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## APPENDICES

### APPENDIX A: DATA OF SDS ADSORPTION ON PAPER FIBER.

**Table A-1** Data of SDS adsorption with no calcium at pH 7.

stock solution $\mu\text{M}$	supernatant liquid $\mu\text{M}$	SDS adsorbed	
		$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
500	330.60	169.40	0.0424
800	516.65	283.35	0.0708
1500	962.78	537.22	0.1343
2000	1209.67	790.33	0.1976
3000	1418.29	1581.71	0.3954
3500	1719.54	1780.46	0.4451
4000	1696.36	2303.64	0.5759
4500	2067.34	2432.66	0.6082
5000	2294.01	2705.99	0.6765
5500	3213.80	2286.20	0.5715
6000	3794.61	2205.39	0.5513
7000	4806.48	2193.52	0.5484
8000	5634.97	2365.03	0.5913
10000	7621.98	2378.02	0.5945
15000	13247.55	1752.45	0.4381
20000	18323.36	1676.64	0.4192

**Table A-2** Data of SDS adsorption with no calcium at pH 9.

stock solution $\mu\text{M}$	supernatant liquid $\mu\text{M}$	SDS adsorbed	
		$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
500	462.89	37.11	0.0093
600	515.37	84.63	0.0212
800	677.99	122.01	0.0305
1000	870.41	129.59	0.0324
1250	1069.32	180.68	0.0452
1500	1267.14	232.86	0.0582
1750	1521.36	228.64	0.0572
2000	1657.74	342.26	0.0856
2250	1913.16	336.84	0.0842
2500	2119.68	380.32	0.0951
2750	2195.78	554.22	0.1386
3000	2305.27	694.73	0.1737
3500	2708.82	791.18	0.1978
4000	3024.22	975.78	0.2439
4500	3438.23	1061.77	0.2654
5000	3740.88	1259.12	0.3148
5500	4253.22	1246.78	0.3117
6000	4643.20	1356.80	0.3392
6500	4941.81	1558.19	0.3895
7000	5475.57	1524.43	0.3811
7500	5857.03	1642.97	0.4107
8000	6371.83	1628.17	0.4070
8500	6883.91	1616.09	0.4040
9000	7320.10	1679.90	0.4200
10000	8164.92	1835.08	0.4588
15000	13098.98	1901.02	0.4753
20000	18159.40	1840.60	0.4601

**Table A-3** Data of SDS adsorption with initial calcium concentration 100  $\mu\text{M}$  at pH 7.

stock solution $\mu\text{M}$	supernatant liquid $\mu\text{M}$	SDS adsorbed	
		$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
200	57.43	142.57	0.0356
500	267.18	232.82	0.0582
800	476.42	323.58	0.0809
1000	669.99	330.01	0.0825
1250	851.12	398.88	0.0997
1500	1002.58	497.42	0.1244
1750	1255.27	494.73	0.1237
2000	1329.94	670.06	0.1675
2250	1433.23	816.77	0.2042
2500	1514.10	985.90	0.2465
2750	1522.56	1227.44	0.3069
3000	1748.92	1251.08	0.3128
3250	1903.03	1346.97	0.3367
3500	1966.78	1533.22	0.3833
4000	2281.13	1718.87	0.4297
4500	2727.54	1772.46	0.4431
7000	4940.78	2059.22	0.5148
8000	6049.39	1950.61	0.4877
10000	8051.78	1948.22	0.4871

**Table A-4** Data of SDS adsorption with initial calcium concentration 100  $\mu\text{M}$  at pH 9.

stock solution $\mu\text{M}$	supernatant liquid $\mu\text{M}$	SDS adsorbed	
		$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
200	148.96	51.04	0.0128
500	423.40	76.60	0.0192
800	694.33	105.67	0.0264
1000	875.16	124.84	0.0312
1500	1353.93	146.07	0.0365
1750	1581.41	168.59	0.0421
2000	1682.89	317.11	0.0793
2500	1985.40	514.60	0.1286
3000	2290.70	709.30	0.1773
3500	2571.03	928.97	0.2322
8000	5976.17	2023.83	0.5060
8500	6283.81	2216.19	0.5540
10000	7719.22	2280.78	0.5702
13000	10638.01	2361.99	0.5905
15000	12890.50	2109.50	0.5274
18000	15791.72	2208.28	0.5521
20000	17668.41	2331.59	0.5829

