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"Green" synthesis of luminescent CdS quantum dots by plant matrix and their toxic effect

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Quantum dots (QDs) or semiconductor nanocrystals are luminescent particles that have the potential to be the next generation fluorophores. Currently, most available QDs have been synthesized using the organic way involving high temperatures and in the presence of surfactants to yield monodisperse and stable particles [1]. However, QDs produced by a biogenic enzymatic process are far superior, in several ways, to those particles produced by chemical methods. The chemical methods are complicated, outdated, costly, and inefficient and produce hazardous toxic wastes that are harmful, not only to the environment but also to human health. Therefore «green» methods of QDs formation are preferable by the fact that they are eco-friendly, easy reproducible and less expensive [2,3]. The present investigation suggests a comparison of the two methods of biosynthesis of CdS nanoparticles using cell suspension culture of *Nicotiana tabacum* L (cv. BY-2) and a hairy root culture of flowering plant *Linaria maroccana* L. Moreover, some aspects of the toxicity of indicated quantum dots are also presented here.

For biological synthesis of CdS nanoparticles by BY-2 suspension culture *Nicotiana tabacum* cells were grown in a liquid hormone free MS medium at 28C during 7 days. Subsequently, the culture was filtered through filter paper to separate cell biomass. At the next step BY-2 cells were immersed in sterile water and centrifuged for10 min at 5000 rpm. In order to produce CdS QDs 700 l of 0.025 M $CdSO_4$ and 250 l of 0.5 M Na_2S solutions were poured into 100 mL flask with 50 mL of BY-2 supernarant. A homogeneous clear bright yellow solution indicated the formation of CdS quantum dots. Biological synthesis of CdS QDs using hairy root culture was described by us earlier [4].

Spectral analysis of CdS quantum dots, produced by BY-2 cell line shown clear absorption peak at 472 nm. For samples containing CdS nanoparticles in luminescence spectrum were observed two distinct peaks at 440 and 490 nm (excitation by a wavelength =340 nm). Optical measurements of CdS quantum dots prepared by hairy root culture indicated that the absorption peaks corresponded to the wavelengths 362 nm, 398 nm and 464 nm,while luminescent peaks corresponded to the wavelengths 425 nm, 462 nm and 500 nm. By using transmission electron microscopy it was demonstrated that synthesized nanoparticles have an average diameter 3 - 6 nm and do not have any surface defects (see fig). Cytotoxic effect of CdS QDs was determined using protoplasts of aseptic *Nicotiana tabacum* plants. Protoplasts from the cells of *N. tabacum* plants were prepared by enzymatic degradation of the cell wall. Cytotoxicity investigation revealed that cytotoxic effects appear only at high concentrations of CdS nanoparticles. The concentraitions of CdS was from 375 g/mL to 3.0 g/mL. It was found that the optimal is the concentration 47 g/mL wherein protoplast survival reached 80%.

Summing up, our work demonstrated that biosynthesis of CdS quantum dots by BY-2 cell line is promising new approach with some advantages compared with hairy root culture. Such as more rapid culturing of cell biomass, the synthesis process occurs at the room temperature without additional heating, this way of synthesis requires a lower concentration of cadmium ions and resulting solution of CdS quantum dots is more stable i.e. does not form a precipitate even since a month after the synthesis. Also we could observed toxicity of the produced CdS nanoparticles which is caused by the presence of Cd^2 but such toxic effect is temperate and can not be an obstacle for the development of new methods for the study of plant cells using synthesized nanoparticles.

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