Are there Unique "Nano" Effects from Exposure to Metal and Metal Oxide Nanoparticles?-Yes and No!

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Engineered nanomaterials (ENMs) have novel properties relative to their bulk counterparts. This "uniqueness" is raising societal concerns about their potential for negative environmental effects. However, it is unclear if ENMs result in unique "nano" effects in the environment. Research in the Center for Environmental Implications of Nanotechnology is identifying cases where nanomaterial exposures indeed lead to unique "nano" effects compared to ionic controls, and cases where they do not, i.e. effects are predicted from existing geochemical principles.

The solubility of silver nanoparticles (Ag NPs) was independent of nanoparticle size down to 5 nm. Solubility increased with decreasing size, but in a manner predictable from thermodynamics. This indicated a constant surface energy and an absence of strain on the FCC structure of the particles. This was confirmed with X-ray absorption spectroscopy and by pair distribution function analysis of total X-ray scattering data. The toxicity of Ag NPs to four different organisms was fully explained by the availability of dissolved silver species in the exposure media. Despite the apparent "non-uniqueness" of Ag NPs, application of Ag NPs in biosolids to terrestrial plants resulted in an increase in N_2O flux from the system relative to biosolids and $AgNO_3$/biosolid controls. This behaviour may be a result of spatial and temporal uniqueness of Ag NPs, i.e. their distribution in the environment and their ability to afford sustained low-level release of Ag ion, rather than from a unique reactivity.

Photoelectrons from minerals and microbial world

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The Earth surface is a multiple open system. Semiconducting minerals, including many metal oxides and sulfides, are ubiquitous on Earth's surface and widely participate in redox reactions following photoelectron/photohole pairs excited by solar light. Microorganisms evolve various pathways to utilize extracellular electrons and to get energy. Recently, Lu[1] presented evidences demonstrating solar energy mediated by semiconducting mineral photocatalysis, promoted the growth of some nonphototrophic bacteria and revealed that the ternary system of microorganisms, minerals and solar light has played a critical role in the life history on Earth. Under simulated sunlight, photoelectrons generated from semiconducting minerals could be used by nonphototrophic microbes to support their metabolisms. The growth of microbe, closely related with the photon quantity and energy, and well fitted the light absorption spectra of the semiconducting mineral. The overall energy efficiency from photon to biomass was 0.13‰ to 1.9‰. Further studies revealed that in natural soil system, semiconducting mineral photocatalysis influenced the microbial community. This solar energy utilization pathway by nonphototrophic microorganisms mediated by semiconducting mineral photocatalysis extends our knowledge on the use of solar energy by nonphototrophic microorganisms, and provides a new concept to evaluate the life origin and evolution. The comprehending of non-phototrophic bacteria solar energy utilization conducted by semiconducting minerals in present environment will greatly help us to better understand the energy transform mechanism among interfaces of lithosphere, pedosphere, hydrosphere and biosphere.

[1] Lu, Li & Jin *et al*.. (2012), *Nature Communications* 3, 768-775.

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