

Supporting Information

Zwitterion Stabilized Silica Nanoparticles: Towards Nonstick Nano

*Zaki G. Estephan, Jad A. Jaber, and Joseph B. Schlenoff **

Department of Chemistry and Biochemistry, The Florida State University, Tallahassee, Florida 32306

schlen@chem.fsu.edu

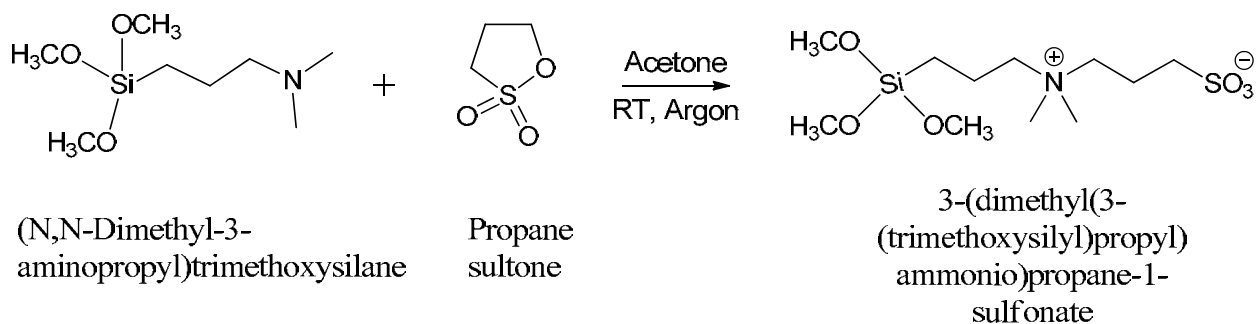
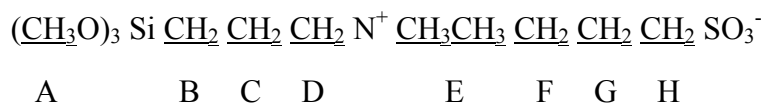


Figure S1. Room temperature synthesis of zwitterion silane SBS.

Table S1. Solution ^1H 300 MHz DMSO- d_6 and ^{13}C CP/MAS solid state peak assignments and chemical shifts for the sulfobetaine silane, SBS. Tetramethylsilane was used as an external standard.



^1H NMR (DMSO- d_6 , 300 MHz): δ 0.4-0.6 (B, t, 2H), 1.6-1.8 (C, m, 2H), 1.9-2.0 (G, m, 2H), 2.4-2.5 (D, t, 2H), 3.0 (E, s, 6H), 3.1-3.3 (F, m, 2H), 3.3-3.4 (H, m, 2H), 3.5 (A, s, 9H).

^{13}C NMR (MAS 15 KHz, 125.8 MHz): δ 49 (A), 13.8 (B), 2.78 (C), 59.25 (D, F), 58 (E), 16.55 (F), 46 (G).

Table S2. Hydrodynamic radii of untreated SiO_2 and SiZwi with different amounts of zwitterion on the surface measured in water at 25°C. All coverages are actual coverages as obtained from TGA.

<u>SiZwi ($\mu\text{mol Zwi}/\text{m}^2$)</u>	<u>Hydrodynamic Radius (± 0.5 nm)</u>
0.00	16.8
0.16	17.3
0.35	17.5
0.51	17.5
1.0	17.5
1.4	17.2
1.7	17.3

