Protein-Nanoparticle Films

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Ultrathin films of redox proteins in nanoparticle matrices may have important advantages for biosensors and bioreactors. We have constructed and evaluated films of heme proteins and enzymes and various nanoparticles including layered MnO2, clay, and SiO2. Dispersions of platelet-shaped clay particles can be mixed with proteins and cast onto electrodes, resulting in quasi reversible electrochemistry of the heme Fe(III)/Fe(II) redox couple of the protein, and the films can be stable for more than 2 months provided the protein is stable. Small proteins such as myoglobin are intercalated between clay layers, while larger proteins such as hemoglobin and horseradish peroxidase were only partly intercalated. Alternatively, ultrathin films with thickness on the nanometer scale were grown layer by layer, providing good control over film thickness and architecture. Layered MnO2, clay, and SiO2 all gave films with myoglobin and cytochrome P450cam that were electrochemically and catalytically active. This approach allowed mass transport effects on charge transfer and catalytic efficiency to be minimized, and films containing a large fraction of electroactive enzymes were constructed. Reductive dechorinations, reduction of hydrogen peroxide and oxygen, and the epoxidation of styrene were catalyzed by these films. Comparative studies of structure and enzyme-like activity of these films will be presented.