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A Toxicologic Review of Quantum Dots: Toxicity Depends on Physicochemical and Environmental Factors

Quantum Dots contain known toxins. They are protected by surface coatings but could deliver very high doses of toxin to individual cells if those coatings fail.

Quantum dots (QD) are either nano crystals (1 to 100 nm) or regions within semiconductors which have electronic properties that are not found in the same material in bulk form. Their electronic state can be manipulated optically or through micro-circuitry. When contained within the bulk of the semiconductor, their potential as toxins is very limited.

Free QD are being used to label biological structures. Specific labelling is possible, providing a mechanism for tissues specific medical imaging.

QD have been made from the following elemental combinations, among others: indium phosphate (InP), indium arsenate (InAs), gallium arsenate (GaAs) and gallium nitride (GaN), zinc sulfide (ZnS), zinc–selenium (ZnSe), cadmium–selenium (CdSe). Bulk toxicities of these are well known. For example, cadmium is a carcinogen.

Before use, QD are functionalised by surface treatments which improve water solubility, mechanical stability, reduced aggregation tendencies and provide a desired bioactivity. Any instability in the coating could expose the body to toxins. Environmental stability of QD coatings are unknown. It is also possible that optical stimulation could make the QD reactive.

Specific toxicity testing would be needed for each QD and combination of surface treatments.

Comment

There are no generic conclusions about QD toxicity other than that the active core contains known toxins. Doses of toxin could be delivered to cells before being dissolved, creating extreme localised doses. The toxicities of such localised doses have not been studied.