

One-Pot Two-Component [3 + 2] Cycloaddition/Annulation Protocol for the Synthesis of Highly Functionalized Thiophene Derivatives

Ganesh Chandra Nandi, Subhasis Samai and Maya Shankar Singh*

Department of Chemistry, Faculty of Science, Banaras Hindu University, Varanasi-

221005, India

mssinghbhu@yahoo.co.in

Table of Content

General.....	02
Typical experimental procedures.....	02
Characterization data for the isolated compound.....	03-09
NMR spectra.....	10-49

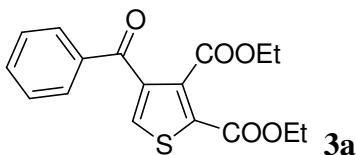
General

The starting materials were commercially available and were used without further purification. β -Oxodithioesters **1a-j** were prepared following the known procedure. All ^1H and ^{13}C NMR spectra were recorded on JEOL AL 300 FT-NMR spectrometer. Chemical shifts are given as δ value with reference to tetramethylsilane (TMS) as the internal standard. The IR spectra were recorded on Varian 3100 FT-IR spectrophotometer. Mass spectra were recorded on Waters Acquity Ultra Performance LC spectrometer. The C, H, and N analyses were performed from microanalytical laboratory with an Exeter Analytical Inc. "Model CE-400 CHN Analyzer". X-ray diffraction was measured on Xcalibur Oxford CCD Diffractometer. All the reactions were monitored by TLC using precoated sheets of silica gel G/UV-254 of 0.25 mm thickness (Merck 60F₂₅₄) using UV light (254 nm/365 nm) for visualization. Melting points were determined with Büchi B-540 melting point apparatus and are uncorrected.

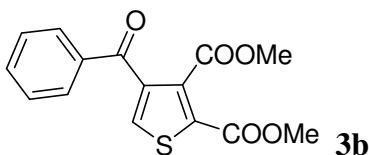
General procedure for the synthesis of the trisubstituted thiophenes (3a-s):

To a mixture of β -ketodithioester (1.0 mmol) and dialkyl acetylenedicarboxylate (1.0 mmol) in dichloromethane (3 mL), 4-dimethylaminopyridine (1.0 mmol) was added and the reaction mixture was stirred for the stipulated period of time at room temperature. After completion of the reaction (monitored by TLC), water (20 mL) was added to the reaction mixture and the mixture extracted with dichloromethane (2×10 mL). The combined organic layer was dried over anhyd. Na_2SO_4 and then evaporated in vacuo. The crude residue was purified by column chromatography over silica gel using ethyl acetate/hexane (1:10) as eluent to afford pure thiophenes.

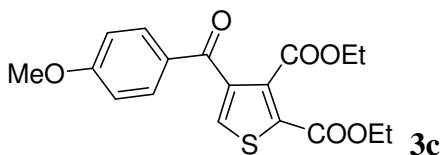
Characterization data of the isolated compounds



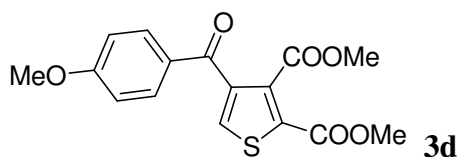
4-Benzoyl-2,3-dicarboethoxythiophene (3a): White solid; mp 53-54 °C. IR (KBr, cm^{-1}): 3031, 1729, 1632, 1220. ^1H NMR (300 MHz, CDCl_3): δ 7.90 (s, 1H), 7.81 (d, $J = 7.2$ Hz, 2H), 7.60 (t, $J = 7.2$ Hz, 1H), 7.48 (t, $J = 7.5$ Hz, 2H), 4.43-4.34 (m, 4H), 1.40- 1.35 (m, 6H). ^{13}C NMR (75 MHz, CDCl_3): δ 188.5, 164.6, 160.3, 139.9, 137.2, 132.9, 132.7, 129.6, 129.1, 128.8, 128.3, 62.2, 62.1, 14.3, 13.6. MS: $m/z = 332$ (M^+). Anal. Calcd for $\text{C}_{17}\text{H}_{16}\text{O}_5\text{S}$: C, 61.43; H, 4.85. Found: C, 61.69; H, 4.62.



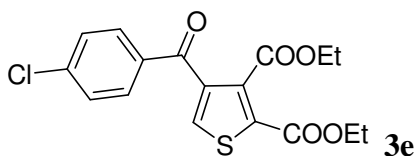
4-Benzoyl-2,3-dicarbomethoxythiophene (3b): White solid; mp 92-93 °C. IR (KBr, cm^{-1}): 3025, 1721, 1609, 1212. ^1H NMR (300 MHz, CDCl_3): δ 7.92 (s, 1H), 7.81 (d, $J = 7.5$ Hz, 2H), 7.61 (t, $J = 7.2$ Hz, 1H), 7.49 (t, $J = 7.5$ Hz, 2H), 3.94 (s, 3H), 3.92 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 188.4, 165.0, 160.6, 139.8, 137.7, 137.0, 133.0, 129.3, 128.5, 128.2, 127.6, 53.0, 52.8. MS: $m/z = 304$ (M^+). Anal. Calcd for $\text{C}_{15}\text{H}_{12}\text{O}_5\text{S}$: C, 59.20; H, 3.97. Found: C, 59.46; H, 4.25.



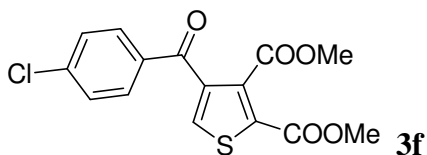
2,3-Dicarboethoxy-4-(4-methoxybenzoyl)thiophene (3c): White solid; mp 75-76 °C. IR (KBr, cm^{-1}): 3020, 1721, 1600, 1526, 1215. ^1H NMR (300 MHz, CDCl_3): δ 7.84-7.81 (m, 3H), 6.95 (d, $J = 8.7$ Hz, 2H), 4.40-4.34 (m, 4H), 3.88 (s, 3H), 1.39-1.33 (m, 6H). ^{13}C NMR (75 MHz, CDCl_3): δ 187.2, 164.6, 163.6, 160.3, 140.5, 139.7, 136.2, 132.9, 131.9, 129.9, 113.8, 62.1, 62.0, 55.5, 14.1, 13.9. MS: $m/z = 362$ (M^+). Anal. Calcd for $\text{C}_{18}\text{H}_{18}\text{O}_6\text{S}$: C, 59.66; H, 5.01. Found: C, 59.82; H, 4.91.



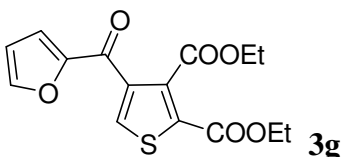
2,3-Dicarbomethoxy-4-(4-methoxybenzoyl)thiophene (3d): White solid; mp 128-129 °C. IR (KBr, cm^{-1}): 3028, 1723, 1598, 1258. ^1H NMR (300 MHz, CDCl_3): δ 7.87 (s, 1H), 7.82 (d, $J = 8.7$ Hz, 2H), 6.96 (d, $J = 8.7$ Hz, 2H), 3.93 (s, 3H), 3.91 (s, 3H), 3.89 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 187.1, 165.1, 163.6, 160.7, 140.4, 139.8, 136.4, 131.9, 129.7, 113.8, 55.5, 53.0, 52.9. MS: $m/z = 334$ (M^+). Anal. Calcd for $\text{C}_{16}\text{H}_{14}\text{O}_6\text{S}$: C, 57.48; H, 4.22. Found: C, 57.32; H, 4.35.



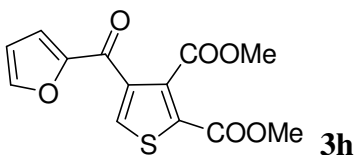
4-(4-Chlorobenzoyl)-2,3-dicarboethoxythiophene (3e): White solid; mp 73-74 °C. IR (KBr, cm^{-1}): 3091, 2954, 1734, 1653, 1256. ^1H NMR (300 MHz, CDCl_3): δ 7.87 (s, 1H), 7.76 (d, $J = 8.4$ Hz, 2H), 7.46 (d, $J = 8.1$ Hz, 2H), 4.43-4.34 (m, 4H), 1.40-1.34 (m, 6H). ^{13}C NMR (75 MHz, CDCl_3): δ 187.2, 164.4, 160.1, 139.5, 139.5, 137.3, 135.4, 133.2, 130.7, 128.9, 62.2, 62.1, 14.0, 13.8. MS: $m/z = 366$ (M^+). Anal. Calcd for $\text{C}_{17}\text{H}_{15}\text{ClO}_5\text{S}$: C, 55.66; H, 4.12. Found: C, 55.45; H, 4.35.



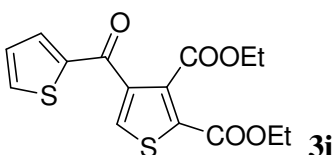
4-(4-Chlorobenzoyl)-2,3-dicarbomethoxythiophene (3f): White solid; mp 123-124 °C. IR (KBr, cm^{-1}): 3098, 2958, 1733, 1653, 1261. ^1H NMR (300 MHz, CDCl_3): δ 7.88 (s, 1H), 7.76 (d, $J = 8.4$ Hz, 2H), 7.47 (d, $J = 8.4$ Hz, 2H), 3.93 (s, 3H), 3.92 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 187.2, 164.9, 160.5, 139.6, 137.4, 135.3, 130.8, 128.9, 53.1, 52.9. MS: $m/z = 338$ (M^+). Anal. Calcd for $\text{C}_{15}\text{H}_{11}\text{ClO}_5\text{S}$: C, 53.18; H, 3.27. Found: C, 52.85; H, 3.46.



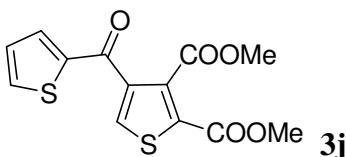
2,3-Dicarboethoxy-4-(2-furoyl)thiophene (3g): White solid; mp 72-73 °C. IR (KBr, cm^{-1}): 3085, 2959, 1723, 1635, 1463, 1270. ^1H NMR (300 MHz, CDCl_3): δ 8.54 (s, 1H), 7.67 (s, 1H), 7.35 (d, $J = 3.6$ Hz, 1H), 6.61 (s, 1H), 4.46 (q, $J = 6.9$ Hz, 2H), 4.36 (q, $J = 6.9$ Hz, 2H), 1.43-1.34 (m, 6H). ^{13}C NMR (75 MHz, CDCl_3): δ 173.6, 164.8, 160.2, 152.2, 146.8, 140.0, 138.3, 137.6, 132.0, 119.9, 112.6, 62.1, 62.0, 14.0, 13.9. MS: $m/z = 322$ (M^+). Anal. Calcd for $\text{C}_{15}\text{H}_{14}\text{O}_6\text{S}$: C, 55.89; H, 4.38. Found: C, 55.61; H 4.52.



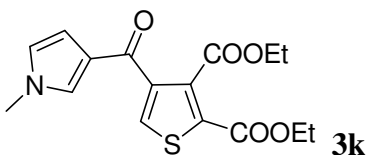
2,3-Dicarbomethoxy-4-(2-furoyl)thiophene (3h): White solid; mp 110-111 °C. IR (KBr, cm^{-1}): 3071, 2954, 1720, 1633, 1279. ^1H NMR (300 MHz, CDCl_3): δ 8.58 (s, 1H), 7.68 (s, 1H), 7.37 (d, $J = 3.3$ Hz, 1H), 6.61 (d, $J = 1.8$ Hz, 1H), 4.00 (s, 3H), 3.91 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 173.5, 165.3, 160.6, 152.3, 146.8, 140.1, 138.3, 137.8, 131.5, 119.9, 112.7, 53.1, 52.8. MS: $m/z = 294$ (M^+). Anal. Calcd for $\text{C}_{13}\text{H}_{10}\text{O}_6\text{S}$: C, 53.06; H, 3.43. Found: C, 53.33; H, 3.22.



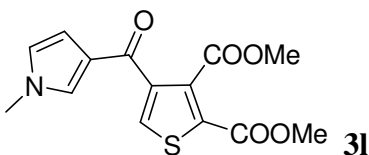
4-(2-Thienoyl)-2,3-dicarboethoxythiophene (3i): White solid; mp 65-67 °C. IR (KBr, cm^{-1}): 3091, 2984, 1737, 1712, 1619, 1258. ^1H NMR (300 MHz, CDCl_3): δ 8.07 (s, 1H), 7.73 (d, $J = 4.2$ Hz, 2H), 7.18 (t, $J = 4.5$ Hz, 1H), 4.45-4.33 (m, 4H), 1.40-1.35 (m, 6H). ^{13}C NMR (75 MHz, CDCl_3): δ 179.8, 164.4, 160.2, 142.8, 139.9, 139.5, 135.7, 134.6, 134.1, 133.1, 128.1, 62.2, 62.1, 14.1, 13.9. MS: $m/z = 338$ (M^+). Anal. Calcd for $\text{C}_{15}\text{H}_{14}\text{O}_5\text{S}_2$: C, 53.24; H, 4.17. Found: C, 53.36; H, 4.07.



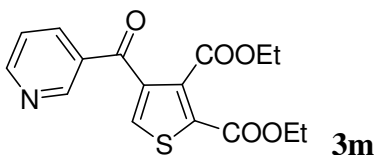
4-(2-Thienoyl)-2,3-dicarbomethoxythiophene (3j): White solid; mp 110-112 °C. IR (KBr, cm^{-1}): 3087, 2976, 1737, 1723, 1260. ^1H NMR (300 MHz, CDCl_3): δ 8.11 (s, 1H), 7.75-7.73 (m, 2H), 7.17 (t, $J = 4.2$ Hz, 1H), 3.95 (s, 3H), 3.91 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 179.6, 164.9, 160.5, 142.5, 139.8, 139.5, 135.9, 134.7, 134.1, 132.4, 128.1, 53.1, 52.9. MS: $m/z = 310$ (M^+). Anal. Calcd for $\text{C}_{13}\text{H}_{10}\text{O}_5\text{S}_2$: C, 50.31; H, 3.25. Found: C, 50.52; H, 3.13.



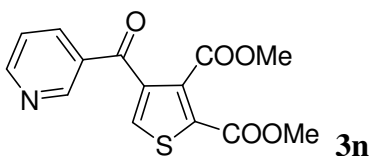
2,3-Dicarboethoxy-4-[3-(N-methylpyrroloyl)]thiophene (3k): White solid; mp 112-113 °C. IR (KBr, cm^{-1}): 3095, 2956, 1725, 1630, 1284. ^1H NMR (300 MHz, CDCl_3): δ 7.96 (s, 1H), 7.22 (s, 1H), 6.63 (s, 2H), 4.44-4.32 (m, 4H), 3.71 (s, 3H), 1.38 (t, $J = 3.6$ Hz, 3H), 1.35 (t, $J = 3.6$ Hz, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 181.9, 164.9, 160.5, 141.9, 139.6, 134.5, 132.3, 128.3, 124.3, 123.6, 110.6, 62.0, 61.9, 36.6, 14.0, 13.9. MS: $m/z = 335$ (M^+). Anal. Calcd for $\text{C}_{16}\text{H}_{17}\text{NO}_5\text{S}$: C, 57.30; H, 5.11; N, 4.18. Found: C, 57.46; H, 5.36; N, 4.02.



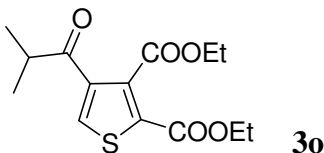
2,3-Dicarbomethoxy-4-[3-(N-methylpyrroloyl)]thiophene (3l): White solid; mp 109-110 °C. IR (KBr, cm^{-1}): 3087, 2935, 1733, 1624, 1285. ^1H NMR (300 MHz, CDCl_3): δ 7.99 (s, 1H), 7.23 (s, 1H), 6.62 (s, 2H), 3.94 (s, 3H), 3.89 (s, 3H), 3.70 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 181.7, 165.4, 160.7, 141.8, 139.6, 134.7, 131.6, 128.3, 124.1, 123.6, 110.5, 52.9, 52.7, 36.6. MS: $m/z = 307$ (M^+). Anal. Calcd for $\text{C}_{14}\text{H}_{13}\text{NO}_5\text{S}$: C, 54.71; H, 4.26; N, 4.56. Found: C, 54.53; H, 4.38; N, 4.64.



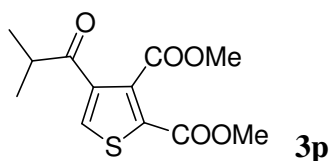
2,3-Dicarboethoxy-4-(3-pyridoyl)thiophene (3m): White solid; mp 72-73 °C. IR (KBr, cm^{-1}): 3075, 2967, 1737, 1714, 1632, 1278. ^1H NMR (300 MHz, CDCl_3): δ 9.03 (s, 1H), 8.82 (s, 1H), 8.11 (d, $J = 8.1$ Hz, 1H), 7.92 (s, 1H), 7.46 (q, $J = 5.1$ Hz, 1H), 4.46-4.35 (m, 4H), 1.41- 1.36 (m, 6H). ^{13}C NMR (75 MHz, CDCl_3): δ 186.6, 164.4, 160.0, 153.3, 150.1, 139.5, 139.1, 138.0, 136.7, 133.4, 132.9, 123.6, 62.3, 62.2, 14.0, 13.8. MS: $m/z = 333$ (M^+). Anal. Calcd for $\text{C}_{16}\text{H}_{15}\text{NO}_5\text{S}$: C, 57.65; H, 4.54; N, 4.20. Found: C, 57.89; H, 4.35; N, 4.46.



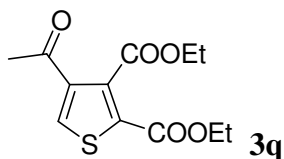
2,3-Dicarbomethoxy-4-(3-pyridoyl)thiophene (3n): White solid; mp 94-95 °C. IR (KBr, cm^{-1}): 3081, 2957, 1731, 1727, 1622, 1276. ^1H NMR (300 MHz, CDCl_3): δ 9.03 (s, 1H), 8.83 (s, 1H), 8.12 (d, $J = 6.6$ Hz, 1H), 7.95 (s, 1H), 7.47 (t, $J = 5.1$ Hz, 1H), 3.96 (s, 3H), 3.93 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 186.6, 164.8, 160.4, 153.4, 150.1, 139.5, 139.1, 138.1, 136.7, 132.9, 132.8, 123.6, 53.2, 53.0. MS: $m/z = 305$ (M^+). Anal. Calcd for $\text{C}_{14}\text{H}_{11}\text{NO}_5\text{S}$: C, 55.08; H, 3.63; N, 4.59. Found: C, 55.25; H, 3.48; N, 4.78.



