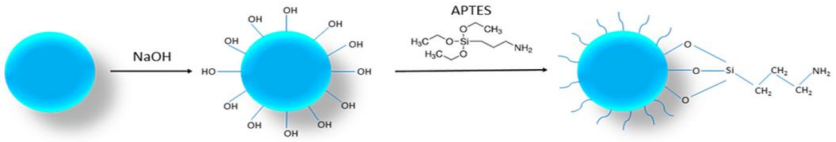
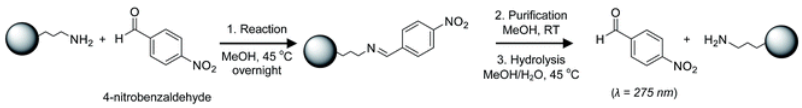
Silica Nanoparticles Surface Modification





Synthesis of silica nanoparticles

To a TEOS (2.5 mL) solution in 115 mL of dried ethanol, 3.75 mL of aqueous ammonium hydroxide solution (14.6 M) and 3.75 mL of water were added while stirring. After 12 h of stirring, silica nanoparticles were isolated by centrifugation at a speed of 15,000 rpm and the supernatant was removed. The isolated products were redispersed in ethanol. The washing process with centrifugation/redispersion was repeated 3 times. Finally, the redispersed nanoparticle solution was centrifuged at a speed of 2,000 rpm to remove any aggregated particles. The purified SiO2 nanoparticles were homogeneously dispersed in ethanol. The size and shape of the nanoparticles were characterized by TEM, FE-SEM, and DLS.

Surface modification of silica nanoparticles with aminofunctional trimethoxy silanes

10 mL of SiO2 nanoparticle solution (5 mg/mL of ethanol) was added into ten different vials. Appropriate amounts of APTMS (or DEATS) were added into each vial to maintain the conditions of surface modification; weight ratios of SiO2 : APTMS (or DETAS) were varied from 1 : 0.01 to 1 : 0.1. After 12 hr of stirring at room temperature, modified silica nanoparticles were isolated and purified by centrifugation/redispersion processes (for 10 min at 15,000 rpm, 3 times) to remove the excess APTMS (or DETAS). Finally, the purified SiO2-APTMS (or SiO2-DETAS) nanoparticles were kept dispersed in ethanol.

Quantification of amine functional groups on silica nanoparticles: 4-Nitrobenzaldehyde assay

A 500 µL aliquot of silica NP dispersion in ethanol was pipetted into a microcentrifuge tube and centrifuged for 20 min. The supernatant was removed and the NPs were redispersed by bath sonication (for at least 5 min) in 1 mL methanol containing an excess of 4-NBA (~100 fold, based on the estimated amine content corresponding to full monolayer coverage) and then reacted by heating overnight at 45 °C at 1100 rpm in a Ther-Mix heated mixer (Vitl Life Science Solutions). The particles were purified by centrifugation for 20 min, after which the supernatant was discarded and the particles were redispersed with fresh methanol to remove unreacted 4-NBA. The centrifuge/redisperse steps were repeated a total of 4 times. The NPs were isolated by centrifugation/removal of the supernatant, re-dispersed in hydrolysis solution, (1 : 1 methanol/H2O) and

incubated at 45 °C overnight. Two additional rounds of hydrolysis were performed for 1 h each. The three hydrolytic washes were saved and diluted for measurement of optical density at 275 nm. Monitoring of individual hydrolysis solutions indicated that 4-NBA was removed quantitatively with three hydrolysis steps. Calibration curves were prepared using 4-NBA in hydrolysis solution.

PEGylation of NP (mPEG-NP)

Note: X-PEG-COOH, NHS, TFP can also be used for NP modification, please check corresponding protocol accordingly.

mPEG-NP was synthesized by the reaction between the prepared NP-NH2 and mPEG-NPC. First, NP-NH2 (50 mg) was dissolved in 10 mL of deH2O. Meanwhile, a solution of mPEG-NPC in deH2O was also prepared. Then, mPEG-NPC solution was added into the NP- NH2 solution in a dropwise manner under continuous stirring for 2 h.

The final product of NP-mPEG was collected by dialysis against distilled water.

Reference

1. Quantification of amine functional groups on silica nanoparticles: a multi-method approach, Nanoscale Adv., 2019, 1, 1598
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3. "Quantitative Analysis and Efficient Surface Modification of Silica Nanoparticles", *Journal of Nanomaterials*, vol. 2012, Article ID 593471, 8 pages, 2012. https://doi.org/10.1155/2012/593471