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APPENDICES

Table A1 Adsorption isotherm of CTAB on clinoptilolite at 30°C

Weight of clinoptilolite = 0.2 g

Volume of CTAB solution = 20 ml

Molecular weight of CTAB = 364.46 g/mol

No.	$[CTAB]_{initial}$ (µmol/L)	$[CTAB]_{equilibrium}$ (µmol/L)	Amount of surfactant adsorbed (µmol/g)
1	92.58	15.42	7.72
2	293.50	21.46	27.20
3	414.75	55.22	35.95
4	501.56	106.38	39.52
5	502.00	122.47	37.95
6	539.99	132.46	40.75
7	555.06	137.98	41.71
8	558.86	139.86	41.90
9	580.31	160.72	41.96
10	611.91	168.96	44.30
11	913.68	348.99	56.47
12	1502.10	805.85	69.62
13	1977.83	1268.88	70.90
14	2990.16	2277.85	71.23
15	3975.73	3223.20	75.25
16	6022.95	5287.83	73.51

Table A2 Zeta-Potential data for CTAB adsorption on clinoptilolite

No.	Amount of surfactant adsorbed (μmol/g)	Zeta potentail (mV)										S.D.
		1st	2nd	3rd	4th	5th	6th	7th	8th	10th	Average	
1	7.7	-68.7	-60.9	-60.7	-70.3	-71.5	-65.5	-59.2	-54.2	-61.3	-57.2	5.8
2	27.2	-68.7	-50.8	-68.4	-54.9	-69.5	-51.4	-67.0	-64.4	-61.1	-55.6	7.6
3	36.0	-28.7	-28.2	-30.6	-29.5	-41.8	-29.8	-29.6	-40.5	-40.5	-29.9	5.8
4	39.5	11.0	-9.3	-10.7	-7.5	-9.1	-8.9	-7.9	-9.2	-7.9	-5.9	6.7
5	38.0	1.2	-7.5	-7.6	-5.5	-8.8	-10.1	-14.0	3.1	-5.3	-5.4	5.3
6	40.8	-3.4	-7.2	-7.0	-7.4	-8.0	-5.3	-5.4	-6.9	-5.4	-5.6	1.4
7	41.7	-3.6	-2.1	-4.9	3.0	1.0	-4.0	2.4	-3.0	-1.2	-1.2	2.9
8	41.9	2.7	-2.7	3.1	16.3	5.6	7.9	6.8	8.0	9.0	5.7	5.2
9	42.0	10.9	13.7	12.7	-2.4	-1.4	11.6	-1.0	12.1	13.0	6.9	7.0
10	44.3	18.0	10.5	16.1	11.2	9.8	11.8	21.2	22.5	8.2	12.9	5.2
11	56.5	49.0	39.0	42.7	39.9	45.7	39.1	54.3	38.1	40.7	38.8	5.5
12	69.6	45.0	51.6	54.3	62.4	46.0	43.6	43.9	54.0	58.6	45.9	6.8
13	70.9	52.0	49.6	45.0	47.3	55.9	56.6	49.5	58.1	46.6	46.1	4.7
14	71.2	62.7	51.2	69.6	71.5	73.0	62.1	50.9	59.3	65.0	56.5	8.1
15	75.3	56.0	62.4	60.7	72.3	64.8	64.5	63.0	64.3	75.1	58.3	5.8
16	73.5	54.6	69.3	64.3	77.7	66.8	73.3	80.8	77.4	59.2	62.3	8.9

Table A3 Dynamic adsorption of DOWFAX 8390 on CTAB-modified clinoptilolite at 30°C

Weight of clinoptilolite = 0.2 g

Volume of DOWFAX 8390 solution = 20 ml

Molecular weight of DOWFAX 8390 = 642 g/mol (36% of active gradient)

Initial concentration of DOWFAX 8390 = 5582.371 μmol/L

Equilibrium time (days)	[DOWFAX8390] equilibrium(μmol/L)	Amount of surfactant adsorbed (μmol/g)	S.D.
1	5214.864	36.751	5.479
2	4982.653	59.972	15.696
3	4974.939	60.743	8.332
4	4951.841	63.053	0.652
6	4906.355	67.6016	0.622

Table A4 Dynamic adsorption of DOWFAX 2A1 on CTAB-modified clinoptilolite at 30°C

