Supporting information

Catalysis and Regioselectivity of the Aqueous Heck Reaction by Pd(0) Nanoparticles under Ultrasonic Irradiation

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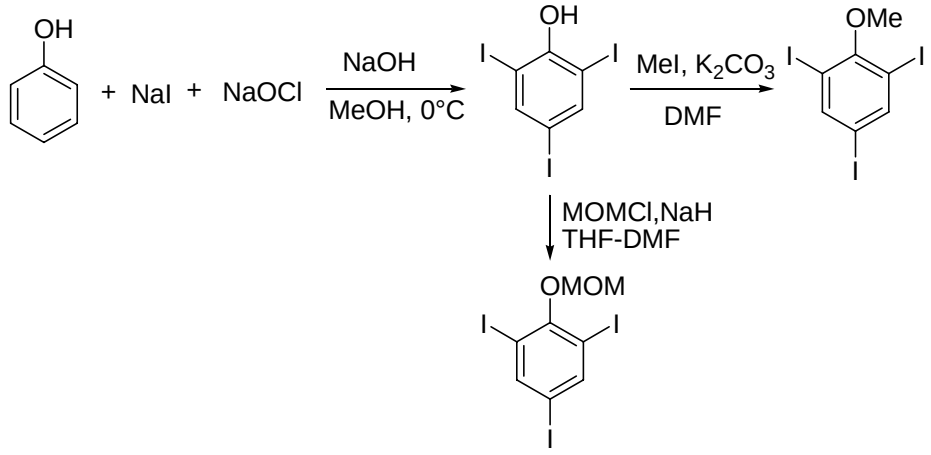
General Experimental: Sonication was performed in a Shanghai Branson-SB2200 ultrasonic cleaner with a frequency of 50 KHz and a power of 80 W. Reagents and solvents were used as supplied. The starting material of aryl iodides list in entries 6-9 (Table 1 in text) was prepared from the iodination of corresponding aromatic compounds[1]. 1-iodo-2-methylbenzene (entry 10, Table1) was prepared from 1-bromo-2-methylbenzene[2]. Those listed in entries 11-16 were prepared by the synthetic paths shown below.

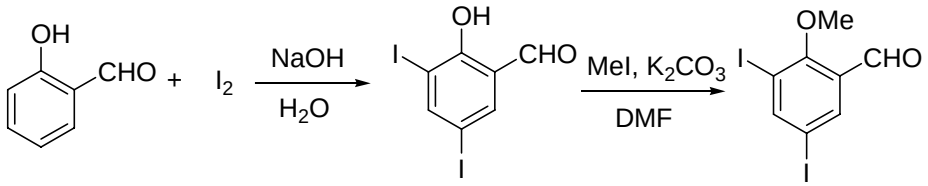
General Procedure for Heck Reaction under Ultrasound: In a 10 ml glass flask was placed phenyl iodide (1mmol), alkene (2mmol), TBAB (0.322g, 1mmol), Na_2CO_3 (0.318g, 3mmol), $PdCl_2$ (0.0035g, 0.02mmol) in 3 ml water (1 mL of CH_2Cl_2 was added for the solid phenyl iodide), after the mixture was sonicated at ambient temperature (25°C) in running water bath for corresponding times, it was extracted with ethyl acetate for three times. The combined organic extracts were dried using anhydrous Na_2SO_4 and evaporated under reduced pressure, the mixture was then purified by column chromatography over silica gel to afford product with high purity.

Typical Procedure for the Catalyst Recycling of Heck Reaction: After completion of the reaction, the mixture was extracted with petroleum ether for three times. Water phase and remnant black solid were used for the next cycle. Iodobenzene (0.208g, 1mmol), methyl aceylate (0.172g, 2mmol) and Na_2CO_3 (0.318g, 3mmol) were then added to mixtures and were sonicated for 4.5h.

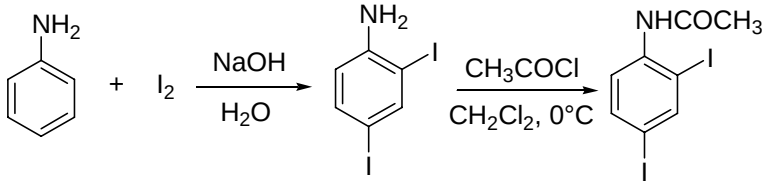
Scheme S1. Synthesis of starting material in entries 12 and 13 (Table1).[3]



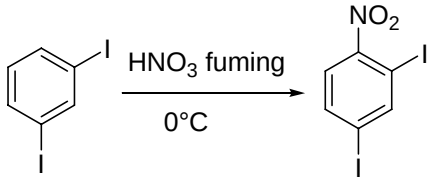
Scheme S2. Synthesis of starting material in entries 14 (Table1). [4]



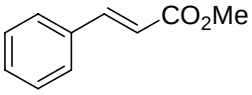
Scheme S3. Synthesis of starting material in entries 15 (Table1).[5]



Scheme S4. Synthesis of starting material in entries 16 (Table1).

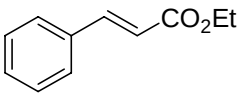


1. (a) Alexander, V. M.; Khandekar, A. C.; Samant, S.D. *Synlett* **2003**, *12*, 1895.
   (b) Luliński, P.; Skulski, L. *Bull. Chem. Soc. Jpn.* **2000**, *73*, 951.
2. Datta, R.L.; Mitter, H. K. *J. Am. Chem. Soc.* **1919**, *41*, 287.
3. Edgar, K. J.; Falling, S.N. *J. Org. Chem.* **1990**, *55*, 5287.
4. Bougault, J.; Cattelain, E.; Chabrier, P.; Quevauviller, A. *Bull. Soc. Chim. Fr.* **1949**, **433**
5. Callaghan, P. D.; Gibson, M. S. *J. Chem. Soc. (C),* **1970**, 2106.



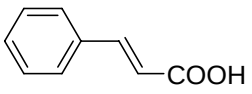
(*E*) - methyl cinnamate (1)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.69 (d, J = 16.1 Hz, 1H), 7.50-7.53 (m, 2H), 7.39-7.37 (m, 3H), 6.44 (d, J = 16.1 Hz, 1H), 3.80 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.1, 114.7, 134.2, 130.2, 128.8, 128.0, 117.7, 51.5. IR (Liquid film, cm^{-1}): ν = 3028, 2951, 1719, 1638, 1450, 1434, 1276, 1203, 1172, 980, 768. HRMS calc. $C_{10}H_{10}O_2$ (M^+): 162.0681. Found: 162.0676.



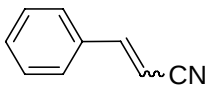
(*E*) - ethyl cinnamate (2)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.69 (d, J = 16.1 Hz, 1H), 7.50-7.54 (m, 2H), 7.40-7.37 (m, 3H), 6.44 (d, J = 16.1 Hz, 1H), 4.27 (q, J = 7.3 Hz, 2H), 1.30 (t, J = 7.3 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.1, 144.7, 134.6, 130.3, 129.0, 128.1, 118.4, 60.6, 14.4. IR (Liquid film, cm^{-1}): ν = 2981, 1713, 1638, 1176, 1039, 980, 767. HRMS calc. $C_{11}H_{12}O_2$ (M^+): 176.0837. Found: 176.08448.



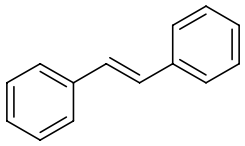
cinnamic acid (3)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.80 (d, J = 16.0 Hz, 1H), 7.58-7.54 (m, 2H), 7.43-7.40 (m, 3H), 6.46 (d, J = 16.1 Hz, 1H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 172.5, 147.3, 134.2, 130.9, 129.1, 128.5, 117.5. IR (KBr film, cm^{-1}): ν = 1682, 1632, 1449, 1315, 1289, 933, 766, 705. HRMS calc. $C_9H_8O_2$ (M^+): 148.0524. Found: 148.0515.



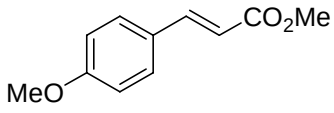
cinnamonitrile (4)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.47-7.38 (m, 5.8H), 7.13 (d, J = 12.2 Hz, 0.2H), 5.88 (d, J = 16.6 Hz, 0.8H), 5.45(d, J = 12.2 Hz, 0.2H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 150.6, 148.7, 133.6, 131.2, 131.0, 129.2, 129.0, 129.0, 127.4, 118.2, 96.4, 95.1. IR (Liquid film, cm^{-1}): v = 3060, 2218, 1619, 1449, 967, 912, 749. HRMS calc. C_9H_7N (M^+): 129.0578. Found: 129.0577.



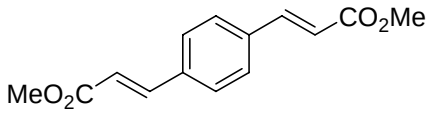
***trans*-Stilbene (5)**

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.54 (dd, J = 9.0 Hz, 1.4 Hz, 4H), 7.38 (dd, J = 7.2Hz, 9.0 Hz, 4H), 7.28 (dd, J = 7.2 Hz, 1.4 Hz, 1H), 7.14 (s, 2H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 137.5, 128.8, 128.5, 127.7, 128.0. IR (KBr film, cm^{-1}): v = 3027, 1599, 1496, 1452, 962, 908, 733. HRMS calc. $C_{14}H_{12}$ (M^+): 180.0939. Found: 180.0933.



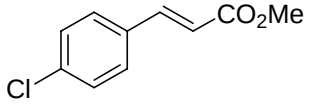
(*E*) - methyl 3 - (4 - methoxyphenyl) acrylate (6)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.65 (d, J = 16.0 Hz, 1H), 7.47 (m, 2H), 6.93-6.89 (m, 2H), 6.31 (d, J = 16.0 Hz, 1H), 3.83 (s, 3H), 3.79 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.6, 161.5, 144.5, 129.7, 127.2, 115.3, 114.4, 55.4, 51.5. IR (KBr film, cm^{-1}): v = 2949, 1717, 1638, 1604, 1513, 1343, 1289, 1257, 1174, 1026, 984, 822, 768. HRMS calc. $C_{11}H_{12}O_3$ (M^+): 192.0786. Found: 192.0797.



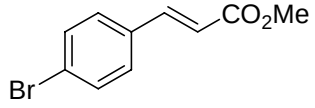
(2*E*,2*E*') - dimethyl 3, 3' - (1, 4 - phenylene) diacrylate (7)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.66 (d, J = 16.1 Hz, 2H), 7.53 (s, 4H), 6.47 (d, J = 16.1 Hz, 2H), 3.81 (s, 6H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.3, 143.8, 136.3, 128.6, 119.1, 51.9. IR (KBr film, cm^{-1}): v = 1696, 1608, 1434, 1322, 1170, 1004, 825, 730. HRMS calc. $C_{14}H_{14}O_4$ (M^+): 246.0892. Found: 246.0895.



(*E*) - methyl 3 - (4 - chlorophenyl) acrylate (8)

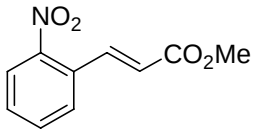
^{1}H NMR (CDCl3, 300 MHz, ppm): δ = 7.64 (d, J = 16.0 Hz, 1H), 7.45 (d, J = 6.6 Hz, 2H), 7.30 (d, J = 6.6 Hz, 2H), 6.40 (d, J = 16.0 Hz, 1H), 3.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.2, 143.4, 136.3, 133.0, 129.3, 129.2, 118.5, 51.8. IR (KBr film, cm^{-1}): v = 3025, 2952, 1714, 1638, 1492, 1319, 1172, 823, 760. HRMS calc. $C_{10}H_9{}^{35}ClO_2$ (M^+): 196.0291. Found: 196.0299.



(*E*) - methyl 3 - (4 - bromophenyl) acrylate (9)

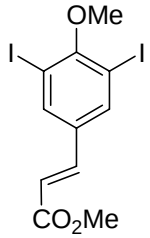
^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.62 (d, J = 16.1 Hz, 2H), 7.51 (d, J = 8.5 Hz, 2H), 7.38 (d, J = 8.5 Hz, 2H), 6.42 (d, J = 16.1 Hz, 2H), 3.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm) δ = 167.1,

143.5, 133.3, 132.2, 129.5, 124.6, 118.6, 51.79. IR (KBr film, cm^{-1}): v = 2950, 1714, 1636, 1587, 1489, 1434, 1317, 1170, 1072, 1010, 910, 819, 730. HRMS calc. $C_{10}H_9{}^{79}BrO_2$ (M^+): 239.9786. Found: 239.9778.



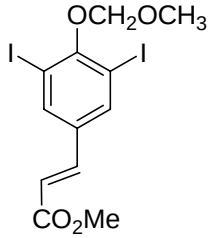
(*E*) - methyl 3 - (2 - nitrophenyl) acrylate (10)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 8.12 (d, J = 15.9 Hz, 1H), 8.59 (d, J = 8.6 Hz, 1H), 7.66-7.64 (m, 2H), 7.58-7.54 (m, 1H), 6.37 (d, J = 15.9 Hz, 1H), 3.83 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm) δ = 166.2, 148.3, 140.1, 133.6, 130.5, 130.4, 129.1, 124.9, 122.8, 52.0. IR (KBr film, cm^{-1}): v = 2954, 1719, 1523, 1346, 1292, 1206, 972, 756. HRMS calc. $C_{10}H_9NO_4$ (M^+): 207.0532. Found: 207.0536.



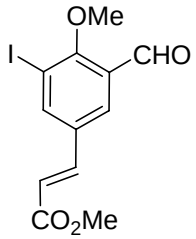
(*E*) - methyl 3 - (3, 5 – diiodo – 4 - methoxyphenyl) acrylate (11)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.91 (s, 2H), 7.47 (d, J = 16.0 Hz, 2H), 6.34 (d, J = 16.0 Hz, 1H), 3.87 (s, 3H), 3.80 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 166.7, 160.4, 140.9, 139.3, 134.4, 119.6, 91.0, 60.9, 52.0. IR (KBr film, cm^{-1}): v = 2933, 1716, 1640, 1457, 1318, 1253, 1197, 1171, 972, 846. HRMS calc. $C_{11}H_{10}{}^{127}I_2O_3$ (M^+): 443.8719. Found: 443.8722.



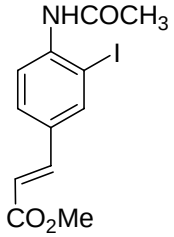
(*E*) - methyl 3 - (3, 5 – diiodo – 4 - (methoxy methoyl) phenyl) acrylate (12)

^{1}HNMR ($CDCl_3$, 300 MHz, ppm): δ = 7.94 (s, 2H), 7.47 (d, J = 16.0 Hz, 1H), 6.34 (d, J = 16.0 Hz, 1H), 5.16 (s, 2H), 3.81 (s, 3H), 3.75 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 166.7, 158.0, 140.8, 139.5, 134.5, 119.7, 100.4, 91.8, 59.1, 52.0. IR (KBr film, cm^{-1}): v = 2924, 1715, 1637, 1432, 1312, 1249, 1197, 1166, 917, 845. HRMS calc. $C_{12}H_{12}{}^{127}I_2O_4$ (M^+): 473.8825. Found: 473.8831.



(*E*) - methyl 3 - (3 – formyl – 5 – iodo – 4 - methoxyphenyl) actylate (13)

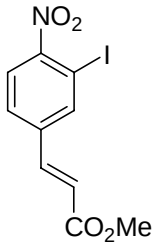
^{1}HNMR ($CDCl_3$, 300 MHz, ppm)**:** δ = 10.31 (s, 1H), 8.18 (d, J = 2.1 Hz, 1H), 7.97 (d, J = 2.1 Hz, 1H), 7.56 (d, J = 16.1 Hz, 1H), 6.44 (d, J = 16.1 Hz, 1H), 3.98 (s, 3H), 3.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 188.7, 166.6, 163.7, 144.2, 141.3, 133.1, 130.1, 128.5, 120.0, 93.7, 64.1, 52.0. IR (KBr film，cm^{-1}): v = 2925, 1729, 1692, 1430, 1320, 1242, 1171, 856. HRMS calc. $C_{12}H_{11}{}^{127}IO_4$ (M^+): 345.9702. Found: 345.9693.



(*E*) - methyl 3 - (4 – acetamido – 3 - iodophenyl) acrylate (14)

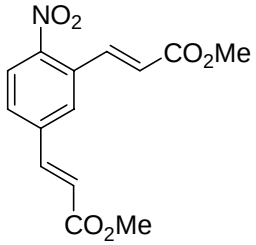
^{1}HNMR (DMSO-d_6, 300 MHz, ppm): δ = 9.85(s, 1H), 8.13 (d, J = 1.4 Hz, 1H), 7.73 (dd, J = 8.5 Hz, 1.6 Hz, 1H), 7.67 (d, J = 16.0 Hz, 1H), 7.23 (dd, J = 8.5 Hz, 3.3 Hz, 1H), 6.64 (d, J = 16.0 Hz, 1H), 3.73 (s, 3H), 2.07 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 168.8, 166.5, 138.9, 138.7, 136.8, 135.1, 130.5, 128.2, 119.8, 90.4, 51.6, 23.2. IR

(KBr film，cm^{-1}): ν = 3272, 1707, 1657, 1520, 1285, 971, 864, 823. HRMS calc. $C_{12}H_{12}{}^{127}INO_3$ (M^+): 344.9862. Found: 344.9865.



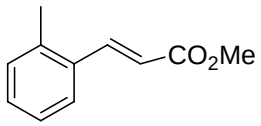
(*E*) - methyl 3 - (3 – iodo – 4 - nitrophenyl) acrylate (15)

^{1}HNMR ($CDCl_3$, 300 MHz, ppm): δ = 8.16 (d, J = 1.5 Hz, 1H), 7.88 (d, J = 8.4 Hz, 1H), 7.62-7.57 (m, 2H), 6.52 (d, J = 16.2 Hz, 1H), 3.83 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 166.3, 141.3, 140.6, 139.7, 128.1, 126.0, 124.3, 122.8, 87.1, 52.3. IR (KBr film，cm^{-1}): ν = 3089, 2950, 1724, 1573, 1519, 1325, 1194, 835. HRMS calc. $C_{10}H_8{}^{127}INO_4$ (M^+): 332.9498. Found: 33.9500.



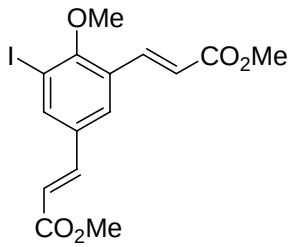
(2*E*, 2*E'*) - dimethyl 3, 3' - (4 – nitro - 1, 3 - phenylene) diacrylate (16)

^{1}HNMR ($CDCl_3$, 300 MHz, ppm): δ = 8.16-8.07 (m, 2H), 7.73-7.65 (m, 3H), 6.59 (d, J = 15.9 Hz, 1H), 6.39 (d, J = 15.9 Hz, 1H), 3.85 (s, 6H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 165.7, 165.4, 149.8, 140.8, 139.2, 139.1, 131.0, 128.4, 128.2, 125.2, 123.0, 122.0, 51.6, 51.6. IR (KBr film, cm^{-1}): ν = 2958, 1728, 1519, 1438, 1294, 1196, 1177, 1023. HRMS calc. $C_{14}H_{13}NO_6$ (M^+): 291.0743. Found: 291.0736.



