Oxindole synthesis by palladium-catalysed aromatic C–H alkenylation

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SUPPORTING INFORMATION

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General Method

^{1}H and ^{13}C NMR spectra were recorded at 400 MHz (^{1}H NMR) and 100 MHz (^{13}C NMR) frequency in $CDCl_3$ or DMSO-*d6*. Chemical shifts are calibrated to the solvent signals. Melting points were determined on a Yanagimoto micro melting point apparatus and are uncorrected. All reagents and solvents were used without further purification from commercial sources. Column chromatography was carried out with silica gel (300-350 mesh). Merck Art 7749 Kieselgel 60 PF 254 was used in preparative thin-layer chromatography (TLC). Exact mass (HRMS) spectra were recorded on a JEOL JMS-SX102A mass spectrometer.

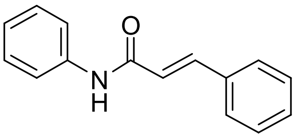
General Procedure for the Synthesis of Anilides

Procedure A: To a stirred solution of aniline (1.0 eq.) in EtOAc were added triethylamine (1.05 eq.) and acid chloride (1.05 eq.) at 0 °C. The reaction mixture was stirred at room temperature for 4 h after which it was extracted with EtOAc. The extract was washed with brine and dried over $MgSO_4$. Concentration under reduced pressure and purification by recrystalization afforded pure anilide.

Procedure B: To a stirred solution of carboxylic acid (1.1 eq.) in DMF were added EDC•HCl (1.1 eq.), $HOBt \cdot H_2O$ (1.1 eq.) and aniline (1.1 eq.) at 0 °C. The reaction mixture was stirred at room temperature for 12 h after which it was extracted with EtOAc. The extract was washed with brine and dried over $MgSO_4$. Concentration under reduced pressure and purification by recrystalization afforded pure anilide.

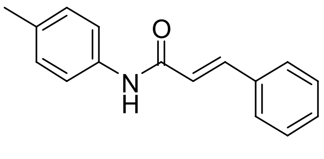
Procedure C: To a stirred solution of aniline (1.0 eq.) in DMF were added NaH (60% in mineral oil, 1.1 eq.) and acid chloride (1.1 eq.) at 0 °C. The reaction mixture was stirred at 60 °C for 6 h after which it was extracted with EtOAc. The extract was washed with brine and dried over $MgSO_4$. Concentration under reduced pressure and purification by recrystalization afforded pure anilide.

N-Phenylcinnamamide (1a)[1]



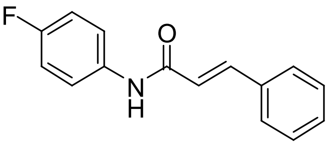
Following the procedure A for anilide synthesis, the reaction was performed on a 20.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (4.19 g, 94%). m.p. 151-152 °C (lit.[1] m.p. 150-153 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.57 (s, 1H), 7.74-7.65 (m, 3H), 7.38-7.33 (m, 2H), 7.30-7.20 (m, 5H), 7.07 (t, 1H, *J* = 7.6 Hz), 6.70 (d, 1H, *J* = 16.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.7, 142.1, 138.1, 134.5, 129.7, 128.9, 128.7, 127.9, 124.4, 121.1, 120.4; MS (EI), *m/z* 223 (M^+)

N-*p*-Tolylcinnamamide (1b)[2]



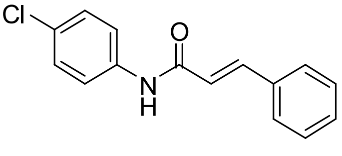
Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (1.04 g, 88%). m.p. 164-165 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.77 (s, 1H), 7.68 (d, 1H, *J* = 15.6 Hz), 7.56 (d, 2H, *J* = 8.4 Hz), 7.34-7.29 (m, 2H), 7.26-7.16 (m, 3H), 7.03 (d, 2H, *J* = 8.4 Hz), 6.71 (d, 1H, *J* = 16.0 Hz), 2.24 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.7, 141.7, 135.6, 134.6, 133.9, 129.6, 129.4, 128.6, 127.8, 121.3, 120.5, 20.8; MS (EI), *m/z* 237 (M$^+$)

N-4-Fluorophenylcinnamamide (1c)[2]



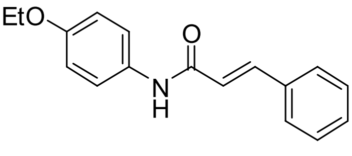
Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (0.86 g, 82%). m.p. 139-141 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.27 (s, 1H), 7.80-7.74 (m, 2H), 7.66-7.61 (m, 3H), 7.49-7.40 (m, 3H), 7.19 (t, 2H, J = 8.8 Hz), 6.84 (d, 1H, J = 16.0 Hz); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.4, 158.0 (J = 241.1 Hz), 140.2, 135.6(J = 2.4 Hz), 134.7, 129.7, 128.9, 127.6, 122.1, 120.9 (J = 8.2 Hz), 115.2 (J = 22.2 Hz); MS (EI), *m/z* 241 (M$^+$)

N-4-Chlorophenylcinnamamide (1d)[3]



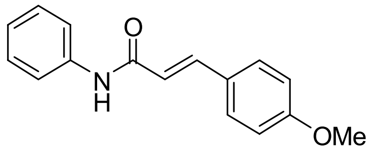
Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (1.08 g, 92%). m.p. 172-173 °C (lit.[3] m.p. 170 °C); ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.36 (s, 1H), 7.79 (d, 2H, J = 8.8 Hz), 7.69-7.63 (m, 3H), 7.48-7.38 (m, 5H), 6.87 (d, 1H, J = 16.0 Hz); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.6, 140.4, 138.2, 134.6, 129.7, 128.9., 128.6, 127.7, 126.9, 122.0, 120.7; MS (EI), *m/z* 257 (M$^+$)

N-4-Ethoxyphenylcinnamamide (1e)[4]



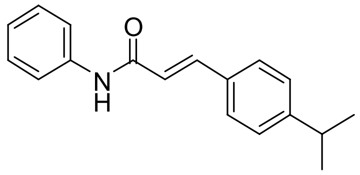
Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (1.05 g, 79%). m.p. 148-149 °C (lit.[4] m.p.145 °C); ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.09 (s, 1H), 7.68-7.57 (m, 5H), 7.48-7.38 (m, 3H), 6.91 (d, 2H, J = 8.8 Hz), 6.84 (d, 1H, J = 16.0 Hz), 3.99 (t, 2H, J = 7.2 Hz), 1.32 (t, 3H, J = 7.2 Hz); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.0, 154.6, 139.6, 134.8, 132.4, 129.6, 129.0, 127.6, 122.4, 120.7, 114.4, 63.1, 14.7; MS (EI), *m/z* 267 (M$^+$)

N-Phenyl-4-methoxycinnamamide (1f)[5]



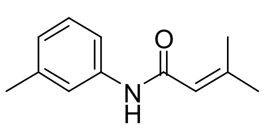
Following the procedure B for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound was isolated by recrystalization (EtOAc-hexane) as a white solid (0.97 g, 77%). m.p. 127-129 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.14 (s, 1H), 7.76 (d, 2H, J = 7.6 Hz), 7.64-7.58 (m, 3H), 7.39-7.32 (m, 2H), 7.10-6.98 (m, 3H), 6.75 (d, 1H, J = 15.6 Hz), 3.81 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.9, 160.5, 139.9, 139.4, 129.3, 128.7, 127.3, 123.1, 119.7, 119.2, 111.4, 55.2; MS (EI), *m/z* 253 (M$^+$)

***N*-Phenyl-4-isopropylcinnamamide (1g)** CAS:541520-03-0



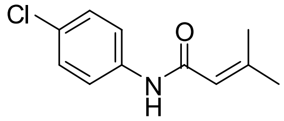
Following the procedure B for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (0.78 g, 63%). m.p. 121-122 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 7.90 (s, 1H), 7.72 (d, 1H, J = 15.6 Hz), 7.64 (d, 2H, J = 7.2 Hz), 7.39 (d, 2H, J = 8.4 Hz), 7.31 (t, 2H, J = 8.0 Hz), 7.17 (d, 2H, J = 8.0 Hz), 7.10 (t, 1H, J = 7.2 Hz), 6.58 (d, 1H, J = 16.4 Hz), 2.94-2.84 (m, 1H), 1.24 (s, 3H), 1.22 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 164.9, 151.1, 142.3, 138.1, 132.2, 129.0, 128.0, 126.9, 124.3, 120.1, 119.9, 34.0, 23.7; HRMS (EI), *m/z* calcd. for $C_{18}H_{19}NO$ (M^+) 265.1467, found: 265.1460.

***N*-(3-Methylphenyl)-3-methyl-2-butenamide (1h)** CAS: 171662-30-9



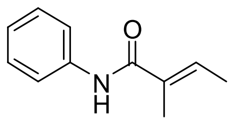
Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (0.86 g, 91%). m.p. 131-132 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 7.69 (s, 1H), 7.42 (s, 1H), 7.30 (d, 1H, J = 7.6 Hz), 7.13 (m, 1H), 6.86 (d, 1H, J = 7.2 Hz), 5.73 (s, 1H), 2.27 (s, 3H), 2.19 (s, 3H), 1.83 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ165.3, 152.7, 138.6, 138.2, 128.5, 124.6, 120.5, 118.9, 116.9, 27.2, 21.3, 19.8; HRMS (EI), *m/z* calcd. for $C_{12}H_{15}NO$ (M^+) 189.1154, found: 189.1152.

***N*-(4-Chlorophenyl)-3-methyl-2-butenamide (1i)**[6]



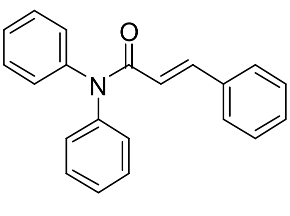
Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (g, 66%). m.p. 117-118 °C (lit.[6] m.p. 116-117 °C); ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.19 (s, 1H), 7.48 (d, 2H, J = 8.0 Hz), 7.18 (d, 2H, J = 8.4 Hz), 5.74 (s, 1H), 2.17 (s, 3H), 1.82 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ165.5, 153.5, 136.8, 128.7, 128.6, 121.3, 118.5, 27.2, 19.9; MS (EI), *m/z* 209 (M^+)

***(E)*-2-Methyl-*N*-phenyl-2-butenamide (1j)**[7]



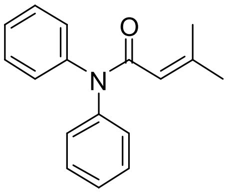
Following the procedure B for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (0.58 g, 86%). m.p. 72-73 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 7.85 (s, 1H), 7.58-7.53 (m, 2H), 7.30-7.24 (m, 3H), 7.09-7.04 (m, 1H), 6.49-6.44 (m, 1H), 1.88 (s, 3H), 1.74 (d, 1H, J = 7.2 Hz); ^{13}C NMR (100 MHz, CDCl$_3$) δ 167.9, 138.1, 132.7, 131.4, 131.0, 128.7, 123.9, 120.1, 13.9, 12.3; MS (EI), *m/z* 175 (M^+)

***N,N*-Diphenylcinnamamide (3a)**[8]



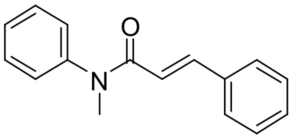
Following the procedure C for anilide synthesis, the reaction was performed on a 10.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (2.09 g, 78%). m.p. 153-154 °C (lit.[8] m.p. 152-153 °C); ^{1}H NMR (400 MHz, CDCl$_3$) δ 7.77 (d, 1H, J = 16.4 Hz), 7.40-7.25 (m, 15H), 6.48 (d, 1H, *J* = 15.6 Hz),; ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.1, 142.7, 142.6, 135.0, 129.6, 129.2, 128.7, 127.9, 127.5, 126.8, 119.7; MS (EI), *m/z* 299 (M^+)

3-Methyl-*N,N*-diphenyl-2-butenamide (3b) (New compound)



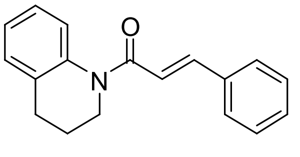
Following the procedure C for anilide synthesis, the reaction was performed on a 10.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (1.96 g, 78%). m.p. 94-95 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34-7.27 (m, 4H), 7.22-7.16 (m, 6H), 5.61 (s, 1H), 2.17 (s, 3H), 1.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.7, 152.2, 142.8, 128.8, 127.2, 126.1, 118.2, 27.4, 20.0; HRMS (EI), *m/z* calcd. for $C_{17}H_{17}NO$ (M^+) 251.1310, found: 251.1308.

***N*-Methyl-*N*-phenylcinnamamide (3c)**[9]

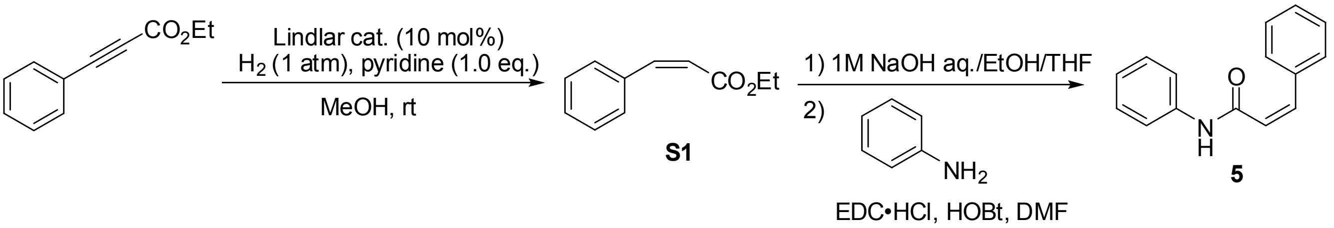


Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (9.36 g, 79%). m.p. 67-68 °C (lit.[9] m.p. 70 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, 1H, *J* = 15.6 Hz), 7.44-7.38 (m, 2H), 7.36-7.20 (m, 8H), 6.38 (d, 1H, *J* = 15.6 Hz), 3.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 143.4, 141.4, 135.0, 129.4, 129.2, 128.4, 127.6, 127.3, 127.1, 118.6, 37.3; MS (EI), *m/z* 237 (M^+)

***N*-Cinnamoyltetrahydroquinoline (3d)**[10]



Following the procedure A for anilide synthesis, the reaction was performed on a 5.0 mmol scale. The title compound as isolated by recrystalization (EtOAc-hexane) as a white solid (1.14 g, 87%). m.p. 90-91 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, 1H, *J* = 16.0 Hz), 7.44-7.40 (m, 2H), 7.33-7.30 (m, 3H), 7.21-7.10 (m, 4H), 6.84 (d, 1H, *J* = 15.6 Hz), 3.91 (t, 2H, *J* = 6.8 Hz), 2.74 (t, 2H, *J* = 6.8 Hz), 2.03-1.94 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 141.6, 138.5, 135.2, 133.1, 129.4, 128.6, 128.4, 127.7, 126.0, 125.1, 124.7, 120.1, 43.2, 26.9, 23.9; MS (EI), *m/z* 263 (M^+)



(*Z*)-*N*,3-Diphenylacrylamide (5)[11]

To a stirred solution of ethyl-3-phenylpropiolate (1.65 ml, 10 mmol) in MeOH (20 ml) was added Lindlar catalyst (5% Pd on $CaCO_3$, poisned with lead) (1.06 g, 1 mmol), and pyridine (815 µl, 10 mmol). The reaction mixture was stirred under H_2 balloon for 2 h at room temperature. The reaction mixture was filtered through a Celite pad and concentrated in vacuo. The residue was purified by column chromatography (Hexane-AcOEt, 20:1) to afford **S1** as colorless oil (1.54 g, 88 % yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.55 (m, 2H), 7.37-7.32 (m, 3H), 6.94 (d, 1H, *J* = 12.8 Hz), 5.95 (d, 1H, *J* = 12.8 Hz), 4.17 (q, 2H, *J* = 7.6 Hz), 1.24 (t, 3H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.2, 142.9, 134.9, 129.7, 129.6, 127.9, 119.9, 60.2, 14.0; MS (EI), *m/z* 176 (M^+).

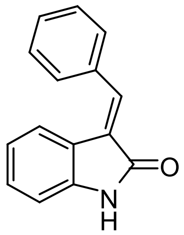
To a stirred solution of **S1** (1.54 g 8.8 mmol) in EtOH (15 ml) and THF (15 ml) was added 1M aqueous NaOH (15 ml) and the reaction mixture was stirred at room temperature for 12 h. The reaction mixture was concentrated in vacuo and extracted with EtOAc. The organic layer was washed with 5% aqueous citric acid and brine. The extract was dried over $MgSO_4$ and concentrated in vacuo to afford crude (*Z*)-3-phenylacrylic acid which was used in next step without further purification.

Following procesure B using (*Z*)-3-phenylacrylic acid and aniline, **5** was isolated by recrystalization (EtOAc-hexane) as a white solid (1.56 g, 80% from **S1**). m.p. 93-94 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51-7.47 (m, 2H), 7.37-7.23 (m, 8H), 7.07 (t, 1H, *J* = 7.2 Hz), 6.89 (d, 1H *J* = 12.0 Hz), 6.10 (d, 1H *J* = 12.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.8, 137.5, 134.7, 129.0, 128.9, 128.6, 128.6, 125.0, 124.4, 119.9; MS (EI), *m/z* 223 (M^+)

General Procedure for the Synthesis of Oxindoles

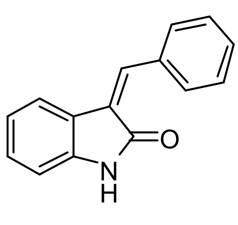
To a dried screw-cap vial was added anilide (0.3 mmol), $AgOCOCF_3$ (132.5 mg, 0.6 mmol), $PdCl_2MeCN_2$ (3.5 mg, 0.015 mmol) and chlorobenzene. The reaction mixture was stirred at 100-120 °C for 6-12 h in pre-heated oil bath. After cooling to room temperature, the reaction was diluted with EtOAc and filtered over glass filter. The filtrate was washed with 5% aqueous $NaHCO_3$ and brine. The extract was dried over $MgSO_4$ and concentrated in vacuo. The crude was purified by preparative TLC.

(*E*)-3-Benzylideneoxindole (2a)[12]



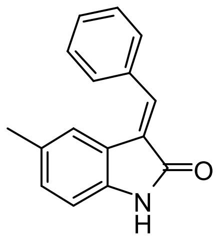
The title compound was isolated by preparative TLC (hexane-EtOAc 2:1) as a orange solid (48.4 mg, 73%). m.p. 178-179 °C (lit.[12] m.p. 179-180 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.34 (s, 1H), 7.85 (s, 1H), 7.69-7.61 (m, 3H), 7.48-7.42(m, 3H), 7.20 (t, 1H, *J* = 8.0 Hz), 6.92 (d, 1H, *J* = 7.6 Hz), 6.85 (t, 1H, *J* = 7.2 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.6, 141.8, 137.5, 134.8, 129.9, 129.6, 129.3, 128.6, 127.7, 123.0, 121.7, 121.6, 110.4; MS (EI), *m/z* 221 (M^+).

(*Z*)-3-Benzylideneoxindole (2a)[12]



The title compound was isolated by preparative TLC (hexane-EtOAc 2:1) as a orange solid (5.3 mg, 8%). m.p. 172-173 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29-8.25 (m, 2H), 7.78 (s, 1H), 7.57-7.51 (m, 2H), 7.48-7.42(m, 3H), 7.22 (t, 1H, *J* = 8.0 Hz), 7.04 (d, 1H, *J* = 7.6 Hz), 6.84 (t, 1H, *J* = 8.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.5, 139.5, 137.6, 133.7, 132.0, 130.6, 128.9, 128.3, 126.1, 125.3, 121.8, 119.3, 109.4; MS (EI), *m/z* 221 (M^+).

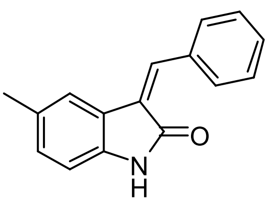
(*E*)-3-Benzylidene-5-methyoxindole (2b)[13]



The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a orange solid (46.5 mg, 66%). m.p. 178-180 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.28 (s, 1H), 7.81, (s, 1H), 7.68-7.64 (m, 2H), 7.50-7.42 (m, 4H), 7.01 (d, 1H, *J*

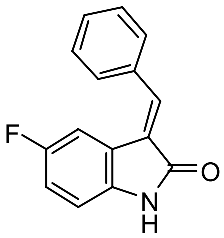
= 8.4 Hz), 6.81 (d, 1H, *J* = 7.6 Hz), 2.20 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.7, 139.6, 137.1, 134.9, 131.0, 130.4, 129.6, 129.3, 128.6, 127.9, 123.5, 121.7, 110.1, 21.1; MS (EI), *m/z* 235 (M^+).

(*Z*)-3-Benzylidene-5-methyoxindole (2b)[14]



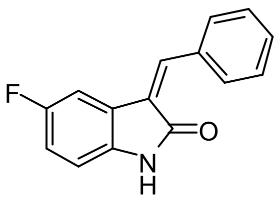
The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a orange solid (6.3 mg, 9%). m.p. 184-185 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.28-8.24 (m, 2H), 8.00 (s, 1H), 7.52 (s, 1H), 7.48-7.41 (m, 3H), 7.34 (s, 1H), 7.02 (d, 1H, *J* = 8.4 Hz), 6.72 (d, 1H, *J* = 8.0 Hz), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.9, 137.4, 137.2, 133.8, 131.9, 131.2, 130.4, 129.4, 128.3, 126.4, 125.3, 120.0, 109.2, 21.2; MS (EI), *m/z* 235 (M^+).

(*E*)-3-Benzylidene-5-fluorooxindole (2c) CAS: 686726-35-2



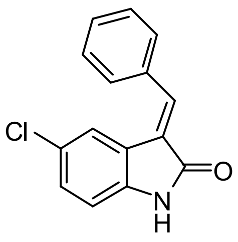
The title compound was isolated by preparative TLC (hexane-EtOAc 2:1) as a orange solid (45.2 mg, 63%). m.p.196-197 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.21 (s, 1H), 7.89 (s, 1H), 7.66-7.61 (m, 2H), 7.52-7.44(m, 3H), 7.36-7.31 (m, 1H), 6.94-6.89 (m, 1H), 6.86-6.81 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.5, 158.3 (d, *J* = 239.5 Hz) 139.0, 137.8, 134.3, 130.1, 129.2, 128.8, 127.5, 122.6 (d, *J* = 9.6 Hz), 116.2 (d, *J* = 2.4 Hz), 110.7 (d, *J* = 8.2 Hz), 110.4 (d, *J* = 26.4 Hz); MS (EI), m/z 239 （M^+).

(*Z*)-3-Benzylidene-5-fluorooxindole (2c) CAS: 686726-35-2



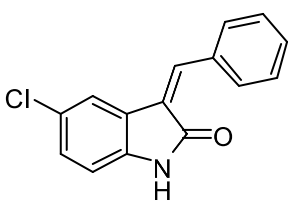
The title compound was isolated by preparative TLC (hexane-EtOAc 2:1) as a orange solid (7.9 mg, 11%). m.p. 212-213 °C °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.63 (s, 1H), 8.40-8.37 (m, 2H), 7.89 (s, 1H), 7.66 (dd, 1H, *J* = 2.8 Hz, *J* = 9.2 Hz), 7.50-7.46(m, 3H), 7.08-7.01 (m, 1H), 6.83-6.78 (m, 1H; ^{13}C NMR (100 MHz, DMSO-d_6) δ 167.1, 157.9 (d, *J* = 236.2 Hz) 138.4, 137.0, 133.7, 132.0, 130.7, 128.2, 127.7, 126.3 (d, *J* = 9.1 Hz), 115.1 (d, *J* = 23.9 Hz), 110.0 (d, *J* = 8.3 Hz), 107.3 (d, *J* = 25.5 Hz); MS (EI), m/z 239 (M^+).

(*E*)-3-Benzylidene-5-chlorooxindole (2d)[12]



The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a orange solid (44.4 mg, 58%). m.p. 219-220 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.93 (s, 1H), 7.89 (s, 1H), 7.66-7.60 (m, 3H), 7.54-7.46 (m, 3H), 7.19 (d, 1H, *J* = 8.4 Hz), 6.85 (d, 1H, *J* = 8.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.0, 140.0, 139.2, 134.3, 130.2, 129.6, 129.3, 128.9, 127.2, 126.8, 123.0, 111.1; MS (EI), *m/z* 255 (M^+).

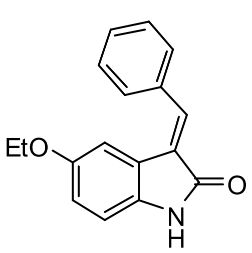
(*Z*)-3-Benzylidene-5-chlorooxindole (2d)[12]



The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a orange solid (7.6 mg, 10%). m.p. 218-220 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.75 (d, 1H, *J* = 6.8 Hz), 8.41-8.37 (m, 2H), 7.95 (s, 1H), 7.86

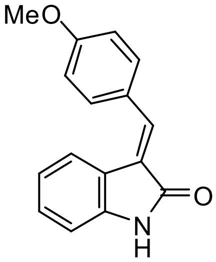
(s, 1H), 7.51-7.46 (m, 3H), 7.25 (d, 1H, *J* = 8.4 Hz), 6.84 (d, 1H, *J* = 8.4 Hz); ^{13}C NMR (100 MHz, DMSO-d_6) δ 166.8, 139.4, 138.7, 133.7, 132.1, 130.8, 128.3, 128.2, 126.8, 125.7, 119.9, 110.7; MS (EI), *m/z* 255 (M$^+$).