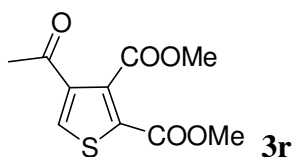
2,3-Dicarboethoxy-4-isobutanoylthiophene (3o): White solid; mp 71-72 °C. IR (KBr, cm^{-1}): 3085, 2986, 1732, 1712, 1693, 1259. ^1H NMR (300 MHz, CDCl_3): δ 8.08 (s, 1H), 4.46 (q, $J = 7.2$ Hz, 2H), 4.33 (q, $J = 7.2$ Hz, 2H), 3.28 (m, 1H), 1.43-1.36 (m, 6H), 1.22 (s, 3H), 1.20 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 185.0, 160.8, 157.3, 129.2, 129.1, 128.5, 127.6, 55.3, 54.3, 34.5, 21.0, 15.0, 14.8. MS: $m/z = 298$ (M^+). Anal. Calcd for $\text{C}_{14}\text{H}_{18}\text{O}_5\text{S}$: C, 56.36; H, 6.08. Found: C, 56.52; H, 5.95.



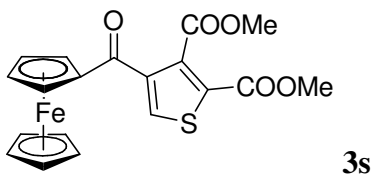
2,3-Dicarbomethoxy-4-isobutanoylthiophene (3p): White solid; mp 108-110 °C. IR (KBr, cm^{-1}): 3094, 2981, 1735, 1720, 1690, 1262. ^1H NMR (300 MHz, CDCl_3): δ 8.09 (s, 1H), 4.00 (s, 3H), 3.89 (s, 3H), 3.31-3.26 (m, 1H), 1.22 (s, 3H), 1.20 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 197.3, 165.7, 160.6, 139.4, 136.1, 131.7, 129.2, 53.1, 52.8, 36.9, 18.9. MS: m/z = 270 (M^+). Anal. Calcd for $\text{C}_{12}\text{H}_{14}\text{O}_5\text{S}$: C, 53.32; H, 5.22. Found: C, 53.46; H, 5.03.



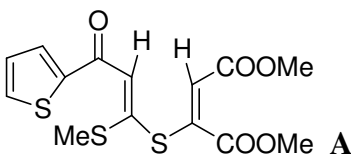
4-Acetyl-2,3-dicarboethoxythiophene (3q): White solid. mp 63-65 °C IR (KBr, cm^{-1}): 3064, 2979, 1725, 1720, 1682, 1270. ^1H NMR (300 MHz, CDCl_3): δ 8.10 (s, 1H), 4.45 (q, J = 6.9 Hz, 2H), 4.34 (q, J = 6.9 Hz, 2H), 2.51 (s, 3H), 1.44-1.33 (m, 6H). ^{13}C NMR (75 MHz, CDCl_3): δ 190.5, 165.1, 160.2, 140.5, 138.7, 136.9, 132.3, 62.2, 62.0, 27.0, 14.0, 13.8. MS: m/z = 270 (M^+). Anal. Calcd for $\text{C}_{12}\text{H}_{14}\text{O}_5\text{S}$: C, 53.32; H, 5.22. Found: C, 53.18; H, 5.47.



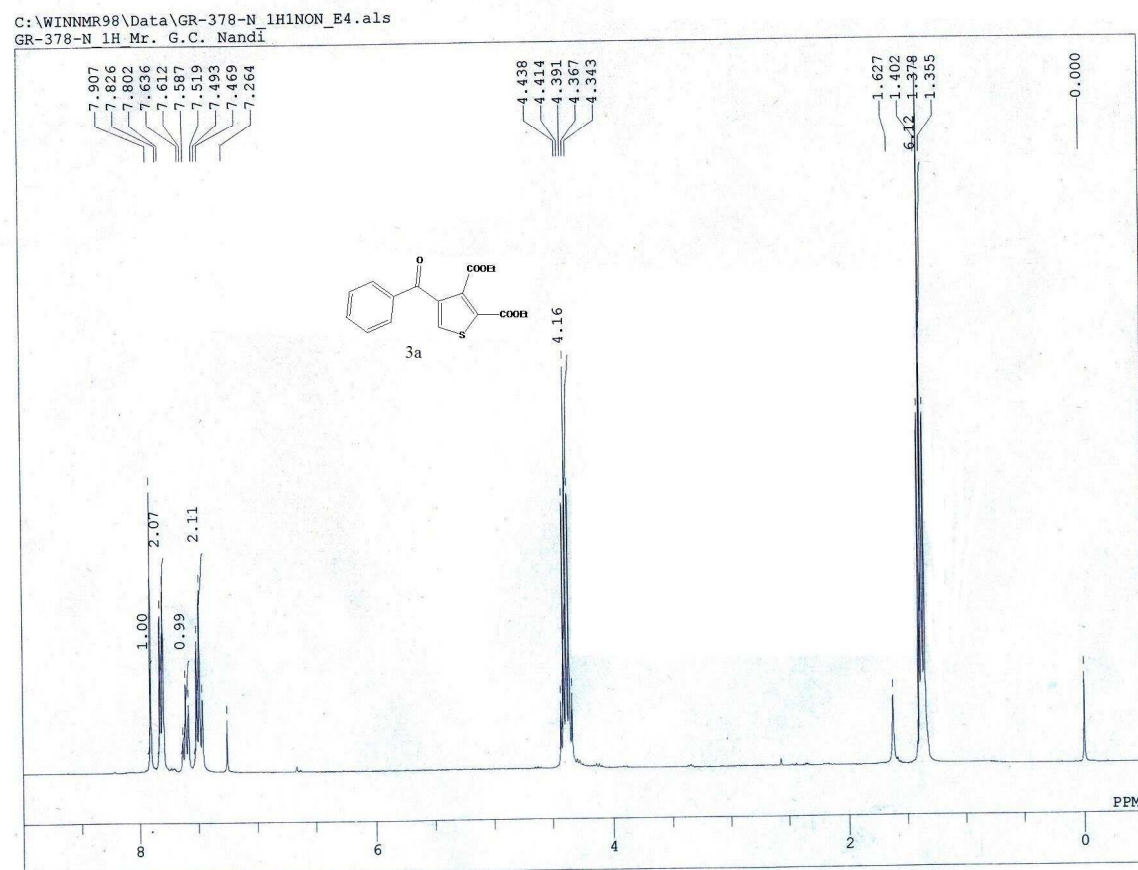
4-Acetyl-2,3-dicarbomethoxythiophene (3r): White solid; mp 99-100 °C. IR (KBr, cm^{-1}): 3056, 2977, 1729, 1714, 1687, 1265. ^1H NMR (300 MHz, CDCl_3): δ 8.10 (s, 1H), 4.00 (s, 3H), 3.89 (s, 3H), 2.52 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 190.5, 165.6, 160.6, 140.6, 138.7, 136.9, 131.9, 53.1, 52.9, 27.0. MS: m/z = 242 (M^+). Anal. Calcd for $\text{C}_{10}\text{H}_{10}\text{O}_5\text{S}$: C, 49.58; H, 4.16. Found: C, 49.76; H, 4.07.

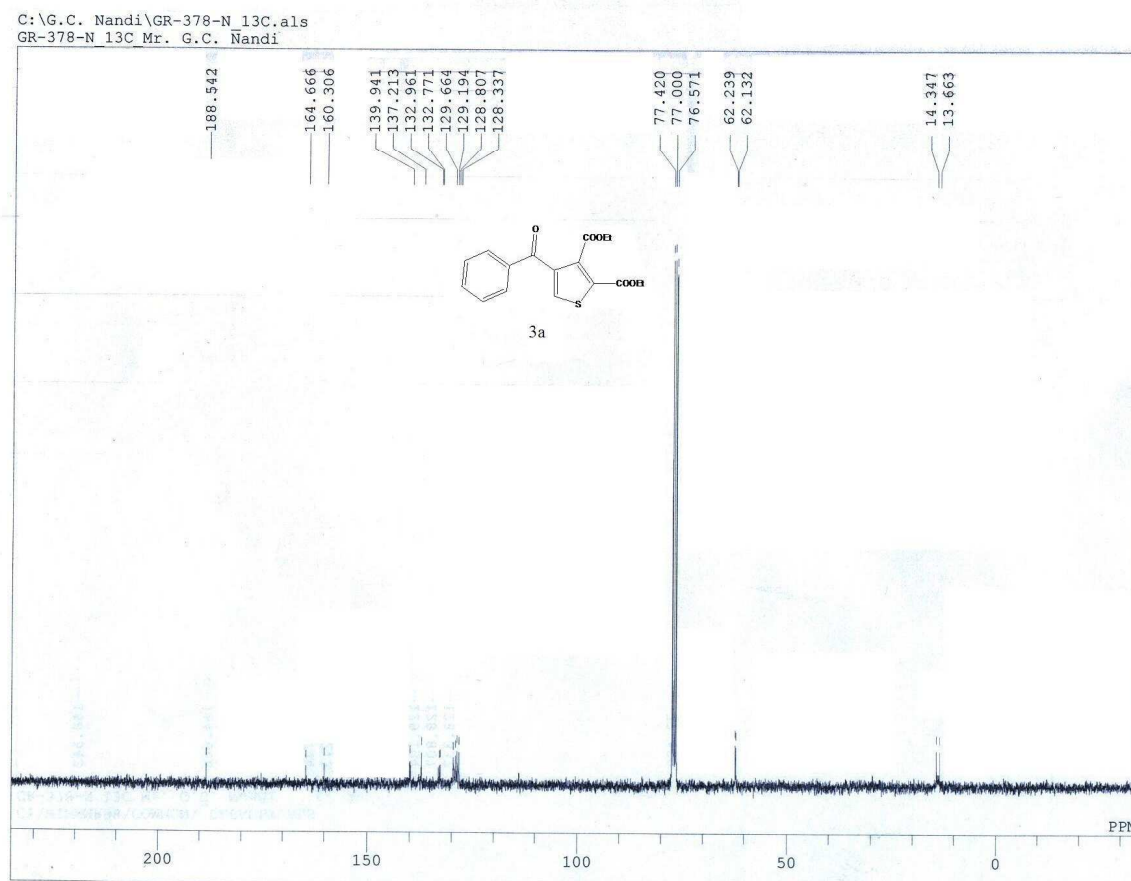


2,3-Dicarbomethoxy-4- η^5 -ferrocenylthiophene (3s): Reddish solid; mp 135-137 °C. IR (KBr, cm^{-1}): 3103, 2926, 1727, 1630, 1262. ^1H NMR (300 MHz, CDCl_3): 8.12 (s, 1H), 4.91 (s, 2H), 4.62 (s, 2H), 4.27 (s, 5H), 4.00 (s, 3H), 3.91 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 190.5, 165.4, 160.8, 141.4, 139.6, 134.1, 131.7, 72.9, 70.9, 70.3, 70.0, 53.0, 52.8. MS: m/z = 412 (M^+). Anal. Calcd for $\text{C}_{19}\text{H}_{16}\text{FeO}_5\text{S}$: C, 55.36; H, 3.91. Found: C, 55.27; H, 4.03.



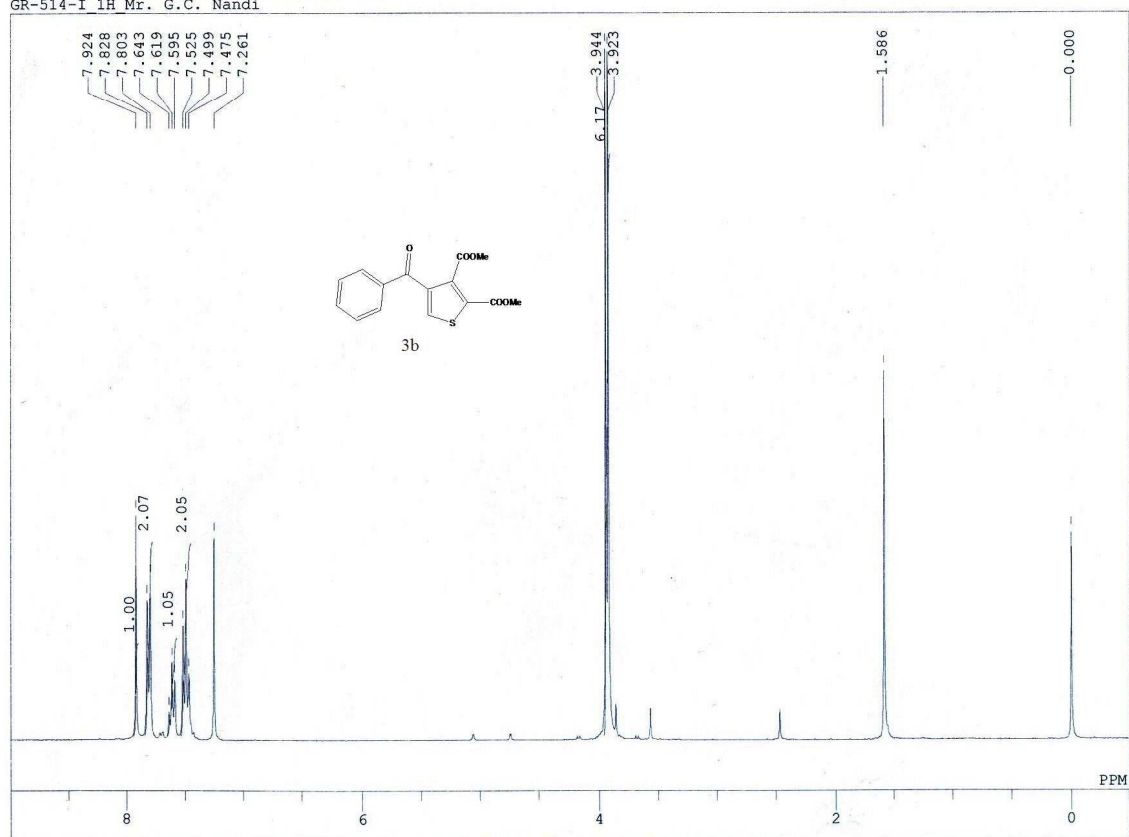
2-(1-Methylsulfanyl-3-(2-thienoyl)-propenylsulfanyl)-but-2-enedioic acid dimethyl ester (A): colourless sticky liquid. IR (KBr, cm^{-1}): 2931, 1723, 1626, 1243. ^1H NMR (300 MHz, CDCl_3): 7.63-7.59 (m, 2H), 7.11 (t, J = 4.2 Hz, 1H), 7.00 (s, 1H), 6.80 (s, 1H), 3.84 (s, 3H), 3.73 (s, 3H), 2.57 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 179.0, 164.8, 158.5, 145.5, 144.7, 133.3, 130.7, 128.2, 128.1, 125.7, 121.1, 53.6, 52.4, 17.3. MS: m/z = 358 (M^+). Anal. Calcd for $\text{C}_{14}\text{H}_{14}\text{O}_5\text{S}_3$: C, 46.91; H, 3.94. Found: C, 47.12; H, 3.76.