Weight of clinoptilolite = 0.2 g

Volume of DOWFAX 2A1 solution = 20 ml

Molecular weight of DOWFAX 2A1 = 576 g/mol (46% of active gradient)

Initial concentration of DOWFAX 2A1 = 5571.605 μmol/L

Equilibrium time (days)	[DOWFAX 2A1] equilibrium(μmol/L)	Amount of surfactant adsorbed (μmol/g)	S.D.
1	5109.671	46.193	0.241
2	5097.529	47.408	5.133
3	5077.273	49.433	6.149
4	5150.703	42.090	1.189
6	5143.455	42.815	1.089

Table A5 Dynamic adsorption of SDBS on CTAB-modified clinoptilolite at 30°C

Weight of clinoptilolite = 0.2 g

Volume of DOWFAX 2A1 solution = 20 ml

Molecular weight of DOWFAX 2A1 = 348.48 g/mol (46% of active gradient)

Initial concentration of DOWFAX 2A1 = 5534.567μmol/L

Equilibrium time (days)	[SDBS]equilibrium (μmol/L)	Amount of surfactant adsorbed (μmol/g)	S.D.
1	5334.619	19.995	0.619
2	5332.935	20.163	1.269
3	4973.33	56.124	1.267
4	4973.875	56.069	0.674
6	4955.675	57.889	0.606

Table A6 Adsorption isotherm of cadmium on clinoptilolite in single-metal system

Weight of clinoptilolite = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.1813	0.0073	0.0174	0.0012
2	0.5031	0.0216	0.0482	0.0027
3	1.3845	0.0908	0.1294	0.0019
4	1.9394	0.1610	0.1778	0.0066
5	2.3461	0.3015	0.2045	0.0029
6	2.7806	0.5059	0.2275	0.0106
7	3.1382	0.8119	0.2326	0.0068
8	3.4314	0.9705	0.2461	0.0213
9	4.1360	1.5729	0.2563	0.0182

Table A7 Adsorption isotherm of cadmium on SMZ-DOWFAX 8390 in single-metal system

Weight of SMZ = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.1239	0.0056	0.0118	0.0001
2	0.4722	0.0221	0.0450	0.0002
3	1.2033	0.0817	0.1122	0.0001
4	1.9781	0.2013	0.1777	0.0015
5	2.5104	0.3216	0.2189	0.0016
6	2.9145	0.5421	0.2372	0.0017
7	3.1050	0.7139	0.2391	0.0036
8	3.4285	0.8662	0.2562	0.0019
9	4.2380	1.4326	0.2805	0.0017

Table A8 Adsorption isotherm of cadmium on SMZ-DOWFAX 2A1 in single-metal system

Weight of SMZ = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.2447	0.0054	0.0239	0.0019
2	0.7343	0.0212	0.0713	0.0015
3	1.2922	0.0515	0.1241	0.0018
4	2.0482	0.1328	0.1915	0.0014
5	2.3182	0.2361	0.2082	0.00012
6	2.8976	0.5601	0.2337	0.0001
7	3.3326	0.8258	0.2507	0.0026
8	3.4990	1.0587	0.2440	0.0014
9	4.0537	1.5829	0.2471	0.0019

Table A9 Adsorption isotherm of cadmium on SMZ-SDBS in single-metal system

Weight of SMZ = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.1549	0.0047	0.0150	0.0015
2	0.4251	0.0211	0.0404	0.0012
3	1.2129	0.0938	0.1119	0.0002
4	2.0438	0.2174	0.1826	0.0019
5	2.3433	0.3015	0.2042	0.0013
6	2.6728	0.3855	0.2287	0.0002
7	3.2770	0.7699	0.2507	0.0015
8	3.5876	0.9946	0.2593	0.0031
9	4.0685	1.4727	0.2596	0.0001

Table A10 Adsorption isotherm of lead on clinoptilolite in single-metal system

Weight of clinoptilolite = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.3021	0.0021	0.0300	0.0032
2	0.4461	0.0031	0.0443	0.0033
3	0.8576	0.0056	0.0852	0.0025
4	1.0301	0.0081	0.1022	0.0014
5	1.3389	0.0119	0.1327	0.0034
6	1.4295	0.0125	0.1417	0.0015
7	1.4295	0.0125	0.1417	0.0026
8	1.4883	0.0133	0.1475	0.0014
9	1.5641	0.0141	0.1550	0.0049
10	1.6999	0.0159	0.1684	0.0018
11	1.7488	0.0168	0.1732	0.0049
12	2.5168	0.0308	0.2486	0.0015
13	3.2106	0.0526	0.3158	0.0011

