

Supplementary Information

Dissolution kinetics of a sodium borosilicate glass in Tris buffer
solutions: Impact of Tris concentration and acid (HCl/HNO₃) identity

Nicholas Stone-Weiss,¹ Nicholas J. Smith,² Randall E. Youngman,² Eric M.

Pierce,³ Ashutosh Goel^{1,1}

¹Department of Materials Science and Engineering, Rutgers, The State University of New Jersey,
Piscataway, NJ 08854, United States

²Science and Technology Division, Corning Incorporated, Corning, NY 14831, United States

³Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831,
United States

¹ Corresponding author:
Email: ag1179@soe.rutgers.edu; Ph: +1-848-333-1523

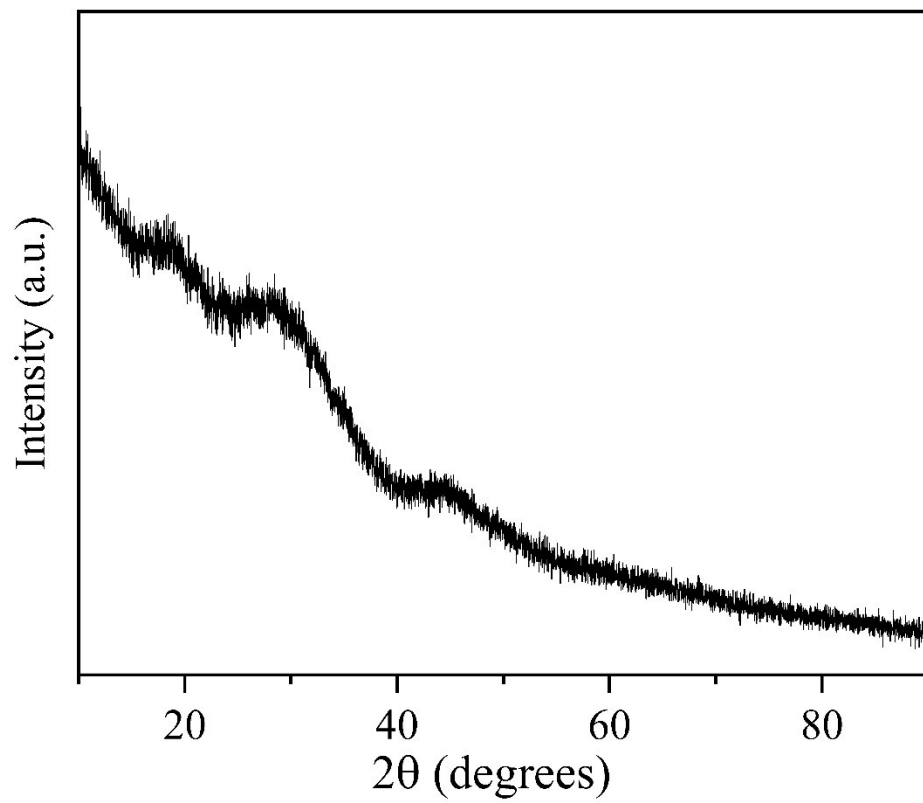


Figure S1. X-ray diffraction pattern verifying the amorphous nature of the as-synthesized glass composition.

