Supporting Information

EFFECT OF OXYGEN SURFACE GROUPS IN THE ELECTROCHEMICAL MODIFICATION OF MULTI-WALLED CARBON NANOTUBES BY 4-AAMINO PHENYL PHOSPHONIC ACID

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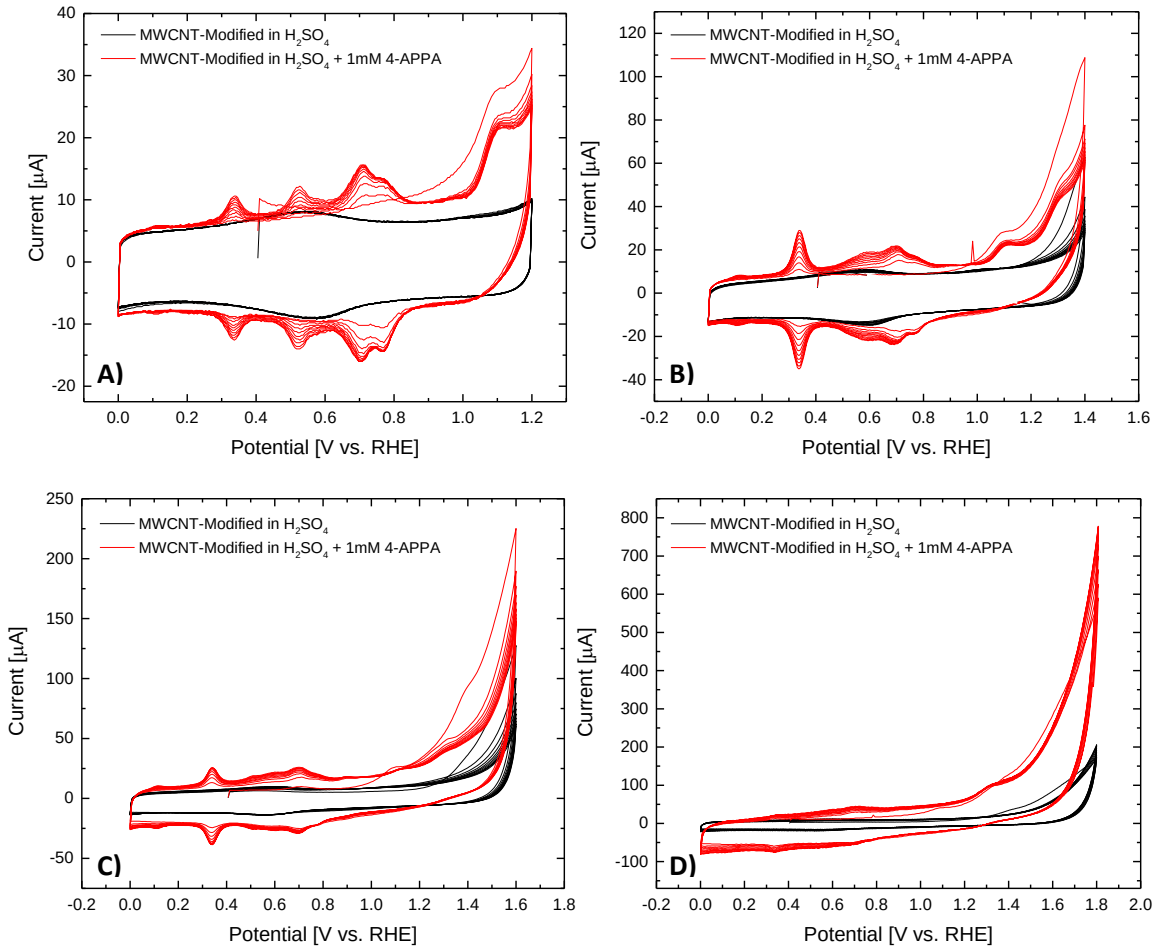


Figure S1. Electrochemical functionalization of MWCNT in 0.5 M H_2SO_4 (Black line) and 0.5 M H_2SO_4 + 1 mM 4-APPA (Red line) at 10 mV s^{-1}, 10 cycles under N_2 atmosphere at different potentials: A) 1.2 V, B) 1.4 V, C) 1.6 V and D) 1.8 V.

