Zinc oxide and silver nanoparticles influence the antioxidative status in a higher aquatic plant, *Spirodelapunctata*.

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*7th ICEENN 2012, BANFF CENTRE, CANADA, 11 SEPTEMBER 2012*
reactivity
solubility
conductivity
strength
SOME FUNDAMENTAL COMPLEXITIES

- Interaction with biological matter?
- Uptake routes: Do NM parameters influence uptake, how?
- Basis for biological response? Molecular definition
- Inducive level of dosage: environmentally relevant?
- Biomarkers of exposure: nano vs bulk

OLD SCIENCE SOLUTIONS FOR NEW TECHNOLOGY PROBLEMS
**LOOK AT WHAT HAD BEEN DONE**

The distribution of L(C)50 values if nanoparticles to different groups of organisms. Kahru and Dubourgier. 2010. *Toxicology* 269: 105-119.


Production of nanoparticles from different sources and respective applications.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type of nanoparticle</th>
<th>Quantity used in terms of tons</th>
<th>Application/uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals and alkaline earth metals</td>
<td>Ag, Fe</td>
<td>High, High</td>
<td>Antimicrobials, paints, coatings, medical use, food packaging, Water treatment</td>
</tr>
<tr>
<td>Metal oxides</td>
<td>TiO₂</td>
<td>High</td>
<td>Cosmetics, paints, coatings</td>
</tr>
<tr>
<td></td>
<td>ZnO</td>
<td>Low</td>
<td>Cosmetics, paints, coatings</td>
</tr>
</tbody>
</table>


*our future through science*
OVERALL APPROACH

THE OXIDATIVE STRESS HYPOTHESIS

1. 
- \( \text{H}_2\text{O}_2 \)
- \( \text{O}_2^- \)
- \( \text{NO} \)
- \( \text{ONOO}^- \)
- \( \text{ROO}^- \)

2. 
- \( 2 \text{O}_2^- + 2 \text{H}^+ \xrightarrow{\text{superoxide dismutase}} \text{H}_2\text{O}_2 + \text{O}_2 \)
- \( \text{H}_2\text{O}_2 + 2 \text{GSH} \rightarrow 2 \text{H}_2\text{O} + \text{GSSG} \)
- \( 2 \text{OH}^- + 2 \text{GSH} \rightarrow \text{H}_2\text{O} + \text{GSSG} \)

3. Oxidative damage

4. Physiological alteration

What are Free radicals?
- Free radicals are like robbers which are deficient in energy.
- Free radicals attack and snatch energy from the other cells to satisfy themselves.

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LABORATORY MAINTANANCE and TESTING

Free floating higher aquatic plant,
• easy laboratory maintenance,
• higher protein content,
• rapid growth.

Holding conditions:
• 22°C±2
• cool-white fluorescent light:dark/8:16hrs
• weekly water renewal.

• Exposure period:
  4 days-static and 14 days- static renewal
• Hoegland’s Medium
• 5 replicates- 30 plants/replicate

Free radical activity
• ROS/RNS
- \( \text{H}_2\text{O}_2 \), \( \text{ROO}^- \), NO, ONOO\(^-\)
- DCFH-DiOxyQ probe

Enzymatic scavengers
• Catalase
• Superoxide dismutase
• Total antioxidant capacity

Size
• TEM
• DLS

Morphology
• TEM
• XRD

Surface area
• BET

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Ag nanoparticles

**Morphology**
- Spherical nanoparticles.

**Surface area**
- Small relative to size.

**XRD pattern**
- Few crystal particles also detected.
- Pure phase: no impurities peaks detected.

<table>
<thead>
<tr>
<th>Sample</th>
<th>$S_{BET}$ (m$^2$/g)</th>
<th>Pore Volume (cm$^3$/g)</th>
<th>Particle size (nm)</th>
<th>Z-potential (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>nAg</td>
<td>3.399</td>
<td>0.01509</td>
<td>40-60</td>
<td>-16.3</td>
</tr>
</tbody>
</table>
ZnO nanoparticles

**Morphology**
- regular (20-50 nm) and irregular spheres (80-120 nm), rods (15-45 nm), cubes (10-130 nm) and hexagonal platelets (60-80 nm).

**Surface area**
- Higher than nAg although bigger sized.

**XRD pattern**
- High crystallisation: hexagonal crystal system.
- Pure phase: no impurities peaks detected.

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</tr>
</thead>
<tbody>
<tr>
<td>nZnO</td>
<td>11.44</td>
<td>0.03020</td>
<td>10-130</td>
<td>22.7</td>
</tr>
<tr>
<td>nAg</td>
<td>3.399</td>
<td>0.01509</td>
<td>40-60</td>
<td>-16.3</td>
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</table>
H$_2$O$_2$
Total Antioxidant Capacity

(a) TAC - 96 hrs

(b) TAC - 14 days
Superoxide dismutase – 96 hrs
Catalase – 96 hrs

- Silver Nanoparticles (AgNP)
- Zinc Oxide NP (ZnO)
CONCLUSIONS and THE FUTURE

• Significant bottom settling of particles → nano tracking analysis.
  → Generally, what are actual environmental implications?
• Exposure period as significant parameter on toxicity
• Clear evidence of significant oxidative offence due nZnO and nAg exposure.
• Suggestion of toxicity influence by nanoparticle parameters
  → further investigate this phenomena (morphologies and z-potential)
  → how does such influence uptake dynamics

CURRENT WORK
• Investigate protein damage and lipid peroxidation.

FUTURE
• DNA damage → focus on oxidative linked DNA damage.
• Physiological pathways integrity – photosynthetic and energy metabolism parameters.
TABLE MOUNTAIN NATIONAL PARK- CAPE TOWN