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Biological effect and adsorption of TiO_2 nanoparticles on two aquatic invertebrates after acute exposure

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BACKGROUND

Titanium dioxide nanoparticles (TiO_2 NPs) have a wide application in industry and are most commonly encountered among nanoparticles. A consequence is that they could become an environmental pollutant. One characterisitc of NPs is their surface adsorption potential, which could be a driving force behind the interactions and dynamic changes between nanomaterials and biological systems (Xia et al.2011). Adsorption of NPs on the surfaces of aquatic invertebrates has been already documented (Ma and Lin 2013).

AIM OF THE STUDY

In this study we investigated biological reactivity of three engineeredTiO_2 NPs, produced by **CINKARNA - Metallurgical and Chemical Industry, Celje, Slovenia.** We hypothesised that the surface-adsorption potential of tested NPs might affect activities of two test organisms, *Daphnia magna* and *Tetrahymena termophila.*

METHODS

TiO_2 CCA 100BS: anatase form with crystallite size ~ 10 nm

TiO_2 CCA 200BS: anatase form with crystallite size from 30 – 40 nm

TiO_2 CCR 110: rutile form with crystallite size ~ 10 nm and surface modified with SiO_2

Exposure concentrations: 1, 10 and 100 mg/L

24h 48h

Daphnia magna acute immobilization test

- ISO 6341:2013
- Scanning electron microscopy (SEM) with energy dispersive x-ray spectroscopy (EDX)

24h

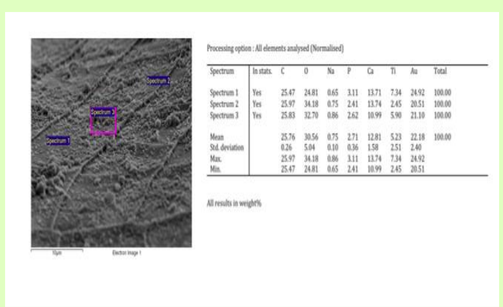
Tetrahymena termophila cell viability assay

- Fluorescent indicator dye alamar blue.
- SEM

RESULTS and CONCLUSIONS

Daphnia magna TiO_2 NPs exposure

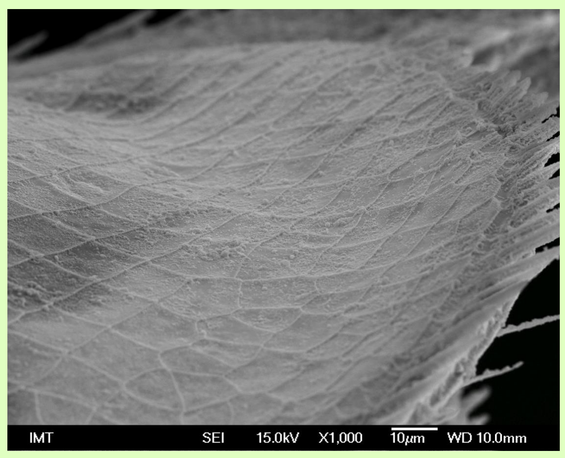
EDX elemental analysis confirming the presence of Ti on *D.magna* surface



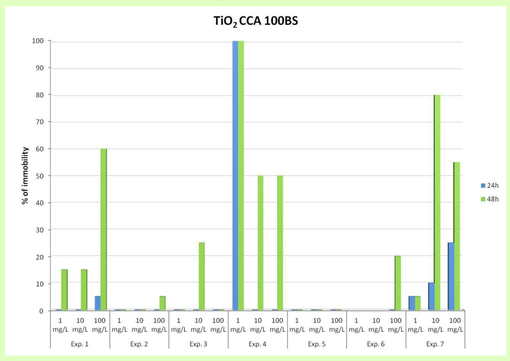
Processing option : All elements analysed (Normalised)

