THE EFFECT OF SILVER NANOPARTICLES ON CHLOROPHYLL FLUORESCENCE PARAMETERS IN MICROALGAE

D.N. Matorin, D.A. Todorenko, B.K. Zayadan and N.A. Kulikova

Lomonosov Moscow State University,

119991, Moscow, Leninskie gory 1 bldg. 12

e-mail: matorin@biophys.msu.ru

Currently, silver-containing materials, including metallic silver nanoparticles (AgNP), are increasingly used in the manufacture of various products. Toxicity of silver ions for algae was studied by several authors. The toxic effect of AgNP to algae was shown by Navarro *et al.*, 2008.

In toxicological experiments with microalgae, fluorescence measurements are widely used as most convenient methods for monitoring photosynthesis processes and provide detailed information about the early disorders in the cell metabolism mainly on the membrane level (Matorin and Rubin, 2012). In addition, such techniques provide information about the state of natural phytoplankton in real time. Using M-PEA2 fluorometer, we studied processes in photosystems 1 и 2 (PS1, PS2) and the development of electrochemical gradient of protons across thylakoid membrane after exposure of the alga *Chlamydomonas reinhardtii* to AgNP in concentrations that cause insignificant changes in the *Fv/Fm* ratio. Analysis of fluorescence induction curves in the presence of low AgNP concentrations has shown an inhibition of electron transport in PS2 and an increase in the fraction of Q_B-non-reducing centers. We found no direct effect of AgNP on oxidation reactions of the pigment P700 in PS1 and on energization processes in photosynthetic membranes. We studied detoxicant effect of a humic preparation on microalgae, when used in combination with nanoparticles. The data show that humic substances modify the toxicity of nanoparticles. The detoxicant activity varied with different humic preparations.

Fluorescence parameters showed effects of nanoparticles on phytoplankton. We have shown that AgNP are able to inhibit photosynthesis in natural phytoplankton, which forms the basis of bioproductivity of natural water bodies. We observed a decrease in the maximum quantum yield of PS2, as measured by Fv/Fm ratio, and in the rate of noncyclic electron transport in phytoplankton under the effect of silver nanoparticles. Especially significant inhibition of photosynthesis in algae was observed under the effect of colloidal solution, containing silver nanoparticles in an "Argonica" preparation which has been approved for medical use. The effect was noted at concentration down to 10^{-8} M, which compared to the effect of highly toxic substances.

Our studies have shown that changes in induction curves of prompt and delayed fluorescence are among the first parameters that responded to the presence of nanoparticles in environment. These parameters may be effectively used to diagnose the effect of nanomaterials on algae, as well as for express detection of the presence of nanomaterials in aquatic environment. This work was supported by a grant from RFFI-N 13-04-01853.

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