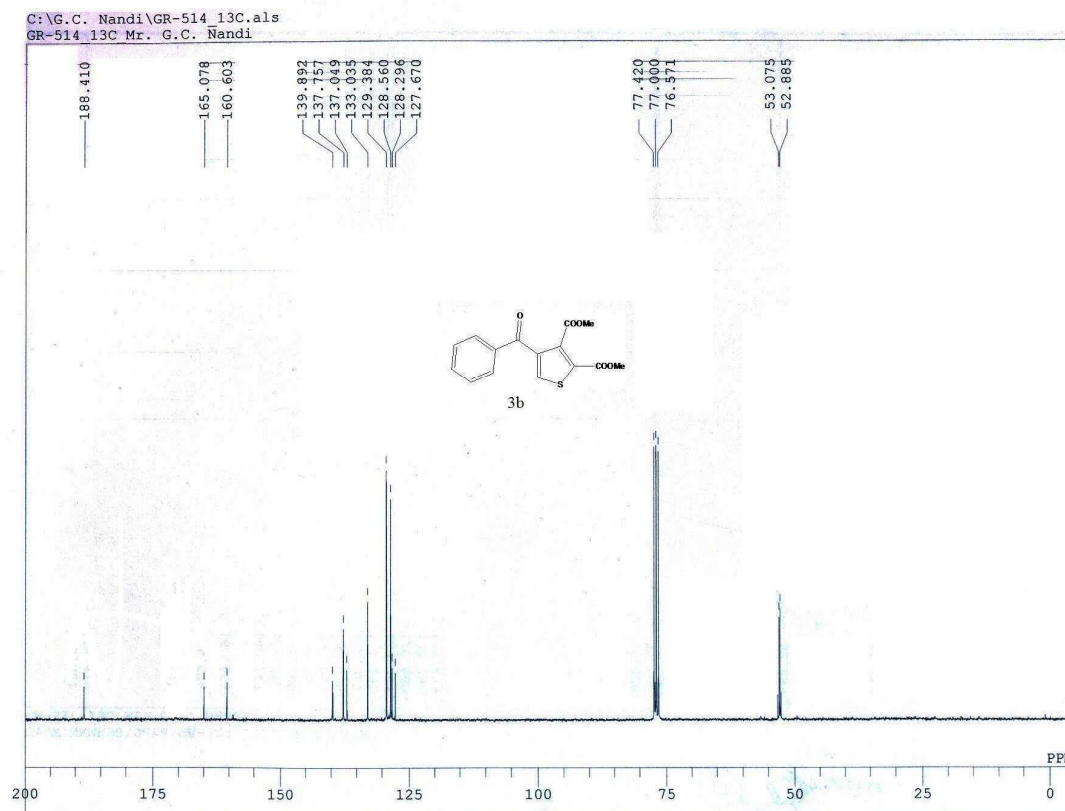
¹H spectra of 3a

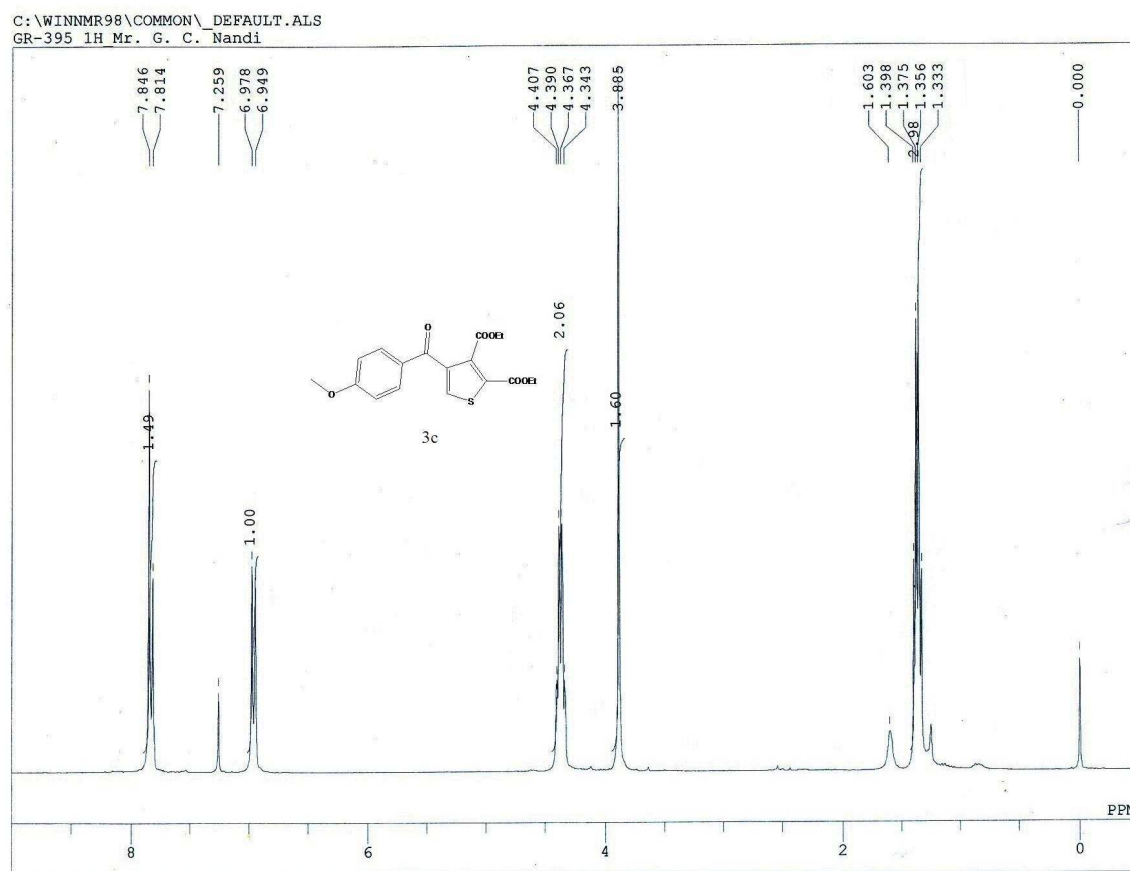
^{13}C spectra of 3a

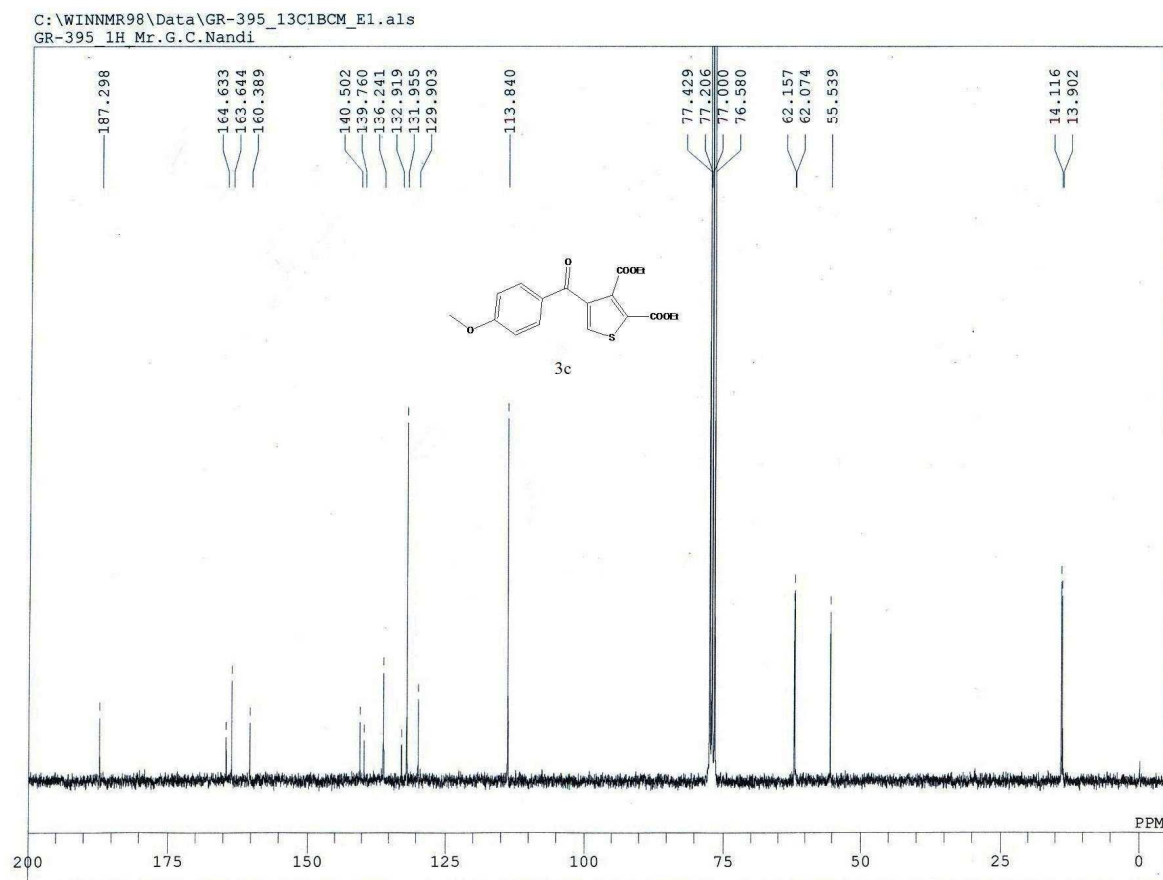
^1H Spectra of 3b

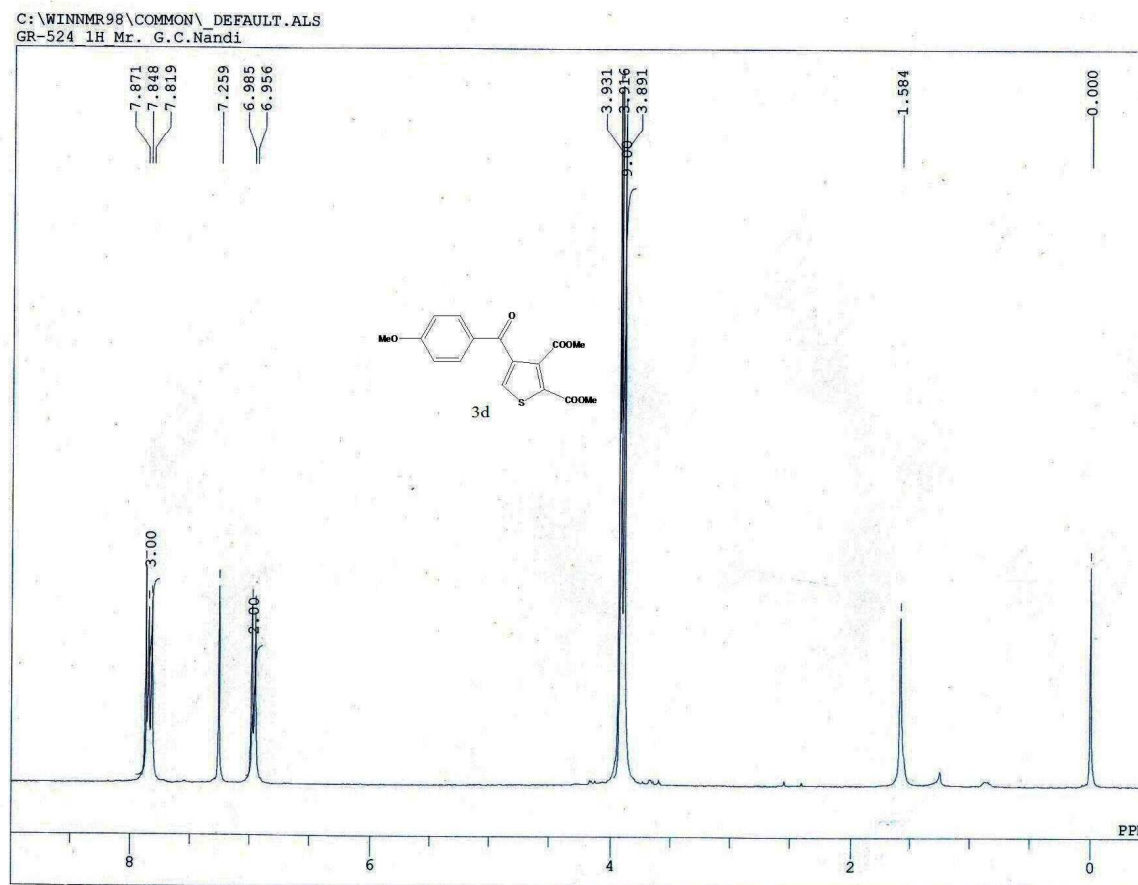
C:\WINNMR98\Data\GR-514-I 1H1NON_E3.als
GR-514-I 1H Mr. G.C. Nandi

