

Synthesis of Nitric Oxide Reductase Active Site Models Bearing

Key Components at both Distal and Proximal Sites

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Supporting Information

Materials and methods

All reagents were obtained from commercial suppliers and used without further purification unless otherwise indicated. All air and moisture-sensitive reactions were carried out under a nitrogen atmosphere in oven-dried glassware. Tetrahydrofuran was distilled from sodium-benzophenone. Acetonitrile and dichloromethane were distilled over calcium hydride. Flash column chromatography was performed on E. Merck silica gel 60 (230-400 mesh). NMR spectra were recorded on either a varian Mercury-400 or Inova-500 MHz spectrometers and referenced to the residual proton signals of the solvent. Mass spectra were obtained from Stanford Mass Spectrometry Laboratory. Melting points were recorded on a MEL-TEMP melting point machine from Laboratory Devices and were uncorrected. UV-vis spectra were recorded on a HP8452 diode array spectrophotometer. 3-(*o*-Methoxy-phenyl)-3*H*-imidazole-4-carboxylic acid ethyl ester (**8**), *cis*- α -(*o*-aminophenyl)- α_2 -(*o*-4-(3-methylimidazolyl)-amidophenyl)- β -(*o*-3-(1-(5-*p*-trifluoromethylphenyl)imidazolylmethyl)-benzamidophenyl)porphyrin (**5a**), and *cis*- α -(*o*-aminophenyl)- α_2 -(*o*-4-(3-methylimidazolyl)-amidophenyl)- β -(*o*-3-(1-(5-*p*-acetylenylphenyl)imidazolylmethyl)-benzamidophenyl)porphyrin (**5b**)

[3-(*o*-Methoxy-phenyl)-3*H*-imidazol-4-yl]-methanol (**11**)

A solution of **8** (2.0 g, 8.12 mmol) in dry tetrahydrofuran (20 mL) was added dropwise into a suspension of lithium aluminum hydride (95%, 648 mg, 16.24 mmol) in dry tetrahydrofuran (20 mL) under nitrogen atmosphere at 0 °C. After the addition, the mixture was stirred at 0 °C for 0.5 h, then at room temperature for 24 h. The reaction mixture was cooled to 0 °C and a 10% solution of potassium hydroxide (10 mL) was slowly added. The mixture was stirred for 15 minutes. It was condensed under vacuum to a small volume. Water was added, and the mixture was extracted with chloroform. The organic extracts were dried over Na₂SO₄. Filtration and evaporation gave **11** as a solid, mp 110-112 °C. Yield: 1.48 g (90%). ¹H NMR (CDCl₃): δ 7.45 (s, 1H), 7.41 (t, 1H, *J* = 8.0 Hz), 7.30 (d, 1H, *J* = 8.0 Hz), 7.06 (s, 1H), 7.03 (m, 2H), 4.41 (s, 2H), 3.76 (s, 3H), 3.11 (s(br), 1H). ¹³C NMR (CDCl₃) : δ 154.2, 138.7, 133.1, 130.4, 128.7, 127.7, 124.7, 121.0, 112.1, 55.8, 53.8. MS (ES): calc. for C₁₁H₁₂N₂O₂ *m/z* 205.1(M+H)⁺, found 205.6.

3-(*o*-Methoxy-phenyl)-3*H*-imidazole-4-carbaldehyde (12)

To a solution of imidazole alcohol **11** (2.0 g, 9.8 mmol) in dichloromethane (60 mL) was added manganese oxide activated (4.0 g, 46 mmol). The suspension was stirred at room temperature, overnight. The reaction mixture was filtered through celite. The filtrate was evaporated. The residue was subjected to chromatography on silica with ethyl acetate/hexane (3:1) as eluent to give **12** as a white solid, mp 86-88 °C. Yield: 1.82 g (92%). ¹H NMR (CDCl₃): δ 9.61 (s, 1H), 7.86 (s, 1H), 7.65 (s, 1H), 7.43 (t, 1H, J = 7.8 Hz), 7.23 (d, 1H, J = 7.8 Hz), 7.02 (m, 2H), 3.74 (s, 3H). ¹³C NMR (CDCl₃): δ 178.6, 154.1, 143.3, 140.5, 132.4, 130.8, 127.6, 124.4, 120.7, 112.0, 55.7. MS (ES): calc. for C₁₁H₁₀N₂O₂ m/z 203.1 (M+H)⁺, found 203.8.

3-(*o*-Hydroxy-phenyl)-3*H*-imidazole-4-carbaldehyde (13)

To a solution of imidazole aldehyde **12** (500 mg, 2.47 mmol) in dichloromethane (40 mL) was added a solution of boron tribromide (1.0 M in CH₂Cl₂, 20 mL) at -78 °C under nitrogen. The mixture was stirred at -78 °C for 30 min, then at room temperature for 72 h. Water (5 mL) was added to quench the reaction while the reaction mixture was cooled to 0 °C, and the mixture was stirred for 30 min. Water (50 mL) was added. The aqueous phase was neutralized to pH = 5~6. It was extracted by dichloromethane. The organic extracts were combined, dried over anhydrous MgSO₄. Filtration and evaporation gave solid residue. It was subjected to chromatography on silica eluting with 1.5% of methanol in chloroform. The starting material (260 mg) was recovered. The desired product was obtained as a white solid. Yield: 60 mg (12.9%).

3-(*o*-Hydroxy-phenyl)-3*H*-imidazole-4-carbaldehyde (13)

Imidazole aldehyde **12** (1.00 g, 4.95 mmol) was dissolved in HBr solution (48% in water, 10 mL). The mixture was heated to reflux and stirred for 24 h under N₂. The solution was cooled to room temperature. Anhydrous K₂CO₃ was added until the evolution of CO₂ ceased and the pH reached 6-7. The mixture was evaporated to dryness. The solids residue was transferred to a column built with silica and chloroform, eluting with 1.5 % -5% MeOH in CHCl₃. The major fraction was collected. Evaporation of solvent gave solids. Yield: 0.58 g (62%), mp 170-172°C. ¹H NMR (CD₃COCD₃): δ 9.68 (s, 1H), 7.90 (m, 2H), 7.35 (d, 2H, J = 6.0 Hz), 7.12 (m, 1H), 6.99 (t, 1H, J = 6.0 Hz). ¹³C NMR (CD₃COCD₃): δ 178.6, 152.3, 139.2, 130.4, 128.0, 122.5, 119.8, 119.1, 116.6, 88.5. MS (ES): calc. for C₁₀H₈N₂O₂ m/z 188.2 (M+H)⁺, found 188.9.

Methyl 5-iodopentanoate

Methyl 5-chloropentanoate (5.0 g, 33 mmol) and NaI (25.0 g, 167 mmol) were in acetone (70 mL). The suspension was stirred at room temperature for three days. Solvent was evaporated. The residue was dissolved in methylene chloride and washed with water. The organic layer was dried over MgSO₄. Filtration and evaporation gave red oil. It was purified by chromatography on silica eluting with hexanes/methylene chloride (2:1) to afford 6.0 g (80%) of the product as a light red oil. ¹H NMR (CDCl₃): δ 3.65 (s, 3H), 3.16 (t, 2H, J = 7.2

Hz), 2.31 (t, 2H, J = 7.2 Hz), 1.82 (m, 2H), 1.72 (m, 2H). ^{13}C NMR (CDCl_3): δ 173.6, 51.6, 32.8, 32.7, 25.7, 5.9.

5-[2-(5-Fornyl-imidazol-1-yl)-phenoxy]-pentanoic acid methyl ester (14)

Compound **13** (1.0 g, 5.32 mmol) and methyl 4-iodopentanoate (2.58 g, 10.7 mmol) were dissolved in dry acetonitrile (50 mL) in a round bottom flask. Anhydrous K_2CO_3 (2.94 g, 21.3 mmol) was added. The mixture was refluxed overnight. It was cooled to room temperature, evaporated to dryness. The residue was dissolved in water, extracted with ethyl acetate. The organic extracts were dried and evaporated to give an oil residue. It was subjected to chromatography on silica with eluent ethyl acetate/hexane (3:1) to give 1.20 g (75%) of solid product, mp 68-70 °C. ^1H NMR (CDCl_3): δ 9.68 (s, 1H), 7.92 (s, 1H), 7.70 (s, 1H), 7.46 (t, 1H, J = 7.5 Hz), 7.29 (d, 1H, J = 7.5 Hz), 7.06 (m, 2H), 3.98 (t, 2H, J = 6.0 Hz), 3.66 (s, 3H), 2.27 (t, 2H, J = 7.0 Hz), 1.64 (m, 4H). ^{13}C NMR (CDCl_3): δ 178.7, 173.8, 154.1, 143.4, 140.5, 132.5, 130.8, 127.5, 124.5, 120.7, 112.8, 68.0, 51.6, 33.4, 28.3, 21.3. MS (ES): calc. for $\text{C}_{16}\text{H}_{18}\text{N}_2\text{O}_4$ m/z 302.1(M+H) $^+$, found 302.9.

3-[2-(4-Methoxycarbonyl-butoxy)-phenyl]-3H-imidazole-4-carboxylic acid (6)

Compound **14** (1.00 g, 3.3 mmol) was dissolved in tert-butanol (30 mL) and 2-methyl-2-butene in THF (10 mL, 2.0 M). A solution of NaClO_2 (80%, 3.74 g, 33 mmol) and $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$ (3.56 g, 2.58 mmol) in water (15 mL) was added. The mixture was stirred at room temperature until TLC shows complete reaction (approximately 1.0 h). Water (100 mL) and NaCl (aqueous saturated, 100 mL) were added. It was extracted with ethyl acetate. Drying (MgSO_4) and evaporation afforded 1.05 g (99%) of solid product, mp 120-122 °C. ^1H NMR (CDCl_3): δ 11.38 (s(br), 1H), 7.83 (s, 1H), 7.68 (s, 1H), 7.36 (t, 1H, J = 7.8 Hz), 7.22 (d, 1H, J = 7.8 Hz), 6.96 (m, 2H), 3.91 (t, 2H, J = 6.0 Hz), 3.58 (s, 3H), 2.22 (t, 2H, J = 7.0 Hz), 1.60 (m, 4H). ^{13}C NMR (CDCl_3): δ 174.1, 162.2, 153.8, 142.1, 135.8, 130.5, 127.5, 125.6, 120.5, 112.6, 67.9, 51.6, 33.4, 28.3, 21.3. MS (ES): calc. for $\text{C}_{16}\text{H}_{18}\text{N}_2\text{O}_5$ m/z 318.1(M+H) $^+$, found 319.0.

2-Iodo-3-(2-methoxy-phenyl)-3H-imidazole-4-carbaldehyde (15)

Imidazole aldehyde **12** (1.00 g, 4.95 mmol) was dissolved in dry THF (25 mL) in a round-bottomed flask. *N*-iodosuccinimide (95%, 2.35 g, 9.92 mmol) was added in one portion. The flask was wrapped with Al foil and the mixture was refluxed under N_2 for 24 h. After cooled to room temperature, saturated $\text{Na}_2\text{S}_2\text{O}_3$ solution was added to destroy excess *N*-iodosuccinimide. Solvent was evaporated. The residue was dissolved in water, extracted with ethyl acetate. The extracts were dried over MgSO_4 . Filtration and evaporation afforded solid residue. It was purified by chromatography on silica eluting with ethyl acetate/hexanes (3:1) to give 1.46 g (90%) of solid product, mp 96-98 °C. ^1H NMR (CDCl_3): δ 9.36 (s, 1H), 7.83 (s, 1H), 7.51 (t, 1H, J = 7.8 Hz), 7.18 (d, 1H, J = 7.8 Hz), 4.09 (q, 2H, J = 7.2 Hz), 3.74 (s, 3H), 1.23 (t, 3H, J = 7.2 Hz). ^{13}C NMR (CDCl_3): δ 177.7, 154.8, 142.2, 136.3, 131.7, 129.3, 125.4, 120.8, 112.3, 104.3, 55.8. MS (ES): calc. for $\text{C}_{11}\text{H}_9\text{IN}_2\text{O}_2$ m/z 328.0 (M+H) $^+$, found 328.9.

Methyl 4-pentynoate

4-Pentynoic acid (5.0 g, 51.0 mmol) and *p*-toluenesulfonic acid (97 mg, 0.51 mmol) were dissolved in MeOH (30 mL) and benzene (50 mL) in a 100 mL round-bottomed flask. The flask was fitted with a Dean-Stark trap. The mixture was refluxed for 3 days. The reaction mixture was poured into a saturated NaHCO₃ solution, then extracted with diethyl ether. The extracts were dried and evaporated. The residue was distilled at ambient pressure to provide 4.1 g (72%) of desired ester. Colorless oil, bp 141-142 °C (760 mmHg) [lit. bp 143-144 °C (760 mmHg)]. ¹H NMR (CDCl₃): δ 3.66 (s, 3H), 2.52 (m, 2H), 2.46 (m, 2H), 1.94 (t, 1H). ¹³C NMR (CDCl₃): δ 172.2, 82.5, 69.1, 51.9, 3.1, 14.3.

5-[5-Formyl-1-(2-methoxy-phenyl)-1*H*-imidazol-2-yl]-pent-4-ynoic acid methyl ester (16)

Iodoimidazole **15** (500 mg, 1.52 mmol), PdCl₂(PPh₃)₂ (53 mg, 0.076 mmol) and CuI (15 mg, 0.079 mmol) were in dry THF (30 mL) in a round-bottomed flask. The mixture was degassed by two freeze-pump-thaw cycles. Diisopropylamine (4.0 mL) was added. The mixture was degassed by two freeze-pump-thaw cycles. Methyl 4-pentynoate (188 mg, 1.68 mmol) was added and the mixture was degassed by two freeze-pump-thaw cycles. Then the flask was placed in a 50 °C pre-heated water bath and the mixture was stirred for 20 h. A yellow solution with some white precipitates was formed. The solvent was evaporated. The residue was subjected to chromatography on silica eluting with ethyl acetate/hexanes (1:1) to afford 333 mg (70%) of the desired product, mp 65-66 °C. ¹H NMR (CDCl₃): δ 9.50 (s, 1H), 7.85 (s, 1H), 7.45 (t, 1H, *J* = 7.8 Hz), 7.25 (d, 1H, *J* = 7.8 Hz), 7.04 (m, 2H), 3.74 (s, 3H), 3.62 (s, 3H), 2.56 (t, 2H, 8.0 Hz), 2.41 (t, 2H, *J* = 8.0 Hz). ¹³C NMR (CDCl₃): δ 178.2, 171.6, 154.5, 140.1, 132.4, 131.1, 128.5, 124.0, 120.5, 112.0, 95.1, 70.5, 55.8, 52.0, 32.3, 15.2. MS (ES): calc. for C₁₇H₁₆N₂O₄ *m/z* 312.1 (M+H)⁺, found 312.9.

5-[5-Formyl-1-(2-methoxy-phenyl)-1*H*-imidazol-2-yl]-pentanoic acid methyl ester (17)

Compound **16** (1.00 g, 3.20 mmol) was dissolved in a mixture of ethyl acetate and methanol (40 mL, 1:1 vol). The solution was degassed with N₂ for 10 min. Pd/C (10% on activated carbon, 230 mg) was added. Hydrogen gas was bubbled through the stirred mixture until TLC showed complete reaction. The reaction mixture was filtered through a silica bed, evaporated to dryness. The residue was subjected to chromatography on silica eluting with ethyl acetate/hexanes (1:1 vol) to give 0.76 g (75%) of the desired compound as an oil. ¹H NMR (CDCl₃): δ 9.45 (s, 1H), 7.77 (s, 1H), 7.42 (t, 1H, *J* = 8.0 Hz), 7.13 (d, 1H, *J* = 8.0 Hz), 7.01 (m, 2H), 3.70 (s, 3H), 3.56 (s, 3H), 2.44 (t, 2H, *J* = 7.6 Hz), 2.19 (t, 2H, *J* = 7.6 Hz), 1.66 (m, 2H), 1.53 (m, 2H). ¹³C (CDCl₃): δ 178.0, 173.6, 155.5, 154.6, 140.7, 132.8, 131.0, 128.5, 124.2, 120.8, 112.0, 55.7, 51.4, 33.5, 26.6, 26.3, 24.3. MS (ES): calc. for C₁₇H₂₀N₂O₄ *m/z* 316.1 (M+H)⁺, found 316.9.

2-(4-Methoxycarbonyl-butyl)-3-(2-methoxy-phenyl)-3*H*-imidazole-4-carboxylic acid (7)

Compound **17** (1.00 g, 3.16 mmol) was dissolved in tert-butanol (30 mL) and 2-methyl-2-butene in THF (10 mL, 2.0 M). A solution of NaClO₂ (80%, 3.74 g, 33 mmol) and

NaH₂PO₄·2H₂O (3.56 g, 2.58 mmol) in water (15 mL) was added. The mixture was stirred at room temperature until TLC shows complete reaction (approximately 1.0 h). Water (100 mL) and NaCl (aqueous saturated, 100 mL) were added. It was extracted with ethyl acetate. After drying (MgSO₄) and evaporation, 1.04 g (99%) of solid product were obtained, mp 118-120 °C. ¹H NMR (CDCl₃): δ 11.1 (s(br), 1H), 7.74 (s, 1H), 7.36 (t, 1H, J = 8.0 Hz), 7.08 (d, 1H, J = 8.0 Hz), 6.96 (m, 2H), 3.67 (s, 3H), 3.55 (s, 3H), 2.41 (t, 2H, J = 7.2 Hz), 2.12 (t, 2H, J = 7.2 Hz), 1.47 (m, 4H). ¹³C NMR (CDCl₃): δ 173.7, 161.8, 154.7, 152.7, 133.1, 130.7, 128.6, 125.7, 124.8, 120.5, 111.8, 55.6, 51.4, 33.4, 26.5, 25.9, 24.1. MS (ES): calc. for C₁₇H₂₀N₂O₅ m/z 332.1 (M+H)⁺, found 332.9.

5-[2-(5-Chlorocarbonyl-imidazol-1-yl)-phenoxy]-pentanoic acid methyl ester (9)

Acid **6** (250 mg, 0.78 mmol) was suspended in dry and degassed acetonitrile (15 mL) under N₂. Oxalyl chloride (275 µL, 3.15 mmol) was added through a syringe followed by a drop of DMF. The clear solution was stirred at room temperature for 4 h, during which a lot of white solids precipitated out. The solution was condensed under vacuum to a small volume (~3 mL). Dry diethyl ether (10 mL) was added and the mixture was stirred for 20 min. It was quickly filtered in the air. The cake was washed with 2 mL of dry diethyl ether, then left under vacuum for overnight. A white solid product was obtained, 220 mg (75%). Characterization of this white solid was achieved by reacting it with dry ethanol to give the corresponding ethyl ester. To the acyl chloride (10 mg) was added dry ethanol (0.5 ml), the solution was then evaporated under vacuum to give an oil. ¹H NMR (CDCl₃): δ 8.60 (s, 1H), 8.02 (s, 1H), 7.53 (t, 1H, J = 7.6 Hz), 7.32 (d, 1H, J = 7.6 Hz), 7.10 (t, 1H, J = 7.6 Hz), 7.04 (d, 1H, J = 7.6 Hz). ¹³C NMR (CDCl₃): δ 173.7, 156.9, 153.4, 138.5, 132.8, 127.3, 126.0, 125.5, 123.0, 121.2, 112.8, 68.5, 62.5, 51.9, 33.5, 28.4, 21.4, 14.1.

5-[5-Chlorocarbonyl-1-(2-methoxy-phenyl)-1H-imidazol-2-yl]-pentanoic acid methyl ester (10)

Acid **7** (250 mg, 0.75 mmol) was dissolved in thionyl chloride (5 mL). The solution was heated to 78-80 °C and stirred for overnight (14 h) under nitrogen. Excess thionyl chloride was removed on a rotavap. The residue was washed with anhydrous ether (1 mL × 2), then left under vacuum overnight to give a light yellow oil residue, 251 mg (86%). Characterization of this oil residue was achieved by reacting it with dry ethanol to give the corresponding ethyl ester. To the acyl chloride solution in dry acetonitrile (0.15 M, 200 µL) was added dry ethanol (0.5 ml), the solution was then evaporated under vacuum to give an oil. ¹H NMR (CDCl₃): δ 7.96 (s, 1H), 7.57 (t, 1H, J = 8.0 Hz), 7.36 (d, 1H, J = 8.0 Hz), 7.22 (m, 2H), 4.16 (q, J = 7.0 Hz), 3.76 (s, 3H), 3.57 (s, 3H), 2.82 (m, 2H), 2.22 (t, 2H, J = 7.0 Hz), 1.75 (m, 2H), 1.52 (m, 2H), 1.19 (t, 3H, J = 7.0 Hz). ¹³C NMR: δ 173.4, 156.8, 154.2, 151.9, 132.9, 128.1, 125.1, 125.0, 121.6, 121.2, 112.3, 62.0, 56.0, 51.6, 33.1, 26.5, 24.9, 23.9, 13.9.

Synthesis of porphyrins

General procedures to make the α -trisimidazole- β -tail-porphyrins following a [2+1] method

3ab and **4ab**: Porphyrin (**5a** 30 mg, **5b** 30 mg) was dissolved in THF/CH₃CN (2:1 vol, 8 mL). Dry HCl gas was bubbled through the solution until it turned brown green. Imidazole acyl chloride **9** or **10** (2.0 equiv) was added. The solution turned green immediately. It was stirred for 10 minutes. Then a solution of Et₂NC₆H₅ (1.26 M in THF) was added dropwise until the green color disappeared. Stirring was carried on for 10 min. The above procedures were repeated until 10 equivalents of acyl chloride were added. Since the product has almost the same polarity as the starting material, the reaction cannot be monitored by TLC. After the reaction was finished, the solution was diluted with CH₂Cl₂ (100 mL). Then it was washed with saturated NaHCO₃ (100 mL) and water (100 mL \times 3). The organic phase was dried (MgSO₄) and evaporated to give purple solids.

The mixture was separated on chromatotron using 0.8% MeOH in NH₃ saturated CH₂Cl₂.

For **3ab**, only one band was observed. Therefore, the porphyrin was collected in small culture tubes (0.5 mL solution). The first 2/3 and the last 1/3 of tubes were combined separately and evaporated. ¹H NMR shows that the first 2/3 of the fraction contained the unreacted starting material and the product **1ab**, while the last 1/3 of the fraction contained the clean **1ab**. For **4ab**, the first fraction was the expected product; the second fraction was the starting material **5ab**.

Yields:

3a: 23 mg (ratio of starting material and product 1:1), 10 mg (clean product)

Yield based on the reacted starting material was 98%.

3b: 22 mg (ratio of starting material and product 2:3), 13 mg (clean product)

Yield based on the reacted starting material was 99%.

4a: 14 mg (product), 15 mg (starting material).

Yield based on the reacted starting material was 75%.

4b: 13 mg (product), 17 mg (starting material).

Yield based on the reacted starting material was 79%.

