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Lipid content changes in cancerous and non-cancerous cells induced by ZnO nanoparticles: Raman spectroscopy approach

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ZnO nanoparticles (NPs) applied in sufficient doses exhibit cytotoxic effect in vitro [1]. However, selective cytotoxicity towards certain cell types is also registered [2]. Proposed selectivity of ZnO NPs for cancer cells is an issue of special importance for the development of new drugs based on ZnO. By generating the reactive oxygen species (ROS) and by acting themselves as an electron-hole redox system, ZnO NPs can alter composition and structure of all main biological macromolecules in the cell, among which the lipids occupy a significant place. Peroxidation of lipids in the cell membrane can directly lead to the cell death of necrotic type, while the products of oxidized lipids act as the signal molecules in induction of apoptosis and autophagy. In this study we have investigated the effect of ZnO NPs on changes in lipid content and structure in cancerous HeLa and non-cancerous MRC-5 cells, using Raman spectroscopy and non-negative principal component analysis (nnPCA) [3]. Common for both cell types are quantitative changes in lipid content and lipid-to-protein and lipid-to-DNA content ratio, in favor of lipids. These changes are mainly deduced from the analysis of 1659 cm^{-1} and 1444 cm^{-1} vibrational modes in the low spectral region and 2855 cm^{-1} and 2933 cm^{-1} vibrational modes in the high region of Raman spectra, whose intensity ratios are used as common markers for relative quantification of cellular lipid and protein content [4]. Nevertheless, in non-cancerous cells the described changes occur after exposure to lower doses of NPs than in cancer cells, which is in accordance with higher sensitivity of MRC-5 cells to ZnO NPs shown by conventional biological cytotoxicity assays. However, there is a significant difference in the spectral components which act as markers of lipid unsaturation, represented by high relative intensity ratio of I_{1300}/I_{1260} and prominent mode at 1659 cm^{-1} [5], suggesting higher degree of lipid saturation in treated MRC-5 than in treated HeLa cells. It is possible to recognize the increase of an early-apoptotic lipid marker in the Raman spectra of treated HeLa cells, while the spectra of treated MRC-5 cells contain lipid markers which indicate a later phase of apoptosis. The differences in lipid structure between untreated HeLa and untreated MRC-5 cells are also deduced from their Raman spectra and correlated with a higher sensitivity of MRC-5 cells. It is concluded that Raman spectroscopy has a great potential in tracing the changes of lipid molecules in the cells, being in that way useful in the studying of NPs cytotoxic effects.

References

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