Zinc oxide nanomaterials toxicity to *Daphnia magna*. Effect of particle coatings on immobilization, reproduction and body size.

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INTRODUCTION & OBJECTIVES

Zinc oxide nanomaterials (ZnO NMs) have remarkable optical, physical, and antimicrobial properties, which result in their use in a wide range of applications such as biosensors, cosmetics, drug-delivery systems, sunscreens, biocides. In general, the purposes of surface coating on nanomaterials (NMs) are extending their applications or changing the properties, or reduce toxicity (safe-by-design).

AIM OF THIS STUDY

To investigate whether coating of ZnO NMs would change the toxicity to *D. magna* through acute immobilisation and chronic reproduction tests.

MATERIALS & METHODS

In this study, the ecotoxicity of triethoxycaprylsilane coated ZnO NMs (76 nm) and uncoated ZnO NMs (70-90 nm), obtained from the Joint Research Centre of the European Commission, were studied using *D. magna* as model species. The Acute Immobilisation Test (OECD 202) and the Reproduction Test (OECD 211) were employed in this study. The parent organisms were cultivated with 16 hours light/ 8 hours dark lighting cycle and fed with algae *Chlorella vulgaris* daily. Neonates aged less than 24 hours were used in the acute experiments. For the preparation of the ZnO NMs suspensions, the protocol from EU FP7 Nanogenotox project was followed and the initial concentration of ZnO NMs was 2.56 mg/mL.

CONCLUSION

Data obtained in this study indicate that coated ZnO NMs are less toxic than uncoated ZnO NMs towards *D. magna* in longer term exposures. It is suggested that further studies including more replicates and other aquatic species should be carried out. The final goal of this study is to obtain data to support nanosafety, working closely with industry, which will benefit both environment and human health.

RESULTS & DISCUSSION

The results indicate that exposures to uncoated and coated ZnO NMs resulted in acute toxicity towards *D. magna*. The 48-hours EC50 values for uncoated and coated ZnO NMs were in a similar range, around 2.3 to 2.6 mg/L (Figures 1 and 2). However, in the chronic reproduction test, exposure to uncoated ZnO NMs resulted in higher mortality compared to coated ZnO NMs. With the concentrations ranging 180, 300, 500 to 840 µg/L, the parent *D. magna* mortality was 10%, 30%, 70% in the coated ZnO NMs group, and 60%, 50%, 90%, 100%, respectively, in the uncoated ZnO NMs group (Table 1). Furthermore, in the coated ZnO NMs group, neonates per parent daphnid and the body size in concentrations 180, 300, 500 and 840 µg/L were significantly lower compared to the control group (Figures 4 and 6); it was also clear that exposure to uncoated ZnO NMs led to a decreasing number of neonates per parent daphnid (Figures 3 and 5).

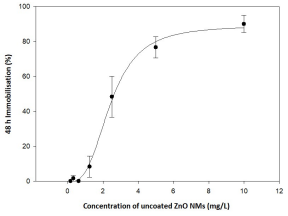


Figure 1. The EC50 of uncoated ZnO NMs on *D. magna* immobilisation was calculated as 2.43 mg/L after 48 hours exposure (n = 3. error bars = SE).

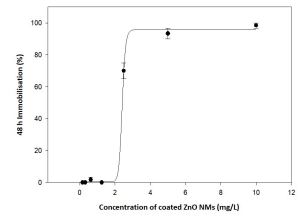


Figure 2. The EC50 of coated ZnO NMs on *D. magna* immobilisation was calculated as 2.41 mg/L after 48 hours exposure (n = 3, error bars = SE).

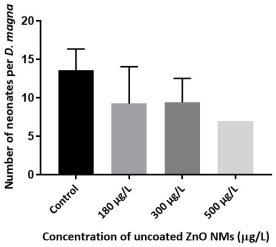


Figure 3. Mean cumulative neonates per surviving *D. magna* after 21 days exposure to uncoated ZnO NMs. The neonates number showed a clear concentration response relationship.

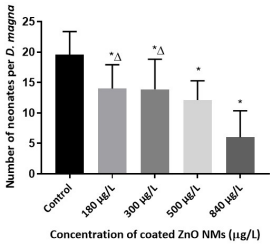


Figure 4. Mean cumulative neonates per surviving *D. magna* after 21 days exposure to coated ZnO NMs. Number of neonates decreased while coated ZnO NMs concentration increased. * P<0.05 compared to the control group. Δ P<0.05 compared to 840 µg /L.

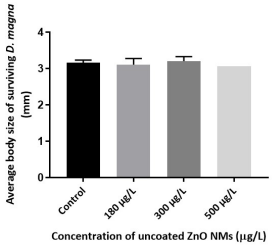


Figure 5. Average body size of surviving *D. magna* after 21 days exposure to uncoated ZnO NMs. There was no significant difference found between treated and control group.

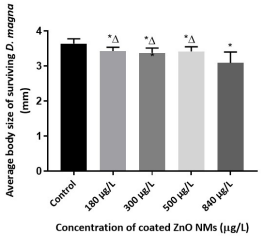
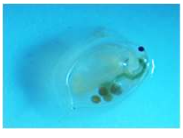


Figure 6. Average body size of surviving *D. magna* after 21 days exposure to coated ZnO NMs. Body size decreased significantly in all treated groups. * P<0.05 compared to the control group. Δ P<0.05 compared to 840 µg /L.

Table 1. Mortality rate of parent *D. magna* after 21 days exposures to uncoated and coated ZnO NMs.

ZnO NMs concentration (µg /L)	Uncoated ZnO NMs	Coated ZnO NMs
Control	10%	10%
180	60%	10%
300	50%	10%
500	90%	30%
840	100%	70%



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