3a: ¹H NMR (CDCl₃): δ 8.88 (m, 9H), 8.46 (d, 1H, J = 8.0 Hz), 8.43 (d, 1H, J = 8.0 Hz), 8.39 (d, 1H, J = 8.0 Hz), 8.27 (s, 1H), 8.14 (d, 1H, J = 7.5 Hz), 8.06 (d, 1H, J = 7.5 Hz), 8.03 (d, 1H, J = 7.5 Hz), 7.88 (m, 5H), 7.74 (m, 2H), 7.59 (m, 4H), 7.46 (t, 1H, J = 7.5 Hz), 7.41 (s, 1H), 7.04 (m, 5H), 6.83 (t, 1H, J = 7.5 Hz), 6.80 (s, 1H), 6.65 (d, 2H, J = 8.0 Hz), 6.51 (d, 1H, J = 8.0 Hz), 6.34 (s, 2H), 6.26 (m, 2H), 6.09 (d, 1H, J = 7.5 Hz), 5.82 (s, 1H), 5.59 (s, 1H), 5.55 (s, 1H), 4.09 (s, 2H), 3.63 (s, 3H), 3.60 (s, 3H), 3.30 (m, 2H), 2.90 (s, 3H), 1.16 (m, 2H), 0.67 (m, 4H), -2.54 (2H). MS (ES): calc. for C₈₈H₆₉F₃N₁₆O₇ m/z 1519.5 (M+H)⁺, found 1519.8. λ_{max} (10⁻³ ϵ , M⁻¹cm⁻¹) 424 (441), 518 (93)

3b: ¹H NMR (CDCl₃): δ 8.88 (m, 9H), 8.46 (d, 2H, J = 8.5 Hz), 8.42 (d, 1H, J = 8.5 Hz), 8.39 (d, 1H, J = 8.5 Hz), 8.29 (s, 1H), 8.14 (d, 1H, J = 7.5 Hz), 8.07 (d, 1H, J = 7.5 Hz), 8.04 (d, 1H, J = 7.5 Hz), 7.88 (m, 5H), 7.74 (t, 1H, J = 8.0 Hz), 7.71 (s, 1H), 7.60 (m, 4H), 7.47 (t,

1H, J = 7.5 Hz), 7.40 (s, 1H), 7.11 (s, 1H), 7.06 (s, 1H), 7.03 (s, 1H), 6.91 (d, 2H, J = 8.0 Hz), 6.89 (s, 1H), 6.82 (m, 1H), 6.74 (s, 1H), 6.64 (d, 1H, J = 7.0 Hz), 6.49 (d, 2H, J = 8.0 Hz), 6.27 (m, 4H), 6.12 (d, 1H, J = 7.5 Hz), 5.80 (s, 1H), 5.60 (s, 1H), 5.59 (s, 1H), 4.01 (s, 2H), 3.64 (s, 3H), 3.60 (s, 3H), 3.30 (m, 2H), 3.00 (s, 1H), 2.91 (s, 3H), 1.14 (m, 2H), 0.70 (m, 4H), -2.55 (2H). MS (ES): calc. for C₈₉H₇₀N₁₆O₇ m/z 1475.6 (M+H)⁺, found 1475.6. $\lambda_{\max}(10^{-3}\epsilon, \text{M}^{-1}\text{cm}^{-1})$ 425 (454), 518 (90)

4a: ¹H NMR (CDCl₃): δ 8.88 (m, 9H), 8.45 (m, 3H), 8.00 (m, 8H), 7.70 (t, 1H, J = 8.0 Hz), 7.58 (m, 4H), 7.47 (s, 1H), 7.41 (t, 1H, J = 7.6 Hz), 7.37 (s, 1H), 7.12 (t, 1H, J = 8.0 Hz), 7.05 (d, 2H, J = 8.0 Hz), 6.98 (s, 2H), 6.94 (d, 1H, J = 6.4 Hz), 6.87 (s, 1H), 6.79 (s, 1H), 6.65 (d, 2H, J = 8.0 Hz), 6.55 (m, 2H), 6.37 (s, 1H), 6.63 (m, 2H), 6.11 (s, 1H), 5.85 5.55, 5.49, 5.40, 5.31 (3H, Im _{α} H4), 4.10 (s, 2H), 3.61, 3.60, 3.59, 3.57 (6H, NMe), 3.45 (s, 3H, COOMe), 3.37, 3.30 (Ph-OMe), 1.90 (m, 4H), 1.16 (m, 4H), -2.52, -2.54 (2H, porNH). MS (ES): calc. for C₈₉H₇₁N₁₆O₇ m/z 1533.5 (M+H)⁺, found 1534.0. $\lambda_{\max}(10^{-3}\epsilon, \text{M}^{-1}\text{cm}^{-1})$ 424 (478), 518 (60)

4b: ¹H NMR (CDCl₃): δ 8.86 (m, 9H), 8.45 (m, 3H), 7.98 (m, 8H), 7.70 (t, 1H, J = 8.0 Hz), 7.58 (m, 4H), 7.41 (m, 3H), 7.09 (t, 1H, J = 7.2 Hz), 6.97 (s, 1H), 6.93 (d, 1H, J = 8.0 Hz), 6.88 (d, 2H, J = 8.0 Hz), 6.79 (d, 1H, J = 4.4 Hz), 6.72 (s, 2H), 6.55 (m, 2H), 6.47 (d, 2H, J = 8.0 Hz), 6.26 (m, 3H), 6.16 (d, 1H, J = 7.2 Hz), 5.88, 5.57, 5.50, 5.43, 5.32 (3H, Im _{α} H4), 4.00 (2H, benzoylCH₂), 3.61, 3.60, 3.58, 3.55 (6H, NMe), 3.454, 3.449 (3H, COOMe), 3.34, 3.27 (3H, Ph-OMe), 2.984, 2.982 (1H, Alkynyl), 1.90 (m, 4H), 1.16 (m, 4H), -2.52, -2.54 (2H, porNH). MS (ES): calc. for C₉₀H₇₂N₁₆O₇ m/z 1489.6 (M+H)⁺, found 1489.7. $\lambda_{\max}(10^{-3}\epsilon, \text{M}^{-1}\text{cm}^{-1})$ 424 (475), 518 (41)

General procedures for saponification reaction of 3-4ab to 1-2ab

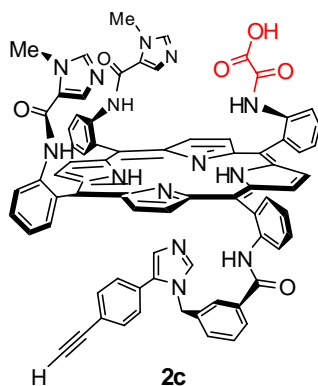
Porphyrin (**3-4ab**, 10 mg) was dissolved in MeOH/THF (10 mL, 1:1 vol). A solution of potassium hydroxide in water (1.0 g/mL, 5mL) was added. The mixture was stirred at room temperature for 2.0 h. The organic solvent was evaporated. The aqueous phase containing porphyrin was extracted with CH₂Cl₂ and washed with saturated NaHCO₃ solution. The organic extracts were dried (Na₂SO₄) and evaporated to give a purple solid. It was purified on chromatotron using 15% MeOH in NH₃ saturated CH₂Cl₂ solution. Yield: **1a** 9.3 mg (94%); **1b** 9.5 mg (96%), **2a** 8.9 mg (90%), **2b** 9.0 (91%)

1a: ¹H NMR (CDCl₃): the carboxylic acid proton is not assigned, δ 9.08 (d, 1H, J = 4.8 Hz), 8.96 (d, 1H, J = 4.8 Hz), 8.81 (m, 9H), 8.58 (d, 1H, J = 8.0 Hz), 8.22 (d, 1H, J = 7.2 Hz), 8.18 (d, 2H, J = 8.0 Hz), 8.02 (d, 1H, J = 7.2 Hz), 7.85 (m, 4H), 7.75 (t, 1H, J = 8.0 Hz), 7.54 (m, 5H), 7.35 (s, 1H), 7.20 (m, 2H), 7.09 (d, 1H, J = 8.0 Hz), 7.04 (d, 2H, J = 8.0 Hz), 6.98 (s, 1H), 6.94 (s, 1H), 6.83 (m, 2H), 6.78 (s, 1H), 6.69 (d, 2H, J = 8.0 Hz), 6.63 (d, 2H, J = 8.0 Hz), 6.27 (m, 4H), 6.11 (d, 1H, J = 7.6 Hz), 5.13 (s, 1H), 4.07 (s, 1H), 4.02 (m 2H), 3.64 (s, 3H), 3.48 (s, 3H), 1.22 (m, 8H), -2.50 (s, 2H). MS (ES): calc. for C₈₇H₆₇F₃N₁₆O₇ m/z 1505.5 (M+H)⁺, found 1505.7. HRMS (ES): calc. for C₈₇H₆₇F₃N₁₆O₇ m/z 1505.5409 (M+H)⁺, found 1505.5419. UV/Vis (CH₂Cl₂): $\lambda_{\max}(10^{-3}\epsilon, \text{M}^{-1}\text{cm}^{-1})$ 424 (460), 518(65)

1b: ^1H NMR (CDCl_3): the carboxylic acid proton is not assigned, δ 9.08 (d, 1H, $J = 4.8$ Hz), 8.95 (d, 1H, $J = 4.8$ Hz), 8.81 (m, 9H), 8.58 (d, 1H, $J = 8.4$ Hz), 8.22 (d, 1H, $J = 7.6$ Hz), 8.18 (d, 2H, $J = 8.0$ Hz), 8.02 (d, 1H, $J = 7.6$ Hz), 7.85 (m, 4H), 7.75 (t, 1H, $J = 8.0$ Hz), 7.54 (m, 5H), 7.35 (s, 1H), 7.18 (m, 2H), 7.08 (d, 2H, $J = 7.6$ Hz), 6.98 (m, 1H), 6.94 (s, 1H), 6.89 (d, 2H, $J = 8.0$ Hz), 6.82 (t, 1H, $J = 8.0$ Hz), 6.78 (s, 1H), 6.70 (m, 2H), 6.46 (d, 2H, $J = 8.0$ Hz), 6.26 (m, 3H), 6.20 (s, 1H), 6.15 (d, 1H, $J = 7.6$ Hz), 5.14 (s, 1H), 4.09 (s, 1H), 3.94 (m, 2H), 3.64 (s, 3H), 3.48 (s, 3H), 2.99 (s, 1H), 1.10 (m, 8H), -2.51 (s, 2H). MS (ES): calc. for $\text{C}_{88}\text{H}_{68}\text{N}_{16}\text{O}_7$ m/z 1461.5 ($\text{M}+\text{H}$) $^+$, found 1461.9. HRMS (ES): calc. for $\text{C}_{88}\text{H}_{68}\text{N}_{16}\text{O}_7$ m/z 1461.5535 ($\text{M}+\text{H}$) $^+$, found 1461.5552. λ_{max} ($10^{-3}\epsilon$, $\text{M}^{-1}\text{cm}^{-1}$) 425 (459), 518 (85)

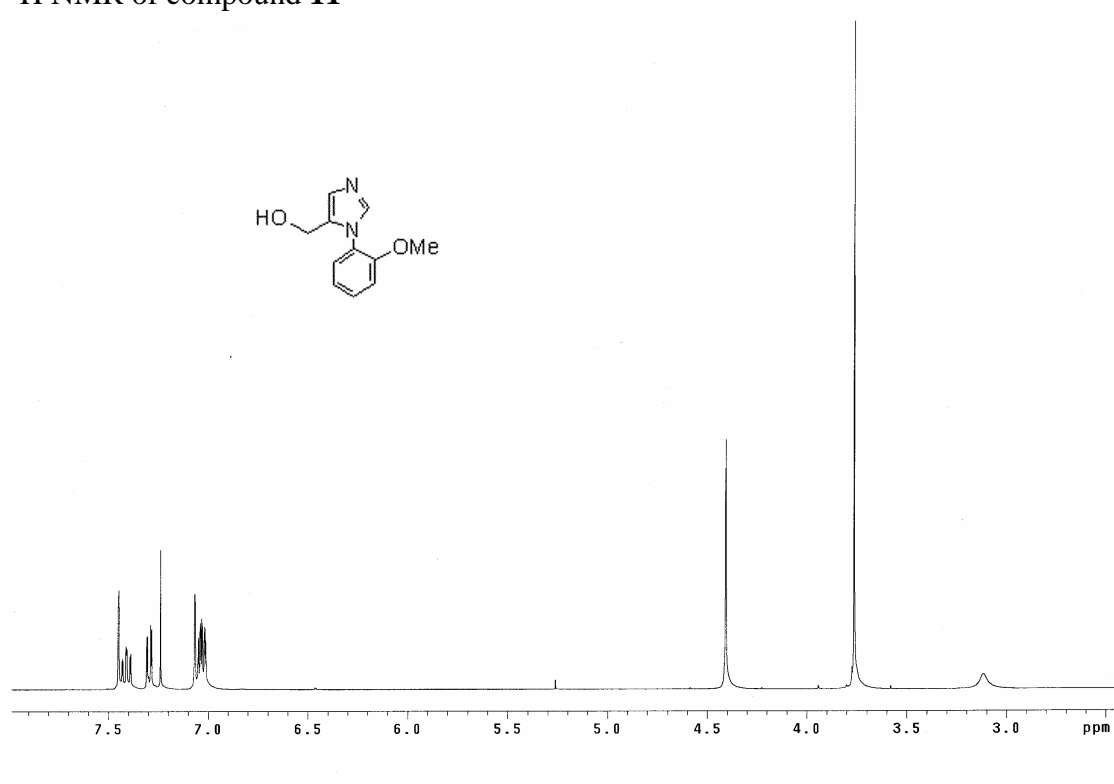
2a: ^1H NMR (CDCl_3): the carboxylic acid proton is not assigned, δ 8.90 (m, 11H), 8.57 (m, 2H), 8.34 (m, 2H), 8.14 (m, 2H), 7.98 (m, 1H), 7.85 (m, 4H), 7.70 (t, 1H, $J = 8.0$ Hz), 7.60 (m, 4H), 7.38 (m, 2H), 7.03 (m, 4H), 6.85 (s, 1H), 6.81 (s, 1H), 6.63 (m, 4H), 6.25 (m, 4H), 6.10 (m, 2H), 5.88 (s, 1H), 4.90, 4.83 (1H, $\text{Im}_\alpha\text{4H}$), 4.06 (2H, benzoyl CH_2), 3.73 (s, 3H, $\text{Im}_\alpha\text{NMe}$), 3.67, 3.62 (3H, $\text{Im}_\alpha\text{NMe}$), 3.23, 3.17 (3H, PhOMe), 2.01 (m, 2H), 1.67 (m, 2H), 0.95 (m, 4H), -2.55 (s, 2H). MS (ES): calc. for $\text{C}_{88}\text{H}_{69}\text{N}_{16}\text{O}_7$ m/z 1519.6 ($\text{M}+\text{H}$) $^+$, found 1520.1. HRMS (ES): calc. for $\text{C}_{88}\text{H}_{69}\text{N}_{16}\text{O}_7$ m/z 1519.5565 ($\text{M}+\text{H}$) $^+$, found 1519.5543. λ_{max} ($10^{-3}\epsilon$, $\text{M}^{-1}\text{cm}^{-1}$) 424 (480), 518 (74)

2b: ^1H NMR (CDCl_3): the carboxylic acid proton is not assigned, δ 8.89 (m, 11H), 8.57 (m, 2H), 8.35 (m, 2H), 8.15 (m, 2H), 7.98 (m, 1H), 7.86 (m, 4H), 7.63 (m, 5H), 7.36 (m, 2H), 7.04 (m, 2H), 6.88 (m, 2H), 6.77 (d, 1H, $J = 4.0$ Hz), 6.74 (s, 1H), 6.63 (m, 3H), 6.47 (d, 2H, $J = 8.0$ Hz), 6.21 (m, 5H), 6.10 (m, 2H), 5.88 (s, 1H), 4.95, 4.87 (1H, $\text{Im}_\alpha\text{4H}$), 3.95 (2H, benzoyl CH_2), 3.72 (s, 3H, $\text{Im}_\alpha\text{NMe}$), 3.66, 3.61 (3H, $\text{Im}_\alpha\text{NMe}$), 3.23, 3.17 (3H, PhOMe), 2.98 (s, 1H), 2.01 (m, 2H), 1.67 (m, 2H), 0.94 (m, 4H), -2.56 (s, 2H). MS (ES): calc. for $\text{C}_{89}\text{H}_{70}\text{N}_{16}\text{O}_7$ m/z 1475.6 ($\text{M}+\text{H}$) $^+$, found 1476.1. HRMS (ES): calc. for $\text{C}_{89}\text{H}_{70}\text{N}_{16}\text{O}_7$ m/z 1475.5692 ($\text{M}+\text{H}$) $^+$, found 1475.5702. λ_{max} ($10^{-3}\epsilon$, $\text{M}^{-1}\text{cm}^{-1}$) 424 (498), 518 (50)

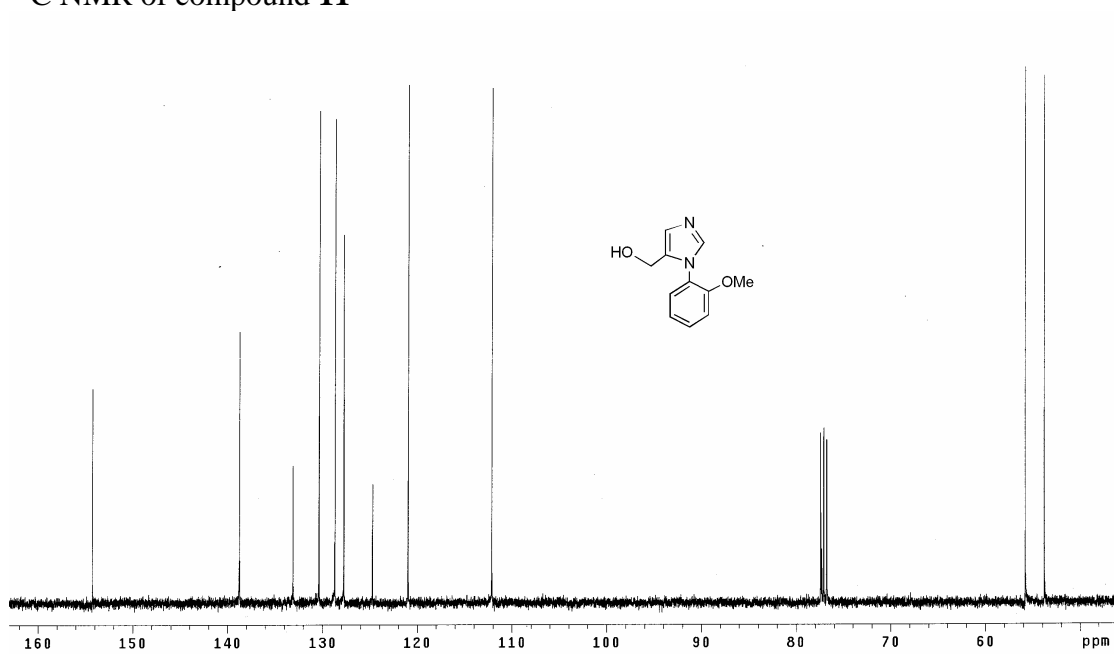


2c: ^1H NMR (CDCl_3): δ 8.77 (m, 11H), 8.45 (d, 1H, $J = 7.0$ Hz), 8.38 (s, 1H), 8.16 (d, 1H, $J = 6.0$ Hz), 8.04 (d, 1H, $J = 6.0$ Hz), 7.81 (m, 7H), 7.57 (q, 2H, $J = 6.0$ Hz), 7.50 (m, 3H), 6.86 (d, 2H, $J = 6.4$ Hz), 6.84 (s, 2H), 6.41 (d, 2H, $J = 6.4$ Hz), 6.28 (t, 1H, $J = 6.4$ Hz), 6.26 (d, 1H, $J = 6.4$ Hz), 6.14 (d, 1H, $J = 6.4$ Hz), 6.08 (s, 1H), 5.85 (s, 1H), 5.67 (s, 1H), 3.82 (s, 2H), 3.52 (s, 6H), 3.45 (s, 3H), 2.99 (s, 1H), -2.63 (s, 2H). MS (ES): calc. for $\text{C}_{75}\text{H}_{54}\text{N}_{14}\text{O}_6$ m/z 1247.5 ($\text{M}+\text{H}$) $^+$, found 1247.7. λ_{max} ($10^{-3}\epsilon$, $\text{M}^{-1}\text{cm}^{-1}$) 424 (457), 518 (46)

¹H NMR of compound **11**



¹³C NMR of compound **11**

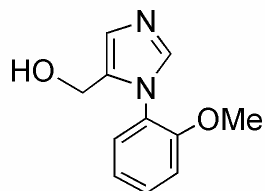
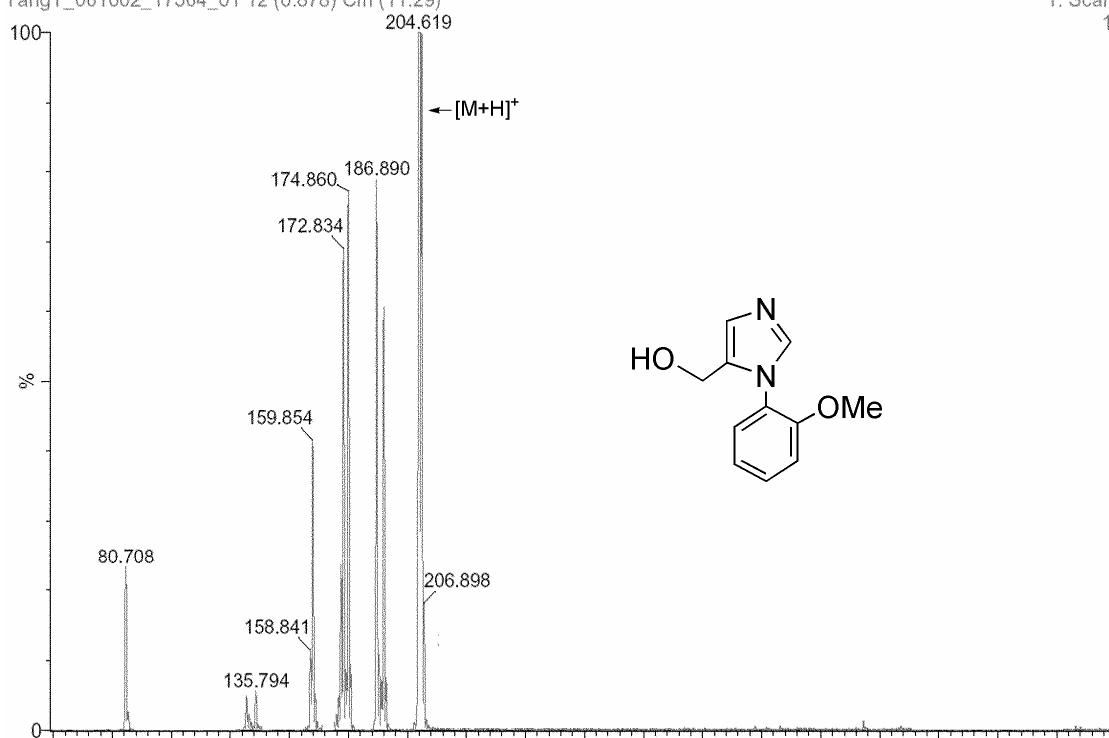


LRMS of compound 11

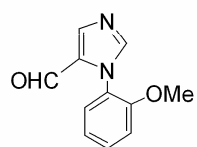
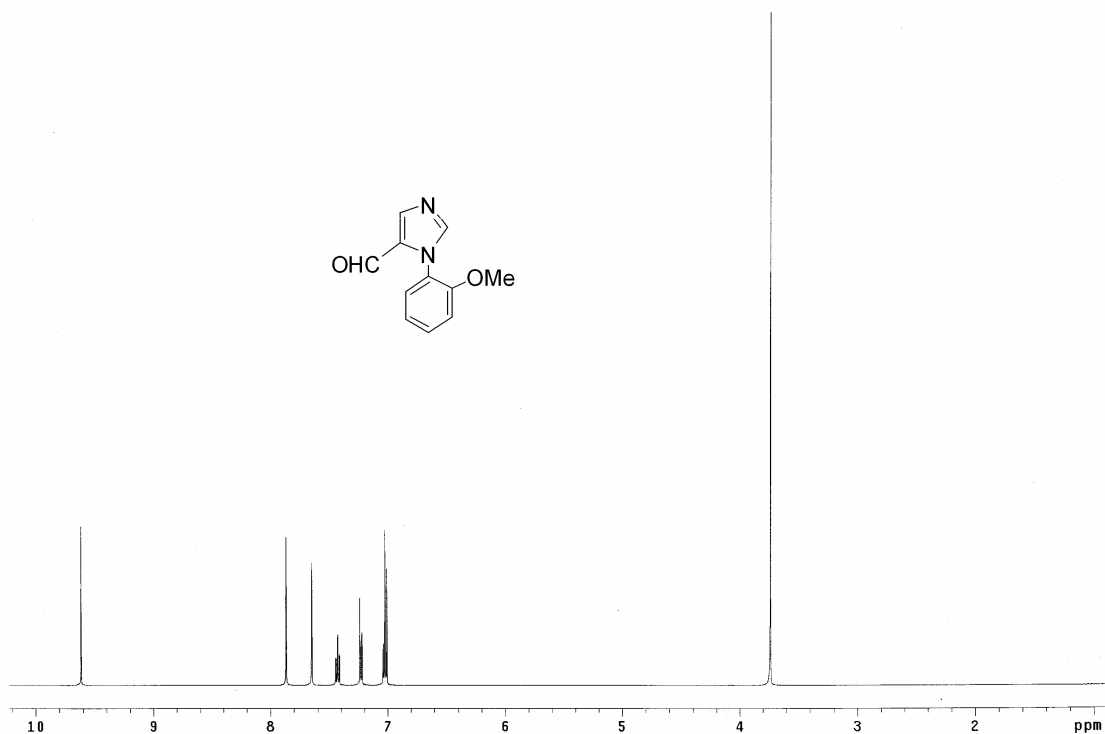
YY-III-81