**Table A-5** Data of SDS adsorption with initial calcium concentration 1,000  $\mu\text{M}$  at pH 7.

stock solution $\mu\text{M}$	supernatant liquid $\mu\text{M}$	SDS adsorbed	
		$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
200	75.18	124.82	0.03120
400	218.74	181.26	0.04531
600	388.57	211.43	0.05286
800	547.43	252.57	0.06314
1000	663.88	336.12	0.08403

**Table A-6** Data of SDS adsorption with initial calcium concentration 1,000  $\mu\text{M}$  at pH 9.

stock solution $\mu\text{M}$	supernatant liquid $\mu\text{M}$	SDS adsorbed	
		$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
200	170.78	29.22	0.0073
400	337.47	62.53	0.0156
600	474.30	125.70	0.0314
800	663.67	136.33	0.0341
1000	833.99	166.01	0.0415

**APPENDIX B: DATA OF CALCIUM ADSORPTION ON PAPER FIBER.**

**Table B-1** Data of calcium adsorption with initial calcium concentration 100  $\mu\text{M}$  and varying SDS concentration at pH 7.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
4.10	102.244	0.89	22.095	80.150	0.0200
4.14	103.142	1.50	37.406	65.736	0.0164
4.01	99.925	1.52	37.805	62.120	0.0155
3.93	98.105	0.66	16.559	81.546	0.0204
4.22	105.187	1.31	32.618	72.569	0.0181
4.27	106.384	0.64	16.010	90.374	0.0226
4.42	110.324	1.10	27.481	82.843	0.0207
4.69	116.833	0.93	23.242	93.591	0.0234
4.56	113.716	1.40	34.963	78.753	0.0197
6.82	170.075	2.60	64.838	105.237	0.0263
4.82	120.200	0.84	20.948	99.252	0.0248
5.64	140.648	1.75	43.641	97.007	0.0243
6.08	151.621	1.41	35.162	116.459	0.0291
5.40	134.663	1.93	48.130	86.534	0.0216
4.98	124.065	1.26	31.372	92.693	0.0232



**Table B-2** Data of calcium adsorption with initial calcium concentration 100  $\mu\text{M}$  and varying SDS concentration at pH 9.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol/m}^2$
4.10	102.244	0.38	9.377	92.868	0.0232
4.14	103.142	0.47	11.671	91.471	0.0229
4.01	99.925	0.43	10.623	89.302	0.0223
3.93	98.105	0.25	6.334	91.771	0.0229
4.22	105.187	0.53	13.167	92.020	0.0230
4.27	106.384	0.54	13.367	93.017	0.0233
4.42	110.324	0.48	12.020	98.304	0.0246
4.69	116.833	0.34	8.354	108.479	0.0271
4.56	113.716	0.70	17.357	96.359	0.0241
6.82	170.075	1.02	25.436	144.638	0.0362
4.82	120.200	0.23	5.736	114.464	0.0286
5.64	140.648	0.26	6.484	134.165	0.0335
6.08	151.621	0.84	21.047	130.574	0.0326
5.40	134.663	0.36	8.878	125.786	0.0314
4.98	124.065	0.13	3.117	120.948	0.0302

**Table B-3** Data of calcium adsorption with initial calcium concentration 1,000  $\mu\text{M}$  and varying SDS concentration at pH 7.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
33.10	825.436	16.75	417.706	407.731	0.1019
31.08	774.938	14.15	352.868	422.070	0.1055
30.18	752.494	13.95	347.880	404.613	0.1012
29.85	744.389	11.45	285.536	458.853	0.1147
29.83	743.766	8.75	218.204	525.561	0.1314

