Stable isotope labelling - a way forward for enhanced detection in monitoring exposure to nanoparticles

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Understanding the behavior of engineered nanoparticles and their detection in the environment and within organisms remains one of the obstacles to the safe development of nanotechnologies. Research is still hampered by the lack of reliable tools to detect, visualize and trace particles in complex environmental and biological systems. In addition, for nanoparticles made of elements such as Cu and Zn, which are essential but also common pollutants, reliable tracing is even a greater challenge due to high background concentrations. In this work we demonstrate how labeling nanoparticles with enriched stable isotopes can enhance detection sensitivity when studying their uptake in biota. The indigenous isotopic composition of engineered nanoparticles falls within the same range found in natural materials of geological and biological origin. Modification of the isotopic composition is thus needed to make the particles distinctive and thus easily traceable.

We synthesized isotopically enriched ZnO (20nm, 90% enriched with Zn^{67} of natural abundance 4.1%), CuO (spheres of 7nm and rods 7x40nm, 99% enriched with Cu65 of natural abundance 30.8%) and Ag (15nm, citrate capped, 99% enriched with Ag^{109} of natural abundance 48.2%) nanoparticles. Freshwater snails were then exposed to the labelled particles either via food (diatoms mixed with $Zn^{67}O$ particles) or via water with a range of concentration of dispersed $Cu^{65}O$ and Ag^{109} nanoparticles. The experiments were conducted with the aim to: 1) determine whether isotopic enrichment can enhance detection of metal uptake in animal tissues after short exposures and 2) determine if limitations imposed by the high natural background concentrations of Zn and Cu in animal tissue can be overcome by using a tracer. After exposure animals were sacrificed and tissues digested with concentrated nitric acid and hydrogen peroxide prior to stable isotopes analysis by ICP-MS. Stable isotope tracing technique [1] used allowed tracking newly accumulated metal (from the labelled particles) independently from the background metal in animal tissue.

Detection of newly accumulated Zn (via dietborne exposure) was only significant at Zn exposure con-

centrations above about 5000 µg g^{-1} if no tracer was used compared with only 15 µg g^{-1} when using a tracer [2]. Copper accumulation was detected at exposure concentration as low as 20 µg L^{-1} when the tracer was used while concentrations well above 150 µg L^{-1} were needed without a tracer [3]. In the case of Ag, when using labelled particles we could detect metal uptake at environmentally realistic exposure concentrations i.e. below 1 µg L^{-1}.

References

[1] Croteau et al 2004 Environmental Science and Technology 38, 5002-5009.

[2] Dybowska et al 2011 Environmental Pollution 159, 266-273.

[3] Misra et al 2012 Environmental Science and Technology 46, 1216−1222.

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