ChE 791 – Nanotechnology in Chemical Engineering
Fall 2012

Instructor: Dr. Todd Hoare (hoaretr@mcmaster.ca JHE-A409 extension 24701)

Course Schedule: Wednesdays, 9:30AM-12:30PM, JHE 342, starting September12 and running through December 5 (class on Dec. 5 will be in JHE 326B instead of JHE 342). There will be no class on October 3.

Course Objectives: This course is intended to give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials. Emphasis will be placed on the interfacial properties present at the nanoscale and how these properties can be applied to design useful materials and devices for engineering applications. Fundamentals of the design, preparation, and properties of nanomaterials are discussed from a chemical engineering perspective. Emphasis will be placed on how physical properties of materials change on the nanoscale, top-down (chemical patterning/lithography techniques) versus bottom-up (self-assembly) approaches to nanostructure preparation, nanoparticle design, characterization of nanoscale structures, nanofluidics and nanomachines (including microelectromechanical systems), and nanobiomaterials (drug and gene delivery, biosensors, and bioseparations).

Course Topics:

1) *Nanoengineering basics* - effect of length scale; unique properties of nanomaterials (quantum effects)

2) *Fabrication of Nanostructures* - biological inspiration; top-down vs. bottom up assembly

3) *Self Assembly as a Route to Nanostructures* - fundamental forces directing self-assembly; applications for nanostructure assembly

4) *Nanoparticle Design and Assembly* - isotropic nanoparticles (micelles, liposomes, polymerosomes, coacervates, solid nanoparticles, nanogels); anisotropic nanoparticles (core-shell particles, Janus particles, patchy particles, nanoshells, nanowires, nanotubes, prisms) - preparation methods and applications

5) *Top-Down Patterning* - lithography (electron beam, photolithography, soft lithography, dip pen); surface wrinkling; applications

6) *Characterization of Nanoscale Structures and Surfaces* – size, charge, shape, crystallinity, topology, chemistry

7) *Nanofluidics and Microelectromechanical Systems* - fundamental principles; lab-on-a-chip designs; fabrication techniques

8) *Nanobiomaterials* - interactions of nanomaterials with cells; drug and gene delivery; biosensors; nanobioseparations

9) *Nanomaterial Safety* - biological and environmental effects of nanomaterials; nanotoxicology

Recommended Resources: While there is no formal textbook for this course, I would recommend the following books as references for this course:

- Self-Assembly and Nanotechnology: A Force Balance Approach (Lee, 2008, Wiley)
- Biomaterials: A Nano Approach (Ramakrishna et al, 2010, CRC Press)
- Nanochemistry (Ozin et al, 2009, RSC Publishing)

Course Structure: This course will be organized as a series of lectures (1.5-2 hours/week) combined with literature discussion, led by students, concerning the topics covered in the previous lecture periods (30 minutes/discussion). There are four methods of evaluation in this course:

1) **Leading a literature discussion** (*20% of final mark*) – Each student will, once over the course of the semester, select one paper from a leading journal on one of the topics covered in the previous week's lecture, give a 5-10 minute summary and critique of the paper, and then lead a discussion on the paper with the rest of the class. A schedule for these discussion slots will be determined during the first week of class.

2) **Participating in literature discussions** (*10% of final mark*) – This mark will be allocated for your attendance and participation in discussing papers selected by other students. Both quantity and quality of questions will be considered when allocating the mark, with the emphasis on quality.

3) **Nanotechnology research presentation** (*40% of final mark*): A research project on any aspect of nanotechnology or nanoengineering, to be chosen by the student and approved by the instructor, will be selected within the first three weeks of the semester. You can discuss topics with Dr. Hoare in class or via e-mail. The research paper must not be directly related to your thesis research, but may be complementary. Evaluation will be based on a 20 minute presentation (30%, to be conducted over the last two weeks of the course, marking scheme posted on Avenue) and the production of a *maximum* two-page hand-out (in the style of class notes) to be distributed to the class electronically prior to your presentation (10%).

4) **Grant proposal** (*30% of final mark)*: A proposal for novel research on some aspect of nanotechnology will be prepared. This proposal may be based on some of the topics covered in your research presentation or may involve some other aspect(s) of nanoengineering, provided it is primarily based on chemical engineering or chemistry principles. Evaluation will be based on a *maximum* 10 page (single spaced, 12 pt. Times New Roman font, 1" margins, figures included) research proposal, of which half (5 pages) should be a review of relevant literature (including references from both the academic literature as well as the patent literature) and half (5 pages) should be a research proposal outlining the objectives, methodology, outcomes/potential pitfalls, and significance of the proposed research. The research may be primarily academic or aimed at the design of a new nanotechnology-based product or device. A marking scheme is posted on Avenue. This project is due at the last class on **December 5**, by the end of the class.

Centre for Student Development:

"Students with disabilities can receive accommodations to assist them in the completion of their assignments and exams. Please contact the Centre for Student Development for advice and for arranging assistance." Further info at: ***http://csd.mcmaster.ca***

Senate and The Faculty Of Engineering Policies:

"The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem, that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible."

Plagiarism and Academic Dishonesty

"You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity."

"Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university."

"It is your responsibility to understand what constitutes academic dishonesty. For information the various types of academic dishonesty please refer to the Academic Integrity Policy, located at http://www.mcmaster.ca/academicintegrity"