Electronic Supplementary Information (ESI)

From macropore to mesopore: diatomite reassembled into a multifunctional composite

Experimental details

In-depth functionalization of diatomite and formation of the SN@SiO_2 composite

2 g of diatomite (purchased from Aladdin Agents, China) was added into 100 ml of 2 mol/L sodium hydroxide, stirred for 24 h at 85 °C. The liquid was centrifuged. Into 100 ml of the supernatant, 240 ml of 0.041 mol/L SN prepared with the raw liquid (chemically named octadecyl dimethyl hydroxyethyl quaternary ammonium nitrate, SN content 60%, provided by Zhejiang Runtu Co., Ltd, China) was added and mixed for 10 min. The pH of solution was adjusted to neutral with concentrated hydrochloric acid. After stationarily aging for 24 h, the liquid was centrifuged. The precipitate, i.e. wet SN@SiO_2 composite was dried with the vacuum freezing dryer (Model FD-1, Shanghai Tianfeng Industrial Co. Ltd, China) and then ground into powder for characterization of the structure, composition and morphology. The wet SN@SiO_2 composite was used directly to distribute into distilled water for measuring ζ−potential and adsorbing the dyes and NP.

Characterization of the materials

A scanning electronic microscopy (SEM) (Model Quanta 200 FEG, FEI Co, USA) and a transmission electron microscopy (TEM) with energy dispersive X-ray detector (Model TECNAI G2 S-TWIN, FEI Co., USA) were used to measure the pore size and morphology of the materials. The infrared spectra of the materials were obtained using a Fourier transform infrared spectrometer (Model Equinoxss/hyperion 2000, BRUKER Co. Germany). The surface area of the materials was measured with a surface area and porosimetry analyzer (Model ASAP2020, Micromeritics Co., USA). The small-angle X-ray diffraction (XRD) of the materials (Model D/Max-2550 PC, Japan) was recorded using CuK radiation in the range of 1 to 10^o (2θ) at 30 kV and 50 mA and the wide-angle XRD (Model Bruker D8 Advance, Germany) in range of 5 to 90^o (2θ) at 40 kV and 40 mA. A thermal analysis system (Model Q600 SDT Simultaneous DSC/TGA, TA instruments, USA) was used for the thermo gravimetric analysis (TGA) of the materials. A ζ-potential instrument (Zetasizer Nano Z, Malvern, UK) was used to determine the surface potential of the materials. The element analyzer (Model Vario EL III, Germany) was used to determine the contents of C, N and H of the SN@SiO_2 composite.

Adsorption of dyes and application as the color antistatic agents

0.1% of the SN@SiO_2 composite was added into the solutions of three sulfonic dyes, respectively i.e. direct fast light flavine 5GL, direct fast red F3B and direct fast turquoise blue GL (purchased from Shanghai Huibang Fine Chemicals Co., China), all being 1 mmol/L. The liquids were mixed thoroughly for 10 min and then centrifuged. The molarity of the dye left in the supernatant was determined with a photodiode array spectrometer (Model S4100, Sinco, Korea). The wet product was used directly as the color antistatic agents and the moisture content determined to be 80%. 50 g of the water-based epoxy paint (EP) (purchased from Shanghai Lvjia Waterborne Coatings Co., China) was mixed thoroughly with 10 g of the above color antistatic agent and 20 g of the curing agent (purchased from Shanghai Lvjia Waterborne Coatings Co., China). Immediately, the mixture was coated on a plastic plate. The paint film solidified and then slowly went dry at room temperature. Simultaneously, the EP-only film was prepared as reference. The film surface was washed with alcohol and its surface resistance was determined with a high resistance measurement device (Model ZC36, Shanghai Precision Instruments Co., China).

Adsorption of nonylphenol (NP) and disposal of the waste

0.05% of the SN@SiO_2 composite was added into the aqueous solutions of NP (purchased from Aladdin Agents, China) containing 4 to 40 mg/L. Each liquid was mixed thoroughly for 20 min. After the centrifugal separation, the concentration of NP in the supernatant was determined by a high-performance liquid chromatography (HPLC) (Model LC 2000, Hitachi, Japan) at 5.1 min with a DAD detector at 290 nm. The flow phase consisted of CH_3OH and H_2O according to 80:20 (v/v) at 1 ml/min of the flow speed through a chromatographic column (Model Allsphere ODS-25μm, Length 250 mm). The injection volume was 20 μl of water sample.

