



## Teaching Guide

| Teaching Guide           |                                                                                                                                                                                                                                                                                                                                                          |        |                    |           |
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| Identifying Data         |                                                                                                                                                                                                                                                                                                                                                          |        |                    | 2020/21   |
| Subject (*)              | Molecular Materials                                                                                                                                                                                                                                                                                                                                      |        | Code               | 610509123 |
| Study programme          | Mestrado Universitario en Investigación Química e Química Industrial (Plan 2020)                                                                                                                                                                                                                                                                         |        |                    |           |
| Descriptors              |                                                                                                                                                                                                                                                                                                                                                          |        |                    |           |
| Cycle                    | Period                                                                                                                                                                                                                                                                                                                                                   | Year   | Type               | Credits   |
| Official Master's Degree | Yearly                                                                                                                                                                                                                                                                                                                                                   | First  | Optional           | 3         |
| Language                 | SpanishGalician                                                                                                                                                                                                                                                                                                                                          |        |                    |           |
| Teaching method          | Face-to-face                                                                                                                                                                                                                                                                                                                                             |        |                    |           |
| Prerequisites            |                                                                                                                                                                                                                                                                                                                                                          |        |                    |           |
| Department               | Departamento profesorado másterQuímica                                                                                                                                                                                                                                                                                                                   |        |                    |           |
| Coordinador              | Pazos Chantrero, Elena                                                                                                                                                                                                                                                                                                                                   | E-mail | elena.pazos@udc.es |           |
| Lecturers                | Pazos Chantrero, Elena                                                                                                                                                                                                                                                                                                                                   | E-mail | elena.pazos@udc.es |           |
| Web                      | www.usc.es/gl/centros/quimica/curso/master.html                                                                                                                                                                                                                                                                                                          |        |                    |           |
| General description      | The subject completes the module Nanochemistry and new materials from the molecular point of view. It also provides panoramic views of the most important applications of these materials                                                                                                                                                                |        |                    |           |
| Contingency plan         | 1. Modifications to the contents<br><br>2. Methodologies<br>*Teaching methodologies that are maintained<br><br>*Teaching methodologies that are modified<br><br>3. Mechanisms for personalized attention to students<br><br>4. Modifications in the evaluation<br><br>*Evaluation observations:<br><br>5. Modifications to the bibliography or webgraphy |        |                    |           |

## Study programme competences

| Code | Study programme competences                                                                                                                                                        |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1   | Define concepts, principles, theories and specialized facts of different areas of chemistry.                                                                                       |
| A3   | Innovate in the methods of synthesis and chemical analysis related to the different areas of chemistry                                                                             |
| A4   | Apply materials and biomolecules in innovative fields of industry and chemical engineering.                                                                                        |
| B1   | Possess knowledge and understanding to provide a basis or opportunity for originality in developing and / or applying ideas, often within a research context                       |
| B4   | Students should be able to communicate their conclusions, and the knowledge and the reasons that support them to specialists and non-specialists in a clear and unambiguous manner |
| B5   | Students must possess learning skills to allow them to continue studying in a way that will have to be largely self-directed or autonomous.                                        |
| B7   | Identify information from scientific literature by using appropriate channels and integrate such information to raise and contextualize a research topic                           |
| B10  | Use of scientific terminology in English to explain the experimental results in the context of the chemical profession                                                             |
| B11  | Apply correctly the new technologies to gather and organize the information to solve problems in the professional activity.                                                        |
| B12  | Being able to work in a team and adapt to multidisciplinary teams.                                                                                                                 |
| C1   | CT1 - Elaborar, escribir e defender publicamente informes de carácter científico e técnico                                                                                         |
| C3   | CT3 - Traballar con autonomía e eficiencia na práctica diaria da investigación ou da actividade profesional.                                                                       |
| C4   | CT4 - Apreciar o valor da calidade e mellora continua, actuando con rigor, responsabilidade e ética profesional.                                                                   |

| Learning outcomes                                                                                                                                                                                                    |                             |                                                  |     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------|-----|
| Learning outcomes                                                                                                                                                                                                    | Study programme competences |                                                  |     |
| The students will understand how the molecular properties and the supramolecular interactions determine the properties of molecular materials                                                                        | AC1<br>AC3<br>AC4           | BC1<br>BC4<br>BC5<br>BC7<br>BC10<br>BC11<br>BC12 | CC1 |
| The students will know the main types of molecular materials (liquid crystals, semiconductors, etc.) as well as their characteristics                                                                                | AC1<br>AC3<br>AC4           | BC1<br>BC4<br>BC5<br>BC7<br>BC10<br>BC11<br>BC12 | CC3 |
| The students will know the techniques used to study molecular materials (polarization optical microscopy, differential scanning calorimetry, etc.)                                                                   | AC4                         | BC1<br>BC5<br>BC7<br>BC10<br>BC11<br>BC12        |     |
| The students will have an overview of the important applications of molecular materials, such as screens, field effect transistors (FETs), light emitting diodes (LEDs), solar cells, sensors and molecular machines | AC1<br>AC3<br>AC4           | BC1<br>BC4<br>BC5<br>BC7<br>BC10<br>BC11         | CC4 |
| The students will know the main specific characteristics of molecular materials                                                                                                                                      | AC1<br>AC3<br>AC4           | BC1<br>BC4<br>BC5<br>BC7<br>BC10<br>BC12         |     |

