How shape and binding to wool fibers influences silver nanoparticle toxicity towards *Nitrosomonas europaea* and *Pseudomonas putida*

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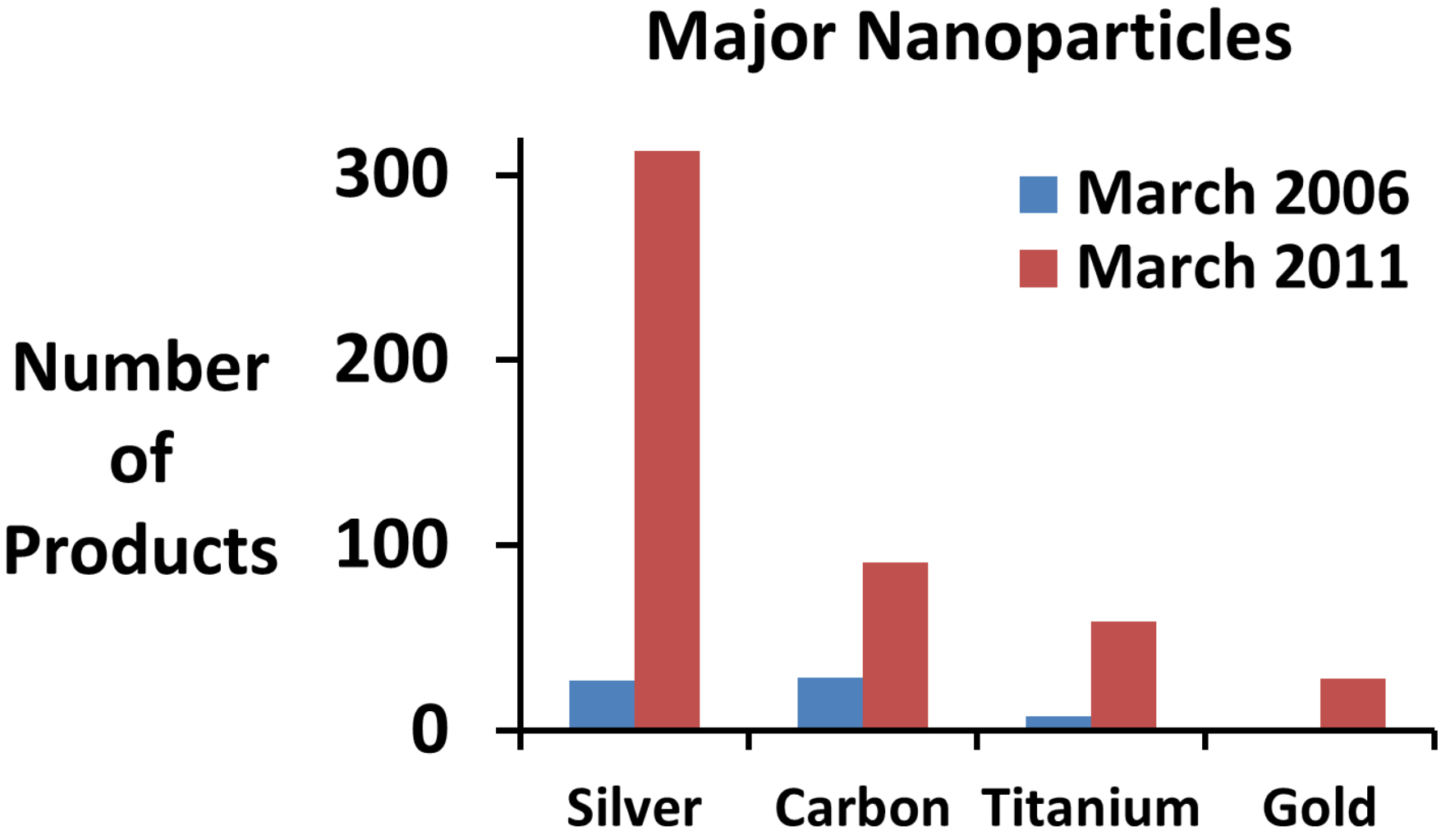
Oregon State
UNIVERSITY

The Rise of Ag-NP



Release of Ag-NP to WWTP





Environ. Sci. Technol. **2008**, *42*, 4133–4139

Nanoparticle Silver Released into Water from Commercially Available Sock Fabrics

TROY M. BENN* AND PAUL WESTERHOFF
Civil and Environmental Engineering, Arizona State University, Box 5306, Tempe, Arizona 85287-5306

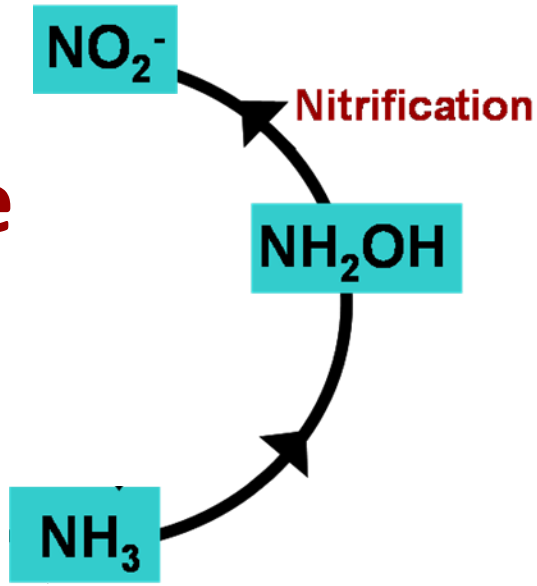
Environ. Sci. Technol. **2009**, *43*, 8113–8118

The Behavior of Silver Nanotextiles during Washing

L. GERANIO,[†] M. HEUBERGER,[‡] AND B. NOWACK*,[†]
Technology and Society Laboratory, and Laboratory of Advanced Fibers, Empa - Swiss Federal Laboratories for Materials Testing and Research, CH 9014 St. Gallen, Switzerland

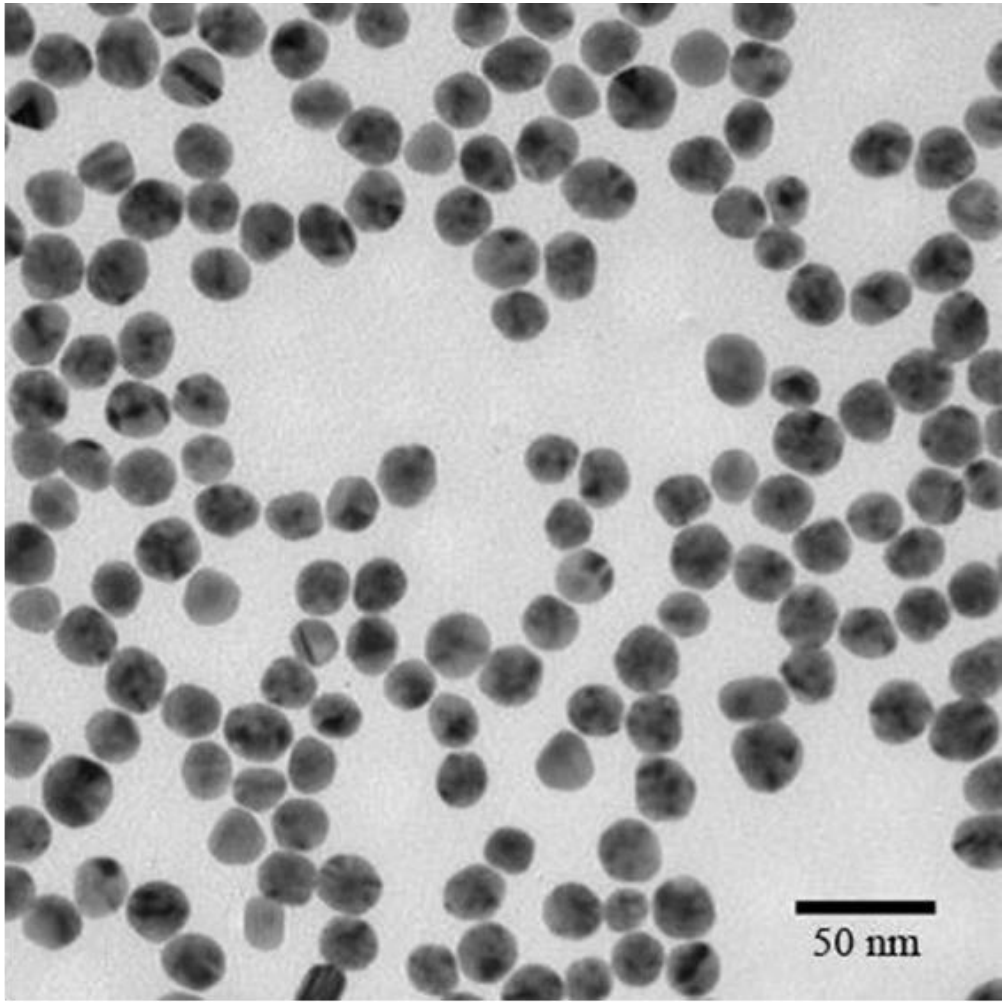
Biological Nitrogen Cycle

Highly Sensitive to Disruption!



Ammonia Oxidizing Bacteria

The Influence of Shape



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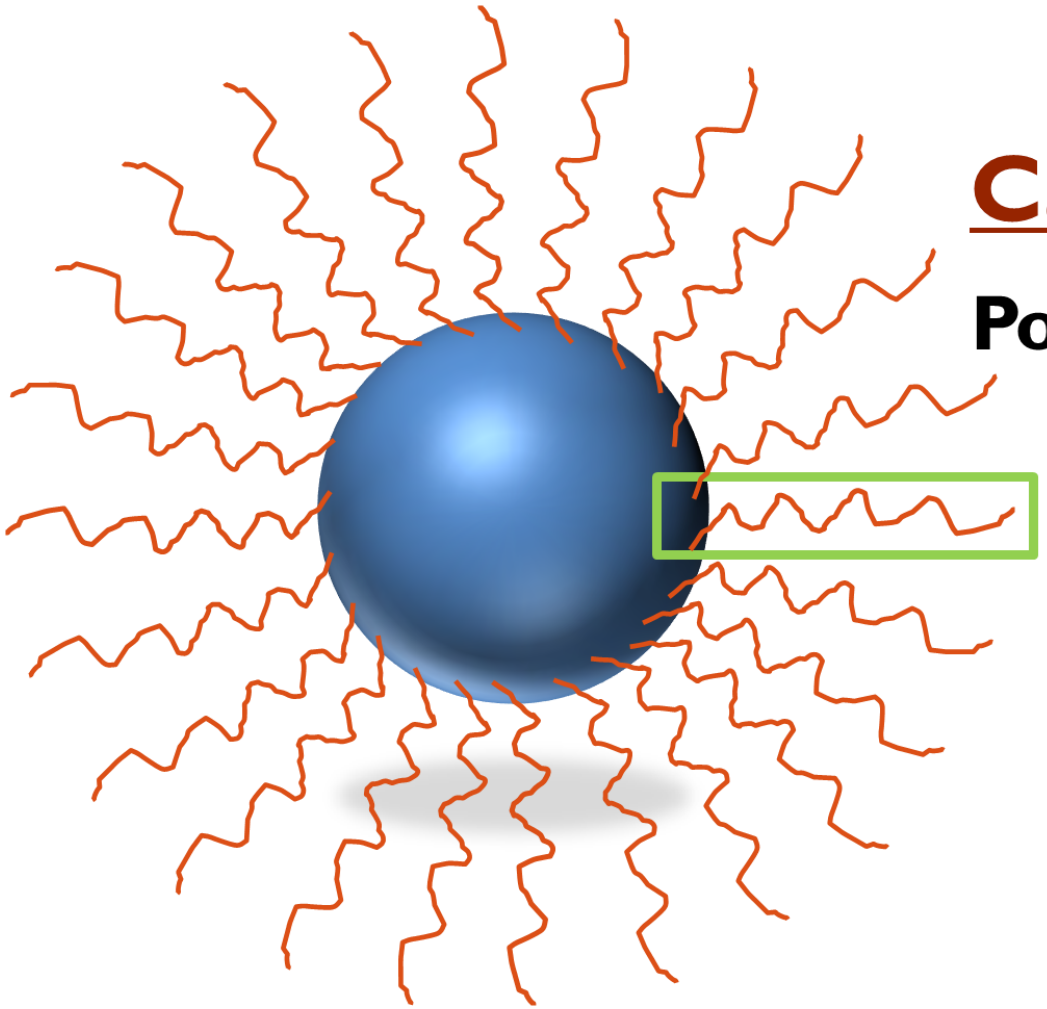
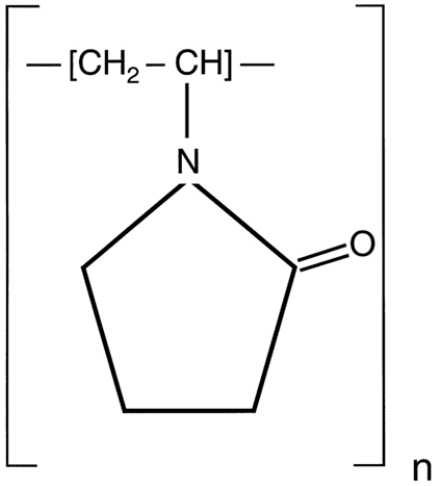
The Influence of Shape



Capping Agents

Polyvinylpyrrolidone (PVP)