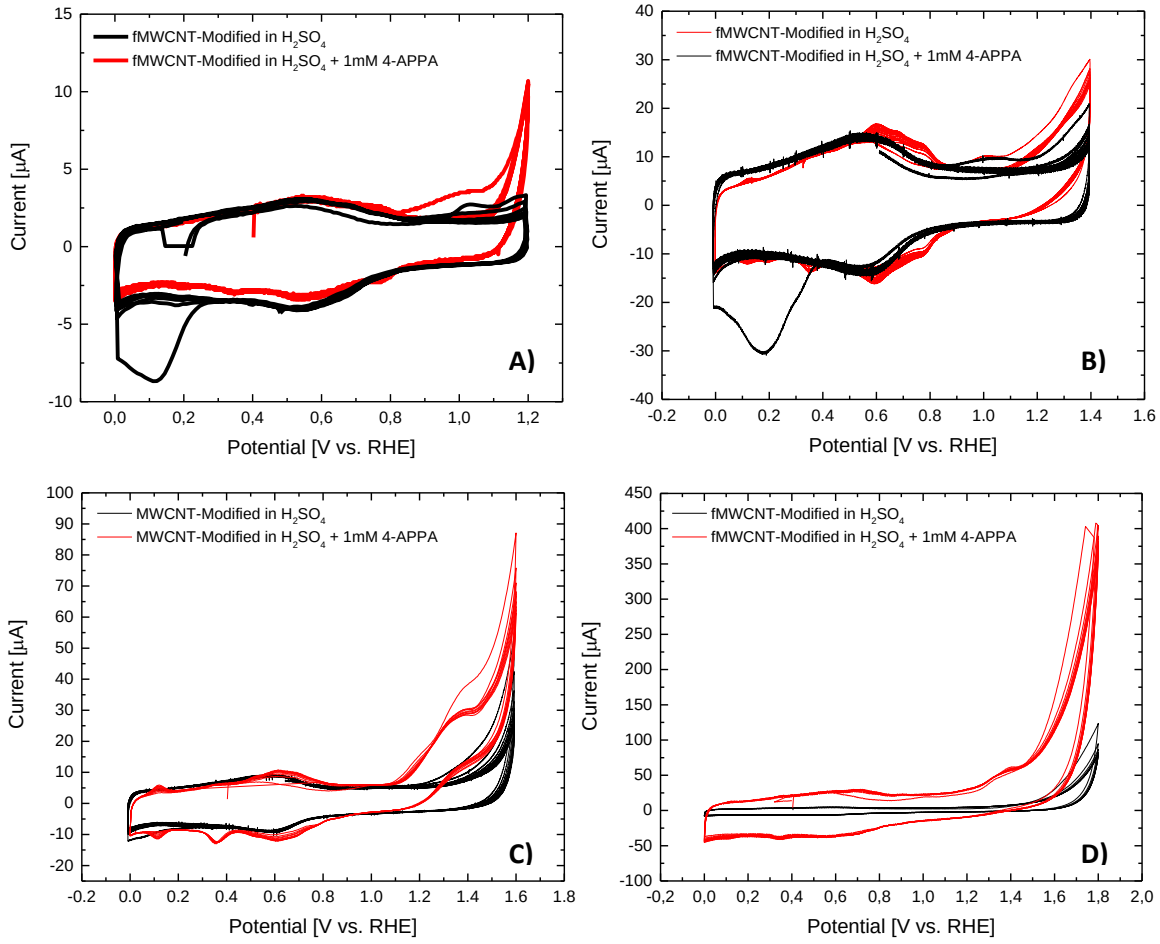


Figure S2. Electrochemical functionalization of fMWCNT in 0.5 M H_2SO_4 (Black line) and 0.5 M H_2SO_4 + 1 mM 4-APPA (Red line) at 10 mV s^{-1}, 10 cycles under N_2 atmosphere at different potentials: A) 1.2 V, B) 1.4 V, C) 1.6 V and d) 1.8 V.