(*E*)-3-Benzylidene-5-ethoxyoxindole (2e) (New compound)



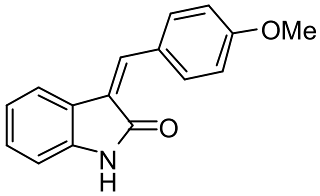
The title compound was isolated by column chromatography (hexane-EtOAc 3:2) as a red solid (46.1 mg, 58%). m.p. 179-180 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.53 (s, 1H), 7.75 (s, 1H), 7.60-7.56 (m, 2H), 7.42-7.35 (m, 3H), 7.14 (s, 1H), 6.73-6.69 (m, 2H), 3.78 (q, 2H, *J* = 7.2 Hz), 1.26 (t, 2H, *J* = 7.2 Hz); ^{13}C NMR (100 MHz, CDCl$_3$) δ 170.4, 154.3, 137.6, 135.4, 134.8, 129.7, 129.2, 128.6, 128.1, 122.5, 116.1, 110.5, 110.3, 64.1, 14.8; HRMS (EI), *m/z* calcd. for $C_{17}H_{15}NO_2$ (M$^+$) 265.1103, found: 265.1110.

(*E*)-3-(4-Methoxybenzylidene)oxindole (2f)[12]



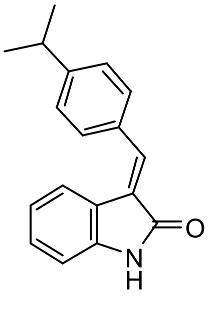
The title compound was isolated by column chromatography (hexane-EtOAc 3:2) as a red solid (39.1 mg, 52%). m.p. 203-204 °C (lit.[12] m.p. 158-159 °C); ^{1}H NMR (400 MHz, CDCl$_3$) δ 9.17 (s, 1H), 7.80 (s, 1H), 7.75 (d, 1H, *J* = 8.0 Hz), 7.68 (m, 2H, *J* = 8.8 Hz), 7.20 (t, 1H, *J* = 7.2 Hz), 7.00 (d, 2H, *J* = 8.8 Hz), 6.95-6.87 (m, 2H), 3.89 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 170.8, 160.9, 141.5, 137.7, 131.5, 129.4, 127.2, 125.7, 122.6, 122.0, 121.6, 114.1, 110.2, 55.4; MS (EI), *m/z* 251 (M$^+$).

(*Z*)-3-(4-Methoxybenzylidene)oxindole (2f)[15]



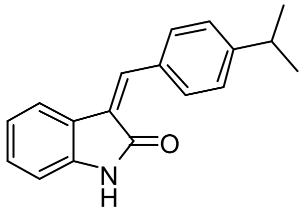
The title compound was isolated by column chromatography (hexane-EtOAc 3:2) as a red solid (7.5 mg, 10%). m.p. 177-178 °C (lit.[15] m.p. 174-176 °C); ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.36 (s, 2H, *J* = 9.2 Hz), 8.22 (s, 1H), 7.57-7.47 (m, 2H), 7.19 (t, 1H, *J* = 8.0 Hz), 7.06-6.95 (m, 3H), 6.84 (d, 1H, *J* = 7.6 Hz), 3.88 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 168.0, 161.7, 139.2, 137.6, 134.5, 128.2, 127.0, 125.8, 123.6, 121.6, 118.8, 113.8, 109.3, 55.4; MS (EI), *m/z* 251 (M$^+$).

(*E*)-3-(4-Isopropylbenzylidene)oxindole (2g)[16]



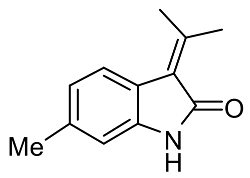
The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a red solid (45.7 mg, 58%). m.p. 144-146 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 9.49 (s, 1H), 7.74 (s, 1H), 7.65 (d, 1H, *J* = 8.0 Hz), 7.54 (d, 2H, *J* = 8.4 Hz), 7.24 (d, 2H, *J* = 8.0 Hz),7.11 (t, 1H, *J* = 8.0 Hz), 6.86 (d, 1H, *J* = 8.0 Hz), 6.77 (t, 1H, *J* = 8.0 Hz), 2.93-2.85 (m, 1H), 1.23 (s, 3H), 1.21 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 171.0, 151.0, 141.8, 137.8, 132.2, 129.7, 129.6, 126.9, 126.7, 122.9, 121.8, 121.6, 110.4, 34.1, 23.8; MS (EI), *m/z* 263 (M$^+$).

(*Z*)-3-(4-Isopropylbenzylidene)oxindole (2g)[16]



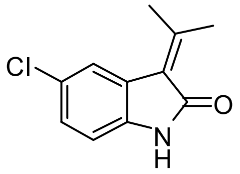
The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a red solid (9.4 mg, 12%). m.p. 131-132 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.32 (s, 1H), 8.24 (d, 2H, J = 8.4 Hz), 7.54 (s, 1H), 7.51 (d, 1H, J = 7.6 Hz), 7.31 (d, 2H, J = 8.4 Hz), 7.20 (t, 1H, J = 7.6 Hz), 7.02 (t, 1H, J = 7.6 Hz), 6.84 (d, 1H, J = 8.0 Hz), 3.00-2.92 (m, 1H), 1.23 (s, 3H), 1.28 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 168.0, 152.0, 139.5, 137.8, 132.3, 131.5, 128.6, 126.7, 126.5, 125.3, 121.7, 119.1, 109.5, 34.2, 23.8; MS (EI), *m/z* 263 (M$^+$).

6-Methyl-3-(propan-2-ylidene)oxindole (2h) (New compound)



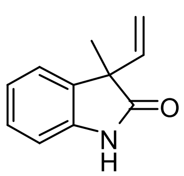
The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a pale yellow solid (30.8 mg, 55%). m.p. 174-175 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.75 (s, 1H), 7.37 (d, 1H, J = 8.4 Hz), 6.80 (d, 1H, J = 7.6 Hz), 6.71 (s, 1H), 2.60 (s, 3H), 2.34 (m, 6H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 170.2, 153.8, 139.6, 137.8, 123.4, 123.0, 122.1, 121.7, 110.2, 25.1, 22.9, 21.6; HRMS (EI), *m/z* calcd. for C$_{12}$H$_{13}$NO (M$^+$) 187.0997, found: 187.0996.

5-Chloro-3-(propan-2-ylidene)oxindole (2i) (New compound)



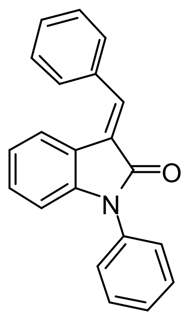
The title compound was isolated by column chromatography (hexane-EtOAc 2:1) as a pale yellow solid (23.6 mg, 38%). m.p. 213-214 °C; ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.54 (s, 1H), 7.47 (d, 1H, J = 2.4 Hz), 7.15 (dd, 1H, J = 2.4 Hz, J = 8.4 Hz), 6.79 (d, 1H, J = 8.4 Hz), 2.62 (s, 3H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 169.3, 157.6, 137.7, 127.2, 126.8, 125.6, 123.8, 122.4, 110.1, 25.3, 23.3; HRMS (EI), *m/z* calcd. for C$_{11}$H$_{11}$ClNO (M$^+$) 207.0451, found: 207.0449.

3-Methyl-3-vinylinoxindole (2j)[17]



The title compound was isolated by column chromatography (hexane-EtOAc 3:2) as a colorless oil (14.4 mg, 28%). ^{1}H NMR (400 MHz, CDCl$_3$) δ 9.05 (s, 1H), 7.25-7.18 (m, 1H), 7.18-7.14 (m, 1H), 7.05 (dt, 1H, J = 1.8 Hz, J = 7.4 Hz), 6.96 (d, 1H, J = 8.0 Hz), 5.97 (dd, 1H, J = 10.4 Hz, J = 17.6 Hz), 5.21-5.14 (m, 2H), 1.52 (s, 3H); ^{13}C NMR (100 MHz, CDCl$_3$) δ 181.6, 140.3, 137.8, 133.3, 128.0, 124.1, 122.5, 115.5, 110.2, 51.7, 22.3; MS (EI), *m/z* 173 (M$^+$).

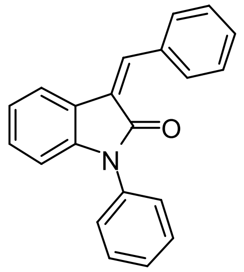
(*E*)-3-Benzylidene-1-phenyloxindole (4a)[12]



The title compound was isolated by column chromatography (hexane-EtOAc 5:1) as Orange oil (55.2 mg, 62%); ^{1}H NMR (400 MHz, CDCl$_3$) δ 7.95 (s, 1H), 7.71-7.65 (m, 3H), 7.55-7.37 (m, 8H), 7.16 (t, 1H, J = 8.0 Hz), 6.89 (t, 1H, J = 7.6 Hz), 6.81 (d, 1H, J = 8.0 Hz); ^{13}C NMR (100 MHz, CDCl$_3$) δ 167.7, 144.1, 137.8, 134.9, 134.5, 129.6, 129.6, 129.2, 128.6, 127.9, 127.0, 126.7, 122.8, 122.2, 121.1, 109.5; MS (EI), *m/z* 297

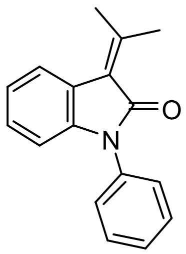
(M$^+$).

(*Z*)-3-Benzylidene-1-phenyloxindole (4a) (New compound)



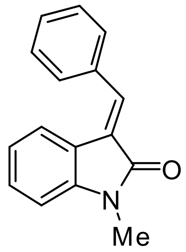
The title compound was isolated by column chromatography (hexane-EtOAc 5:1) as a orange solid (16.0 mg, 18%). m.p. 116-117 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.33-8.28 (m, 2H), 7.66 (s, 1H), 7.62 (d, 1H, J = 7.2 Hz), 7.55-7.40 (m, 8H), 7.22 (t, 1H, J = 8.0 Hz), 7.10 (t, 1H, J = 8.0 Hz), 6.82 (d, 1H, J = 8.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 142.2, 138.0, 134.7, 133.7, 132.1, 130.6, 129.5, 128.8, 128.2, 127.9, 126.8, 125.8, 124.4, 122.4, 119.2, 109.2; HRMS (EI), *m/z* calcd. for $C_{21}H_{15}NO$ (M$^+$) 297.1154, found: 297.1154.

1-Phenyl-3-(propan-2-ylidene)oxindole (4b) (New compound)



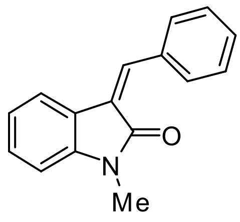
The title compound was isolated by column chromatography (hexane-EtOAc 5:1) as a orange oil (32.1 mg, 43%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, 2H, J = 7.6 Hz), 7.54-7.48 (m, 2H), 7.42-7.37 (m, 3H), 7.16 (t, 1H, J = 8.0 Hz), 7.06 (t, 1H, J = 7.6 Hz), 2.65 (s, 3H), 2.44 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.7, 156.4, 142.4, 135.3, 129.9, 128.2, 127.9, 127.6, 124.1, 124.0, 122.9, 122.5, 109.3, 25.9, 23.8; HRMS (EI), *m/z* calcd. for $C_{17}H_{15}NO$ (M$^+$) 249.1154, found: 249.1150.

(*E*)-3-Benzylidene-1-methyloxindole (4c)[12]



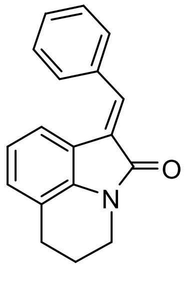
The title compound was isolated by column chromatography (hexane-EtOAc 3:1) as yellow oil (24.6 mg, 35%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (s, 1H), 7.65-7.60 (m, 3H), 7.48-7.40 (m, 3H), 7.25 (t, 1H, J = 8.0 Hz), 6.87 (t, 1H, J = 8.0 Hz), 6.81 (d, 1H, J = 8.0 Hz), 3.27 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 144.2, 137.1, 134.9, 129.7, 129.4, 129.2, 128.6, 127.7, 122.7, 121.7, 121.1, 108.1, 26.1; MS (EI), *m/z* 235 (M$^+$).

(*Z*)-3-Benzylidene-1-methyloxindole (4c)[18]



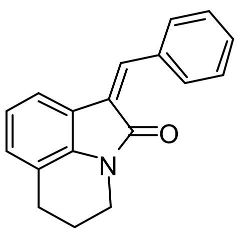
The title compound was isolated by column chromatography (hexane-EtOAc 3: 1) as a orange solid (4.3 mg, 6%). m.p. 90-91 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.31-8.27 (m, 2H), 7.55-7.52 (m, 2H), 7.47-7.41 (m, 3H), 7.29 (t, 1H, J = 8.0 Hz), 7.06 (t, 1H, J = 8.0 Hz), 6.81 (d, 1H, J = 8.0 Hz), 3.28 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.1, 142.4, 137.1, 133.8, 131.9, 130.4, 128.9, 128.2, 126.1, 124.4, 121.8, 118.9, 25.9; MS (EI), *m/z* 235 (M$^+$).

(*E*)-1-Benzylidene-5,6-dihydro-1*H*-pyrrolo[3,2,1-ij]quinolin-2(4*H*)-one (4d) (New Compound)



The title compound was isolated by column chromatography (hexane-EtOAc 3:1) as a orange solid (48.5 mg, 62%). m.p. 103-104 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (s, 1H), 7.68-7.64 (m, 2H), 7.48-7.40 (m, 4H), 7.00 (d, 1H, J = 7.2 Hz), 6.77 (t, 1H, J = 8.0 Hz), 3.78 (t, 2H, J = 6.0 Hz), 2.76 (t, 2H, J = 6.0 Hz), 2.05-1.98 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.3, 140.2, 136.9, 135.0, 129.4, 129.3, 128.5, 128.5, 128.2, 121.2, 120.1, 120.0, 119.6, 38.7, 24.6, 20.9; HRMS (EI), *m/z* calcd. for $C_{18}H_{15}NO$ (M^+) 261.1154, found: 261.1150.

(*Z*)-1-Benzylidene-5,6-dihydro-1*H*-pyrrolo[3,2,1-ij]quinolin-2(4*H*)-one (4d) (New compound)



The title compound was isolated by column chromatography (hexane-EtOAc 3:1) as yellow oil (8.6 mg, 11%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.32-8.28 (m, 2H), 7.51 (s, 1H), 7.47-7.40 (m, 3H), 7.34 (d, 1H, J = 8.0 Hz), 7.03 (d, 1H, J = 7.2 Hz), 6.95 (t, 1H, J = 7.6 Hz), 3.77 (t, 2H, J = 6.0 Hz), 2.78 (t, 2H, J = 6.0 Hz), 2.08-2.01 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1, 138.4, 137.4, 133.9, 131.9, 130.3, 128.7, 128.2, 127.4, 123.0, 121.4, 119.7, 116.9, 38.4, 24.3, 21.2; HRMS (EI), *m/z* calcd. for $C_{18}H_{15}NO$ (M^+) 261.1154, found: 261.1153.

References

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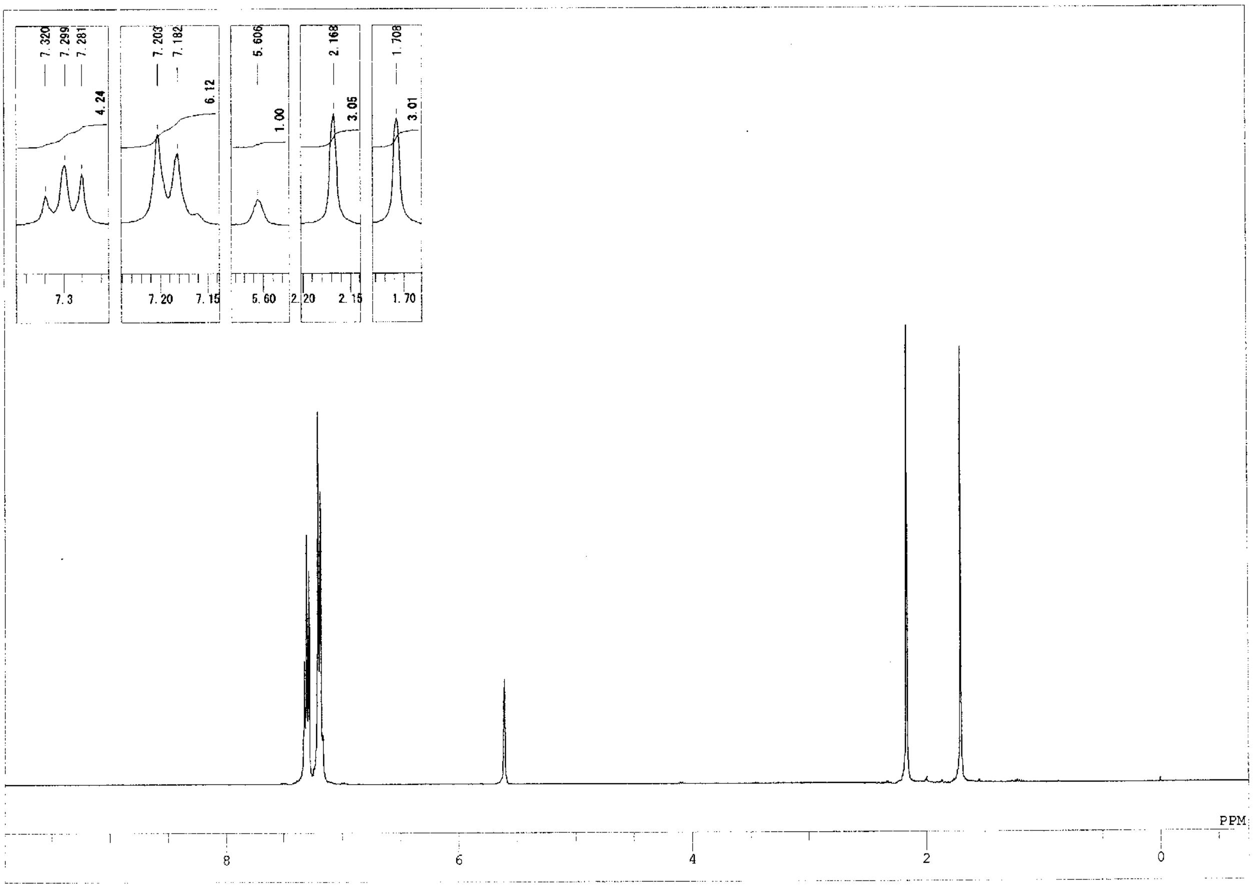

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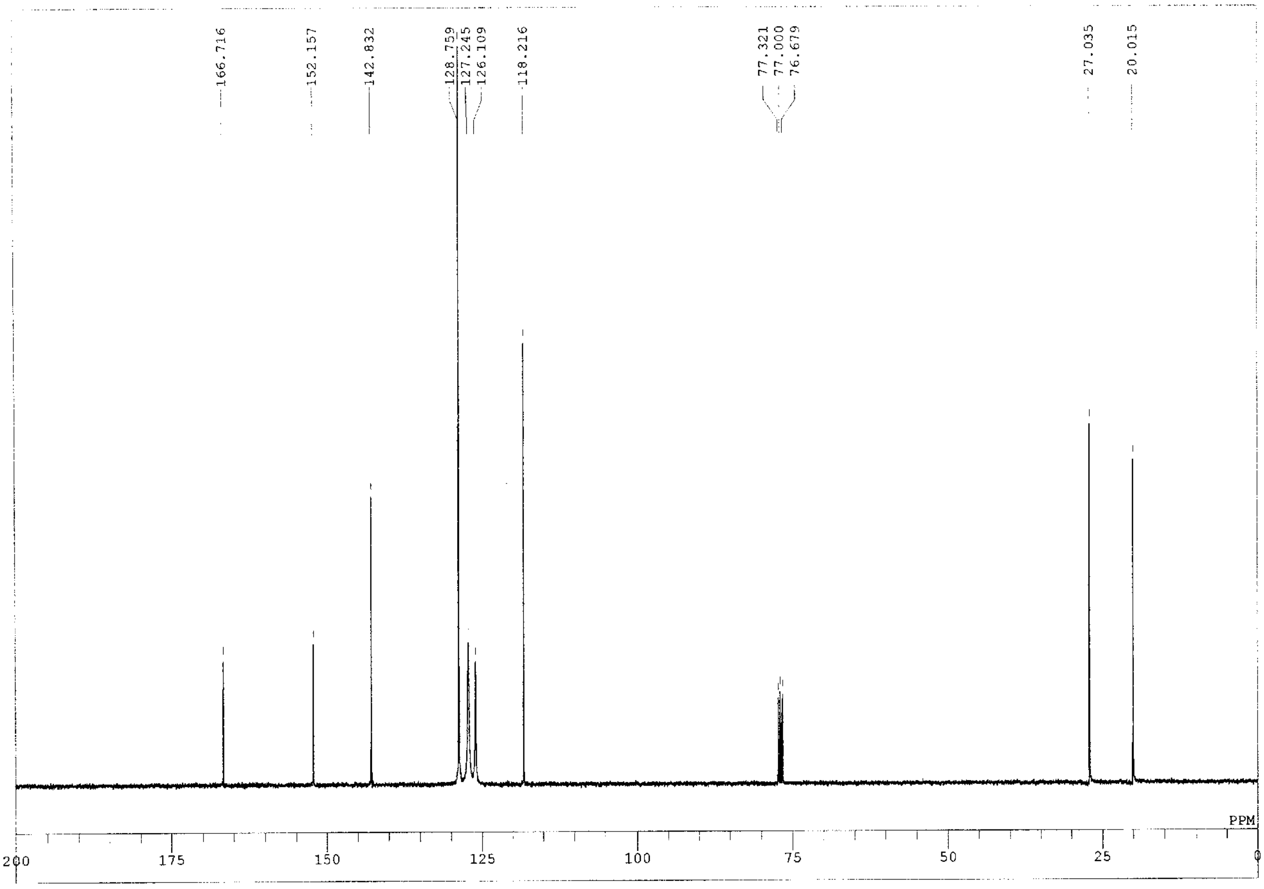

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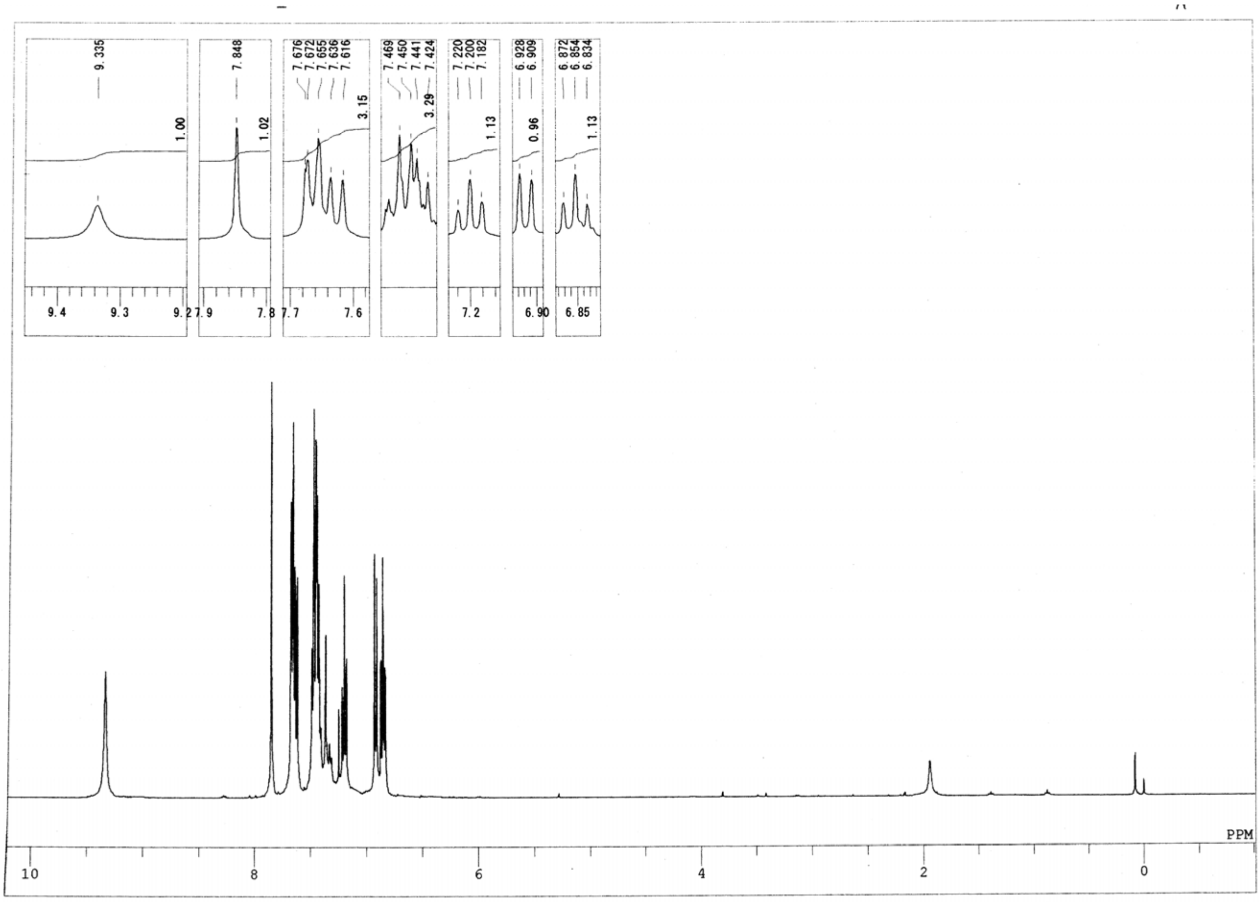

