Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary information of

Electrical Properties of Outer Membrane Extensions from *Shewanella Oneidensis* MR-1

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S1. Additional data to Figure 1a.

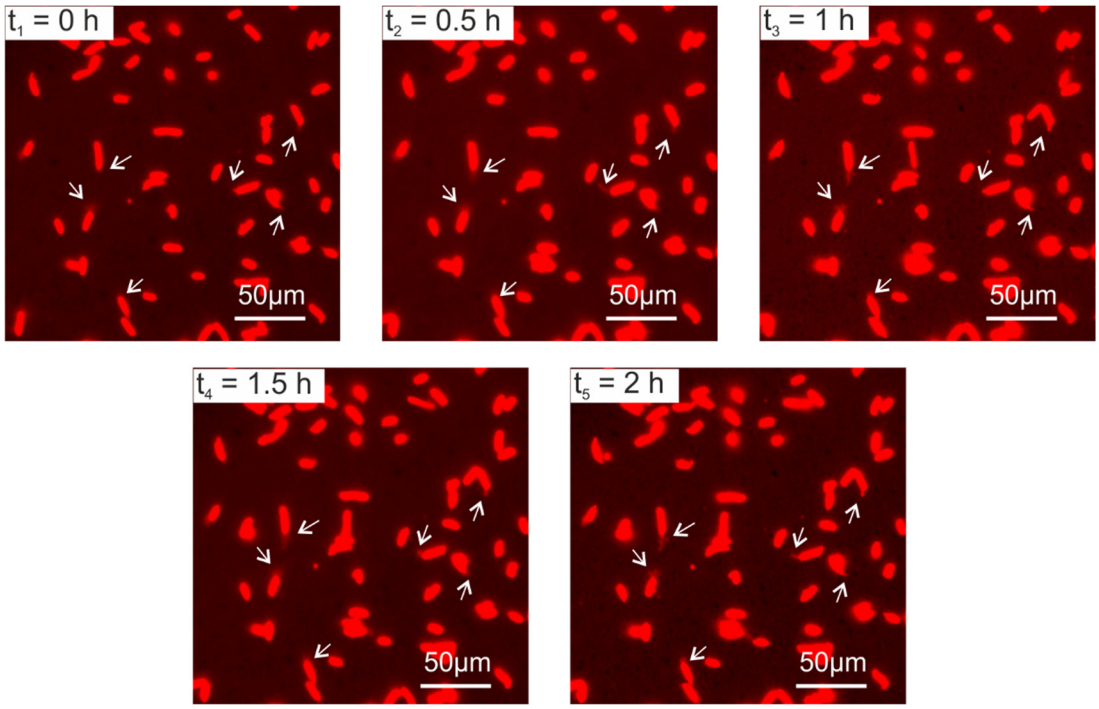

Figure S1*: Time sequence of fluorescence light microscope images of S. oneidensis bacterial cells labelled with the membrane dye* FM™-464FX*. White arrows point towards some of the OMEs.*

