Supporting Information

For

Improving the Efficiency of Dye-Sensitized Solar Cells via the Impact of Triphenylamine-Based Inventive Organic Additives in Bio-Degradable Cellulose Polymer Gel Electrolytes

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1. Cyclic voltammetry Study

To evaluate the effect of organic additive in polymer gel electrolytes to be studied by cyclic voltammetry. It has done by three electrolyte system Pt wire as counter electrode, Pt micro electrode as working electrode and reference electrode as Ag/AgCl saturated calomel electrode with overall scan of Ewe with dE/dt is 100 mV/s. The E_{red} and $E_{oxd}$of the polymer electrolytes was observed high and the current in cyclic voltammetry was increased from 0.0064 to 0.0083 mA. From the cyclic voltammetry (CV) result to recognize that the impact of organic additives in the electrolyte improves current when compare to bare.[1]

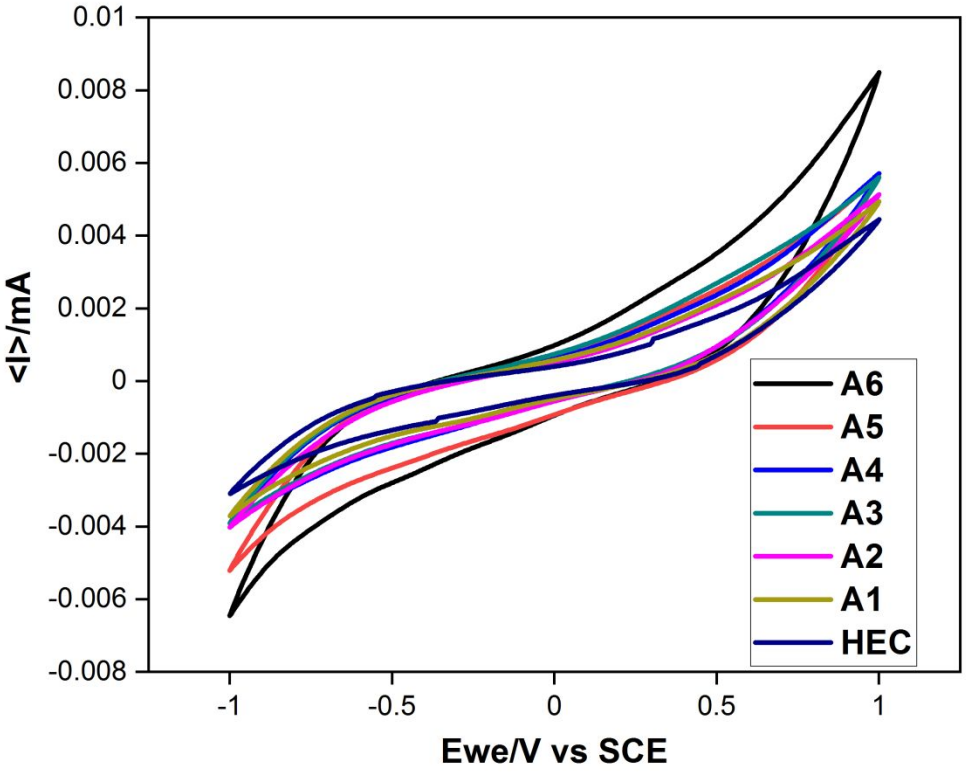

Figure S1: The Cyclic voltammetry diagram for the prepared polymer gel electrolytes with/without organic additives.

2. **Table S1:** Comparison study of the past research using Bio-degradable polymers as electrolytes in DSSCs.

S.no	Electrolyte	Solvent	Dye	Jsc	Voc	FF	η%	Year &ref
1[a]	MC/LiBOB/TMAI/I_2	DMSO	N3	8.08	0.67	0.65	3.52	2018[2]
2[a]	MC/LiBOB/TMAI/ BMII/I_2	DMSO	N3	12.34	0.62	0.60	4.63	2018[2]
3[a]	MC/TMAI/LiI/I_2	DMSO	N3	14.02	0.63	0.64	5.72	2018[2]
4[a]	AA-g-Cellulose/KI/I_2	-	N3	12.65	0.71	0.61	5.51	2011[3]
5[a]	CA/GCN/Pr_4I/I_2	EtOH	N719	9.83	0.70	0.58	4.0	2017[4]
6[a]	Phthaloyl Cellulose/LiI/I_2	DMSO	N719	7.89	0.59	0.71	3.29	2019[5]
7[a]	Ethyl Cellulose/LiI/I_2	EtOH	N719	14.47	0.68	0.57	5.6	2015[6]
8[a]	HEC/Co(II)/Co(III)/A6	PC/EC	N719	13.4	895	0.53	9.10	2018[7]
9[b]	Agar/EMDCA/KI/I_2	DMF	N3	0.0033	0.62	0.66	1.36	2017[8]
10[c]	Chitosan/BMII/NH_4I/I_2	aqAA	N3	4.55	0.64	0.40	1.20	2019[9]
11[c]	HC/PVC/NaI/I_2	THF	N3	8.62	0.58	0.59	2.93	2019[10]

12[d]	RS/TiO_2/LiI/MPII/I_2	Water	N3	0.49	0.45	0.75	0.17	2014[11]
13[e]	Sago Palm/KI/I_2	Water	N3	0.29	0.58	-	0.57	2015[12]
14	**HEC/TPIPA/KI/I_2**	**DMF**	**N3**	**9.4**	**0.75**	**0.52**	**5.72**	***This Work***

Key Note: **MC:** methyl cellulose; **LiBOB:** lithium bis-oxalato borate; **TMAI:**tetramethylammonium iodide; **AA:** acrylic acid: **CA:** cellulose acetate; **GCN:**guanidiniumthiocyanate; **Additive-6:** Synthesis of 1,1'-(3,3',5,5'-tetramethyl-[1,1'-biphenyl]-4,4'-diyl)bis(3-(3,4,5-trimethoxyphenyl)thiourea);**PC:** propylene carbonate, **EC:** ethylene carbonate; **EMDCA**: 1-ethyl-3-methylimidazolium dicyanamide; **BMII:** 1-butyl-3-methylimidazolium iodide; **PVC:** polyvinyl chloride; **aqAA:** aqueous acetic acid; **HC:**hexanoyl chitosan; **RS**: Rice starch; **AS:** Arrowroot starch; **MPII:** 1-methyl-3-propylimidazolium iodide; **HEC:**Hydroxyethyl cellulose; **TPIPA:** tris(4-(1*H*-phenanthro[9,10-d]imidazol-2-yl)phenyl)amine.

3. References

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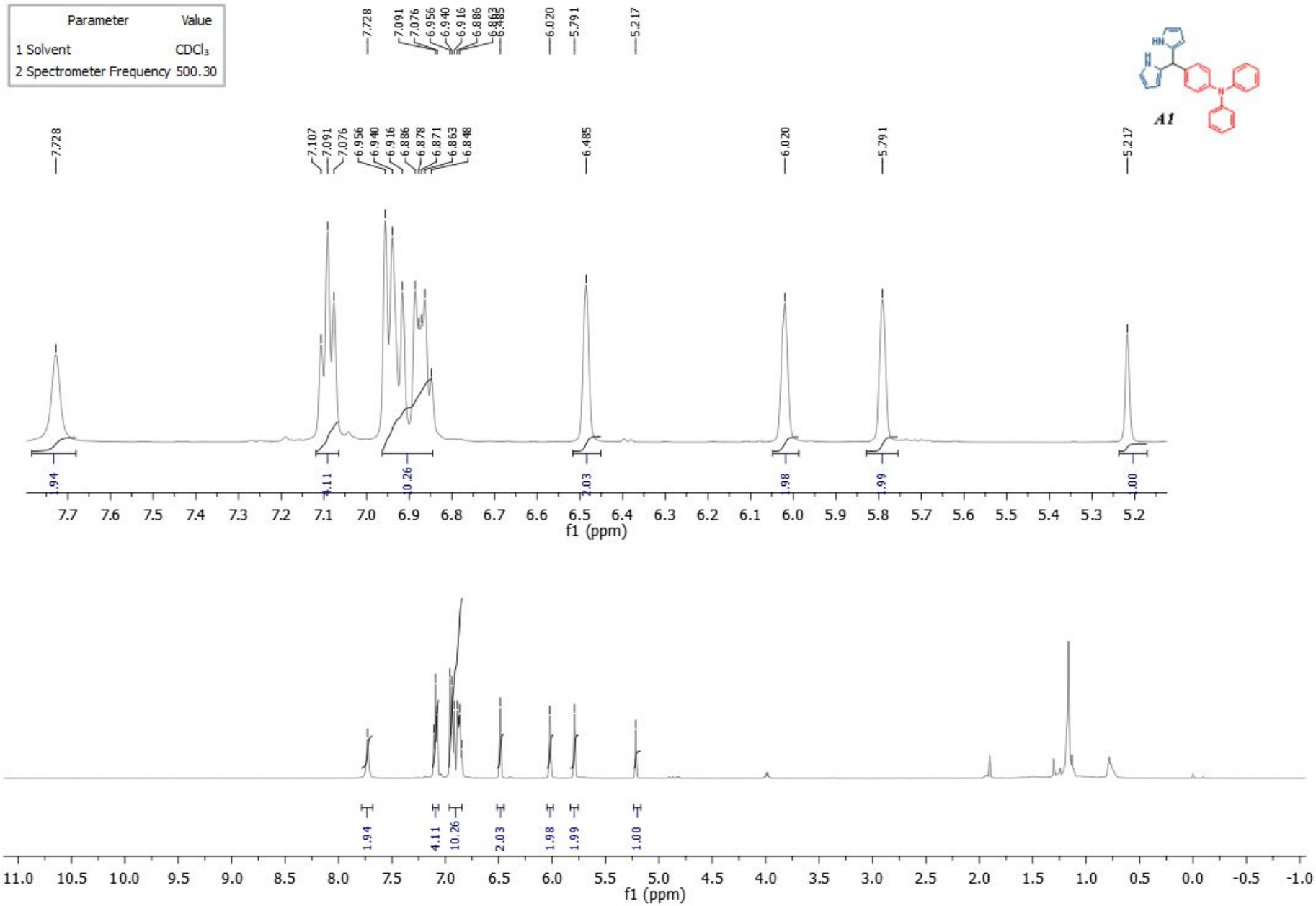

