Universitat Autònoma de Barcelona

2023/2024

Nanochemistry and Nanomaterials

Code: 102509
ECTS Credits: 6

Degree	Type	Year	Semester
2502444 Chemistry	OT	4	1

Contact

Name: Jordi Hernando Campos

Email: jordi.hernando@uab.cat

Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

Gonzalo Guirado Lopez

Prerequisites

- It is recommended to have taken and passed most of the 3rd year courses.
- Although lectures are in Catalan, most of the material used and literature sources are in English. Therefore, a good level in English is recommended.

Objectives and Contextualisation

This course aims at providing the student with basic knowledge in Nanochemistry and Nanomaterials, which should allow him/her to understand supramolecular processes and recognize the most important nanometer-sized materials as well as their properties and applications.

The specific objectives of this course are:

- To introduce the concepts of Nanomaterial and bottom-up and top-down nanofabrication methods.
- To recognize the main types of Nanomaterials, their preparation methods, their properties and their applications.
- To introduce the concept of Supramolecular Chemistry, to learn the types of non-covalent interactions that it is built on, and to understand the main methods of characterization and manipulation of supramolecular complexes.

Competences

- "Interpret data obtained by means of experimental measures, including the use of IT tools; identify their meaning and relate the data with appropriate chemistry, physics or biology theories."
- Adapt to new situations.
- Apply knowledge of chemistry to problem solving of a quantitative or qualitative nature in familiar and professional fields.
- Be ethically committed.
- Communicate orally and in writing in one's own language.
- Develop synthesis and analyses studies in chemistry from previously established procedures.
- Handle chemical products safely.
- Handle standard instruments and material in analytic and synthetic chemical laboratories.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Manage, analyse and synthesise information.
- Obtain information, including by digital means.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Resolve problems and make decisions.
- Show an understanding of the basic concepts, principles, theories and facts of the different areas of chemistry.
- Show initiative and an enterprising spirit.
- Show motivation for quality.
- Show sensitivity for environmental issues.
- Use IT to treat and present information.
- Use the English language properly in the field of chemistry.
- Work in a team and show concern for interpersonal relations at work.

Learning Outcomes

1. Adapt to new situations.
2. Be ethically committed.
3. Communicate orally and in writing in one's own language.
4. Describe the main methods for preparing primary layers and nanostructuring surfaces.
5. Differentiate between the main types of micro- and mesoporous materials, and between their methods of preparation, properties and applications.
6. Identify the different types of supramolecular interactions and predict their relative magnitude in the most characteristic molecular and supramolecular systems applied to nanochemistry.
7. Identify the main types of carbon nanostructures and their properties and applications.
8. Identify the nature and magnitude of the interactions produced in supramolecular systems.
9. Justify the results obtained in the laboratory from processes of synthesising and characterising solid, soft and nano materials on the basis of knowledge of their structure and properties.
10. Learn autonomously.
11. Manage the organisation and planning of tasks.
12. Manage, analyse and synthesise information.
13. Obtain information, including by digital means.
14. Properly handle the chemical products required to prepare solid, soft and nano materials.
15. Properly use the required material and instruments to prepare and characterise solid, soft and nano materials.
16. Propose creative ideas and solutions.
17. Read, analyse and extract information from texts in the English language on the different areas of the field of material chemistry.
18. Reason in a critical manner
19. Recognise the English names used in the field of preparing and characterising solid and soft materials, as well as in nanochemistry and nanomaterials.
20. Relate the properties, synthesis methods and applications of nanoparticles.
21. Resolve problems and make decisions.
22. Show initiative and an enterprising spirit.
23. Show motivation for quality.

24. Show sensitivity for environmental issues.
25. Synthesise a zeolite, characterise it and study its most characteristic properties.
26. Synthesise and characterise solid materials with electrical, magnetic or optical properties, and measure said properties.
27. Use IT to treat and present information.
28. Work in a team and show concern for interpersonal relations at work.

Content

1. Introduction to nanochemistry and nanomaterials

The "nano" scale: general aspects and physico-chemical principles. Nanoscience and Nanotechnology. Bottom-up and top-down fabrication methods. Techniques for the characterization and manipulation of nanomaterials.

2. Supramolecular chemistry

Introduction to supramolecular chemistry: supramolecular non-covalent interactions; host-guest complexes and self-assembly. Basic concepts: thermodynamic and kinetic selectivity; preorganization and complementaity; cooperativity and chelate effect; solvent effects; acyclic vs. cyclic hosts. Molecular recongnition of cations, anions, neutral molecules and multiple guests. Artificial and biological self-assembled systems. Molecular and supramolecular devices.

3. Nanoparticles

General aspects: nucleation and growth. Stability. Metal nanoparticles: structure, synthesis, properties and applications. Semiconductor nanoparticles: structure, synthesis, properties and applications. Other types of nanoparticles.

4. Carbon nanostructures

New carbon forms. Fullerenes: structure, synthesis, properties and applications. Carbon nanotubes: nomenclature, synthesis, properties and applications. Graphene: synthesis, properties and applications.