**Table B-4** Data of calcium adsorption with initial calcium concentration 1,000  $\mu\text{M}$  and varying SDS concentration at pH 9.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol}/\text{m}^2$
33.10	825.436	14.85	370.324	455.112	0.1138
31.08	774.938	11.85	295.511	479.426	0.1199
30.18	752.494	11.50	286.783	465.711	0.1164
29.85	744.389	11.15	278.055	466.334	0.1166
29.83	743.766	10.50	261.845	481.920	0.1205

**Table B-5** Data of calcium adsorption with no SDS at pH 7.

stock solution		supernatant liquid		adsorbed Ca <sup>2+</sup>	
ppm	μM	ppm	μM	μM	μmol/m <sup>2</sup>
2.19	54.613	0.43	10.765	43.849	0.0219
6.77	168.828	0.79	19.701	149.127	0.0746
16.71	416.708	6.86	171.072	245.636	0.1228
25.14	626.933	16.50	411.471	215.461	0.1077
36.00	897.756	30.90	770.574	127.182	0.0636
49.80	1241.895	39.60	987.531	254.364	0.1272
82.00	2044.888	68.85	1716.958	327.930	0.1640
97.25	2425.187	81.05	2021.197	403.990	0.2020
126.50	3154.613	110.30	2750.623	403.990	0.2020
159.30	3972.569	142.30	3548.628	423.940	0.2120
193.40	4822.943	172.20	4294.264	528.678	0.2643
252.80	6304.239	214.40	5346.633	957.606	0.4788
325.90	8127.182	295.70	7374.065	753.117	0.3766
503.69	12560.873	461.56	11510.175	1050.698	0.5253
654.32	16317.082	560.99	13989.751	2327.332	1.1637
870.75	21714.464	721.31	17987.690	3726.774	1.8634
1052.50	26246.883	798.04	19901.228	6345.655	3.1728
1887.50	47069.825	997.42	24873.348	22196.477	11.0982
2234.11	55713.479	1044.48	26046.887	29666.592	14.8333

**Table B-6** Data of calcium adsorption with no SDS at pH 9.

stock solution		supernatant liquid		adsorbed Ca <sup>2+</sup>	
ppm	μM	ppm	μM	μM	μmol/m <sup>2</sup>
2.04	50.873	0.82	20.449	30.424	0.0152
6.47	161.347	1.98	49.377	111.970	0.0560
16.65	415.212	6.89	171.820	243.392	0.1217
26.15	652.120	15.05	375.312	276.808	0.1384
31.95	796.758	19.95	497.506	299.252	0.1496
44.55	1110.973	33.90	845.387	265.586	0.1328
60.45	1507.481	47.55	1185.786	321.696	0.1608
74.85	1866.584	63.95	1594.763	271.820	0.1359
86.35	2153.367	73.60	1835.411	317.955	0.1590
116.70	2910.224	104.40	2603.491	306.733	0.1534
139.80	3486.284	126.50	3154.613	331.671	0.1658
168.00	4189.526	154.80	3860.349	329.177	0.1646
224.50	5598.504	209.50	5224.439	374.065	0.1870
300.90	7503.741	271.70	6775.561	728.180	0.3641
454.20	11326.683	435.00	10847.880	478.803	0.2394
600.75	14981.297	574.95	14337.905	643.392	0.3217
871.00	21720.698	715.57	17844.693	3876.005	1.9380
1052.50	26246.883	779.97	19450.645	6796.238	3.3981
1887.50	47069.825	1004.24	25043.336	22026.490	11.0132
2234.00	55710.723	1072.55	26746.832	28963.891	14.4819

**Table B-7** Data of calcium adsorption with initial SDS concentration 500  $\mu\text{M}$  at pH 7.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol/m}^2$
2.10	52.369	0.39	9.726	42.643	0.0213
4.59	114.464	1.14	28.429	86.035	0.0430
7.68	191.521	1.87	46.633	144.888	0.0724
13.78	343.641	4.96	123.691	219.950	0.1100
20.48	510.723	10.12	252.369	258.354	0.1292
25.41	633.666	13.22	329.676	303.990	0.1520
33.65	839.152	20.45	509.975	329.177	0.1646
65.25	1627.182	48.75	1215.711	411.471	0.2057
123.55	3081.047	97.05	2420.200	660.848	0.3304