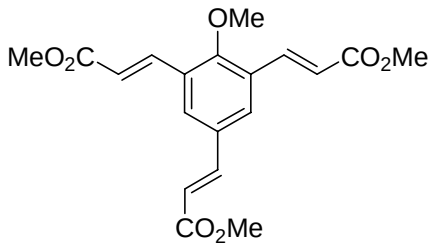
(*E*) - methyl 3 – o - tolylacrylate (17)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.98 (d, J = 16.0 Hz, 1H), 7.56-7.53 (m, 1H), 7.30-7.18 (m, 3H), 6.36 (d, J = 16.0 Hz, 1H), 3.81 (s, 3H), 2.44 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.4, 142.5, 137.6, 133.3, 130.8, 130.0, 126.4, 126.3, 118.8, 51.6, 19.7. IR (Liquid film, cm^{-1}): ν = 2951, 1718, 1634, 1435, 1318, 1276, 1220, 1172, 981, 764. HRMS calc. $C_{11}H_{12}O_2$ (M^+): 176.0837. Found: 176.0836



(2*E*,2*E'*) - dimethyl 3, 3' - (5 – iodo – 4 – methoxy - 1, 3 - phenylene) diacrylate (18)

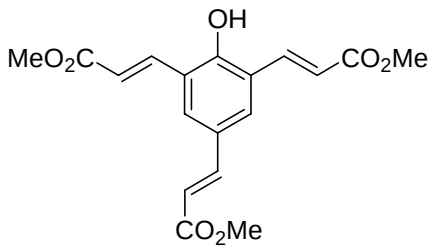
^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.97(d, J = 2.1 Hz, 1H), 7.87 (d, J = 16.2 Hz, 2H), 7.64 (d, J = 2.1 Hz, 1H), 7.56 (d, J = 16.0 Hz, 1H), 6.52 (d, J = 16.2 Hz, 1H), 6.38 (d, J = 16.0 Hz, 1H), 3.83 (s, 3H), 3.82 (s, 3H), 3.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 166.9, 160.1, 142.0, 140.1, 138.8, 132.9, 129.4, 128.2, 121.2, 119.3, 93.6, 62.1, 52.0, 52.0. IR (KBr film, cm^{-1}): ν = 2923, 1728, 1710, 1642, 1468, 1434, 1279, 1172, 987, 857. HRMS calc. $C_{15}H_{15}{}^{127}IO_5$ (M^+): 401.9964. Found: 401.9970.



(2*E*, 2*E'*, 2*E''*) - trimethyl 3, 3', 3'' – (2 – methoxybenzene - 1, 3, 5 - triyl) triacylate (19)

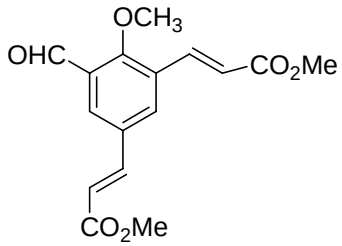
^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.94 (d, J = 16.2 Hz, 2H), 7.72 (s, 2H), 7.66 (d, J = 16.0 Hz,

1H), 6.56 (d, *J* = 16.2 Hz, 2H), 6.44 (d, *J* = 16.0 Hz, 1H), 3.85 (s, 6H), 3.84 (s, 3H), 3.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.1, 167.1, 159.7, 143.0, 138.4, 131.2, 129.6, 129.0, 120.9, 118.9, 63.2, 52.0, 51.9. IR (KBr film, cm^{-1}): ν = 2954, 1723, 1638, 1434, 1277, 1187, 1138, 991, 859. HRMS calc. $C_{19}H_{20}O_7$ (M^+): 360.1209. Found: 360.1219.



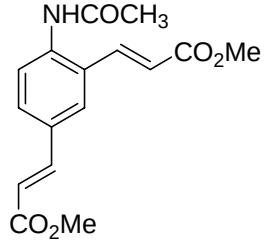
(2*E*, 2*E'*, 2*E''*) - trimethyl 3, 3', 3'' – (2 – hydroxybenzene - 1, 3, 5 - triyl) triacylate (20)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 7.84 (d, *J* = 16.1 Hz, 2H), 7.69 (s, 2H), 7.65 (d, *J* = 16.1 Hz, 1H), 7.45 (d, J=16.1 Hz, 1H), 7.44 (d, *J* = 16.1Hz, 2H), 5.33 (s, 2H), 3.83 (s, 6H), 3.78 (s, 6H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 167.0, 166.6, 154.3, 142.7, 138.1, 132.1, 129.9, 129.0, 121.6, 119.5, 52.0. IR (KBr film): ν = 3429, 2952, 1718, 1638, 1437, 1278, 1173, 981, 859 cm^{-1}. HRMS calc. $C_{18}H_{18}O_7$ (M^+): 346.1053. Found: 346.1056.



(2*E*, 2*E'*) - dimethyl 3, 3' - (5 – formyl – 4 – methoxy – 1, 3 – phenylene) diacrylate (21)

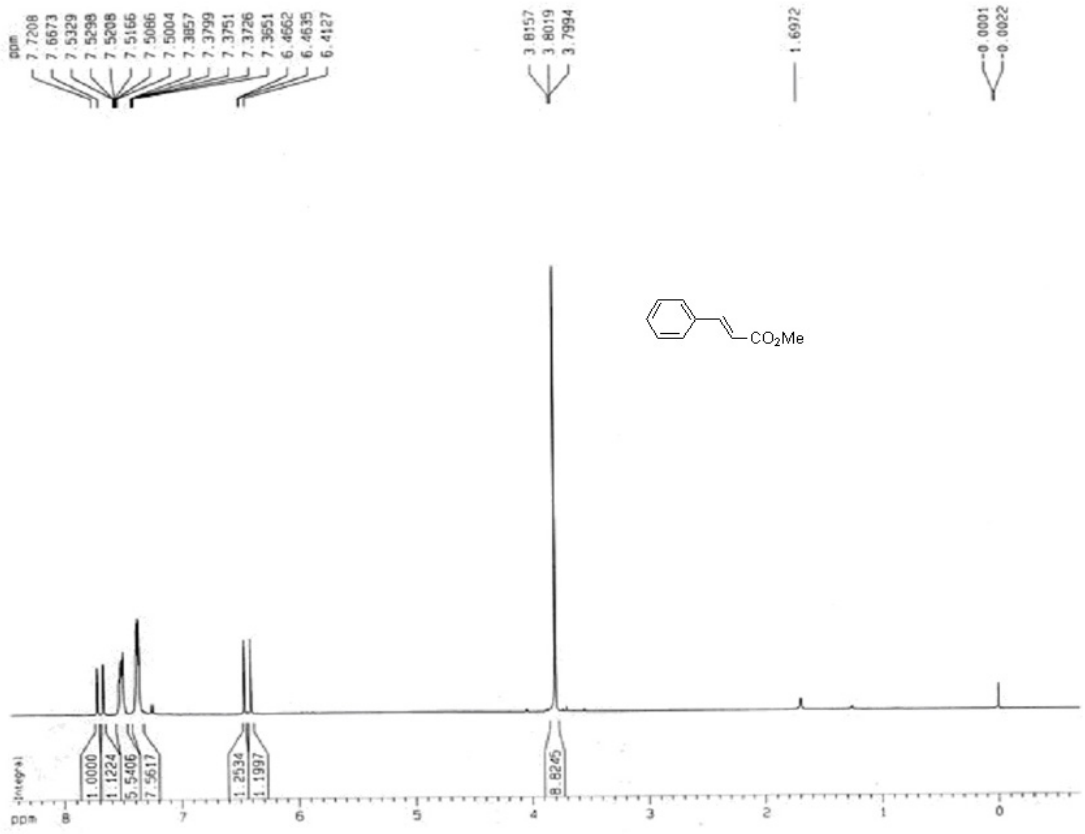
^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 10.40 (s, 1H), 8.03 (d, *J* = 2.3 Hz, 1H), 7.93 (d, *J* = 16.2 Hz, 1H), 7.91 (d, *J* = 2.3 Hz, 1H), 7.67 (d, *J* = 16.0 Hz, 1H), 6.58 (d, *J* = 16.2 Hz, 1H), 6.48 (d, *J* = 16.0 Hz, 1H), 3.96 (s, 3H), 3.85 (s, 3H), 3.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 188.8, 166.9, 163.1, 142.3, 137.4, 133.1, 131.4, 130.3, 130.1, 129.6, 121.5, 119.8, 65.1, 52.1, 52.0. IR (KBr film, cm^{-1}): ν = 3416, 2923, 1719, 1683, 1637, 1334, 1274, 1180, 986. HRMS calc. $C_{16}H_{16}O_6$ (M^+): 304.0947. Found: 304.0950



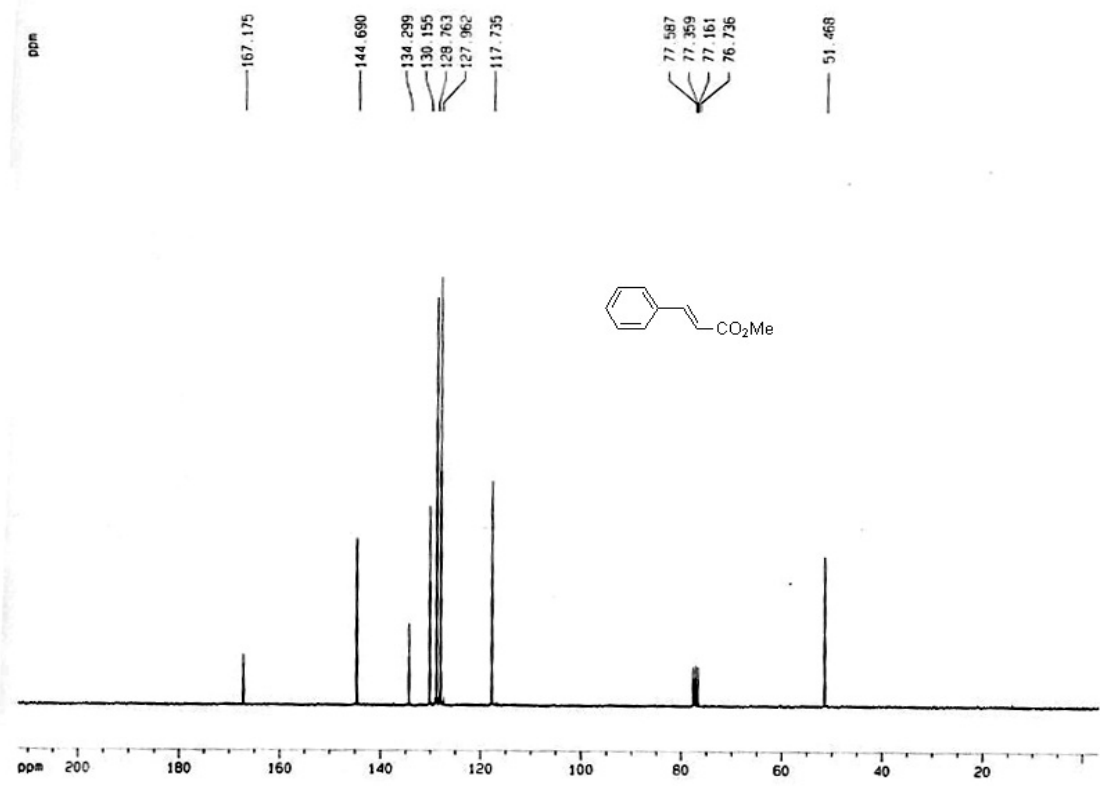
(2*E*,2*E'*) - dimethyl 3, 3' - (4 – acetamido - 1, 3 - phenylene) diacrylate (22)

^{1}H NMR ($CDCl_3$, 300 MHz, ppm): δ = 9.94 (s, 1H), 8.20 (s, 1H), 7.82-7.54 (m, 4H), 6.78 (d, *J* = 15.9 Hz, 1H), 6.77 (d, *J* = 16.1 Hz, 1H), 3.74 (s, 3H), 3.73 (s, 3H), 2.07 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz, ppm): δ = 168.9, 166.8, 143.5, 139.6, 138.8, 131.1, 130.1, 128.1, 127.1, 126.1, 119.5, 118.0, 51.6, 51.5, 23.4. IR (KBr film, cm^{-1}): ν = 3439, 3268, 2923, 1719, 1645, 1281, 1164. HRMS calc. $C_{16}H_{17}NO_5$ (M^+): 303.1107. Found: 303.1115

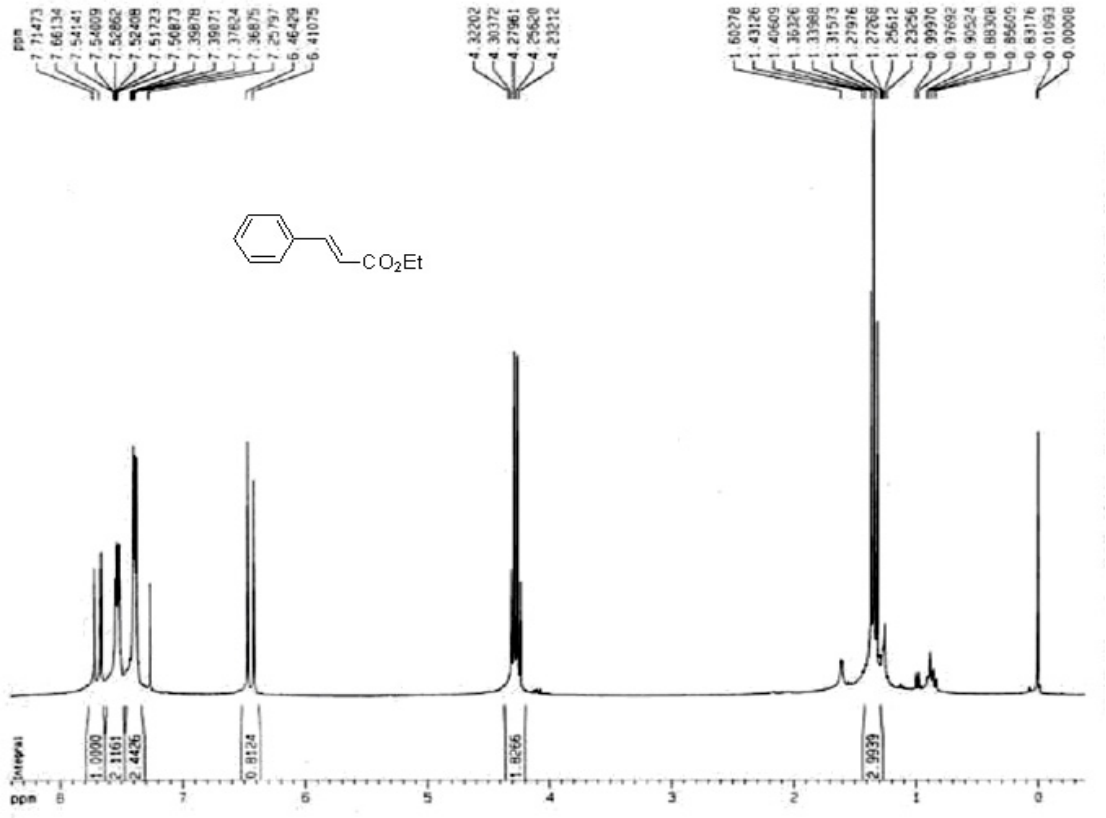
1 (^{1}H NMR)



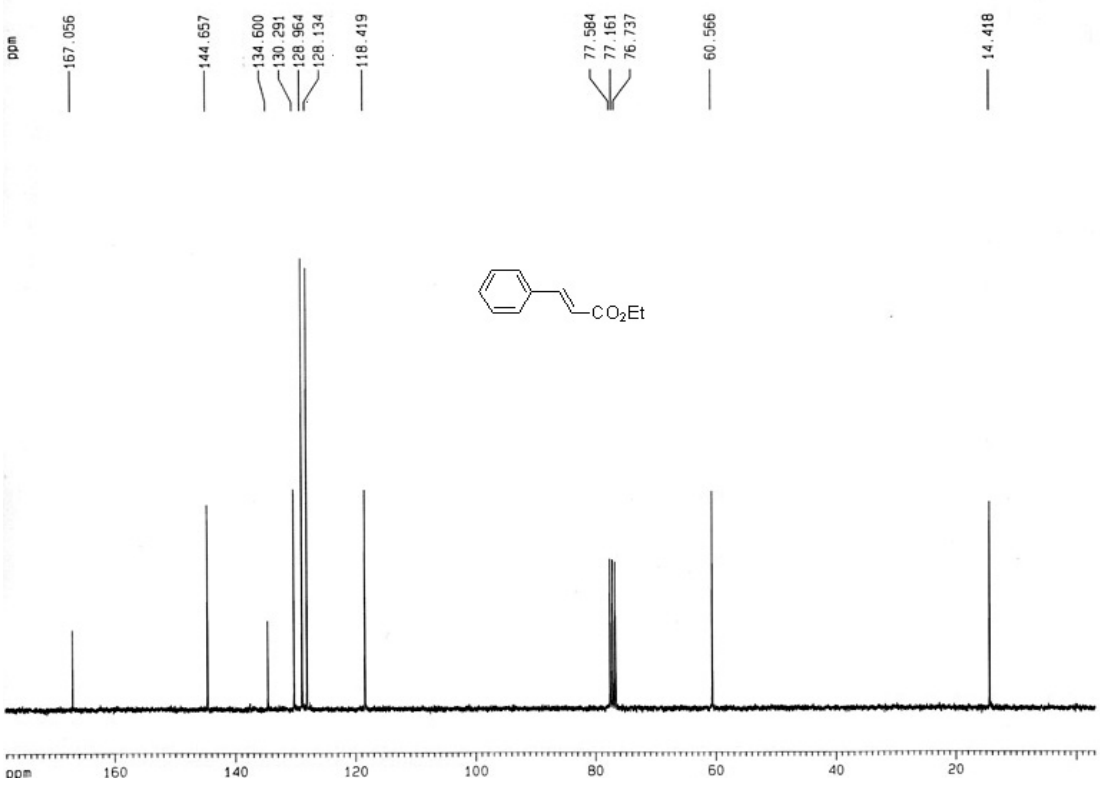
1 (^{13}C NMR)



