Name(s)
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Project Number
S0503

Project Title
Bright, Luminescent Silicon Nanoparticles for Biological Applications

Abstract

Objectives/Goals
In recent decades, there has been increased interest in fluorescent semiconductor nanoparticles or quantum dots (QDs). QDs behave like single atoms and provide clear benefits over the organic dyes currently used for tracking biological processes. Since the production of QDs is very costly, the search continues for an industry-ready synthesis of nanoparticles with optimal characteristics for bioimaging. Towards this goal, I explored creating silicon QDs as silicon is electrochemically stable and the second most abundant element in the Earth#s crust.

Methods/Materials
The first part of my project dealt with synthesizing the compound sodium silicide (NaSi). My synthesis involved reacting sodium and silicon in a high temperature furnace. To create spherical Si-QDs, I developed an approach that reacts NaSi with ammonium bromide in dimethyl formamide (DMF) on a Shlenk line. I terminated the QDs with propylamine rendering them air and water stable. I also developed a synthesis in dioctyl ether (DOE) that yields luminescent, octane terminated silicon nanorods. To test if the QDs would be bright enough to image a human cell, I performed cell studies with human monocytes.

Results
I confirmed the synthesis of NaSi with Powder X-Ray Diffraction. The properties of the QDs were explored via UV-Vis, PL, and Transmission Electron Microscopy. My QDs are luminescent, monodisperse, and produced in 3X higher yield than prior publications on such a synthesis. Confocal microscopy scans indicated that the QDs are bright enough to image cells. Regarding the DOE reaction, a solution state synthesis to create Si nanorods had never before been accomplished. Creating luminescent Si nanorods was immensely significant as it proves that shape control of Si at the nanoscale is possible.

Conclusions/Discussion
I have demonstrated the facile synthesis of water-soluble propylamine capped Si-QDs. The QDs have optimal fluorescence, are homogenous, and their synthesis provides for high yield. Cell studies on monocytes showed that the particles can image cells. This extends the utility of the QDs beyond inorganic chemistry into biology and medicine as potential candidates for bioimaging. An unexpected result of my work was the creation luminescent silicon nanorods. The shape of the nanorods would be preferable for bioimaging applications due to their smaller diameter and are further proof of the applications my work could have for medicine.

Summary Statement
I created silicon nanoparticles, visible only under ultraviolet light, which will help doctors image malignant cells in the body in a safer way.

Help Received
Performed research at the Lab of Professor Susan M. Kauzlarich and the Lab of Angelique Louie at the University of California at Davis.