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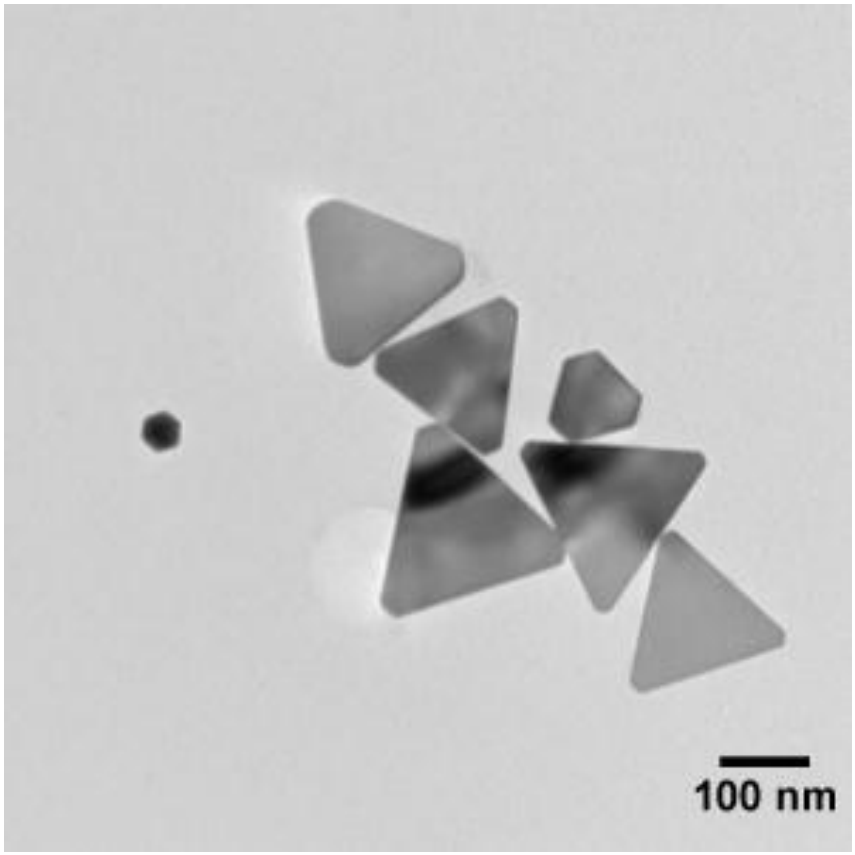

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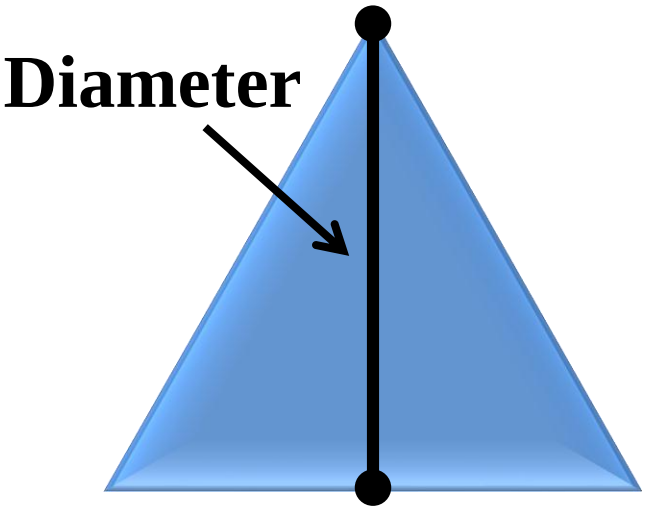
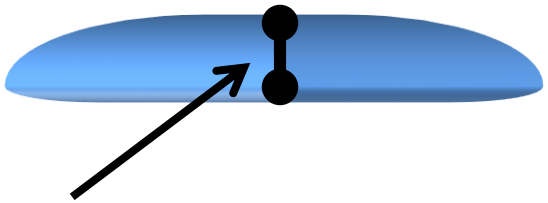
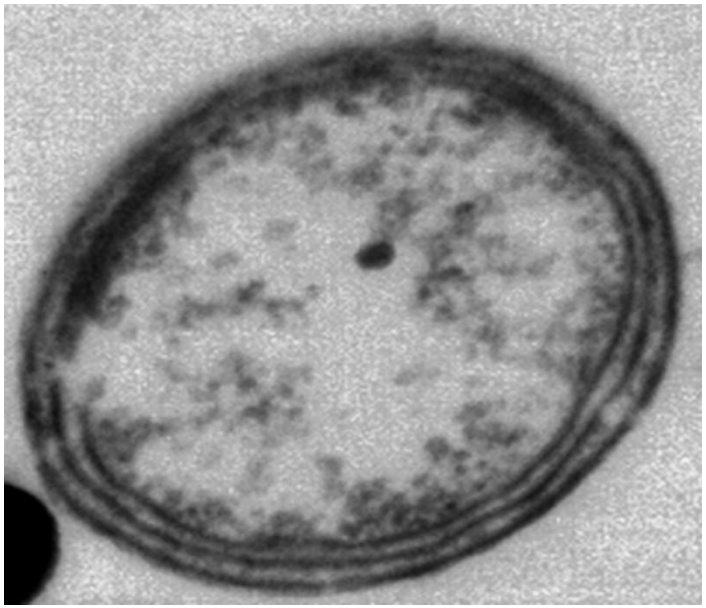




Thickness = 10 nm

Nitrosomonas europaea

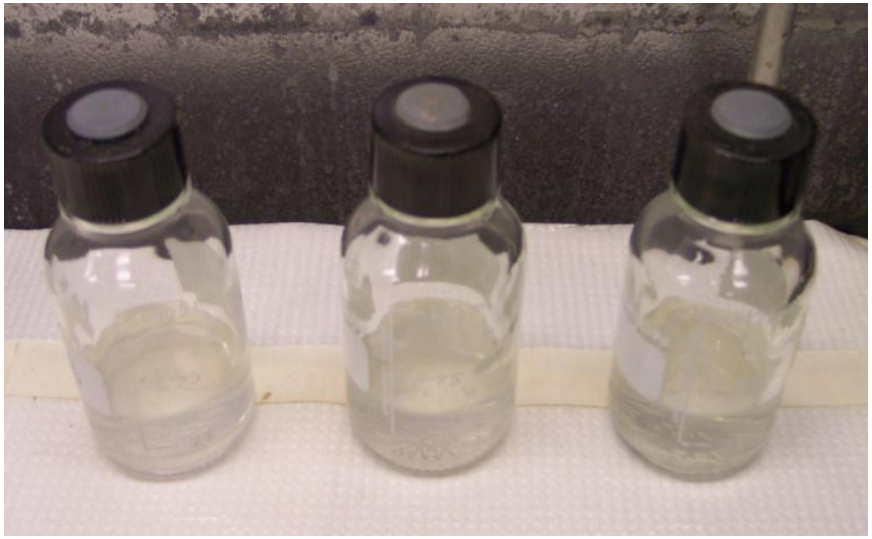
- The model Ammonia Oxidizing Bacteria
- Oxidizes $NH_3 \rightarrow NO_2^-$
- Gram Negative
- Chemolithoautotroph
- 8-12 h Doubling Time

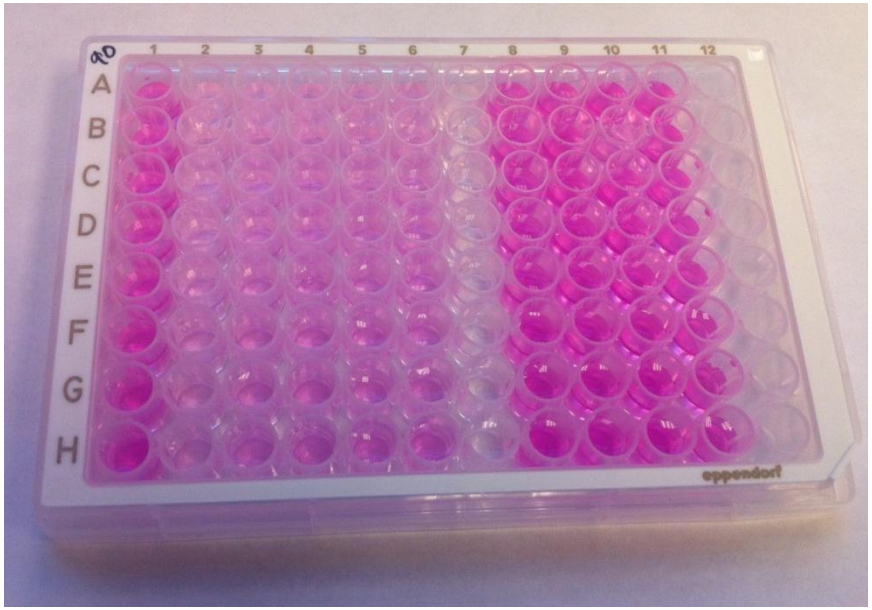


Radniecki, et. al., ES&T, 2008

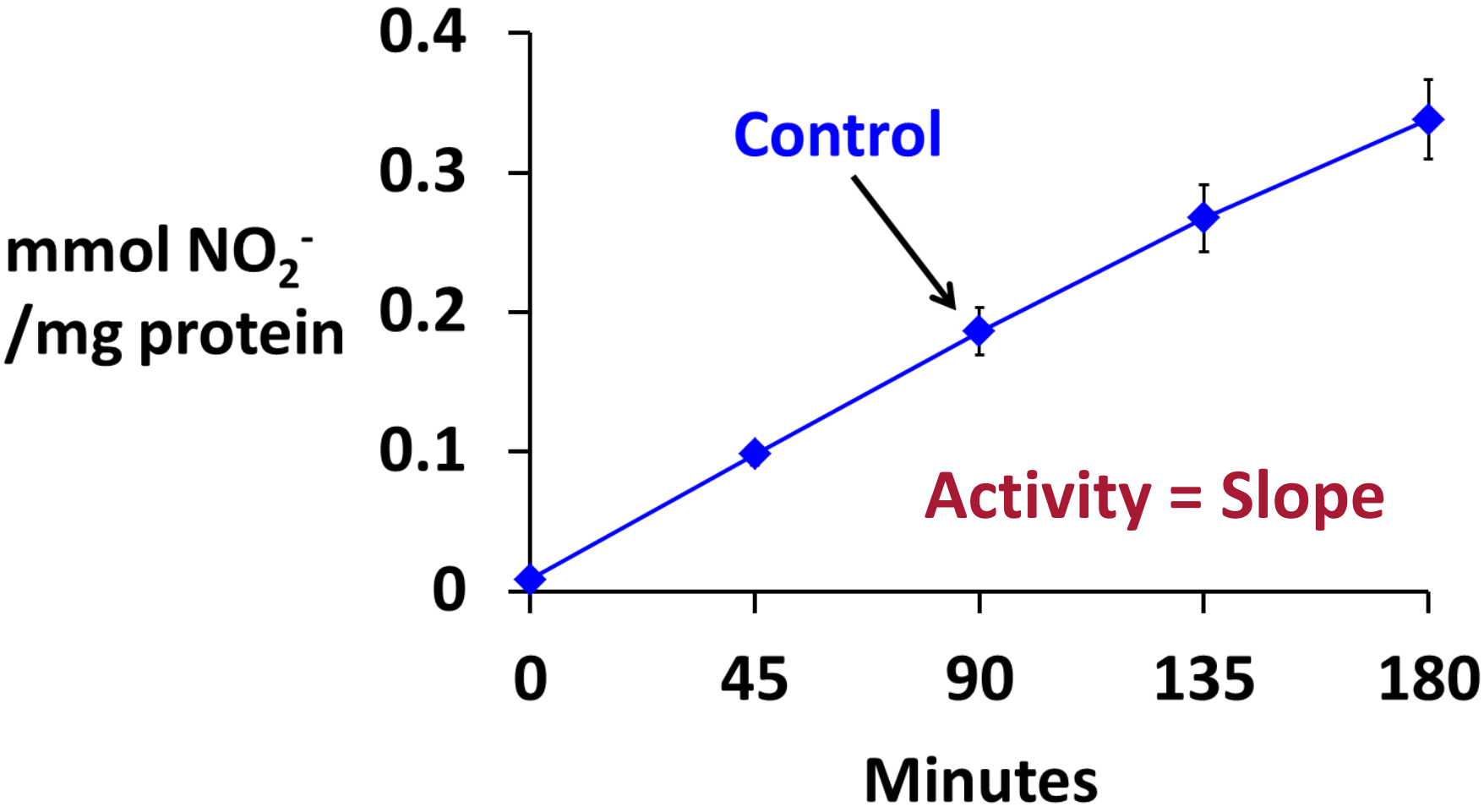
Experimental Set-up

- 2.5 mM $(NH_4)_2SO_4$
- 30 mM HEPES
- pH 7.8
- 6 mg protein/L
- 250 rpm
- 30°C in the dark
- 3 h duration
- Measure NO_2^-

