“Seeing” the nanoscale structure of soft materials

**SYLLABUS**

# Lecturer information

**Dr Khay Fong**

*Monash University*

[khay.fong@monash.edu](mailto:khay.fong@monash.edu)

Proposed by: Debora Berti

e-mail: Debora.berti@unifi.it

# Title of the course

“Seeing” the nanoscale structure of soft materials

# Course program

This intensive course bridges the gap between molecular theory and advanced analytical techniques, exploring the intricate nanoscale universe of soft materials. Students will journey through the fundamental principles of molecular self-assembly, uncovering the complex mechanisms that drive spontaneous structural formation. Through this series of workshops, participants will develop a deeper understand of how these cutting-edge techniques used in colloid and interface science works to probe and interpret the invisible architectural landscapes of matter at the molecular level, and how they are used in drug delivery.

The course integrates theoretical foundations with practical applications, emphasising hands-on learning and critical analytical skills. By examining light scattering, small angle X-ray scattering, and cryo-transmission electron microscopy, students will gain comprehensive insights into the sophisticated techniques used to interrogate nanoscale structures, preparing them for advanced research and interdisciplinary scientific exploration.

# Course content detailed per lesson of two hours (possibly with dates and room real and virtual)

1. **Soft Materials and Molecular Self-Assembly**
   * Principles of amphiphilic self-assembly and intermolecular interactions
   * Mechanisms of spontaneous structure formation
   * Case studies in formulation and lipid drug delivery
2. **Light Scattering Techniques**
   * Principles of light interaction with nanoscale objects
   * Dynamic and static light scattering methods
   * Particle size and distribution analysis
   * Instrumentation and data interpretation
   * Applications in soft matter research
3. **Small and Wide Angle X-ray Scattering (SAXS)**
   * X-ray interaction with nanomaterials
   * Data collection and analysis
   * Morphological investigations
   * Applications in soft matter research
4. **Cryo-Transmission Electron Microscopy (cryo-TEM)** **and synchrotron imaging**
   * Sample preparation techniques
   * Imaging principles and challenges, and image processing e.g. Fourier transformations
   * Synchrotron science basics

# Suggested reading

Willmott, Phil. An introduction to synchrotron radiation: techniques and applications. 2019.

The SAXS Guide: Getting acquainted with the principles, Heimo Schnablegger & Yashveer Singh: <https://www.anton-paar.com/au-en/saxs-guide/>

Glatter, O, 2018, Scattering Methods and their Application in Colloid and Interface Science. ISBN

978-0-12-813580-8 <https://doi.org/10.1016/C2016-0-04640-5>

# Learning Objectives

* Understand the fundamental principles of molecular self-assembly
* Master advanced nanoscale analytical and imaging techniques
* Develop critical skills in data interpretation and analysis
* Gain insights into the structural complexity of soft materials

# Knowledge and Skills to be acquired

By the end of this course, students will acquire:

1. Deep understanding of molecular self-assembly principles, including how amphiphilic molecules spontaneously form complex nanoscale structures through non-covalent interactions and thermodynamic driving forces.
2. Advanced data interpretation skills for sophisticated analytical techniques like light scattering, X-ray scattering, and cryo-TEM, enabling critical evaluation of nanoscale structural information.
3. Comprehensive knowledge of nanoscale characterisation methods used in colloid and interface science, with specific emphasis on their applications in drug delivery and formulations.
4. Theoretical insights into the relationship between molecular interactions and emergent material properties, bridging microscopic behaviours with macroscopic material characteristics.
5. Analytical capabilities to recognise and interpret structural morphologies in soft matter systems, particularly in lipid-based and colloidal drug delivery platforms.
6. Critical scientific reasoning skills to evaluate and understand how different nanoscale imaging techniques provide complementary structural information.
7. Comprehension of synchrotron science basics and its role in advanced material characterisation.

# Prerequisites

* Basic understanding of physics and chemistry
* Introductory knowledge of materials science
* Familiarity with basic scientific instrumentation

# Teaching Methods

MODE 1 - Pre-recorded lessons uploaded on the moodle platform (a meeting must be organized with PhD students in order to clarify eventual doubts)

x MODE 2 (preferred) - Lessons delivered in-person and in remote with simultaneous recording by the WEBEX platform

(The lessons must be recorded and available to all the students that cannot take part to the lessons in streaming. The Webex platform must be used. All course content should be uploaded to the Moodle platform on the Chemical Sciences PhD page “Courses and Seminars of the PhD in Chemical Sciences 2022-2023”)

# Further information

# Type of Assessment

The final evaluations will have to be validated maximum 1 month after the end of the course

1. Spreadsheets from data modelling to be done during workshops
2. Short report on how to understanding the nanoscale translates to material properties.

# Period