| Contents                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                     | Sub-topic                                                                                                                                                                                                                                                                                                                                                                                                                             |
| UNIT 1. Molecular materials                               | Basic concepts                                                                                                                                                                                                                                                                                                                                                                                                                        |
| UNIT 2. Molecular structures of main molecular materials. | Conjugated polymers: polyacetylenes, polyphenylenevinylenes, polythiophenes<br>-structure, properties and synthesis<br>Polycyclic aromatic compounds:<br>-2D: acenes, nanographenes, graphene<br>--structure, properties and synthesis<br>-3D: fullerenes, carbon nanotubes<br>--structure, properties and synthesis<br>Other compounds: polyamines, heterocyclic compounds, metal complexes<br>- structure, properties and synthesis |



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|--------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNIT 3. Types of molecular materials: liquid crystals, semiconductors, optoelectronic materials, molecular magnets | <p>Liquid crystals</p> <ul style="list-style-type: none"> <li>- basic concepts</li> <li>-classification: calamitic, discotic</li> <li>-characterization methods: optical polarization microscopy, DSC, X-rays</li> <li>-representative structures</li> <li>-optical and electrical properties, interaction with surfaces</li> </ul> <p>Semiconductors and molecular electronics</p> <ul style="list-style-type: none"> <li>- basic concepts (intrinsic conductivity and doping, band models and hopping, polarons and solitons)</li> <li>- methods of characterization</li> <li>-representative structures</li> </ul> <p>Optoelectronic materials</p> <ul style="list-style-type: none"> <li>- basic concepts (excitons, quantum dots)</li> <li>-representative structures</li> </ul> <p>Molecular magnets</p> |
| UNIT 4. Devices and applications.                                                                                  | <p>Displays and liquid crystal displays. Smart windows.</p> <p>Field effect transistors (FETs)</p> <p>Light emitting diodes (LEDs)</p> <ul style="list-style-type: none"> <li>-lighting</li> <li>-screens</li> </ul> <p>Solar cells</p> <p>Gears and molecular machines</p> <p>Sensors</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

| Planning                                                                                                                        |                         |                      |                               |             |
|---------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------------------|-------------------------------|-------------|
| Methodologies / tests                                                                                                           | Competencies            | Ordinary class hours | Student's personal work hours | Total hours |
| Guest lecture / keynote speech                                                                                                  | B1 B4 B5 C3 C4          | 12                   | 34                            | 46          |
| Seminar                                                                                                                         | B4 B7 B10 B11 B12       | 7                    | 7                             | 14          |
| Oral presentation                                                                                                               | B4 B7 B10 B11 B12<br>C1 | 2                    | 9                             | 11          |
| Mixed objective/subjective test                                                                                                 | A1 A4 A3 B1 B4 B5       | 2                    | 0                             | 2           |
| Personalized attention                                                                                                          |                         | 2                    | 0                             | 2           |
| (*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. |                         |                      |                               |             |

| Methodologies                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Guest lecture / keynote speech  | Expositive classes (use of blackboard, computer, projector), complemented with the tools of virtual teaching                                                                                                                                                                                                                                                                                                                                                  |
| Seminar                         | <ul style="list-style-type: none"> <li>- Seminars carried out by the Master's teaching staff, or with professional guests from companies, administration or other universities. Interactive sessions related with the different subjects, discussions and exchange of opinions with the students.</li> <li>- Resolution of practical exercises (problems, information interpretation and processing, evaluation of scientific publications, etc.).</li> </ul> |
| Oral presentation               | The oral presentation will be prepared individually on a topic related to the theoretical contents of the subject                                                                                                                                                                                                                                                                                                                                             |
| Mixed objective/subjective test | A final exam will be programmed, which will allow to assess objectively the degree of assimilation and the ability to apply the contents of the subject by the student                                                                                                                                                                                                                                                                                        |

| Personalized attention |             |
|------------------------|-------------|
| Methodologies          | Description |