YangY_061002_17564_01 12 (0.878) Cm (11:29)

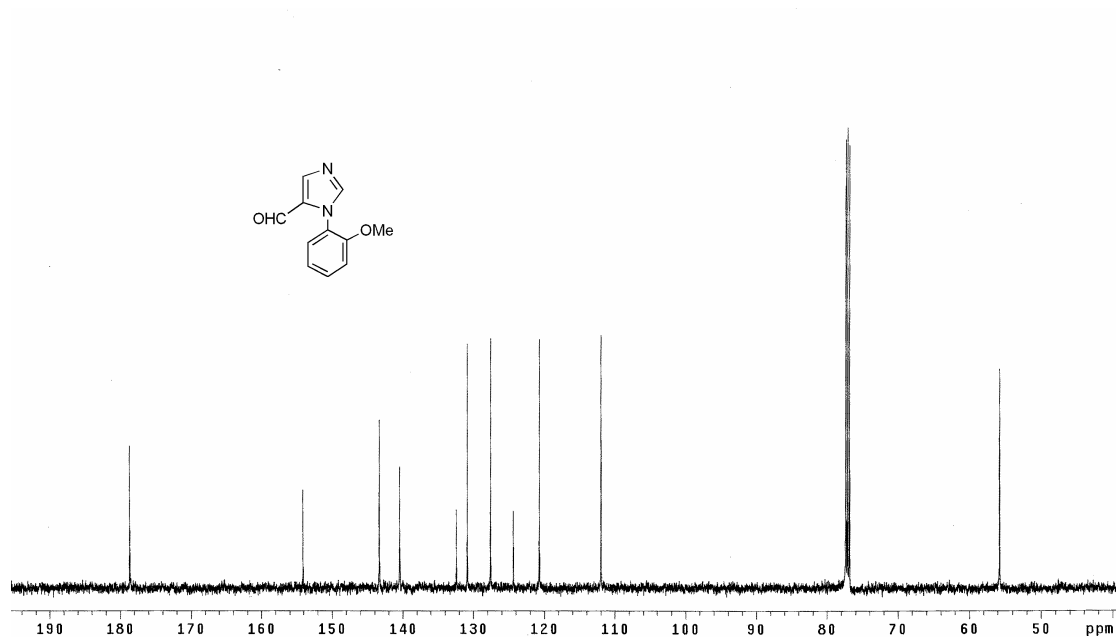
1: Scan ES+
1.34e6



¹H NMR of compound 12



¹³C NMR of compound **12**

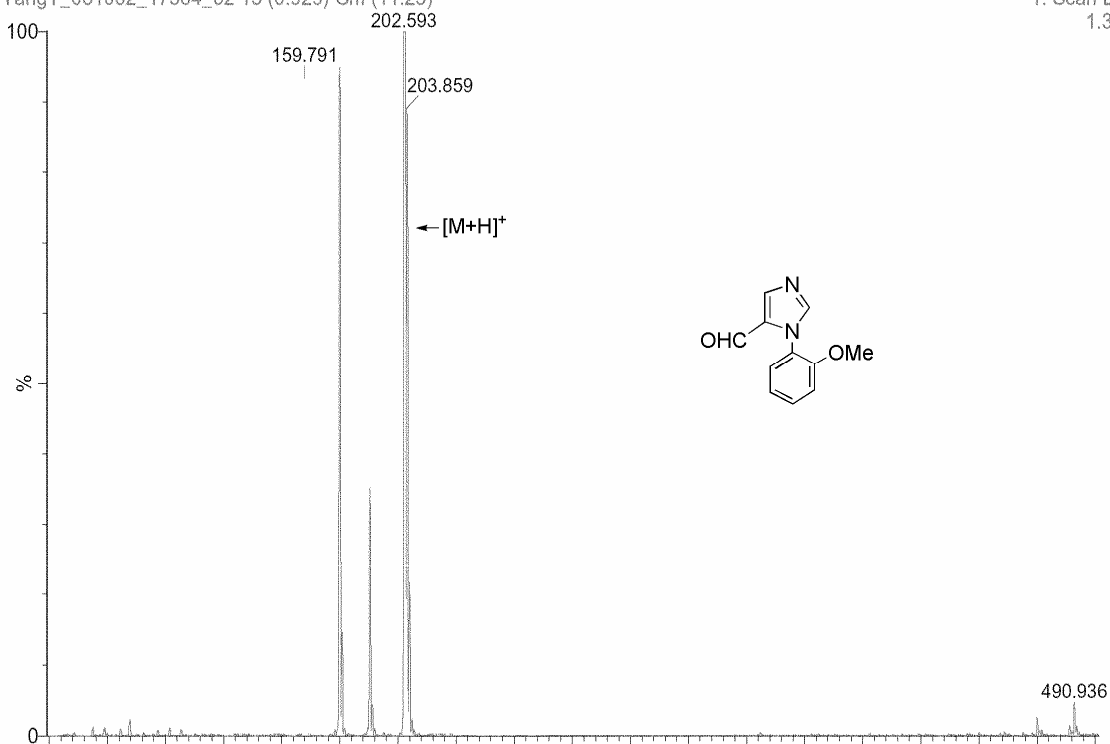


LRMS of compound **12**

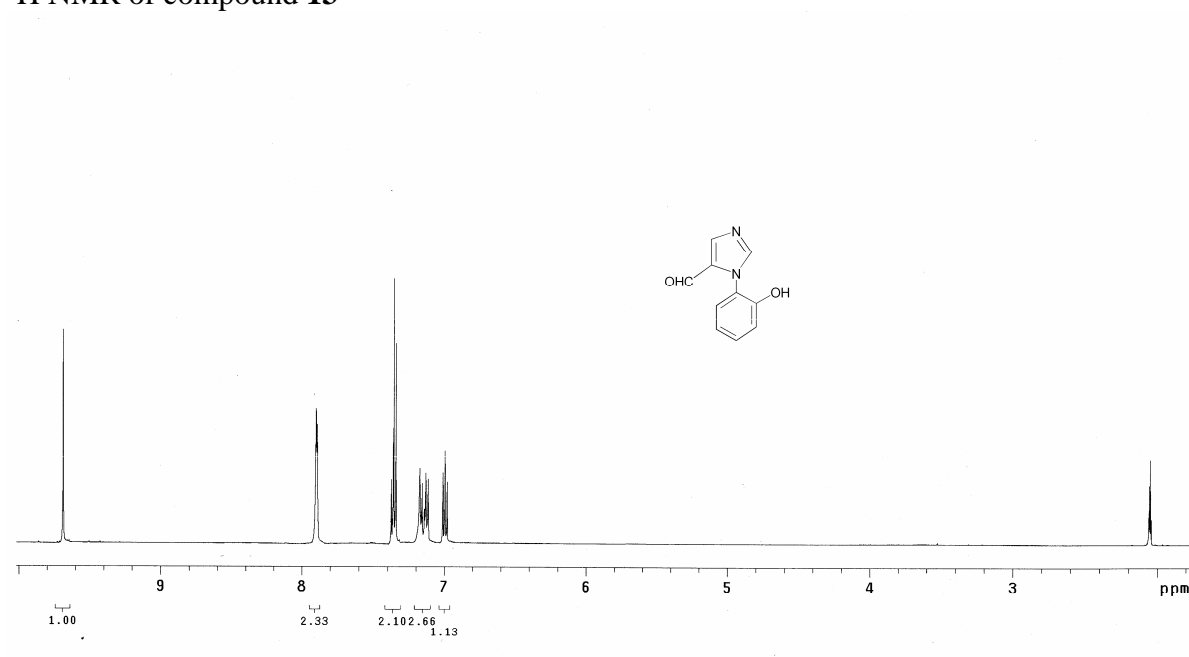
YY-III-83

YangY_061002_17564_02 13 (0.929) Cm (11:23)

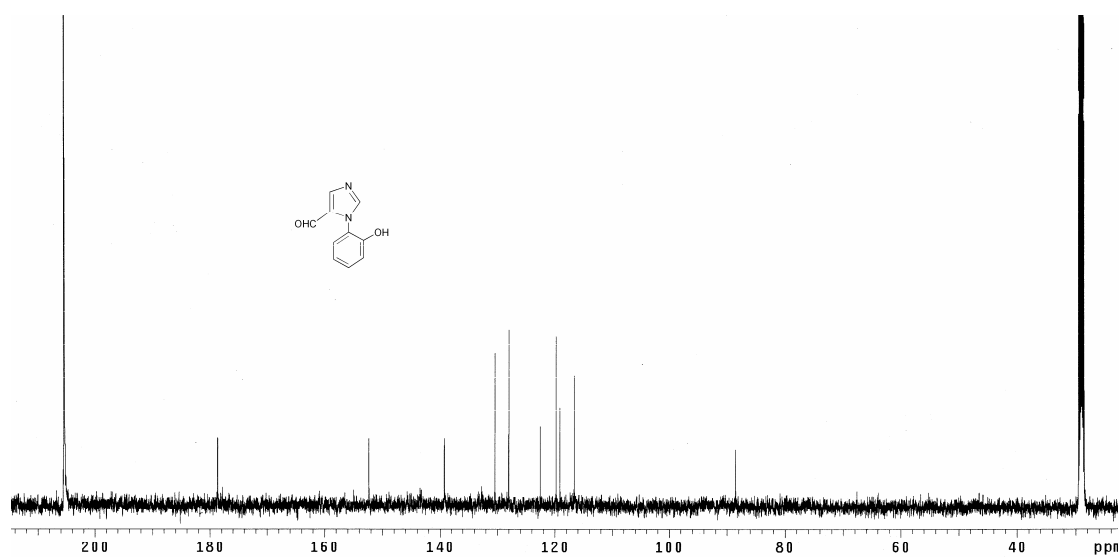
1: Scan ES+
1.34e8



¹H NMR of compound **13**



¹³C NMR of compound **13**

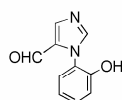
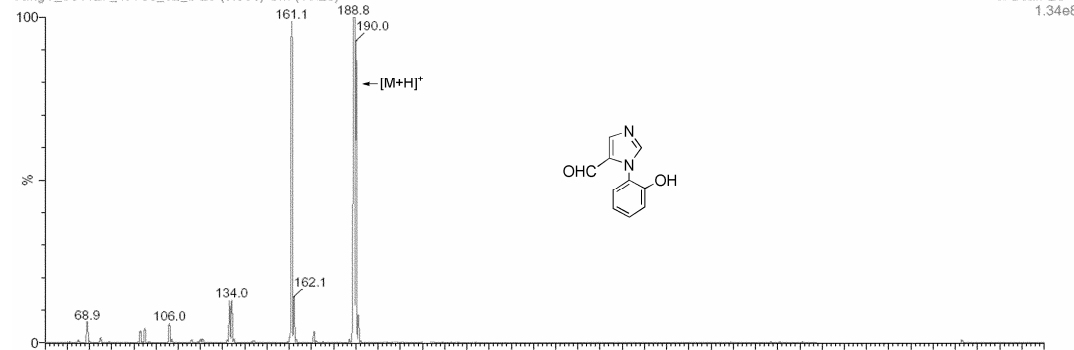


LRMS of compound **13**

YY-IV-30-F3

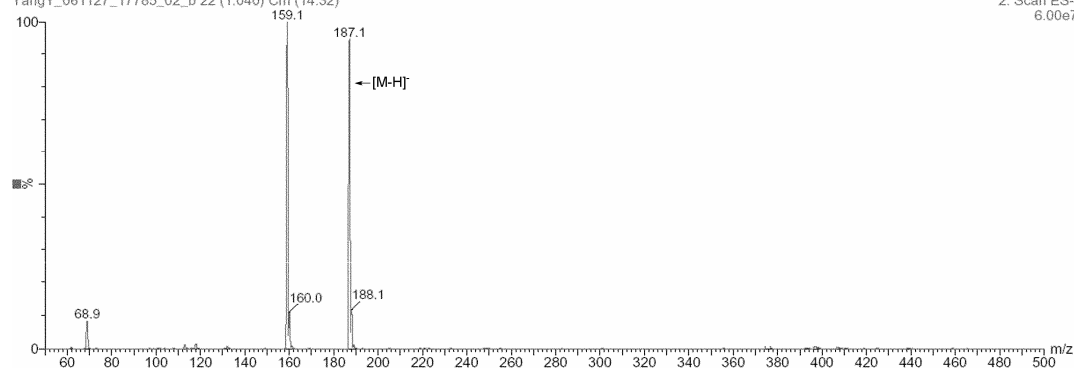
YangY_061127_17785_02_b 20 (0.956) Cm (13:28)

1: Scan ES+
1.34e8

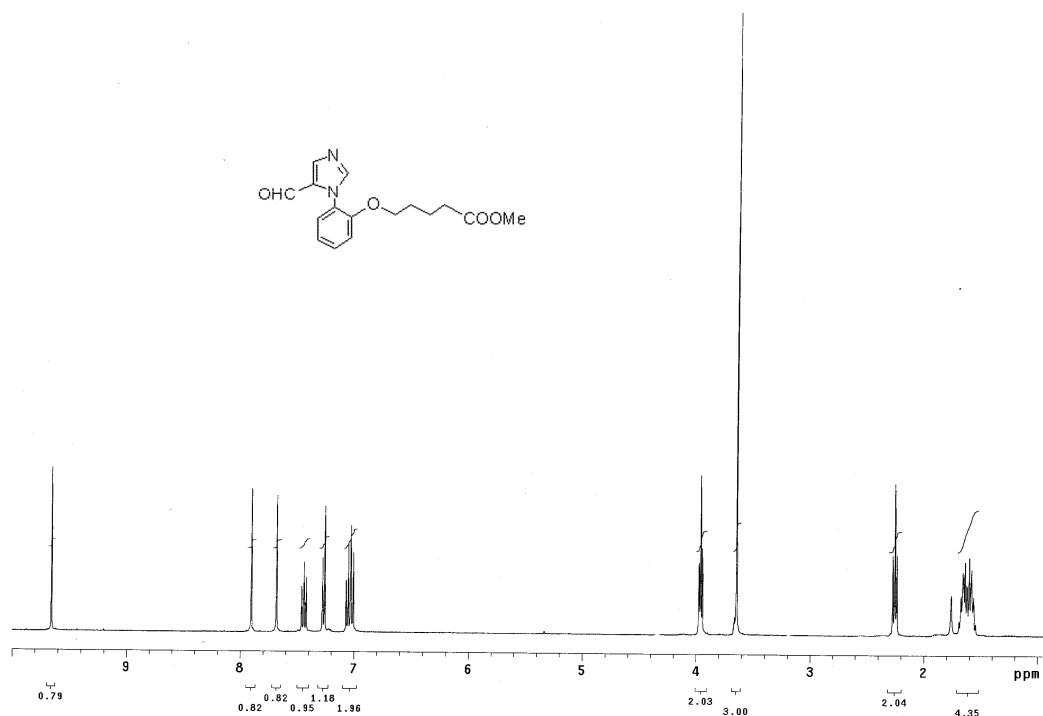
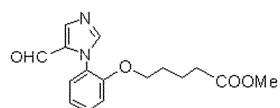


YangY_061127_17785_02_b 22 (1.040) Cm (14:32)

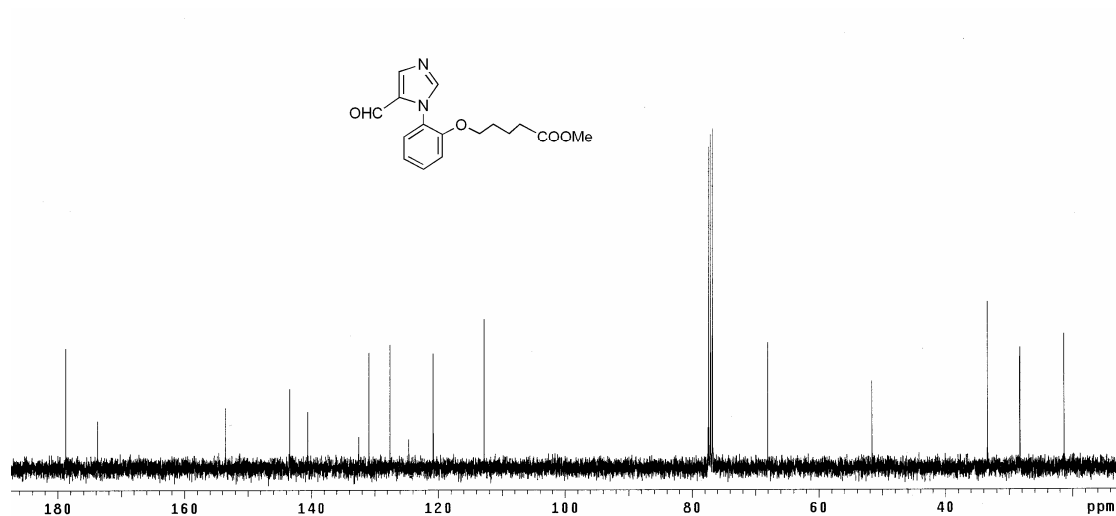
2: Scan ES-
6.00e7



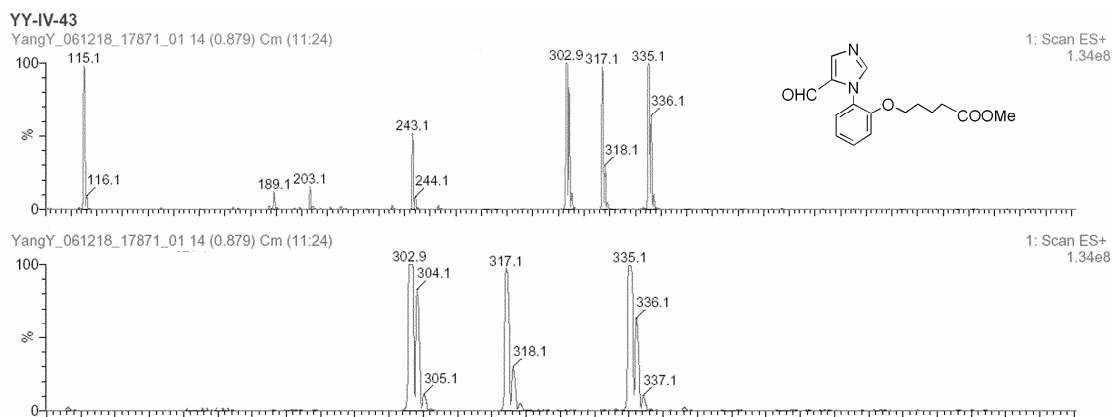
^1H NMR of compound **14**



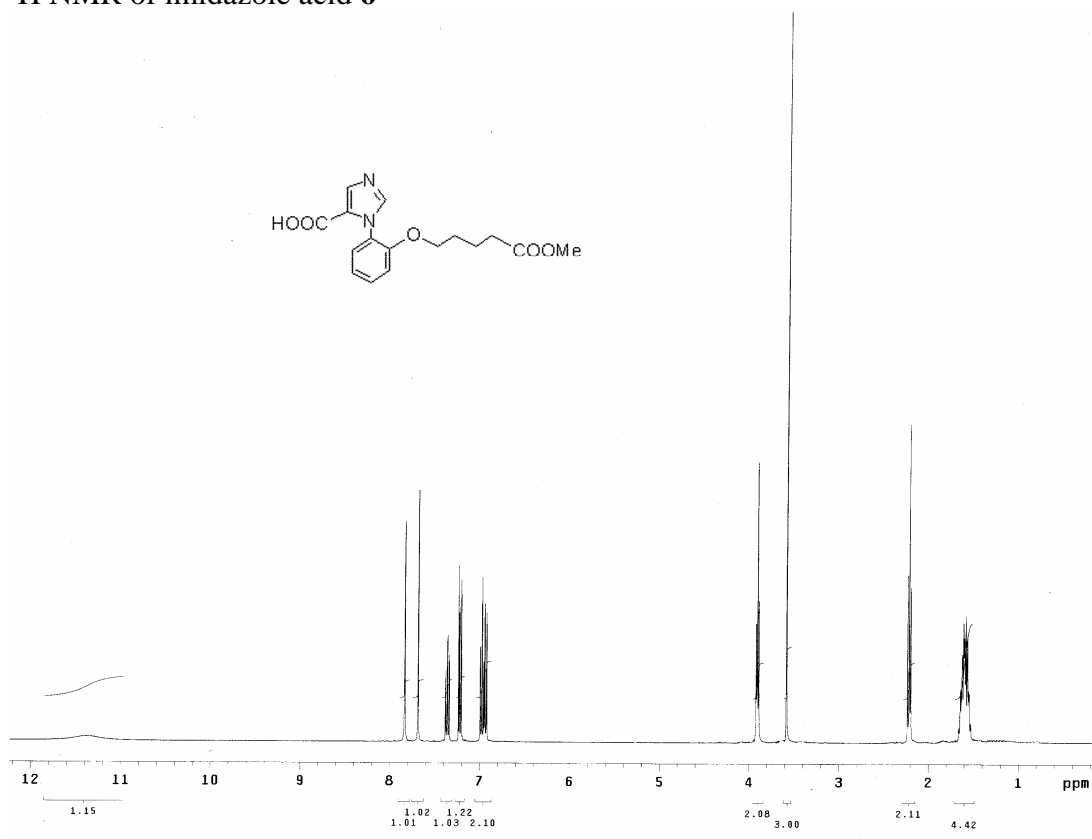
¹³C NMR of compound **14**



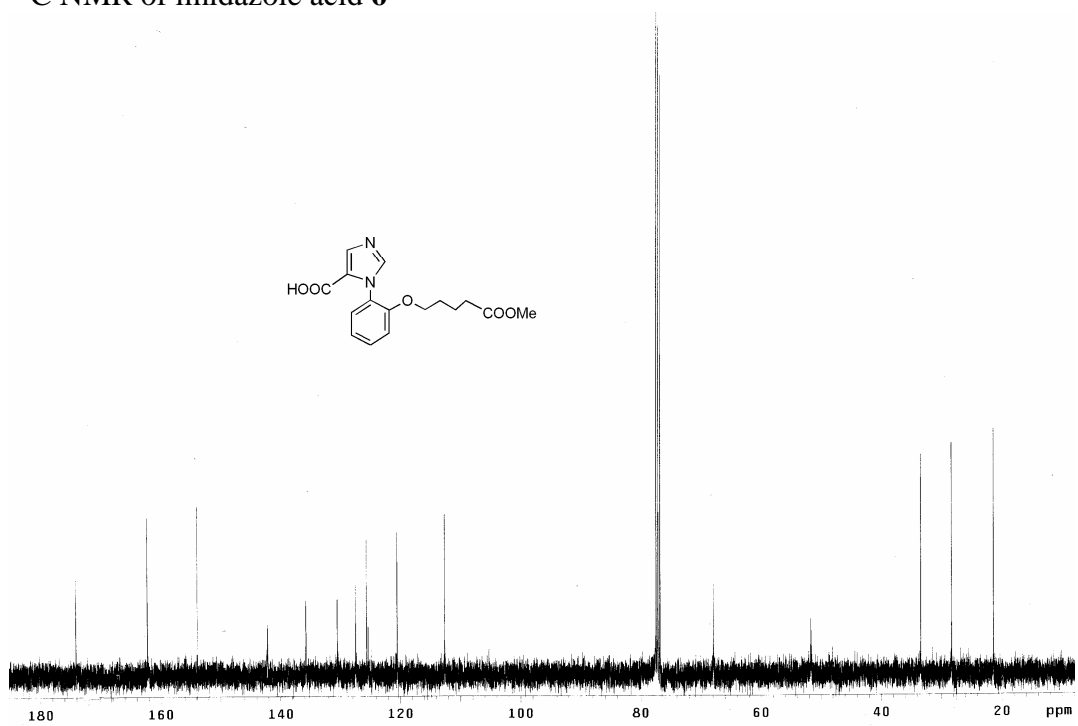
LRMS of compound **14**



¹H NMR of imidazole acid **6**



¹³C NMR of imidazole acid **6**



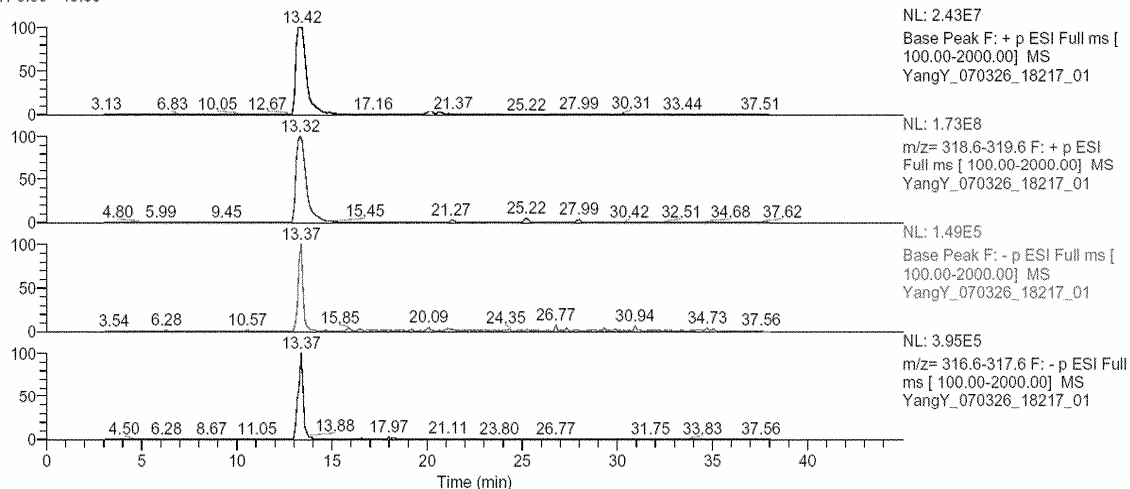
HPLC-MS of imidazole acid **6** (wavelength for HPLC detection is 254 nm)

