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# The effect of solutions concentrations on the optical properties of CdS nanoparticles formed in the polymeric matrix

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The effect of the change in concentration of electrolyte solutions on the optical properties of nanoparticles of cadmium sulfide formed in a polymeric matrix volume by the method of layered chemisorptions of ions is considered. It is shown, that with increase in concentration of cadmium ions in a solution at equal quantity of the cycles the band gap of nanoparticles decreases. It is explained by that with an increase in concentration of cadmium ions in electrolyte solutions the degree of filling adsorption centers increases. This leads to the decrease in distance between the particles, and promotes the acceleration of the coalescent process of nanoparticles in polymeric matrix volume.

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*Keywords:* CdS nanoparticle, Polymeric matrix, Optical properties

## 1. Introduction

Nanomaterials of chalcogenide semiconductors are prospective materials for creation of high-velocity processors in terra hertz range [1-3], gas sensors [4-8] and other facilities. One of the important tasks set for technology of nanomaterials is obtaining nanomaterials with the definite dimensions, as many physical properties of the materials depend on their size. In order to obtain the materials with certain characteristics it is important to elaborate the technological methods, which permit to regulate the growing structures dimensions. The selective methods of growth of thin films and nanoparticles [9-11] possess such a possibility. The selective methods of growth are one of the methods for formation of the thin films [12,13] and nano-structures [14-16]. In this process the anion and cation sub-lattice of growing substance is formed separately. In the system a full thermodynamic equilibrium of both components is absent. The driving force of crystallization process is the difference of chemical potentials of atoms in crystallization medium and growing structure [16]. In the this case a change in concentration of atoms[ions] of one kind in crystallization medium should lead to change in energetic state of the same atom in growing structure. Such an alternation is possible by forming defects, and changing of crystalline structure, geometry etc. of nanoparticles. The study of the effect of change of solution concentration on physical and chemical properties of nanoparticles is actual. In the present work the influence of change in solutions concentration on optical properties of nanoparticles of cadmium sulfide is considered.

## 2. Technology of obtaining nanoparticles of cadmium sulfide

Nanoparticles of cadmium sulfide in polymer matrix volume have been formed by the methods described in the works [11,14]. A glass, on which gelatinous film was drawn, was used as a substrate. As a source of cation, water solution of cadmium nitrate was used. Water solution of $Na_2S{\cdot}9H_2O$ served as a source of anion. The process of layered chemosorption began from solutions of cadmium nitrate. The growing process was proceeded in two conditions. In the first case concentration of natrium sulfide remained constant (0.2 m). It was varied with the concentration of cadmium nitrate. There were prepared the samples of CdS polymer from solutions with concentration $Cd(NO_3)_2$ – 0.1 m, 0.2 m, 0.4 m, 0.8 m. In other cases the concentration of $Cd(NO_3)_2$ is constant, when the concentration of $Na_2S{\cdot}9H_2O$ is varied.

## 3. Optical properties of obtained structures

Transmission spectra of the structures obtained were measured by means of two-ray spectra photometer *Shimadzu* UV-1700 in the range of wavelength of 400 - 800 nm. Resolution along wavelength made up 0.1 nm. There were investigated nanoparticles of cadmium sulfide formed in polymeric matrix volume in the different technological conditions. In Fig. 1 the dependence of transmission spectra against wavelength is shown. As it seems from Fig. 1a in constant concentration of sodium sulfide solution transmission spectra depends on cadmium ions concentration. In case of constant concentration of cadmium nitrate solutions a change of sulfur ions concentration in solution does not cause an essential change in transmission spectrum (Fig. 1b).

