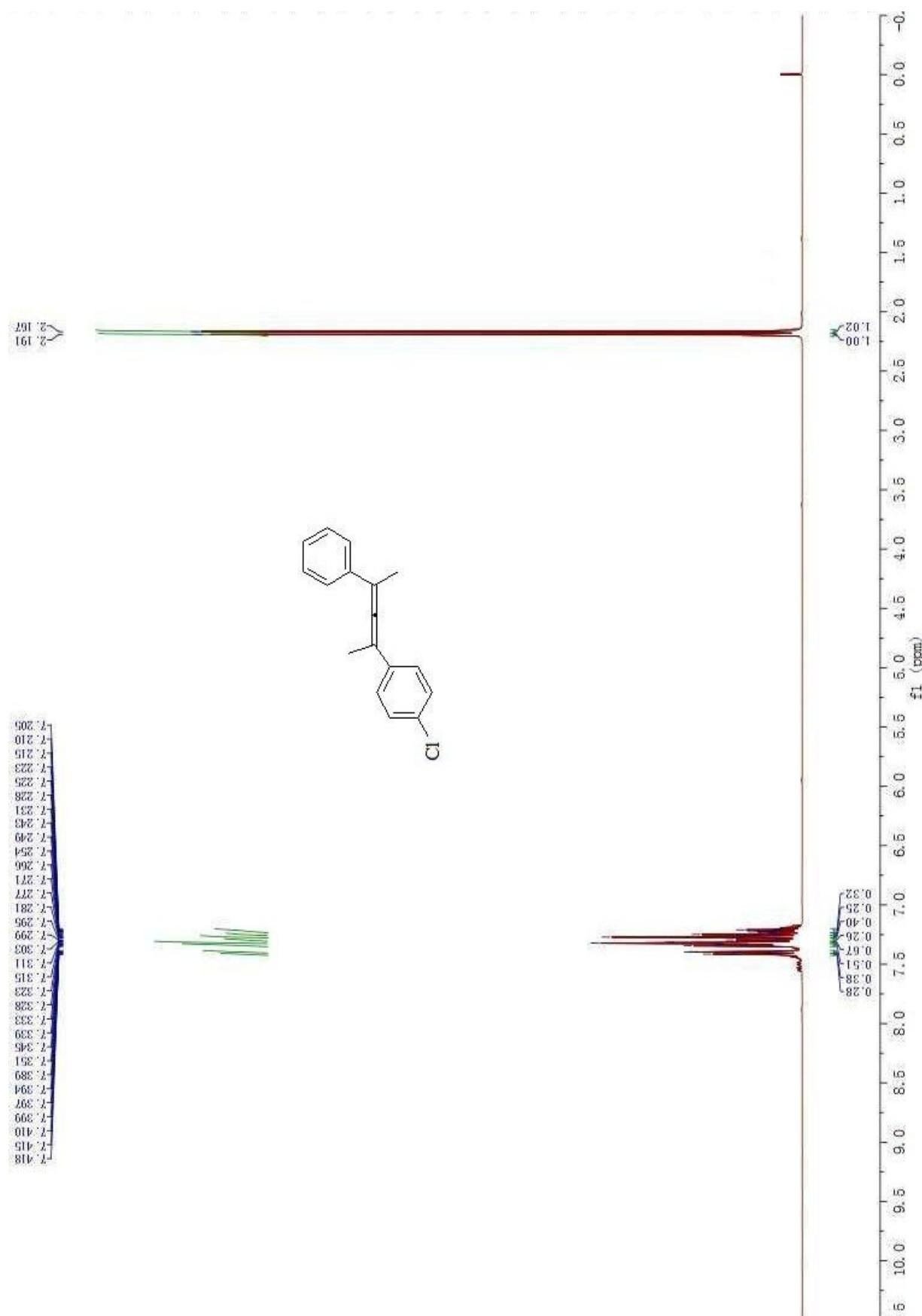
¹H NMR Spectrum of 1-fluoro-4-(3-phenylbuta-1,2-dienyl)benzene (**5q**)