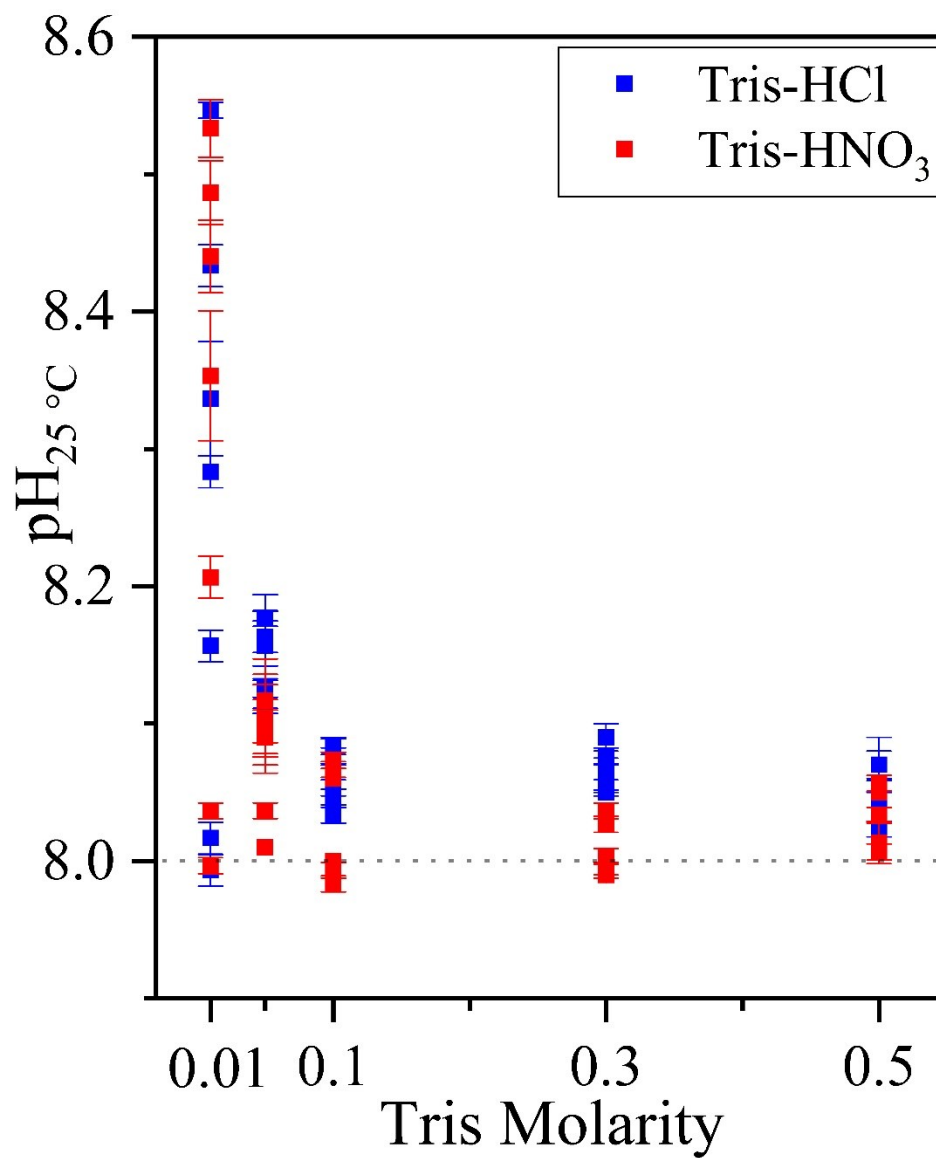
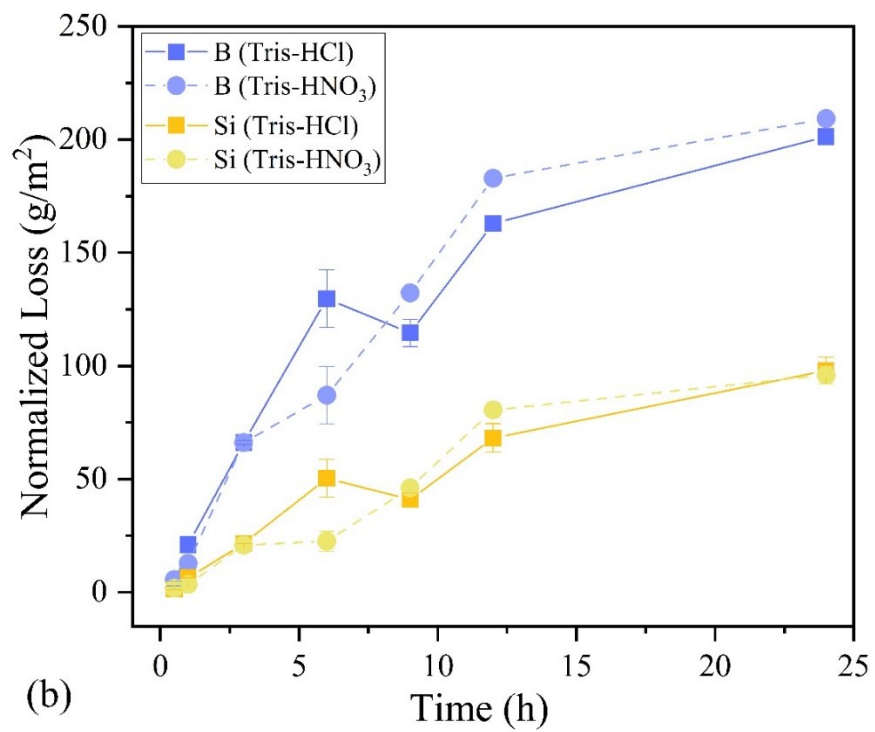
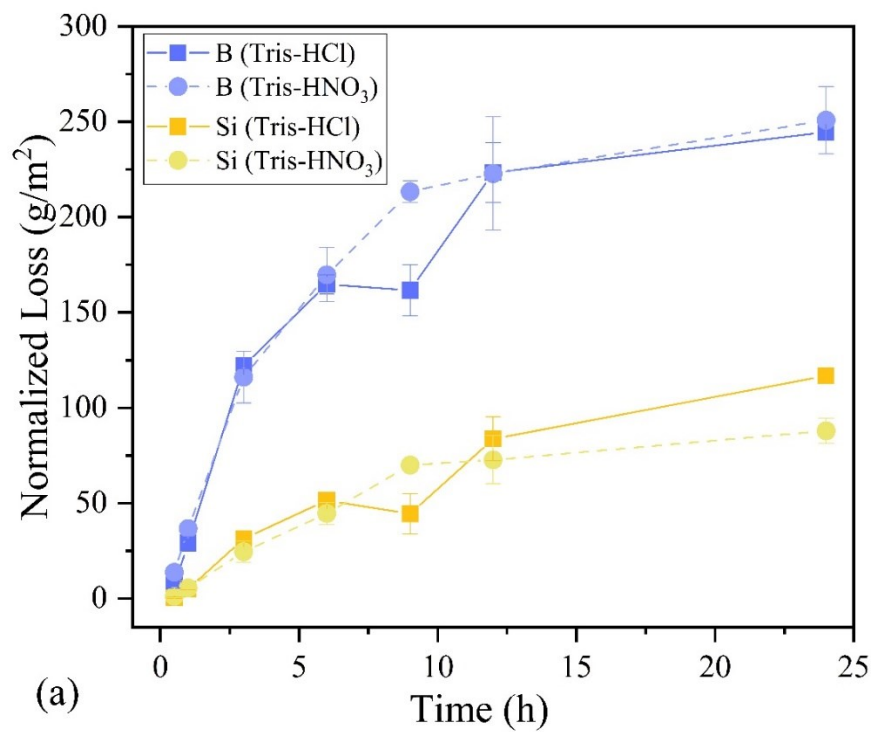


