

Buffer More Than Buffering Agent: Introducing the New Class of Stabilizers for Protein BSA

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■ SUPPORTING INFORMATION

Table S. 1. DLS data of hydrodynamic diameter (d_H) for BSA in 0.05 M, 0.5 M, and 1.0 M HEPES buffer solutions at different temperatures

0.05 M HEPES		0.5 M HEPES		1.0 M HEPES	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
25	8.0	25	11.2	25	15.1
30	8.3	30	11.7	30	15.0
35	8.2	35	11.4	35	14.7
40	8.1	40	10.9	40	14.7
45	7.8	45	11.1	45	14.3
50	7.4	50	10.3	50	13.5
51	7.5	51	10.6	50	13.2
52	8.0	52	10.7	51	13.6
53	8.0	53	10.8	52	13.8
54	9.3	54	10.1	53	13.9
55	15.0	55	10.4	54	13.8
59	17.2	56	11.4	55	14.2
61	17.8	57	12.2	56	13.8
63	18.7	58	17.2	57	15.3
65	28.5	59	38.9	58	16.4
70	34.2	61	62.6	59	76.7
75	35.6	65	116.9	61	117.0
		70	197.1	60	177.7
		75	272.2	65	259.5
				70	311.2
				75	613.6

Table S. 2. DLS data of hydrodynamic diameter (d_H) for BSA in 0.05 M, 0.5 M, and 1.0 M EPPS buffer solutions at different temperatures

0.05 M EPPS		0.5 M EPPS		1.0 M EPPS	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
25	5.5	25	10.8	25	15.6
30	5.7	30	11.1	30	15.8
35	5.4	35	10.5	35	14.7
40	5.5	40	10.1	40	15.0
45	5.6	45	9.6	45	14.5
50	5.9	50	9.7	50	14.5
51	5.5	51	9.9	51	14.4
52	6.2	52	10.5	52	15.2
53	7.1	53	11.2	53	14.7
54	7.8	54	12.5	54	14.6
55	13.2	55	14.9	55	15.9
58	15.7	56	18.7	56	41.6
61	16.1	60	47.8	59	69.5
65	17.3	64	75.6	62	97.9
70	19.2	68	128.9	65	134.8
75	21.3	70	198.5	70	265.1
		75	245.6	75	328.5

Table S. 3. DLS data of hydrodynamic diameter (d_H) for BSA in 0.05 M, 0.5 M, and 1.0 M HEPES–Na buffer solutions at different temperatures

0.05 M HEPES–Na		0.5 M HEPES–Na		1.0 M HEPES–Na	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
25	8.6	25	11.8	25	17.2
30	8.5	30	12.2	30	16.9
35	8.2	35	11.6	35	15.9
40	8.5	40	11.5	40	15.4
45	8.1	45	11.4	45	15.7
50	8.2	50	10.8	50	14.3
51	7.9	51	11.1	51	14.7
52	8.4	52	10.5	52	14.5
53	8.4	53	10.9	53	14.5
54	8.8	54	10.7	54	14.3
55	23.0	55	10.3	55	13.6
57	25.8	56	10.4	56	13.6
59	29.0	57	11.4	57	14.2
62	33.1	58	11.4	58	13.9
65	48.6	59	11.8	59	14.4
70	56.4	60	30.1	60	15.3
75	78.6	61	62.8	61	15.8
		65	128.8	62	86.9
		70	358.6	64	209.2
		75	435.6	66	614.1
				68	677.1
				70	988.5
				75	2805.0

Table S. 4. DLS data of hydrodynamic diameter (d_H) for BSA in 0.05 M, 0.5 M, and 1.0 M MOPS–Na buffer solutions at different temperatures.

