Quantum Dots as New Labels for Electrochemical Sensing of Prion Proteins

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Prion protein is a biomolecule naturally occurring in the animal cells as natural (α-helix, PrPc) and infectious (β-sheet, PrPSc). The insufficiency of the physiological PrPc and toxic incidence of PrPSc participate on the genesis of prion neurodegenerative diseases (transmissible spongiform encephalopathies including bovine spongiform encephalopathy (BSE))1. With the outbreak of epidemics and discovery of BSE case almost everywhere in Europe, the question arises of how to improve screening methods and the possibility of detection of prions including those, which can be used in vivo. Excellent optical properties of quantum dots (namely high quantum yield, broad absorption spectra and narrow, symmetric fluorescence spectra from UV to NIR, large effective excitation and emission Stokes shifts), long life-time (high resistance to photobleaching) compared to ordinary fluorophores and stability (resistance to photo- and chemical degradation) predestinate them in usage for imaging and as optical probes for detection of peptides, proteins, nucleic acids and other biomolecules.

There are many various methods how to characterize quantum dots, but their quantification and fast stability test is still searched for. Therefore, one of our main aims is to find an easy way how to study quantum dots (QDs). Primarily, we optimized microwave synthesis of CdTe QDs, which was coated with mercapto-propionic acid. These particles were then characterized and their electrochemical behaviour was studied using differential pulse voltammetry at hanging mercury drop electrode. Based on our results, it can be concluded that QDs gave several signals related to various chemicals, which was used to their synthesis, and one (-0.75 vs. Ag/AgCl/3 M NaCl) related to QDs itself. Based on the changes of this signal, we can easily quantify the dots and estimate their stability. Moreover, we studied the interactions of QDs with prion proteins. For this purpose, we transformed bacterial cells to produce human PrPc. Results showed that the electrochemical signals of prion protein were strongly quenched by CdTe QDs. This phenomenon can be considered as a first step of suggesting of a biosensor for determination of prions in real samples without a sample pre-treatment. Moreover, we studied the interactions of prion proteins with copper(II) ions and metallothioneins as the maintainers of the metal homeostasis in neuronal cells.

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