**Quantitative analysis and efficient surface modification of silica nanoparticles**

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**Figure S1.** 1H-NMR spectra of APTES in D2O after (a) just mixing, (b) 30 min, (c) 1h, and (d) 4h.



**Figure S2.** ESI-MS spectra of APTES in methanol: (a) as prepared, (b) after 30min, (c) after 3h, (d) after 6h.



**Figure S3.** Photograph of SiO2-DETAS(RITC) nanoparticles prepared from various amounts of DETAS ligand.



**Figure S4.** (a) UV-Vis absorption spectra and (b) the calibration curve of Rhodmaine B isothiocyanate (RITC) at various concentrations



**Figure S5.** Schematic illustration of the synthesis of SiO2-EDA in a way analogous to dendrimer synthesis



**Figure S6.** The absorption spectra of a) as prepared SiO2-DETAS(RITC), b) after 1.5 month of SiO2-DETAS(RITC).

**Table S1.** Acid-base back-titration results of surface modified silica nanoparticles.

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| --- |
| Concentration of standardized NaOH solution: 0.86 mM |
| Concentration of HCl solution for back-titration: 1.1 mM |
| Volume of HCl solution for back-titration: 10.00 mL |
| Amount of used HCl: 11 μmol |
|  | Volume of NaOH solution (mL) |  | Amount of NaOH (μmol) |  | Amount of HCl reacted with surface amine sites (μmol) |
| SiO2-APTMS-1 | 11.25 |  | 9.7 |  | 1.3 |
| SiO2-APTMS-2 | 11.75 |  | 10 |  | 1 |
| SiO2-APTMS-3 | 11.40 |  | 9.8 |  | 1.2 |
|  |  |  |  |  |  |
| SiO2-EDA-1 | 9.95 |  | 8.6 |  | 2.4 |
| SiO2-EDA-2 | 10.55 |  | 8.1 |  | 2.9 |
| SiO2-EDA-3 | 8.75 |  | 7.5 |  | 3.5 |
| Concentration of standardized NaOH solution: 3.6 mM |
| Concentration of HCl solution for back-titration: 1.2 mM |
| Volume of HCl solution for back-titration: 10.00 mL |
| Amount of used HCl: 12 μmol |
|  | Volume of NaOH solution (mL) |  | Amount of NaOH (μmol) |  | Amount of HCl reacted with surface amine sites (μmol) |
| SiO2-DETAS-1 | 2.45 |  | 8.75 |  | 3.25 |
| SiO2-DETAS-2 | 2.45 |  | 8.75 |  | 3.25 |
| SiO2-DETAS-3 | 2.40 |  | 8.57 |  | 3.43 |
| Calculated weight of a single SiO2 NP from the bulk density  | 1.2ⅹ10-12 mg/ea |
| Used amount of SiO2 NP  | 10 mg |
| Numbers of SiO2 NPs in 10 mg sample  | 8.3ⅹ1012 ea |
| Surface area of a single SiO2 NP  | 31000 nm2 |
| Total surface area of 10 mg SiO2 NPs sample  | 2.6ⅹ1017 ea·nm2 |
|  | **Number of amine (ea)** |  | **ea/nm2** |  | **Average value (ea/nm2)** |
| SiO2-APTMS-1 | 7.8ⅹ1017 | 3.0 |  |  |  |
| SiO2-APTMS-2 | 6.0ⅹ1017 | 2.3 |  | 2.7±0.29 |  |
| SiO2-APTMS-3 | 7.3ⅹ1017 | 2.8 |  |  |  |
|  |  |  |  |  |  |
| SiO2-EDA-1 | 1.4ⅹ1018 |  | 5.6 |  |  |  |
| SiO2-EDA-2 | 1.1ⅹ1018 | 6.7 |  | 6.8±1.1 |  |
| SiO2-EDA-3 | 2.1ⅹ1018 | 8.2 |  |  |  |
|  |
| SiO2-DETAS-1 | 2.0ⅹ1018 |  | 7.6 |  |  |  |
| SiO2-DETAS-2 | 2.0ⅹ1018 | 7.6 |  | 7.7±0.19 |  |
| SiO2-DETAS-3 | 2.1ⅹ1018 | 8.0 |  |  |  |