Table A11 Adsorption isotherm of lead on SMZ-DOWFAX 8390 in single-metal system

Weight of SMZ = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.3326	0.0006	0.0332	0.0031
2	0.4698	0.0008	0.0469	0.0022
3	0.5037	0.0007	0.0503	0.0018
4	0.7555	0.0015	0.0754	0.0013
5	0.7844	0.0014	0.0783	0.0021
6	0.9371	0.0021	0.0935	0.0001
7	1.4805	0.0055	0.1475	0.0001
8	1.5059	0.0049	0.1501	0.0001
9	1.9447	0.0097	0.1935	0.0001
10	2.2875	0.0125	0.2275	0.0002
11	2.4137	0.0267	0.2387	0.0031
12	2.6222 ·	0.0562	0.2566	0.0035
13	2.7451	0.1001	0.2645	0.0012

Table A12 Adsorption isotherm of lead on SMZ-DOWFAX 2A1 in single-metal system

Weight of SMZ = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.2061	0.0001	0.0206	0.0034
2	0.2161	0.0001	0.0216	0.0035
3	0.3973	0.0003	0.0397	0.0014
4	0.5514	0.0004	0.0551	0.0024
5	0.6836	0.0006	0.0683	0.0032
6	0.9990	0.0010	0.0998	0.0046
7	1.7889	0.0039	0.1785	0.0034
8	1.8148	0.0028	0.1812	0.0015
9	2.1899	0.0119	0.2178	0.0025
10	2.1998	0.0098	0.2190	0.0023
11	2.3163	0.0223	0.2294	0.0034
12	2.4222	0.0492	0.2373	0.0034
13	2.5011	0.0951	0.2406	0.0015

Table A13 Adsorption isotherm of lead on SMZ-SDBS in single-metal system

Weight of SMZ = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.2761	0.0001	0.0276	0.0029
2	0.2761	0.0001	0.0276	0.0022
3	0.5873	0.0003	0.0587	0.0011
4	0.8286	0.0006	0.0828	0.0540
5	0.8286	0.0006	0.0828	0.0018
6	1.1668	0.0008	0.1166	0.0034
7	1.3844	0.0014	0.1383	0.0022
8	1.5438	0.0018	0.1542	0.0047
9	2.1366	0.0066	0.2130	0.0011
10	2.2456	0.0096	0.2236	0.0018
11	2.4135	0.0245	0.2389	0.0026
12	2.5019	0.0449	0.2457	0.0015
13	2.5672	0.0972	0.2470	0.0054

Table A14 Adsorption isotherm of cadmium on clinoptilolite in mixed-metal system

Weight of clinoptilolite = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.2262	0.0044	0.0222	0.0014
2	0.4422	0.0160	0.0426	0.0015
3	0.5064	0.0300	0.0476	0.0021
4	0.6797	0.0871	0.0593	0.0034
5	0.7324	0.0974	0.0635	0.0015
6	1.0402	0.4036	0.0637	0.0023
7	1.0697	0.4322	0.0637	0.0015
8	1.9273	1.2817	0.0646	0.0023
9	1.5312	0.8579	0.0673	0.0215

Table A15 Adsorption isotherm of cadmium on SMZ-DOWFAX 8390 in mixed-metal system

Weight of SMZ = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.2654	0.0060	0.0259	0.0011
2	0.4406	0.0094	0.0431	0.0026
3	0.5542	0.0304	0.0524	0.0012
4	0.7028	0.0808	0.0622	0.0067
5	1.0845	0.4007	0.0684	0.0074
6	1.0963	0.4121	0.0684	0.0002
7	1.8305	1.1355	0.0695	0.0205
8	0.8463	0.1449	0.0701	0.0046
9	1.5014	0.7504	0.0751	0.0051

