66102 - 3. Assembly and Fabrication of Nanostructures

Course 2013 - 2014

Curso: 1, Semestre: 0, Créditos: 8.0

Basic information

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Recommendations to attend this course

The “Assembly and Fabrication of Nanostructures” module is obligatory and counts for 8 ECTS credits or 200 student work hours. Of these 8 credits, 6 are for theory and 2 correspond to laboratory practicals. The course is given in the first term of the academic year. As with the other modules in this Master's, this module is taught and assessed completely in English.

The objective of this module is to show the student the various assembly and production methods for Nanostructures.

This is an eminently oriented and practical module where students analyse, debate and evaluate different nanostructure assembly and production methods. The theory classes are accompanied and complemented by six practicals through which the students can see up close in the laboratory the difficulties and advantages of the different preparation methods for these materials, with access to highly specialised equipment that they will be able to use - under supervision of the staff - as there will be so few people per group (3-4 students). As the whole course is taught in English, students need to have an upper-intermediate level in the language: minimum level B1 in the European Common Framework Language Reference, but preferably level B2. Level B1 is reached when the student is able to understand the main points of clear, standard-language texts when covering known matters - whether in terms of work, study or leisure; when able to cope in most situations which the student encounters during a trip to places where the language is spoken; when able to write simple, coherent texts on familiar topics or those in which the student has an interest; and when able to describe experiences, happenings, wishes and ambitions as well as briefly justify opinions or explain plans. B2 is achieved when the student is able to understand the main ideas of complex texts that deal with both specific and abstract topics, even if these are technical - though lying within the field of specialisation; when able to communicate with native speakers with the degree of fluency and ease such that the communication takes place without effort on either side; and when able to write clear, detailed texts on diverse subjects as well as defend a point of view on general topics - giving the pros and cons of the different options.

Additional information about this master (grants, events, etc.) can be found on the web site:
www.unizar.es/nanomat

Course Schedule and Deadlines

Classes for this module start at the end of module 2 (around the second week of November) and continue for about five weeks.

The classes and laboratory practicals are given in the afternoon and the calendar for these and the exam dates will be published prior to the beginning of each academic year in the web site of the Faculty of Science (https://ciencias.unizar.es/web/horarios.do).

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Learning outcomes that define this course

The student, in order to pass the course, will have to show her/his competence in the following skills:

1:
Clearly identify the different nanostructure types (0D, 1D, 2D and 3D) and the chemical and physical methods available for their production.

2:
Recognise the different supramolecular and macromolecular architectures, their importance in chemistry and their potential application in various fields in Nanotechnology, suggesting rational structural designs and effective chemical synthesis tools to produce and assemble functional structures.

3:
Plan, design and undertake experiments aimed at producing nanomaterials, evaluating the problems, risks and results.

Introduction

Brief presentation of the course

As a continuation of the previous module, here the necessary basic chemistry concepts are introduced to make the molecular self-assembly and self-organisation processes understandable as they let students make practical use of this chemistry to the benefit of the production of structures of interest in Nanoscience and Nanotechnology.

The contents of this subject are:

Nanomaterials, nanostructures and their production: nanoparticles, quantum points, nanotubes, nanothreads, nanosheets, nanocomposites, polymers, dendrimers and liposomes. Hierarchical self-assembly and molecular self-organisation: supramolecular nanostructures, growth by biochemical self-assembly, etc. Surface chirality. Nanostructure functionalization. Inorganic layers.

The theory classes are complemented by six practical sessions including:

1.- Nanotube synthesis

2.- Synthesis of magnetic nanoparticles in solution

3.- Growth of layers

4.- Assembly in nanostructure production

5.- Preparation of block co-polymer micelle aggregates

6.- Supramolecular Chemistry; self-assembled anisotropic stages: liquid crystals.

Competences

General aims of the course

The expected results of the course respond to the following general aims

This module is aimed at making students aware of the importance of order at the atomic and molecular levels and how this order can determine the properties of a nanostructured material; how they can be different to what this same compound exhibits in a three-dimensional structure with no preferential order. It is precisely this order that, naturally or imposed by different assembly techniques, directed intermolecular interactions, 'click' chemical strategies, controlled polymerization, chemical functionalization of nano-objects, etc., on a nanoscopic scale can create properties that condition the possible applications and uses for these materials - which will be analysed in later modules in this Master's. Therefore, it is essential that students on this course see and know how to apply the chemical and physical processes that can result in this order.

Context/Importance of the course for the master degree

The objective of this module, together with the “Fabrication of Nanostructured Materials” module, is to instruct the student in the different methods available to obtain nanostructured materials, which is the first stage in the production of nanodevices with properties that are of interest in fields as diverse as physics, chemistry, biochemistry and medicine.

After completing the course, the student will be competent in the following skills:

1:
Assess how an extensive control of order at an atomic and molecular level allows the properties of the materials to be optimised and strengthened.

2:
Recognise the chemical potential in the production of self-assembled nanostructures, hierarchical structures, chirals, etc.

3:
Make use of the necessary chemical and chemical-physical knowledge to see the real applications of the assembly and production of functional nanostructures.

Relevance of the skills acquired in the course

The first step to fabricate a nanodevice is choosing and designing an appropriate method for the assembly of the constituent atoms or molecules for the nanodevice. Therefore, this subject, taught in parallel with modules 1 (Fundamental Properties of Nanostructured Materials) and 3 (Assembly and Fabrication of Nanostructures), takes place at the beginning of the academic year before later moving on to studying how the nanostructured material obtained can be characterised and its properties and potential market applications assessed.

