Surface charge controls the sorption of gold nanoparticles on pyrite

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Engineered and natural nanoparticles (NPs) are widely distributed in the earth system. Hence, study on the sorption of NPs on other minerals has fundamental implications to many environmental and geochemical processes. Sorption of gold nanoparticles (AuNPs) on sulfide minerals may also play an important role in the mineralization of certain ores (e.g., Carlin-type gold ore).

We have synthesized negatively and positively charged AuNPs using Frens method [1] and a seed-mediated method [2], respectively. Pyrite was synthesized using a hydrothermal method [3], and was pretreated in a HCl solution with ultrasonication to remove oxidized surface species. For a typical sorption experiment, 32 mL of Au colloid (14-18 nm; 20-60 ppm) was mixed with 0.04 g of pyrite for up to 7 days under different pH (2.0-10.0). The effect of hexadecyl trimethyl ammonium bromide (CTAB) was investigated by adding CTAB (0-200 ppm) to the Au colloids containing positively charged AuNPs. All the sorption experiments were conducted under anaerobic conditions, and atomic absorption spectrometry was employed to monitor the Au concentrations in the liquid phase.

Almost no sorption of negatively charged AuNPs was found on pyrite under pH 4-10, which is attributed to the electrostatic repulsion between the negatively charged AuNPs and pyrite with a measured isoelectric point value of 2.0. In contrast, positively charged AuNPs could be easily adsorbed on pyrite surface because of the electrostatic attraction. SEM revealed that most positively charged AuNPs were randomly distributed on pyrite. The fact that the sorption of AuNPs decreased with the increasing pH was most likely due to the decreasing zeta potential of AuNPs and also the increasing competitive sorption of free CTAB on pyrite. We suggest that AuNPs might experience substantial electrostatic and steric repulsive forces from the pre-adsorbed CTAB molecules.

[1] Frens (1973) *Nature Phys. Sci.,* **241**, 20-22. [2] Sau *et al.* (2004) *J Am Chem soc*, **126**, 8648-8649. [3] Yang *et al.* (2014) *J Appl Electrochem*, **44**,1075–1080.