ENPRA Risk Assessment of Engineered NanoParticles

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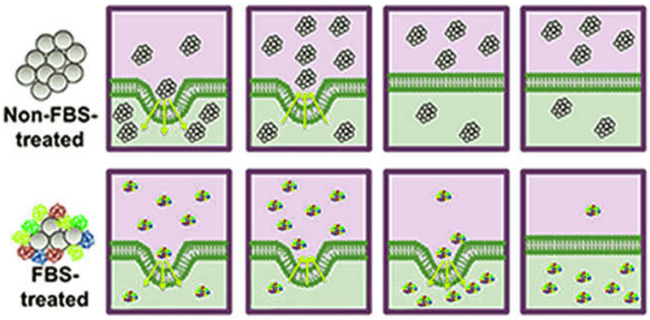


# Environmental, Health and Safety Impacts of Nanoparticles

European Observatory on NanoSafety

N°6
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**Environmental, Health and Safety Impacts of Nanoparticles n°6**
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Effect of serum pre-incubation on $TiO_2$ NP aggregation and cellular uptake. FBS: fetal bovine serum. Reprinted with permission from ACS Nano 6(5), 4083 (2012). Copyright 2012 ACS. To see also: "Univ. of New South Wales: Effect of serum on $TiO_2$ nanoparticle aggregation, cellular uptake and toxicity" on page 10.



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# Environmental, Health and Safety Impacts of Nanoparticles

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# Introduction

*The sixth meeting of the European Observatory on NanoSafety (EONS) has been held in Paris on May 24, 2012. The present report summarises the literature analysis and the discussions developed during this event.*

*About the European Observatory on NanoSafety*

*The European Observatory on NanoSafety (EONS) is a collective initiative launched in 2009 by the Observatory for Micro&Nanotechnologies (OMNT) and the European consortium ENPRA (Risk Assessment of Engineered NanoParticles). Every 6 months, EONS meetings bring together experts in nanotechnology environmental health and safety (including OMNT experts, partners of the ENPRA project and invited key scientists) and provide them with the unique opportunity to collectively review and comment the latest research progresses of the domain. Topics addressed by the panel cover the full scope of 'NanoSafety' including detection and characterization of nanomaterials, toxicology, ecotoxicology, risk assessment and risk management as well as normative and regulatory aspects. Proceedings of the meetings are published by the OMNT*

# Environmental Impacts

## NIST & CCEHBR:
## Environmental fate of silver nanoparticles from everyday consumer products. Evidence of silver release and accumulation in the aquatic compartment

**Reviewed by N. Manier**

**A mesocosm study showing silver release from nanomaterial-based consumer products**

Engineered nanomaterials are now being manufactured in ever increasing quantities and incorporated in a wide range of products and sectors. Among them, silver nanoparticles can be found in several everyday consumer products including antibacterial textiles, antibacterial wound dressing as well as tooth paste or toys. Based on the life cycle of these products, silver nanoparticles are likely to end up in the environment. Assessment of the environmental risk posed by such kind of consumer products is a real challenge and, one research priority is to estimate the potential release as well as the environmental fate and behavior of the nanoparticles for which very little information are currently available.

In this context, **Danielle Cleveland** and collaborators from the **National Institute of Standards and Technology** and the **Center for Coastal Environmental Health and Biomolecular Research** have used replicated estuarine mesocosm systems in order to study the leaching, the environmental fate and the bioaccumulation behavior of silver nanoparticles from selected consumer products: a nanocrystallin silver-coated antimicrobial wound dressing, a dress sock advertised to contain silver-coated nylon fibers and a stuffed toy bear that was advertised to contain silver nanoparticles in its foam stuffing [1].

Estuarine mesocosm systems (Figure 5) were established in a greenhouse and the environmental compartment of interest contained the seawater, the sediment (intertidal) as well as biofilm, aquatic plants (Spartina alterniflora), mud snails (Ilyanassa obsoleta), grass shrimp (Palaemonetes pugio) and hard clams (Mercenaria mercenaria). Each consumer product was placed intact on the water surface and left to float or sink undisturbed for 60 days (Figure 6). Total silver was tracked over the testing period in each compartment and in the organisms as well as in the products themselves. This pilot study can be seen as a first approximation of the environmental fate of nanosilver contained in consumer products discarded in an estuarine environment.

