

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Elektrokemijski procesi in protikorozijska zaščita materialov
Course title:	Electrochemical Processes and Corrosion Protection

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 3. stopnja Nanosciences and Nanotechnologies, 3 rd cycle	-	1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: NANO3-796

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike Others	Samost. delo Individ. work	ECTS
15	15			15	105	5

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transferred to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Ingrid Milošev

Jeziki / Languages: **Predavanja / Lectures:** Slovensko, angleško / Slovenian, English
Vaje / Tutorial:

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Zaključena druga stopnja bolonjskega študija.
Predznanje iz fizikalne in anorganske kemije.

Prerequisites:

Completed the second-level of the Bologna study program. Basic knowledge of physical and inorganic chemistry.

Vsebina:

1. Uvod v elektrokemijo in korozijo materialov
 2. Termodinamika elektrokemijskih procesov; kinetika elektrokemijskih procesov; pH-diagrami
 3. Vrste korozije: splošna korozija, intergranularna, selektivno raztapljanje, napetostno korozijsko pokanje, jamičasta, plastovita, korozijsko utrujanje, galvanska, erozivna, špranjska
 4. Metode merjenja korozijskih procesov: merilna oprema in korozijska celica; elektrokemijske metode; slana vlažna komora, metoda izgube mase
 5. Protikorozijska zaščita: izbira materiala in design; modifikacije elektrolita; korozijski inhibitorji; anodna in katodna zaščita; prevleke: elektroplatiniranje, konverzijske prevleke, anodizacija, fosfatiranje, kromiranje

Content (Syllabus outline):

1. Introduction to electrochemistry and corrosion of materials
 2. Thermodynamics of electrochemical processes; kinetics of electrochemical processes; pH-diagrams
 3. Types of corrosion: general, intergranular, selective, stress corrosion cracking, pitting, exfoliation, fatigue, galvanic, erosion, crevice
 4. Measurements of corrosion processes: instrumentation and experimental set-up; electrochemical methods, salt spray chamber, gravimetric method
 5. Corrosion prevention and control: materials selection and design; modification of electrolyte, corrosion inhibitors; anodic and cathodic protection; coatings: electroplating, conversion

6. Sodobni načini zaščite: samourejene plasti; sol-gel prevleke; funkcionalne prevleke
 7. Korozijski procesi pod specifičnimi pogoji: korozija v vodi in vodnih raztopinah (morje, tla, beton, industrijski procesi); atmosferska korozija; mikrobiološka korozija; korozija biomaterialov
 8. Izbrani primeri protikorozijske zaščite pomembnih inženirskih materialov: jekla in nerjavna jekla; aluminij in aluminijeve zlitine, baker in bakrove zlitine, nikelj in nikeljeve zlitine, cink, titan in titanove zlitine, kobalt in kobaltove zlitine

coatings, anodization, phosphating, chromating
 6. Contemporary corrosion protection: sol-gel coatings, self-assembled layers, functional coatings
 7. Corrosion processes under specific conditions: corrosion in water and aqueous solutions (sea, soil, concrete, industrial atmospheres); atmospheric corrosion, microbial corrosion, corrosion of biomaterials
 8. Corrosion protection of important engineering materials; steels and carbon steels, aluminium and its alloys, copper and its alloys, nickel, zinc, titanium and titanium alloys, cobalt and cobalt alloys

Temeljni literatura in viri / Readings:

- »Modern Electrochemistry 2A«, J. O'M Bockris, A.K.N. Reddy, M. Gamboa-Aldeco, 2nd ed., Kulwer Academic / Plenum Publishers, New York, 2000
- »Corrosion Mechanisms in Theory and Practice«, P. Marcus, J. Oudar (Eds.), M. Dekker, New York, 2002.
- »Uhling's Corrosion Handbook«, R. Winstone Revie (Ed.), 3rd ed., Electrochemical Society Series, Wiley-Interscience, 2011
- »Active protective coatings«, A.E. Hughes, J.M.C. Mol, M.L. Zheludkevich, R.G. Buchheit, R.G. (Eds.) Springer, 2016
- »Fundamentals of metallic corrosion«, Corrosion Engineering Handbook, P.A. Schweitzer, 2nd. ed., CRC Press, 2007
- »Corrosion of aluminum and aluminum alloys«, J.R. Davis (ed.), ASM International, 2000
- »Corrosion behaviour and protection of copper and aluminium alloys in seawater«, D. Féron (ed.), Woodhead Publishinh in Materials, 2007

Cilji in kompetence:

- pridobiti osnovno znanje o elektrokemijskih procesih s posebnim poudarkom na koroziji
- osvojiti elektrokemijske in ostale metode, ki se uporabljajo pri študiju korozijskih procesov
- spoznati se z različnimi tipi korozijskih procesov pri različnih pogojih
- vrednotiti različne metode protikorozijske zaščite
- pridobiti znanja o karakterizaciji različnih protikorozijskih zaščit
- priporočati, kako uporabiti pridobljena znanja v praksi oz. industrijskih aplikacijah

Objectives and competences:

- to gain knowledge on electrochemical processes with an emphasis on corrosion processes
- to learn about different electrochemical methods used in the study of of corrosion protection
- to learn about other methods used in the study of of corrosion protection
- to acquire knowledge of different forms of corrosion under various conditions
- to learn about the methods of corrosion protection
- to learn about the methods for characterization of corrosion protection
- to discuss how to apply knowledge gained in everyday life and industrial application

Predvideni študijski rezultati:

- Znanje in razumevanje:
- Poznavanje mehanizmov elektrokemijskih procesov kot osnova za razumevanje korozijskih

Intended learning outcomes:

- Knowledge and understanding:
- Knowledge on mechanisms of electrochemical reactions which are the basis for understanding

procesov, ki potekajo v različnih okoljih.

- Združitev teoretičnih in praktičnih znanj, ki bo omogočila izbiro primerne protikorozijske zaščite.
- Razširitev splošnega znanja na področju materialov.

of corrosion processes in various environments.

- Theoretical and practical knowledge on selection of appropriate corrosion protection.
- Course will contribute to a broader knowledge on materials

Metode poučevanja in učenja:

Predavanja in seminarji
Individualno delo s študenti

Learning and teaching methods:

Lectures and seminars
Individual work with students

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
<ul style="list-style-type: none"> • seminar • ustni izpit 	50 % 50 %	<ul style="list-style-type: none"> • seminar • oral exam

Reference nosilca / Lecturer's references:

- I. Milošev, G.S. Frankel
Conversion coatings based on zirconium and/or titanium: a review
Journal of the Electrochemical Society, 165 (3) (2018) C1-C18
- U. Tiringer, J. Kovač, I. Milošev
The effect of mechanical and chemical pre-treatments on the surface morphology and composition of aluminium alloys 7075-T6 and 2024-T3
Corrosion Science, **119** (2017) 46-59
- G. Žerjav, A. Lanzutti, F. Andreatta, L. Fedrizzi, I. Milošev
Characterization of self-assembled layers made with stearic acid, benzotriazole or 2-mercaptobenzimidazole on surface of copper for corrosion protection in simulated urban rain
Materials and Corrosion, **68** (2017) 30-41
- I. Milošev, P. Rodič
Cerium chloride and acetate salts as corrosion inhibitors for AA7075-T6 in sodium chloride solution
Corrosion, **72 (8)** (2016) 1021-1034
- P. Rodič, J. Iskra, I. Milošev
Hybrid organic-inorganic sol-gel coatings for protection of AA7075-T6 alloy against corrosion in Harrison's solution
Journal of Sol-Gel Science and Technology **70** (2014) 90-103