Figure S2. The distribution in experimental solution pH during pH = 8 dissolution experiments, as a function of the Tris molarity in the starting solution.



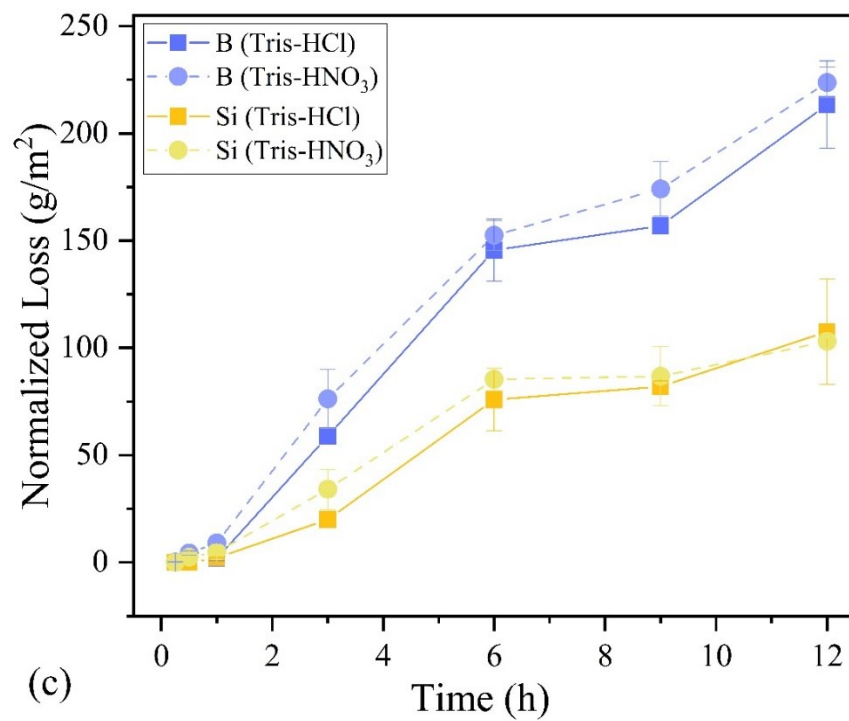


Figure S3. NL vs. time for 0.1 M Tris-based solutions at (a) pH = 7, (b) pH = 8, and (c) pH = 9. Direct comparisons between B and Si release from Tris-HCl and Tris-HNO₃ solutions are displayed.