0.05 M MOPS–Na		0.5 M MOPS–Na		1.0 M MOPS–Na	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
25	8.2	25	12.2	25	15.1
30	8.3	30	12.2	30	15.1
35	8.1	35	12.0	35	15.4
40	8.0	40	11.8	40	14.6
45	7.9	45	12.1	45	14.6
50	7.7	50	11.3	50	13.9
51	7.7	51	11.2	51	14.2
52	7.8	52	11.1	52	14.0
53	7.9	53	11.4	53	13.7
54	8.5	54	11.2	54	14.2
55	18.2	55	11.0	55	13.1
58	23.8	56	11.3	56	13.5
61	26.9	57	11.4	57	13.0
64	30.6	58	11.6	58	13.7
70	33.2	59	11.0	59	13.5
75	42.1	60	11.2	60	13.1
		61	11.9	61	13.3
		62	12.6	62	14.2
		63	35.6	63	14.1
		68	256.9	64	15.9
		70	399.5	65	49.0
		75	680.3	70	361.8
				75	536.4

Table S. 5. DLS data of hydrodynamic diameter (d_H) for PNIPAM in 0.0 M, 0.1 M, 0.3 M, 0.5 M, 0.7 M, and 0.9 M HEPES buffer solutions at different temperatures

Water		0.1 M HEPES		0.3 M HEPES		0.5 M HEPES		0.7 M HEPES		0.9 M HEPES	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
10	18.1	10	17.1	10	18.7	10	19.0	10	24.0	10	17.8
13	21.0	13	17.7	13	19.3	13	21.6	12	34.3	12	19.3
16	20.9	16	18.2	16	19.6	16	22.2	14	32.4	14	21.6
19	20.2	19	18.3	19	20.0	19	22.3	16	36.1	16	27.6
22	19.5	22	18.6	22	20.0	22	24.3	18	36.9	18	29.3
25	18.2	25	18.7	25	20.0	23	23.2	20	36.3	19	30.0
28	17.8	28	18.8	28	20.7	24	23.7	22	37.2	20	70.0
31	17.6	31	19.0	29	21.4	25	23.8	23	36.4	26	295.7
32	17.4	32	19.6	30	295.8	26	25.0	24	369.1	30	330.8
33	18.6	33	181.4	35	366.6	27	331.5	29	447.8	40	364.4
34	274.7	34	281.4	40	395.2	32	327.7	34	421.4	45	374.2
39	279.9	39	292.9	45	400.4	37	321.7	39	418.5		
44	294.1	44	297.6			42	319.7	45	448.5		
						45	360.6				

Table S. 6. DLS data of hydrodynamic diameter (d_H) for PNIPAM in 0.0 M, 0.1 M, 0.3 M, 0.5 M, 0.7 M, and 0.9 M EPPS buffer solutions at different temperatures

Water		0.1 M EPPS		0.3 M EPPS		0.5 M EPPS		0.7 M EPPS		0.9 M EPPS	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
10	18.08	10	17.49	10	18.27	10	22.91	10	23.92	10	10
13	21.03	13	17.54	13	19.41	12	24.76	12	20.73	12	13
16	20.93	16	17.71	16	19.77	14	24.97	14	26.11	14	16
19	20.17	19	17.83	19	19.95	16	24.98	16	25.89	16	19
22	19.54	22	18.07	22	20.48	17	24.77	18	26.85	18	22
25	18.21	25	18.24	25	20.83	18	24.85	20	27.41	19	25
28	17.81	27	18.35	28	21.62	19	24.92	22	29.41	20	28
31	17.62	29	18.43	29	22.19	21	25.21	23	64.41	21	31
32	17.42	31	19.01	30	281.9	23	25.44	28	255.3	25	32
33	18.58	32	19.11	35	269	24	26.07	33	250.1	30	33
34	274.7	33	302.5	40	256.4	25	26.03	38	247	35	34
39	279.9	37	336.8	45	250.8	26	27.23	43	238	40	39
44	294.1	41	329.1			27	351.8	47	236.1	45	44
		45	328.6			32	350.3				
						37	248.4				
						42	252				
						45	246				

Table S. 7. DLS data of hydrodynamic diameter (d_H) for PNIPAM in 0.0 M, 0.1 M, 0.3 M, 0.5 M, 0.7 M, and 0.9 M HEPES–Na buffer solutions at different temperatures