Figure: S2. a. 4-(di(1*H*-pyrrol-2-yl)methyl)-N,N-diphenylaniline [DPMDA].

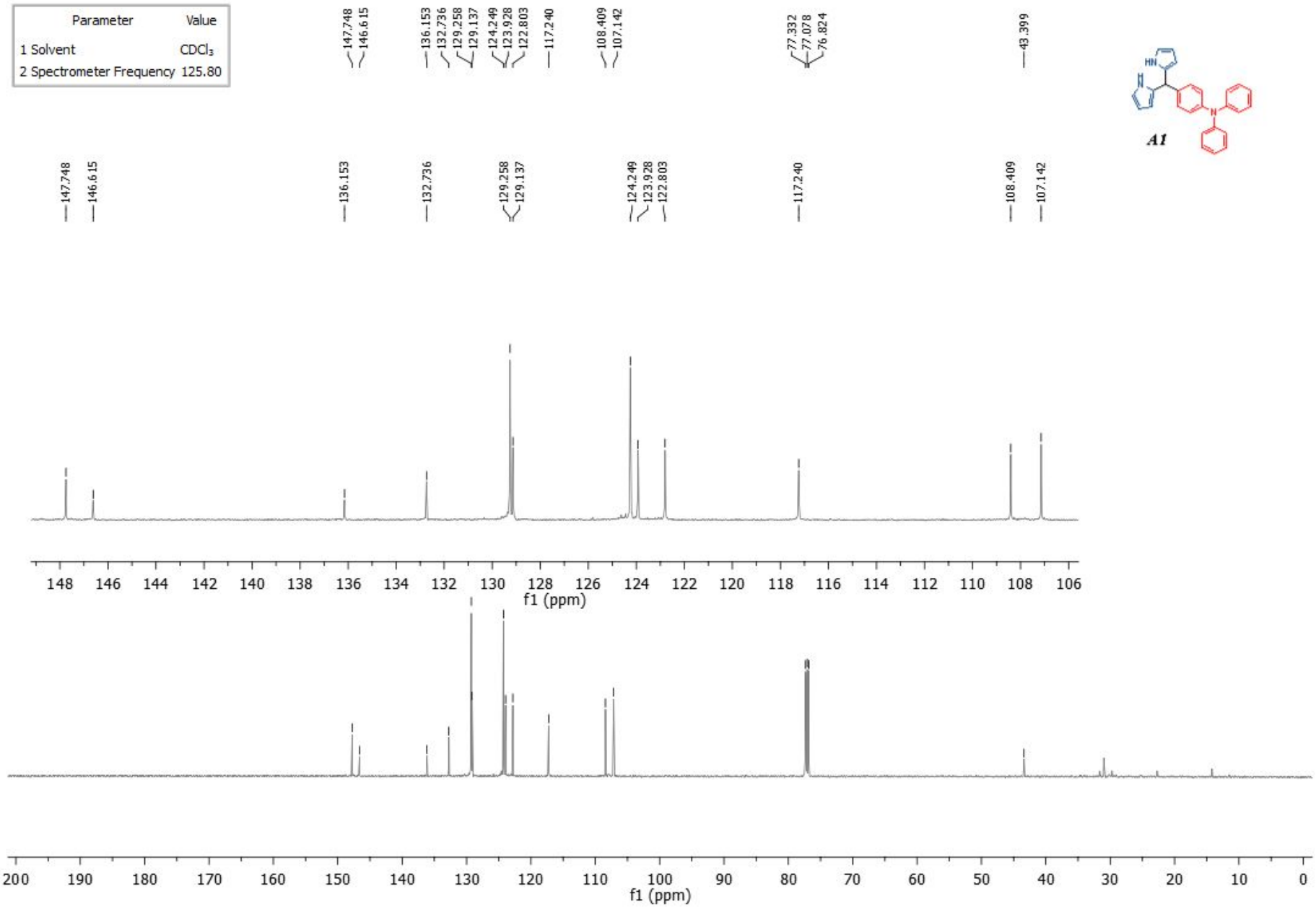

Figure: S2.b. 4-(di(1*H*-pyrrol-2-yl)methyl)-N,N-diphenylaniline[DPMDA].

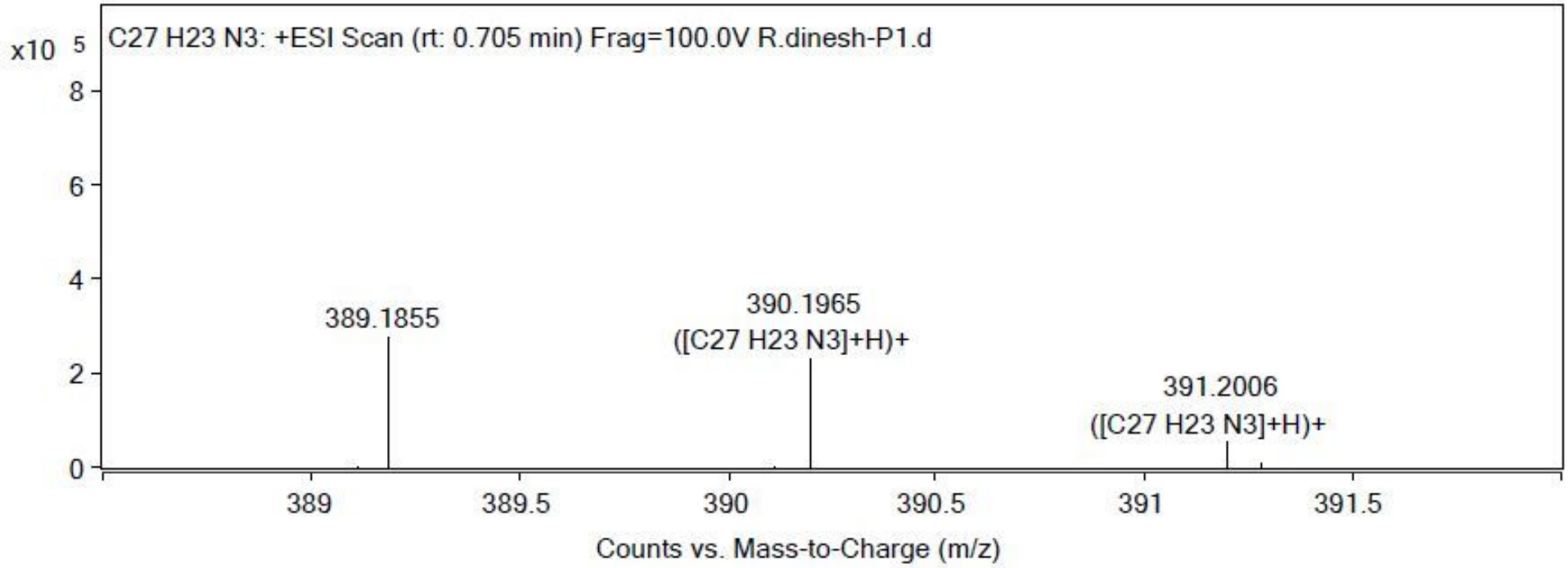

Figure: S2. c. 4-(di(1*H*-pyrrol-2-yl)methyl)-N,N-diphenylaniline[DPMDA].