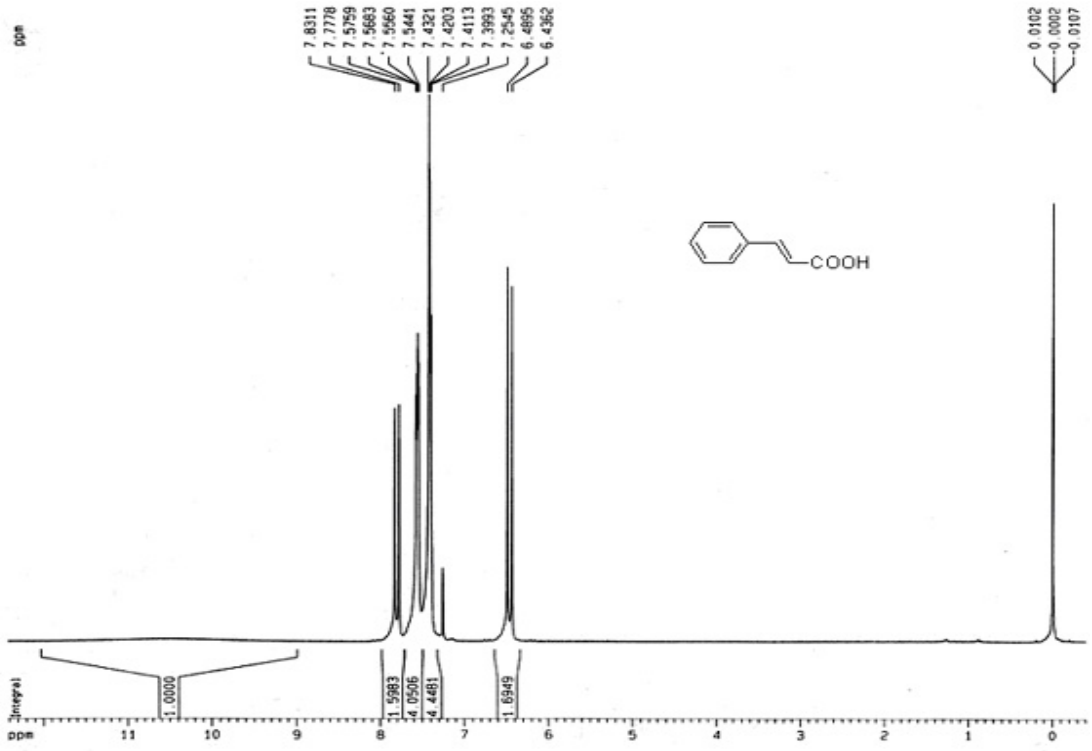
2 (^{1}H NMR)



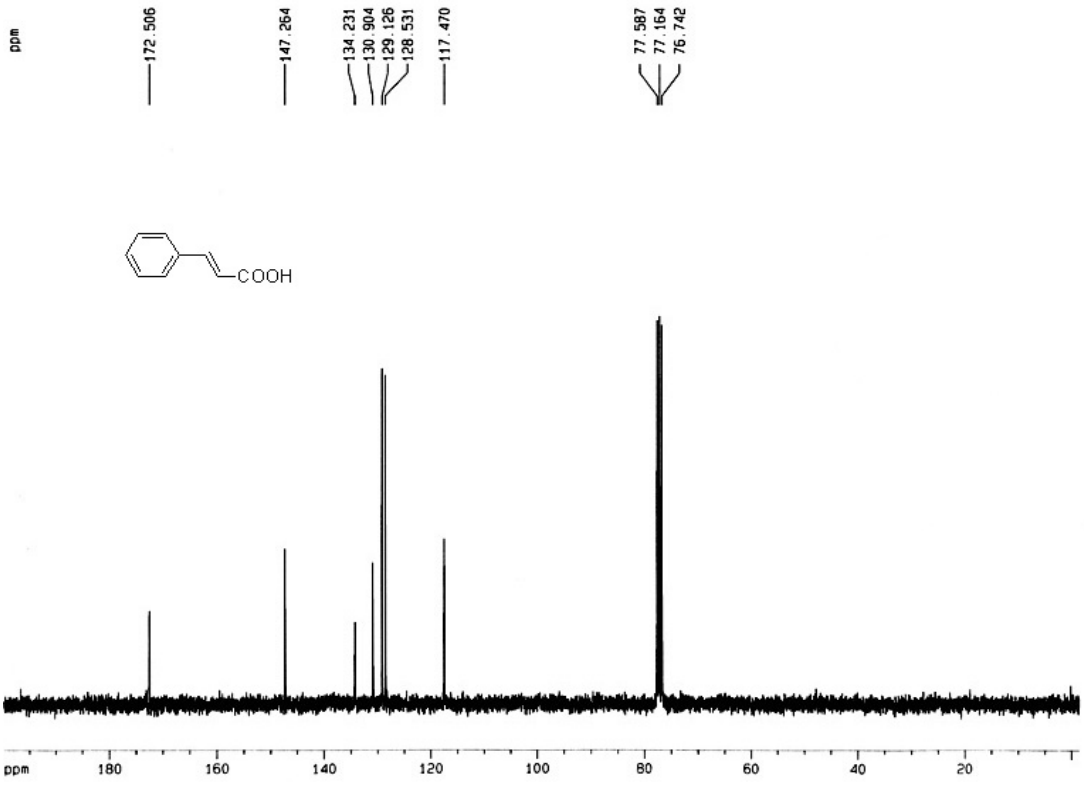
2 (^{13}C NMR)



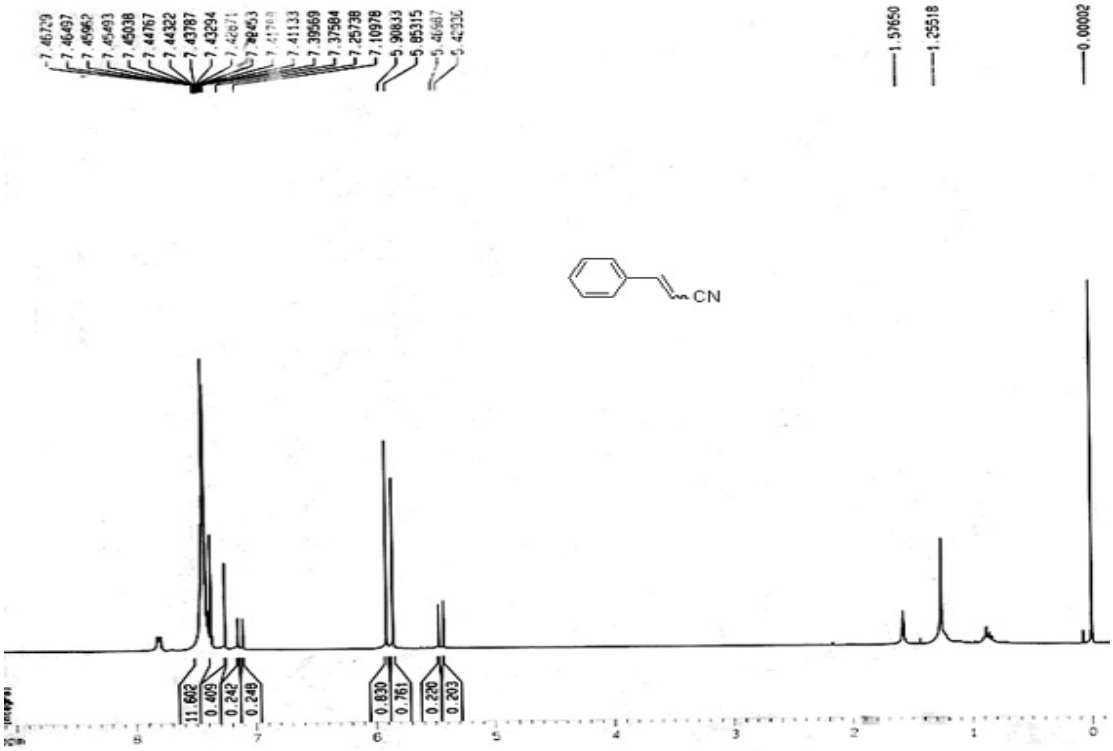
3 (^{1}H NMR)



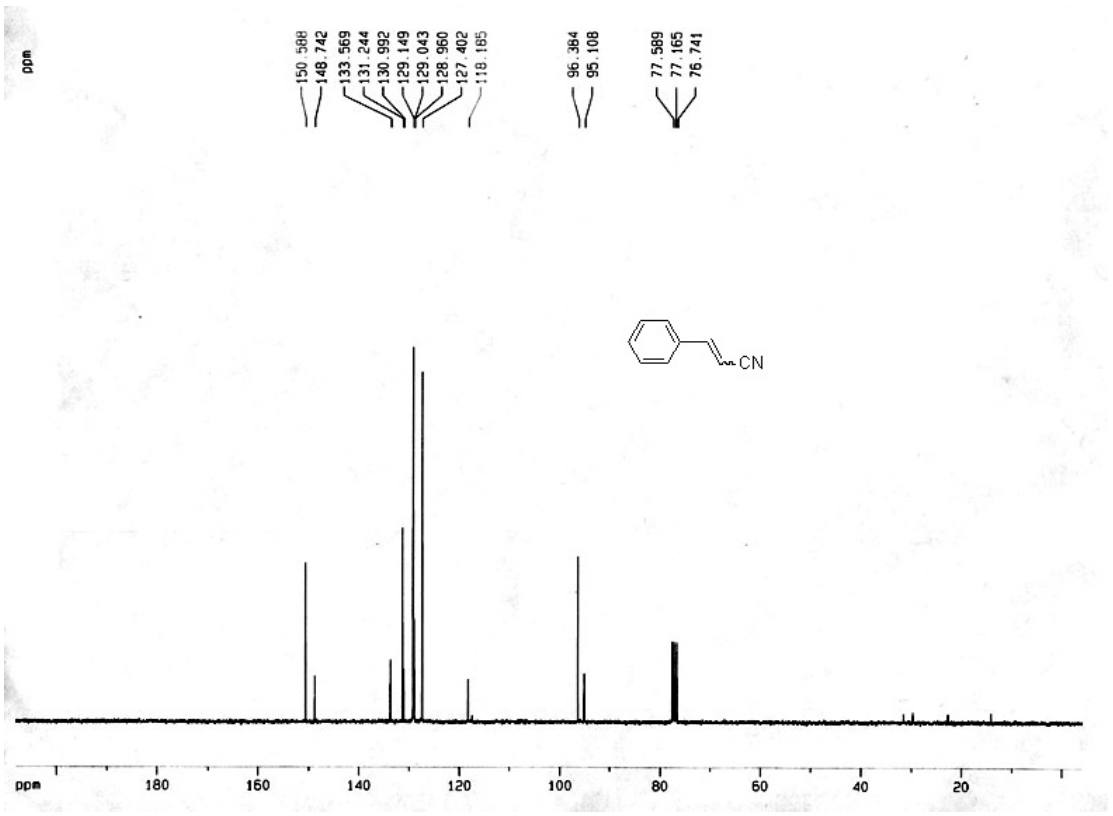
3 (^{13}CNMR)



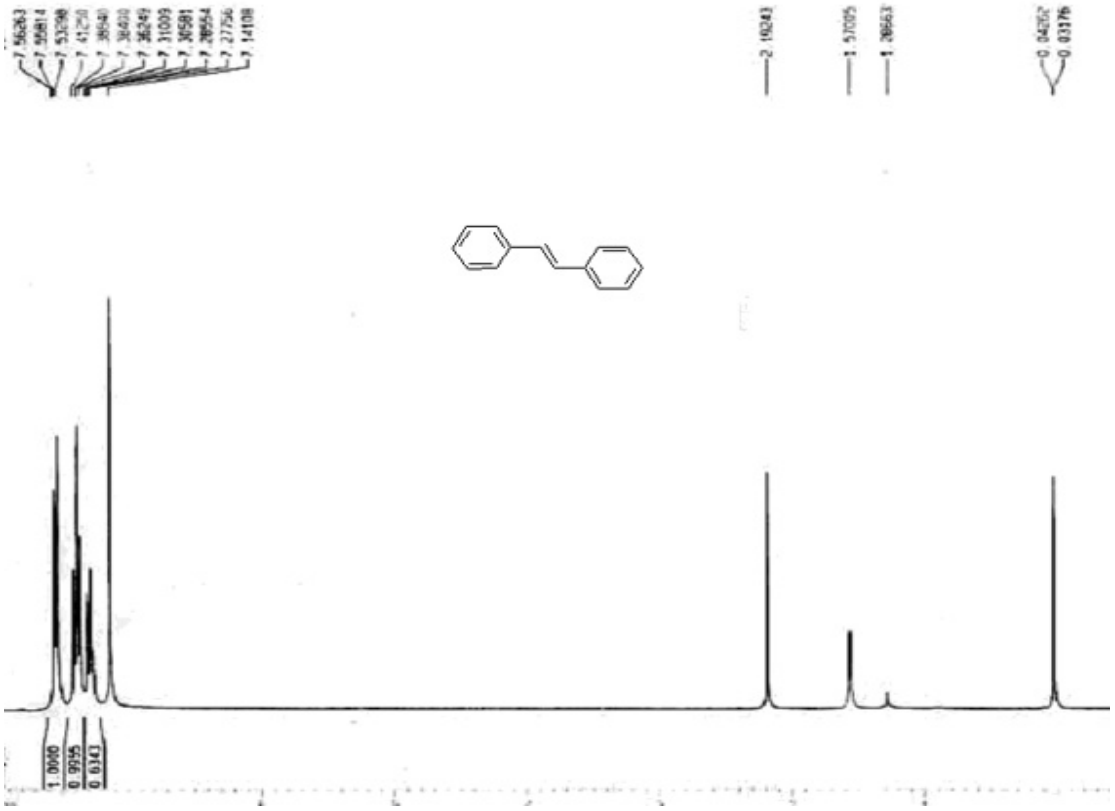
4 (^{1}HNMR)



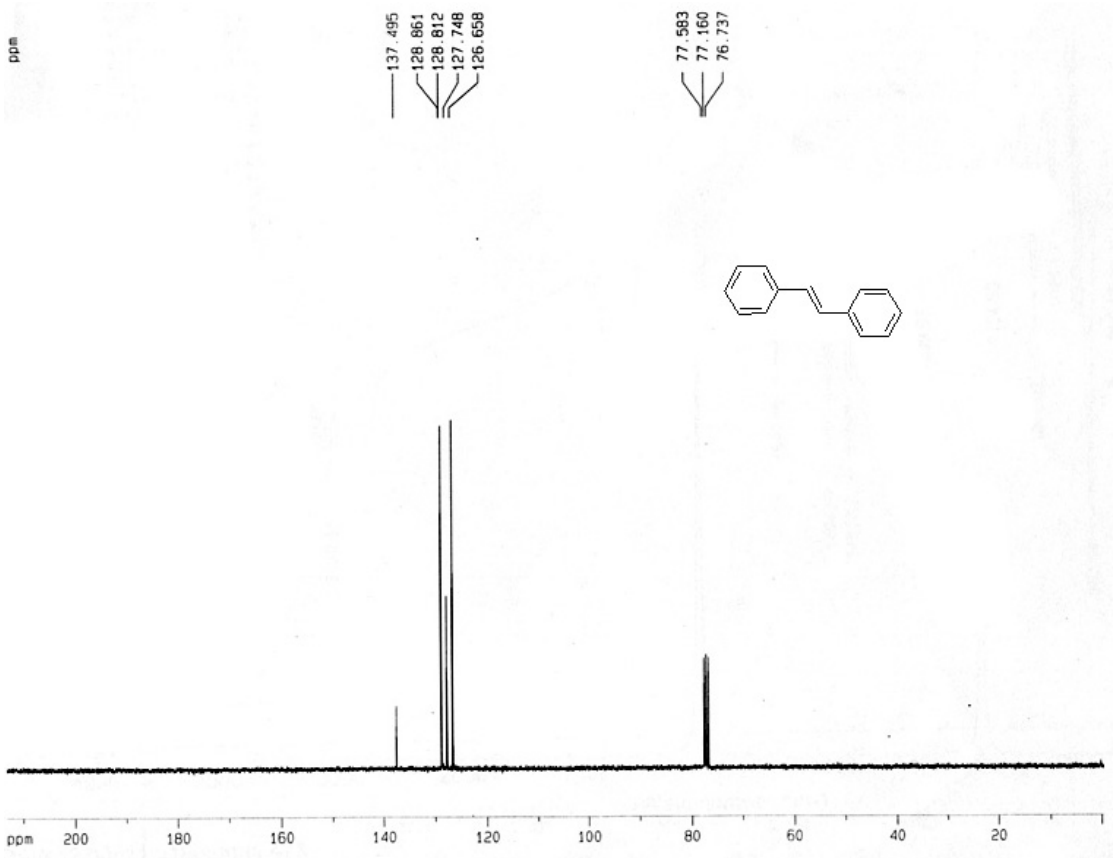
4 (^{13}C NMR)



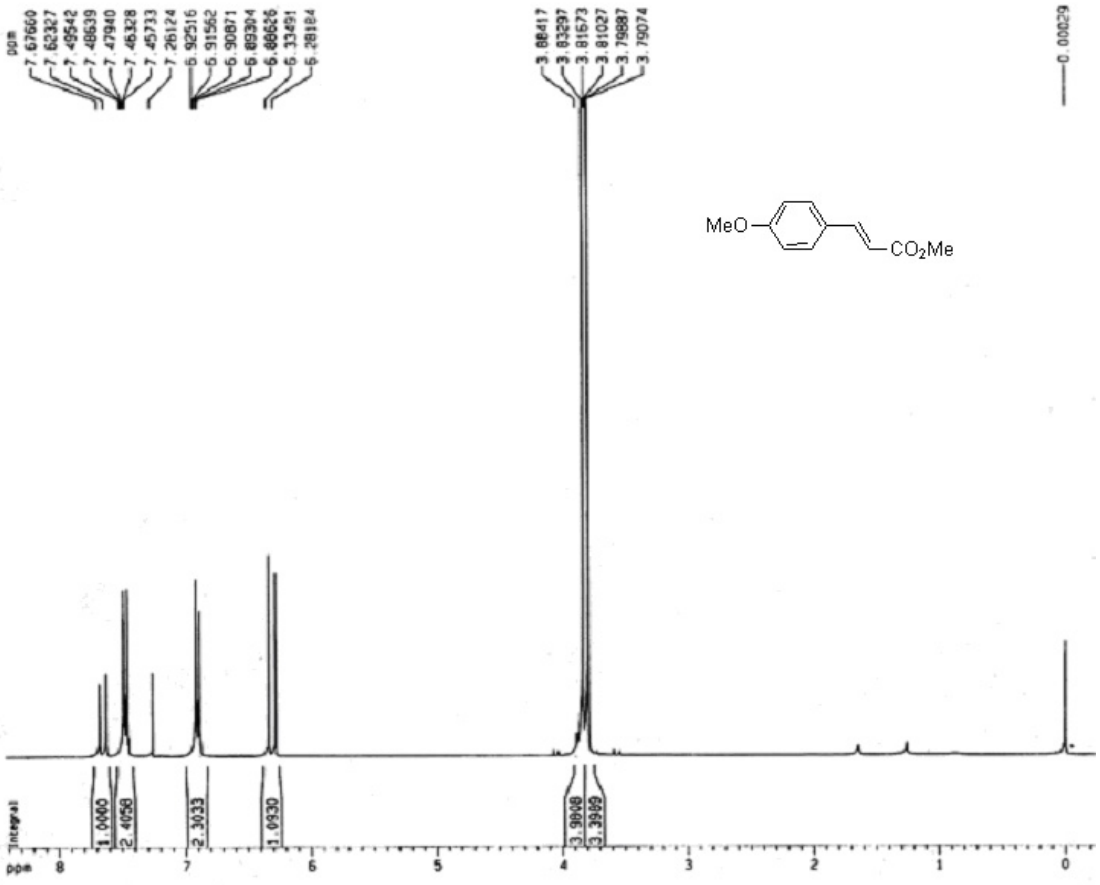
5 (^{1}H NMR)