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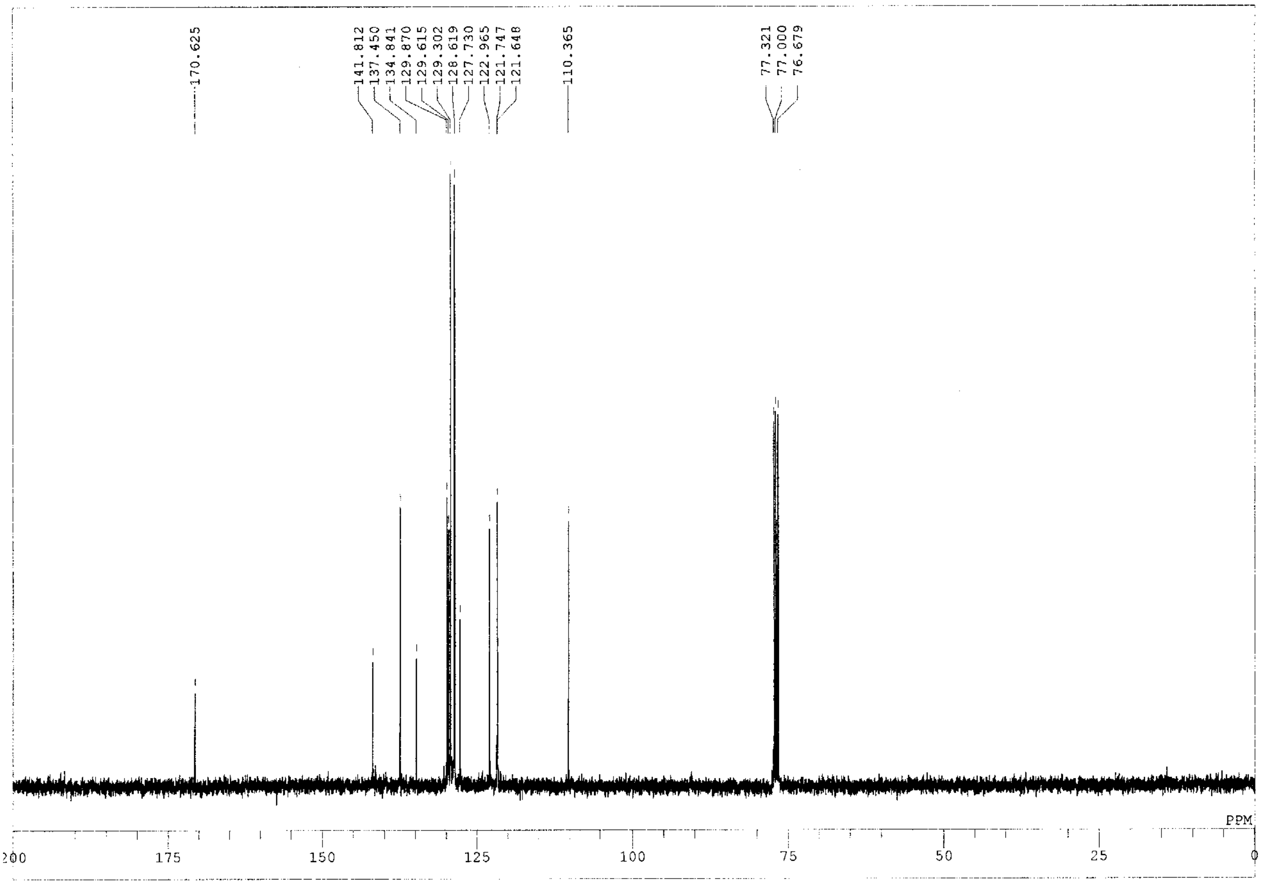

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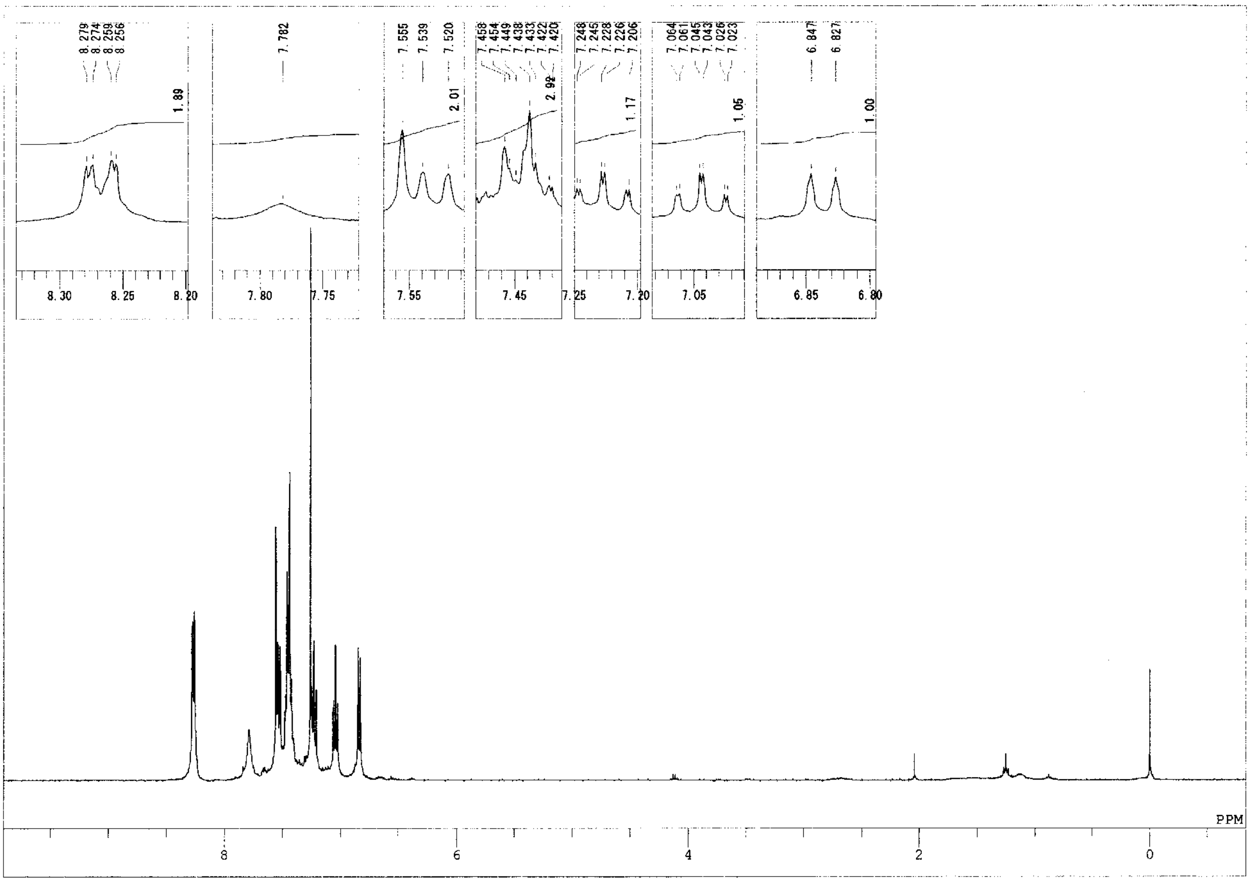

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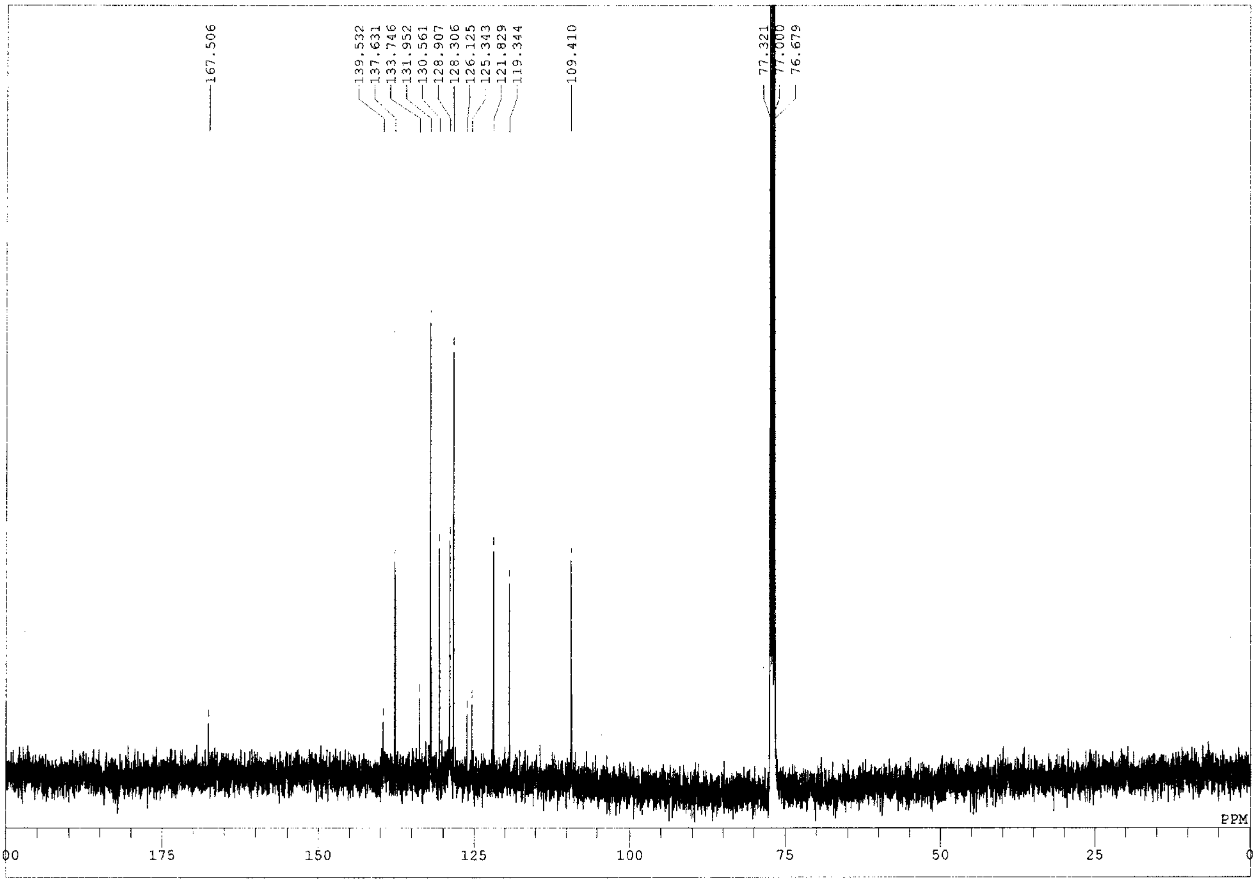

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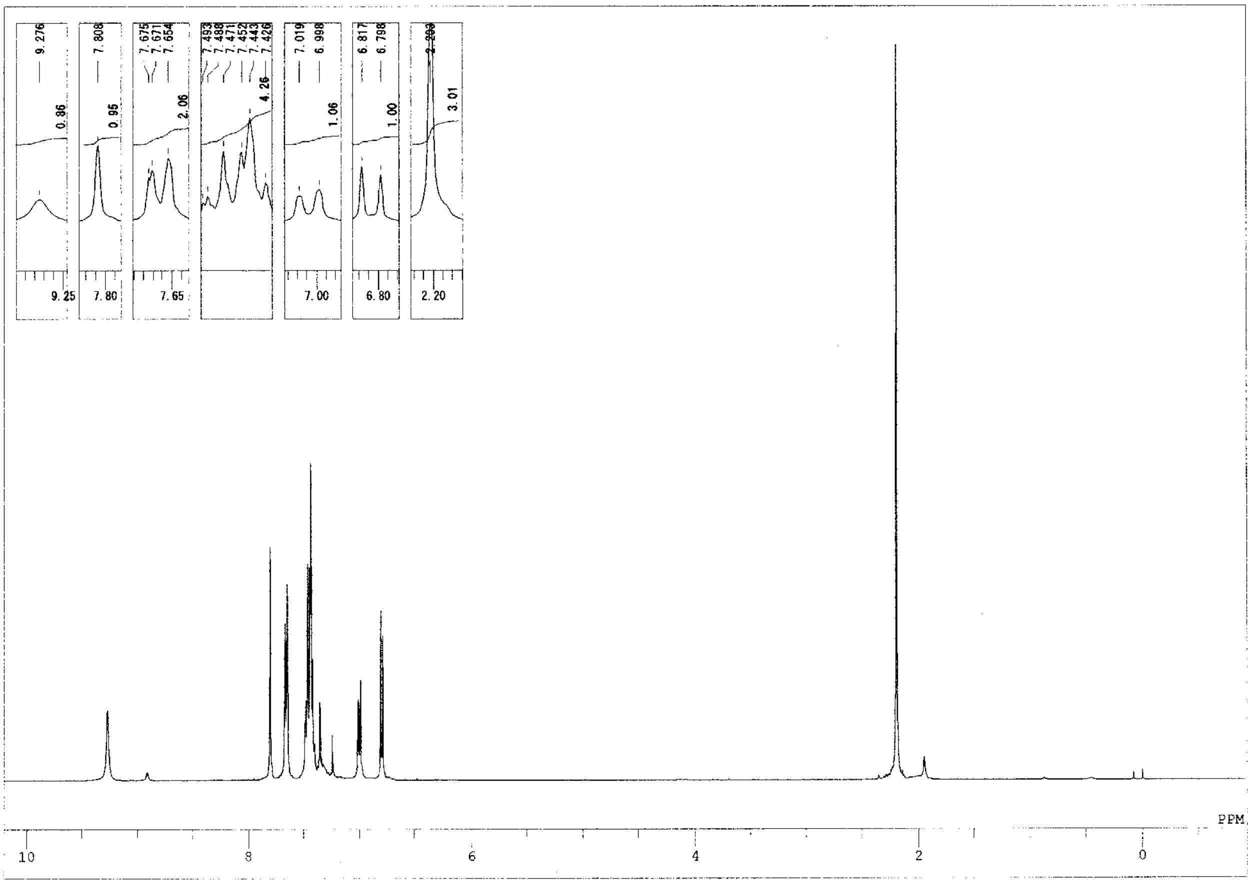

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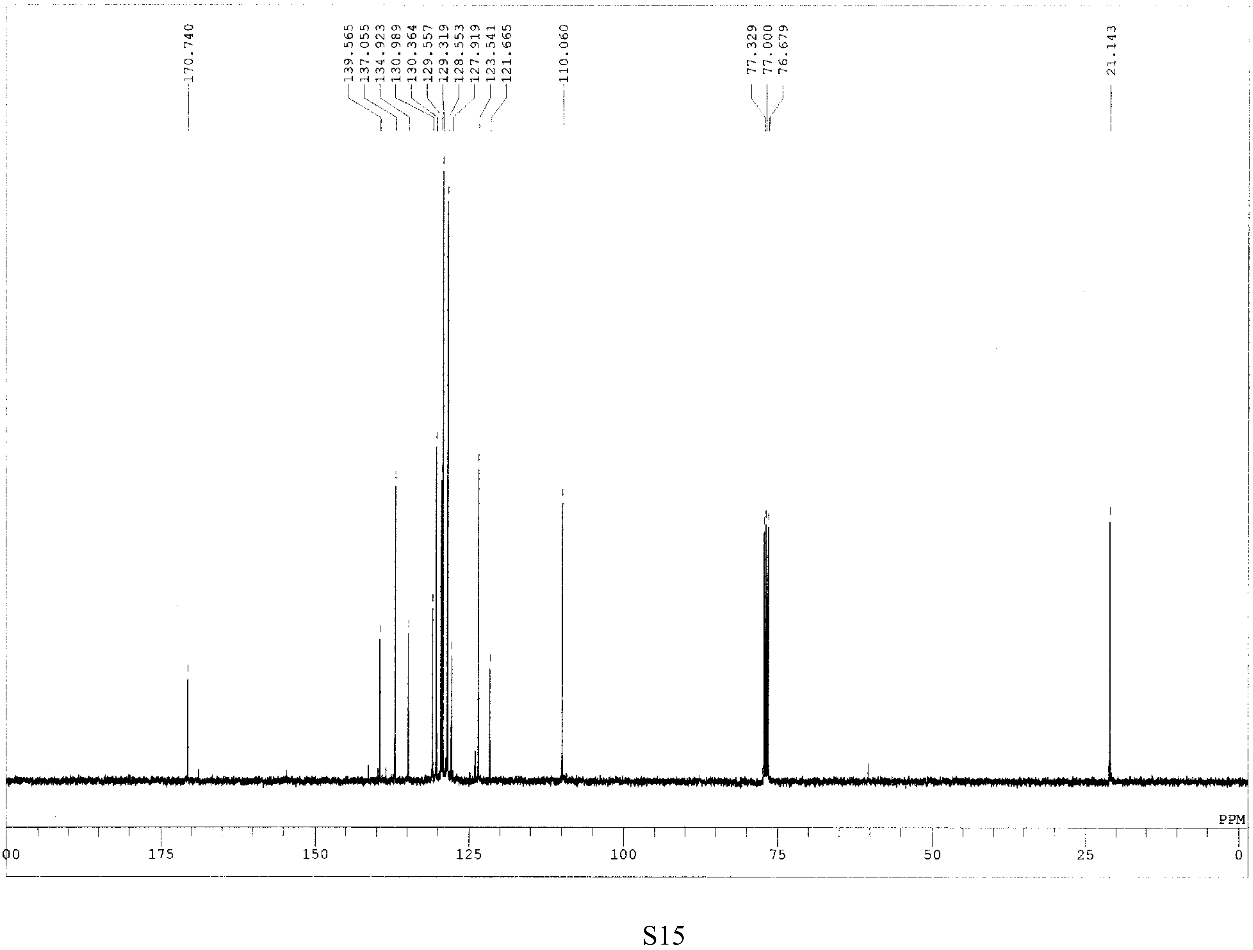

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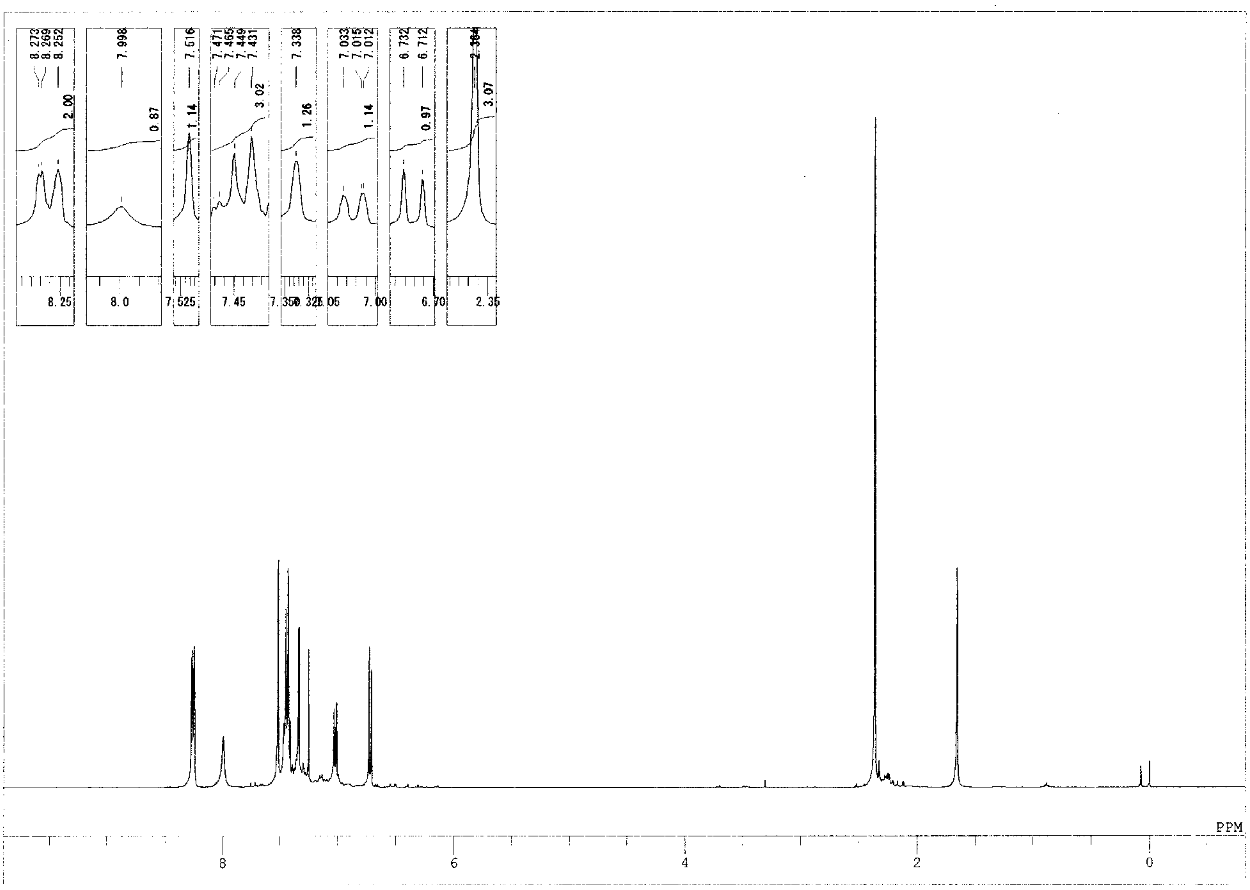

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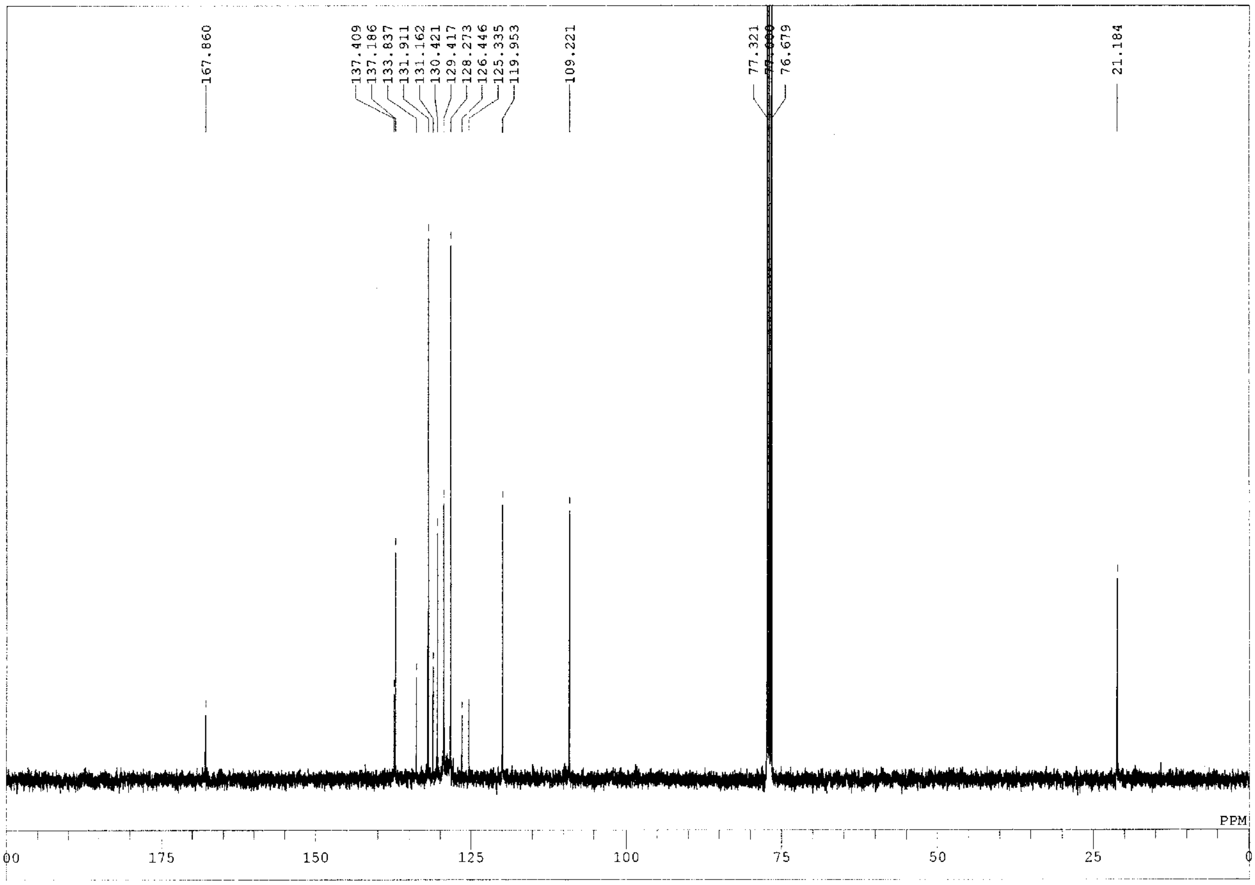

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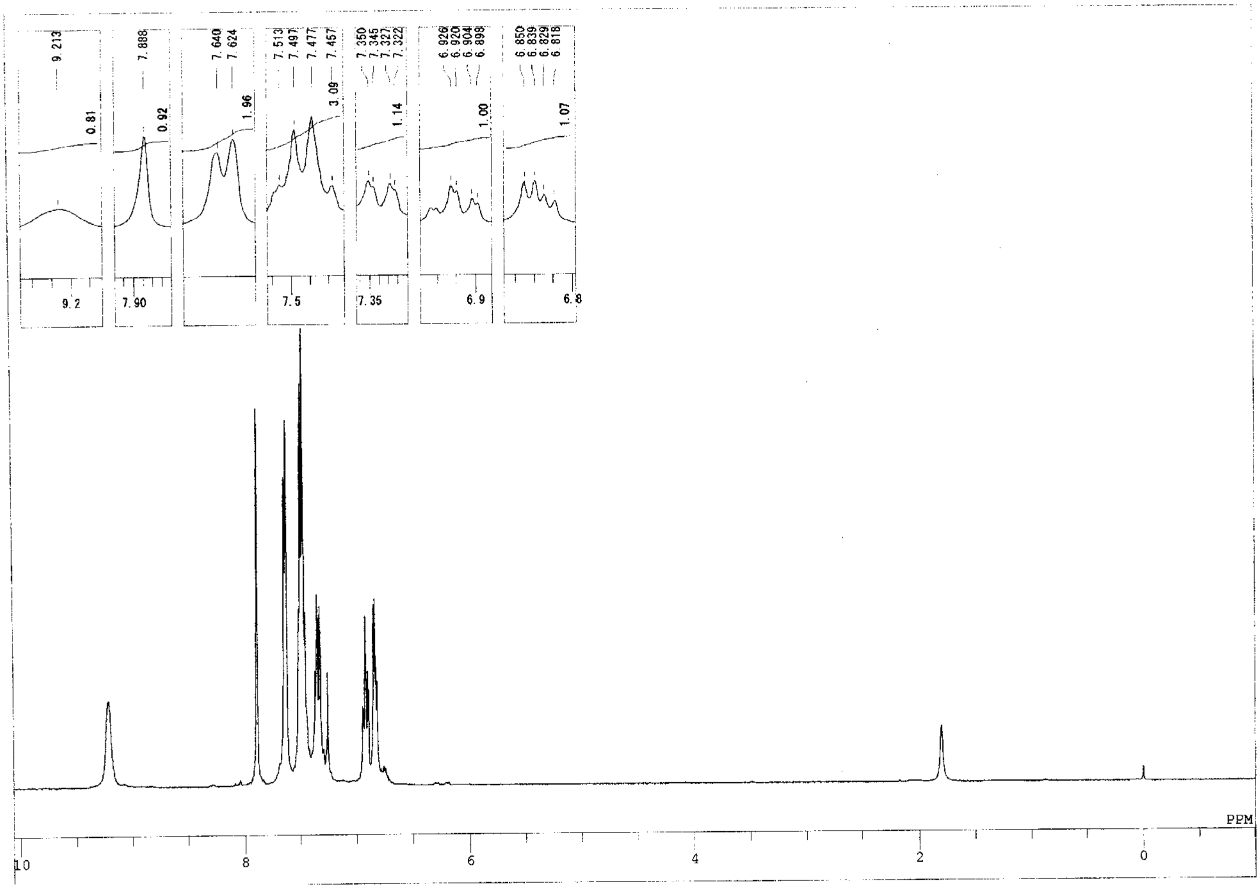

