Supporting Information

Investigating kinetics and adsorption isotherm study for fluoride removal from aqueous solution by mesoporous Cerium-Aluminum Binary Oxide Nanomaterials

Rumman Zaidi, *a Saif Ullah Khan, b I. H. Farooqi, b and Ameer Azam a

^aDepartment of Applied Physics, Z.H. College of Engineering & Technology, Aligarh Muslim University, Aligarh-202002, India

^bEnvironmental Engineering Section, Department of Civil Engineering, Z.H. College of Engineering & Technology, Aligarh Muslim University, Aligarh-202002, India

Table 1s. Pseudo-first order Kinetics parameters for the sorption of fluoride ions onto Ce-Al (1:3) binary oxide nanoadsorbent

Kinetic models	Dosage of Ce-Al Binary oxides nanoparticles												
		0.1	g/l			0.5	g/l		1 g/l				
Pseudo-first order													
Linear Fitting	Initial concentrations (mg/l)												
	10	15	25	35	10	15	25	35	10	15	25	35	
q _e exp (mg/g)	68.9	99.9	159	197.9	15.4	24.2	42.22	60.42	9.43	13.58	23.36	32.9	
q _e cal (mg/g)	52.50	68.98	137.61	119.7 9	11.12	12.38	18.33	49.73	1.35	9.35	13.03	21.17	
K ₁ (g/mg/hour)	0.4454	0.7277	0.8756	2.663 1	0.4454	0.7277	0.8756	2.663	2.3934	2.478	0.6441	0.6932	
R ²	0.7735	0.9491	0.9621	0.901 5	0.6257	0.5714	0.5714	0.9947	0.9687	0.9962	0.5626	0.996	
Non-linear													
Best-fit													
q _e exp	68.9	99.9	159	197.9	15.4	24.2	42.22	60.42	9.43	13.58	23.36	32.9	
(mg/g) q _e cal	67.75	89.55	147	188.6	14.76	24.61	42.61	60.27	9.3025	13.445	23.297	32.472	
(mg/g) K ₁	0.8202	0.5940	0.9500	3.992	0.6051	0.8745	0.9874	5.214	1.3011	0.7745	0.1474	0.2428	
(g/mg/hour)				1									
Std. Error													
q _e cal (mg/g)	0.4734	4.6652	6.1028	5.591 1	0.2137	0.3892 3	0.275	0.09	0.0763	0.1008	0.0862	0.1782	
K ₁ (g/mg/hour)	0.5478	0.8579	0.1478	0.254 1	0.5478	1.2478	1.3697	0.4732	0.5247	0.3698	0.1245	0.7894	
95% Confidence Intervals													
q _e cal	66.2432	74.7032	127.577	170.8565	14.07992	23.371	41.7398	59.9835	9.0596	13.1239	23.023	31.9052	
(mg/g)	3 to 69.2567	3 to 104.396	95 to 166.422	to 206.4435	to 15.44008	3 to 25.848	3 to 43.4901	8 to 60.5564	5 to 9.5453	8 to 13.7660	to 23.572	3 to 33.0397	
	7	77	05			7	7	2	5	2		7	
K1	0.34789	0.45789	0.45217	0.87415	0.51478	0.4254	0.52173	3.21478	0.5678	0.25789	0.11457	0.14777	
(g/mg/hour)	to 0.97652	to 0.78596	to 0.84521	to 3.45781	to 1.52778	1 to 1.6987 4	to 2.64712	to 7.47851	1 to 6.1457 8	to 3.12479	to 0.97546	to 0.74691	
Goodness of Fit									0				
Degrees of Freedom	3	3	3	3	3	3	3	3	3	3	3	3	
R ²	0.9990	0.9478	0.9664	0.9826	0.9958	0.9950	0.9991	0.9999	0.9986	0.9988	0.9997	0.9994	
Residual Sum of	2.69	261.17	446.94	375.13	0.548	1.818	0.9075	0.0972	0.0698	0.1221	0.0892	0.3812	
Squares													
Sy.x	0.9469	9.3304	12.2057	11.1822	0.4274	0.7784	0.55	0.18	0.1526	0.2017	0.1725	0.3565	
Number of	5	5	5	5	5	5	5	5	5	5	5	5	
points analvzed													

Table 2s. Pseudo-second order Kinetics parameters for the sorption of fluoride ions onto Ce-Al (1:3) binary oxide nanoadsorbent

