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Biological synthesis of CdS quantum dots using hairy root culture of *Linaria maroccana* L

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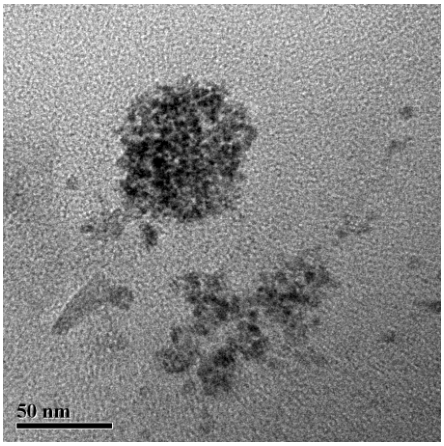
Quantum dots (QDs) or semiconductor nanocrystals are luminescent particles that have the potential to be the next generation fluorophores. They can be synthesised by an organic or aqueous route and, recently, a microwave-assisted method has also been described. Currently, most available QDs have been synthesised using the organic way involving high temperatures and in the presence of surfactants to yield monodisperse and stable particles [1]. However, nanoparticles 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 The chemical methods are complicated, outdated, costly, and inefficient and produce hazardous toxic wastes that are harmful, not only to the environment but also to human health. Several biological methods using microorganisms including bacteria, fungi, actinomycetes and yeast have been suggested [2,3]. But production of nanoparticles using plants has drawn attention of scientists because of its rapid, economical, eco-friendly protocol and it provides a single-step technique for the biosynthesis process [4].The present investigation suggests a novel approach to the biosynthesis of cadmium sulfide quantum dots using hairy root culture of flowering plant *Linaria maroccana* L.

In this study hairy root culture was grown in a liquid medium which consists of MS basal salt mixture, ferum chelate, vitamins and sucrose during 7 days under 28°C. Subsequently root material was thoroughly washed in sterile distilled water and cut into fine pieces. These pieces were heated and filtered through filter paper in order to remove root residues. 0,025 M solution of $CdSO_4$ was added in the resulting extracellular liquid and cultured during 4 days. After that 0,5M Na_2S was added to the solution. After 3 days culturing 6 ml of liquid culture was sampled and centrifuged (10 min, 5000 rpm). It is important that resulted solution retained homogeneity after centrifugation. Selected samples were used for further analysis. It was found that the maximum in absorption spectrum correspond to the wavelength $\lambda_m \sim 474$ nm. For samples containing CdS nanoparticles in luminescence spectrum were observed several distinct peaks at 425, 470, 490 nm (excitation by a wavelength λ=340 nm). By the method of transmission electron microscopy was revealed that obtained quantum dots have spherical shape and size in the range of 3 – 6 nm.



Our work demonstrated that hairy root culture can be effective for biotransformation of the inorganic compounds into luminescent semiconductor nanocrystals. However, mechanisms or substances that provide the formation of nanoparticles require further investigation. The resulting CdS nanoparticles will be applied in future biological studies as intracellular fluorescent labels.

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