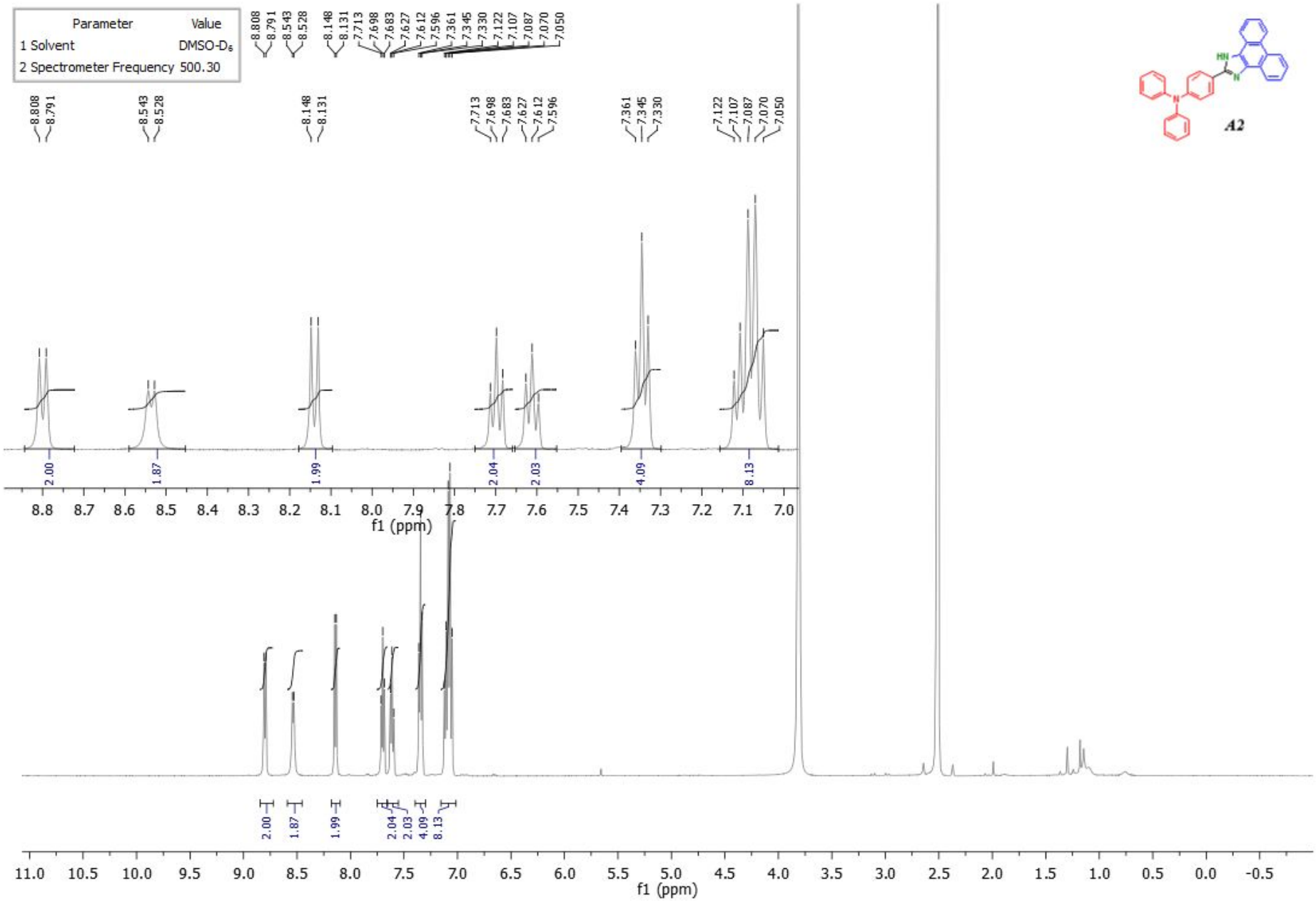

Figure: S3. a. 4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)-N,N-diphenylaniline[PIDA].

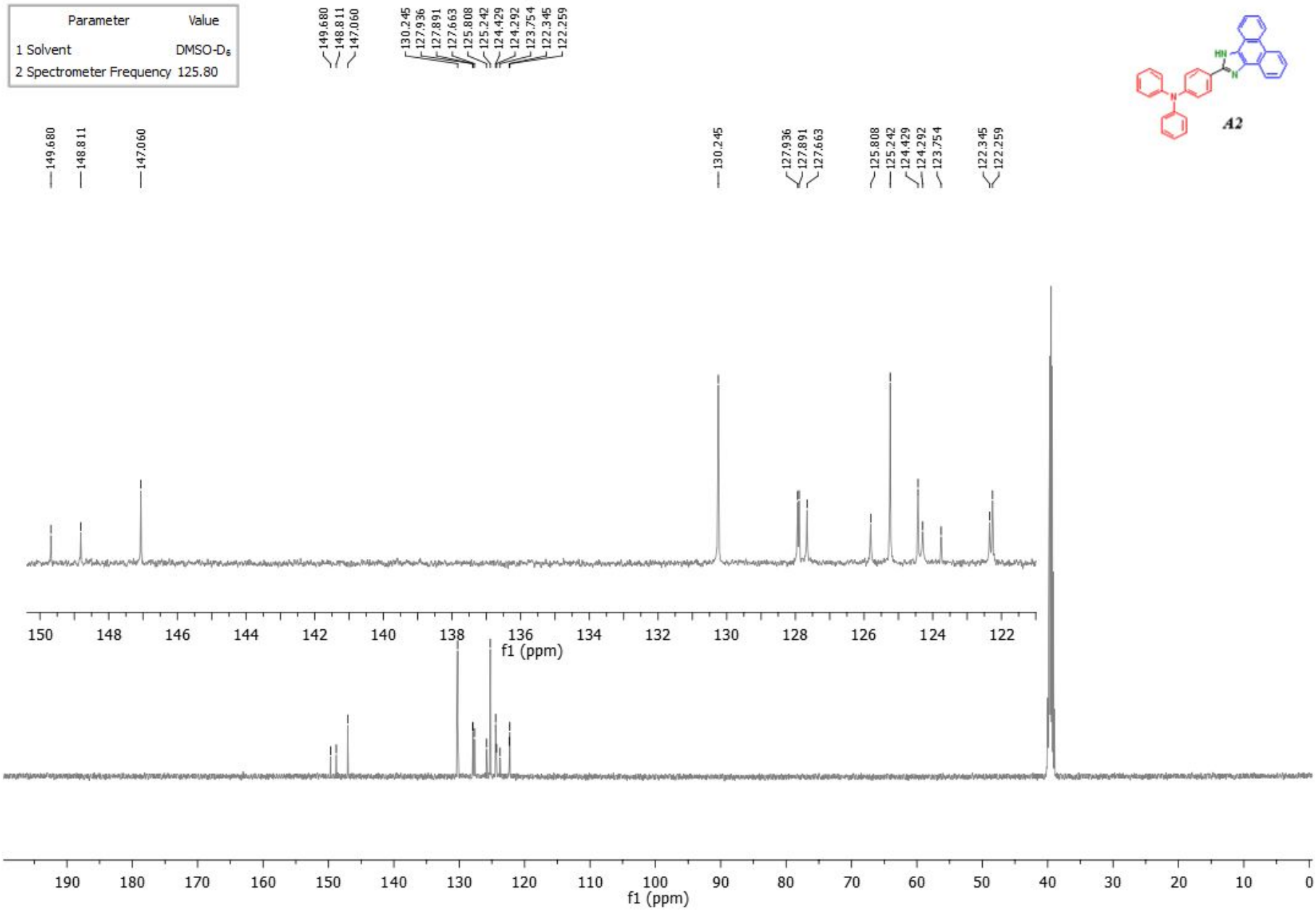

Figure: S3. b. 4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)-N,N-diphenylaniline[PIDA].

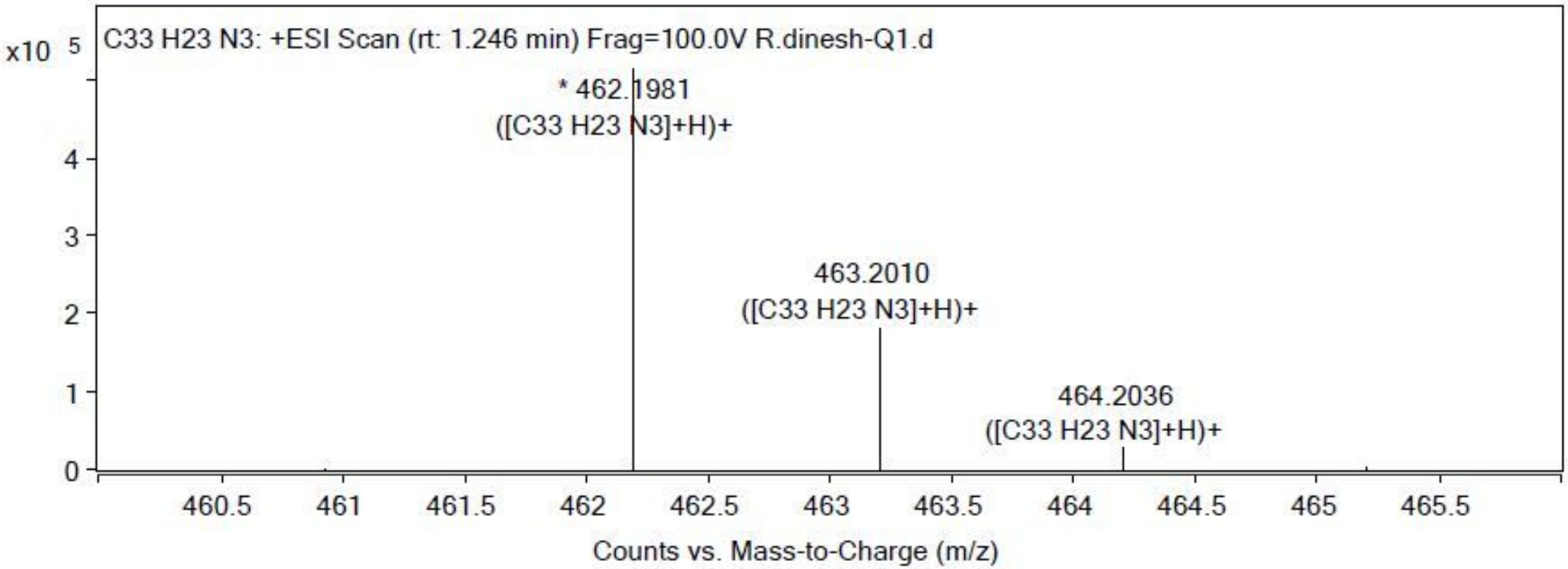

Figure: S3. c. 4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)-N,N-diphenylaniline [PIDA].

