Research and Reviews in BioSciences

Research & Reviews in BioSciences
ISSN: 0974-7532

Extended Abstract | Vol 16 Iss 1

Biomaterials 2019: Hybrid smart nanocrystals and the shielding effect of phospholipid bilayer for biomedical application

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Abstract

The Statement of the Problem: Zinc oxide nanocrystals (ZnO NCs), thanks to their unique properties, are receiving much attention for their use in nanomedicine, in particular for therapy against cancer. To be efficiently employed as diagnostic and therapeutic (yet theranostic) tools, highly dispersed, stable and non-toxic nanoparticles are required. In the case of ZnO NCs, there is still a lack of knowledge about cytotoxicity mechanisms and stability in the biological context, as well as immunological response and hemocompatible features. We thus propose a novel approach to render stable, immune and hemocompatible ZnO NCs in various biological media using artificial and natural phospholipidic bilayers.

Methodology & Theoretical Orientation: We synthesized amino-functionalized ZnO NCs, then shielded with phospholipid bilayers either from synthetic origin or natural biovesicles. We characterized their structural, morphological, physico-chemical properties, focusing on the coupling mechanism between ZnO NCs and the lipid vesicles. The stability behavior of different hybrid nanocrystals was evaluated, comparing their biodegradation profiles in different inorganic and biological media. The study aims to investigate how the particle surface chemistry and charge could influence their aggregation/degradation in the different media and interaction with cells. We actually proved their hemocompatibility in human plasma and their internalization into cancer cells and related cytotoxicity mechanisms. A stimuli responsive activation by UV-light was investigated for inducing high mortality of cancer cells based on the hybrid NCs.

Findings: We demonstrated that pristine ZnO NCs strongly aggregate when suspended in both simulated and biological media, showing small dissolution into potentially cytotoxic Zn-cations, also slightly affecting their crystalline structure. In contrast, high colloidal stability and integrity was retained for hybrid lipid-shielded ZnO NCs in all media, accompanied by high biocompatibility, efficient cell internalization and effective killing ability only upon stimuli-activation. These features render these hybrid ZnO NCs ideal “Trojan horses” for further theranostic applications.

This work is partly presented at 4th Annual Conference and Expo on Biomaterials February 25-26, 2019.

Special Issue: Valentina Cauda, Hybrid smart nanocrystals and the shielding effect of phospholipid bilayer for biomedical application. Res Rev Biosci. 2020:15(S):1.