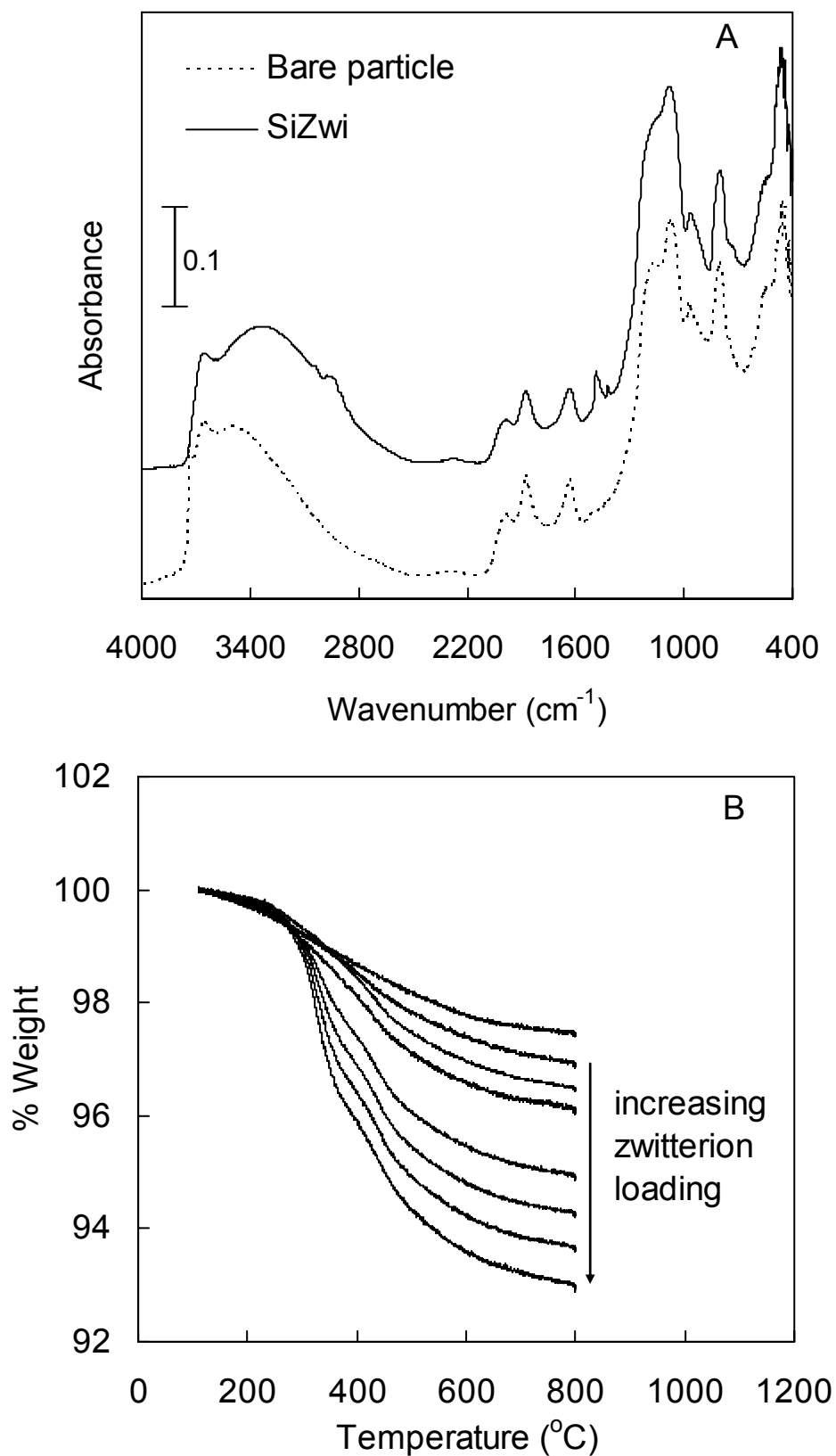


Figure S2. (A) DRIFT spectra of bare SiO₂ nanoparticle (solid line) and 1.0 μmol/m² SiZwi (dashed line). (B) From top to bottom, TGA of untreated and zwitterion surface treated silica colloids with 0.00,

0.16, 0.35, 0.51, 1.0, 1.4, and 1.7, and 1.8 $\mu\text{mol Zwi/m}^2$ run under inert atmosphere. All samples were first held at 105 °C to remove adsorbed water and then heated to 800 °C at a rate of 10 °C/min.