20 g of the NP-SN@SiO_2 waste produced above was calcined for 6 h at 550 ^oC with a Muffle furnace (Model SXL-1008, Shanghai Jinghong Lab Equipments Co., China). The residue was ground into powder approximately being 200 mesh and its electronic microscopic images obtained with the above SEM and TEM.

Figures S1 to S8

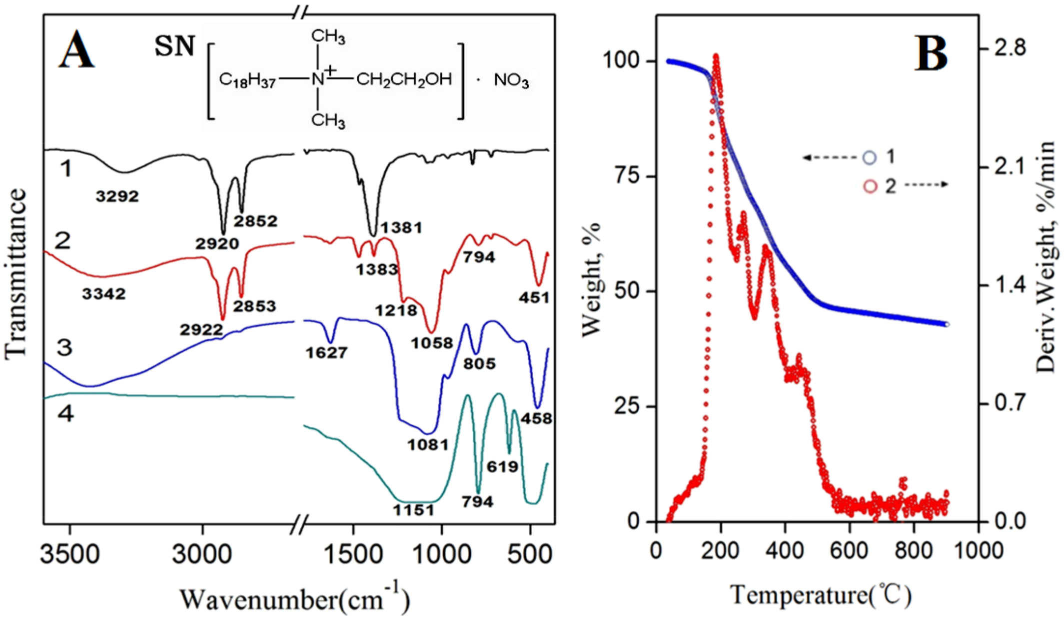


Fig. S1 A: IR spectra of the SN (1), $SN@SiO_2$ composite (2), the $NP\text{-}SN@SiO_2$ waste calcined (3) and diatomite (4); B: TG of the $SN@SiO_2$ composite (1) and its derivative weight (2)