Table A16 Adsorption isotherm of cadmium on SMZ-DOWFAX 2A1 in mixed-metal system

Weight of SMZ = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.4727	0.0036	0.0469	0.0011
2	0.5349	0.0161	0.0519	0.0027
3	1.3614	0.7878	0.0574	0.0047
4	0.6068	0.0253	0.0581	0.0020
5	1.7384	1.1535	0.0585	0.0109
6	0.6770	0.0842	0.0593	0.0062
7	1.0069	0.4108	0.0596	0.0059
8	1.0557	0.4440	0.0612	0.0085
9	0.7469	0.1208	0.0626	0.0032

Table A17 Adsorption isotherm of cadmium on SMZ-SDBS in mixed-metal system

Weight of SMZ = 0.2 g

Volume of cadmium solution = 20 ml

No.	$[Cd^{2+}]_{initial}$ (mM)	$[Cd^{2+}]_{equilibrium}$ (mM)	Amount of Cd^{2+} adsorbed (mmol/g)	S.D.
1	0.2343	0.0033	0.0231	0.0001
2	0.4649	0.0144	0.0450	0.0058
3	0.4717	0.0153	0.0456	0.0018
4	0.5113	0.0217	0.0490	0.0015
5	0.7133	0.1154	0.0598	0.0040
6	0.8135	0.2618	0.0552	0.0040
7	1.0787	0.4929	0.0586	0.0046
8	1.2318	0.6447	0.0587	0.0035
9	1.6089	1.0203	0.0589	0.0027

Table A18 Adsorption isotherm of lead on clinoptilolite in mixed-metal system

Weight of clinoptilolite = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.2058	0.0037	0.0202	0.0034
2	0.3927	0.0047	0.0388	0.0017
3	0.5586	0.0074	0.0551	0.0047
4	0.7302	0.0066	0.0724	0.0021
5	0.9107	0.0092	0.0902	0.0028
6	1.1405	0.0120	0.1128	0.0018
7	1.3556	0.0148	0.1341	0.0018
8	1.5392	0.0211	0.1518	0.0030
9	1.9148	0.0372	0.1878	0.0121
10	2.0393	0.0414	0.1998	0.0018
11	2.1592	0.0568	0.2102	0.0046
12	2.2521	0.0631	0.2189	0.0017

Table A19 Adsorption isotherm of lead on SMZ-DOWFAX 8390 in mixed-metal system

Weight of SMZ = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.2058	0.0018	0.0204	0.0033
2	0.3927	0.0020	0.0391	0.0017
3	0.5586	0.0028	0.0556	0.0048
4	0.7302	0.0036	0.0727	0.0022
5	0.9107	0.0054	0.0905	0.0026
6	1.1405	0.0103	0.1130	0.0018
7	1.3556	0.0116	0.1344	0.0018
8	1.5392	0.0188	0.1520	0.0030
9	1.9148	0.0377	0.1877	0.0120
10	1.9490	0.0423	0.1907	0.0026
11	2.0492	0.0557	0.1993	0.0015
12	2.0878	0.0625	0.2025	0.0034

Table A20 Adsorption isotherm of lead on SMZ-DOWFAX 2A1 in mixed-metal system

Weight of SMZ = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.2058	0.0007	0.0205	0.0033
2	0.3927	0.0018	0.0391	0.0017
3	0.5586	0.0021	0.0557	0.0049
4	0.7302	0.0034	0.0727	0.0019
5	0.9107	0.0045	0.0906	0.0026
6	1.1405	0.0075	0.1133	0.0016
7	1.3556	0.0122	0.1343	0.0016
8	1.5392	0.0188	0.1520	0.0030
9	1.9091	0.0458	0.1863	0.0026
10	1.9148	0.0395	0.1875	0.0116
11	1.9676	0.0568	0.1911	0.0005
12	2.0090	0.0618	0.1947	0.0015

Table A21 Adsorption isotherm of lead on SMZ-SDBS in mixed-metal system

Weight of SMZ = 0.2 g

Volume of lead solution = 20 ml

No.	$[Pb^{2+}]_{initial}$ (mM)	$[Pb^{2+}]_{equilibrium}$ (mM)	Amount of Pb^{2+} adsorbed (mmol/g)	S.D.
1	0.2295	0.0005	0.0229	0.0022
2	0.3803	0.0007	0.0380	0.0012
3	0.5931	0.0010	0.0592	0.0033
4	0.7150	0.0019	0.0713	0.0021
5	0.8918	0.0041	0.0888	0.0018
6	1.1289	0.0070	0.1122	0.0015
7	1.3685	0.0106	0.1358	0.0020
8	1.5623	0.0166	0.1546	0.0001
9	1.8748	0.0439	0.1831	0.0002
10	1.8966	0.0544	0.1842	0.0011
11	1.9330	0.0628	0.1870	0.0019
12	2.0002	0.0377	0.1962	0.0001

