# Quantum dots in food analysis

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Several potential, mainly medical applications of quantum dots (QDs), including nanodiagnostics, imaging, targeted drug delivery, and photodynamic therapy have been investigated to date. These fluorescent semiconductor nanocrystals are exceptionally suitable for immunolabeling, cell motility assays, in situ hybridization, as live cell markers due to their high photostability. QDs are adapted to the desired application by conjugation to a recognition moiety, e.g., antibodies, peptides, oligonucleotides or aptamers, or by coating with streptavidin. QDs are applied with other techniques, including polymerase chain reaction (PCR), fluorescence resonance-energy transfer (FRET) analysis, fluorescence in-situ hybridization (FISH) and western blot analysis.

QDs have been most often used for *in vitro* and *in vivo* staining of particles of interest. Bruchez et al. [1998] performed an experiment where F-actin in fixed cells was stained with antibodies labeled with CdSe/ZnS QDs. Kaul et al. [2003] used QD immunoconjugates to show that heat shock protein-70 can be a marker for detection of cancer cells. Ness et al. [2003] developed an immunohistochemical protocol for detection of intracellular antigens in rodent brain tissue that combines conventional enzymatic signal amplification and QD labeling. The results showed that use of QDs for immunohistochemical labeling has sensitivity superior to conventional dyes. Similarily, QDs can be used to track drug delivery and dynamics in the cell [Ozkan, 2004].

Tokuraku et al. [2009] demonstrated the preparation of QD-labeled amyloid-β peptide (QDAβ), the major component of senile plaques in Alzheimer's disease, and its applications for the imaging of the inhibition of oligomer-forming QDAβ construct by anti-Aβ antibody. The process was observed by real-time 3D imaging using slit-scanning confocal microscopy. Labeling with QDs proved superior over fluorescein-labeled Aβ peptides due to their limitation to short-term live imaging studies. Potential cytotoxicity for long term QD applications in cells was reduced by masking the core cadmium atom with a polyethylene glycol (PEG) coating.

QDs can also be used as labels for detection of mRNA [Chan et al., 2003], DNA [Crut et al., 2005] or Single Nucleotide Polymorphisms [Xu et al., 2003, Gerion et al., 2003, Liu et al., 2005]. Oligonucleotide probes can be labeled with QDs or biotinylated oligonucleotide probes may be coupled to QDs coated with streptavidin.

QDs found application in the detection of pathogens, including *Cryptosporidium parvum* and *Giardia lamblia* [Zhu et al., 2004, Lee et al., 2004], *Escherichiacoli 0157:H7*, *Salmonella Typhi* [Yang, 2006] and *Listeria monocytogenes* [Tully et al., 2006].

More complex applications of QDs as components of multifunction complexes were also proposed. Nikitin et al. [2010] constructed three-module superstructure which consisted of a magnetic particie connected with several quantum dots and antitumor single chain scFv antibody fragments to demonstrate the application of barnase–barstar complex as a nanoassembler. Such structures can be used for simultaneous identification with antibodies, labelling with QD and destruction of cancer cells with magnetic particles heated with AC magnetic field. Chemicell and Qdot® 605 quantum dots from Invitrogen were used in this experiment. Antibodies were targeted against human ovarian carcinoma SKOV-3 cells that overexpress the HER2/neu receptor on their surface. Magnetic particles of the superstructures were capable of moving the labeled cells to the permanent magnet poles. The results were visualized under a fluorescencje microscope.

Photodynamic therapy (PDT) was discovered in the early 1900s and has been approved by the U.S. Food and Drug Administration. QDs can emit in the near IR regions and thus can be suitable for use in PDT for deep tumors, because they allow to avoid light scattering by tissue [Bakalova et al., 2004]