FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish: Sensory i biosensory w przemyśle produktów specjalistycznych
Name of subject in English: Sensors and biosensors in fine chemicals manufacturing
Main field of study (if applicable): Chemical Technology
Specialization (if applicable): Technology of Fine Chemicals
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code: TCC024029
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	60		90		
Form of crediting	crediting with grade		crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	2		3		
including number of ECTS points for practical (P) classes			3		
including number of ECTS points for direct teacher-student contact (BK) classes	1		1		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge in the field of inorganic, analytical, physical, organic chemistry and physics.
2. Basic knowledge in the field of analytical techniques.

SUBJECT OBJECTIVES

C1 Acquainting students with issues on the mechanisms of the action of chemical sensors and biosensors and the detection methods used in sensorics.
C2 To familiarize students with the fundamentals of physicochemical design of chemical sensors and biosensors.
C3 To familiarize students with issues on the use of chemical sensors and biosensors as analytical tools in medical diagnostics, bioanalytics, food analytics, environmental protection and process control.

SUBJECT LEARNING OUTCOMES

relating to knowledge:

SEE_K01 – has knowledge about defining the concept of a chemical sensor and biosensor and knowledge about the classification of sensors due to the principle of operation and the way of detection of the analyte.
SEE_K02 – can explain the principles of operation (detection) of the electrochemical, optical, mass or thermal sensor.
SEE_K03 − can classify receptor elements in a sensor device, describe the principles of their operation in particular types of chemical sensors and biosensors.
SEE_K04 – is able to define analytical parameters of sensors and biosensors and assess the possibilities of their use as analytical tools in various industries, in environmental protection, and in the broadly understood diagnostics.

PROGRAMME CONTENT

Lectures		**Number of hours**
Lec 1	General characteristics of a chemical sensor and biosensor. Types of chemical sensors. Division of biosensors due to the classic principle of operation.	2
Lec 2	Basics of chemical recognition - operational parameters of sensors: measuring range, detection limits, sensitivity, selectivity, repeatability, response time, operational lifetime and life time during storage. Measurement methods: based on the calibration curve and internal standard method.	2
Lec 3	Classification of sensors due to the type of transducer (electrochemical, optical, mass, thermal).	2
Lec 4	Classification of biosensors due to the type of receptor (e.g. enzymes, antibodies, DNA) affecting the bioselectivity of the sensor and the type of transducer affecting the sensitivity of the biosensor.	2
Lec 5-6	Physical basis of analytical optical methods used in the sensors: radiation absorption, fluorescence, chemiluminescence, bioluminescence. Optical sensors for the determination of pH, oxygen, metal ions. The phenomenon of the evanescent wave and its application in optical biosensors. Surface plasmon resonance (SPR). Piezoelectric effect. Application of a piezoelectric crystal as a mass sensor (quartz microbalance). Sensors using acoustic waves in piezoelectric crystals. The use of reaction heat in the construction of thermal sensors.	4
Lec 7	Biological material used in the construction of biosensors: enzymes, tissues, cellular organelles (mitochondria, chloroplasts), microorganisms (bacteria, yeast, unicellular algae), higher organisms and their organs (e.g. insects), antibodies, nucleic acids (DNA), other compounds biologically active (e.g., hemoglobin). Indicator organisms as biosensors.	2
Lec 8	Methods of immobilization of biological material in biosensors: adsorption, cross-linking, entrapment in polymeric gels, covalent bonding, microencapsulation.	2
Lec 9	Amperometric enzyme electrodes on the example of a classic electrode for determining glucose concentration. First, second and third generation electrodes.	2
Lec 10-11	Applications of sensors and biosensors in sports medicine and medicine, in production control and food analysis (including GMO), in the control of biotechnological processes, in environmental protection, in defense, in scientific research.	4
Lec 12	Lab-on-a-chip (LOC), the idea of the analytical microchip, the use of LOC in chemical and biochemical analysis (medical diagnostics), the use of devices in the food industry, cosmetics and environmental protection.	2
Lec 13	Nanomaterials used in the construction of sensing devices.	2
Lec 14	Biomimetic sensor devices: artificial nose, artificial tongue, fragrance reproduction.	2
Lec 15	Perspectives for the development of sensor devices: further miniaturization of devices and related problems, multifunctional devices, personalized diagnostics (POC, *point-of-care*), commercialization.	2
	Total hours	**30**
Laboratory		**Number of hours**

