Evaluation of Aquatic Toxicity of Nanoscale Silver, Zinc Oxide, Titanium Dioxide and Cadmium Selenide Quantum Dots, and Their Ionic Particulates to the MetPLATE™ Bioassay

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Current understanding on potential toxicity upon exposure of aquatic microorganisms to engineered nanoparticles (NP) is limited for risk assessment and management. Rapid screening test such as MetPLATE™ bioassay is envisioned as a promising tool for screening potential toxicity of NPs to aquatic microorganisms. We tested five types of NPs (citrate-nAg, PVP-nAg, nZnO, $nTiO_2$, and nCdSe Quantum Dots) using MetPLATE™ bioassay. MetPLATE™ bioassay is a simple, rapid and cost effective test that uses a mutant strain of *Escherichia coli* assay - the enzymatic activity of which is measured as the percentage inhibition compared to the untreated negative control. Toxicity of NPs was also compared with their corresponding dissolved ionic chemicals. The physicochemical properties of the NPs were characterized using dynamic light scattering (DLS), UV-Vis Spectrophotometry, Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), and electron microscopy. Results showed that ionic Ag, Zn, and Cd were highly toxic than their corresponding NPs suspensions to the MetPLATE bacteria. However, both nano- and ionic-particulates of TiO_2 were not toxic at concentration as high as 2.5 g/L. Moreover, fractionating nAg using 10 KD polysulfone hollow fiber membranes allowed us to distinguish nAg-specific toxicity from dissolved Ag ions toxicity. We found that ionic-Ag toxicity was 16X and 2.25X more toxic than clean citrate-nAg and polyvinylpyrrolidone-nAg, respectively. As the dilution and bioassay matrix constituted moderately hard water, the NPs stability was evaluated as a measure of particle size distributions (PSD) using DLS method. The observed nanotoxicity is explained based on the particle size distributions (PSD), zeta potential values, and sedimentation of the particles in the suspensions. Although we found that the tested NPs are relatively less toxic than their ionic forms, we caveat to disposing NPs into the receiving waters as physicochemical properties of NPs may change with changeable water chemistry which may alter NPs toxicity.

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