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Electronic Supporting Information for

Elucidating the mechanism behind the laccase-mediated modification of poly(ethersulfone)

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Experimental

Chemicals and general remarks

2,4,6-tris(Dimethylaminomethyl)phenol (95%) and laccase from *Trametes versicolor* (12.9 U mg^{-1} according to supplier, EC number: 1.10.3.2) were bought from Sigma Aldrich. 4-(Trifluoromethoxy)phenol (98%), 4-((4-isopropoxyphenyl)sulfonyl)phenol (95%) and *N*,*N*-dimethyltyramine (95%) were obtained from Fluorochem. Disodium 4,5-dihydroxy-1,3-benzenedisulfonate (Tiron) monohydrate (>98%) and potassium guaiacolsulfonate hemihydrate (>98%) were supplied by TCI. 4-Hydroxybenzoic acid (99+%) was bought at Acros Organics. NovaPEG Wang resin (batch 1: 0.62 mol g^{-1}, batch 2: 0.46 mol g^{-1}) was obtained from Merck Millipore. Poly(ethersulfone) membranes (0.2 µm pores, 50 mm diameter) were bought at Sartorius Stedim. Poly(ethersulfone) sheets (10×10 mm) were obtained from Goodfellow.

For the sake of consistency, numbering of phenol carbon atoms was based on that of 4-hydroxybenzoic acid. Concerning solid-phase chemistry, equivalents or amounts of mol in quotation marks ("") are based on full loading of the resin. Flash column chromatography was conducted using flash silica gel 60. ^{1}H and ^{13}C NMR spectra were either recorded on a 400 MHz Bruker Avance spectrometer or a 600 MHz Avance III spectrometer equipped with a cryo-probe. All signals were referenced relative to the residual solvent signal and coupling constants *J* are given in Hz. High-resolution mass spectra were recorded on a Thermo Scientific Exactive instrument. Prior to modification, PES membranes were flushed with water and PES sheets were sonicated in methanol. All MS chromatograms were normalised to the peak with highest intensity. Extracted ion chromatograms are always displayed as a plot of $[M - H]^-$ ± 0.50 Da.

Synthetic procedures

***tert*-Butyl 4-hydroxybenzoate (E1).**[1] 4-Hydroxybenzoic acid (5.0 g, 36.2 mmol, 1 eq.), *tert*-butanol (70 ml, 0.72 mol, 20 eq.) and *N*,*N*-dimethyl-4-aminopyridine (DMAP, 180 mg, 1.45 mmol, 0.04 eq.) were dissolved in anhydrous tetrahydrofuran (120 ml) in a flame-dried round-bottom flask under argon. A solution of *N*,*N*'-dicyclohexylcarbodiimide (DCC, 11.2 g, 54.3 mmol, 1.5 eq.) in anhydrous tetrahydrofuran (50 ml) was subsequently added dropwise over the course of 30 min. This mixture was thereafter stirred for 20 h under an argon atmosphere at room temperature and subsequently filtered. Succeeding concentration in vacuo, the filtrate was washed with a 1 M aqueous sodium bicarbonate solution (50 ml) and thereafter purified using flash chromatography (elution from 0% to 30% ethyl acetate in petroleum ether 40-60). The final product (**E1**) was yielded as a white solid (37%, 2.61 g, 13.4 mmol). δ_H (400 MHz, $CDCl_3$) 7.93 – 7.86 (2 H, m, ArH), 6.88 – 6.81 (2 H, m, ArH), 1.58 (9 H, s, CH_3). δ_C (101 MHz, $CDCl_3$) 166.4, 160.1, 131.7, 124.0, 115.1, 81.1, 28.3. HRMS (ESI) *m/z* $[M - H]^-$ 193.0870 (calcd. 193.0870).

General procedure for Mannich reaction.[2, 3] The respective para-substituted phenol (**B1**-**E1**, 3.0 mmol, 1.0 eq.) was dissolved in ethanol (10 ml) under argon, after which dimethylamine (40 wt% in water, 1.1 ml, 9.0 mmol, 3.0 eq.) was added. Careful dropwise addition of formaldehyde (37 wt% in water, 0.58 ml, 7.8 mmol, 2.6 eq.) to this mixture was followed by refluxing overnight. The volatiles were evaporated under reduced pressure after which the concentrated residue was diluted with diethyl ether (20 ml) and washed with a saturated aqueous sodium carbonate solution (20 ml) before being extracted with diethyl ether (3× 20 ml; to minimise yellowing, the extracts were intermittently purged with argon). Subsequent to evaporation of all volatiles, the crude product (**B2**-**E2**) was sufficiently pure to start follow-up chemistry, and was stored between 2 to 7 °C under argon prior to further use.

General procedure for methylation. The respective Mannich base (**B2**-**F2**, 2.6 mmol, 1 eq.) was dissolved in anhydrous acetonitrile (15 ml) in a flame-dried round-bottom flask under argon, after which methyl iodide (0.97 ml, 15.6 mmol, 6 eq.) was added dropwise. Subsequent to being stirred at room temperature for 48 h, a second portion of methyl iodide (0.97 ml, 15.6 mmol, 6 eq.) was added dropwise and stirring was continued for another 24 h. After filtration, the product (**B3**-**F3**) was used in the subsequent step without further purification.

1,1'-(5-Carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) diiodide (E4). 1,1'-(5-(*tert*-Butoxycarbonyl)-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) diiodide (**E3**, 200 mg, 0.34 mmol, 1 eq.) was suspended in acetonitrile (3 ml) after which trifluoroacetic acid (3 ml, 40 mmol, 117 eq.) was added dropwise. The suspension was stirred at room temperature for 3 h, after which the remaining solid (**E4**) was concentrated *in vacuo* and used in the next step without further purification.

General I/Cl ion exchange procedure. Dowex Cl-form ion exchange resin (1X8-200) was washed and wetted with a 1:1 mixture of methanol/water (1:3 *V*/*W* washing solvent/resin). The resin was further rinsed with water to wash off all methanol and the wet resin was isolated by filtration. The respective diiodide salt (**B3**-**D3**, **E4** or **F3**) and wet resin (10 g per g diiodide salt) were then added to water (20 ml per g diiodide salt) and stirred gently at room temperature for 1 h. Subsequent removal of the resin through filtration and evaporation of water yielded the white/off-white product.

***N*,*N*,*N*-Trimethyltyramine chloride (A).** *N*,*N*-Dimethyltyramine (400 mg, 2.42 mmol, 1 eq.) was dissolved in anhydrous acetonitrile (16 ml) in a flame-dried round-bottom flask under argon, after which methyl iodide (0.97 ml, 15.6 mmol, 6 eq.) was added dropwise. Subsequent to rapid emergence of a precipitate, the mixture was stirred at room temperature for 24 h. The mixture was thereafter cooled on ice and diluted with ice-cold diethyl ether. Filtration afforded the product as a tanned white powder which was used in the next step without further purification. Dowex Cl-form ion exchange resin (1X8-200) was washed and wetted with a 1:1 mixture of methanol/water (1:3 *V*/*W* washing solvent/resin). The resin was further rinsed with water to wash off all methanol and the wet resin was isolated by filtration. *N*,*N*,*N*-Trimethyltyramine iodide (690 mg, 2.25 mmol) and wet resin (8 g) were then added to water (30 ml) and stirred gently at room temperature for 1 h. After filtering off the resin and evaporation of water, the resulting *N,N,N*-trimethyltyramine chloride (**A**) was isolated as a white solid (96% over two steps, 502 mg, 2.33 mmol). δ_H (400 MHz, D_2O) 7.32 – 7.13 (2 H, m, ArH), 6.98 – 6.83 (2 H, m, ArH), 3.60 – 3.42 (2 H, m, CH_2), 3.17 (9 H, s, NCH_3), 3.12-3.03 (2 H, m, CH_2). δ_C (101 MHz, D_2O) 154.5, 130.3, 127.4, 115.8, 67.2 (t), 52.9 (t), 27.9. HRMS (ESI) *m/z* $[M]^+$ 180.1381 (calcd. 180.1383).

1,1'-(2-Hydroxy-5-methoxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (B). Off-white solid, 13% over three steps. δ_H (400 MHz, D_2O) 7.27 (2 H, s, ArH), 4.60 (4 H, s, CH_2), 3.87 (3 H, s, OCH_3), 3.16 (18 H, s, NCH_3). δ_C (101 MHz, D_2O) 153.1, 150.0, 122.7, 119.8, 64.1, 56.2, 52.7. HRMS (ESI) *m/z* $[M]^{2+}$ 134.1064 (calcd. 134.1070).

1,1'-(2-Hydroxy-5-(methoxycarbonyl)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (C). White solid, 38% over three steps. δ_H (400 MHz, D_2O) 8.22 (2 H, s, ArH), 4.62 (4 H, s, CH_2), 3.93 (3 H, s, OCH_3), 3.14 (18 H, s, NCH_3). δ_C (101 MHz, D_2O) 167.9, 164.3, 138.8, 120.0, 118.0, 64.1, 52.6, 52.5. HRMS (ESI) *m/z* $[M]^{2+}$ 148.1043 (calcd. 148.1045).

1,1'-(2-Hydroxy-5-(trifluoromethoxy)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (D). Additionally purified through preparative HPLC. White solid, <1% over three steps. δ_H (400 MHz, D_2O) 7.61 (2 H, s, ArH), 4.58 (4 H, s, CH_2), 3.13 (16 H, s, NCH_3). δ_C (151 MHz, D_2O) 158.5, 140.1, 130.3, 119.3, 64.0, 52.6. HRMS (ESI) *m/z* $[M]^{2+}$ 161.0927 (calcd. 161.0929).

1,1'-(5-Carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (E). White solid, 20% over four steps. δ_H (400 MHz, D_2O) 8.27 (2 H, s, ArH), 4.68 (4 H, s, CH_2), 3.15 (18 H, s, NCH_3). δ_C (101 MHz, D_2O) 168.6, 160.9, 139.1, 123.0, 118.0, 63.6, 52.6. HRMS (ESI) *m/z* $[M]^{2+}$ 141.0965 (calcd. 141.0966).

1,1',1''-(2-Hydroxybenzene-1,3,5-triyl)tris(*N*,*N*,*N*-trimethylmethanaminium) trichloride (F). Additionally purified through precipitation from methanol and preparative HPLC. White solid, 16% over two steps. δ_H (400 MHz, D_2O) 7.66 (2 H, s, ArH), 4.55 (4 H, s CH_2), 4.45 (2 H, s, CH_2), 3.12 (18 H, s, NCH_3), 3.10 (9 H, s, NCH_3). δ_C (101 MHz, D_2O) 165.9, 141.4, 118.8, 114.3, 68.9, 64.7, 52.5 (t), 51.9 (t). HRMS (ESI) *m/z* $[M]^{3+}$ 103.4283 (calcd. 103.4281).

4,4'-Sulfonylbis(methoxybenzene) (G). 4,4'-Sulfonyldiphenol (2.5 g, 9.90 mmol, 1 eq.) was dissolved in dimethylformamide (120 ml) after which potassium carbonate (6.9 g, 49.9 mmol, 5 eq.) and methyl iodide (9.3 ml, 149 mmol, 15 eq.) were added. This mixture was stirred at room temperature for 48 h and subsequently filtered over Celite and washed with dichloromethane. Volatiles (including dimethylformamide) were removed *in vacuo*, after which the concentrate was diluted with ethyl acetate (150 ml) and subsequently washed with water (100 ml). The aqueous phase was extracted with ethyl acetate (2× 50 ml) and the combined organic phases were subsequently washed with 5% aqueous sodium metabisulfite (2× 50 ml), saturated aqueous sodium bicarbonate (2× 20 ml) and brine (100 ml). Evaporation of all volatiles afforded **G** as a white solid (87%, 2.41 g, 8.66 mmol). δ_H (400 MHz, $CDCl_3$) 7.83 (4 H, d, *J* 8.7, ArH), 6.93 (4 H, d, *J* 8.7, ArH), 3.82 (6 H, s, CH_3). δ_C (101 MHz, $CDCl_3$) 163.1, 133.9, 129.5, 114.4, 55.6. HRMS (ESI) *m/z* $[M + H]^+$ 279.0681 (calcd. 279.0686).

2,2'-((Sulfonylbis(4,1-phenylene))bis(oxy))diacetic acid (H). 4,4'-Sulfonyldiphenol (2.0 g, 8.00 mmol, 1 eq.) was dissolved in dimethylformamide (20 ml) after which potassium carbonate (1.7 g, 12.0 mml, 1.5 eq.) and ethyl chloroacetate (1.7 ml, 16.0 mmol, 2 eq.) were added. This mixture was stirred at 100 °C for 3 h, cooled to rt and subsequently diluted with water (50 ml) before being extracted with ethyl acetate (3× 50 ml). The intermediate ethyl ester was concentrated *in vacuo* and used without further purification in the next step by dissolving it (1.9 g, 4.49 mmol, 1 eq.) in methanol (20 ml) and cooling the solution down to 0 °C. After addition of a 1 M aqueous solution of sodium hydroxide (11 ml, 11.0 mmol, 2.5 eq.) the mixture was stirred at room temperature for 2 h. Concentration *in vacuo* was followed by dilution with a 1 M aqueous solution of hydrochloric acid (13 ml, 13.0 mmol, 3 eq.). Extraction with ethyl acetate (3× 50 ml), washing of the combined organic layers with brine followed by concentration *in vacuo* afforded **H** as a white solid (63% over two steps, 1.34 g, 3.66 mmol). δ_H (400 MHz, MeOD) 7.85 (4 H, d, *J* 8.8, ArH), 7.07 (4 H, d, *J* 8.8, ArH), 4.75 (4 H, s, CH_2). δ_C (101 MHz, MeOD) 171.7, 163.2, 135.7, 130.6, 116.3, 65.8. HRMS (ESI) *m/z* $[M - H]^-$ 365.0334 (calcd. 365.0337).

4-((Tetrahydro-2*H*-pyran-2-yl)oxy)benzoic acid 4-(OTHP)BA.[4] 4-Hydroxybenzoic acid (2.0 g, 14.5 mmol, 1 eq.), 2,3-dihydropyran (6.6 ml, 72.4 mmol, 5 eq.) and *para*-toluenesulfonic acid (catalytic amount) were stirred in anhydrous tetrahydrofuran (10 ml) in a flame-dried round-bottom flask under nitrogen at room temperature for 5 h. After addition of a saturated aqueous sodium bicarbonate solution (20 ml) and subsequent extraction with ethyl acetate (3× 20 ml) the product was yielded as a white solid (38%, 1.2 g, 5.58 mmol). δ_H (400 MHz, $CDCl_3$) 8.09 – 8.03 (2 H,

m, ArH), 7.13 – 7.07 (2 H, m, ArH), 5.53 (1 H, t, *J* 3.1, CH), 3.87 (1 H, ddd, *J* 11.2, 10.1, 3.1, C(*H*)H), 3.68 – 3.59 (1 H, m, C(*H*)H), 2.09 – 1.97 (1 H, m, C(*H*)H), 1.89 (2 H, dt, *J* 7.6, 3.7, CH_2), 1.79 – 1.65 (2 H, m, 2× C(*H*)H), 1.65 – 1.57 (1 H, m, C(*H*)H). δ_C (101 MHz, $CDCl_3$) 171.8, 161.6, 132.2, 122.3, 116.0, 96.1, 62.1, 30.1, 25.1, 18.5. HRMS (ESI) *m/z* [M - H]$^-$ 221.0819 (calcd. 221.0821).

4-(4-((4-Isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid (mPES$_3$). A mixture of 4-((4-isopropoxyphenyl)sulfonyl)phenol (500 mg, 1.71 mmol, 1 eq.) and potassium carbonate (355 mg, 2.57 mmol, 1.5 eq.) in anhydrous butanone (10 ml) was refluxed under nitrogen for 1 h, after which ethyl 4-bromobutanoate (501 mg, 2.57 mmol, 1.5 eq.) was added, and this mixture was further refluxed overnight. After addition of water and extraction with ethyl acetate (3× 20 ml) the intermediate ester was concentrated *in vacuo* and used in the next step without further purification. The intermediate ester was dissolved in ethanol (10 ml) and the mixture was cooled to 0 °C before addition of sodium hydroxide (137 mg, 3.42 mmol). After being stirred at room temperature for 6 h, the reaction mixture was neutralised by addition of saturated aqueous hydrochloric acid (0.13 ml, 4.28 mmol). Extraction with ethyl acetate (3× 20 ml) and evaporation of all volatiles afforded the product as a yellowish solid (90% over 2 steps, 580 mg, 1.54 mmol). δ_H (400 MHz, $CDCl_3$) 7.82 (4 H, t, *J* 9.5, ArH), 6.91 (4 H, t, *J* 9.1, ArH), 4.59 (1 H, hept, *J* 6.0, CH), 4.04 (2 H, t, *J* 6.0, CH_2), 2.56 (2 H, t, *J* 7.2, CH_2), 2.12 (2 H, q, *J* 6.5, CH_2), 1.33 (6 H, d, *J* 6.1, CH_3). δ_C (101 MHz, $CDCl_3$) 178.6, 162.2, 161.6, 134.2, 133.2, 129.5, 115.7, 114.8, 70.4, 66.9, 30.2, 24.1, 21.8. HRMS (ESI) *m/z* [M - H]$^-$ 377.1064 (calcd. 377.1064).

11-(4-((4-Isopropoxyphenyl)sulfonyl)phenoxy)undecanoic acid (mPES$_{10}$). A mixture of 4-((4-isopropoxyphenyl)sulfonyl)phenol (1.00 g, 3.42 mmol, 1 eq.) and potassium carbonate (615 mg, 4.45 mmol, 1.3 eq.) in anhydrous butanone (20 ml) was refluxed under nitrogen for 1 h, after which ethyl 11-bromoundecanoate (1.30 g, 4.45 mmol, 1.3 eq.) was added and this mixture was further refluxed overnight. After addition of water and extraction with ethyl acetate (3× 20 ml), the intermediate ester was concentrated *in vacuo* and used in the next step without further purification. The intermediate ester (1.00 g, 1.98 mmol, 1 eq.) was dissolved in ethanol (10 ml) and the mixture was cooled to 0 °C before addition of sodium hydroxide (137 mg, 3.42 mmol, 1.7 eq.). The reaction mixture had been stirred at room temperature for 6 h, after which it was concentrated *in vacuo*. Addition of ethyl acetate (20 ml) and aqueous hydrochloric acid (1 M, 20 ml) followed by extraction with ethyl acetate (3× 20 ml) and evaporation of all volatiles afforded the product as a white solid (79% over 2 steps, 842 mg, 1.72 mmol). δ_H (400 MHz, $CDCl_3$) 7.81 (4 H, dd, *J* 8.5, 6.5, ArH), 6.91 (4 H, t, *J* 9.4, ArH), 4.58 (1 H, hept, *J* 6.0, CH), 3.96 (2 H, t, *J* 6.5, CH_2), 2.33 (2 H, t, *J* 7.5, CH_2), 1.75 (2 H, p, *J* 6.6, CH_2), 1.61 (2 H, p, *J* 7.2, CH_2), 1.45 – 1.36 (2 H, m, CH_2), 1.36 – 1.25 (16 H, m, CH_2 & CH_3). δ_C (101 MHz, $CDCl_3$) 180.0, 162.7, 161.6, 133.7, 133.4, 129.5, 129.5, 115.7, 114.8, 70.4, 68.4, 34.0, 29.4, 29.3, 29.2, 29.2, 29.0, 29.0, 25.9, 24.6, 21.8. HRMS (ESI) *m/z* [M - H]$^-$ 475.2157 (calcd. 475.2160).

Solid-phase chemistry

Coupling of 4-((tetrahydro-2*H*-pyran-2-yl)oxy)benzoic acid. NovaPEG Wang Resin (100 mg, ”0.06 mmol”, “1 eq.”, 0.62 mmol g^{-1} loading) was swollen in anhydrous dichloromethane for 4 h, after which 4-((tetrahydro-2*H*-pyran-2-yl)oxy)benzoic acid (34 mg, 0.15 mmol, 2.5 eq.), *N*,*N*'-dicyclohexylcarbodiimide (44 mg, 0.21 mmol, 3.5 eq.) and *N*,*N*-dimethyl-4-aminopyridine (4 mg, 0.03 mmol, 0.5 eq.) were added. The mixture was subsequently stirred gently under a nitrogen atmosphere at 40 °C for 5 h. The resin was thereafter consecutively washed with methanol and dichloromethane (2×).

Deprotection of resin-bound 4-((tetrahydro-2*H*-pyran-2-yl)oxy)benzoic acid. Resin-bound 4-((tetrahydro-2*H*-pyran-2-yl)oxy)benzoic acid (100 mg,”0.06 mmol”, 1 eq.) was swollen in dichloromethane for 1 h, after which a solution of *para*-toluenesulfonic acid (catalytic amount) in methanol was added. The resulting mixture was gently stirred overnight under a nitrogen atmosphere at room temperature. The resin was thereafter consecutively washed with methanol and dichloromethane (2×).

Coupling of mPES$_3$. NovaPEG Wang Resin (565 mg,”0.26 mmol”, “1 eq.”, 0.46 mmol g^{-1} loading) was swollen in a mixture of anhydrous dichloromethane (18 ml) and dimethylformamide (2 ml) for 1 h. Addition of mPES$_3$ (500 mg, 1.32 mmol, 5 eq.), *N*,*N*'-dicyclohexylcarbodiimide (161 mg, 0.78 mmol, 3 eq.) and *N*,*N*-dimethyl-4-aminopyridine (6 mg, 0.05 mmol, 0.2 eq) was followed by gentle overnight stirring under a nitrogen atmosphere at room temperature. The resin was thereafter consecutively washed with methanol and dichloromethane (2×).

Coupling of mPES$_{10}$. NovaPEG Wang Resin (565 mg,”0.26 mmol”, “1 eq.”, 0.46 mmol g^{-1} loading) was swollen in a mixture of anhydrous dichloromethane (18 ml) and dimethylformamide (2 ml) for 30 min. Addition of mPES$_{10}$ (743 mg, 1.56 mmol, 6 eq.), *N*,*N*'-dicyclohexylcarbodiimide (161 mg, 0.78 mmol, 3 eq.) and *N*,*N*-dimethyl-4-aminopyridine (DMAP, 6 mg, 0.05 mmol, 0.2 eq) was followed by gentle stirring overnight under a nitrogen atmosphere at room temperature. The resin was thereafter consecutively washed with methanol and dichloromethane (2×).

Laccase purification

Desolvation and subsequent filtration (GP 0.22 µm filter unit, Sterivex™) of commercially available laccase from *Trametes versicolor* (EC number: 1.10.3.2) ensured removal of large particulates. Initial purification was achieved by

means of ion exchange column chromatography (Source 15Q (XK 16 mm × 12 cm), ÄKTA explorer chromatography system). Gradient elution (2 ml min^{-1}) from 0 M sodium chloride in 20 mM tris HCl buffer (pH 7) to 1 M sodium chloride in 20 mM tris HCl buffer (pH 7) over 20 column volumes was followed by fraction selection based on a *N*,*N*-diethyl-*p*-phenylenediamine sulfate assay. Selected fractions were pooled and concentrated to approximately 2 ml using a 10 kDa Amicon ultrafiltration system. Further purification was achieved through gel filtration chromatography (Sephacryl S300 (XK hiload 26 mm × 60 cm), ÄKTA explorer chromatography system). Elution with a 0.1 M sodium acetate/acetic acid buffer (pH 6) afforded fractions that were selected based on a 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) diammonium salt assay, pooled and concentrated using a 10 kDa Amicon ultrafiltration system. Concentrated laccase fractions proved to contain 6.6 mg ml^{-1} of protein as based on a Pierce BCA protein assay with bovine serum albumin as standard. Laccase purity was assessed using SDS-PAGE gel chromatography (12% acrylamide, ESI Fig. S34).

Laccase activity assay

The specific activity of both commercially available and purified laccase from *Trametes versicolor* (EC number: 1.10.3.2) were determined spectroscopically on a UV/Vis spectrometer (Varian Cary 50 Scan) by measuring the increase of absorbance for the oxidation of ABTS to the ABTS radical cation (ε = 36000). ABTS diammonium salt was dissolved in an aqueous sodium acetate/acetic acid buffer (0.1 M, pH 5), to which laccase was added. The subsequent increase of the optical absorbance at λ = 420 nm was followed for 60 s.

Laccase-mediated oligomerisation of phenolics in the presence of model compounds

Laccase-mediated oligomerisation of 4-HBA in the presence of G. A solution of 4-HBA (0.1 mg, 0.8 µmol, 14.5 mM final concentration, 0.004 eq.) and laccase (0.23 U, 4.5 U ml^{-1}) in an ammonium acetate/acetic acid buffer (100 µl, 0.1 M, pH 5) was deposited on crystals of PES model compound **G** (50 mg, 0.18 mmol, 1 eq.) and allowed to react at rt for 24 h.

Work-up: laccase was removed from the reaction mixture using a 9 kDa protein concentrator by employing centrifugal force (Hermle Z 206A). The reaction medium was appropriately diluted with water and analysed by LC-MS (LC-method LC3). The solids were dissolved in ethyl acetate, washed with water and the combined aqueous phases were thereafter extracted with fresh ethyl acetate. After evaporation of ethyl acetate, the extracts were dissolved in methanol and diluted with water to be analysed by LC-MS (LC-method LC3).

Laccase-mediated oligomerisation in the presence of H. 4-HBA or vanillic acid (3.3 µmol, 6.88 mM final concentration, 0.05 eq.) and laccase (4.4 U, 9 U ml^{-1}) were dissolved in an ammonium acetate/acetic acid buffer (480 µl, 0.1 M, pH 5). PES model compound **H** (24 mg, 66 µmol, 1 eq.) was added and the mixture was shaken at 40 °C for 24 h. Alternatively, 4-HBA (0.46 mg, 3.3 µmol, 6.6 mM final concentration, 0.1 eq.), TEMPO (13 µl of a 10 mg per 25 ml (1% methanol in buffer) stock, 33 nmol, 0.01 eq.) and laccase (2.3 U, 4.5 U ml^{-1}) were dissolved in an ammonium acetate/acetic acid buffer (500 µl, 0.1 M, pH 5). PES model compound **H** (12 mg, 33 µmol, 1 eq.) was added and the mixture was shaken at rt for 24 h.

Work-up: the reaction mixture was diluted with methanol and laccase was subsequently removed using a 9 kDa protein concentrator by employing centrifugal force (Hermle Z 206A). The filtrate was thereafter analysed by LC-MS (LC-method LC4).

Laccase-mediated oligomerisation of 3-F-4-HBA in the presence of resin-bound 4-HBA. 3-Fluoro-4-hydroxybenzoic acid (3-F-4-HBA, 1.03 mg, 6.6 µmol, 13.2 mM final concentration, 1.1 eq.) and laccase (0.13 U, 0.26 U ml^{-1}) were dissolved in an aqueous ammonium acetate/acetic acid buffer (0.5 ml, 0.02 M, pH 5). After addition of resin-bound 4-HBA (10 mg, "6.2 µmol" 4-HBA, "1 eq." 4-HBA) the mixture was agitated at rt for 2 h. Washing of the modified resin was thereafter conducted with water and methanol consecutively (2×). Cleavage from the resin was achieved in a 1:1 mixture of trifluoroacetic acid and dichloromethane. After evaporation of all volatiles, the cleaved material was analysed by LC-MS (LC-method LC3). For a proper comparison, 3-F-4-HBA and 4-HBA were also oligomerised separately under the same conditions, but without the presence of resin-bound 4-HBA. The resin washing procedure was mimicked by adding methanol (1 ml) to the reaction mixture, followed by evaporation of water and methanol. Cleavage was thereafter simulated by addition of a 1:1 mixture of trifluoroacetic acid and dichloromethane (2 ml) and evaporation of all volatiles.

Laccase-mediated oligomerisation in the presence of R-mPES$_3$. Either of the phenolics 4-HBA, vanillic acid or syringic acid (0.15 mmol, 30.0 mM final concentration, 6 eq.) was dissolved in 0.2 ml, 0.5 ml or 1 ml methanol, respectively. This phenol stock and laccase (5 U, 1 U ml^{-1}) were thereafter dissolved in an aqueous ammonium acetate/acetic acid buffer (5 ml, 0.02 M, pH 5). After addition of R-mPES$_3$ (54 mg, "0.025 mmol" mPES$_3$, "1 eq." mPES$_3$) the mixture was gently shaken at 40 °C for 60 h. Washing of the modified resin was conducted with dichloromethane followed by acetone and finally water (3×). Cleavage from the resin was achieved using a 1:1

mixture of trifluoroacetic acid and dichloromethane. After evaporation of all volatiles, the cleaved material was analysed by LC-MS (LC-method LC2).

