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Toxicity of dissolved silver and silver nanoparticles to *Daphnia magna*: The effects of natural organic matter and pH

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Abstract

OECD guidelines for testing the toxicity of chemicals are the most widely used toxicity tests for regulatory purposes, offering variability in test conditions. This flexibility has led to their adaptation for use in testing toxicity of nanoparticles, despite the uncertainty associated with effects the testing parameters exert upon their toxicity.[1,2] In particular, the addition of natural organic matter (NOM) has been shown to stabilize nanoparticles in aqueous suspensions[3] and thus might solve the problem of particle stability during toxicity testing. This study provides new insight into the effects of pH and NOM on the toxicity of NM-300K OECD silver nanoparticles (AgNPs) to *Daphnia magna* using OECD Testing Guideline 202.

Toxicity tests performed with AgNPs in M7 media (concentration range: 12.5-100 µg/L) were compared to toxicity tests utilizing dissolved silver from $AgNO_3$. NOM was added in the form of humic acid. An 8.9 mM MOPS buffer added to the M7 medium in order to keep a constant pH during incubation. For each silver form and at two different pH-values (pH 7 and pH 8), different concentrations of NOM were added, and their outcome were compared to baseline tests. The results are shown in Figure 1.

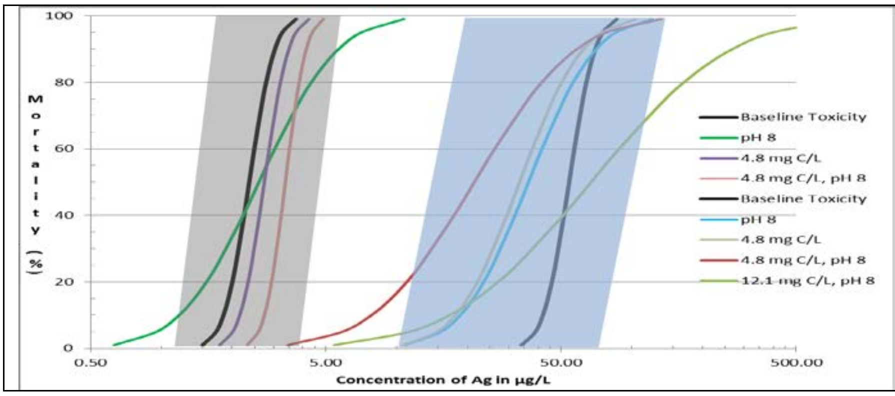

Figure 1: Fitted dose-response trendlines comparing the toxicity of AgNO3 ± DOM addition (as mg C/L, shown in the grey shaded area on the left) with the toxicity of AgNPs ± DOM addition (as mg C/L in the blue shaded area on the right) in M7 media and M7 media at a fixed pH 8.

The $AgNO_3$ toxicity results were in general agreement with previously published studies[4] which indicated that silver toxicity was reduced by the presence of NOM at around 4.8 mg C/L. For the AgNPs, the addition of 4.8 mg C/L resulted in a significant increase in toxicity for tests both in the presence and absence of MOPS pH buffering. The addition of 12.1 mg C/L to the AgNPs resulted in a general reduction in toxicity at both pH 7 and pH 8. These results suggest that the presence of NOM in the test media can exert a significant effect upon the toxicity of AgNPs and the reporting of NOM content as well as testing conditions during OECD Guideline 202 testing is strongly recommended.

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[1]Crane, et. al. 2008. Ecotoxicity test methods and environmental hazard assessment for engineered nanoparticles. *Ecotoxicity*. 17(5):421-437. DOI: 10.1007/s10646-008-0215-z

[2]M.E.J. Pronk, et. al. 2009. Nanomaterials under REACH. Nanosilver as a case study. National Institute for Public Health and Environment. RIVM report 601780003/2009

[3]Gao J, et. al. 2012. Influence of Suwannee River humic acid on particle properties and toxicity of silver nanoparticles. Chemosphere. 89:96-101. DOI:10.1016/j.chemosphere.2012.04.024

[4]Karen D J, et. al. 1999. Influence of water quality on silver toxicity to rainbow trout (Oncorhynchus mykiss), fathead minnows (Pimephales promelas) and water fleas (Daphnia magna). Env. Tox. Chem. 18(1):63-70.

