Sunlight-Driven Formation of Silver Nanoparticles: the Roles of Natural Organic Matter, and Silver-Chloride Complex

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Silver nanoparticle (AgNP)-enabled water purification technologies have been proposed as promising, new water or wastewater treatment processes. Silver ions (Ag\(^+\)) can be released into the treated water and enter the aquatic environment. Wastewater effluents can also contain some levels of silver as a result of the use of silver (nano) materials in consumer and industrial products. It is important to understand the fate of the released Ag\(^+\) in the aquatic environment. In this presentation, we show the role of natural organic matter (NOM) and chloride ion (Cl\(^-\)) on the solar photoreduction of Ag\(^+\). In sunlight irradiated surface waters, Ag\(^+\) bound to NOM (Ag-NOM), and Cl\(^-\), forming soluble Ag\(^+\)-Cl\(^-\) complexes (AgCl\(_x\)(x−1)\(^-\)) were shown to form AgNPs. The AgNP formation rate is significantly higher at pH > 7, and 8.3 in Ag-NOM, and AgCl\(_x\)(x−1)\(^-\) conditions, respectively. AgCl\(_{aq}\) was found to be the most photoactive among various AgCl\(_x\)(x−1)\(^-\) species. We show that the high ionic strength due to Cl\(^-\) has little impact on the formation of AgNPs. Whereas, light wavelength dependent study reveals that the UV part of the solar light spectrum is the primary driver in the photoreduction process. Results also suggest that the formation rate of AgNPs in the AgCl\(_{aq}\) system is higher than the Ag-NOM system. Overall, our results indicate that under sunlight, ionic Ag-NOM, and Ag\(^+\)-Cl\(^-\) complexes can be a source of AgNPs in the environment.