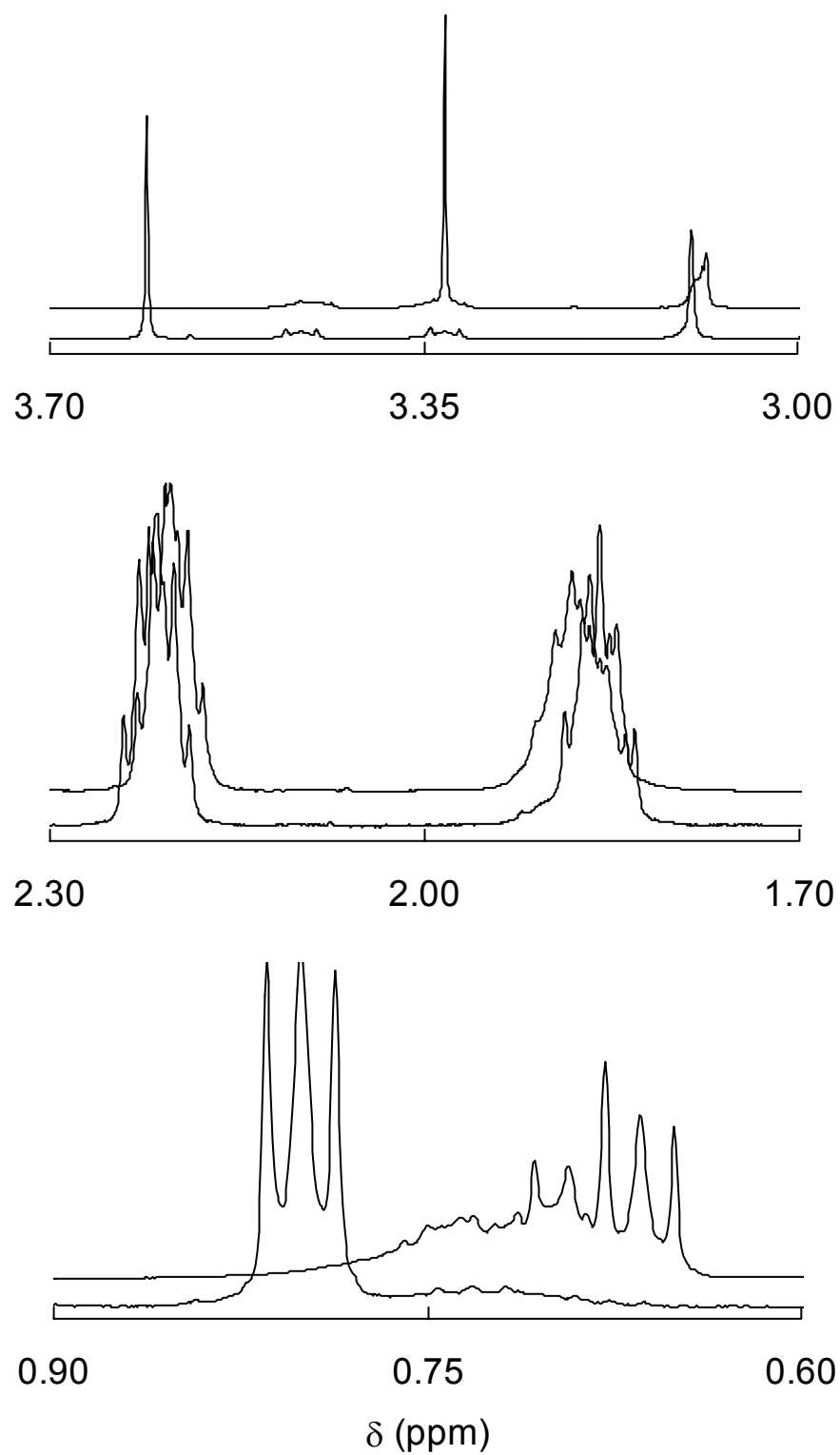


Figure S3. NMR spectra of zwitterion silane in D₂O taken 30 seconds (lower) and 14 hours (upper) after the addition of the silane to D₂O. The peak at 3.6 ppm attributed to the methoxy group disappears

and a new peak at 3.3 ppm related to methanol formation appears. Also, an upfield shift is observed for the methylene carbon attached to the silicon atom from 0.8 ppm to 0.66 ppm.

