Short-Term Chronic Toxicity of Photocatalytic Nanoparticles to Bacteria, Algae, and Daphniad

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Abstract

The overall objective of this project was to assess the effect of photocatalytic nano-particles on the toxicity of three organisms, including bacteria, algae and daphniad. Among target organisms studied were: bacteria (*Escherichia coli*; TK2), algae (*Selenastrum capricornutum*) and daphniad (*Ceriodaphnia dubia*). A series of TiO_2 nan-nanoparticles in different particle size fractions were manufactured using the sol gel or CMVD technique. The TiO_2 particles were characterized for the particle size using both the SEM and the DLS methods before use. Experimentally, a 28-h *E. coli* culture or 2-day neonates or log-phase algae culture were exposed to photocatalytic nano-TiO_2 at various concentrations (e.g., 0 to 1 g/L) and particle size (e.g., 3 to 100 nm) both in darkness and the presence of a simulated solar light. The growth or survival rate was used to determine the LC_{50} value of all tested organisms. EC_{50} values of daphniad were determined from reproduction rate. Results show that in the size range of 5 to 30 nm, there appeared to be no significant difference in toxic response to the photocatalytic TiO_2 particles. The presence of light irradiation significantly enhanced the survival and the reproduction (in the case of daphniad) of tested organisms due to additional photocatalytic activity. Photocatalytic reactions generated hydroxyl radical, which is strong oxidation agent that can cause great stress and damage to the cells. Cell damage was observed in terms of lipid peroxidation (e.g., production of malondialdehyde, MDA), cellular respiration (e.g., reduction of 2,3,5-triphenyltetrazolium chloride, TTC) and antioxidant enzyme (e.g., glutathione-S-transferase, GST). Results indicated increase in the generation of MDA, TTC, and GST upon exposure of tested organisms to nano-TiO_2; photocatalytic activity markedly increased the production of MDA, TTC, and GST.