INTER AMERICAN UNIVERSITY OF PUERTO RICO
_____ CAMPUS
_____DEPARTAMENT
CHEMISTRY PROGRAM

SYLLABUS

I. GENERAL INFORMATION

Course Tittle	**:**	Introduction to Nanotechnology
Code and Number	**:**	CHEM 3380
Credits	**:**	3 credits
Academic Term	**:**	
Professor	**:**	
Office Hours	**:**	
Office Phone Number	**:**	
Email	**:**	

II. DESCRIPTION

Theoretical analysis concerning the physical, chemical, and structural properties of nanoscale materials based on the difference between their properties and those of the highest volume materials. Study of the preparation and handling of nanotechnological materials. It includes applications in medicine, technology, and the energy sector. Requirements: CHEM 2222 and CHEM 3320.

III. OBJECTIVES

At the end of the course, the student will be able to:

1. **General Aspects of Structure** – Determine the fundamental characteristics of the binding of atoms and the energy that binds them together to form the fundamental blocks of nanostructures.

    1.1. Distinguish between atoms, molecules, clusters, colloids, and volume.
    1.2. Define and distinguish what nanomaterials are.
    1.3. Establish the correlation between the properties of these materials and the distribution of atoms in the material.
    1.4. Explain how chemical, physical, and electric (magnetic) properties change depending on the size of the material, composition, shape, and structure.
    1.5. Identify ideal characteristics of size uniformity (les tan 100 nm) and high particle dispersion.

2. **Aspects of Preparation and Manipulation** – Propose methods and use techniques that allow you to prepare, manipulate and study materials at the atomic level.

    2.1 Recognize physical and chemical methods for nanoparticle formation.
    2.2 Compare the different preparation methods: electrodeposition; chemical vapor deposition (CVD), sol-gels; ball miling, and natural nanomaterials that serve as molds.
    2.3 Distinguish between the different lithographic methods used for semiconductor manufacturing in the micron range at 100 n.
    2.4 Identify and use electron microscopy techniques: SEM, TEM, STM, AFM, to analyze and manipulate these materials at the atomic level.

2.5 Describe how the self-assembly technique can be used to generate ordered surfaces that serve as the source for the development of nanomachines.

3. **Characterization** – At the end of the study of this topic the student must have the ability to distinguish advantages and disadvantages, as well as the usefulness and application of different techniques of analysis of composition, structure, size, among other characteristics typical of nanomaterials.

3.1 Contrast between techniques used for analysis of the size, shape and crystallography of the nanomaterial, High Resolution Transmission Electron Microscopy (HRTEM), and X-ray Diffraction (XRD).
3.2 Determine material composition from, X-Ray microanalysis (XRD), and X-Ray Photoelectron Spectroscopy (XPS).
3.3 Know the correct studies for the structure details determination: dispersion, interatomic distances, nanoparticles coordination number. Studies such as Extended X-ray absorption fine structure (EXAFS) and X-ray absorption near-edge structure (XANES).
3.4 Relate changes in color and behavior in UV/VIS analysis to differences in size and dispersion of nanoscale material.

4. **Variety of nanosystems** – At the end of this topic the student must be able to contrast and illustrate several of the different types of nanosystems and their uses.

4.1 Describe carbon nanotubes, their properties and uses.
4.2 Recognize self-assembled monolayers (SAMs) as a two-dimensional nanostructure.
4.3 Understand the use of SAMs as a template alternative that facilitate the formation of organized nanostructures.
4.4 Classify semiconductor or quantum dots semiconductors as a subclass within the broad family of nanoparticles that includes semiconductors, metals, insulators, organics, among others.
4.5 Recognize hybrid nanoparticle systems in which the properties and characteristics of a sell-defined cortex and nucleus, both in the nano range, can be distinguish.

5. **Current and future applications** – At the end of this topic the student should be able to understand the applications and uses of the nanosystems.

5.1 Analyze the natural nanomachines present in living organisms, (lipids, DNA, and proteins).
5.2 Examine the interactions of objects at the nano level and understand how friction processes at the molecular level determine the development and performance of nanoelectromechanical systems.
5.3 Explain the characteristics and functions of various nanosensors.

IV. CONTENT

Topics/Subtopics:

1. Background of nanomaterials:
a. Types of nanomaterials: properties and characteristics.
a.1. Size, structure, shape, chemical composition
b. Metal, colloids, aggregates, molecules
c. Atomic structures
d. Physical-chemical interactions
e. Effect of quantum size

2. Preparation, design, and handling:

a. Molecular Precursors
b. Lithography: optic, atomic, electron beam
c. Electroplating
d. Self-assembled monolayers (SAMs)
e. Scanning Probe Microscopies

3. Characterization

a. X-Ray Diffraction (XRD)
b. X-Ray Photoemission spectroscopy (XPS)
c. Electron Energy Loss Spectroscopy (EELS)
d. Extended X-Ray Absorption Fine Structure (EXAFS)
e. X-Ray Absorption Near-Edge Structure (XANES)
f. Transmission Electron Microscopy (TEM)
g. Atomic Force Microscopy (AFM)
h. Scanning Tunneling Microscopy (STM)

