Universidad Zaragoza

Academic Year/course: 2022/23

27124 - Bioreactors

Syllabus Information

Academic Year: 2022/23
Subject: 27124 - Bioreactors
Faculty / School: 100 - Facultad de Ciencias
Degree: 446 - Degree in Biotechnology
ECTS: 6.0
Year: 4
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

The aims of the course are the following:

1. To know and use the concepts, nomenclature, and basic concepts of biochemical reaction engineering
2. To propose, develop and solve kinetic models for enzymatic and microbial processes.
3. To know the mechanisms of biocatalysts' immobilization, and mass transfer phenomena in reactors with immobilized biocatalysts.
4. To Know and apply the basic equations of design and optimization of biochemical reactors.
5. To Know the main criteria for the selection of bioreactors in different industrial processes.

These approaches and objectives are aligned with some of the Sustainable Development Goals, SDG, of the 2030 Agenda (https://www.un.org/sustainabledevelopment/es/) and certain specific goals, in such a way that the acquisition of the Learning outcomes of the subject provides training and competence to the student to contribute to a certain extent to their achievement:

? **Goal 2**: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
Target 2.1 By 2030, end hunger and ensure access by all people, in particular, the poor and people in vulnerable situations including infants, to safe, nutritious, and sufficient food all year round.

Target 2.3 By 2030, double the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists, and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets, and opportunities for value addition and non-farm employment.

Goal 3: ensure healthy lives and promote well-being for all ages.

Target 3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, waterborne diseases, and other communicable diseases.

Target 3.9: By 2030, substantially reduce the number of deaths and illnesses caused by hazardous chemicals and air, water, and soil pollution.

Target 3.d Strengthen the capacity of all countries, particularly developing countries, in early warning, risk reduction, and management of national and global health risks.

Goal 4: Ensure inclusive, equitable, and quality education and promote lifelong learning opportunities for all

Target 4.4 By 2030, significantly increase the number of young people and adults who have the necessary skills, particularly technical and professional ones, to access employment, decent work, and entrepreneurship.

Goal 9: Industry, innovation, and infrastructure

Target 9.5 Increase scientific research and improve the technological capacity of industrial sectors in all countries, particularly developing countries, by fostering innovation and significantly increasing, by 2030, the number of people working in research and development per million inhabitants and the spending of the public and private sectors in research and development.

1.2. Context and importance of this course in the degree

The industrial development of current bioprocesses requires acquiring the needed knowledge by biotechnologists on the performance and the main characteristics of the different types of enzyme and microbial bioreactors.

From the kinetic models governing these processes, during this course, the necessary tools to attain the needed knowledge related to the basic methods of selection, design, and optimization of equipment where these kinds of reactions take place are provided.

1.3. Recommendations to take this course

The professors teaching this subject belong to the areas of Chemical Engineering and Biochemistry and Molecular Biology. To take this course it is recommended to have passed the subjects of Mathematics, Chemistry, Physics and Chemical Engineering.

2. Learning goals

2.1. Competences

The competencies that the student should have acquired after completing the course are:

Calculate the numerical values of the parameters shown in the different enzymatic and microbial kinetic models.
Apply and select different methods of immobilization of biocatalysts.
Select and design enzymatic and microbial bioreactors: batch, semi-continuous, and continuous.
Optimize the operation of enzymatic and microbial bioreactors.

2.2. Learning goals

Know the different types of bioreactors and their main operating characteristics.
Know the main kinetic models applicable to enzymatic and microbial processes.
Understand and apply the different methods of estimating the kinetic parameters.
Understand and apply the equations for the basic design of enzymatic and microbial bioreactors.
Know the basic methods of selection and optimization of ideal reactors (i.e., batch reactor (BR), plug flow reactor (PFR), and the continuous stirred tank reactor, CSTR).
Know and select different methods of immobilization of biocatalysts.

