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Uncovering alternate charge transfer mechanisms in *Escherichia coli* chemically functionalized with conjugated oligoelectrolytes

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Supplementary Information

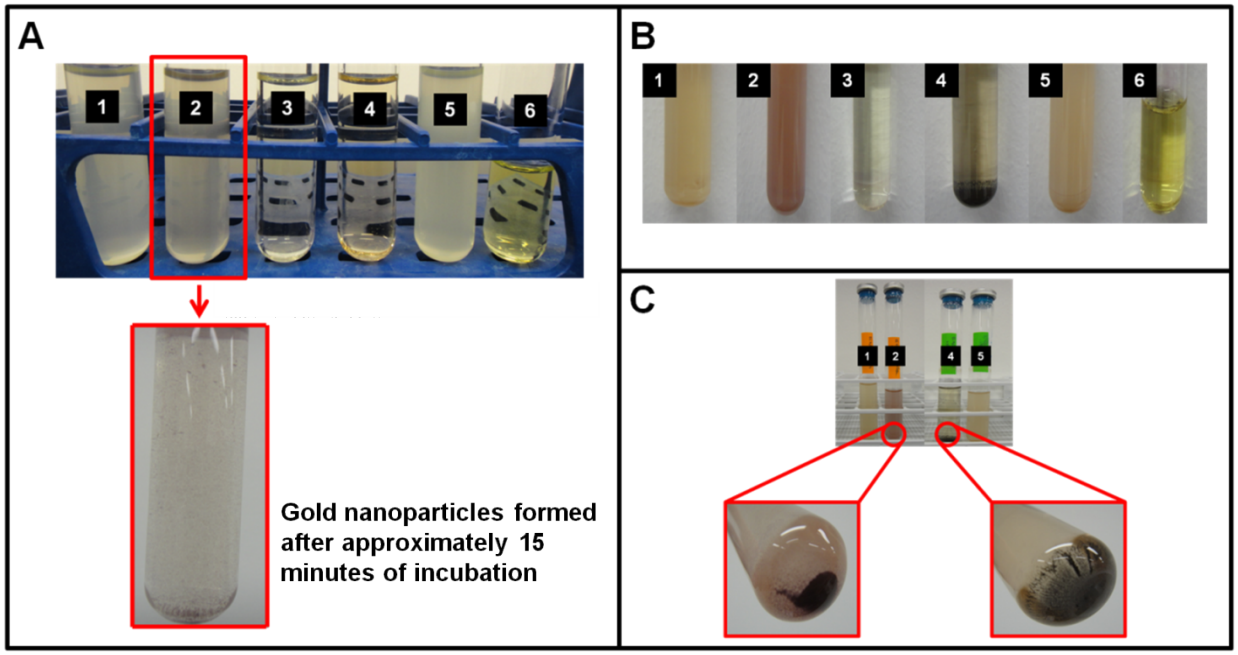

Fig. S1 (A) Photograph depicting reaction tubes at 0 hours. (1) Ultrapure water + *E. coli* + $HAuCl_4$ (2) Ultrapure water + *E. coli* + $HAuCl_4$ + DSSN+ (3) Ultrapure water + $HAuCl_4$ (4) Ultrapure water + supernatant (from DSSN+ incorporated *E. coli*) + $HAuCl_4$ (5) Ultrapure water + *E. coli*/DSSN+ pellet + $HAuCl_4$ (6) $HAuCl_4$ + DSSN+. Dark purple particles were observed after approximately 15 minutes of incubation in Tube 2. (B) Photograph depicting reaction tubes after 6 days. (C) Comparison between various reaction tubes.