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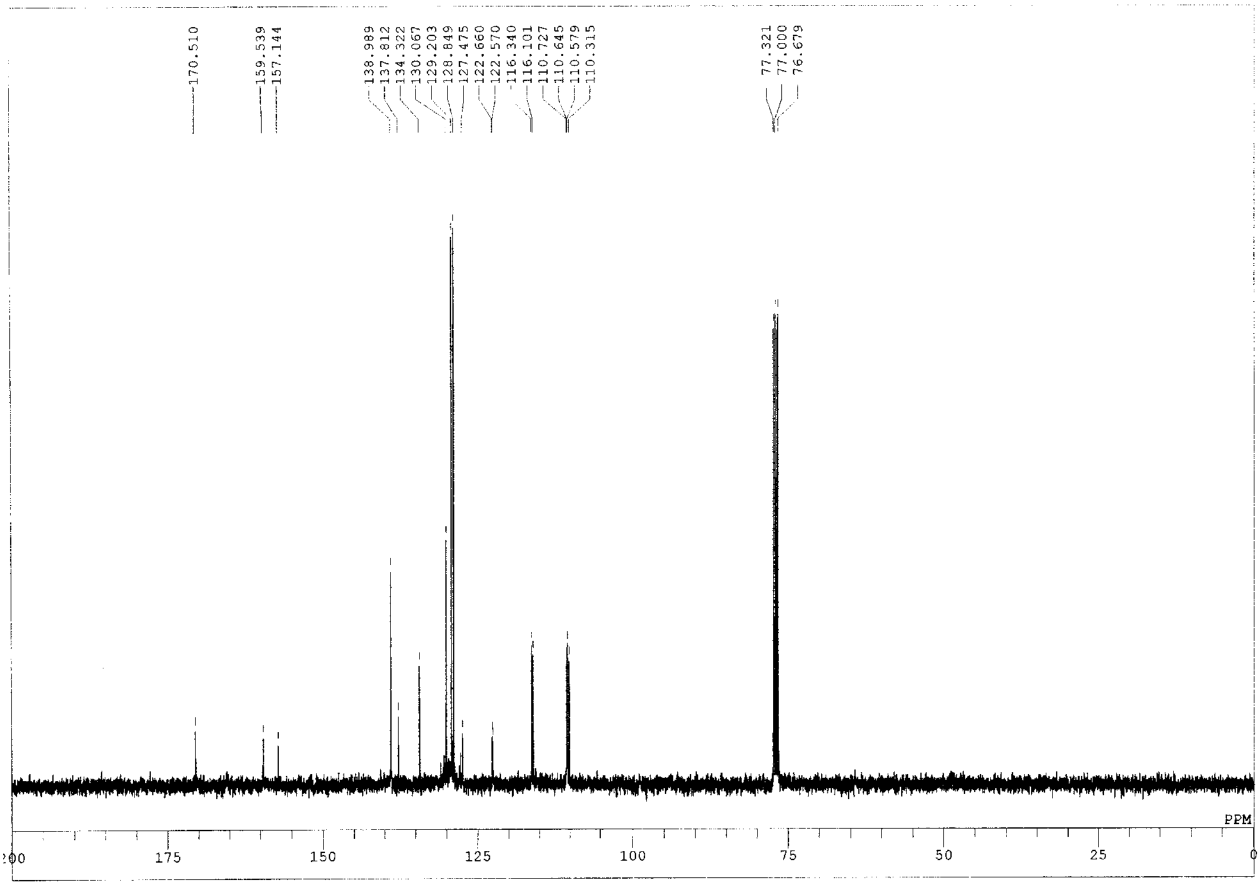

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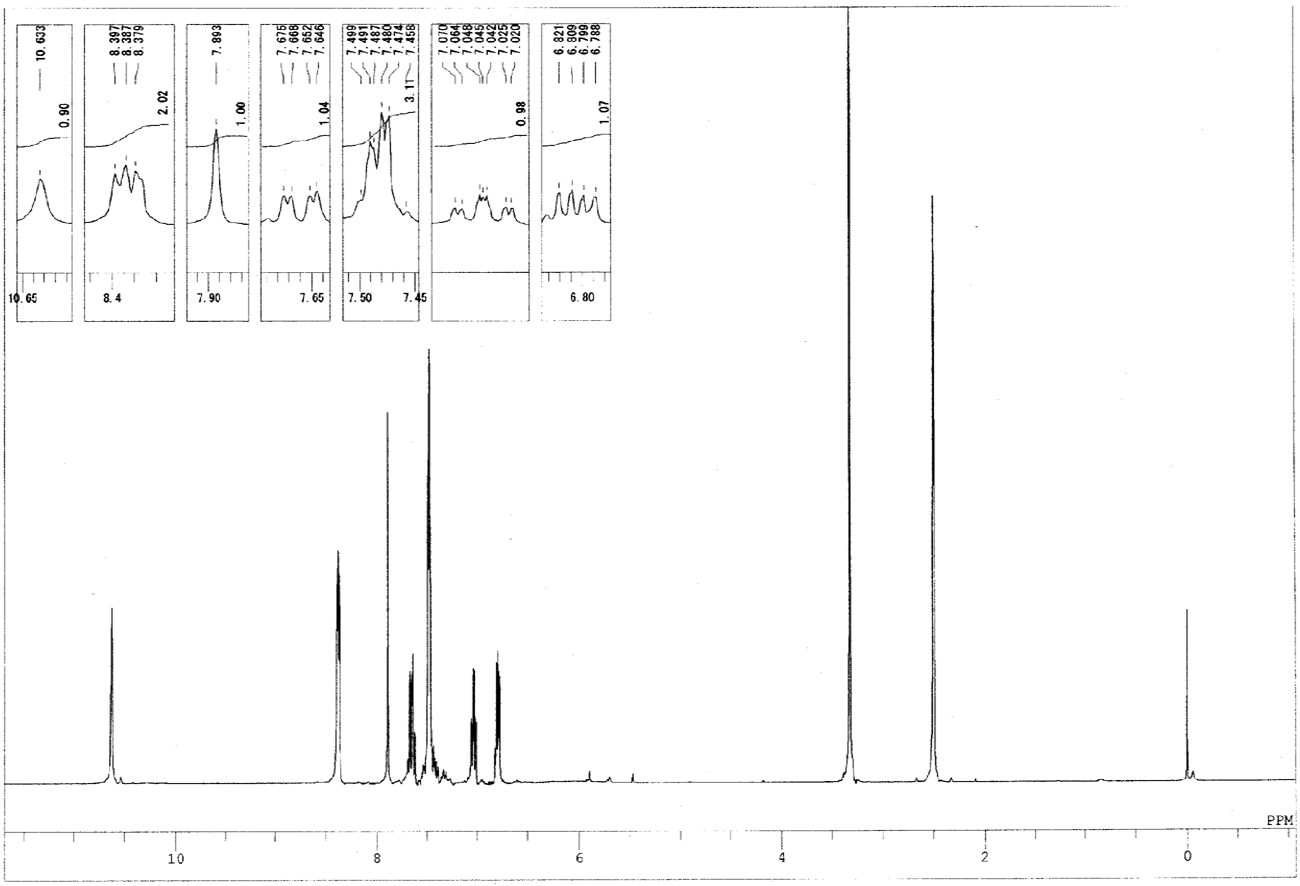

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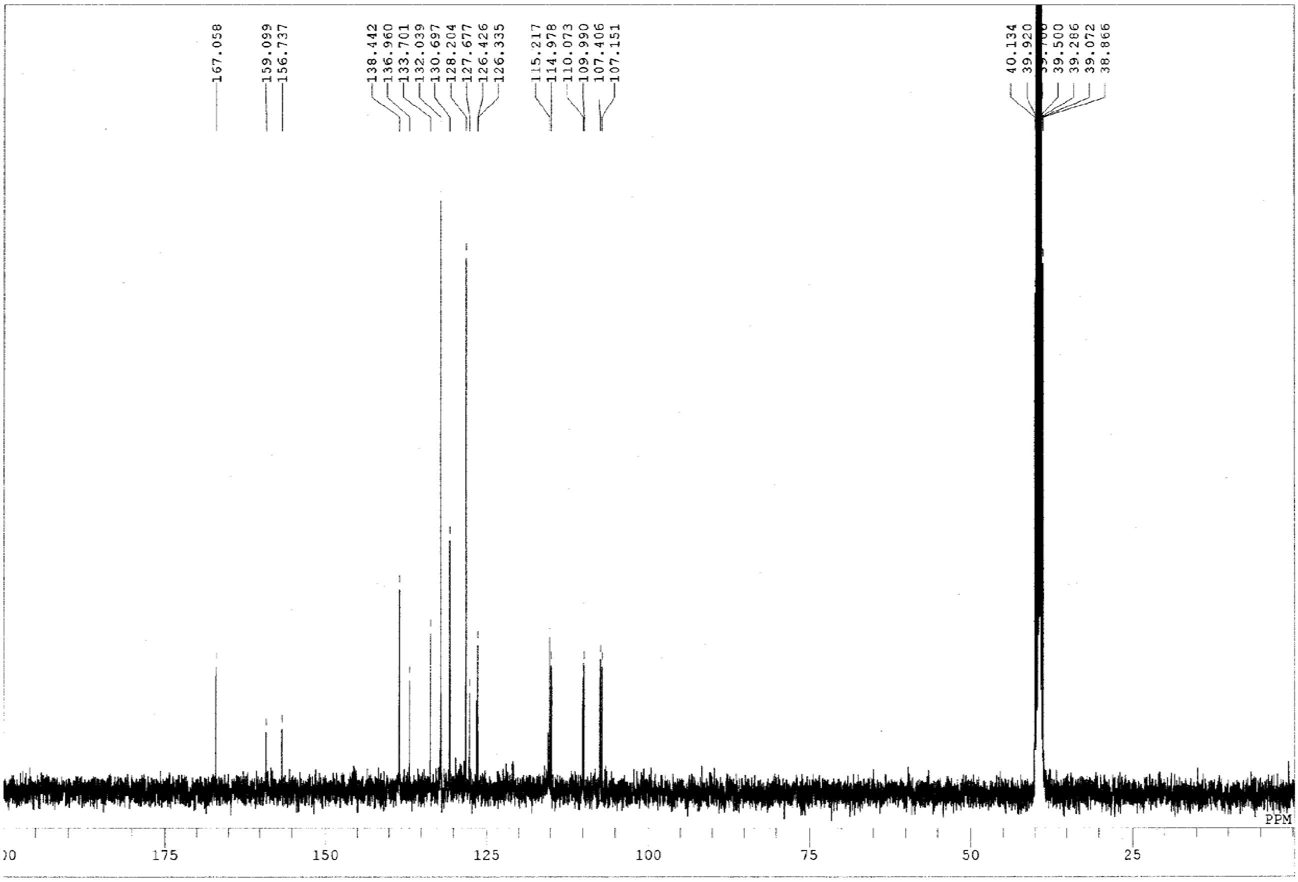

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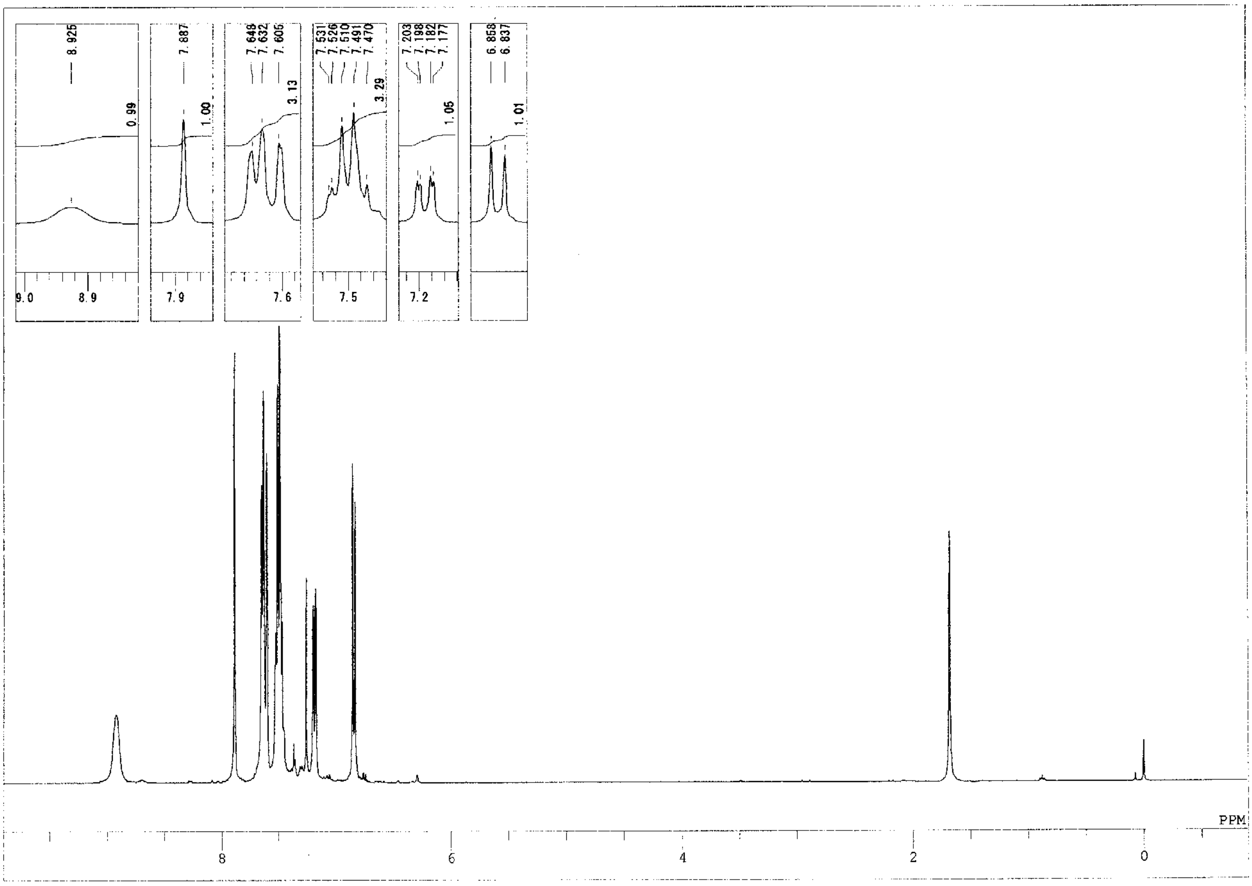

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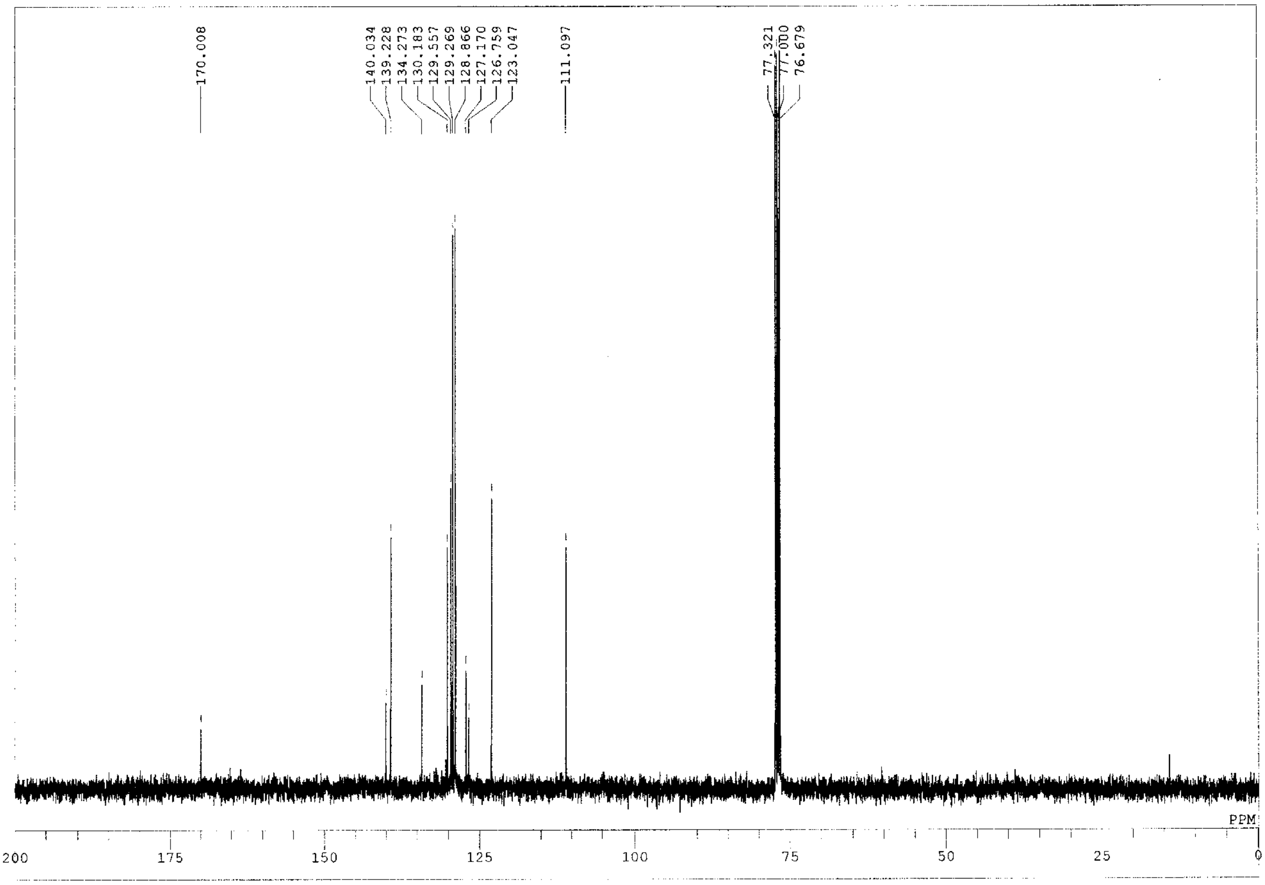

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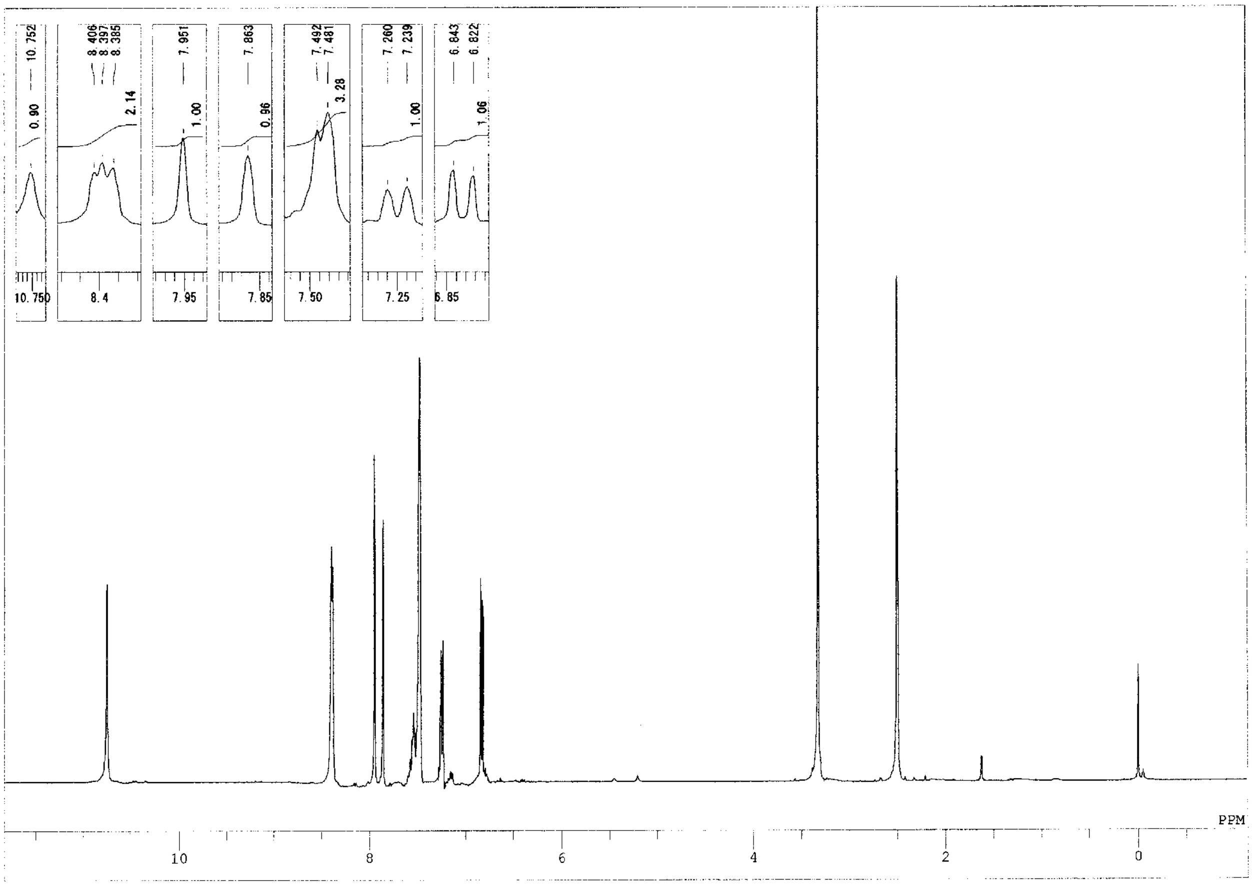

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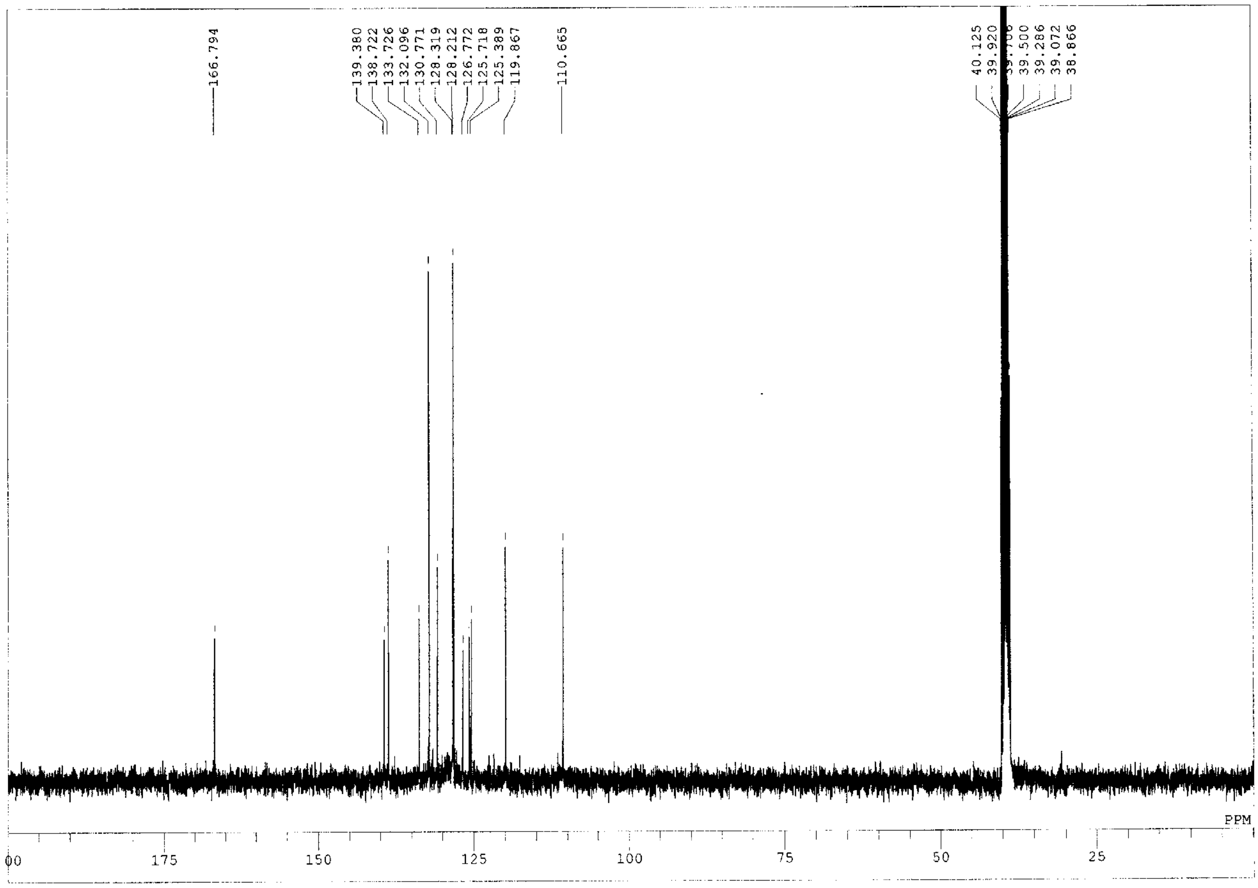

