



## IDENTIFYING DATA

### Production of Basic Components from Lignocellulosic Waste

|                     |                                                                                                                           |          |      |            |
|---------------------|---------------------------------------------------------------------------------------------------------------------------|----------|------|------------|
| Subject             | Production of Basic Components from Lignocellulosic Waste                                                                 |          |      |            |
| Code                | O01M142V01213                                                                                                             |          |      |            |
| Study programme     | Máster Universitario en Ciencia y Tecnología Agroalimentaria y Ambiental                                                  |          |      |            |
| Descriptors         | ECTS Credits                                                                                                              | Choose   | Year | Quadmester |
|                     | 3                                                                                                                         | Optional | 1st  | 2nd        |
| Teaching language   | #EnglishFriendly Galician                                                                                                 |          |      |            |
| Department          |                                                                                                                           |          |      |            |
| Coordinator         | Gullón Estévez, Beatriz                                                                                                   |          |      |            |
| Lecturers           | García del Río, Pablo<br>Gullón Estévez, Beatriz<br>Romaní Pérez, Aloia                                                   |          |      |            |
| E-mail              | bgullon@uvigo.es                                                                                                          |          |      |            |
| Web                 |                                                                                                                           |          |      |            |
| General description | Know and implement the main technologies for the production of platform chemicals from residual lignocellulosic materials |          |      |            |

## Training and Learning Results

|      |                                                                                                                                                                                             |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                             |
| A1   |                                                                                                                                                                                             |
| B3   | (*)Que os estudantes sexan capaces de desenvolver habilidades persoais de razoamento crítico e constructivo para mellorar o funcionamento dos proxectos de investigación en que intervéñen. |
| B4   | (*)Que os estudantes sexan capaces de adaptarse a novas situacións, con grandes doses de creatividade e ideas para asumir o liderado de investigadores.                                     |
| C1   |                                                                                                                                                                                             |
| C8   |                                                                                                                                                                                             |
| C10  |                                                                                                                                                                                             |
| D1   |                                                                                                                                                                                             |
| D2   |                                                                                                                                                                                             |
| D3   |                                                                                                                                                                                             |
| D4   |                                                                                                                                                                                             |
| D5   |                                                                                                                                                                                             |
| D6   |                                                                                                                                                                                             |
| D7   |                                                                                                                                                                                             |
| D8   |                                                                                                                                                                                             |
| D9   |                                                                                                                                                                                             |
| D10  |                                                                                                                                                                                             |
| D11  | Motivación poa calidade con sensibilidade hacia temas medioambientais                                                                                                                       |

## Expected results from this subject

|                                    |                               |
|------------------------------------|-------------------------------|
| Expected results from this subject | Training and Learning Results |
|------------------------------------|-------------------------------|

|                                                                                                                                                                                                                                                                                                                         |                                                                              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Knowing the potential of lignocellulosic residues (wood, prunings, straws, ...) as substrates for obtaining high added value products, candidates to replace to those now obtained from petroleum. Knowing the potential as platform chemicals of hydroxymethylfurfural (HMF), furfural, levulinic acid and formic acid | A1<br>B4<br>C10<br>D1                                                        |
| Knowing the different processes in the treatment of lignocellulosic materials for obtaining the aforementioned platform chemicals. Obtain laboratory skills to carry them out.                                                                                                                                          | A1<br>B3<br>B4<br>C1<br>C8<br>C10<br>D1<br>D2<br>D4<br>D5<br>D7<br>D8<br>D11 |
| Knowing the different analytical techniques for determining the chemical composition and structure of materials and studied compounds. Obtain skills to perform them at laboratory and knowledge for interpretation of the obtained data.                                                                               | A1<br>C1<br>C8<br>C10<br>D1<br>D2                                            |
| Critical analysis of recent studies published in scientific literature.                                                                                                                                                                                                                                                 | A1<br>B3<br>B4<br>C1<br>C10<br>D1<br>D2<br>D3<br>D4<br>D6<br>D8<br>D9<br>D10 |
| Acquiring skills in synthesis and organization of information, writing and exposition, through the development and public presentation of a related topic work.                                                                                                                                                         | A1<br>B3<br>B4<br>C10<br>D1<br>D2<br>D3<br>D4<br>D6<br>D8<br>D11             |

