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MODULATION OF MEMBRANE ELECTROKINETIC PROPERTIES BY SEMICONDUCTOR NANOPARTICLES

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INTRODUCTION

Core/shell CdSe/CdS nanocrystals are one of the most important II–VI semiconductors with applications in solar cells, optoelectronics and electronic devices. CdSe / CdS nanocrystals are coated with thioglycolic acid to be water soluble. CdSe / CdS core-shell quantum dots have also been used, which reduce the toxicity of CdS nanocrystals on biological membranes. Semiconductor nanoparticles have great potential serving as a new generation of multifunctional agents for clinic diagnosis and treatment. This study will highlight the main biophysical points to be considered in order to evaluate the electrokinetic potential of erythrocyte membranes under treatments with semiconductor nanoparticles and discuss the issues and challenges emerging in the field of nanotechnology and electroketic stability of the erythrocytes.

We measure the electrophoretic mobility of human erythrocytes using three types of core/shell CdSe/CdS nanocrystals (NP1, NP2, NP3) by the method of microelectrophoresis. The restricted change in electrokinetic properties of erythrocyte membrane indicated that the structural phenomena observed are due to the erythrocyte-nanocrystals interaction.

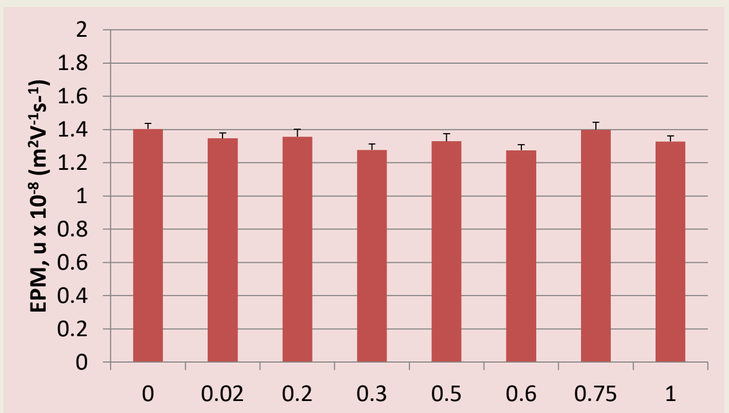
The surface electric properties of erythrocyte membranes as a model of biological membranes may be closely associated with changes in physicochemical properties of inorganic nanoparticles.

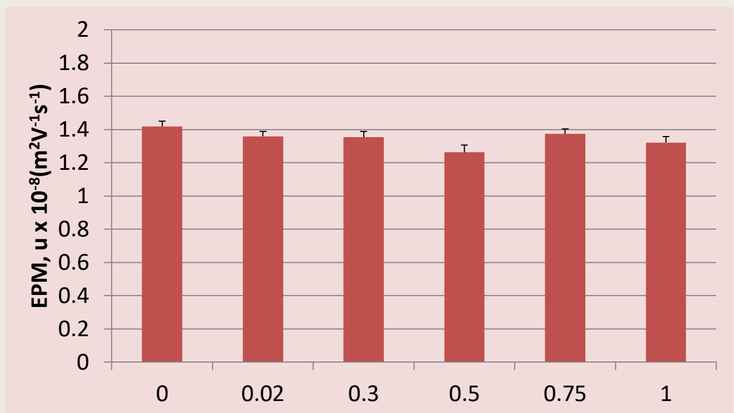
A strong decrease in membrane transport across the human erythrocyte membrane is occurred due to OH^-/Cl^- antiport as well as H^+/Cl^- cotransport' inhibition.

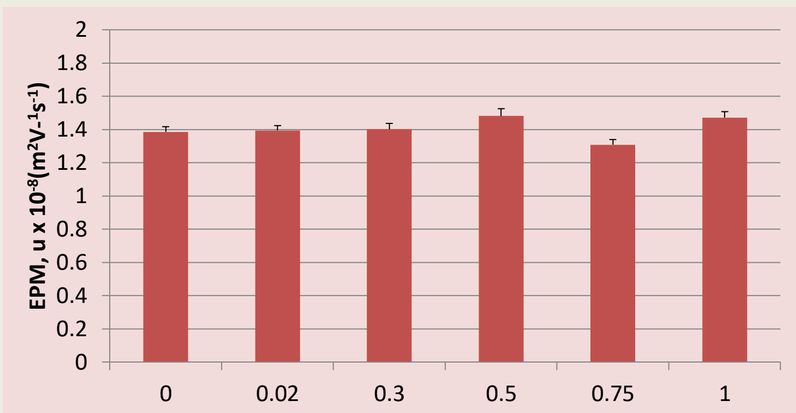
Higher lipid peroxidation of erythrocytes in the presence of CdSe/CdS nanocrystals is determined compared to untreated erythrocyte membranes.