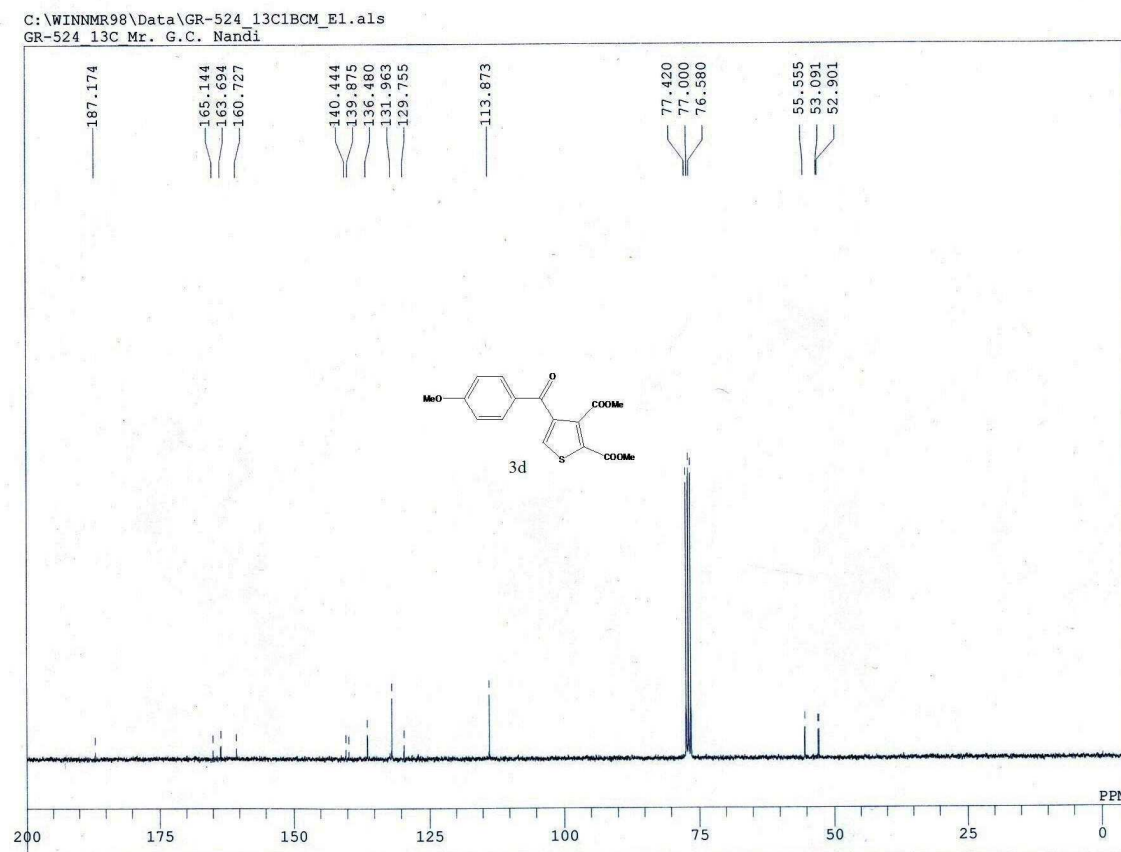


^{13}C spectra of 3b

^1H spectra of 3c

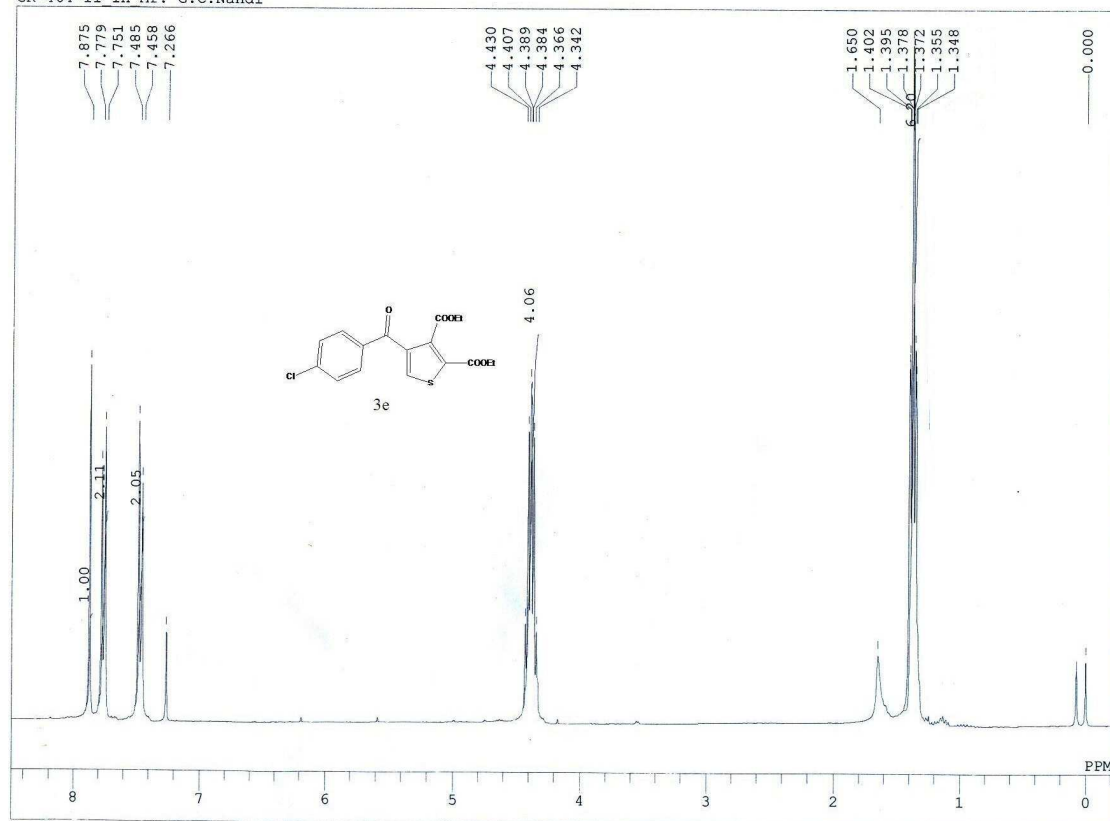
^{13}C spectra of 3c

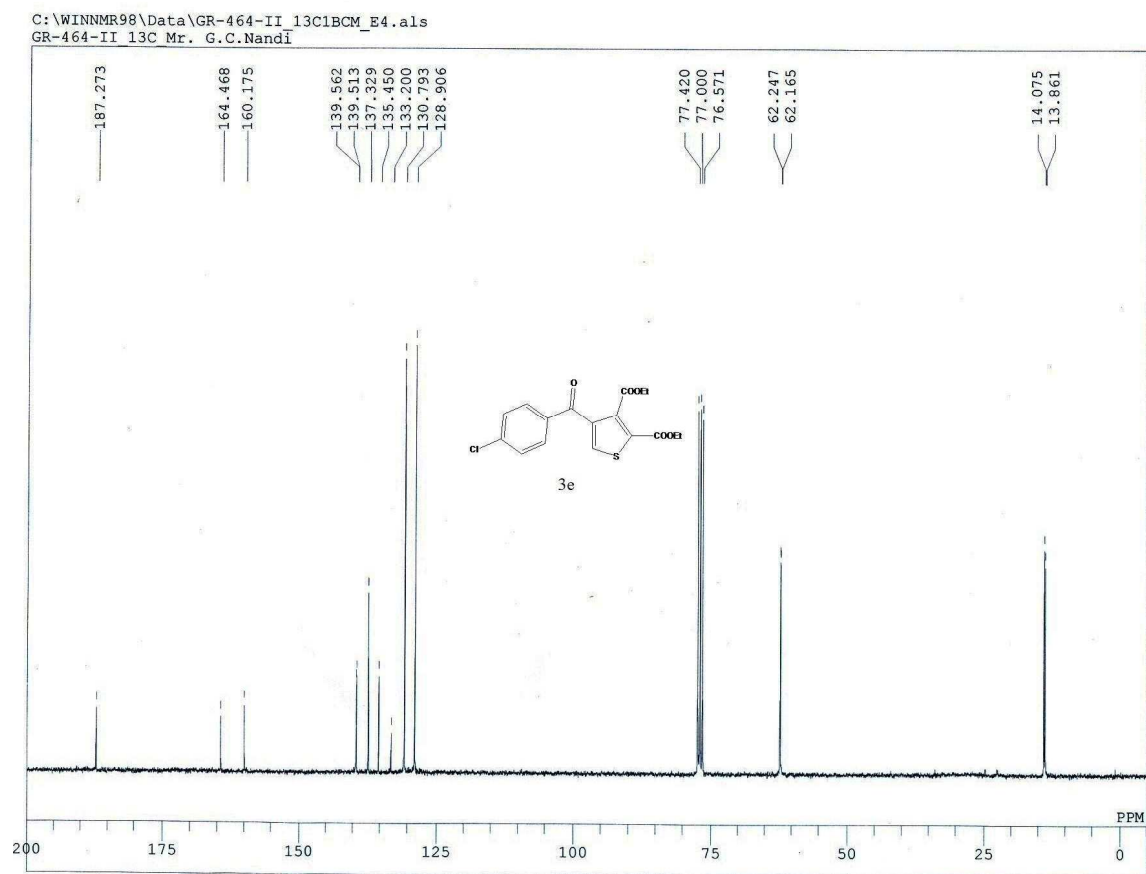
¹H spectra of 3d

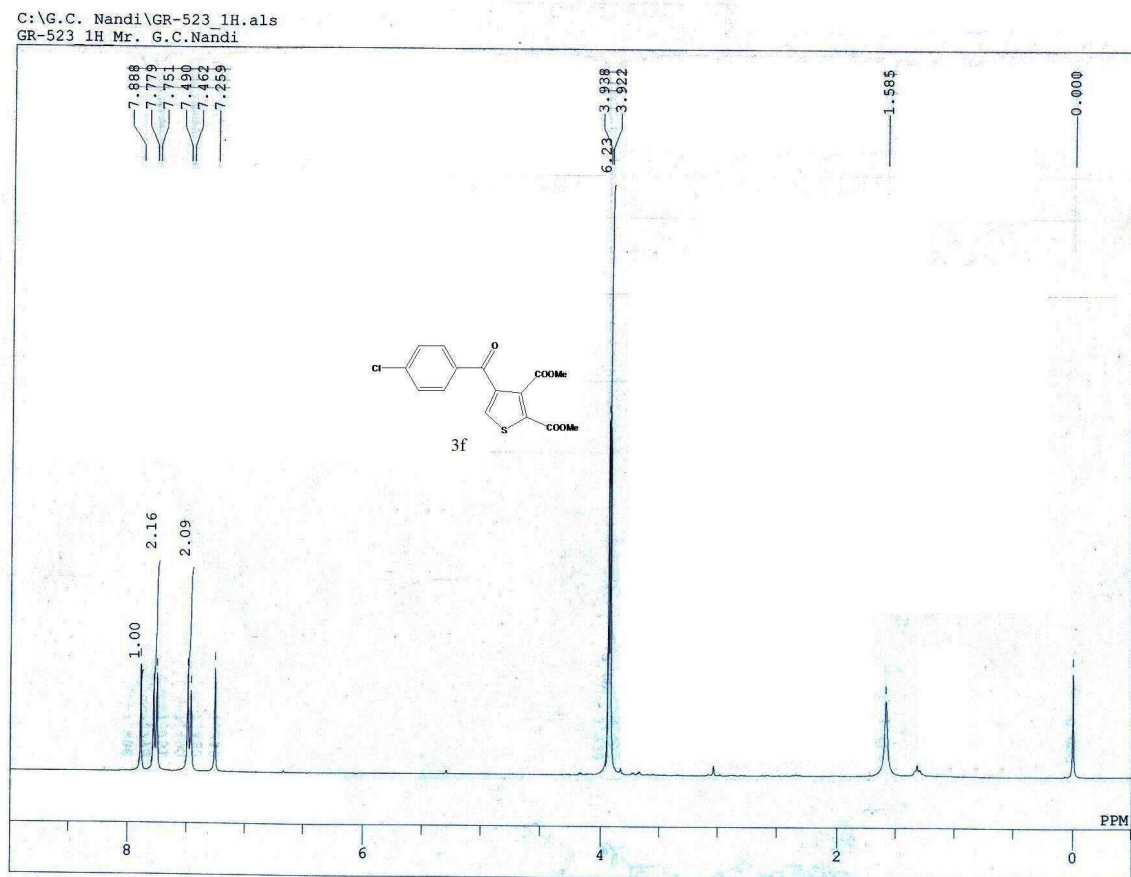
^{13}C spectra of 3d

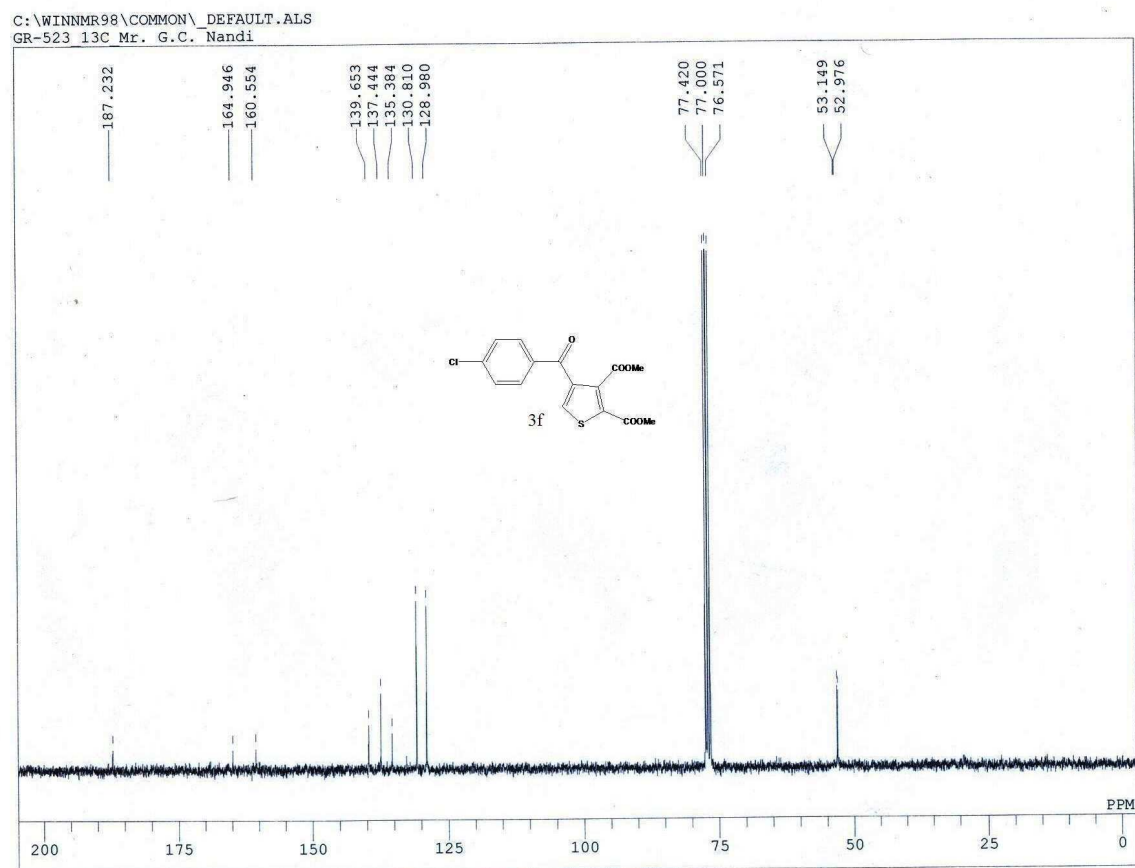
¹H spectra of 3e

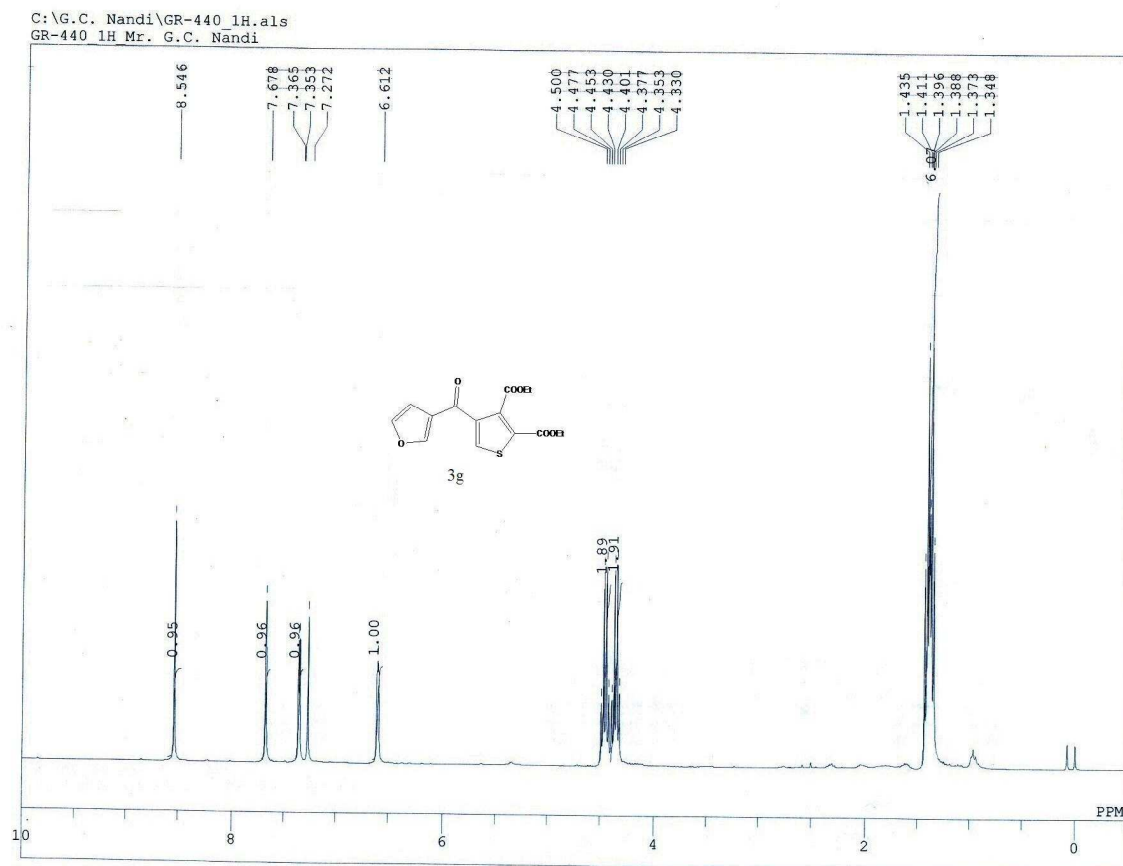
C:\WINNMR98\Data\GR-464--II_1HINON_E1.als
GR-464-II_1H Mr. G.C.Nandi

