

Supplementary Information for “Adsorption of Pb(II) on O₂ Plasma Oxidized Multi-Walled Carbon Nanotubes: Thermodynamics, Kinetics, and Desorption”

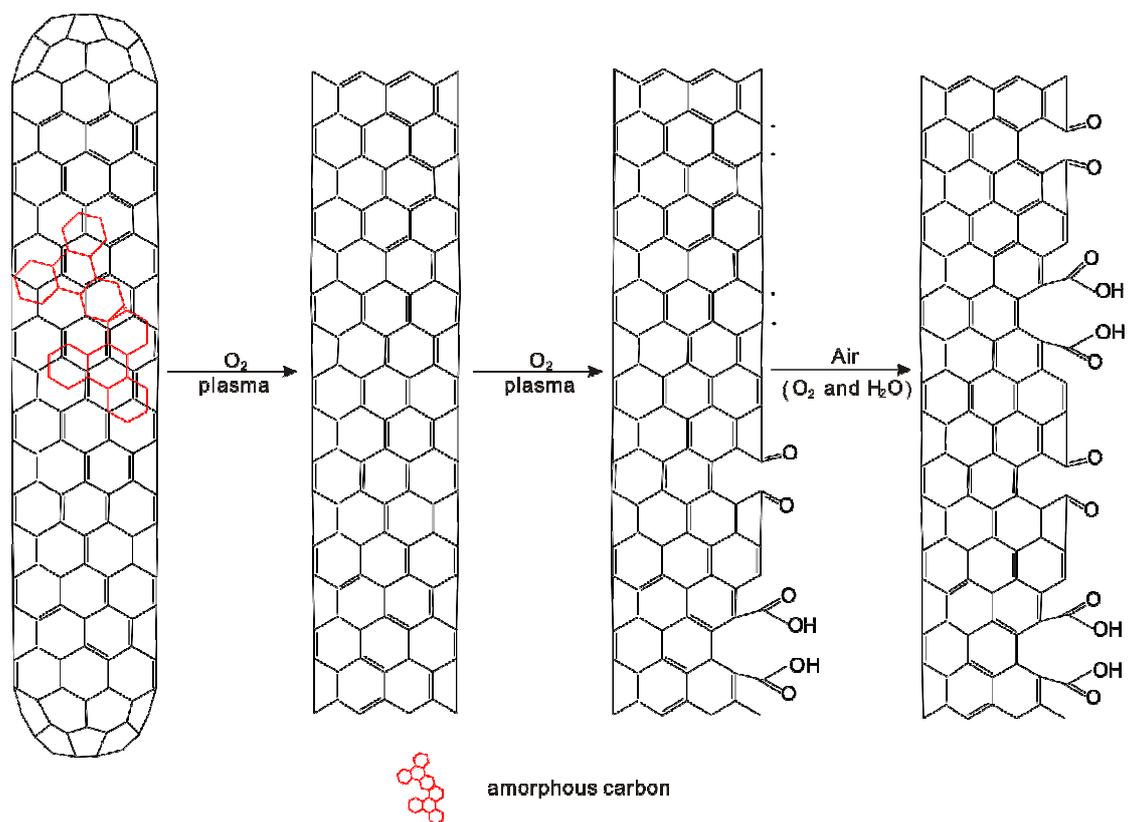


Fig. S1. Possible mechanism of MWCNTs oxidized by O₂ plasma

Table S1 The specific surface area and pore structure parameters of raw-MWCNTs and po-MWCNTs (oxidation time t=30 min)

Sample	S_{BET} (m^2/g)	S_{mi} (m^2/g)	S_{e} (m^2/g)	V_{t} (cm^3/g)	V_{mi} (cm^3/g)	W_{p} (nm)
raw-MWCNTs	126.9179	7.2017	119.7162	0.4559	0.0039	14.3676
po-MWCNTs	151.8988	4.3157	147.5831	0.4263	0.0020	11.2252

Table S2 The results of XPS and Raman spectroscopy of raw-MWCNTs and po-MWCNTs oxidized with different plasma oxidation time

Sample	XPS						Raman ($I_{\text{D}}/I_{\text{G}}$)
	C (%)	O (%)	sp^2 (%)	sp^3 (%)	C=O (%)	O-C=O (%)	
raw-MWCNTs	99.06	0.94	69.81	25.69	—	4.50	0.9774
3 min	93.18	6.82	46.77	24.89	16.34	12.00	0.9471
10 min	90.56	9.44	44.19	23.91	19.27	12.63	0.9643
30 min	88.43	11.57	41.29	20.25	23.42	15.04	1.0895

Table S3 Pseudo second-order kinetic parameters for the adsorption of Pb(II) onto raw-MWCNTs, po-MWCNTs and coconut shell AC at various initial Pb(II) concentrations

Initial concentration of Pb(II)		9 (mg/L)			17 (mg/L)		
adsorbent types		raw-MWCNTs	po-MWCNTs	AC	raw-MWCNTs	po-MWCNTs	AC
Pseudo second-order model	k_2 (g/mg/min)	0.2657±0.0128	1.6033±0.0802	0.0068±0.0003	0.1443±0.0071	1.4738±0.0707	0.0012±0.0001
	$q_{\text{e,exp}}$ (mg/g)	1.8060±0.0871	6.0396±0.3021	6.2584±0.2941	2.0517±0.1009	10.5317±0.5055	11.2045±0.5490
	$q_{\text{e,cal}}$ (mg/g)	1.8120±0.0873	6.0306±0.3017	6.3796±0.3197	2.0653±0.1016	10.5641±0.5071	11.5022±0.5762
	R^2	0.9999	1.0000	0.9997	0.9997	1.0000	0.9923

Table S4 Parameters of the Langmuir and Freundlich models for adsorption of Pb(II) onto raw-MWCNTs and po-MWCNTs at various temperatures

Sample	T (K)	Langmuir			Freundlich		
		q_m (mg/g)	K_L	R^2	n	K_F	R^2
raw-MWCNTs	293	4.32±0.21	0.0500±0.0001	0.9805	3.33±<0.01	0.8793±0.0440	0.9676
	308	7.96±0.37	0.0948±<0.0001	0.9968	3.89±<0.01	2.2517±0.1128	0.9678
	323	9.79±0.46	0.1667±<0.0001	0.9982	5.06±<0.01	3.8315±0.1920	0.9504
po-MWCNTs	293	35.08±1.69	0.0818±<0.0001	0.9757	2.43±<0.01	5.4224±0.2717	0.9630
	308	41.02±1.97	0.2220±<0.0001	0.9923	3.08±<0.01	10.7760±0.5402	0.9789
	323	54.11±2.67	0.3857±0.0001	0.9976	2.82±<0.01	15.1811±0.4112	0.9077

Table S5 Thermodynamic parameters for Pb(II) adsorption onto raw-MWCNTs and po-MWCNTs

Sample	T (k)	Thermodynamic constant			
		K_0	ΔG^0 (J/mol)	ΔH^0 (J/mol)	ΔS^0 (J/mol)
raw-MWCNTs	293	6.55±0.05	-4578.26±18.60	10864.17	52.70±0.06
	308	8.26±0.05	-5407.92±15.50	10864.17	52.83±0.05
	323	9.90±0.05	-6158.04±13.56	10864.17	52.70±0.04
po-MWCNTs	293	8.77±0.05	-5290.05±27.77	5966.05	38.42±0.09
	308	10.58±0.05	-6040.34±12.10	5966.05	38.98±0.04
	323	10.99±0.05	-6436.52±12.22	5966.05	38.40±0.04