Course Guide
M6-44422 Molecular nanomaterials: Methods of preparation, properties and applications

COURSE DATA

Data Subject	
Code	M6-44422
Name	Molecular nanomaterials: Methods of preparation, properties and applications
Cycle	Master's degree
ECTS Credits	6.0

Study (s)

Degree	Center	Acad. year	Period
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	Faculty of Chemistry	1	First term

Subject-matter

Degree	Subject-matter	Character
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	6 - Molecular nanomaterials: Methods of preparation, properties and applications	Obligatory

Coordination

Name	Department
TORRES CEBADA, TOMÁS	Organic Chemistry- U. Autónoma de Madrid

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 (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

2208 - Master's Degree in 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 possess the necessary knowledge and abilities to continue with future studies in the PhD program in Nanoscience and Nanotechnology.
- 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.
- To know the methodological approaches used in Nanoscience.
- To acquire supramolecular chemistry conceptual concepts necessary for the design of new nanomaterials and nanostructures.
- To know the ?state of the art? in molecular nanomaterials with optical, electric and magnetic properties.
- To assess the relationships and differences between the materials macroscopic properties and those of unimolecular systems and nanomaterials.
- To know the main molecular nanomaterials technological applications and to be able to put them in the Material Science general context.
- To know the main applications of nanoparticles and nanostructured materials ?obtained or functionalised using a molecular approach- in magnetism, molecular electronics and biomedicine.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

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.

DESCRIPTION OF CONTENTS

1. Molecular Nanomaterials: Preparation methods, properties and applications.
Molecular Nanomaterials: Preparation methods, properties and applications.

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

ACTIVITY	Hours	% To be attended
Theory classes	30,00	100
Seminars	9,00	100
Tutorials	8,00	100
Other activities	2,00	100
Preparation of evaluation activities	80,00	0
Preparing lectures	21,00	0
TOTAL	**150,00**	

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

Basic

- - G.A. Ozin, A.C. Arsenault: Nanochemistry. The Royal Society of Chemistry, 2005.
- H.S. Nalwa Ed.: Handbook of Avanced Electronic and Photonic Materials and Devices, Academic Press, 2001.
- D.M. Guldi, N. Martín Eds.: Fullerenes: From Synthesis to Optoelectronic Properties. Kluwer Academic Press, Dordrecht, Netherland, 2002.
- P.J. Collings, Liquid Crystals: Natuers delicate of Mater. 2ª Ed., Princenton University Press, 2002.
- M.C. Petty, M.R. Bryce, D. Bloor, Eds.: Introdction to Molecular Electronics, Oxford University Press, NY, 1995.
- Ulman, An Introduction to Ultrathin Organic Films: from Langmuir-Blodgett to Self-Assembly, Academic Press, San Diego, 1991
- Supramolecular Chemistry: From Molecules to Nanomaterials, ed. P. Gale and J. Steed, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2012
- 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
- "Liquid Crystals: Fundamentals and Applications" by Lekshmi C. Pillai, Sudhindra Rayaprol, and Surajit Dhara. CRC Press. 2017.
- "Nonlinear Optics: Principles and Applications" by Karsten Rottwitt and Peter T. Rakich. CRC Press. 2018.
- "Nanomedicine: Principles and Perspectives" by Raffaele Vecchione, Joshua Reineke, and Veerle Bloemen. CRC Press. 2018.
- "Photodynamic Therapy: From Theory to Application" by Michael R. Hamblin. CRC Press. 2016.
- - Fullerenes: principles and applications; F. Langa and J.-F. Nierengarten (Eds.), RSC (Nanoscience and Nanotechnology Series) 2012
- Fullerenes, A. Hirsch, M. Brettreich Wiley-VCH2005
- Carbon Nanotubes. Jorio, Ado; Dresselhaus, Gene; Dresselhaus, Mildred S. (Eds.) Springer (2008)
- 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 Chemists View of Bonding in Extended Structures R. Hoffmann, VCH Publishers, 1988.

Additional

- - Carbon Nanotubes: Present and Future Commercial Applications. Michael F. L. De Volder, Sameh H. Tawfick, Ray H. Baughman, A. John Hart Science, 2013, 339, 535.
- Molecular magnetism: from chemical design to spin control in molecules, materials and devices, E. Coronado, Nature Reviews Materials 5(2), 87-104 (2020)