2.3. Importance of learning goals

Learning outcomes described above are necessary to conceive, design, optimize and operate the various basic types of industrial bioreactors.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

Option 1:
Global evaluation includes:
Realization of laboratory practices. The attendance, the presentation of a brief report of the activity, as well as the presentation and interpretation of the obtained results will be evaluated.
Realization of students? autonomous works. The deliverables corresponding to these works will be graded considering their contents, the understanding of the concepts involved, and their correct presentation.

Realization of a final exam. This test will consist of: (a) pure theoretical, theoretical-practical questions reasoned in which the application of the theory will be applied to specific cases and examples, and (b) problem-solving.

The grade of the subject will be calculated according to the following formula: Note = 0,1 P + 0,1 T + 0,8 E
Being: P the mark of the laboratory practices (evaluation activity 1), T the note of the supervised works (evaluation activity 2), and E the final exam score (evaluation activity 3).
A minimum grade is required on the exam, E, of 4.0 out of 10 to pass the subject.

If the student does not reach a 4 in the required exam the final score will not take into account the scores of the laboratory practice or one from the students? autonomous works but the score of that exam only.

Option 2:
Those students who do not want to follow the evaluation according to option 1, can choose to take the exam (100% of the final mark) with similar characteristics as the final exam of option 1 (evaluation activity 3).

A minimum grade is required on this exam of 5.0 out of 10 to pass the subject.

Additional comment: The total or partial fraud or plagiarism in any of the evaluation tests will lead to failing the subject with the minimum mark, in addition to the disciplinary sanctions that the faculty quality-guarantee commission adopts for these events.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards the achievement of the learning objectives. It is based on lectures, class of problems, and laboratory practices that favor the development/acquisition of the knowledge associated with the main topics of the subject. A wide range of teaching and learning tasks are implemented, such as solving problem classes, use of spreadsheets, and critical revision of scientific papers related to the topics.

In the lectures, the theoretical concepts of the subject will be presented and accompanied by explanatory examples. In addition, the students will face and solve problems and case studies directly related to the theoretical concepts that will expose along the course.

Students are expected to actively participate in the class throughout the semester.

Exercises are planned to be solved at home, the resolution will be discussed in the class. Classes, both theoretical and practical problems, will be participatory, and there will be tutorials to address the doubts of the students.

The laboratory practice sessions are complementary to the lectures and to the numerical problems. They are carried out in groups of 2 students, in a participatory and collaborative way. After the laboratory work, students will prepare a report where a discussion of the experimental methodology used, the results obtained, and their outputs are included.

However, if the epidemiological circumstances force new confinement or more restrictive distancing measures than the current ones, it is expected that the evaluation will be carried out online using some of the usual tools for this, e.g. the Meet app.

In any case, the exam will consist of 2 parts, one of Theory with 2 or 3 questions, and the other of problems, with 2 numerical problems. Both parts will be carried out consecutively, having the necessary time for the theoretical part and for the problems (around 2.0-2.5 hours). Between both parts, the students will be left the reasonable time necessary to send the answers from the theoretical part to the teachers.

The exam will be sent to students enrolled shortly before the start of the exam, both by email and through the Moodle platform. The problems exam will be sent to the students, once the Theory exam has been completed. Once all students have received the exam, the testing time for each part begins.

To send their answers to the teacher, the student must use the email, using exclusively the UNIZAR email address that each enrolled student has. Replies sent from another email address will not be accepted.

The email to send the answers is: arruebom@unizar.es

However, to avoid possible problems in sending via email, the delivery of responses through Moodle will also be enabled as a task resource. The email for the connection will also be UNIZAR, unique, and non-transferable for each student.

The answers must be in Word, jpg or pdf format, or in some other format compatible with them, by email or via moddle

During the online exam, students must be connected to the application continuously.

Classroom materials will be available via Moodle. These include a repository of the lecture notes used in class, the course syllabus, as well as other learning resources such as several web links provided in the classroom notes. Further information regarding the course will be provided on the first day of class.