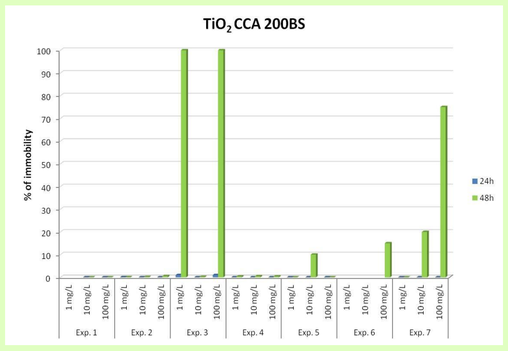
Spectrum	In stats.	C	O	Na	P	Ca	Ti	Au	Total
Spectrum 1	Yes	25.47	24.81	0.65	3.11	13.71	7.34	24.92	100.00
Spectrum 2	Yes	25.97	34.18	0.75	2.41	13.74	2.45	20.51	100.00
Spectrum 3	Yes	25.83	32.70	0.86	2.62	10.99	5.90	21.10	100.00
Mean		25.76	30.56	0.75	2.71	12.81	5.23	22.18	100.00
Std. deviation		0.26	5.04	0.10	0.36	1.58	2.51	2.40	
Max.		25.97	34.18	0.86	3.11	13.74	7.34	24.92	
Min.		25.47	24.81	0.65	2.41	10.99	2.45	20.51	

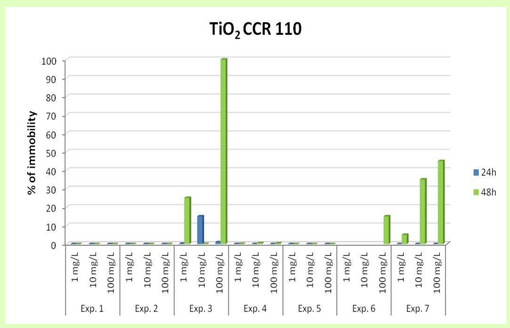
All results in weight%.

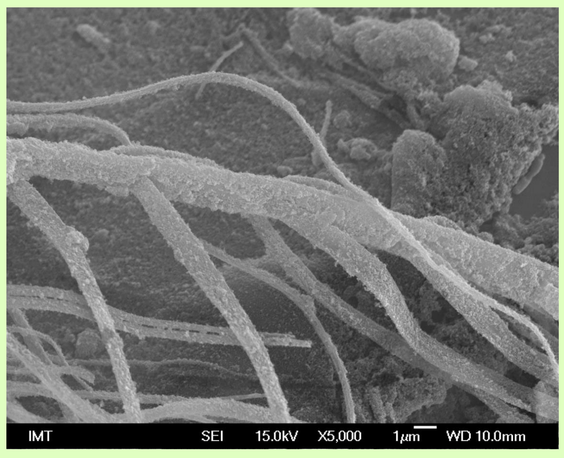


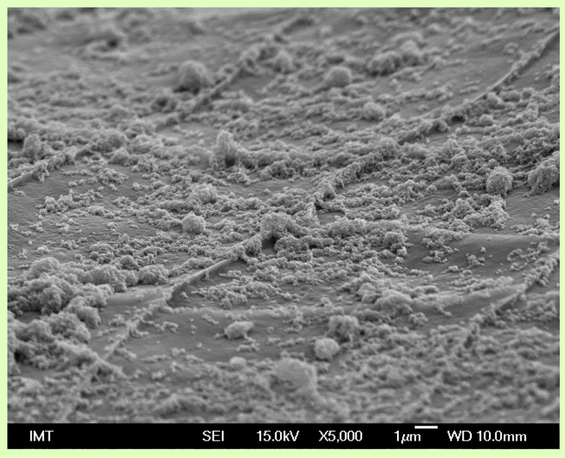
Percent of immobility of *D.magna* after TiO_2 exposures