Laccase-mediated oligomerisation in the presence of R-mPES$_{10}$. 4-HBA (40 mg, 0.30 mmol, 30.0 mM final concentration, 6 eq.) and laccase (32 U, 3 U ml^{-1}) were dissolved in an aqueous ammonium acetate/acetic acid buffer (10 ml, 0.02 M, pH 5). After addition of R-mPES$_{10}$ (109 mg, "0.05 mmol" mPES$_{10}$, "1 eq." mPES$_{10}$) the mixture was gently shaken at 40 °C for 24 h. Washing of the modified resin was achieved with dichloromethane followed by acetone and finally water (3×). Cleavage from the resin was achieved in a 1:1 mixture of trifluoroacetic acid and dichloromethane. After evaporation of all volatiles, the cleaved material was analysed by LC-MS (LC-method LC2).

Laccase-mediated conversion of charged phenolics in the presence of a PES membrane or sheet

The positively or negatively charged phenolic (28.8 or 57.6 mM, 1 eq.), laccase (1 or 4 U ml^{-1}) and, in those cases where either of the phenols **B**, **C**, **D** or **F** was used, TEMPO (0.02 eq.) were dissolved in an aqueous sodium acetate/acetic acid buffer (0.1 M, pH 5). A cleaned PES membrane or sheet was placed in the reaction medium and agitated at rt or 40 °C for 24 h. Alternatively, a 50 µl aliquot of the reaction mixture was placed on a cleaned PES sheet which was allowed to stand for 24 h in the vicinity of a dish filled with water (at the start, this set-up was covered to minimise evaporation). Cleaning of both membranes and sheets was conducted by rinsing with water. Some modified PES sheets were gently wiped with a soft cotton swab for additional cleaning.

Laccase-mediated oligomerisation of 4-HBA in the presence of a PES membrane

4-HBA (2.0 mg, 0.06 mmol, 28.8 mM) and laccase (4 mg, 8 U, 4 U ml^{-1}) were dissolved in an aqueous sodium acetate/acetic acid buffer (0.1 M, pH 5) in a petri dish. A rinsed membrane was placed in the reaction medium and agitated at 40 °C for 4 h. The membrane was then flushed with lukewarm tap water for 2 min or 5 min on one side. Additional washing was thereafter either conducted by agitating the membrane in water or in an aqueous solution of TWEEN® (0.1 wt%) at 40 °C for 72 h.

Separation and analysis

LC-MS. For liquid chromatography-mass spectrometry (LC-MS) analysis a MS pump (Thermo Finnigan Surveyor) was coupled to a photodiode array detector (Thermo Finnigan Surveyor PDA) and a mass spectrometer (Finnigan LXQ). Measurements were conducted in negative ionisation mode. Separation was achieved on an Alltima HP C18 column (2.1 mm × 100 mm, 3 µm; Grace) at room temperature at a flow rate of 0.2 ml min^{-1}. The mobile phases consisted of 0.1% formic acid in water (mobile phase A) and in acetonitrile (mobile phase B).

LC1: Separation was achieved through isocratic elution with 15% B for 5.0 min followed by isocratic elution with 20% B for 12.0 min, after which the column was flushed through isocratic elution with 100% B for 13.0 min. The column was re-equilibrated by employing 15% B for 15.0 min.

LC2: Separation was achieved through elution with a linear gradient starting with 20% B and ending with 100% B after 30.0 min, after which the column was flushed through isocratic elution with 100% B for 15.0 min. The column was re-equilibrated by employing 20% B for 15.0 min.

LC3: Separation was achieved through elution with a linear gradient starting with 5% B and ending with 95% B after 20.0 min, after which the column was flushed through isocratic elution with 95% B for 20.0 min. The column was re-equilibrated by employing 5% B for 12.0 min.

LC4: Separation was achieved through elution with a linear gradient starting with 5% B and ending with 75% B after 20.0 min, additional separation was thereafter achieved through isocratic elution with 75% for 5.0 min. Flushing of the column was subsequently achieved through isocratic elution with 95% B for 15.0 min (25.0 min when using highly concentrated material), after which the column was re-equilibrated by employing 5% B for 12.0 min.

Preparative HPLC. Preparative HPLC-separations were performed on an Alltima C18 column (22 mm × 250 mm, 5 µm; Grace). A LC-8A Shimadzu LC-pump was connected to a SPD-M10AVP Shimadzu diode array detector. Separation was achieved at room temperature through elution with 3% methanol in water at a flow rate of 15 ml min^{-1}.

FT-IR. FT-IR spectra were measured on a diamond crystal (Platinum ATR, Bruker) integrated in a Bruker Tensor 27 spectrophotometer system controlled through OPUS software (version 7.2.139.1294). All spectra were recorded with at least 16 scans, using ambient air as background.

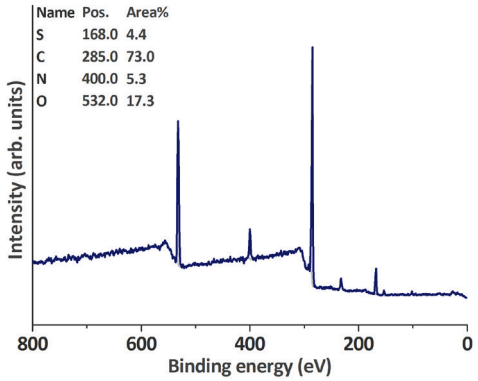
XPS. X-ray photoelectron spectroscopy (XPS) core electron binding energies were measured on a JPS-9200 photoelectron spectrometer (JEOL). Surfaces were irradiated at one or more spots with an Al Kα source emitting 1486.7 eV photons while charge compensation was being applied with an accelerating voltage of 2.8 eV and a filament current of 4.80 A to compensate for charging of the carbon-based polymer surfaces. Spectra were analysed

using CasaXPS version 2.3.16 PR 1.6. The C 1s peak emission was calibrated to a binding energy of 284.5 eV when measuring on PES, and C 1s narrow scans were deconvoluted into their component peaks using Gaussian–Lorentzian sum functions having 30%–70% Gaussian–Lorentzian character.

SWCA measurement. SWCA measurements were performed on a Krüss DSA 100 drop shape analyser. SWCA's were assessed for 3 µl water droplets, where drop shape was fitted according to Tangent-2 fitting parameters (Krüss DSA software version 1.90.0.14) by fitting at least 10× for each droplet. Reported values are an average of SWCA's measured over multiple droplets on a surface.

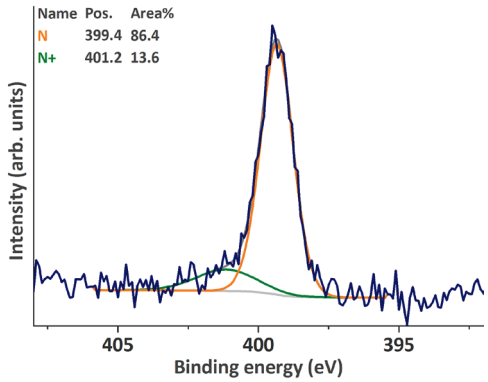
Supporting figures

Fig. S1 – XPS wide scan of PES membrane after incubation with **A** (28.8 mM) and laccase (4 U ml^{-1}) at room temperature.



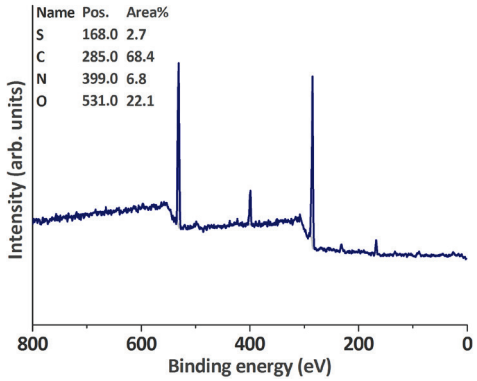
Corresponds to Table 1, entry 2.

Fig. S2 – XPS N 1s narrow scan of PES sheet after incubation with **B** (28.8 mM) and laccase (4 U ml^{-1}) at room temperature.



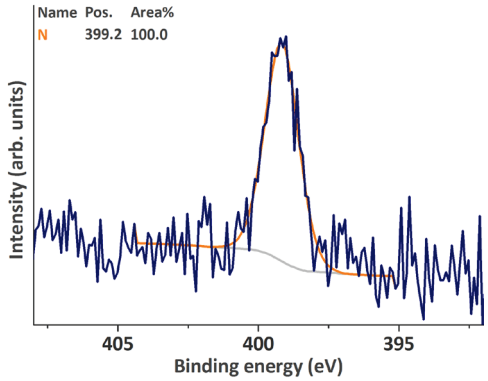
Corresponds to Table 1, entry 3.

Fig. S3 – XPS wide scan of PES sheet after incubation with **B** (57.6 mM) and laccase (4 U ml^{-1}) at 40 °C.



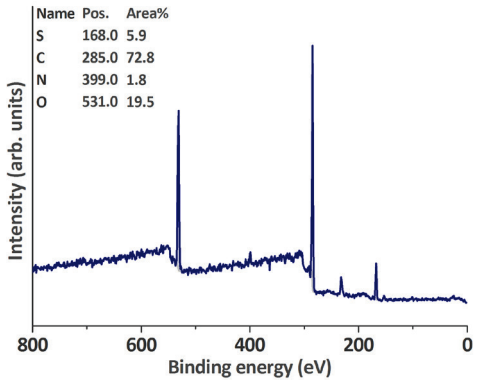
Corresponds to Table 1, entry 6.

Fig. S4 – XPS N 1s narrow scan of PES sheet after incubation with **B** (57.6 mM) and laccase (4 U ml^{-1}) at 40 °C and subsequent wiping.



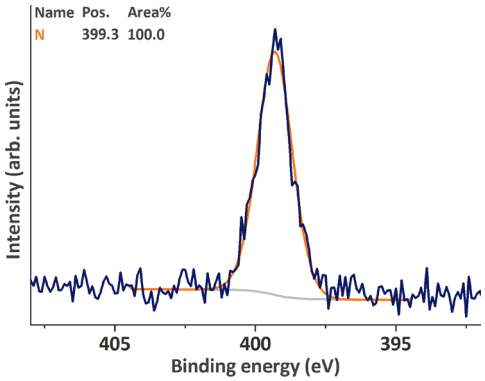
Corresponds to Table 1, entry 7.

Fig. S5 – XPS wide scan of PES sheet after incubation with **B** (57.6 mM) and laccase (4 U ml^{-1}) at 40 °C and subsequent wiping.



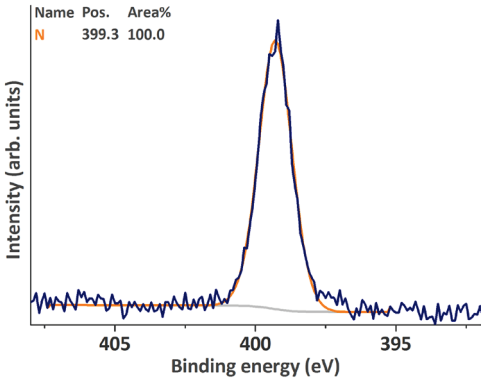
Corresponds to Table 1, entry 7.

Fig. S6 – XPS N 1s narrow scan of PES sheet after incubation with **C** (28.8 mM) and laccase (4 U ml^{-1}) at room temperature.



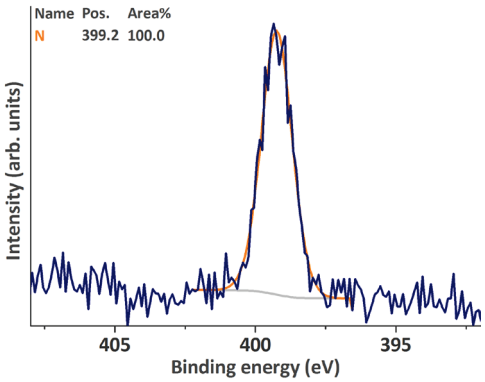
Corresponds to Table 1, entry 8.

Fig. S7 – XPS N 1s narrow scan of PES sheet after incubation with **C** (28.8 mM) and laccase (4 U ml^{-1}) at 40 °C.



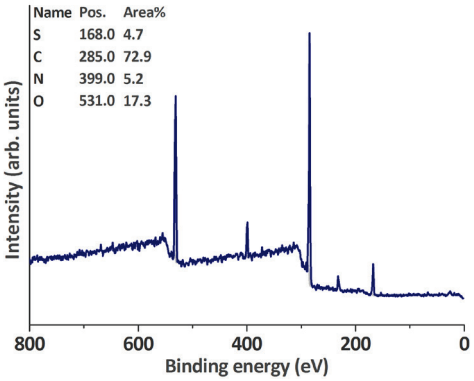
Corresponds to Table 1, entry 10

Fig. S8 – XPS N 1s narrow scan of PES sheet after incubation with **D** (28.8 mM) and laccase (4 U ml^{-1}) at room temperature.



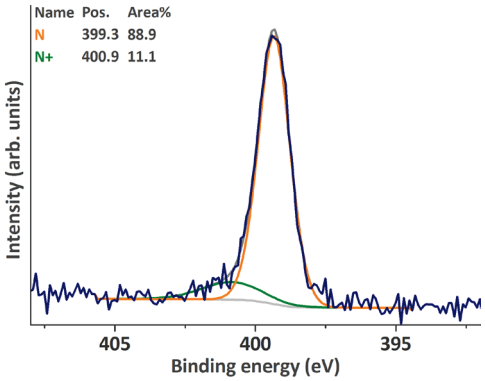
Corresponds to Table 1, entry 12.

Fig. S9 – XPS wide scan of PES sheet after incubation with **D** (28.8 mM) and laccase (4 U ml^{-1}) at room temperature.



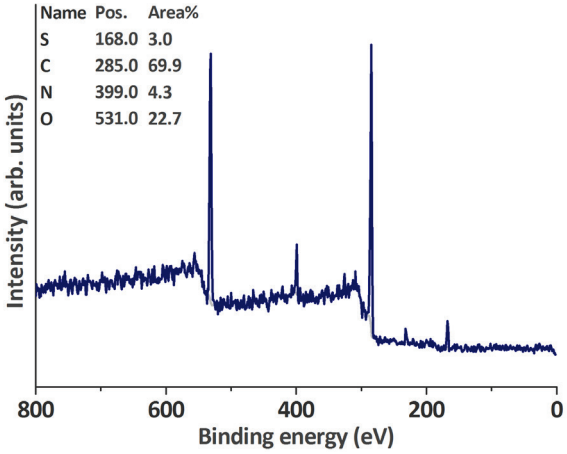
Corresponds to Table 1, entry 12.

Fig. S10 – XPS N 1s narrow scan of PES sheet after incubation with **F** (28.8 mM) and laccase (4 U ml^{-1}) at room temperature.



Corresponds to Table 1, entry 14.

Fig. S11 – XPS N 1s narrow scan of PES sheet after incubation with laccase (4 U ml^{-1}) at room temperature.



Corresponds to Table 1, entry 16.

Fig. S12 – XPS N 1s narrow scan of PES sheet after incubation with **A** (28.8 mM) and purified laccase (4 U ml^{-1}) at room temperature.

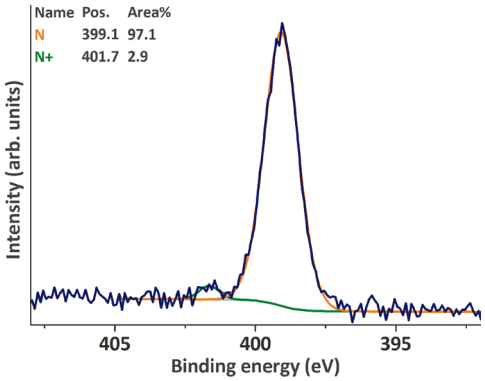


Fig. S13 – XPS wide scan of PES sheet after incubation with **A** (28.8 mM) and purified laccase (4 U ml^{-1}) at room temperature.

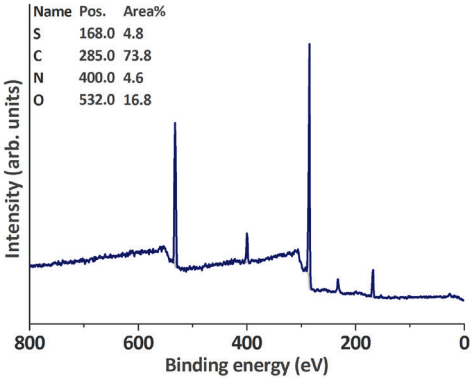
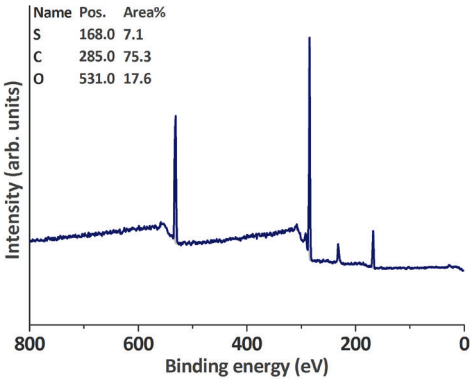


Fig. S14 – XPS wide scan of blank (non-modified) PES sheet.



Corresponds to Table 1, entry 19.

Fig. S15 – XPS N 1s narrow scan of **F3** dropcasted on an etched silicon wafer.

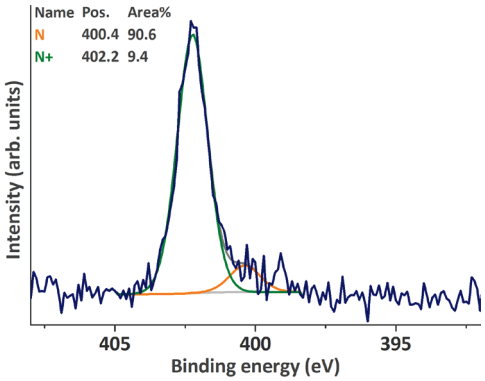
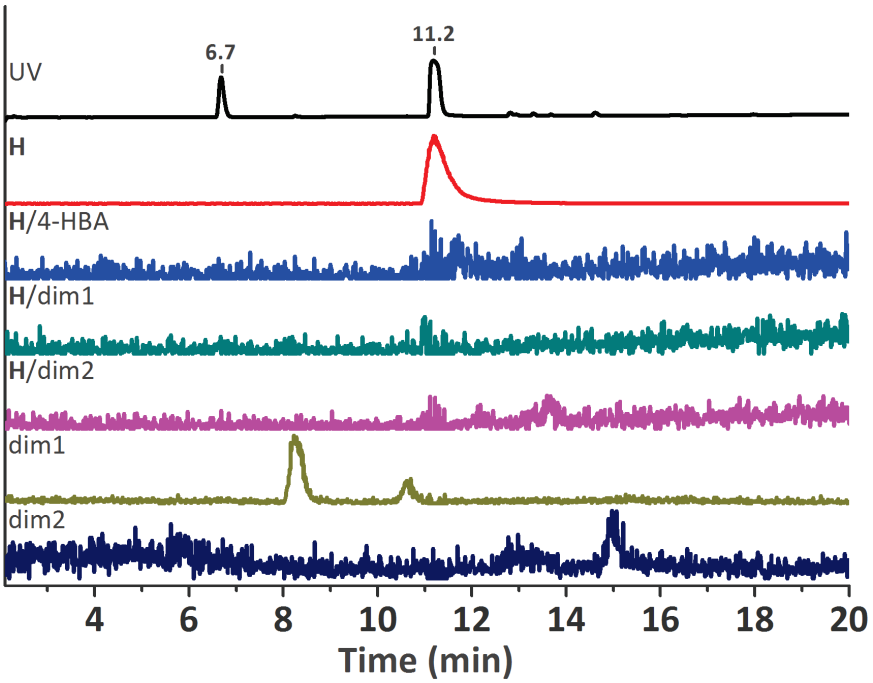
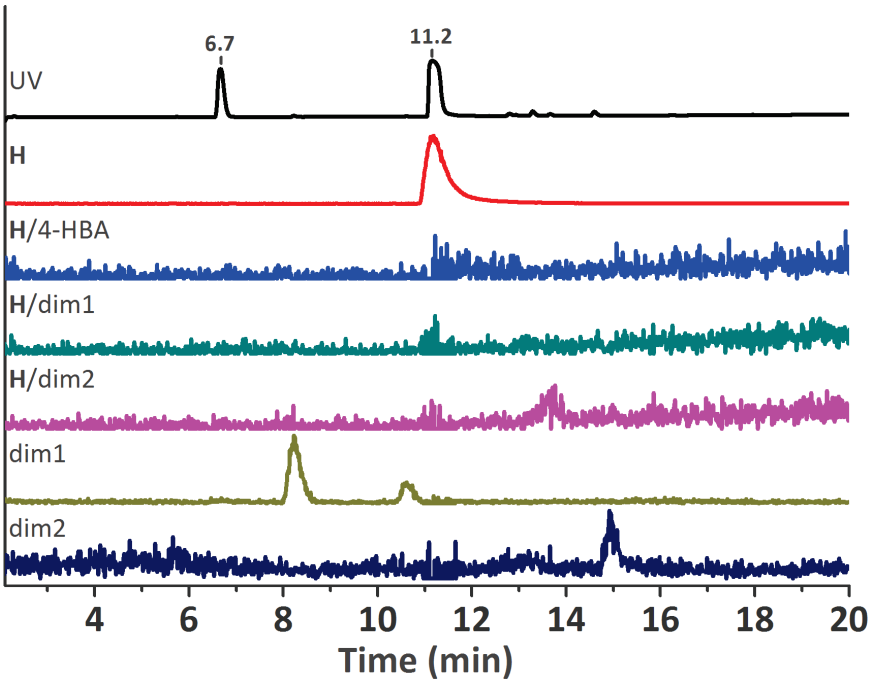


Fig. S16 – LC-MS analysis of the reaction medium after incubation of 4-HBA, laccase and **H**.



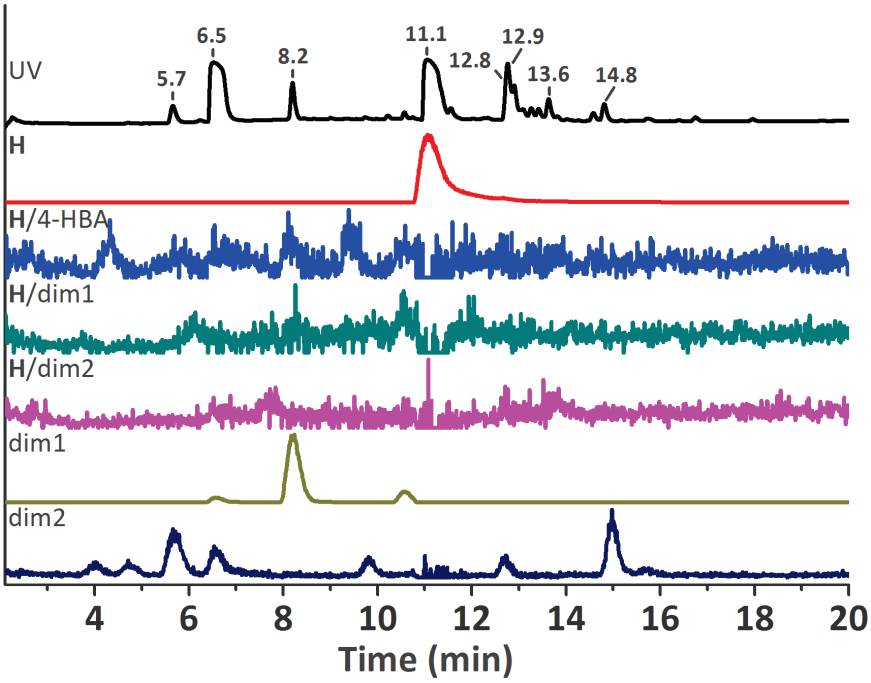
UV trace and extracted ion chromatograms of ions whose *m/z* ($[M-H]^-$ ± 0.50 Da) corresponds to that of **H**, dim1/dim2 or their conjugates after incubation of 4-HBA, laccase and **H**.

Fig. S17 – LC-MS analysis of the reaction medium after incubation of 4-HBA, laccase, TEMPO and **H**.



UV trace and extracted ion chromatograms of ions whose *m/z* ([M-H]$^-$ ± 0.50 Da) corresponds to that of **H**, dim1/dim2 or their conjugates after incubation of 4-HBA, laccase, TEMPO and **H**.

Fig. S18 – LC-MS analysis of the highly concentrated reaction medium after incubation of 4-HBA, laccase and **H**.



UV trace and extracted ion chromatograms of ions whose *m/z* ([M-H]$^-$ ± 0.50 Da) corresponds to that of **H**, dim1/dim2 or their conjugates after incubation of 4-HBA, laccase and **H**.

Fig. S19 – Mass spectrum corresponding to peak at 5.7 min in ESI Fig. S18.

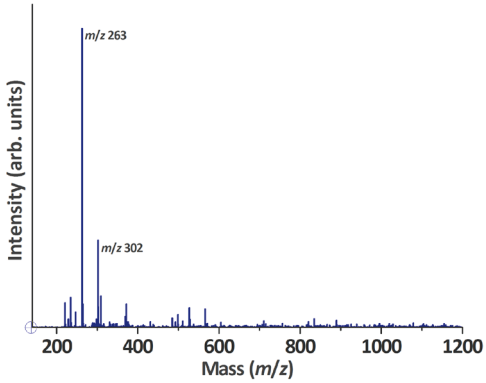


Fig. S20 – Mass spectrum corresponding to peak at 6.5 min in ESI Fig. S18.

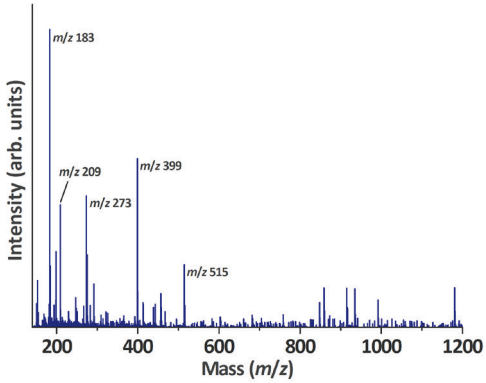


Fig. S21 – Mass spectrum corresponding to peak at 8.2 min in ESI Fig. S18.

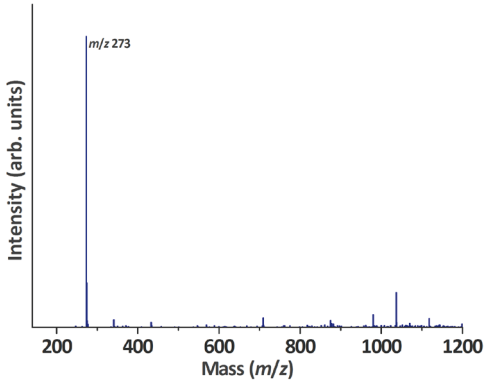


Fig. S22 – Mass spectrum corresponding to peak at 11.1 min in ESI Fig. S18.

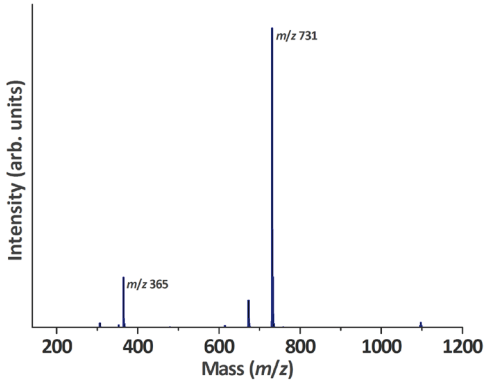


Fig. S23 – Mass spectrum corresponding to peak at 12.8 min in ESI Fig. S18.

