Optical diagnostics of nanoparticles in *Culex pipiens molestus* Forskal

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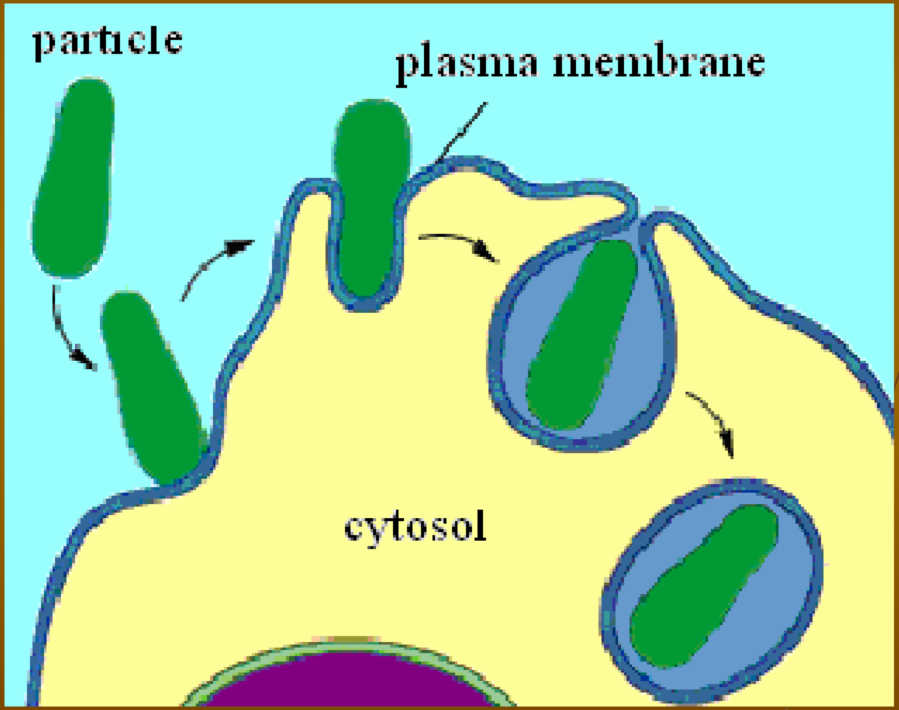
Motivation

Endocytosis



- Luminescence spectra of gnat larvae were investigated with taking into account a possible influence of nanosized natural impurities in water which can be accumulated in the cells of their organisms.

The aim of this work

was to reveal

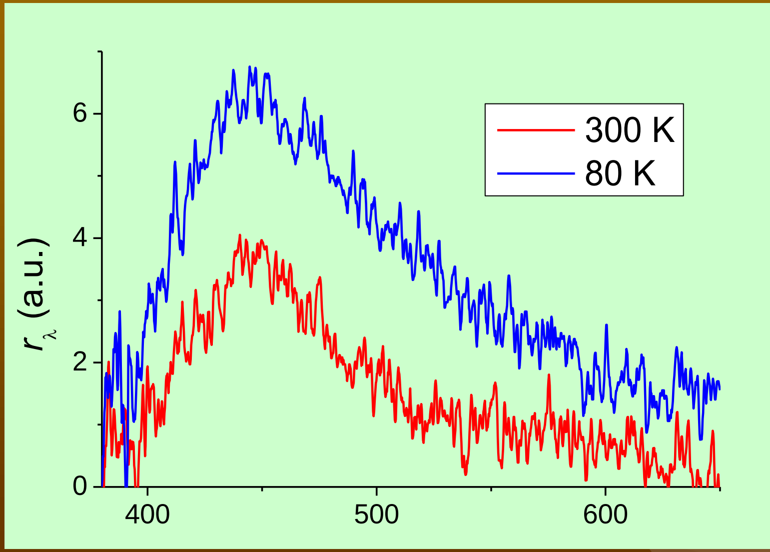
- the features of photoluminescence in organisms that can be described by the content of natural impurities with quantum-size effects and
- luminescence bands that could characterize physical condition of organism.

