CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

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Project Number

S0602

Project Title

Synthesis and Characterization of Novel Internal Alkyne-Stabilized Nanoparticle for Effects on Optoelectronic Properties

Abstract

Objectives/Goals

Electronics has depended on the concept of miniaturization, building circuitry from increasingly smaller parts to maximize efficiency and minimize cost. However, this size reduction in silicon-integrated circuitry leads to significant power losses due to increased electron tunneling. To address this problem, molecular electronics proposes using nanoparticles instead of bulk materials because of their advantages in size, assembly and synthetic tailorability. This project synthesized and characterized a novel internal alkyne-stabilized ruthenium nanoparticle by changing interfacial bonding of the ligand to the ruthenium core from terminal to lateral. In order to evaluate effectiveness of the novel nanoparticles in replacing conventional circuitry, it is important to characterize intraparticle charge transfer and quantization of energy states, which can be changed by manipulating the interfacial bonding between the metal core and organic ligand.

Methods/Materials

The new ruthenium nanoparticles were successfully synthesized. The new nanoparticle has alcohol groups and internal triple bonds, which cause lateral binding. The control particle has standard methyl groups and terminal triple bonds. The Ru core was synthesized following colloidal synthesis. Unlike the control particles, which have standard methyl groups, the alcohol groups on the ligand of the experimental particle make the particles insoluble in many different solvents. To address this problem, the alcohol groups were oxidized to carboxyl groups, increasing the particle solubility allowing the particles to be tested in spectroscopies such as FT-IR, UV-vis, and photoluminescence.

Results

For our new particle, the ligand is bonded laterally onto the ruthenium instead of terminally, resulting in a conjugated system of alternating single and triple bonds. This structural change increased localization of electrons, increased quantization of energy states, and led to a much greater energy band gap in comparison to our control particle.

Conclusions/Discussion

The new properties in our particle have not been observed before, and the even greater energy band gap prove that our particles may have the potential to replace key elements of electrical circuitry such as the silicon dioxide of an insulator. This work serves as an initial step in defining the potential of nanocomposite structures as mediators for controlling the properties of a material.

Summary Statement

This project synthesized novel internal alkyne-stabilized nanoparticles, which exhibited new fluorescence properties, electron localization, and an even greater band gap or more quantization, to help reduce power loss in silicon circuitry.

Help Received

Worked at University of California Santa Cruz under the supervision of Dr. Shaowei Chen and Xaongwu Kang