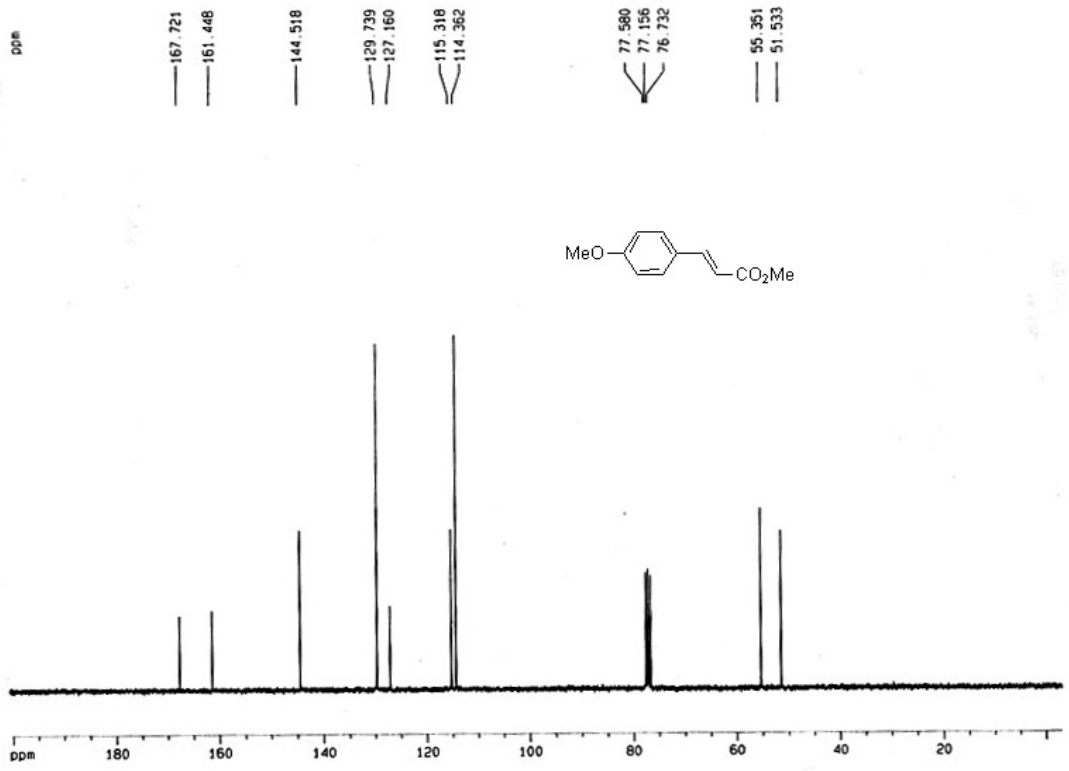
5 (^{13}C NMR)



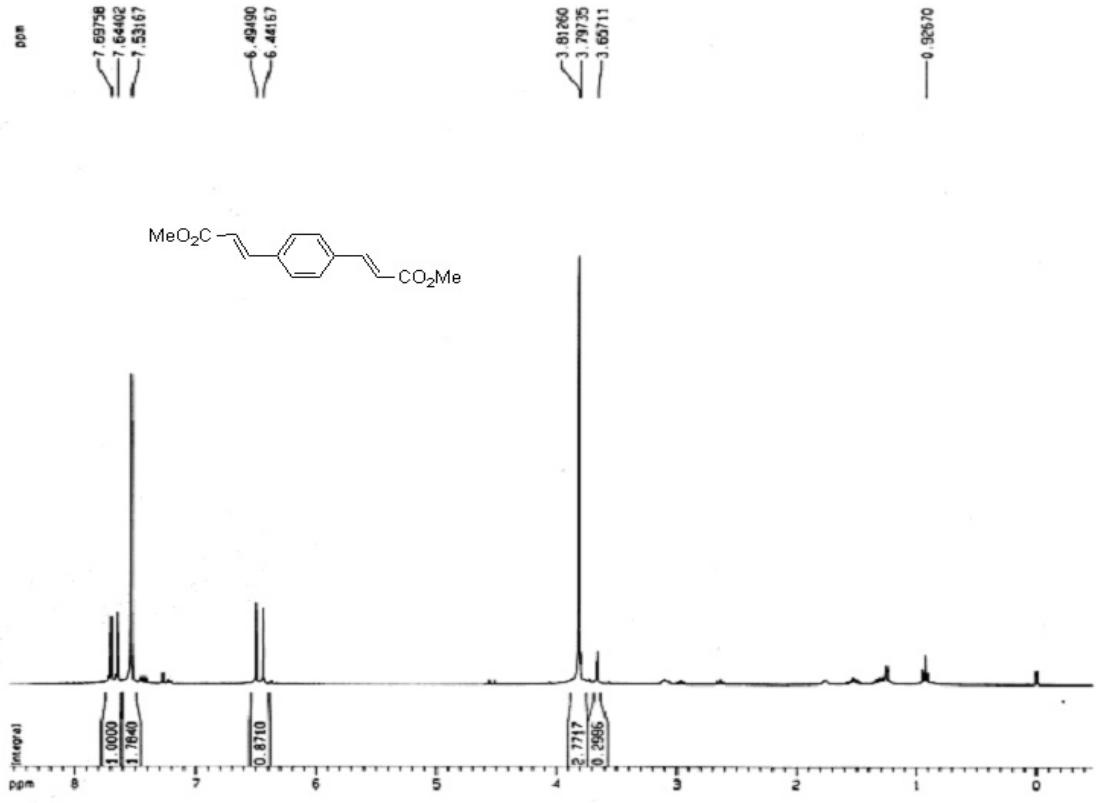
6 (^{1}H NMR)



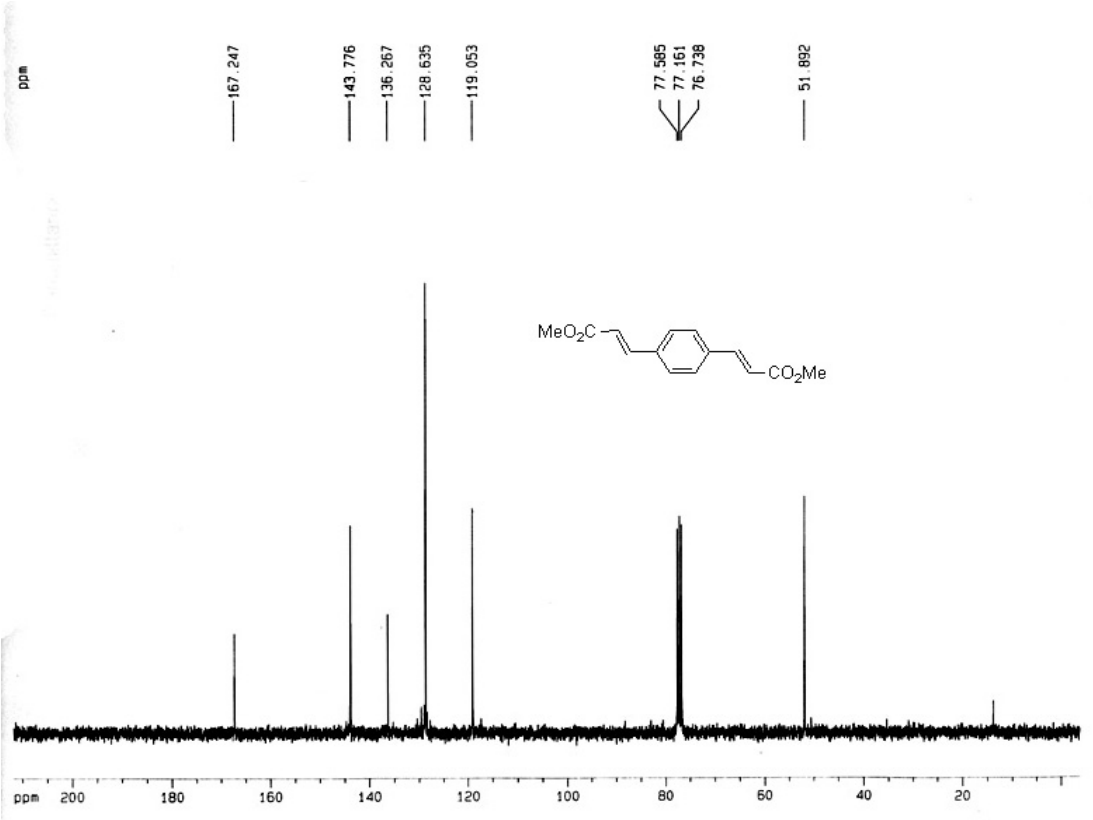
6 (^{13}C NMR)



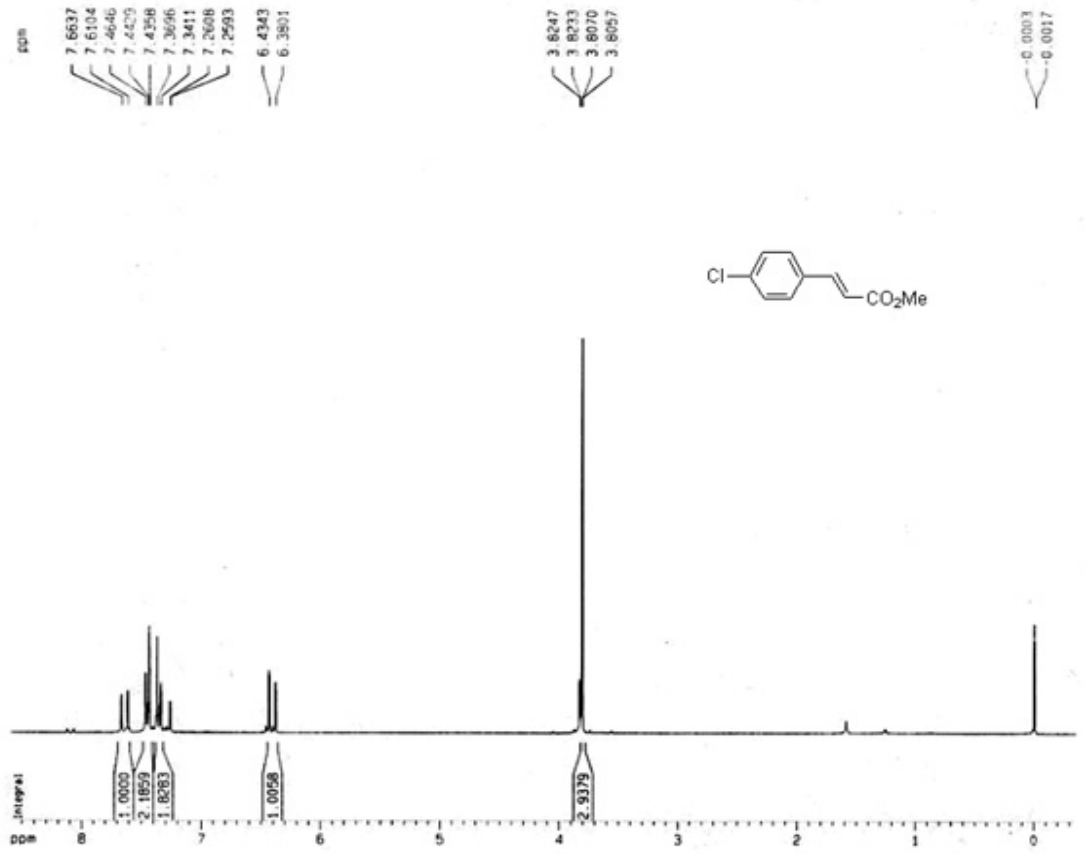
7 (^{1}H NMR)



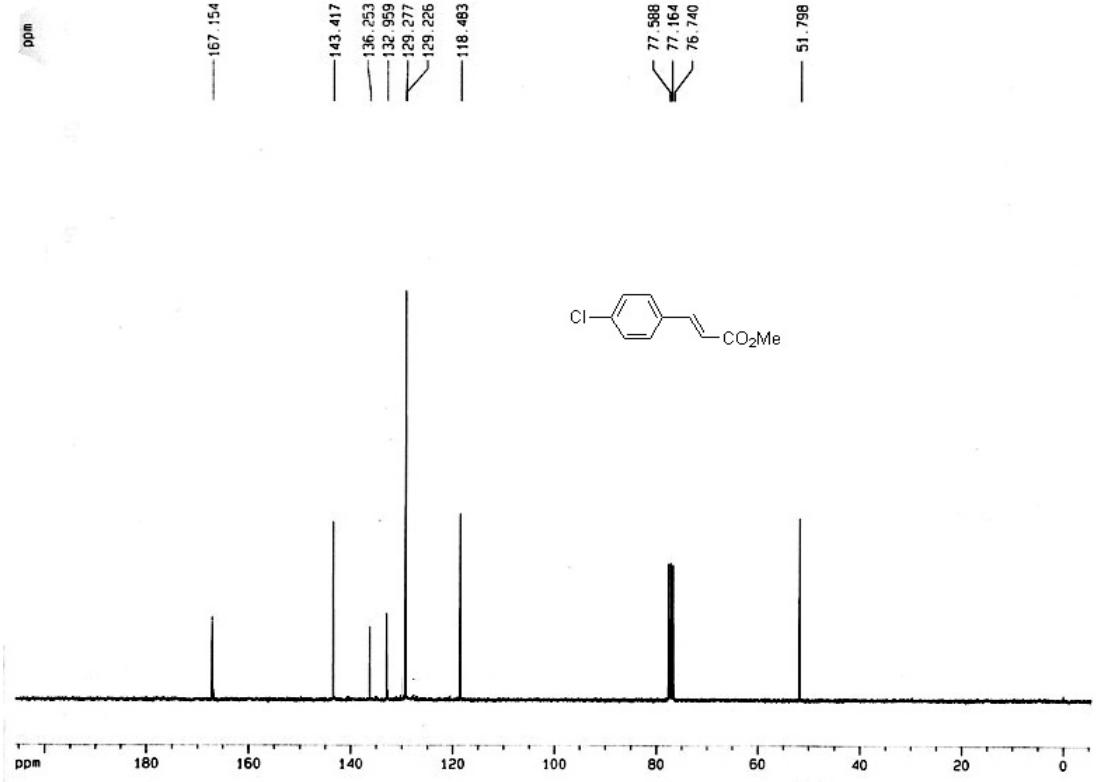
7 (^{13}C NMR)



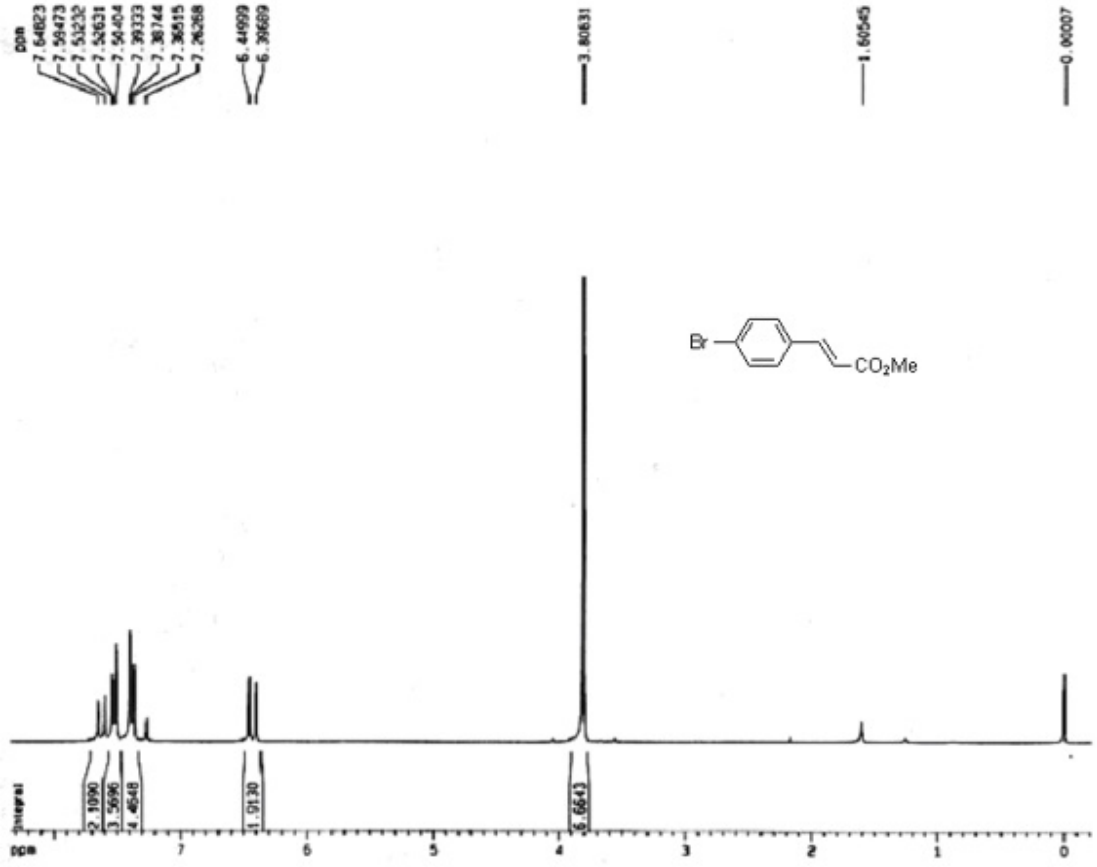
8 (^{1}H NMR)



