

Supplementary Information for:

**Fabrication of Monodisperse Silica-Polymer Core-Shell
Nanoparticles with Excellent Antimicrobial Performance**

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1. Experimental Section

Synthesis of ADMH: A solution of 6.4 g (0.05 mol) of 5,5-dimethylhydantoin (DMH) in 25 mL H₂O containing 2.8 g (0.05 mol) of KOH was mixed with a solution of 4.4 mL (0.05 mol) allyl bromide in 10 mL of methanol. The solution was stirred at 60 °C for 2 h, cooled, and dried under reduced pressure at room temperature. The resulting product was recrystallized from petroleum ether.

Fabrication of Core-Shell Nanoparticles: Silica-poly(ADMH-co-MMA) core-shell nanoparticles were obtained using a seeded polymerization. Silica nanoparticles of three diameters (diameter: 7, 12, and 22 nm; BET surface area: 345, 220, and 140 m² g⁻¹) were employed as the nanoseed. To fabricate the core-shell nanoparticles, first, 0.5 g of silica nanoseeds was dispersed by sonication for 10 min in 200 mL of distilled water. Subsequently, 0.01 g of CAN was dissolved in 2 mL of 0.1 M HNO₃ solution and then introduced into the colloidal silica solution. The ADMH/MMA mixture (0.05 g/0.95 g) was added into the solution. The redox-initiated radical copolymerization of ADMH/MMA proceeded on the surface of the CAN-covered nanoseeds for 24 h at 75 °C. After several washing steps, the resulting core-shell nanoparticles were dried in a vacuum oven at room temperature.

The BET surface area of the core-shell nanoparticles was strongly affected by the core nanoparticles used and the use of a larger starting nanoparticle led to a smaller difference between before and after BET surface areas, as shown in Table S1 (References: Arnal et al.

Chem. Commun. **2006**, 1203–1205; Jang et al. *Chem. Commun.* **2005**, 4214–4216). Therefore, the surface area or size effect of the core-shell nanoparticles on biocidal efficacy could be examined.

Table S1. The BET surface area of silica nanoparticles before and after polymer coating

Core size (nm)	Before ^[a] (m ² g ⁻¹)	BET surface area After ^[b] (m ² g ⁻¹)	Difference (a–b)
7	345	284	61
12	220	190	30
22	140	125	15

Chlorination of Core-Shell Nanoparticles: The hydantoin groups of the copolymers were transformed into *N*-halamine structures. 0.5 g of the core-shell nanoparticles was dissolved in 20 mL of 4 wt% sodium hypochlorite (NaOCl) solution, stirred for 24 h at 80 °C, and then washed thoroughly with a large excess of distilled water to remove free chlorine and other impurities.

Investigation of Antibacterial Activities: The antibacterial properties of the grafted samples were explored according to the spread plate method. First, the stock solution was prepared by adding 0.2 mL of phosphated buffer saline (PBS) to a 50 mL Falcon tube containing 9.7 mL of distilled water and 0.1 mL of bacteria stock solution adjusted initial

concentration to 2×10^9 CFU mL⁻¹. Subsequently, 1 mL of the stock solution was added to a 1.6 mL Eppendorf tube containing 10 mg of the core-shell nanoparticles. After centrifuging to separate the powder, 0.1 mL of supernatant was withdrawn to an Eppendorf tube containing 0.9 mL of PBS at each sampling time. Viable cell counts were performed using the spread plate method, which included plating *E. coli* and *S. aureus* cells on nutrient agar incubated at 37 °C for 24 h and counting the number of viable colonies, respectively.