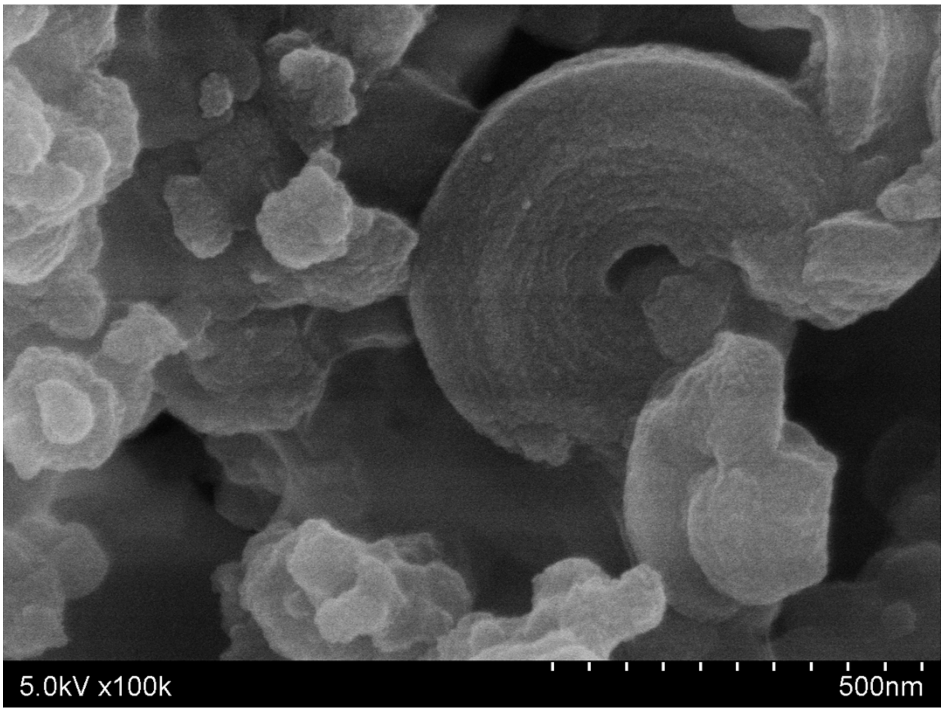


Fig. S2 SEM images of the $SN@SiO_2$ composite

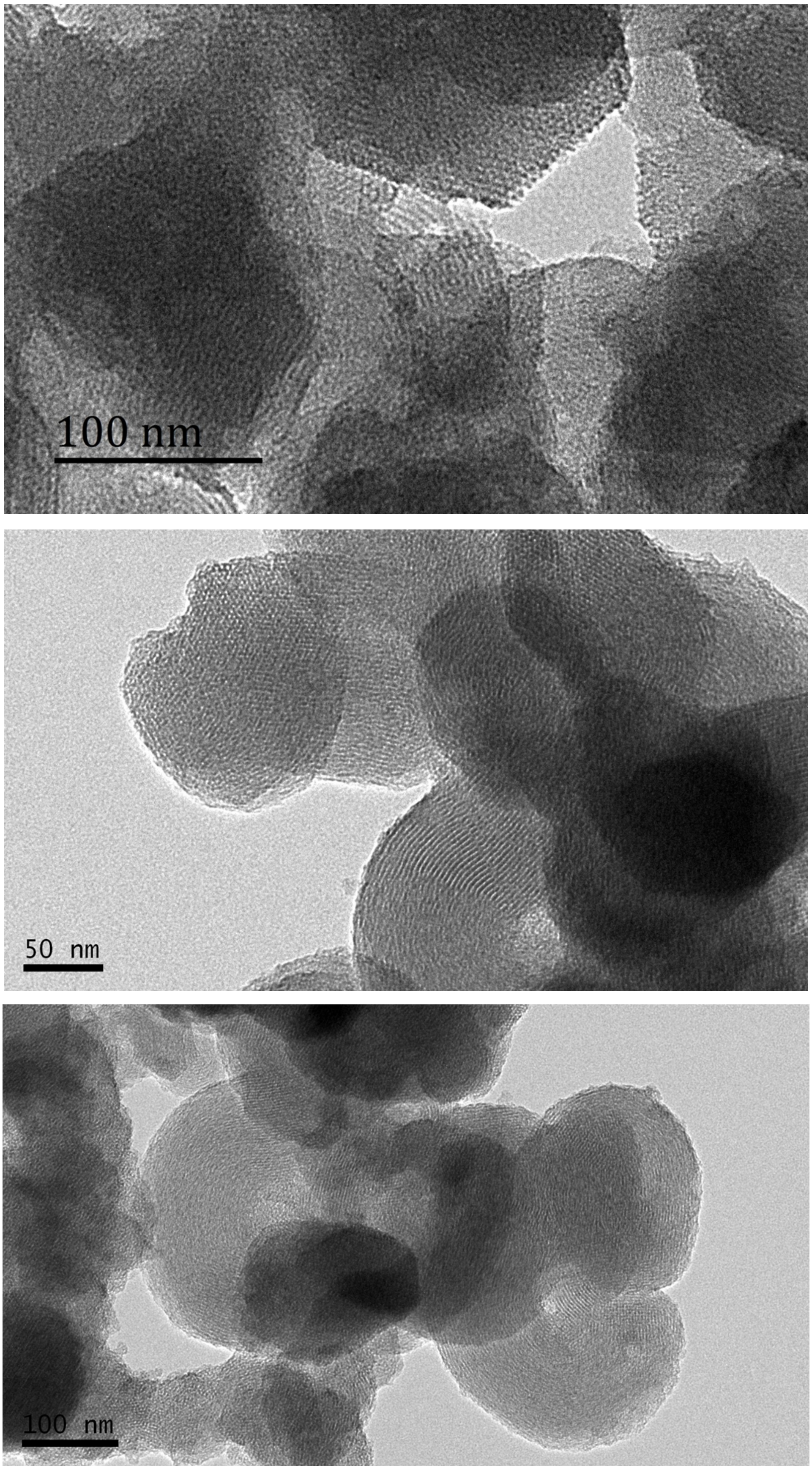


Fig. S3 TEM images of the SN@SiO_2 composite

