Protein immobilisation on nanoscopic electrodes

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The aim is to scale down electrochemistry measurements to the single-enzyme level to obtain a truly molecular picture of substrate turnover and electron relay by the cofactors in the enzyme. Single-enzyme voltammetry may reveal subpopulations of enzymes with different properties, and fluctuations of the turnover rate. Typical enzymatic turnover rates of 10 to 10^4 s^{-1} yield attoampère (10^{-18} A = 6.3 *e*/s) to femtoampère (10^{-15} A) of current per molecule. Therefore, single-enzyme voltammetry requires an electrochemical setup with unprecedented sensitivity. To suppress the background current, the size of the electrode has to be comparable to that of the enzyme, *i.e.* <10 nm diameter. With electron beam lithography, we fabricated devices in which the electrode consists of an individual single-walled carbon nanotube (SWNT), partially exposed to solution [1], and devices with individually addressable nanoscopic gold electrodes [2]. We are developing methods for trapping and immobilising redox protein molecules, with retention of their native properties, both on carbon nanotube devices [3] and on gold electrodes [4]. Cytochrome *c* from yeast (YCC) contains a surface cysteine residue, Cys102, located opposite the docking site for redox enzymes. Atomic force microscopy combined with voltammetry shows that YCC can be chemisorbed directly on a bare gold electrode via Cys102. On carbon nanotubes, similar vectorial immobilisation of YCC has been achieved.

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