Lab 1	**Organizational classes -** health and safety regulations, discussion of the program of classes and the conditions for passing the course. Discussion of basic electroanalytical techniques used in sensorics and biosensorics (voltammetric techniques, i.e. cyclic voltammetry - CV, differential-pulse voltammetry - DPV, chronoamperometry - CA, polarographic techniques, potentiometric techniques).	2
Lab 2	**Potentiometry -** direct potentiometry methods (standard addition method), the use of ion-selective electrodes to determine the content of i.e. chloride, magnesium, potassium and hydrogen ions in food products. Selectivity of ion-selective electrodes, limits of quantification.	4
Lab 3	**Voltammetric methods -** characteristics of the working electrode (platinum electrode, glassy carbon (GC), and gold electrode). Selection of the reference electrode. Preparation of electrodes for work, storage, cleaning, measurements and selection depending on the depolarizer used.	4
Lab 4	**Techniques of the DC voltammetry in sensors -** determination of N-acetyl-4-aminophenol (paracetamol) by cyclic voltammetry (CV) and differential-pulse voltammetry (DPV).	4
Lab 5	**Semiconducting structures in sensors' fabrication -** electrode modification. Electropolymerization of conjugated systems (eg. aniline and its derivatives) by voltammetric and chronoamperometric method. Characteristics of the obtained polymer films.	4
Lab 6	**Biosensors.** Study of the activity of enzymes used in biosensorics by spectrophotometric methods. Determination of optimal working conditions of the enzyme as a native and immobilized protein.	4
Lab 7	**Biosensor for determination of the glucose level.** Characteristics of the work of enzyme biosensors based on a glucometer - familiarization with enzyme immobilization techniques on the electrode surface, determination of glucose concentration in solutions and biological samples. Determination of the limits of quantification, selectivity of	4
Lab 8	**Semiconducting nanostructures in sensors and biosensors** - synthesis and modification of the nanomaterials' surface to prepare the substructure for the construction of biosensors.	4
	Total hours	**30**

TEACHING TOOLS USED

T1. Lecture with audiovisual media.
T2. Laboratory classes - performing experiments.
T3. Laboratory classes - preparation of the report.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P (lecture)	SEE_K01 – SEE_K04	Rating of the final test to verify the student's knowledge of the sensorics
F1 (laboratory)	SEE_K01 – SEE_K04	Rating of the final test to verify the student's knowledge of the analytical techniques connected with sensors
F2 (laboratory)	SEE_K01 – K04	The correctness of the performing of experiments and

		the preparation of reports

P (laboratory) = F1 + F2

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Z. Brzózka, W. Wróblewski, *Sensory chemiczne*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 1999
[2] Z. Brzózka, *Mikrobioanalityka*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2009
[3] Florinel-Gabriel Bănică, *Chemical Sensors and Biosensors: Fundamentals and Applications*, John Wiley and Sons, Chichester, 2012
[4] Elementy Analizy Instrumentalnej, *Ćwiczenia z Chemii Analitycznej – Zaawansowane Materiały i Nanotechnologia*, Akademia Górniczo – Hutnicza w Krakowie, 2009

SECONDARY LITERATURE:

[5] W. Szczepaniak: Metody instrumentalne w analizie chemicznej, PWN, Warszawa 1996.
[6] I. Ufnalska, *Woltamperometria*, Politechnika Warszawska, Warszawa, 2015.
[7] R. F. Taylor, J. S. Schultz (red.), *Handbook of chemical and biological sensors*, Wydawnictwo IOP, Philadelphia, Bristol, 2003
[8] B.D. Malhotra, A. Chaubey, S.P. Singh, *Prospects of conducting polymers in Biosensors*, Analytica Chimica Acta 578 (2006) 59 – 74
[9] M. Gerard, A. Chaubey, B.D. Malhotra, *Application of conducting polymers to biosensors*, Biosensors & Bioelectronics 17 (2002) 345 – 359
[10] A. Hulanicki, *Współczesna chemia analityczna*, PWN, Warszawa 2001

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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