S2. Effect of hydration on the OMEs physical dimensions

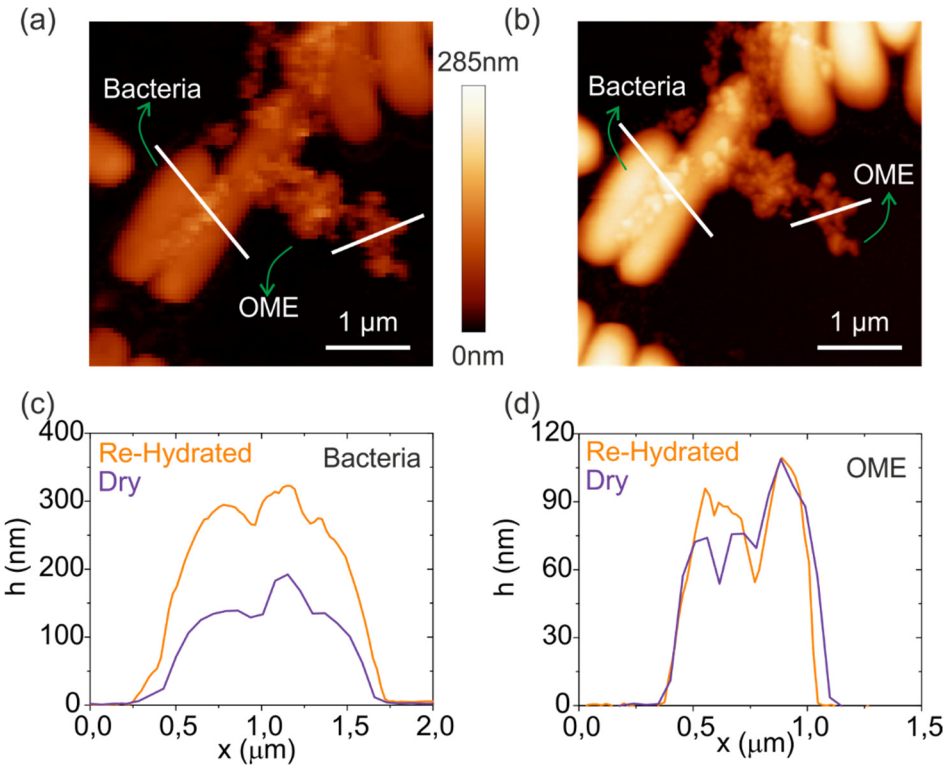

Figure S2*: (a) and (b) AFM topography images of S. oneidensis bacterial cells with OMEs adsorbed on a glass substrate in dry air and fully re-hydrated conditions, respectively. (c) and (d) Topographic cross-section profiles of the bacterial cell and of the OMEs, respectively, in air and re-hydrated conditions along the lines in (a) and (b). While the bacterial cell nearly doubles its size upon-rehydration, OMEs remain almost unaffected.*

S3. Additional data to Figure 2c

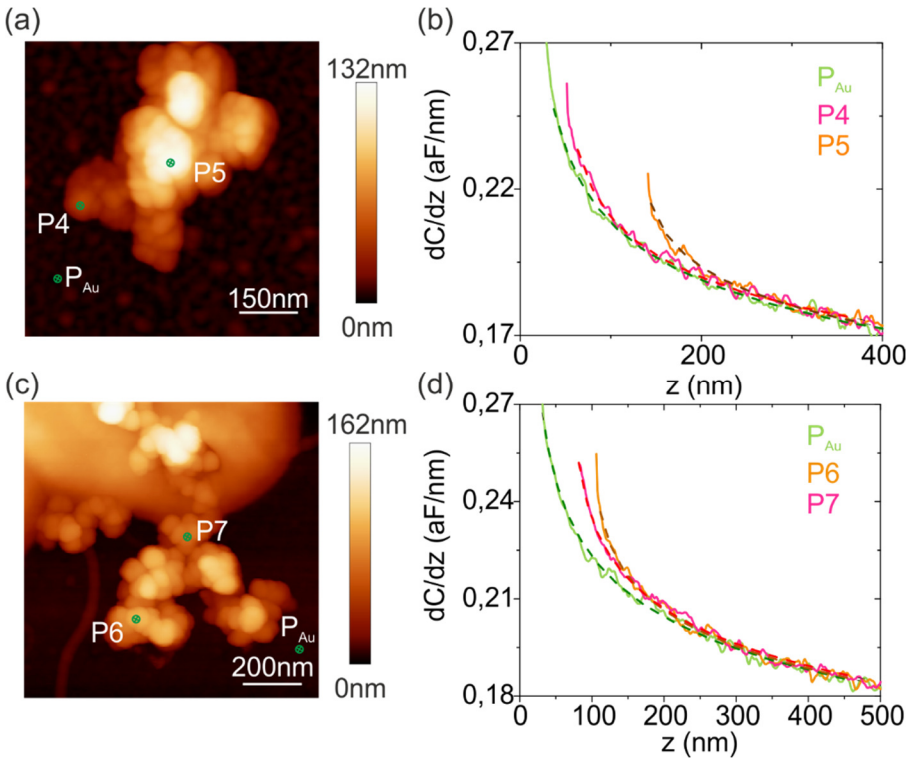

***Figure S3**: (a) and (c) AFM topographic images of two Shewanella oneidensis OMEs, and (b) and (d) corresponding capacitance gradient curves measured at selected positions. The dashed lines represent the theoretically fitted curves, from where the tip geometry and the equivalent homogeneous dielectric constants have been extracted. Parameters for (a) and (b): tip PtSi-CONT, k = 0.4 N/m, V_{ac} = 5 V, f_{el} = 2kHz, R = 31 ± 2 nm, ϑ = 22 ± 3°, C'_{offset} = 88 ± 1 zF/nm, ε_{OME} = 3.6 ± 0.1. Parameters for (c) and (d): tip PtSi-CONT, k = 0.3 N/m, V_{ac} = 5 V, f_{el} = 2kHz, R = 25 ± 2 nm, ϑ = 22 ± 3°, C'_{offset} = 103 ± 1 zF/nm, ε_{OME} = 4.3 ± 1.0.*

S4. Additional data to Figure 3.

