UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2021/2022
MASTER'S DEGREE (MSC)	BIOMEDICAL ENGINEERING
INTEGRATED COURSE	MATERIALS BIOCOMPATIBILITY AND BIODEGRADATION - INTEGRATED COURSE
CODE	20273
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	ING-IND/23, ING-IND/22
HEAD PROFESSOR(S)	DINTCHEVA NADKA TZANKOVA — Professore Associato — Univ. di PALERMO
OTHER PROFESSOR(S)	DI FRANCO FRANCESCO — Professore Associato — Univ. di PALERMO DINTCHEVA NADKA TZANKOVA — Professore Associato — Univ. di PALERMO
CREDITS	12
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**DI FRANCO FRANCESCO** Monday 13:00 14:00 Studio personale. Wednesday 13:00 14:00 Studio personale. Friday 13:00 14:00 Studio personale. **DINTCHEVA NADKA TZANKOVA** Tuesday 14:00 16:00 DICAM - Ed. 6, terzo piano Thursday 14:00 16:00 DICAM - Ed. 6, terzo piano

DOCENTE: Prof.ssa NADKA TZANKOVA DINTCHEVA

PREREQUISITES	General and Inorganic Chemistry, science and technology of materials, basic electricity with an emphasis on Ohm's Laws.
LEARNING OUTCOMES	Knowledge and understanding At the end of the course student is expected to have a deep understanding of the mechanism of degradation processes and on their nature as a function of the environmental physico-chemical conditions with special emphasis on the degradation in biological environment. Student will be aware on the biocompatibility of employed materials, and of the synergistic effect of stress in materials degradation and failure. He/she is expected to know the protection methods and strategies and to isolate the critical issues responsible of material degradation and the consequent effect on human body. Applying knowledge and understanding Student is expected to know degradation mechanism and morphology of the material in different environments. Thanks to this fundamental knowledge he/she will be able to understand causes of the degradation processes involving biomaterials, being able to select the most appropriate surface treatment to enhance degradation resistance of material according to the environmental conditions. Making judgments Starting from knowledge of the theoretical aspects of the degradation processes as well as from the laboratory experiences the student is expected to be able to match the right metallic biomaterial with the environment where the latter is supposed to work, and he/she will regulate the material composition and its surface finishing, in order to ensure safe and correct functioning during operating conditions. Communication Student is expected to be able to work autonomously and collaborate with other team members involved in the same project (biomaterial selection and/or maintenance). Learning skills Following a deep understanding of the theoretical aspects and after laboratory experience, student is expected to be able to seek advice from technical regulations, technical manuals, scientific literature updating frequently his/her knowledge.
ASSESSMENT METHODS	Oral exam and discussion on a case study selected by the student. To earn the minimum score, student must know the fundamental aspects of the course. Higher score will be attributed according to the student ability in applying knowledge and skills learned in this course to practical and technical problems, and according to what extent students are aware of the steps they go through in solving problems and how well they can explain their problem-solving steps. The final assessment, properly graded, will be made on the basis of the following conditions: a) sufficient knowledge of subjects and theories addressed in the course; sufficient degree of awareness and autonomy in the application of theories to solve the problems (rating 18-21); b) Good knowledge of subjects and theories addressed in the course; fair degree of awareness and autonomy in the application of theories to solve the problems (rating 22-25); c) Good knowledge of subjects and theories addressed in the course; good degree of awareness and autonomy in the application of theories to solve the problems (rating 26-28); d) Excellent knowledge of subjects and theories addressed in the course; excellent level of awareness and autonomy in the application of theories to solve the problems (rating 29-30L). The final assessment will be performed in the same way for attending and not attending students.
TEACHING METHODS	Frontal lectures, Laboratory and Demonstration Sessions, Laboratory Practice Sessions.

MODULE **BIOCOMPATIBILITY AND BIODEGRADATION OF METALLIC AND CERAMIC MATERIALS** *Prof. FRANCESCO DI FRANCO*

SUGGESTED BIBLIOGRAPHY	
Pietro Pedeferri, Corrosione e protezione dei materiali metallici. Vol. I e Vol. II, polipress, 2007, Milano Italia, ISBN 8873980619. Advances in Metallic Biomaterials, M. Niinomi, T. Narushima, M. Nakai Editors, Springer-Verlag Berlin Heidelberg 2015, ISBN 978-3-662-46836-4. Lectures notes and powerpoint presentations.	
AMBIT	20909-Attivit Formative Affini o Integrative
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
EDUCATIONAL OBJECTIVES OF THE MODULE	
The aim of the course is to provide basic concepts of corrosion processes and the tools for a correct selection of the biomaterials, of the protection and prevention methods to control and limit the damages and failure.	