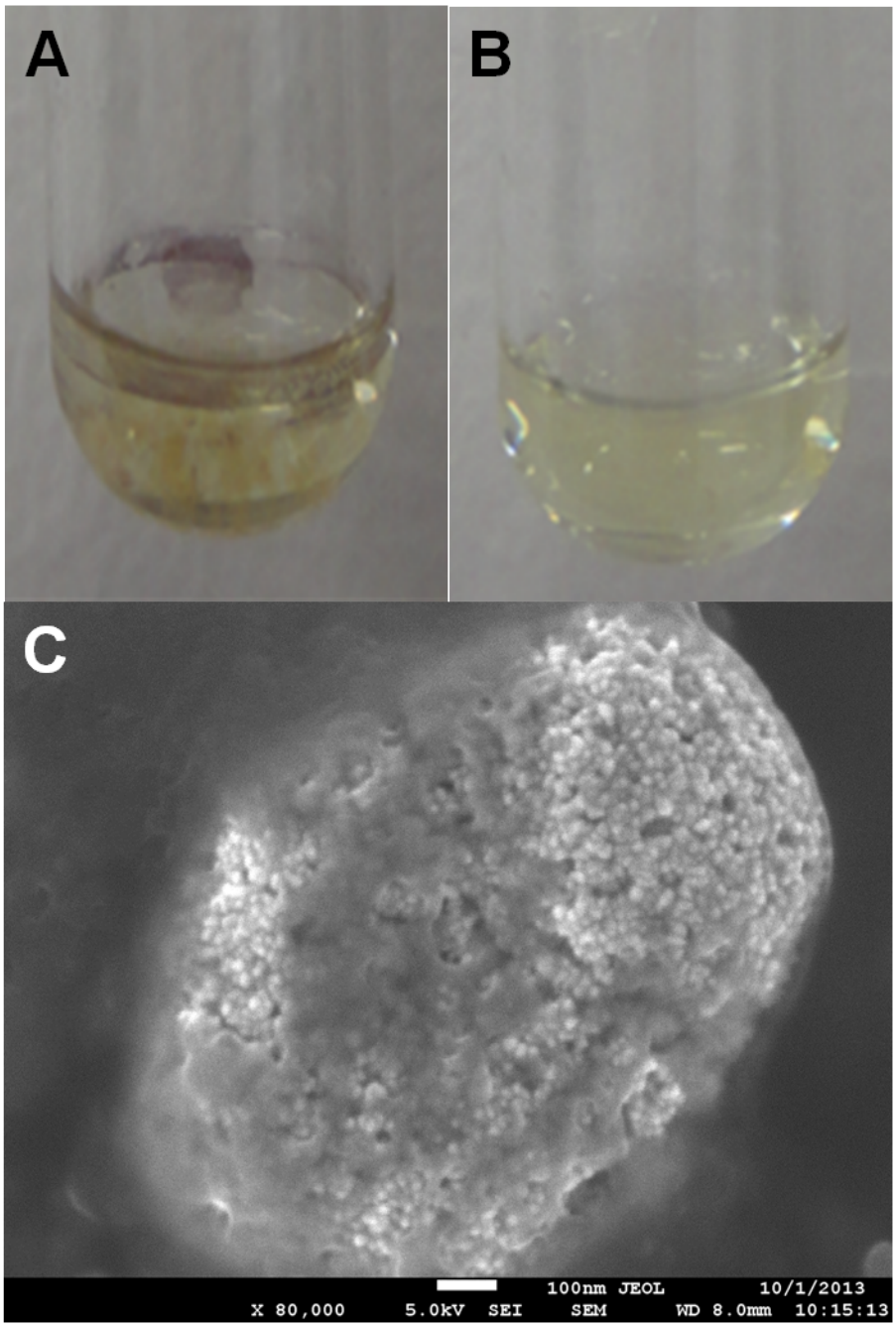

Fig. S2 Photograph depicting reaction tubes containing gold precursor mixed with (A) Supernatant collected from *E. coli* with sonication for 20 minutes; (B) Supernatant collected from *E. coli* with no sonication. (C) Field emission scanning electron microscopy image of gold nanoparticles collected from precipitates in Tube A. Reactions in tubes occurred over 24 hours.