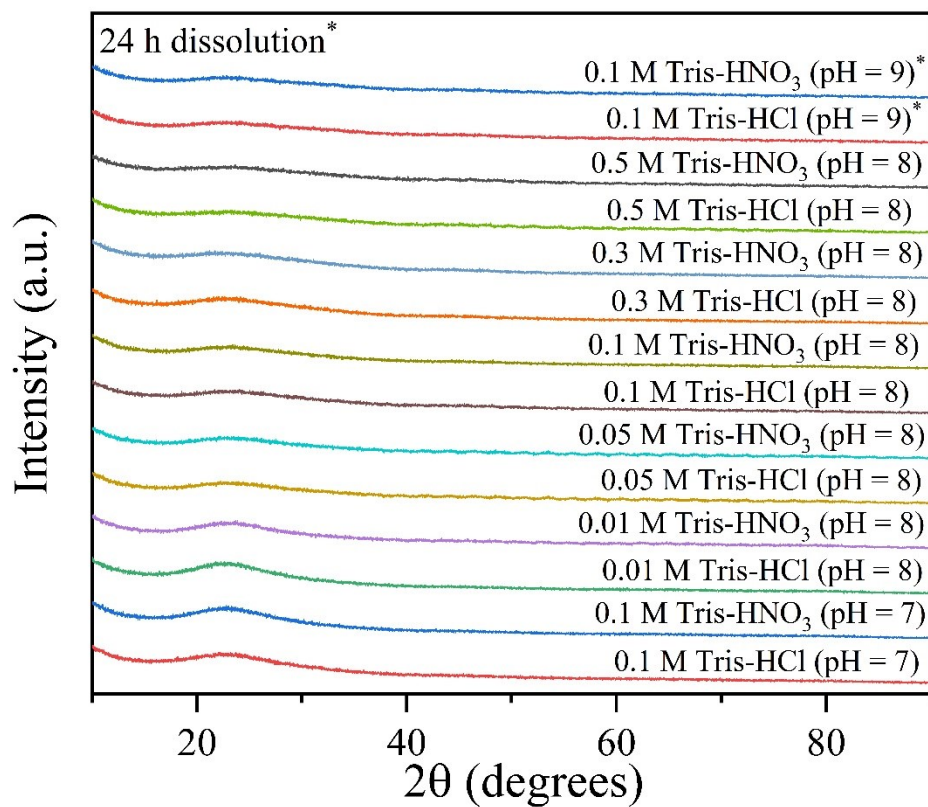


Figure S4. X-ray diffraction patterns of the powders recovered from 24 hours of dissolution experiments.
 (*) Denotes that the sample was recovered from 12 h experiments.