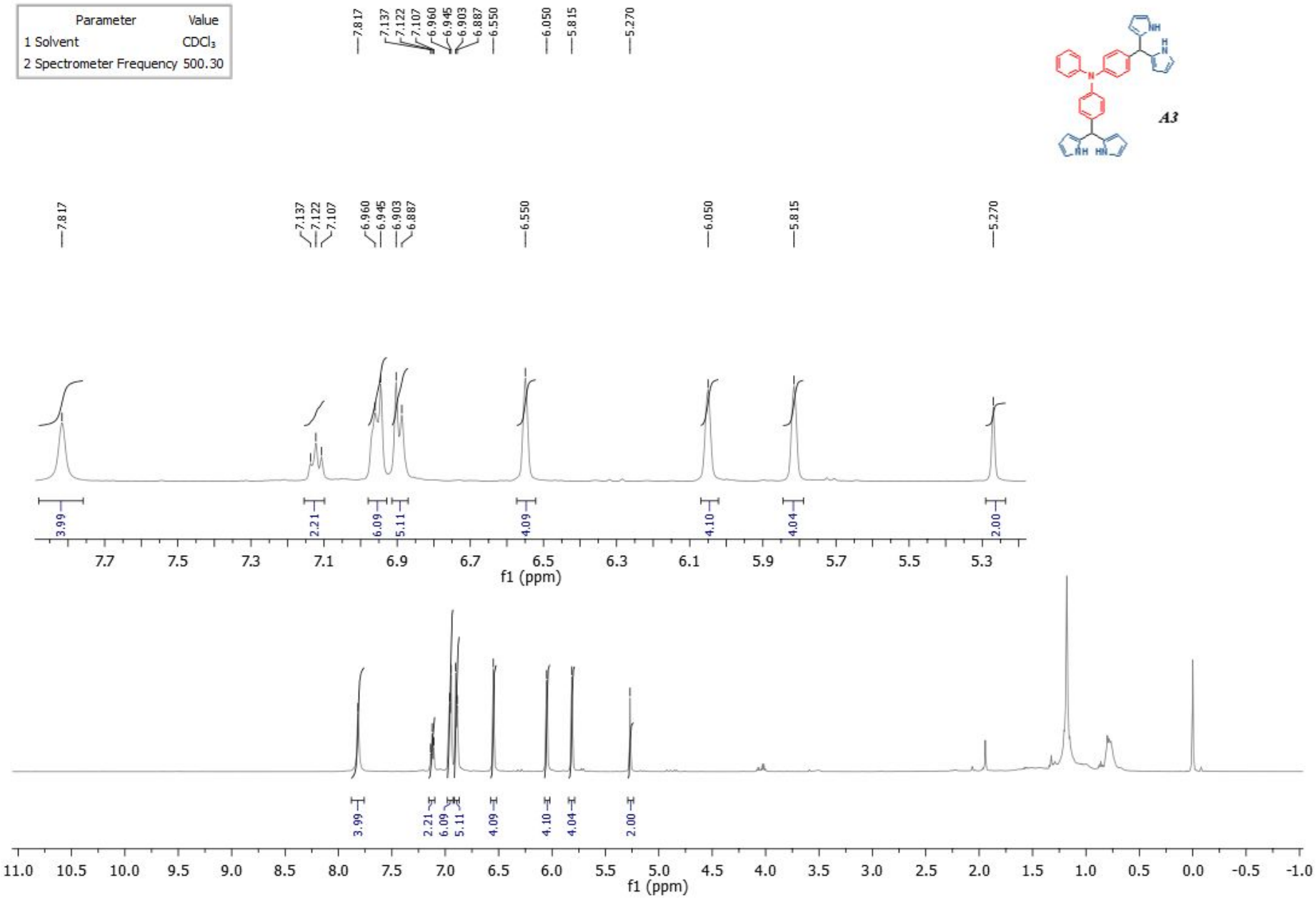

Figure: S4. a. 4-(di(1*H*-pyrrol-2-yl)methyl)-N-(4-(di(1*H*-pyrrol-2-yl)methyl)phenyl)-N-phenylaniline [DPMPPA].

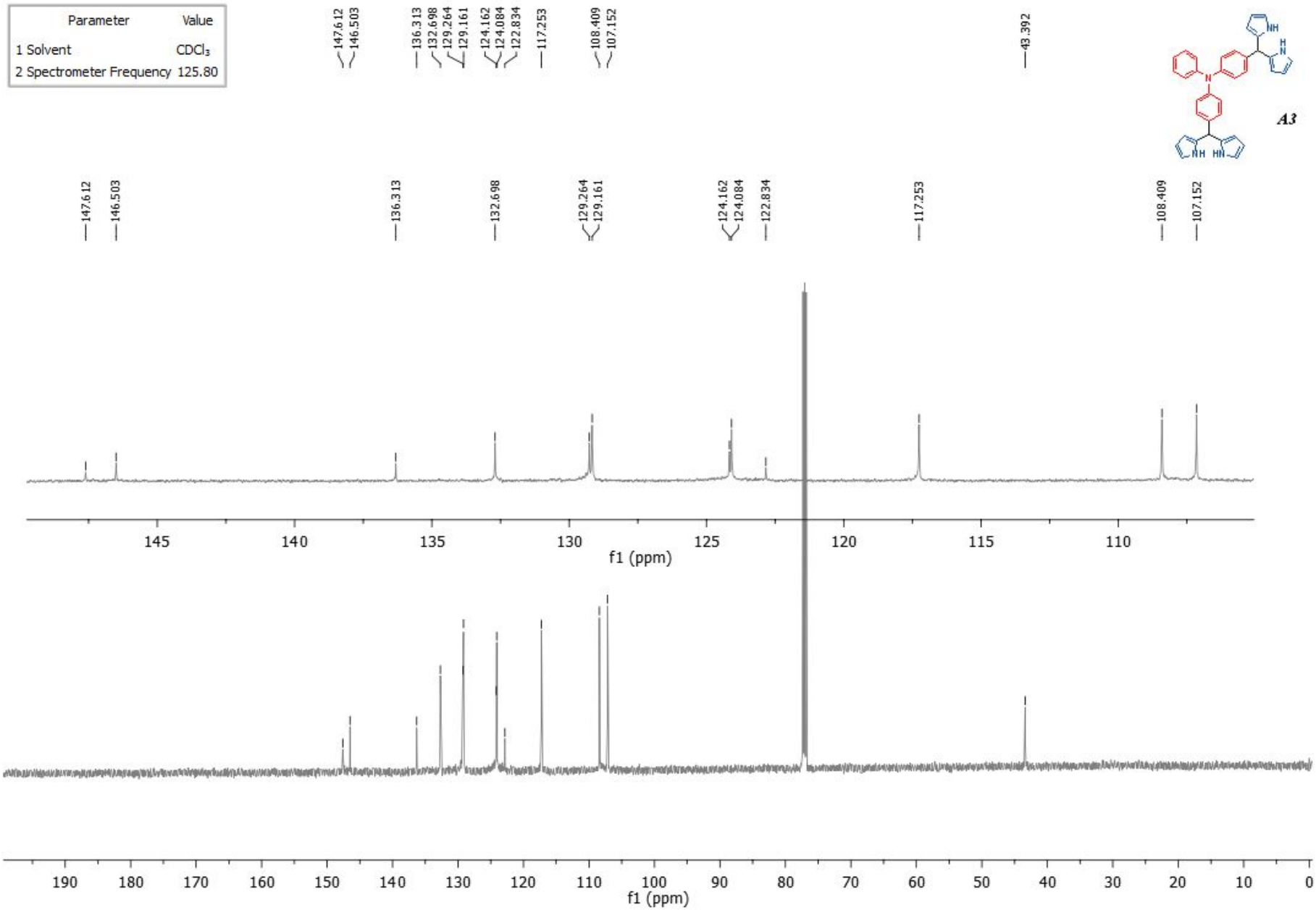

Figure: S4. b. 4-(di(1*H*-pyrrol-2-yl)methyl)-N-(4-(di(1*H*-pyrrol-2-yl)methyl)phenyl)-N-phenylaniline [DPMPPA].