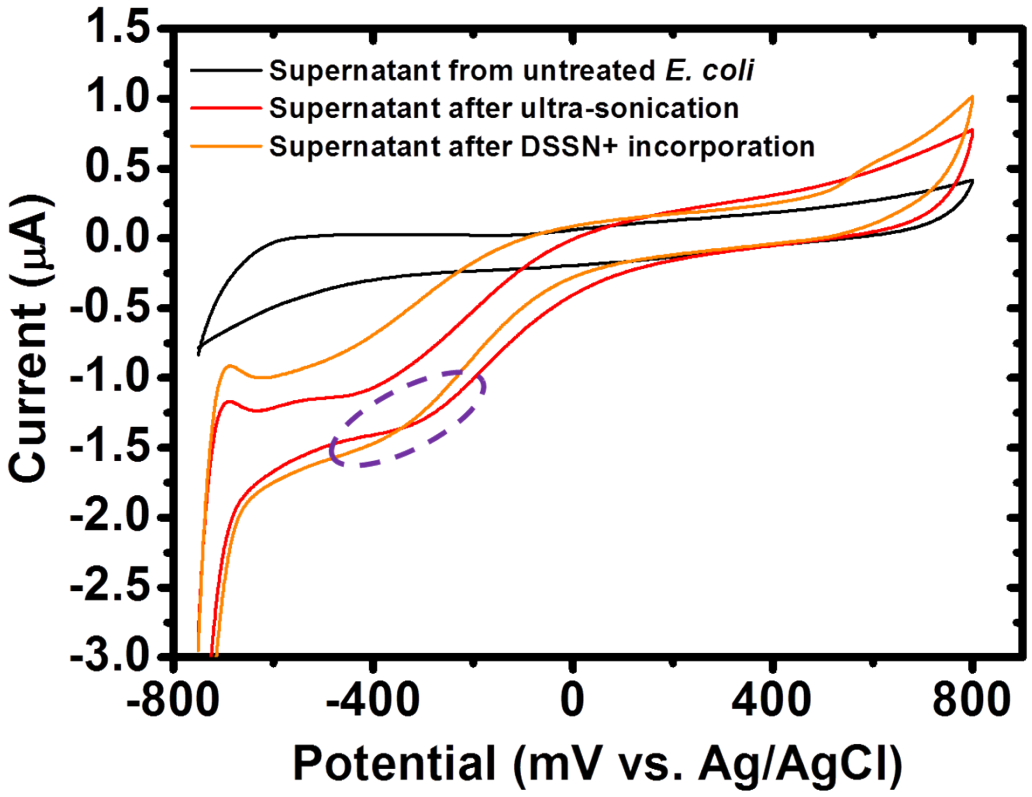

Fig. S3 Individual cyclic voltammetry traces of supernatants collected from untreated *E. coli*, after ultra-sonication and DSSN+ incorporation, suggesting presence of electroactive components, such as quinones. Supernatants were in 1 M KCl (pH ~7.4). Scan rate was fixed at 1 mV/s.