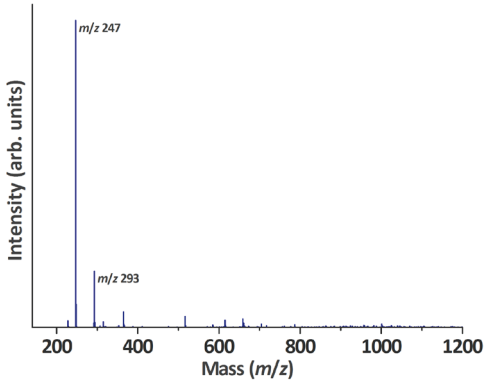


Fig. S24 – Mass spectrum corresponding to peak at 12.9 min in ESI Fig. S18.

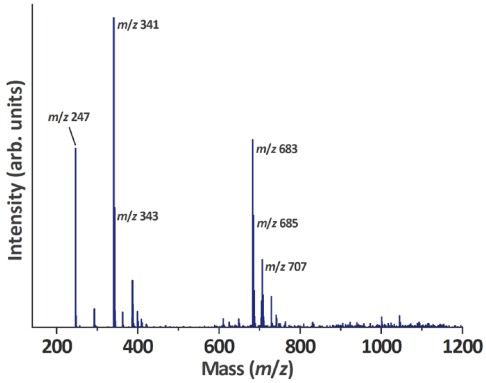


Fig. S25 – Mass spectrum corresponding to peak at 13.6 min in ESI Fig. S18.

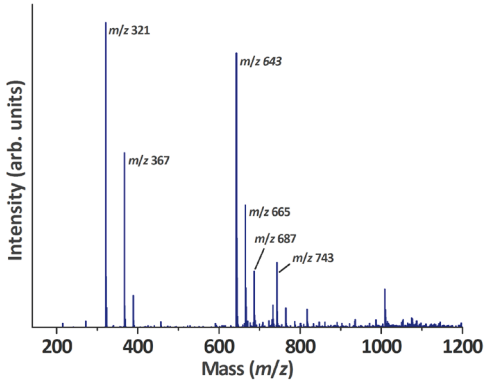


Fig. S26 – Mass spectrum corresponding to peak at 14.8 min in ESI Fig. S18.

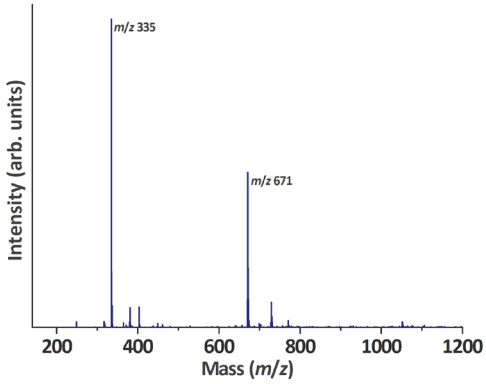
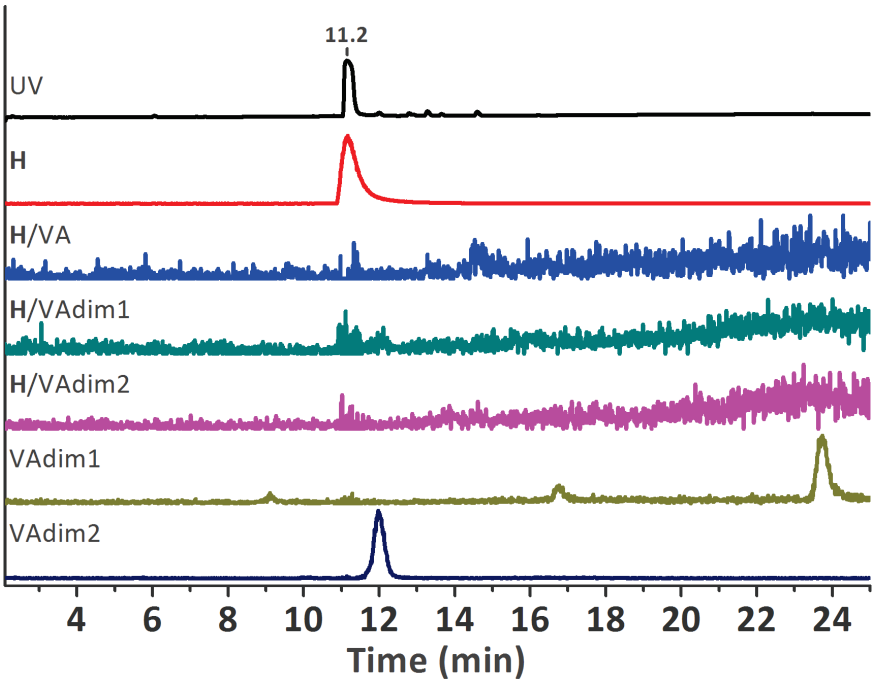
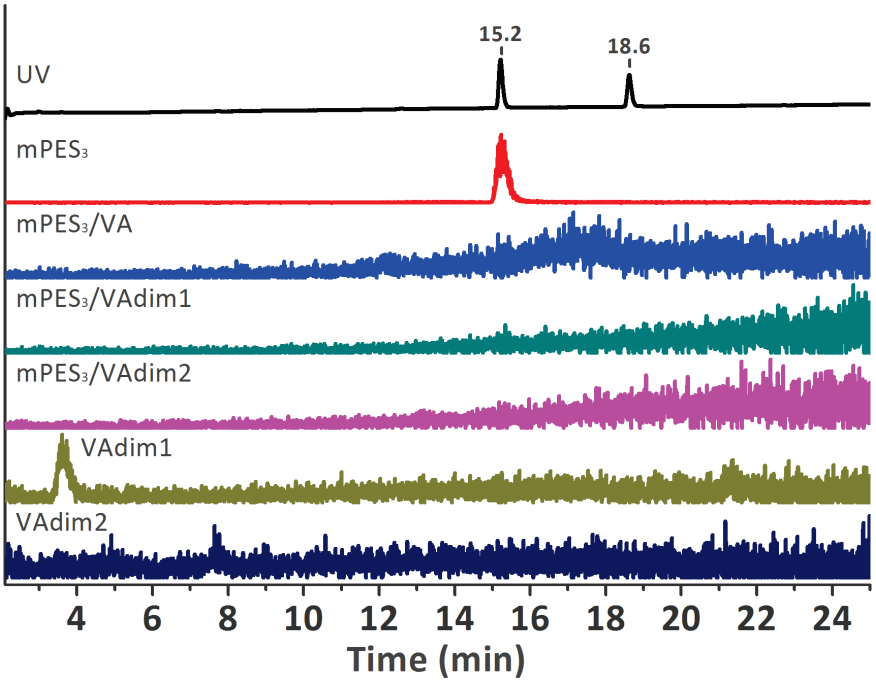


Fig. S27 – LC-MS analysis of the reaction medium after incubation of vanillic acid (VA), laccase and **H**.



UV trace and extracted ion chromatograms of ions whose *m/z* ($[M-H]^-$ ± 0.50 Da) corresponds to that of **H**, VAdim1/VAdim2 or their conjugates after incubation of VA, laccase and **H**.

Fig. S28 – LC-MS analysis of the material cleaved from R-mPES$_3$ after its incubation with vanillic acid (VA) and laccase.



UV trace and extracted ion chromatograms of ions whose *m/z* ($[M-H]^-$ ± 0.50 Da) corresponds to that of mPES$_3$, VAdim1/VAdim2 or their conjugates after incubation of VA, laccase and R-mPES$_3$.

Fig. S29 – LC-MS analysis (mass spectrum) of the material cleaved from R-mPES$_3$ after its incubation with syringic acid and laccase.

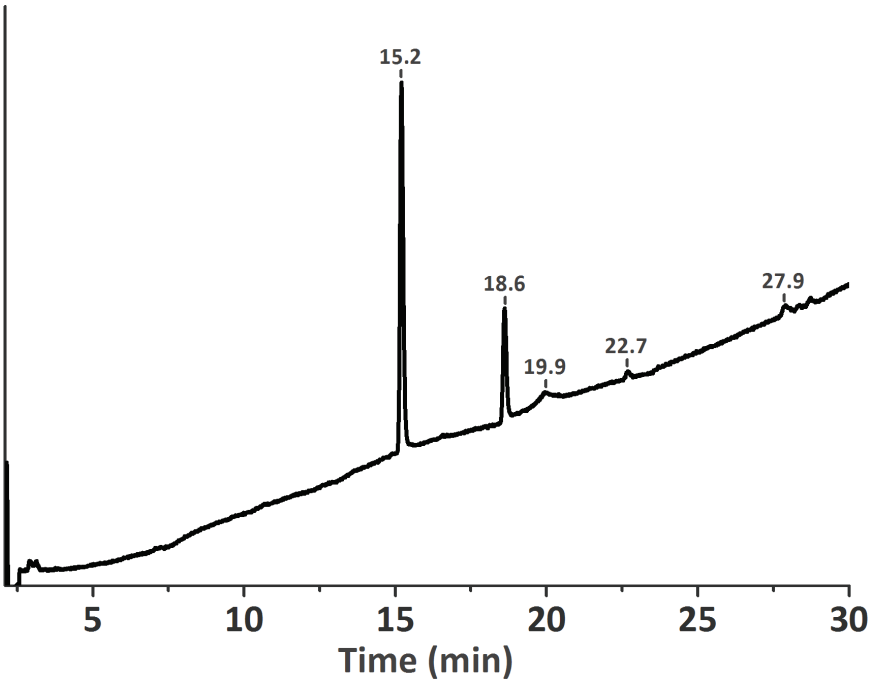


Fig. S30 – Mass spectrum corresponding to peak at 19.9 min in ESI Fig. S29.

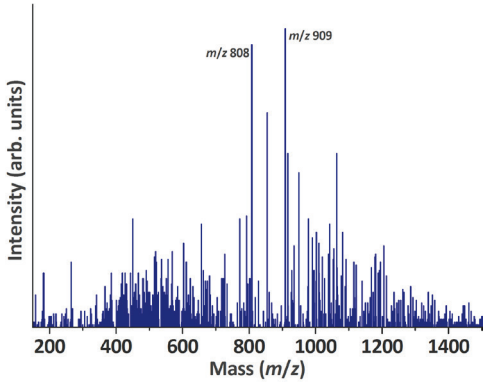


Fig. S31 – Mass spectrum corresponding to peak at 22.7 min in ESI Fig. S29.

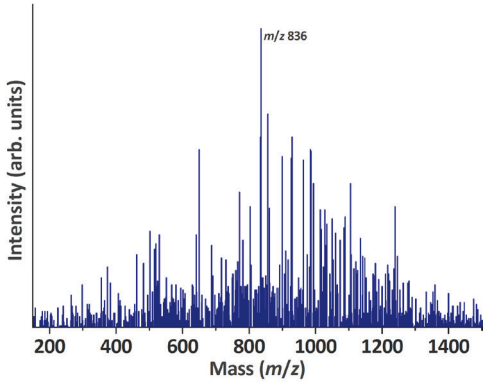


Fig. S32 – Mass spectrum corresponding to peak at 27.9 min in ESI Fig. S29.

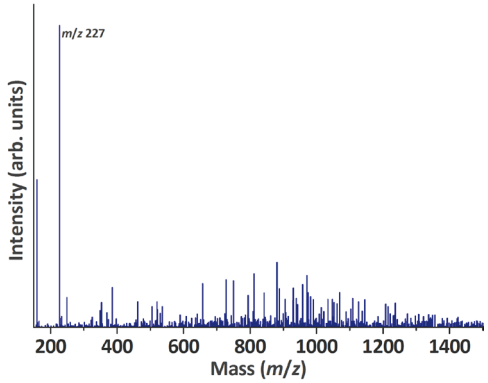
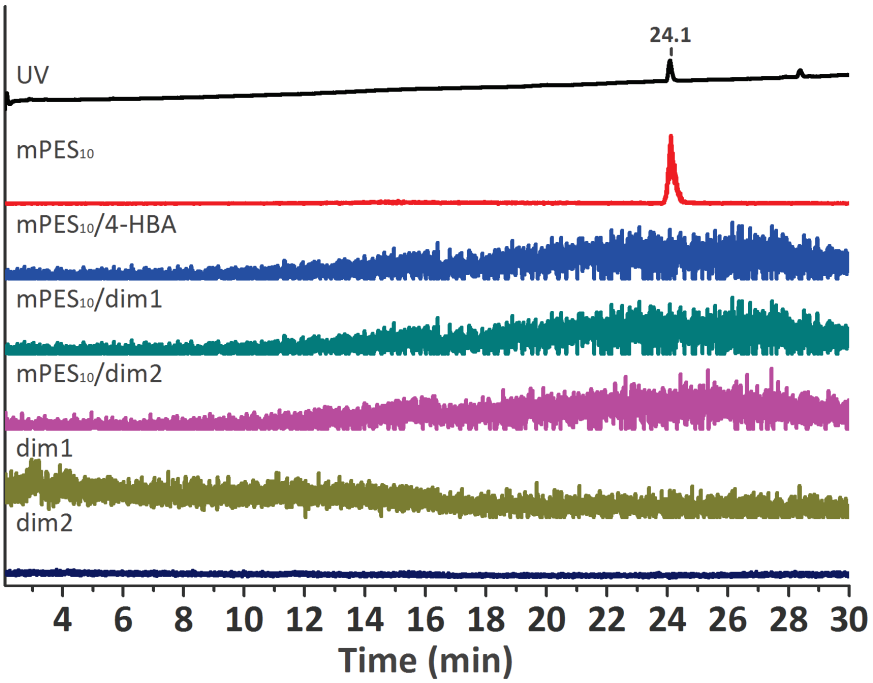


Fig. S33 – LC-MS analysis of the material cleaved from R-mPES$_{10}$ after its incubation with 4-HBA and laccase.



UV trace and extracted ion chromatograms of ions whose *m/z* ([M-H]$^-$ ± 0.50 Da) corresponds to that of mPES$_{10}$, dim1/dim2 or their conjugates after incubation of 4-HBA, laccase and R-mPES$_{10}$.

Fig. S34 – SDS-PAGE gel of purified laccase (Lac) and mass markers (M)

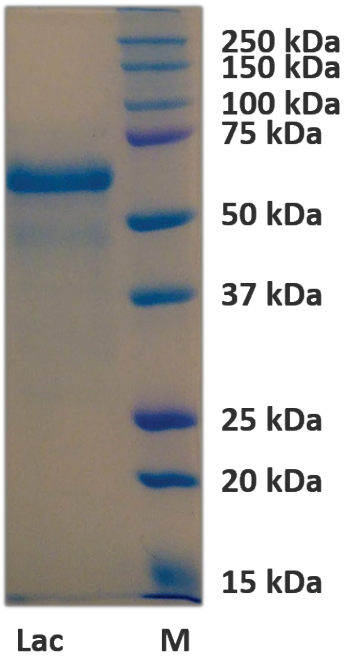


Fig. S35 – ^{1}H NMR spectrum of *tert*-butyl 4-hydroxybenzoate (**E1**) (solvent: $CDCl_3$).

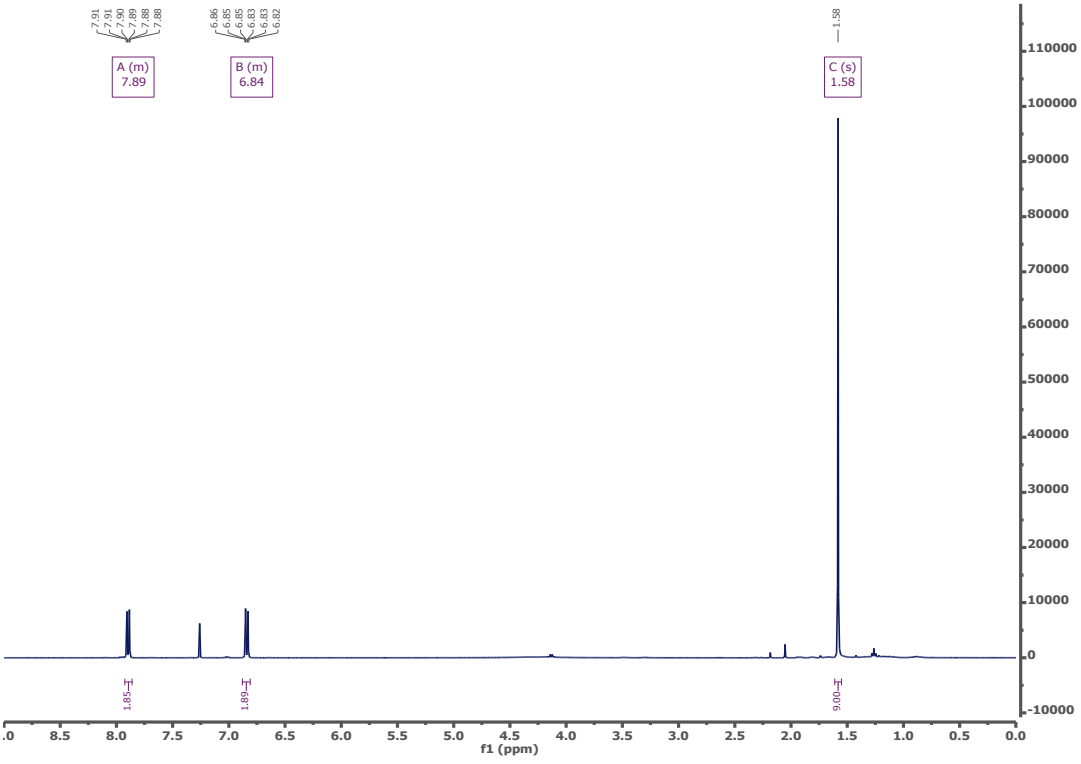


Fig. S36 – ^{13}C NMR spectrum of *tert*-butyl 4-hydroxybenzoate (**E1**) (solvent: $CDCl_3$).

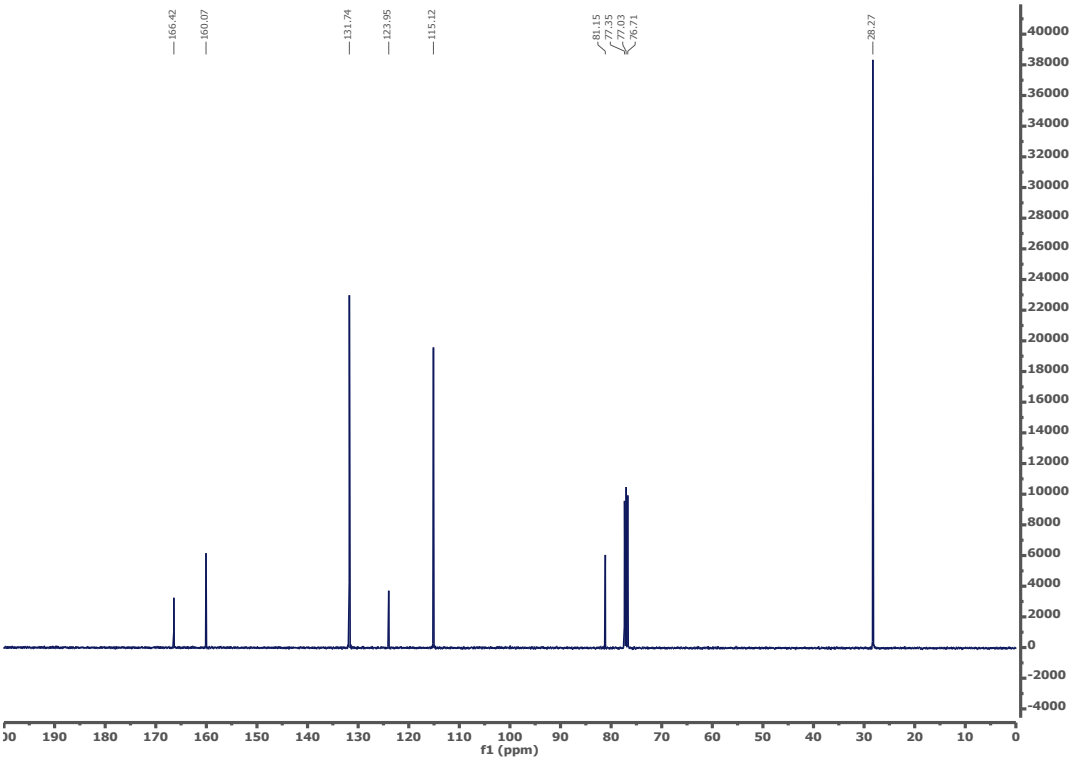


Fig. S37 – ^{1}H NMR spectrum of *N,N,N*-trimethyltyramine chloride (**A**) (solvent: D_2O).

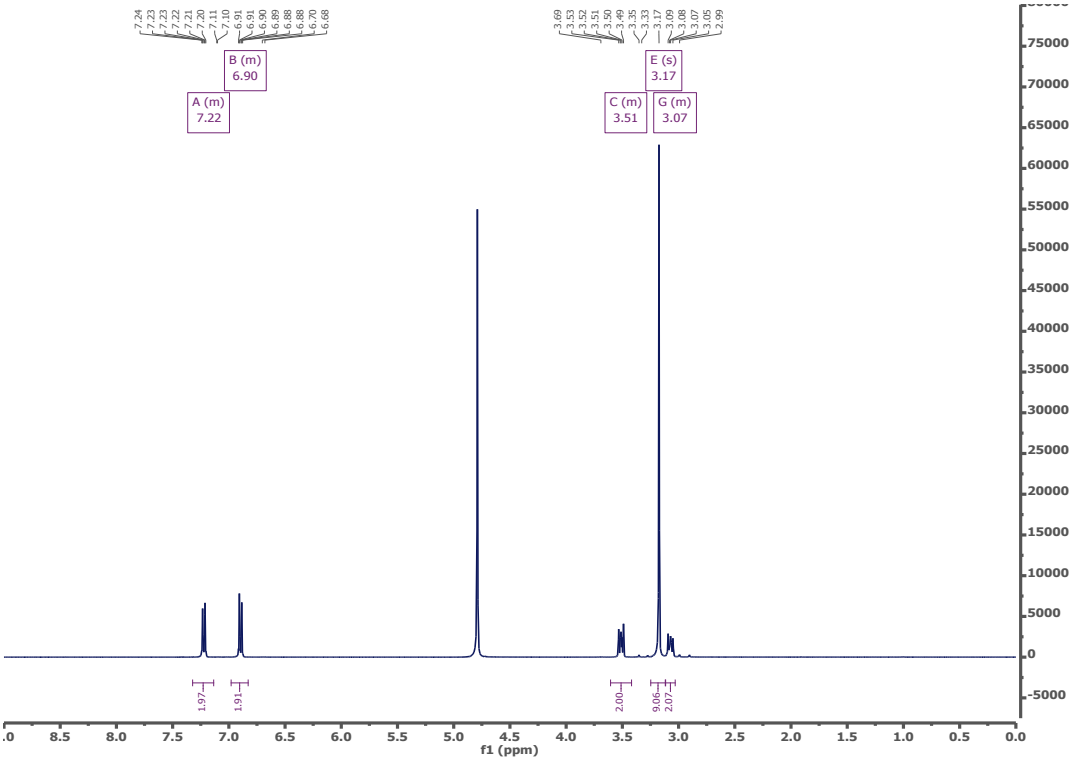


Fig. S38 – ^{13}C NMR spectrum of *N,N,N*-trimethyltyramine chloride (**A**) (solvent: D_2O).

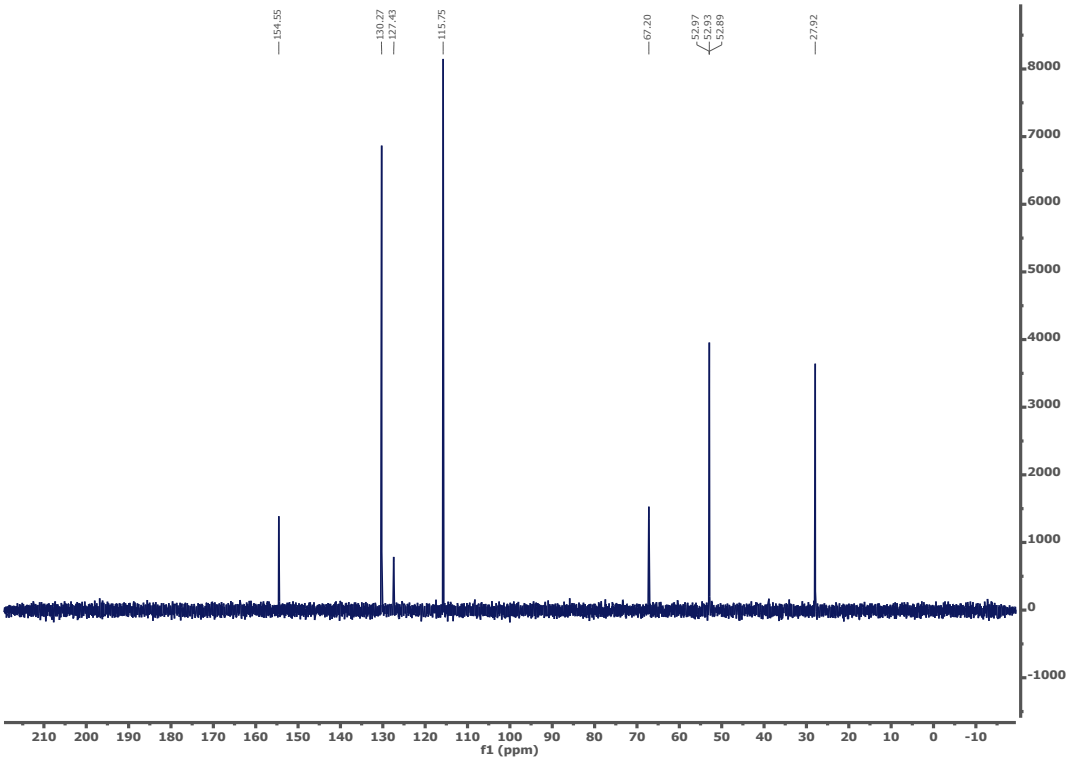


Fig. S39 – DEPT135 spectrum of *N,N,N*-trimethyltyramine chloride (**A**) (solvent: D_2O).

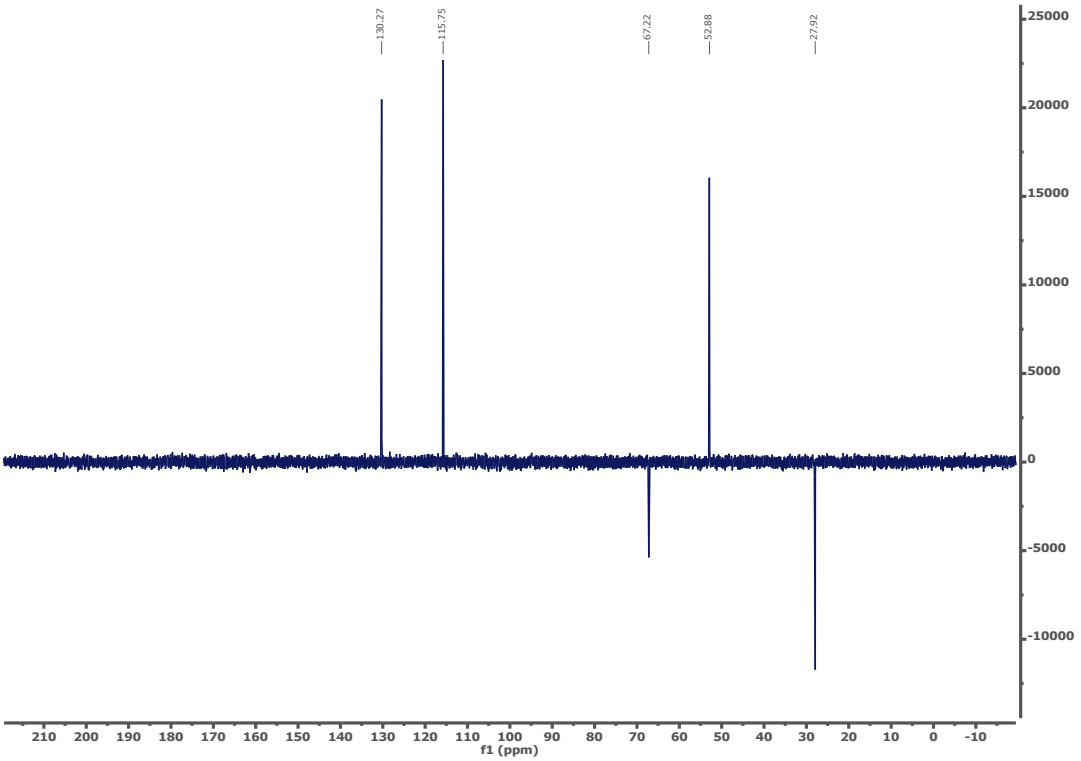


Fig. S40 – COSY spectrum of *N,N,N*-trimethyltyramine chloride (**A**) (solvent: D_2O).