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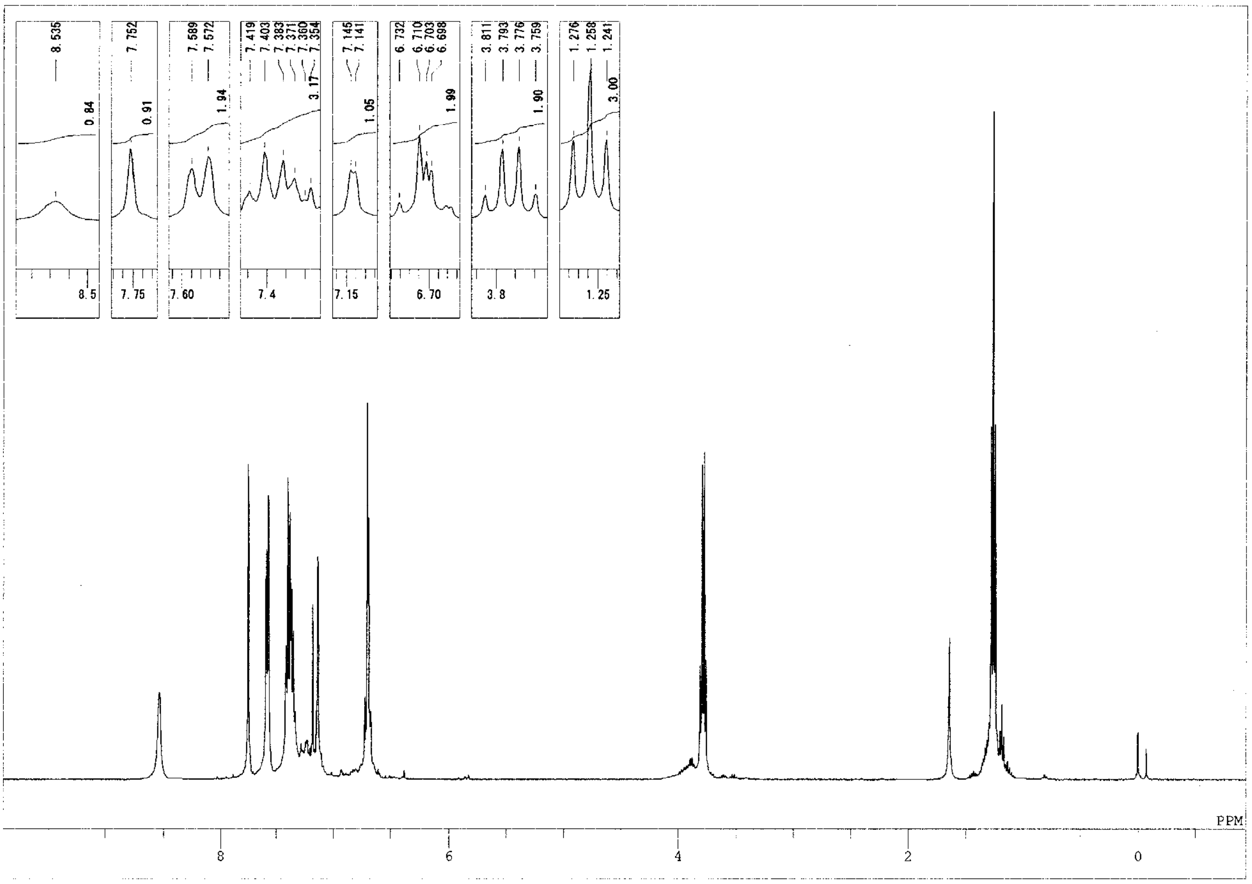

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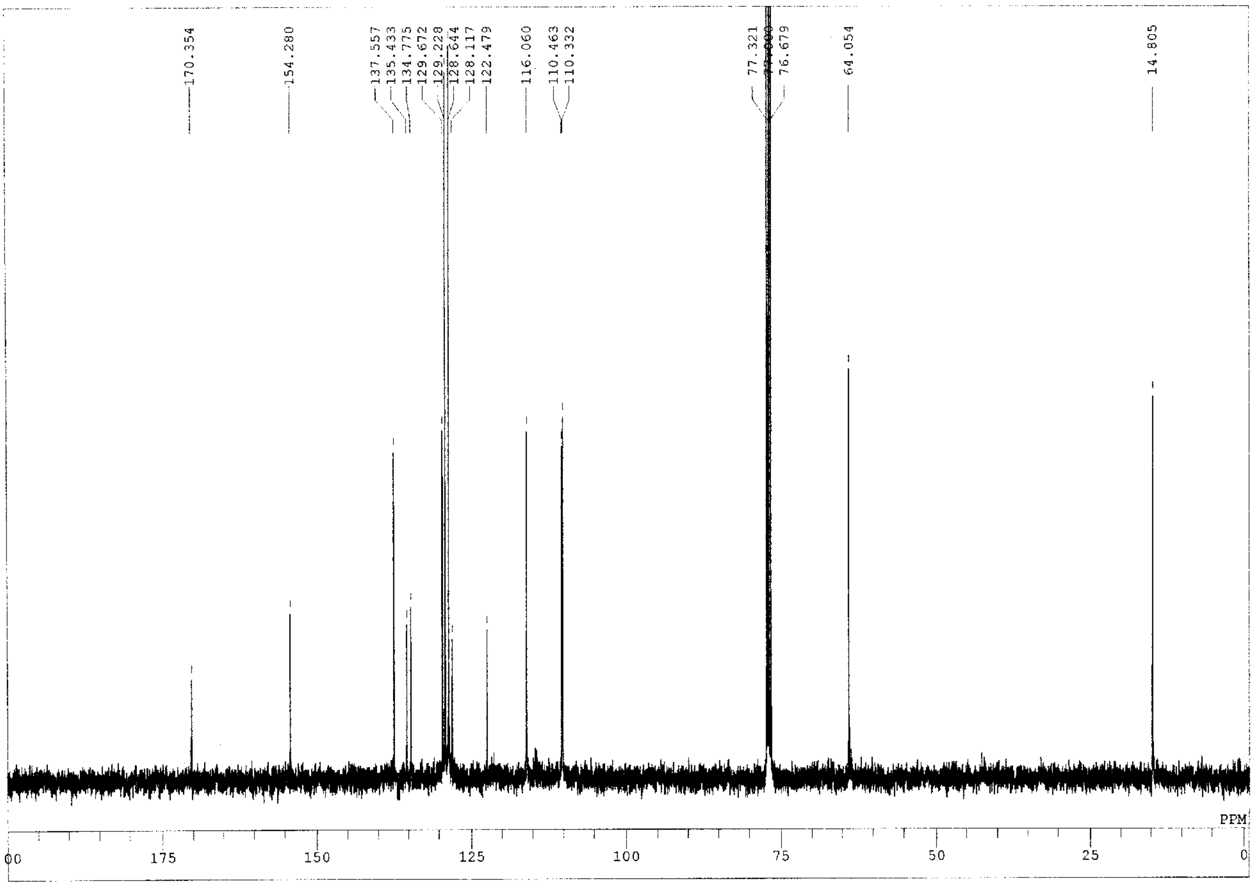

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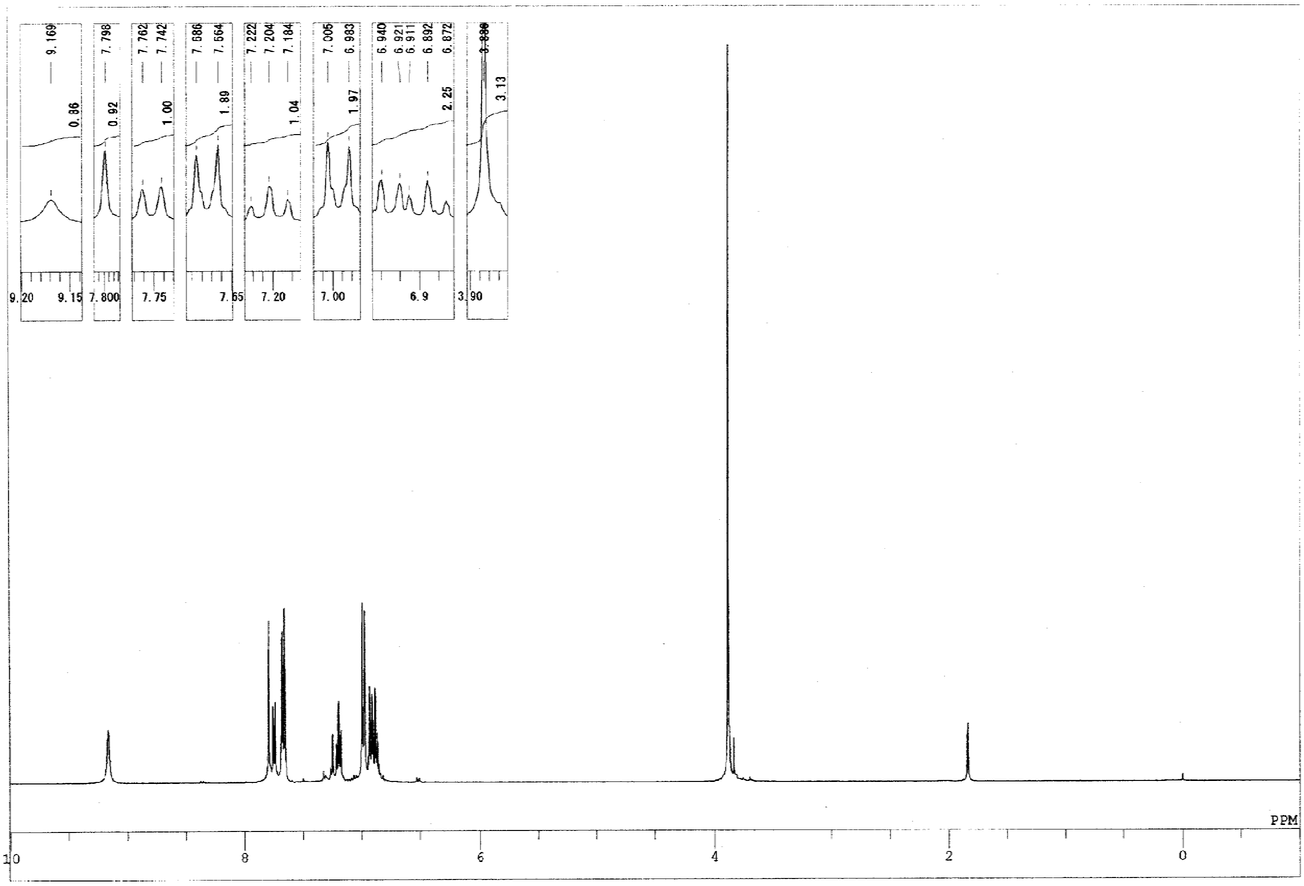

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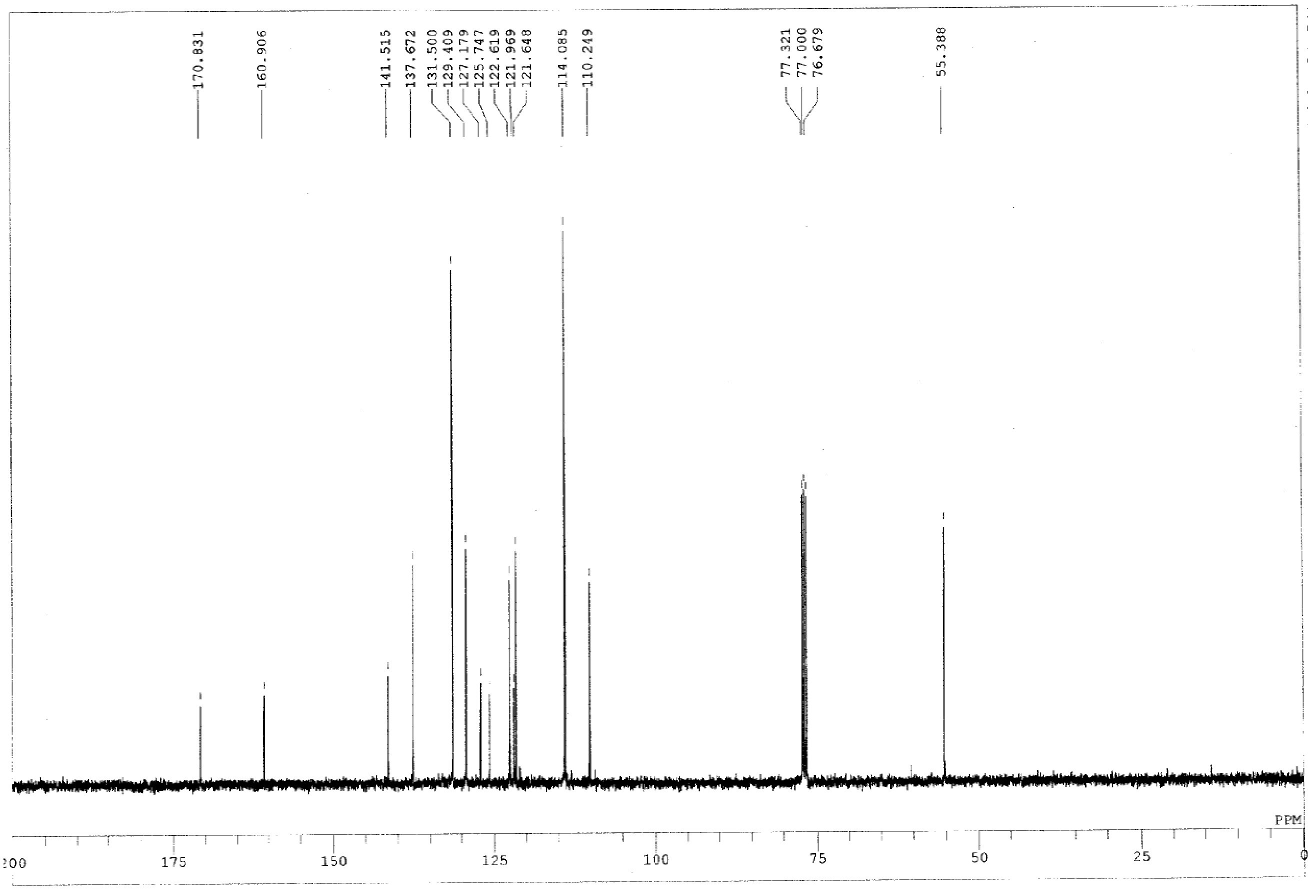

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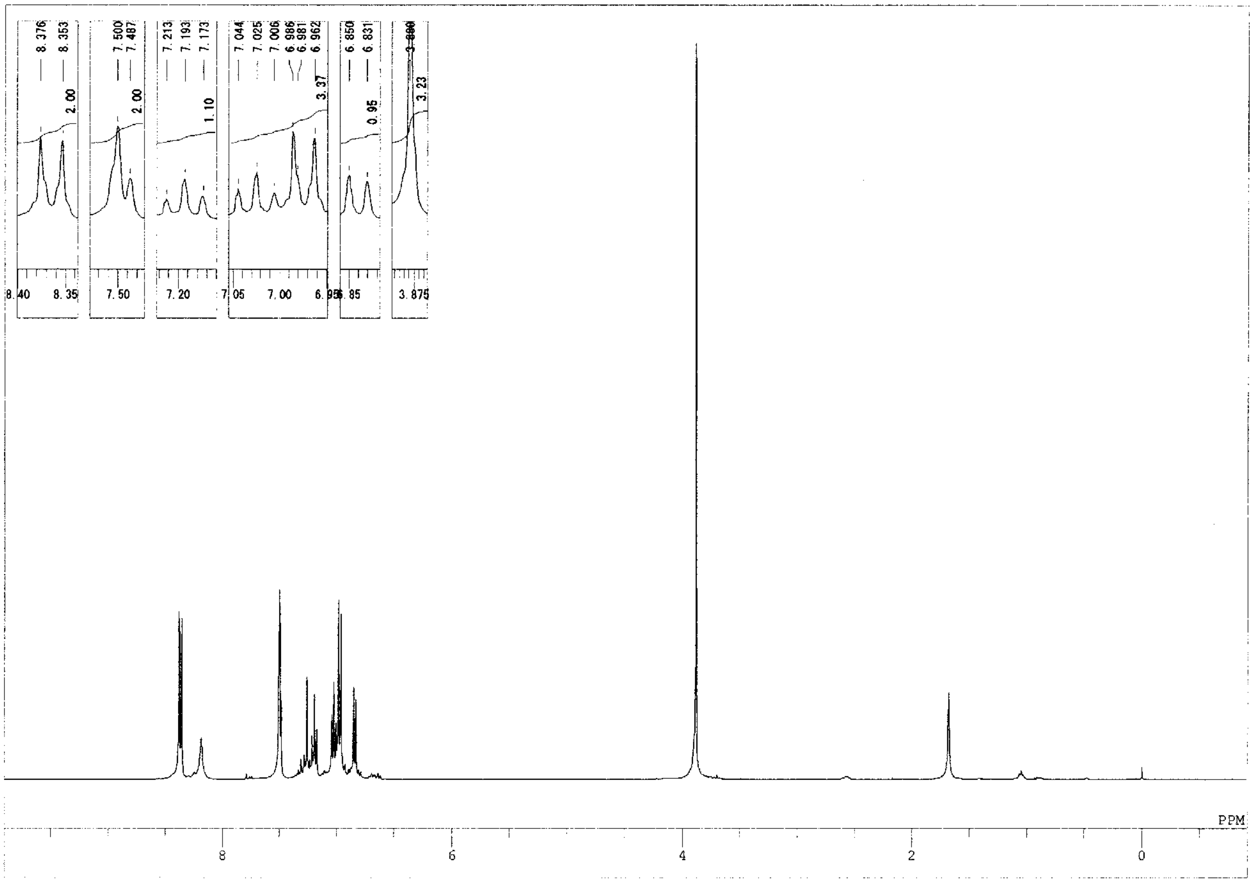

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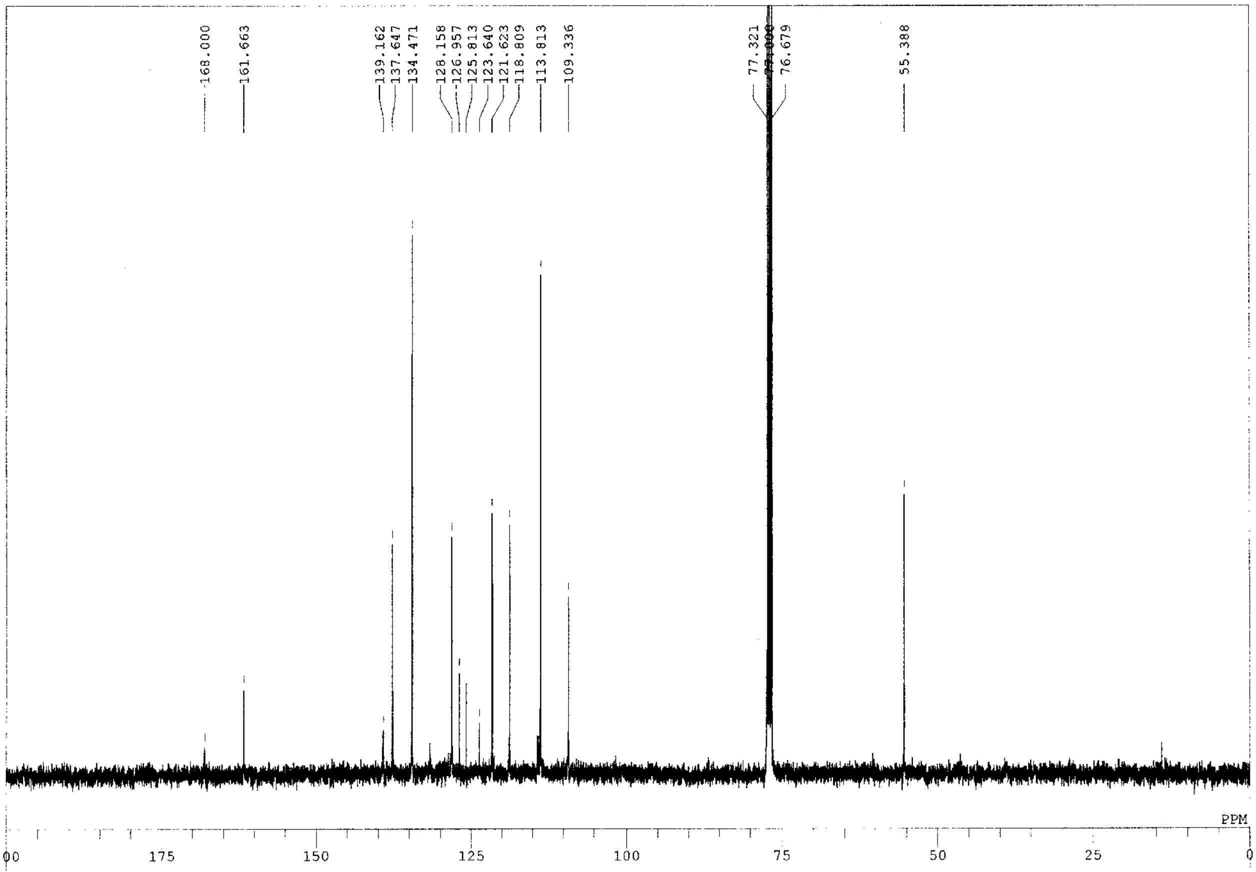

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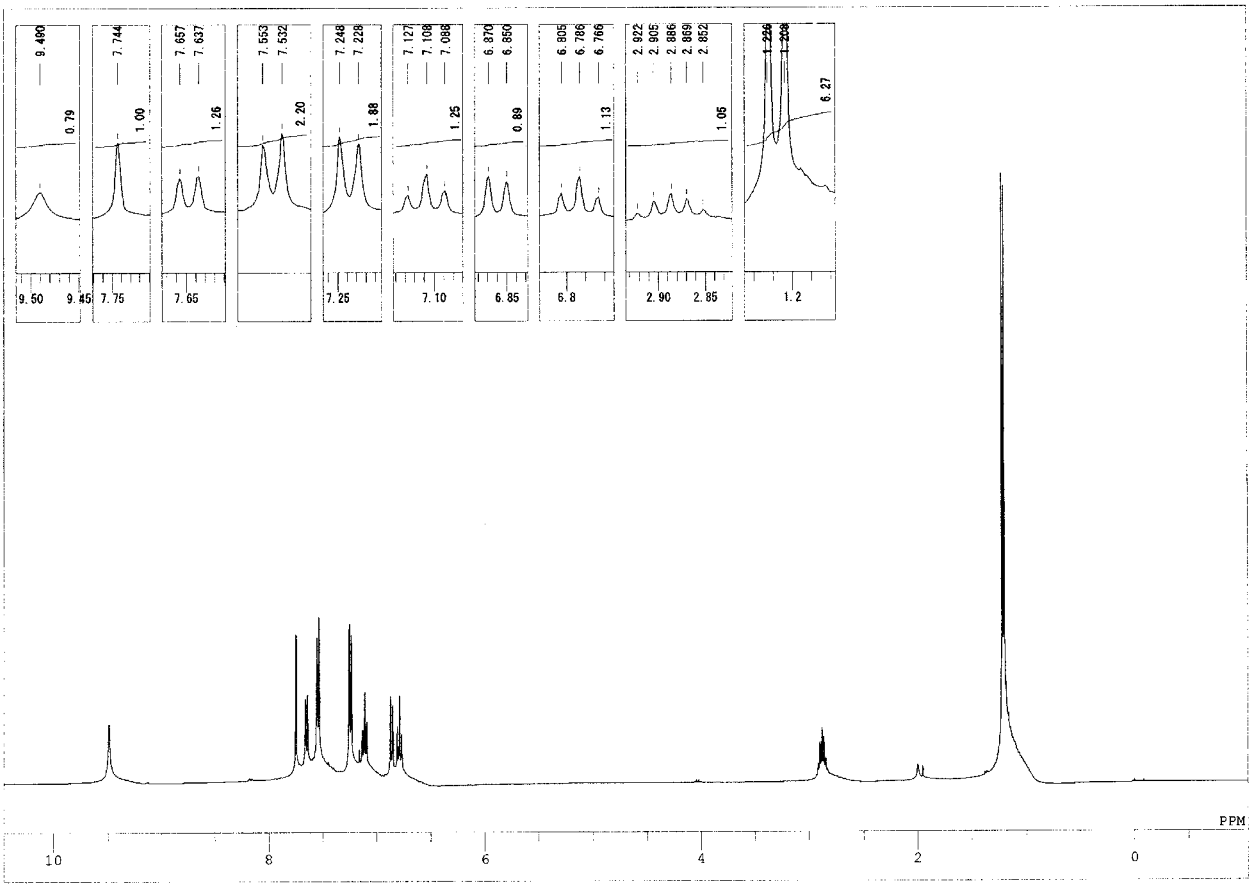