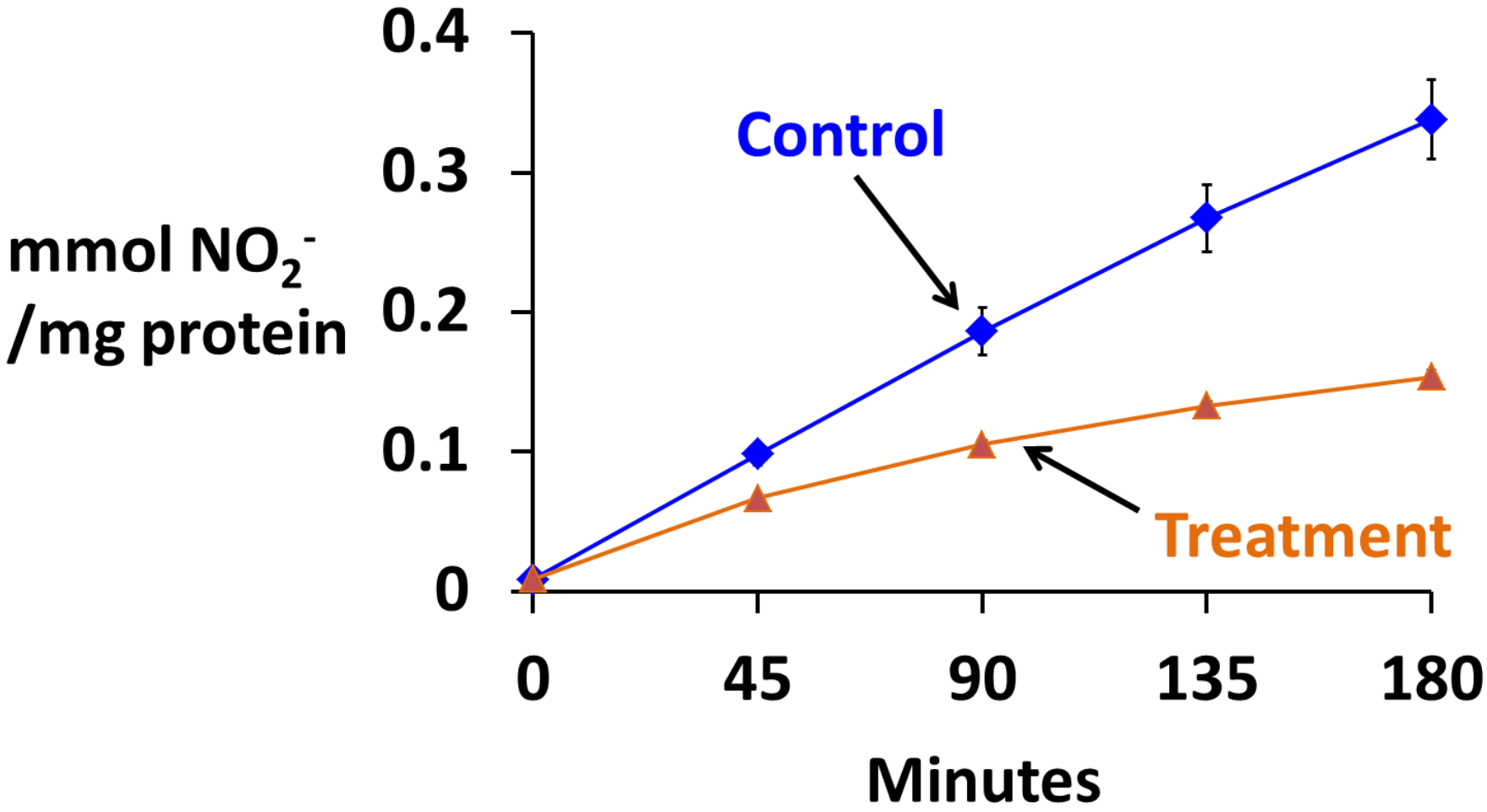




Experimental Set-Up

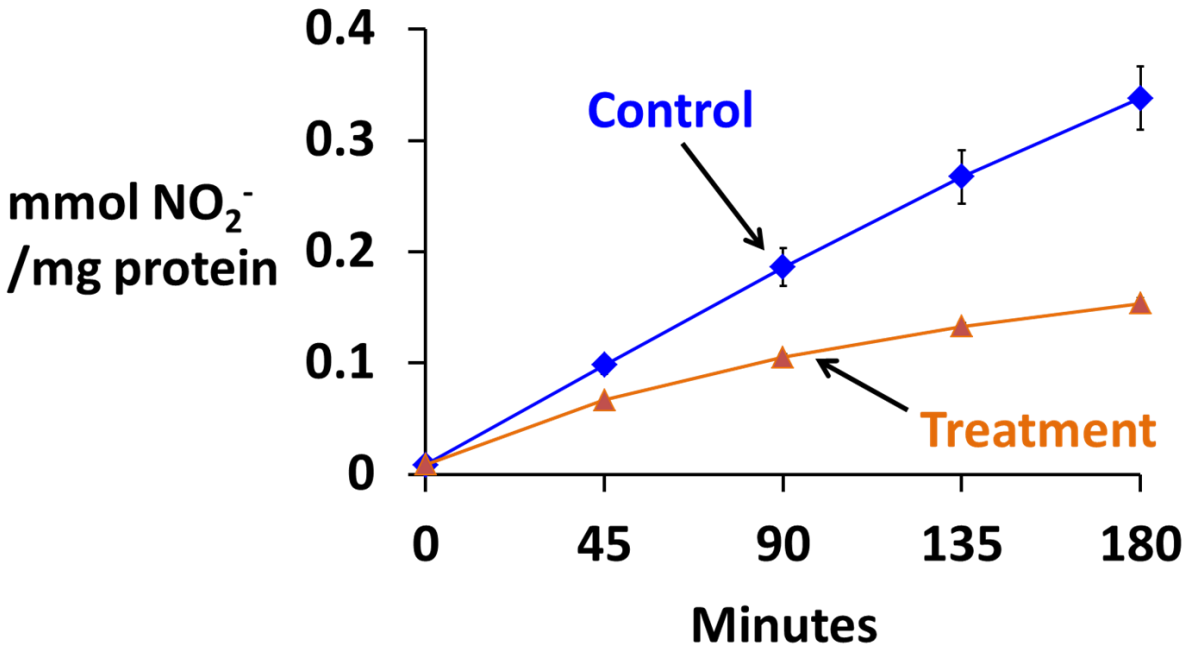


Experimental Set-Up



Experimental Set-Up

$$\text{\% Nitrification Activity} = \frac{\text{Treatment Slope}}{\text{Control Slope}} \times 100\%$$



AgNP Toxicity

Ag-NP Dissolution to Ag^+

Quantifying AgNP Dissolution

Ultrafiltration-ICP method

AgNP in Test Media

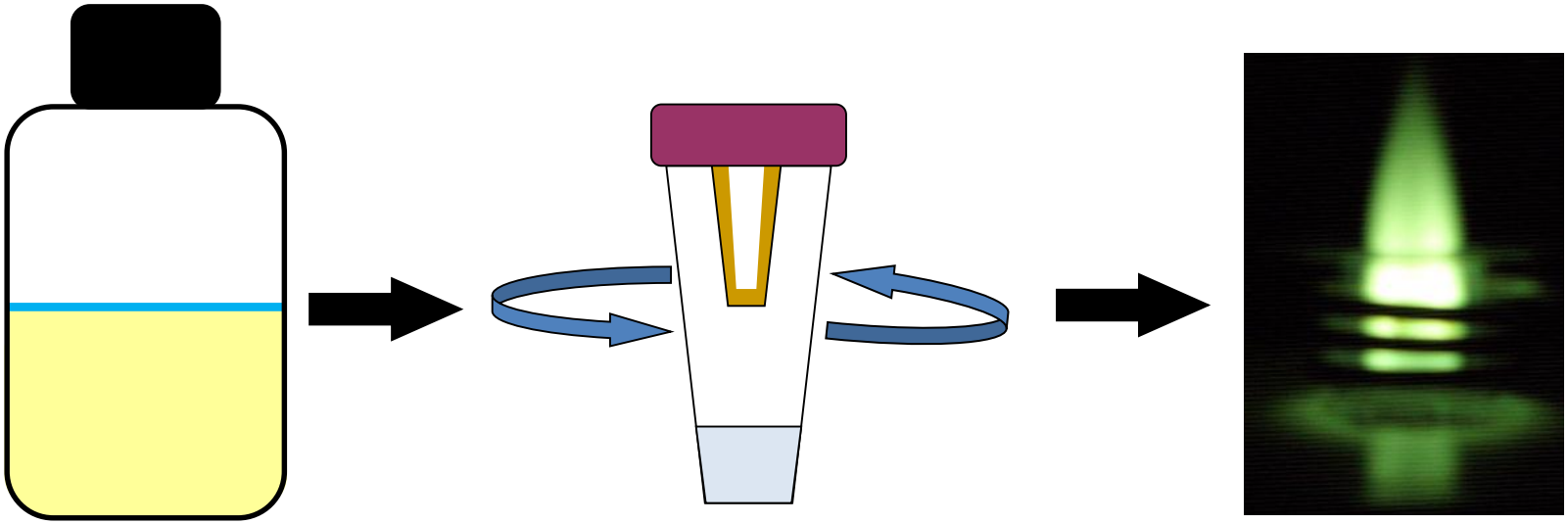
(**No cells**)

Pass through a 3kDa filter

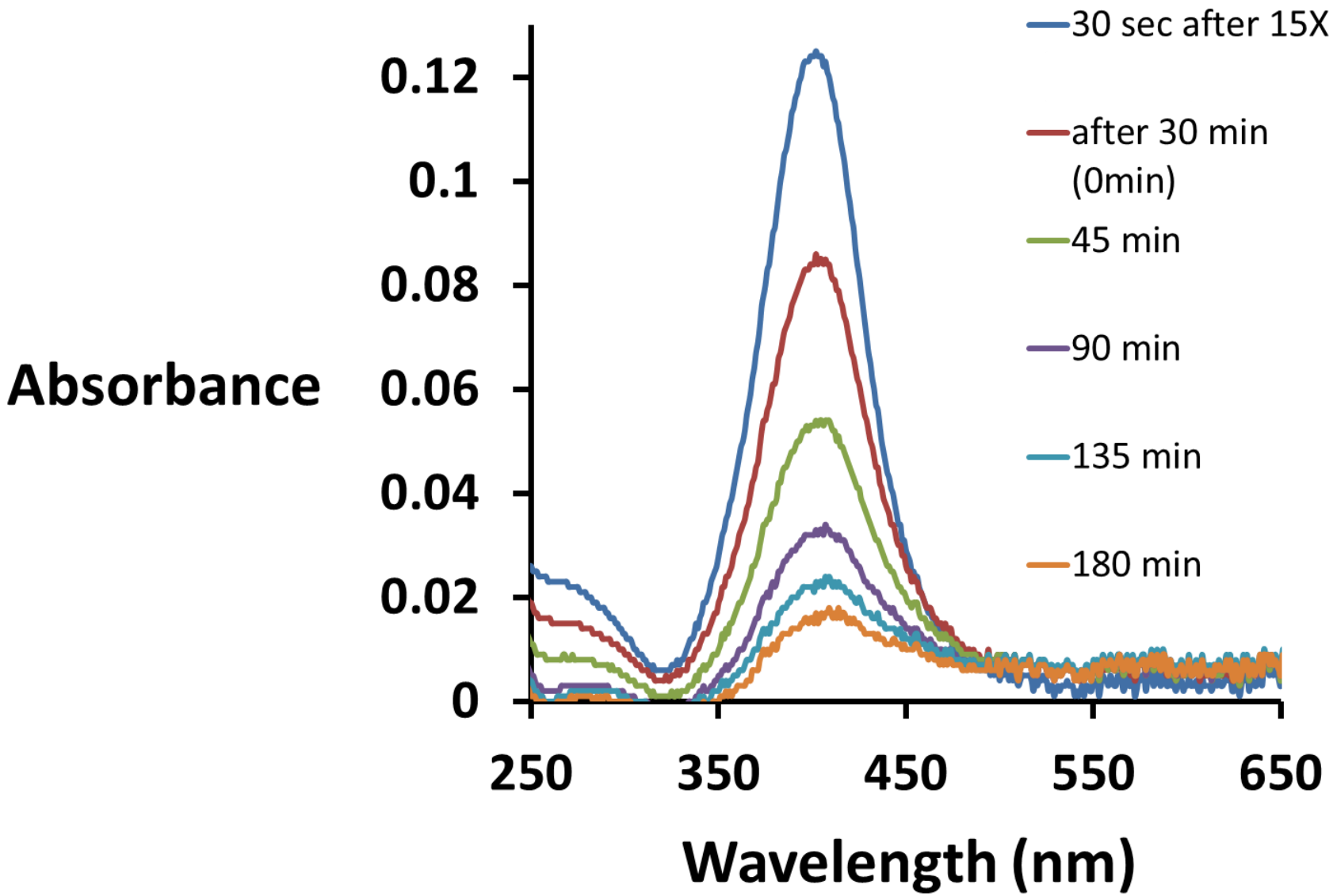
(**~ 0.2 nm**)

[Ag] measured in filtrate

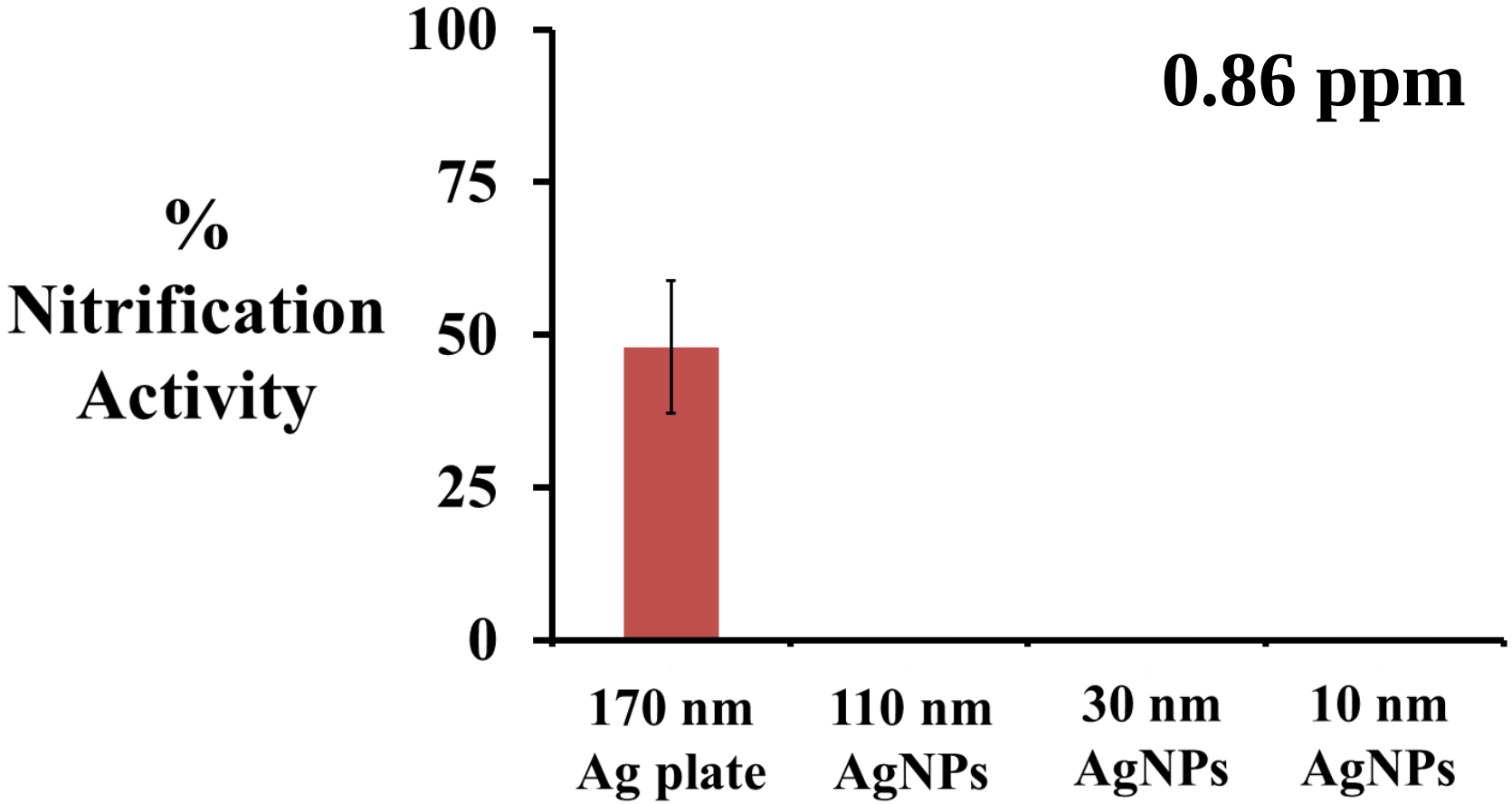
(**ICP**)



