COURSE DATA

DATA SUBJECT

Code: 44422
Name: Molecular nanomaterials: Methods of preparation, properties and applications
Cycle: Master's Degree / Doctorate
ECTS Credits: 6
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	Facultat de Química	1	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	Molecular nanomaterials: Methods of preparation, properties and applications	COMPULSORY

COORDINATION

CORONADO MIRALLES EUGENIO

SUMMARY

We intend to provide the students with the necessary knowledge on the basic aspects of Nanoscience alongside with its implications in the design and development of new molecular materials with unconventional properties.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

Previous knowledge of chemistry, physics or materials science as taught in the degrees indicated in the recommended entry profile to the master's degree is required. Previous knowledge of molecular nanoscience and nanotechnology as taught in the Introduction Module is required.

COMPETENCES / LEARNING OUTCOMES

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For students from field of knowledge (e.g. chemistry) to be able to scientifically communicate and interact with colleagues from another field (e.g. physics) in the resolution of problems laid out by the Molecular Nanoscience and Nanotechnology.

Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.

Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.

Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.

Students should demonstrate self-directed learning skills for continued academic growth.

Students should possess and understand foundational knowledge that enables original thinking and research in the field.

To acquire supramolecular chemistry conceptual concepts necessary for the design of new nanomaterials and nanostructures.

To assess the relationships and differences between the materials macroscopic properties and those of unimolecular systems and nanomaterials.

To know the main applications of nanoparticles and nanostructured materials obtained or functionalised using a molecular approach- in magnetism, molecular electronics and biomedicine.

To know the main molecular nanomaterials technological applications and to be able to put them in the Material Science general context.

To know the methodological approaches used in Nanoscience.

To know the state of the art in molecular nanomaterials with optical, electric and magnetic properties.

To possess the necessary knowledge and abilities to continue with future studies in the PhD program in Nanoscience and Nanotechnology.

DESCRIPTION OF CONTENTS

1. Molecular Magnetic Materials: Design, synthesis, characterization and applications of i) molecular nanomagnets; ii) magnetic nanoparticles obtained by a molecular approach; iii) switchable magnetic molecules and materials (e.g. spin-crossover compounds) iv)

multifunctional magnetic materials, v) low dimensional magnetic materials.
2. Materials with optical properties: Liquid crystals, classification, characterization, properties and applications; materials for nonlinear optics (NLO): NLO effects, molecules for second and third order, optical limiters, techniques for the determination of non-linear optics coefficients.
3. Materials with electrical properties: molecular conductors and superconductors: electronic structures, organization on surfaces and interfaces, properties and applications (chemical sensors, field effect transistors (FETs), etc.).
4. Conducting polymers: Properties and applications.
5. Carbon nanoforms: Fullerenes, Carbon Nanotubes and Graphene. Structures, functionalization, properties, methods of production and organization and applications.
6. 2D crystals.
7. Applications of nanomaterials in biomedicine (contrast agents, drug delivery; photodynamic therapy systems, teragnostic systems).

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	8,00
Theory	30,00
Seminar	9,00
Other activities	2,00
Total hours	**49,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	0,00
Preparation of lessons	21,00
Preparation for assessment activities	80,00
Resolution of case studies	0,00
Total hours	**101,00**

TEACHING METHODOLOGY

The classes of this subject will be taught, together with the rest of the basic module, intensively during 3 weeks in January and each year at a different university.

During the **theory classes**, the teaching staff will give an overview of the subject under study, emphasising new or particularly complex aspects. The necessary bibliographical sources will be indicated for students to study the subject in depth.

The **practical classes** of this subject will be devoted to the organisation of seminars in which problems related to the theoretical content will be posed and solved. Likewise, practical cases and other topics related to the subject will be discussed with the students.

During these hours of practical activities, as far as possible, visits to laboratories and facilities related to the contents of the theoretical classes will be organised. This includes visits to the laboratories of fabrication and electrical, magnetic and optical characterisation of nanomaterials. In addition, simple practical exercises will be carried out with the main computer programmes used for the theoretical modelling of the properties of nanomaterials.

After the intensive face-to-face classes, the lecturers will ask students a series of **questions** about the contents of the course that the student will have to solve.

Professors will hold **tutorials** with the students to resolve any doubts and questions they may have. These tutorials will take place in person or remotely (email, videoconference, telephone, etc.) depending on whether the student and teacher are from the same or a different university.

Through all these activities, students will acquire the competences described in the corresponding section. The basic competences will be worked on above all during the seminars.

EVALUATION

The acquisition of the competences of the subject will be assessed by means of a written exam based on the questions posed to the students. The mark for this exam will represent 90% of the final mark for the subject.

Student participation during the training activities will represent 10% of the final grade.

In order to pass the course, it will be necessary to have attended 80% of the face-to-face training activities.

REFERENCES

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- Molecular magnetism: from chemical design to spin control in molecules, materials and devices, E. Coronado, Nature Reviews Materials 5(2), 87-104 (2020)
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- D.M. Guldi, N. Martín Eds.: Fullerenes: From Synthesis to Optoelectronic Properties. Kluwer Academic Press, Dordrecht, Netherland, 2002.
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- Nanomedicine, in Nanotechnology, ed. H. Fuchs, M. Grätzel, H. Krug, G. Schmid, V. Vogel and R. Waser, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010, vol. 5
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- Graphene: Synthesis, Properties, and Phenomena C.N.R. Rao, A.K. Sood. Wiley-VCH 2013.
- "Molecular Magnetism" O. Kahn, VCH, New York, 1993
- Solids and Surfaces: A Chemist's View of Bonding in Extended Structures R. Hoffmann, VCH Publishers, 1988.