D:\Data-LCQ2\...\YangY_070326_18217_01

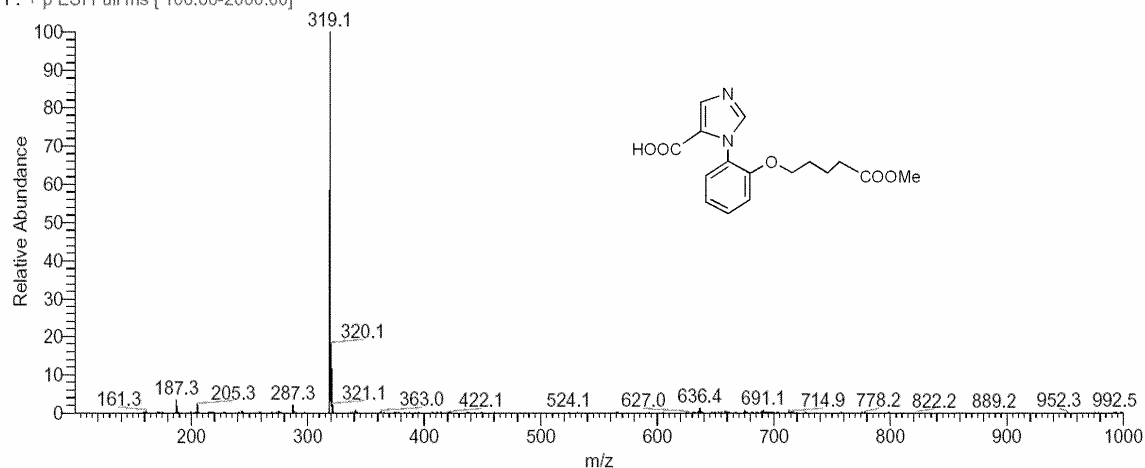
03/27/07 02:53:39 AM

acidester1

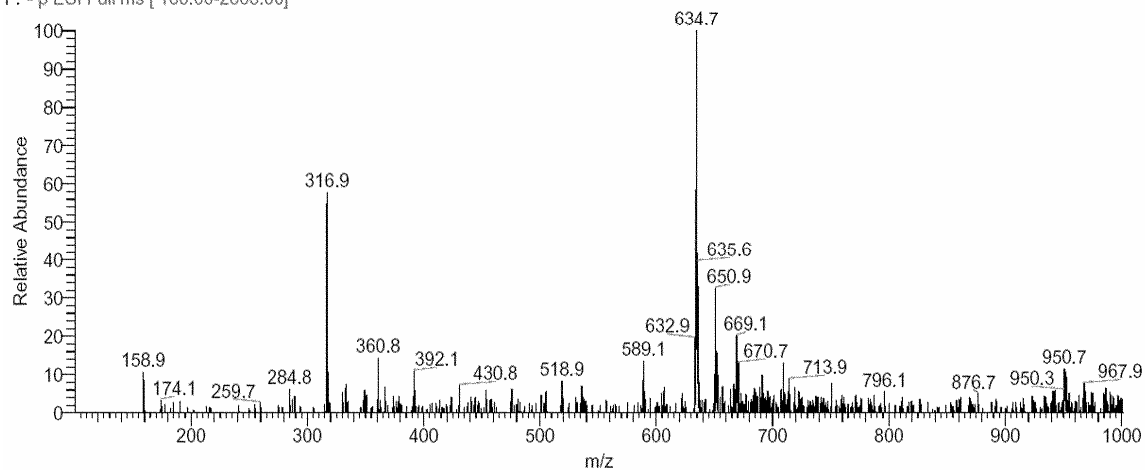
RT: 0.00 - 45.00



YangY_070326_18217_01 #306-322 RT: 13.03-13.83 AV: 9 NL: 1.56E7
F: + p ESI Full ms [100.00-2000.00]



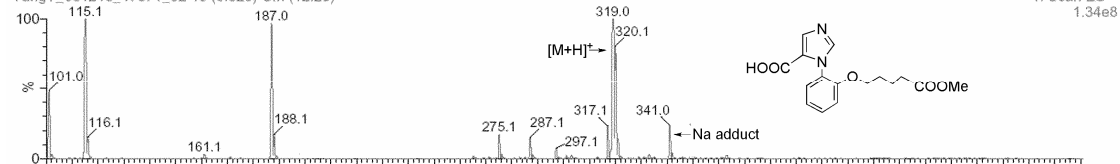
YangY_070326_18217_01 #309-316 RT: 13.18-13.47 AV: 4 NL: 8.50E4
F: - p ESI Full ms [100.00-2000.00]



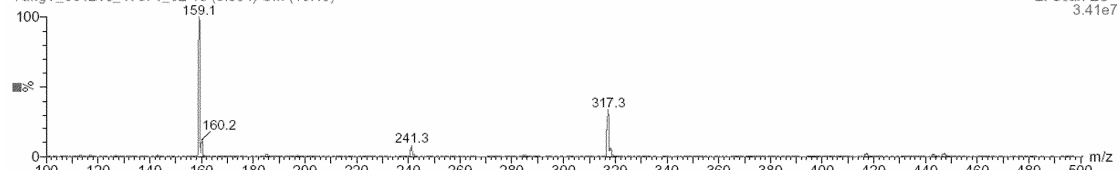
LRMS spectrum of imidazole acid **6**

YY-49-IV

YangY_061218_17871_02 15 (0.929) Cm (12:25)

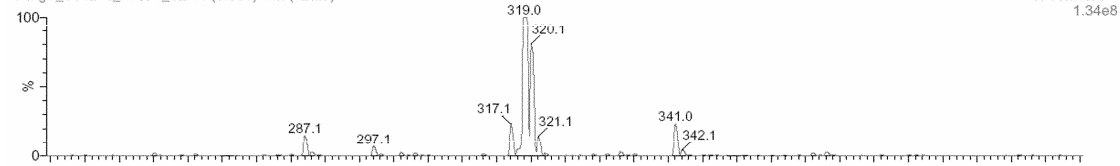


YangY_061218_17871_02 15 (0.954) Cm (13:19)

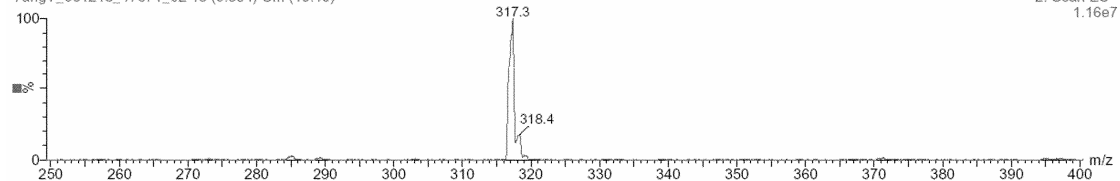


YY-49-IV

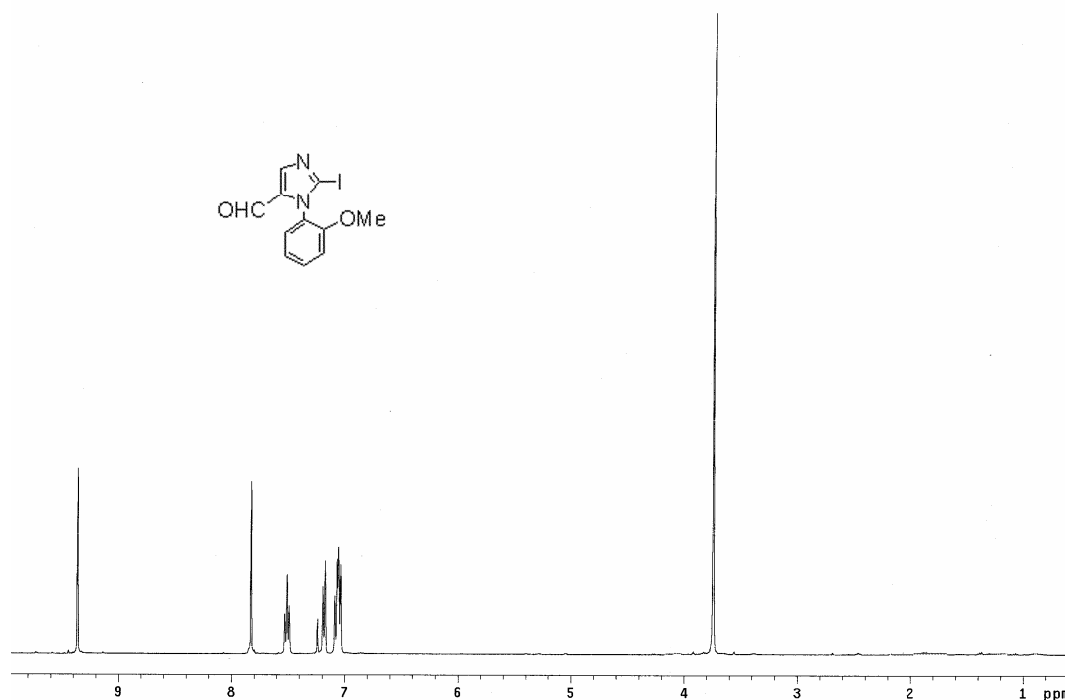
YangY_061218_17871_02 15 (0.929) Cm (12:25)



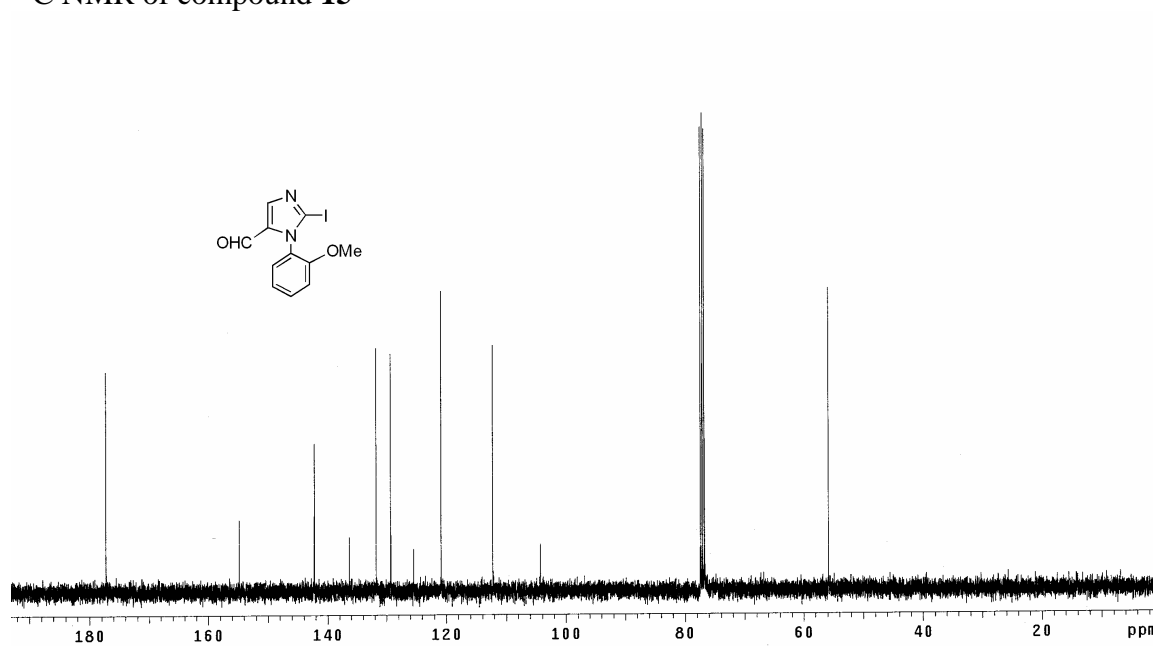
YangY_061218_17871_02 15 (0.954) Cm (13:19)