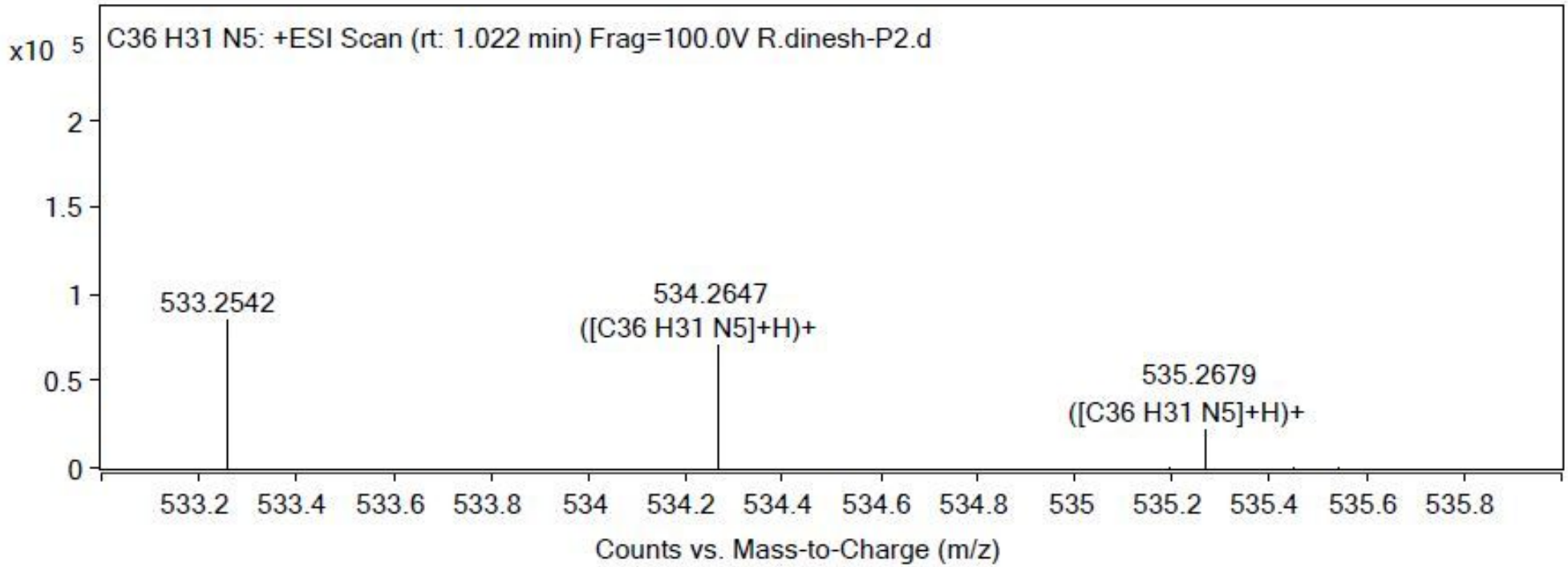

Figure: S4. c. 4-(di(1*H*-pyrrol-2-yl)methyl)-N-(4-(di(1*H*-pyrrol-2-yl)methyl)phenyl)-N-phenylaniline [DPMPPA].

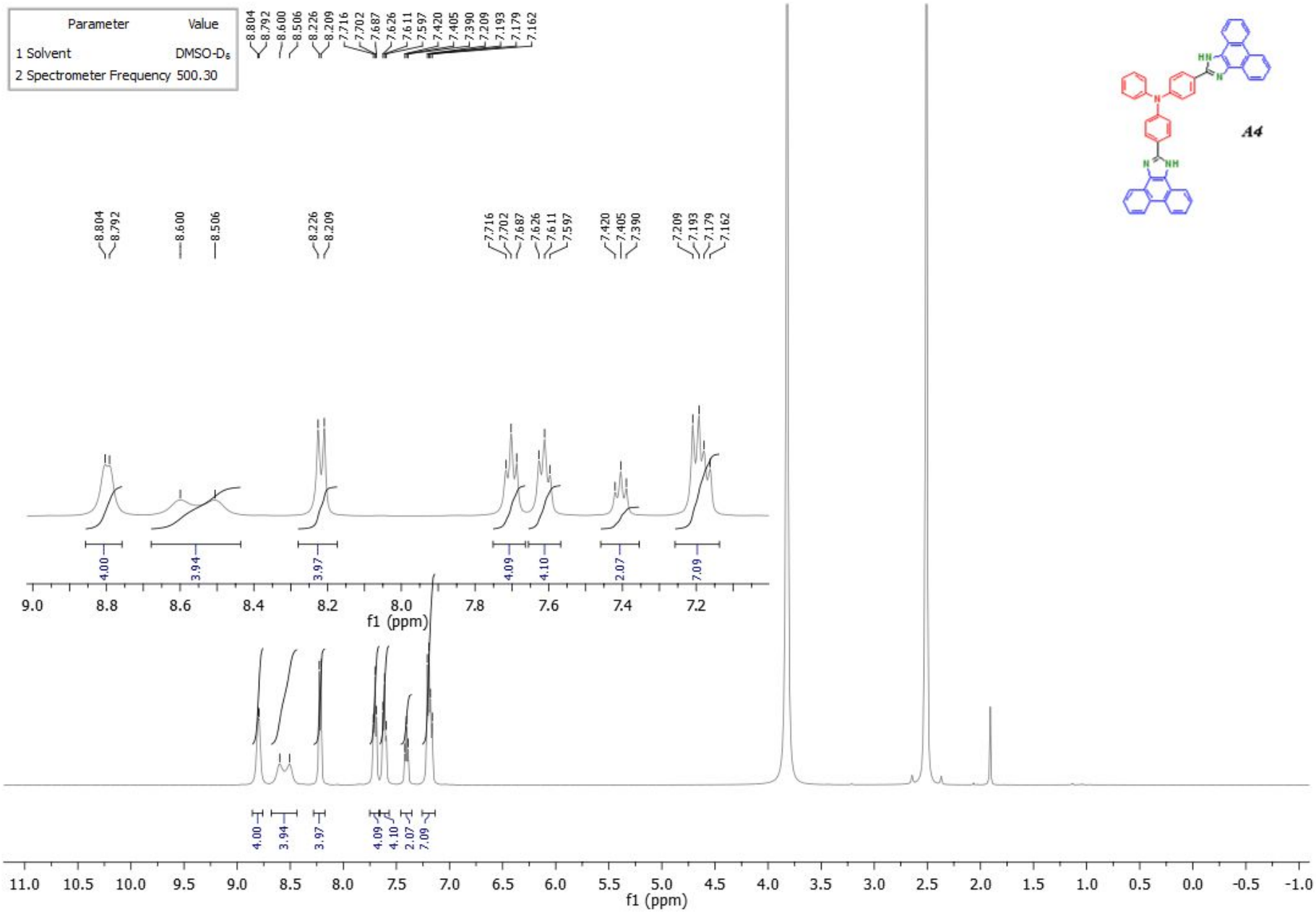

Figure: S5. a. N-(4-(1H-phenanthro[9,10-d]imidazol-2-yl)phenyl)-4-(1H-phenanthro[9,10-d]imidazol-2-yl)-N-phenylaniline [DPIPA].

