Biochemical Engineering

Code: 102407
ECTS Credits: 6

2024/2025

Degree	Type	Year
2500897 Chemical Engineering	OT	4

Contact

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is recommended having reached the basic knowledge on: Biology and General Biochemistry, Reactors, Computer Applications and Simulation of Chemical Processes.

Objectives and Contextualisation

To relate and apply known concepts and methods in different subjects (from biology and biochemistry to the fundamental principles of chemical engineering) in the analysis and design of bioprocesses: how, when and where to apply the knowledge acquired. For this, basic knowledge must be achieved, know how to apply it and solve problems on different relevant aspects i bioindustrial processes, such as mass and energy balances, transport phenomena, design and proper use of a bioreactor according to its application, as well as the interaction between kinetics and operational mode. Finally, it is necessary to know how to correctly describe and design the variety of separation processes at different scales in the field of bioprocesses.

Competences

- Apply relevant knowledge of the basic sciences, such as mathematics, chemistry, physics and biology, and the principles of economics, biochemistry, statistics and material science, to comprehend, describe and resolve typical chemical engineering problems.
- Communication
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- Understand and apply the basic principles on which chemical engineering is founded, and more precisely: balances of matter, energy and thermodynamic momentum, phase equilibrium and kinetic chemical equilibrium of the physical processes of matter, energy and momentum transfer, and kinetics of chemical reactions

Learning Outcomes

1. "Relate and apply known concepts and methods from different subjects (from biology and biochemistry to the principles of chemical engineering) to the analysis and design of bioprocesses; know how, when and where to apply this acquired knowledge."
2. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
3. Describe the interaction between kinetics and bioreactor operation mode.
4. Develop a capacity for analysis, synthesis and prospection.
5. Develop critical thinking and reasoning
6. Develop curiosity and creativity.
7. Develop scientific thinking.
8. Explain, apply and resolve problems regarding matter and energy balance in bioindustrial processes.
9. Identify and apply immobilisation systems and their operation modes.
10. Work autonomously.

Content

TOPIC 1.- BIOCHEMICAL ENGINEERING AND BIOTECNOLOGY

- 1.1. Introduction to Biotechnological Processes. Involved sectors
- 1.2. Biochemical Engineering
- 1.3. Applications of enzymes, microorganisms and cells. New products
- 1.4. Fermentation

TOPIC 2.- ENZYMES. KINETICS AND APPLICATION

- 2.1. Introduction to enzymatic catalysis
- 2.2. Classification of enzymes
- 2.3. Enzyme kinetics
  - 2.3.1. Enzymatic reactions with one substrate
  - 2.3.2. *Michaelis-Menten* equation
  - 2.3.3. Determination of kinetic parameters
  - 2.3.4. Enzymatic reactions with inhibition
  - 2.3.5. Factors that influence activity and enzymatic stability
- 2.4. Use and application of enzymes

TOPIC 3.- CELULAR GROWTH

- 3.1. Phases of cell culture
- 3.2. Growth kinetics. Models
- 3.3. Effects of culture conditions in growth kinetics
- 3.4. Determination of cell density
- 3.5. Culture media and cell composition