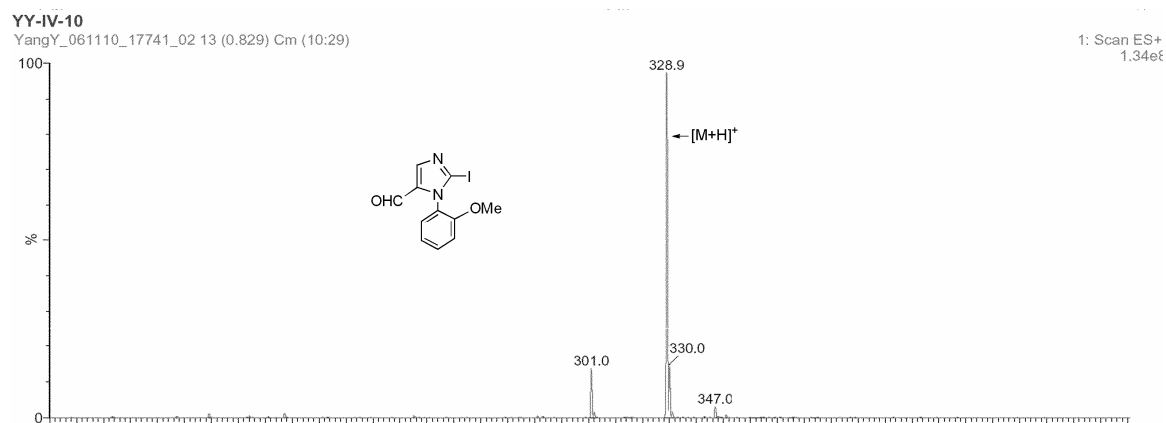
¹H NMR of compound **15**



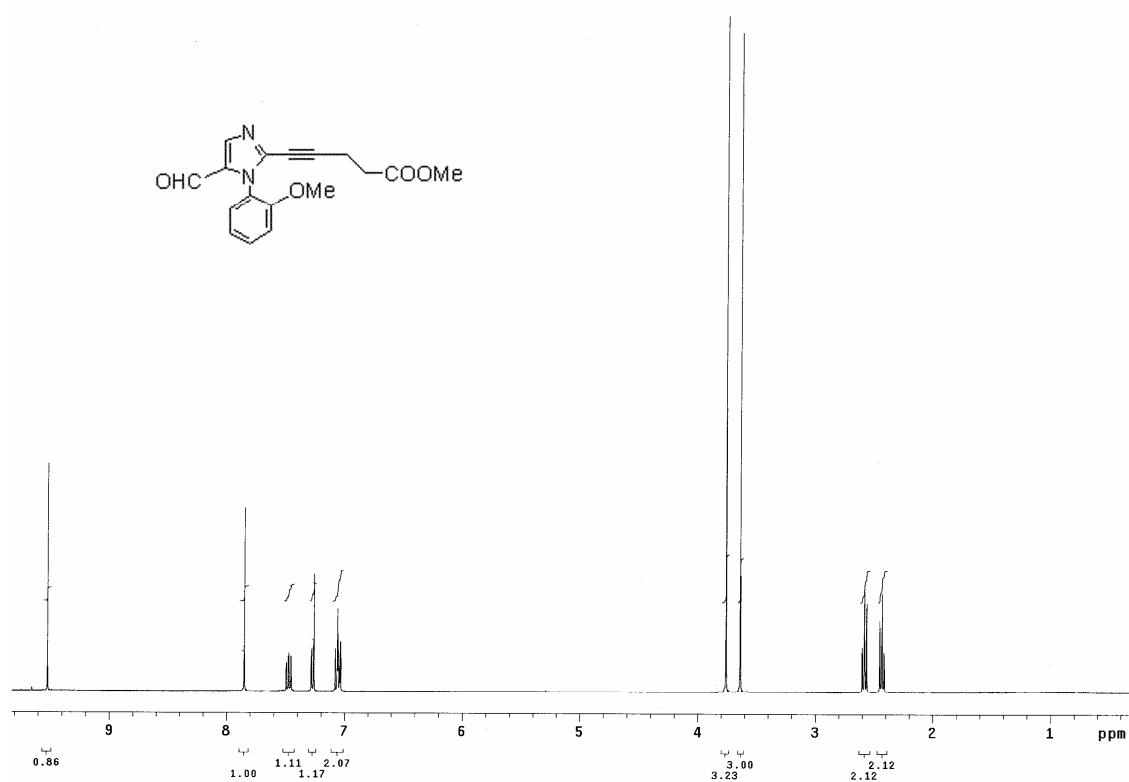
¹³C NMR of compound **15**



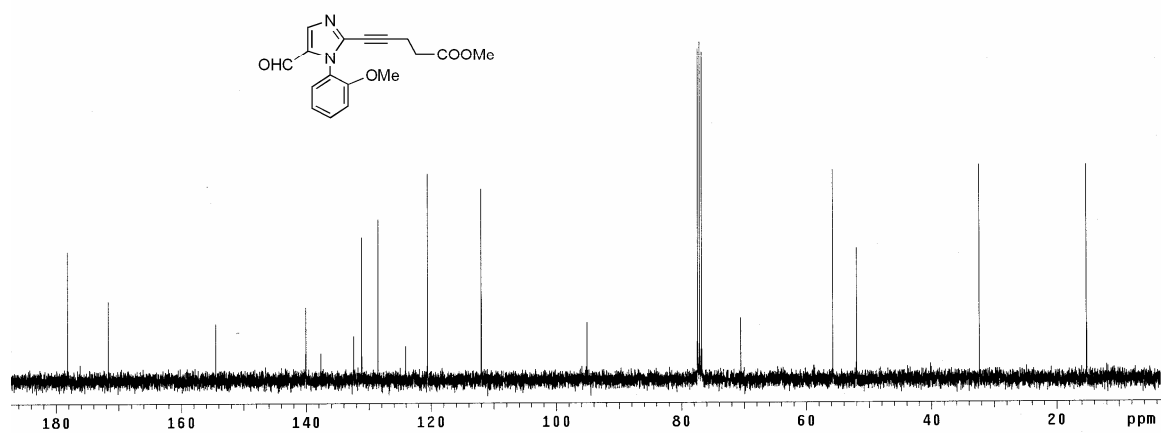
LRMS of compound **15**



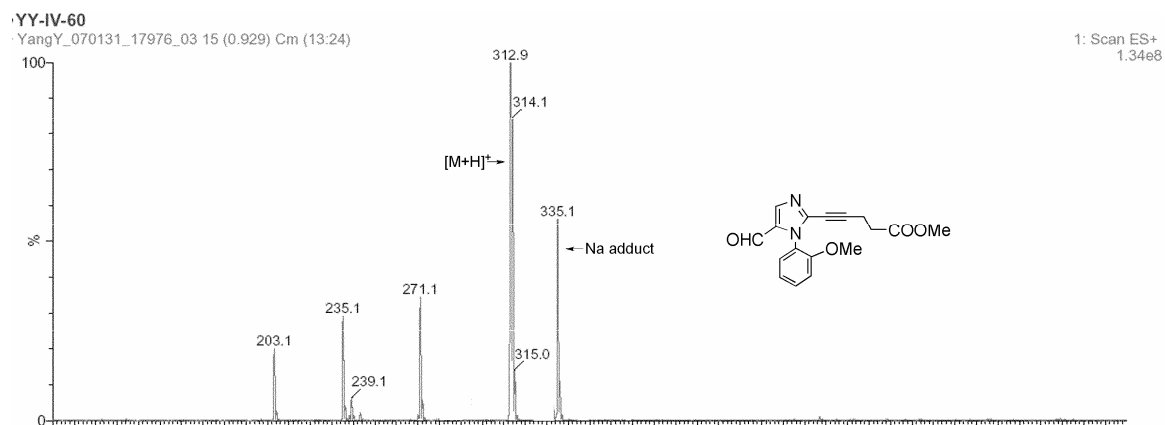
¹H NMR of compound **16**



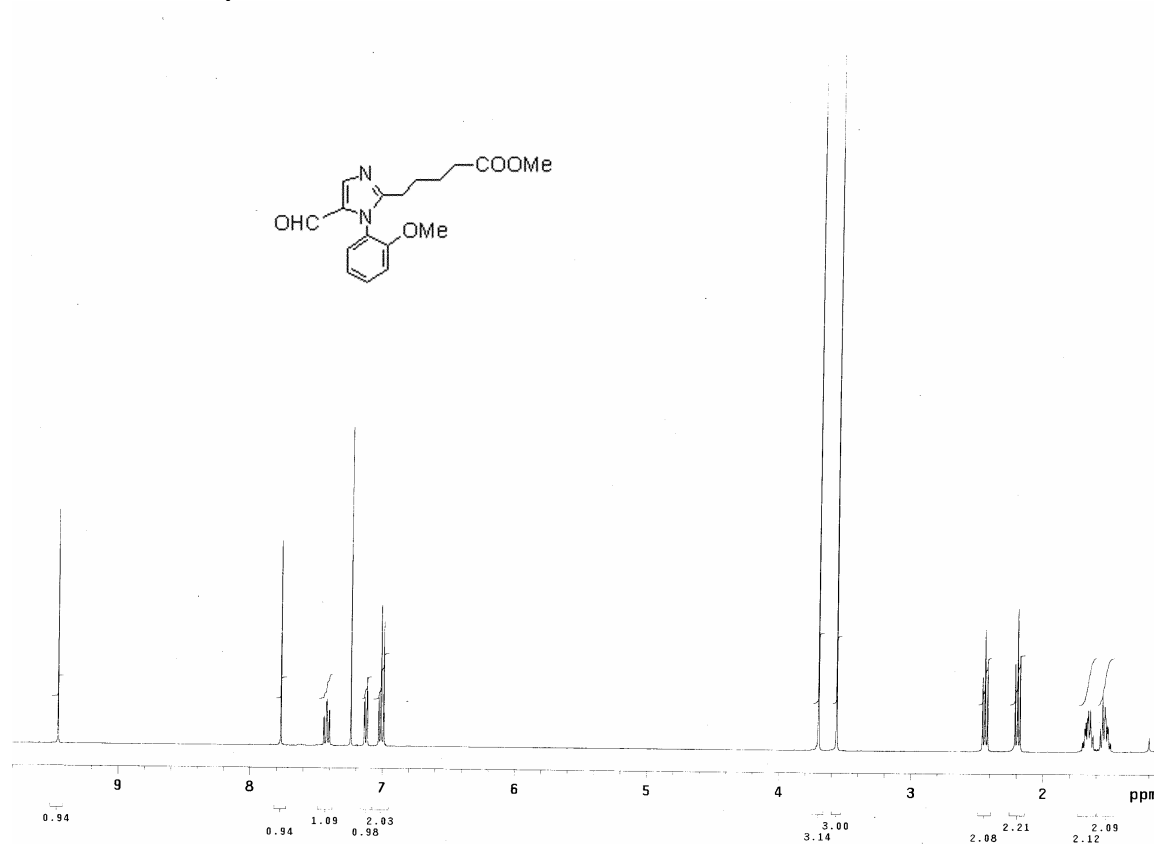
¹³C NMR of compound **16**



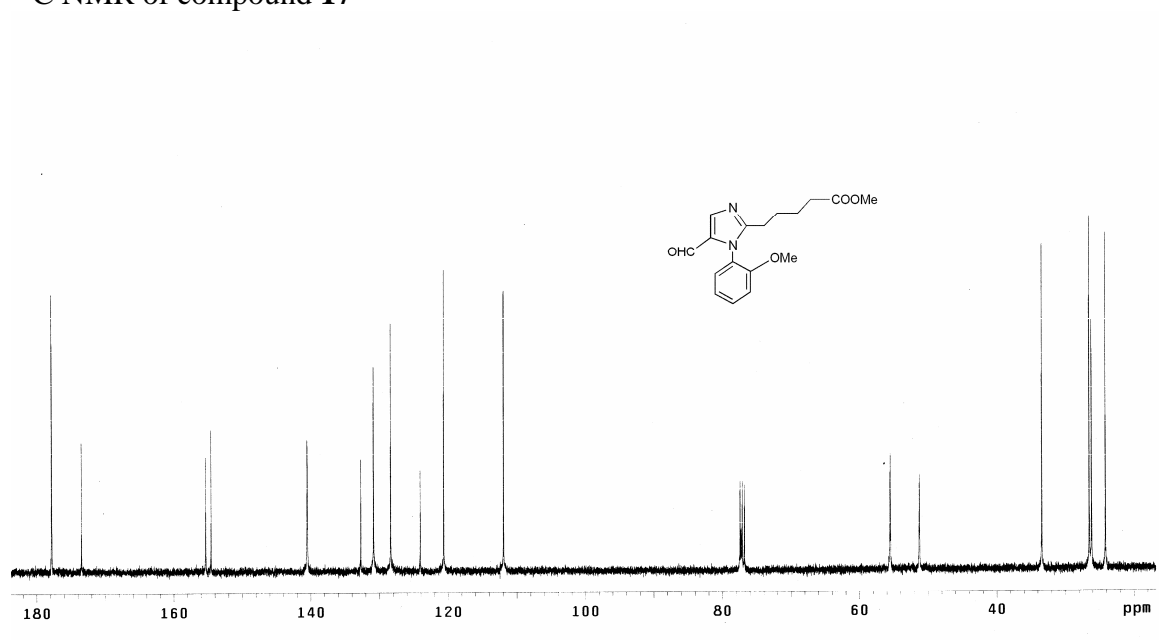
LRMS of compound **16**



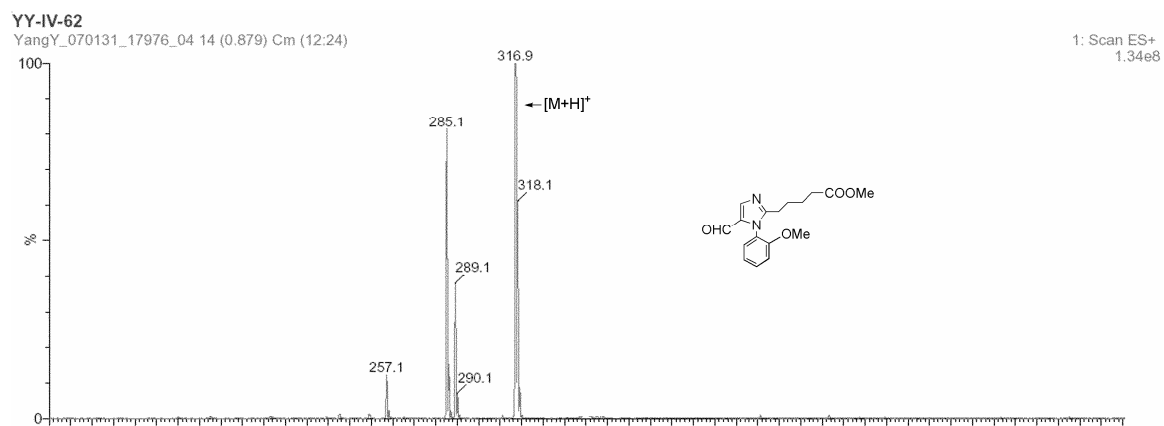
^1H NMR of compound **17**



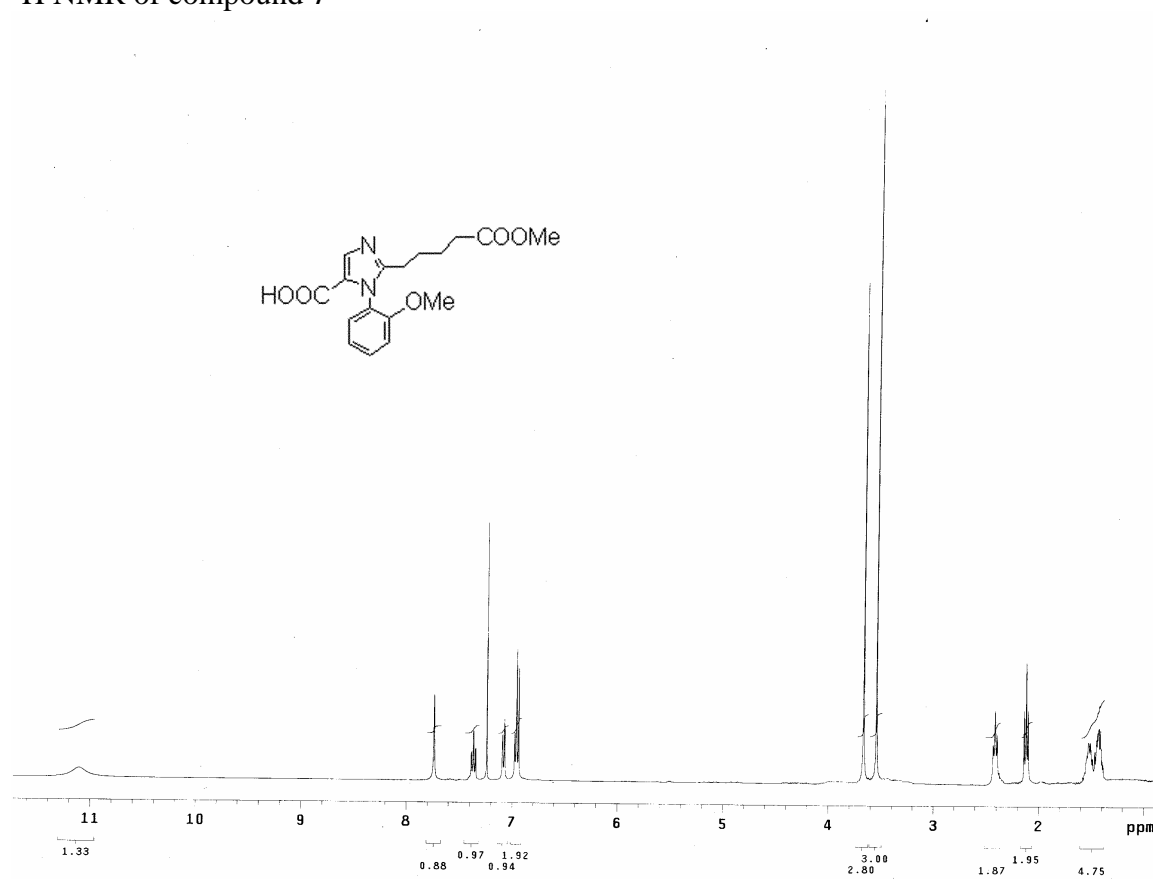
^{13}C NMR of compound **17**



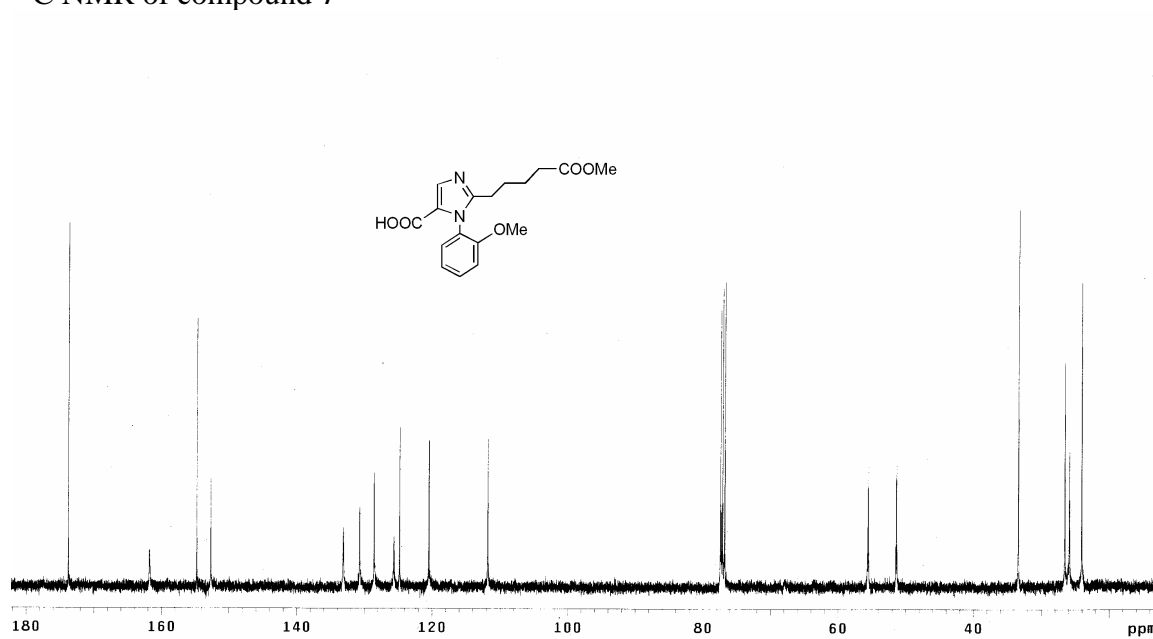
LRMS of compound **17**



¹H NMR of compound **7**



¹³C NMR of compound **7**



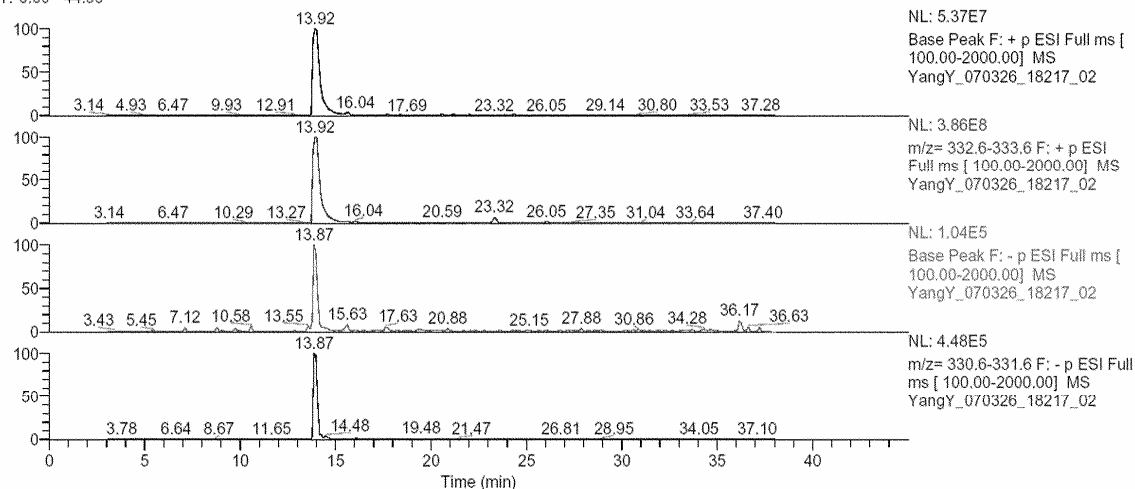
HPLC-MS of compound **7** (wavelength for HPLC detection is 254 nm)

D:\Data-LCQ2\...\YangY_070326_18217_02

03/27/07 04:25:30 AM

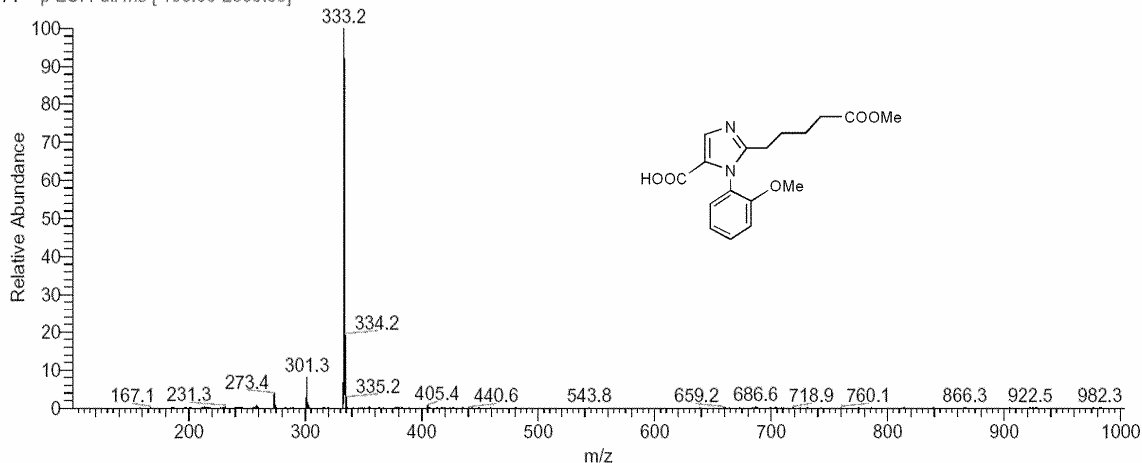
acidester2

RT: 0.00 - 44.99



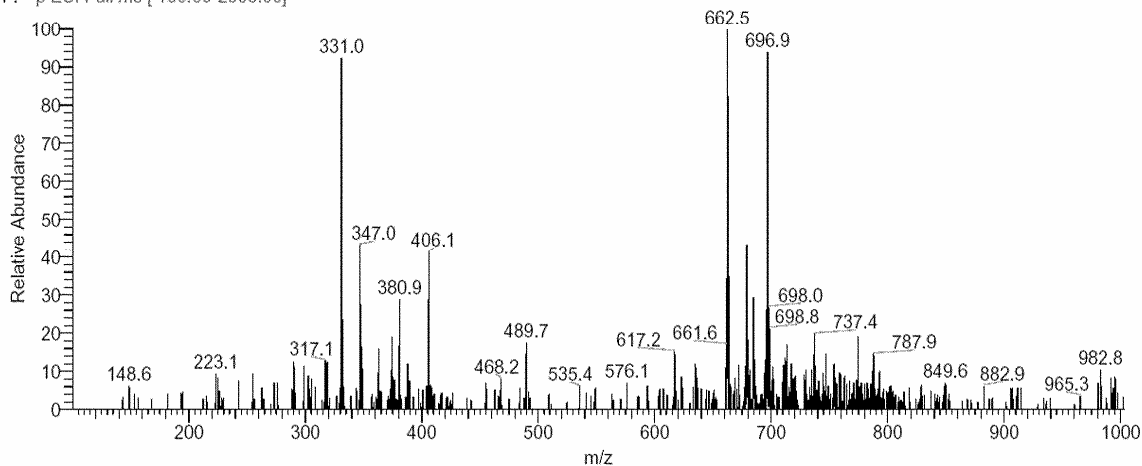
YangY_070326_18217_02 #320-331 RT: 13.83-14.33 AV: 6 NL: 3.63E7

F: + p ESI Full ms [100.00-2000.00]



YangY_070326_18217_02 #320-326 RT: 13.87-14.07 AV: 3 NL: 5.78E4

F: - p ESI Full ms [100.00-2000.00]

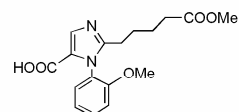
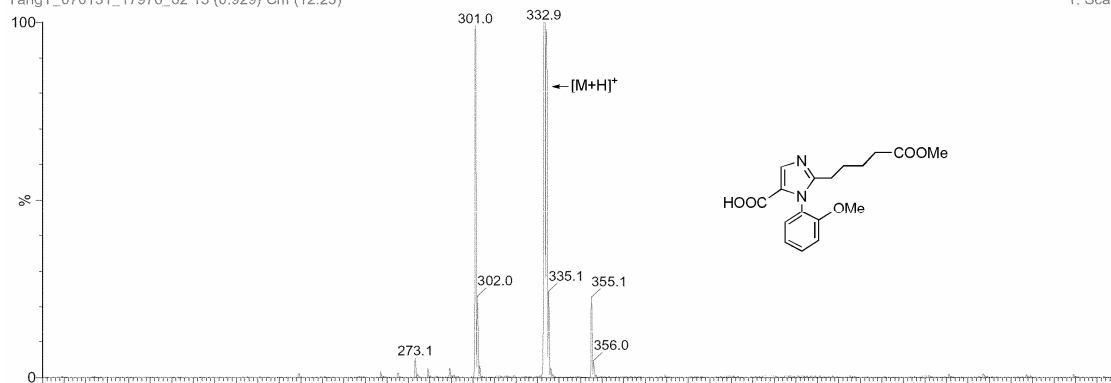


LRMS of compound 7

YY-IV-70

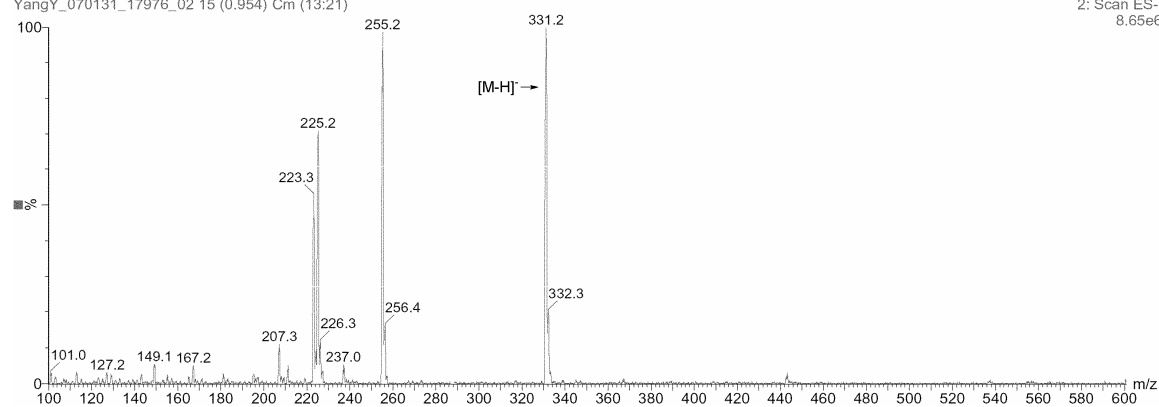
YangY_070131_17976_02 15 (0.929) Cm (12:25)

1: Scan ES+
1.34e8

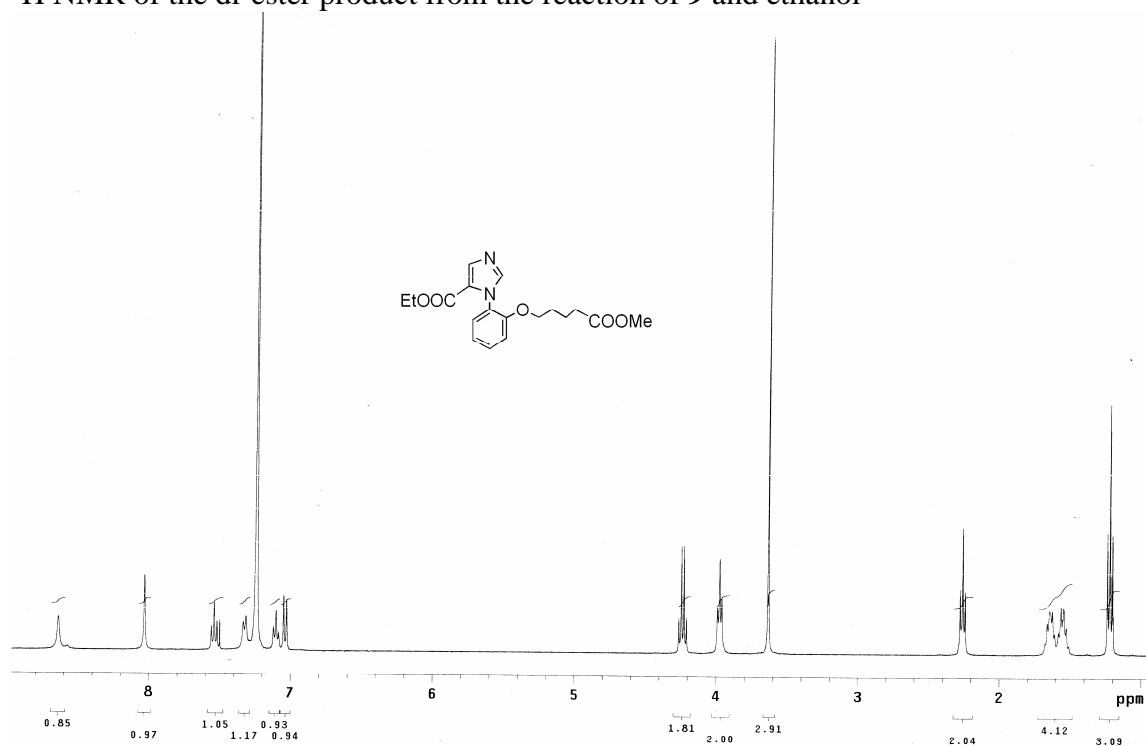


YangY_070131_17976_02 15 (0.954) Cm (13:21)