Table A22 Adsorption isotherm of toluene on clinoptilolite

Weight of clinoptilolite = 0.2 g

Volume of toluene solution = 20 ml

No.	$[\text{Toluene}]_{\text{initial}}$ (μM)	$[\text{Toluene}]_{\text{equilibrium}}$ (μM)	Amount of toluene adsorbed (μmol/g)	S.D.
1	730.82	662.08	6.87	1.248932
2	1603.43	1469.06	13.44	0.653421
3	2518.52	2309.26	20.93	2.083149
4	4768.91	4419.62	34.93	4.252484
5	5496.58	5013.88	48.27	2.249888

Table A23 Adsorption isotherm of toluene on SMZ-DOWFAX 8390

Weight of SMZ = 0.2 g

Volume of toluene solution = 20 ml

No.	$[\text{Toluene}]_{\text{initial}}$ (μM)	$[\text{Toluene}]_{\text{equilibrium}}$ (μM)	Amount of toluene adsorbed (μmol/g)	S.D.
1	594.95	483.08	11.19	1.837406
2	1445.01	1150.27	29.47	4.554528
3	2561.72	1964.83	59.69	5.687909
4	4550.96	3527.85	102.31	14.13783
5	5436.79	4328.70	110.81	4.353836

Table A24 Adsorption isotherm of toluene on SMZ-DOWFAX 2A1

Weight of SMZ = 0.2 g

Volume of toluene solution = 20 ml

No.	$[Toluene]_{initial}$ (μM)	$[Toluene]_{equilibrium}$ (μM)	Amount of toluene adsorbed (μmol/g)	S.D.
1	826.32	709.95	11.64	2.923568
2	1558.77	1310.23	24.85	6.13567
3	2917.25	2447.89	46.94	5.685081
4	4904.80	4009.50	89.53	8.349473
5	5220.08	4320.94	110.81	4.353836

Table A25 Adsorption isotherm of toluene on SMZ-SDBS

Weight of SMZ = 0.2 g

Volume of toluene solution = 20 ml

No.	$[Toluene]_{initial}$ (μM)	$[Toluene]_{equilibrium}$ (μM)	Amount of toluene adsorbed (μmol/g)	S.D.
1	688.94	618.44	7.05	1.428887
2	1597.05	1441.04	15.60	3.592674
3	2477.56	2220.27	25.73	3.273298
4	4875.32	4437.98	43.73	1.535213
5	5306.23	4769.52	53.67	4.823618

Sample of calculation

Surfactant Adsorption Isotherms

Surfactant adsorption isotherm was constructed by plotting the amount of surfactant adsorbed per gram of clinoptilolite (μmol/g) versus equilibrium concentration of surfactant (μM).

1. To convert the amount of carbon from TOC (ppm) to initial and equilibrium concentration of CTAB (μM)

   Equation from TOC: Y = 4.1797*X

   X = the amount of carbon from TOC (ppm) = 32.053 ppm

   Y = the concentration of CTAB (μM) = 4.1797× 32.053

   = 133.9803 μM

2. Finding CTAB adsorbed concentration (μM)

   $[CTAB]_{Adsorbed}$ = $[CTAB]_{Initial}$-$[CTAB]_{Equilibrium}$

   $[CTAB]_{Initial}$ = 555.06 μM

   $[CTAB]_{Equilibrium}$ = 133.9803 μM

   $[CTAB]_{Adsorbed}$ = 555.06-133.9803 = 421.0797 μM

3. To convert adsorption concentration to moles of adsorption

   $$\text{Mole} = \frac{\text{Concentration}\times\text{Volume}}{1000}$$

   $$\text{Adsorbed } (\mu\text{mol}) = \frac{(\text{Adsorbed } (\mu\text{M}))\times\text{Volume of solution}}{1000}$$

   $$\text{Adsorbed } (\mu\text{mol}) = \frac{421.0797\times 20}{1000} = 8.4216\ \mu\text{mol}$$

4. Finding CTAB adsorbed per gram of clinoptilolite

   $$\text{CTAB adsorbed } (\mu\text{mol/g of clinoptilolite}) = \frac{\text{Adsorbed } (\mu\text{mol})}{\text{the amount of clinoptilolite (g)}}$$

   $$= \frac{8.4216}{0.2} = 42.1079\ \mu\text{mol/g}$$

Heavy metal Adsorption Isotherms

Heavy metal (cadmium and lead) adsorption isotherm was constructed by plotting the amount of cadmium adsorbed per gram of SMZ (mmol/g) versus equilibrium concentration of cadmium (mM).

