A Multidisciplinary and Modular Approach for the Introduction of Nanotechnology to Undergraduate Engineering and Science Curricula

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Abstract **- This project is undertaken to introduce the undergraduate engineering and science students to nanoscience and nanotechnology by creating a new modular and multidisciplinary course, incorporating relevant modules into existing courses, and involving students in the preparation of these tools. Through the activities of this project, the undergraduate engineering and science students are expected to develop a deeper insight into nanoscience and nanotechnology, thus, being encouraged to select careers in these areas in either research or technology development. An important contribution of this work to undergraduate engineering education arises from the extensive involvement of undergraduate students in the project, thus, also integrating research into education.**

Index Terms - interdisciplinary, modular, undergraduate nanotechnology education

PROJECT ACTIVITIES

Contribution of this project to the undergraduate learning is mainly through the use of the course and laboratory modules on nanoscience and nanotechnology, introduced in various existing freshman, sophomore and junior courses in the chemical engineering, physics and chemistry curricula; an elective multidisciplinary and modular nanotechnology course in the senior year of these programs; and a seminar series. Additionally the students hired under this project will work in the development and performance of the laboratory modules related to nanotechnology, and will, also, contribute to the preparation of the course modules. These experiences will contribute to their education in nanotechnology.

The senior level elective course will cover the topics of survey of the current status and applications of nanotechnology; methods for the synthesis of nanostructured materials; synthesis and characterization of nanostructured catalysts; computational nanotechnology; commercial applications and synthesis of nanocrystals; optical spectroscopy of nanocrystals; and health, environmental and safety issues associated with nanotechnology. This course is an elective course open to students in the disciplines of engineering, chemistry, physics, computer science, mathematics, biology, and pharmacy in senior standing. The first time offering will be in Spring 2007. In the second offering of the course, the course notes will be distributed to the students to get their input and to make improvements in the course material. The team is in the process of preparing each module, with the participation of the undergraduate students hired under the grant. The course is designed to evolve with the recent developments in nanoscience and nanotechnology, and the modules and their contents will be continuously updated and expanded.

There are two laboratory modules, one on nanostructured catalysts and the other one on nanocrystals. The former one is the synthesis of aerogels as nanostructured catalyst supports for energy and environmental solutions. This module is being developed in the Chemical Engineering Department. Five engineering students were employed under the grant and in Spring 2006 semester, each student prepared research papers on aerogel synthesis; XRD, XPS and SEM analysis; and surface area and porosity measurement of porous materials, respectively, and made presentations on their topics. In summer 2006, two engineering undergraduates will be part of a research team which will design and construct a setup for the manufacture of nanostructured aerogel catalysts and start their synthesis. The design aspect in the course and laboratory modules will be very important for the development of the synthesis and analysis skills of the students and their comprehension of the new concepts. In Fall 2006, some of the students will formalize the aerogel synthesis procedures and prepare the write-ups, while a second group will design and perform experiments to measure some physical properties of the synthesized aerogels such as surface area, pore volume and thermal conductivity. These students are trained by the investigators in the Chemical Engineering Department in research and experimental design methods. Such research experiences provide opportunities to the selected undergraduates to become knowledgeable in an area at the forefront of scientific and technical developments. These students will learn to use the state-of-the-art equipment and interpret the results of their measurements. Also, these activities are expected to motivate them to pursue graduate studies in the areas of nanoscience and nanotechnology. Eventually, these experiments will be expanded to become experiential learning modules for the nanotechnology course.

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They will also be implemented into the other chemical engineering courses.

In the Physics Department, the students will work on the optical analysis of semiconductor quantum dots; characterization of nanoaerogels (silica, RF, and carbon) with the group in Chemical Engineering; computational analysis of quantum confinement of quantum dots with the group in Chemistry; preparation of semiconductor quantum dots in polymers; and the measurement of nonlinear optical properties of quantum dots and nanoaerogels.

In the Chemistry Department, modules on computational chemistry with specific applications to nanotechnology are being developed. Application areas include carbon clusters, laser dyes, photochromic and thermochromic materials and organic semiconductors. These modules introduce the undergraduate students to semiempirical and ab initio calculations in materials science, thus, computational materials science. Modeling of molecular and electronic properties are being carried out on single molecules and multichromophoric systems, furan-, pyrrole-, and thiophene-based organic semiconductors and carbon clusters to demonstrate the use of calculations in determining material properties required for a certain function; and explain the relationship between polymer properties such as tensile strength and structure.

As part of the seminar series, Dr. Phillip Williams**,** a research scientist at the National Institute of Aerospace, presented the topic *"Nanotechnology: Bright and 'Small' Future"* in Spring 2006. There will be more seminars in Fall 2006 by the presenters on topics such as professional ethics, societal impact of nanoscience and nanoengineering, and recent developments in these areas.

This project will contribute to the development of the future workforce in the field of nanotechnology by introducing a large number of African American engineering and science students to these novel areas at the undergraduate level. Through the activities of this project, the undergraduate engineering and science students will develop a deeper insight into nanoscience and nanotechnology, thus, being encouraged to select careers in these areas in either research or technology development.

ACKNOWLEDGMENT

This project is funded by the National Science Foundation under the Nanotechnology Undergraduate Education program.