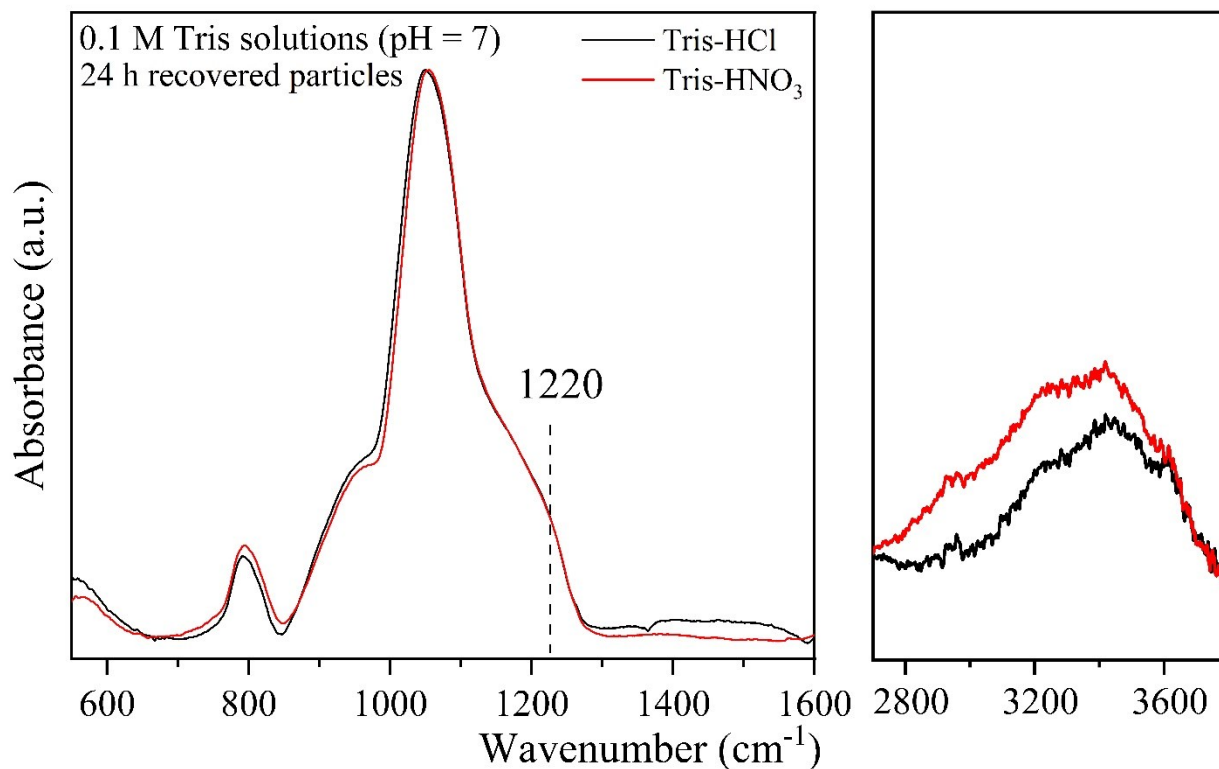


Figure S5. FTIR spectra of powders recovered from 24 h of pH = 7 environments. The band at 1220 cm^{-1} indicates the development of a silica gel layer on the sample surface while the signatures in the region 3000-3700 cm^{-1} are indicative of various O-H stretching vibrations of water and silanol species.

Table S1. Average concentration (ppm), averaged normalized loss (g/m^2), and pH as a function of time (h) for all glasses in varied Tris-based solutions. The reported errors are calculated 1σ standard deviation for duplicate samples.

0.1 M Tris-HCl (pH = 7)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	6.97±0.01	3.1	±0.8	2.0	±0.4	0.3	±0.2	6.9	±1.9	7.0	±1.7	0.5	±0.4
1	7.02±0.01	14.2	±1.6	6.8	±0.7	2.8	±0.3	31.1	±3.5	29.1	±3.3	5.0	±0.6
3	7.07±0.02	57.4	±0.0	26.7	±0.3	17.5	±0.4	125.8	±0.0	121.9	±1.3	31.3	±0.7
6	7.08±0.03	80.5	±2.2	35.9	±1.1	28.7	±0.5	176.3	±4.8	164.7	±5.1	51.5	±0.9
9	7.12±0.02	78.3	±6.3	35.2	±2.9	24.8	±5.9	171.5	±13.7	161.7	±13.3	44.5	±10.5
12	7.15±0.01	106.6	±8.1	48.5	±3.3	46.7	±6.4	233.4	±17.7	223.4	±15.6	83.8	±11.4
24	7.17±0.01	115.0	±0.2	53.0	±0.2	65.2	±0.1	251.9	±0.4	244.6	±0.9	116.8	±0.2
0.1 M Tris-HNO₃ (pH = 7)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	7.03±0.01	4.4	±0.8	3.0	±0.0	0.7	±0.3	9.7	±1.8	13.8	±0.0	1.2	±0.6
1	7.03±0.01	16.8	±0.5	7.9	±0.1	3.1	±0.1	36.8	±1.0	36.6	±0.3	5.6	±0.1
3	7.06±0.01	52.3	±5.8	24.9	±2.9	13.7	±3.1	114.6	±12.7	116.0	±13.5	24.5	±5.6
6	7.16±0.00	78.5	±7.1	36.4	±3.1	24.9	±3.2	171.9	±15.5	169.8	±14.3	44.6	±5.8
9	7.16±0.02	97.2	±2.1	45.8	±1.2	39.0	±0.3	212.9	±4.6	213.3	±5.7	70.0	±0.6
12	7.19±0.00	101.5	±13.6	47.8	±6.4	40.5	±7.0	222.4	±29.9	222.8	±29.7	72.7	±12.6
24	7.16±0.00	113.3	±8.1	53.8	±3.8	49.1	±3.7	248.1	±17.8	250.8	±17.7	88.0	±6.6
0.01 M Tris-HCl (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	7.99±0.01	2.3	±0.4	3.1	±0.3	<0.2	--	5.0	±0.9	4.4	±1.2	--	--
1	8.02±0.01	9.5	±1.8	6.0	±0.7	2.5	±0.8	20.8	±3.9	18.1	±3.1	4.4	±1.4
3	8.16±0.01	36.0	±0.2	16.9	±0.2	17.3	±0.0	78.8	±0.5	69.0	±0.9	31.0	±0.0
6	8.28±0.01	57.4	±0.5	26.5	±0.1	27.8	±1.4	125.8	±1.1	113.6	±0.5	49.9	±2.4
9	8.43±0.02	73.4	±8.0	33.5	±3.7	40.6	±5.7	160.8	±17.5	146.4	±17.2	72.8	±10.3
12	8.34±0.04	64.2	±2.1	29.9	±0.8	29.3	±2.1	140.5	±4.6	129.4	±3.8	52.6	±3.8
24	8.55±0.01	106.0	±2.8	48.4	±1.2	62.4	±0.4	232.2	±6.2	215.5	±5.8	111.8	±0.7
0.01 M Tris-HNO₃ (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.00±0.01	2.7	±0.7	3.1	±0.3	<0.2	--	5.8	±1.5	5.4	±1.4	--	--
1	8.04±0.01	7.1	±0.9	4.8	±0.4	1.4	±0.5	15.5	±2.0	13.8	±2.1	2.6	±0.9
3	8.21±0.02	29.1	±2.7	13.9	±1.1	13.3	±1.6	63.7	±5.9	56.0	±5.3	23.8	±2.9
6	8.35±0.05	45.9	±5.3	22.6	±4.3	17.1	±0.4	100.5	±11.7	96.7	±19.8	30.6	±0.7
9	8.44±0.03	75.4	±2.0	33.7	±1.1	43.0	±3.1	165.0	±4.3	148.1	±5.1	77.1	±5.5
12	8.53±0.02	93.2	±3.7	42.0	±1.5	56.4	±1.7	204.1	±8.0	186.8	±6.9	101.1	±3.1
24	8.49±0.02	114.0	±0.3	51.4	±0.1	74.7	±2.5	249.6	±0.6	230.4	±0.7	133.9	±4.4