TOPIC 4.- MASS AND ENERGY BALANCES

4.1. Cell growth, substrate uptake and product formation

4.2. Stoichiometry of the system

4.3. Yields

4.4. Mass and energy balances

4.4.1. Substrate as energy source. Intrinsic yield and maintenance coefficient

4.4.2. Elemental balances

4.4.3. Redox balance. Degree of reduction

TOPIC 5.- IMMOBILIZED BIOCATALYSTS

5.1. General concepts

5.1.1. Immobilization methods

5.1.2. Adsorption

5.1.3. Covalent chain

5.1.4. Cross-linking

5.1.5. Entrapment

5.1.6. Membranes

5.2. Selection of immobilization method

5.3. Kinetics of immobilized biocatalysts

5.3.1. External mass transfer

5.3.2. Internal mass transfer

5.4. Application of immobilized biocatalysts

TOPIC 6.- DESIGN OF IDEAL BIOREACTORS

6.1. Cell reactors

6.1.1. Batch reactor

6.1.2. Fed-batch reactor

6.1.3. CSTR

6.1.4. CSTR's in Series

6.1.5. CSTR with Recirculation

6.1.6. PFR

6.2. Enzyme reactors

6.2.1. Batch reactor

6.2.2. CSTR

6.2.3. PFR

TOPIC 7.- AERATION

7.1. Oxygen transfer rate (OTR)

7.2. Factors that influence the oxygen transfer rate

7.3. Oxygen uptake rate (OUR)

7.4. Experimental determination of $k_L a$ coefficient

7.4.1. Indirect methods

7.4.2. Direct methods

TOPIC 8.- AGITATION

8.1. Fermentation-broth rheology

8.2. Factors and effects of shear stress

8.3. Design of agitation systems

8.3.1. Type of Agitators

8.3.2. Agitator power requirements

8.4. Estimation of $k_L a$ coefficient in aerated systems

TOPIC 9.- STERILIZATION

9.1. Introduction and objectives

9.2. Physical methods of sterilization

9.2.1. Thermal treatments

9.2.2. Sterilization of gases

9.3. Chemical treatments

9.4. Other methods for microorganism control

TOPIC 10.- BIOREACTOR CONFIGURATION AND OPERATION

10.1. Configuration and elements of the different type of bioreactor

10.2. Bioreactor operation. Instrumentation and control

10.2.1. Fermenters

10.2.2. Cell culture

10.3. Scale-up

10.3.1. Theory of similarity

10.3.2. Most commonly applied methods

TOPIC 11.- SEPARATION AND RECOVERY OF PRODUCTS

11.1. Introduction to downstream processing in bioprocesses

11.2. Separation sequence

11.3. Separation of insoluble products

11.4. Cell disruption

11.5. Separation of soluble products

11.6. Examples in different bioprocesses

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Class practices (Problem solving)	15	0.6	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Expository lectures	30	1.2	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Seminars	5	0.2	1, 3, 4, 5, 6, 7
Type: Supervised			
Furhter tutorials	2	0.08	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Type: Autonomous			
Problem solving	50	2	1, 2, 3, 4, 5, 6, 8, 9, 10
Study	40	1.6	1, 2, 3, 4, 5, 6, 8, 9, 10
Tutorials with professor	2	0.08	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

The teaching methodology and the proposed evaluation may be modified depending on the restrictions applied by health authorities to the presentiality.

Teaching strategies: Expository lectures/Answers to questions. Seminars. Tutorials in group and individual. Problem solving in the classroom and proposals to the student.

Lectures and workshops: Students receive a set of, on one hand, theoretical concepts, and on the other hand practical skills for solving examples or easy problems. This learning will provide the basics for understanding the course and problem solving. In the workshop sessions the students will practice the concepts and skills acquired during the lectures. Small groups will easy the participation of the students in the problem solving process.

Specific Seminars: In these sessions the students will receive more practical and specific concepts acquired during the lectures. Presentation of case-studies are emphasized, promoting the participation of the students in the discussion of concepts and alternatives.

Communication environments: Virtual Forum. e-mail. Materials for study and documentation. Structured material: dossiers, exercises, etc ... Bibliography and other complementary materials on-line. Other teaching resources: Optional Specific software with teaching purposes.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Delivery and presentation of problems, activities and exercises	25 %	0	0	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Partial tests	30 %	2	0.08	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Synthesis test	45 %	4	0.16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

The teaching methodology and the proposed evaluation may be modified depending on the restrictions applied by health authorities to the presentiality.

To consider the subject passed, it will be necessary to obtain a minimum overall mark of 50/100.

a) Evaluation process and programmed activities
The continuous evaluation will be made considering a series of tests and activities:

- Problems, tasks, and exercises (PTE): 25 % of the final course mark.
- 1st partial test (PP1)) (topics 1 to 5): 15 % of the final course mark.
- 2nd partial test (PP2) (topics 6 to10): 15 % of the final course mark.
- Synthesis test (PS) (topics 1 to 11): 45 % of the final course mark.