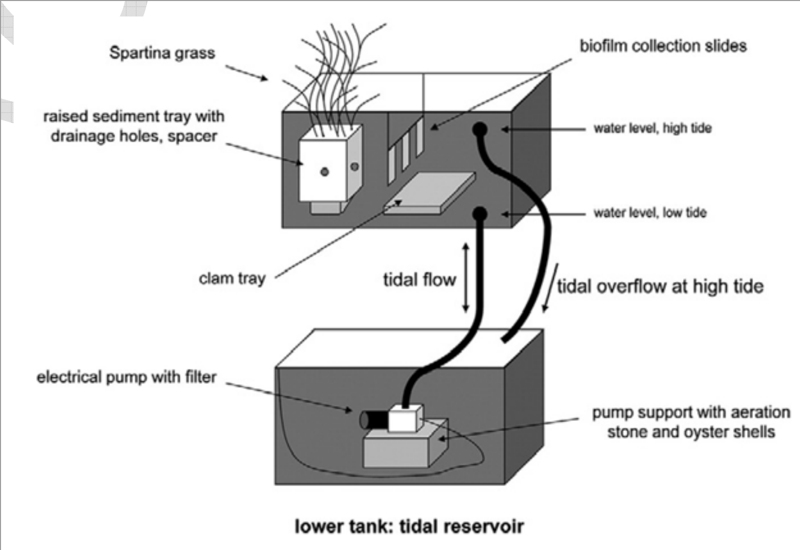


**Figure 5: Representative scheme of an estuarine mesocosm system. The top tank mimics a tidal stream and marsh while the bottom tank served as a tidal reservoir. Water is delivered to the upper tank via an electrical pump during high tide cycles.**
*Reprinted with permission from Science of Total Environment 421-422, 267 (2012). Copyright 2012 Elsevier.*

The authors firstly showed that the consumer products exhibited long-term release of significant amount of silver over the 60 days residence time in the mesocosm. Ultimately release of 95% of the sock total silver loads was reported while the wound dressing and toy bear had released up to 99% and 82% of their total silver content, respectively. These findings are in line with previous data from **Benn** and **Westerhoff** (2008), who reported that ordinary laundering can wash off substantial amounts of nanosilver particles from antibacterial socks [2].

Figure 6: Picture of a mesocosm treated with a toy bear.
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The authors then showed that once released in the water column, silver was quickly transferred from the seawater to the sediment and readily adsorbed to the biofilm. Silver also accumulated in the estuarine biota (snails, shrimp and clams). The authors calculated the bioaccumulation factor (BCF) and the trophic transfer factors (TTF) and suggested that silver nanoparticles can be directly taken up from the seawater, by biofilms, sediment or sand, whereas primary transfer route of silver into the snails, shrimp and clams is likely via trophic intake of the biofilms.

This paper presents the first mesocosm study addressing and quantifying the release and fate of nanoparticles from consumer products in estuarine aquatic compartment, as well as the potential bioaccumulation behavior in living organisms. Despite the lack of nanoparticles characterization in the different compartments, Cleveland et al. have published here an interesting data set that can be useful for estimating or modeling the release and fate of nanoparticles from consumer products, which are crucial for the environmental risk assessment.

[1] "Pilot estuarine mesocosm study on the environmental fate of Silver nanomaterials leached from consumer products" ; D. Cleveland, S.E. Long, P.L. Pennington, E. Cooper, M.H. Fulton, G.I. Scott, T. Brewer, J. Davis, E.J. Petersen, L. Wood : ***Science of Total Environment*** **421-422**, 267 (2012).
[2] "Nanoparticle silver release into water from commercially available sock fabrics" ; T.M. Benn, P. Westerhoff : ***Environmental Science and Technology*** **42**, 4133 (2008).

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## ILSI:
## Guidance for addressing potential safety issues associated with the use of nanomaterials in food products

**Reviewed by K. Aschberger**

**A tiered approach for safety assessment of nanomaterials in food**

The paper presents a systemic, tiered approach to assess the safety of engineered nanomaterials (ENM) in food [1]. The underlying work was commissioned by the Novel Foods and Nanotechnology Task Force of the European Branch of the **International Life Sciences Institute** (ILSI Europe) for which additional experts were consulted during a Workshop organized in 2011.

The safety assessment of ENM for food applications is presented in five steps: characterization of the bulk material(s) from which the ENM is derived; characterization of the physicochemical properties of the ENM; identification of ENMS requiring focused toxicological assessment (Decision tree); toxicological assessment (tiered approach) and safety evaluation of ENM 'as used' in its intended food matrix.