2. FT-IR spectra

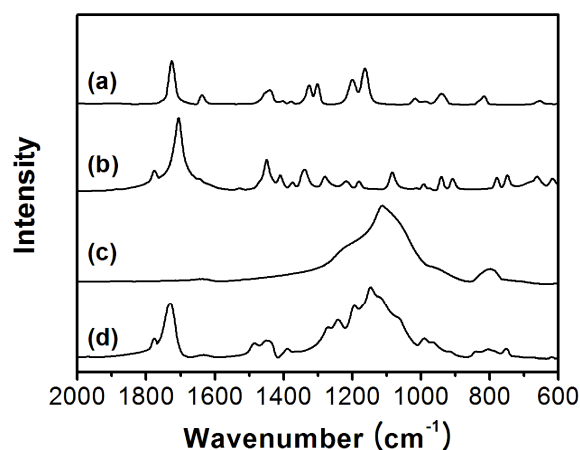


Fig. S1 FTIR spectra of (a) MMA, (b) ADMH, (c) silica, and (d) silica-poly(ADMH-*co*-MMA) core-shell nanoparticles.

The spectroscopic analysis of the core-shell nanoparticles was performed by FT-IR spectroscopy. **Figure S1** exhibits the comparative spectra of individual components for the core-shell nanoparticles. In Figure S1d, the characteristic peaks of poly(CADMH-*co*-MMA) was observed at 2998, 2952, 1791, 1487–1389 and 988 cm^{-1} , which demonstrated the formation of the copolymer shell onto the silica core. The peaks at 2998 cm^{-1} and 2952 cm^{-1} are ascribed to CH_3 stretch vibration. The peaks at 1487–1389 cm^{-1} represent the deformation of $-\text{CH}_2$ and $-\text{CH}_3$ groups. The peak at 988 cm^{-1} is attributed to C–O–C stretching mode and the band at 1732 cm^{-1} refers to the stretching vibration of C=O. After the polymerization, the C=C stretching peak of MMA (Figure S1a) and ADMH (Figure S1b) monomers disappeared

at 1620 cm^{-1} on the spectrum of the polymer coated core-shell nanoparticles. Importantly, a broad band centered at *ca.* 1791 cm^{-1} was detectable, which could be attributed to the *N*-halamine structure. Judging from these data, it can be concluded that silica-poly(CADMH-*co*-MMA) core-shell nanoparticle was successfully synthesized.

3. Photos of *E. Coli* culture plates

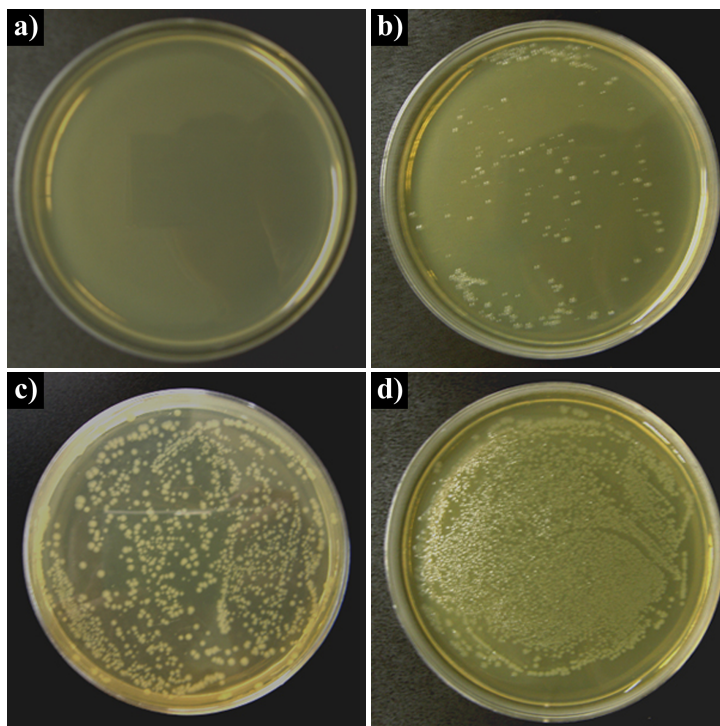


Fig. S2 Photographs showing the *E. Coli* culture plates upon 30 min-exposure to the core-shell nanoparticles (5 mg mL^{-1}) of different diameters: (a) 11 nm, (b) 16 nm, (c) 26 nm, (d) bulk.