Concern about the toxicity potential of semiconductor nanoparticles is mainly attributed to this small size, large surface area and high reactivity compared to bulk-sized materials. The results of the present study provide new insights into the biological impacts of semiconductor nanoparticles *in vivo*.

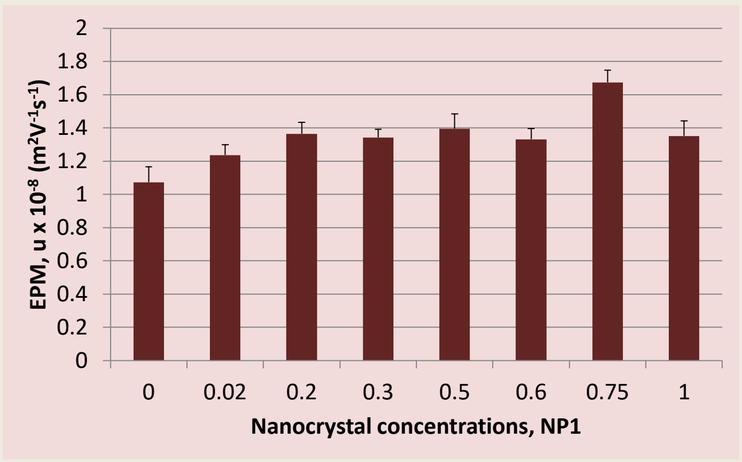
RESULTS

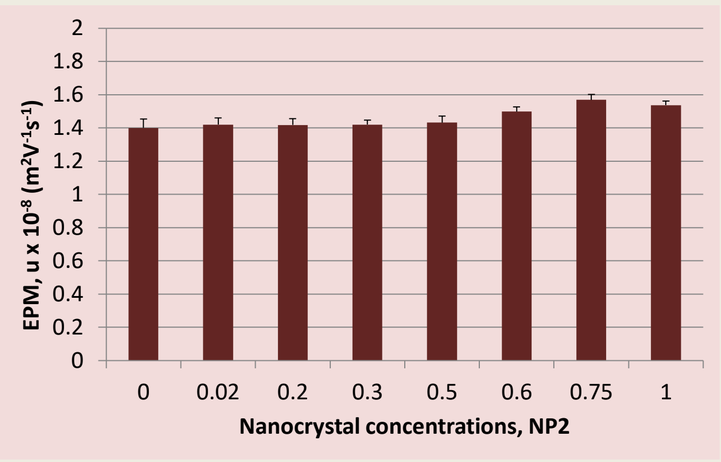




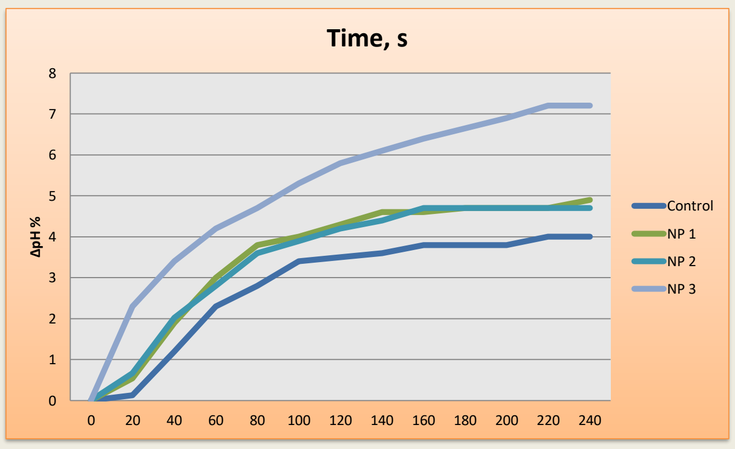


Electrophoretic mobilities (EPM) of human erythrocytes in the presence of CdSe/CdS nanocrystals (μg/mL). The medium contained PBS (pH 7.4). Data are means (vertical bars indicate SEM) of 15-30 cells. Electrophoretic migration of human erythrocytes was measured in a rectangular chamber at a constant electric field of 10 mA and 25 °C (Cytopherometer OPTON).