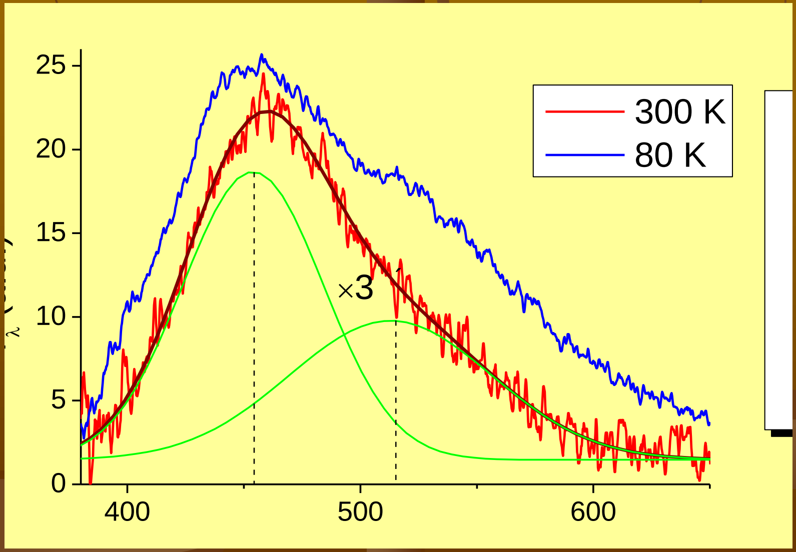
The main points

- Investigation of *C. p. molestus* larvae photoluminescence of different age and condition.
- Analysis of the luminescence spectra of natural water and its electrolytic precipitates.
- Theoretical description of the photoluminescence spectrum shape for nanosized impurities in water.

Photoluminescence spectra of larva homogenate for different ages

- Figure 1. PL of stage II *C. p. molestus* larvae at different temperatures
- Figure 2. PL of stage IV *C. p. molestus* larvae. The curves measured at the room temperature is approximated with two Gauss curves