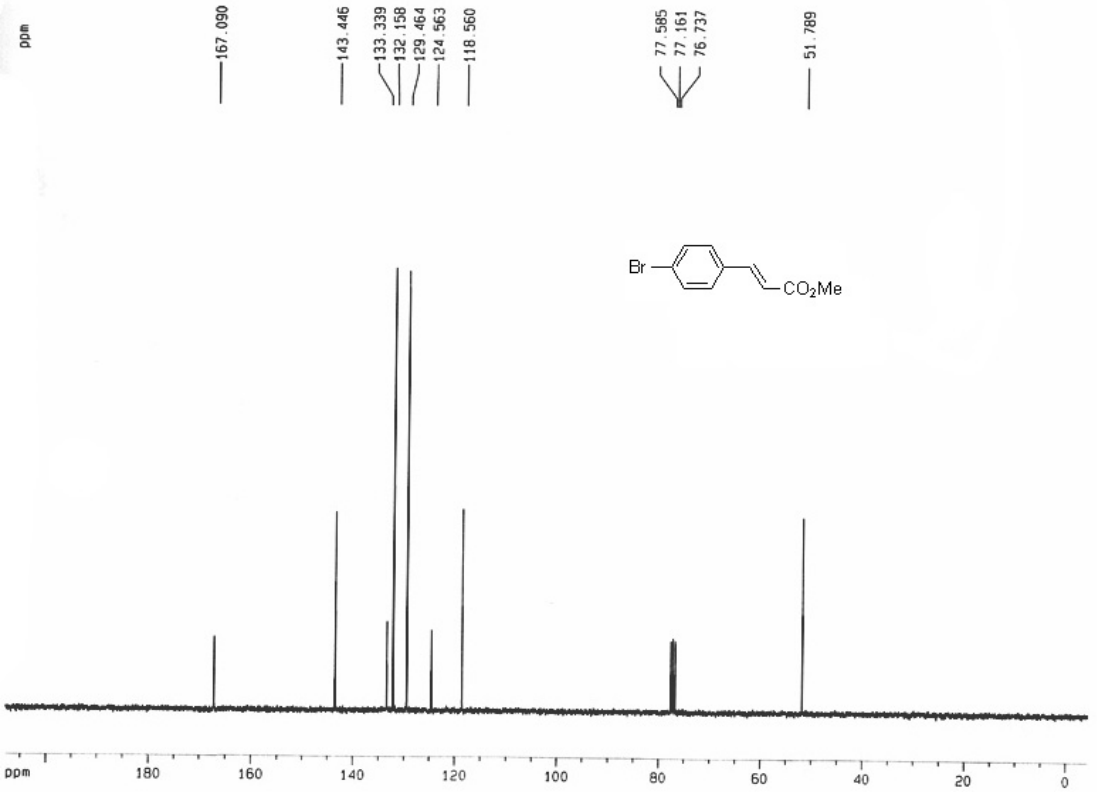
8 (^{13}C NMR)



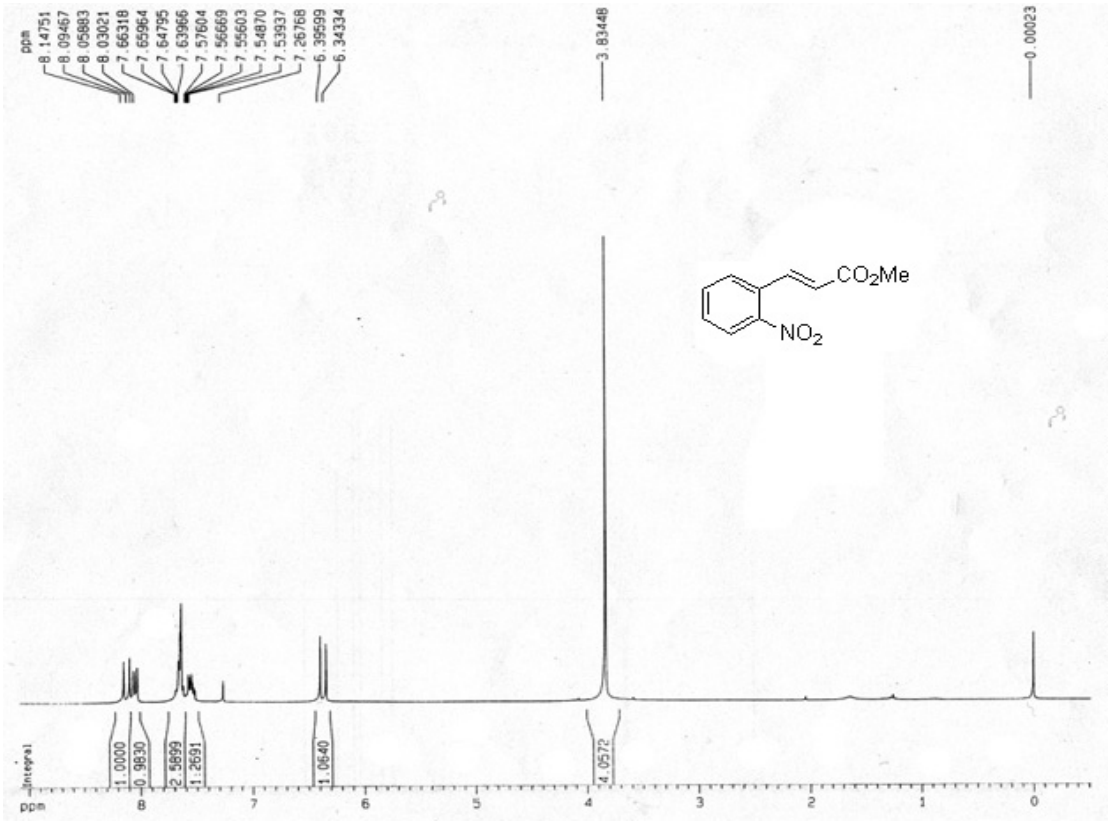
9 (^{1}H NMR)



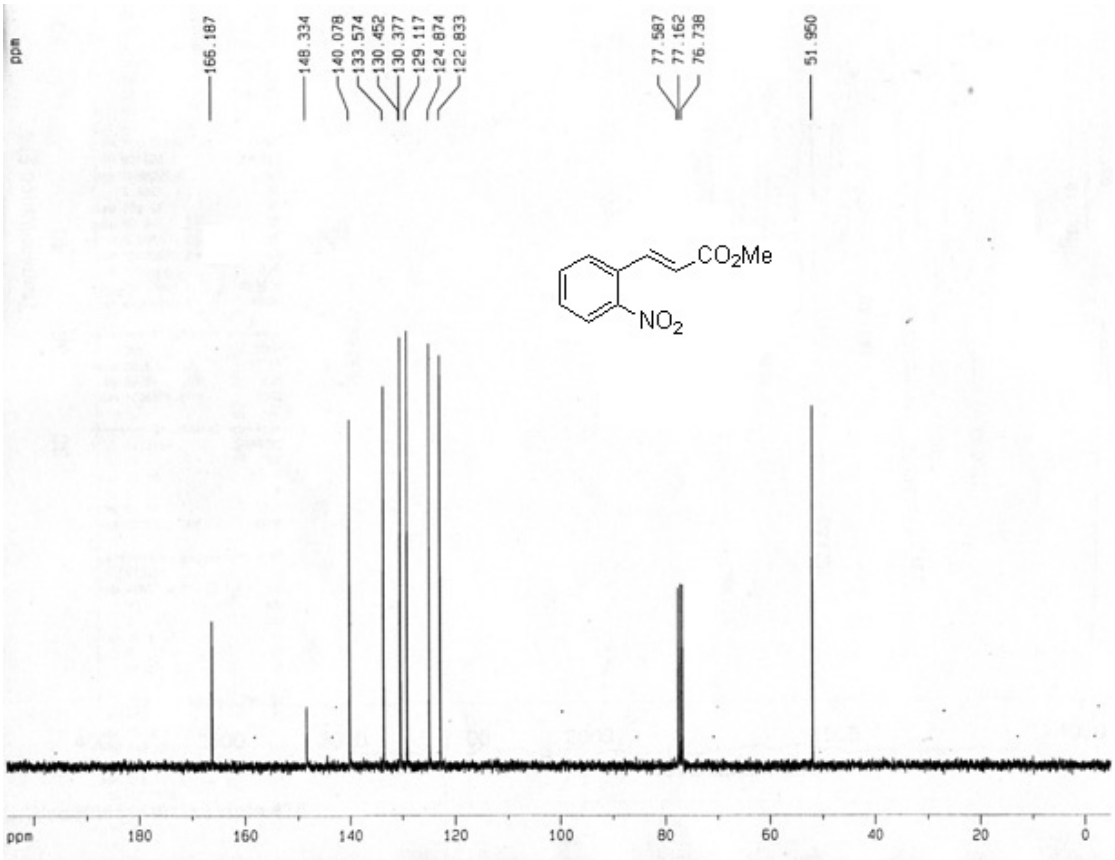
9 (^{13}C NMR)



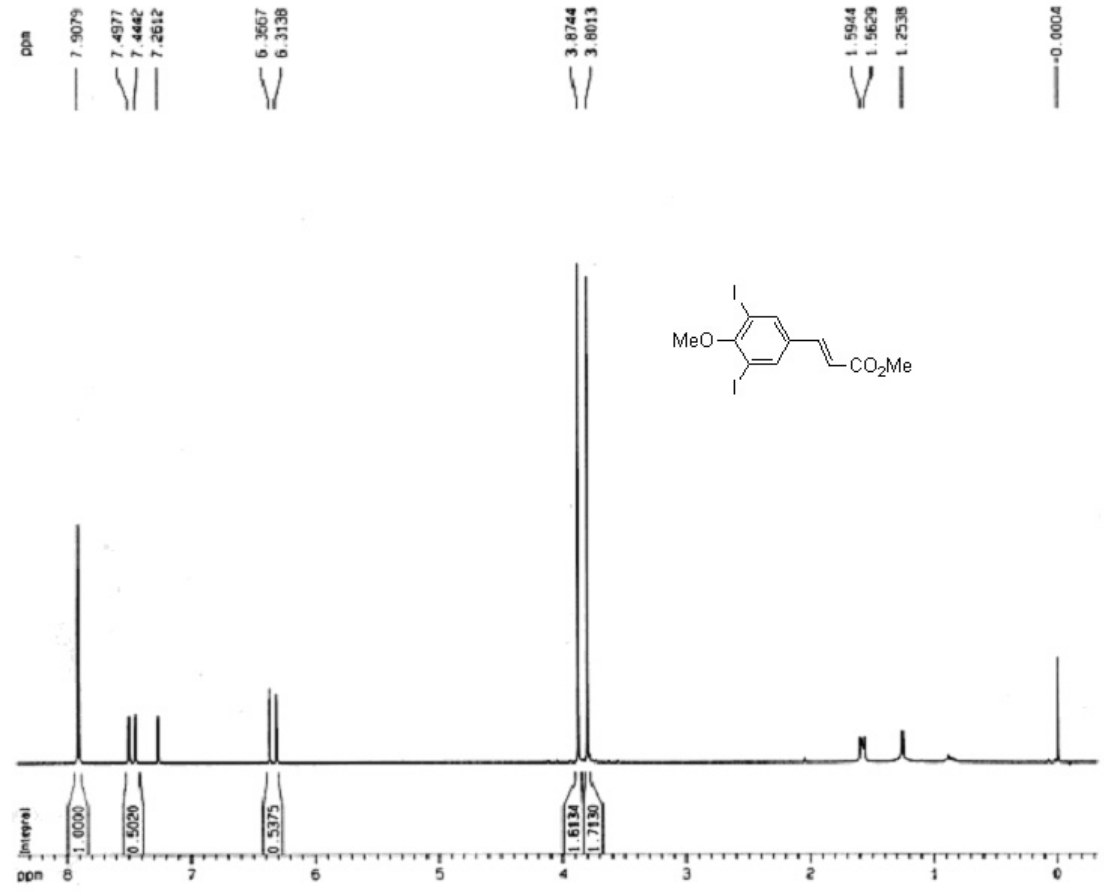
10 (^{1}H NMR)



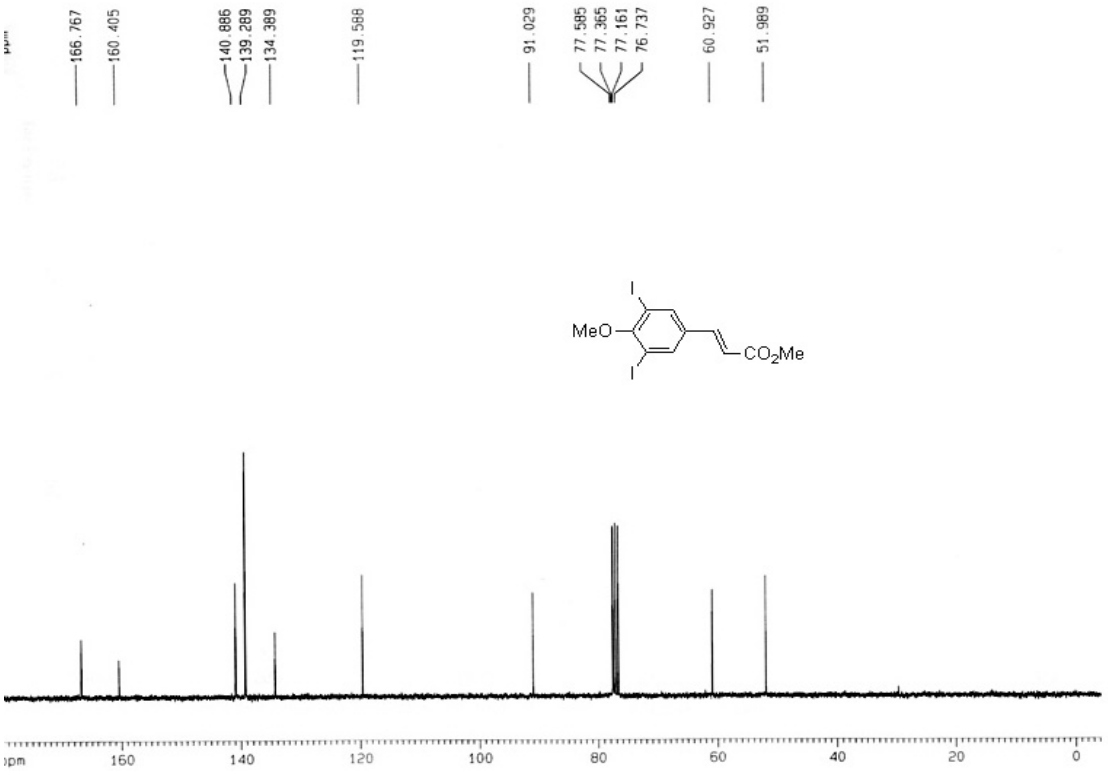
10 (^{13}C NMR)



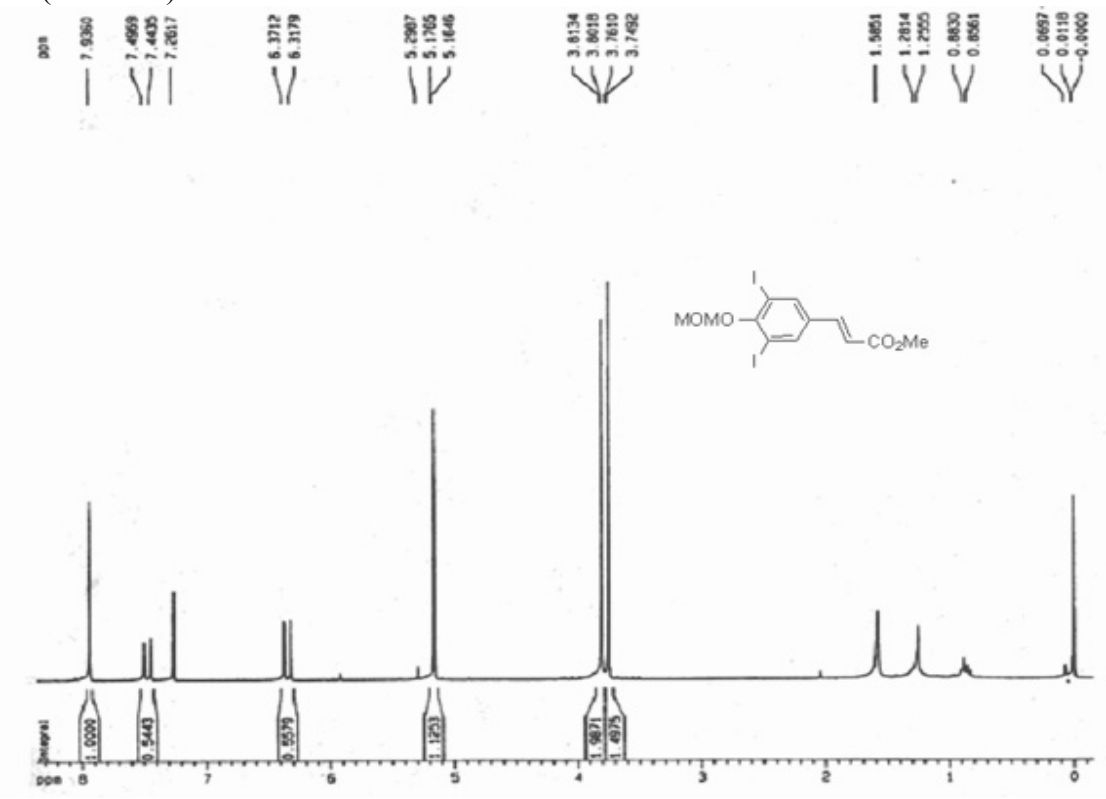
11 (^{1}H NMR)



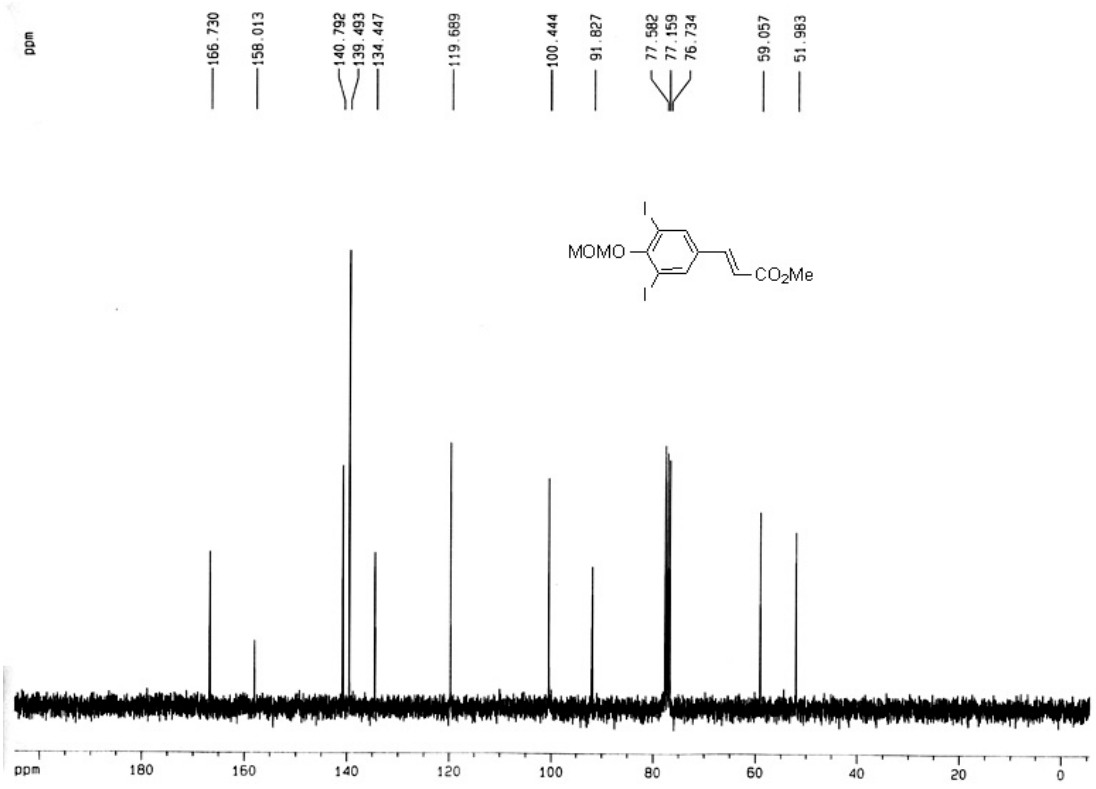
11 (^{13}C NMR)