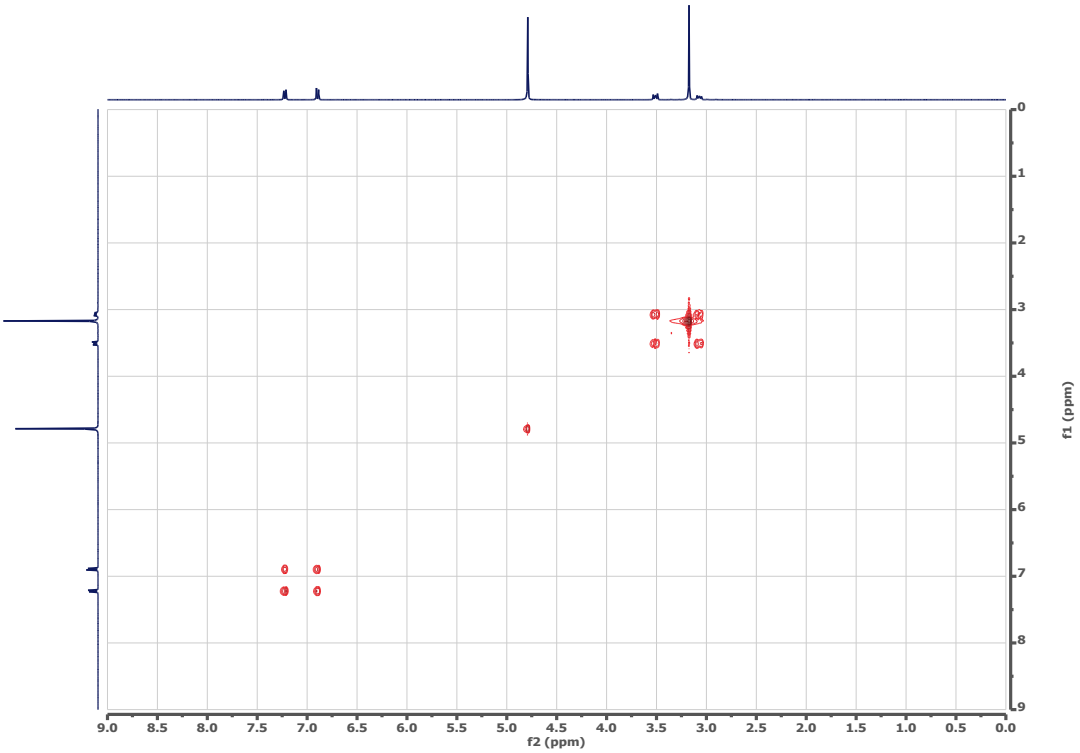


Fig. S41 – HSQC spectrum of *N,N,N*-trimethyltyramine chloride (**A**) (solvent: D_2O).

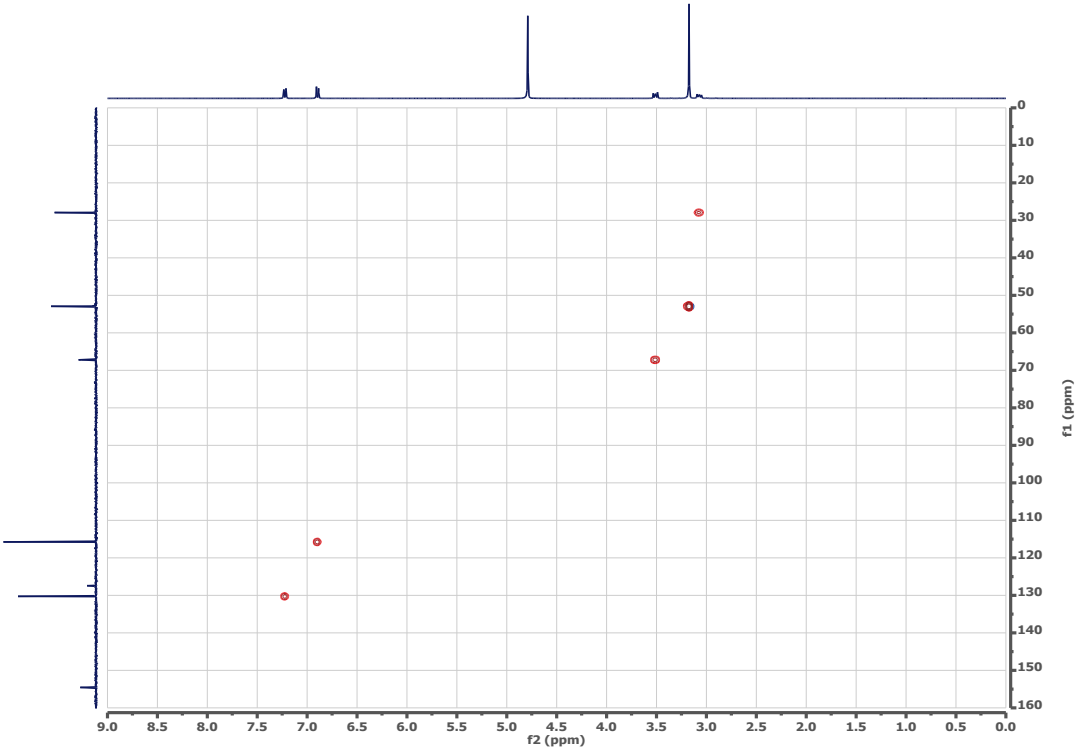


Fig. S42 – HMBC spectrum of *N,N,N*-trimethyltyramine chloride (**A**) (solvent: D_2O).

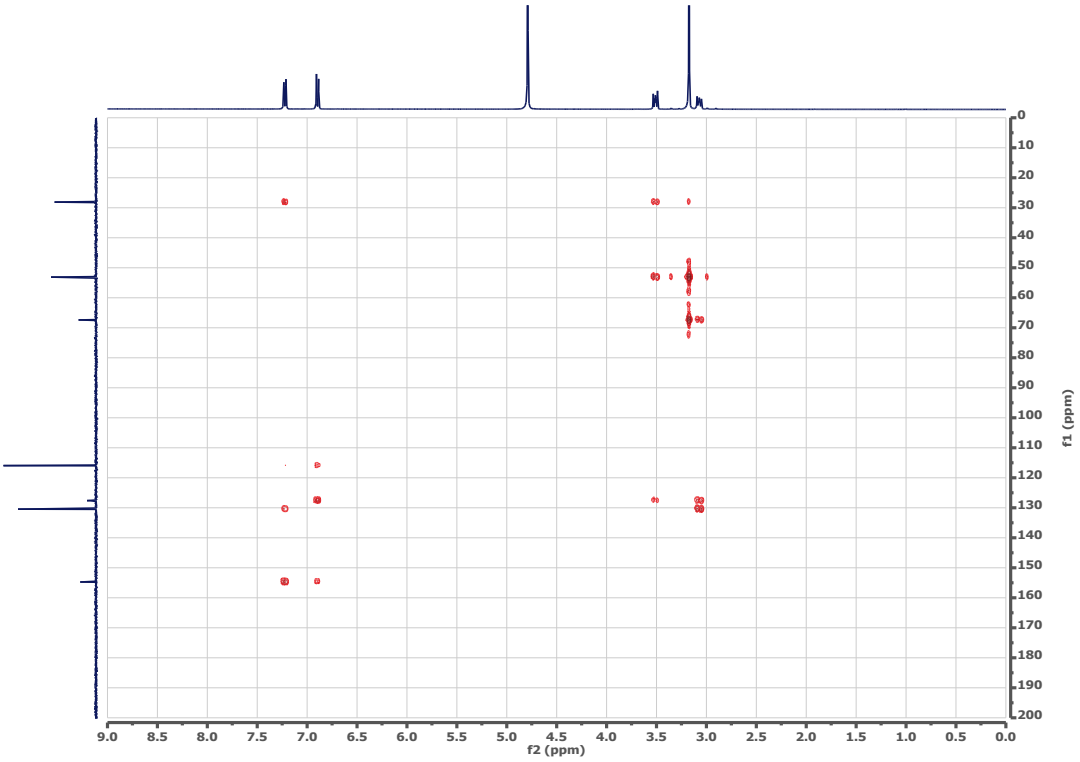


Fig. S43 – ^1H NMR spectrum of 1,1'-(2-hydroxy-5-methoxy-1,3-phenylene)bis(*N,N,N*-trimethylmethanaminium) dichloride (**B**) (solvent: D_2O).

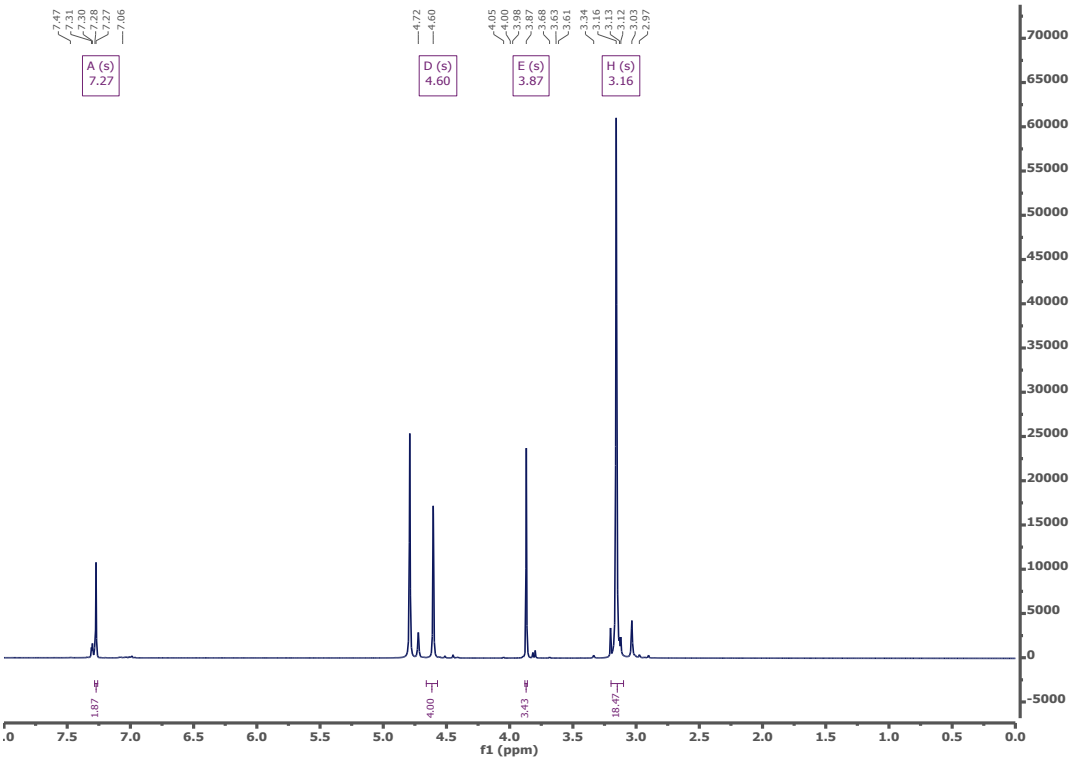


Fig. S44 – ^{13}C NMR spectrum of 1,1'-(2-hydroxy-5-methoxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**B**) (solvent: D_2O).

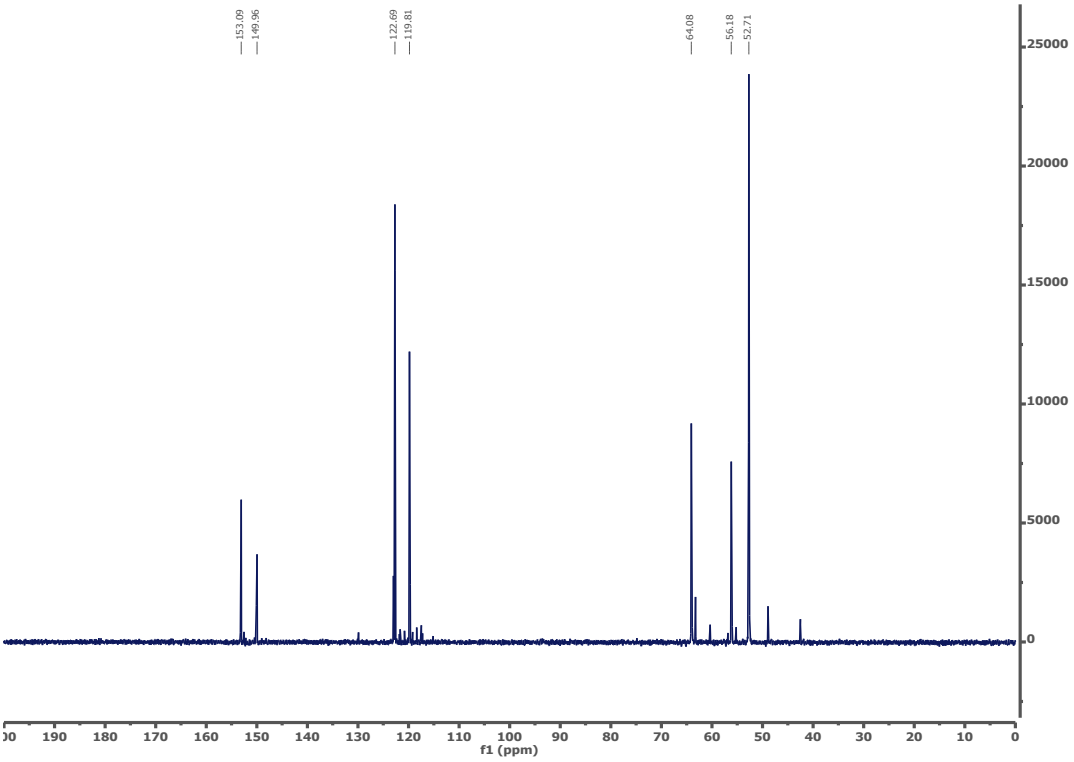


Fig. S45 – DEPT135 spectrum of 1,1'-(2-hydroxy-5-methoxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**B**) (solvent: D_2O).

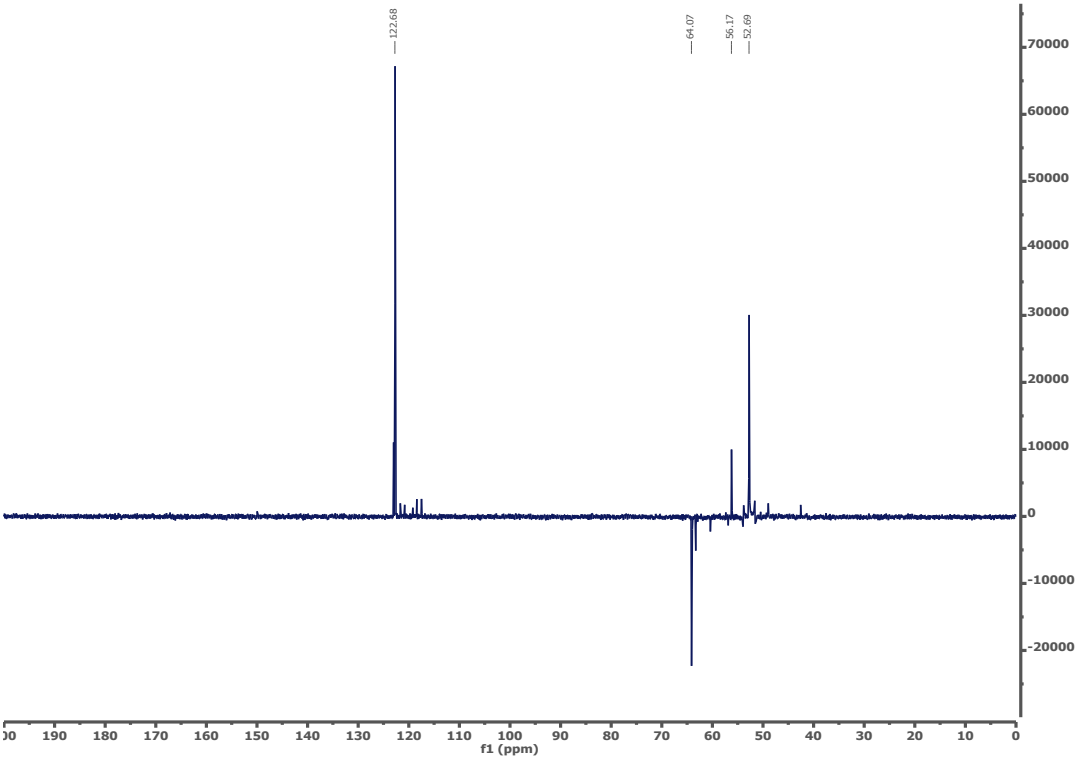


Fig. S46 – COSY spectrum of 1,1'-(2-hydroxy-5-methoxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**B**) (solvent: D_2O).

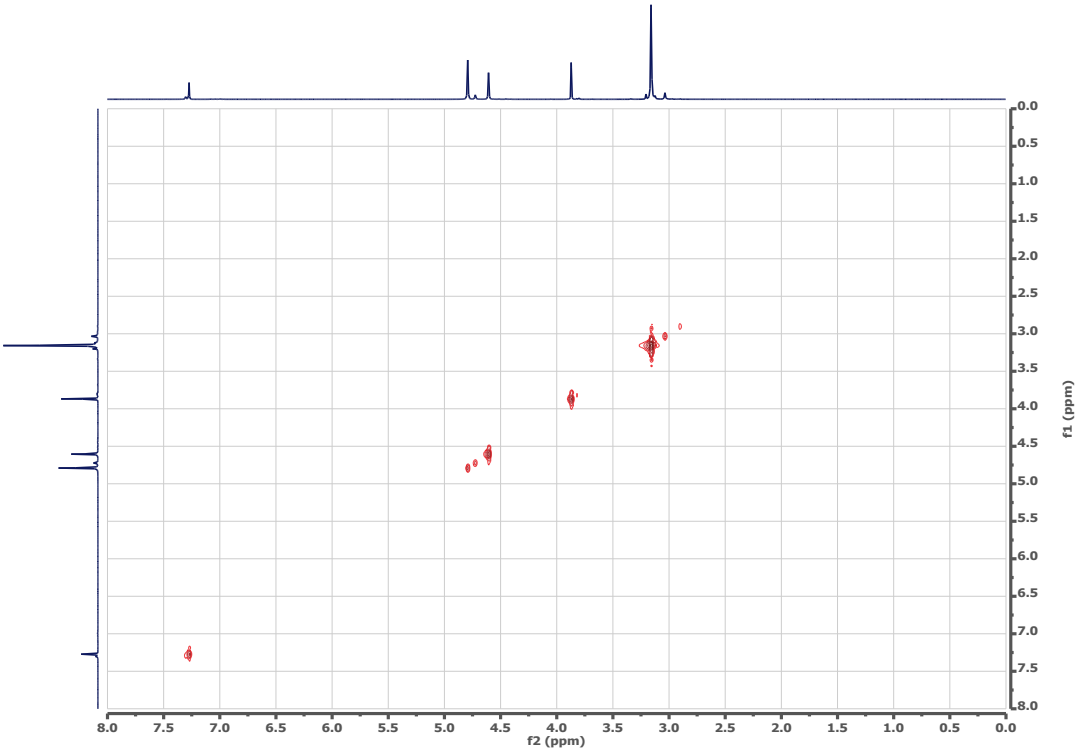


Fig. S47 – HSQC spectrum of 1,1'-(2-hydroxy-5-methoxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**B**) (solvent: D_2O).

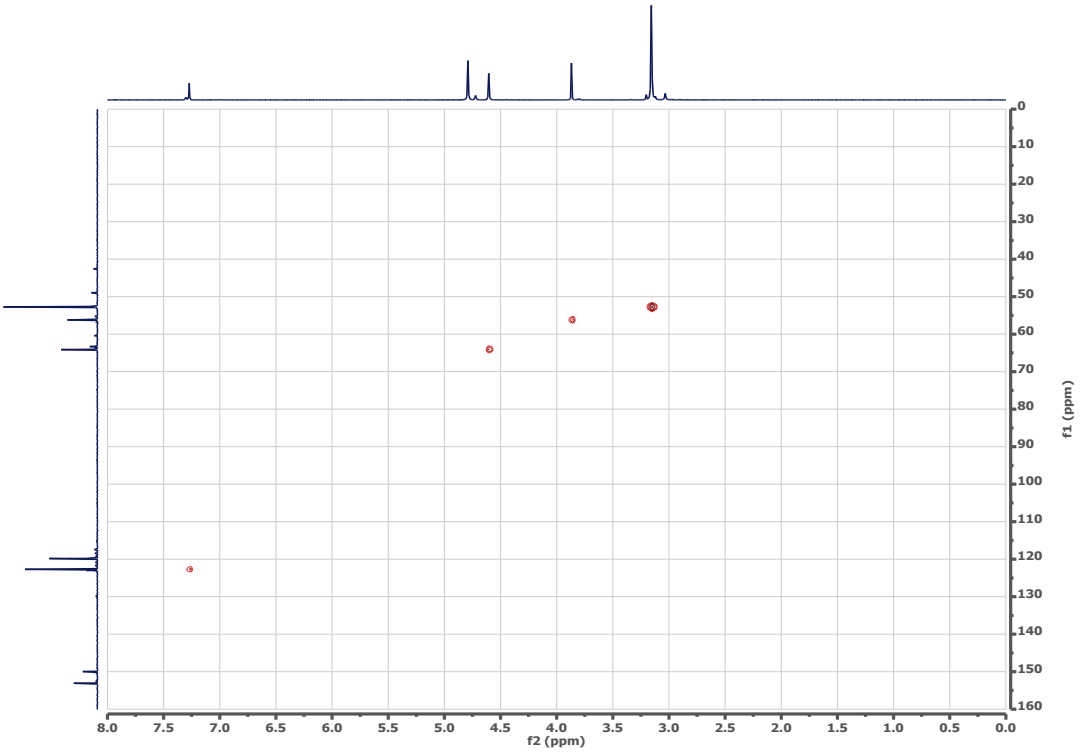


Fig. S48 – HMBC spectrum of 1,1'-(2-hydroxy-5-methoxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**B**) (solvent: D_2O).

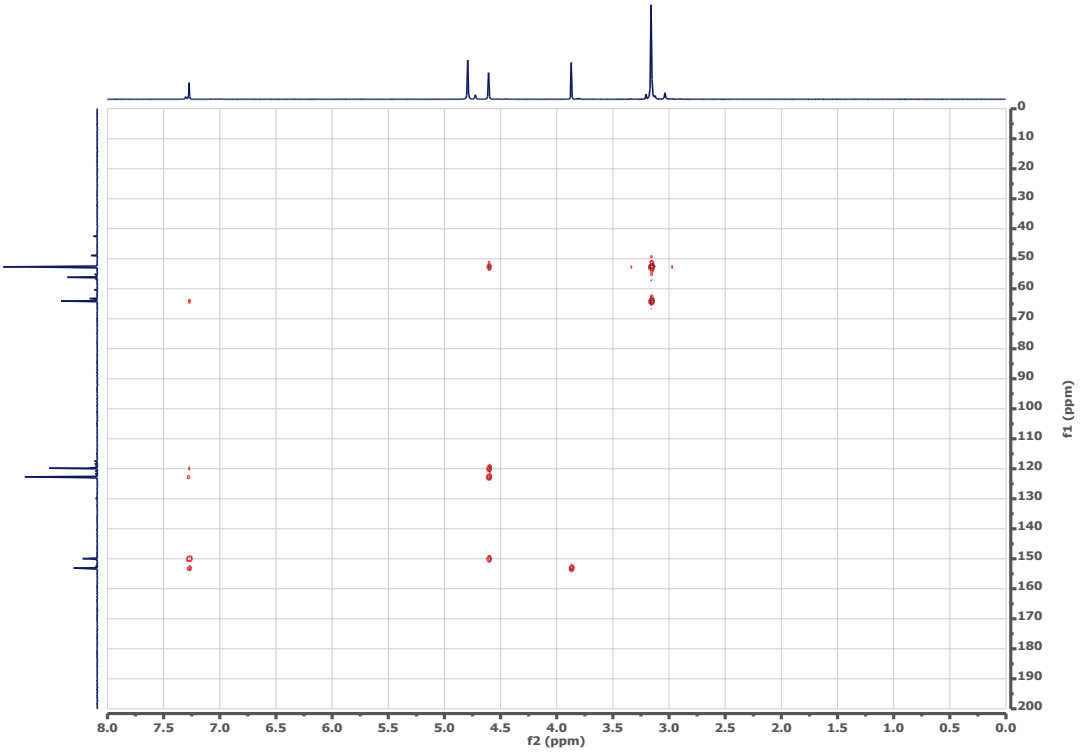


Fig. S49 – ^1H NMR spectrum of 1,1'-(2-hydroxy-5-(methoxycarbonyl)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**C**) (solvent: D_2O).

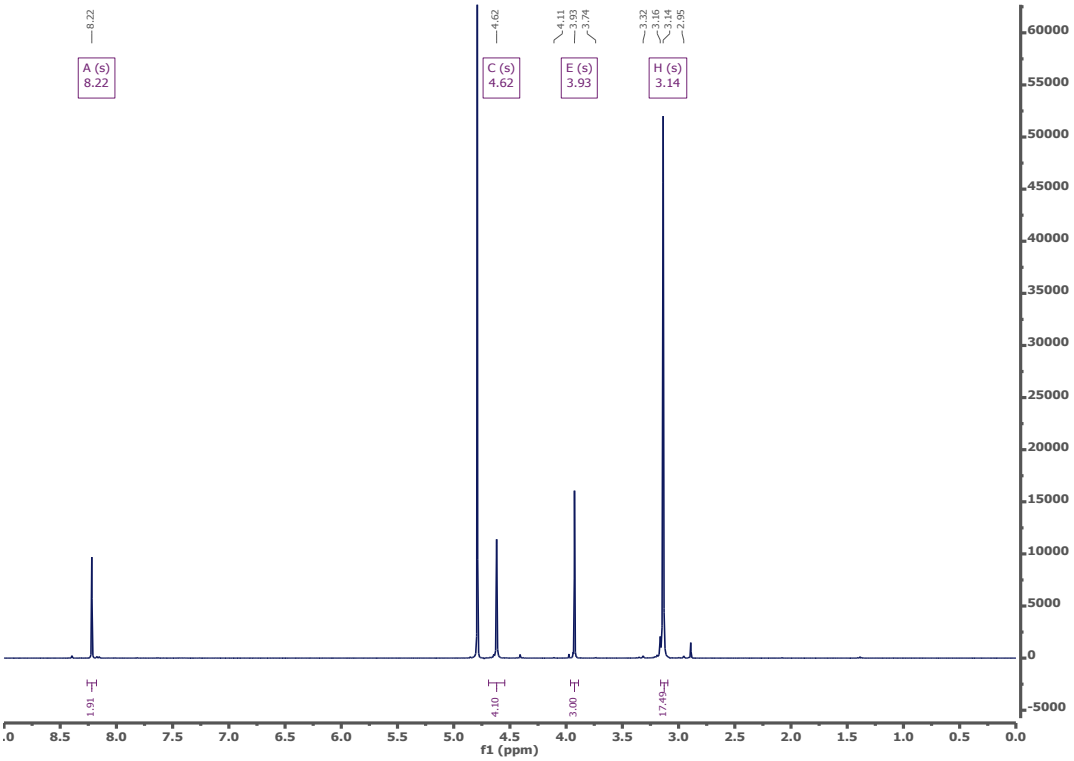


Fig. S50 – ^{13}C NMR spectrum of 1,1'-(2-hydroxy-5-(methoxycarbonyl)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**C**) (solvent: D_2O).