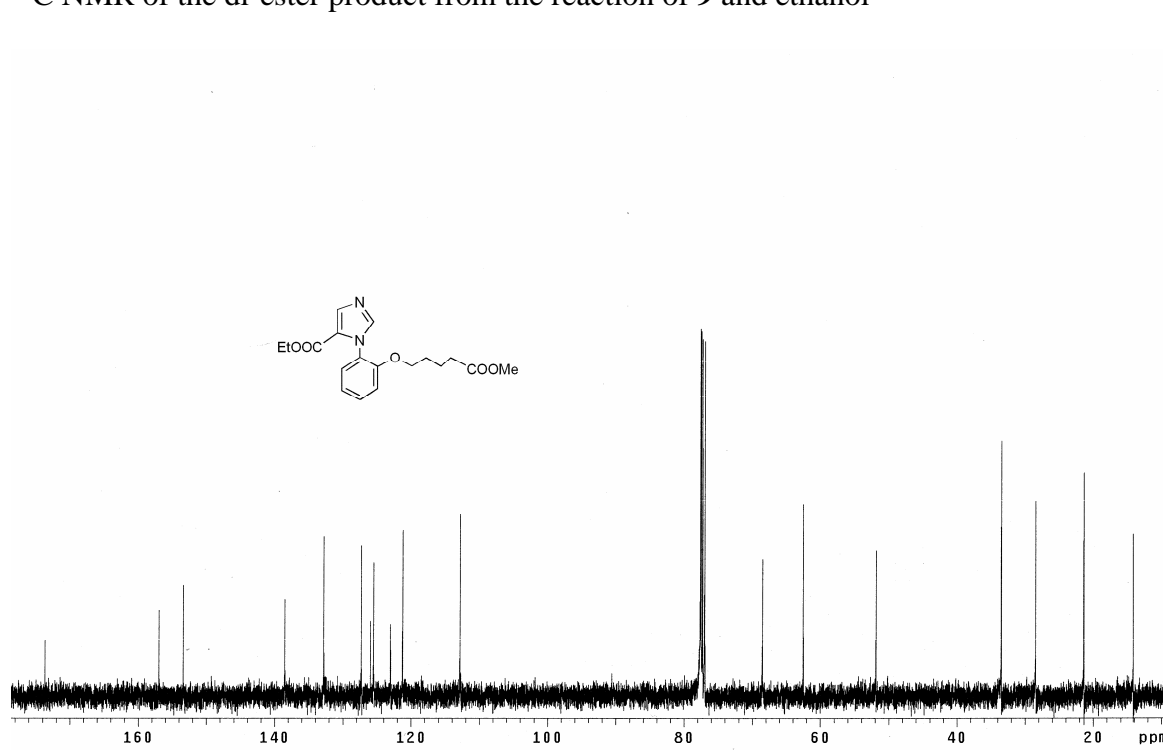
2: Scan ES-
8.65e6



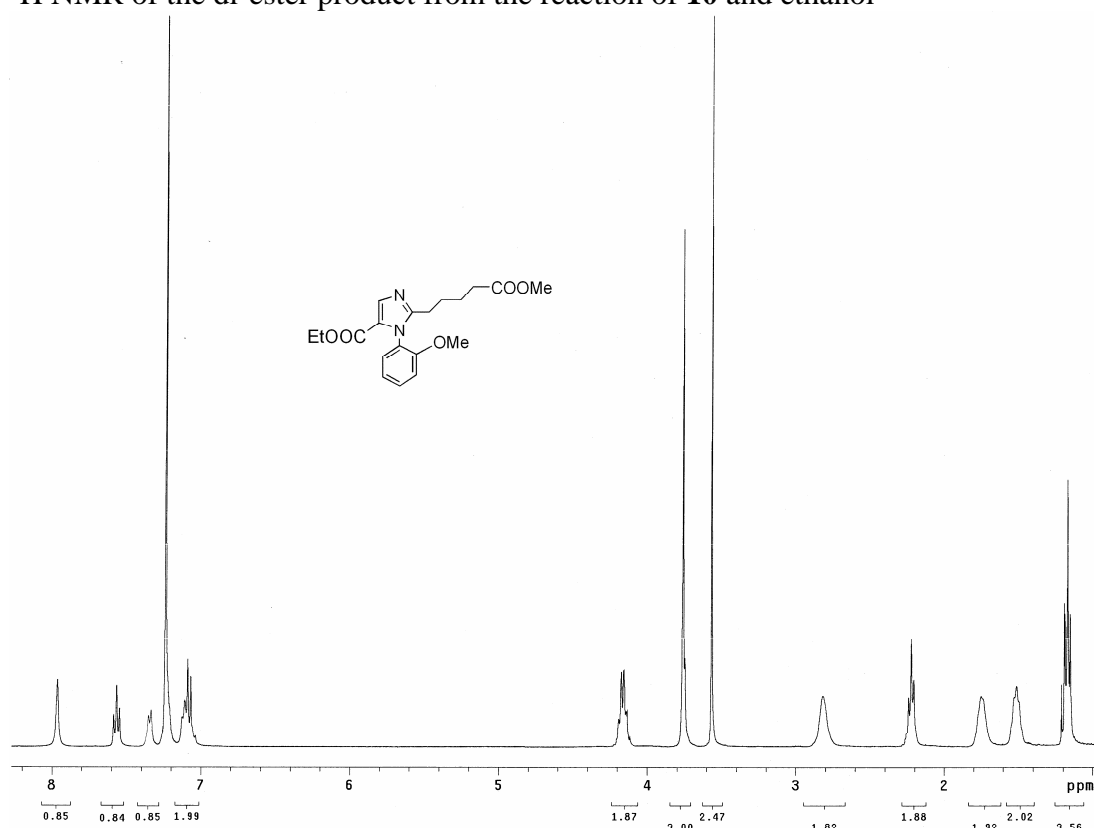
^1H NMR of the di-ester product from the reaction of **9** and ethanol



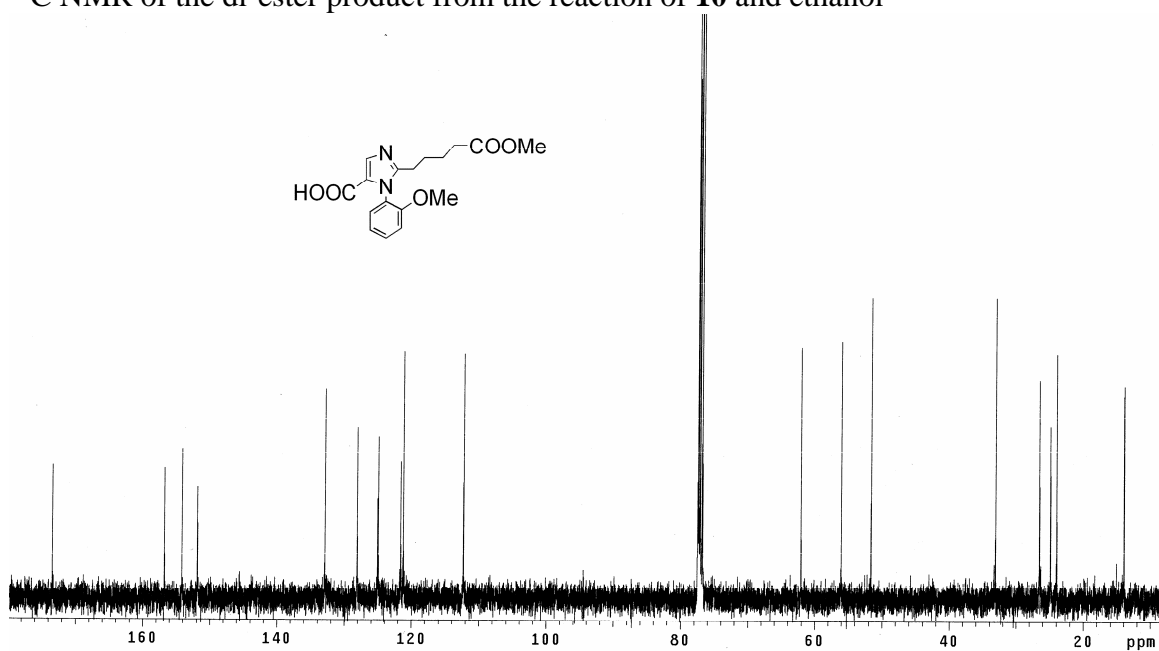
^{13}C NMR of the di-ester product from the reaction of **9** and ethanol



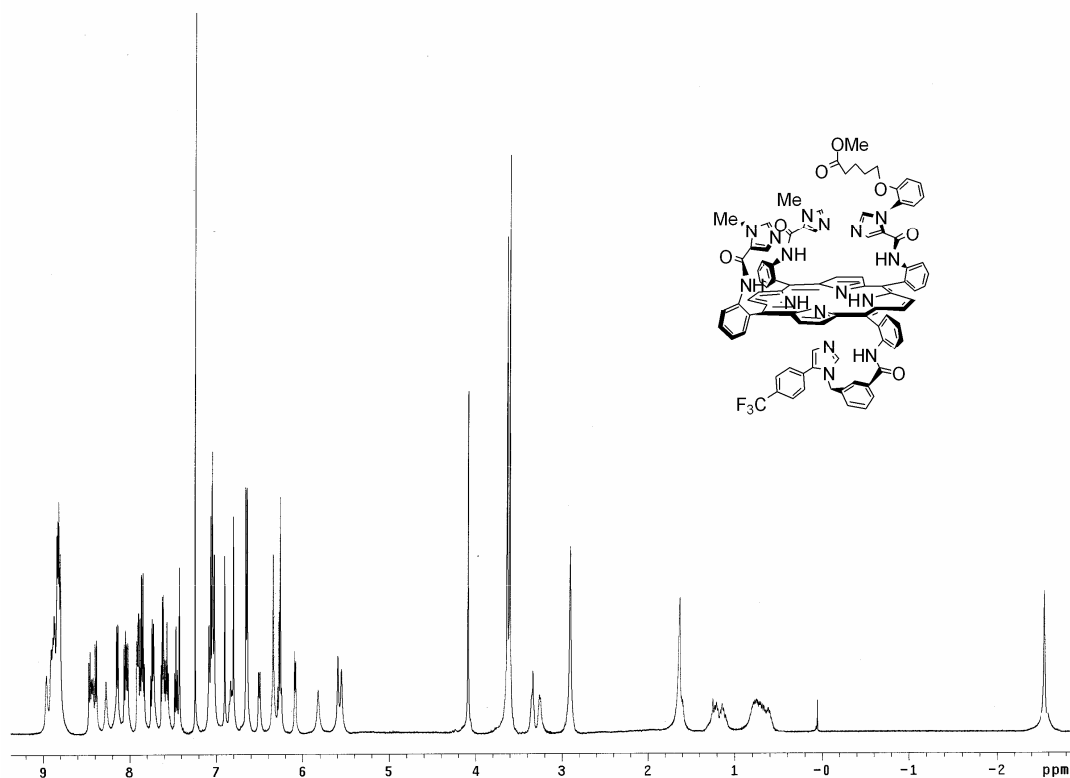
^1H NMR of the di-ester product from the reaction of **10** and ethanol



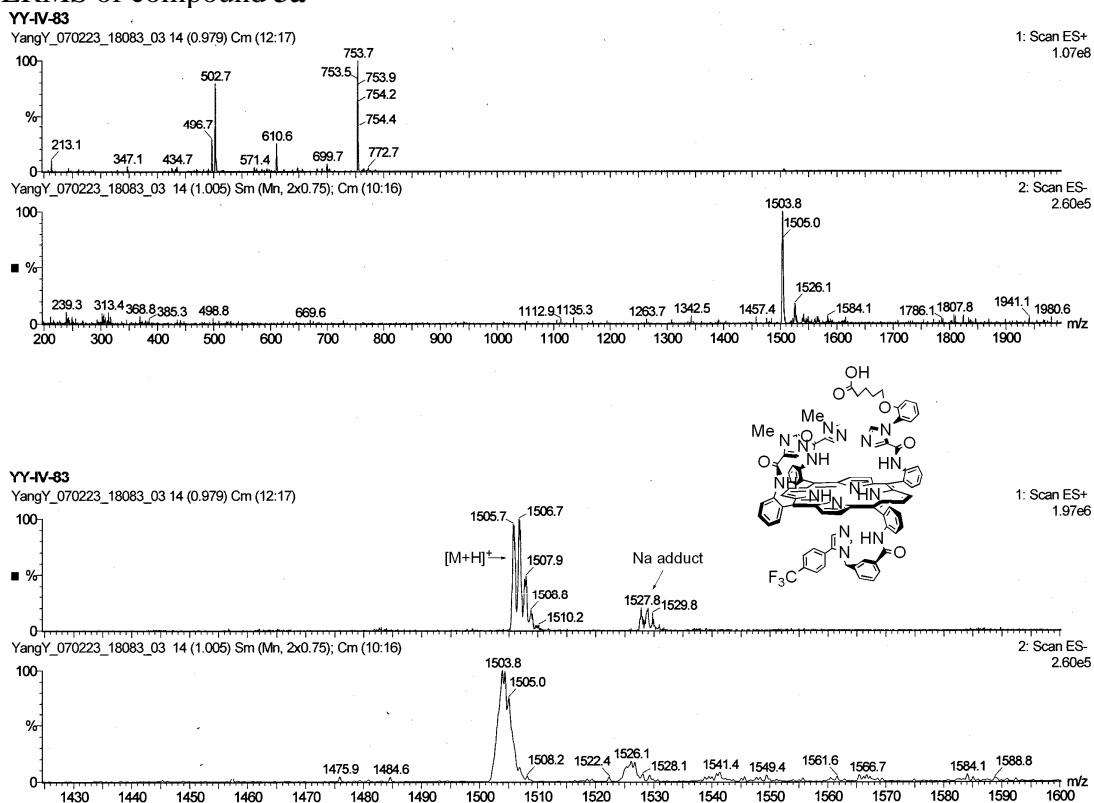
^{13}C NMR of the di-ester product from the reaction of **10** and ethanol



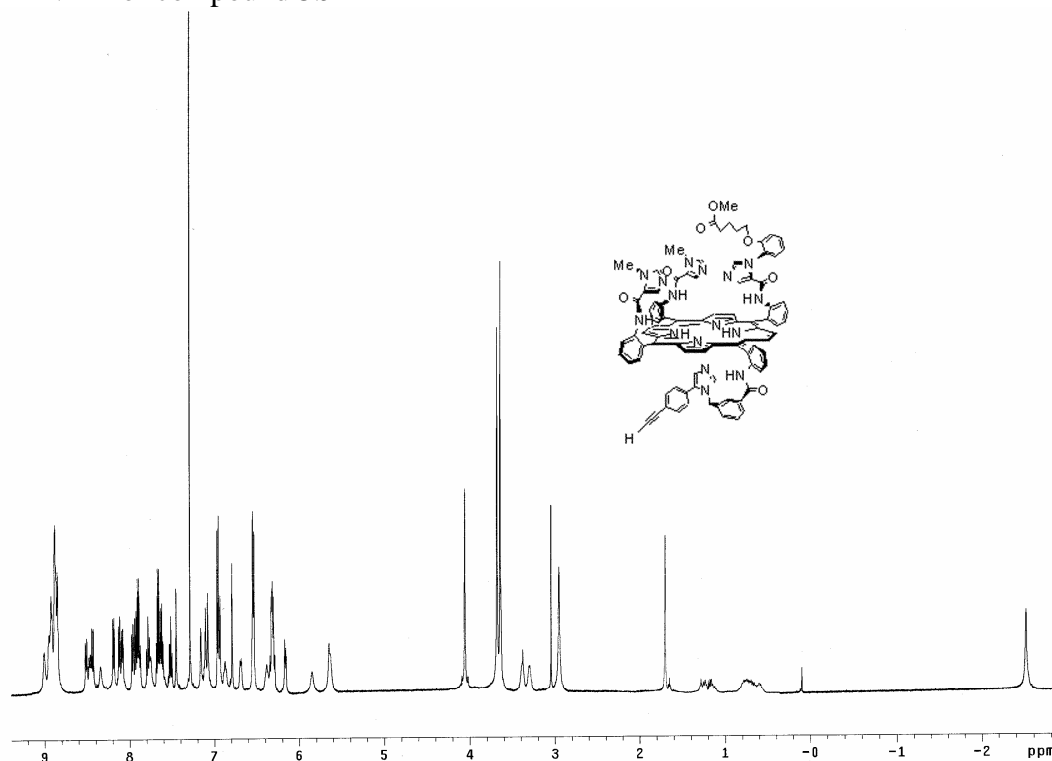
¹H NMR of compound **3a**



LRMS of compound **3a**



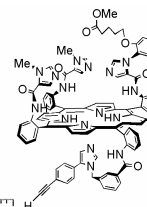
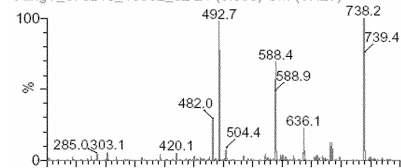
¹H NMR of compound **3b**



LRMS of compound **3b**

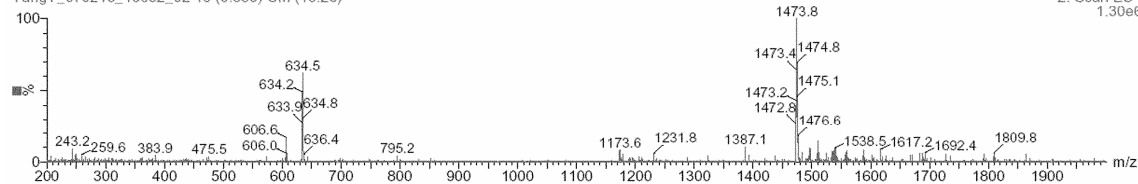
YY-IV-68-F2

YangY_070215_18052_02 21 (0.989) Cm (17:27)



1: Scan ES+
1.34e8

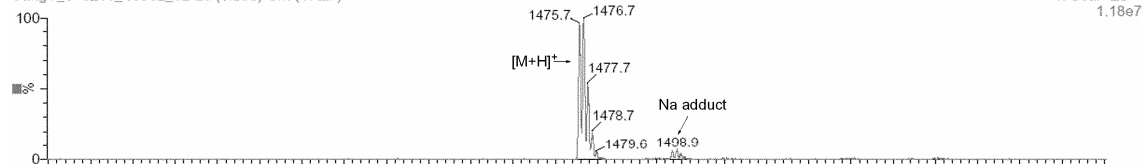
YangY_070215_18052_02 19 (0.939) Cm (16:26)



2: Scan ES-
1.30e6

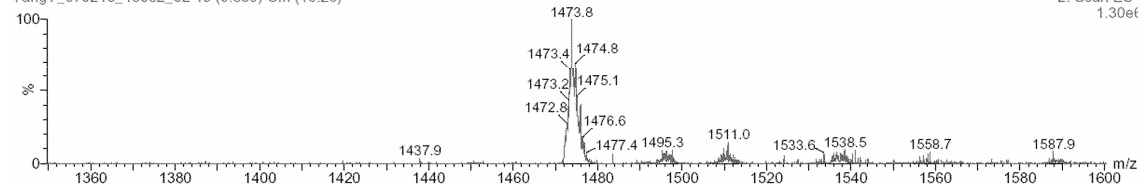
YY-IV-68-F2

YangY_070215_18052_02 21 (0.989) Cm (17:27)



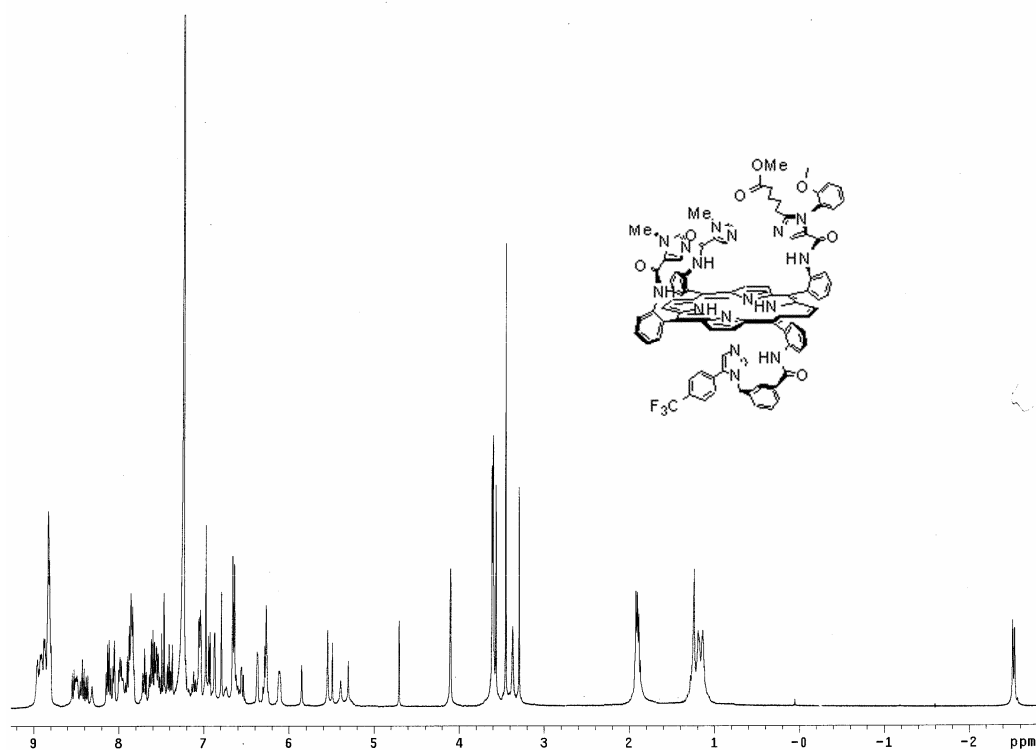
1: Scan ES+
1.18e7

YangY_070215_18052_02 19 (0.939) Cm (16:26)



2: Scan ES-
1.30e6

¹H NMR of compound 4a



LRMS of compound 4a

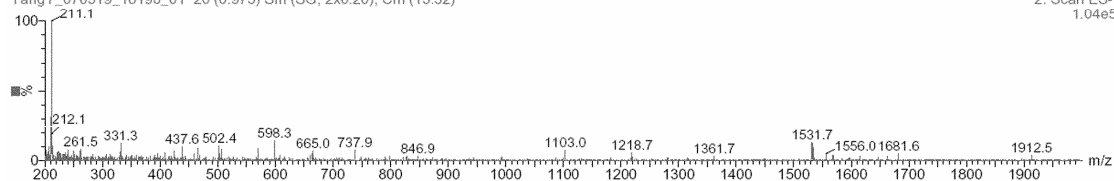
YY-IV-96

YangY_070319_18190_01 20 (0.956) Cm (16:30)



1: Scan ES+
1.34e8

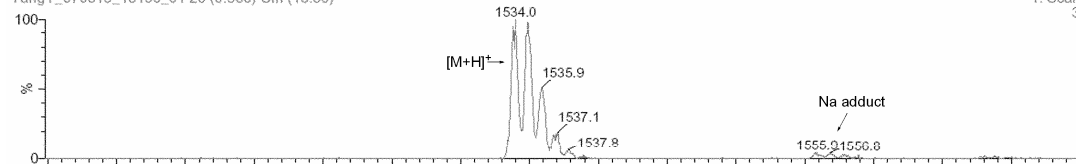
YangY_070319_18190_01 20 (0.973) Sm (SG, 2x0.20); Cm (15:32)



2: Scan ES-
1.04e5

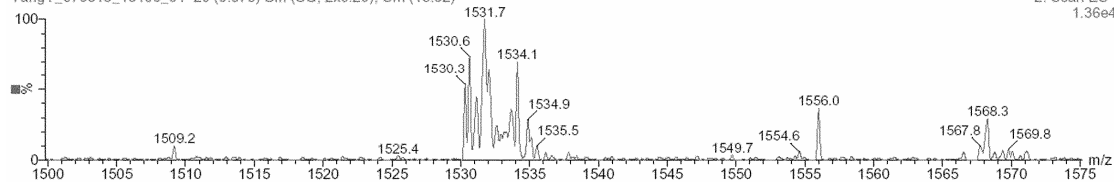
YY-IV-96

YangY_070319_18190_01 20 (0.956) Cm (16:30)



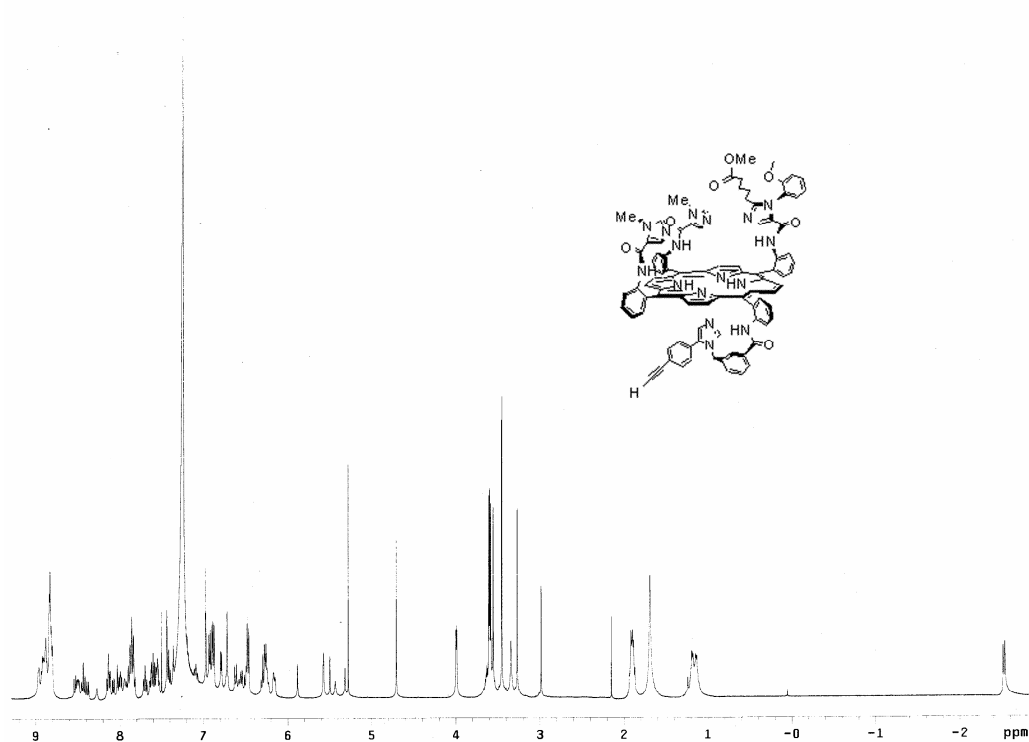
1: Scan ES+
3.51e6

YangY_070319_18190_01 20 (0.973) Sm (SG, 2x0.20); Cm (15:32)