0.05 M Tris-HCl (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.13±0.02	4.1	±1.0	4.0	±0.5	0.3	±0.4	9.0	±2.2	7.0	±2.2	0.5	±0.7
1	8.09±0.00	9.6	±0.0	6.2	±0.1	2.2	±0.4	21.0	±0.1	17.4	±0.7	4.0	±0.8
3	8.11±0.01	36.0	±0.6	17.4	±0.2	12.4	±0.8	78.9	±1.3	69.5	±1.0	22.3	±1.4
6	8.16±0.03	54.0	±11.7	25.4	±4.7	21.3	±8.4	118.2	±25.7	106.7	±21.7	38.2	±15.0
9	8.18±0.01	80.4	±2.0	37.1	±2.2	40.7	±3.6	176.2	±4.4	161.0	±10.1	72.9	±6.5
12	8.16±0.01	76.5	±15.2	35.3	±7.1	35.5	±20.1	167.5	±33.4	153.1	±33.0	63.6	±36.1
24	8.16±0.03	102.5	±3.2	47.1	±1.1	57.0	±2.5	224.5	±6.9	207.8	±4.9	102.1	±4.5
0.05 M Tris-HNO₃ (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.12±0.03	9.8	±0.3	5.9	±0.1	0.9	±0.0	21.5	±0.6	18.7	±0.5	1.7	±0.0
1	8.01±0.00	17.3	±0.6	9.4	±1.0	3.4	±0.0	37.8	±1.3	35.1	±4.5	6.1	±0.1
3	8.10±0.04	37.9	±1.3	17.9	±0.6	10.8	±1.0	83.1	±2.9	74.4	±2.8	19.4	±1.8
6	8.09±0.02	58.6	±0.8	26.8	±0.9	19.8	±1.2	128.3	±1.8	115.8	±4.1	35.5	±2.1
9	8.10±0.02	68.0	±0.5	30.5	±0.4	24.0	±0.8	149.0	±1.0	133.2	±1.7	43.1	±1.4
12	8.04±0.01	73.4	±0.7	32.9	±0.3	24.3	±0.4	160.8	±1.4	144.3	±1.5	43.5	±0.7
24	8.10±0.03	93.1	±2.4	42.1	±1.2	42.3	±5.5	204.0	±5.3	187.4	±5.5	75.8	±9.9
0.1 M Tris-HCl (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.08±0.01	<0.5	--	0.6	±0.0	1.4	±0.0	--	--	2.8	±0.0	1.3	±0.1
1	8.05±0.01	8.8	±0.5	4.5	±0.1	4.3	±0.1	19.2	±1.0	21.1	±0.5	6.4	±0.2
3	8.08±0.01	30.0	±0.4	14.2	±0.2	12.7	±0.0	65.7	±0.8	66.2	±0.9	21.5	±0.0
6	8.03±0.01	57.0	±2.9	27.8	±2.7	28.8	±4.7	124.8	±6.5	129.7	±12.7	50.4	±8.4
9	8.05±0.01	52.4	±3.4	24.6	±1.3	23.6	±1.5	114.8	±7.3	114.6	±6.1	41.0	±2.7
12	8.08±0.01	73.5	±0.1	35.0	±0.1	38.7	±3.6	160.9	±0.3	163.0	±0.3	68.1	±6.4
24	8.04±0.00	90.9	±1.8	43.2	±0.5	55.4	±3.2	199.1	±3.9	201.3	±2.2	98.0	±5.8
0.1 M Tris-HNO₃ (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.07±0.01	1.5	±0.6	1.2	±0.2	1.7	±0.2	3.3	±1.3	5.6	±0.8	1.8	±0.3
1	8.06±0.00	4.3	±1.1	2.7	±0.5	2.7	±0.5	9.5	±2.3	12.8	±2.1	3.5	±0.8
3	8.07±0.01	29.3	±1.2	14.2	±0.4	12.4	±0.9	64.3	±2.5	66.1	±2.1	20.9	±1.5
6	8.07±0.01	37.7	±4.1	18.7	±2.7	13.3	±2.5	82.6	±8.9	87.1	±12.8	22.5	±4.4
9	7.98±0.01	60.2	±1.0	28.4	±0.4	26.5	±0.7	131.8	±2.2	132.3	±1.7	46.1	±1.3
12	8.00±0.00	81.7	±0.7	39.3	±0.4	45.7	±0.2	178.8	±1.5	182.9	±1.9	80.6	±0.3
24	7.99±0.01	93.8	±0.1	44.9	±0.0	54.2	±2.2	205.4	±0.1	209.3	±0.1	95.9	±3.9