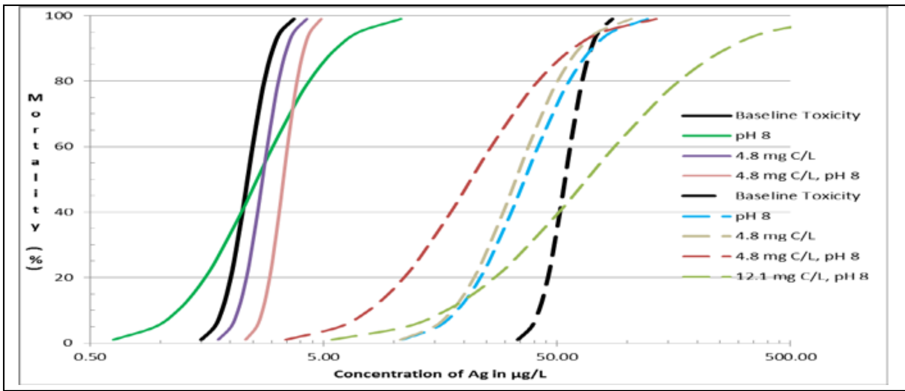

Figure 1: Fitted dose-response trendlines comparing the toxicity of AgNO3 ± DOM addition (as mg C/L, shown as solid lines) with the toxicity of AgNPs ± DOM addition (as mg C/L, shown as dotted lines) in M7 media and M7 media at a fixed pH 8.

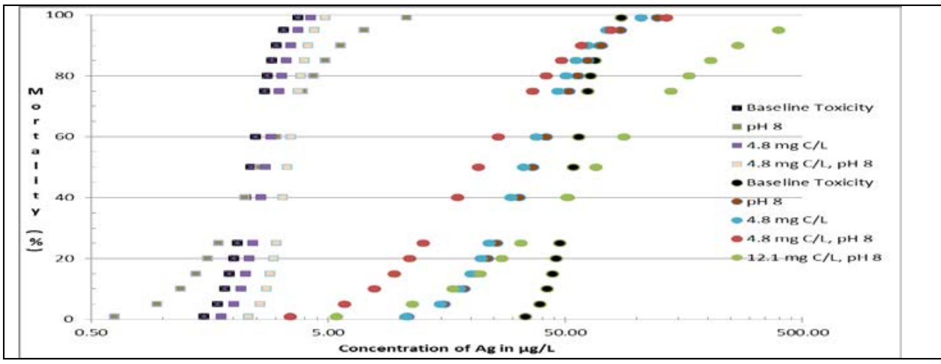

Figure 1: Fitted dose-response trendlines comparing the toxicity of AgNO3 ± DOM addition (as mg C/L, shown as filled squares) with the toxicity of AgNPs ± DOM addition (as mg C/L, shown as filled circles) in M7 media and M7 media at a fixed pH 8.

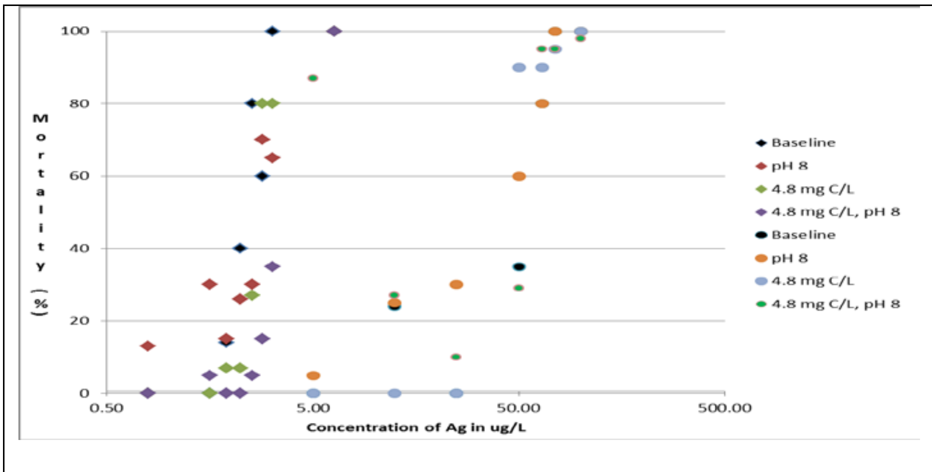

Figure 1: Data points comparing the toxicity of AgNO3 ± DOM addition (as mg C/L, shown as filled diamonds) with the toxicity of AgNPs ± DOM addition (as mg C/L, shown as filled circles) in M7 media and M7 media at a fixed pH 8.