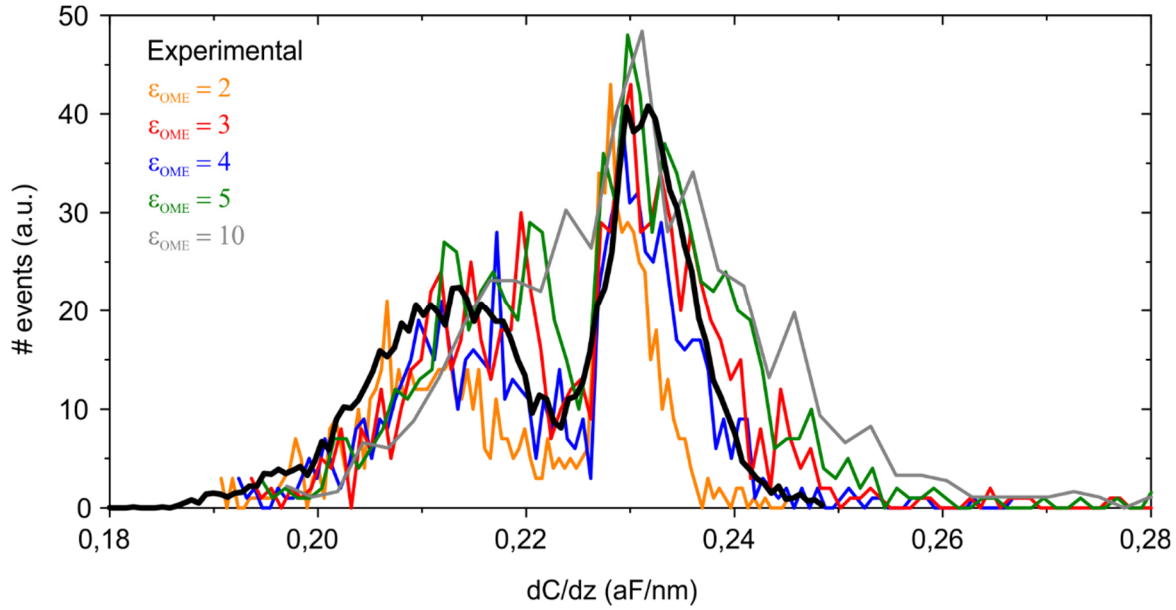

***Figure S4**: Histogram analysis of the experimental lift-mode dC/dz SDM image shown in Fig. 3b of the main text (black line), and the theoretically calculated ones shown in Figs. 3h-3l corresponding to equivalent homogeneous dielectric constants ε_{OME} = 2, 3, 4, 5, 10 (remaining lines). The best agreement is found for ε_{OME} = 3 – 4 (red and blue lines).*

S5. Effect of the shell conductivity on the dC/dz values for a core-shell model of the OMEs.

