Ecotoxicity of Nanoparticles Exemplified by Bacteria, Algae and Daphniad

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Objectives

• To determine the short-term chronic toxicity of photocatalytic nanoarticles to aquatic organisms, e.g., *E. coli*, *Ceriodaphnia dubia*, *Selenastrum capricornutum*

• To assess factors that may affect the ecotoxicity of photocatalytic nanoparticles, e.g., TiO$_2$
Nanoparticles as Environmental Toxicants

- **Small size**
  - procaryotic cells: 0.3 – 2 mm (or 300 – 2000 nm)
  - eucaryotic cells: 2 – 20 mm (or 2000 – 20000 nm)
  - nano-particles: 0.1 – 100 nm.

- **Surface charge**
- **Photocatalysis**
- **Chemical composition**
Effect of Particle Size (Dark)  Effect of Particle Type

Particle Size Effect

Dose-Response UV-100

R5 30 min Dose Response E. coli

C (mg/L)

% Kills (30 min)
Effect of Light Source: *E. coli*

**Graph 1:**
- **x-axis:** P25 Concentration (mg/L)
- **y-axis:** N/No
- **Legend:**
  - Agrosun-40
  - Solux-70
  - UV-100
  - Halogen-100

**Graph 2:**
- **x-axis:** 0.167, 1, 2
- **y-axis:** N/No
- **Legend:**
  - Solux-70
  - Agrosun-40
  - UV-100
  - Halogen-100

**Notes:**
- **Time (h):** 0.167, 1, 2
- **Wavelength (nm):** 200, 400, 600, 800, 1000, 1200
- **Radiant Power (uW/10nm/lumens):** 0, 100, 200, 300, 400, 500, 600, 700
Enzynamatic response: MDA

\[
\frac{Y^L_c - Y^D_c}{Y^L_{c=0} - Y^D_{c=0}}
\]
Enzymatic Response: TTC
SEM Observation: *E. coli*
## Acute Test (24-h Survival): *C. dubia*

<table>
<thead>
<tr>
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<th>95% Confidence Limits</th>
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<tbody>
<tr>
<td></td>
<td>LC 50</td>
<td>Lower</td>
</tr>
<tr>
<td>R5</td>
<td>98.3</td>
<td>37.0</td>
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<tr>
<td>P25</td>
<td>38.1</td>
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<td>MA11S</td>
<td>433.4</td>
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</table>

Unit: mg/L
Chronic Test (24-h Survival): *C. dubia*

<table>
<thead>
<tr>
<th></th>
<th>95% Confidence Limits</th>
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<tbody>
<tr>
<td></td>
<td>LC 50 Lower Upper NOEC LOEC</td>
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<tr>
<td>R5</td>
<td>683.38 298.76 4774.69 60 100</td>
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<tr>
<td>P25</td>
<td>810.93 429.90 2780.88 100 200</td>
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Unit: mg/L
Chronic Test (7-day Reproduction): *C. dubia*

Trap Regression – Piecewise Tailed

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<th>EC50</th>
<th>Lower</th>
<th>Upper</th>
<th>NOEC</th>
<th>LOEC</th>
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<tr>
<td>R5</td>
<td>14.4</td>
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Unit: mg/L
SEM Observation: Daphniad
Chronic Tests: *S. capricornutum*

\[
\left( \frac{N_c}{N_{c=0}} \right) = \left( \frac{K}{N}_{c=0} \right) \left( \frac{C}{C_{2.6}} \right)
\]

LC50 (log) = 2.6 (396 mg/L)
95% LCL (log) = 2.1 (125.8 mg/L)
95% UCL (log) = 3.0 (1000 mg/L)

\[
q(mg/mg) = \frac{6C(mg/L)}{18 + C(mg/L)}
\]
SEM Observation: *S. capriocornutum*
Expected Benefits

• Dose-response of photocatalytic nanoparticles is useful to the evaluation of ecological risk imposing by nanoparticles.
• Exposure experiments reveal mechanistic information on the effects of nanoparticles to aquatic community.
• Toxicity studies will lead to increased understanding of the potential effects of nano-particles on trophically important aquatic organisms.
Acknowledgement

“Short-term Chronic Toxicity of Photocatalytic Nanoparticles to Bacteria, Algae, and Zooplankton”

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