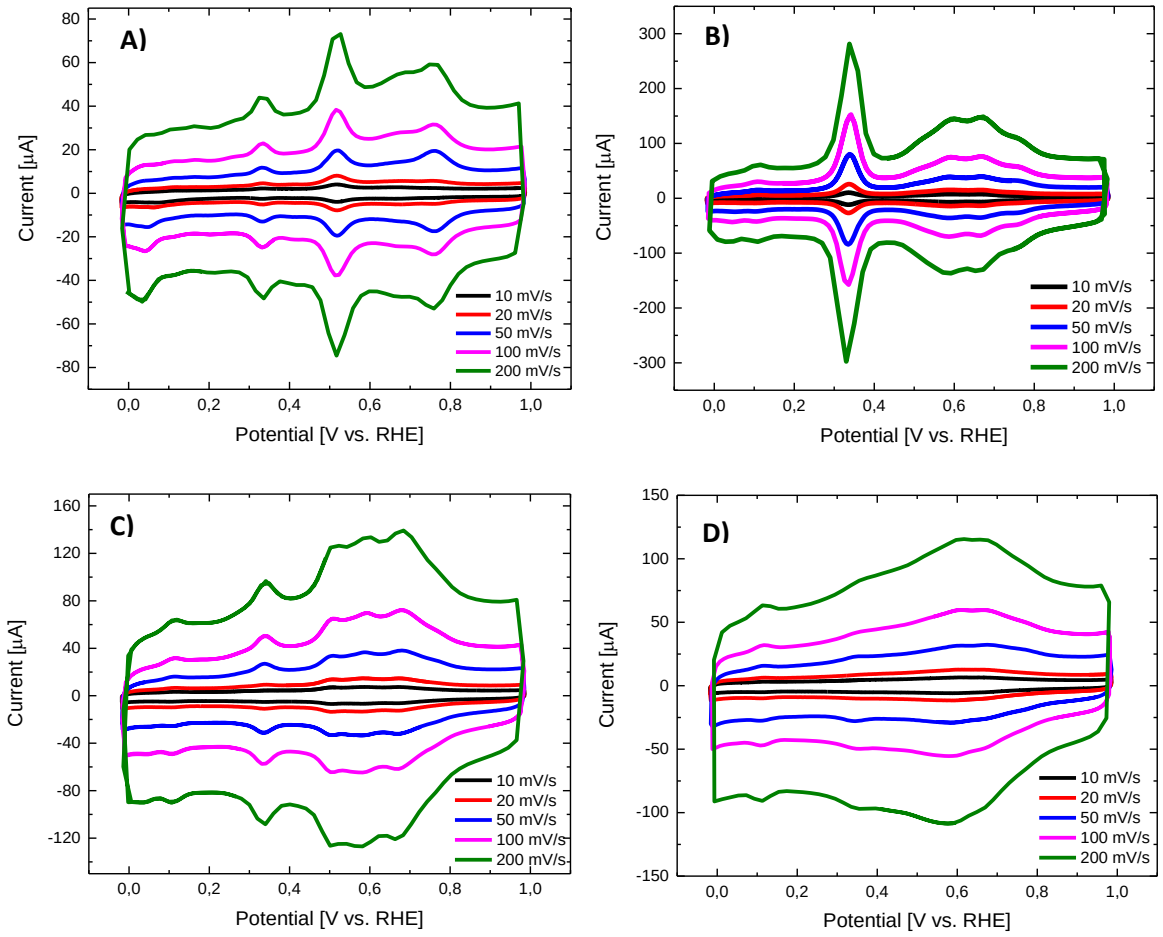


Figure S3. Cyclic voltammetry of MWCNT electrochemical modified with 4-APPA at different upper potential limit: A) 1.2 V, B) 1.4 V, C) 1.6 V and D) 1.8 V in 0.5 M H_2SO_4 at different v_{scan} under N_2 atmosphere.