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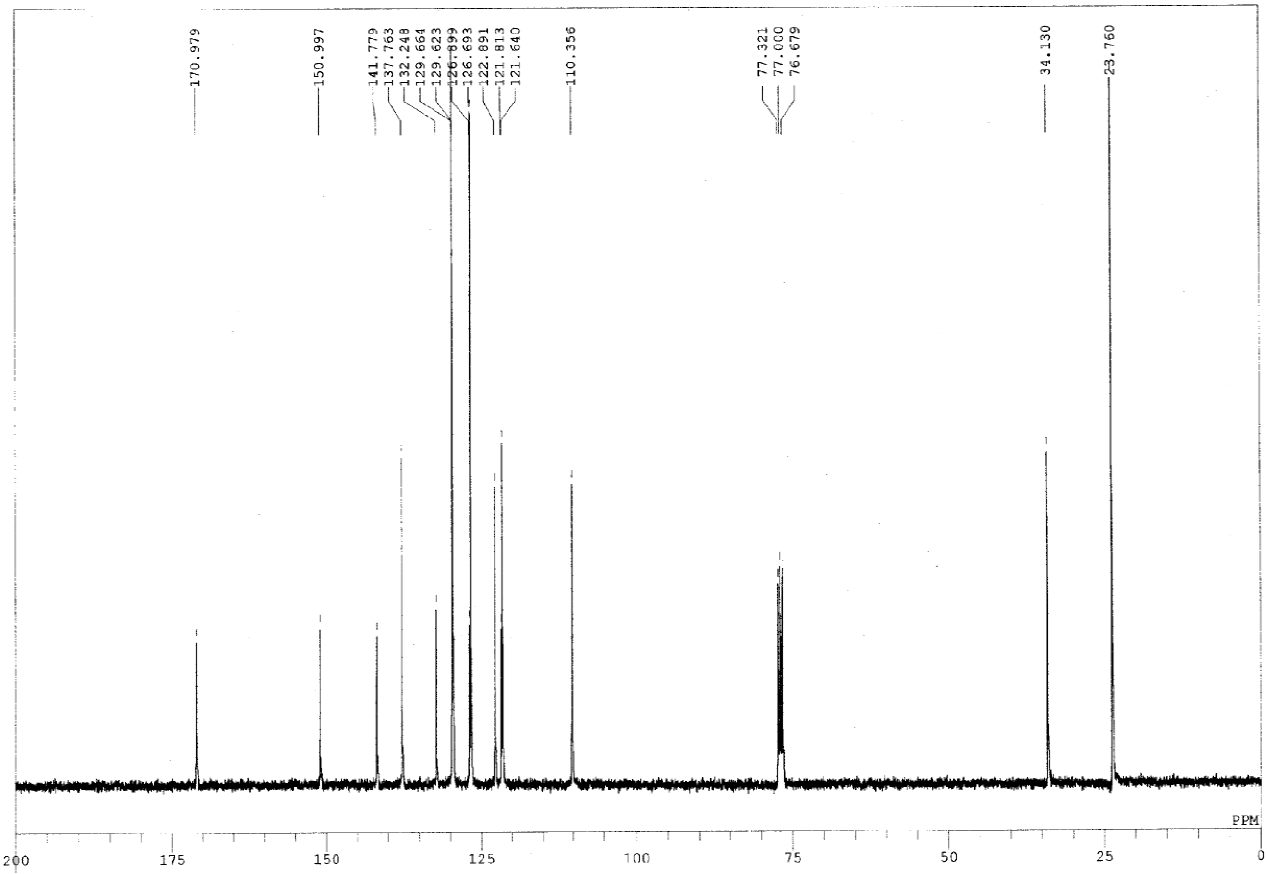

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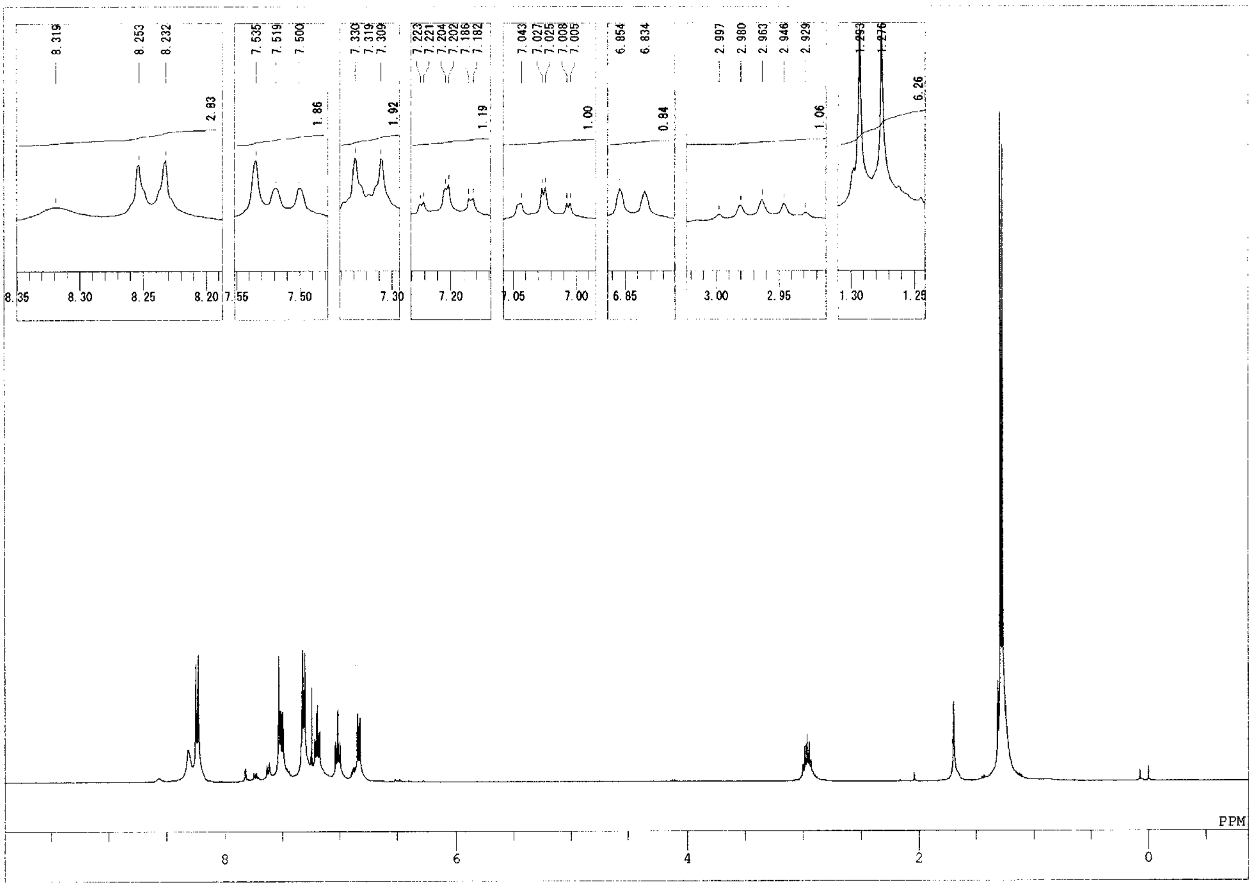

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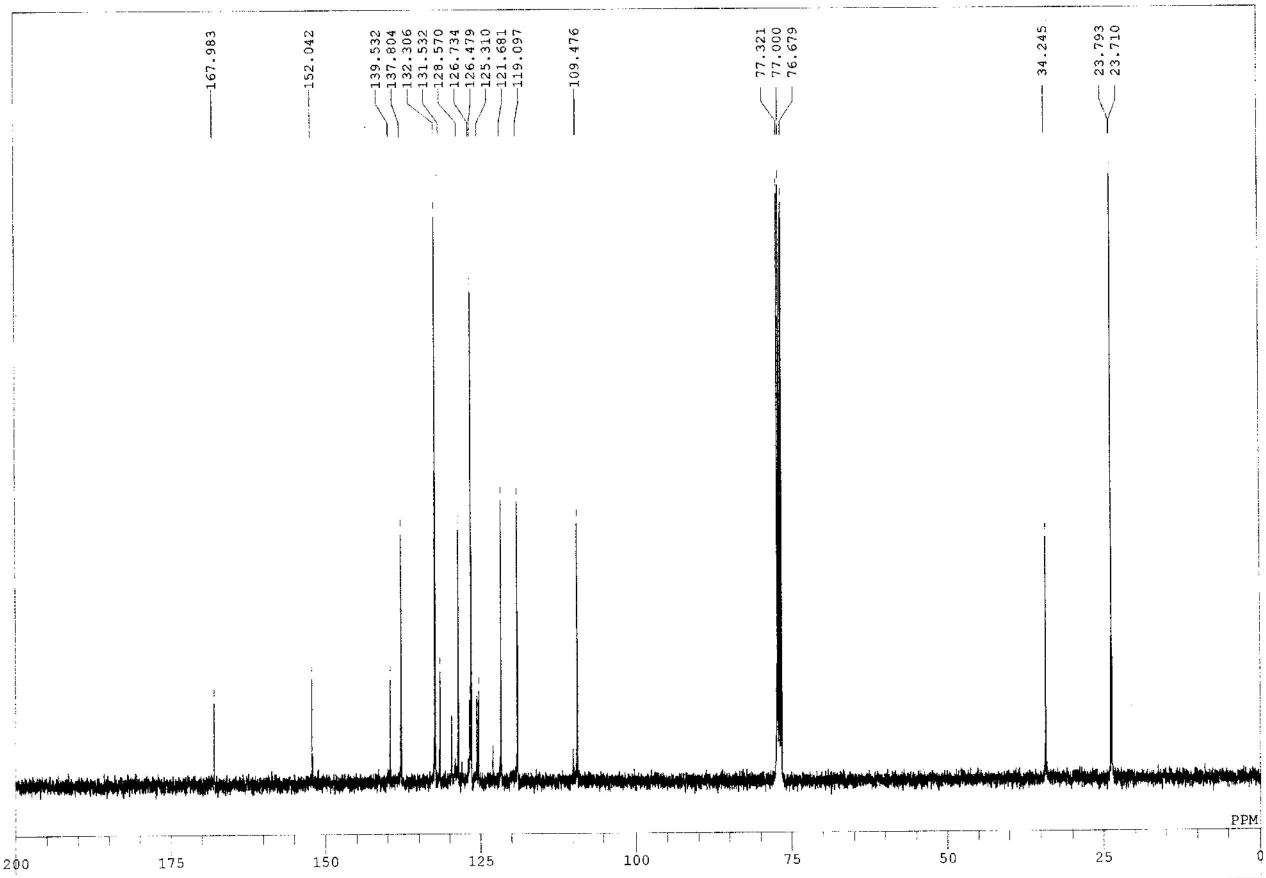

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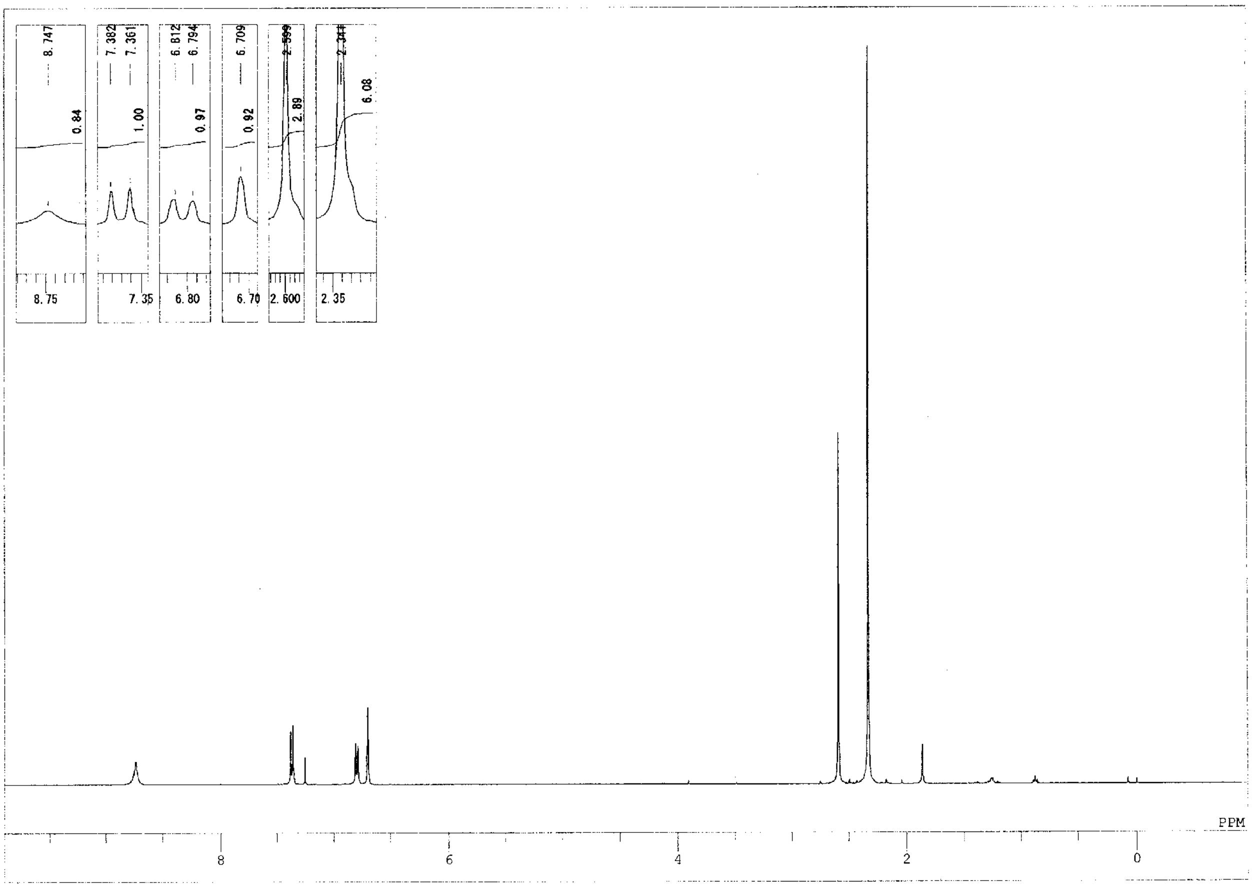

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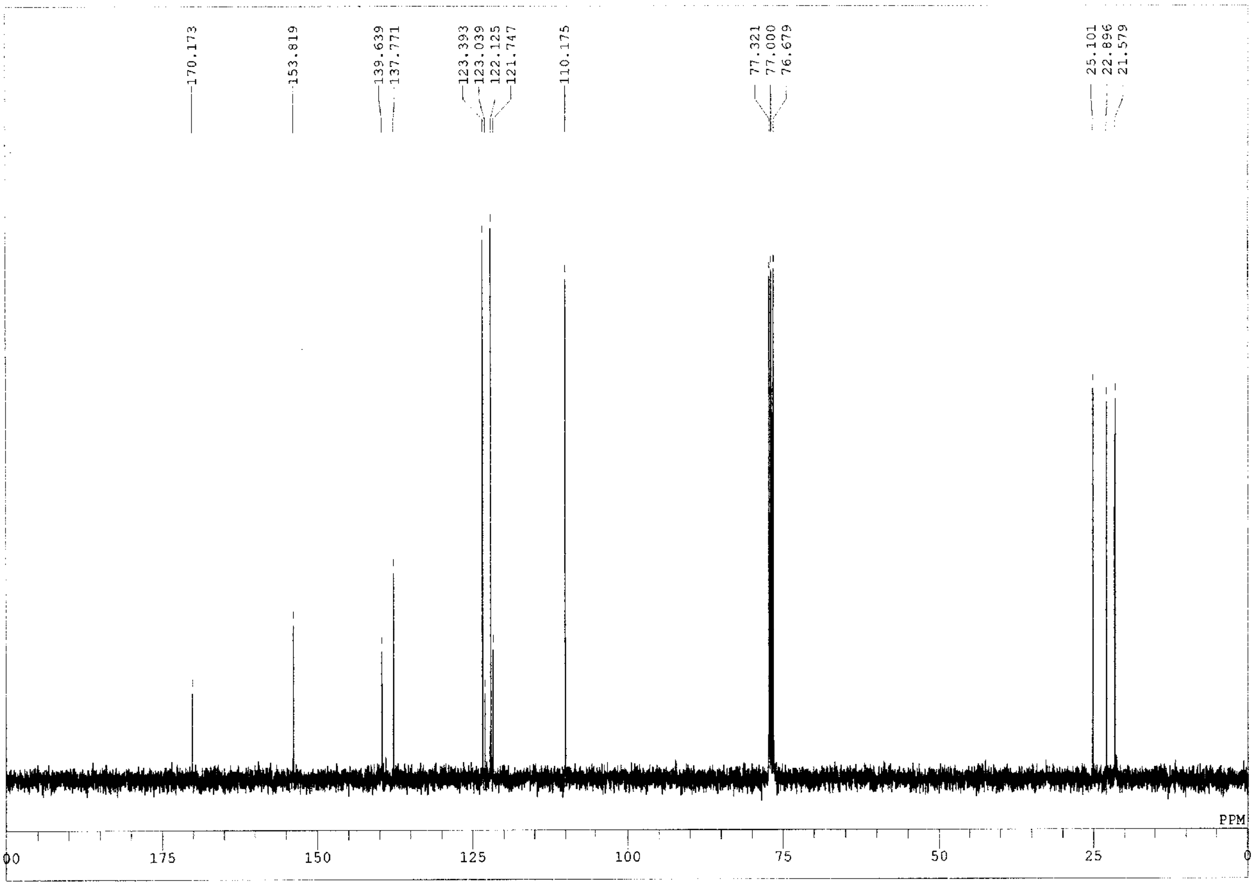

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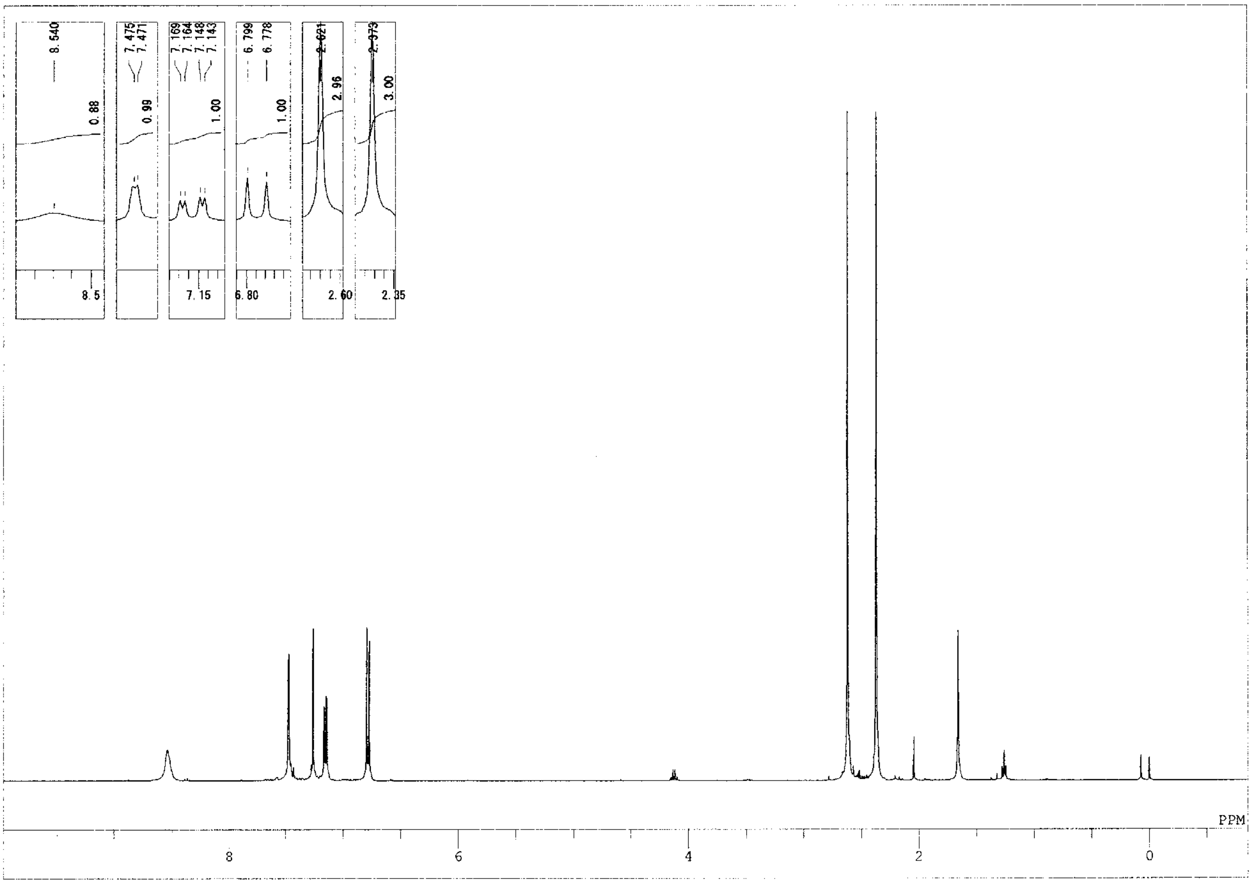

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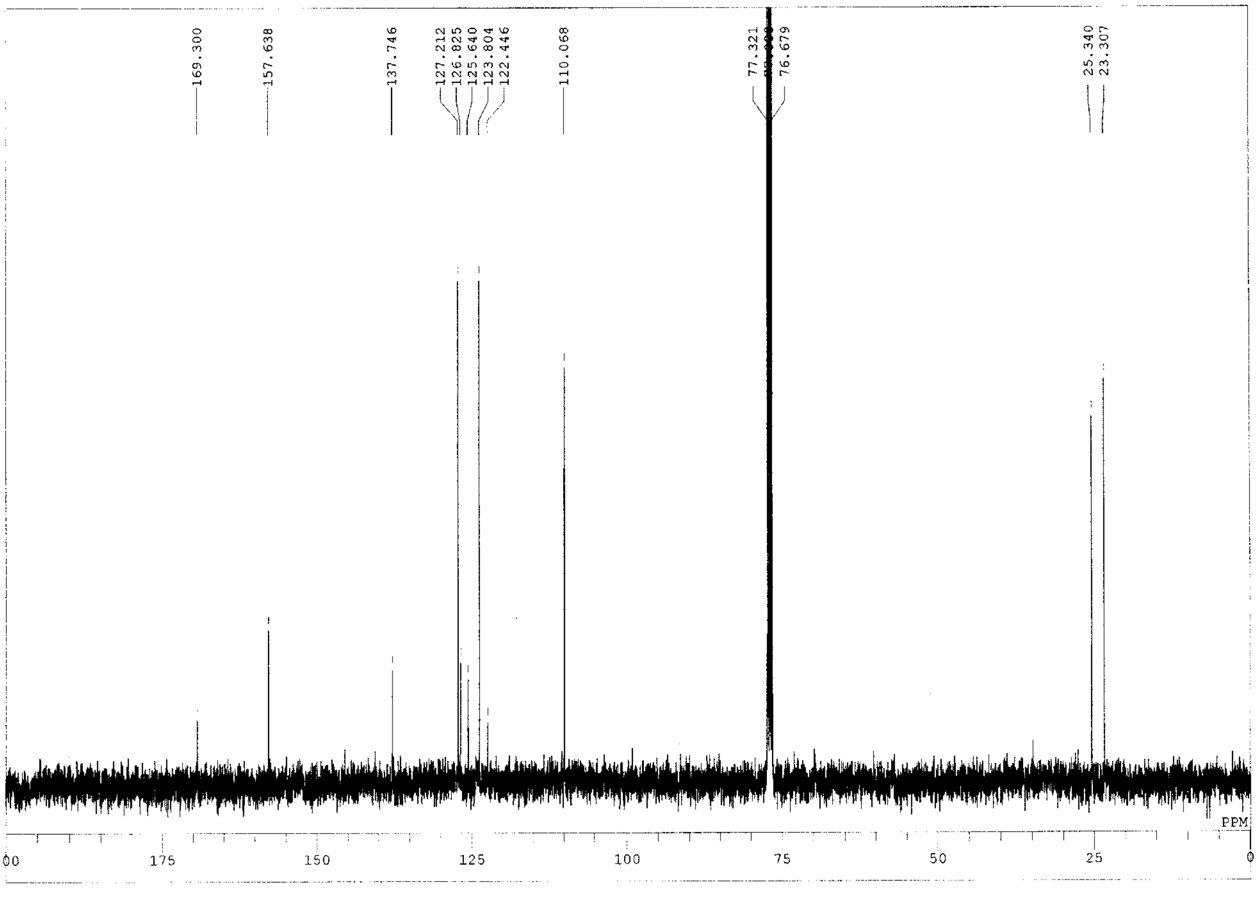

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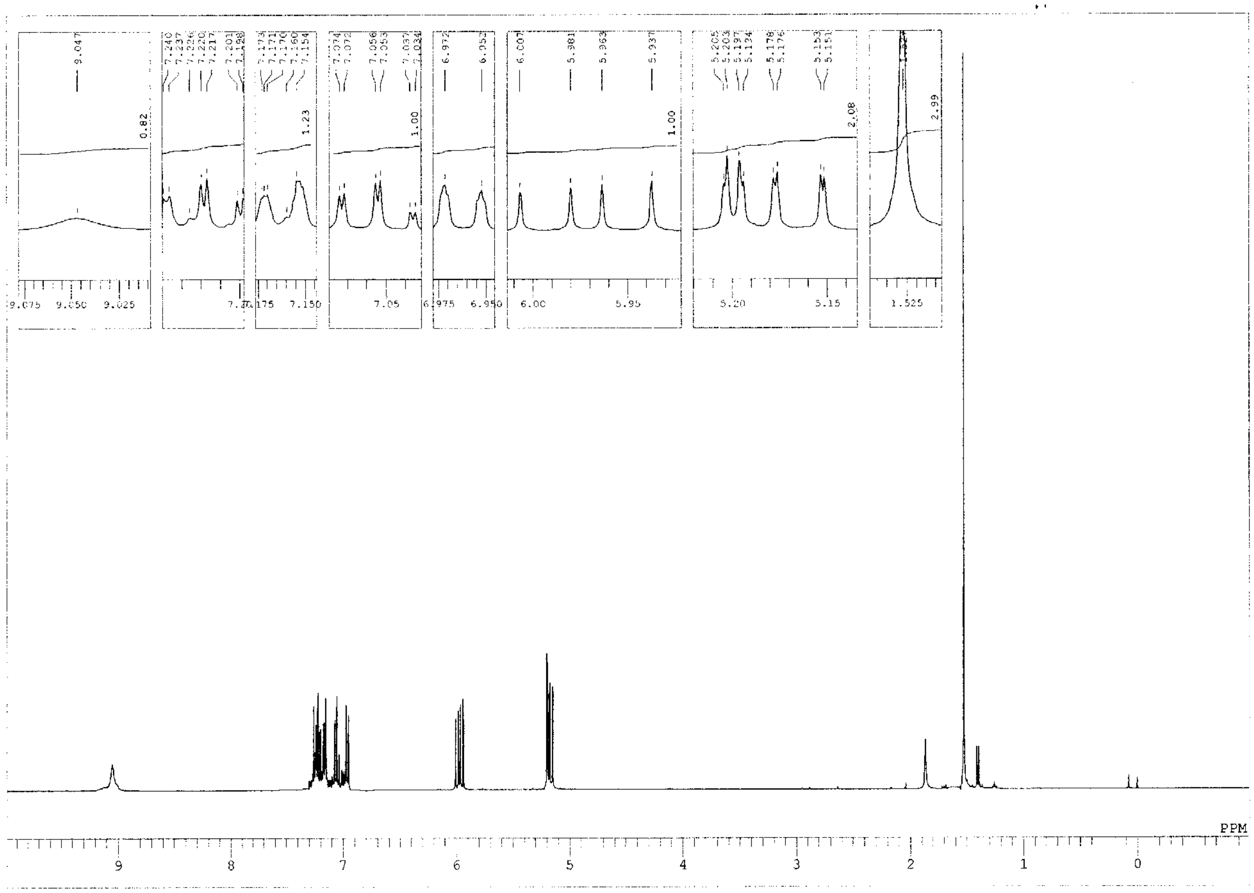