Evaluation

Assessment tasks

The student will prove that he/she has achieved the expected learning results by means of the following assessment tasks:

1:
The assessment of the 6 ECTS credits represents 75% of the final mark. There will be a written test (50% of the assessment of these 6 theory credits). Here the abilities acquired by the student in the shape of theoretical knowledge obtained in relation to nanostructure assembly and production are assessed. The exam will feature theory matters including: (i) topic(s) expanded from those corresponding to the contents of this subject, given in the "brief introduction to the subject" section and (ii) short answer or multiple choice questions. In these theory questions, the student has to show that the abilities required for the subject have been obtained which, consequently, will be scored between 1 and 10 for accuracy in topic presentation (scientific quality and written communication abilities) as well as conciseness and quality in the answers given.

In addition to the written exam, problem solving, exercises and questions during the classes handed in by the student at that time or later as per the lecturer's indications will also be scored (50% of the qualification for these theory credits). Specifically, a score of 1 to 10 is given for: the right approach to solving the question or problem, correct solution, interpretation of the results and explanation of how the problem was solved, giving equations or graphs where necessary.

2. Assessment of the 2 ECTS credits for the practical part of the module (25% of the final mark for the module):

a.- The lecturers for the practicals will assess (scored between 1 and 10) the abilities and skills of the students in the laboratory (25% of the mark for the practical credits). Instrument handling ability, accuracy performing experiments, attention to detail, ability to solve problems or unforeseen difficulties that may arise, ability to work on experiments in a group, etc. will be taken as essential aspects in this area.

b.- Answers to multiple choice questions and Q&As laid out before, during and/or after the practical sessions (25% of the evaluation for the practical credits). Likewise, students will create a highly detailed report (introduction where the state of art of the corresponding topic lies, objectives, results, debate, conclusions and bibliography) on one of the six practicals in this module (50% of the assessment for the practical credits). Special attention will be paid to checking that students have acquired the right abilities for these practical sessions, i.e. the ability to make nanostructured materials in the laboratory through self-assembly procedures, control over the techniques for nanostructure functionalization and knowledge of the nanolithographic techniques which they will have access to in the practical sessions in this module. Likewise, the student's written communication skills, use of language with appropriate scientific rigour, quality and report presentation will also be assessed.

A minimum mark of 4 out of 10 is needed for each of the two parts - theory and practice - to pass the subject. In addition, an average of 5 out of 10 or more needs to be obtained to pass.

2:

For **hybrid students coming to other sittings or wishing to increase their mark**, the assessment consists of:

1.- 75%: A written test with theory questions including: (i) topic(s) to de developed based on those given in the "brief introduction to the subject" section in this teaching manual where the complete contents are given and (ii) multiple choice and/or short answer questions, also in reference to the class course content and problem solving and exercises where the student shows knowledge regarding the manufacturing of nanomaterials, nanostructures and nanolithographic techniques. A score of 1 to 10 will be given for scientific quality and communication skills.

3.- 25%. A multiple choice test must be passed before going into the laboratory. Here the judgement is on whether or not the student is ready to respect the laboratory safety norms and if the student is able to manage the instruments involved in the practical test. This is an elimination test which can only be passed with a score of 8 out of 10. This first test counts for 5% of the total for this test. Once the test is passed, the student begins the laboratory exam. This consists of an experiment in which the student must show the capability to plan the necessary experiments given the objectives to be achieved. These experiments must be performed adequately, correctly using the corresponding instruments (an expert will at all times be supervising and will halt the exam if this person sees that the student is endangering the equipment used or their own safety). This part counts for 65% of the mark in this test. Lastly, the student must interpret the data obtained and write a report in which the results obtained are analyzed and the main conclusions given. A score of between 1 and 10 will be given for the scientific quality of the report presented and the student's communication skills. This report is worth 30% of the total mark for this test.

A minimum mark of 4 out of 10 is needed for each of the two parts of the exam to pass the subject. In addition, an average of 5 out of 10 or more needs to be obtained to pass.

Activities and resources

Course methodology

The learning process that has been designed for this course is based on the following activities:

The aim of this module is to provide students with knowledge of the nanostructure assembly and production methods, identifying the relevance of chemistry in molecular assembly, supramolecular chemistry, obtaining chiral and functionalized structures, etc.

Therefore, following a general examination of these possibilities through participatory master classes, there will be case and problem analysis activities where these principles can be observed, examined in depth, evaluated and clarified.

The lectures are complemented with laboratory practicals where the students can apply the acquired theoretical knowledge to real nanostructure production cases.

Following practical case analysis, there will be a seminar preparation activity for which the student will write a report on more specific details not previously examined in class of a preparation method and its importance in the scientific, technological, social and economic context.

Outline of the Programme

The programme offered to the students to help them achieve the learning results includes the following activities :

1:

Each topic area making up the programme for the module will be presented, analysed and discussed by the lecturer through participatory master classes lasting 50 minutes. The lecturers will provide the students with notes, handouts or summaries of class content prior to the beginning of the class (preferably via ADD) along with the recommended reading for more in-depth understanding of the topic.

2:

Open forum on the basic concepts and their application. Comparison with real developments. Problem solving and practical case studies. All the above will take place in participatory 50 minute classes.

3:

Six laboratory practicals through which the student faces real problems in the preparation of nanostructured materials. Thanks to the work with their colleagues in the practical groups, the student will develop group work skills and, though the writing of a report in great detail on one of the practicals, the student will become used to professionally presenting pieces of work and learning to communicate the results in English.

Course planning

Calendar of actual sessions and presentation of works

This calendar will be published at the beginning of each academic year in the web site of the Faculty of Science: https://ciencias.unizar.es/web/horarios.do. All classes will be in the afternoon.

Bibliographic references of the recommended readings