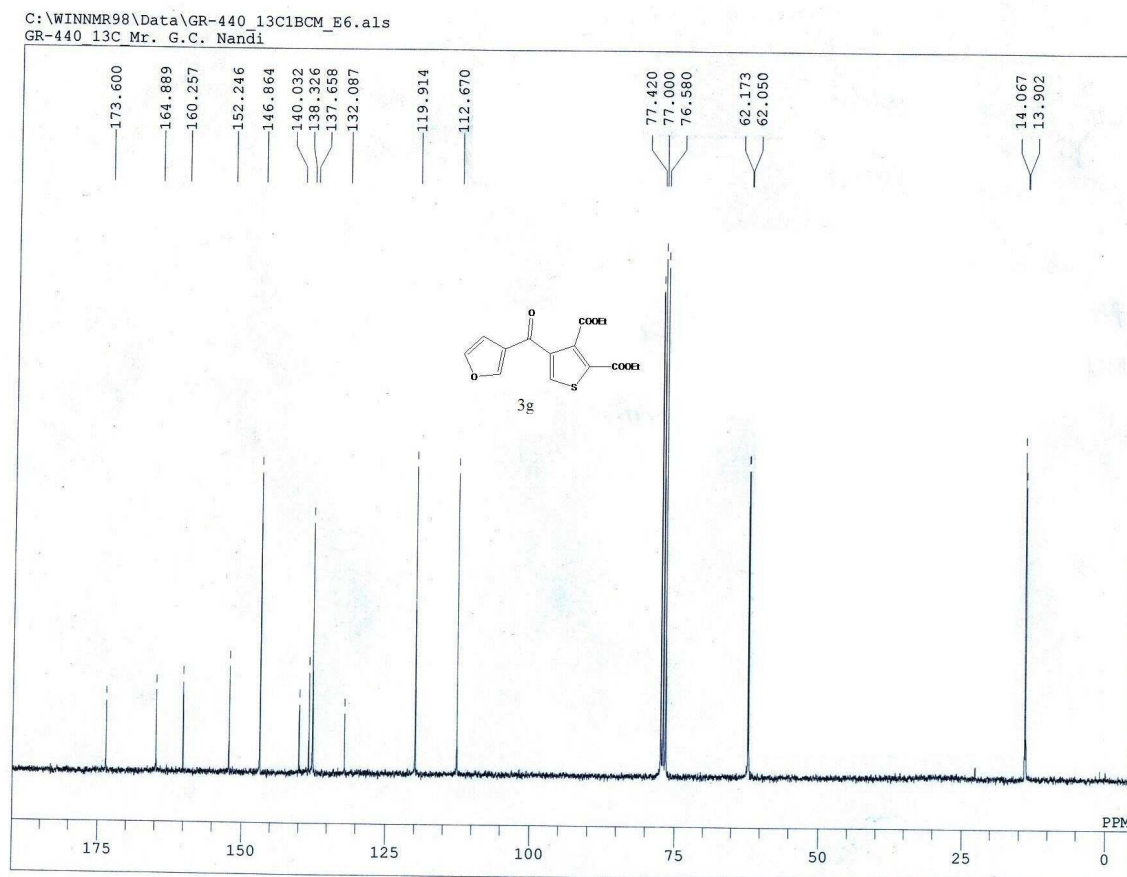


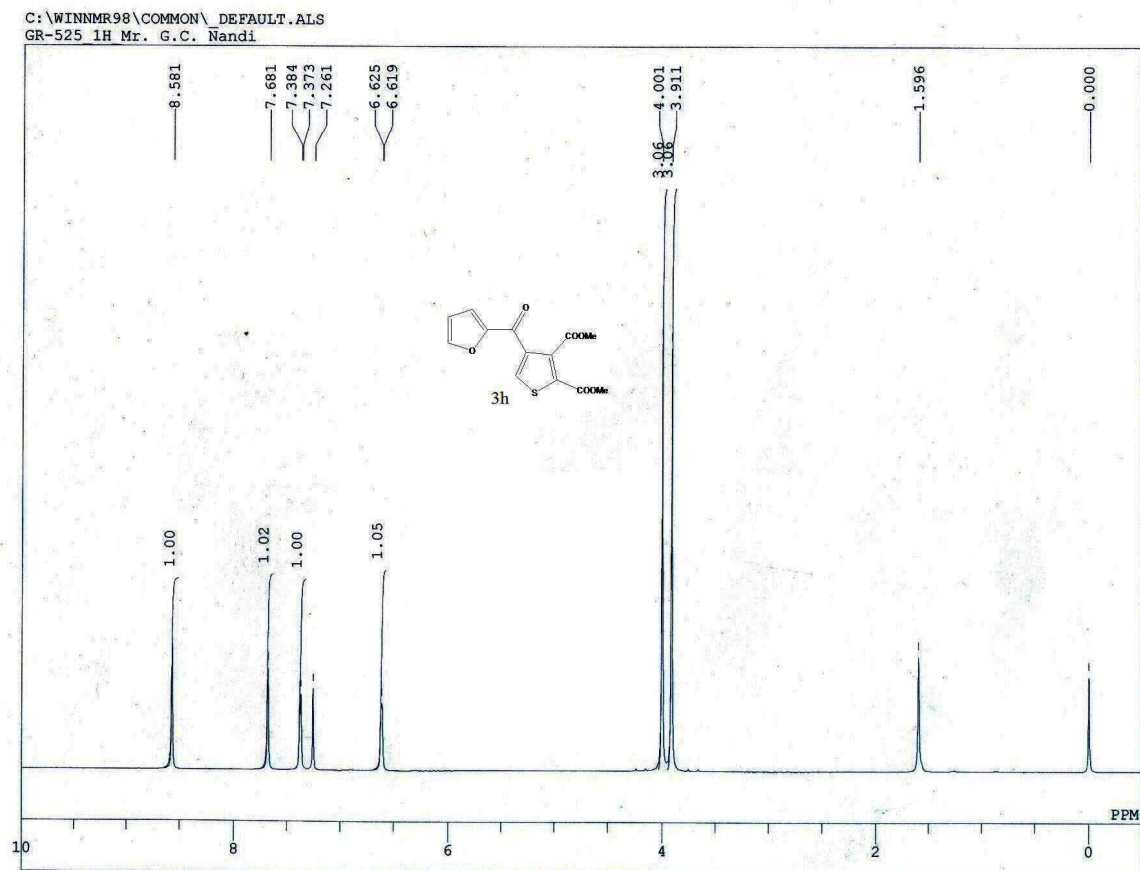
^{13}C spectra of 3e

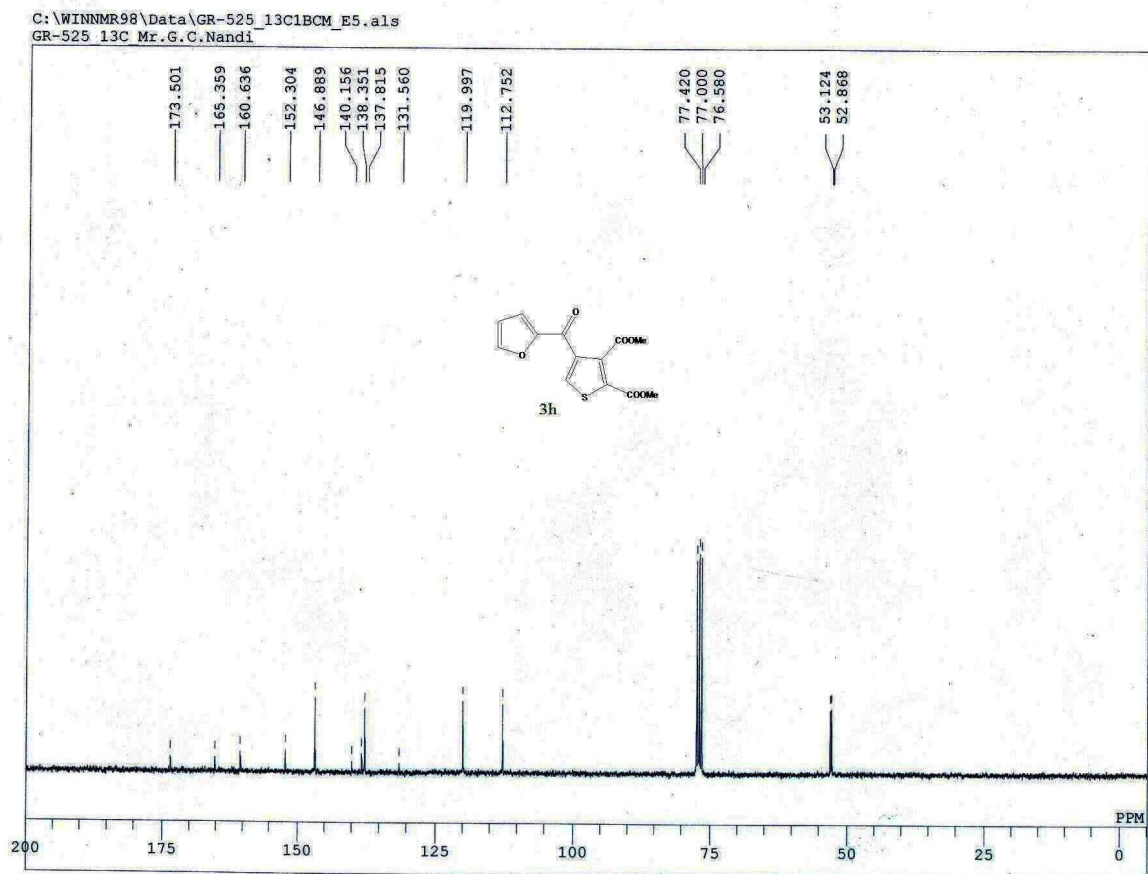
¹H spectra of 3f

^{13}C spectra of 3f

¹H spectra of 3g

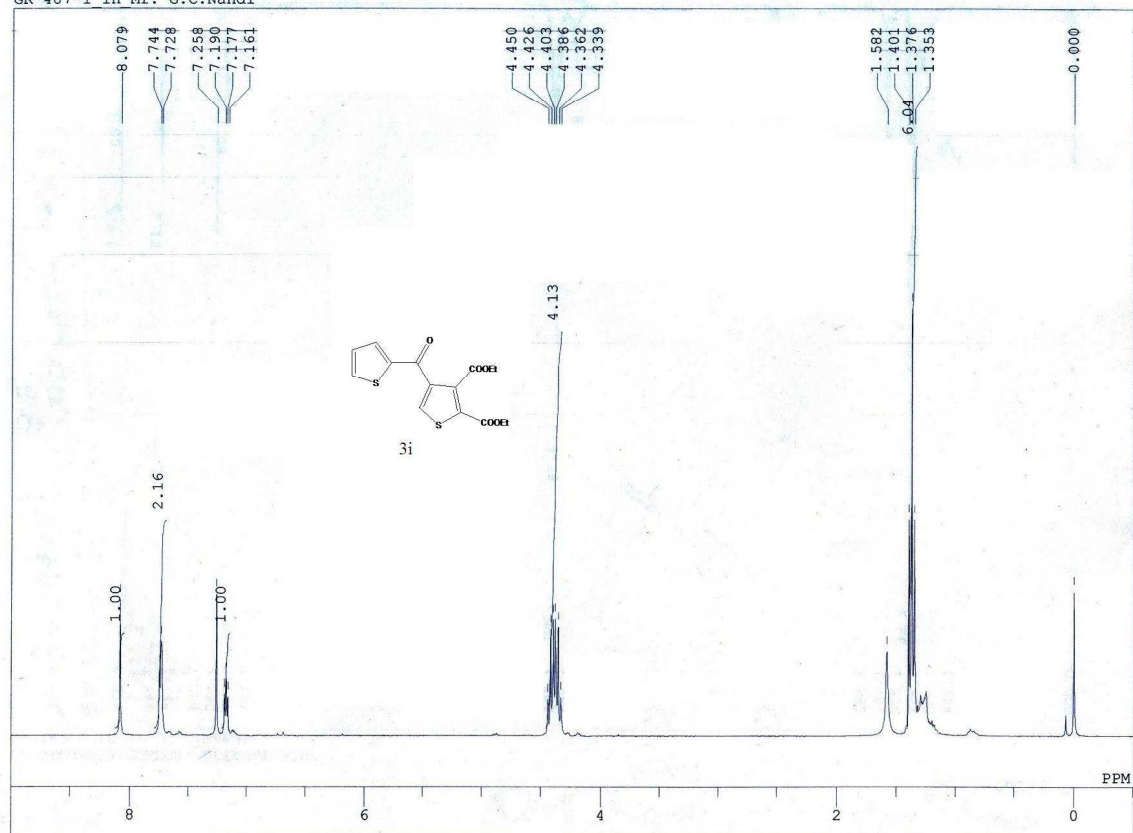
^{13}C spectra of 3g

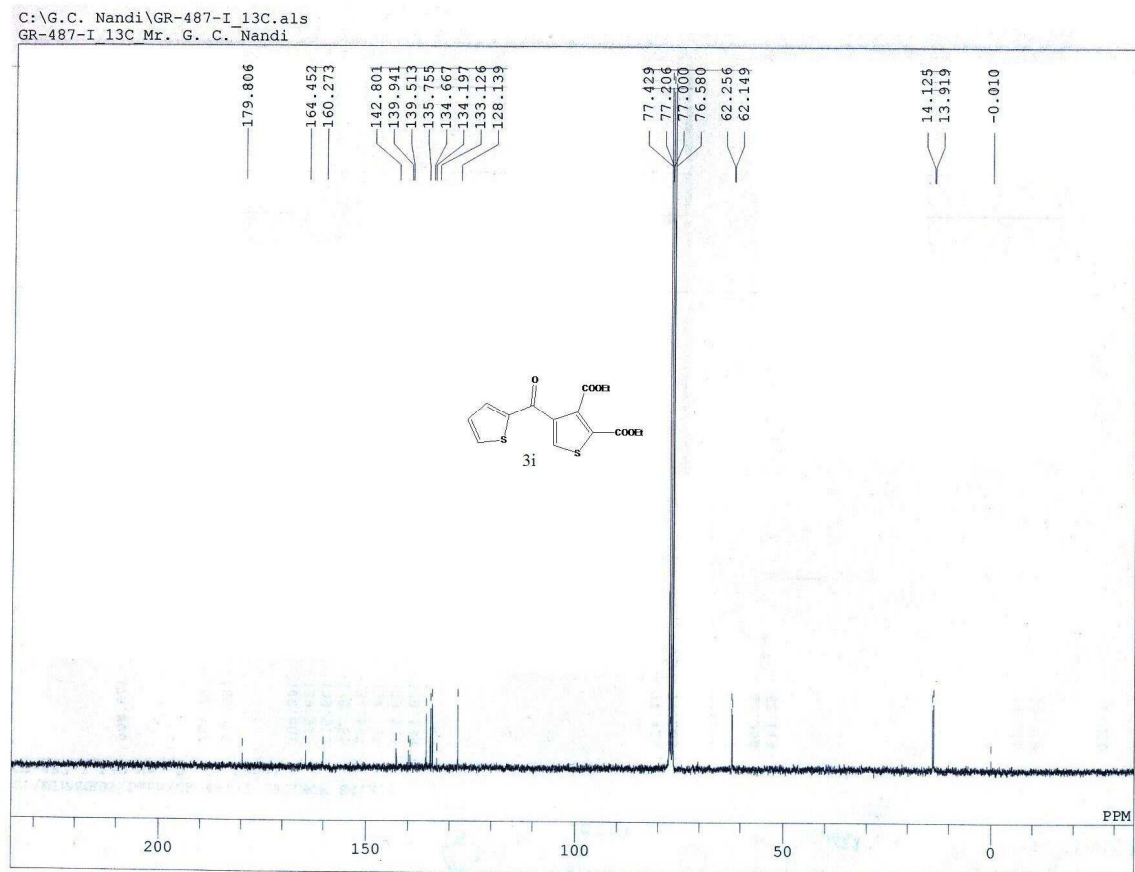
¹H spectra of 3h

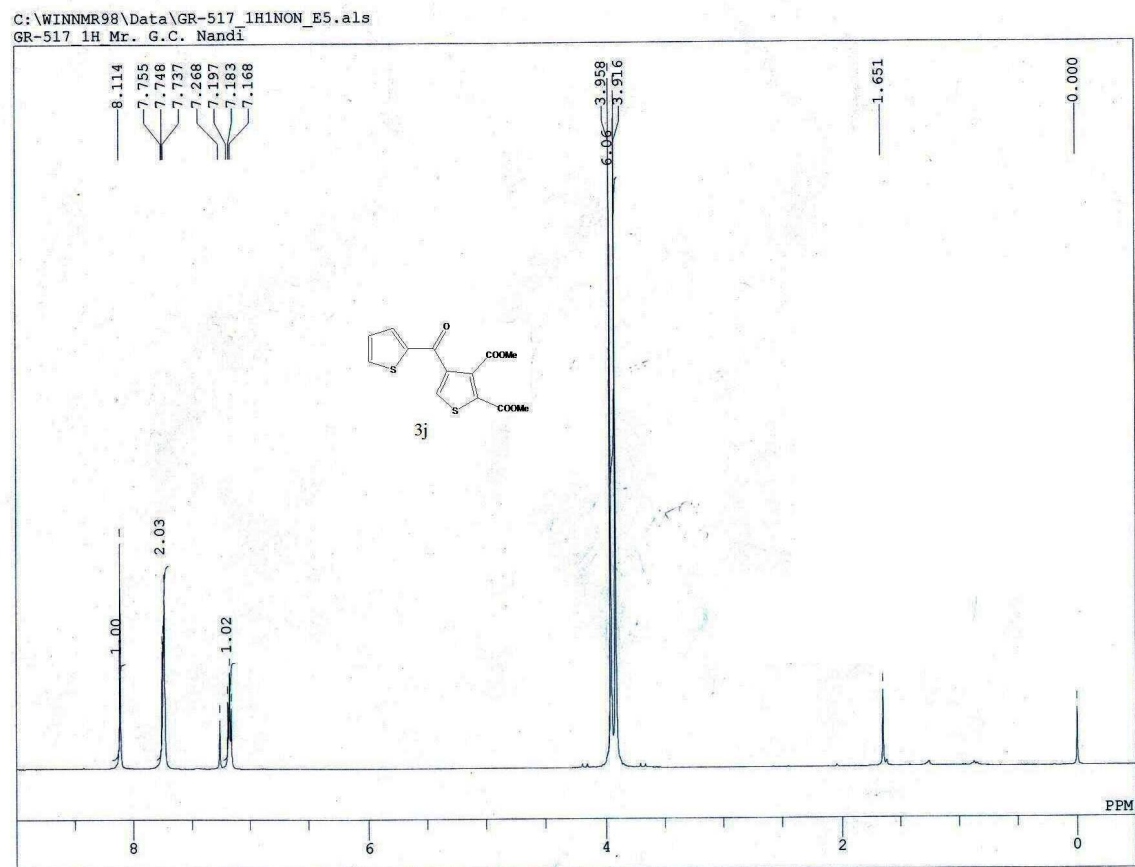
^{13}C spectra of 3h

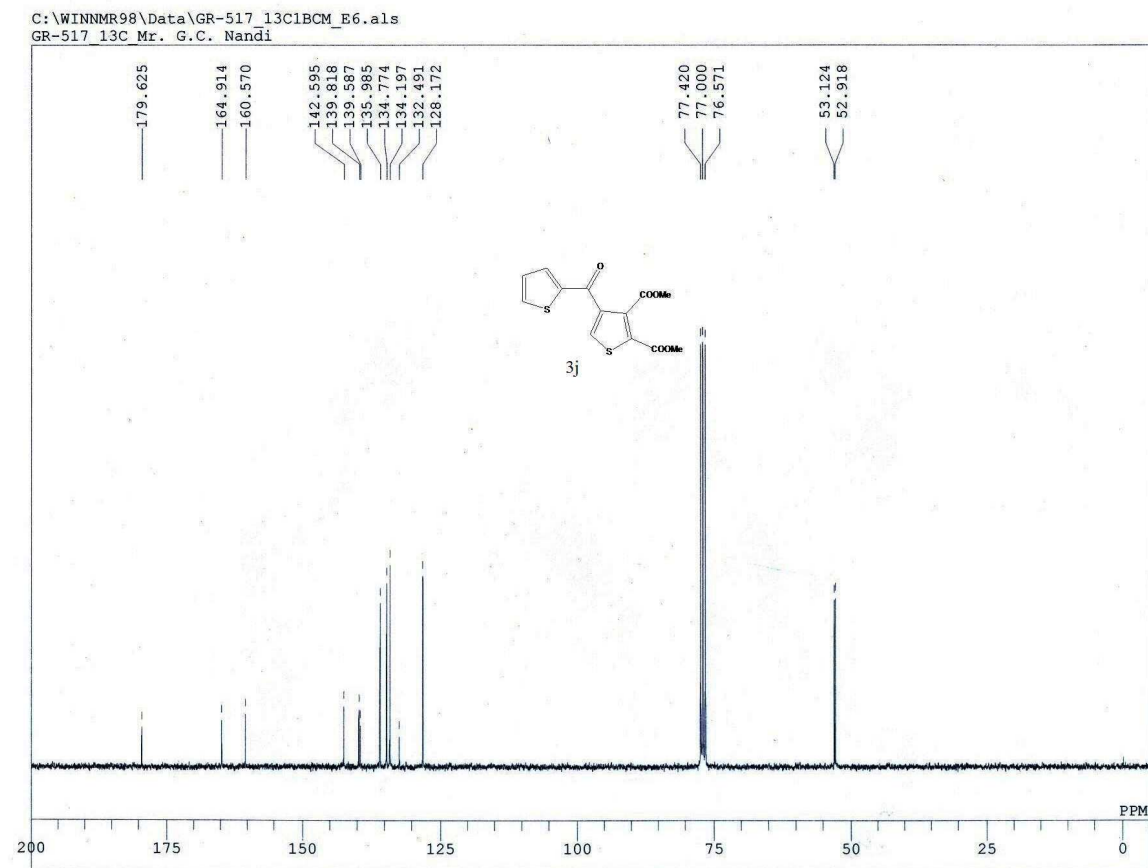
¹H spectra of 3i

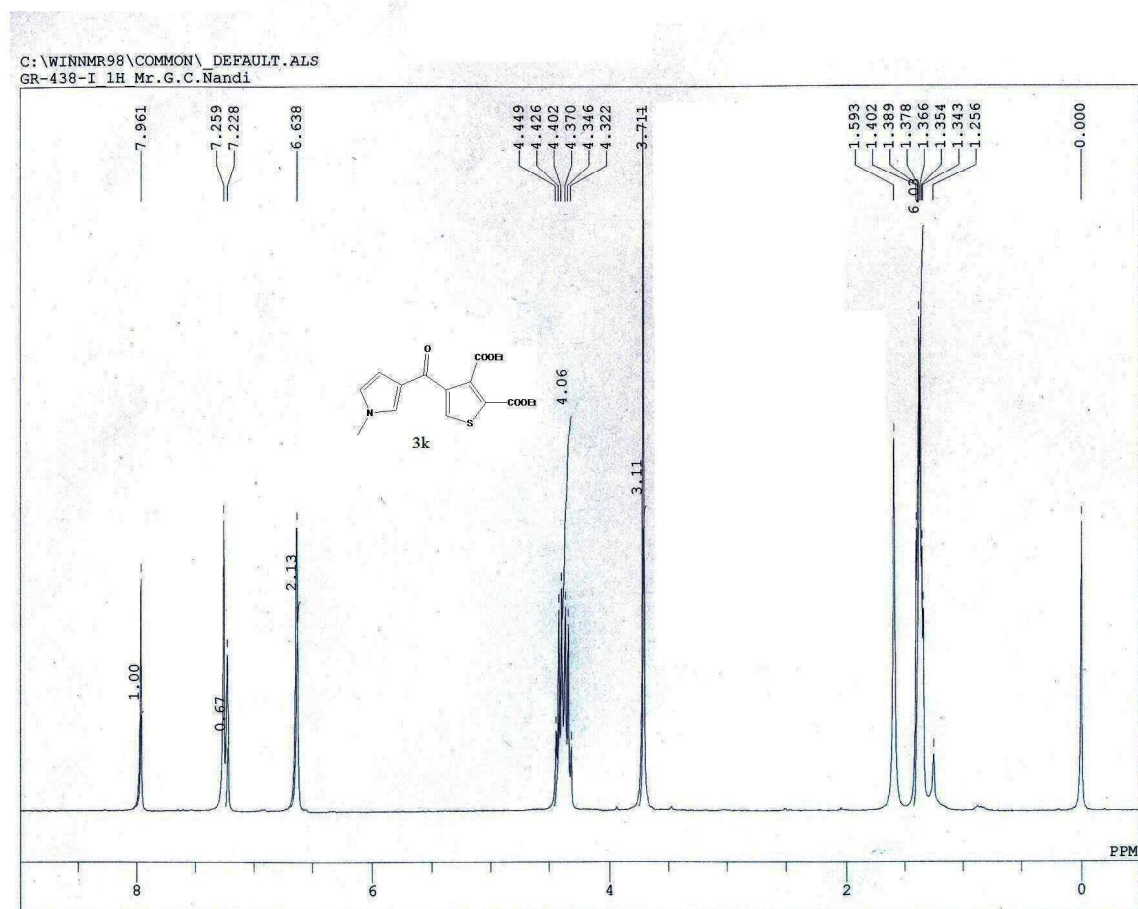
C:\G.C. Nandi\GR-487-I_1H.als
GR-487-I 1H Mr. G.C.Nandi