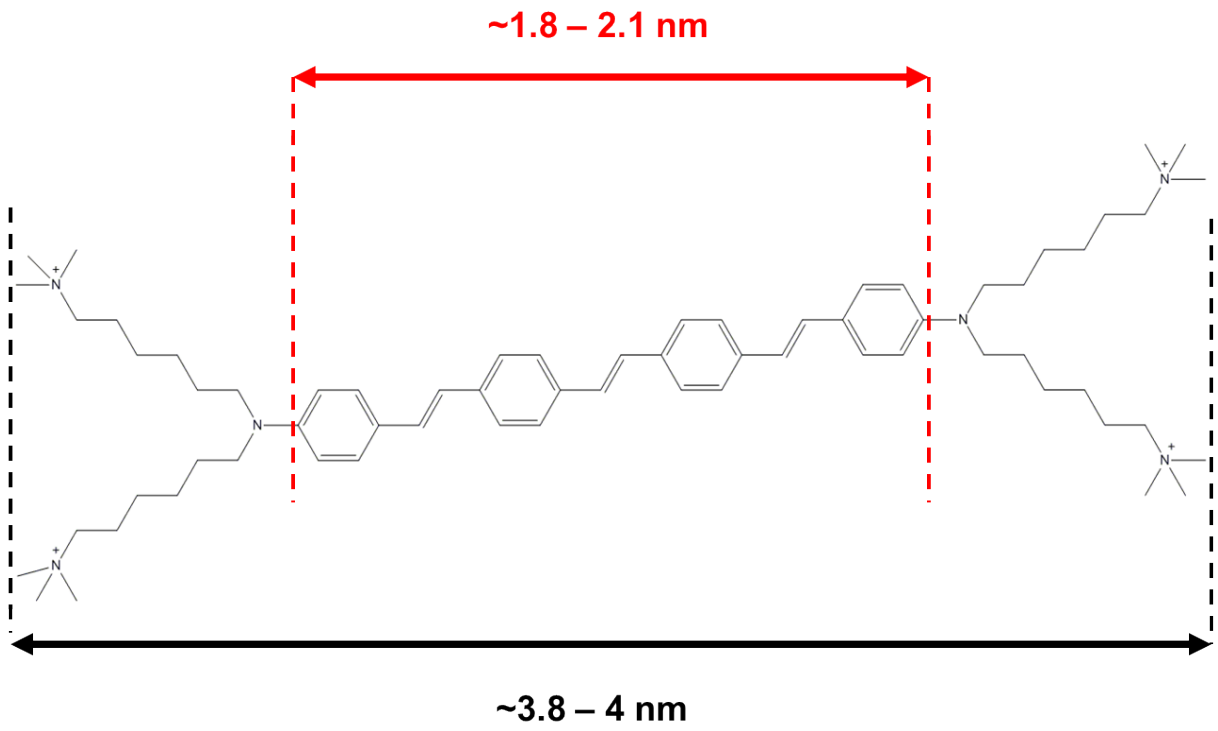

Fig. S4 Schematic depicting lengths of DSSN+ and its conducting core

Materials and Methods

Bacterial strain and growth conditions

E. coli K-12 (ATCC #10798) was purchased from American Type Culture Collection (Manassas, VA). The stock culture was stored in lysogeny broth (LB) medium with 25% glycerol at -80°C. *E. coli* was grown aerobically in 20 mL of LB medium at 37°C overnight. For DSSN+ incorporation, 100 µL of filter-sterilized DSSN+ stock solution (1 mM prepared in ultrapure water) was added to the culture solution (OD_{600} ~ 1.0) to achieve a 5 µM DSSN+ concentration. The mixture was incubated at 37°C (200 rpm) for 5 hours for full intercalation of DSSN+ in the microbial membrane. The synthesis of DSSN+ is described in the literature[1].

Formation of gold nanoparticles

All reaction tubes, bungs and ultrapure water were autoclaved for sterility after thorough cleansing. 5 mM of chloroauric acid solution ($HAuCl_4$, Sigma Aldrich) was prepared in ultrapure water and filter-sterilized. 50 µL of DSSN+ stock solution was added to 2 mL of *E. coli* culture and 2 mL of as-prepared chloroauric acid solution. The balance of the reaction solution was supplemented with 6 mL of sterile ultrapure water to make up a total working volume of 10 mL. Control experiments with unmodified *E. coli* under the same reaction conditions were also prepared. Experimental procedures for water-based formation of gold nanoparticles were modified from reported literature[2].

Procedures for ultra-sonication

E. coli culture was grown as described. Prior to ultra-sonication with a SM Vibracell CVX750 Probe Ultrasonicator, the culture was centrifuged (8000 rpm for 5 minutes) and washed with ultrapure water to remove any residual components on the cell periphery. The resulting pellet was resuspended in ultrapure water for sonication. Ultra-sonication was carried out for 20 minutes at 30% amplitude at 20 kHz. The total process was 40 minutes with 5 seconds of pulsing, followed by 5 seconds of rest. In addition to this precaution to prevent overheating the system, which may cause the intracellular components to denature, ice was used to cool the system during ultra-sonication. Centrifugation at 12 000 rpm for 10 minutes was performed to isolate the supernatant containing the released cytosolic components from the insoluble membrane fragments in the resulting pellet.

Conditions of MFCs and electrochemical set-up

Dual chamber U-tube MFCs were constructed as reported previously[3-5]. The supernatant was introduced to the anode. 20 mL of re-suspended *E. coli*/DSSN+ pellet was also introduced into a separate anode. Data recording started immediately after devices were placed in the incubator. Cyclic voltammetry was performed using a three-electrode setup with a CHI-660D Electrochemical Workstation (CH Instrument). The working electrode was platinum, the reference electrode was Ag/AgCl and glassy carbon was used as the counter electrode. Scan rate was 1 mV/s. Supporting electrolyte was 1 M KCl (pH ~7.4).

Morphology and optical characterization of gold nanoparticles

Sediment nanoparticles were dislodged and homogenized via quick ultra-sonication of the reaction test tubes. Optical absorption measurements were performed using a Shimadzu UV 3600 UV-visible absorption spectrometer between the wavelengths of 450 nm to 800 nm. Presence of gold element in chemically transformed nanoparticles was characterized with energy-dispersive x-ray (EDX) spectroscopy and morphology of nanoparticles collected from reaction test tubes was imaged with a JEOL, JSM-7600 F field emission scanning electron microscopy (FESEM) with an Oxford attachment at an operating voltage of 5 kV.

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