## Contents

| Topic                       |                                                                                                                                                    |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| Introducion                 | - Biomass as a renewable resource<br>- Platform chemicals obtained from biomass                                                                    |
| Biomass fractionation       | - Treatments for hemicellulose solubilization<br>- Delignification treatments<br>- Cellulose hydrolysis                                            |
| Hemicelluloses              | - Composition<br>- Obtention                                                                                                                       |
| Cellulose                   | - Caracterization<br>- Obtention                                                                                                                   |
| Levulinic acid              | - Characteristics and properties<br>- Production by acid hydrolysis of hexoses<br>- Production using solid catalysts<br>- Production using enzymes |
| Hydroxymethylfurfural (HMF) | - Characteristics and properties<br>- Production by acid hydrolysis of hexoses<br>- Biphasic systems<br>- Production using ionic liquids           |

- Characteristics and properties
- Production by acid hydrolysis of pentoses
- Biphasic systems
- Production using ionic liquids

### Planning

|               | Class hours | Hours outside the classroom | Total hours |
|---------------|-------------|-----------------------------|-------------|
| Presentation  | 2           | 36                          | 38          |
| Mentored work | 4           | 17                          | 21          |
| Lecturing     | 8           | 8                           | 16          |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

### Methodologies

|               | Description                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Presentation  | The supervised work made by the student will be presented in the classroom to the teacher and classmates.<br>Evaluation will consider organization of the information and domain of the exposed subject. Additionally the answers to the questions posed by the teacher and classmates will be considered, and participation as listener, according to the comments and questions raised in the classmates' presentations. |
| Mentored work | Related with "Laboratory Practice" methodology, scheduled seminars address to perform analysis of the obtained experimental data. More specifically, applying material balances to the studied processes, implementing the kinetic modeling for acid hydrolysis of sugars in a spreadsheet, or offline integration of different chromatograms.                                                                             |
| Lecturing     | Presentation at classroom of the fundamentals of the subject, using audiovisual methods and, in some cases, making basic experiments requiring little material and low-tech.                                                                                                                                                                                                                                               |

### Personalized assistance

| Methodologies | Description                                                                                                                                                                                                                                                                                                                                                      |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Presentation  | During the performance of the tutored work the professor will orient in the compiling, classifying and organizing of the information. This orientation will continue during subsequent elaboration of material to be used in exposition in classroom.                                                                                                            |
| Mentored work | In the presential part of the seminars, calculation methodologies to be employed for the interpretation of the experimental data obtained will be presented. Any student doubt will be solved. In the non presential part any question or consult made by the students will be answered using the e-learning platform, e-mail or in person during tutoring time. |

### Assessment

| Assessment    | Description                                                                                                                                                                                                                                                                                   | Qualification |    | Training and Learning Results |                                   |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|----|-------------------------------|-----------------------------------|
| Presentation  | As "emitter: The organization and synthesis of the presented material, the clarity in the exposition, and the answer to the questions will be evaluated.<br>As "receptor": Participation in classmates presentations will be evaluated, taking into account the comments / questions realized | 35            | A1 | C1                            | D1<br>D3<br>D4<br>D7<br>D8<br>D11 |
| Mentored work | To be valued: the attitude and aptitude, the skills in the use of the required software tools (spreadsheet, chromatographic analysis software), and the elaborated material.                                                                                                                  | 30            | A1 | C1<br>C8<br>C10               | D1<br>D4<br>D6<br>D8<br>D9<br>D11 |
| Lecturing     | Realization of an exam of the subject. It Will include relative questions to theoretical concepts, production methodologies, analytical methods and practical cases                                                                                                                           | 35            | A1 | B4<br>C1<br>C8<br>C10         | D3<br>D5<br>D8                    |

### Other comments on the Evaluation

1. It is necessary to obtain a minimum qualification of 4.0 (base 10) in every part to pass the subject (Exam, laboratory practices, oral presentations and seminars).
2. Students that can not attend in person must demonstrate that they have the necessary knowledge of the matter and laboratory skills. They will have to do the exam of the subject, to elaborate a homework whose oral presentation can be video recorded and uploaded to the e-learning platform, to solve some of the cases dealt in seminars, and to

realize a exam about laboratory aspects. However, respect to laboratory practices, you are kindly requested to attend in person if possible.

