

Course Plan: Nanostructures Analyzes

Course Information

- **Course Title:** Nanostructures Analyzes
- **Credits:** 2 units (theoretical)
- **Course Lecturer:** Dr. Hamed Morad
- **Responsible Lecturer:** Dr. Hamed Morad
- **Target Audience:** Master students in Pharmaceutical Nanotechnology
- **Schedule:**
 - Duration: 14 sessions
 - Each session: 120 minutes (10:00 AM to 12:00 PM)
 - Day: Every Monday
 - Start Date: September 29, 2025
 - Session Dates:
 1. October 6, 2025
 2. October 13, 2025
 3. October 20, 2025
 4. October 27, 2025
 5. November 3, 2025
 6. November 10, 2025
 7. November 17, 2025
 8. November 24, 2025
 9. December 1, 2025
 10. December 8, 2025
 11. December 15, 2025
 12. December 22, 2025
 13. December 29, 2025
 14. January 5, 2026

Students' Responsibilities

- Attend all sessions regularly; attendance will be tracked and contributes to the final grade.
- Actively participate in class discussions, group activities, and Q&A segments.
- Complete assigned readings and preparatory materials before each session.
- Submit homework assignments, including literature reviews, case analyses, and problem sets, by the specified deadlines (typically one week after assignment).

- Prepare and present a short group project on a selected nanostructure analysis technique (sessions 12-14).

Course Description

This course provides an in-depth exploration of analytical techniques used to characterize and evaluate nanostructures in the context of pharmaceutical nanotechnology. Designed for master-level students, it bridges theoretical principles with practical applications in drug delivery systems, nanomaterials, and biopharmaceuticals. The focus is on understanding how nanostructures' properties—such as size, shape, surface chemistry, and stability—influence their pharmaceutical performance and safety.

Course Objectives

- To introduce students to the fundamental principles and advanced methods for analyzing nanostructures relevant to pharmaceutical applications.
- To equip students with the knowledge to select appropriate analytical techniques for characterizing nanomaterials in drug formulation and delivery.
- To foster critical thinking in interpreting analytical data for quality control, regulatory compliance, and innovation in pharmaceutical nanotechnology.
- To highlight emerging trends and challenges in nanostructure analysis, including scalability, reproducibility, and ethical considerations.

Student Learning Objectives

By the end of the course, students will be able to:

- Describe the key properties of nanostructures and their significance in pharmaceutical contexts.
- Explain the principles, advantages, limitations, and applications of various analytical techniques for nanostructures.
- Analyze and interpret data from common characterization methods, such as microscopy, spectroscopy, and scattering techniques.
- Design experimental protocols for nanostructure analysis in pharmaceutical research scenarios.
- Evaluate the impact of analytical results on drug efficacy, toxicity, and formulation optimization.
- Critically review scientific literature on nanostructure analysis and apply it to real-world pharmaceutical problems.

What Students Are Expected To...

- Gain proficiency in theoretical concepts without hands-on lab work (as this is a theoretical course), but with emphasis on case studies and simulations.
- Develop skills in data interpretation through examples from pharmaceutical nanotechnology, such as liposomes, nanoparticles, and dendrimers.
- Collaborate with peers on projects to simulate interdisciplinary teamwork in research settings.
- Stay updated with recent advancements by reviewing assigned journal articles.
- Achieve a holistic understanding that prepares them for thesis work, industry roles, or further studies in nanomedicine.

Session Plan

Each 120-minute session includes a 60-75 minute lecture, 20-30 minutes of interactive discussion or examples, and 15-20 minutes for Q&A or review. Topics build progressively from foundational concepts to advanced applications.

