SUPPLEMENTARY MATERIAL

Investigation of MnO_2 nanoparticles anchored 3D-Graphene Foam Composites (3DGF-MnO_2) as an adsorbent for strontium adsorption using Central Composite Design (CCD) method

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Table S1. Experimental parameters and their levels in CCD.

Parameters	Codes	Coded level of parameters				
		-α (-2)	**-1**	**0**	**+1**	**+α (+2)**
pH	X_1	2	4	6	8	10
Initial Sr^{+2} concentration (mg/mL)	X_2	10	45	80	115	150
Shaking time (min.)	X_3	10	30	50	70	90
Solid (3D-MGF)/liquid (mg/mL)	X_4	0.4	0.8	1.2	1.6	2

Table S2. CCD matrix with coded factors and their results.

Coded Factors					Responses, qe(mg/g)	
Run	**X_1**	**X_2**	**X_3**	**X_4**	**Experimental Responses**	**Predicted Responses**
1	4	115	70	0.8	23.71	22.71
2	6	80	90	1.2	16.84	16.36
3	4	115	30	0.8	22.77	21.79
4	6	80	50	1.2	15.76	17.59
5	8	115	70	1.6	18.36	19.32
6	6	10	50	1.2	6.41	6.73
7	4	45	70	1.6	10.35	9.32
8	6	80	50	1.2	17.42	17.59
9	8	45	70	0.8	18.58	19.12
10	6	80	50	1.2	15.39	17.59
11	8	45	70	1.6	11.98	12.58
12	8	115	70	0.8	28.90	29.55
13	6	80	50	1.2	20.17	17.59
14	4	45	70	1.6	10.62	10.62
15	6	80	50	0.4	28.73	30.01
16	8	45	30	0.8	22.81	23.25
17	8	115	30	0.8	32.72	32.57
18	4	115	70	1.6	17.46	16.63
19	8	115	30	1.6	20.73	21.34
20	4	45	30	0.8	15.32	13.71
21	10	80	50	1.2	28.54	25.78
22	6	80	50	1.2	18.63	17.59
23	2	80	50	1.2	9.75	13.05
24	8	45	30	1.6	14.35	15.21
25	4	45	70	0.8	14.51	13.51
26	6	80	50	2.0	16.65	15.90
27	6	80	10	1.2	17.08	18.09
28	4	115	30	1.6	14.90	14.21
29	6	150	50	1.2	21.85	22.05
30	6	80	50	1.2	18.17	17.59

Table S3. ANOVA (analysis of variance) results.

ANOVA

	df	*SS*	*MS*	*F-value*	*P-value*
Regression	14	1024.65	73.19	21.6	< 0.0001
Residual	15	50.67	3.38		
Total	29	1075.28			

Table S4. Results of Student's t-test.

	Coefficients	*Standart Error*	*P-value*
Intercept	**17.59**	**0.75**	**< 0.0001**
x1	**3.18**	**0.38**	**< 0.0001**
x2	**3.83**	**0.38**	**< 0.0001**
x3	-0.43	0.38	0.2695
x4	**-3.53**	**0.38**	**< 0.0001**
x1x2	0.31	0.46	0.5118
x1x3	**-0.98**	**0.46**	**0.0491**
x1x4	-0.91	0.46	0.0655
x2x3	0.28	0.46	0.5536
x2x4	-0.80	0.46	0.1033
x3x4	0.38	0.46	0.4271
x1x1	0.46	0.35	0.2136
x2x2	**-0.80**	**0.35**	**0.0379**
x3x3	-0.09	0.35	0.7988
x4x4	**1.34**	**0.35**	**0.017**

Table S5. Optimum points for adsorption parameters

Parameters	
pH	6.5
Concentration (mg/L)	142
Shaking time (min.)	16
Solid (3D-MGF)/liquid ratio (mg/mL)	0.5

Table S6. Parameters of Langmuir and Freundlich isotherms for strontium ions sorption on 3D-MGF.

Model	**Parameters**	
Langmuir	q_{max} ($mg.g^{-1}$)	47.39
	b ($L.mg^{-1}$)	0.03
	R^2	0.95
Freundlich	K	18.79
	n	7.65
	R^2	0.99

Table S7 Parameters of D-R isotherm for strontium ions sorption on 3D-MGF.

D-R		
C_m (mol.g^{-1})	**K (mol^2 kJ^{-2})**	**R^2**
0.02	-0.01	1.000

Table S8 Thermodynamic parameters of strontium ions sorption on 3D-MGF.

			ΔG^o (kJ.mol^{-1})				
	ΔH^o (kJ.mol^{-1})	**ΔS^o (kJ.mol^{-1}K^{-1})**	293 K	303 K	313 K	323 K	333 K
3D-MGF	-20.08	0.02	-26.60	-26.82	-27.04	-27.26	-27.48