Water		0.1 M HEPES-Na		0.3 M HEPES-Na		0.5 M HEPES-Na		0.7 M HEPES-Na		0.9 M HEPES-Na	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
10	18.08	10	19.21	10	26.76	10	39.42	10	44.88	10	58.54
13	21.03	13	19.53	12	27.72	12	40.86	12	46.72	11	63.78
16	20.93	16	20.42	14	28.28	14	40.26	14	46.42	12	66.18
19	20.17	20	19.36	16	28.32	16	41.02	16	46.58	13	75.44
22	19.54	23	19.55	18	29.42	18	41.62	17	48.54	14	101.8
25	18.21	26	20.06	20	27.54	20	41.98	18	49.26	15	126.9
28	17.81	28	20.01	21	27.46	22	41.64	19	56.01	17	309.1
31	17.62	29	20.62	22	26.84	23	48.16	20	4715	18	774
32	17.42	30	20.38	23	27.08	24	3947	25	6287	22	24880
33	18.58	31	20.64	24	27.02	29	11580	30	7916		
34	274.7	32	7207	25	27.06	34	34960	35	5035		
39	279.9	35	5460	26	27.08						
44	294.1	38	5410	27	27.68						
				28	5751						
				32	18270						
				36	15790						

Table S. 8. DLS data of hydrodynamic diameter (d_H) for PNIPAM in 0.0 M, 0.1 M, 0.3 M, 0.5 M, 0.7 M, and 0.9 M MOPS–Na buffer solutions at different temperatures

Water		0.1 M MOPS–Na		0.3 M MOPS–Na		0.5 M MOPS–Na		0.7 M MOPS–Na		0.9 M MOPS–Na	
T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)	T (°C)	d_H (nm)
10	18.08	10	25.77	10	35.31	10	31.16	10	45.45	10	82.69
13	21.03	13	25.31	13	30.19	13	29.32	13	45.22	11	82.26
16	20.93	16	24.95	16	32.83	16	31.68	16	45.89	12	82.34
19	20.17	19	24.81	19	32.22	19	33.24	19	44.97	13	81.25
22	19.54	22	24.95	22	31.18	22	29.98	20	44.64	14	85.63
25	18.21	25	24.36	25	30.12	25	30.18	21	43.73	15	83.58
28	17.81	27	22.97	28	30.07	26	29.63	22	45.07	16	73.58
31	17.62	28	23.64	29	30.29	27	11620	23	46.93	17	71.79
32	17.42	29	23.78	30	19850	32	49980	24	20990	18	77.34
33	18.58	30	21.98	35	13320	42	50990	29	40700	19	73.21
34	274.7	31	23.42	40	6267			34	32620	20	75.06
39	279.9	32	22.82	45	3691			39	30490	21	23920
44	294.1	33	4511					44	32470	30	27030
		35	6772							35	71020
		40	7542								
		45	6302								

Table S. 9. The experimental values of densities (ρ) and viscosities (η) of HEPES, EPPS, HEPES-Na, and MOPS-Na aqueous solutions at 25 °C.

<i>Conc. (mol.kg⁻¹)</i>	<i>ρ (g.cm⁻³)</i>		<i>η (mPa.s)</i>
		HEPES	
0.0	0.99708		0.873
0.2	1.01140		0.965
0.4	1.02452		1.072
0.6	1.03847		1.212
0.8	1.04885		1.340
1.0	1.05945		1.472
		EPPS	
0.2	1.01090		0.990
0.4	1.02370		1.112
0.6	1.03614		1.269
0.8	1.04706		1.427
1.0	1.05777		1.598
		HEPES-Na	
0.2	1.01432		1.018
0.4	1.03018		1.186
0.6	1.04539		1.396
0.8	1.06033		1.649
1.0	1.07263		1.877
		MOPS-Na	
0.2	1.01196		0.974
0.4	1.02611		1.098
0.6	1.03862		1.233
0.8	1.05118		1.368
1.0	1.06230		1.517

