Antibacterial Activity Of Selenium Nanoparticles

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NPs are attractive tools for different applications.

- Nanomaterials
- Nanoelectronics
- Nanomedicine
  - Drug delivery
  - Cancer Treatment
  - Coating of transplants
  - Antimicrobial agents

Adapted from: Heinz et al., Surf Sci Rep, 2017
How is the interaction between metal NPs and cells proposed?

Net negatively charged lipid bilayer

Penetration

Endocytosis

Electrostatics and van der Waals forces

ROS

Wang et al., Int J Nanomedicine, 2017

Metal ion release
Selenium might be an alternative to silver.

- Selenium is cheaper.
- Selenium shows a low toxicity to the human body.
- Selenium NPs exhibit antimicrobial activity.¹

How do selenium NPs INTERACT with bacterial cells?
Does SURFACE CHARGE affect their TOXICITY?

¹ Nguyen et al., Food Control, 2017
## Selenium NPs and model bacterial strains

<table>
<thead>
<tr>
<th>NP-coating</th>
<th>Zetapotential (mV)</th>
<th>Diameter (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chitosan (+)</td>
<td>+1.3 ± 0.4</td>
<td>85 ± 27</td>
</tr>
<tr>
<td>Undefined (-)</td>
<td>- 3.9 ± 0.7</td>
<td>86 ± 21</td>
</tr>
<tr>
<td>BSA (- - -)</td>
<td>- 14.7 ± 1.1</td>
<td>73 ± 29</td>
</tr>
</tbody>
</table>

Gram positive vs. Gram negative

- **Lysinibacillus sphaericus** vs. **Stenotrophomonas bentonitica**
NP toxicity depends on CONCENTRATION, SURFACE CHARGE and CELL WALL COMPOSITION.

• Cell viability was measured by propidium iodide and FDA staining.
• Neutrally charged NPs show higher toxicity than negatively charged.
• Grampositive bacteria seem to be more resistant to negatively charged NPs.
Reactive oxygen species level is increased.

- DC-FDA was used to measure intracellular reactive oxygen content.
- Selenium NPs might generate ROS which damage enzymes, DNA and lipids.
Selenium NPs decrease intracellular DNA content.

- Acridine Orange is used to quantify intracellular DNA content.
- Selenium NPs might release ROS and metal ions\(^1\), which interact with the DNA and DNA repair enzymes\(^2\).

1 Palza \textit{et al.}, J Appl Polym Sci, 2017
2 Letavayová \textit{et al.}, Toxicology, 2006
ESEM confirms interaction with the bacterial membrane and extracellular proteins.

S. bentonitica, 3 h
100 µM SeNPs
76 % dead cells
SeNPs accumulate intracellularly.

*S. bentonitica*, 24 h
100 µM SeNPs
86 % dead cells
Take home messages

- Selenium NPs possess antibacterial activity, proven by flow cytometry.
- Dependent on concentration, surface charge and cell wall composition.
- Toxic properties due to generation of reactive oxygen species and putative release of metal ions.
- Subsequent interaction with intracellular enzymes and destruction of DNA.
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Erasmus+
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THANK YOU!