3. In July the student can opt for examining of the exam or the methodologies not surpassed in the previous opportunity, or of those that wish to improve the previous qualification. The assigned qualification will be the best of that obtained in June or July for exam or every methodology.
4. The communication with the students will be made through the e-learning platform of the University of Vigo.
5. Examination dates: March, 16th 2021 at 11.00 and July, 7th 2021 at 11.00

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## Sources of information

### Basic Bibliography

Robert-Jan Van Putten et al, **Hydroxymethylfurfural, a versatile platform chemical made from renewable resources**, 113, ACS, 2013

Atsushi Takagaki et al., **Catalytic transformations of biomass-derived materials into value-added chemicals**, 16, Springer, 2012

Jean-Paul Lange et al., **Furfural- A promising platform for lignocellulosic biofuels**, 5, Willey-VCH, 2012

D.W. Rackemann y W.O.S. Doherty, **The conversion of lignocellulosics to levulinic acid**, 5, 198-214, John Willey and Sons, 2011

A. Morone, M. Apte, R.A. Pandey, **Levulinic acid production from renewable waste resources: Bottlenecks, potential remedies, advancements and applications**, 51, 548-565, Elsevier, 2015

### Complementary Bibliography

Edwin R.P. Keijsers et al., **The cellulose resource matrix**, 93, Elsevier, 2013

Yomaira J. Pagán-Torres et al., **Production of 5-Hydroxymethylfurfural from Glucose Using a Combination of Lewis and Brønsted Acid Catalysts in Water in a biphasic reactor ...**, 2, ACS, 2012

S. Rivas, **Valorización de hemicelulosas de biomasa vegetal**, UVigo,

S. Dutta, S.De, B. Saha, I. Alam, **Advances in conversion of hemicellulosic biomass to furfural and upgrading to biofuels**, Catal. Sci. Technol., 2, 2025-2036, R. Society of Chemistry, 2012

J. Cui, J. Tan, T. Deng et al., **Conversion of carbohydrates to furfural via selective cleavage of the carbon carbon bond**, Green Chem., 18(6), R. Society of Chemistry, 2015

A.M. Raspolli Galletti, C. Antonetti, V. de Luise et al., **Levulinic acid production from waste biomass**, BioResources 7(2), Carolina State University, 2012

J. Sadhukhan, K. Siew, E. Martínez-Hernández, **Novel integrated mechanical biological treatment systems for the production of levulinic acid from fraction of municipal waste**, BRT 215, 131-143, Elsevier, 2016

Peleteiro, S.; Santos, V.; Garrote, G.; Parajó, J. C, **Furfural production from Eucalyptus wood using an acidic ionic liquid**, Carbh. Polym., 1, 20-25, Elsevier, 2016

Rivas, S.; Galletti, A.M.R.; Antonetti, C.; Licursi, D.; Santos, V.; Parajó, J. C., **A biorefinery cascade conversion of hemicellulose-free Eucalyptus globulus wood: Production of concentrated levulinic acid solutions for gamma-valerolactone sustainable preparation products**, Catalysts 8(4):169, MDPI, 2018

Zhanrong Zhang, Jinliang Song, e Buxing Han, **Catalytic Transformation of Lignocellulose into Chemicals and Fuel Products in Ionic Liquids**, Chem. Rev., 117, 6834-6880, ACS, 2017

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## Recommendations

### Subjects that are recommended to be taken simultaneously

Instrumental Techniques for Agri-Food and Environmental Analyses/O01M142V01109