Physico-chemical and toxicological properties of the Zn containing nanoparticles

O. Uski[1], T. Torvela[1], O. Sippula[1], T. Karhunen[1], H. Koponen[1], S. Peräniemi[2], P. Jalava[1], M. Happo[1], J. Jokiniemi[1], M.-R. Hirvonen[1], A. Lähde[1]

[1] Department of Environmental and Biological Sciences, University of Eastern Finland, P.O. Box 1627, 70211 Kuopio, Finland
[2] School of Pharmacy, Biocenter Kuopio, University of Eastern Finland, P.O. Box 1627, 70211 Kuopio, Finland
Keywords: zinc, nanoparticle, composition, solubility, toxicity
Presenting author email: anna.lahde@uef.fi

Nanomaterials have become a part of our modern everyday life. People are exposed to particles not only through pollution but also through the daily use of various products containing nanomaterials. For example, around 10^5 tons of ZnO is produced annually for sunscreens, catalyst etc. (Colvin, 2003; Klingshirn, 2007).

Based on the studies the particle size has been regarded as the dominant factor determining the toxicological effects of nanoparticles (Becker et al. 2003). However, particle composition plays has also been shown to play an important role (Schwarze et al. 2006). This is supported by our results showing different inflammatory, genotoxic and cytotoxic responses in immunotoxicological cells to different wood combustion particles of similar size (Jalava et al 2009).

In the current study the physico-chemical properties of Zn containing nanoparticles and their relationship to induced toxicity was investigated. The particles were synthesized using aerosol methods, while $ZnCl_2$ was used as a reference. The solubility of the particles in cell culture medium was measured with atomic absorption spectroscopy and modelled using a Pitzer ion interaction model. The toxicity of the particles was studied with a RAW 264.7 mouse macrophage cell line. Cells were exposed for 24 h to the NPs containing similar amounts of Zn.

Table 1 shows the properties and composition of the particle samples used in the toxicological studies. The particles consisted of zinc containing species with varying composition. The agglomerate size of the particles was between 35 nm and 44 nm. The shape of the particles varied from irregular (CVS-1), and spherical agglomerates (CVS-2, CVS-3) to rod shaped particles (FSP-1).

The solubility of the species in the cell culture medium depended on their composition. The particles consisting of Zn salts were fully soluble in pure water. However, the high carbonate concentration in the cell culture medium resulted in a conversion of zinc to ZnO and $ZnCO_3$ and subsequently in the precipitation of the Zn species. The ZnO nanoparticles (CVS-1 and FSP-1), on the other hand, had low solubilities in both water and cell culture medium.

It was found that the toxicological profiles of zinc containing nanoparticles and $ZnCl_2$ were dependent on the size, shape and solubility of the particles. The observed release of Zn^{2+} in the cell culture media was consistent with the cytotoxic effects of the studied Zn compounds on RAW 264.7 cells (Figure 1).

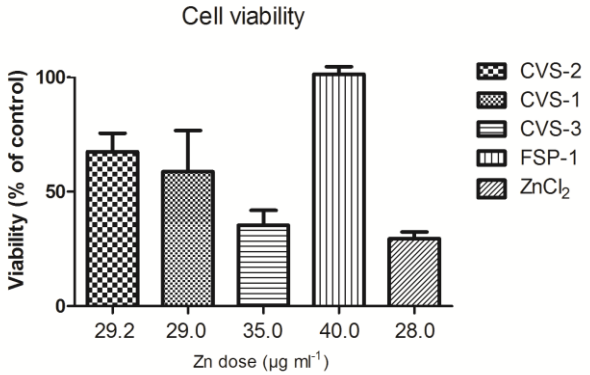

Figure 1. Cytotoxicity was evaluated using the propidium iodide (PI) exclusion test (n = 3). Each whisker represents the standard error of the mean (SEM).

References:

Becker, S. (2003) *Exp. Lung. Res.* **29**, 29-44.
Colvin, V.L. (2003) *Eur. J. Pharmacol.* **479**, 171-185.
Jalava, P. et al. (2009) *Inhal. Toxicol.* **21**, 994-1006.
Klingshirn, C. (2007) *Chem. Phys. Chem.* **8**, 782-803.
Schwarze, P.E. (2006) *Hum. Exp. Toxicol.* **25**, 559-579.

Table 1. Properties of the produced particles and their toxicological effects.

Powder	Composition	Crystalline size [nm]	Solubility in cell culture medium [%]*	MIP-2 [pg/ml]***
CVS-1	ZnO	n.a.	1.0	500
	K_2SO_4	29		
CVS-2	ZnO	34		
	$C_4H_4O_4Zn$	33	n.a.	1600
	K_2SO_4	~39		
CVS-3	$K_2Zn(SO_4)_2 \bullet 6H_2O$	75		
	$C_6H_8O_7$	~63	1.97**	1300
	K_2SO_4	~50		
FSP-1	ZnO	56	0.11	800
$ZnCl_2$ ref.	$ZnCl_2$	na.a	2.12	200

*values from Pitzer model, **without $ZnCO_3$ formation Zn is fully soluble, *** control value 400 pg/ml.