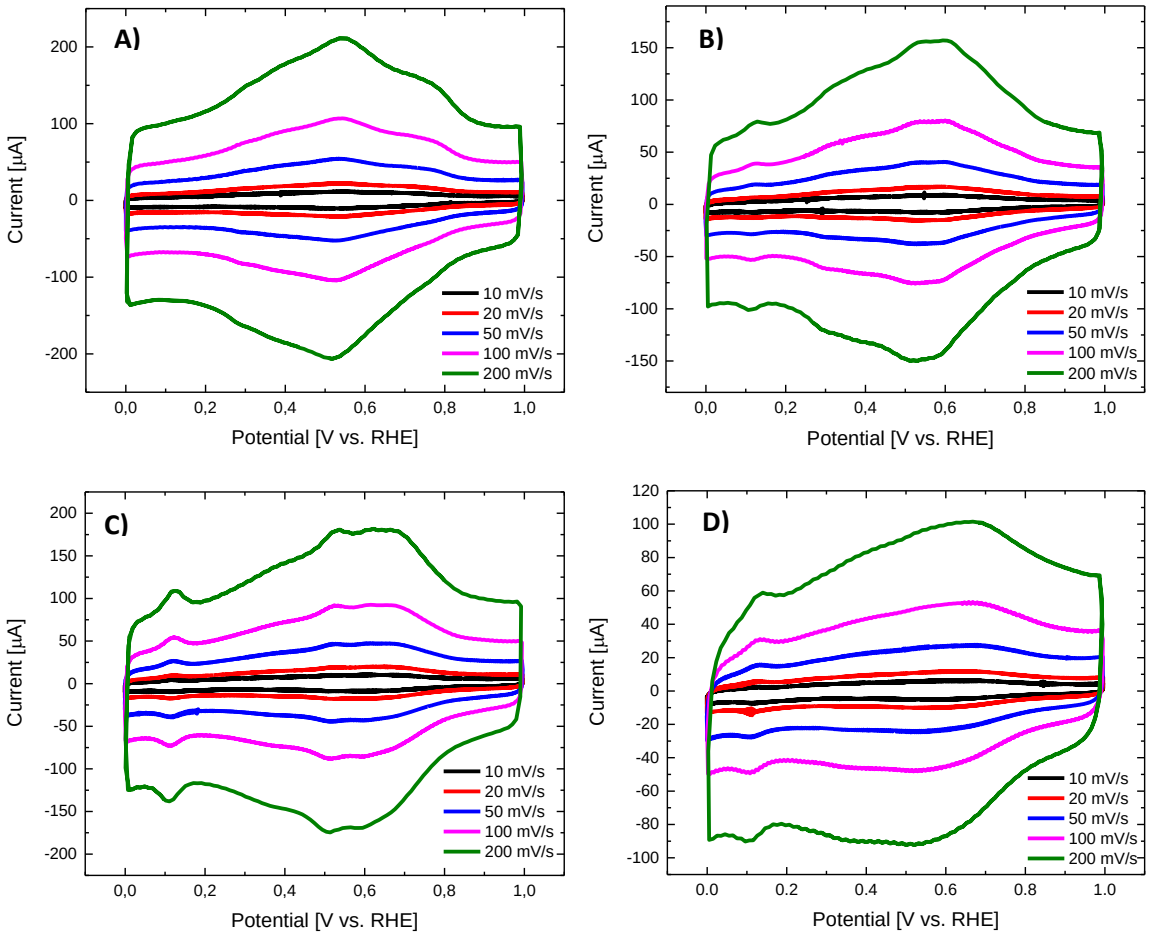


Figure S4. Cyclic voltammetry of fMWCNT electrochemical modified with 4-APPA at different upper potential limit: A) 1.2 V, B) 1.4 V, C) 1.6 V and D) 1.8 V in 0.5 M H_2SO_4 at different v_{scan} under N_2 atmosphere.