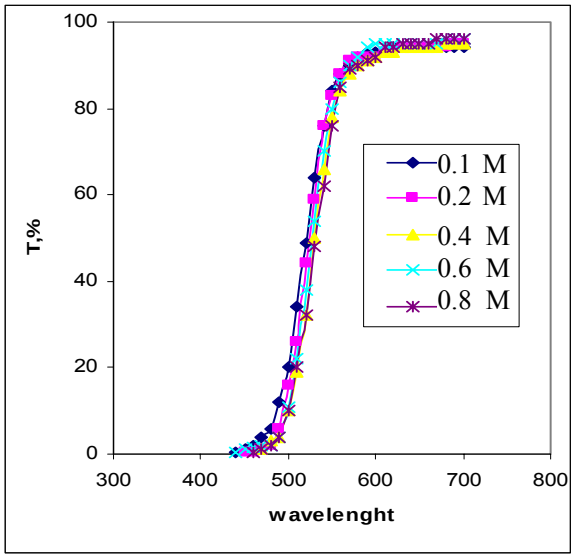


*Fig. 1a. Transmission spectra of samples in constant concentration of copper ions in electrolyte solutions. Concentration of cadmium nitrate solutions varied in the range (0.1-0.8) M.*

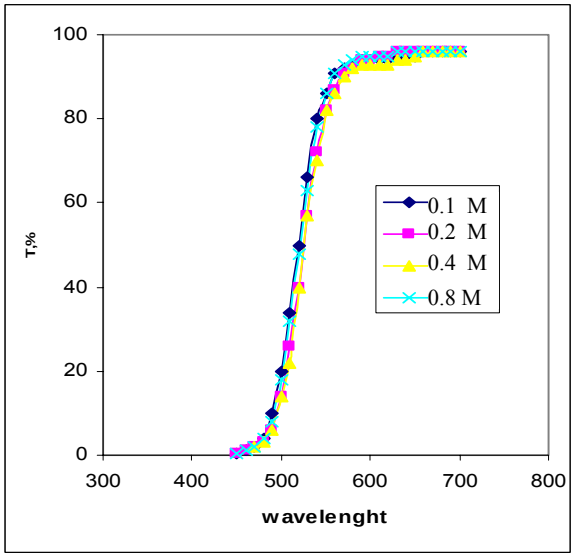


*Fig. 1b. The transmission spectra of samples in constant concentration of cadmium ions in electrolyte solutions. Concentration of sodium sulfide solutions varied in the range (0.1-0.8)M.*

The calculation of the band gap was carried out by using the dependence $(\alpha h\nu)^2$ on ħν [11]. In Fig. 2 the dependence for the samples prepared at the constant concentration of cadmium nitrate is shown. As Fig. 2 displays, a change of concentration of sulphur ions in a solution does not cause an essential change and gives 2.46 eV. In Fg. 3 is shown the dependence $(\alpha h\nu)^2$ on $h\nu$ for the samples at constant concentration of cadmium ions in the range (0.1-0.8) M. As can be seen in Fig. 3, with increase in concentration of cadmium ions in solution of electrolytes in the range (0.1-0.8)m, the band gap decreases from 2.48 to 2.42 eV.

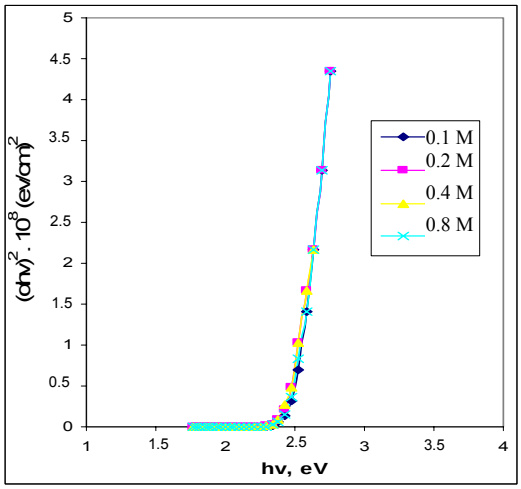


*Fig. 2. The dependence $(\alpha\hbar\nu)^2$ on energy of photons for the samples prepared for various concentration of surface ions in solution. The concentration of cadmium ions is 0.2 M.*