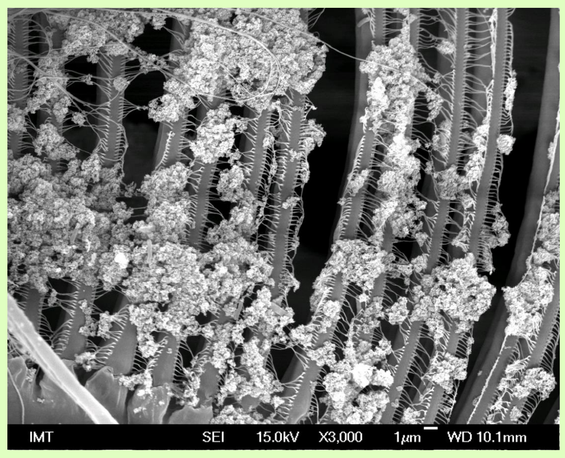








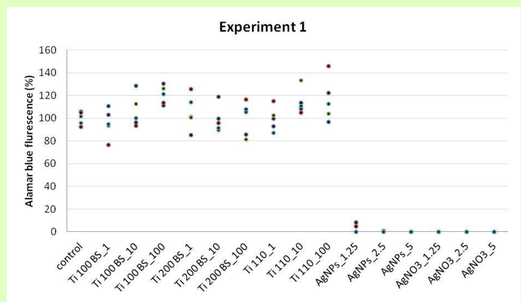
SEM images of *D. magna* exposed to TiO_2 CCA 100BS NPs after 48h exposure to concentration 100 mg/L

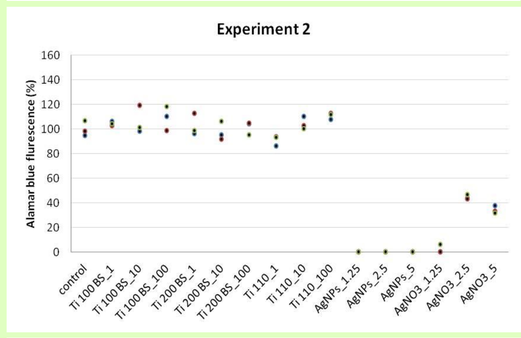


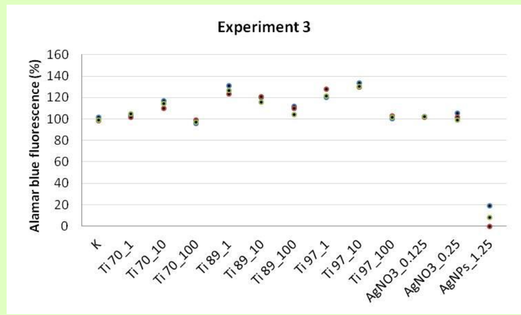
SEM images of *D. magna* exposed to TiO_2 CCA 200BS NPs after 48h exposure to concentration 100 mg/L

Tetrahymena termophila TiO_2 NPs exposure

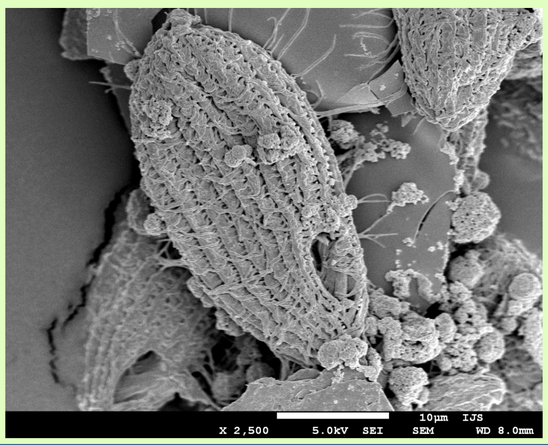
Alamar blue fluorescence after 24h exposure to TiO_2 NPs (Ag NPs - positive control)







SEM image of *T. termophila* exposed to TiO_2 CCA 100BS (100 mg/L) NPs for 24h



	Biological effect	Adsorbtion on the surface
D.magna	✓(sporadic)	✓
T. termophila	✗	✓

Tested NPs have LOW biological potential and STRONG adsorbtion potential for model organism surface.

Altered physiological behavior is expected after longer period of exposure.

References. Ma S. and Lin D. H. 2013. Environmental Science-Processes & Impacts 15: 145-160, Xia X. R., Monteiro-Riviere N. A., Mathur S., Song X., Xiao L., Oldenberg S. J., Fadeel B. and Riviere J. E. 2011. Acs Nano 5: 9074-81