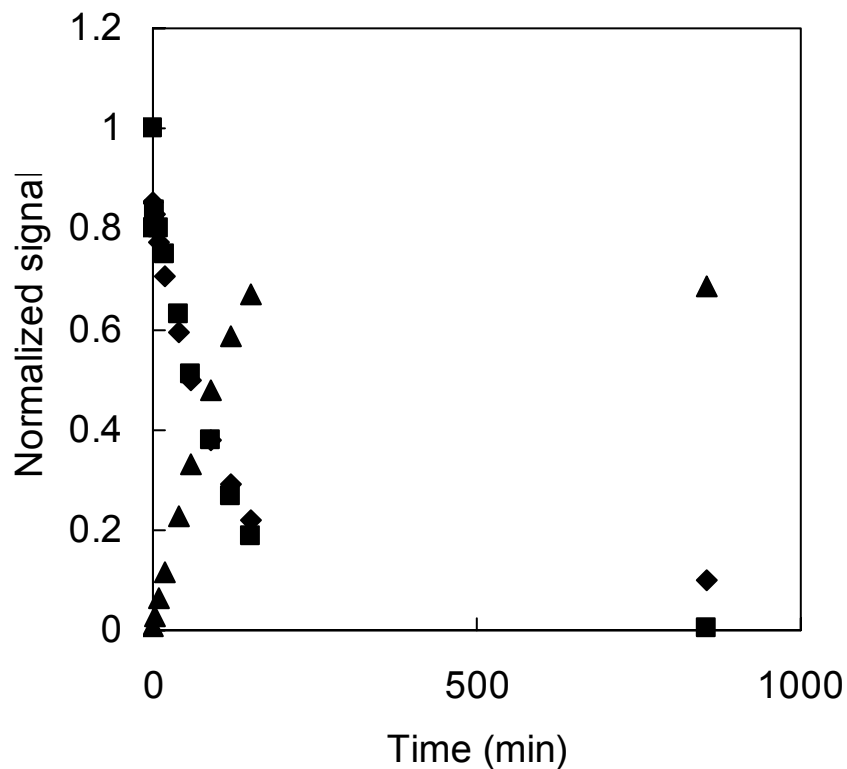


Figure S4. Hydrolysis of zwitterion silane SBS in D₂O measured by ¹H NMR. Disappearance of the methoxy groups attached to the silicon atom at δ 3.6 ppm (♦); Appearance of methanol peak at δ 3.3 ppm (▲). The decrease in the methylene signal at δ = 0.80 (■).