4.2. Learning tasks

The course includes the following learning tasks:

- Lectures (36 h). The theoretical contents of the topics will be taught, developing generic cases related with the main topics of the subject.
- Solving problem cases (19 h). In these classes, the student will solve problems supervised by the teacher. The problems or cases will be related to the theoretical part explained in the lectures.
- Laboratory session (4 h). There will be 1 session of 5 hours. In it the student will study in the laboratory some of the contents developed in the lectures and problem solving classes.
- Works supervised (16 h). During the development of the course, and related to the main topics, the students will be proposed to carry out several works of application and extension of the concepts studied. These will consist of the resolution by spreadsheet, and in an individualized way, of different problems related to the theoretical contents of the subject. The student, together with the spreadsheet, must send an explanatory report of the methods and calculations made for the resolution of each problem. Both documents will be evaluated.
- Autonomous work and study (70 h). The student is advised to carry out the individual study on a continuous basis throughout the term.
- Assessment tasks (4 h). In addition to the evaluation of the reports of the practical session and of the supervised works, there will be a final exam, or an overall test. The theoretical and practical knowledge reached by the student will be evaluated.

The teaching and evaluation activities will be carried out in face-to-face mode, unless, the provisions issued by the competent authorities and by the University of Zaragoza require them to be carried out telematically

4.3. Syllabus

The course will address the following topics:

- Topic 1. Introduction to biochemical reaction engineering. Biochemical products and processes.
- Topic 2. Kinetics of enzyme catalysed reactions. Reactions with one substrate: General model and Michaelis-Menten and Briggs-Haldane approximations. Methods of calculation of kinetic parameters. Reversible

reactions. Reactions with several substrates. Cooperativity: Hill model. Types and kinetic effects of inhibition. Influence of pH and temperature. Enzyme deactivation.

- Topic 3. Microbial growth kinetics. Stoichiometry, yield and reaction rate. Kinetics of substrate consumption and product formation. Phases of cellular growth. Non-structured models. Substrate limited growth: Monod model. Other kinetic models. Effects of inhibition. Diauxic growth. Environmental effects. Thermal death kinetics. Introduction to structured kinetic models.
- Topic 4. Immobilization of enzymes and biocatalysts. Technology of enzymatic immobilization. Types of immobilization: adsorption, covalent bond, cross bonds, self-immobilization, membranes. Selection of the immobilization method. Effects of immobilization on the mass transfer resistances. External and internal effectiveness factors.
- Topic 5. Design of enzymatic bioreactors. Ideal bioreactors: Batch reactor, fed-batch reactor, continuous stirred tank reactor (CSTR), CSTR in series, plug-flow reactor. Productivity and optimization of ideal reactors. Effect of enzyme inhibition and deactivation. Comparison of bioreactors.
- Topic 6. Design of microbial fermenters. Types of reactors: Batch and Fed-batch reactors. Continuous stirred tank: Chemostat. Chemostat with recycle. Chemostats in series. Plug flow fermenter. Multiphase fermenters. Comparison and selection of bioreactors.

4.4. Course planning and calendar

The period of the lectures and problems coincide with the schedule of classes officially established. This is available at the following link: https://ciencias.unizar.es/grado-en-biotecnologia. The timetable and laboratory practice groups will be established in coordination with the other subjects, at the beginning of the academic year. At the beginning of the course, the coordinator of the degree distribute practice groups in order to avoid overlaps with other subjects.

The subject is taught in the first semester. Teaching activities are developed in theory classes, solving numerical problems and laboratory practices. Tests will be conducted during the official period marked by the Faculty of Science. For those enrolled students, the times and dates of lectures and practical sessions will be announced through the official notice board Biotechnology Grade, and also in the moodle platform. These media will also be used to communicate to students enrolled, their distribution by groups of practices, made from the coordination of the Degree. A tentative dates will be available on the website of the Faculty of Science in the relevant section of the Degree in Biotechnology: https://ciencias.unizar.es/grado-en-biotecnologia. In this web may also consult the exam dates.

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=27124