2: Scan ES-
1.36e4

¹H NMR of compound **4b**



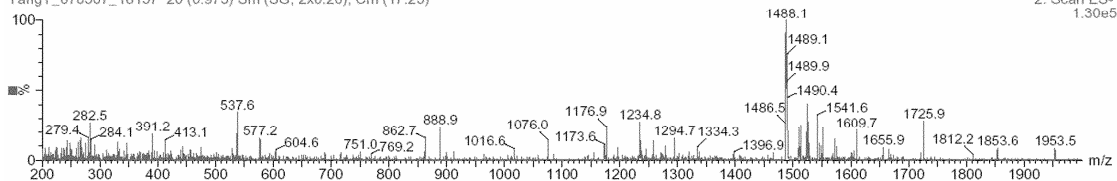
LRMS of compound **4b**

YY-IV-88-F1

YangY_070307_18157 21 (0.989) Cm (17:28)

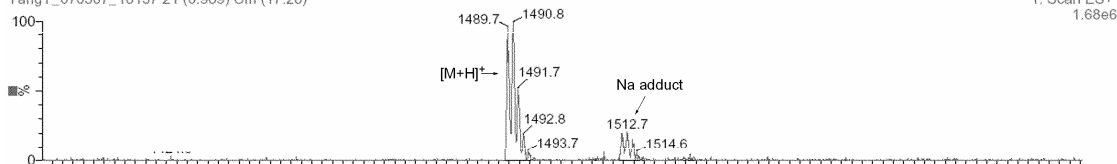


YangY_070307_18157 20 (0.973) Sm (SG, 2x0.20); Cm (17:25)

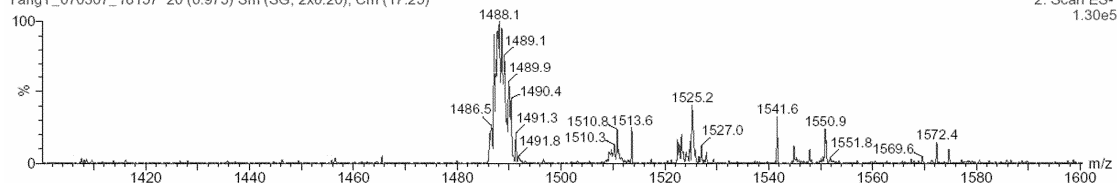


YY-IV-88-F1

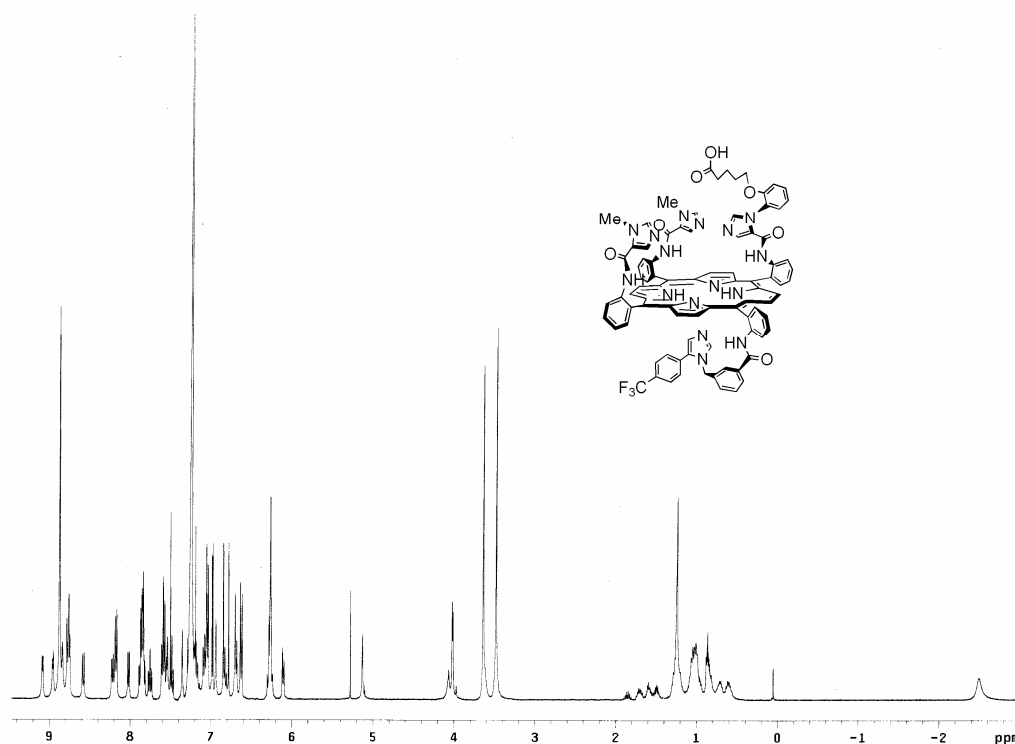
YangY_070307_18157 21 (0.989) Cm (17:28)



YangY_070307_18157 20 (0.973) Sm (SG, 2x0.20); Cm (17:25)



¹H NMR of compound 1a



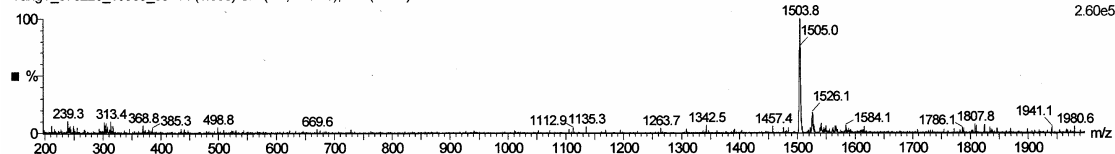
LRMS of compound 1a

YY-IV-83

YangY_070223_18083_03 14 (0.979) Cm (12:17)

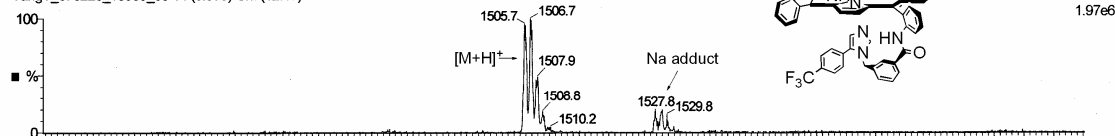


YangY_070223_18083_03 14 (1.005) Sm (Mn, 2x0.75); Cm (10:16)

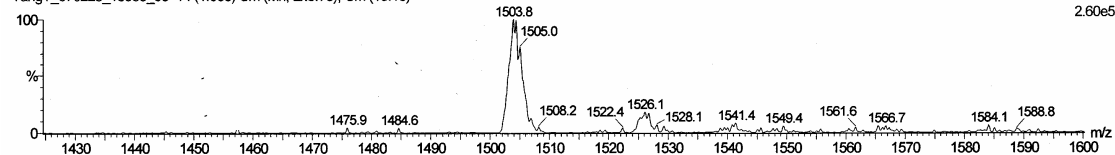


YY-IV-83

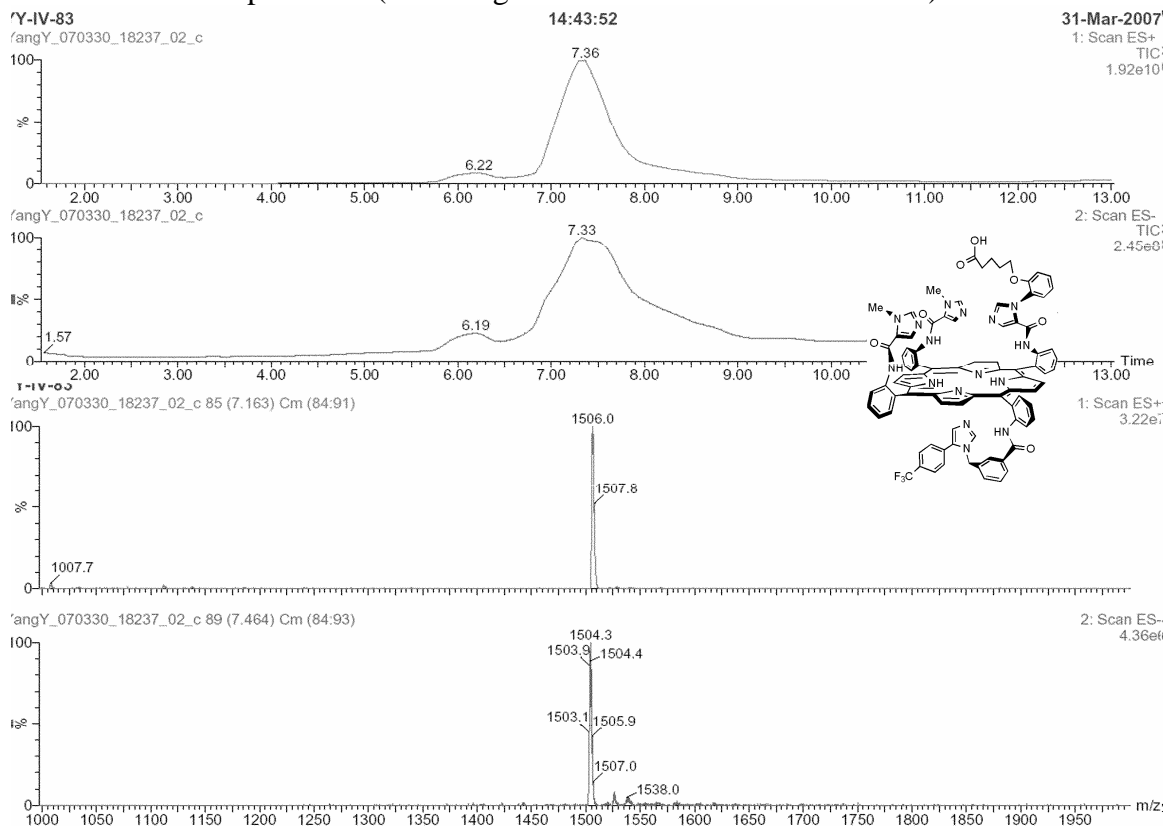
YangY_070223_18083_03 14 (0.979) Cm (12:17)



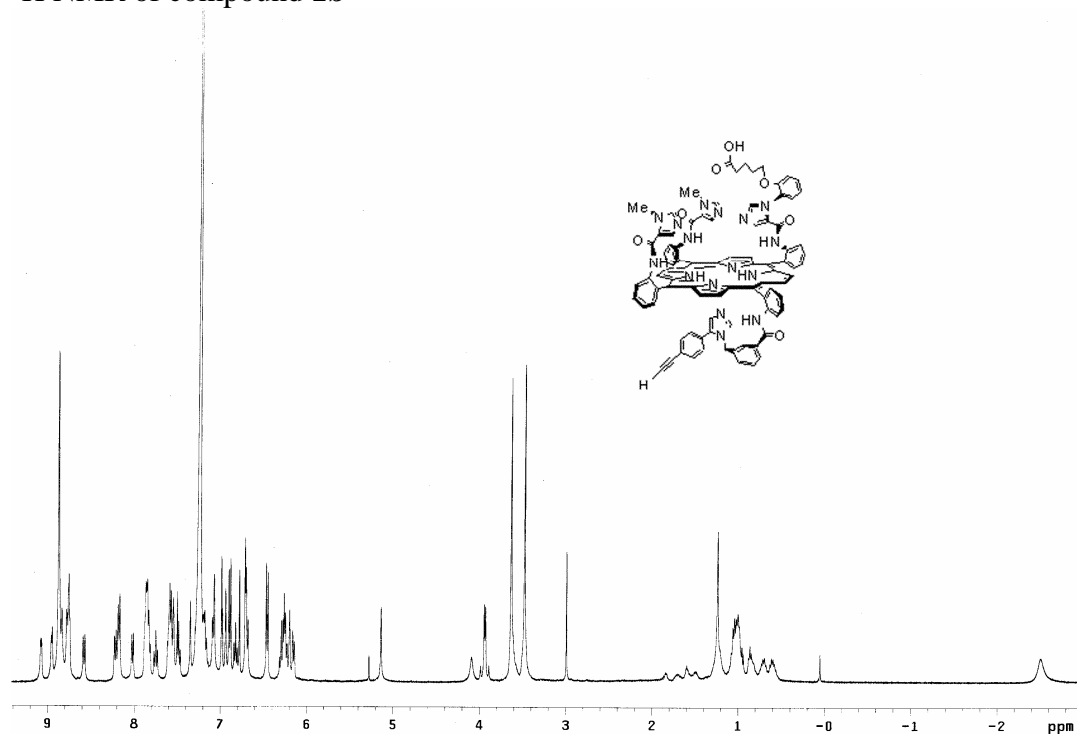
YangY_070223_18083_03 14 (1.005) Sm (Mn, 2x0.75); Cm (10:16)



HPLC-MS of compound **1a** (wavelength for HPLC detection is 254 nm)



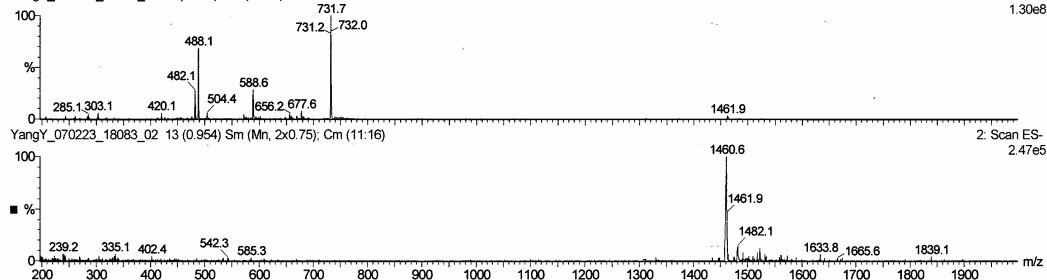
¹H NMR of compound **1b**



LRMS of compound **1b**

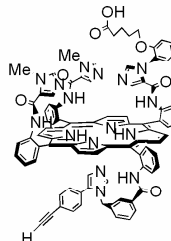
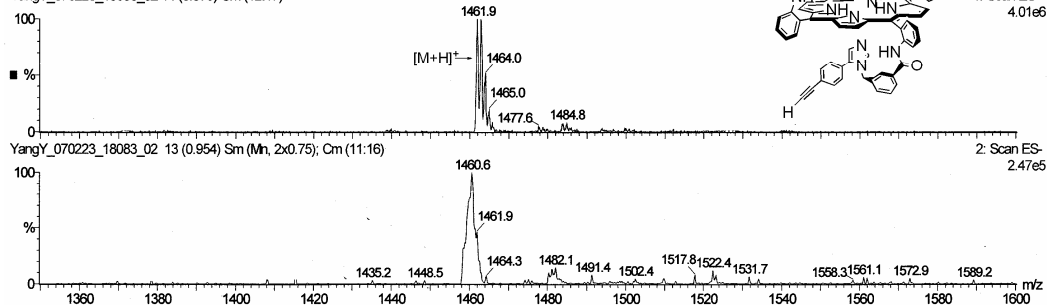
YY-IV-81

YangY_070223_18083_02 14 (0.979) Cm (12:17)



YY-IV-81

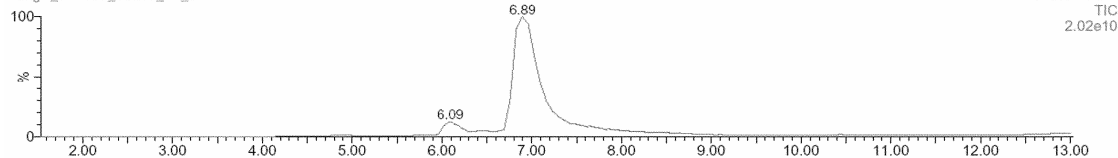
YangY_070223_18083_02 14 (0.979) Cm (12:17)



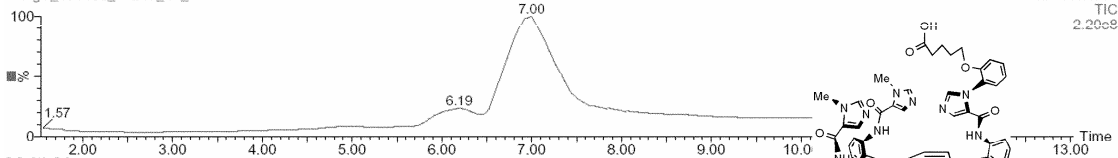
HPLC-MS of compound **1b** (wavelength for HPLC detection is 254 nm)

YY-IV-81

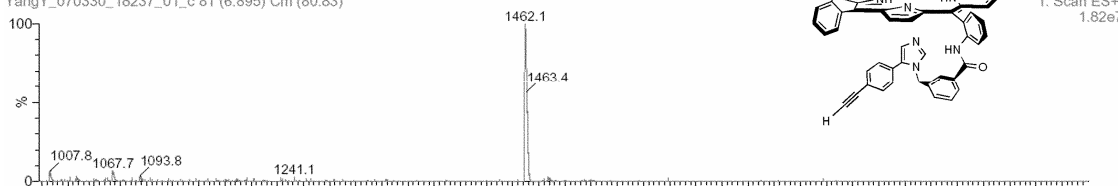
YangY_070330_18237_01_c



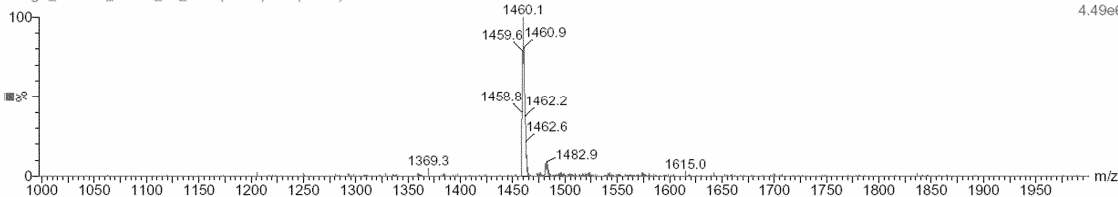
YangY_070330_18237_01_c



YangY_070330_18237_01_c 81 (6.895) Cm (80:83)



YangY_070330_18237_01_c 81 (6.928) Cm (79:85)



HRMS of compound 1b

Elemental Composition Report

Page 2

Single Mass Analysis

Tolerance = 5.0 PPM / DBE: min = -1.5, max = 80.0

Isotope cluster parameters: Separation = 1.0 Abundance = 1.0%

Monoisotopic Mass, Odd and Even Electron Ions

19202 formula(e) evaluated with 219 results within limits (up to 140 closest results for each mass)

Ying Yang, Collman

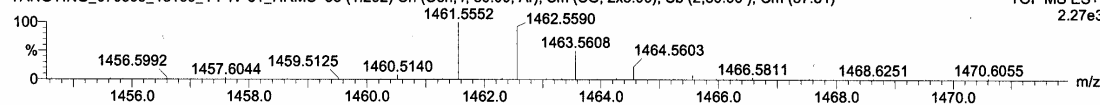
YANGYING_070309_18160_YY-IV-81_HRMS 38 (1.292) Cn (Cen,4, 80.00, Ar); Sm (SG, 2x3.00); Sb (2,30.00); Cm (37:51)

Cone V =

09-Mar-2007, 10:20:07

TOF MS ES+

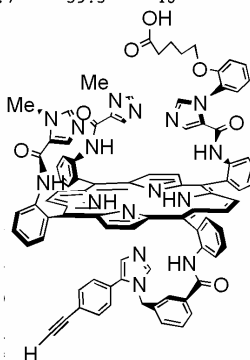
2.27e3



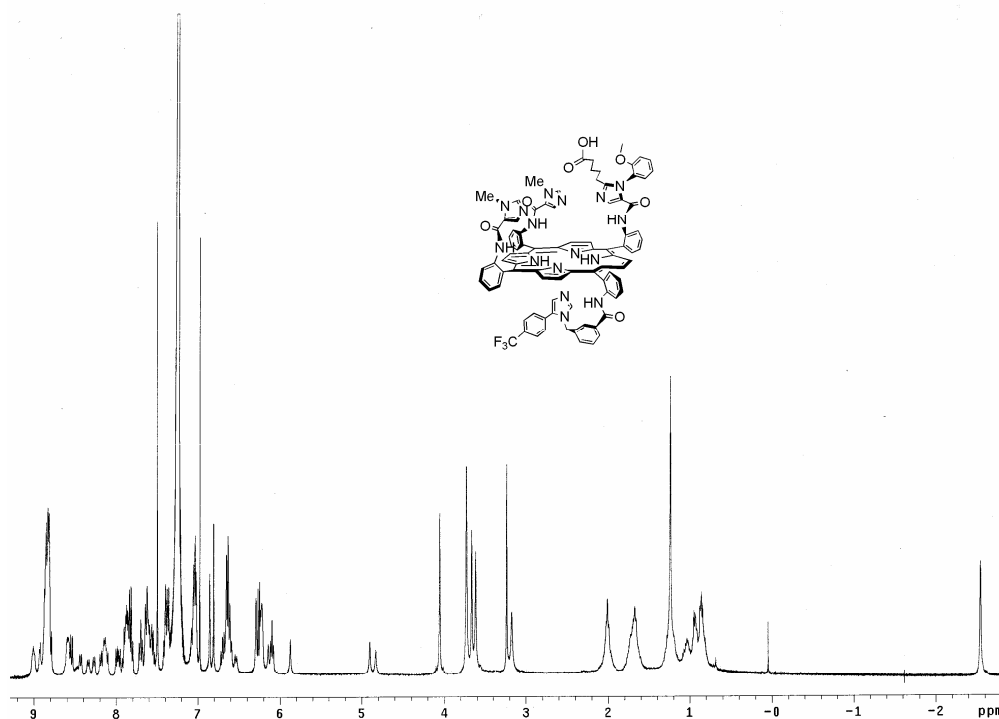
Minimum:
Maximum:

