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Abstract

What Phytoplankton Species Can Tell Us about the Implications of Engineered Nanoparticles in the Aquatic Environment †

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Nanotechnology is considered as the "sixth truly revolutionary technology" introduced into the modern world. The central question of how to benefit from this powerful technology, while maximizing and avoiding possible risks, represents a challenge for regulatory agencies and an important area of scientific research. With examples from our own research, we will illustrate what happens when aquatic microorganisms are inadvertently exposed to engineered nanoparticles (ENPs) that are increasingly released into the environment. The specific focus will be on nanoAg and nanoTiO_2, as representatives of the most widely used nanomaterials. We compared the ENP-induced responses in two phytoplankton species: the presumably "particle-proof" green alga *Chlamydomonas reinhardtii* and the "particle-ingesting" microalgal predator flagellate *Poterioochromonas malhamensis*. Generation of the reactive oxygen species (ROS), disturbing the cellular pro- and antioxidant equilibrium, as well as membrane damage and effect of ENPs on the photosynthesis were followed. The results revealed a significant increase in the cellular ROS and membrane damage upon exposure to ENPs, but the intensity of the effects was dependent on the nature, size and concentration of the ENPs, the exposure duration and the feeding pattern of the phytoplankton species. Liquid chromatography-based targeted metabolomics revealed that the abundance of metabolites involved in various pathways corresponding to amino acid, nucleotides, fatty acids, tricarboxylic acid cycle and antioxidant metabolism was altered in various treatments. The metabolomics results correlated well with the physiological results and confirmed that (i) oxidative stress is a major toxicity mechanism for nanoTiO_2 exposure [1]; and (ii) dissolved Ag released by nanoAg seems to be a major toxicity driver, even though nanoAg is internalized in the food vacuoles of *P. malhamansis* [2]. However, nanoAg plays an important role in the perturbation of amino acid metabolism, TCA cycle and oxidative stress. The implications of the obtained results for assessing the ENP-induced toxicity and tolerance responses in phytoplankton and for enabling the discovery of sensitive markers for early warning are highlighted.

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