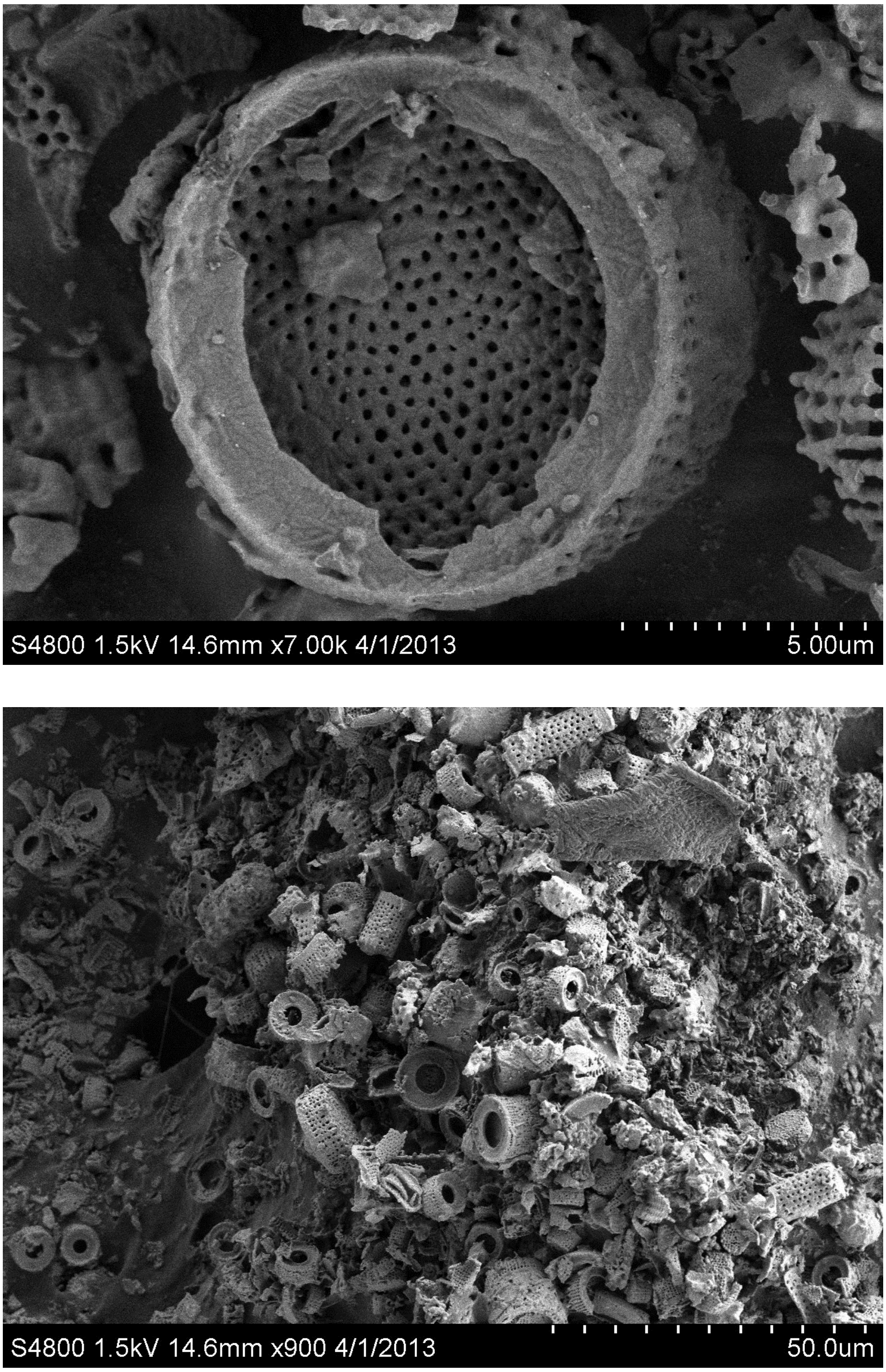


Fig. S4 SEM images of diatomite

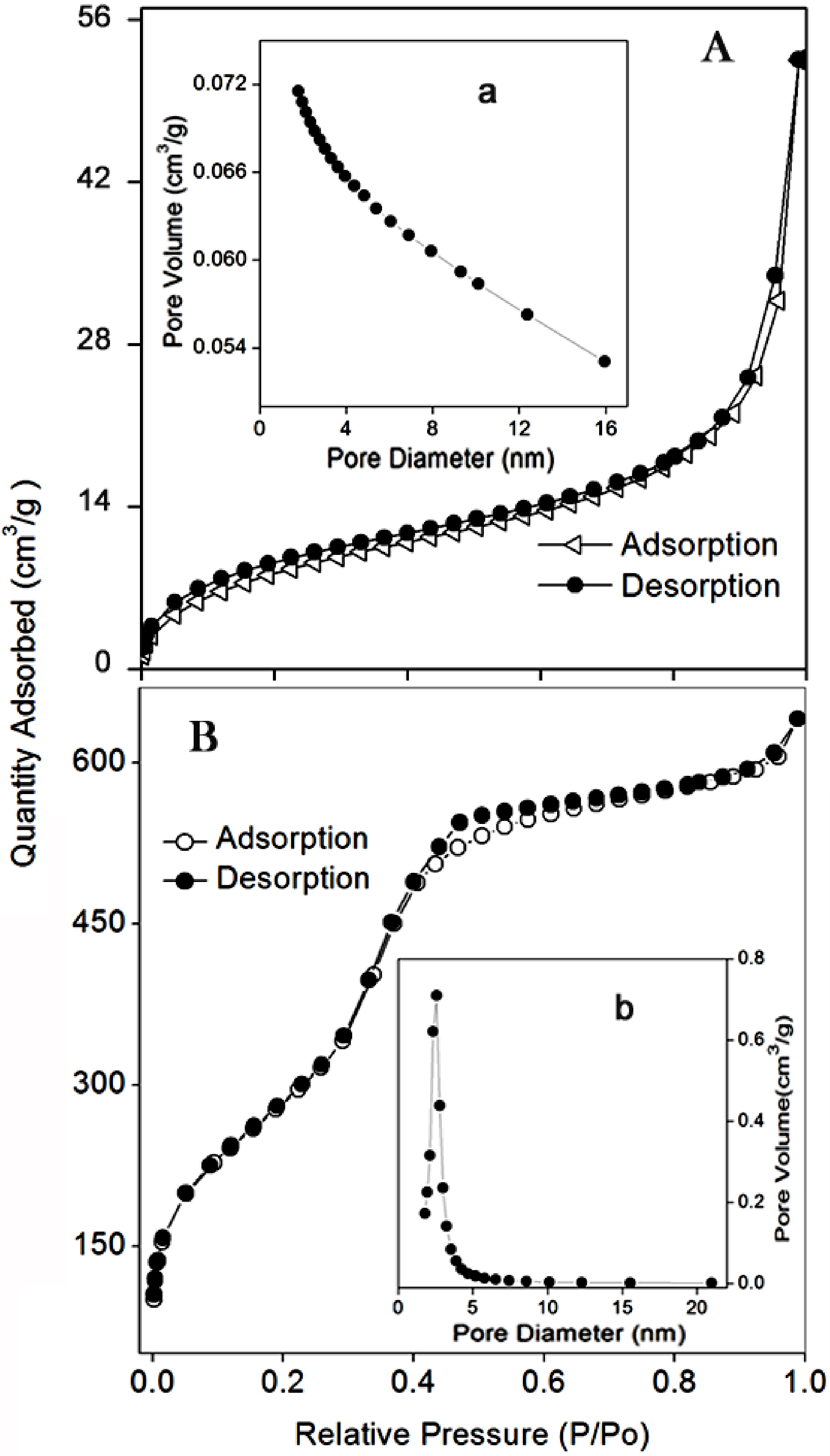


Fig. S5 N_2 adsorption / desorption isotherm curves for the SN@SiO_2 composite (A) and the NP-SN@SiO_2 waste calcined (B) and their pore size distribution curves (a and b).

