Submission for TIC by Steve Diamond, 6/07/09

Title: Phototoxicity of Selected Nanomaterials

Meeting: The Society of Environmental Toxicology and Chemistry (SETAC) North America 30th Annual Meeting, 19-23 November 2009, New Orleans, LA, USA.

Authors: Stephen A Diamond, Amanda Brennan, Sarah Hoheisel, Alan Kennedy

Abstract: Many nanomaterials posses physical, and potentially biological, activity that is unique relative to their macro-scaled or soluble forms. One such property is surface plasmon resonance; a phenomenon that can generate or facilitate photoreactivity. Optimization of these properties is, in some cases, the primary focus of development. (e.g. anatase TiO2). This suggests that the hazard or environmental risk for some nanomaterials is dependant on wavelengths of light present at the point of exposure. We are currently testing nanoscale TiO2, silver (n-Ag), and C60 in multiple species acute exposures to identify and quantify their phototoxicity. Our testing approach is to first develop exposure media having consistent and repeatable particle characteristics and then to complete 96-hr assays under lighting regimes that are typical of either laboratory conditions or solar radiation exposures that occur in natural sunlight (using a solar simulator). Exposures of medaka larvae and Daphnia magna were completed in very low ionic-strength water; an approach that consistently yields mean particle sizes of approximately 200 nm and does not involve the use of aggressive solvents or high-energy (probe sonication) techniques. Under these conditions, LC50s ranged from 1 to 10 mg TiO2/L, under levels of simulated solar radiation ranging from 25% to 50% of clear-sky summer sunlight. No toxicity was detected under laboratory lighting and maximal TiO2 concentrations of 100 mg/L. Similar testing of fullerene C60 and nano-scale silver (citrate stabilized, mean particle size of 56 nm) revealed no photoactivation of toxicity. Additional definitive assays are underway to better define the appropriate dose metric for expressing TiO2 photoactivated toxicity and to determine whether particle size is a significant factor.

Impact Statement: Nanotechnology is an emerging field that will produce hundreds of new and novel substances that have the potential for biological activity not typical of their bulk forms. One concern with many of these materials is their nano scale facilitates the conversion of photon energy to electron energy, leading to production of reactive oxygen species. The work presented here indicates that nano-scale TiO2 exhibits at least two orders of magnitude greater toxic potency in simulated sunlight. The work will be of significant value to regulators of nanomaterials.