Chemistry 461 or 579: Concepts in Nanochemistry

Location (TBD)
Monday & Thursday 10:20 am-11:40 am

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COURSE DESCRIPTION AND GOALS: 'Concepts in Nanochemistry' is a course that explores the frontier of nanoscience and nanotechnology, two fields that have revolutionized material science and expanded chemical applications. The course focuses on nanoscience and nanotechnology, which combine the precision of chemical science and biology with the transformative potential of nanoscale materials. This course delves into the idea that skilled chemists can create, synthesize, and modify nanomaterials with unique physicochemical properties, resulting in complex nanostructures ranging from the molecular to the nanoscale.

Going beyond traditional chemical/material education, this course enhances students' skill-set and knowledge base. Students will explore the synthesis and customization of innovative nanomaterials such as graphene, lipid nanoparticles, and magnetic nanoparticles and their role in practical applications, particularly in drug design, development, and delivery of therapeutic molecuels. The course will examine how nanomaterials are revolutionizing the pharmaceutical industry, addressing challenges in modern medicine through improved drug solubility, bioavailability, targeted delivery, and controlled release. A significant part of the course focuses on understanding how the desired drug design applications influence nanomaterials' physicochemical properties, guiding their synthesis and functionalization processes.

The aim of this course is to provide a comprehensive understanding of nanochemistry, especially its intersection with pharmaceutical sciences, to students at various academic levels. The curriculum covers key topics, such as nanomedicine, molecular imaging, advanced drug/gene delivery systems, and the development of nanobio devices and systems. These topics not only represent the core applications in nanochemistry, but also highlight the transformative impact of nanotechnology in drug discovery and therapeutic strategies.

By the end of the course, students will have gained a theoretical foundation in nanochemistry and practical insights into its application in drug design and delivery of therapeutics. This knowledge is essential for aspiring scientists and innovators who aim to apply nanochemistry principles in developing more effective, targeted, and patient-friendly therapeutic solutions, contributing to cutting-edge pharmaceutical research and development.

- **Module 1: Foundations of Nanochemistry**
  - ✓ Introduction and Course Overview
  - ✓ Basic Concepts of Nanoscience and Nanomaterials
  - ✓ Introduction to Conjugation Chemistry
  - ✓ Overview of Applications in Nanochemistry
- **Module 2: Synthesis and Characterization of Nanomaterials**
  - ✓ Design Strategies for Inorganic, Organic, and Polymer Nanomaterials
  - ✓ Synthesis of Fluorescent, Magnetic, and Novel Metal Nanoparticles
  - ✓ Techniques for Characterizing Nanomaterials
- **Module 3: Dimensional Perspectives in Nanochemistry**
  - ✓ Exploring 0D, 1D, 2D, and 3D Nanomaterials (Including Graphene and Carbon Nanomaterials)

- ✓ Bioapplications of Dimensional Nanomaterials

❖ **Module 4: Biomimetics and High-Throughput Approaches in Nanochemistry**
- ✓ Principles of Biomimetic Nanochemistry
- ✓ High-throughput Screening (HTS) and High-Content Analysis (HCA) in Nanomaterial Research
- ✓ Scaling up: Approaches to Large-Scale Synthesis

❖ **Module 5: Nanotechnology in Drug Development and Delivery**
- ✓ Nanomaterials in Drug and Gene Delivery Systems
- ✓ Designing Nanomaterials for Targeted Therapies
- ✓ Case Studies: Nanotechnology in Drug Delivery and Cell Therapy

❖ **Module 6: Advanced Topics in Nanochemistry**
- ✓ Special Focus on Nanomedicine and Bioapplications
- ✓ Emerging Trends and Future Directions in Nanochemistry
- ✓ Ethical, Legal, and Social Implications of Nanochemistry

❖ **Module 7: Practical Applications and Laboratory Techniques**
- ✓ Laboratory Techniques in Nanochemistry
- ✓ Hands-on Projects: Synthesis and Application of Nanomaterials
- ✓ Case Studies and Problem-Solving Sessions

❖ **Module 8: Integrative Learning and Research Opportunities**
- ✓ Collaborative Research Projects
- ✓ Guest Lectures from Industry and Academic Experts (5~8 lectures)
- ✓ Discussion of Current Research and Future Trends in Nanochemistry

PREREQUISITES: Undergraduates who took general/AP chemistry, or special permission of the instructor

ASSIGNMENT AND GRADING: (*No Written Exams*) Grades will be based on the following:

1. Attendance: *150 pts.*
2. 10 Min Presentation: *150 pts.*
3. **Mid-Term Papers:** Term paper showing a critical understanding of a set of topics. Due dates will be announced later.*300 pts.*
4. **Final-Term (Project) Paper and Presentation:** One 5-page paper proposing a new idea/project based upon the knowledge and topics that will be covered during this class and a 15 min presentation on the aforementioned proposal. *400 pts.*
5. **Total:** *1000 pts.*

READING TEXTBOOK AND REFERENCES:

1. Nanochemistry: Synthesis, Characterization and Applications (2023), Ashutosh Sharma (Editor), Goldie Oza (Editor)
2. Nanotechnology in Drug Delivery: Design and Applications (2023): Miranda Cowan (Editor)
3. Geoffrey A Ozin; André C Arsenault; Ludovico Cademartiri; (2009), **Nanochemistry : a chemical approach to nanomaterials** Royal Society of Chemistry (Great Britain)
4. Greg T. Hermanson (1996), **Bioconjugate Techniques** : Academic Press
5. Recent published Nanomedicine papers (will be selected by the professor)