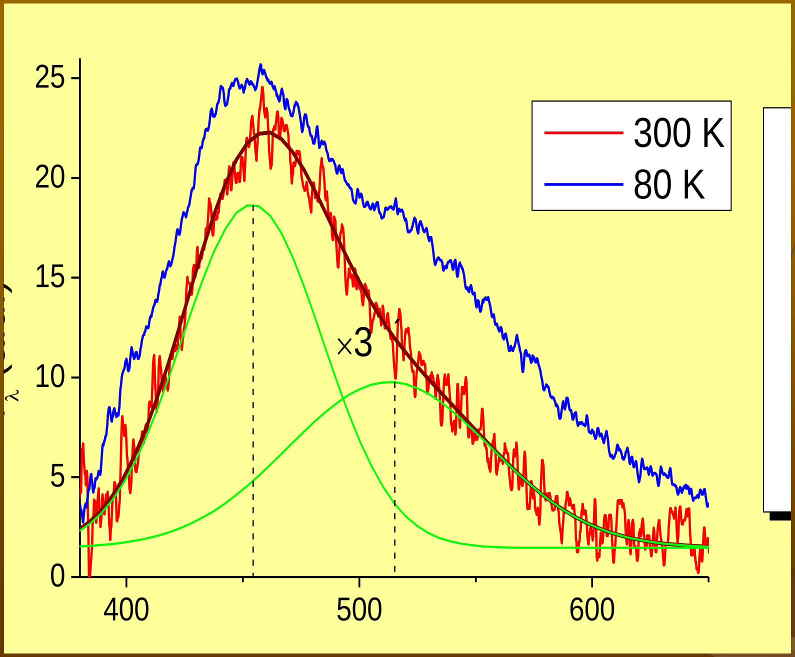
It is found that…

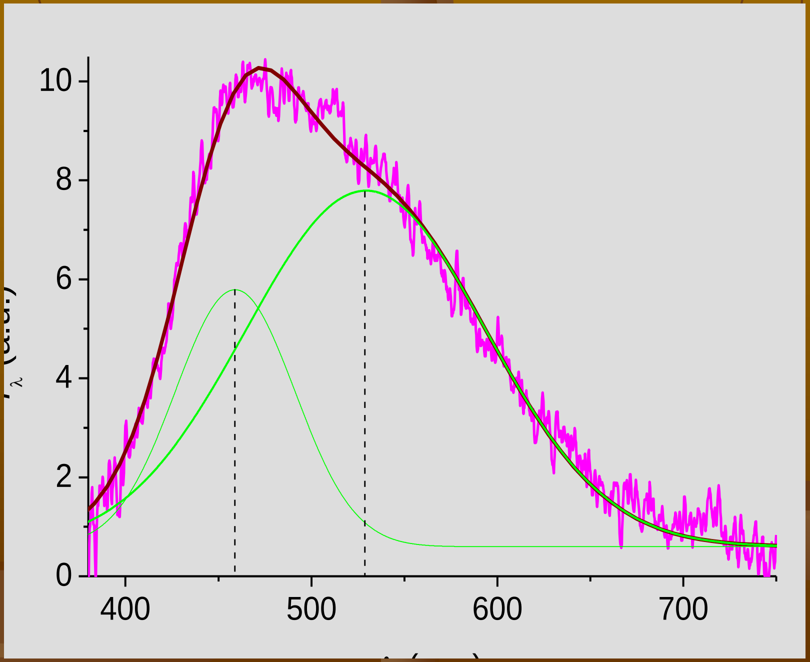
- development stage IV gnat luminescence intensity in the region of wavelengths from 400 to 600 nm is higher, than that for development stage II. Concerning the photoluminescence spectrum composition, we can say that no correlation was revealed with gnat age;
- gnat homogenate luminescence of the same age but from various groups are different by both the efficiency and the spectrum structure.

Photoluminescence spectra of larva homogenate for different condition

- Figure 2. PL of stage IV *C. p. molestus* larvae. The curves measured at the room temperature is approximated with two Gauss curves

Fig. 3. PL spectra of dried homogenate of stage IV *C. p. molestus* larvae (4 days after preparation) at room temperature.





It is found that…

- if the components of larva tissues are luminescence origin, they are undoubtedly the components which are not decomposed after the animal death;
- all this give cause for doubt that luminescence spectrum composition in this spectrum region can be an index of physical condition of gnat organism. Moreover, homogenate keeps capacity for radiate even in dry condition.

Photoluminescence spectra of the homogenate and natural water

Figure 2. PL of stage IV *C. p. molestus* larvae. The curves measured at the room temperature is approximated with two Gauss curves