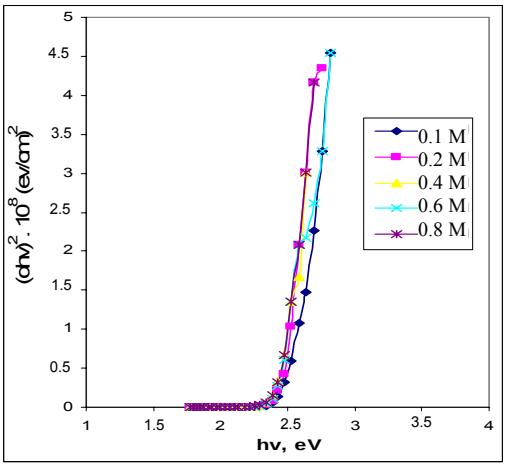


*Fig. 3. The dependence $(\alpha\hbar\nu)^2$ vs. energy of photons for the samples prepared at change of concentration of cadmium ions in solution. Concentration of sulfur ions is 0.2 M.*

It is known that the band gap of nanoparticles depends on their dimension as follows [14]

$$\Delta E_g = \frac{h^2\pi^2}{2\mu^* d^2} \qquad (1)$$

Where h is a Planck constant, $\pi$ is constant, $\mu^*$-the reduced effective mass of electrons and holes in crystals of cadmium sulfide, d is the average size of nanoparticles. The reduced effective mass was calculated as follows:

$$\mu^* = \frac{m_h^* m_e^*}{m_h + m_e} \quad (2)$$

where $m^*_h$ is the effective mass of holes, $m^*_e$- the effective mass of electrons. As it was noted in the works [11,14], the mass of electrons and holes in nanoparticles should differs from the effective mass in bulk crystals. The calculations carried out on the basis of formula (1) are estimative. In Fig. 4 the dependence of particles dimension and the band gap on solution concentration is shown. Fig. 4 (curve 1) shows that during the increase of solutions concentration the particle dimension increases. For high concentration (Fig. 4 curve 2) the band gapapproaches the value of bulk crystal: -2.42 eV. This is explained by the fact that with the increase of solution concentration the degree of filling adsorption centers in polymeric matrix increases.

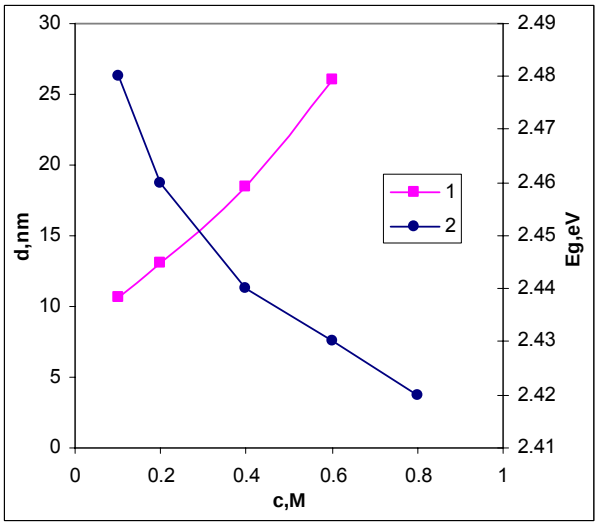


*Fig. 4. Dependence of the particle size (1) and band gap of CdS nanoparticles (2) on solution concentration are diminished.*

Short distances between the particles facilitate the coalescent processes between nanoparticles. As a consequence the particle size increases. The growth of the particles dimensions according to formula (1) leads to the decrease in the band gap.

## 4. Conclusion

In this paper the influence of solutions concentration on optical properties of CdS nanoparticles formed in a polymeric matrix has been investigated. It is shown that the increasing concentration of the cadmium ions in a solution leads to the decrease of the band gap of the particles of cadmium sulfide. This is due to the fact that during the change in concentration of cadmium ions, the degree of filling of adsorption centers changes. This, in its turn, leads to coalescent processes, and as a consequence, the particle size increases.

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