Session	Date	Topic	Key Content and Activities	lecturer
1	September 29, 2025	Introduction to Nanostructures in Pharmaceutical Nanotechnology	Overview of nanostructures (e.g., nanoparticles, micelles); importance of analysis in drug delivery; course syllabus review; introductory case study.	Dr. Morad
2	October 6, 2025	Basic Principles of Nanostructure Characterization	Size, shape, and surface properties; thermodynamic and kinetic aspects; introduction to sampling and preparation techniques.	Dr. Morad
3	October 13, 2025	Microscopy Techniques I: Scanning Electron	Principles, instrumentation,	Dr. Morad

		Microscopy (SEM) and Transmission Electron Microscopy (TEM)	sample preparation; applications in nano drug delivery systems; data interpretation examples.	
4	October 20, 2025	Microscopy Techniques II: Atomic Force Microscopy (AFM) and Scanning Tunneling Microscopy (STM)	High-resolution imaging; force measurements; pharmaceutical case studies (e.g., surface topology of nanocarriers).	Dr. Morad
5	October 27, 2025	Scattering Techniques: Dynamic Light Scattering (DLS)	Particle size distribution, z-average size; zeta potential analysis; stability assessments in formulations.	Dr. Morad
6	November 3, 2025	X-Ray Based Techniques: X-Ray Diffraction (XRD) and Small-Angle X-Ray Scattering (SAXS)	Crystallinity and polymorphism; structural analysis of nanomaterials.	Dr. Morad
7	November 10, 2025	Spectroscopic Methods I: UV-Vis, Fluorescence, and Infrared Spectroscopy	Absorption, emission, and vibrational analysis; applications in drug loading and release studies. Midterm review.	Dr. Morad
8	November 17, 2025	Spectroscopic Methods II: Raman Spectroscopy and Nuclear Magnetic Resonance (NMR)	Molecular fingerprinting; structural elucidation in complex nanostructures.	Dr. Azizian
9	November 24, 2025	Chromatographic Techniques: HPLC, GC, and Mass Spectrometry Interfaces	Separation and quantification; molecular weight determination;	Dr. Morad

			impurity profiling in pharma nano.	
10	December 1, 2025	Thermal Analysis: Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA) & Simultaneous Thermal Analyzes (STA)	Phase transitions, stability, and decomposition; applications in formulation development.	Dr. Morad
11	December 8, 2025	Advanced and Emerging Techniques: AI in Analysis	Integration of machine learning for data processing.	Dr. Azizian
12	December 15, 2025	Case Studies in Pharmaceutical Applications I	Group project presentations: Characterizations of Polymeric nanoparticles, Lipid-based nanostructures, Liposomes, Noisomes, Exosomes,...	Dr. Morad
13	December 22, 2025	Case Studies in Pharmaceutical Applications II	Group project presentations: Characterizations of Dendrimers, quantum dots, metallic nanomaterials and other nanostructures.	Dr. Morad
14	December 29, 2025	Case Studies in Pharmaceutical Applications II	Group project presentations: Characterizations of Nanofibers, Nanowires, Nanowells,... & microfluidic systems.	Dr. Morad

References

The following textbooks are recommended for core reading. Students are encouraged to access them through university libraries or online resources.

- **Nanoparticle Characterization: Principles and Applications** by Wolfgang Parak (Editor), 2020. Focuses on analytical methods for nanoparticles with pharmaceutical relevance.
- **Pharmaceutical Nanotechnology: Fundamentals and Practical Applications** by Costas Demetzos, 2016. Covers analysis techniques in the context of drug delivery systems.
- **Characterization of Pharmaceutical Nano- and Microsystems** by Leena Peltonen (Editor), 2020. Detailed on microscopy, spectroscopy, and scattering methods for pharma nano.
- **Nanostructures for Drug Delivery** by Ecaterina Andronescu and Alexandru Mihai Grumezescu (Editors), 2017. Includes chapters on analytical tools for nanostructured materials.
- **Handbook of Nanomaterials for Industrial Applications** by Chaudhery Mustansar Hussain (Editor), 2018. Broad reference with sections on characterization in nanotechnology.

Marks ratios:

Parts	Marks
Presentation & Homework	5
Final exam	15

Teacher's marks ratio:

Teacher	Marks
Dr. Morad	3
Dr. Azizian	17