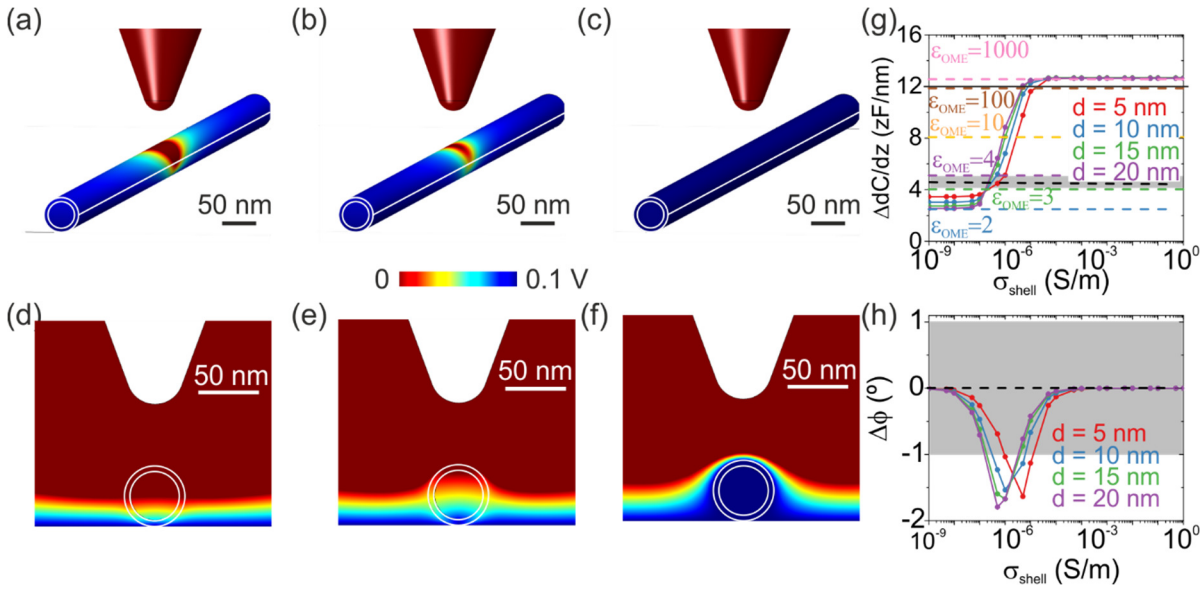

***Figure S5**: Calculated electric potential distributions on the surface (a)-(c) and cross-section (d)-(f) of a cylindrical conductive core-shell model of an OME for three characteristic homogeneous conductivities of the shell $\sigma_{shell} = 10^{-9}$ S/m (insulator), $\sigma_{shell} = 2.5 \cdot 10^{-6}$ S/m (insulator with losses) and σ_{shell}=1 S/m (conductor). (g) Capacitance gradient contrast and (h) dephasing as a function of the conductivity of the shell, σ_{shell}, for four different values of the thickness of the shell (d = 5 nm, 10 nm, 15 nm and 20 nm). The black dashed lines correspond to the value of a homogeneous dielectric model with the experimentally found equivalent homogeneous dielectric constant ($\varepsilon_{eq} = 3.7$). The remaining dashed lines correspond to the indicated values in the figure. The grey areas correspond to the uncertainty in the measurements due to the noise of the measuring set-up. Parameters used in the calculations: width and height of the OME $h_{OME} = w_{OME} = 50$ nm, length of the OME $L_{OME} = 4$ µm, tip-sample distance = 50 nm, ε_{core}=3, ε_{shell}=2, σ_{core}=0 S/m, R = 23 nm, $\vartheta = 20°$, H = 12.5 µm, $L_c = 3$ µm and $W_c = 3$ µm.*

S6. OMEs growth reactor

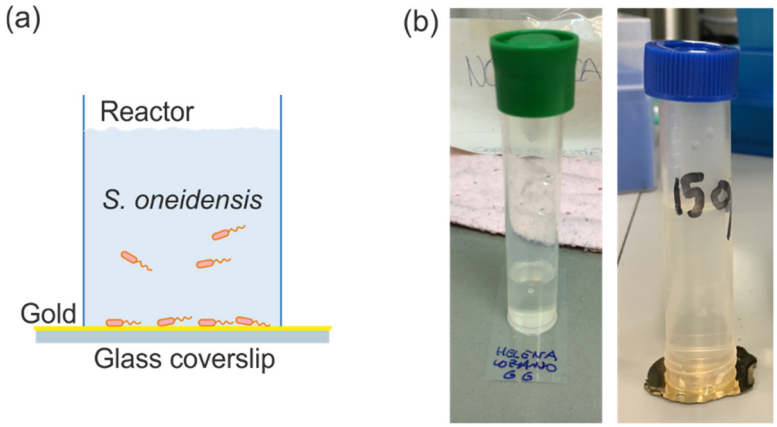

Figure S6*: (a) Schematic representation of the reactor used to growth the OMEs. (b) Pictures of the reactor set-up used with a glass coverslip and a gold-coated glass coverslip.*