Quantifying AgNP Dissolution



Influence of Shape on Toxicity



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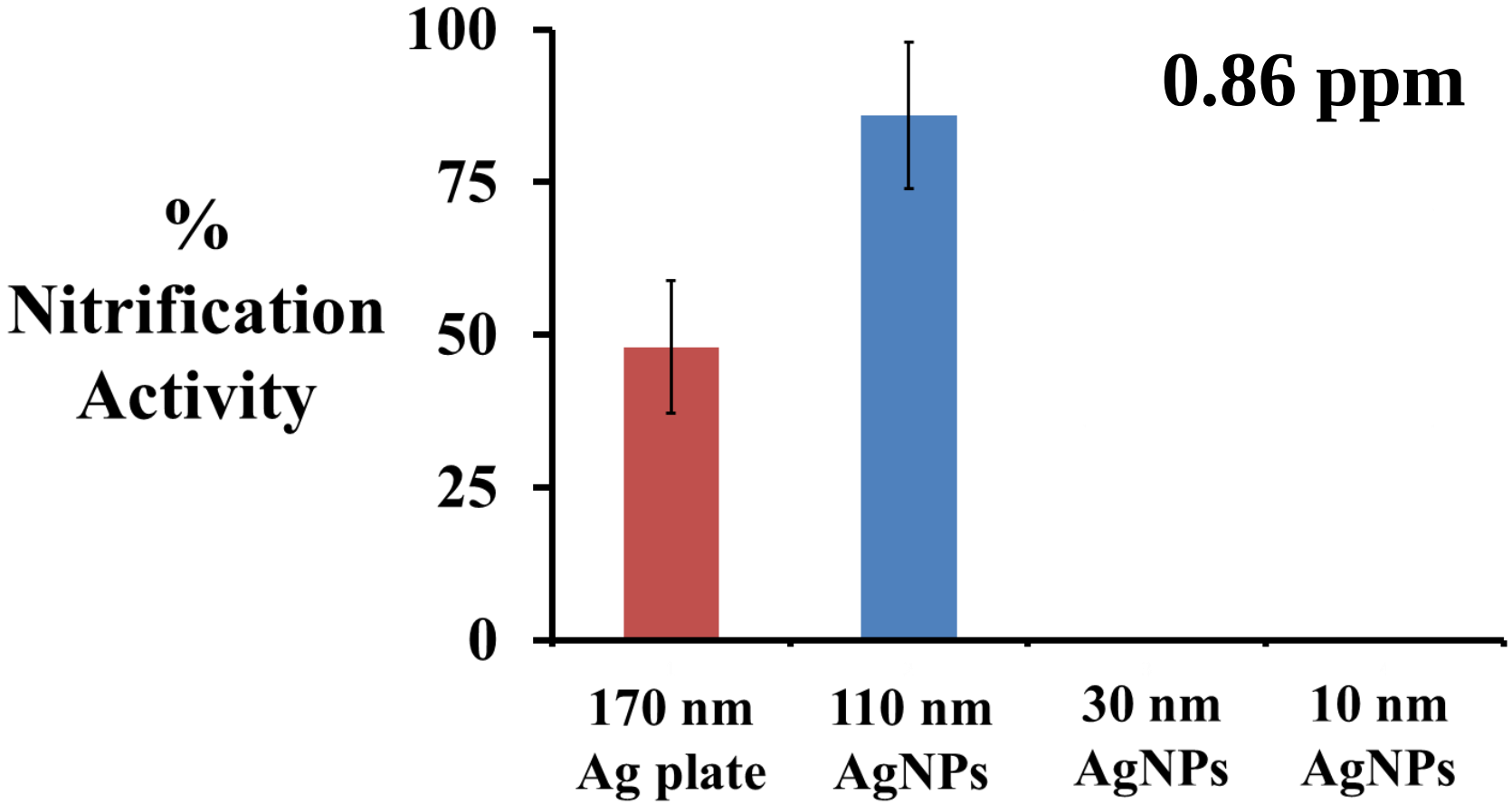

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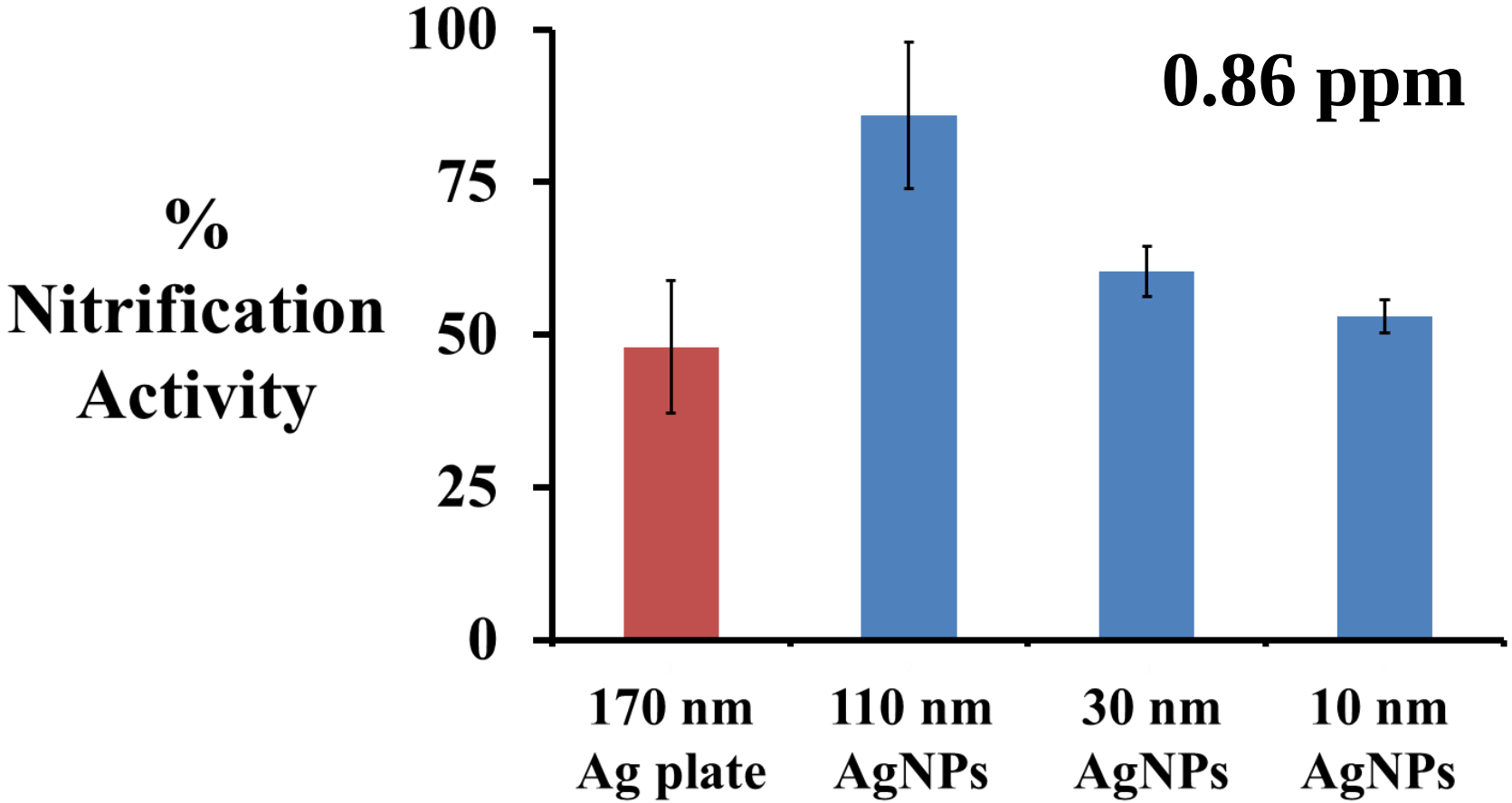

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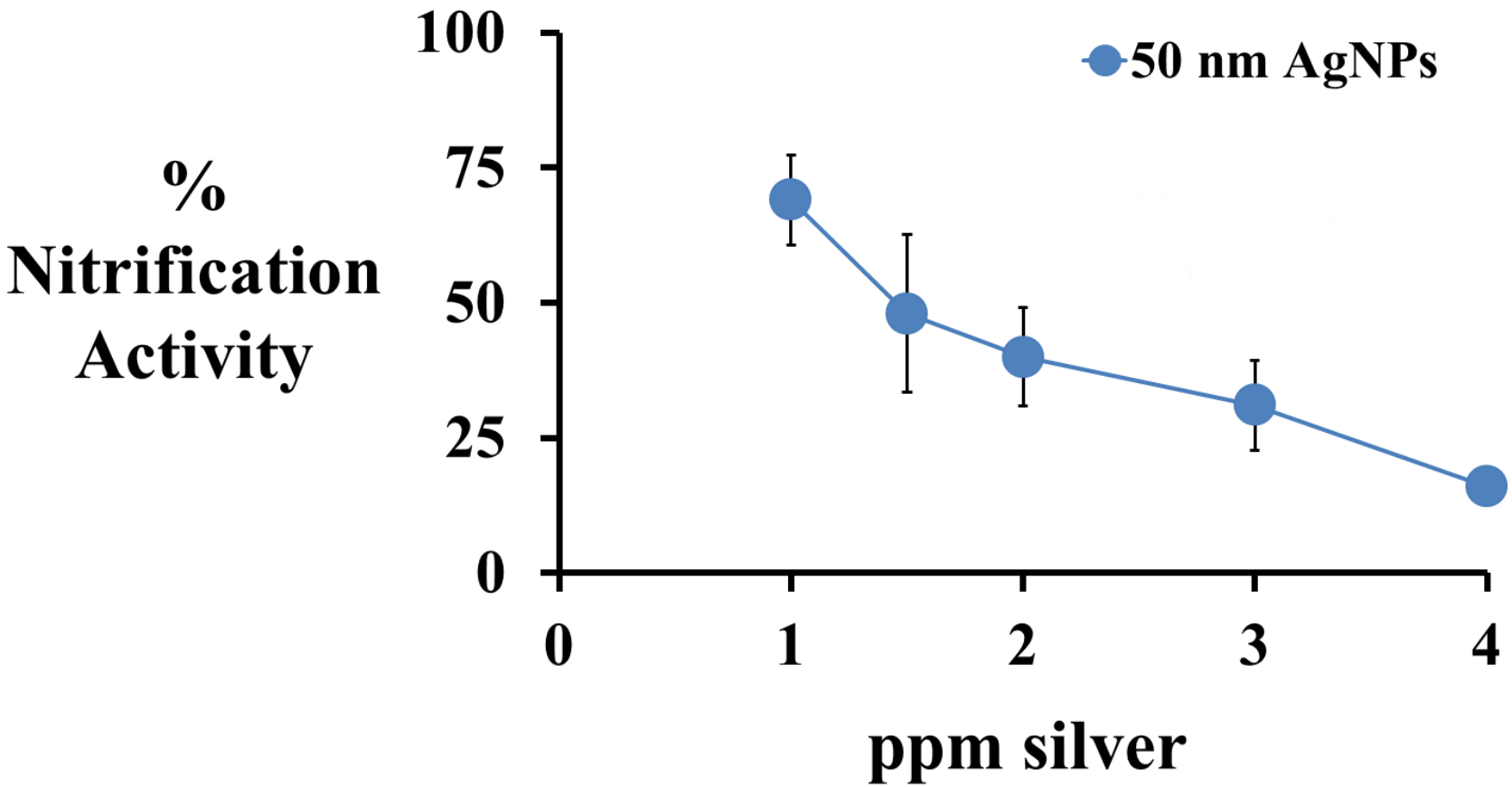

