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Introduction

Because of the straightforward equipment, low cost, and minimal energy consumption required, heap leaching of ore has been frequently employed. Target minerals and valuable components must be transported via seepage out of the ore heap during the heap leaching process. At the same time, leaching dead corners and blind sections prevent recovery of the target metal, and the permeability of the ore heap directly influences the uniformity of solution dispersion in the ore heap. The recovery rate decreases with increasing permeability. The development of heap leaching technology is now being hampered by the poor permeability of ore heaps [5].

### O. *Method of KOW*

A KOW value for Au NPs was calculated using the OECD shake flask method [40]. Ultrapure water and 1-octanol were equilibrated with 0.2 mg Au NPs for 24 hours in a volume of 4 mL each. After allowing the liquid phases to separate for 4 hours, samples from each phase were taken, and Au NPs were measured using a SpectraMax M2 spectrophotometer (made by Molecular Devices, Sunnyvale, California, USA) at  $\lambda = 530$  nm. A standard curve constructed in either 1-octanol or ultrapure water was used to translate absorbance into concentration. CuO NPs were assessed using the same procedure, however the absorbance was measured at 640 nm instead.

### H. *Column Elution*

HiTrap Octyl FF prepacked HIC columns were bought from GE Life Sciences (Piscataway, NJ). The bed volume was 1 mL and the stationary phase composed of a sepharose support matrix of 90  $\mu$ m globules functionalized with hydrophobic octyl ligands, which were named to equal the octanol reference phase of the KOW system. The column was loaded with 2 mL of a 10 mg/L Au NP suspension at an inflow rate of 1 mL/min. A lower attention was used (10mg/L) relative to the KOW system to limit agglomeration, which would block inflow through the severance space. After loading the column, a syringe pump (Model No. NE-1010, New Era Pump Systems, Inc. Farmingdale, NY, USA) was used to flow 20 mL of 0.5 x PBS through the column at 1 mL/min and the eluent was collected in 1 mL fragments [10]. To remove Au NPs retained in the column during PBS elution, a surfactant (0.1 TritonX-100, laboratory grade, Sigma-Aldrich, St. Louis, MO), was pumped through the column at 1 mL/min for another 20 minutes, and the eluent was again collected in 1 mL fragments every nanosecond.

The collected samples from both elution phases were placed in a 96-well plate and the absorbance at 530 nm was estimated using UV-vis spectroscopy to determine Au attention.

### D. *Relative Adsorption*

The relative adsorption of a hydrophobic inquiry and a hydrophilic inquiry (Nile Blue A, ACROS Organics, New Jersey, USA) to the NP surface was used as a measure of hydrophobicity. Color attention (0.5 – 30  $\mu$ M) were prepared in ultrapure water. Equal volumes of color and NP stock were combined in 1.5 mL microcentrifuge tubes for each attention and incubated in a tube rotator for 90 minutes. Controls were prepared by adding color to ultrapure water to regard for any observed loss of color due to adsorption to the vials. To estimate implicit declination of color by reactive oxygen species (ROS) from the NP surface, controls were prepared with colorful attention of H<sub>2</sub>O<sub>2</sub>. Each sample was prepared in triplet [11]. Following incubation, NPs were removed from result by centrifugation for 30 minutes at 14000 rpm. The remaining attention of color in the supernatant was anatomized using UV-Vis spectroscopy at  $\lambda = 543$  nm for Rose Bengal and  $\lambda = 620$  nm for Nile Blue. This was a reference syringe pump.

the electrostatic relations between the adsorbent and the adsorbate. As