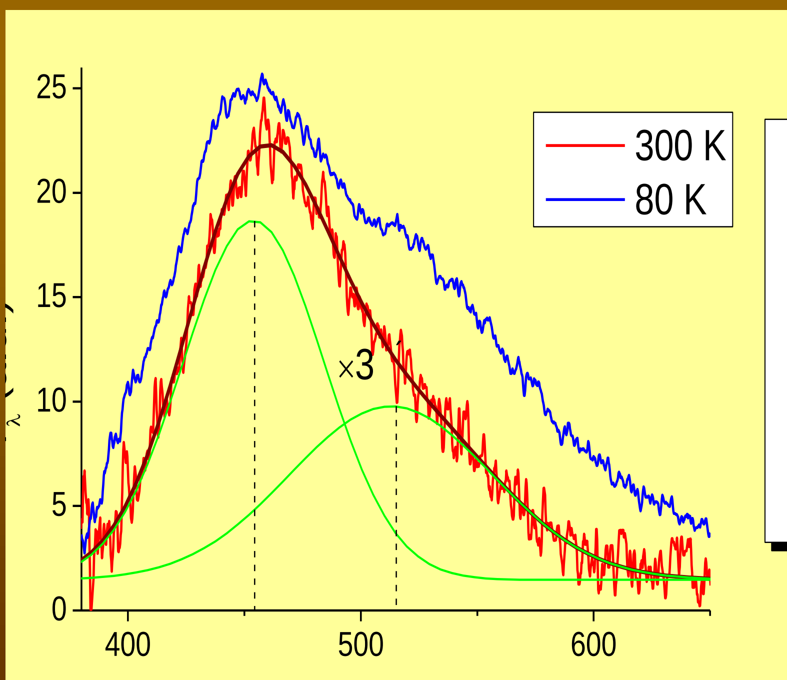
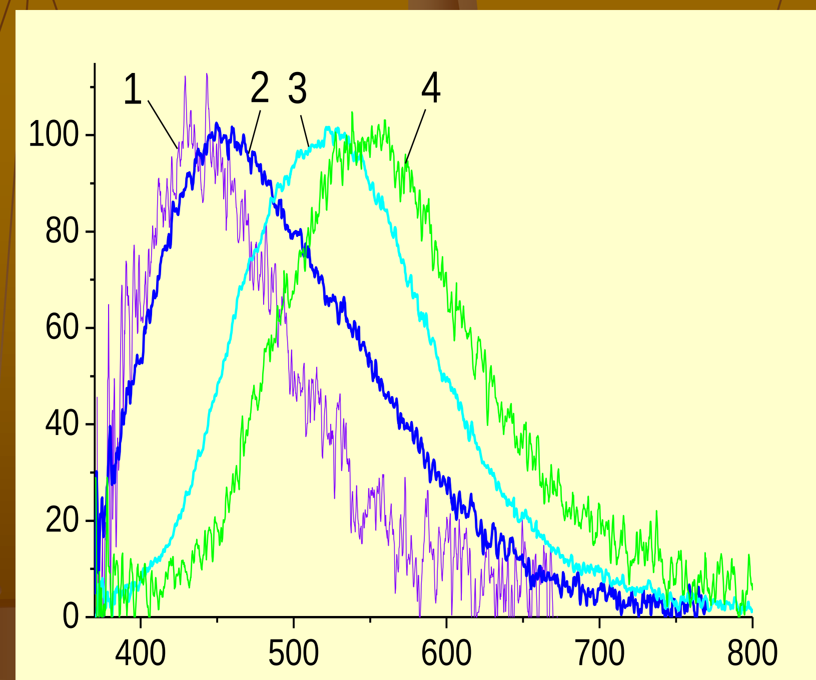


Fig. 4. Normalized PL spectra of natural water (1), its deposited impurities (2), deposit after 7 days (3) and dried deposit (4).