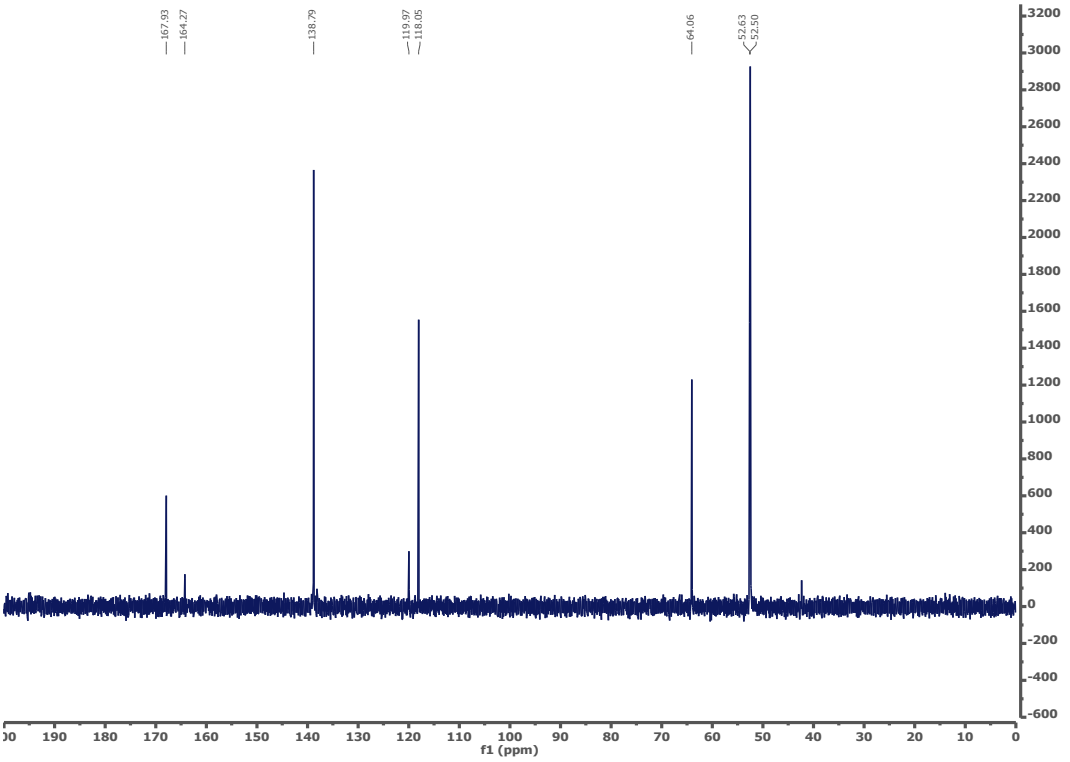


Fig. S51 – DEPT135 spectrum of 1,1'-(2-hydroxy-5-(methoxycarbonyl)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**C**) (solvent: D_2O).

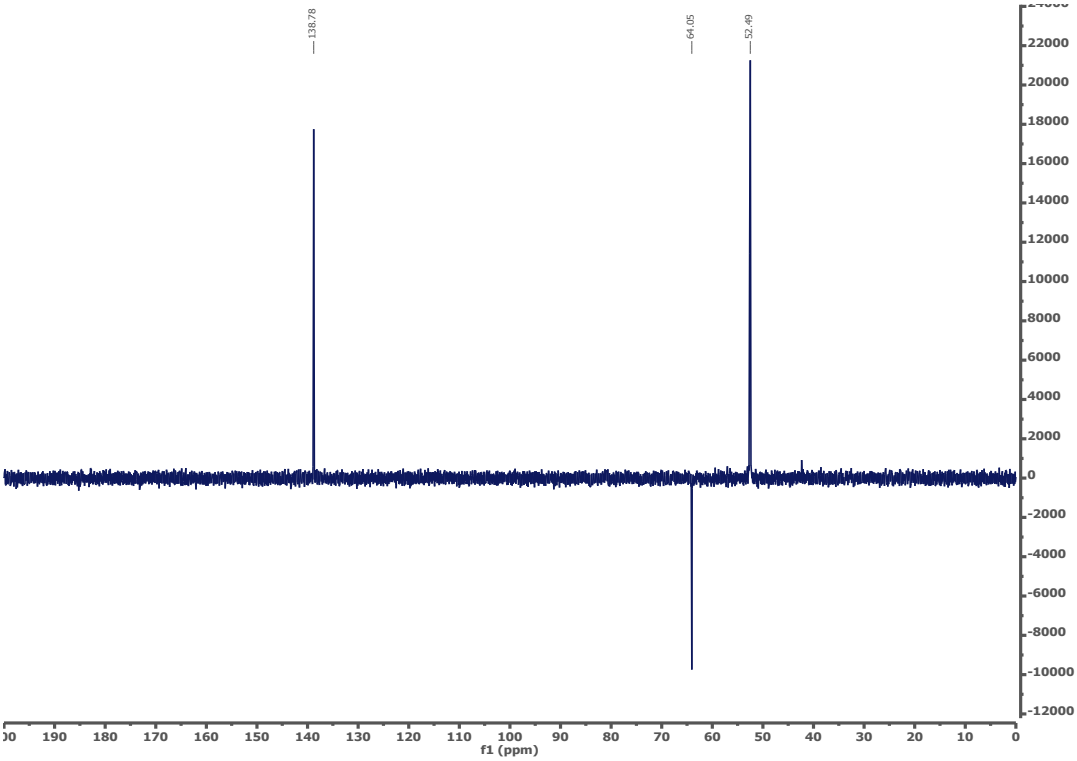


Fig. S52 – COSY spectrum of 1,1'-(2-hydroxy-5-(methoxycarbonyl)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**C**) (solvent: D_2O).

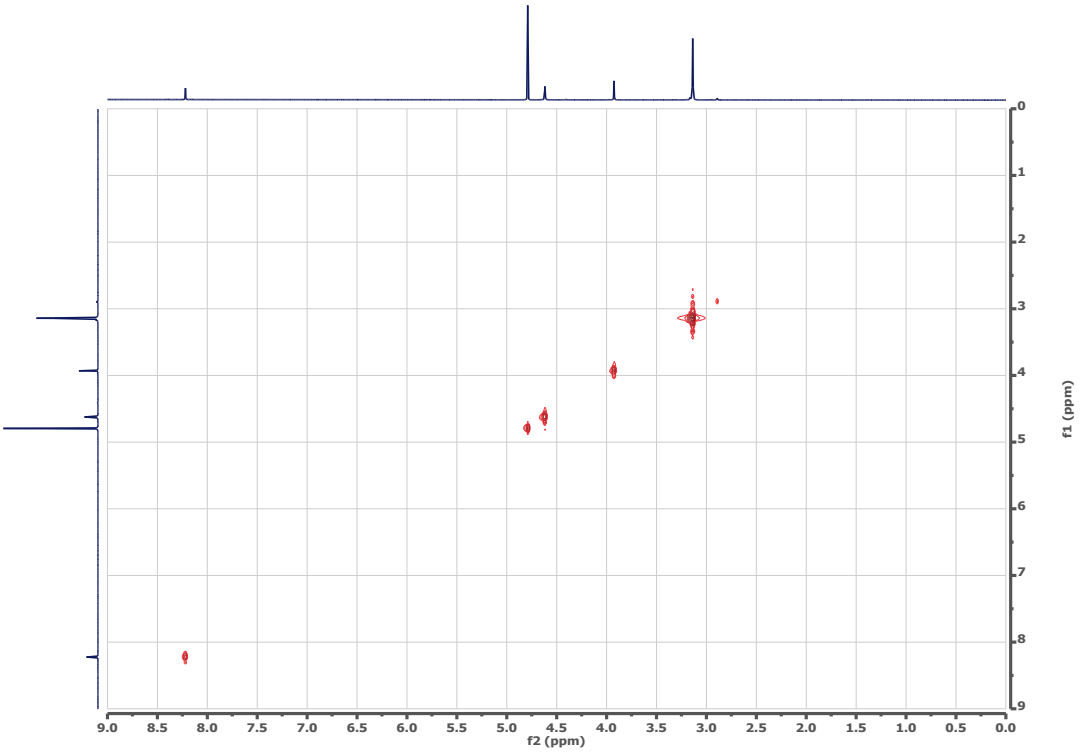


Fig. S53 – HSQC spectrum of 1,1'-(2-hydroxy-5-(methoxycarbonyl)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**C**) (solvent: D_2O).

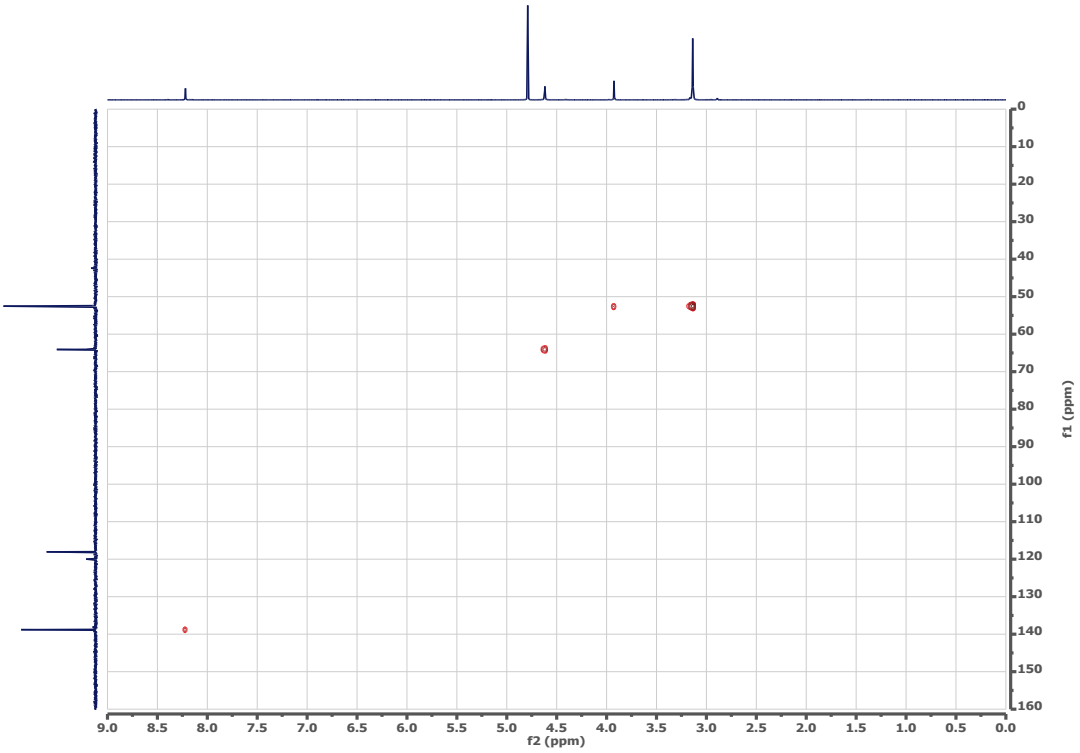


Fig. S54 – HMBC spectrum of 1,1'-(2-hydroxy-5-(methoxycarbonyl)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**C**) (solvent: D_2O).

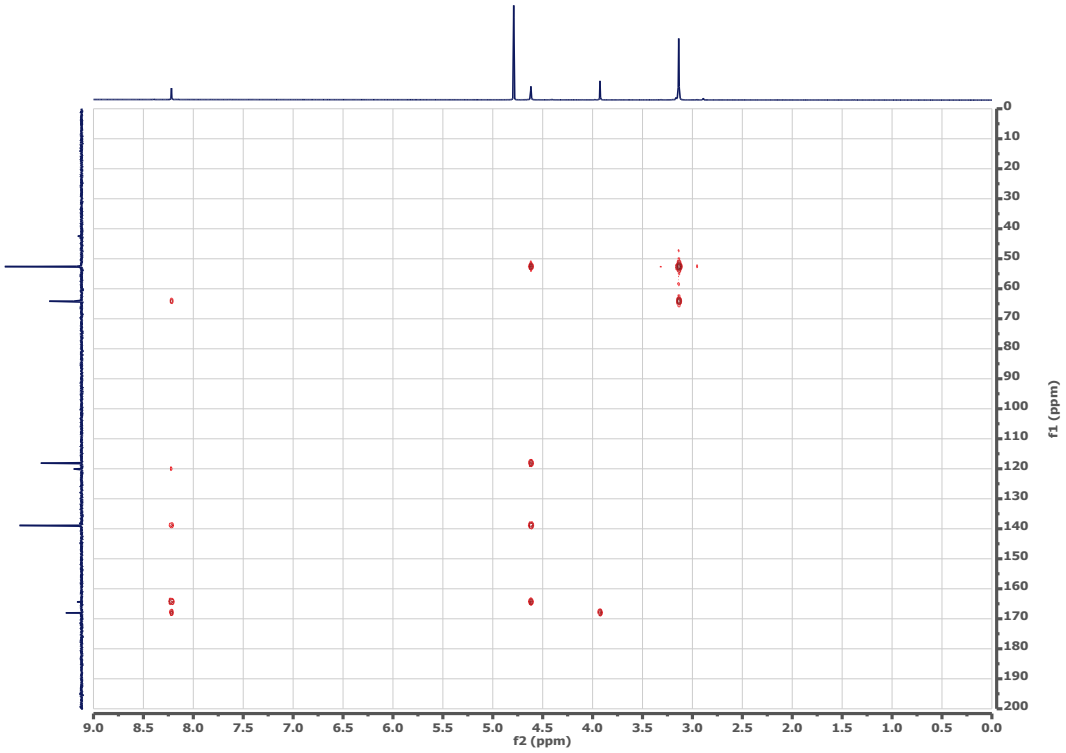


Fig. S55 – ^1H NMR spectrum of 1,1'-(2-hydroxy-5-(trifluoromethoxy)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**D**) (solvent: D_2O).

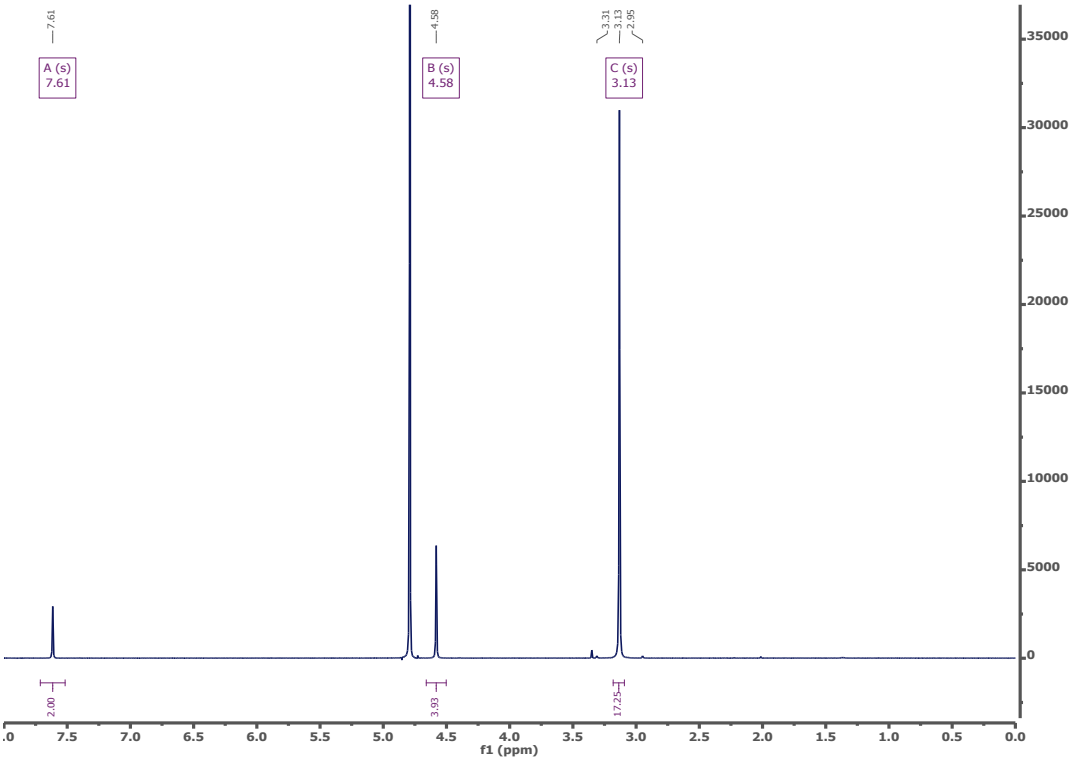


Fig. S56 – ^{13}C NMR spectrum of 1,1'-(2-hydroxy-5-(trifluoromethoxy)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**D**) (solvent: D_2O).

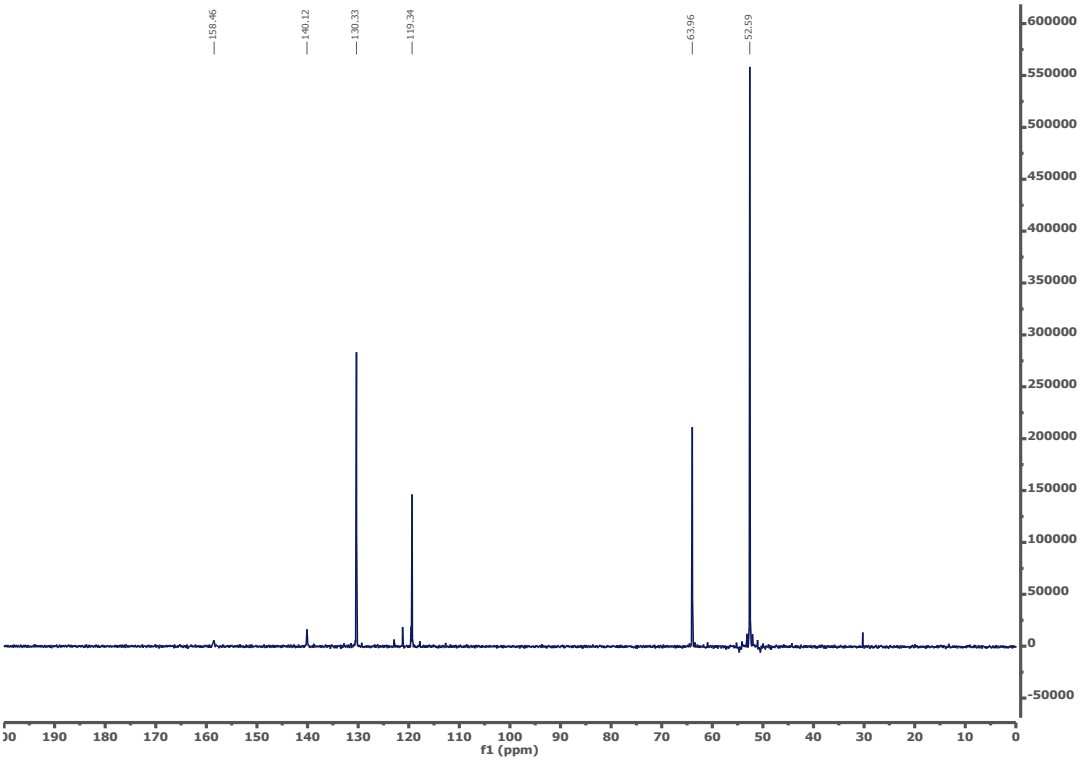


Fig. S57 – DEPT135 spectrum of 1,1'-(2-hydroxy-5-(trifluoromethoxy)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**D**) (solvent: D_2O).

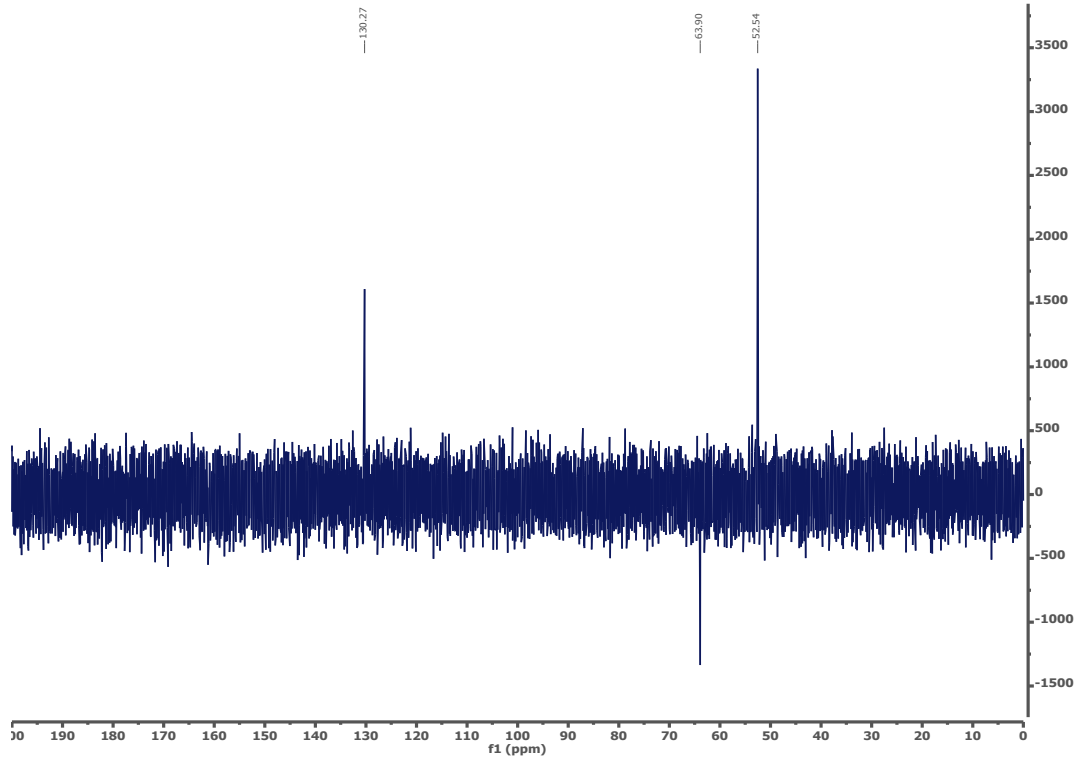


Fig. S58 – COSY spectrum of 1,1'-(2-hydroxy-5-(trifluoromethoxy)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**D**) (solvent: D_2O).

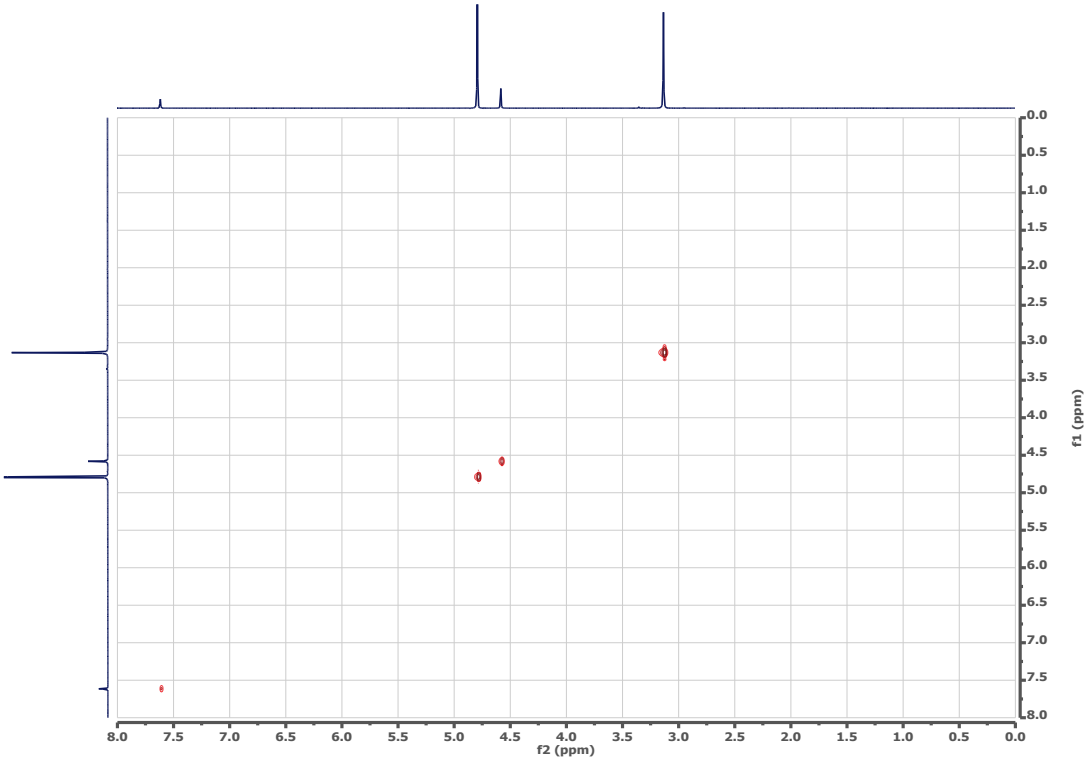


Fig. S59 – HSQC spectrum of 1,1'-(2-hydroxy-5-(trifluoromethoxy)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**D**) (solvent: D_2O).

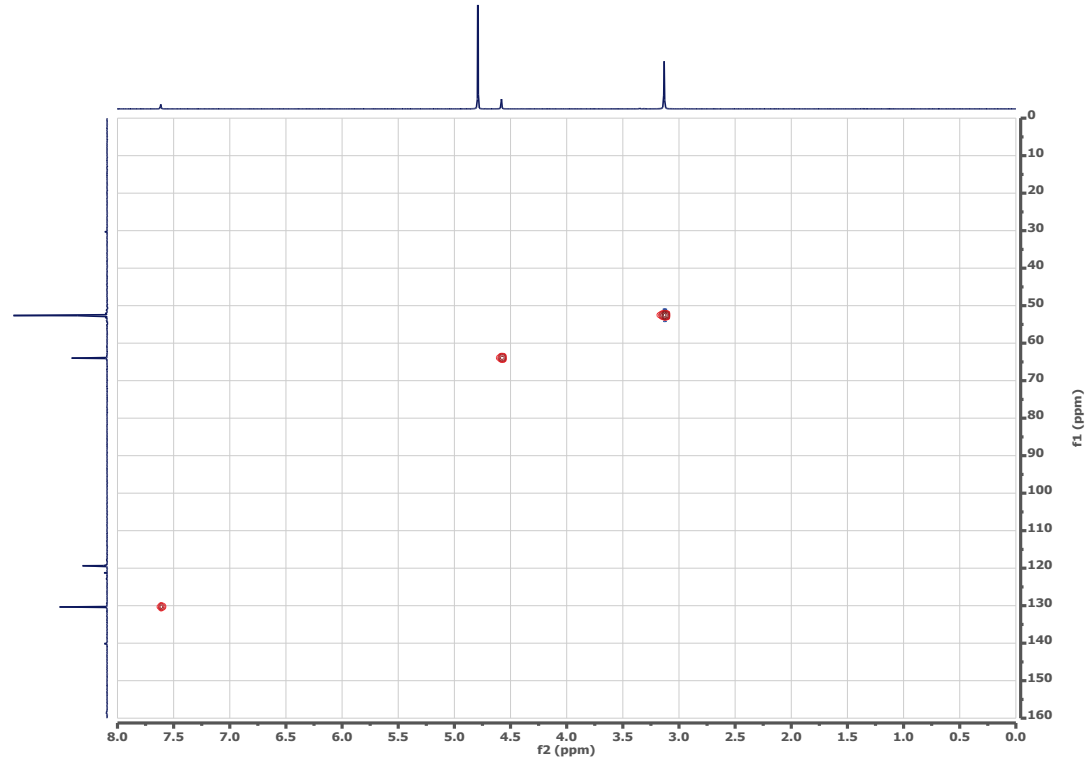


Fig. S60 – HMBC spectrum of 1,1'-(2-hydroxy-5-(trifluoromethoxy)-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**D**) (solvent: D_2O).