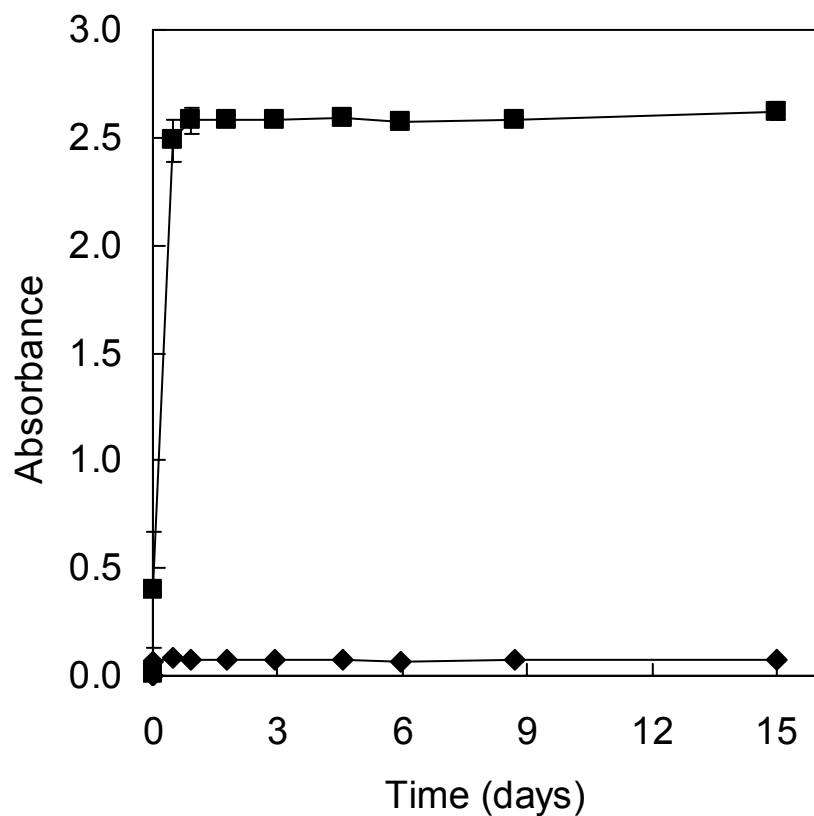


Figure S5. Turbidimetry study at $\lambda = 500$ nm showing the stability of untreated SiO₂ (■); and 1.0 $\mu\text{mol/m}^2$ SiZwi (◆) in 3 M NaCl buffered at pH 7.4. Nanoparticle concentration is 2% w/v. Error bars are of the same scale as the points. Solid lines are a guide to the eye.

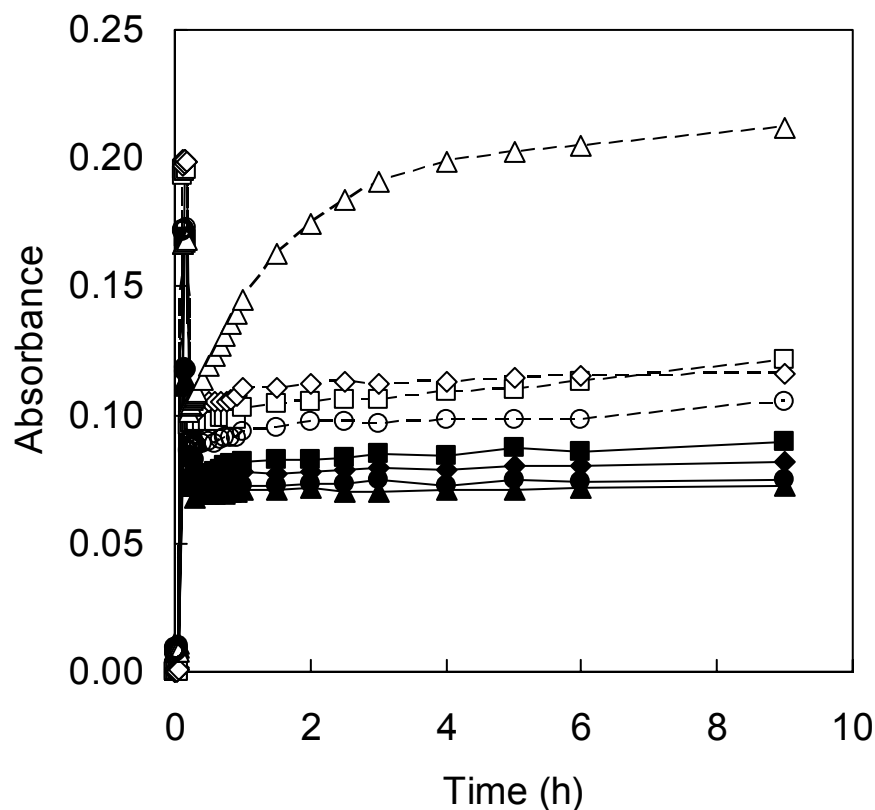


Figure S6. Turbidimetry study at $\lambda = 500$ nm showing the effect of heat and ammonia on the stability of dialyzed and undialyzed SiZwi samples in the presence 50% FBS in PBS (dashed lines) and 3 M NaCl in phosphate buffer pH 7.4 (solid lines). Sample prepared by simple addition of zwitterion to silica at r.t with no dialysis step after (\blacksquare, \square); sample dialyzed after r.t. zwitterion addition ($\blacktriangle, \triangle$); sample prepared with heating at 80 °C in the presence of ammonia with no dialysis step (\blacklozenge, \lozenge); sample prepared by heating at 80 °C in presence of ammonia and dialyzed (\bullet, \circ). Nanoparticle concentration is 2% w/v. The initial dip in absorbance is due to the addition of the colloids to the FBS or NaCl solution. The absorbance of untreated silica is similar to that shown in Figure S5. All data refer to zwitterion surface concentration of $1.7 \mu\text{mol Zwi/m}^2$.