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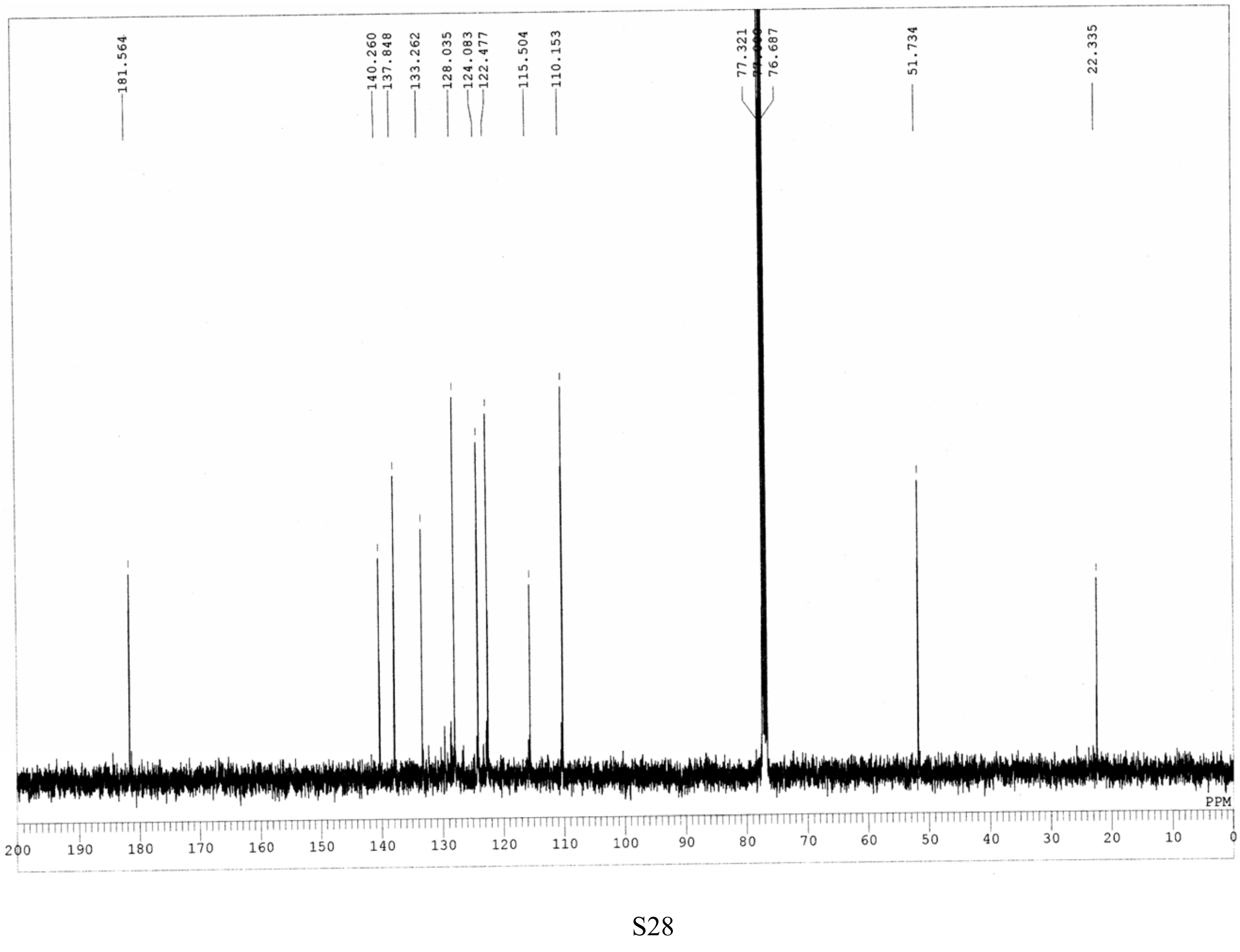

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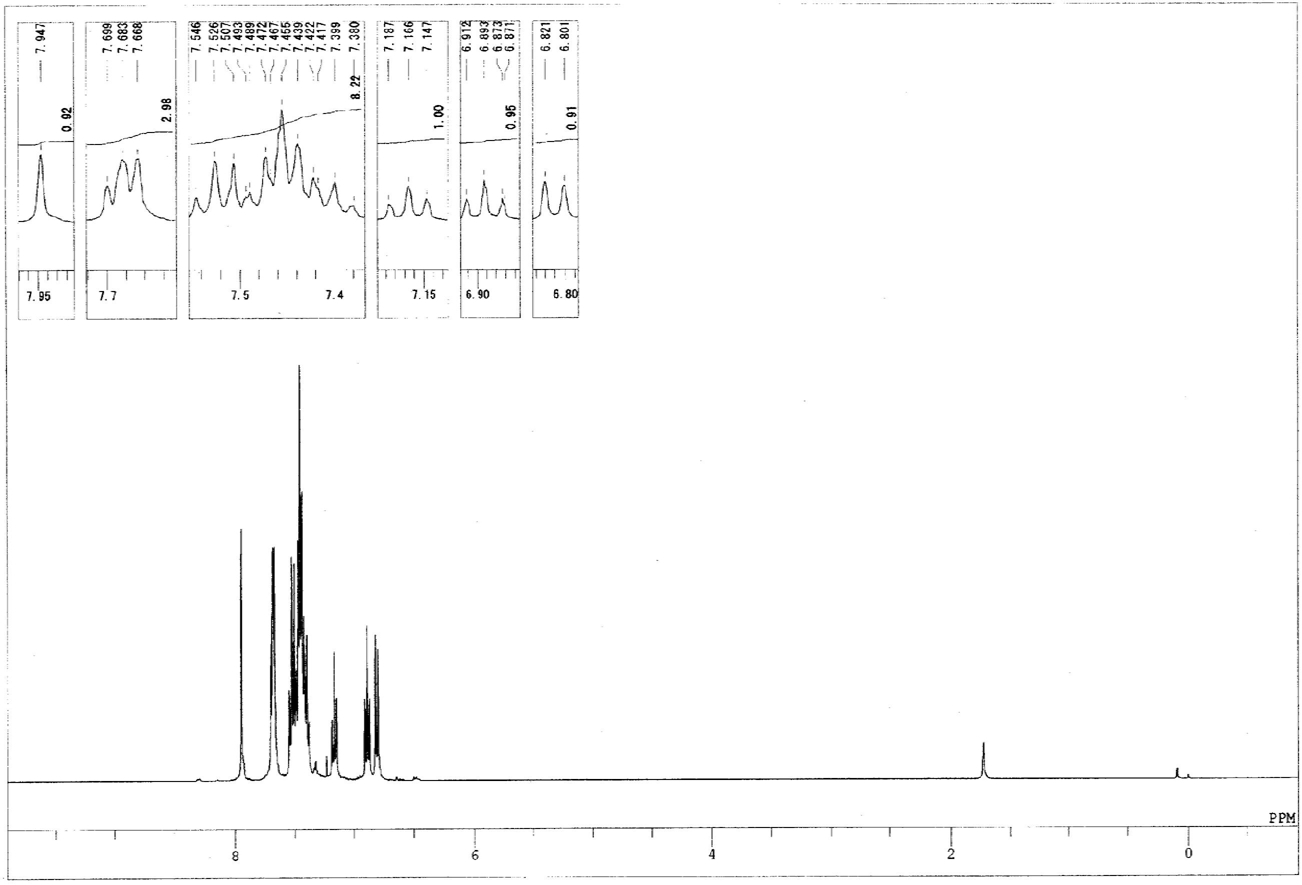

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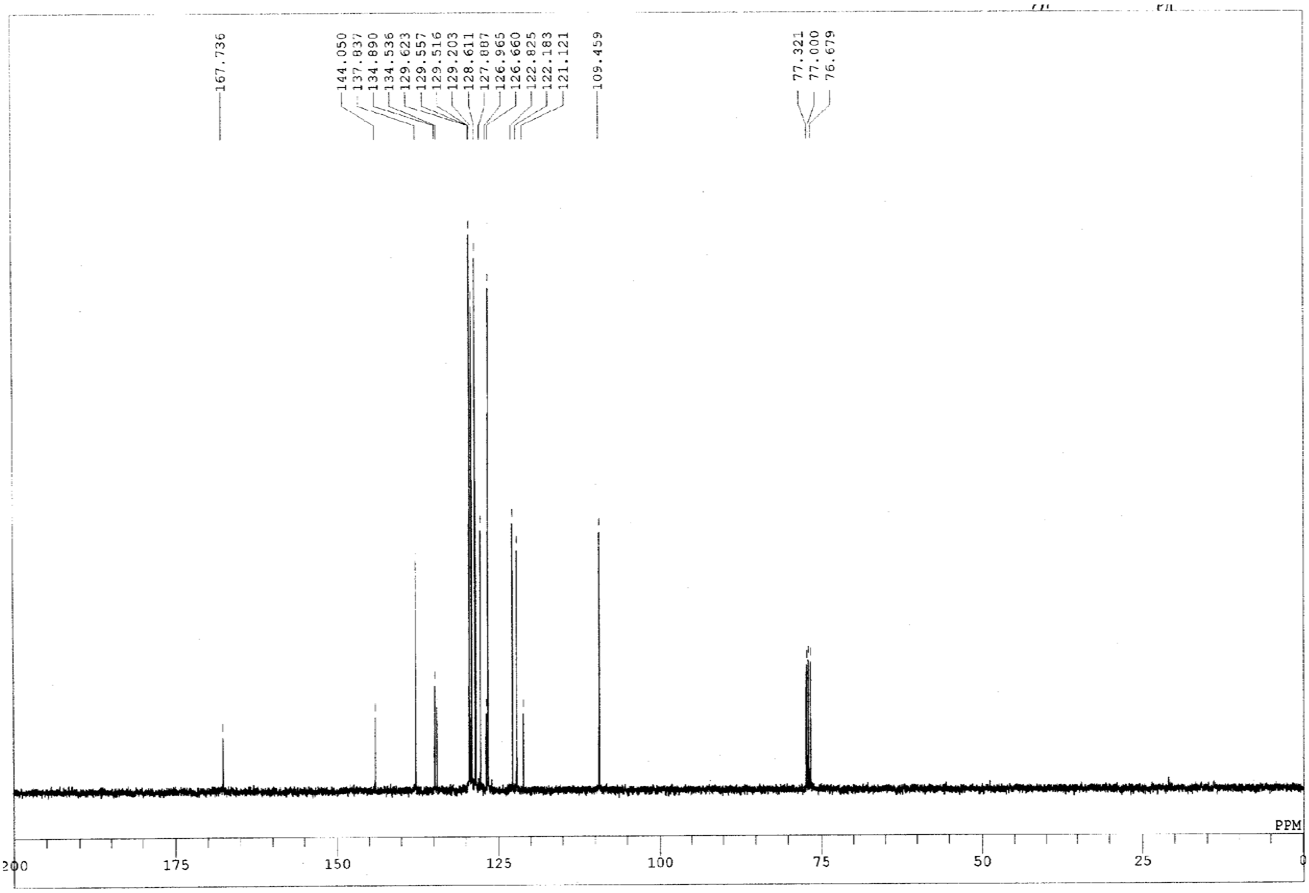

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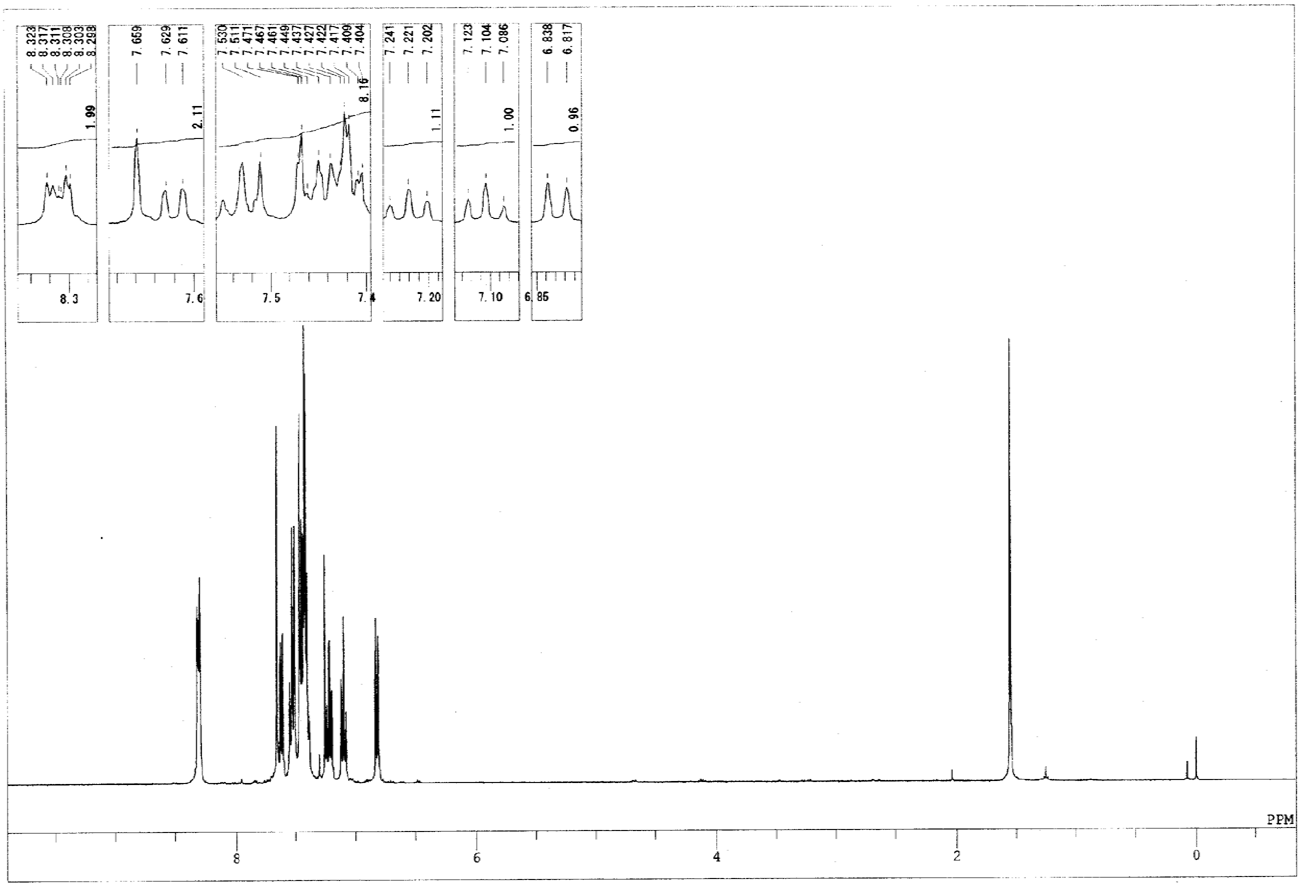

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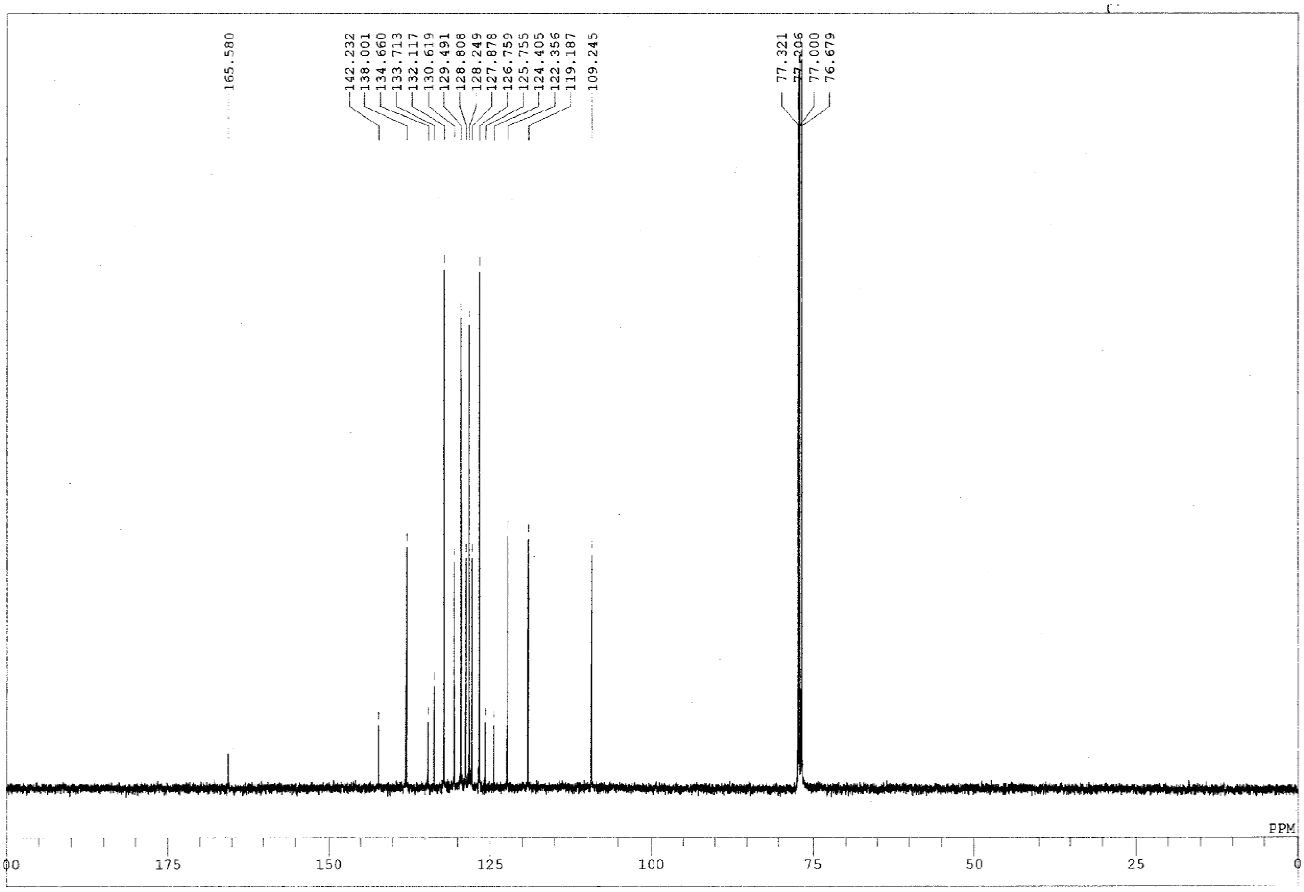

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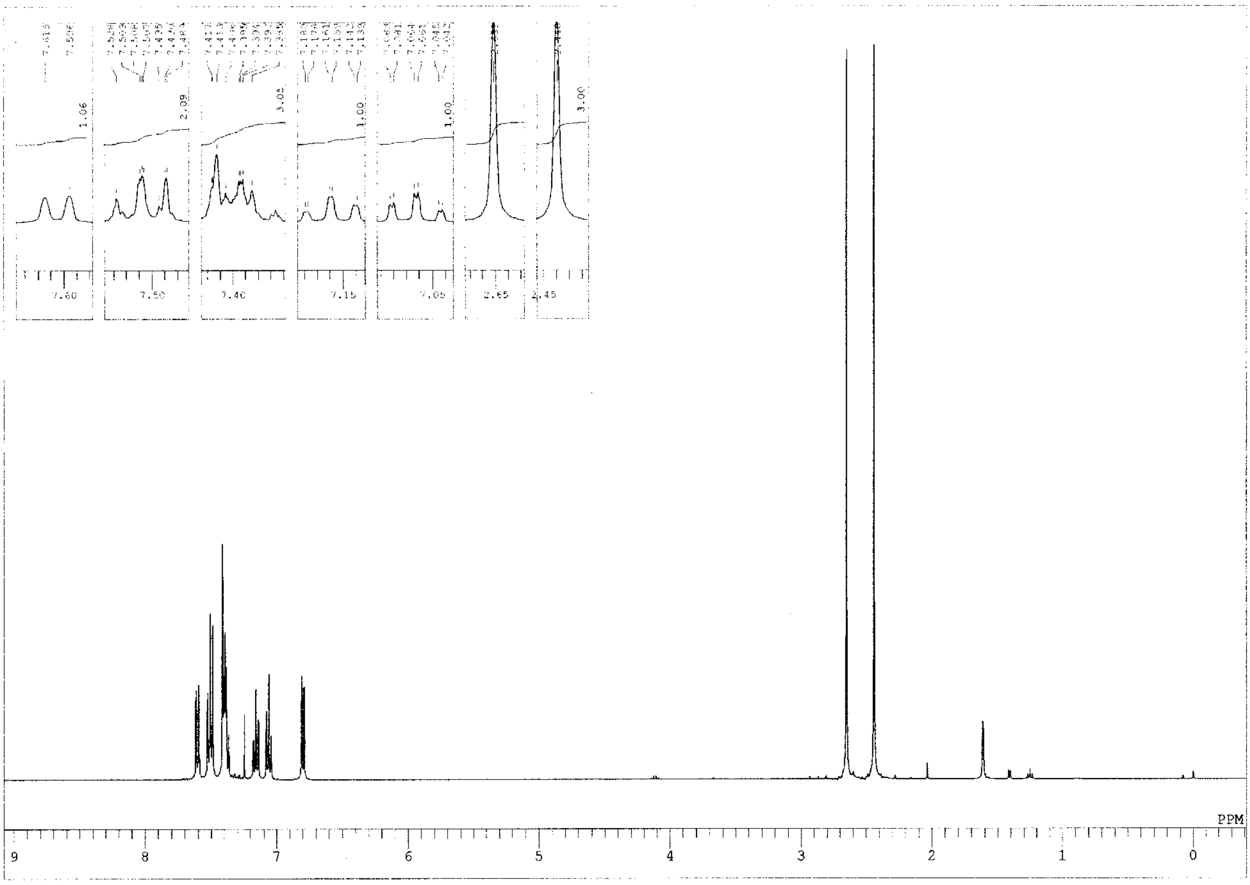

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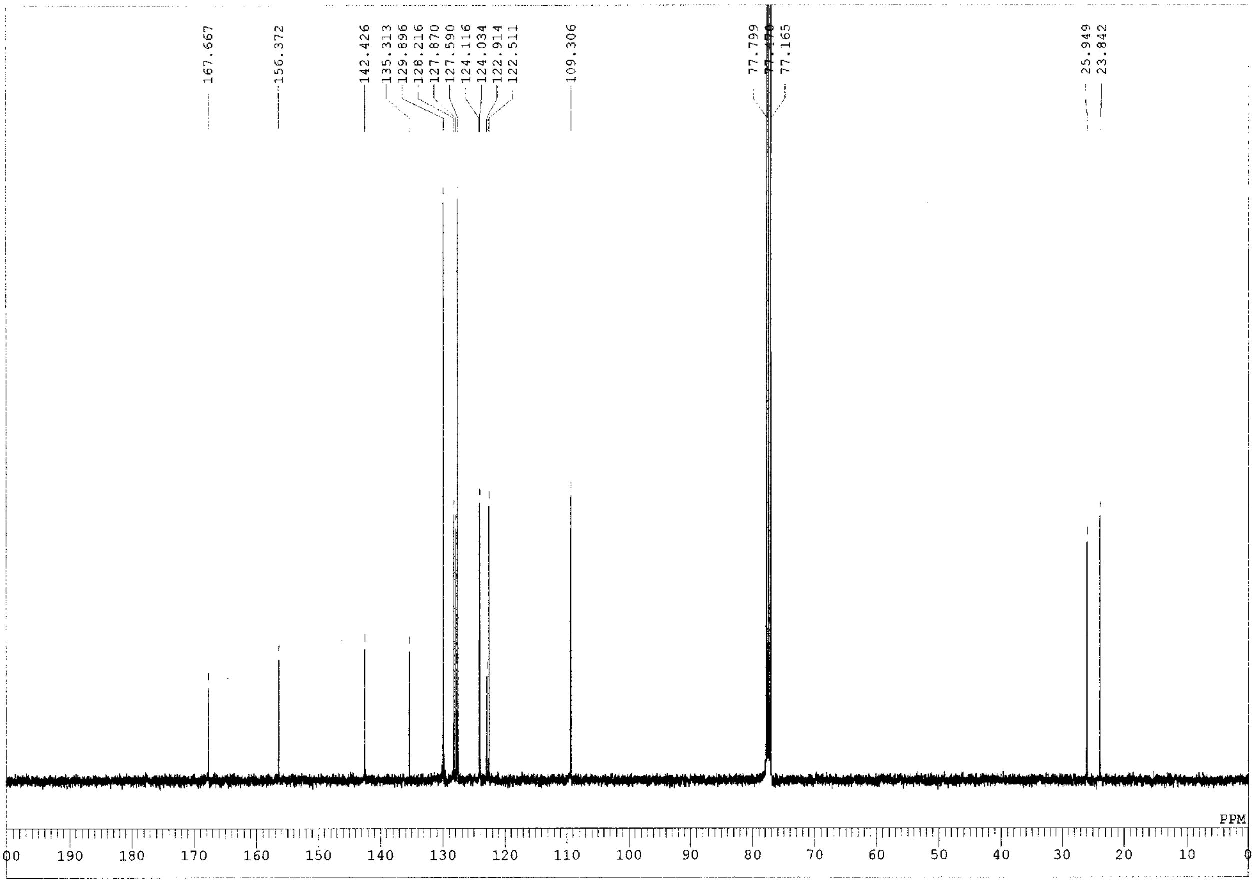