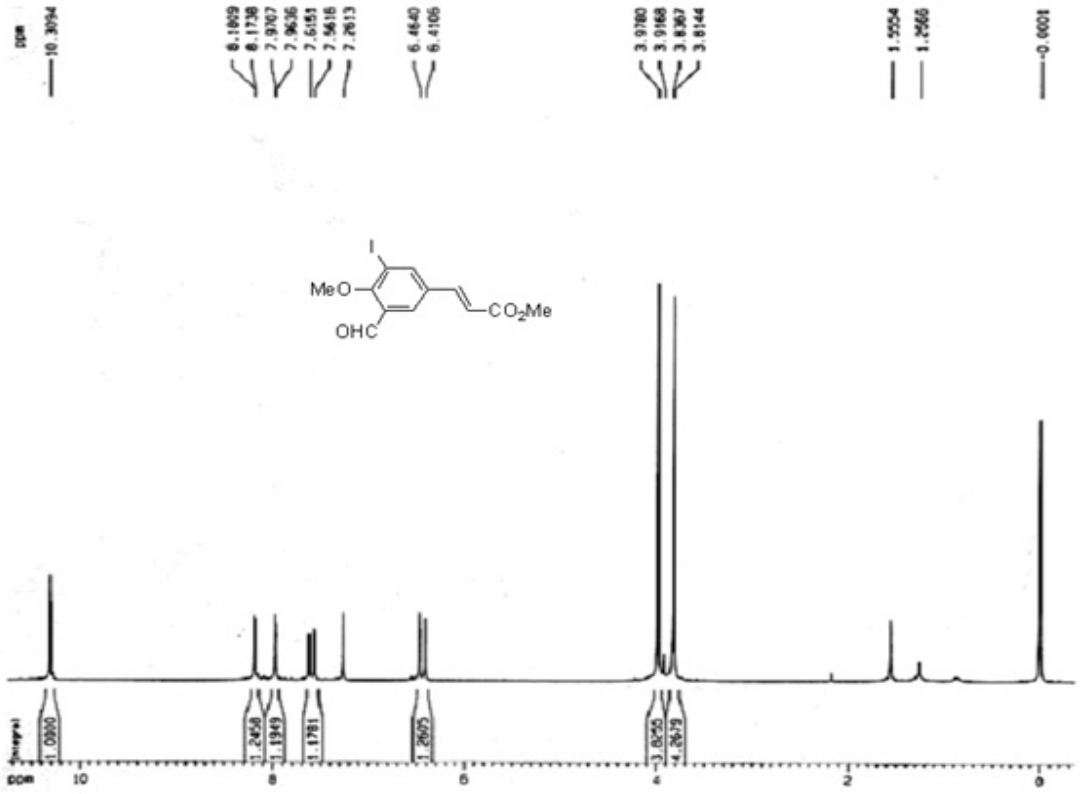
12 (^{1}H NMR)



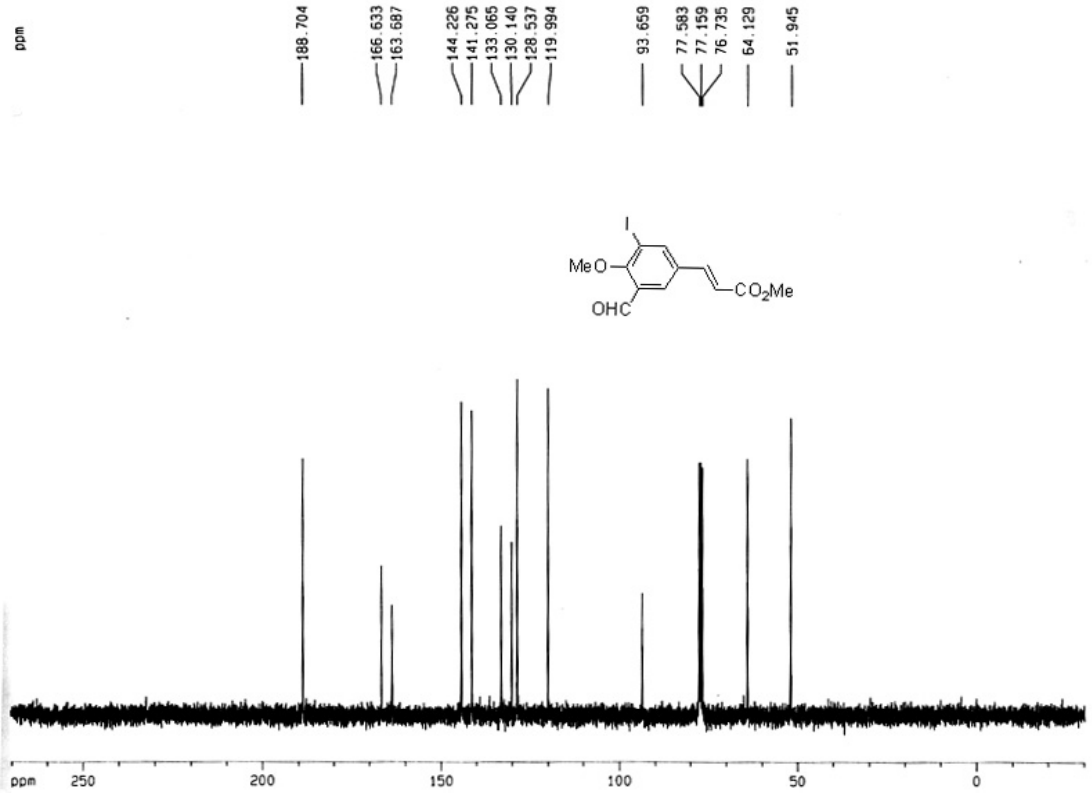
12 (^{13}C NMR)



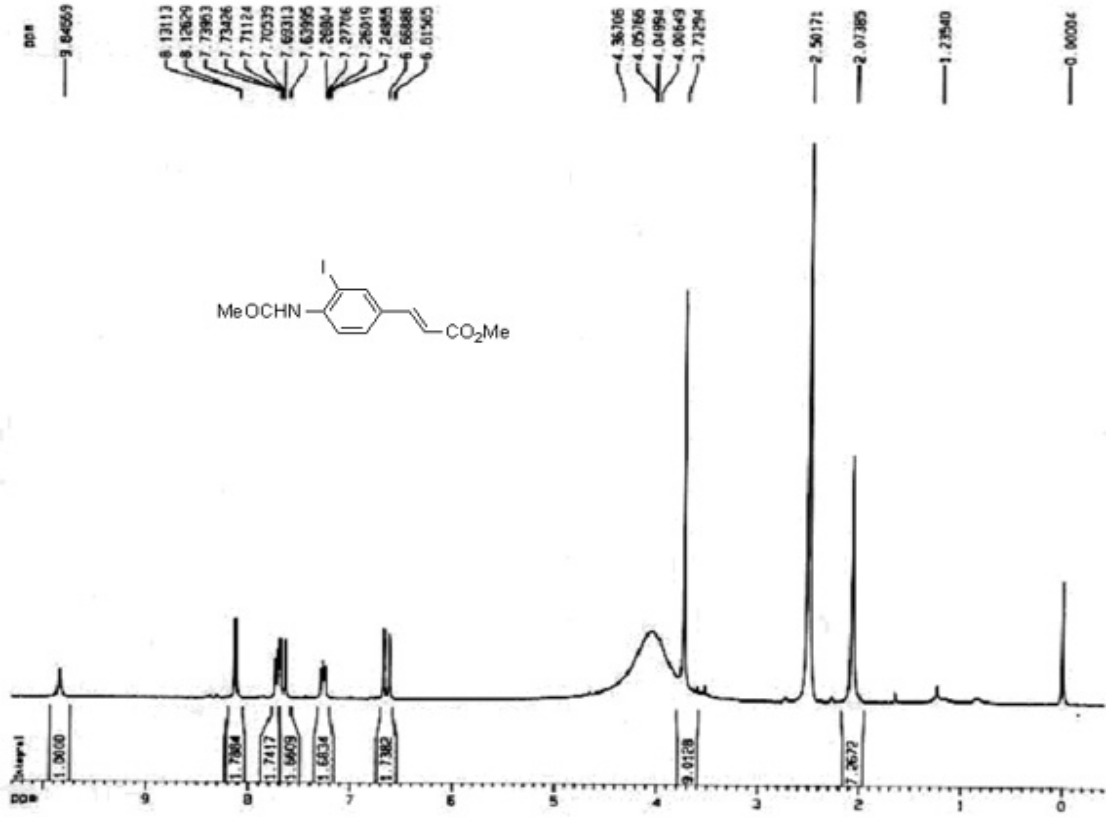
13 (^{1}H NMR)



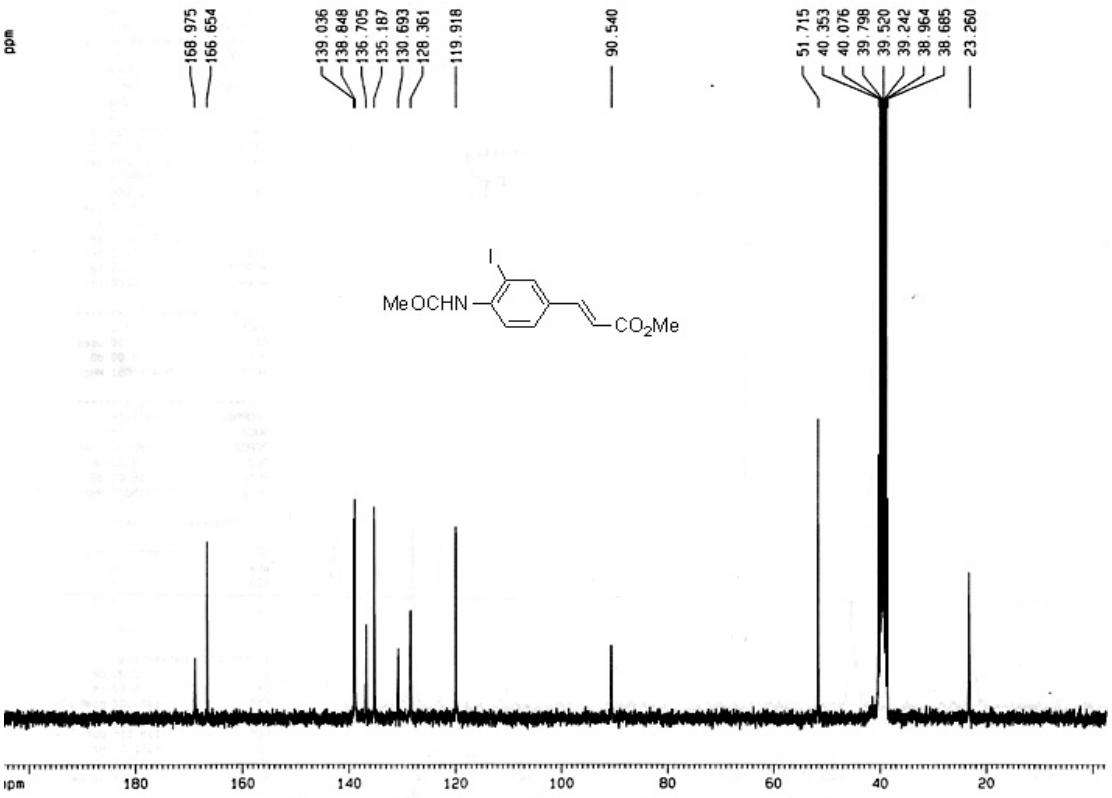
13 (^{13}C NMR)



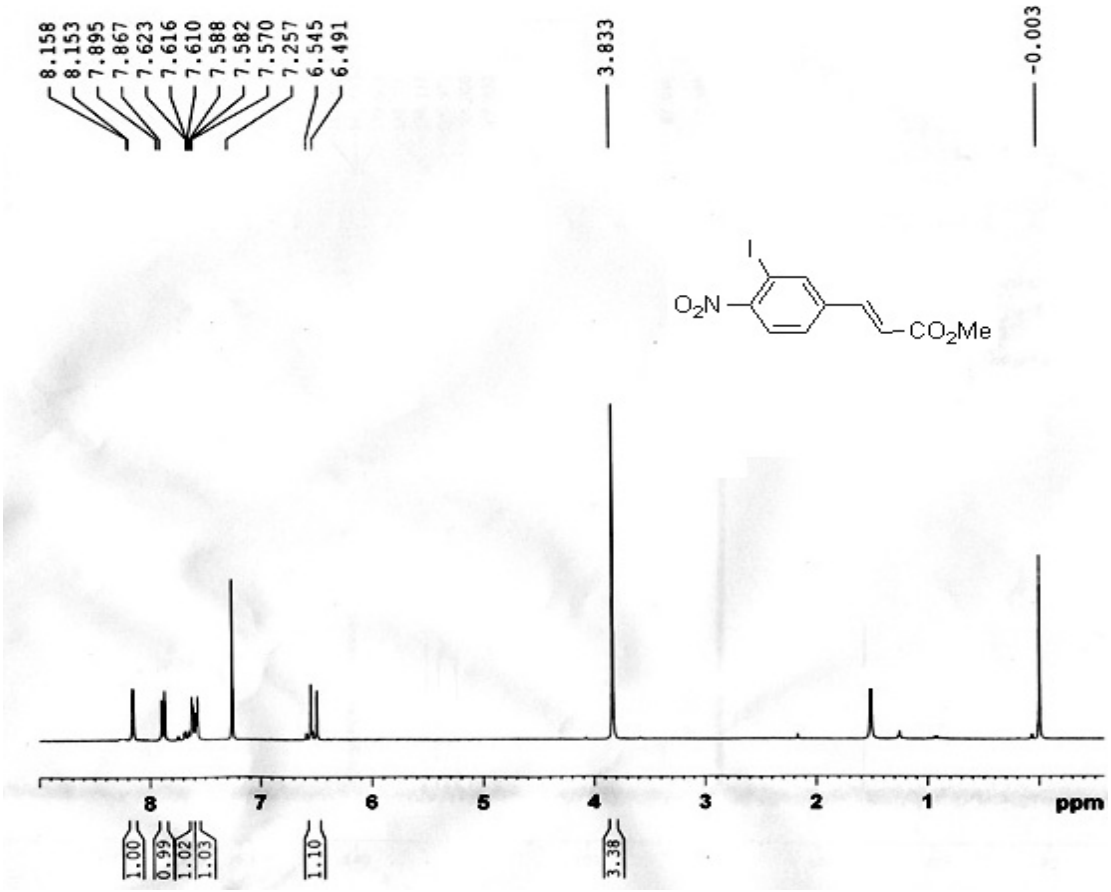
14 (^{1}H NMR)



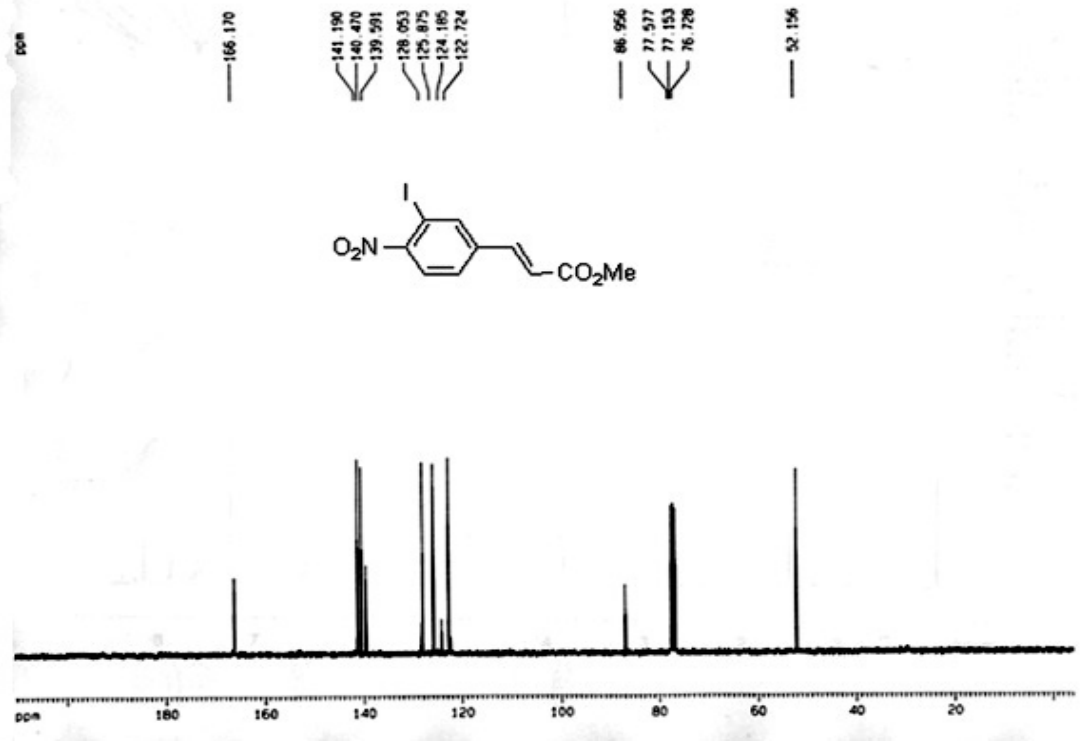
14 (^{13}C NMR)