1. To convert absorbance from AAS to $[Metal]_{AAS}$ (ppm) of standard solution

For example

Equation from standard solution: Y = 0.2969X

Y = Absorbance from AAS = 0.4128

X = $[Metal]_{AAS}$ (ppm) of standard solution = 0.4128 / 0.2969

= 1.3905 ppm

2. To convert $[Metal]_{AAS}$ (ppm) of standard solution to real equilibrium metal concentration (mM)

For example

$[Cd^{2+}]_{AAS}$ (ppm) of standard solution = 0.5288 ppm

(dilution factor = 334.3333) = 0.5288*334.3333

= 176.794 ppm

equilibrium Cd^{2+} concentration (mM) = 176.7940 /112.41

= 1.5729 mM

2. Finding Cd^{2+} adsorbed concentration

$[Cd^{2+}]_{Adsorbed} = [Cd^{2+}]_{Initial} - [Cd^{2+}]_{Equilibrium}$

$[Cd^{2+}]_{Initial}$ = 4.1360 mM

$[Cd^{2+}]_{Equilibrium}$ = 1.5729 mM

$[CTAB]_{Adsorbed}$ = 4.1360 – 1.5729 = 2.5631mM

4. To convert adsorption concentration to mass of adsorption

$$\text{Mole} = \frac{\text{Concentration} \times \text{Volume}}{1000}$$

$$\text{Adsorbed (mmol)} = \frac{\text{(Adsorbed (mmol))} \times \text{Volume of solution}}{1000}$$

$$\text{Adsorbed (mmol)} = \frac{2.5631 \times 20}{1000} = 0.0513 \text{ mmol}$$

5. Finding Cd^{2+} adsorbed per gram of SMZ

$$Cd^{2+} \text{ adsorbed (mg/g of clinoptilolite)} = \frac{\text{Adsorbed (mmol)}}{\text{the amount of SMZ (g)}}$$

$$= \frac{0.0513}{0.2} = 0.2563 \text{ mmol/g}$$

Toluene Adsorption Isotherms

Toluene adsorption isotherm was constructed by plotting the amount of toluene adsorbed per gram of SMZ (μmol/g) versus equilibrium concentration of toluene (μM).

1. To convert area from GC-Headspace to equilibrium concentration of toluene (μM)

Equation from GC-Headspace: Y = 1.2076*X

Y = area from GC-Headspace = 799.53

X = equilibrium concentration of toluene (μM) = 799.53/1.2076

= 662.08 μM

2. Finding toluene adsorbed concentration (ppm)

$[\text{toluene}]_{Adsorbed} = [\text{toluene}]_{Initial} - [\text{toluene}]_{Equilibrium}$

$[\text{toluene}]_{Initial} = 730.82$ μM

$[\text{toluene}]_{Equilibrium} = 662.08$ μM

$[\text{toluene}]_{Adsorbed} = 730.82 - 662.08 = 68.74$ μM

3. To convert adsorption concentration to moles of adsorption

$$\text{Mole} = \frac{\text{Concentration (ppm)} \times \text{Volume}}{1000 \times \text{Molecular weight}}$$

$$\text{Adsorbed (mmol)} = \frac{\text{(Adsorbed (ppm))} \times \text{Volume of solution}}{1000 \times \text{Molecular weight}}$$

$$\text{Adsorbed (mmol)} = \frac{68.74 \times 20}{1000} = 1.37 \text{ μmol}$$

4. Finding toluene adsorbed per gram of SMZ

$$\text{toluene adsorbed } (\mu mol/g \text{ of SMZ}) = \frac{\text{Adsorbed } (\mu mol)}{\text{the amount of SMZ (g)}}$$

$$= \frac{1.37}{0.2} = 6.87 \ \mu mol/g$$

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