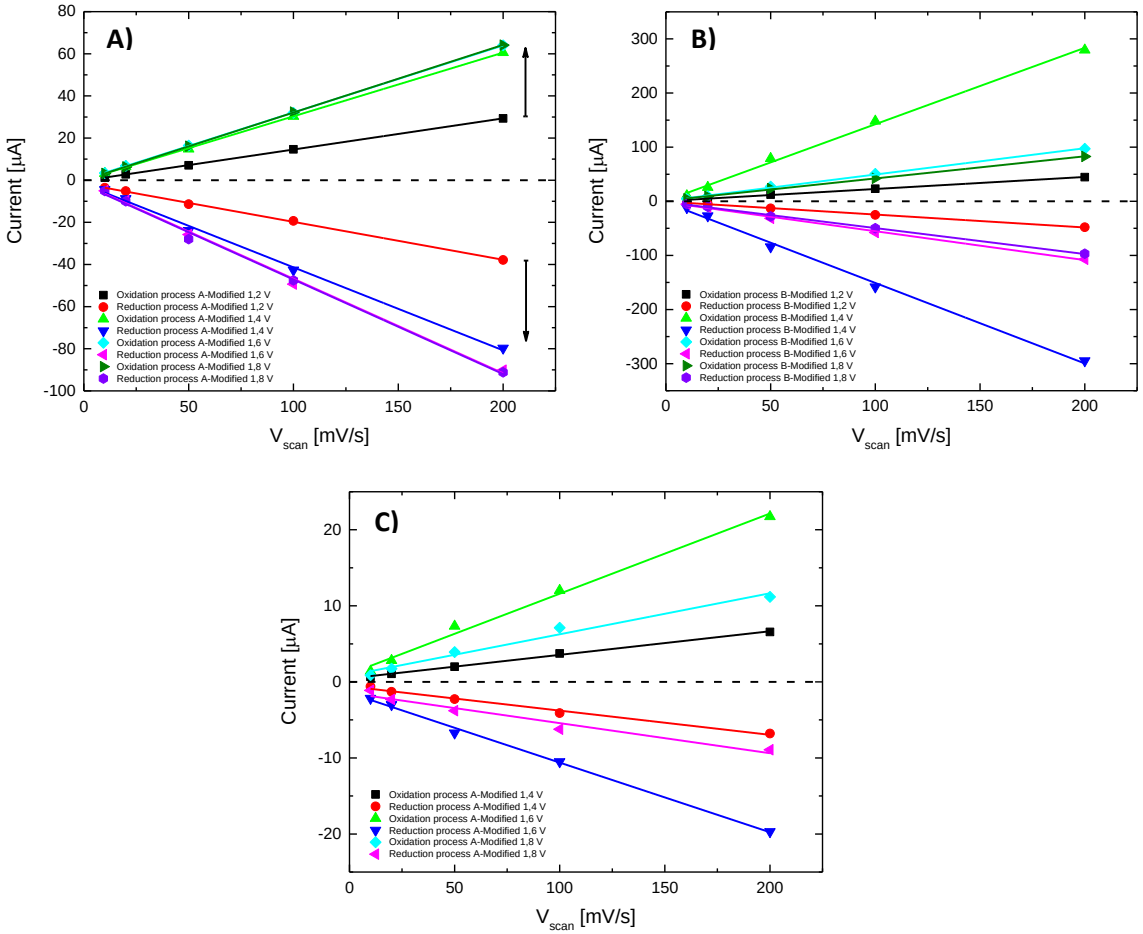


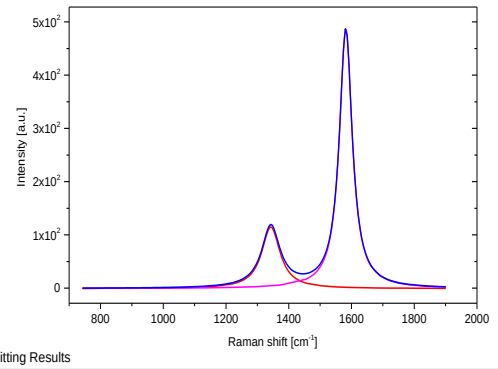
Figure S5. Plot of cathodic and anodic currents vs. v_{scan} for process A and B in different carbon nanotubes modified at different potential with 4-APPA in 0.5 M H_2SO_4: A) Process A of MWCNT, B) Process B of MWCNT and C) Process A of fMWCNT.

Table S1. Electrochemical parameters for the different electrochemical processes on carbon nanotubes modified with 4-APPA at different potentials in 0.5 M H_2SO_4. All the values were determined for the CVs at v_{scan} =50 mV·s^{-1}.