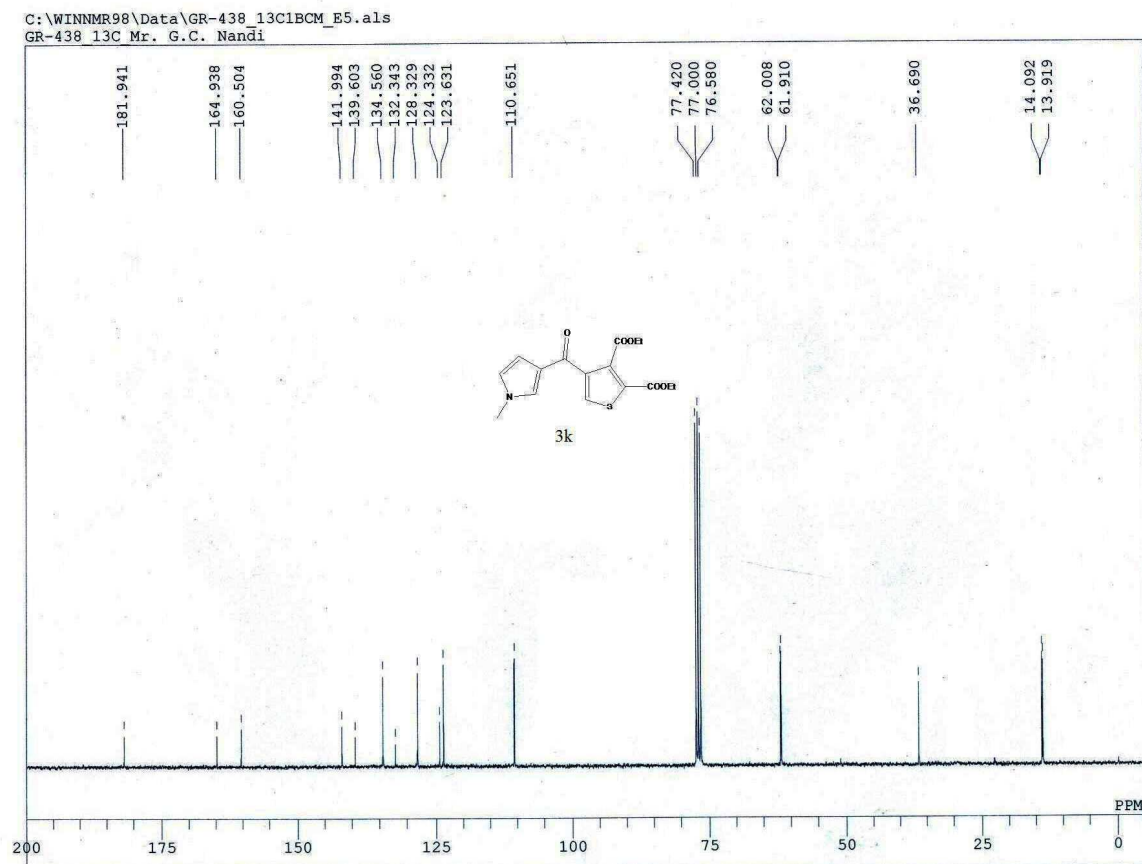


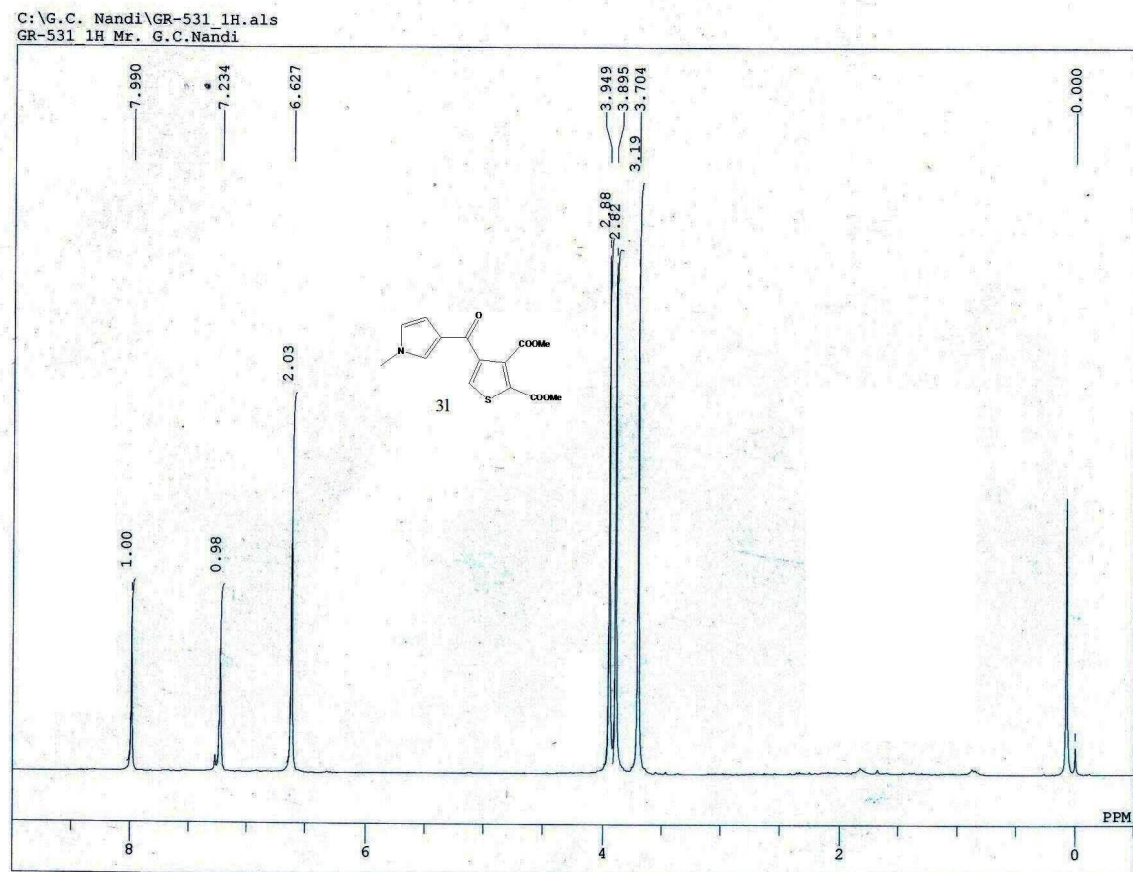
^{13}C spectra of 3i

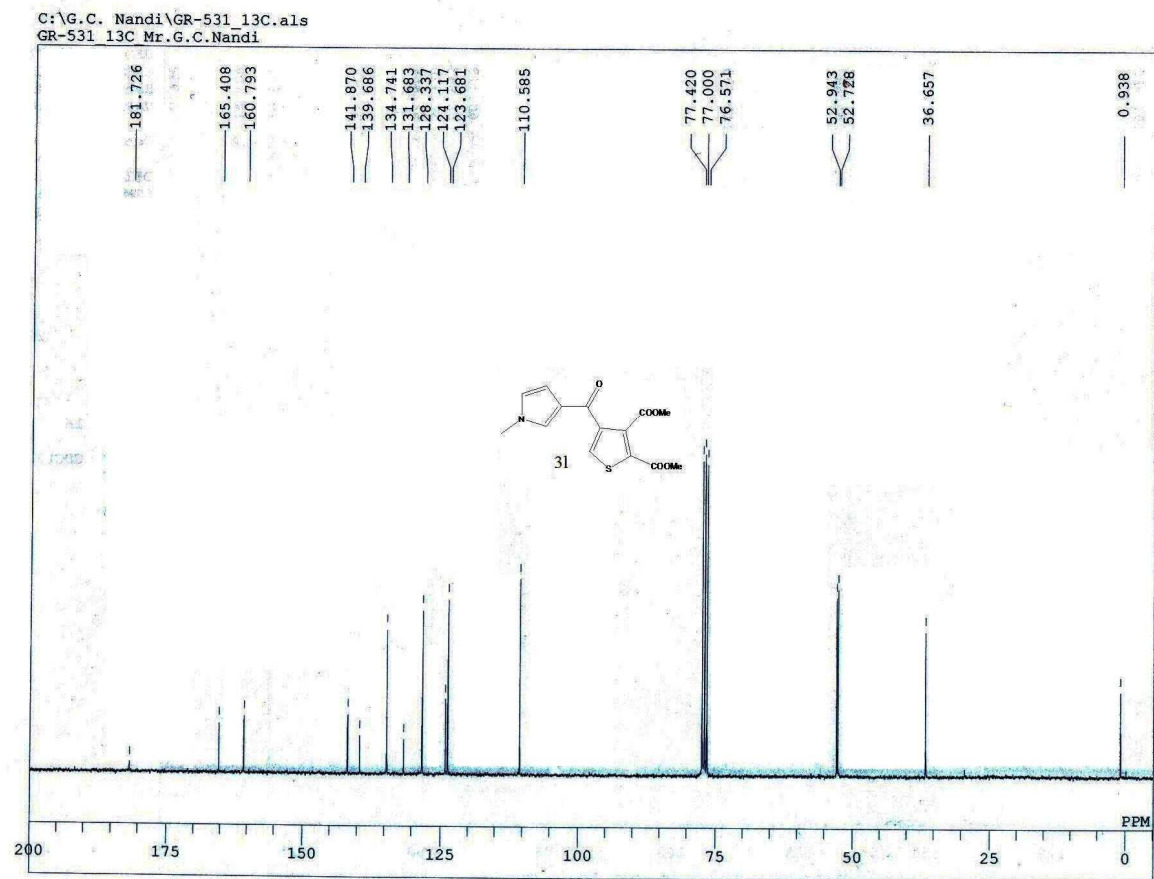
¹H spectra of 3j

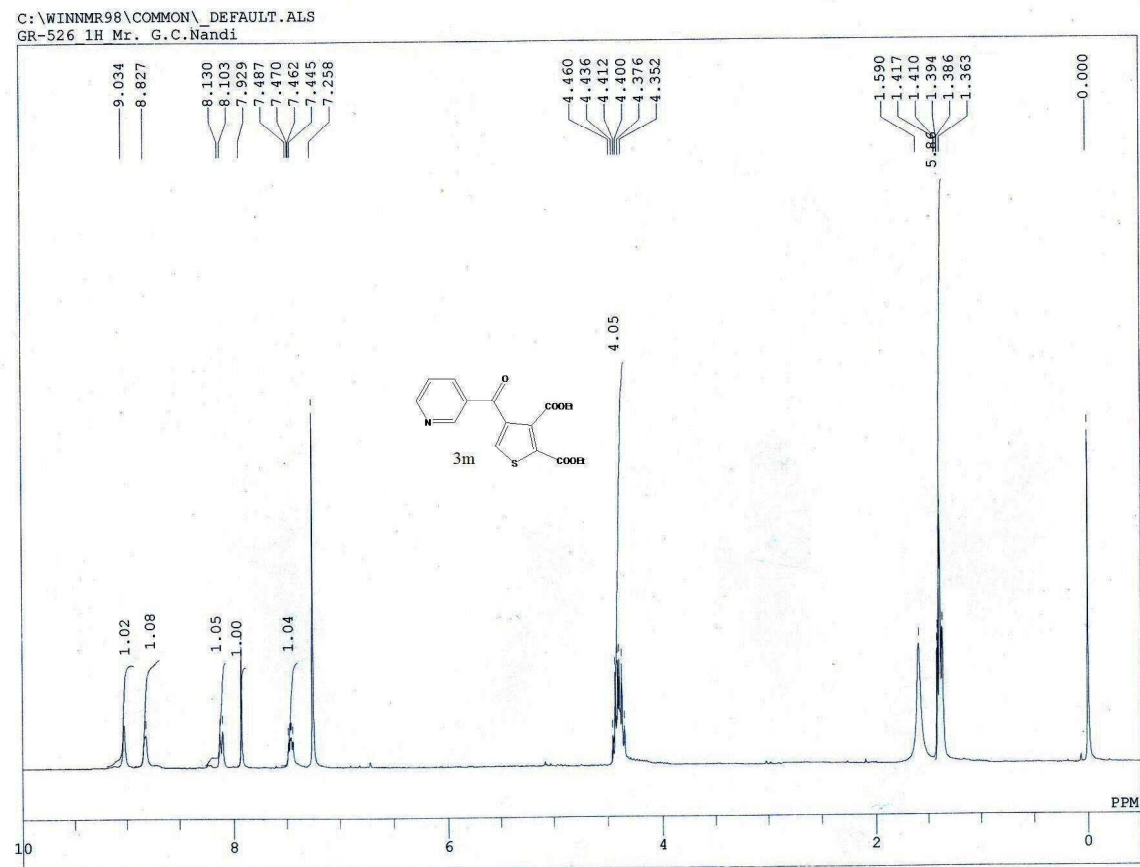
^{13}C spectra of 3j

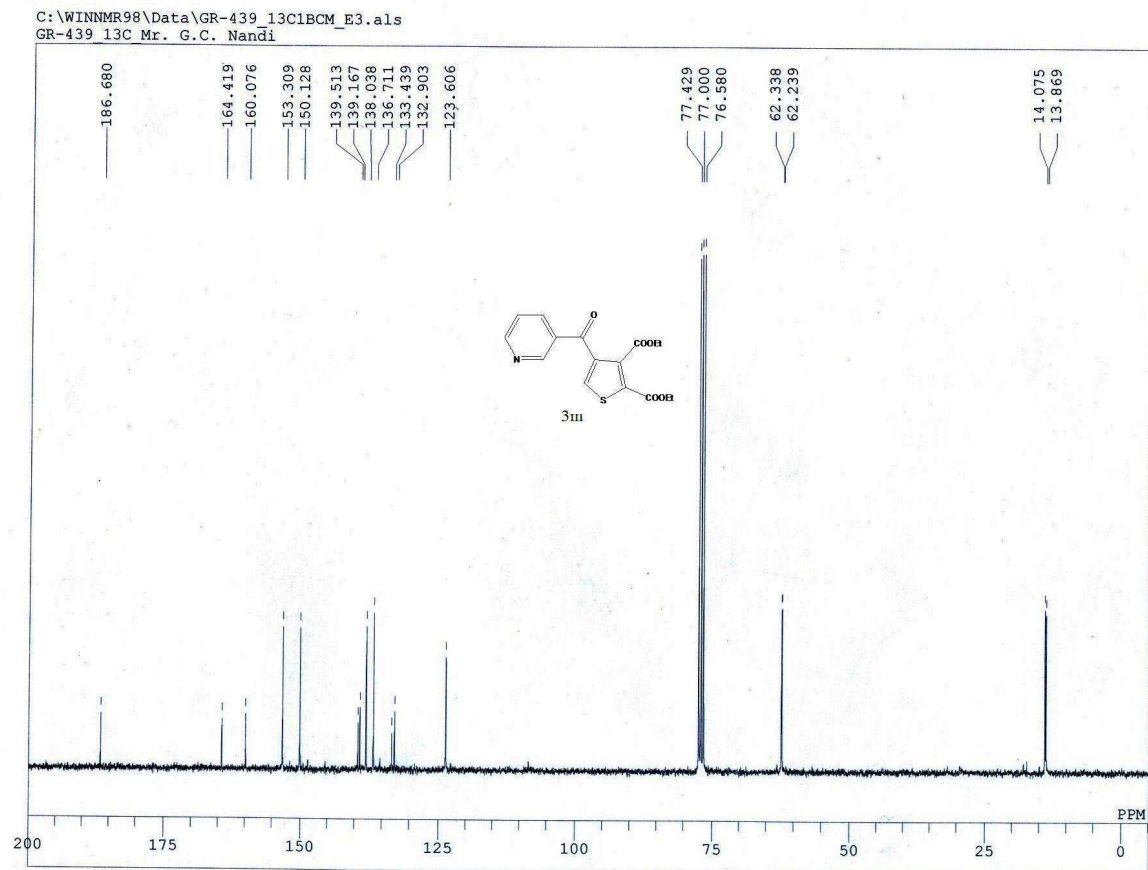
^1H spectra of 3k

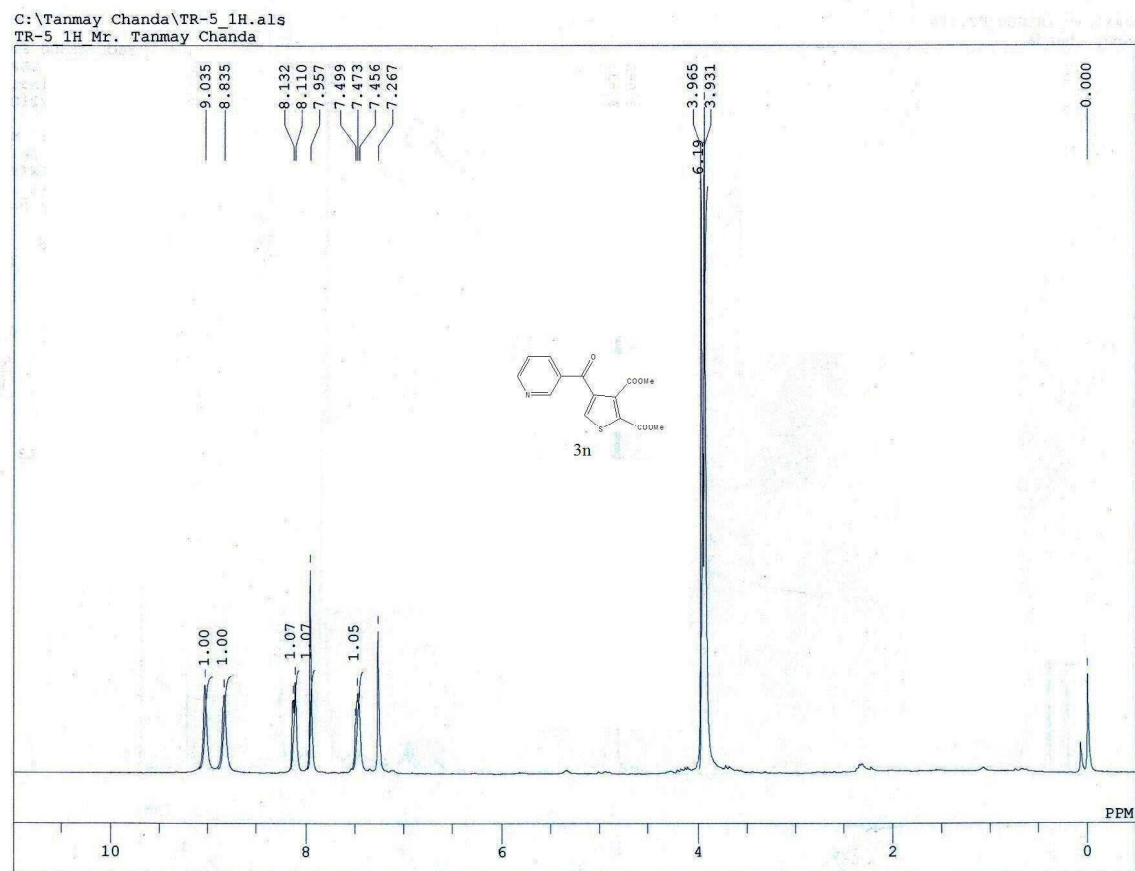
^{13}C spectra of 3k

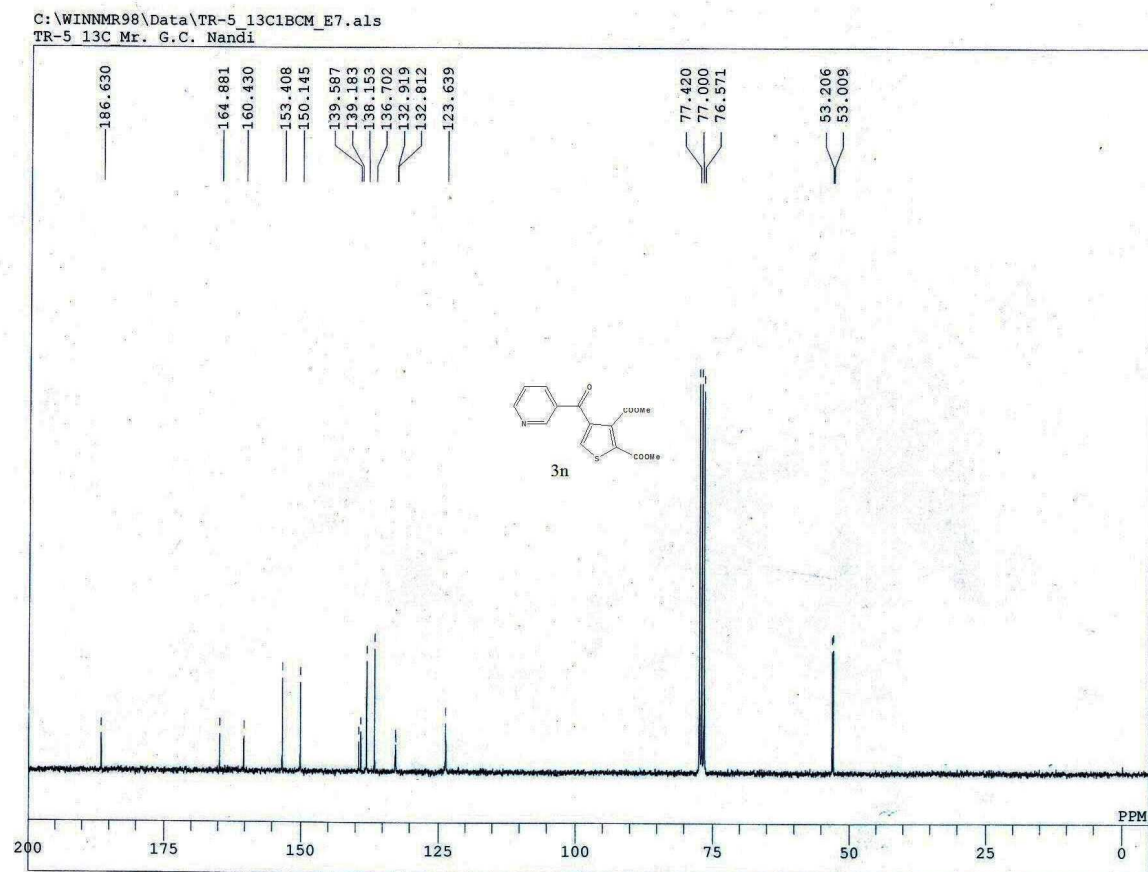
¹H spectra of 3l

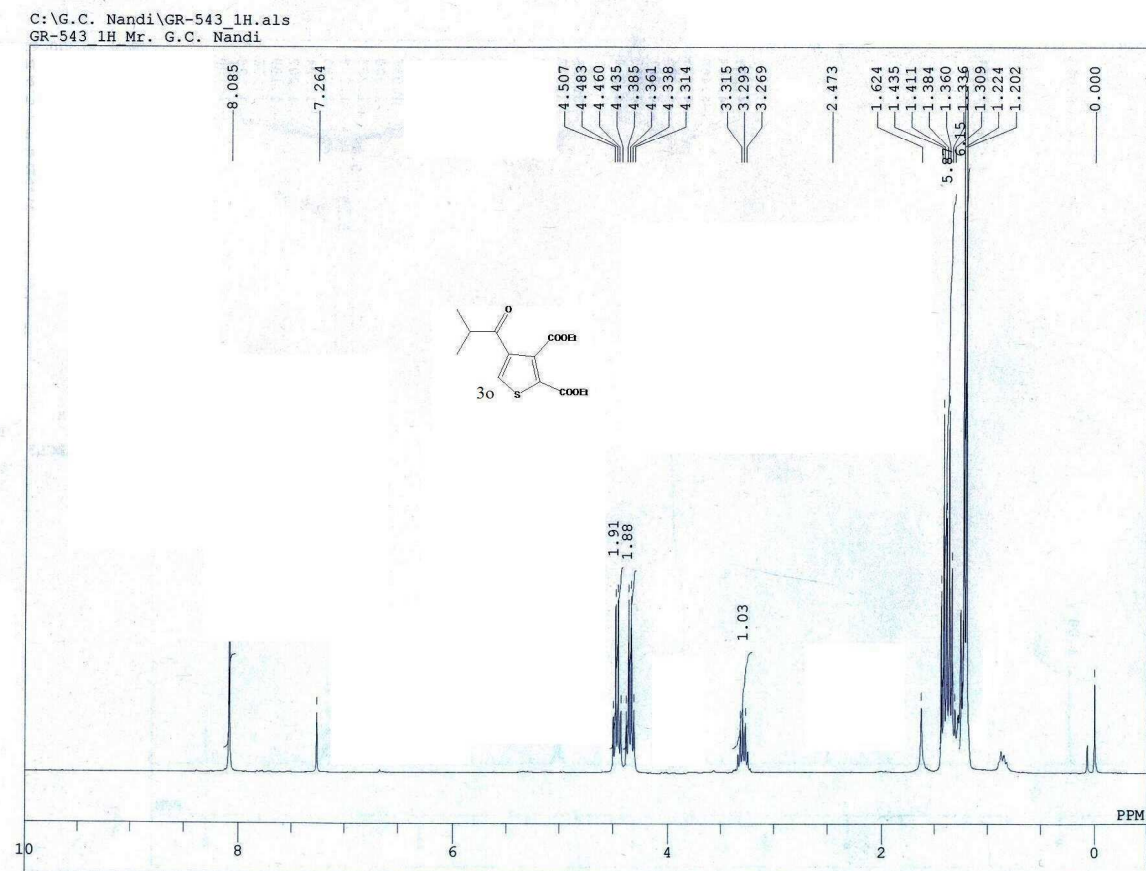
