CHEMPHYSCHEM

Supporting Information

Supercapacitors Based on *c*-Type Cytochromes Using Conductive Nanostructured Networks of Living Bacteria

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cphc_201100865_sm_miscellaneous_information.pdf

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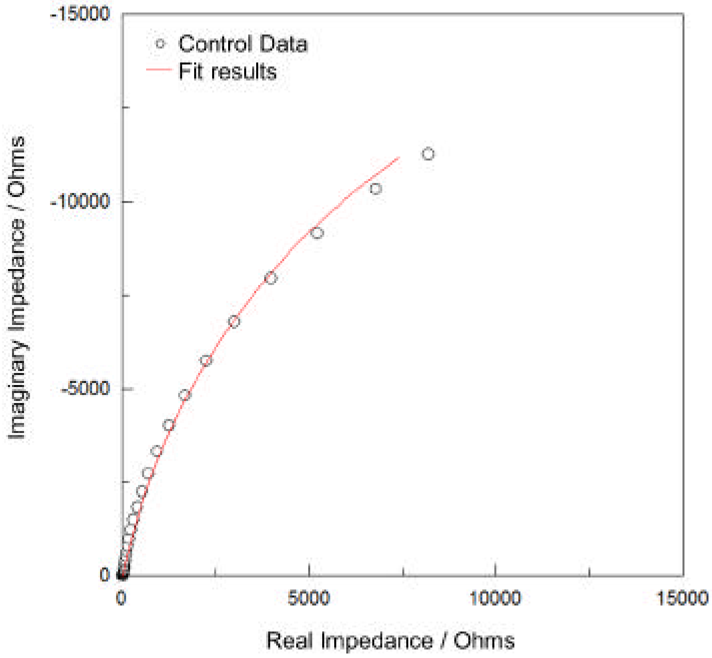

Supporting Figure S1. Representive impedance spectra (black open circles) and the corresonding fit results (red line) for the control electrodes which lacked the biofilm.

Derivation for Pseudocapacitance

Consider the following redox reaction of an iron atom in the cytochrome heme:

$$Fe^{3+} + e ?\ \ Fe^{2+}$$

This reaction can be written in a general form:

$$Ox + e ?\ \ Red$$

where Ox and Red are oxidized and reduced species respectively.

The Nernst equation for the equilibrium redox potential *E* for such a one electron system is written as : [17]

$$E=E^{0'} + (RT/F) \ln [Ox]/[Red]$$

where [ ] represents the concentration or activity of the redox species and $E^{0'}$ is the formal potential of the redox couple. F is the Faraday constant, R is the molar gas constant and T is the temperature. F/RT=38.92 V^{-1} at room temperature.

Defining Q = total [Ox] + [Red] is the charge associated with the total oxidizable or reducible material, we can rewrite above Nernst equation as:

$$E = E^{0'} + (RT/F) \ln [Ox/Q]/[Red/Q]$$

$$= E^{0'} + (RT/F) \ln [Ox/Q]/(1- [Ox/Q])$$

Rearranging, we get

$$[Ox/Q]/(1- [Ox/Q]) = \exp((E-E^{0'})F/RT) = \exp(?E \cdot F/RT)$$

Differentiating above equation w.r.t. $?E$ and rearranging gives following expression for pseudocapacitance,

$$C_f = Q \frac{(F/RT)\exp(\Delta E \cdot F/RT)}{[1+\exp(\Delta E \cdot F/RT)]^2}$$

This equation is a kind of “universal function” for redox systems with the right hand side of the equation has a maximum when $?E$=0, i.e., $E=E^{0'}$. At this potential, the total number of reduced and oxidized cytochromes is equal. At room temperature, the maximum value is ca. 10Q per volt.