Carbon nanotube	Potential applied [V vs. RHE]	E^A [mV]	E^B [mV]	E^C [mV]	I^{ox}/I^{red}_A	I^{ox}/I^{red}_B	I^{ox}/I^{red}_C
MWCNT	1.2	1.5	4.9	--	0.81	0.88	--
	1.4	3.4	6.1	--	0.83	0.97	--
	1.6	5.0	4.5	--	0.76	0.91	--
	1.8	10	--	--	0.65	--	--
fMWCNT	1.2	--	5.5	11.4	--	1	1
	1.4	4.2	7.1	13.9	0.76	0.96	1
	1.6	8.0	8.2	0	0.72	1	0.99
	1.8	8.0	--	--	0.72	--	--

Pristine MWCNT

BaseLine:Straight
Chi^2=5.69875E+001 Adj. R-Square=9.92003E-001 # of Data Points=1159
SS=6.56496E+004 Degree of Freedom=1152

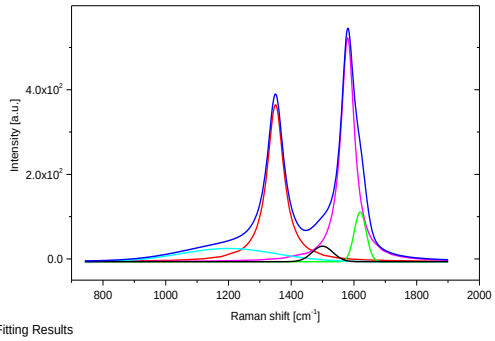


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	12303.56259	70.50095	115.58095	1343.00146	25.21618
2	Lorentz	36488.77534	49.37393	487.02911	1581.91814	74.78382

MWCNT electrochemical modified at 1.2 V with 4-APPA

BaseLine:Straight
Chi^2=1.33888E+002 Adj. R-Square=9.90660E-001 # of Data Points=1141
SS=1.51293E+005 Degree of Freedom=1130

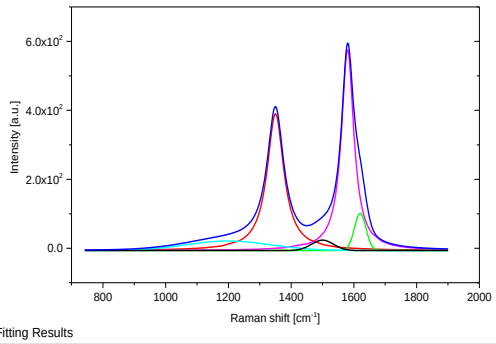


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	35726.04362	63.57558	370.72418	1350	36.53364
2	Lorentz	41453.92048	51.75366	528.69336	1580	42.39099
3	Gaussian	5613.03238	44.93701	117.34409	1620	5.73992
4	Gaussian	11944.29338	359.41673	31.26226	1200	12.2143
5	Gaussian	3052.16661	78.24464	36.64556	1500	3.12116

MWCNT electrochemical modified at 1.4 V with 4-APPA

BaseLine:Straight
Chi^2=1.40639E+002 Adj. R-Square=9.91002E-001 # of Data Points=1158
SS=1.61313E+005 Degree of Freedom=1147

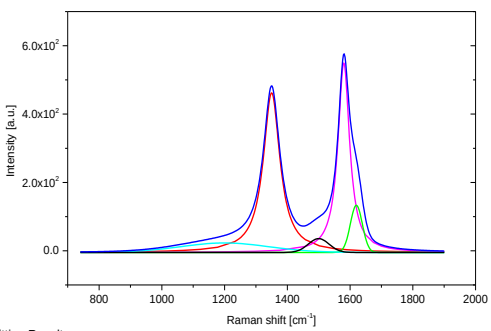


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	38577.88147	64.1899	396.62484	1350	39.37352
2	Lorentz	42344.85525	47.92567	581.6135	1580	43.21819
3	Gaussian	4989.52969	43.49632	107.76429	1620	5.09244
4	Gaussian	9403.6042	319.17576	27.68801	1200	9.59755
5	Gaussian	2663.37689	82.82225	30.21018	1500	2.71831