5. Nanostructured surfaces

Self-assembled monolayers (SAMs). Self-assembled multilayers: techniques for layer by layer deposition. Other fabrication techniques of thin films. Surface nanostructuration by lithography techniques.

6. Nanoporous materials

Introduction: micro- and mesoporous materials. Zeolites: structure, synthesis, properties and applications.

Practical sessions

1) Synthesis of metal nanoparticles (Ag, Au and Au/Ag core-shell).

2) Determination of host-guest complex association constants by spectrophotometry.

3) Synthesis of magnetic nanoparticles (ferrofluid).

4) Synthesis and characterization of calix[4]pyrrole for the recognition of molecular anions.

Methodology

The students will develop different learning activities along the course:

a) Directed activities: Theory lectures on the contents of the course. In addition, practical sessions will be conducted in the lab, where the synthesis and/or characterization of nanomaterials will be performed.

b) Supervised activities: To assist the students on the preparation of a presentation on a scientific article, tutorials will be carried out.

c) Autonomous activities: On their own, students will learn the contents of the course, solve problems, prepare the practical sessions, and perform a presentation on a scientific article.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practical sessions	16	0.64	1, 3, 22, 23, 11, 8, 9, 17, 14, 15, 2, 24, 18, 19, 20, 21, 26, 28, 27
Theory lectures	34	1.36	3, 4, 5, 6, 7, 8, 17, 19, 20, 27
Type: Supervised			
Tutorial	2	0.08	3, 22, 23, 17, 2, 13, 16, 18, 27
Type: Autonomous			
Autonomous study	50	2	1, 10, 23, 4, 5, 11, 12, 6, 7, 8, 17, 2, 13, 18, 19, 20, 21
Preparation of practical sessions	3.75	0.15	10, 11, 12, 6, 8, 17, 13, 19, 20
Presentation on a scientific article	20	0.8	1, 10, 3, 22, 23, 4, 5, 11, 12, 6, 7, 8, 17, 2, 13, 16, 18, 19, 20, 27

Assessment

Student could select between continuous and one-step evaluation.

Continuous evaluation: Students will be graded on the basis of the following items:

- Written theoretical exams: Two midterm exams will be conducted, each of which will account for 35% of the final grade. If the average of these two exams is lower than 5, a final exam will be scheduled by the end of the semester in which all the contents of the course will be evaluated. The mark of the final exam will account for 70% of the final grade (and will replace the mark from the midterm exams). *Access to the final exam will only be granted to those students who had previously developed evaluation activities during the course that account for 2/3 of the final note. Those students that do not meet this condition will obtain a "No presentat" grade.*
- Practical sessions: Practical sessions will be graded by: i) presentation of lab reports (30%), and ii) a written exam (70%). The weighted average of these two marks will account for 15% of the final grade.
- Oral presentation on a scientific article: A scientific article related to the contents of the course will be assigned to each student (or group of students). An oral presentation will then be conducted on the contents of the article. Each student will then get a mark depending on the quality of the presentation and the answers given during the subsequent discussion. This mark will account for 15% of the final grade.

One-step evaluation: The following activities will be evaluated on the same day a the end of the course:

- Written theoretical exam: One final exam will be conducted at the end of the course, which will account for 70% of the final grade. If the mark of this exam is lower than 5, a resit exam will be scheduled by the end of the semester. *Access to the resit exam will only be granted to those students who had previously attended the one-step evaluation activities. Those students that do not meet this condition will obtain a "No presentat" grade.*
- Practical sessions: Practical sessions will be graded by: i) presentation of lab reports (30%), and ii) a written exam (70%). The weighted average of these two marks will account for 15% of the final grade.
- Oral presentation on a scientific article: An oral presentation will then be conducted on the contents of an assigned scientific article. Depending on the quality of the presentation and the answers given during the subsequent discussion, a mark will be given that will account for 15% of the final grade.

Regardless of the evaluation mode chosen, to pass the course students must:

1) Obtain a mark for theoretical exams higher than 5.

2) Obtain an average mark for the course higher than 5.

3) Attend the 4 practical sessions in the lab. Warning about lab safety: students involved in accidents resulting from not following lab safety rules might be banned and fail the course.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Oral presentation on a scientific article	15%	0.25	0.01	1, 10, 3, 22, 23, 4, 5, 11, 12, 6, 7, 8, 17, 2, 13, 16, 18, 19, 20, 27
Practical sessions	15%	18	0.72	1, 3, 22, 23, 11, 12, 6, 8, 9, 17, 14, 15, 2, 24, 16, 18, 19, 20, 21, 26, 28, 27
Written exams	70%	6	0.24	1, 3, 23, 4, 5, 6, 7, 8, 2, 16, 18, 19, 20, 21, 25

Bibliography

J.W. Steed, D.R. Turner, K. Wallace, Core Concepts in Supramolecular Chemistry and Nanochemistry, Wiley, Chichester, 2007.
G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London, 2004
J.W. Steed, P.A. Gale, Supramolecular Chemistry: from Molecules to Nanomaterials, Wiley, Chichester, 2012.

Software

No specific software is required.