

Use of stable isotope labelling to study the transformation of silver nanoparticles and silver ions in aquatic environments

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Silver nanoparticles (AgNPs) are mutable in the water column. As the oxidation of AgNPs to release Ag^+ and reduction of Ag^+ to regenerate AgNPs co-existed in certain compartments [1], it is very difficult to monitor the reaction kinetics. In this work, isotopically enriched $^{107}\text{AgNPs}$ and $^{109}\text{AgNO}_3$ were synthesized to trace the transformation of AgNPs and Ag^+ in aquatic environments, and evaluate the impacts of environmental factors on the transformation. We found that the oxidation of AgNPs dominated the reaction in simple waters containing both $^{107}\text{AgNPs}$ and $^{109}\text{Ag}^+$. Sunlight significantly accelerated the dissolution of $^{107}\text{AgNPs}$, triggered aggregation of $^{107}\text{AgNPs}$ and therefore reduced the reaction rate at long irradiation. In the presence of DOM, the reduction of $^{109}\text{Ag}^+$ played the leading role. Elevated pH could even completely inhibit the oxidation of $^{107}\text{AgNPs}$. Except for the dissolution of $^{107}\text{AgNPs}$ under solar irradiation, all the reactions seemed stalled at low temperature. Although the presence of divalent cations induced agglomeration of $^{107}\text{AgNPs}$, it did not significantly affect the reduction of $^{109}\text{Ag}^+$. These findings suggests that the transformation between AgNPs and Ag^+ is rather complex and greatly depended on the external conditions. Considering that Ag^+ is much more toxic than AgNPs, the speciation change could dramatically impact the final toxicity and bioavailability, which calls a strong request for assessing environmental risks of AgNPs under more realistic conditions.

[1] Yu et al. (2014) *Environ. Sci. Technol.*, 48, 403-411.