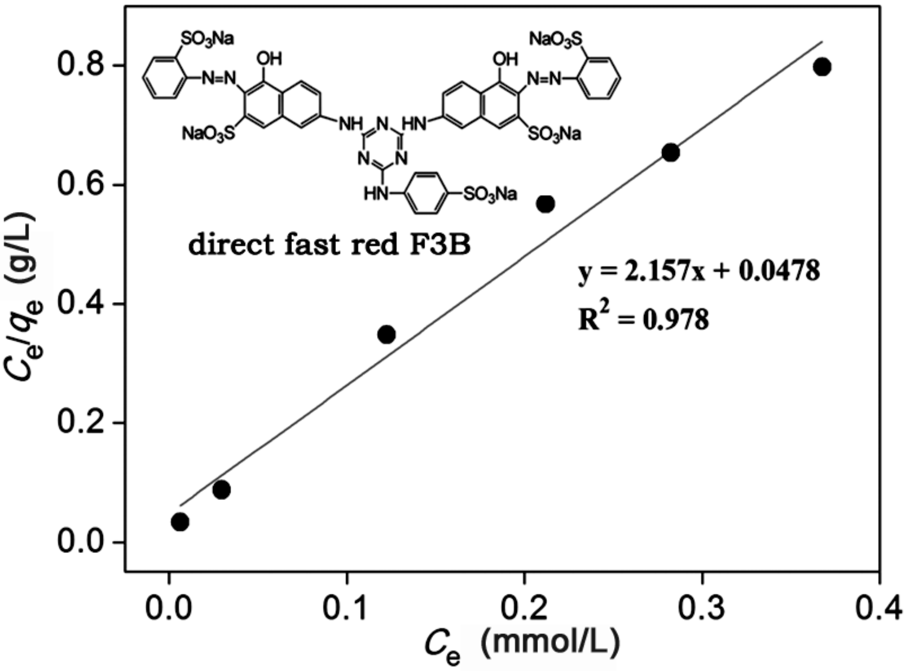


Fig. S6 Plots C_e/q_e vs. C_e for the adsorption of direct fast red F3B on the SN@SiO$_2$ composite, C_e - the equilibrium molarity of direct fast red F3B in mmol/L and q_e - the binding amounts of direct fast red F3B in mmol/g.

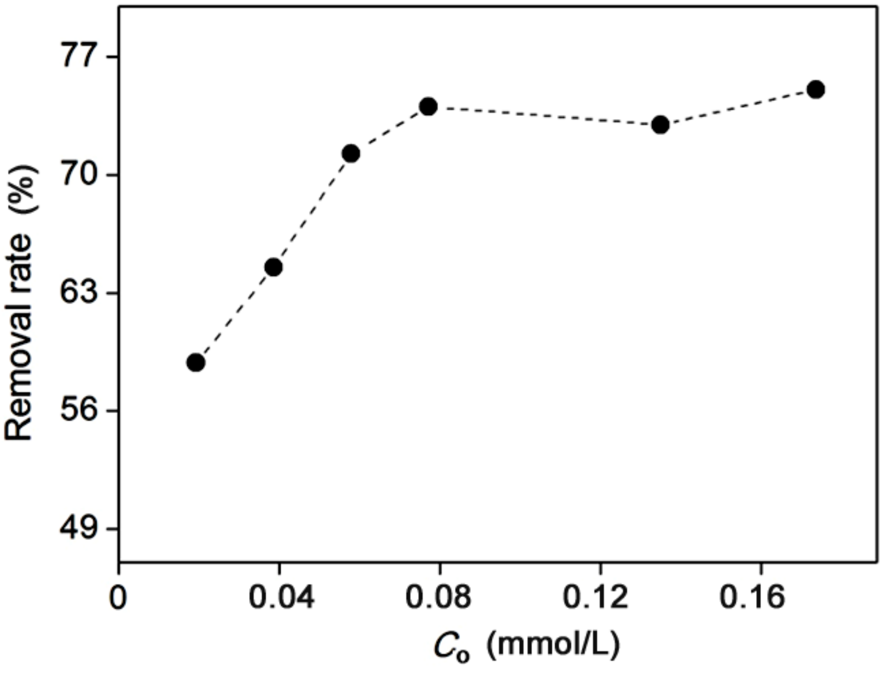
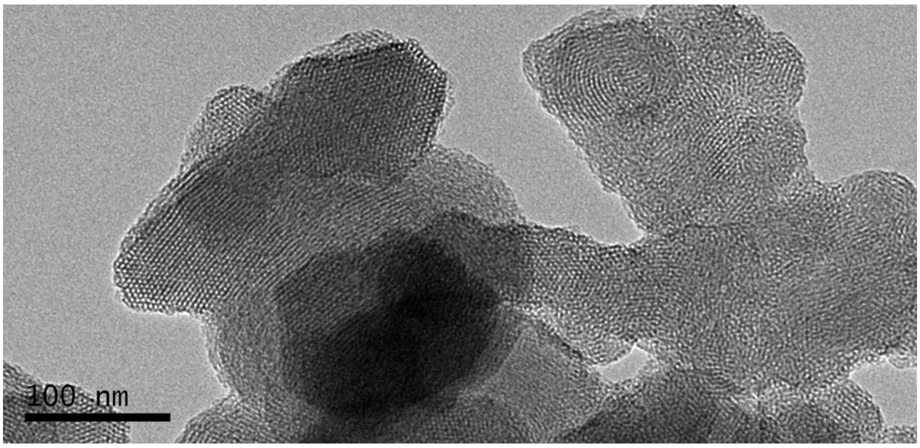