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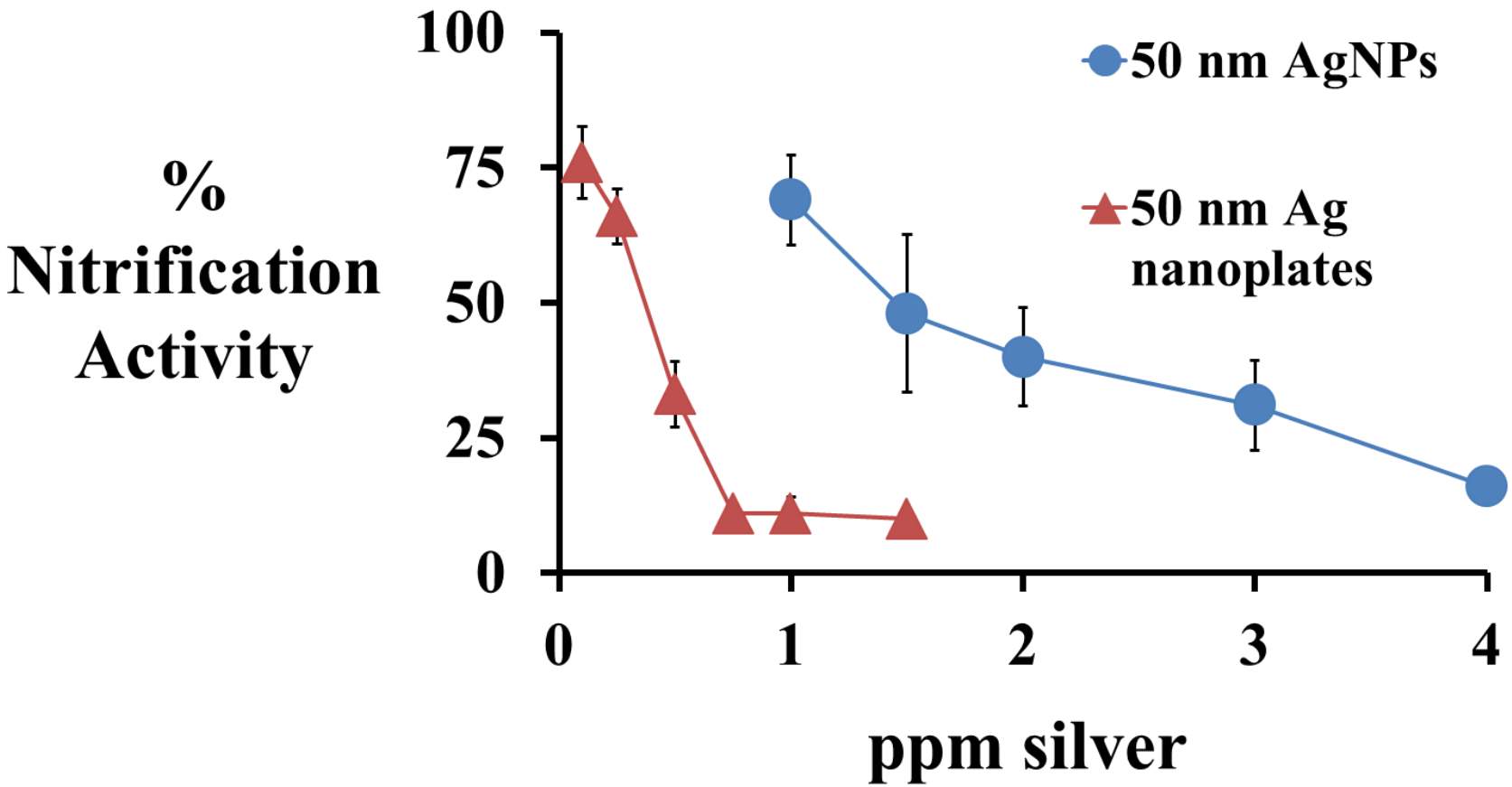

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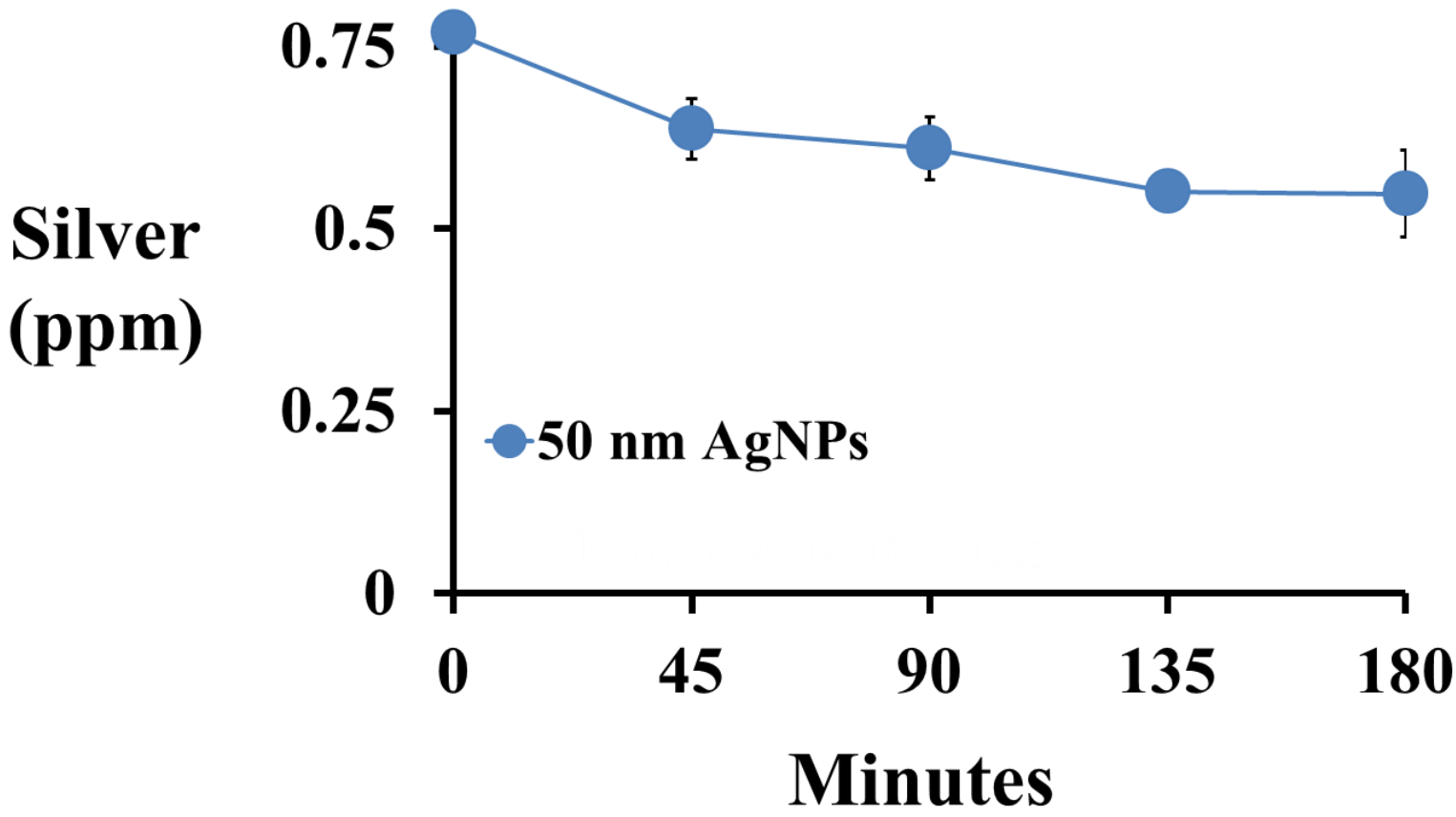

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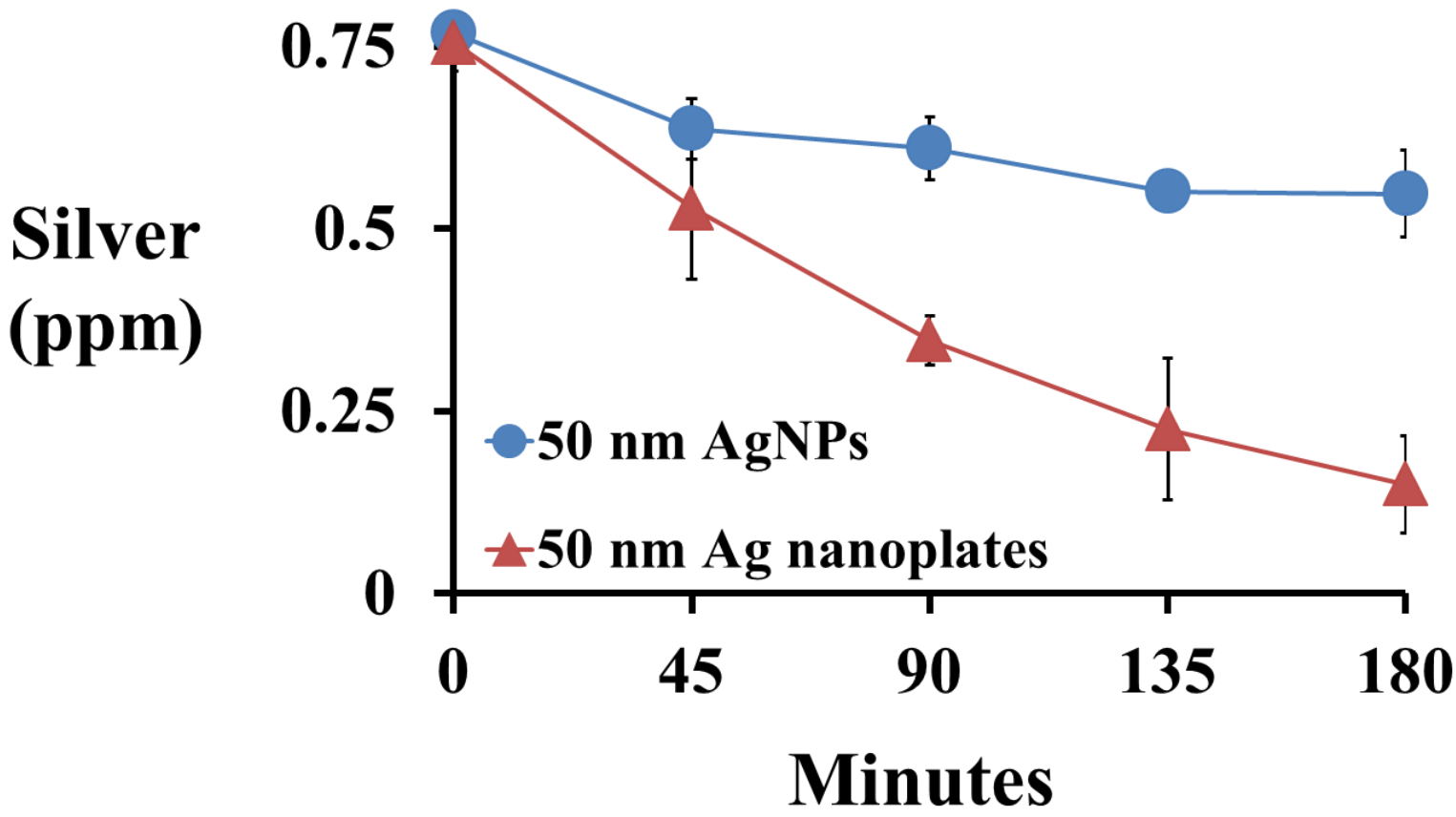

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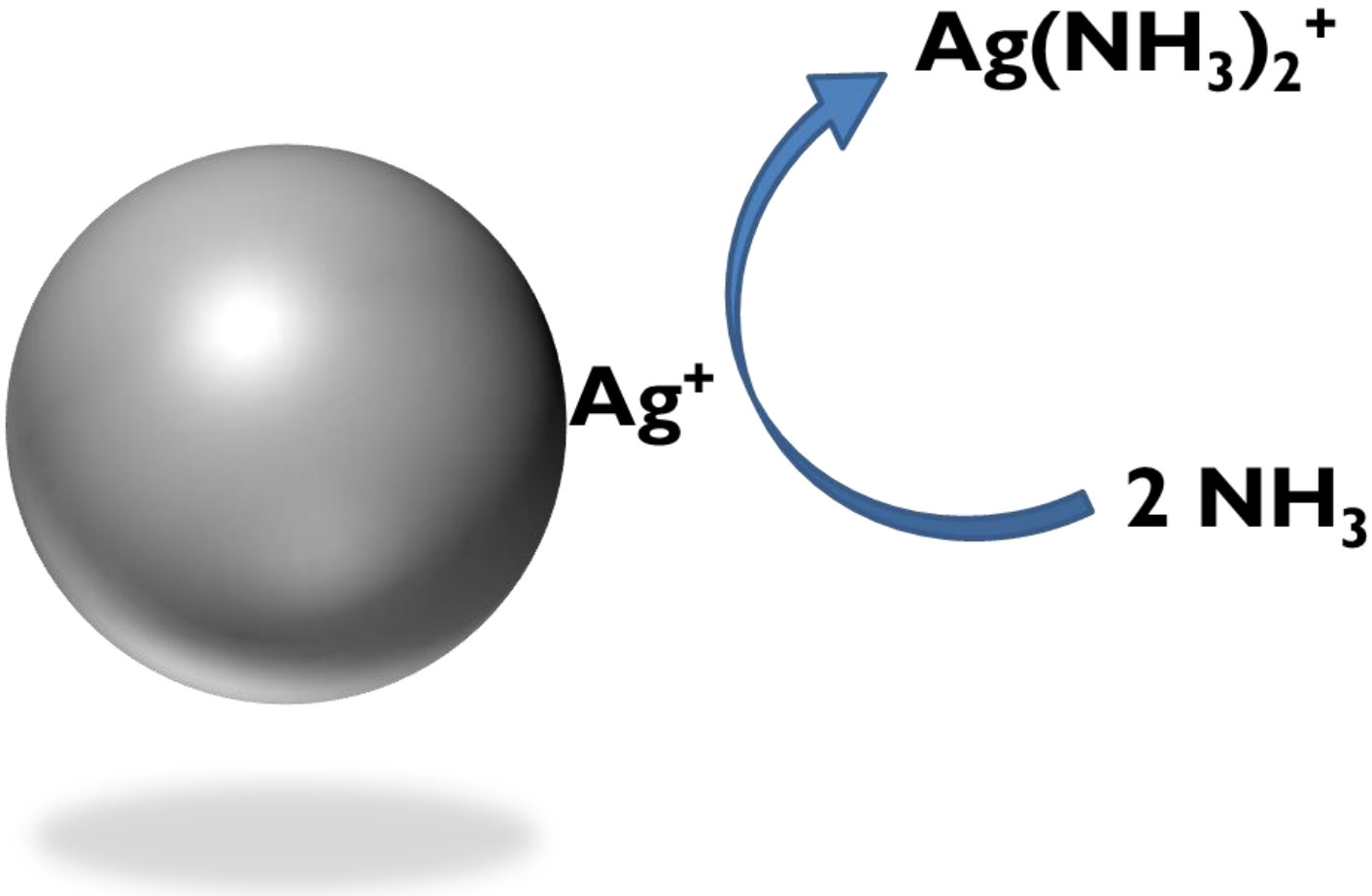