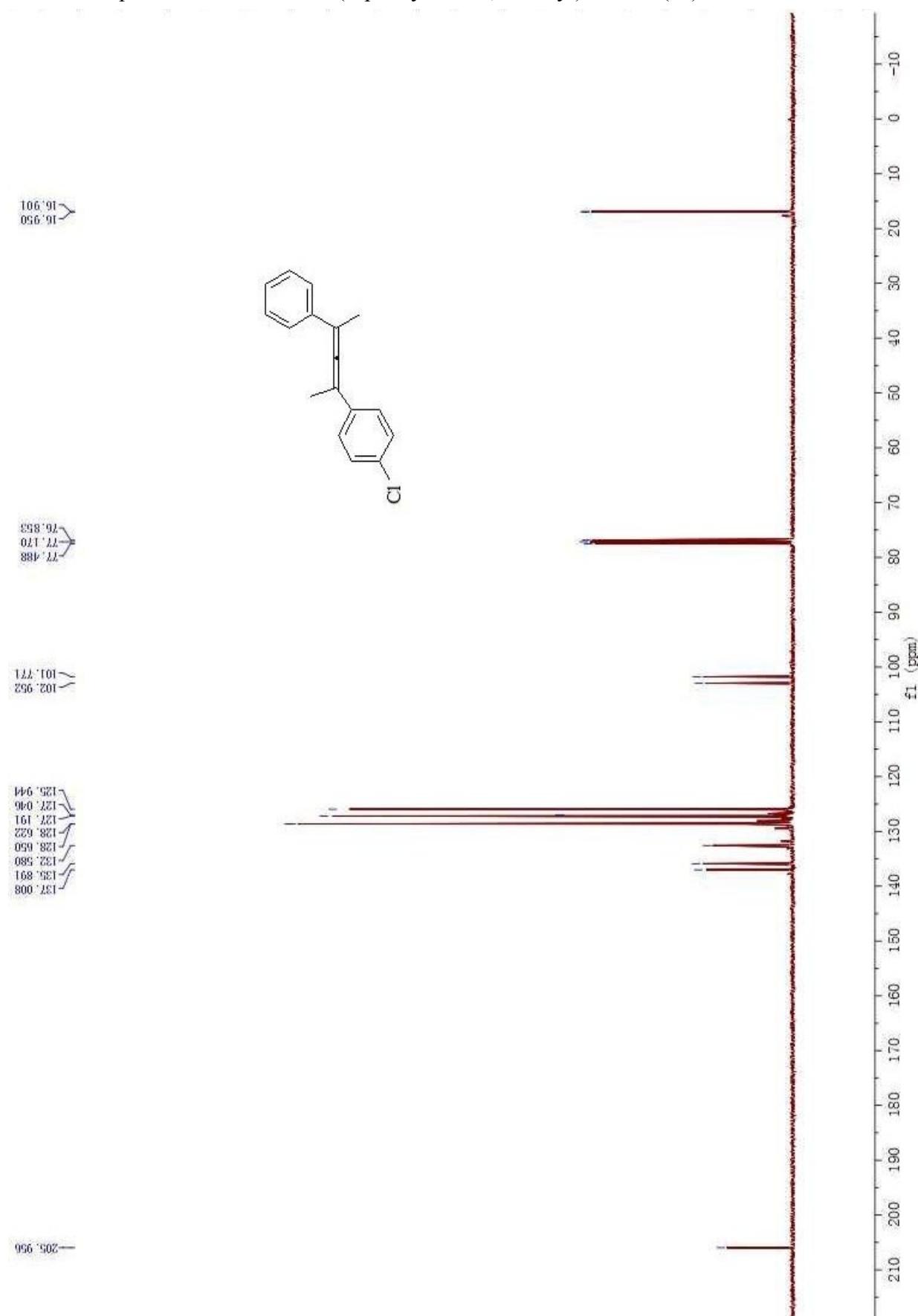
¹³C NMR Spectrum of 1-fluoro-4-(3-phenylbuta-1,2-dienyl)benzene (**5q**)



¹H NMR Spectrum of 1-chloro-4-(3-phenylbuta-1,2-dienyl)benzene(**5r**)



¹³C NMR Spectrum of 1-chloro-4-(3-phenylbuta-1,2-dienyl)benzene(**5r**)



IV. Control experiments

Under a dry nitrogen atmosphere, a mixture of $\text{Ni}(\text{PPh}_3)_2\text{Cl}_2$ (0.0131 g, 0.02 mmol), PPh_3 (0.0104 g, 0.04 mmol) in a reaction vessel was added an organoaluminum (0.02 mmol) in 1 mL THF followed by an addition of propargyl ester (0.50 mmol). The resulted solution was stirred at 60°C for 2 h. Then the mixture was evaporated *in vacuum*. The residue was analyzed by infrared spectroscopy and ^1H NMR.