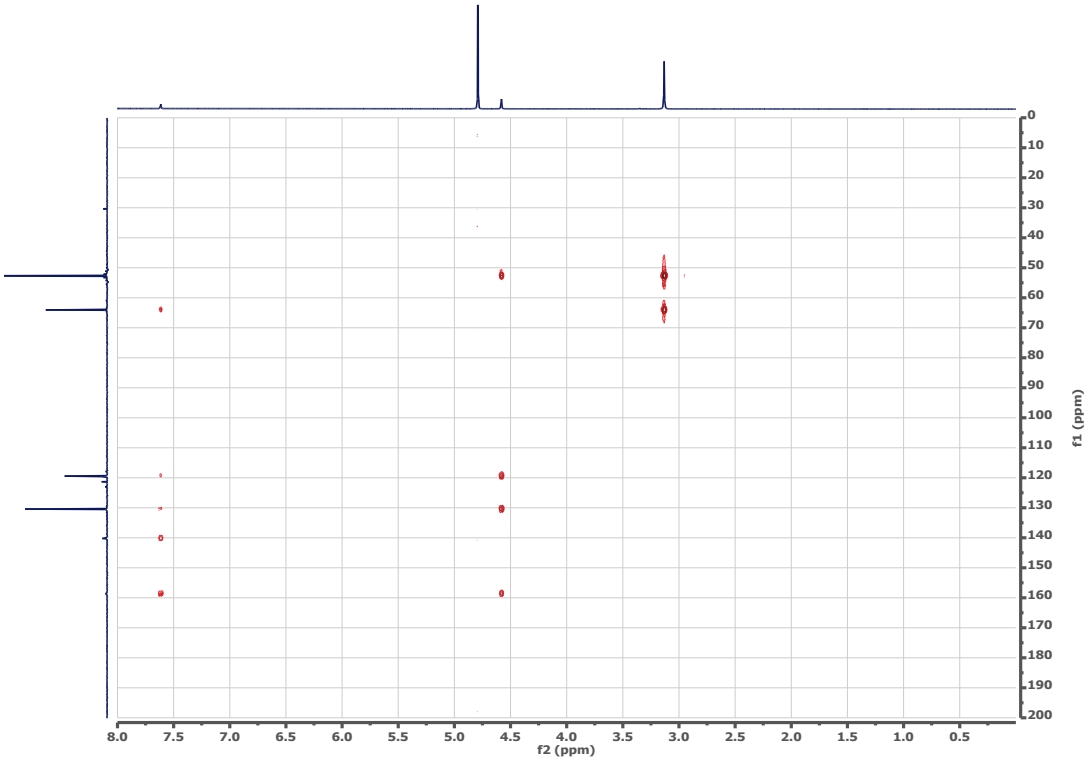


Fig. S61 – ^1H NMR spectrum of 1,1'-(5-carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**E**) (solvent: D_2O).

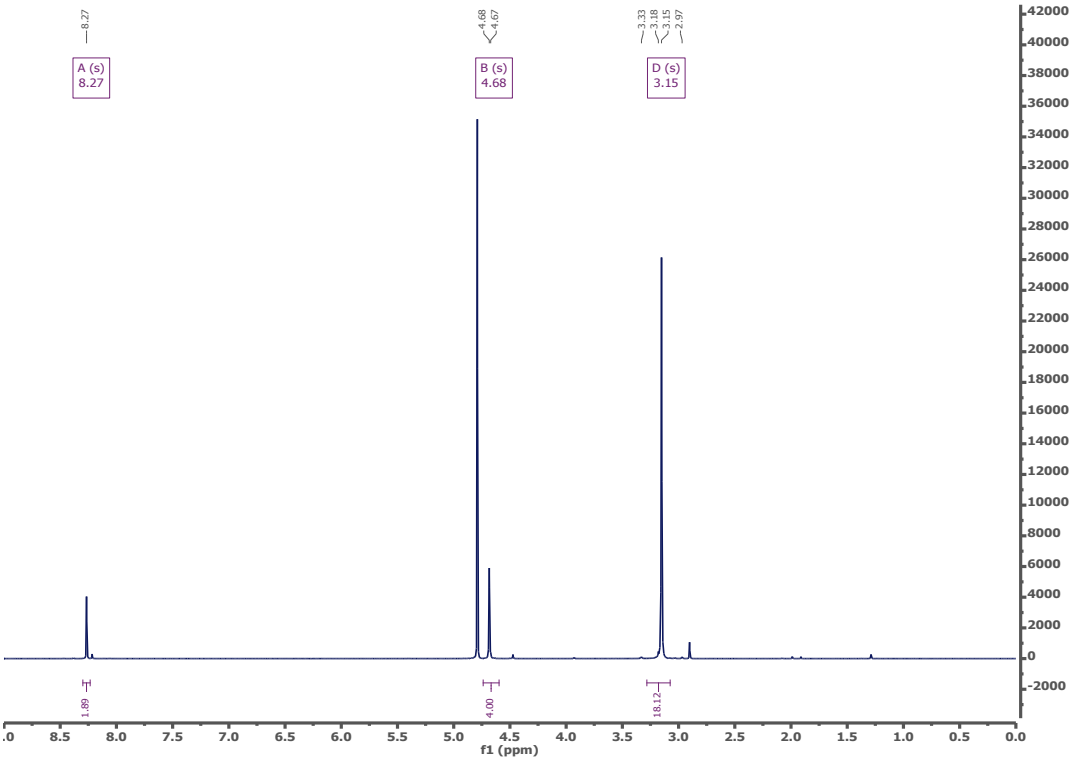


Fig. S62 – ^{13}C NMR spectrum of 1,1'-(5-carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**E**) (solvent: D_2O).

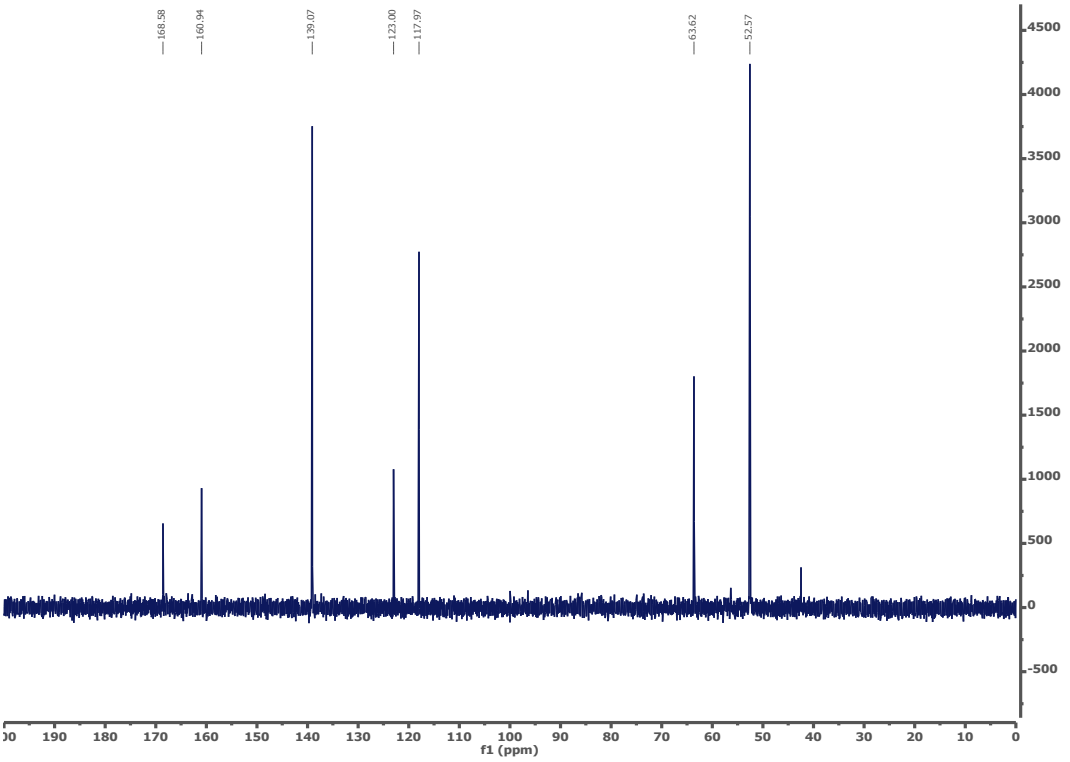


Fig. S63 – DEPT135 spectrum of 1,1'-(5-carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**E**) (solvent: D_2O).

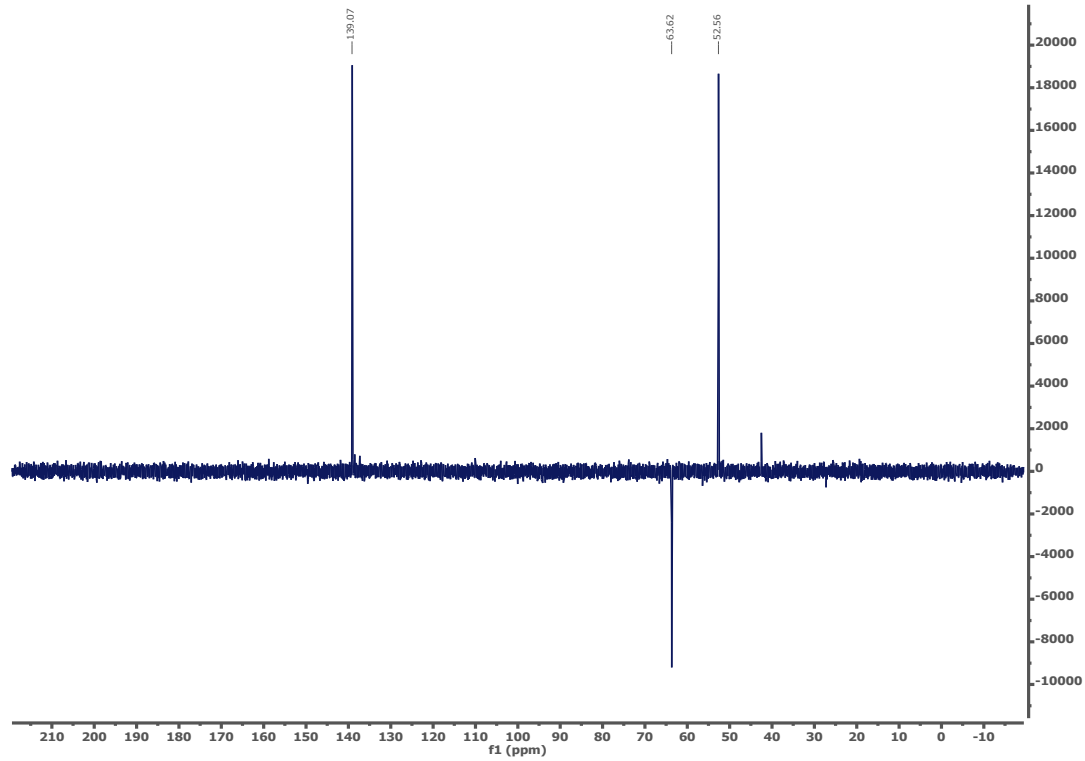


Fig. S64 – COSY spectrum of 1,1'-(5-carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**E**) (solvent: D_2O).

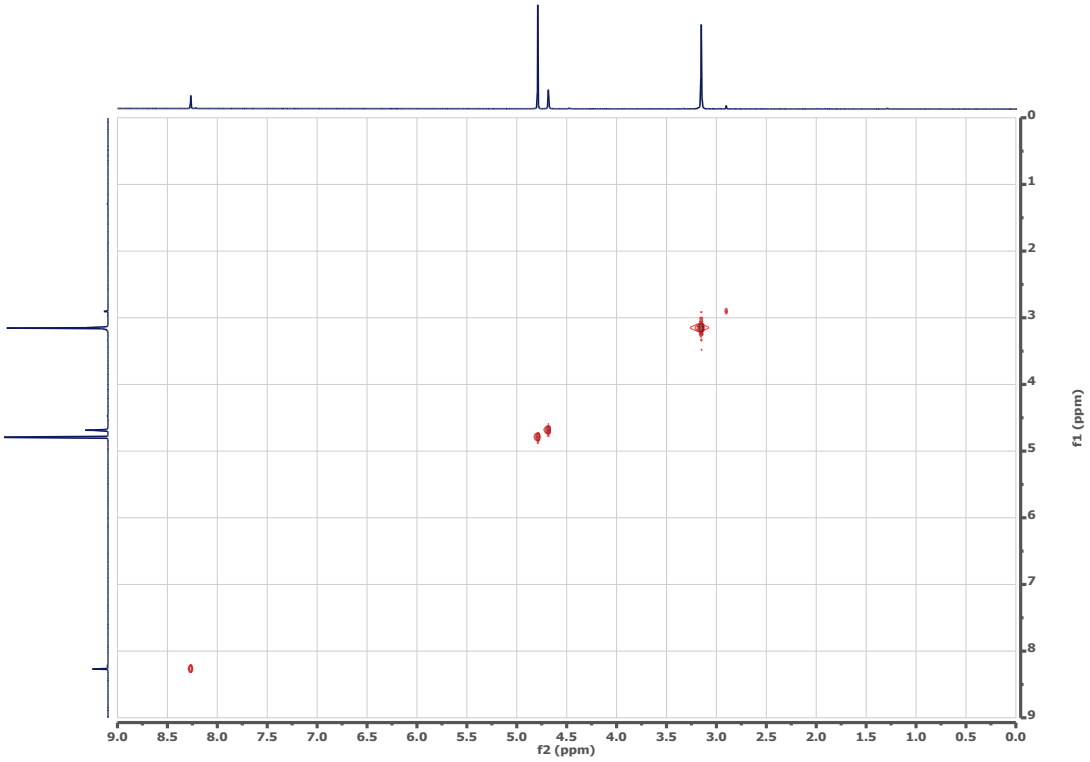


Fig. S65 – HSQC spectrum of 1,1'-(5-carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**E**) (solvent: D_2O).

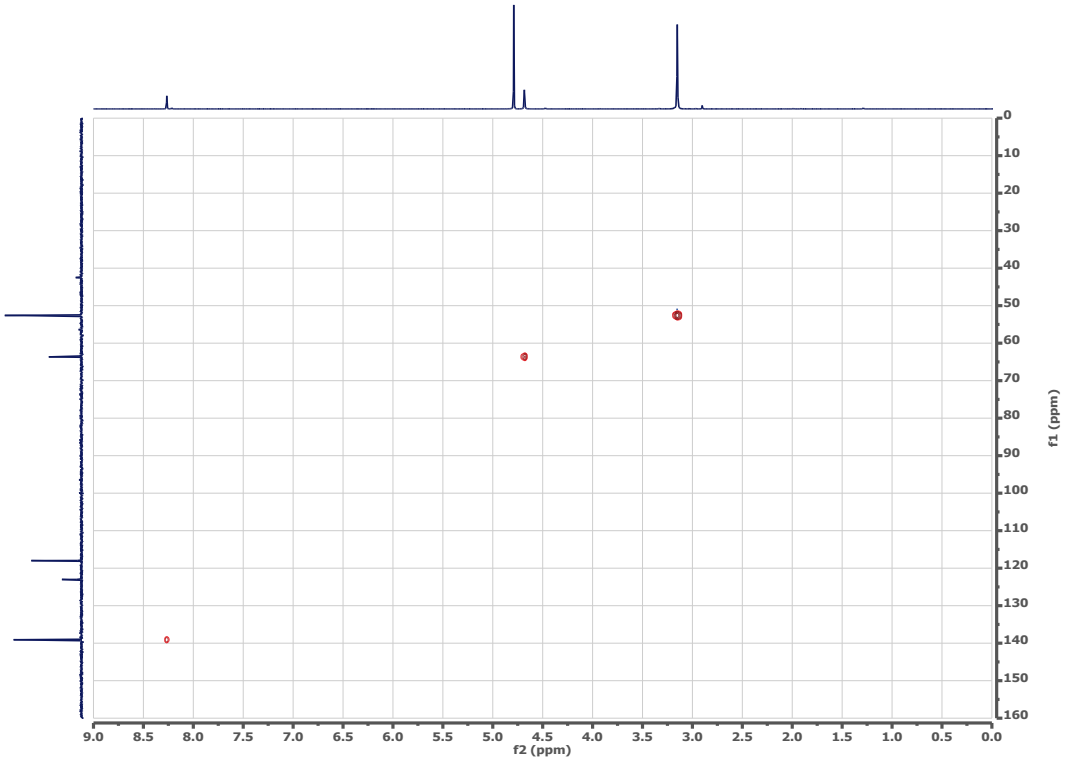


Fig. S66 – HMBC spectrum of 1,1'-(5-carboxy-2-hydroxy-1,3-phenylene)bis(*N*,*N*,*N*-trimethylmethanaminium) dichloride (**E**) (solvent: D_2O).

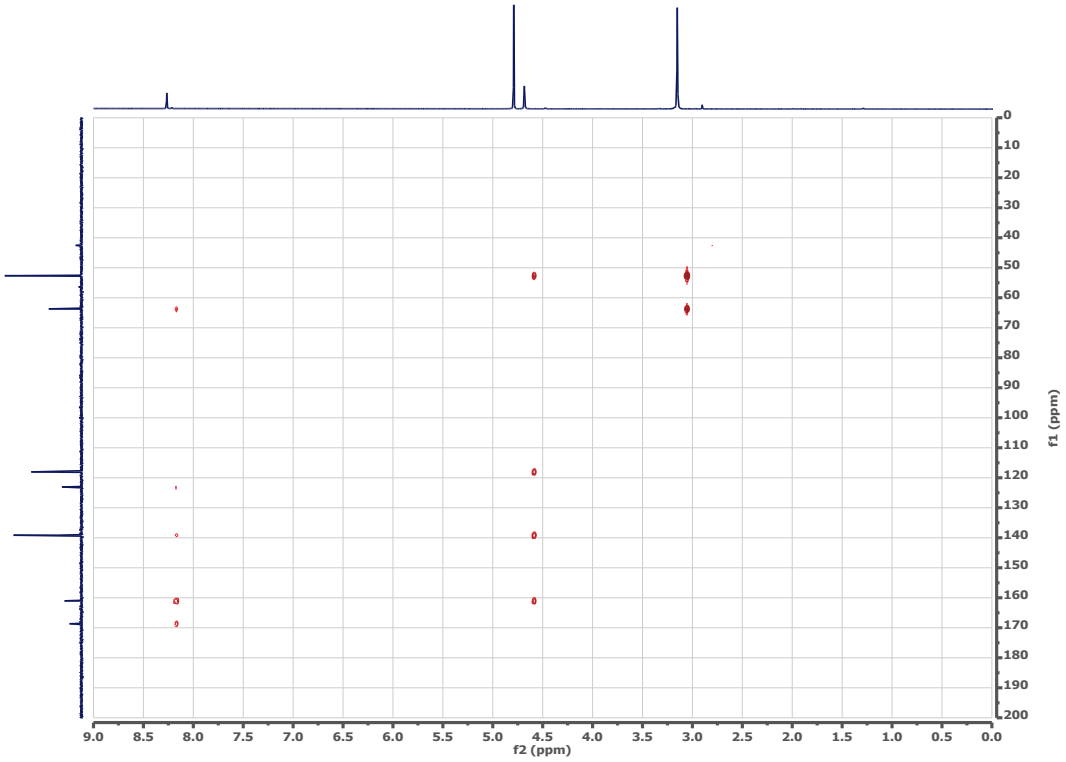


Fig. S67 – ^1H NMR spectrum of 1,1',1''-(2-hydroxybenzene-1,3,5-triyl)tris(*N*,*N*,*N*-trimethylmethanaminium) trichloride (**F**) (solvent: D_2O).

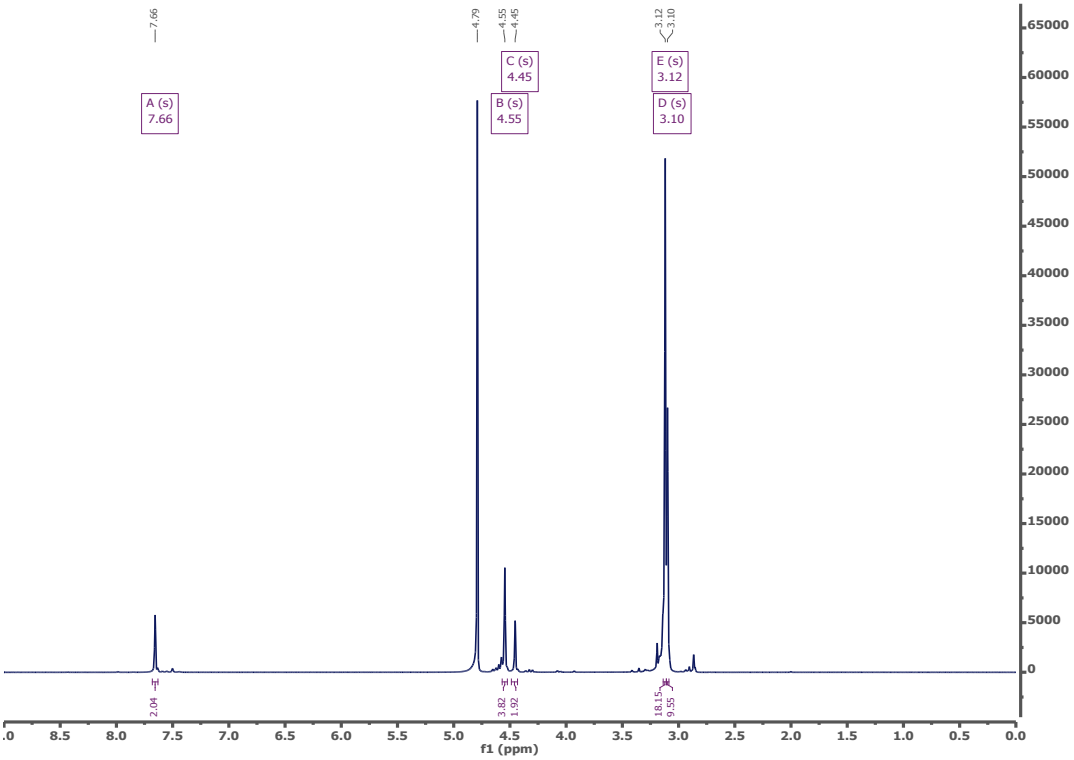


Fig. S68 – ^{13}C NMR spectrum of 1,1',1''-(2-hydroxybenzene-1,3,5-triyl)tris(*N*,*N*,*N*-trimethylmethanaminium) trichloride (**F**) (solvent: D_2O).

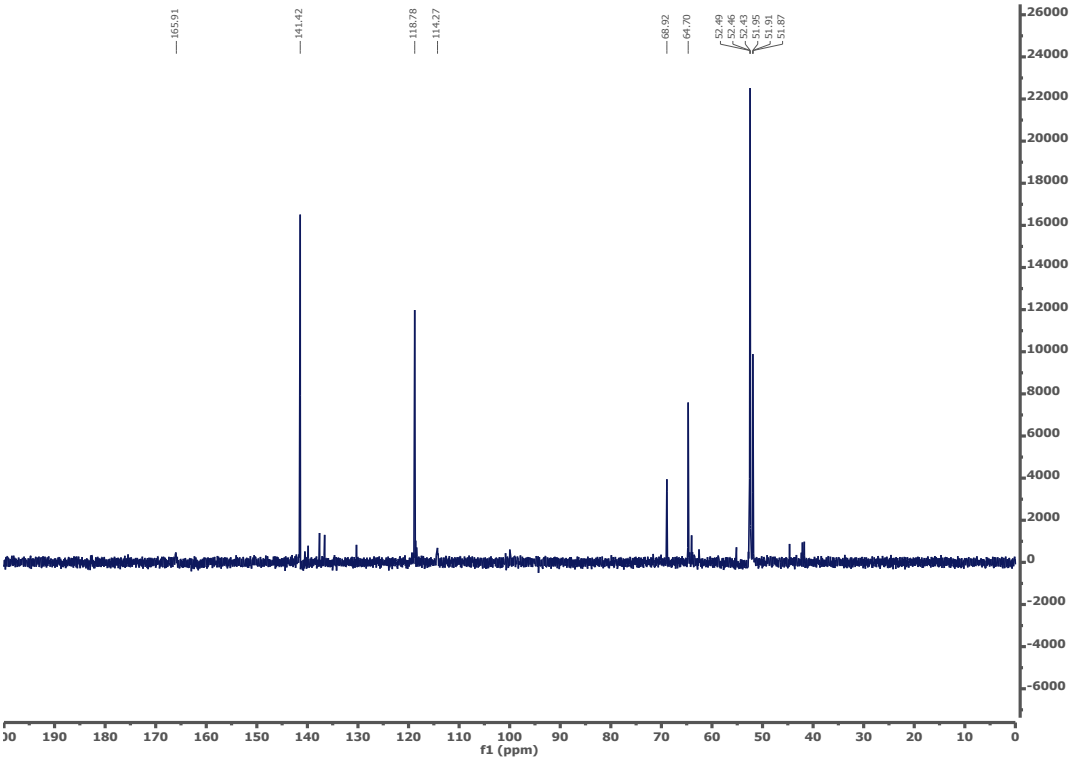


Fig. S69 – DEPT135 spectrum of 1,1',1''-(2-hydroxybenzene-1,3,5-triyl)tris(*N*,*N*,*N*-trimethylmethanaminium) trichloride (**F**) (solvent: D_2O).

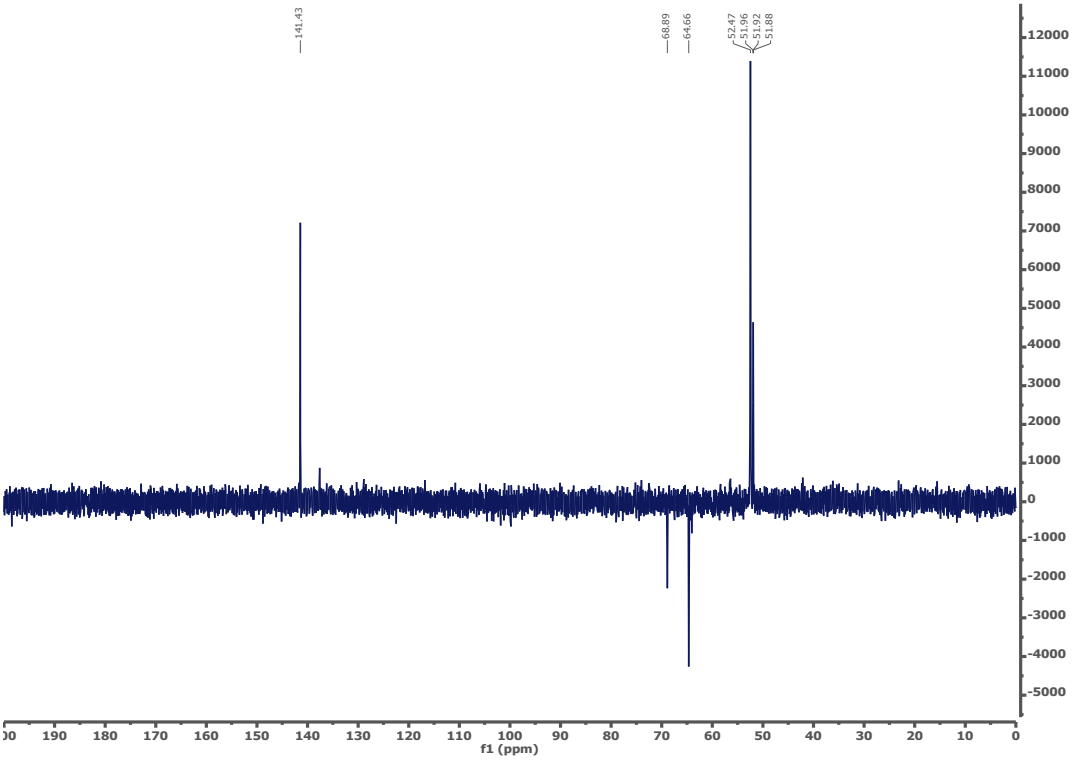


Fig. S70 – COSY spectrum of 1,1',1''-(2-hydroxybenzene-1,3,5-triyl)tris(*N*,*N*,*N*-trimethylmethanaminium) trichloride (**F**) (solvent: D_2O).