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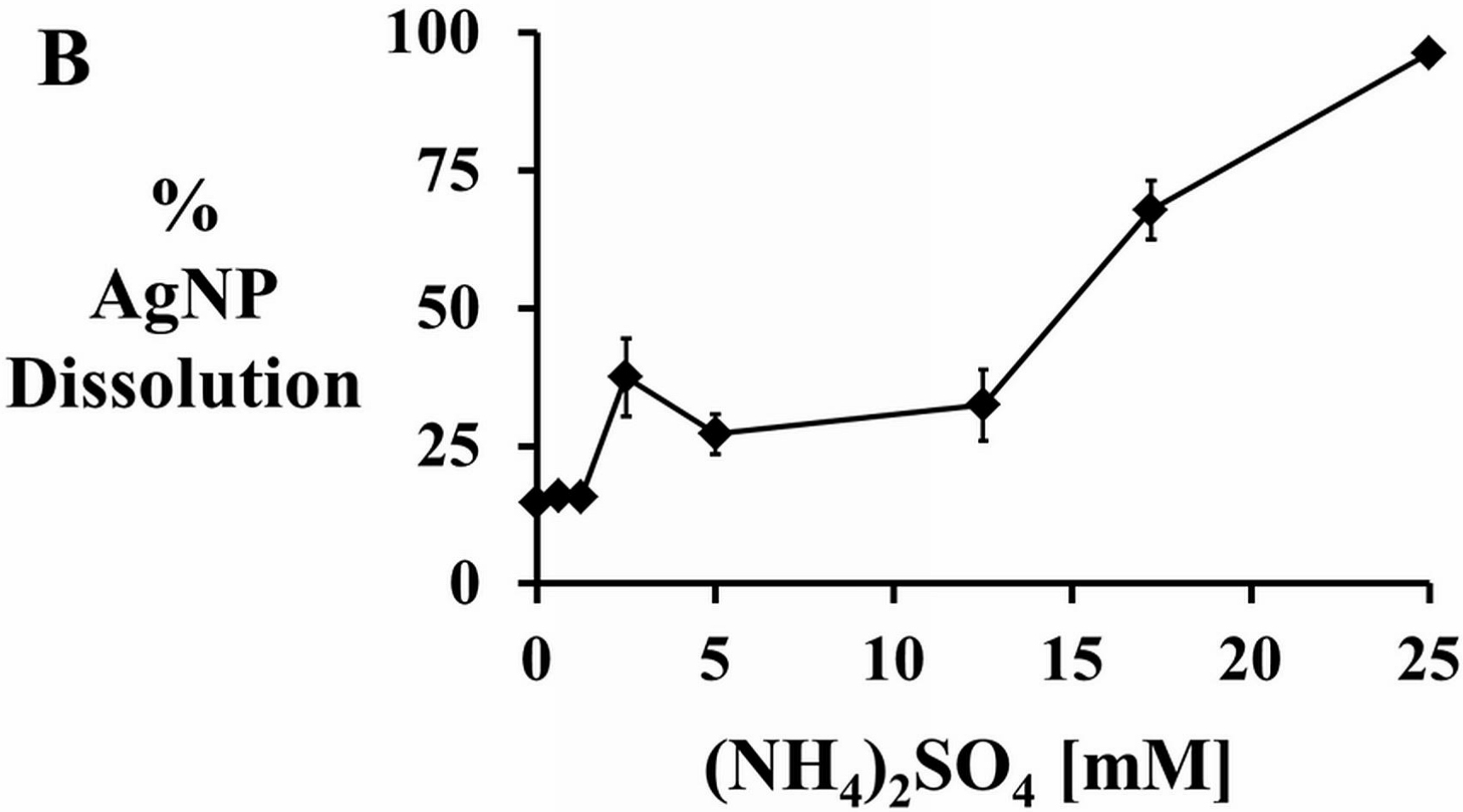

Kostigen Mumper et al. Chemosphere (2013) v. 93, n. 10., pp. 2493-2498

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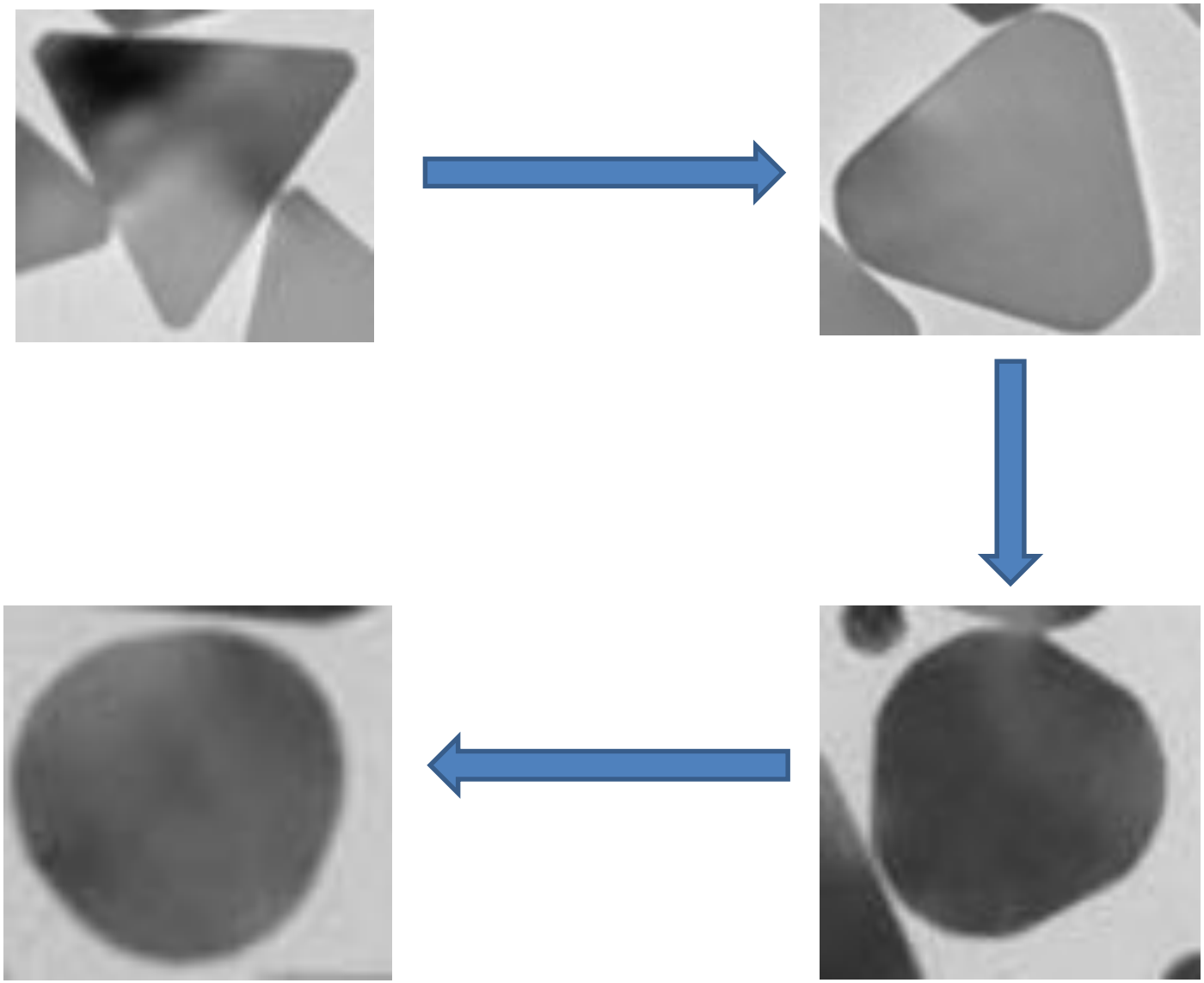
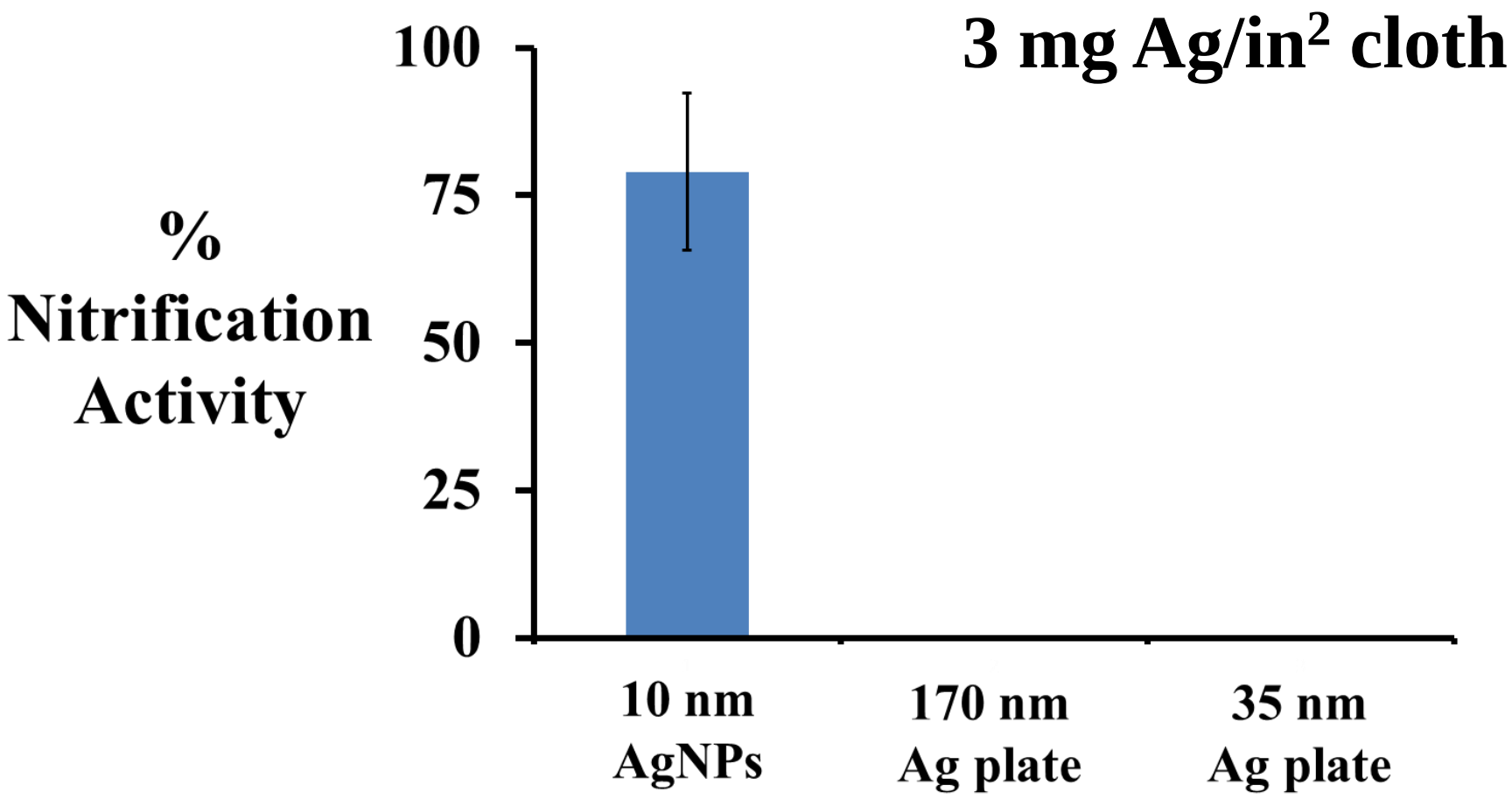


Influence of Attachment to Wool



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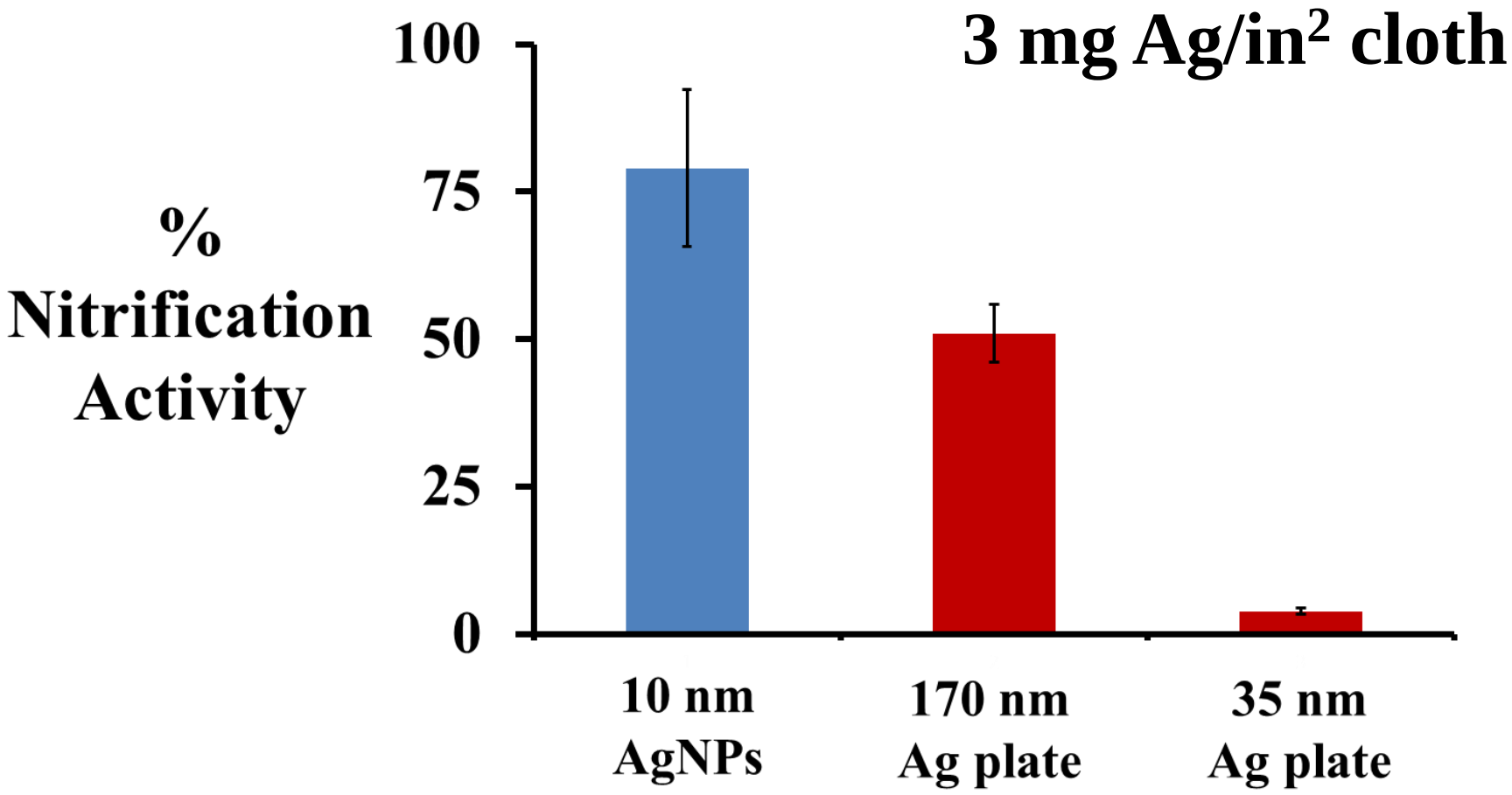