0.3 M Tris-HCl (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.09±0.01	6.8	±0.0	4.8	±0.0	0.9	±0.3	14.8	±0.1	13.6	±0.1	1.6	±0.5
1	8.08±0.01	11.2	±0.5	6.5	±0.2	3.5	±0.2	24.3	±1.2	21.1	±0.9	6.2	±0.3
3	8.05±0.00	26.9	±1.1	14.6	±0.5	10.6	±0.7	58.7	±2.3	59.2	±2.5	19.1	±1.2
6	8.06±0.01	42.2	±3.3	22.7	±1.4	20.9	±1.8	92.4	±7.3	96.9	±6.6	37.4	±3.1
9	8.06±0.01	48.2	±1.0	25.4	±0.5	23.6	±2.0	105.5	±2.1	109.6	±2.5	42.3	±3.5
12	8.05±0.01	54.3	±0.9	28.5	±0.7	28.1	±3.3	118.8	±1.9	123.8	±3.1	50.3	±5.9
24	8.06±0.01	69.3	±1.6	36.4	±1.5	44.0	±4.5	151.6	±3.4	160.4	±7.2	78.9	±8.1
0.3 M Tris-HNO₃ (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.04±0.01	6.2	±1.1	3.5	±0.5	0.9	±0.4	13.7	±2.3	15.4	±2.2	1.6	±0.7
1	8.03±0.01	9.6	±0.9	5.2	±0.4	2.5	±0.4	21.0	±1.9	23.3	±2.0	4.5	±0.7
3	7.99±0.01	27.0	±0.2	14.0	±0.1	10.5	±0.2	59.2	±0.4	64.3	±0.4	18.8	±0.4
6	8.00±0.01	40.9	±3.9	21.2	±1.8	17.5	±2.9	89.5	±8.5	98.1	±8.2	31.3	±5.1
9	8.00±0.00	48.5	±3.1	24.9	±1.9	21.2	±4.3	106.2	±6.9	115.1	±9.0	38.1	±7.7
12	8.00±0.00	53.9	±5.0	27.8	±2.7	26.1	±3.9	118.1	±11.0	128.7	±12.5	46.8	±6.9
24	7.99±0.00	68.6	±0.2	35.4	±0.1	39.5	±0.6	150.3	±0.4	164.2	±0.3	70.8	±1.1
0.5 M Tris-HCl (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.07±0.02	5.3	±0.7	2.8	±0.4	0.8	±0.5	11.3	±1.5	12.8	±1.8	1.4	±0.9
1	8.07±0.01	6.9	±0.5	3.6	±0.2	1.4	±0.3	14.7	±1.0	16.7	±1.0	2.5	±0.5
3	8.02±0.00	21.2	±0.4	11.2	±0.2	8.4	±0.5	46.1	±0.9	52.1	±1.0	15.0	±0.9
6	8.03±0.00	35.2	±0.2	18.2	±0.1	16.9	±0.5	76.6	±0.3	84.7	±0.3	30.4	±0.9
9	8.04±0.02	39.1	±0.0	20.6	±0.1	18.5	±0.7	85.1	±0.1	95.7	±0.6	33.2	±1.3
12	8.03±0.01	42.0	±0.8	21.9	±0.6	20.0	±2.5	91.6	±1.7	102.1	±2.9	35.9	±4.4
24	8.02±0.01	56.5	±0.7	29.6	±0.4	30.4	±1.5	123.3	±1.5	137.8	±1.7	54.5	±2.7
0.5 M Tris-HNO₃ (pH = 8)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.5	8.06±0.01	4.3	±0.0	2.1	±0.0	<0.2	--	9.4	±0.0	9.8	±0.0	--	--
1	8.05±0.00	8.4	±0.1	4.4	±0.1	2.1	±0.0	18.5	±0.3	20.3	±0.4	3.8	±0.0
3	8.01±0.01	21.2	±0.5	11.1	±0.2	7.7	±0.6	46.5	±1.0	51.9	±0.9	13.8	±1.1
6	8.01±0.01	36.4	±2.0	19.0	±1.0	17.4	±1.7	79.7	±4.3	88.6	±4.5	31.1	±3.1
9	8.03±0.01	38.3	±0.2	20.5	±0.0	16.8	±0.9	83.9	±0.4	95.3	±0.0	30.1	±1.5
12	8.01±0.01	39.0	±0.3	20.6	±0.1	16.0	±0.4	85.3	±0.7	95.8	±0.4	28.7	±0.7
24	8.01±0.02	56.9	±3.1	30.0	±1.7	32.5	±4.2	124.7	±6.8	139.8	±8.0	58.3	±7.5