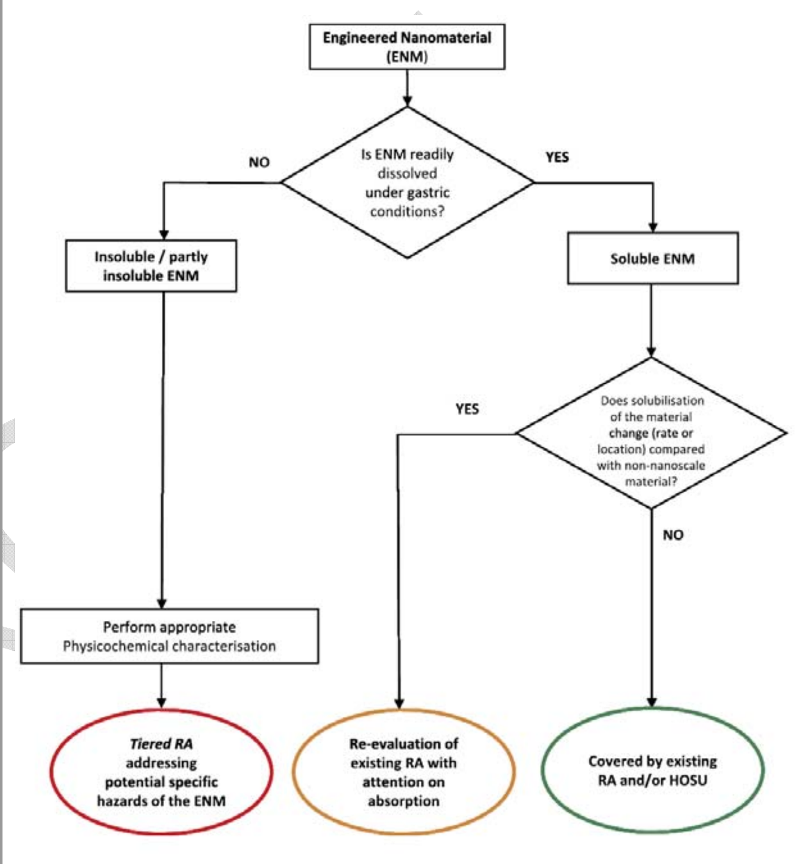


**Figure 8: Decision tree.**
*Reprinted with permission from Food and Chemical Toxicology 50(6), 2224 (2012). Copyright 2012 Elsevie.*

The safety assessment is mainly based on a comparative approach to exploit available information on the non-nano counterpart. A key part of the assessment is the decision tree (Figure 8) based on solubility and dissolution rate, which sorts ENMs for toxicological testing. The toxicity testing follows a tiered approach, where the first tier is considered a screening level, and the second tier serves for the hazard identification and characterization. The tiered approach has to be followed on a case by case basis, therefore further decision guidance cannot be given. For the exposure assessment eventual modification of the ENM in the food matrix and dosimetry considerations are considered.

In May 2011 the **European Food Safety Authority** (EFSA) published the "Guidance on the risk assessment of the application of nanoscience and nanotechnologies in the food and feed chain" [2]. In comparison to it, the current paper focuses more on the hazard assessment and presents the tiered approach which can be better tailored to toxicity testing on a case by case basis than decision trees. The structure of the paper follows a conventional risk assessment paradigm.

The guidance is comprehensive and presents the current scientific status with a view to possible methodologies in future. In addition, it presents examples to explain better the decision tree. The decision tree as main criteria for toxicity testing or not, might be understood as oversimplification, as decisions may not always be so straightforward as presented (YES/NO), especially as the time component is not given.

In conclusion, this is a highly relevant document for authorities, researchers and ENM developers to give guidance on how to perform a risk assessment, but also on how to focus testing and/or development of new food ingredients.

[1] "Approaches to the safety assessment of engineered nanomaterials (ENM) in food" ;
A. Cockburn, R. Bradford, N. Buck, A. Constable, G. Edwards, B. Haber, P. Hepburn, J. Howlett, F. Kampers, C. Klein, M. Radomski, H. Stamm, S. Wijnhoven, T. Wildemann, A.M. Chiodini : ***Food and Chemical Toxicology*** **50**(6), 2224 (2012).
[2] "Guidance on the risk assessment of the application of nanoscience and nanotechnologies in the food and feed chain" ; EFSA Scientific Committee : ***EFSA Journal*** **9**(5), 36 (2011).

EONS09-12-9

# Companies, organisations & experts quoted in this report

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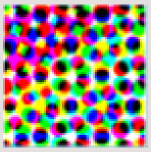

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