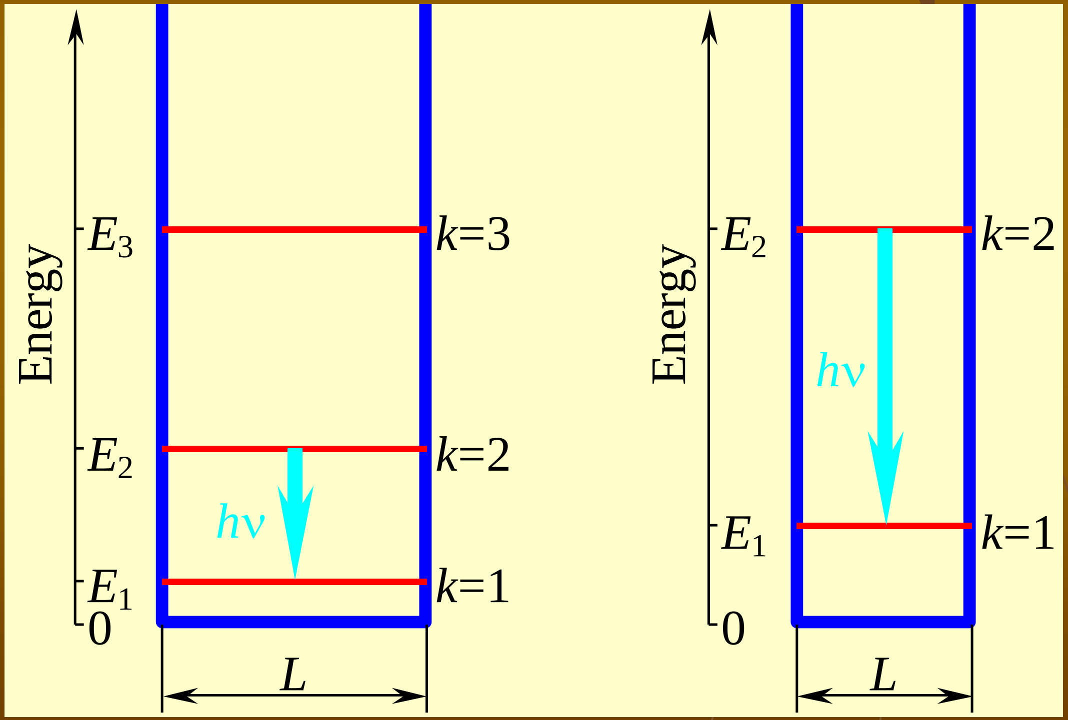


It is found that…

- as the water precipitate is dried, its photoluminescence band moves to long waves which is associated with the particle size increase;
- gnat luminescence is mainly caused by the water impurities;
- luminescence spectra of the gnat larvae extend over all the visible range;
- all this range is overlapped by the water impurity spectra.

Optical transitions in quantum wells

- Two potential wells with different thicknesses *L*



$$\lambda \propto L^2$$

$$h\nu \propto L^{-2}$$

Theory of the luminescence spectrum shape of nanosized impurities in water

The emitting transitions may happen between two energy levels of the quantum well for electron, which positions is known to be described as

$$E_n = \frac{\pi^2 \hbar^2}{2m_0}\left(\frac{k_1^2}{L_1^2} + \frac{k_2^2}{L_2^2} + \frac{k_3^2}{L_3^2}\right), \quad k_1, k_2, k_3 = 1, 2, 3, \ldots, \qquad (1)$$

where L_i are linear sizes of the quantum well along 3 coordinates, k_i are the respective quantum numbers and m_0 is the electron mass. In this case, the emission wavelength does not depend of chemical nature of the particle but only its sizes. Suggesting the emitting transitions happen between the 1st an 2nd electron levels of the quantum well, one can conclude that the size is not to be above 1.5 nm along if only one of the coordinates.

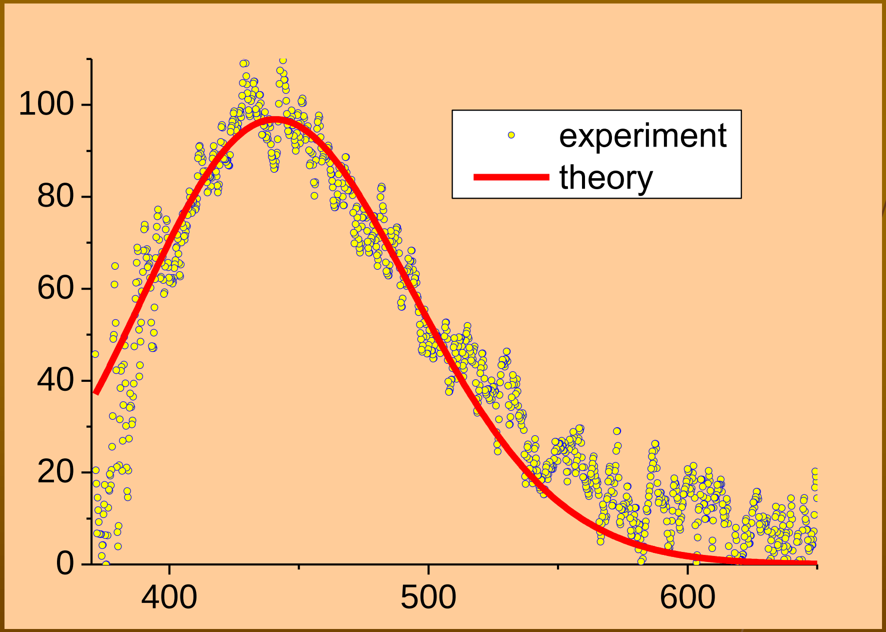
Supposing that the size distribution function of the particles has the Gauss shape, we have the shape of the spectral band

$$r_\lambda(\lambda) \propto L^{-3} \cdot e^{-\frac{(L-L_0)^2}{\delta L^2}}, \qquad (2)$$