**Table B-8** Data of calcium adsorption with initial SDS concentration 500  $\mu\text{M}$  at pH 9.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol/m}^2$
1.73	43.142	0.31	7.606	35.536	0.0178
4.06	101.247	0.90	22.444	78.803	0.0394
6.56	163.591	1.94	48.379	115.212	0.0576
12.42	309.726	4.71	117.456	192.269	0.0961
19.32	481.796	9.13	227.681	254.115	0.1271
24.52	611.471	14.67	365.835	245.636	0.1228
31.15	776.808	19.95	497.506	279.302	0.1397
60.55	1509.975	47.85	1193.267	316.708	0.1584
119.55	2981.297	102.85	2564.838	416.459	0.2082

**Table B-9** Data of calcium adsorption with initial SDS concentration 1,000  $\mu\text{M}$  at pH 7.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol/m}^2$
2.10	52.369	0.94	23.541	28.828	0.0144
3.54	88.217	1.36	34.015	54.202	0.0271
7.29	181.796	2.64	65.935	115.860	0.0579
13.34	332.606	5.28	131.671	200.935	0.1005
20.38	508.105	11.77	293.516	214.589	0.1073
25.53	636.658	16.79	418.703	217.955	0.1090
36.20	902.743	22.32	556.608	346.135	0.1731

**Table B-10** Data of calcium adsorption with initial SDS concentration 1,000  $\mu\text{M}$  at pH 9.

stock solution		supernatant liquid		adsorbed $\text{Ca}^{2+}$	
ppm	$\mu\text{M}$	ppm	$\mu\text{M}$	$\mu\text{M}$	$\mu\text{mol/m}^2$
2.10	52.369	0.50	12.469	39.900	0.0200
3.54	88.217	0.83	20.648	67.569	0.0338
7.29	181.796	1.72	42.993	138.803	0.0694
13.34	332.606	4.39	109.476	223.130	0.1116
20.38	508.105	10.83	270.075	238.030	0.1190
25.53	636.658	14.06	350.623	286.035	0.1430
36.20	902.743	20.27	505.362	397.382	0.1987

### APPENDIX C: DATA OF ZETA POTENTIAL OF PAPER FIBER.

**Table C-1** Data of zeta potential of paper fiber with varying SDS concentration and no calcium at pH 7.

initial SDS concentration $\mu\text{M}$	Equilibrium SDS concentration $\mu\text{M}$	Zeta Potential (-) mV
100	98.9412	28.1
300	298.2291	26.7
500	498.9412	26.4
800	798.2291	24.7
1000	996.6424	23.8
2000	1995.0604	22.9
4000	3985.6022	21.8
5000	4983.0876	21.2

**Table C-2** Data of zeta potential of paper fiber with varying SDS concentration and no calcium at pH 9.

initial SDS concentration $\mu\text{M}$	Equilibrium SDS concentration $\mu\text{M}$	Zeta Potential (-) mV
100	99.7680	31.0
300	299.4711	30.1
500	499.7680	29.9
800	799.2374	28.1
1000	998.8708	27.1
2000	1997.8609	24.8
4000	3993.9014	23.2
5000	4992.1305	22.7

**Table C-3** Data of zeta potential of paper fiber with varying SDS concentration and initial calcium concentration 100  $\mu\text{M}$  at pH 7.

initial SDS concentration $\mu\text{M}$	Equilibrium SDS concentration $\mu\text{M}$	Zeta Potential (-) mV
200	199.1089	25.4
500	498.5449	23.1
1000	997.9374	23.8
1500	1496.8911	23.2
2000	1995.8121	22.1
2500	2493.8381	21.8
3000	2992.1807	21.2
4000	3989.2571	20.1
5000	4988.9221	19.8

