Project 1: Synthesis and Characterization of Different Forms of Cu Nanoparticles to Mitigate Cu Leaching to Water Bodies

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Project Summary

The application of various Cu-based pesticides has resulted in increased Cu concentrations in agricultural soils. Although Cu is an effective biocide, it may also affect non-target organisms and could pose environmental concerns. High Cu concentrations in soils were reported to have adverse effects on soil biota and plants. Additionally, Cu may be washed into the aquatic environment from agricultural and urban application locations and may also enter aquatic environments when Cu is used as a biocide in antifouling paint formulations. As such, contaminated soils with increased levels of Cu pose a risk for surface water and groundwater qualities as well as a threat to aquatic organisms. Furthermore, it may also affect the performance of biological water and wastewater treatment facilities. In recent years, applications of Cu-based pesticides have extended the use of bulk and ionic forms into Cu-based micro- and/or-nano-particles such as Cu, Cu_2O, CuO, and CuCO3 nanoparticles. This great demand has been largely due to the wide range of unique physicochemical and biocidal/biostatic properties of these materials at the nanoscale. In general, Cu-based nanoparticles have been used in fungicides, wood preservation, and agricultural pesticide applications. Some research suggests that nano Cu toxicity depends on particle size. It has been reported that there is a 15 to 65 fold increase in toxicity when

nanosized Cu particles are used in relation to bulk Cu. In most studies, the increase in Cu-based NPs toxicity is attributed to, among other things, an increase in solubility and ion release and, consequently, bioavailability.

In the Environmental Chemistry Laboratory, participant teachers will synthesize Cu and polyvinyl alcohol (PVA) nanocomposites. In this synthesis process $CuSO_4$/ $CuCl_2$/ $Cu(NO_3)_2$ as Cu precursors, $NaBH_4$ as reducing agent, $NaHCO_3$/ Na_2CO_3/ NaOH/ NaI/ NaBr as electrolyte salts, and PVA as stabilizing agent will be used. The hydrodynamic diameter and zeta potential, the morphology, and the absorbance and wavelength of the synthesized particles will be measured using dynamic light scattering, tunneling electron microscopy (TEM), and UV-Vis spectroscopy techniques, respectively. Figure 1a and 1b shows the TEM image of the synthesized nanoparticles (**Figure 1a** indicates the synthesized nanoparticles using $CuSO_4$, $NaHCO_3$ and PVA, whereas **Figure 1b** using $CuSO_4$, NaF, and PVA). The leaching (ionic portions) of the synthesized particles in different pH, ionic strength and humic acids values will be evaluated by centrifugal ultrafiltration process using Amicon ultrafiltration tubes. The concentrations of the leachates will be analyzed using UV-Vis and/or atomic absorption spectroscopy techniques. Negative and positive controls will be used for comparison.

The main objective of this study is to understand the impact of different concentrations of Cu salts, PVA, and electrolyte salts on the size and stability of the synthesized nanoparticles, and the impact of environmental parameters such as pH, ionic strength, and humic acids on the leaching of ionic copper.

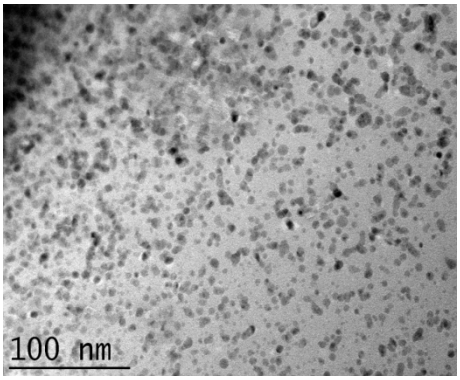

Figure 1a. TEM image of Nanoparticles Using $CuSO_4$, $NaHCO_3$ and PVA

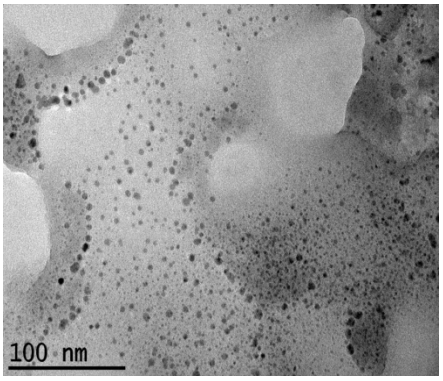

Figure 1b. TEM Image of Nanoparticles Using $CuSO_4$, NaF, and PVA

Possible Ideals for Classroom Implementation

This project is expected to open the realm of the multidisciplinary field of nanotechnology to the teachers. It will empower them with integrated knowledge to solve inter-related and consequential environmental problems. It will be attractive to students and teachers who tend to choose a career pathway that could potentially improve the quality of the environment. Participant teachers will be provided with the necessary documentation for experimental procedures and will be trained prior to conducting any experiments. Teachers who participate in this project will have the capacity and chance to train new teachers and students at their schools depending on the resources available to them. This kind of activity exposes students to problems faced by environmental engineers as they develop new materials or technology to improve the quality of the environment.