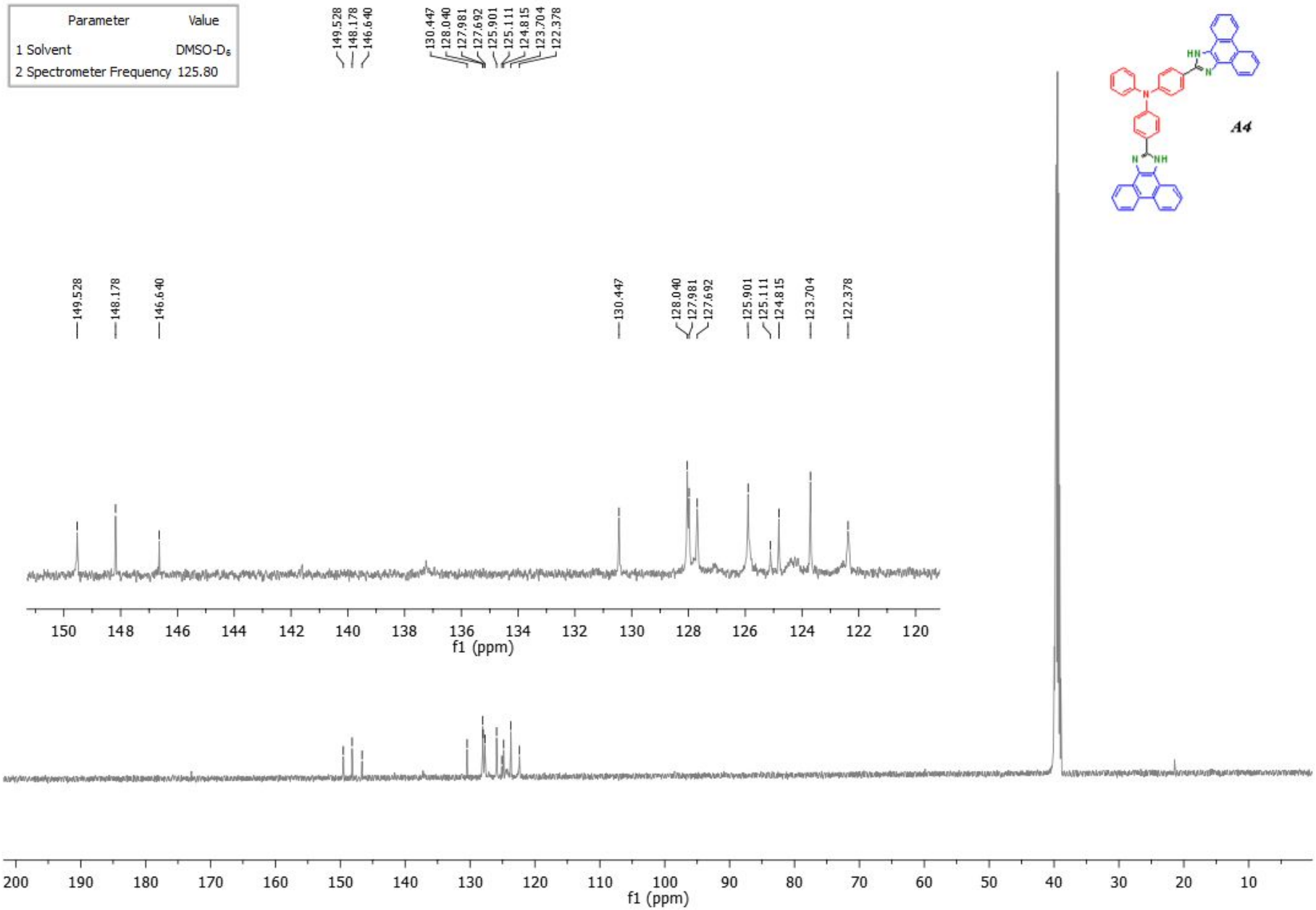

Figure: S5. b. N-(4-(1*H*-phenanthro[9,10-d]imidazol-2-yl)phenyl)-4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)-N-phenylaniline [DPIPA].

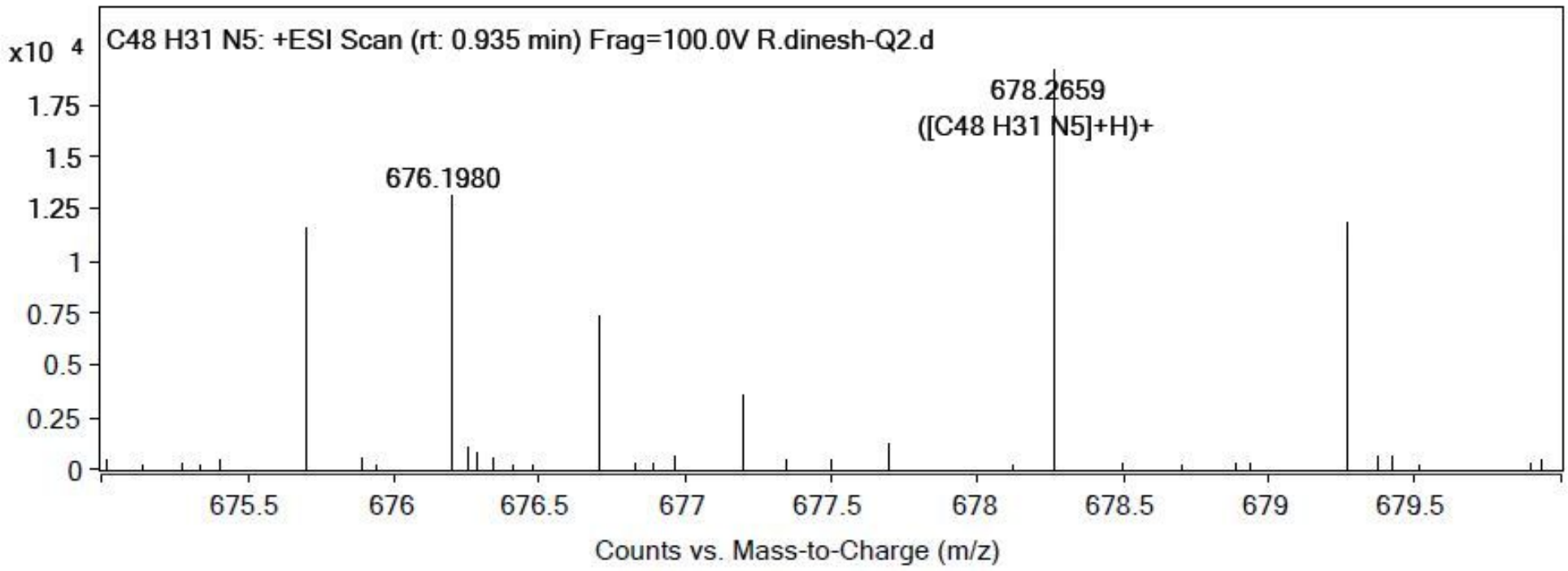

Figure: S5. c. N-(4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)phenyl)-4-(1*H*-phenanthro[9,10-d]imidazol-2-yl)-N-phenylaniline [DPIPA].

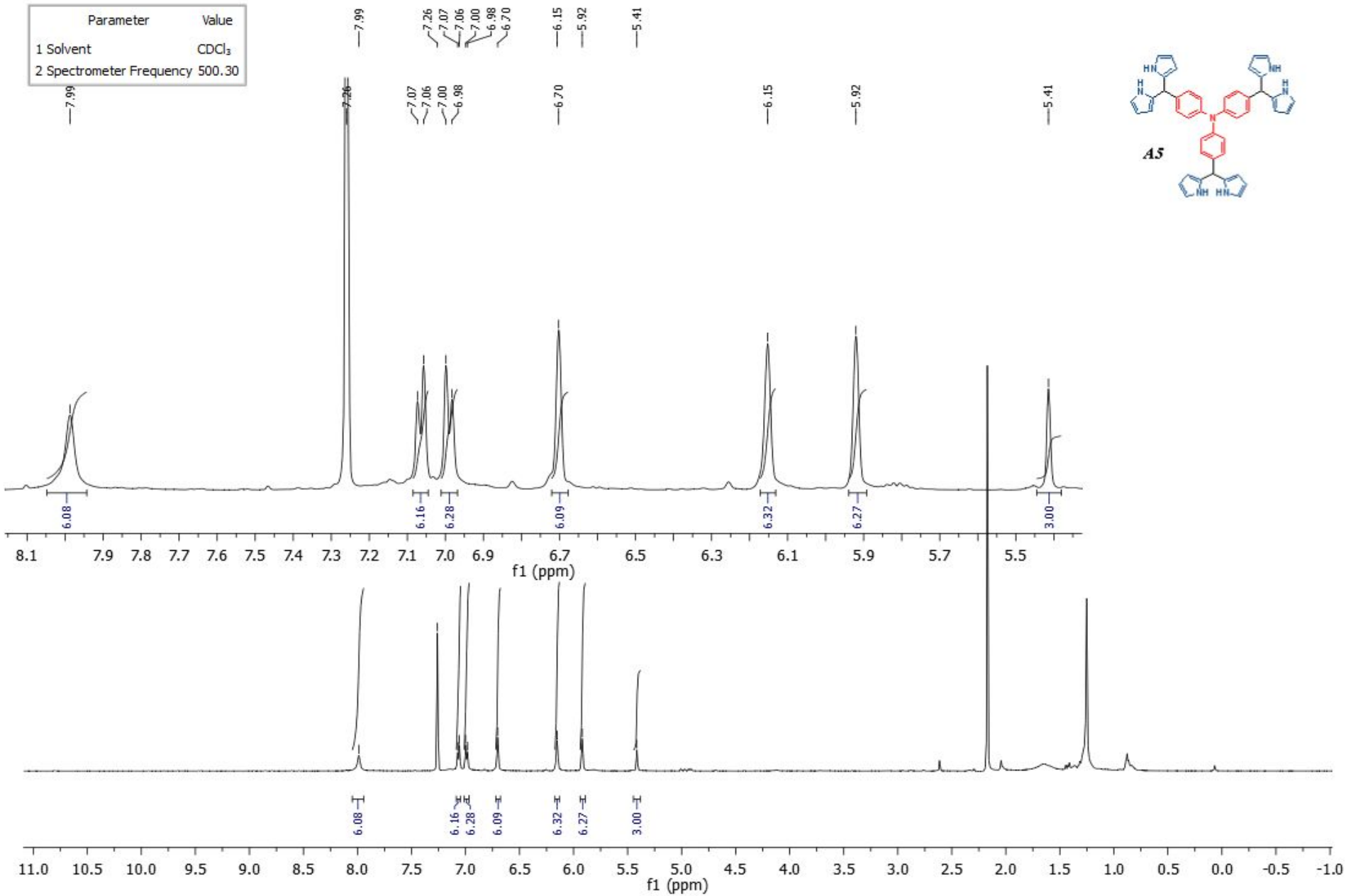

Figure: S6. a. tris(4-(di(1*H*-pyrrol-2-yl)methyl)phenyl)amine [TDPMPA].