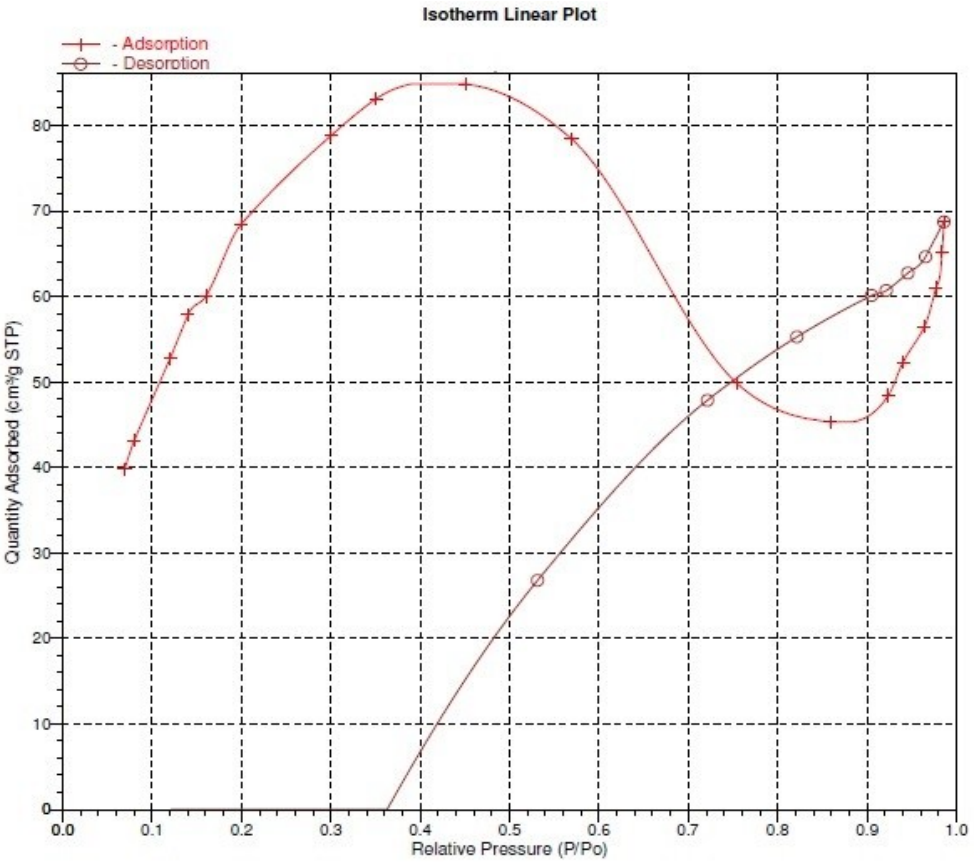

Figure S1. N_2 adsorption/desorption curves for 3DGF

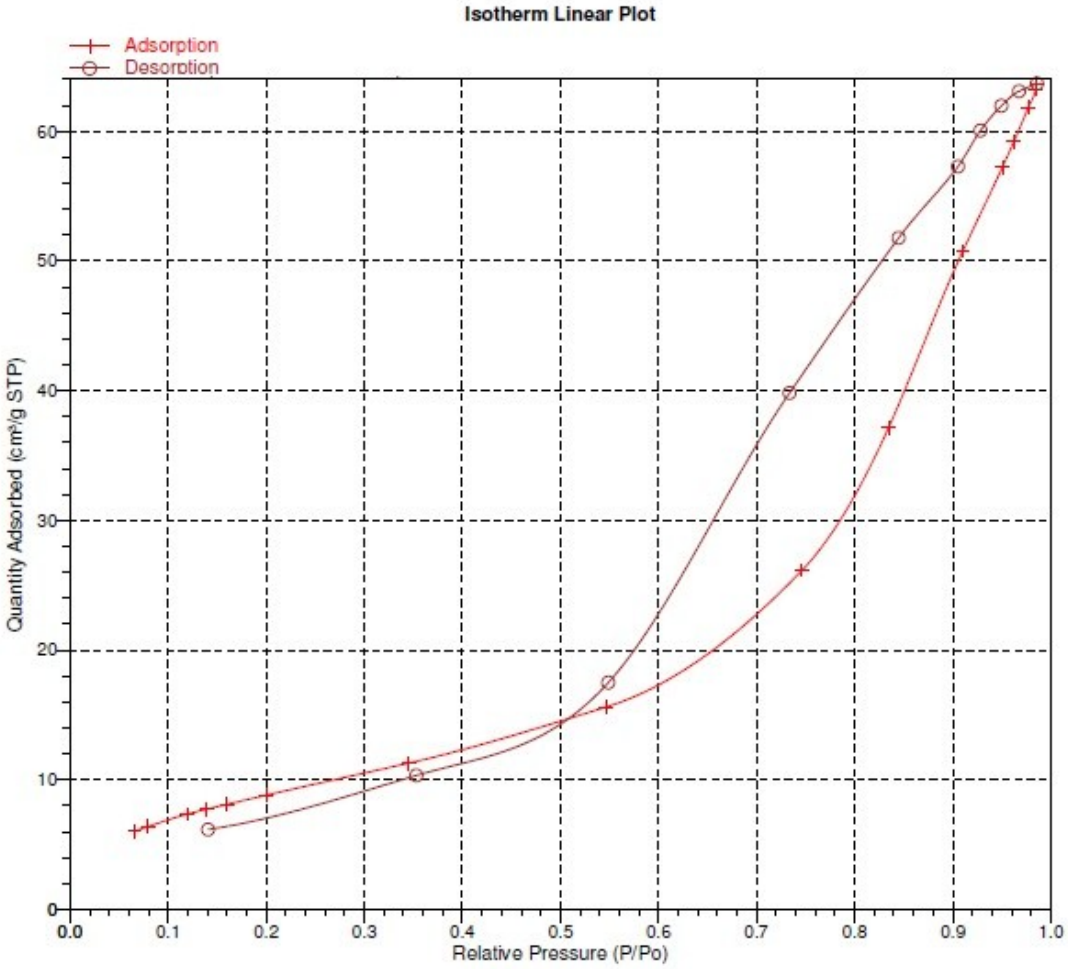

Figure S2. N_2 adsorption/desorption curves for 3DGF-MnO_2