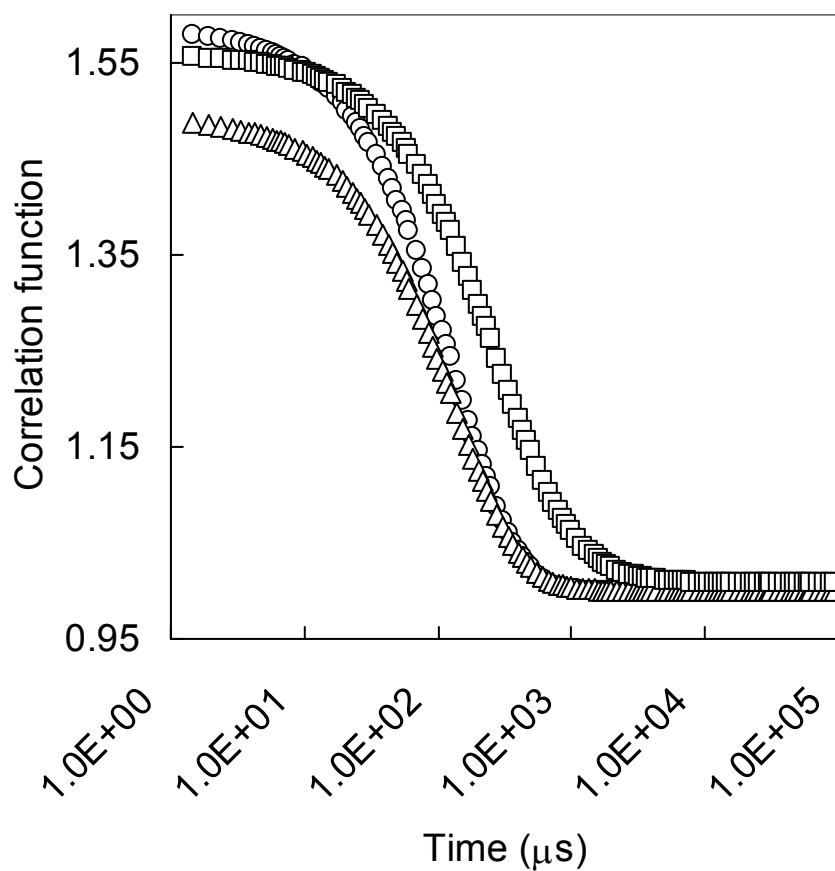


Figure S7. Correlation function for $1.7 \mu\text{mol Zwi}/\text{m}^2 \text{SiO}_2$ measured in PBS at 37°C in the presence of lysozyme at different times after incubation: (○) 50 s after ($18.6 \pm 0.3 \text{ nm}$); (Δ) 30 h after ($17.9 \pm 0.4 \text{ nm}$); (□) 43 h after ($40.5 \pm 4.3 \text{ nm}$). The correlation function for SiZwi before lysozyme addition (not shown here) is similar to the one collected after 50 s of lysozyme addition.