Fig. S7 Removal of NP from aqueous solution treated with the SN@SiO$_2$ composite. C_o is the initial concentration of NP in mmol/L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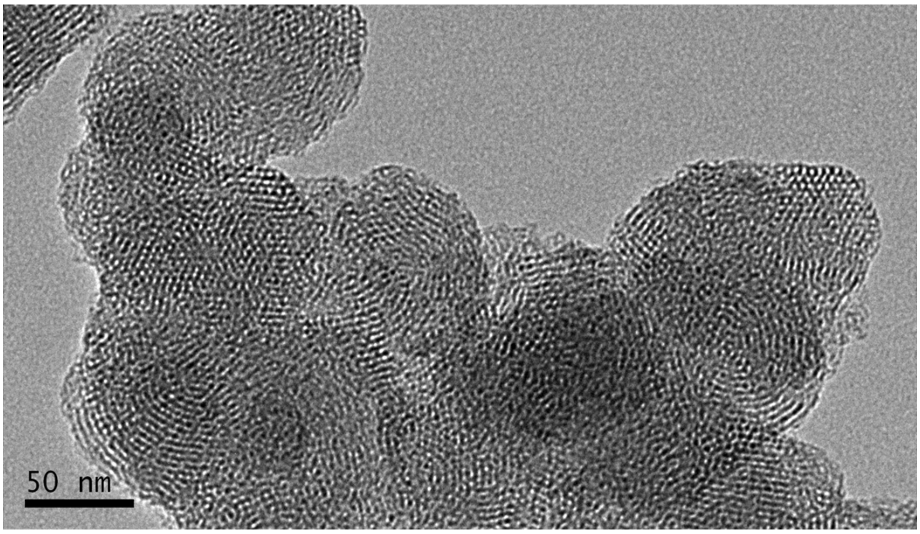