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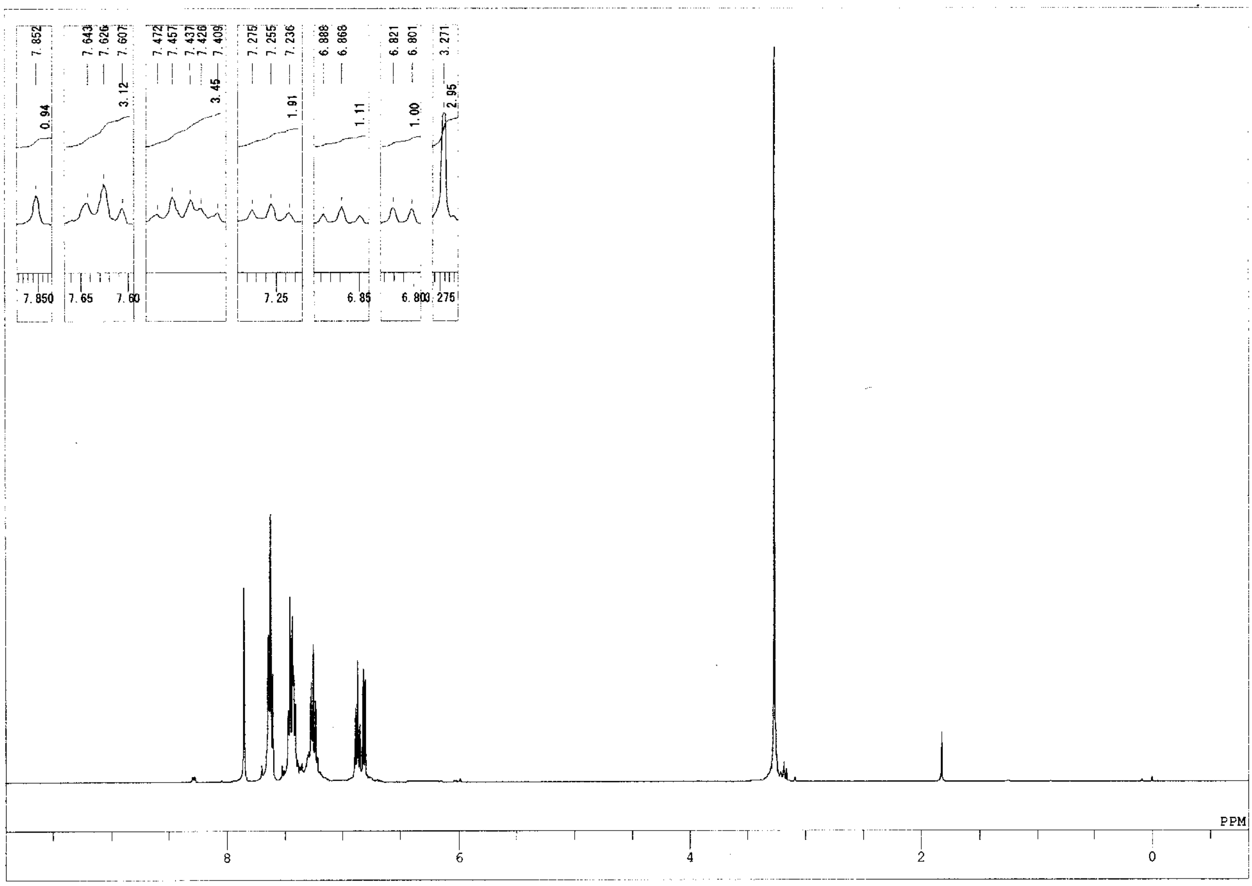

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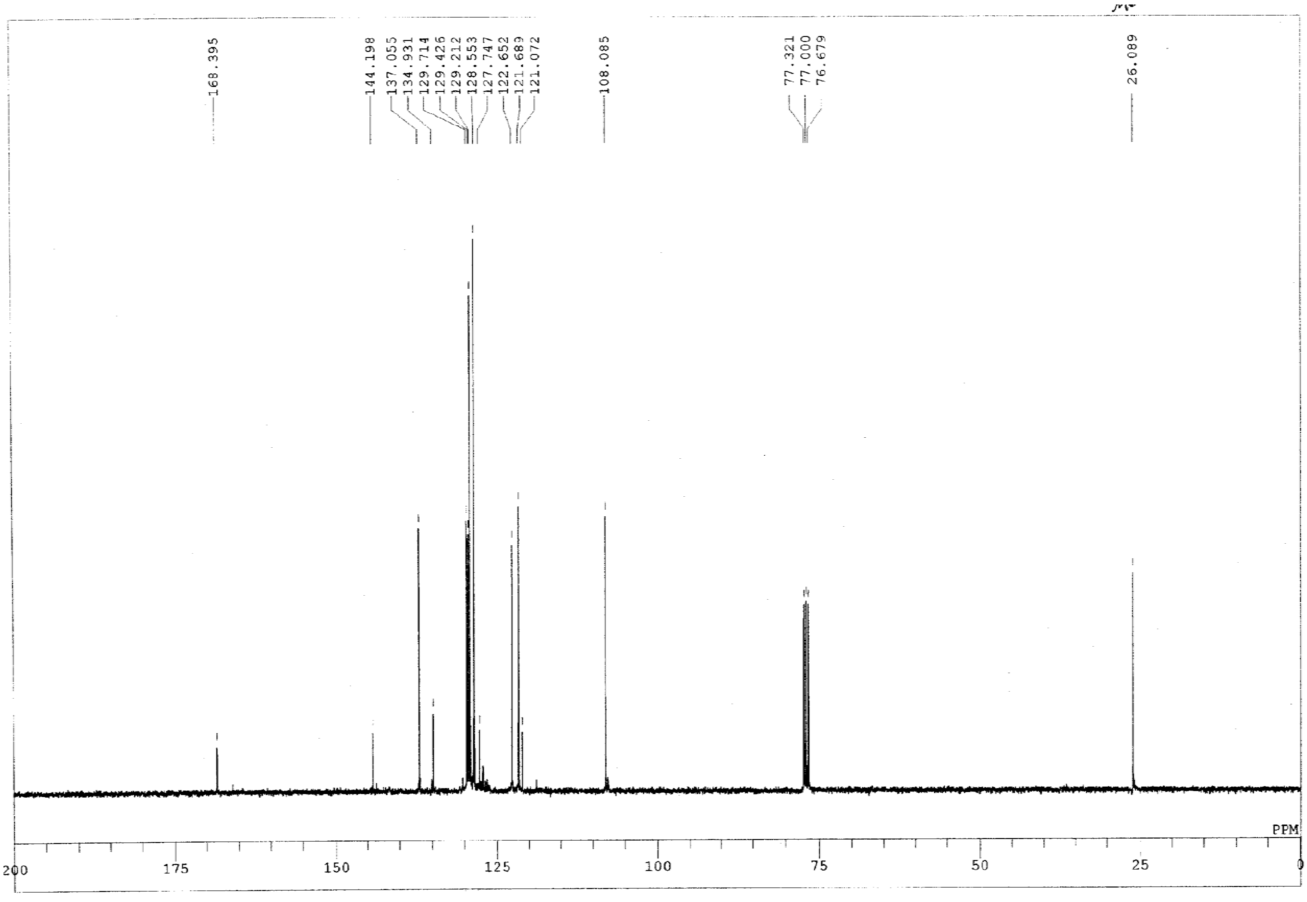

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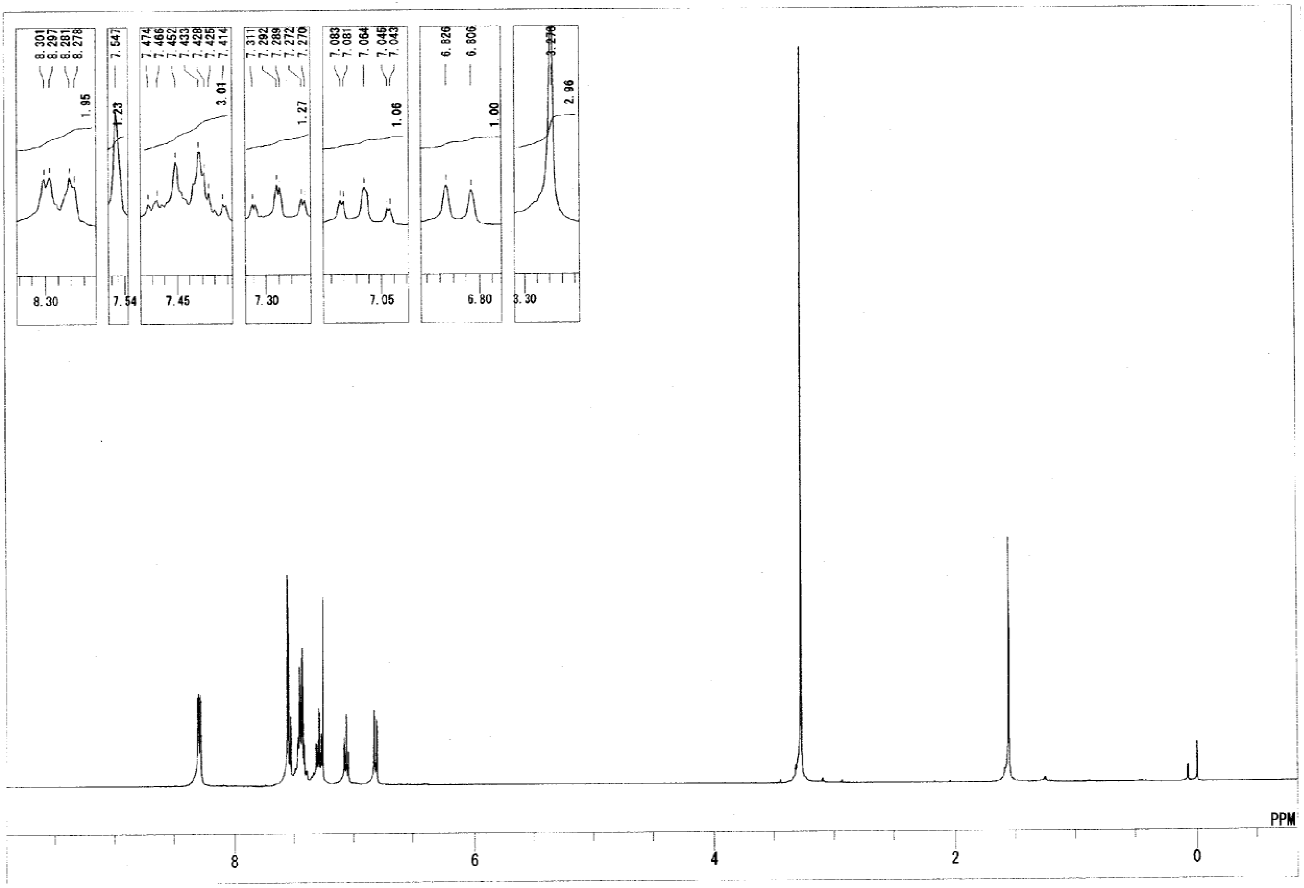

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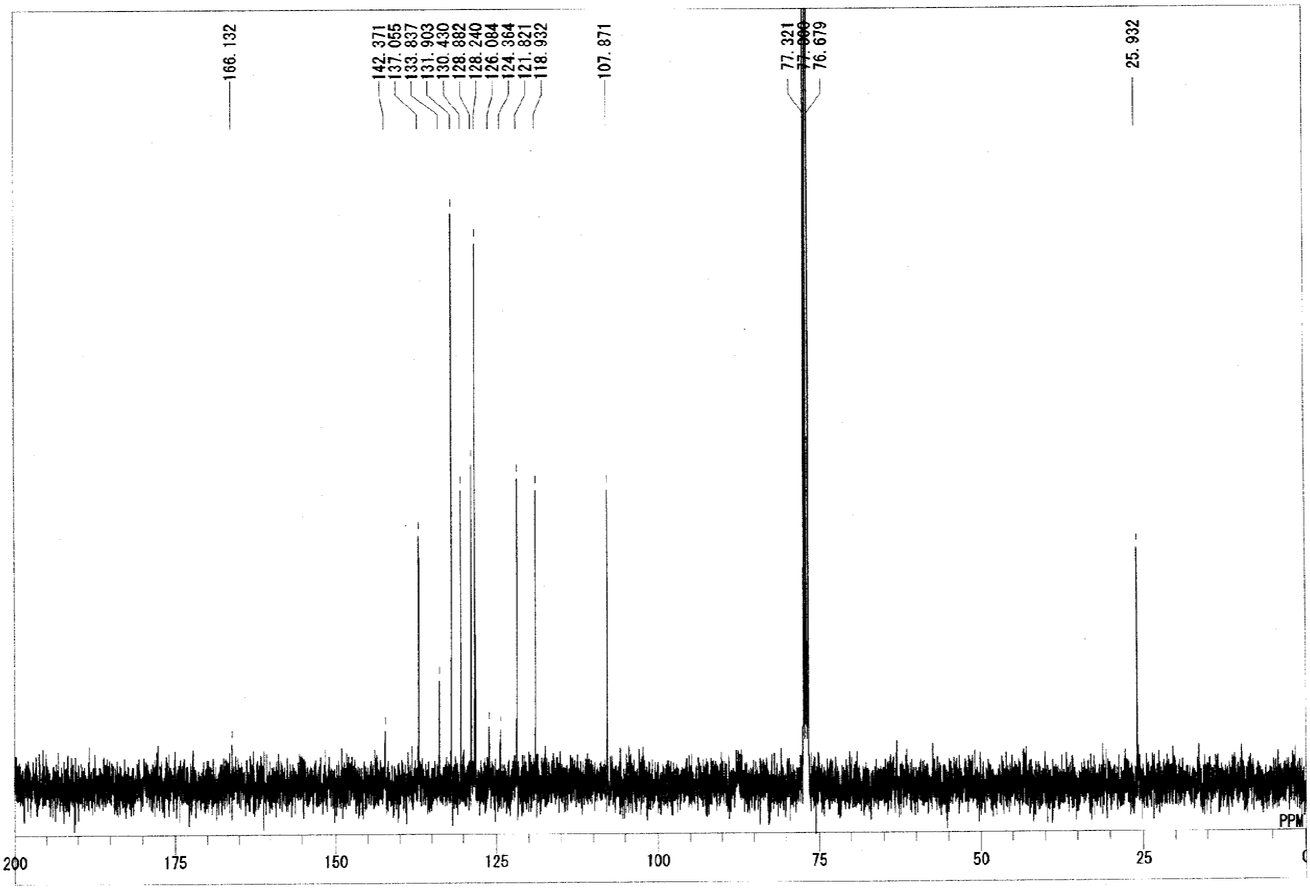

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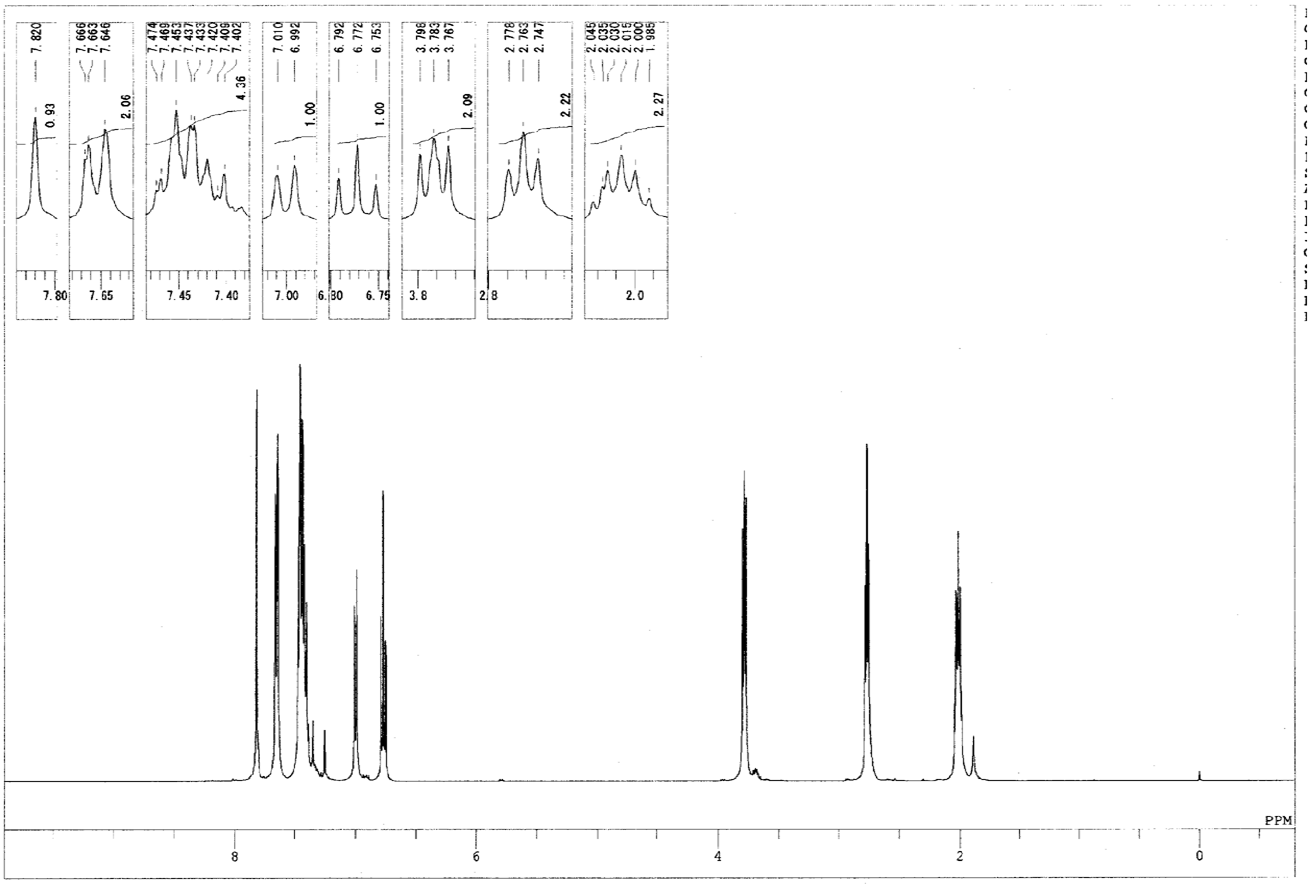

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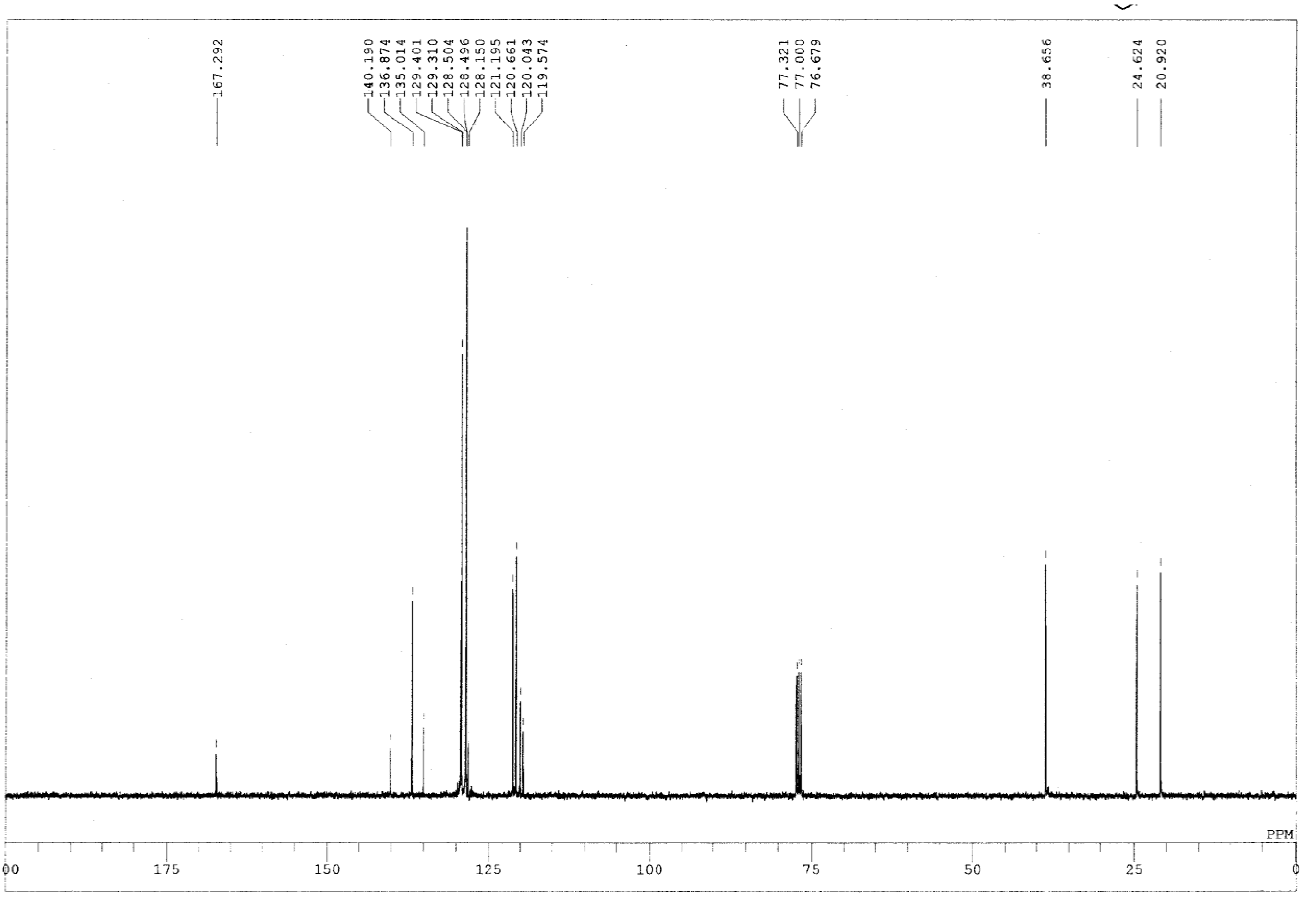

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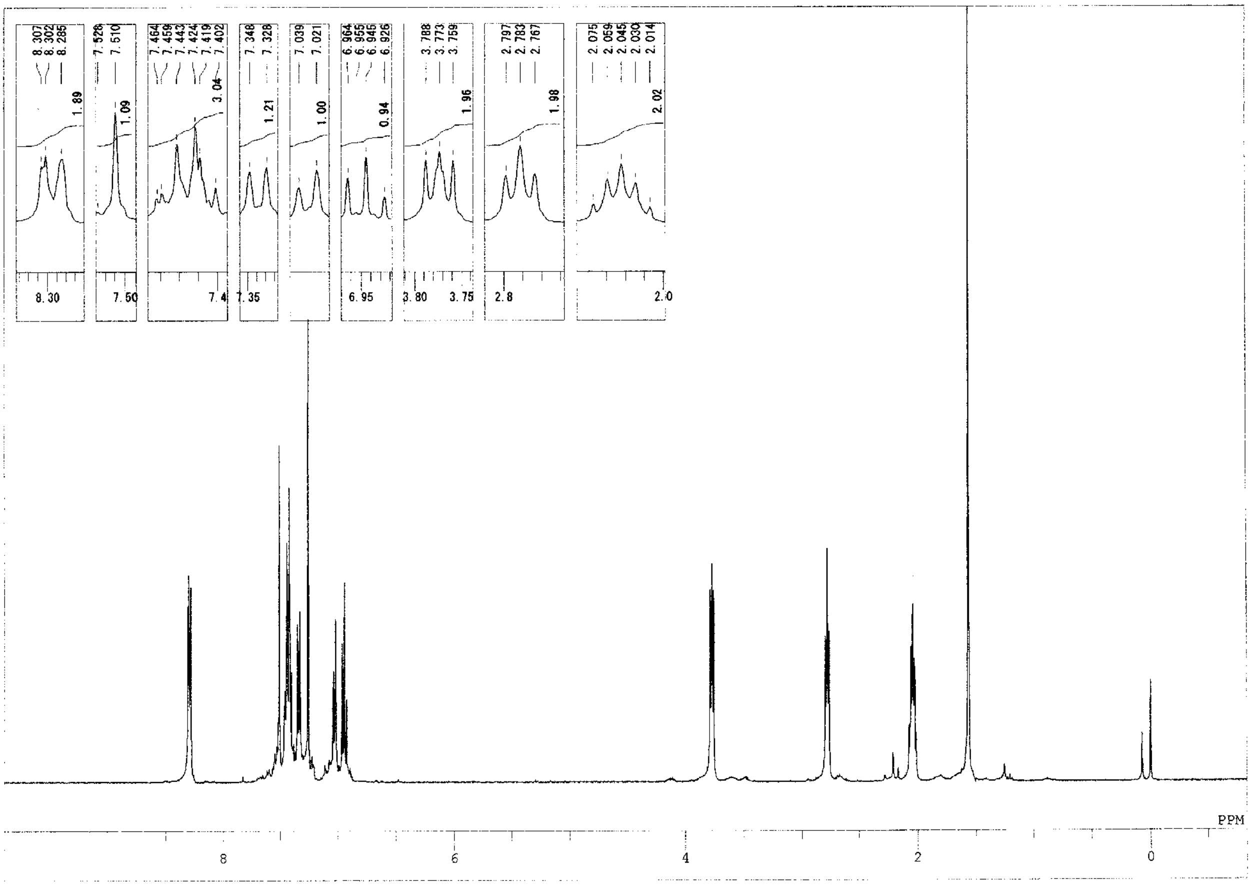

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