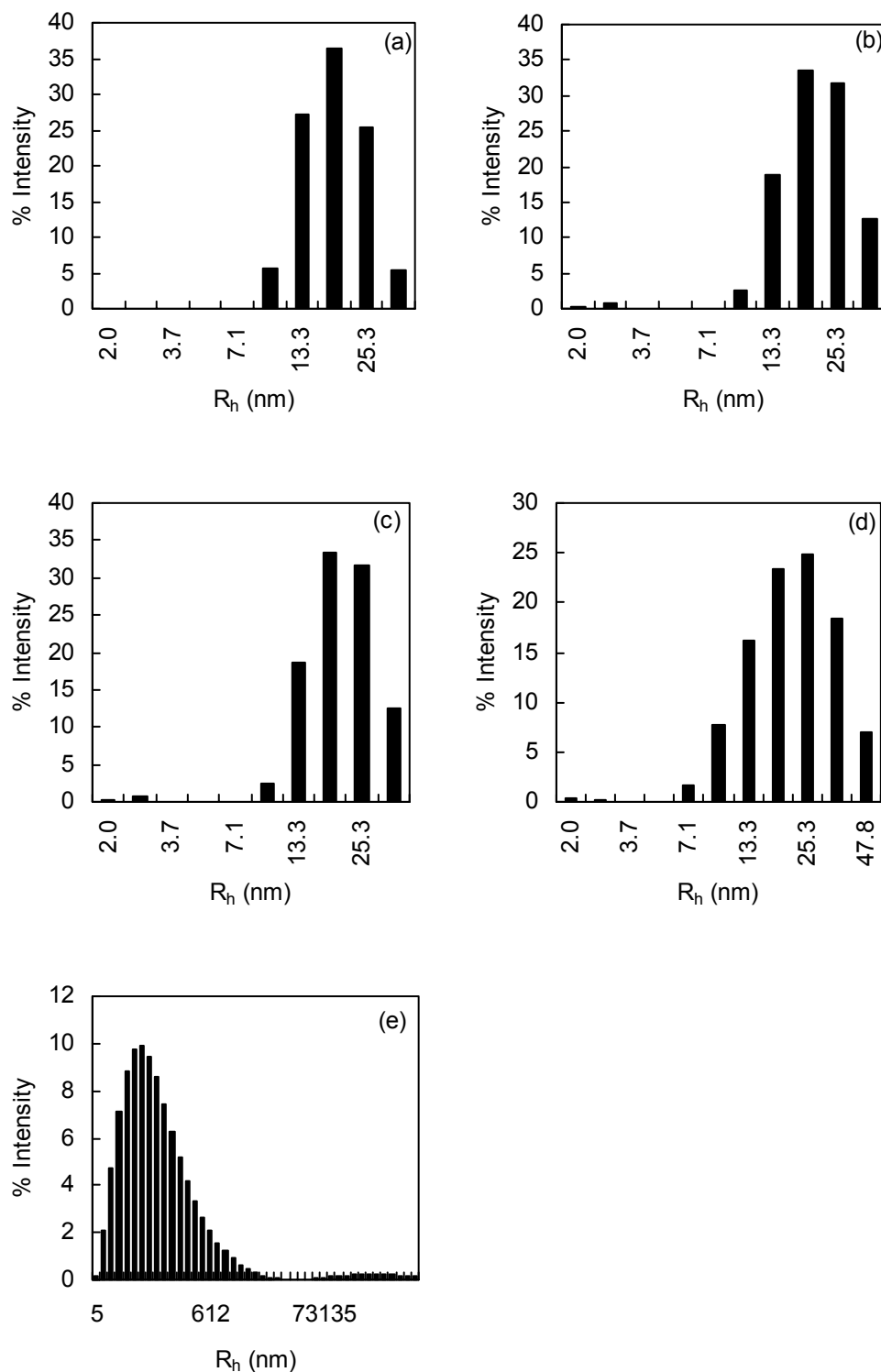


Figure S8. The hydrodynamic distribution of 1.7 $\mu\text{mol Zwi/m}^2$ SiO₂ (as determined from TGA) as a function of time in presence of lysozyme. Prior to lysozyme addition (a); after incubation with lysozyme for: 50 s (b); 17 h (c), 30 h (d); and 43 h (e). Experiments were performed in 10 mM PBS at 37 °C. 1mL of 3.5 mg/mL lysozyme was added to 3.8 mg of nanoparticles in 2.5 mL PBS.