Biomembrane interaction analysis of Cadmium telluride quantum dots

Girish Malhotra, Shengwen Zhang, Rongjun Chen

Centre for Molecular Nanoscience, School of Chemistry, University of Leeds, Leeds, United Kingdom, LS2 9JT
cmgkm@leeds.ac.uk

Abstract

Recent advances in the sphere of nanotechnology has yielded the development of a unique type of nanoparticles called quantum dots that can be employed as inorganic fluorophores in biological systems[1]. Structurally they are somewhere between discrete matter and bulk semiconductors: their construction means that bulk binding geometry and surface states are eliminated because the atoms of one element are enclosed within a material with a larger band gap[2]. This gives way to these particles exhibiting atom-like behaviour and exhibiting size dependent optical and electrical properties: in CdS quantum dots, band gaps can be tuned to be anywhere between 2.5 and 4.5 eV (which has effects upon the lowest allowed optical excitation) and melting points can be increased from 400°C to 1600°C by changing the size of its core[3]. The way that their excitons are confined in a small area within the structures gives rise to unique optical properties, and a number of advantages over conventional organic fluorophores. Optically speaking they are advantageous because of their size tuneable light emission, improved signal brightness, resistance against photobleaching and simultaneous excitation of multiple fluorescence colours with a high level of brightness and photostability[4]. Biologically speaking their inorganic nature makes them more resistant to metabolic degradation and they share some dimensional similarities with biological molecules such as nucleic acids and proteins[5].

CdTe core quantum dots were tested in mercury electrode DOPC monolayer systems at different pHs and different coatings to change the degree of their hydrophobicity. In addition to this they were tried in sBLM QCMD (vibrational analysis for behavioural change) and electrochemical QCMD. An example of the monolayer testing that was carried out is shown below.

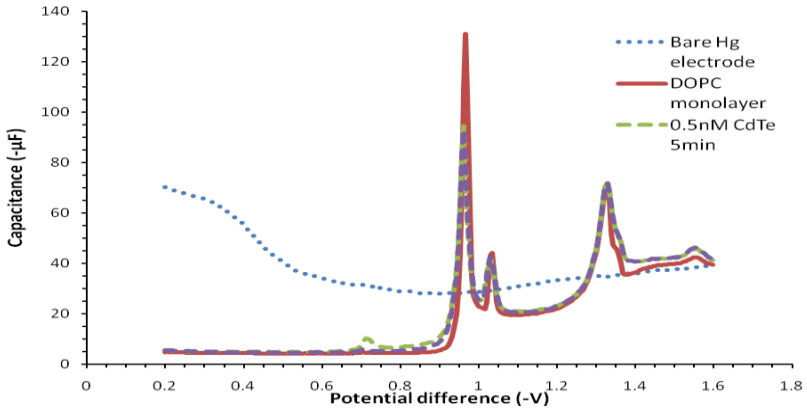

Figure 1: Capacitance versus potential profile of the bare Hg electrode, DOPC monolayer and CdTe cores over a period of 10 min at pH 7.4. Whilst some signal suppression by the CdTe cores is seen at -1 V, it is not significant enough to indicate interaction occurring. At ~-0.7 V a small peak is seen, which could be down to mercury redox or pore formation in the monolayer.

[1] Chan, W. C. W., D. J. Maxwell, et al. (2002). "Luminescent quantum dots for multiplexed biological detection and imaging." Current Opinion in Biotechnology **13**(1): 40-46.
[2] Alivisatos, A. P. (1996). "Semiconductor Clusters, Nanocrystals, and Quantum Dots." Science **271**(5251): 933-937.
[3] Goldstein, A. N., C. M. Echer, et al. (1992). "Melting in Semiconductor Nanocrystals." Science **256**(5062): 1425-1427.
[4] Qi, L. and X. Gao (2008). "Emerging application of quantum dots for drug delivery and therapy." Expert Opin Drug Deliv **5**(3): 263-267.
[5] Nirmal, M. and L. Brus (1998). "Luminescence Photophysics in Semiconductor Nanocrystals." Accounts of Chemical Research **32**(5): 407-414.