^{13}C spectra of 3l

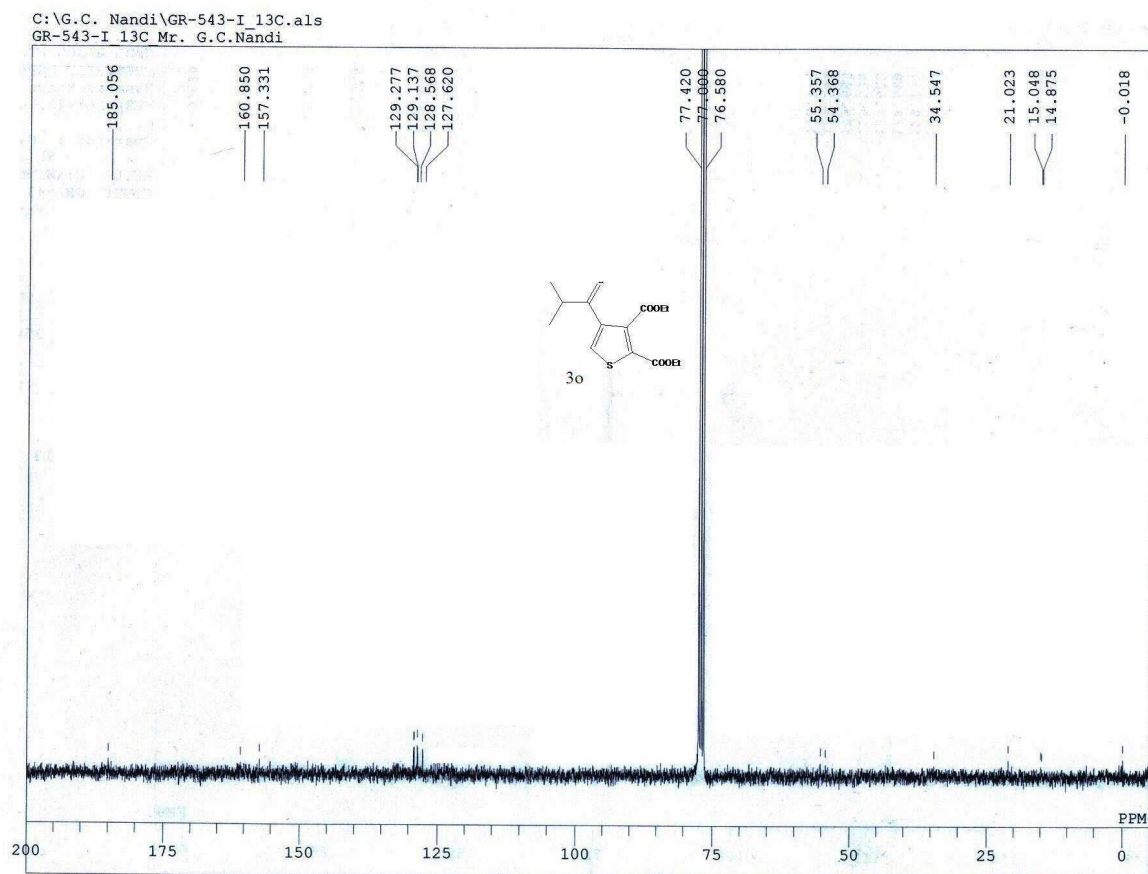
^1H spectra of 3m

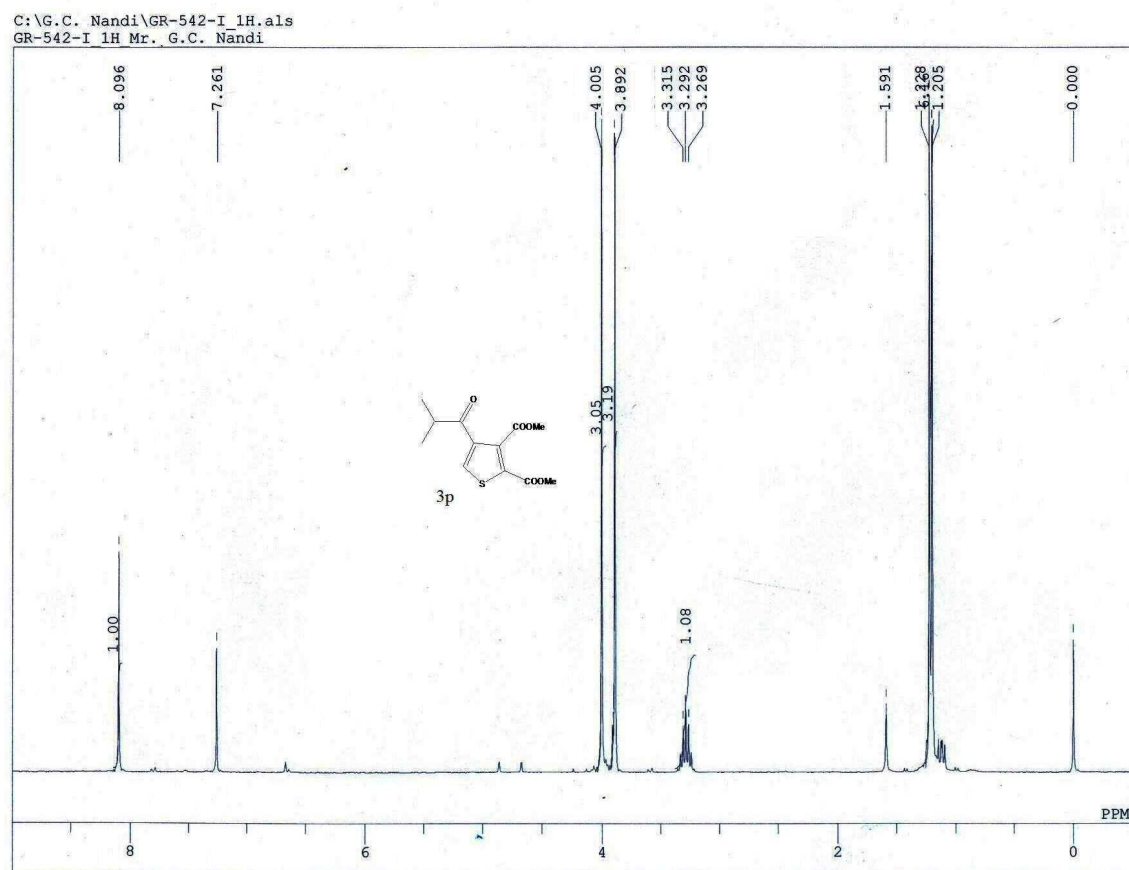
^{13}C spectra of 3m

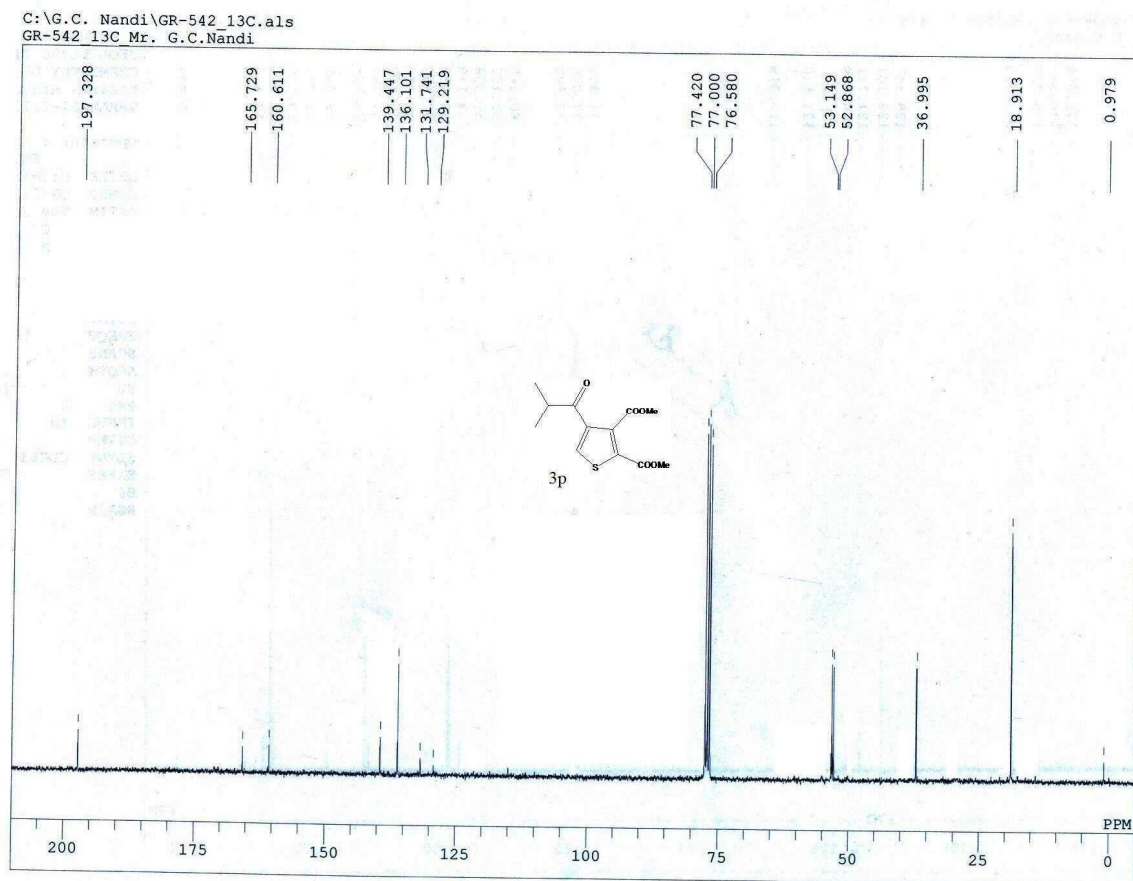
^1H spectra of 3n

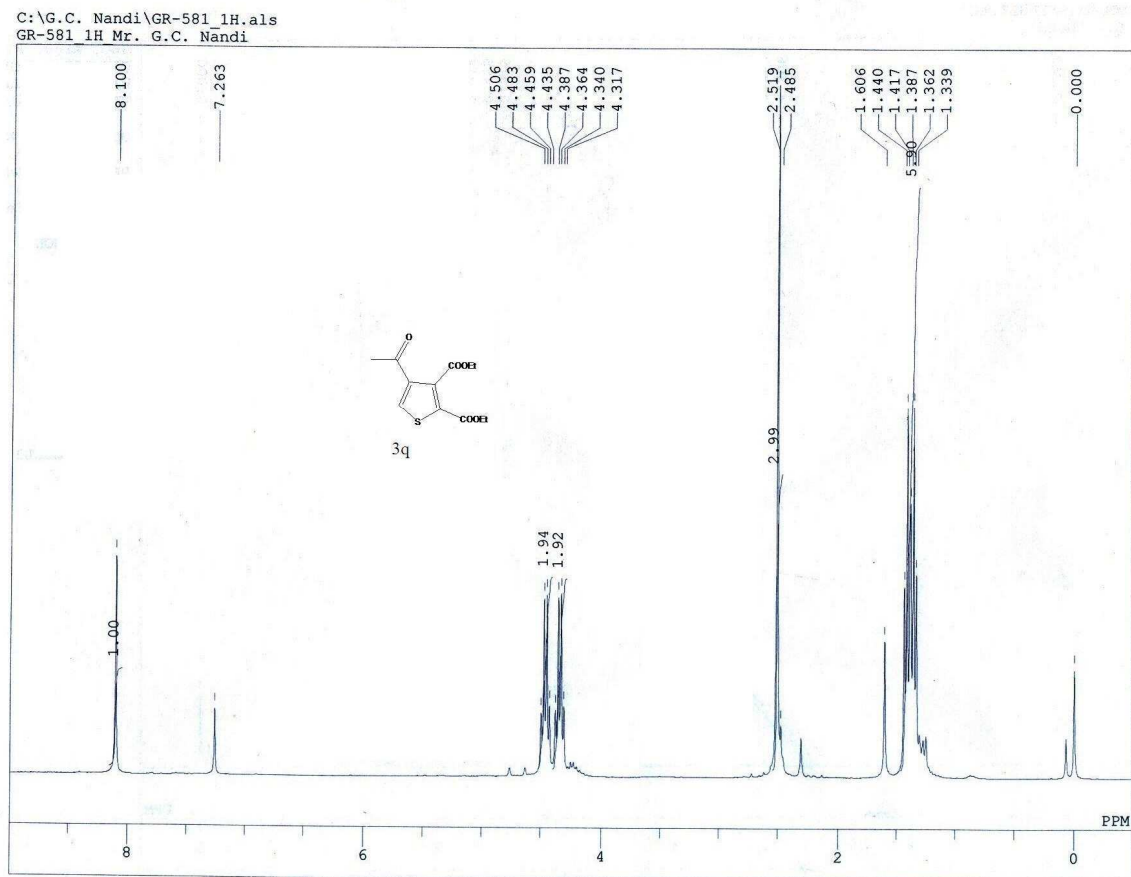
^{13}C spectra of 3n

^1H spectra of 3o

^{13}C spectra of 3o

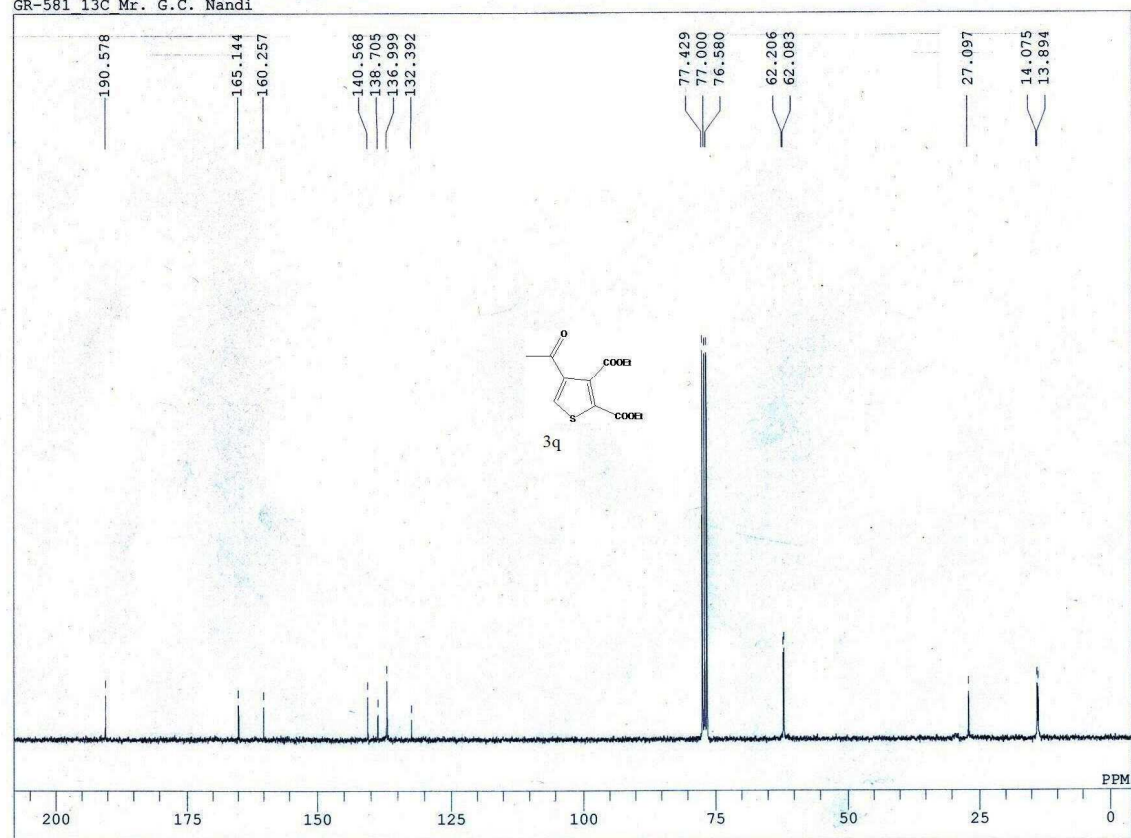
¹H spectra of 3p

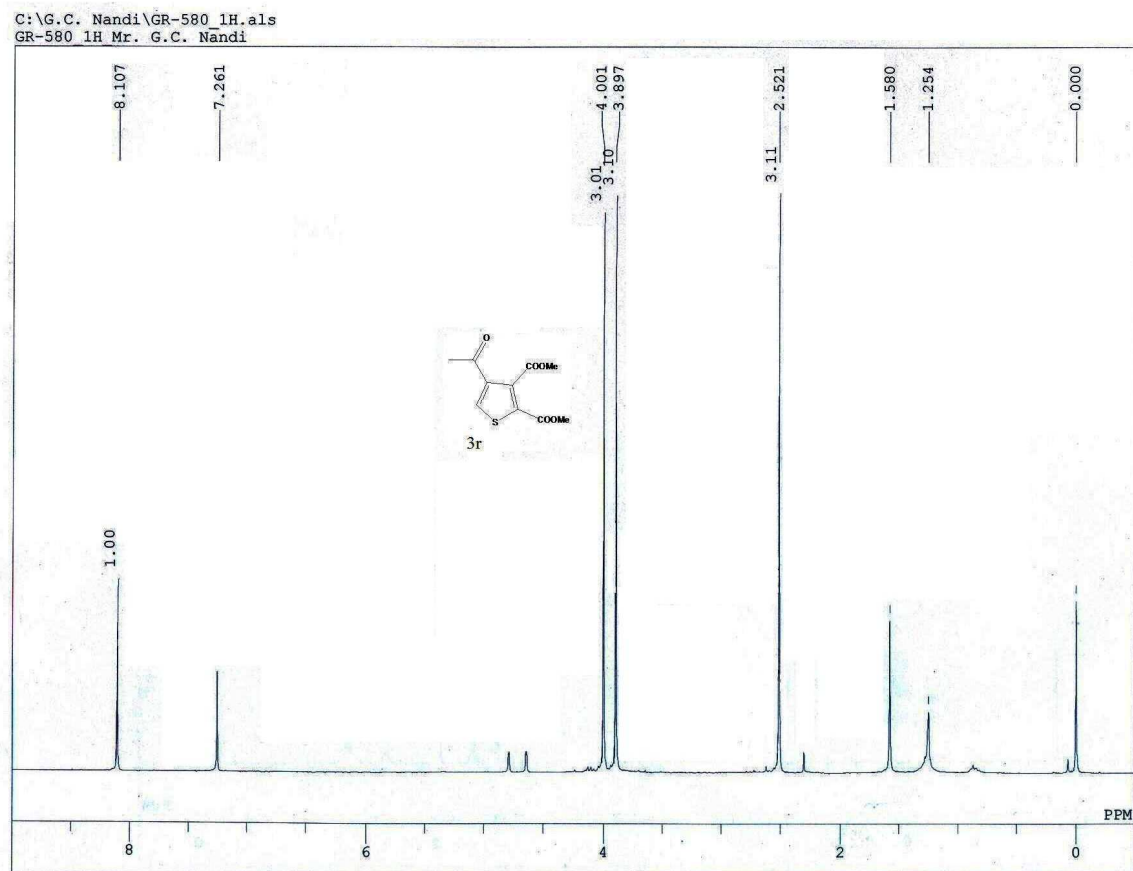
^{13}C spectra of 3p

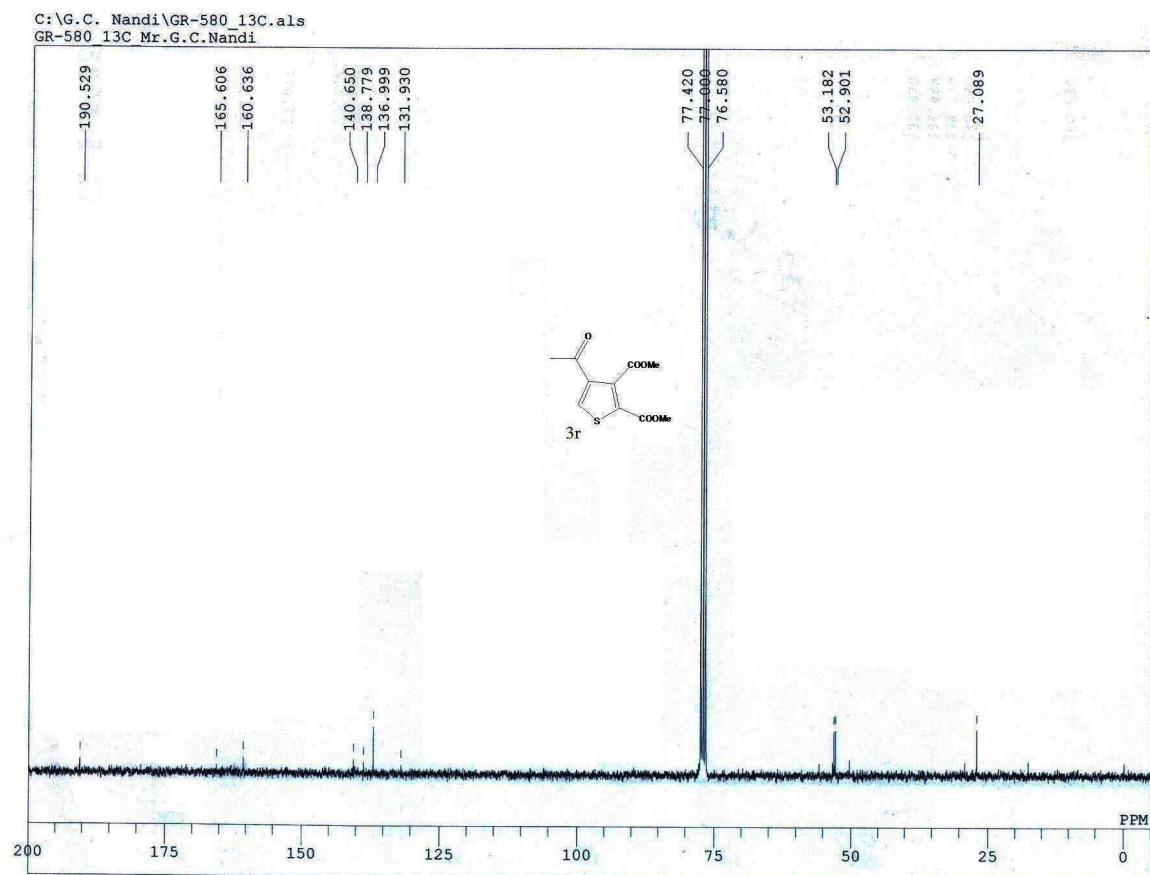