4. Nanosystems

a. Carbon nanotubes
b. Semiconductors
c. Hybrid nanomaterial systems

5. Current and future applications

a. Nanotechnology and its fusion with biotechnology
b. Nanosensors
c. Nanoelectromechanical systems (NEMS) from Feyman to present
d. The defining nanotribology in NEMS

V. ACTIVITIES

- Conference
- Exams
- Practice excercises
- Research work

VI. EVALUATION CRITERIA

The course evaluation consists of:

Evaluation Criteria	Points	Final Grade Percent
Partial Exam 1	100	20%
Partial Exam 2	100	20%
Quizes and scientific articles assigned	100	20%
Monography	100	20%
Seminar - Oral Presentation	100	20%
Total	**500**	**100%**

VII. SPECIAL NOTES

1. **Auxiliary services or special needs.** Any student who requires auxiliary services or special assistance must apply for them at the beginning of the course or as soon as he/she has knowledge that needs them, through the corresponding registration, at the Guidance Center with _____

2. **Honesty, fraud, and plagiarism.** Dishonesty, fraud, plagiarism, and any other inappropriate conduct in relation to academic work constitute major violations sanctioned by the General Student Guidelines. Major offences, as required by the General Student Guidelines, may result in the suspension from the university for a defined period of more than one year or the permanent expulsion from the university, among other sanctions.

3. **Use of electronic devices.** Cell phones and any other electronic device that could disrupt teaching and learning processes or alter the environment leading to academic excellence will be disabled. Critical situations will be addressed, as appropriate. The handling of electronic devices that allow access, storage or sending data during evaluations or exams is prohibited.

4. **Compliance with the provisions of Title IX.** The Federal Higher Education Act, as amended, prohibits discrimination on the grounds of sex in any academic, educational, extracurricular, athletic, or other program or employment, sponsored or controlled by a higher education institution regardless of whether it is conducted on or off the institution's premises, if the institution receives federal funds.

    a. As provided by applicable federal regulations, our academic unit has appointed a Title IX Assistant Coordinator who will help and guidance in connection with any alleged incident constituting gender, sexual harassment, or sexual assault. You can contact the Auxiliary Coordinator _____ at extension _____, and email _____

    b. The Normative Document entitled Standards and Procedures for Addressing Alleged Violations of the Provisions of Title IX is the document containing the institutional rules for channeling any complaint that is filed based on this type of claim. This document is available on the portal of the Inter-American University of Puerto Rico (www.inter.edu).

VIII. EDUCATIONAL RESOURCES

Pradeep, T. **(2008)**. *Nano: The Essentials: Understanding Nanoscience and Nanotechnology*. New York: McGraw-Hill Professional Publishing.

IX. BIBLIOGRAPHY

Books:

1. Torrens, F., Hanghi, A.K., Chakraborty, T. editors. **(2021)**. *Chemical Nanoscience and Nanotechnology: New Materials and Modern Techniques.* Apple Academic Press.

2. Sindhu, R.K., Chitkara, M. Sandhu, I.S. **(2021)**. *Nanotechnology: Principles and Applications*. Jenny Stanford Publishing.

3. Jai Poinern, G.E. **(2021)**. *A Laboratory Course in Nanoscience and Nanotechnology.* CRC Press.

4. Sanders, W.C. **(2018)**. *Basic Principles of Nanotechnology.* London, United Kingdon: Taylor & Francis Ltd.

5. Van de Voorde, M., editor. **(2018)**. Nanoscience and Noanotechnology: Advances and Developments in Nano-sized Materials. Walter de Gruyter GmbH & Co KG.

6. Roy, S., Ghosh, C.K., Sarkar, C.K., editors. **(2017).** *Nanotechnology: Synthesis to applications.* Boca Raton, FL: CRC Press, Taylor & Francis Group.

7. Bhushan, B., editor. **(2016)**. *Encyclopedia of nanotechnology.* Dordrecht: Springer.

8. Rogers, B., Adams, J., Pennathur, S. **(2014).** *Nanotechnology: Understanding small systems.* Third Edition. Boca Raton: CRC Press, Taylor & Francis Group.

9. Agrawal, D.C. **(2013).** *Introduction to nanoscience and nanomaterials.* Singapore; London: World scientific Publishing.

10. Pradeep, T. **(2012).** *A Textbook o Nanosciene and Nanotechnology*. New Delhi: McGraw-Hill Education.

11. Shong**,** C.W.**,** Haur**,** S.C.**,** and Wee**,** A.T.S. **(2010)** *Science at the Nanoscale: An Introductory Textbook*, Pan Stanford Publishing, Singapore.

12. Wiesner, M. R.; Bottero, J-Y. **(2007)**. *Environmental Nanotechnology, Applications and Impacts of Nanomaterials.* New York: McGraw-Hill.

13. Christian, G. D. **(2004)**. *Analytical Chemistry*. (6th Ed.) John Wiley & Sons.

14. Wilson, M.; Kannangara, K.; Smith, M.; Raguse, B. **(2002)**. *Nanotechnology, Basic Science and emerging technologies.* Boca Raton: Chapman & Hall / CRC Press.

Revised in November 2018
Updated in September 2021