Kinetic models	Dosage of Ce-Al Binary oxides nanoparticles											
		C).1 g/l			0.	.5 g/l		1 g/l			
Pseudo- Second Order												
Linear Fitting					Initi	al concentra	tions (mg/l)					
	10	15	25	35	10	15	25	35	10	15	25	35
q _e exp (mg/g)	68.9	99.9	159	197.9	15.4	24.2	42.22	60.42	9.43	13.58	23.36	32.9
q _e cal (mg/g)	69.44	104.1	163.9	204.0	15.57	24.21	42.19	60.60	9.48	13.64	23.36	33.11
K ₂ (g/mg/hour)	0.5184	0.0485	0.0465	0.0300	4.896	1.312	1.404	3.025	5.049	5.372	1.831	1.302
R ²	1	0.9995	0.9999	0.9998	0.9991	0.9999	0.9998	1	1	1	1	1
Non-linear model					·							
a exp (mg/g)	68.9	99.9	159	197 9	15.4	24.2	42.22	60.42	9.43	13 58	23 36	32.9
Ye CAP (116/6/	00.5	55.5	155	157.5	15.4	24.2	72.22	00.42	5.45	13.50	25.50	52.5
q _e cal (mg/g)	69.92	99.99	160.25	198.16	15.50	25.39	43.01	60.67	9.65	13.89	23.52	33.28
K ₂	0.40167	0.02415	0.02162	0.02106	1.15667	1.108	0.29122	0.20666	2.4509	1.9565	1.8584	1.0806
(g/mg/hour)												
Std. Error												
q _e cal (mg/g)	0.32291	2.16266	4.70601	4.51167	0.45979	1.04311	0.74891	0.04547	0.04637	0.10272	0.20072	0.11796
K_2	0.05848	0.00235	0.00361	0.00475	0.71988	1.43724	4.17567	0.23375	0.31704	0.44251	3.1799	0.15208
(g/mg/nour) 95%												
Confidence												
g cal (mg/g)	68.8964	910.3383	155.2744	192.8047 to	14.03688	22.0786	40.62265	60.53242	9.5089	13.5638	22.8907	32.9114
	3 to	to	2 to	231.52099	to	2 to	to	to	to	9 to	1 to	7 to
	70.9516	124.1034	195.2276		16.96342	28.7178	45.38941	60.82183	9.80402	14.2177	24.1682	33.6622
	9		6			8				2	8	6
K_2	0.2155	0.01668t	0.0101 to	0.01193 to	0.1343 to	0.46594	1.9976 to	0.4627 to	1.44199	0.5482	2.26143	0.5966
(g/mg/nour)	0 58778	0 03162	0.0331	0.0422	3.44704	ιυ 5 6819	15.5800	2.95054	3 45993	3 36481	13 9782	1 56468
	0.50770	0.03102				5.0015			3.13333	5.50 101	9	1.50100
Goodness of Fit					1							
Degrees of Freedom	3	3	3	3	3	3	3	3	3	3	3	3
R ²	0.9999	0.9995	0.9988	0.9991	0.9979	0.9959	0.9993	1	0.9999	0.9999	0.9998	0.9999
Residual Sum of Squares	0.14094	2.67027	16.1114	18.6471	0.26887	1.4710	0.81987	0.00305	0.00285	0.01421	0.05874	0.01926
Sy.x	0.21675	0.94345	2.31743	2.49314	0.29937	0.7002	0.52277	0.03187	0.03081	0.06883	0.13992	0.08013
Number of points	5	5	5	5	5	5	5	5	5	5	5	5
analyzed												

Kinetic models	Dosage of Ce-Al Binary oxides nanoparticles											
		0.	1 g/l		0.5 g/l				1 g/l			
Intra-particle												
diffusion												
Initial concentrations (mg/l)												
	10	15	25	35	10	15	25	35	10	15	25	35
Kid	1.26	4.27	5.30	8.90	0.1679	0.2315	0.2544	0.285	0.2466	0.2897	0.3395	0.6325
(mg/g/hour ^{0.5})												
C (mg/g)	10.67	18.80	25.01	27.55	13.905	24.314	42.584	59.905	8.9868	13.074	23.223	31.663
R ²	0.7794	0.8712	0.8476	0.8151	0.7677	0.8278	0.9006	0.7882	0.8207	0.8481	0.9255	0.9896

Table 3s. Weber–Morris intraparticle diffusion kinetic parameters for the sorption of fluoride ions onto Ce-Al (1:3) binary oxide nanoadsorbent