S7. SDM measurements on chemically fixed OMEs

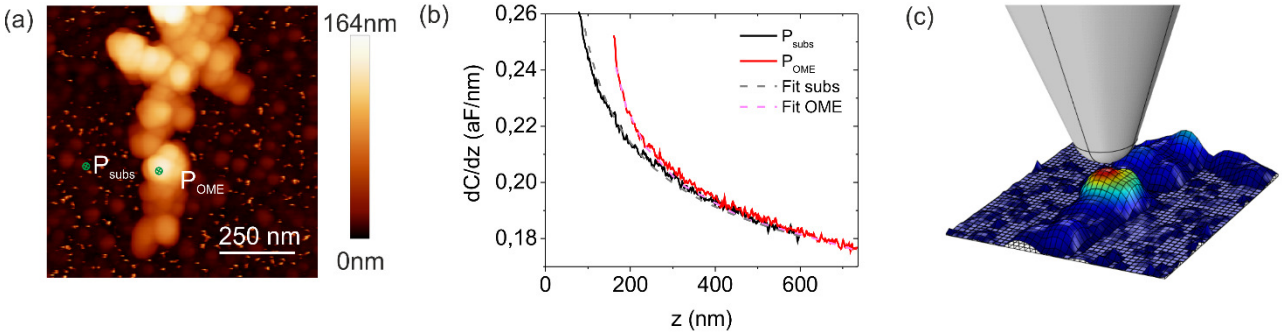

***Figure S7**: (a) AFM topographic image of a chemically fixed Shewanella oneidensis OME on an ITO substrate, and (b) corresponding capacitance gradient curves measured at the selected positions (continuous lines). The dashed lines represent the theoretically fitted curves calculated with the geometrical model shown in (c), obtained from the topographic image around point P_{OME}, from where the tip geometry and the equivalent homogeneous dielectric constants have been extracted. Parameters: tip PtSi-CONT, k = 0.15 N/m, V_{ac} =4 V, f_{el} = 2kHz, R = 117 ± 6 nm, ϑ = 20 ± 1°, C'_{offset} = 112 ± 1 zF/nm, ε_{OME} = 3.2 ± 0.6.*

S8. Effect of an asymmetric shell conductivity on the dC/dz values for a core-shell model of the OMEs.

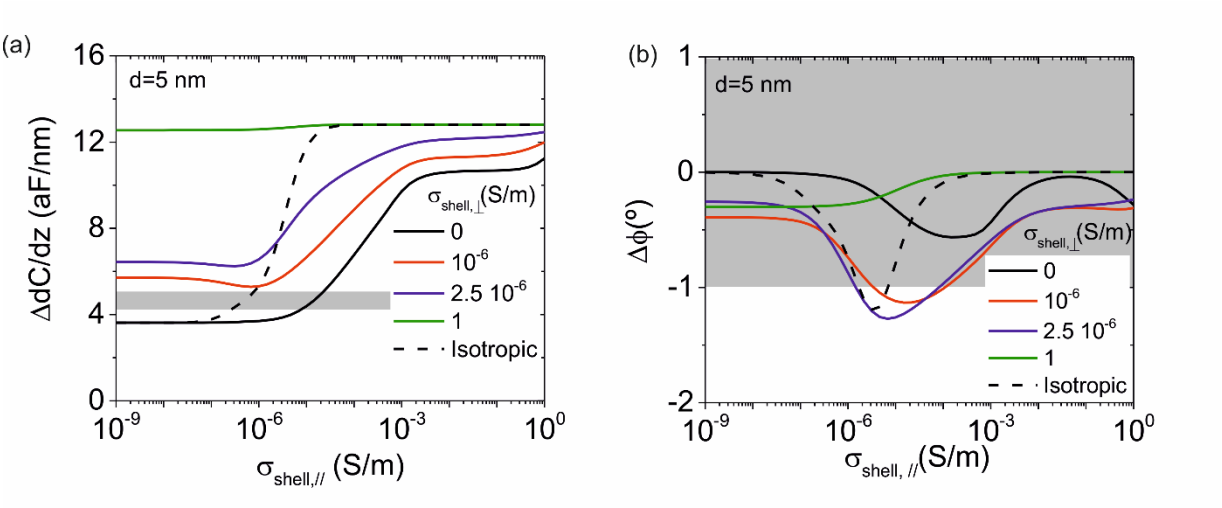

Figure S8*: Calculated (a) capacitance gradient contrast and (b) dephasing as a function of the parallel conductivity of the shell,* $\sigma_{shell,II}$*, for four different values of the perpendicular conductivity of the shell* $\sigma_{shell,\perp}$*, for the core-shell model described in Fig. S5 for a shell of thickness d=5 nm. The parallel conductivity refers to the conductivity tangent to the shell (both longitudinally and azimuthally), while the perpendicular conductivity refers to the conductivity across the shell. The black dashed lines correspond to the values of an isotropic shell model with the conductivity equal to* $\sigma_{shell,II}$ *(same data as in Fig. S5 (g) and (h) for d=5 nm, respectively). The grey areas correspond to the values, and experimental uncertainty, corresponding to the extracted homogeneous dielectric constant experientially determined Parameters used in the calculations: same as in Fig. S5.*