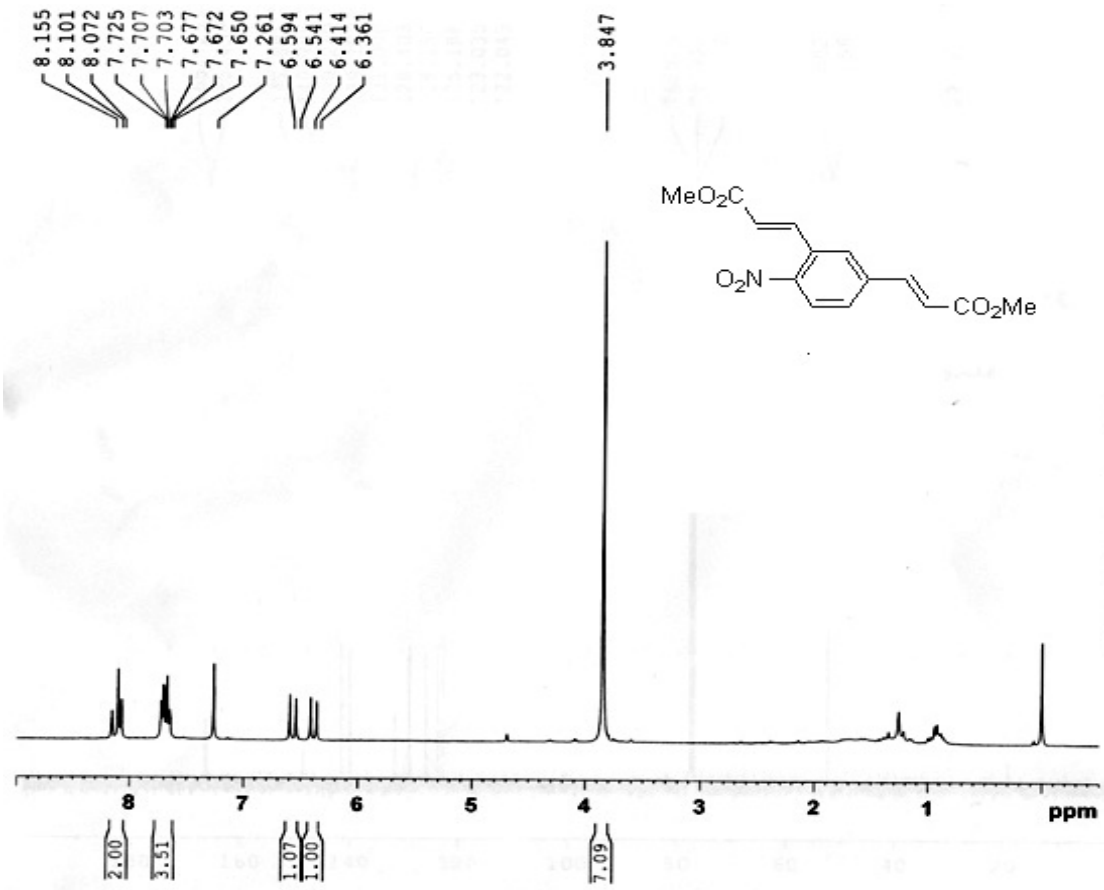
15 (^{1}H NMR)



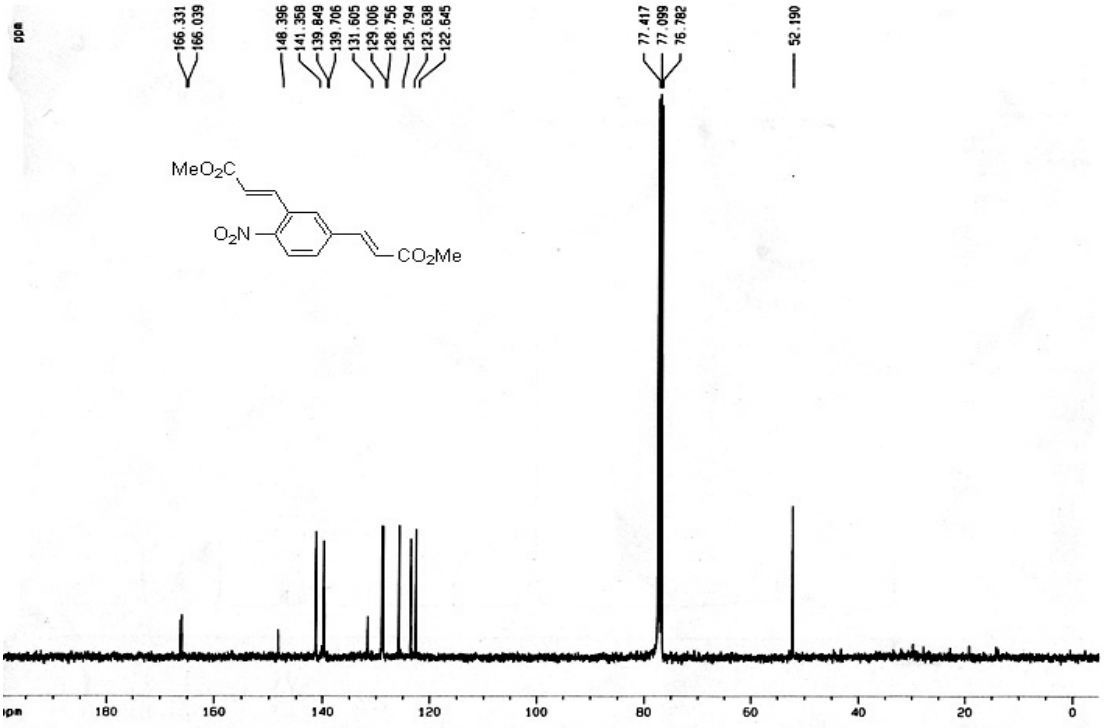
15 (^{13}C NMR)



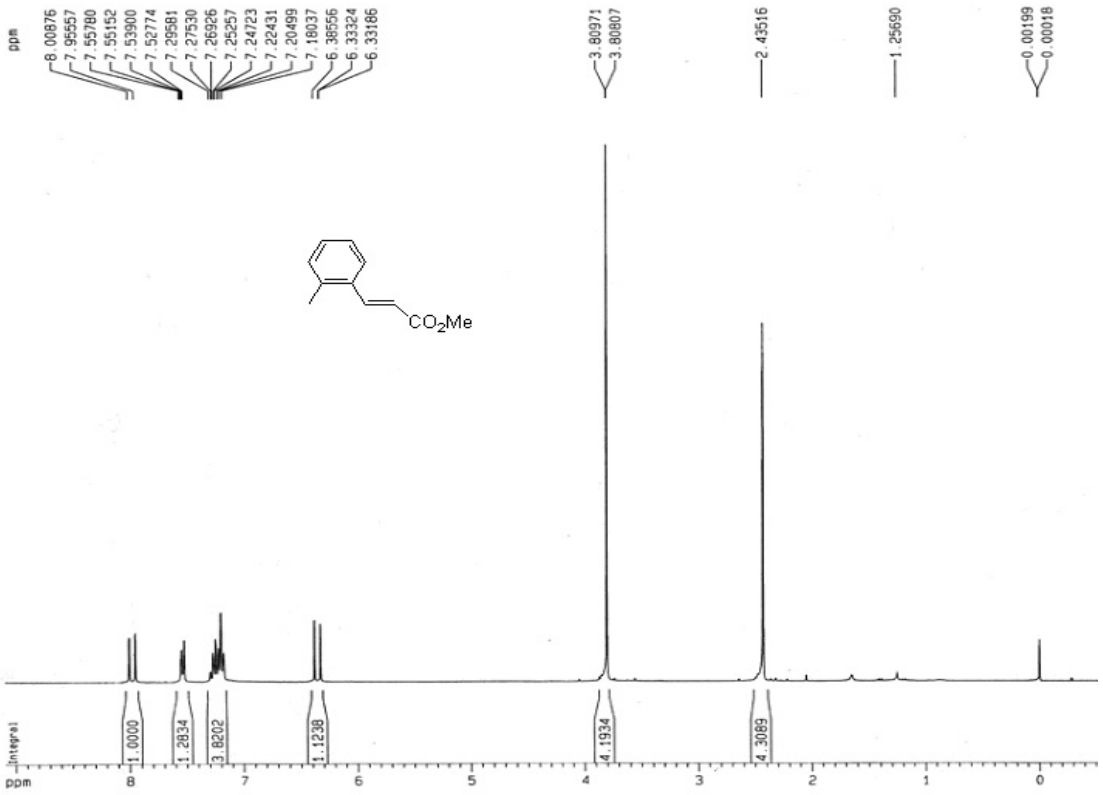
16 (^{1}H NMR)



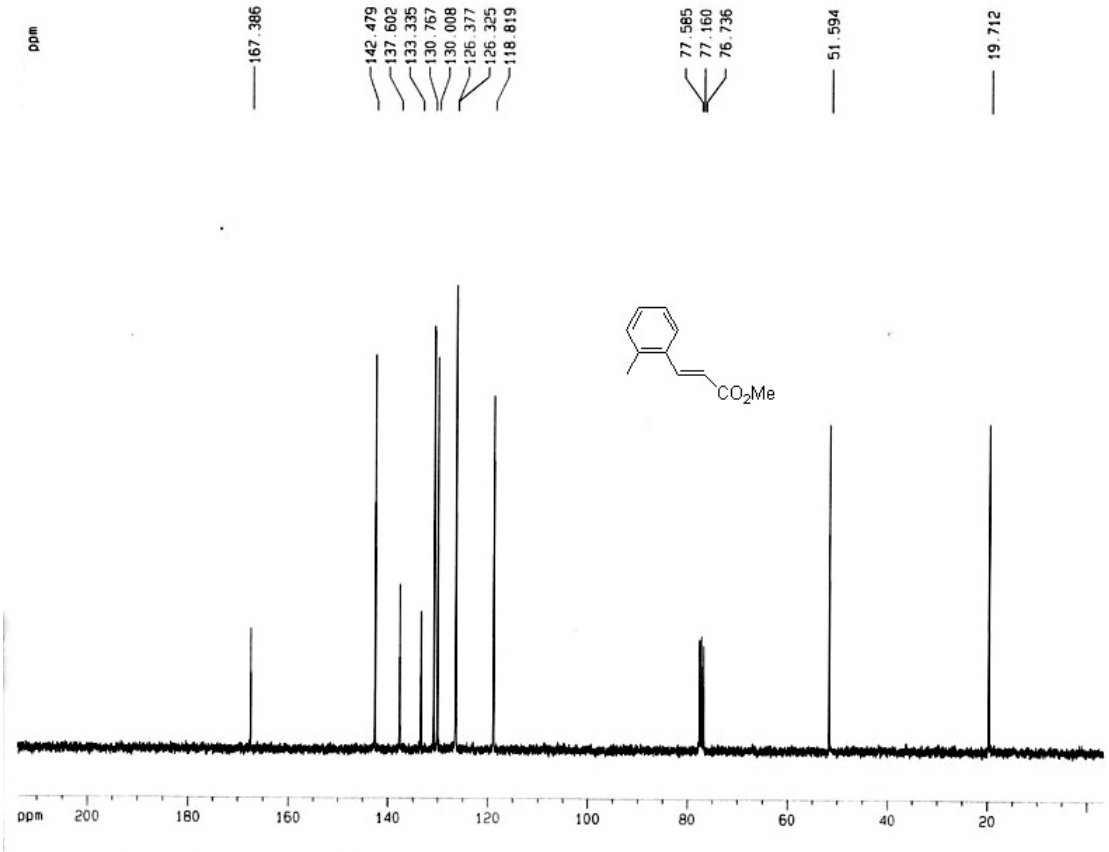
16 (^{13}C NMR)



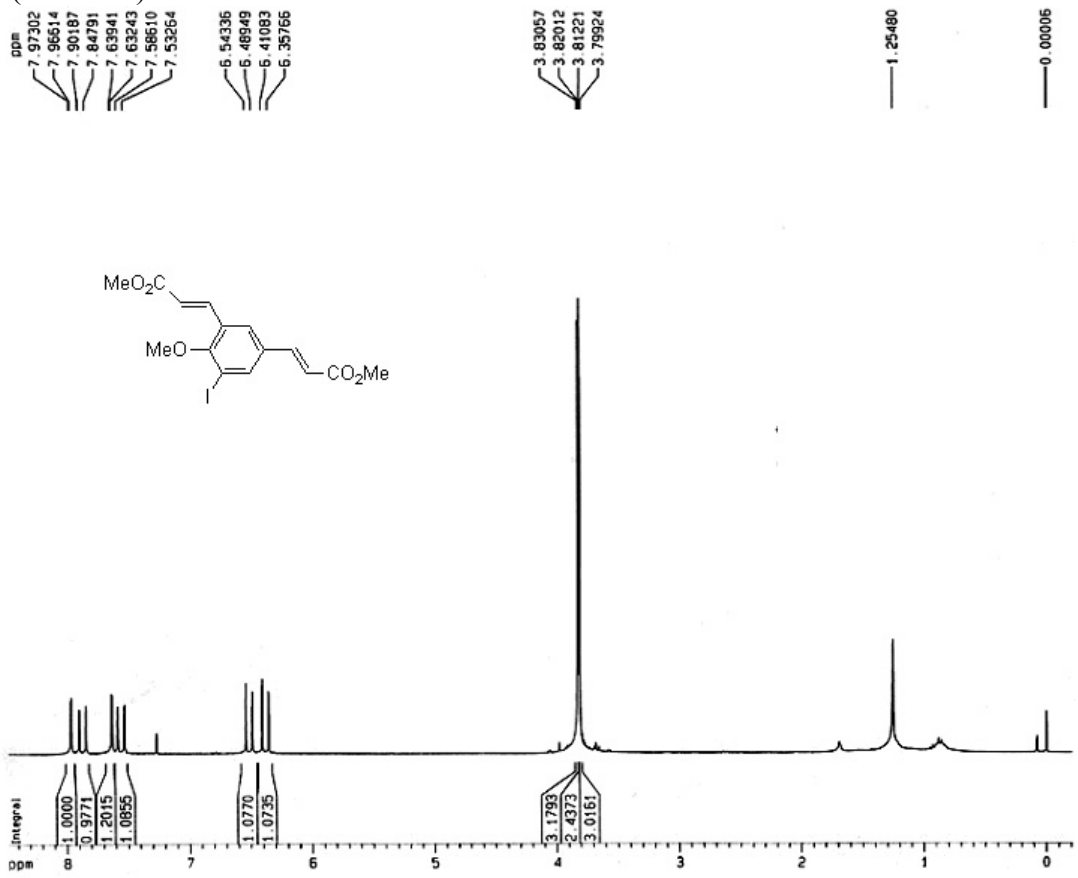
17 (^{1}H NMR)



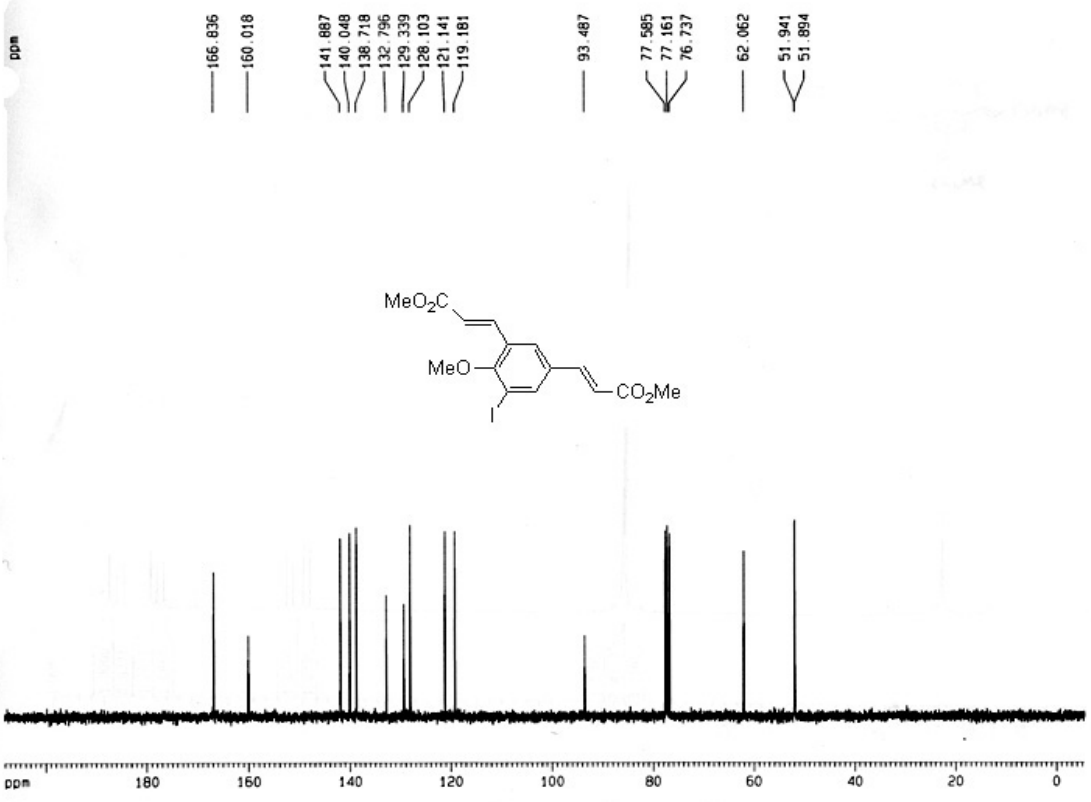
17 (^{13}C NMR)



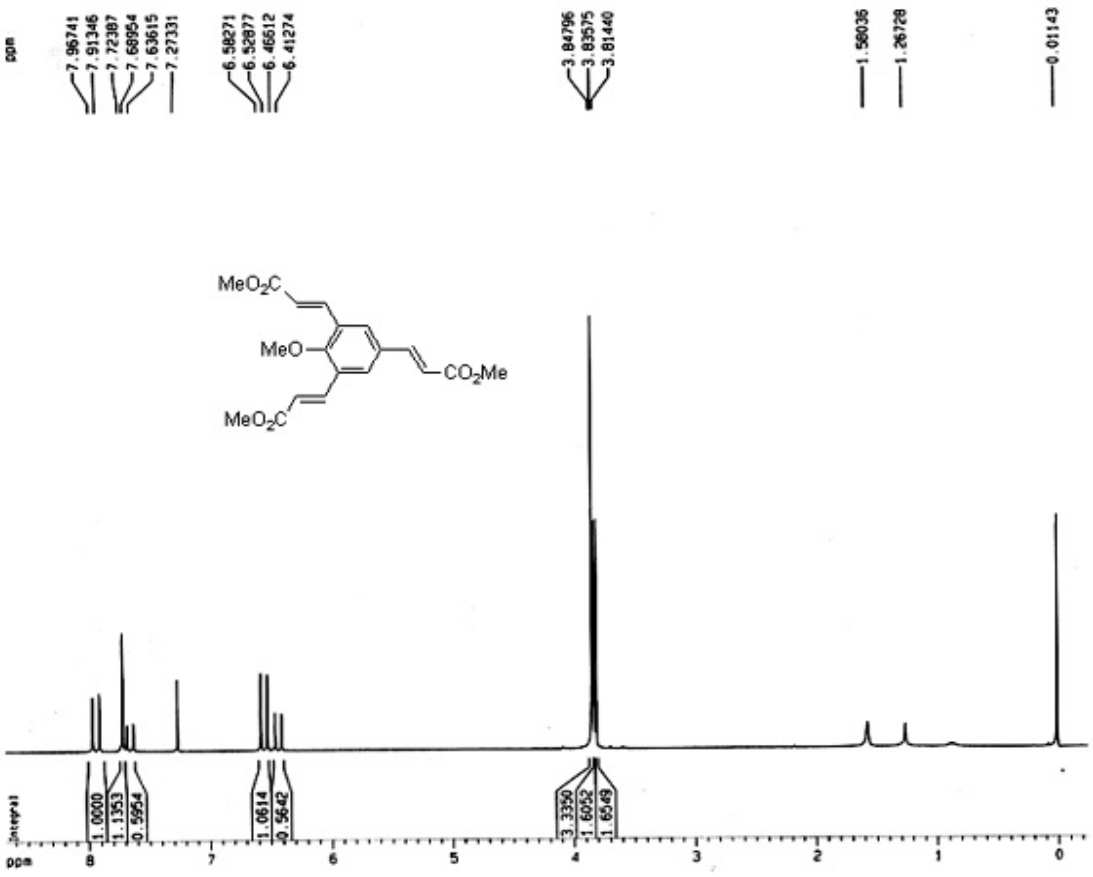
18 (^{1}H NMR)