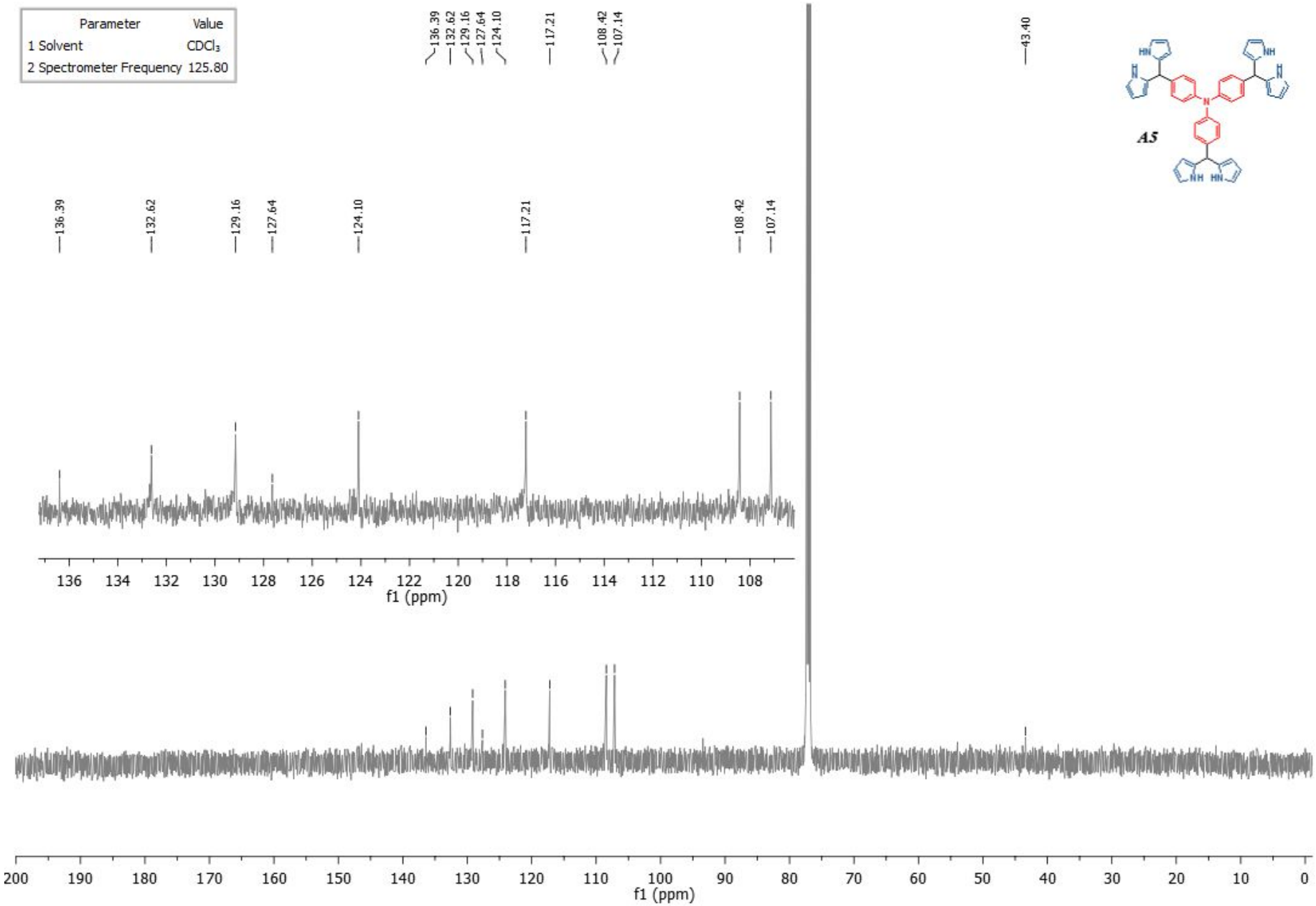

Figure: S6. b. tris(4-(di(1*H*-pyrrol-2-yl)methyl)phenyl)amine [TDPMPA].

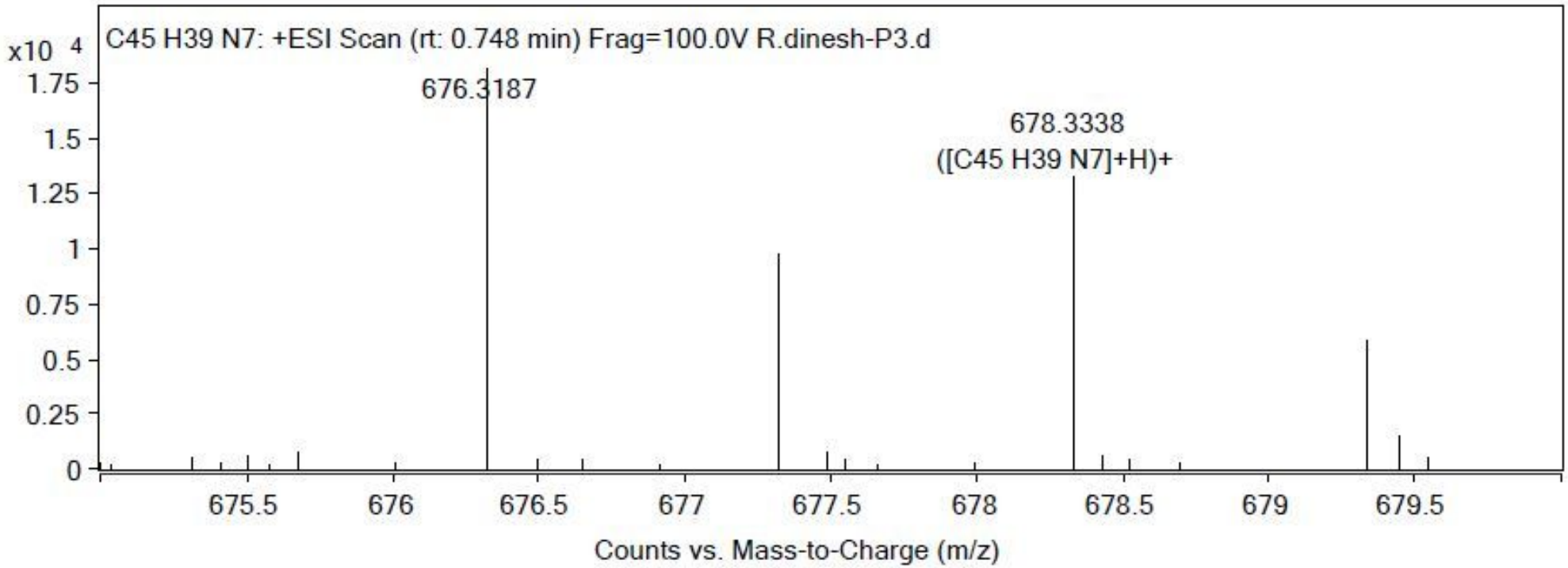

Figure: S6. c. tris(4-(di(1H-pyrrol-2-yl)methyl)phenyl)amine [TDPMPA].