The problems, tasks, and exercises (PTE) will be done individually or in groups and may or may not be problems from the subject list, specific study cases and activities based on key theoretical concepts of the corresponding topics.
The partial tests (PP1, PP2) will consist of a short problem and theoretical concepts of the corresponding topics (1h). The synthesis test (PS) will include all the content of the subject and will consist of a theoretical part and another with three problems (4h).
In the partial tests and the problems of the synthesis test, support material can be used: notes, books, forms, solved problems, computer, calculation tools, etc. In the theory part of the synthesis test no type of additional material may be used unless indicated by the teacher.

b) Time-scheduling of evaluation activities
The time-schedule of the evaluation and delivery of work activities will be published in the corresponding virtual platform (Moodle) and may be subject to possible programming changes for reasons of adaptation to possible incidents. Always being informed in the corresponding virtual Platform about these changes, since it is understood that this is the usual platform for exchange of information between teachers and students.

Tests will not be held on dates, times, and places other than those scheduled and disseminated by the Degree Coordination/School of Engineering. No change may be introduced without the approval of the degree coordination. After 30 minutes of the scheduled time of the evaluation activity, if it has not started, it will be cancelled. Canceled activities will be rescheduled.

c) Recovery process
Students who have failed the continuous evaluation or want to raise the mark will be able to take the final

recovery test (PR 75%) of all the partial and synthesis tests, not only of some of the tests. They must have been evaluated from a set of activities that represents a minimum of 2/3 parts of the total subject qualification. By taking this final recovery test, they waive the mark for all the partial and synthesis tests.
The final test will include all the content of the subject and will consist of a theoretical part and another with three problems (4h). In the problems of the final test, supporting material can be used: notes, books, forms, solved problems, computer, calculation tools, etc ... In the theory part of the final test no type of additional material can be used unless indicated by the teacher. In case of not taking the final test, the final course mark for the subject will be the obtained from the continuous evaluation.

d) Revision of the qualifications
For each evaluation activity, a place, date, and time of review will be indicated at the corresponding virtual platform (Moodle) in which the student can review the activity with the teacher.

e) Special qualifications
Granting a qualification of "matrícula de honor" (MH), apart from the minimum mark that can give access (≥ 9.00), is the decision of the faculty responsible for the course that will take into account the proactivity towards the subject, the understanding of the fundamentals and their relationship with other subjects and the fluency, reliability, expression and rational thinking. Special attention will be paid to the theoretical part of the synthesis and final tests. The MH resulting from calculating the 5% or fraction of people enrolled may be granted. Students will be considered Not Evaluable (NA) if have not been evaluated from a set of activities that represents a minimum of 2/3 parts of the total subject qualification.

f) Irregularities from the student, copying and plagiarism
If the student performs any irregularity that may lead to a significant variation in the grade of an evaluation act, this evaluation act will be graded with a 0, regardless of the disciplinary process that may be instructed. This evaluation activity will not be recoverable. The professor responsible for the subject will have to report these cases to the coordination of the degree that will record the fact.

g) Second registration or more
From the second registration, the student could choose between new continuous evaluation or a synthesis test that will be the same test (equal date and time) as the synthesis test (PS) for the students of first registration. It is mandatory to be communicated by e-mail to the teacher within the first 15 days of the course. Thus, the qualification of the course will correspond either to the continuous evaluation or just the mark of this test (PS 100%), replacing the continuous evaluation for all purposes. They could also do a final recovery test (PR 75% o 100%), according to requirements and conditions for the modality selected, and will be the same test (equal date and time) than the recovery test (PR 75%) for the students of first registration.

g) Single evaluation
This subject does not provide for a single evaluation system.

Bibliography

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- El-Mansi, EMT, Bryce, C.F.A., Demain, A.L., Allman, A.R. Fermentation Microbiology and Biotechnology, 3rd ed. CRC Press. (2011).
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- Liu, Sh. Bioprocess Engineering. Kinetics, Sustainability, and Reactor Design. Elsevier B.V. 2n ed. (2017). Versió digital.
- Shuler, M.L., Kargi, F., De Lisa, M. Bioprocess engineering: basic concepts. Prentice Hall PTR. 3rd ed. (2017).

Software

- Pal, Nirupam & Siletti, Charles & Petrides, Demetri. (2008). Superpro Designer: An Interactive Software Tool for Designing and Evaluating Integrated Chemical, Biochemical, and Environmental Processes.

Language list

Information on the teaching languages can be checked on the CONTENTS section of the guide.