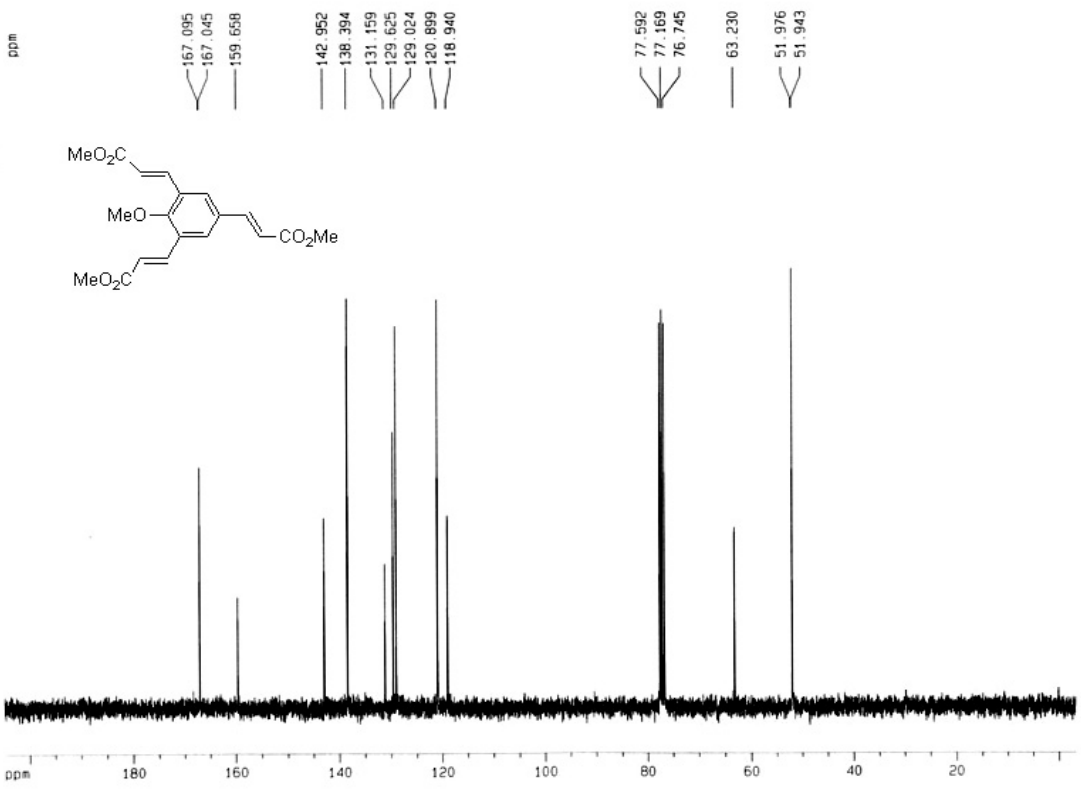
18 (^{13}C NMR)



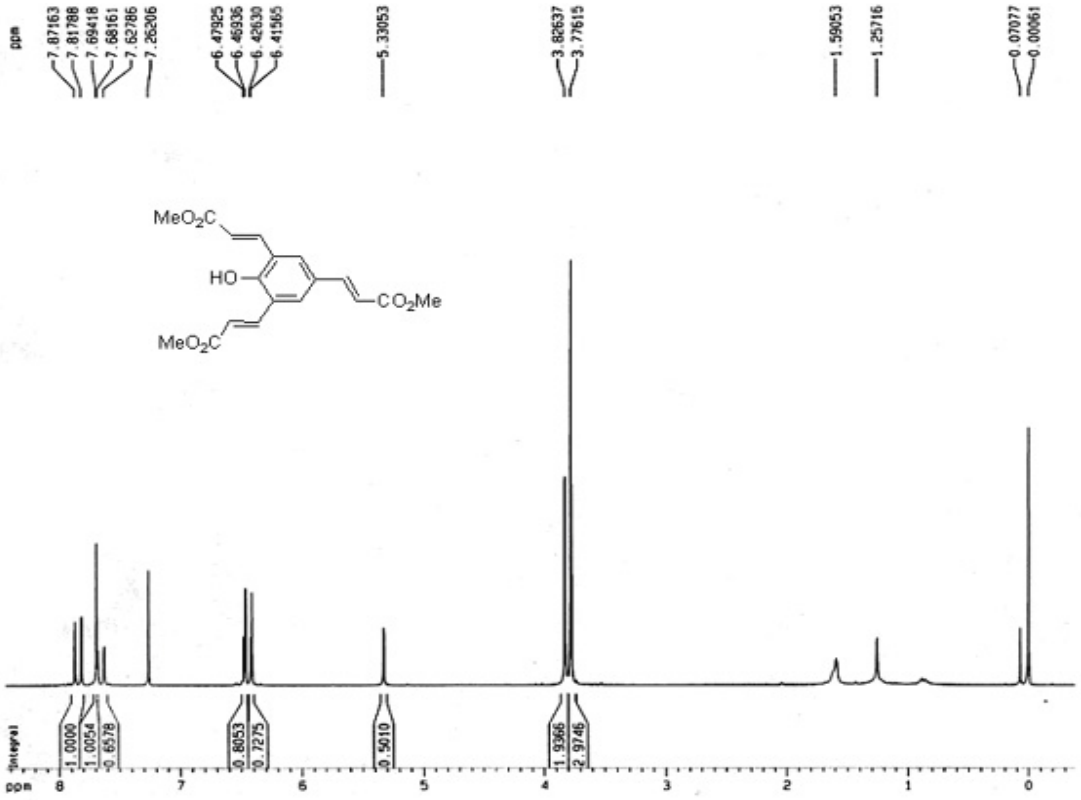
19 (^{1}H NMR)



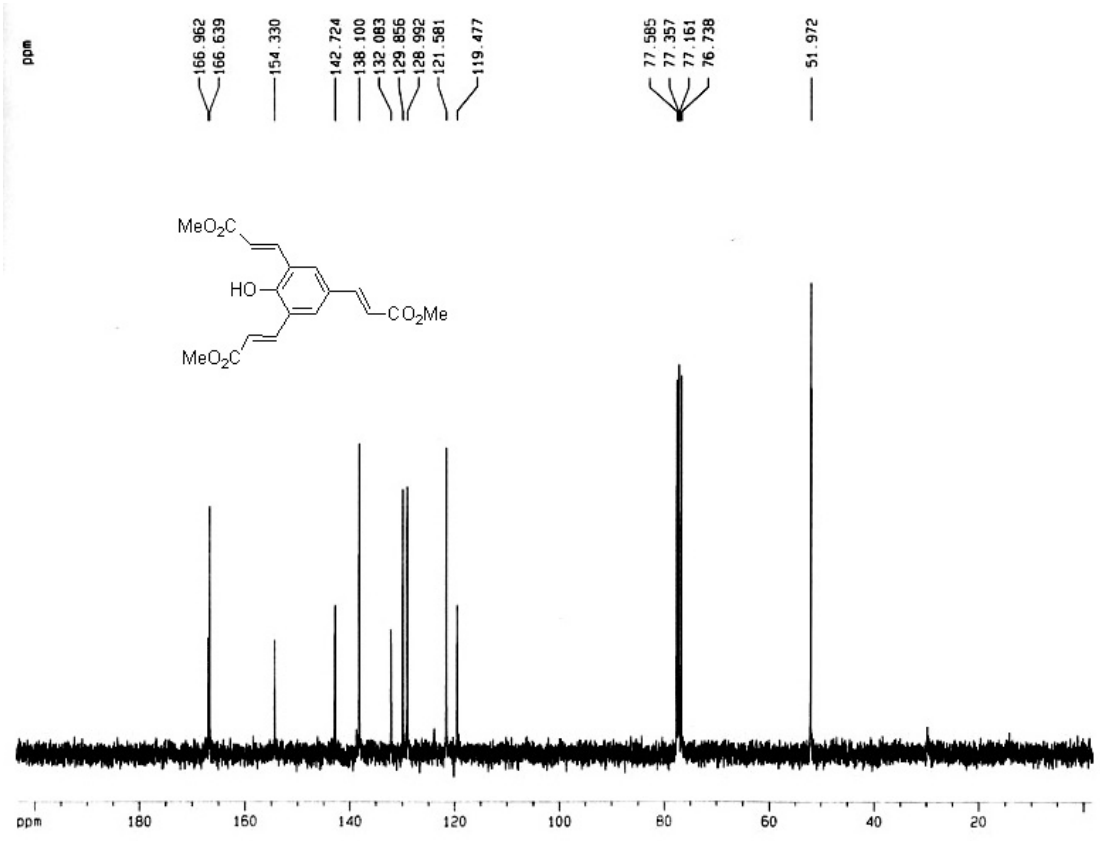
19 (^{13}C NMR)



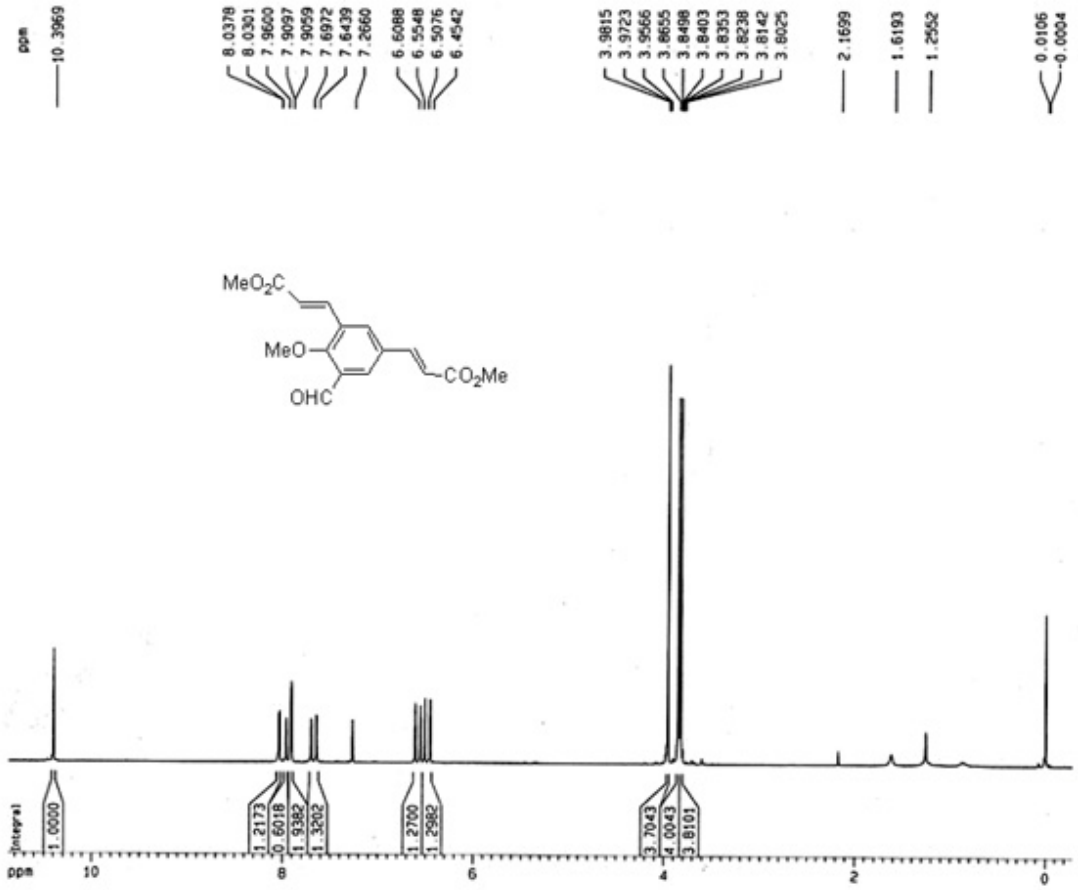
20 (^{1}H NMR)



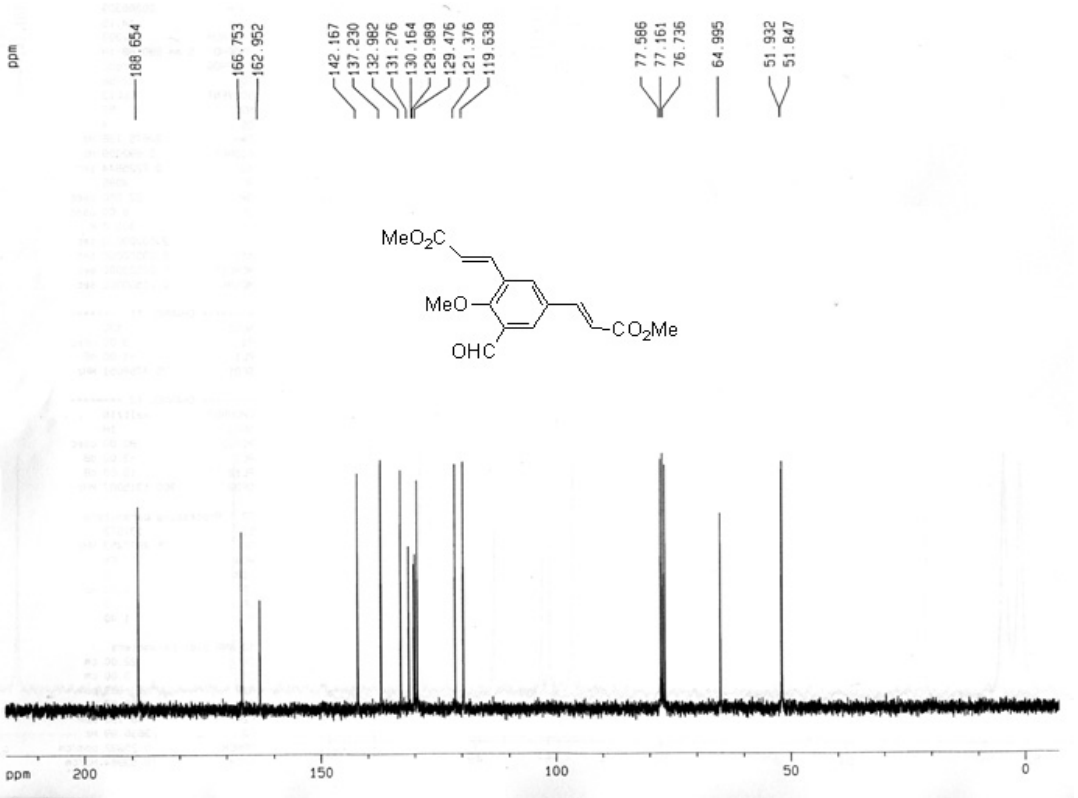
20 (^{13}C NMR)



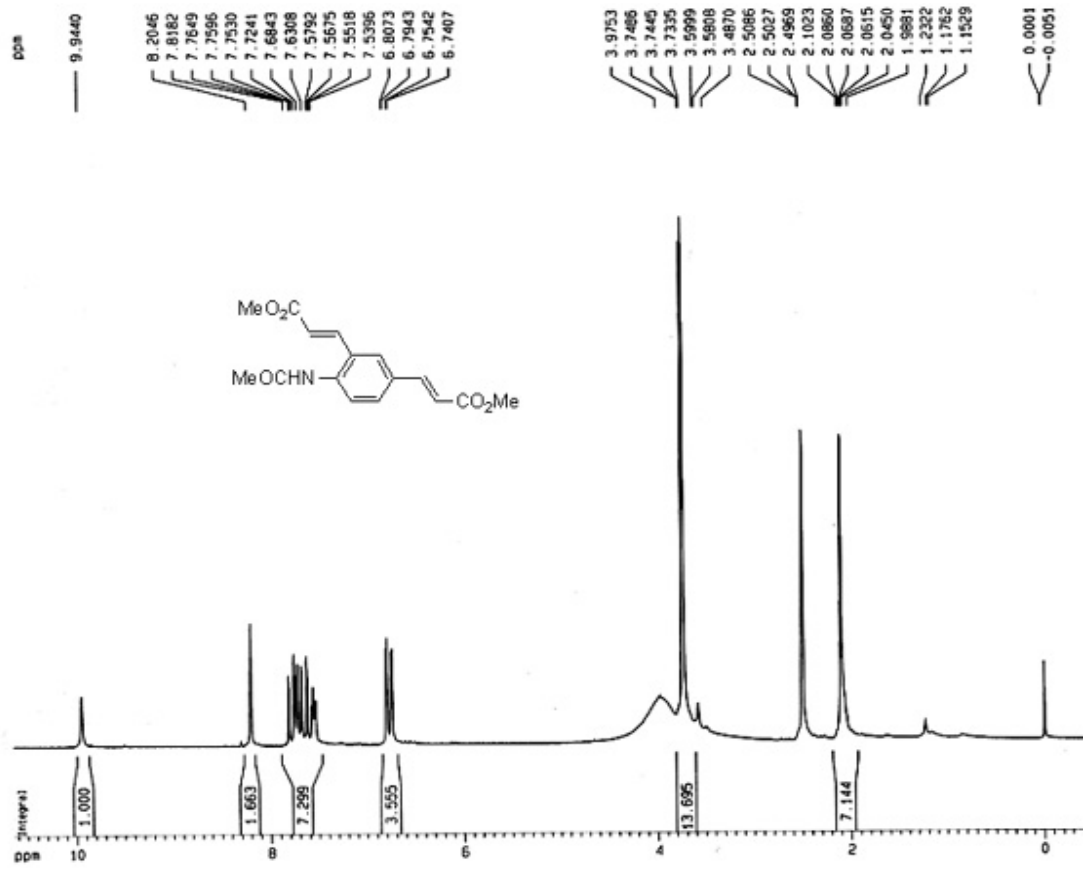
21 (^{1}H NMR)



21 (^{13}C NMR)



22 (^{1}H NMR)



22 (^{13}C NMR)