**Table C-4** Data of zeta potential of paper fiber with varying SDS concentration and initial calcium concentration 100  $\mu\text{M}$  at pH 9.

initial SDS concentration $\mu\text{M}$	Equilibrium SDS concentration $\mu\text{M}$	Zeta Potential (-) mV
200	199.6810	27.6
500	499.5212	26.1
800	799.3396	25.5
1000	999.2198	24.4
1500	1499.0871	23.7
2000	1998.0181	23.2
2500	2495.5669	22.7
3000	2995.5669	21.5
3500	3494.1940	20.2
4000	3994.1940	19.6



**Table C-5** Data of zeta potential of paper fiber with varying SDS concentration and initial calcium concentration 1,000  $\mu\text{M}$  at pH 7.

initial SDS concentration $\mu\text{M}$	Equilibrium SDS concentration $\mu\text{M}$	Zeta Potential (-) mV
200	199.2199	25.1
400	398.8671	23.7
600	598.6785	21.7
800	798.4214	19.6
1000	997.8993	18.8

**Table C-6** Data of zeta potential of paper fiber with varying SDS concentration and initial calcium concentration 1,000  $\mu\text{M}$  at pH 9.

initial SDS concentration $\mu\text{M}$	Equilibrium SDS concentration $\mu\text{M}$	Zeta Potential (-) mV
200	199.8174	27.5
400	399.6092	26.3
600	599.2144	24.4
800	799.1479	23.5
1000	998.9625	22.9

**Table C-7** Data of zeta potential of paper fiber with no SDS and varying calcium concentration at pH 7.

initial Ca <sup>2+</sup> concentration $\mu\text{M}$	Equilibrium Ca <sup>2+</sup> concentration $\mu\text{M}$	Zeta Potential (-) mV
50	49.4519	32.7
100	99.4519	23.1
200	198.1359	21.2
500	496.9296	18.6
1000	998.4102	12.6
2000	1995.9009	9.38

**Table C-8** Data of zeta potential of paper fiber with no SDS and varying calcium concentration at pH 9.

initial Ca <sup>2+</sup> concentration $\mu\text{M}$	Equilibrium Ca <sup>2+</sup> concentration $\mu\text{M}$	Zeta Potential (-) mV
50	50.0000	31.5
100	99.4929	26
200	198.1338	21.6
500	495.9435	18.8
1000	995.0125	15
2000	1994.6384	14.6

**Table C-9** Data of zeta potential of paper fiber with initial SDS concentration 500  $\mu\text{M}$  and varying calcium concentration at pH 7.

initial $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Equilibrium $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Zeta Potential (-) mV
100	98.2793	27.4
200	197.1022	27.2
400	395.6010	24.3
600	594.8329	20.4
800	793.9202	16.5
1000	993.4165	18.6
2000	1991.7710	18.2

**Table C-10** Data of zeta potential of paper fiber with initial SDS concentration 500  $\mu\text{M}$  and varying calcium concentration at pH 9.

initial $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Equilibrium $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Zeta Potential (-) mV
100	98.4239	28.3
200	197.6958	25.2
400	369.1546	21.6
600	594.9177	20.5
800	795.0873	20.7
1000	994.4140	19.6
2000	1993.6660	18.4

**Table C-11** Data of zeta potential of paper fiber with initial SDS concentration 1,000  $\mu\text{M}$  and varying calcium concentration at pH 7.

initial $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Equilibrium $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Zeta Potential (-) mV
50	49.6397	28.6
100	99.6397	26.1
200	199.3225	24.1
400	398.5517	22.8
600	597.3176	21.9
800	795.6733	19.8

**Table C-12** Data of zeta potential of paper fiber with initial SDS concentration 1,000  $\mu\text{M}$  and varying calcium concentration at pH 9.

initial $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Equilibrium $\text{Ca}^{2+}$ concentration $\mu\text{M}$	Zeta Potential (-) mV
50	49.5012	27.1
100	99.5012	26.1
200	199.1554	23.3
400	398.2650	21.7
600	597.0246	18.3
800	795.0327	17.2

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