¹H spectra of 3q

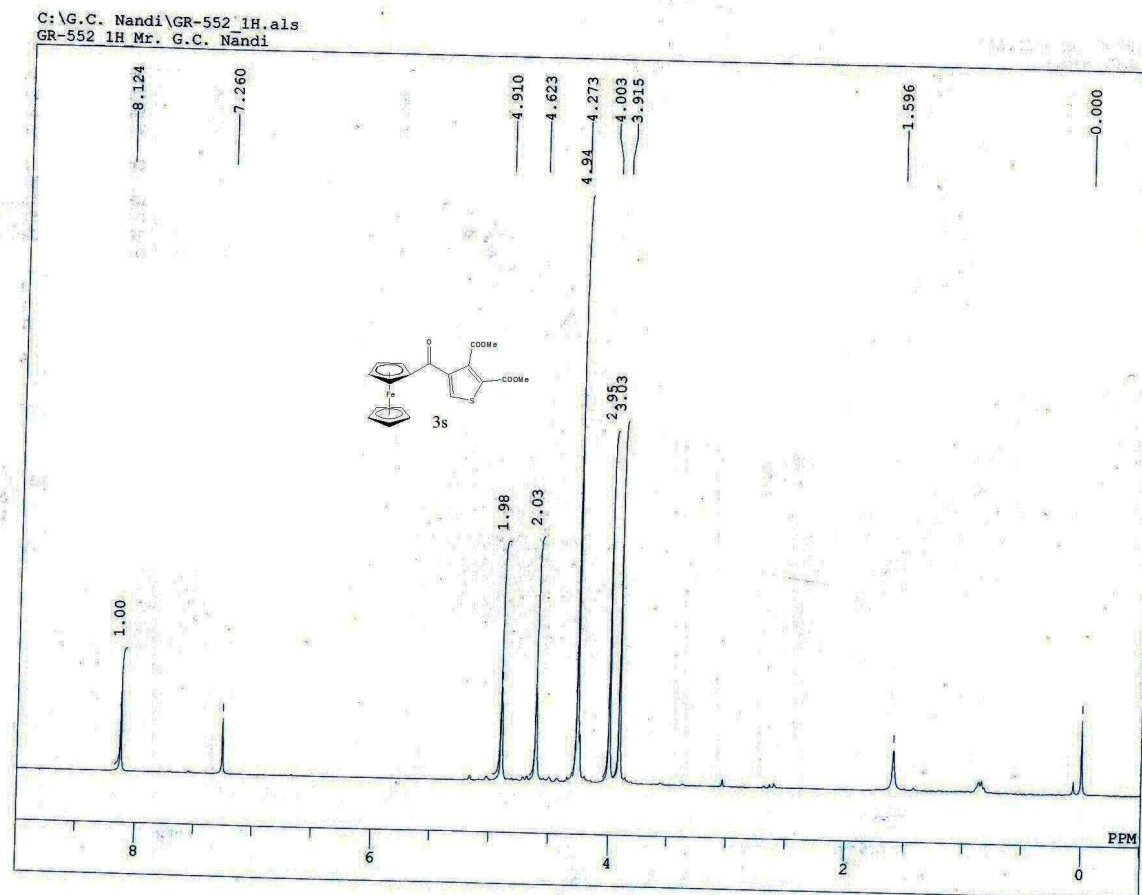
^{13}C spectra of 3q

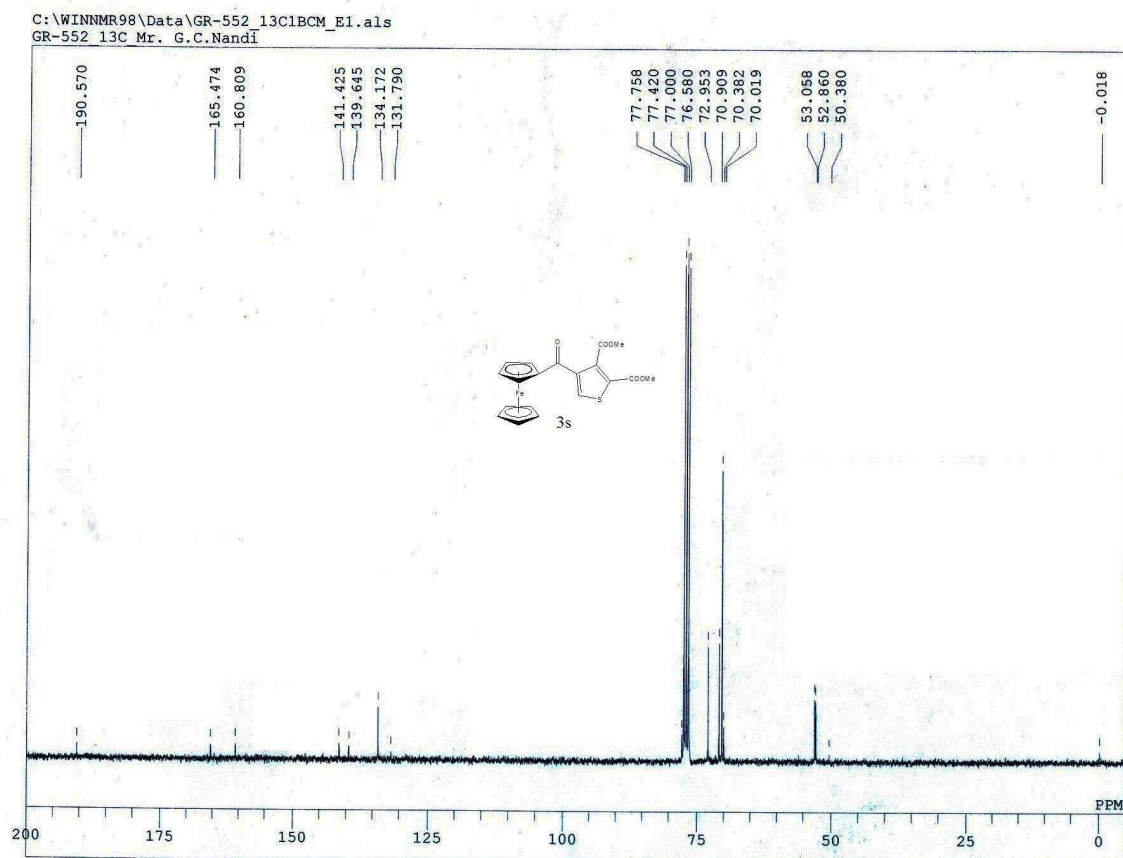
C:\WINNMR98\Data\GR-581_13C1BCM_E5.als
GR-581 13C Mr. G.C. Nandi



¹H spectra of 3r

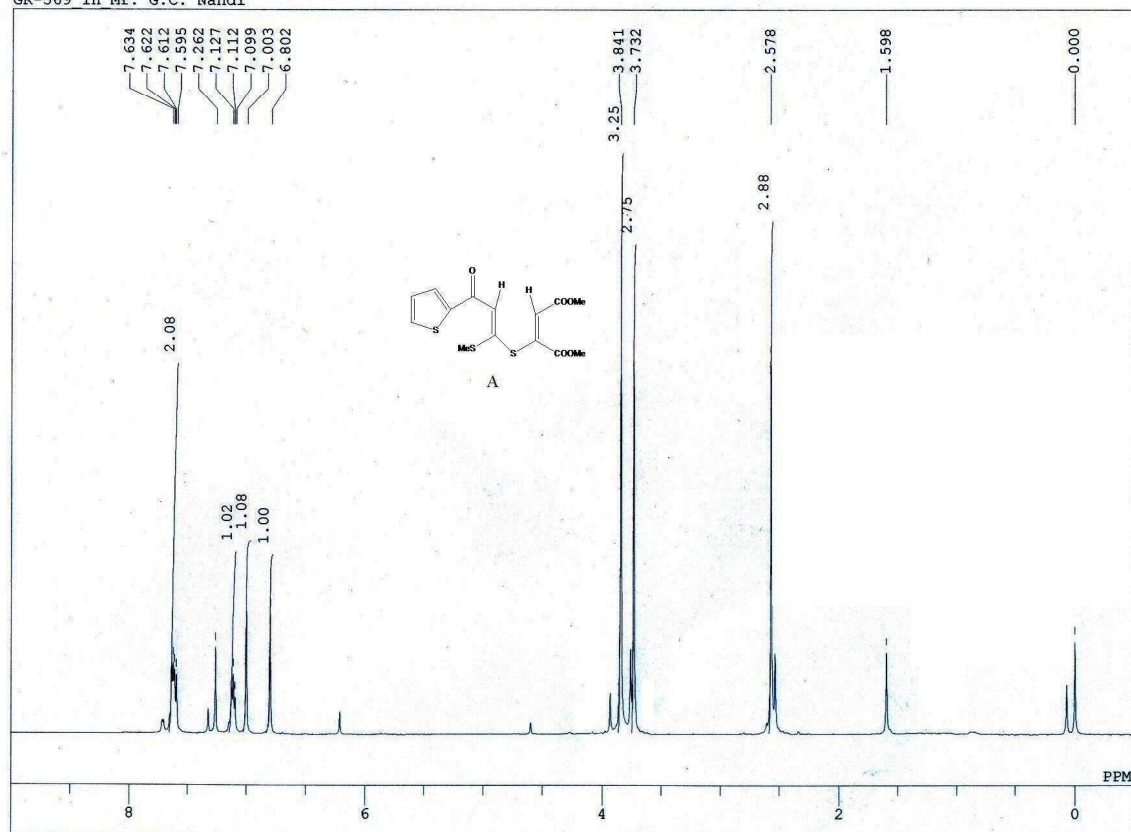
^{13}C spectra of 3r

^1H spectra of 3s

^{13}C spectra of 3s

¹H spectra of A

C:\G.C. Nandi\GR-569 1H.als
GR-569 1H Mr. G.C. Nandi



^{13}C spectra of A

C:\G.C. Nandi\GR-569 13C.als
GR-569 13C Mr.G.C.Nandi