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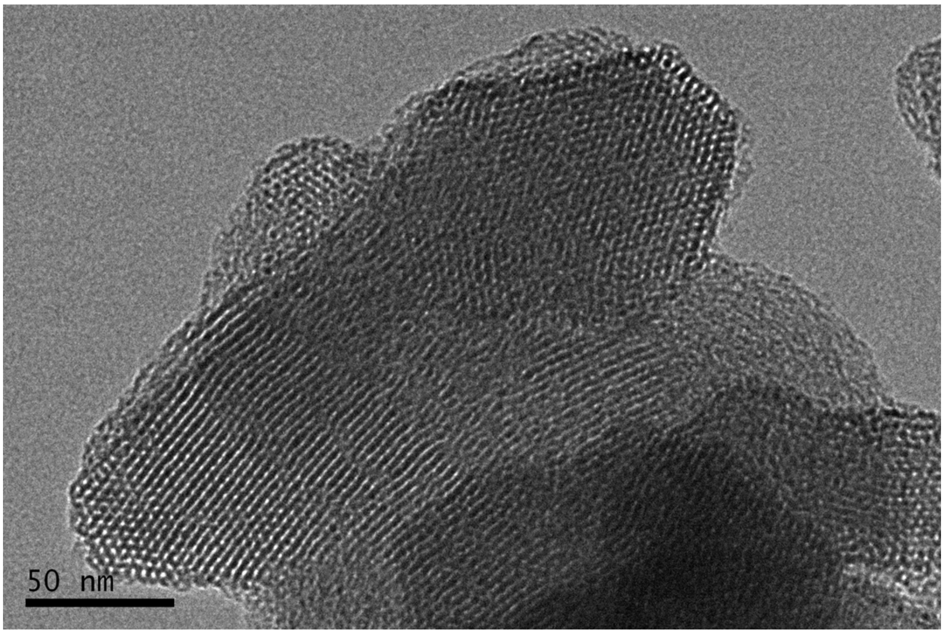
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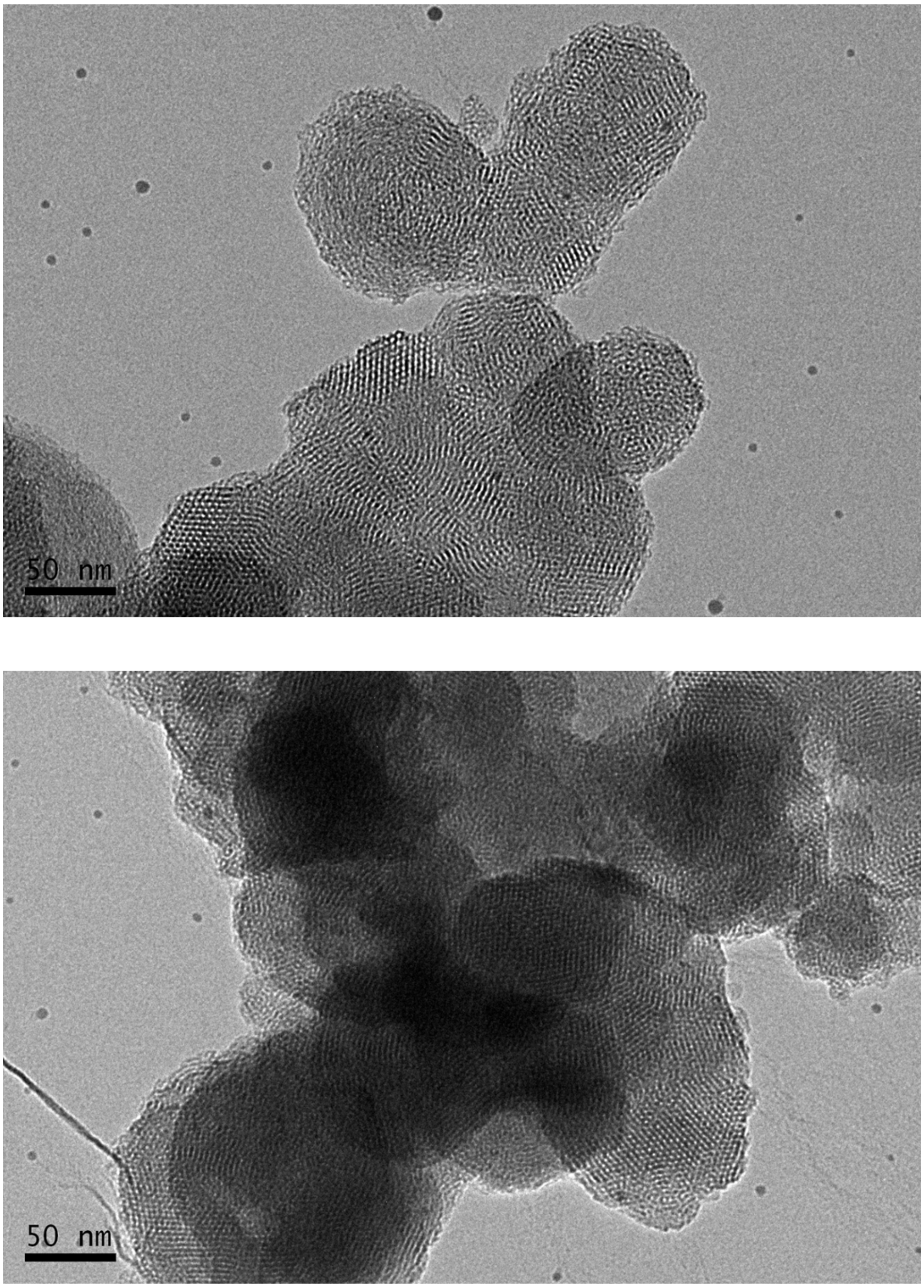

Fig. S8 TEM images of the NP-SN@SiO$_2$ waste calcined at 550 ^{o}C.