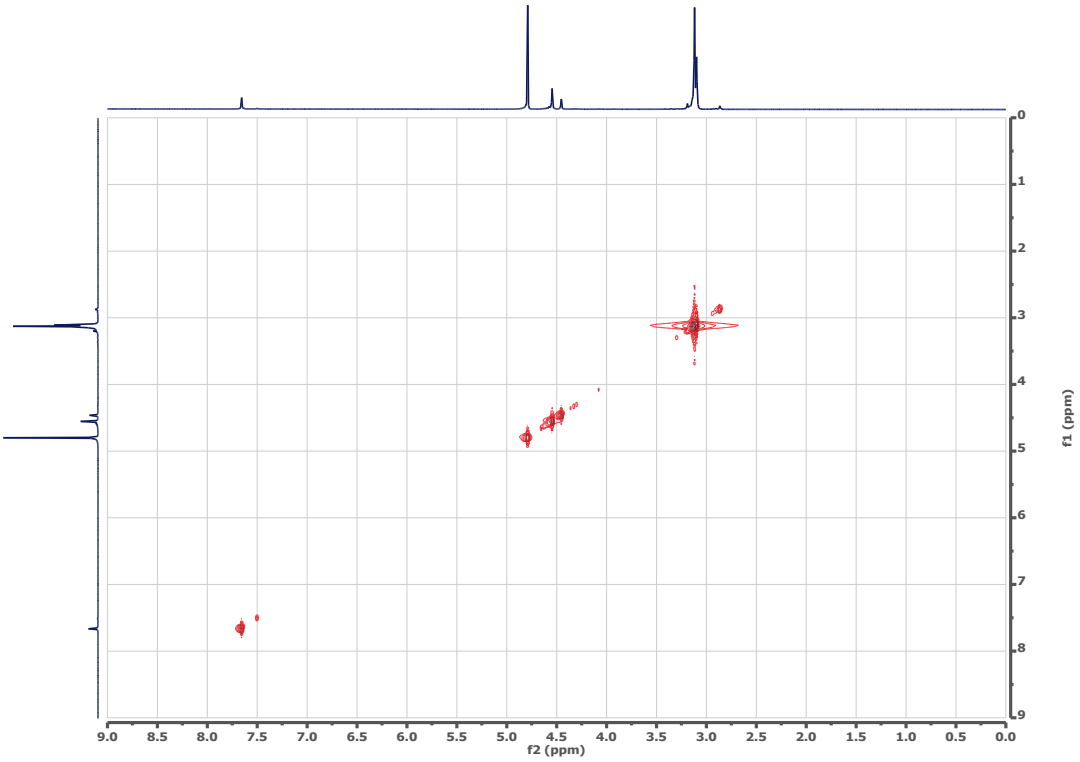


Fig. S71 – HSQC spectrum of 1,1',1''-(2-hydroxybenzene-1,3,5-triyl)tris(*N*,*N*,*N*-trimethylmethanaminium) trichloride (**F**) (solvent: D_2O).

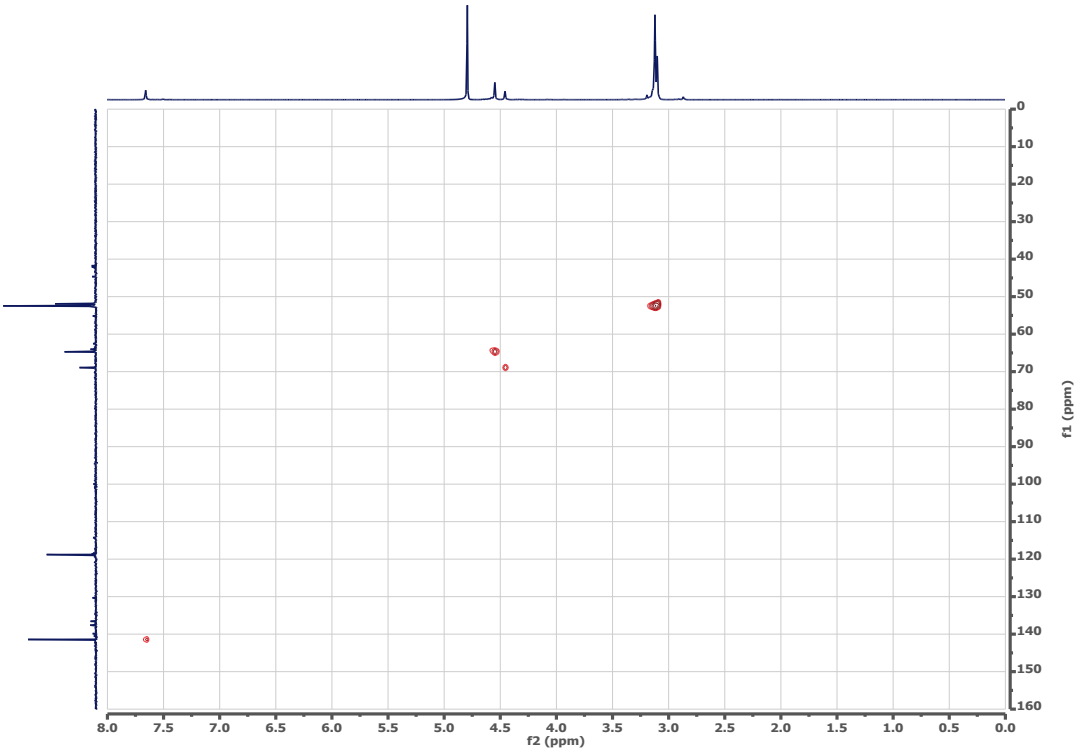


Fig. S72 – HMBC spectrum of 1,1',1''-(2-hydroxybenzene-1,3,5-triyl)tris(*N*,*N*,*N*-trimethylmethanaminium) trichloride (**F**) (solvent: D_2O).

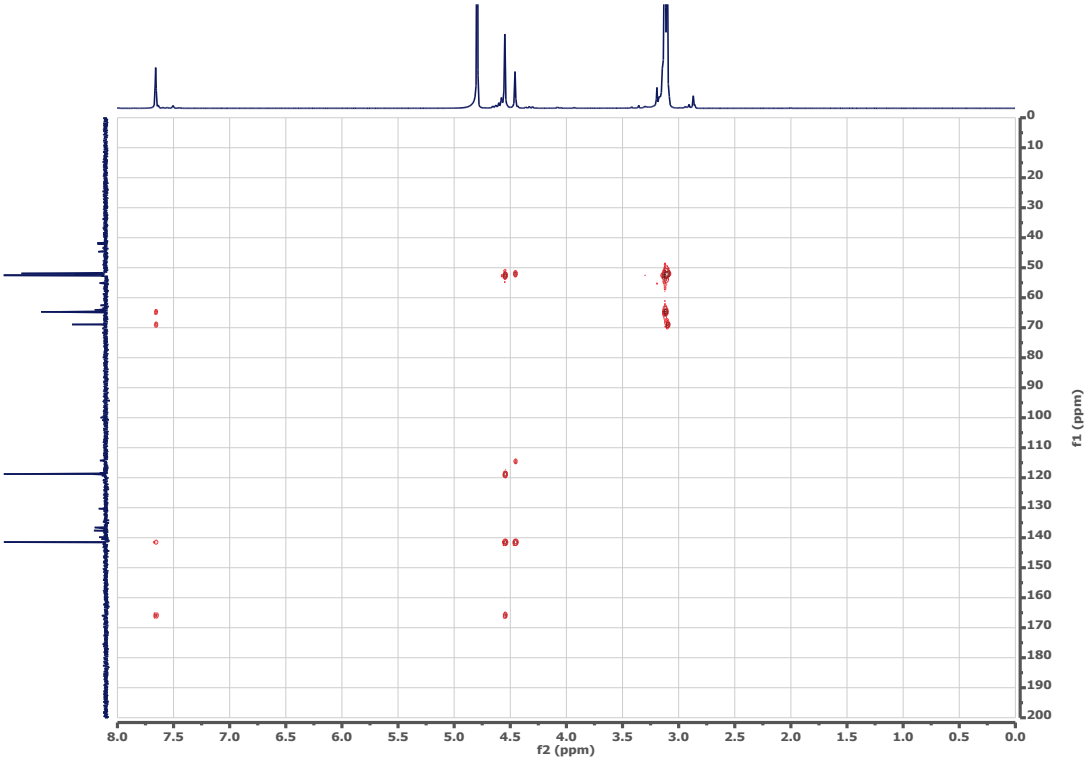


Fig. S73 – ^1H NMR spectrum of 4,4'-sulfonylbis(methoxybenzene) (**G**) (solvent: $CDCl_3$).

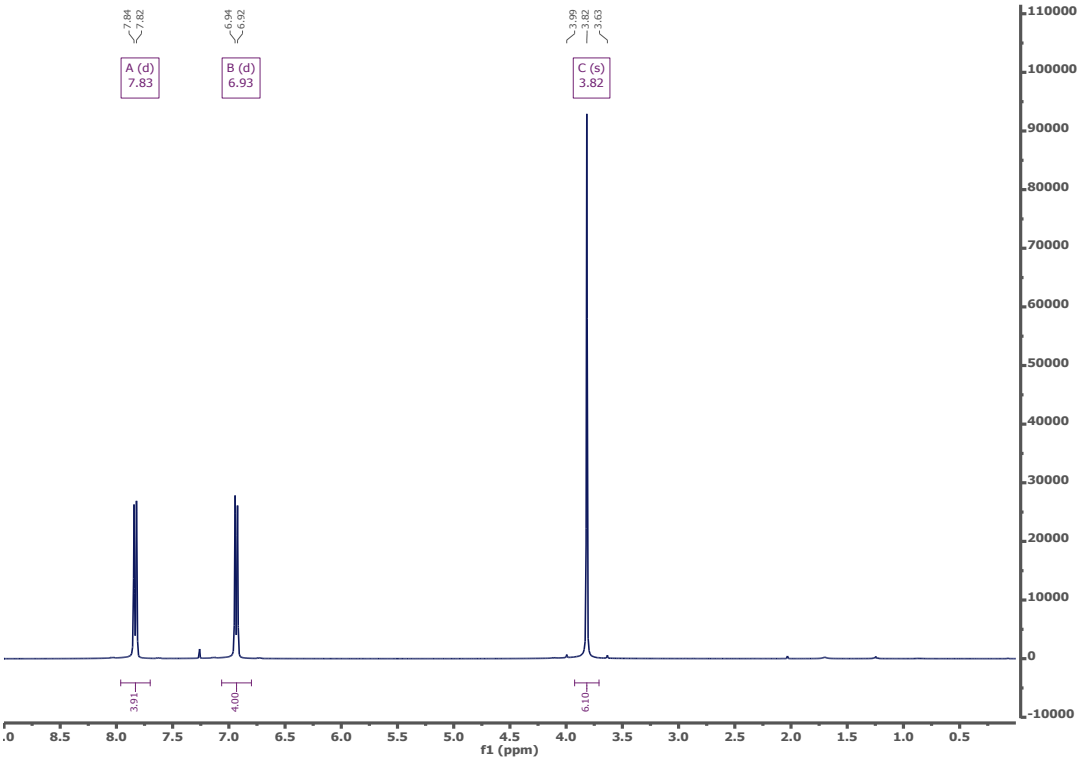


Fig. S74 – ^{13}C NMR spectrum of 4,4'-sulfonylbis(methoxybenzene) (**G**) (solvent: $CDCl_3$).

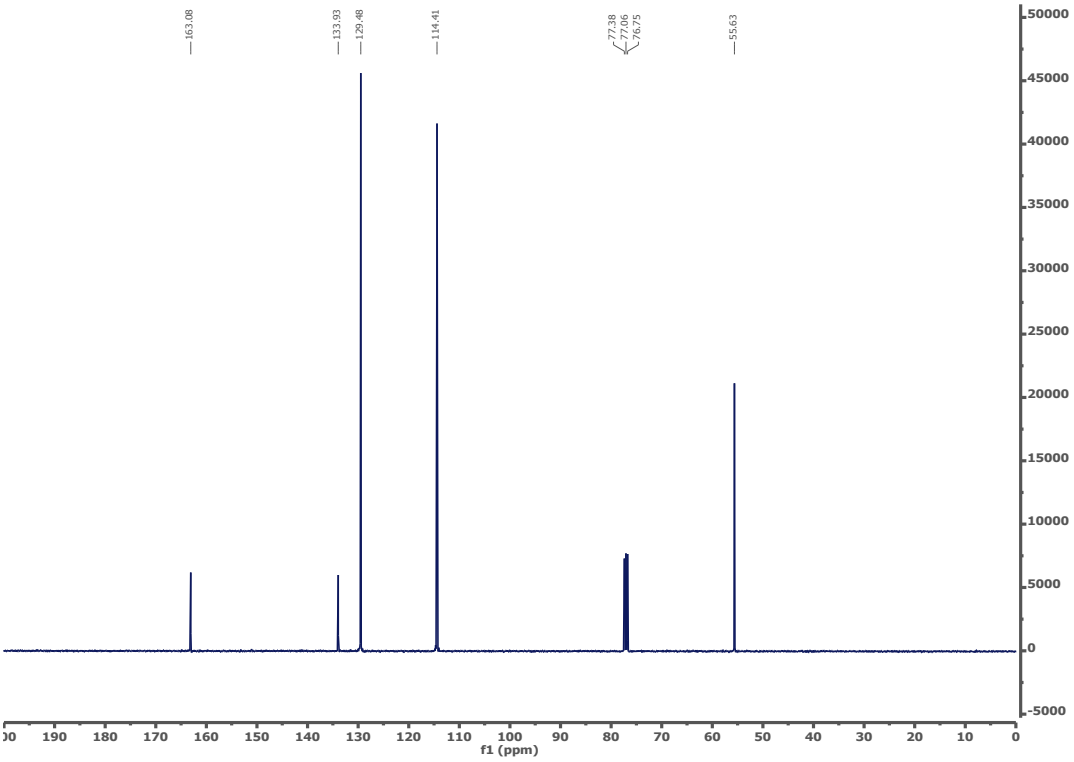


Fig. S75 – ^{1}H NMR spectrum of 2,2'-((sulfonylbis(4,1-phenylene))bis(oxy))diacetic acid (**H**) (solvent: MeOD).

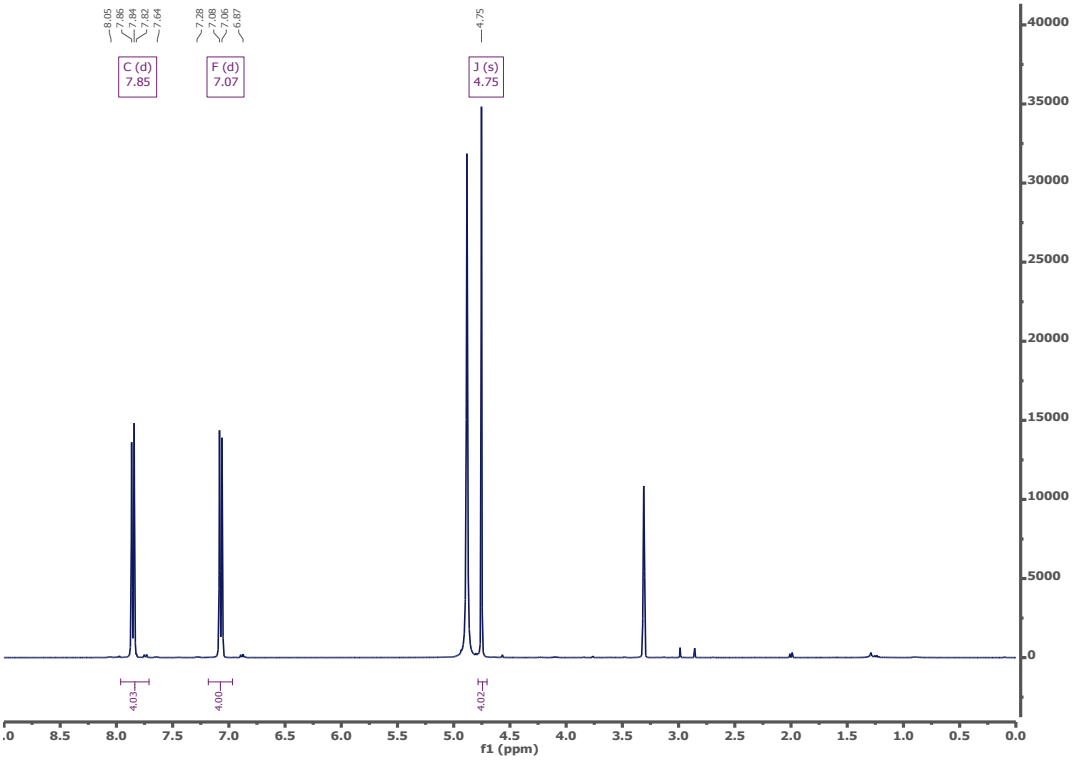


Fig. S76 – ^{13}C NMR spectrum of 2,2'-((sulfonylbis(4,1-phenylene))bis(oxy))diacetic acid (**H**) (solvent: MeOD).

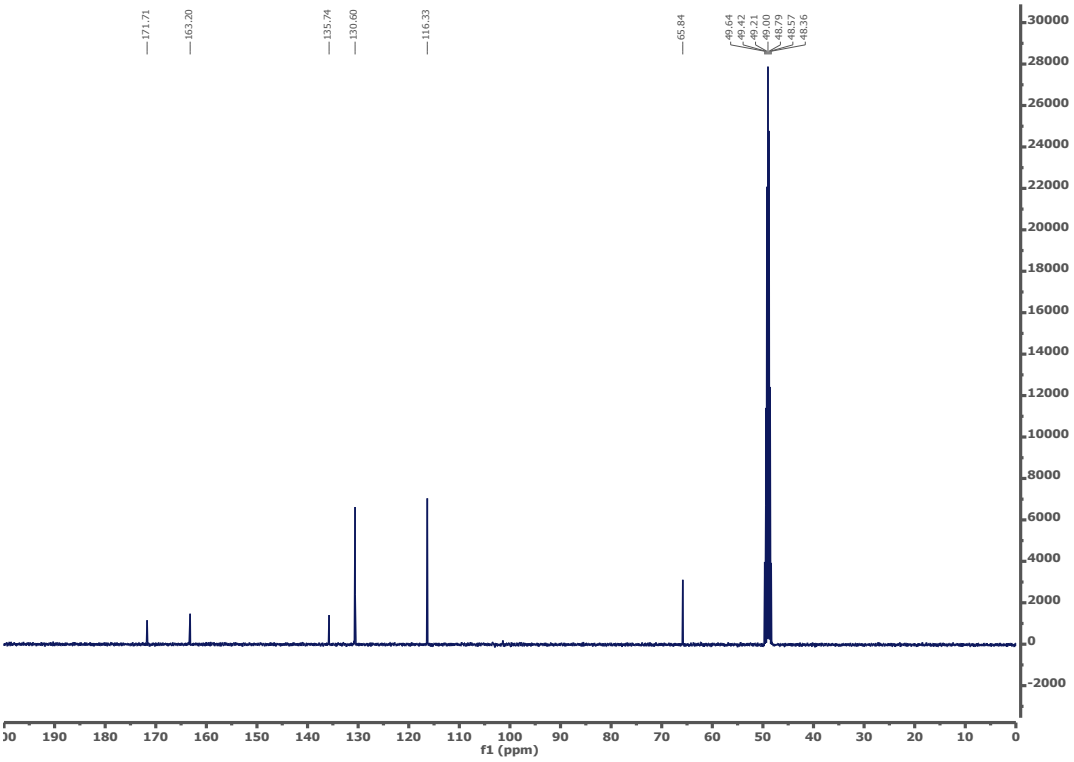


Fig. S77 – ^{1}H NMR spectrum of 4-((tetrahydro-2*H*-pyran-2-yl)oxy)benzoic acid (solvent: $CDCl_3$).

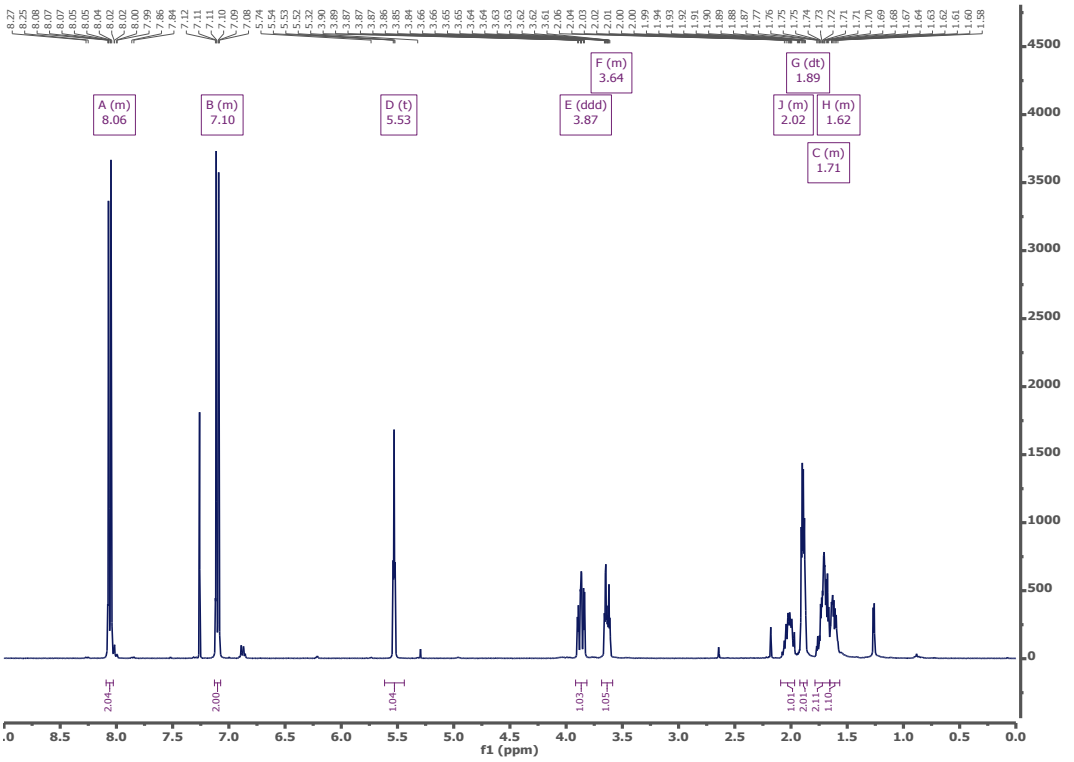


Fig. S78 – ^{13}C NMR spectrum of 4-((tetrahydro-2*H*-pyran-2-yl)oxy)benzoic acid (solvent: $CDCl_3$).

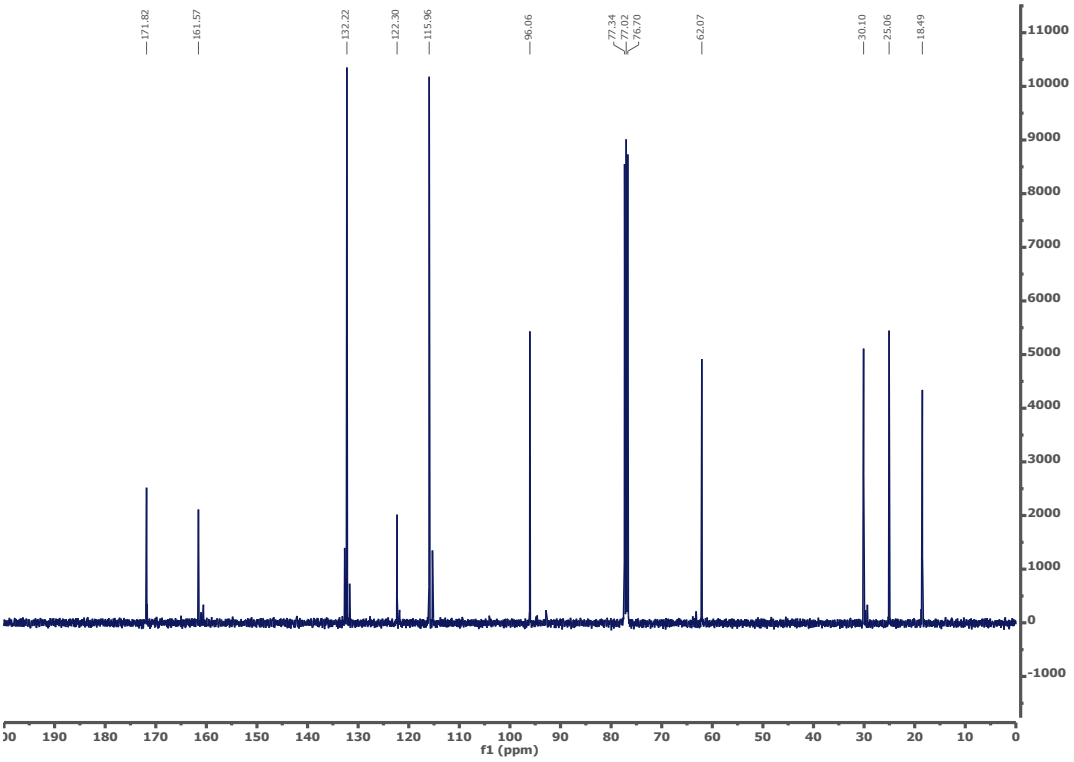


Fig. S79 – ^{1}H NMR spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_3$) (solvent: $CDCl_3$).

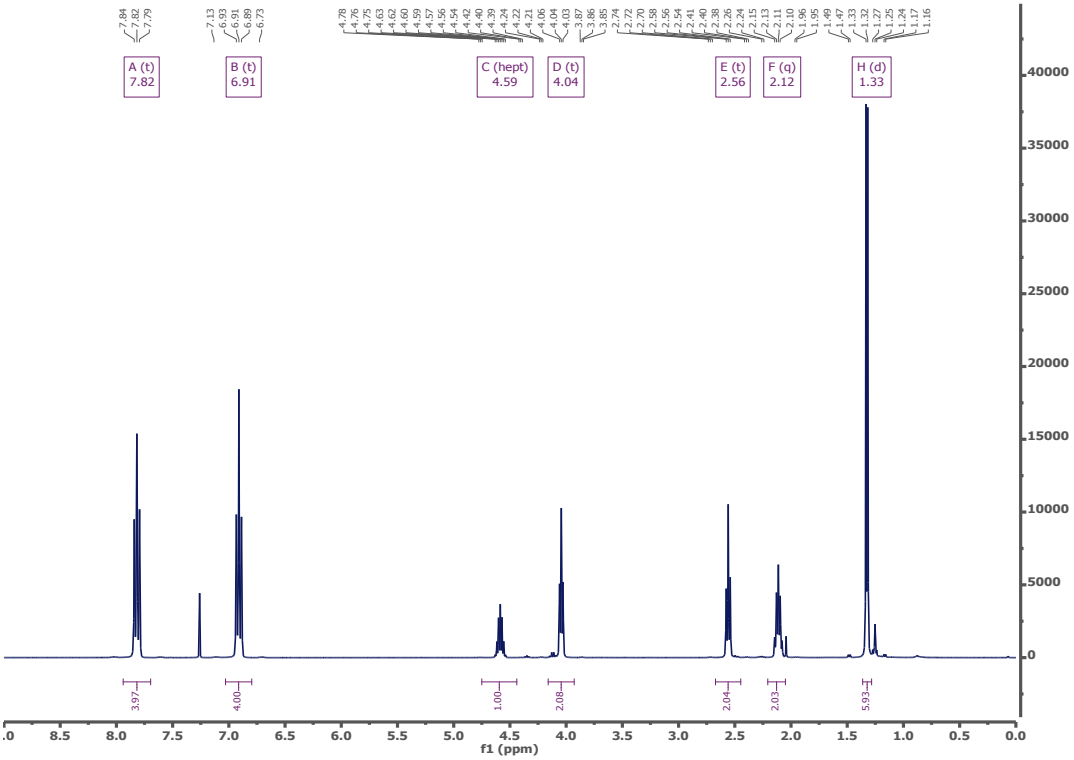


Fig. S80 – ^{13}C NMR spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_3$) (solvent: $CDCl_3$).