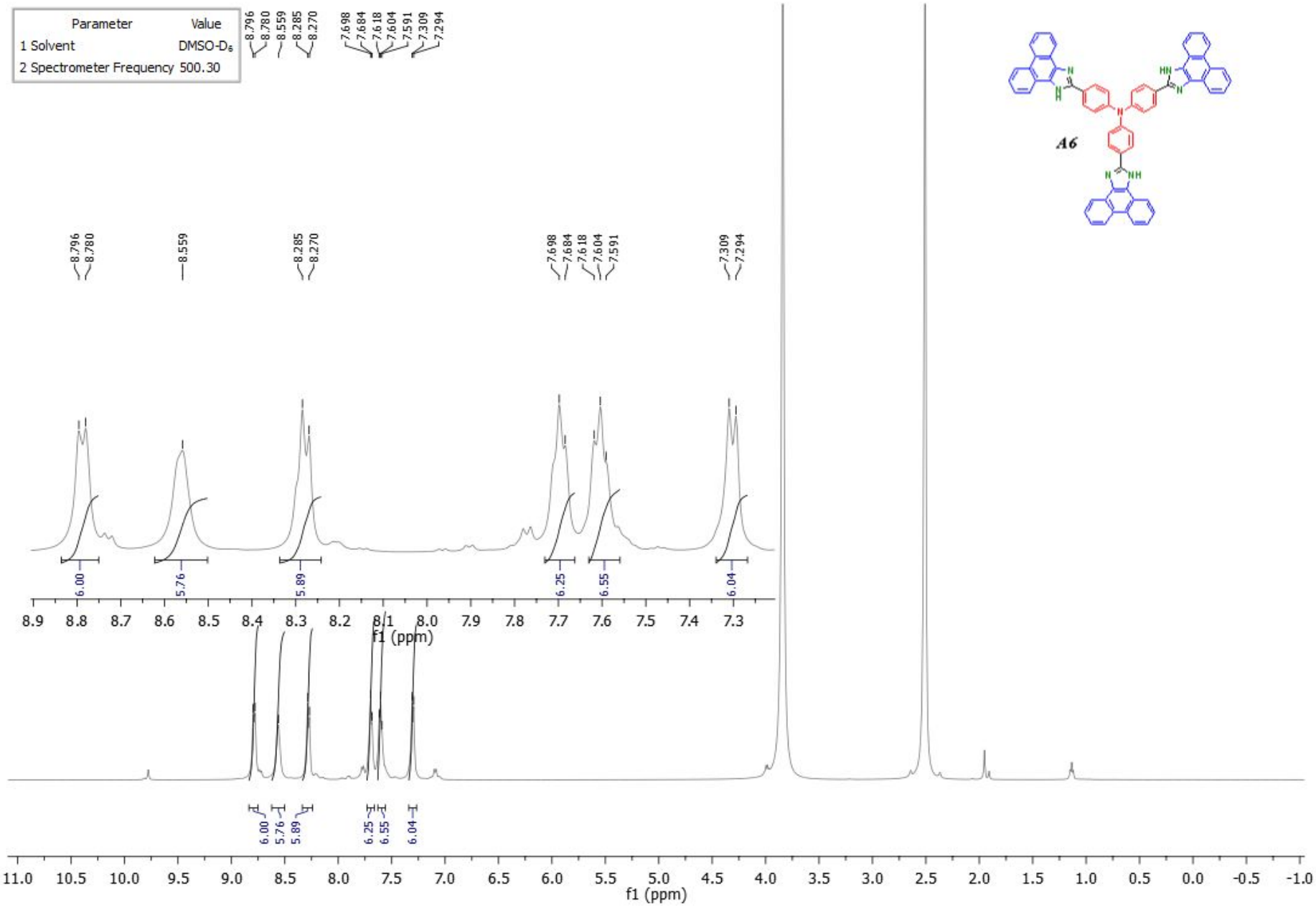

Figure: S7. a. tris(4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)phenyl)amine [TPIPA].

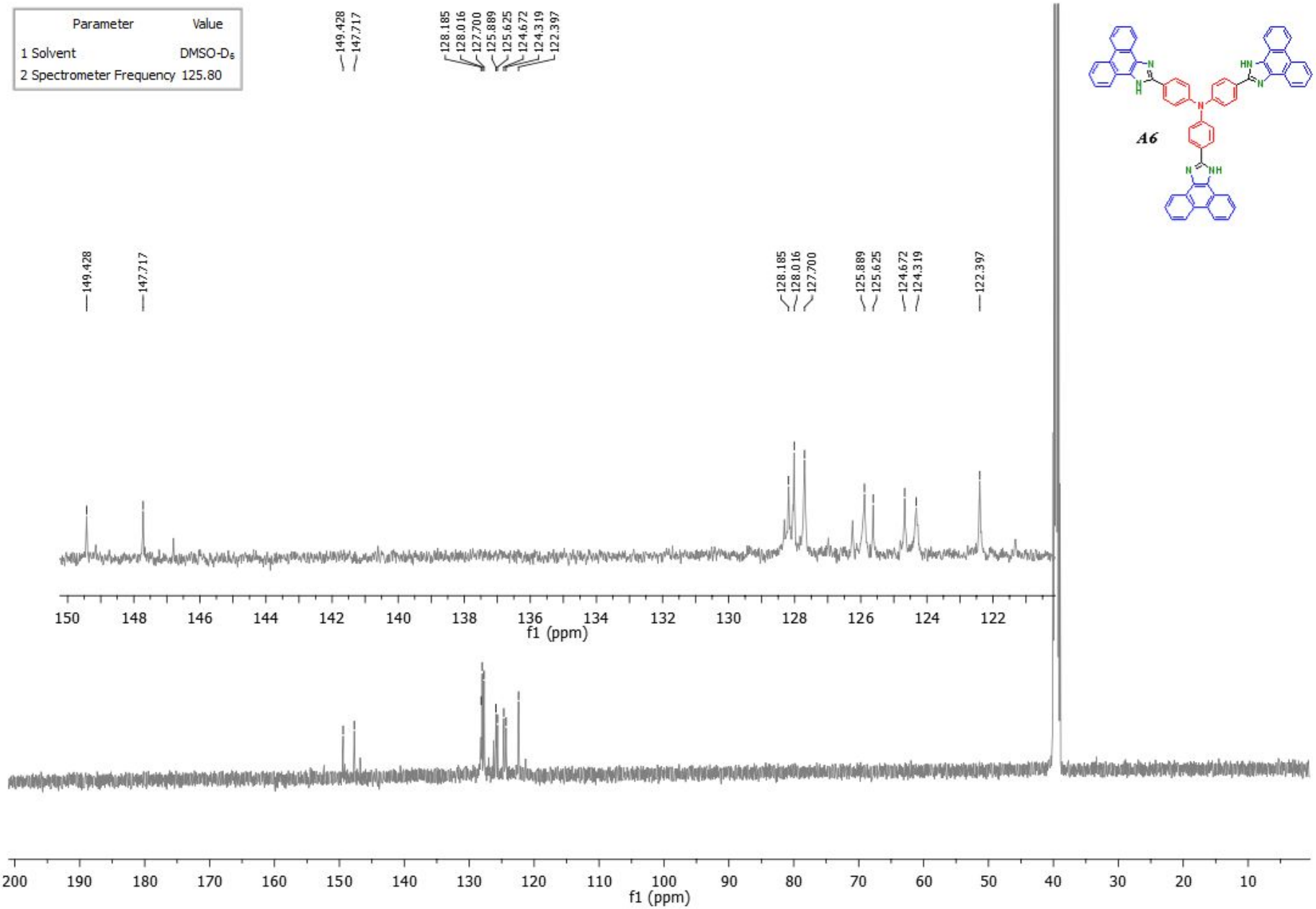

Figure: S7. b. tris(4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)phenyl)amine [TPIPA].

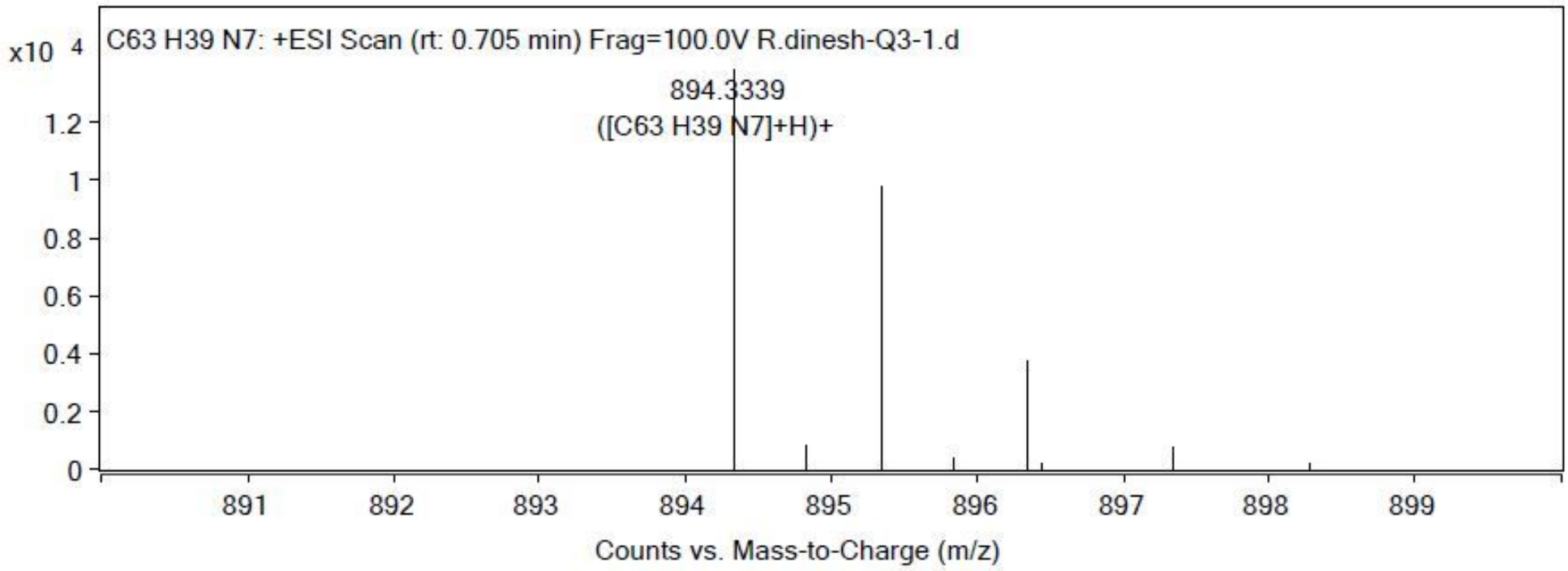

Figure: S7.c. tris(4-(1*H*-phenanthro[9,10-*d*]imidazol-2-yl)phenyl)amine [TPIPA].