Cells in Contact to Carbon Dots: A label-free, impedance-based and multidimensional approach

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Carbon Dots (Cdots) represent a relatively new allotropic form of carbon with interesting material properties such as high quantum yield photo-luminescence and long-term photostability [1]. Cdots as model nanoparticles are only a few nanometers in size and can be synthesized via hydrothermal carbonization of starch and L-tryptophan. The nanoparticles exhibit moderate toxicity up to concentrations in the mg/mL range which was investigated for different cell lines using Electric Cell-Substrate Impedance Sensing (ECIS®) which allows for label-free and time-resolved monitoring of the cells. The results were confirmed by cross-checking against the resazurin-based viability assay PrestoBlue® which yielded similar results. Furthermore, the time-dependent cell response in presence of non-toxic Cdot concentrations in the incubation buffer was investigated in several *in vitro* scenarios during (i) attachment and spreading, (ii) proliferation and (iii) migration. Significant delays have been found in all phenotypic studies (i) to (iii) for increasing particle concentrations. Impedance-based measurements have additionally shown that Cdots in higher concentrations affect the regular beating of cardiomyocytes (Cor.At®), as the cells' ability to contract synchronously is heavily compromised for higher particle concentrations.

Cdots are en route to their application as labels in bioanalysis and even constitute a possible candidate for applications in photo-dynamic therapy. The nanoparticles produce reactive oxygen species upon irradiation at wavelengths from 330 - 380 nm [2] and can thus be used to destroy selected cells loaded with the particles. ECIS® studies revealed that Cdots exert phototoxic effects not only on cell monolayers of different cell lines but also on multicellular tumor spheroids (MCTS) when excited by near-ultraviolet light. The method is therefore not limited to two-dimensional cell structures but can also be used to monitor three-dimensional tissue models.

These studies demonstrate the advantages of impedance-based methods to non-invasively monitor the impact of nanomaterials and other stimuli on living cells in real-time. The work with luminescent and phototoxic Cdots underlines strongly the value of label-free, non-optical readouts of cell behavior that is otherwise hard to study in such detail.

References:

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