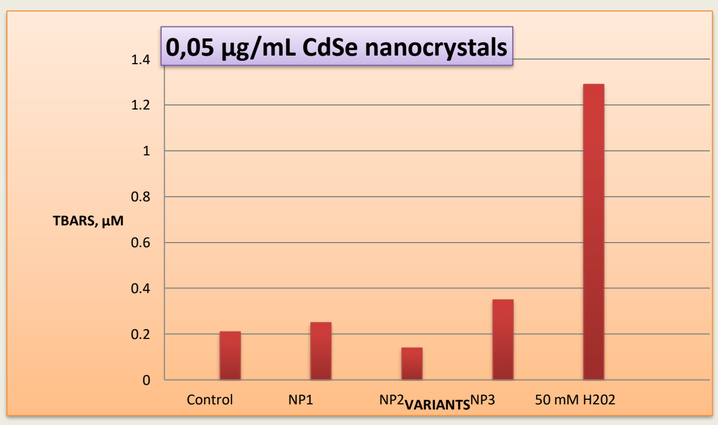


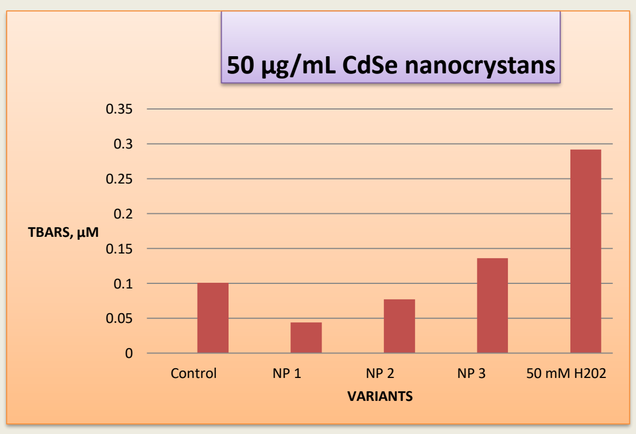


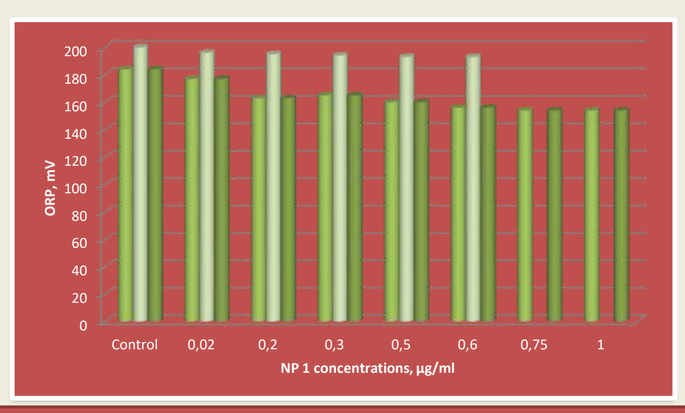
Electrophoretic mobilities (EPM) of human erythrocytes in the presence of CdS nanocrystals (NP , 10 μg/mL). The medium contained PBS (pH 7.4). Data are means (vertical bars indicate SEM) of 15-30 cells. Electrophoretic migration of human erythrocytes (***at the end of stored human blood***) was measured in a rectangular chamber at a constant electric field of 10 mA and 25 °C (Cytopherometer OPTON).



Effect of CdSe/CdS nanocrystals membrane transport in human erythrocytes, suspended in 0.3 M Sucrose, pH 7.4 without and after treatment with NPs.







Effect of CdSe/CdS nanocrystals on oxidation-redox potential (ORP) of erythrocytes

Effect of CdSe/CdS nanocrystals on lipid peroxidation of erythrocyte membranes. Thiobarbituric acid reactivity substances in erythrocytes, suspended in PBS, pH 7.4 after NP treatments.

CONCLUSION

Concern about the toxicity potential of nanoparticles is mainly attributed to this small size, large surface area and high reactivity compared to bulk-sized materials (Oberdorster, 2010). However, if the nanoparticles interact with biological materials, such as proteins and electrolytes, under physiological conditions, it is strongly probable that they form agglomerates or aggregates by electrostatic attraction and hydrophobic interaction, resulting in larger-sized materials (Choi et al., 2013). Here, agglomerates and aggregates represent physically (such as strong sinter forces) –assembled particles, respectively. Furthermore, this interaction evidently leads to decrease in surface area and change in surface charge, which is important to cellular interaction.

CdSe/CdS nanocrystals enhanced the lipid peroxidation of the human erythrocytes.

A strong decrease in membrane transport across the human erythrocyte membrane was occurred due to OH^-/Cl^- antiport as well as H^+/Cl^- cotransport' inhibition in the presence of CdSe/CdS nanocrystals .

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