Nanotechnology in Undergraduate Engineering and Science Education

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For the United States to have a leadership position in the world in nanotechnology, all the human resources need to be utilized and a diverse workforce needs to be created. Therefore, this new area must be introduced at the undergraduate level to all engineering and science majors. Contribution of this project to the undergraduate engineering and science education is mainly through the use of the course and laboratory modules on nanotechnology, introduced in various existing freshman, sophomore, junior and senior courses in the chemical engineering, physics and chemistry curricula; and an elective multidisciplinary and modular nanotechnology course in the senior year of these programs.

In this presentation, the type of modules being prepared, and the contents of the multidisciplinary and modular elective nanotechnology course will be described. The course is designed to evolve with the recent developments in nanotechnology, and the modules and their contents will be continuously updated and expanded. The modules in the senior elective course include the survey of the current status and applications of nanotechnology; methods for the synthesis of nanostructured materials; synthesis and characterization of nanostructured catalysts; computational nanotechnology; nanoscale thermodynamics and transport; properties and commercial applications of nanoscale materials; optical spectroscopy of nanoscale materials; health, environmental and safety issues associated with nanotechnology.

Another important aspect of this project is the integration of research into education. Twelve undergraduate students are employed, six from chemical and electrical engineering, three from physics and three from chemistry departments. These undergraduate students are participating in the preparation of the course and laboratory modules. In the 2006 Spring semester, undergraduate engineering students made oral presentations on the preparation of aerogels, measurement of the surface area and porosity, and characterization of aerogels by SEM, XRD and XPS techniques. In the 2006 Fall semester, these students will perform experiments on their topics. The engineering undergraduate students are contributing to the setup of an aerogel nanocatalyst synthesis facility and development of a laboratory experiment on the synthesis of aerogel catalyst supports in Summer 2006. These activities will result in the preparation of a laboratory module to be used in the senior Chemical Engineering Laboratory

course; and a module to be used in the elective interdisciplinary course, and in the junior chemical reaction engineering course.

In the Physics Department, the undergraduate students 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 nanoscale thermodynamics and 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 differences between macroscopic scale thermodynamics (standard thermodynamics generally introduced in beginning chemistry courses) and thermodynamics at the nanoscale. Undergraduate students are also introduced to semiempirical and ab initio calculations and their use in materials science.

A very important impact of this activity will be to increase the quantity and quality of underrepresented minority engineers and scientists in the area of nanoscience and nanotechnology. By introducing a large number of minority engineering and science students to these novel areas of national importance during their undergraduate education, this project attempts to tap into an underutilized capacity of the nation and contribute to the development of the future workforce in the field of nanoscience and nanotechnology. 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.