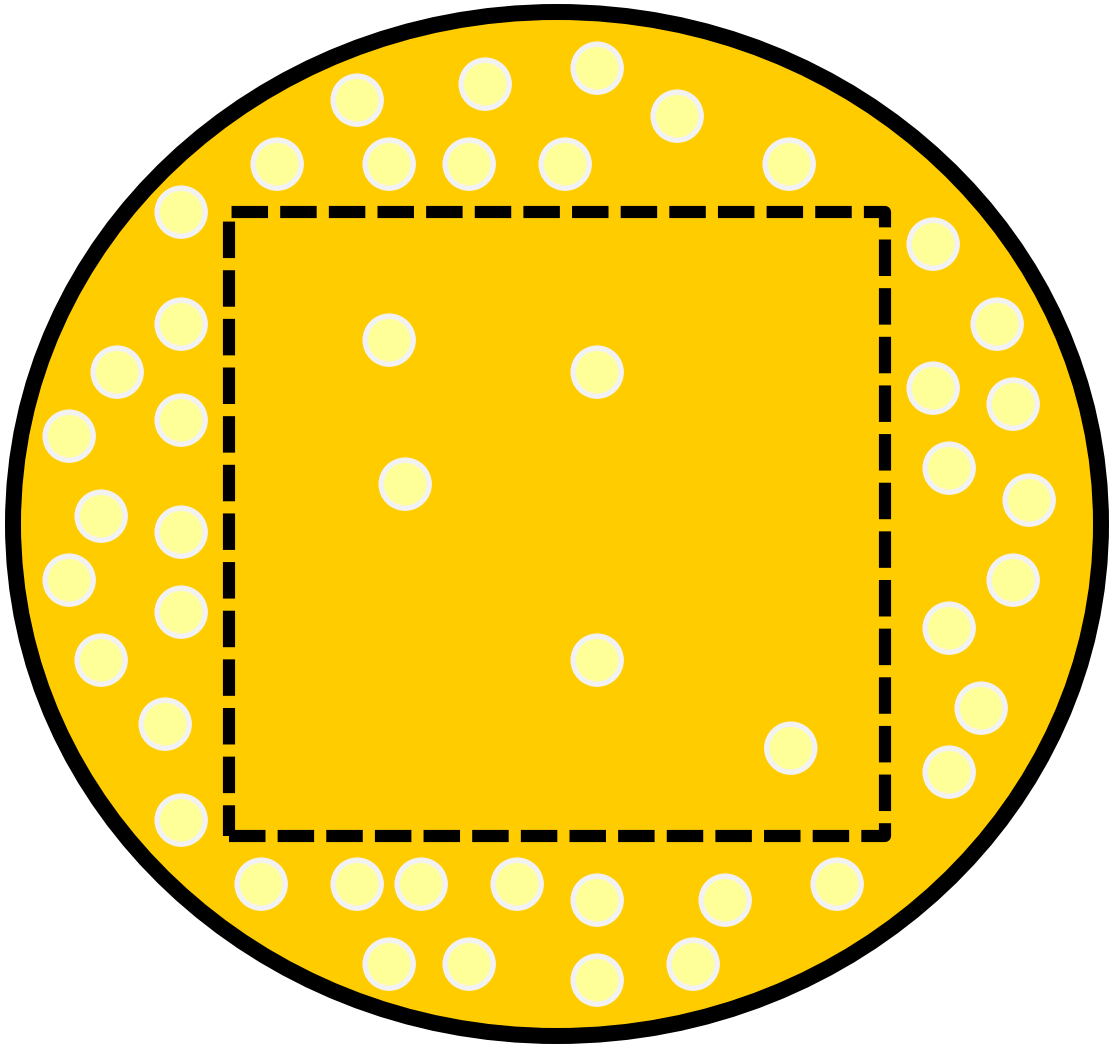
Pseudomonas putida Toxicity Tests

Pseudomonas putida

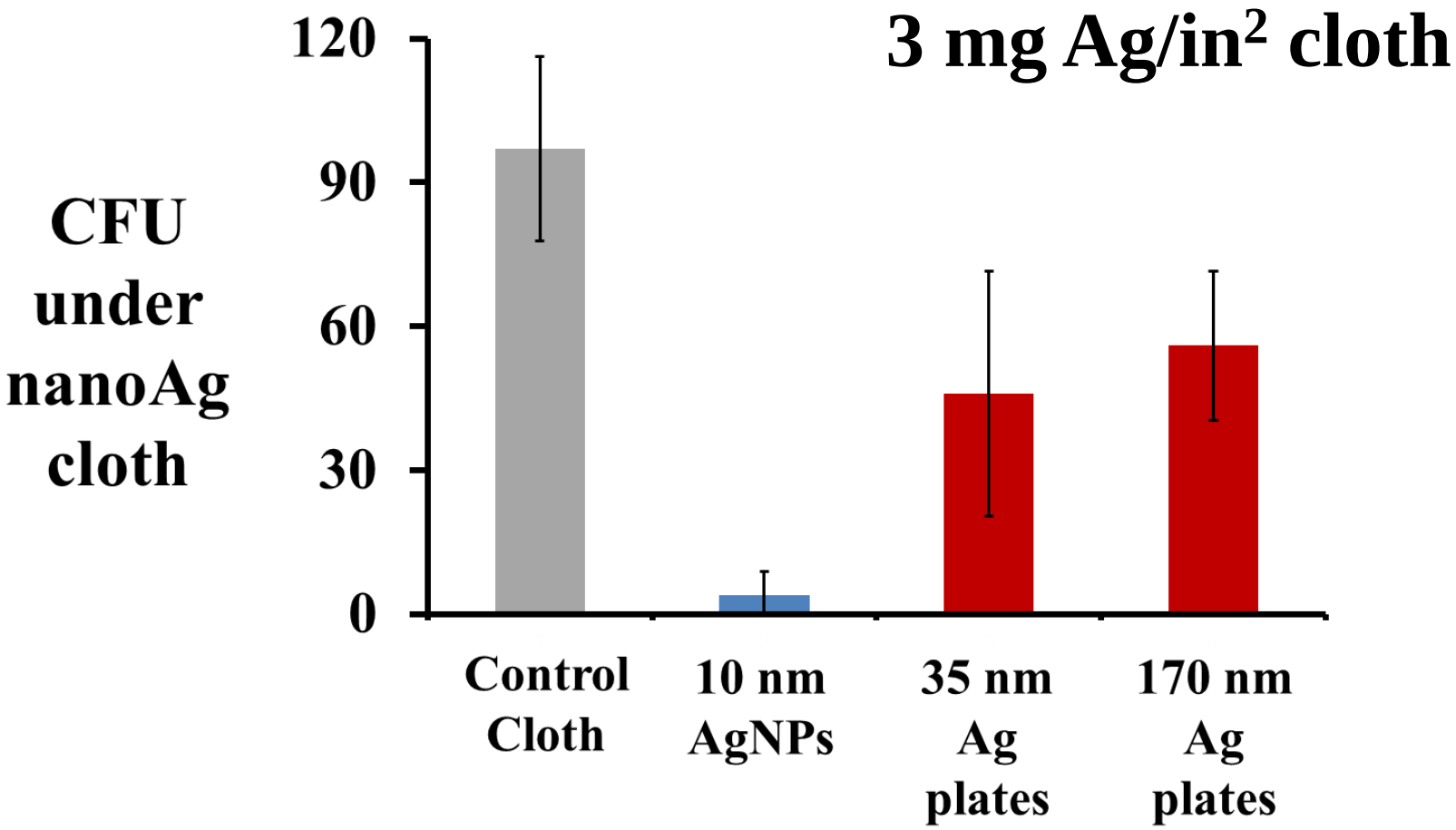
Wool with nanoAg

Pseudomonas putida Toxicity Tests

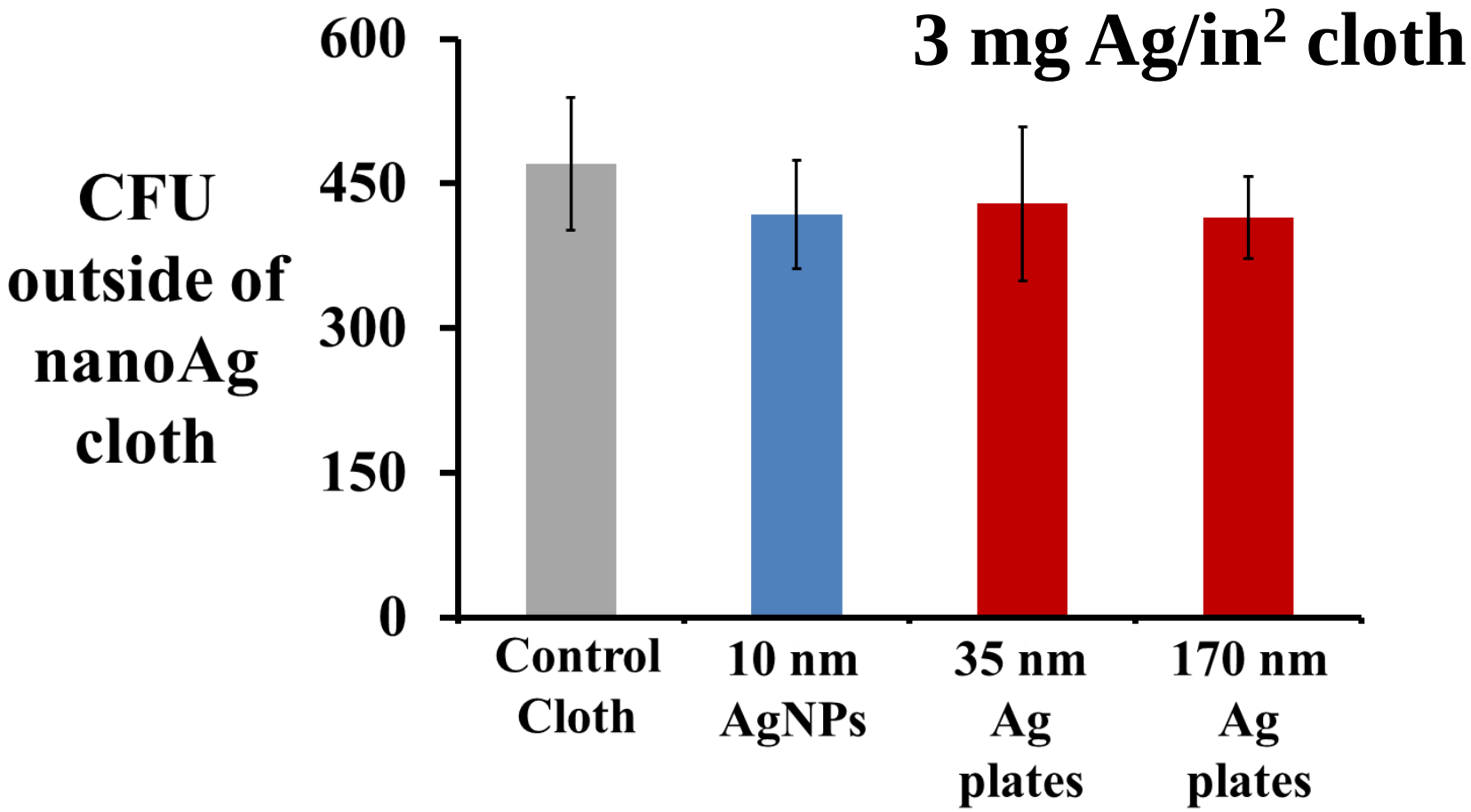
Pseudomonas putida Toxicity Tests



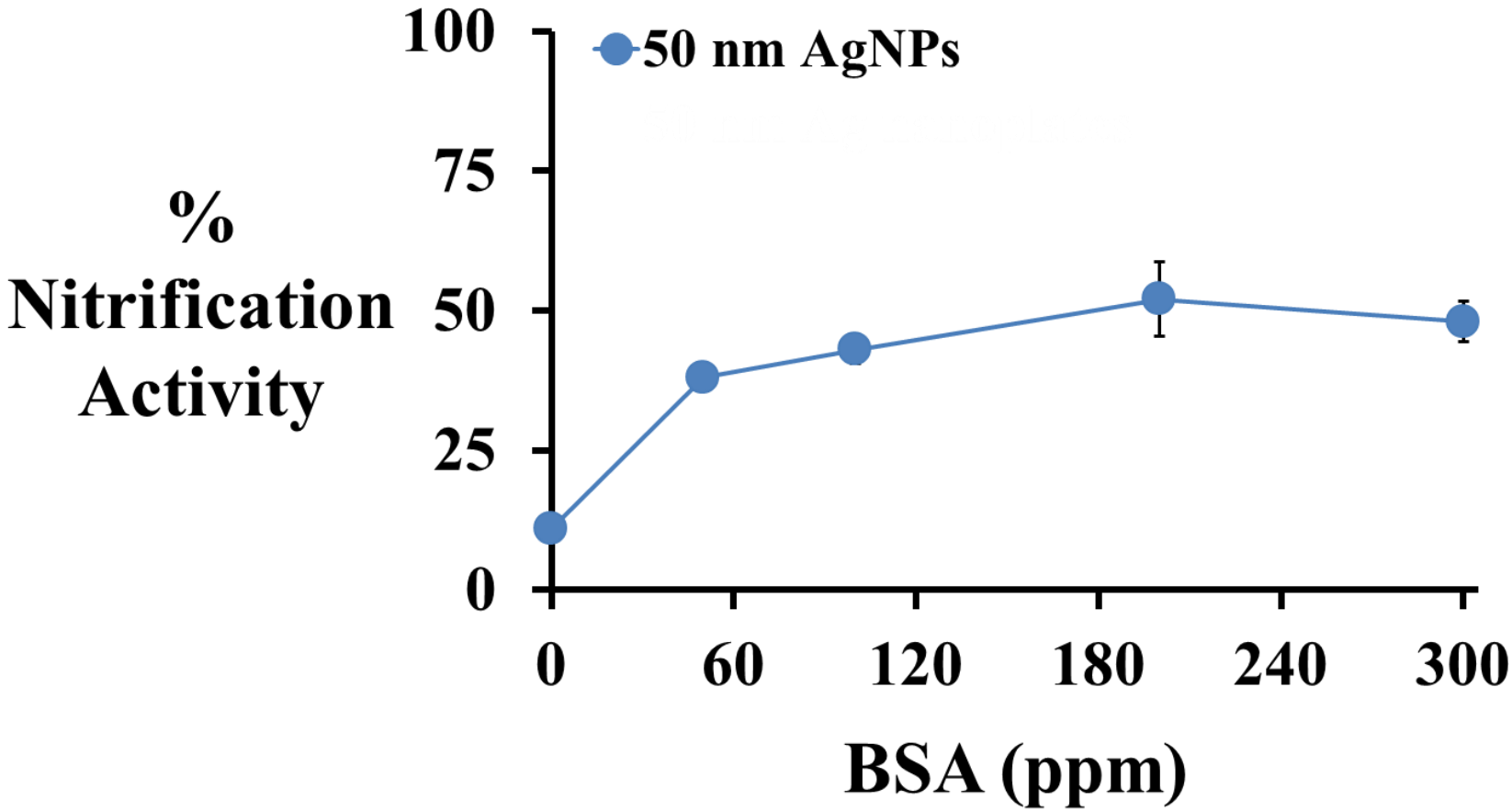
Pseudomonas putida toxicity tests



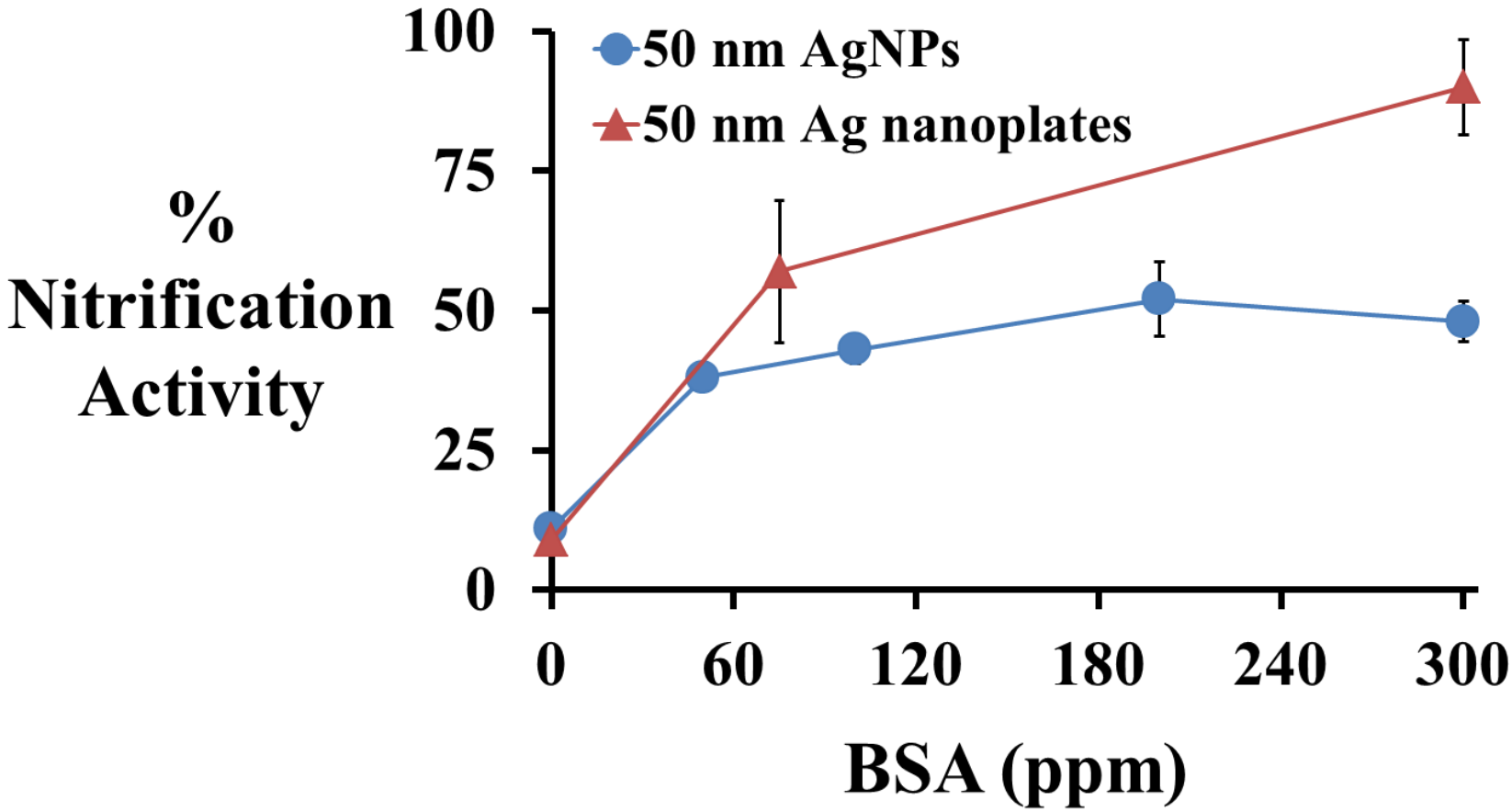
Pseudomonas putida Toxicity Tests



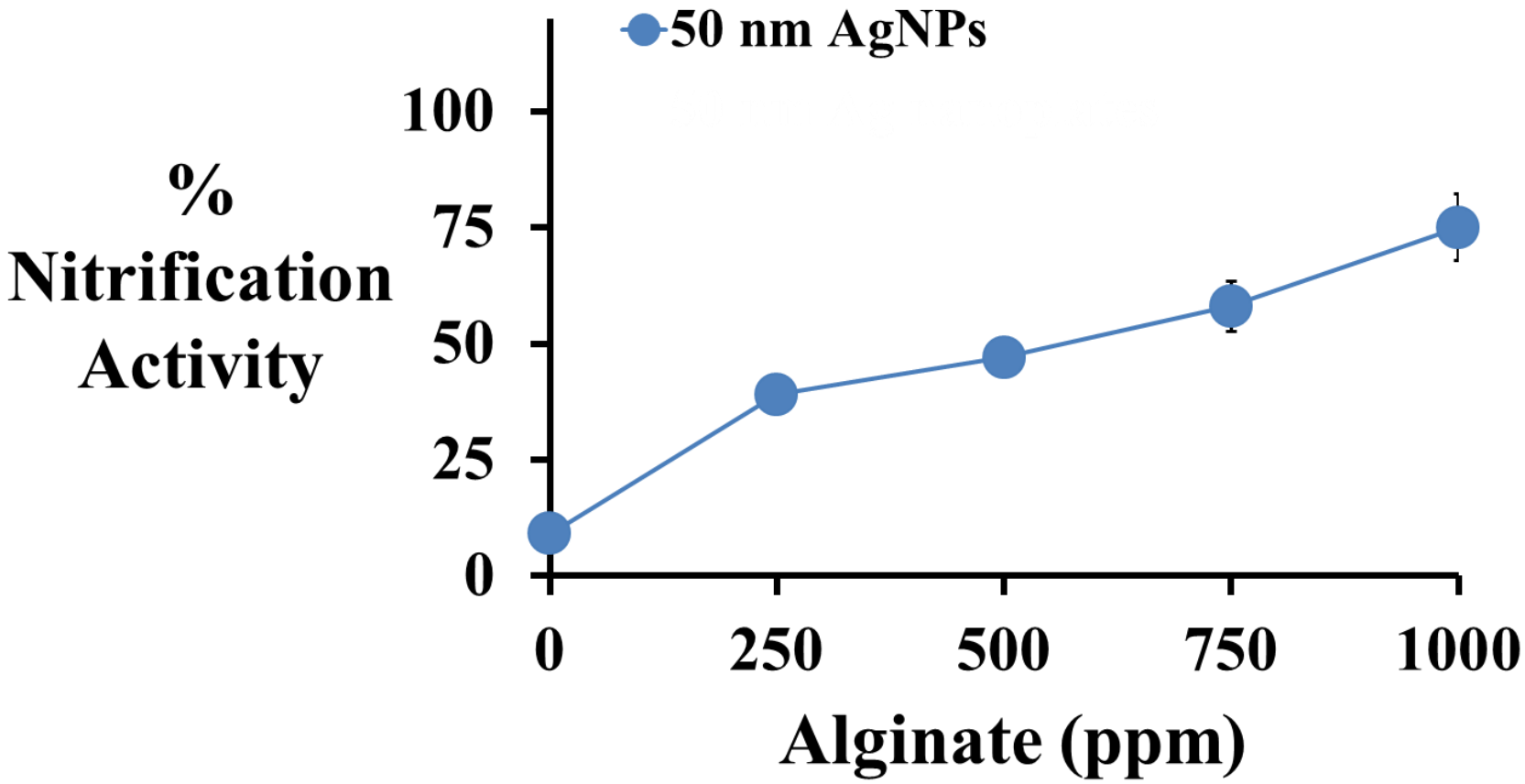
N. europaea and BSA Protection



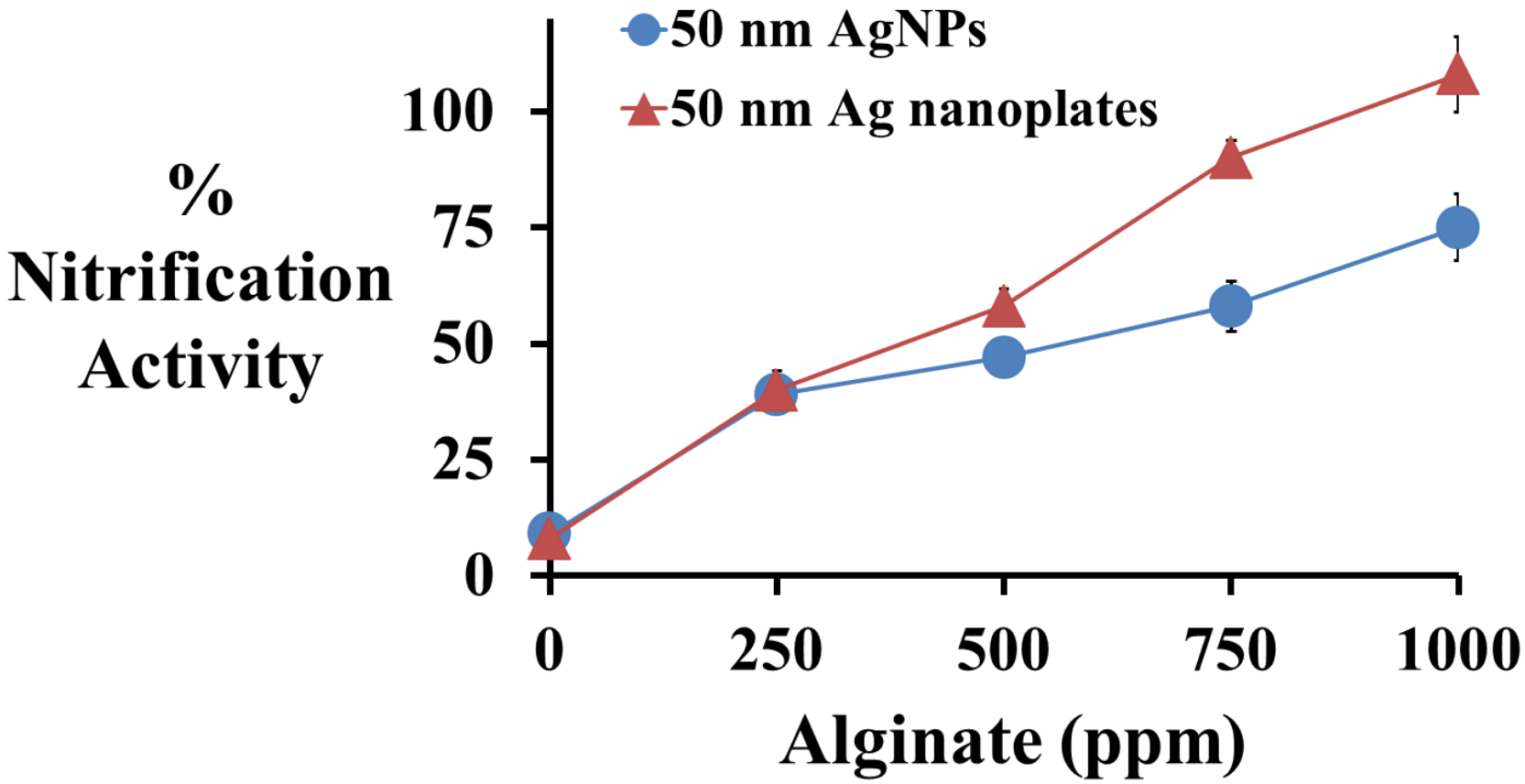
N. europaea and BSA Protection



N. europaea and Alginate Protection



N. europaea and Alginate Protection



Conclusions

- AgNP shape greatly influences toxicity
- In the presence of NH_3, Ag nanoplates are more toxic than AgNPs due to increased dissolution
- In the presence of proteins and LPS, AgNPs are more toxic than Ag nanoplates due to decreased interactions with the biological macromolecules
- Proper test media matters!

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Mr. Tanner Houston – Undergraduate Researcher

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