The toxicity effects of Fe$_2$O$_3$, TiO$_2$, ZnO, and Ag engineered nanomaterials (ENMs) on the macrophyte Spirodela species

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Nanomaterials are increasingly being used in consumer products, especially sunscreens and beauty products, with limited research about the environmental effect of these nanomaterials once they are released into the environment.

WHAT IS NANOTECHNOLOGY?

It is the development and application of materials with at least one dimension in 1-100 nano-meter range ($10^{-9}$ m) in any phase of matter. Nanomaterials possess strikingly different properties relative to macroscopic materials mainly due to high surface area and increased atom density at the surface. The global nanotechnology industry is growing rapidly.

NANOTECHNOLOGY AND ENVIRONMENTAL CONCERNS

Data indicates increasing nanotechnology use whilst concerns have been raised because ENMs are generally highly reactive and their environmental fate and effects are less understood.

BACKGROUND

Nanotoxicology is a relatively new toxicology field which started in the mid 2000s. Data so far indicates algae to be relatively sensitive to other groups of aquatic organisms, but there is minimal data on algae and no data exist on macro-algae or macrophytes (Kahru and Dubourguier 2010). Nanoecotoxicity data is useful for product safety data sheets, ecological risk assessment and environmental guidelines development. The current uncertainties about ENMs environmental fate and effects limit a wider nanotechnology application. Current literature suggests oxidative stress as a basic form of toxicity induction on biological systems.

STUDY AIM

To investigate the influence Fe$_2$O$_3$, TiO$_2$, ZnO and Ag engineered nanomaterials on oxidative stress, structural cellular integrity and photosynthesis on the algal Spirodela species.

Selected Engineered Nanomaterials

Hansen et al. (2008) indicated that silver (Ag), carbon nanotubes, Zinc (Zn), Silica (Si) and Titanium dioxide (TiO$_2$) respectively, were five of the most used ENMs in consumer nanoproducts. ENMs used in high volumes are likely to end up in the environment during application and also waste disposal where they will pose some level of risk. Four of these highly-used ENMs are selected for the current study.

Fe$_2$O$_3$ (iron oxide)

Nanocake iron is extensively used in biomedication (Zhang 2003) and its use in environmental clean-up operations is increasing. Therefore a significant portion of nanoscale iron entering the environment will be introduced intentionally during environmental biomedication. Considering the potential benefits and increasing usage of nanoscale iron and also that it is one of the highly-used ENMs, raises concerns about the potential toxicity of nanoscale iron.

TiO$_2$ and ZnO (lithium dioxide and zinc oxide)

Nanoscale TiO$_2$ and ZnO are currently few of the ENMs that are already widely used in market products, such as beauty care products. Some known toxic effects of TiO$_2$ and ZnO include oxidative stress induction (Hartmann et al. 2009). A high proportion of TiO$_2$ and ZnO introduced into the environment will be unintentional as waste from domestic (mainly cosmetic) and also industrial applications.

AgNP (silver nanoparticles)

Silver has long been used for its microbicidal properties to treat microbial infections and burn wounds. Engineered nano-silver is used to disinfect fabrics, medical equipment and facilities (Anna et al., 2009). Nano-silver is known to possess other toxicity tendencies including generation of reactive oxygen species. Nano-silver will mostly enter natural ecosystems unintentionally as waste; literature has already reported nano-silver release from washing fabrics.

STUDY ENDPOINTS

Oxidative Stress (OS)

Oxidative stress is a condition during which the generation of reactive oxygen species (ROS) within a cell exceeds metabolic detoxification mechanisms. These mechanisms include the activation of antioxidant enzymes such as superoxide dismutase, catalase, ascorbate peroxidase and glutathione peroxidase. High and continuous ROS dosages can eventually lead to cell death. The increased activity of antioxidant enzymes when samples are exposed to toxins is utilised as a biomarker indicating the induction of oxidative stress.

REFERENCES