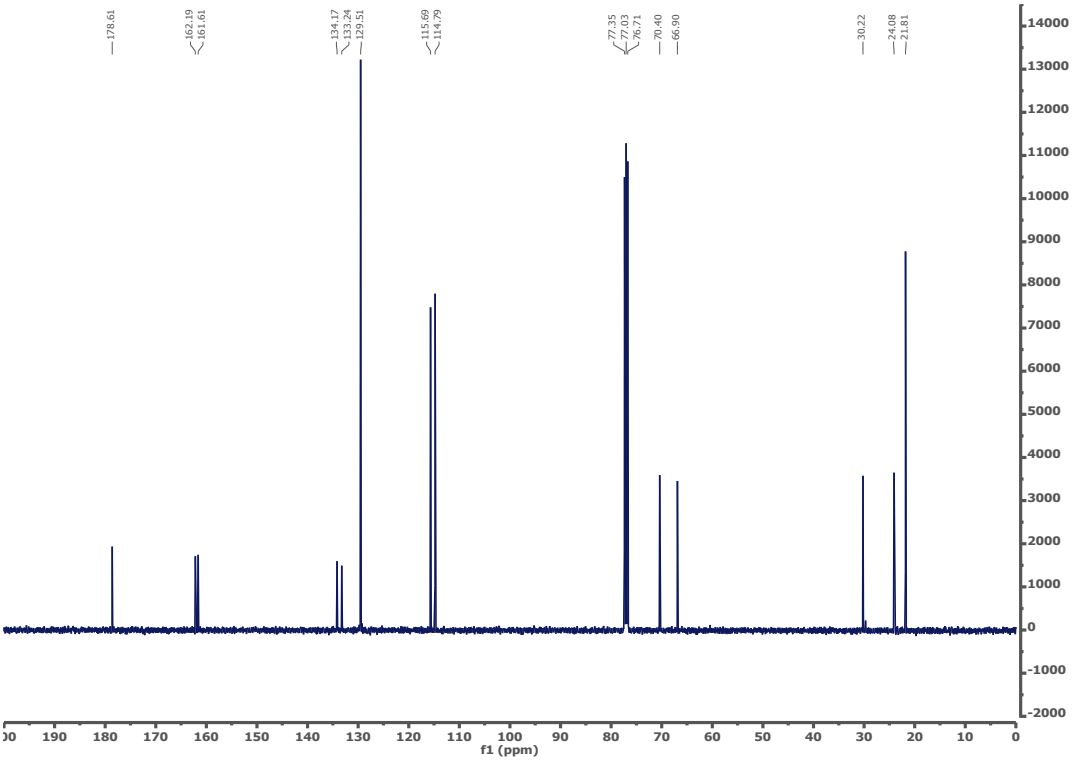


Fig. S81 – DEPT135 spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_3$) (solvent: $CDCl_3$).

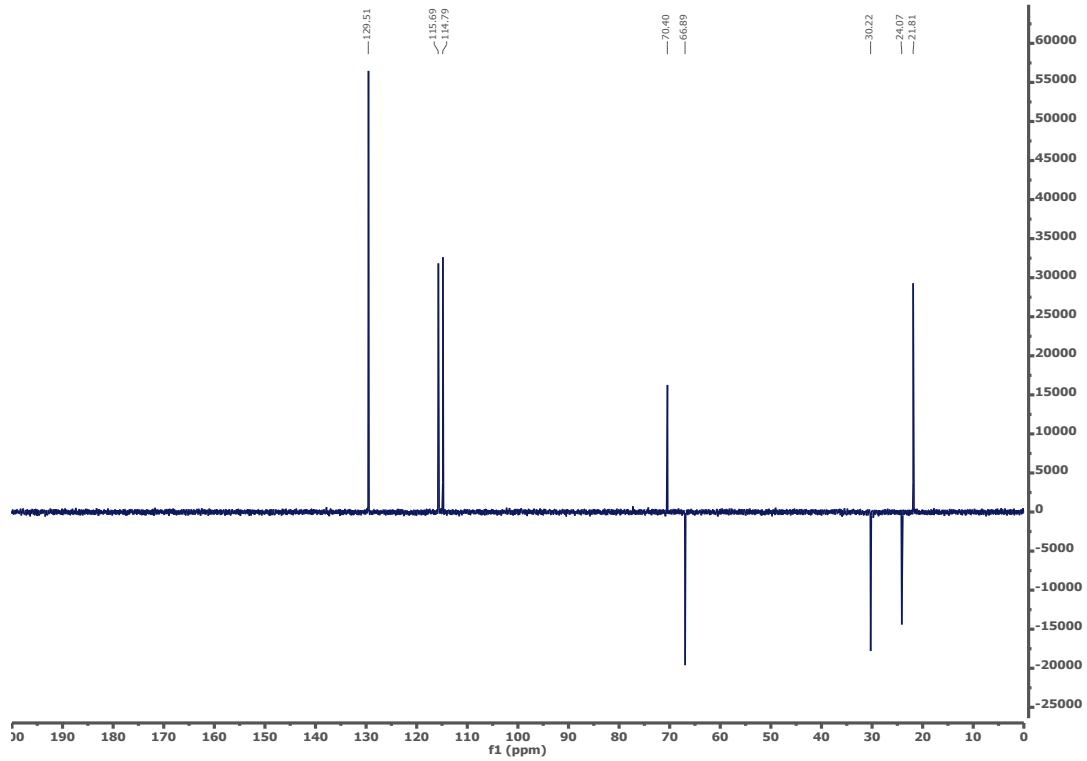


Fig. S82 – COSY spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_3$) (solvent: $CDCl_3$).

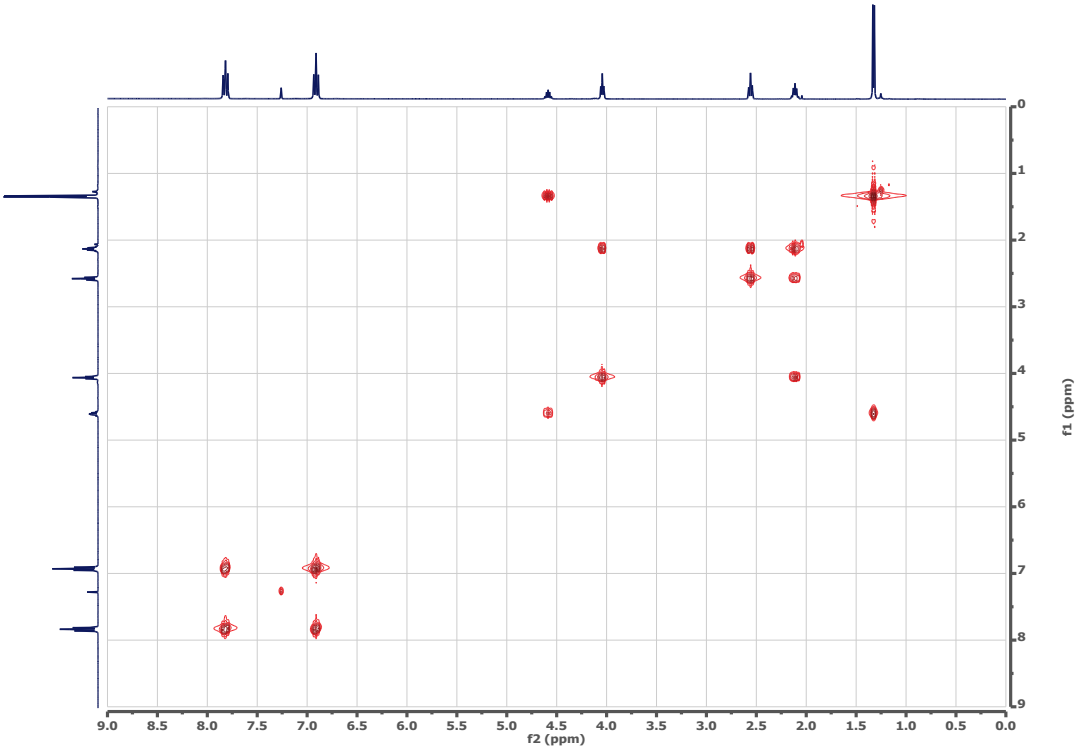


Fig. S83 – HSQC spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_3$) (solvent: $CDCl_3$).

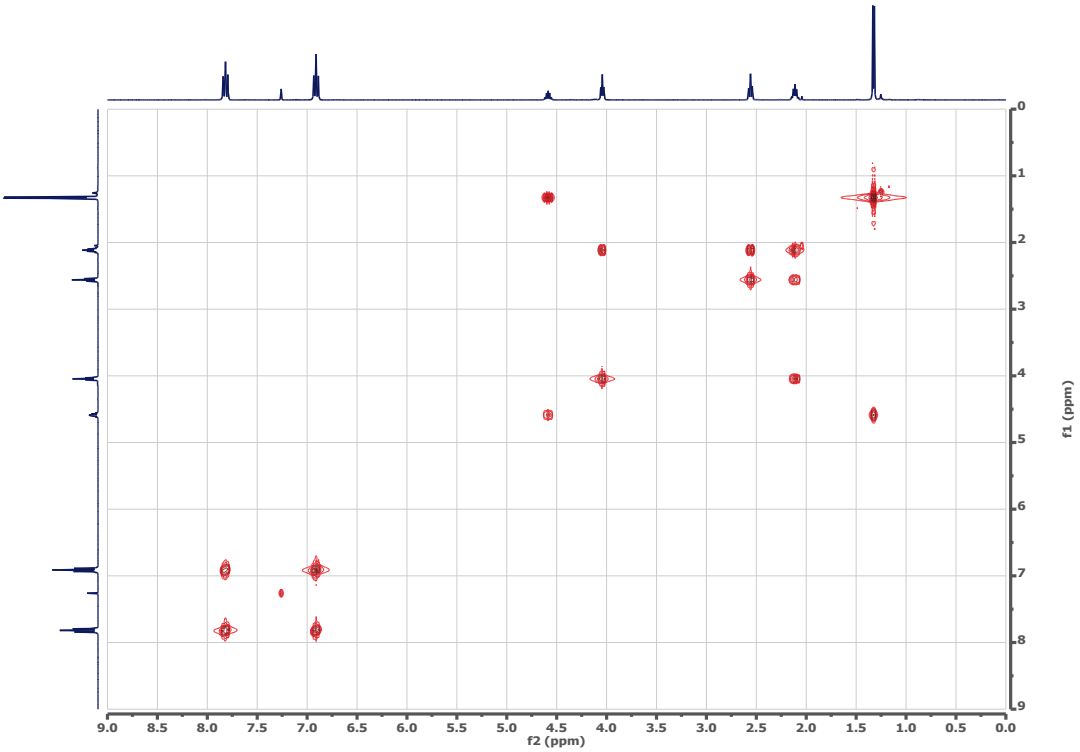


Fig. S84 – HMBC spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_3$) (solvent: $CDCl_3$).

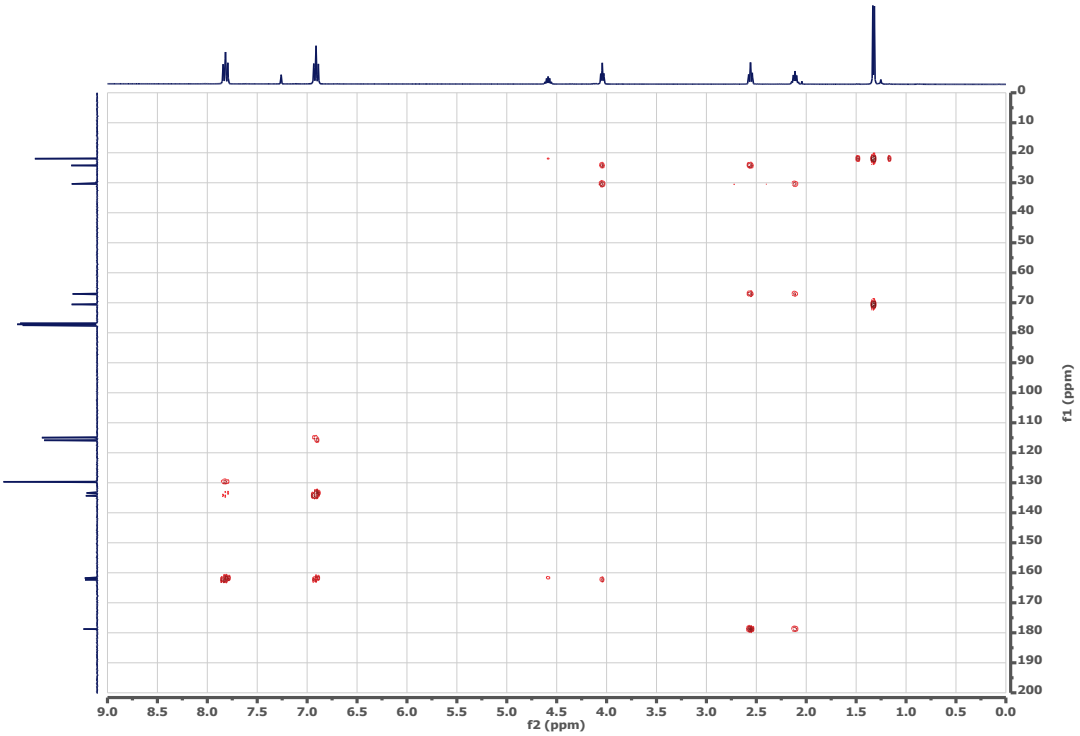


Fig. S85 – ^1H NMR spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_{10}$) (solvent: $CDCl_3$).

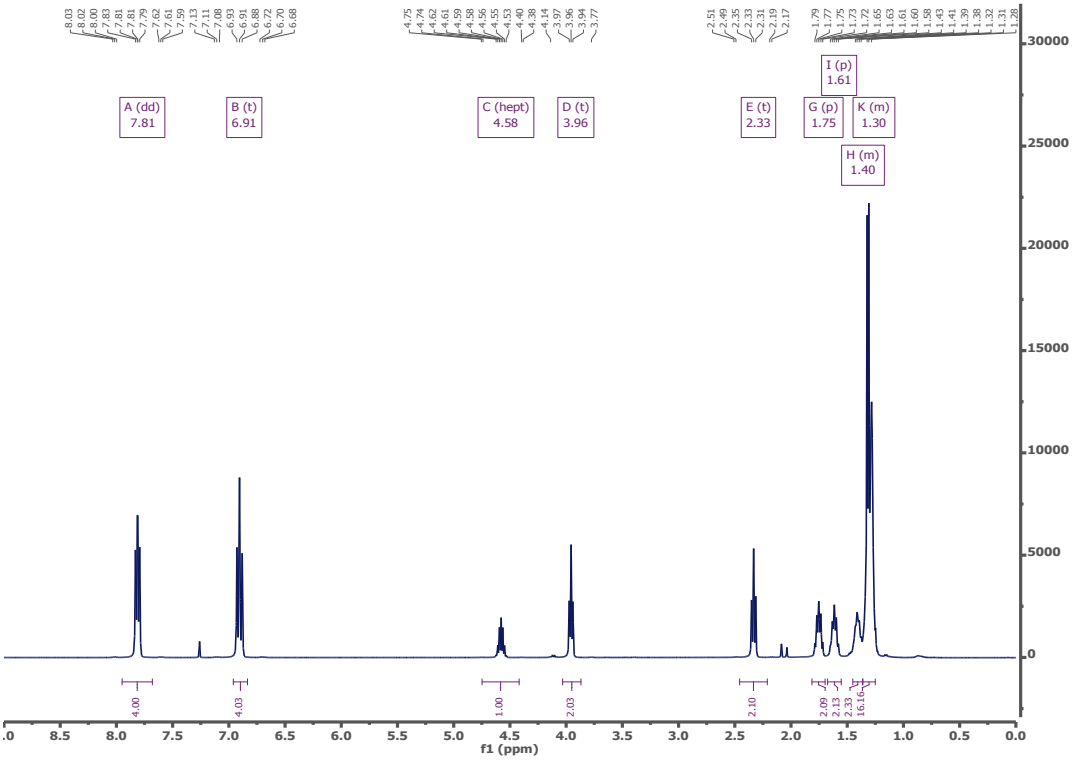


Fig. S86 – ^{13}C NMR spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_{10}$) (solvent: $CDCl_3$).

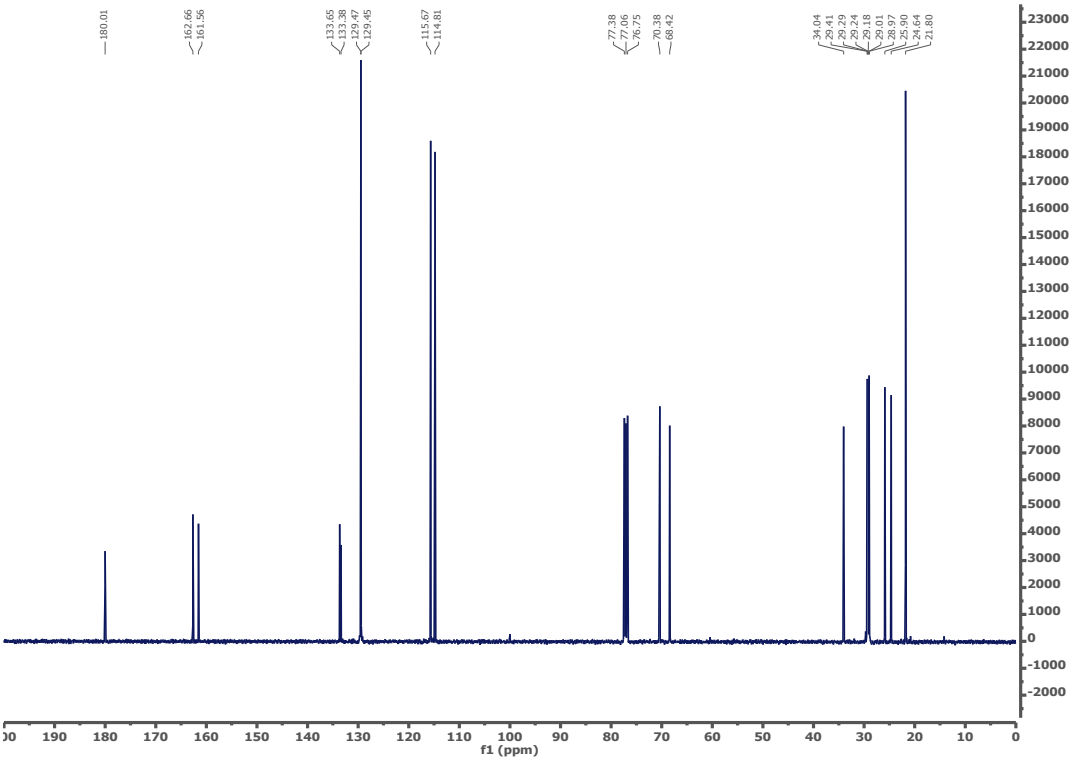


Fig. S87 – DEPT135 spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_{10}$) (solvent: $CDCl_3$).

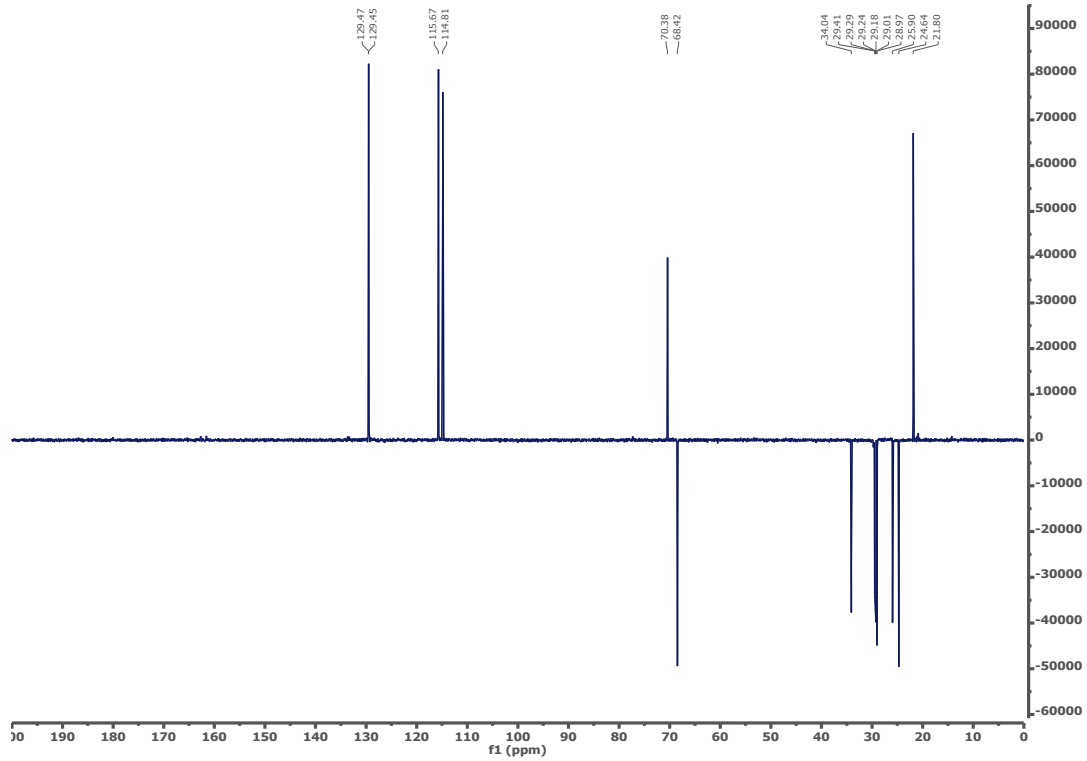


Fig. S88 – COSY spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_{10}$) (solvent: $CDCl_3$).

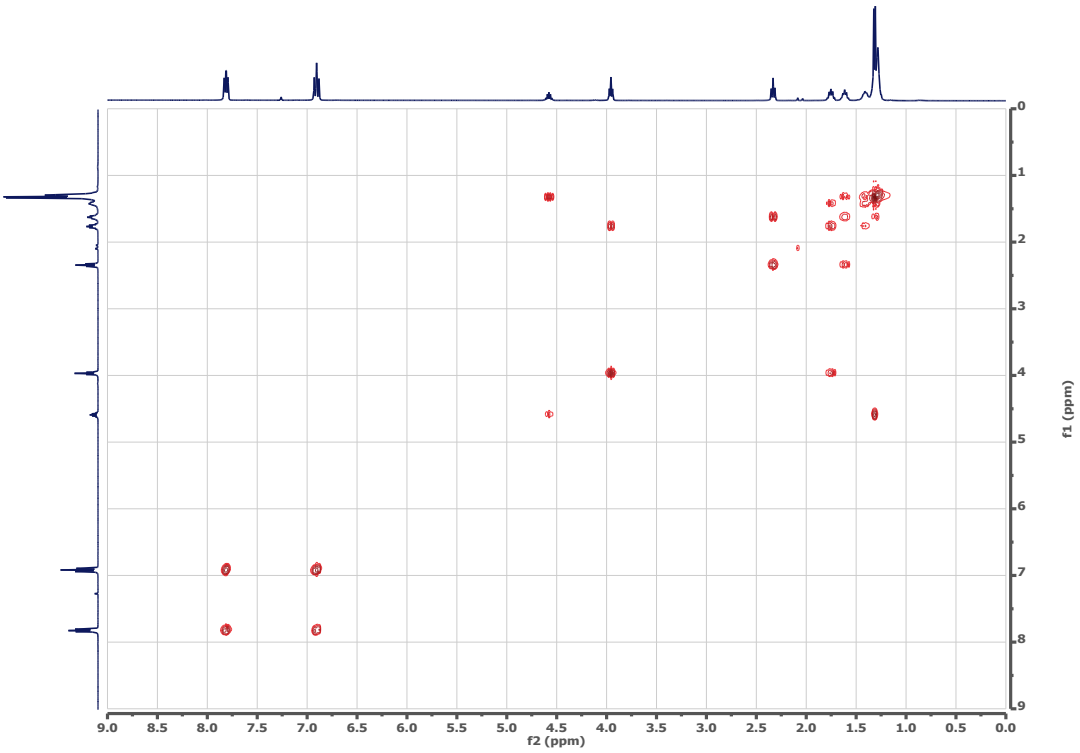


Fig. S89 – HSQC spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_{10}$) (solvent: $CDCl_3$).

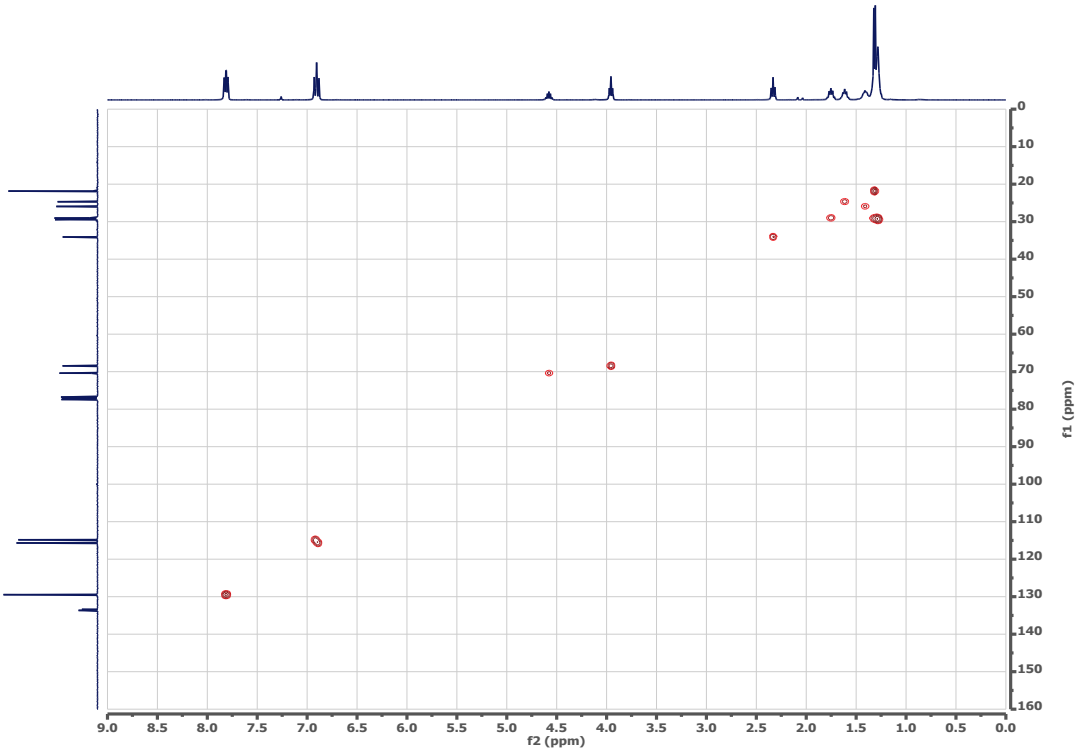
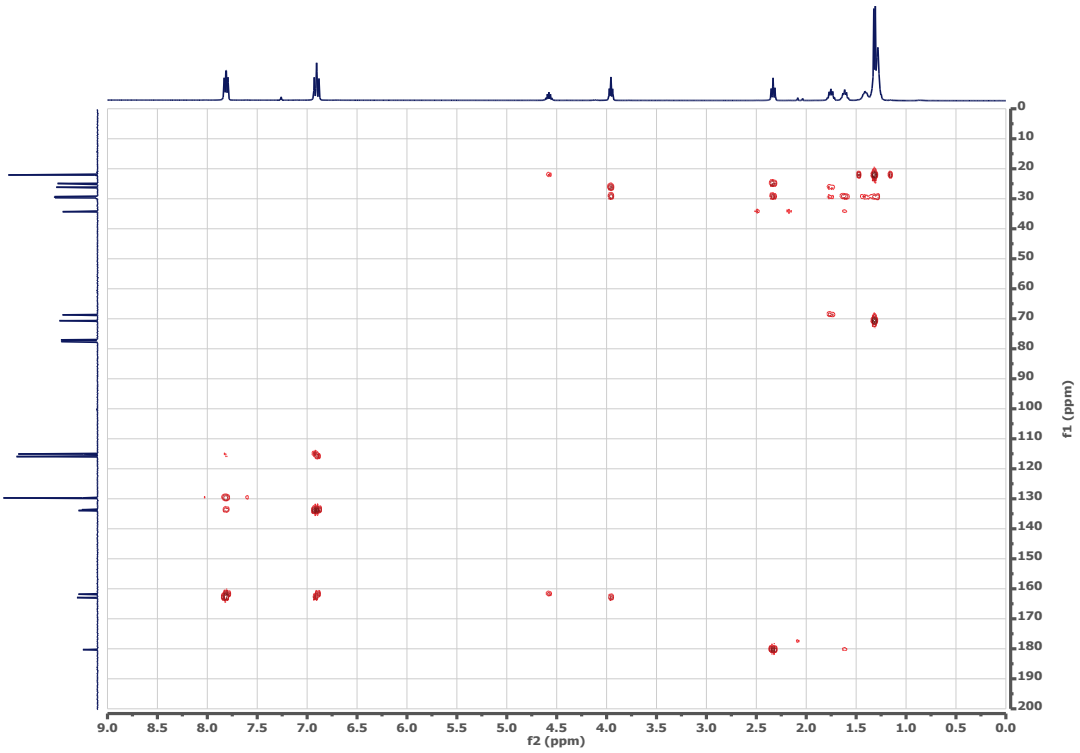


Fig. S90 – HMBC spectrum of 4-(4-((4-isopropoxyphenyl)sulfonyl)phenoxy)butanoic acid ($mPES_{10}$) (solvent: $CDCl_3$).



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