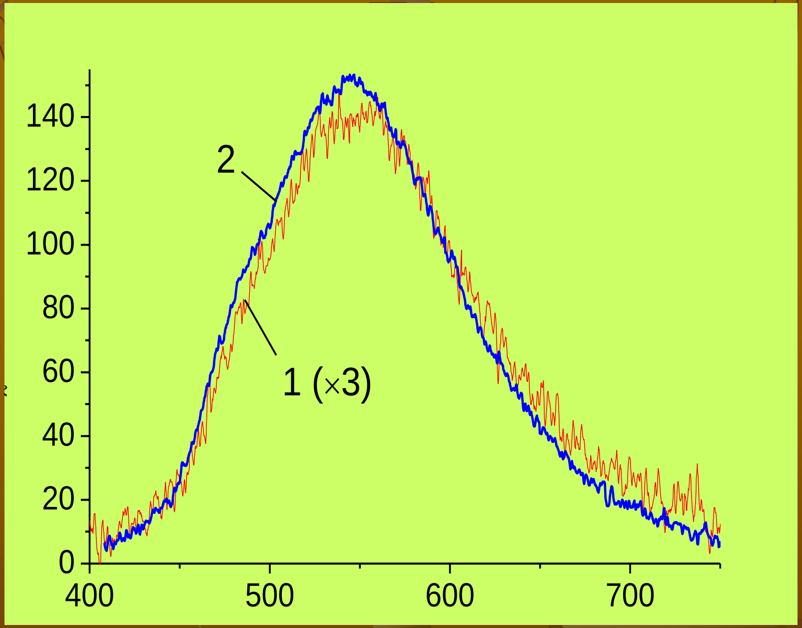
here $L \propto \lambda^{1/2}$ is the linear size of the particle, L_0 and δL are the constant values. The curve 1 of Figure 4 and its approximation by (1) are presented in Fig.5

The luminescence spectrum of impurities in water

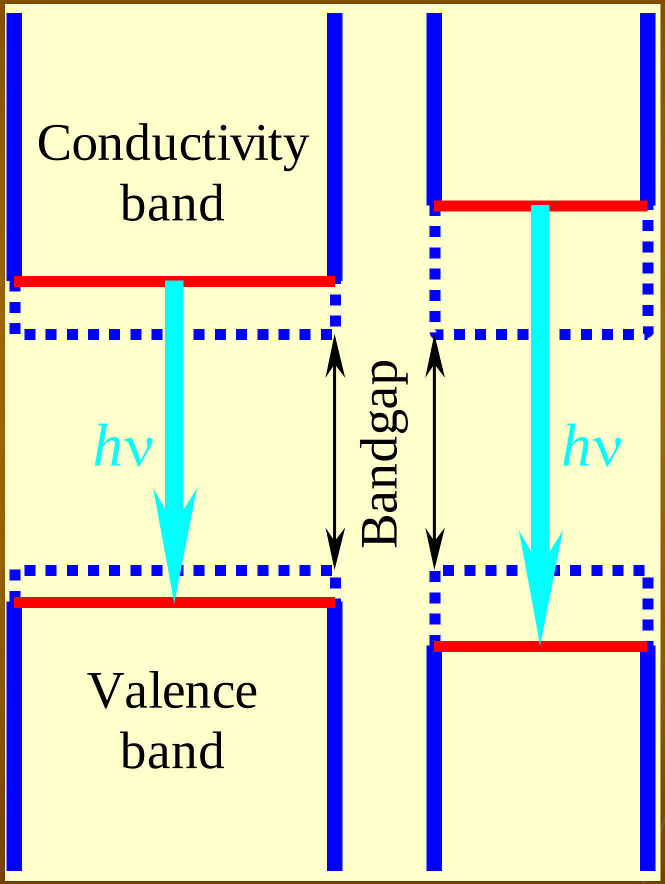
- Fig. 5. PL spectra of water (curve 1 in Fig. 4) and its theoretically calculated shape (1).



- Fig. 6. PL spectra of the dried deposit of water at room temperature (1) and at 80 K (2).



The luminescence of dielectric particles



The spectral curve shape of the band-to-band luminescence should be described by (2) as well, but the expression for the particle linear size as a function of wavelength is another, namely,

$$L \propto \left(\frac{hc}{n\lambda} - \varepsilon_g \right)^{-1/2}$$

where ε_g is the bandgap of the nanoparticle material and n is the refractive index of the material.