MWCNT electrochemical modified at 1.6 V with 4-APPA

BaseLine:Straight
Chi^2=1.84448E+002 Adj. R-Square=9.88970E-001 # of Data Points=1160
SS=2.11931E+005 Degree of Freedom=1149

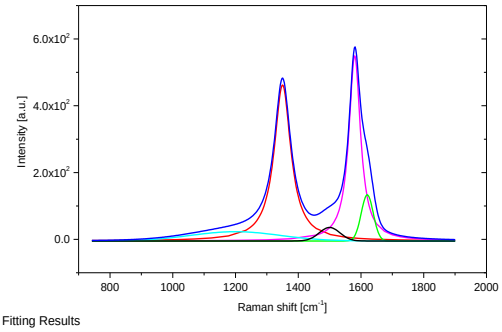


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	45023.52171	63.61794	466.87656	1350	43.93563
2	Lorentz	37676.43663	44.64392	554.23379	1580	36.76607
3	Gaussian	6594.51204	44.91557	137.92836	1620	6.43517
4	Gaussian	9844.87791	332.76216	27.80946	1200	9.607
5	Gaussian	3336.76252	77.36964	40.51562	1500	3.25614

MWCNT electrochemical modified at 1.8 V with 4-APPA

BaseLine:Straight
Chi^2=1.84768E+002 Adj. R-Square=9.88960E-001 # of Data Points=1158
SS=2.11928E+005 Degree of Freedom=1147



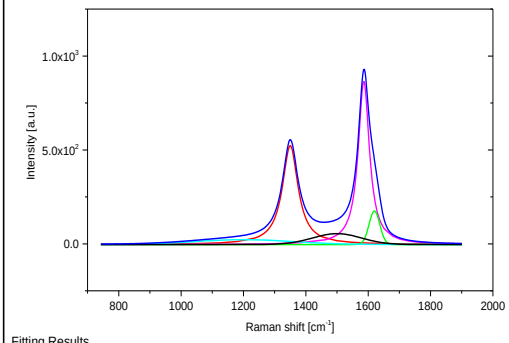
Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	45007.70614	63.6053	466.82838	1350	43.90339
2	Lorentz	37669.34238	44.64483	554.12999	1580	36.74508
3	Gaussian	6601.25649	44.98556	137.85459	1620	6.43929
4	Gaussian	9902.98576	334.03029	27.86895	1200	9.66001
5	Gaussian	3334.03262	77.34069	40.49763	1500	3.25223

Figure S6. Deconvolution of Raman spectra for MWCNT electrochemically modified with 4-APPA at different positive potentials in the D and G region.

Pristine fMWCNT

BaseLine:Straight
Chi^2=2.89367E+002 Adj. R-Square=9.91242E-001 # of Data Points=1159
SS=3.32193E+005 Degree of Freedom=1148

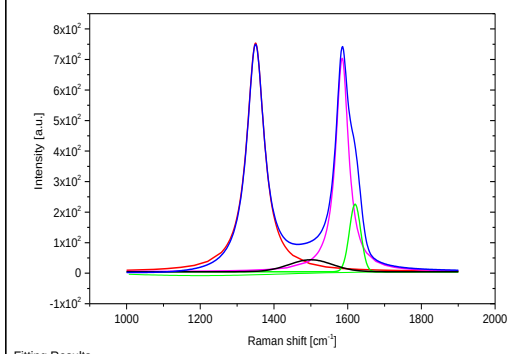


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	47954.45438	60.03607	525.89	1350	35.77942
2	Lorentz	56947.95829	43.09172	867.24977	1586	42.48958
3	Gaussian	7642.11348	40.27722	178.24681	1620	5.70188
4	Gaussian	10220.46384	373.2517	25.77443	1200	7.62562
5	Gaussian	11263.05876	182.7897	57.88586	1500	8.40351

fMWCNT electrochemical modified at 1.2 V with 4-APPA

BaseLine:Straight
Chi^2=5.81709E+001 Adj. R-Square=9.98431E-001 # of Data Points=900
SS=5.17139E+004 Degree of Freedom=889