SYLLABUS

Hrs	Frontal teaching
1	Introduction. General aspects of corrosion processes. Metallic biomaterials in aggressive enviroments. Direct and indirect corrosion damages.
6	Wet and dry corrosion. Electrochemical mechanism of corrosion. Corrosion reactions: anodic and cathodic half cell reactions. Farday’s law. Thermodynamics of corrosion. Standard potential, Nernst Equation and Pourbaix diagrams.
6	Kinetic of corrosion. Cathodic and anodic overvoltage.Charge transfer and mass transfer control. Passivation conditions. Evan’s diagrams. Influence of metal on corrosion processes.
2	Fundamentals of Surfaces: Physics and Chemistry of Surfaces (and Relevance to Biomedical Application). Surface tension and wettability, surface charges.Influence of body fluid on surface chemistry. Biological behaviour of surfaces: protein adsorption on surfaces, Cell material interaction, Influence of biology on material behaviour.
5	Corrosion attack morphology: generalized corrosion, galvanic coupling, pitting corrosion, crevice corrosion, selective dissolution, intergranular corrosion, turbulence corrosion, erosion corrosion, impingement corrosion, stress corrosion cracking, fatigue corrosion, hydrogen embrittlement, microbial corrosion.
5	Corrosion of metallic biomaterials in cell colture. Effect of Components and Physiological Environment on Corrosion of Metallic Biomaterials Corrosion of Degradable and Hybrid Metallic Biomaterials Corrosion of Nanostructure Metallic Implants. Corrosion of Bio-absorbable Metallic Materials. Corrosion of implant materials in the body. Mechanical working conditions in the human body.
3	Protection of metallic biomaterials. Surface finishing: tumbling, electropolishing, passivation and anodizing. Surface oxide film on metallic materials in biological environment.
2	Electrochemical Measurements in Cell Culture Environments. Electrochemical Impedance measurements. Standard Tests for Evaluation of Corrosion of Metallic Biomaterials in Physical Body Fluid.
2	Alloying electrochemistry and corrosion resistance of metallic biomaterials: stainless steel, Cobalt-based alloys, Titanium alloys, NiTi shape-memory alloys, Magnesium alloys, Tantalum, Zirconium alloys.
1	Effect of corrosion-failure of implants (Cardiovascular Implants, Corrosion of Dental Implants, Corrosion of Orthopedic Implants).
1	Monitoring, Control and Prevention Practices of Biomaterials Corrosion.
2	Corrosion tests (corrosion rate estimate, coating efficiency corrosion prevention and/or in corrosion mitigation, interpretation of the experimental results, etc.).
1	Design and selection of material: data base consulting, smart systems and regulations. Economic evaluation and reliability assessment.

Hrs	Practice
2	Pourbaix diagrams from thermodynamics data and their use in corrosion studies.
2	Kinetic parametrs estimated from polarization curves. Evans diagram construction.
2	Kinetic of redox $K_4Fe(CN)_6$ - $K_3Fe(CN)_6$ redox reaction. H_2 evolution on Pb and Pt. O_2 reduction.
3	Impedance in the complex plane: resistance, capacitor, inductor. Frequency responce of RC series and parallel. Lab course on Impedance of RC circuit on bread board
2	Experimental determination of corrosion potential and corrosion rate (d.c. and a.c. methods to estimate polarization resistance)

2	Corrosion products identification by X-ray diffraction and Raman Spectroscopy. Analysis of the attack morphology by scanning electron microscopy.
2	Growth and corrosion resistance of anodic films on Al and Mg alloys.
2	Passivation and corrosion resitance of Ti and Ti alloys, and of carbon and stainless steels.

MODULE
BIOCOMPATIBILITY AND BIODEGRADATION OF POLYMERIC MATERIALS

Prof.ssa NADKA TZANKOVA DINTCHEVA

SUGGESTED BIBLIOGRAPHY

• Frederick H. Silver and David L. Christiansen, “Biomaterials Science and Biocompatibility”, Springer (ISBN: 978-1-4612-0557-9)
• Shayne Cox Gad, Samantha Gad-McDonald, “Biomaterials, Medical Devices, and Combination Products: Biocompatibility Testing and Safety Assessment”, CRC Press (ISBN 9781482248371)
• Myer Kutz, “Handbook of Environmental Degradation of Materials”, Elsevier (;eBook ISBN: 9780323524735; Hardcover ISBN: 9780323524728)
• W.F. Smith, “Scienza e Teclonologia dei Materiali”, Mc Graw Hill (ISBN-13: 9788838667657)

AMBIT	20909-Attivit Formative Affini o Integrative
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

The course aims to investigate some issues related to the definition and verification of biocompatibility of polymeric, ceramic and metal materials. The main methods of formulation, production and characterization of biocompatible materials will be studied. Some concepts of formulation, production and characterization of biocompatible composite materials will also be discussed. A further objective of the course is to further study the mechanisms of degradation and biodegradation of materials and natural and artificial aging. The final part of the course includes a brief introduction on the methods of protection and stabilization of the biocompatible materials.

SYLLABUS

Hrs	Frontal teaching
4	Definitions of biocompatibility of materials and regulatory aspects of the interactions between biological materials and tissues
2	Evaluation of biocompatibility through experimental methods: in vitro, in vivo and animal model tests or clinical trials on patients
4	Cytotoxicity and genotoxicity: definitions and examples
8	Biocompatible polymeric materials: structure, composition and production
4	Additives for biocompatible polymeric materials (antioxidants, stabilizers, lubricants and elasticizers): chemical composition, introduction into biomaterials and release
8	Biocompatible ceramic materials: structure, composition, production and properties
6	Metallic materials and biocompatible metal alloys: structure, composition, production and properties
3	Biocompatible composites: structure, composition, production and properties
5	Mechanisms of degradation and biodegradation of materials: times and rate of degradation
6	Protection and stabilization of biocompatible materials

Hrs	Practice
2	Evaluation of biocompatibility through experimental methods
8	Properties, functioning and biocompatibility of biocompatible polymeric materials
3	Biocompatible composites: structure, composition, production and properties
5	Mechanisms of degradation and biodegradation of materials: times and rate of degradation
4	Natural and artificial aging of materials: definition and monitoring through experimental methods