200.0 5.0 -1.5
80.0

Mass	Calc. Mass	mDa	PPM	DBE	Score	Formula
1461.5575	-2.3	-1.6	66.5	97	C93 H69 N14 O5	
1461.5551	0.1	0.0	58.0	64	C92 H76 N7 O10 Na	
1461.5515	3.7	2.5	64.5	84	C92 H68 N14 O2 F2 Na	
1461.5600	-4.8	-3.3	62.0	80	C92 H72 N11 O7 F	
1461.5526	2.6	1.8	68.0	94	C92 H65 N17 O F2	
1461.5551	0.1	0.1	58.0	63	C92 H74 N7 O8 F3	
1461.5590	-3.8	-2.6	58.5	70	C92 H75 N8 O8 F Na	
1461.5554	-0.2	-0.1	65.0	92	C92 H67 N15 F3 Na	
1461.5513	3.9	2.7	57.5	61	C92 H75 N6 O10 F2	
1461.5565	-1.3	-0.9	68.5	99	C92 H66 N18 O Na	
1461.5540	1.2	0.8	54.5	54	C92 H77 N4 O9 F3 Na	
1461.5562	-1.0	-0.7	61.5	74	C92 H73 N10 O9	
1461.5540	1.2	0.8	60.0	69	C91 H71 N11 O4 F3 Na	
1461.5600	-4.8	-3.3	67.5	93	C91 H66 N18 O2 F	
1461.5590	-3.8	-2.6	64.0	81	C91 H69 N15 O3 F Na	
1461.5551	0.1	0.0	63.5	78	C91 H70 N14 O5 Na	
1461.5513	3.9	2.7	63.0	72	C91 H69 N13 O5 F2	
1461.5551	0.1	0.1	63.5	77	C91 H68 N14 O3 F3	
1461.5562	-1.0	-0.7	67.0	85	C91 H67 N17 O4	
1461.5576	-2.4	-1.7	59.0	56	C90 H73 N11 O7 F Na	
1461.5538	1.4	1.0	58.5	52	C90 H74 N10 O9 Na	
1461.5549	0.3	0.2	62.0	62	C90 H71 N13 O8	
1461.5538	1.4	1.0	58.5	53	C90 H72 N10 O7 F3	
1461.5513	3.9	2.7	68.5	83	C90 H63 N20 F2	
1461.5527	2.5	1.7	55.0	44	C90 H75 N7 O8 F3 Na	
1461.5587	-3.5	-2.4	62.5	67	C90 H70 N14 O6 F	
1461.5576	-2.4	-1.7	64.5	71	C89 H67 N18 O2 F Na	
1461.5549	0.3	0.2	67.5	76	C89 H65 N20 O3	
1461.5527	2.5	1.7	60.5	58	C89 H69 N14 O3 F3 Na	
1461.5573	-2.1	-1.5	57.5	41	C89 H74 N10 O10 F	
1461.5538	1.4	1.0	64.0	66	C89 H68 N17 O4 Na	
1461.5537	1.5	1.0	64.0	68	C89 H66 N17 O2 F3	
1461.5513	3.9	2.6	55.5	34	C88 H73 N10 O7 F3 Na	
1461.5573	-2.1	-1.5	63.0	55	C88 H68 N17 O5 F	
1461.5535	1.7	1.2	62.5	51	C88 H69 N16 O7	[M+H] ⁺
1461.5563	-1.1	-0.7	59.5	48	C88 H71 N14 O6 F Na	



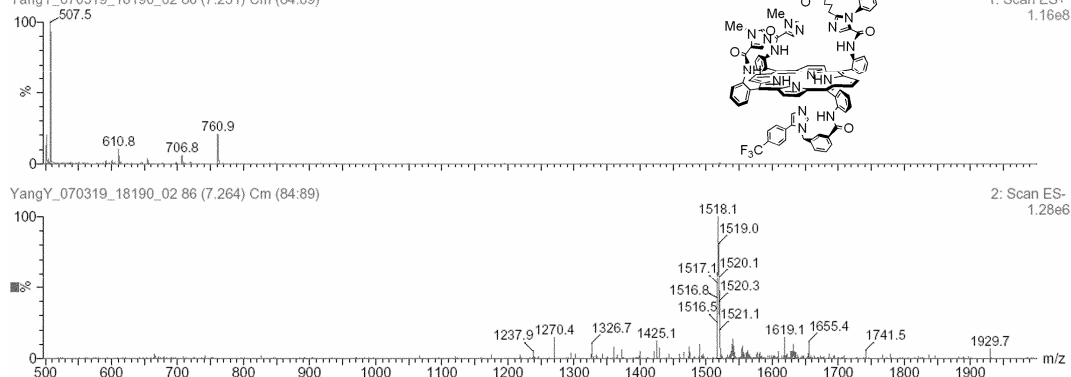
¹H NMR of compound 2a



LRMS of compound 2a

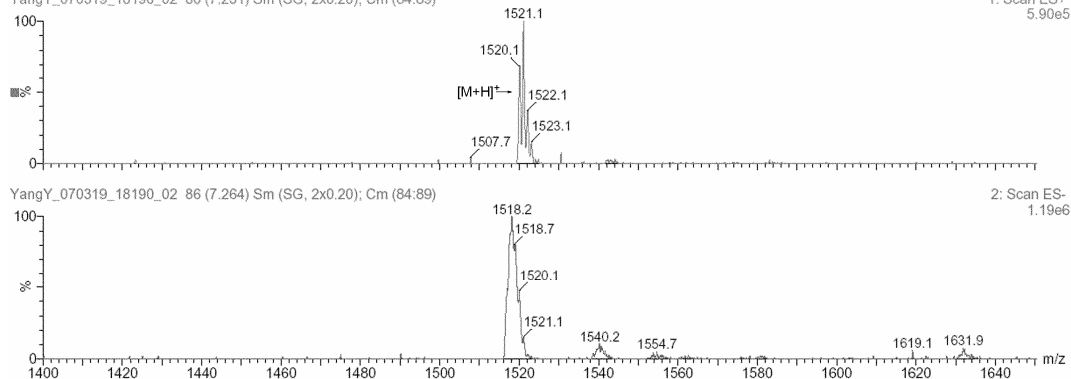
YY-IV-96-acid

YangY_070319_18190_02 86 (7.231) Cm (84:89)



YY-IV-96-acid

YangY_070319_18190_02 86 (7.231) Sm (SG, 2x0.20); Cm (84:89)



HRMS of compound 2a

Elemental Composition Report

Page 1

Single Mass Analysis

Tolerance = 5.0 PPM / DBE: min = -1.5, max = 80.0

Isotope cluster parameters: Separation = 1.0 Abundance = 1.0%

Monoisotopic Mass, Odd and Even Electron Ions

13624 formula(e) evaluated with 291 results within limits (up to 140 closest results for each mass)

Ying Yang, Collman

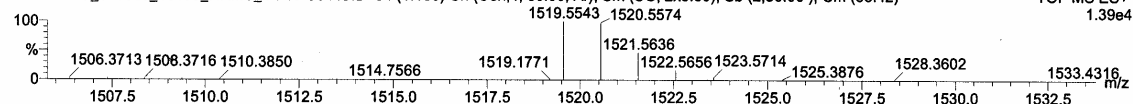
Cone V =

20-Mar-2007, 18:43:00

YANGYING_070320_18198_HRMS_YY-IV-96-ACID 34 (1.166) Cn (Cen,4, 80.00, Ar); Sm (SG, 2x3.00); Sb (2,30.00); Cm (33:42)

TOF MS ES+

1.39e4



Minimum:

Maximum:

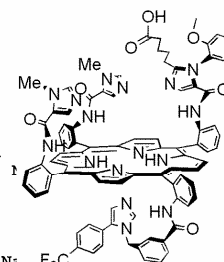
200.0

5.0

-1.5

80.0

Mass	Calc. Mass	mDa	PPM	DBE	Score	Formula
1519.5543	1519.5558	-1.5	-1.0	77.0	140	C100 H65 N17 O
	1519.5547	-0.4	-0.3	73.5	137	C100 H66 N14 F3
	1519.5509	3.4	2.3	73.0	138	C100 H67 N13 O2 F2
	1519.5547	-0.4	-0.3	73.5	139	C100 H68 N14 O2 Na
	1519.5536	0.7	0.4	70.0	134	C100 H69 N11 O F3
	1519.5525	1.8	1.2	66.5	121	C100 H70 N8 F6 Na
	1519.5572	-2.9	-1.9	63.5	123	C100 H75 N4 O7 F4
	1519.5545	-0.2	-0.1	66.5	135	C100 H75 N6 O10
	1519.5534	0.9	0.6	63.0	125	C100 H76 N3 O9 F3
	1519.5572	-2.9	-1.9	63.5	130	C100 H77 N4 O9 F Ne
	1519.5523	2.0	1.3	59.5	108	C100 H77 O8 F6
	1519.5561	-1.8	-1.2	60.0	113	C100 H78 N O8 F4 Na
	1519.5523	2.0	1.3	59.5	115	C100 H79 O10 F3 Na
	1519.5576	-3.3	-2.2	45.5	6	C77 H74 N16 O10 F6 Na
	1519.5513	3.0	2.0	49.5	3	C78 H72 N18 O10 F4 Na
	1519.5537	0.6	0.4	52.5	2	C80 H71 N18 O10 F4
	1519.5564	-2.1	-1.4	49.5	1	C80 H73 N16 O9 F5 Na
	1519.5578	-3.5	-2.3	49.0	4	C82 H75 N13 O10 F5 Na
	1519.5525	1.8	1.2	56.5	11	C83 H70 N18 O9 F3
	1519.5514	2.9	1.9	53.0	5	C83 H71 N15 O8 F6
	1519.5553	-1.0	-0.6	53.5	7	C83 H72 N16 O8 F4 Na
	1519.5515	2.8	1.9	53.0	8	C83 H73 N15 O10 F3 Na
	1519.5517	2.6	1.7	54.5	10	C84 H70 N16 O5 F6 Na
	1519.5577	-3.4	-2.2	56.5	15	C85 H71 N16 O8 F4
	1519.5539	0.4	0.3	56.0	16	C85 H72 N15 O10 F3
	1519.5528	1.5	1.0	52.5	12	C85 H73 N12 O9 F6
	1519.5577	-3.4	-2.3	56.5	19	C85 H73 N16 O10 F Na
	1519.5566	-2.3	-1.5	53.0	13	C85 H74 N13 O9 F4 Na
	1519.5517	2.6	1.7	49.0	9	C85 H76 N9 O10 F6 Na
	1519.5541	0.2	0.1	57.5	18	C86 H69 N16 O5 F6
	1519.5514	2.9	1.9	60.5	26	C86 H69 N18 O8 F2
	1519.5580	-3.7	-2.4	58.0	21	C86 H70 N17 O5 F4 Na
	1519.5541	0.2	0.1	57.5	22	C86 H71 N16 O7 F3 Na
	1519.5530	1.3	0.8	54.0	14	C86 H72 N13 O6 F6 Na
	1519.5544	-0.1	-0.1	59.0	24	C87 H68 N17 O2 F6 Na
	1519.5541	0.2	0.1	52.0	17	C87 H75 N9 O10 F6
	1519.5580	-3.7	-2.4	52.5	20	C87 H76 N10 O10 F4 Na
	1519.5565	-2.2	-1.5	60.5	34	C88 H70 N16 O7 F3
	1519.5554	-1.1	-0.8	57.0	25	C88 H71 N13 O6 F6
	1519.5527	1.6	1.0	60.0	36	C88 H71 N15 O9 F2
	1519.5516	2.7	1.8	56.5	27	C88 H72 N12 O8 F5
	1519.5566	-2.3	-1.5	60.5	40	C88 H72 N16 O9 Na
	1519.5555	-1.2	-0.8	57.0	28	C88 H73 N13 O8 F3 Na
	1519.5544	-0.1	-0.1	53.5	23	C88 H74 N10 O7 F6 Na
	1519.5517	2.6	1.7	56.5	30	C88 H74 N12 O10 F2 Na
	1519.5568	-2.5	-1.6	62.0	38	C89 H67 N17 O2 F6
	1519.5530	1.3	0.9	61.5	39	C89 H68 N16 O4 F5
	1519.5568	-2.5	-1.7	62.0	43	C89 H69 N17 O4 F3 Na
	1519.5557	-1.4	-0.9	58.5	32	C89 H70 N14 O3 F6 Na
	1519.5530	1.3	0.9	61.5	45	C89 H70 N16 O6 F2 Na
	1519.5519	2.4	1.6	58.0	33	C89 H71 N13 O5 F5 Na
	1519.5532	1.1	0.7	63.0	47	C90 H67 N17 O F5 Na
	1519.5579	-3.6	-2.4	60.0	48	C90 H72 N13 O8 F3
	1519.5568	-2.5	-1.6	56.5	35	C90 H73 N10 O7 F6
	1519.5541	0.2	0.2	59.5	49	C90 H73 N12 O10 F2

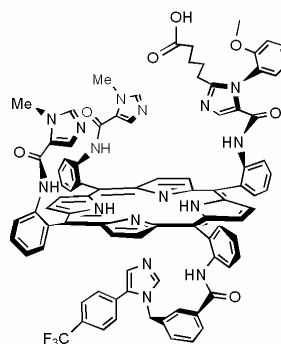


[M+H]⁺

YY-IV-96-acid

14:41:53

1: Scan ES+



8.26e9

2: Scan ES-

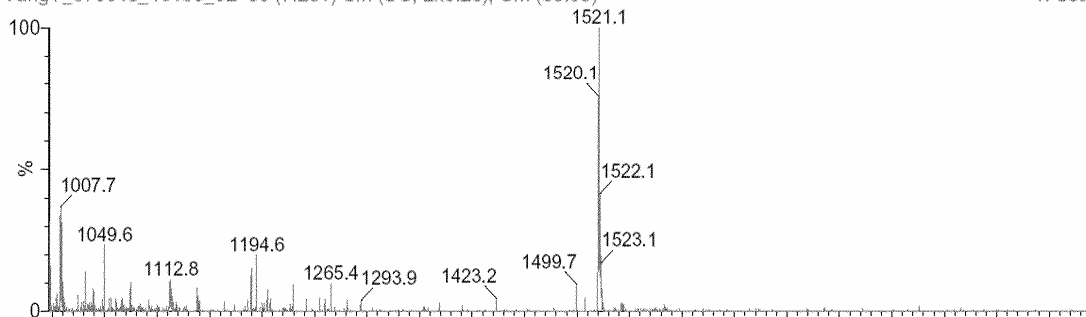
8.56e7



YY-IV-96-acid

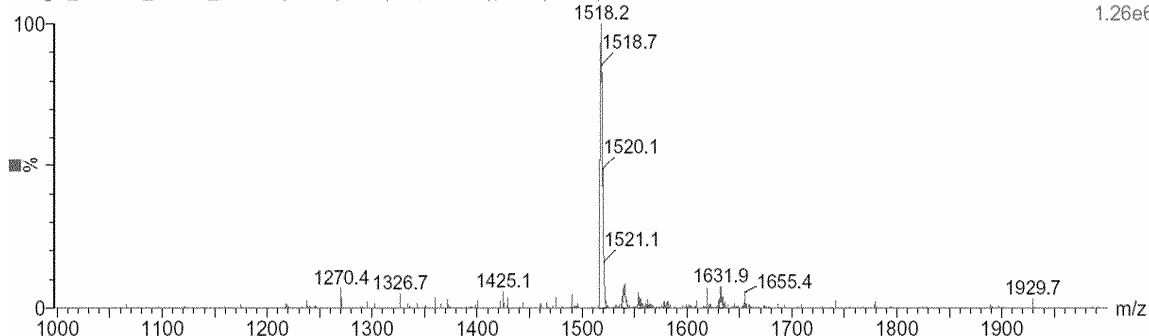
1: Scan ES+

6.30e5

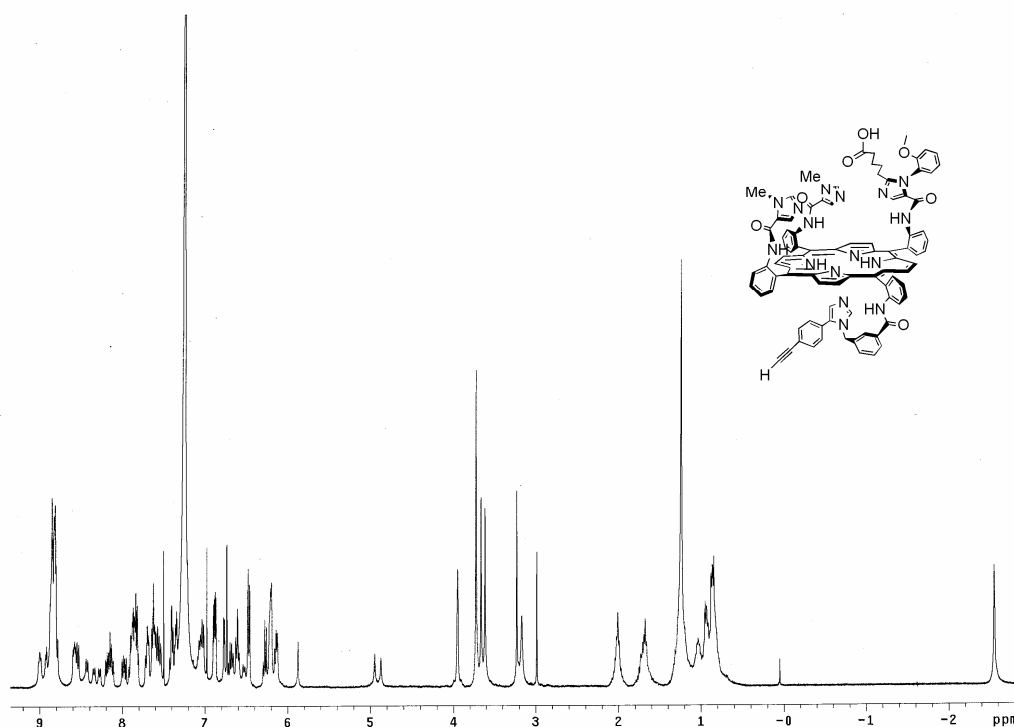


2: Scan ES-

1.26e6



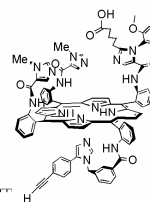
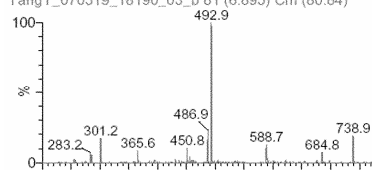
¹H NMR of compound **2b**



LRMS of compound **2b**

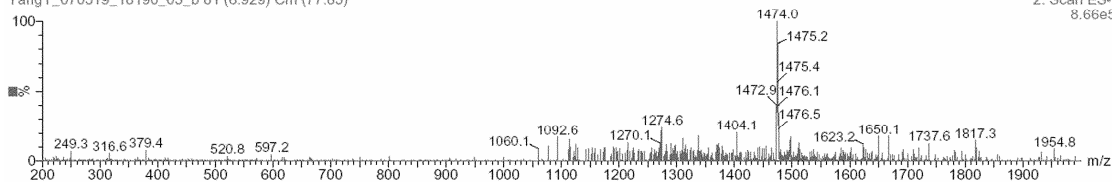
YY-IV-97

YangY_070319_18190_03_b 81 (6.895) Cm (80:84)



1: Scan ES+
1.25e8

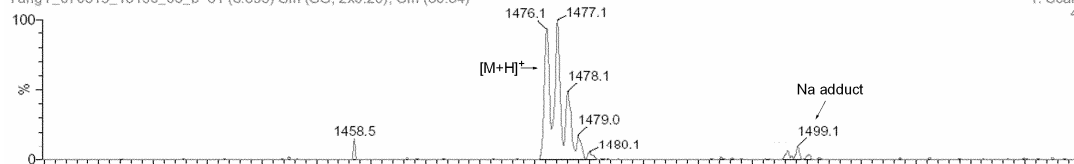
YangY_070319_18190_03_b 81 (6.929) Cm (77:85)



2: Scan ES-
8.66e5

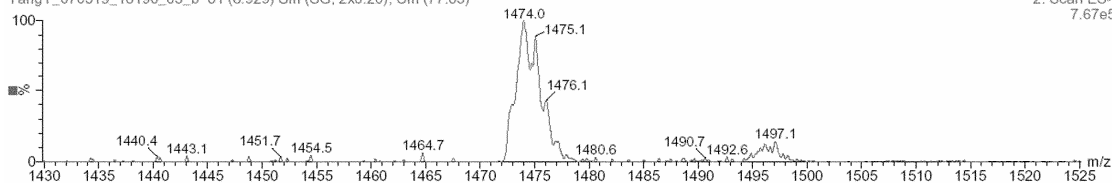
YY-IV-97

YangY_070319_18190_03_b 81 (6.895) Sm (SG, 2x0.20); Cm (80:84)



1: Scan ES+
4.08e5

YangY_070319_18190_03_b 81 (6.929) Sm (SG, 2x0.20); Cm (77:85)



2: Scan ES-
7.67e5

HRMS of compound **2b**

Elemental Composition Report

Page 2

Single Mass Analysis

Tolerance = 5.0 PPM / DBE: min = -1.5, max = 80.0

Isotope cluster parameters: Separation = 1.0 Abundance = 1.0%

Monoisotopic Mass, Odd and Even Electron Ions

17296 formula(e) evaluated with 363 results within limits (up to 140 closest results for each mass)

Ying Yang, Collman

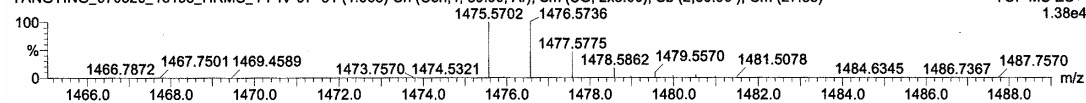
YANGYING_070320_18198_HRMS_YY-IV-97 31 (1.063) Cn (Cen,4, 80.00, Ar); Sm (SG, 2x3.00); Sb (2,30.00); Cm (27:35)

Cone V =

20-Mar-2007, 18:53:29

TOF MS ES+

1.38e4



Minimum:

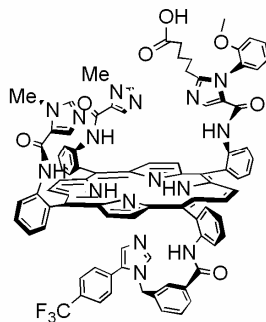
Maximum:

200.0 5.0 -1.5
80.0

Mass	Calc. Mass	mDa	PPM	DBE	Score	Formula									
1475.5730	-2.8	-1.9	63.0	67		C89	H70	N17	O5	F					
1475.5719	-1.7	-1.1	59.5	54		C89	H71	N14	O4	F4					
1475.5692	1.0	0.7	62.5	69		C89	H71	N16	O7						
1475.5681	2.1	1.4	59.0	55		C89	H72	N13	O6	F3					
1475.5719	-1.7	-1.2	59.5	57		C89	H73	N14	O6	F	Na				
1475.5708	-0.6	-0.4	56.0	47		C89	H74	N11	O5	F4	Na				
1475.5681	2.1	1.4	59.0	60		C89	H74	N13	O8	Na					

[M+H]⁺

[M+H]⁺



HPLC-MS of compound **2b** (wavelength for HPLC detection is 254 nm)

YY-IV-97

YangY_070319_18190_03_b

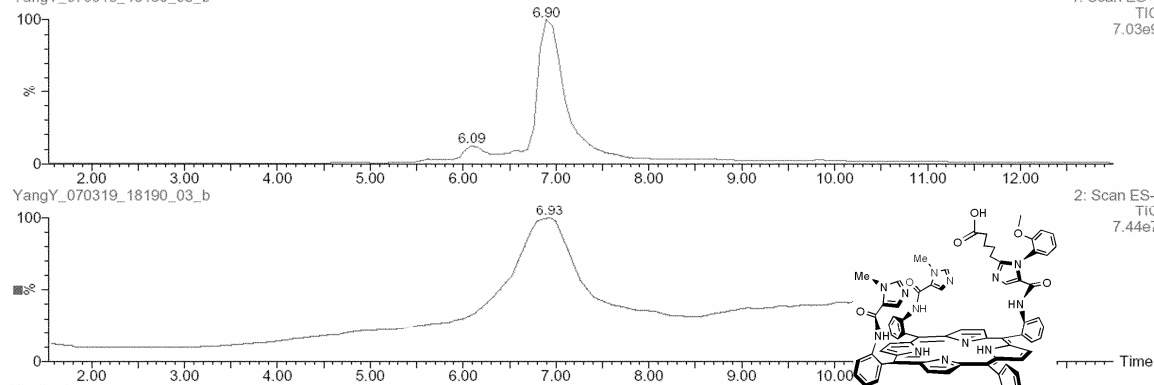
11:36:10

20-Mar-2007

1: Scan ES+

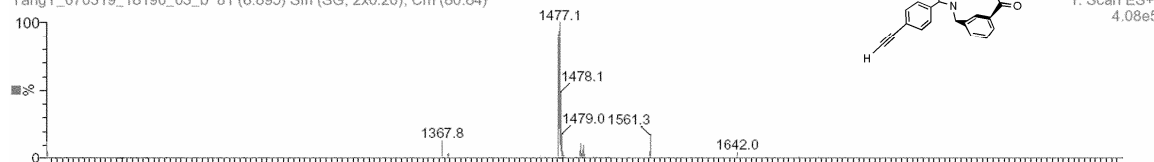
TIC

7.03e9



YY-IV-97

YangY_070319_18190_03_b 81 (6.895) Sm (SG, 2x0.20); Cm (80:84)



YangY_070319_18190_03_b 81 (6.929) Sm (SG, 2x0.20); Cm (79:83)