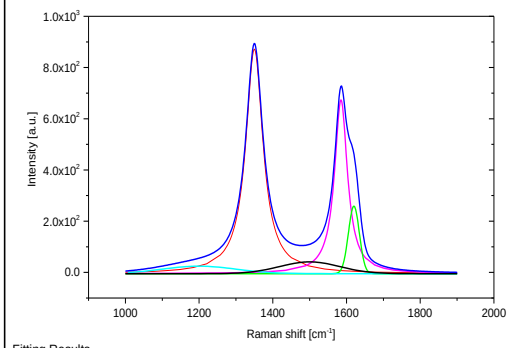


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	63533.47299	56.39653	748.54693	1350	54.46293
2	Lorentz	44009.91468	41.42506	698.81667	1585	37.72671
3	Gaussian	8533.84849	36.31252	220.77828	1620	7.31549
4	Gaussian	5733.86276	137.59776	39.14747	1500	4.91525

fMWCNT electrochemical modified at 1.4 V with 4-APPA

BaseLine:Straight
Chi^2=1.10655E+002 Adj. R-Square=9.97541E-001 # of Data Points=900
SS=9.83725E+004 Degree of Freedom=889

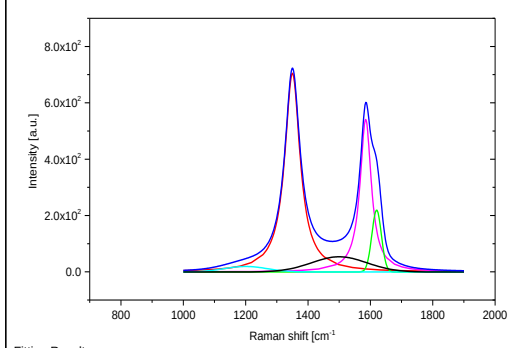


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	73513.31258	55.71017	876.33472	1350	51.37654
2	Lorentz	43333.87632	42.06191	678.00955	1585	30.28492
3	Gaussian	9758.88397	34.81523	263.32899	1620	6.82023
4	Gaussian	7132.67949	234.39926	29.23925	1200	4.98484
5	Gaussian	9348.5574	190.7956	46.03034	1500	6.53346

MWCNT electrochemical modified at 1.6 V with 4-APPA

BaseLine:Straight
Chi^2=1.25182E+002 Adj. R-Square=9.95967E-001 # of Data Points=900
SS=1.11286E+005 Degree of Freedom=889

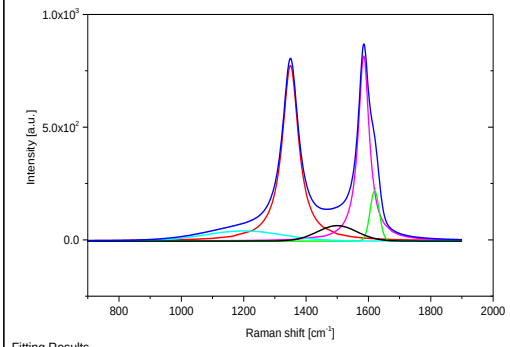


Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	62026.75257	58.57395	704.81424	1350	51.12876
2	Lorentz	35482.2222	43.20169	541.0082	1585	29.24806
3	Gaussian	8366.68443	35.84605	219.27036	1620	6.89667
4	Gaussian	3407.92233	163.1223	19.665	1200	2.80916
5	Gaussian	12031.2277	209.1138	54.0501	1500	9.91736

fMWCNT electrochemical modified at 1.8 V with 4-APPA

BaseLine:Straight
Chi^2=8.20076E+001 Adj. R-Square=9.97911E-001 # of Data Points=1245
SS=1.01197E+005 Degree of Freedom=1234



Fitting Results

Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP
1	Lorentz	73283.65775	61.87021	779.02399	1350	45.90825
2	Lorentz	53215.43958	42.52274	820.26228	1585	33.3366
3	Gaussian	8190.5109	34.75492	221.39227	1620	5.13091
4	Gaussian	14098.50843	295.00055	44.89739	1200	8.83195
5	Gaussian	10842.5763	149.3363	68.20793	1500	6.79229

Figure S7. Deconvolution of Raman spectra for fMWCNT electrochemically modified with 4-APPA at different positive potentials in the D and G region.