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|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Seminar | The proposed teaching methodology is based on student work, which thus becomes the main protagonist of the teaching-learning process. In order for the student to obtain optimum performance of his effort, it is important that there is a continuous and close student-teacher interaction, so that the latter can guide the student in this process. This interaction will be given in a special way in the workshops and problem-solving sessions. Through the student-teacher interaction, as well as the different assessment activities, it will be determined to what extent the students achieved the competency objectives established in each thematic unit, and will help to identify the students who need personalized attention through individualized tutorships. Therefore, periodically the teaching staff may organize tutorships, which will be held in the most suitable hours for each student, with the intention of receiving the necessary guidance. Regardless of the tutorships proposed by the teaching staff, the student can attend the tutorships at his own request, as many times as desired, and at the time that is most convenient. |
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| Assessment                      |                      |                                                                                                                                                                                                                                                                                                             |               |
|---------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Methodologies                   | Competencies         | Description                                                                                                                                                                                                                                                                                                 | Qualification |
| Mixed objective/subjective test | A1 A4 A3 B1 B4 B5    | In order to evaluate the acquisition of knowledge and competencies a final test will be carried out (according to the calendar established in the Center). This test will consist in problems and questions related with the contents of the subject, analogous to the ones done during the course sessions | 60            |
| Guest lecture / keynote speech  | B1 B4 B5 C3 C4       | The participation of the student will be assessed in the keynote sessions, through questions asked by the teacher or through discussions with the classmates.                                                                                                                                               | 10            |
| Oral presentation               | B4 B7 B10 B11 B12 C1 | The students will present orally, during the course, one or several of the results obtained within the activities carried out in the seminars                                                                                                                                                               | 10            |
| Seminar                         | B4 B7 B10 B11 B12    | Within the seminars a series of evaluable activities will be organized:<br>Problems resolution and practical cases (10%)<br>Written report preparation (10%)                                                                                                                                                | 20            |

| Assessment comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
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| The student must review the theoretical concepts introduced in the different topics using the support material provided by the teaching staff and the recommended bibliography for each topic. Those students who encounter important difficulties when working on the proposed activities should consult the teacher, with the objective of being able to analyze the problem and help solve these difficulties. Attendance to all the evaluable activities is necessary to pass the subject. The absences associated with any of the face-to-face activities (seminars, oral presentations, seminars) must be justified, accepting only the reasons contemplated in current university regulations. To pass the subject it will be necessary to obtain an average mark in all the evaluable activities of 5 out of 10. The students who participate in a number of evaluable activities not exceeding 15% will obtain the qualification Not Presented. Regarding the second opportunity of evaluation, the qualification of the exam of July will replace that one obtained in the exam of June. The qualification corresponding to the other evaluable activities may be retained in the July opportunity or, alternatively, as a final part of the July exam, the students will be able to carry out a free exercise, with activities similar to those developed in the seminars during the course. The students assessed in the second opportunity can only opt for the qualification "with honors" if the maximum number of these for the corresponding course has not been fully covered in the first opportunity. Regarding successive academic courses, the teaching-learning process, including assessment, refers to an academic course, and therefore would start with a new course, including all activities and assessment procedures that are scheduled for the course. |

| Sources of information |
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| <b>Basic</b>         | <p>Básica (manuais de referencia).? Molecular Electronics: From Principles to Practice. M. C. Petty, John Wiley &amp; Sons, 2007</p> <p>Complementaria.? Dekker Encyclopedia of Nanoscience and Nanotechnology. J. A. Schwarz, C. I. Contescu, Karol Putyera (eds.). New York: Marcel Dekker, 2004? Handbook of Conducting Polymers. T. A. Skotheim, J. R. Reynolds (eds), 3rd ed., Boca Raton: CRC Press, 2007.? <a href="http://61.188.205.38:8081/hxgcx/polymer/UploadFiles/swf/???/Handbook%20of%20Conducting%20Polymers,%20Third%20Edition%20-%202%20Volume%20Set.pdf">http://61.188.205.38:8081/hxgcx/polymer/UploadFiles/swf/???/Handbook%20of%20Conducting%20Polymers,%20Third%20Edition%20-%202%20Volume%20Set.pdf</a>? Organic Optoelectronic Materials. Y. Li (ed), Springer, 2015? Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technologies. C. Brabec, U. Scherf, V. Dyakonov, (eds), 2nd ed., Weinheim: Wiley-VCH, 2014? Organic Photovoltaics: Mechanism, Materials, And Devices. S.-S. Sun, N. S. Sariciftci, (eds.) Boca Raton: Taylor &amp; Francis, cop. 2005? Light-Emitting Diodes. E. F. Schubert, Cambridge: Cambridge University Press, 2003? Chemical Sensors and Biosensors: Fundamentals and Applications. F.-G. B?nic?. Chichester: John Wiley, 2012? Introduction to Liquid Crystals Chemistry and Physics. P. J. Collings, London: Taylor &amp; Francis, 2001? Liquid Crystals: Experimental Study of Physical Properties and Phase Transitions. S. Kumar, Cambridge: Cambridge University Press, 2001? Liquid Crystals. S. Chandrasekhar, Cambridge: Cambridge University Press, 1992</p> |
| <b>Complementary</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

## Recommendations

### Subjects that it is recommended to have taken before

### Subjects that are recommended to be taken simultaneously

Advanced Materials Characterization Techniques/610509121

Material Properties/610509122

### Subjects that continue the syllabus

### Other comments

It is mandatory to have previously studied the subjects of the Compulsory Advanced Formation module and it is advisable to take the remaining subjects of the Nanochemistry and New Materials module

(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.