The modification of the spectrum may be explained by the following

- The concentration of the corresponding impurities in the natural water is comparatively low, they are mainly diluted and sizes of the not numerous nanoparticles are minimal, the spectrum is therefore shifted to short waves (curve 1 in Fig. 4).

- Under electrolyze, the impurities are clustered near one of the electrodes, its local concentration increases, the particles with larger sizes appear. Therefore, the luminescence intensity rises, the spectral band becomes more asymmetric and expanded whereas the peak is shifted to long waves (curve 2 in Fig. 4).

- Drying the suspense, the particles increase in value further but there is obviously some limit for the particle size. Due to this, the peak shifts further, but the width of the band and its asymmetry decrease (curves 3 and 4 in Fig. 4).

Particle size distribution

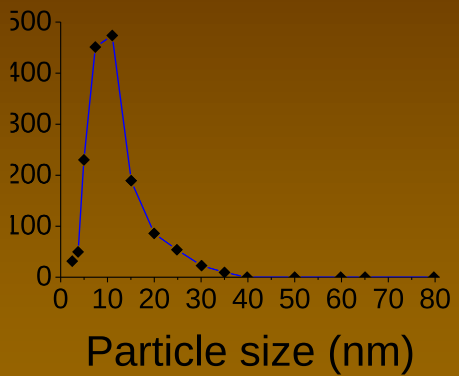


Рис. 7a. Particle size distribution for Al_2O_3 preparation of nanopowders by electrical explosion of wire.

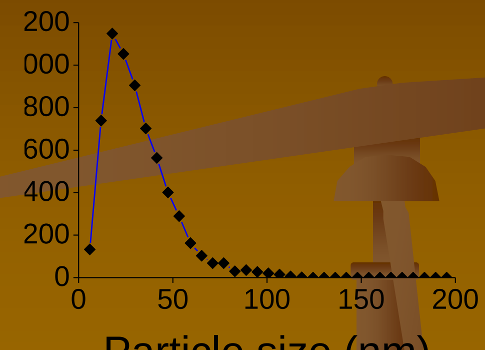


Рис. 7b. Particle size distribution for GdDCe preparation of nanopowders by pulsed CO_2 laser evaporation.

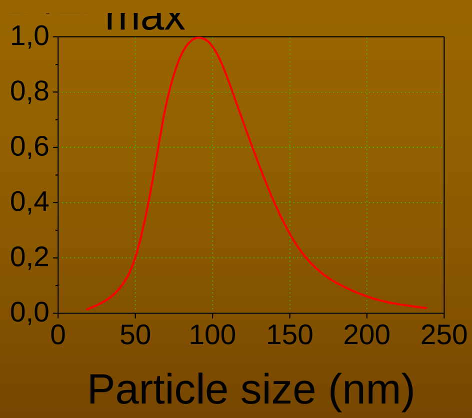


Рис. 7c. Particle size distribution for producible powders of chemical reaction microwave plasma-chemical synthesis of ultra-dispersed materials.

Nanoparticle technology: production and application development – a mission to Russian and Ukraine. – September, 2005. – http://www.oti.globalwatchonline.com/online_pdfs/36556MR.pdf

The impurities of the natural waters

- There are different derivates of silicon acid and iron, organic matters such as the products of plant and animal organism decomposition in the natural waters.
- The calcium and magnesium ions are assigned to the most important inorganic impurities of the water and these ions produce the sparingly soluble compositions with some anions in water, e.g., $CaSO_4$, $Ca(OH)_2$, $CaSiO_3$, $Ca_3(PO_4)_2$; $MgCO_3$, $Mg(OH)_2$, MgF_2, $Mg_3(PO_4)_2$.

- Obviously, these impurities have property of being accumulated in an organism and are present in tissues in concentrated form. Therefore, the luminescence of the living creatures and their remains is more intense than that of water. It should be expected that the impurities in different tissues are concentrated in different manner and have different mean sizes. In particular, this explains existence of more than one luminescence band in the spectrum.

Conclusions

- The PL spectra of the gnat larvae cannot be an index of physical condition of gnat organism.
- Gnat luminescence can be associated with nanosized impurities in water.
- The obtained results can be the basis for development of the optical method for nanoparticle diagnostics.