0.1 M Tris-HCl (pH = 9)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.25	8.99±0.01	<0.5	--	<0.2	--	<0.2	--	--	--	--	--	--	--
0.5	8.99±0.01	<0.5	--	<0.2	--	<0.2	--	--	--	--	--	--	--
1	9.02±0.02	2.3	±0.4	0.4	±0.2	1.2	±0.2	5.1	±1.0	1.8	±1.0	2.1	±0.4
3	9.02±0.03	25.9	±0.7	12.7	±0.4	11.2	±0.3	56.6	±1.5	58.9	±1.7	20.1	±0.5
6	9.05±0.03	63.1	±6.2	31.3	±3.1	42.3	±8.1	138.3	±13.7	145.6	±14.4	75.9	±14.4
9	9.03±0.01	68.0	±0.5	33.7	±0.3	45.8	±1.4	149.0	±1.2	156.9	±1.4	82.0	±2.6
12	9.04±0.00	91.0	±7.4	45.8	±4.3	60.0	±13.7	199.3	±16.1	213.4	±20.2	107.5	±24.6
0.1 M Tris-HNO₃ (pH = 9)		Concentration, ppm						Normalized Loss, g/m²					
Time (h)	pH	Na	Na-error	B	B-error	Si	Si-error	Na	Na-error	B	B-error	Si	Si-error
0.25	8.95±0.01	0.7	±0.3	<0.2	--	<0.2	--	1.6	±0.7	--	--	--	--
0.5	8.95±0.01	3.8	±0.3	0.9	±0.2	1.4	±0.1	8.3	±0.6	4.4	±1.1	2.5	±0.3
1	8.93±0.01	5.5	±0.0	2.0	±0.0	2.7	±0.1	12.2	±0.1	9.2	±0.1	4.8	±0.1
3	8.98±0.01	34.3	±4.9	16.4	±3.0	19.0	±5.2	75.0	±10.8	76.3	±13.9	34.1	±9.3
6	8.98±0.00	66.5	±2.7	32.7	±1.5	47.6	±2.8	145.5	±5.9	152.5	±6.9	85.4	±5.1
9	9.00±0.01	75.3	±4.0	37.4	±2.7	48.4	±7.6	165.0	±8.7	174.1	±12.8	86.8	±13.7
12	9.01±0.01	95.1	±3.2	48.0	±1.5	57.5	±1.7	208.2	±6.9	223.7	±7.2	103.2	±3.1