UČNI NAČRT

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Termična, sestavna in morfološka analiza materialov
Course title:	Thermal, textural and morphological analysis of materials

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
MŠP Kemija, 2. stopnja	Materiali za shranjevanje in pretvorbo energije	2	3
USP Chemistry, 2nd Cycle	Materials for Energy Storage and Conversion	2nd	3rd

Vrsta predmeta / Course type	Obvezni / Mandatory
Univerzitetna koda predmeta / University course code:	

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
20	10	15	/	/	45	3

Nosilec predmeta / Lecturer:	doc. dr. Boštjan Genorio & izr. prof. dr. Marjan Marinšek / dr. Boštjan Genorio, Assistant Professor & dr. Marjan Marinšek, Associate Professor

Jeziki / Languages:	**Predavanja / Lectures:**	**Angleški / English**
	Vaje /	**Angleški / English**

Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Predmet imajo opredeljen kot študijsko obveznost študenti, ki so vključeni v projekt "Materiali za shranjevanje in pretvorbo energije +" (MESC+). Lahko ga vpišejo tudi drugi tuji študenti na mednarodni izmenjavi na UL. Študenti morajo biti vpisani na MŠP Kemija, 2. stopnja, ali imeti podpisan učni sporazum (LA) med UL FKKT in drugimi tujimi izobraževalnimi ustanovami.	This course will be assigned to the students who are part of the “Materials for Energy Storage and Conversion +” (MESC+) project. It is available to other foreign international exchange students as well. Students must be enrolled to the USP Chemistry, 2nd Cycle or have signed learning agreement between UL FKKT and other foreign educational institution.

Vsebina:	**Content (Syllabus outline):**
1. Metode določevanja velikosti in porazdelitve velikosti delcev: definicija disperznega sistema, problem določevanja velikosti nepravilnih delcev, meritve velikosti delcev in porazdelitve velikosti delcev, določevanje faktorjev oblike, definicija specifične površine in meritev specifične površine disperznega sistema, definicija poroznosti in merjenje poroznosti disperznega sistema. 2. Termoanalizne tehnike: definicija koncepta termične analize, termogravimetrija (TG), diferenčna termična analiza (DTA) in dinamična kalorimetrija (DSC), TG in DSC kot komplementarni metodi (termična dekompozicija/fazni prehodi). Analiza eksperimentalnih podatkov, zajetih s TG, DTA in DSC metodami za vzorec neznane sestave. 3. Elektronska, IR in Ramanska spektroskopija: teoretične osnove IR in Ramanske spektroskopije, principi in primeri IR in Ramanskih meritev. 4. Mikroskopija (optična, elektronska): optična in elektronska (SEM, TEM) mikroskopija,EDS in WDS spektroskopija, elektronska difrakcija v TEM mikroskopiji,	1. Methods for particle size measurement: Definition of disperse systems, particle size determination for irregular particles, particle size and size distribution measurements, shape factor determination, specific surface of a disperse system and specific surface measurements, porosity of a disperse system and porosity measurements. 2. Thermoanalytical techniques: Definition of the concept “thermal analysis”. Thermogravimetry (TG); differential thermal analysis (DTA) and dynamic scanning calorimetry (DSC). TG and DSC as complementary methods (thermal decomposition/phase transition). Analysis of experimental data from TG, DTA and DSC curves, obtained from the compounds with known composition. 3. Electron, IR and Raman spectroscopy: theory of IR and Raman spectroscopies, principles and examples of IR and Raman measurements. 4. Microscopy (optical, electron, scanning probe): optical and electron microscopy (SEM, TEM), EDS and WDS spectroscopy, electron

mikroskopija na atomsko silo (AFM), vrstična tunelska mikroskopija (STM), primeri mikrostrukturne kvantitativne analize različnih materialov.	diffraction in TEM microscopy, atomic force microscopy (AFM), scanning tunneling microscopy (STM), examples of microstructure quantitative analysis of materials.

Temeljni literatura in viri / Readings:

1.) D. A. Skoog, F. J. Holler, S. R. Crouch, Principles of instrumental analysis, 7th Edition, Cengage Learning, **2017**, 992 strani (50%).
2.) P. Haines, Principles of Thermal Analysis and Calorimetry, Royal Society of Chemistry, **2002**, 268 strani (20%).
3.) Paul van der Heide, X-ray Photoelectron Spectroscopy: An introduction to Principles and Practices, John Wiley & Sons, Inc., 2011, 264 strani (20%)
4.) J.R. Ferraro, K. Nakamoto, C.W. Brown, Introductory Raman Spectroscopy, Academic Press, 2003, 434 strani (10%)

Cilji in kompetence:	**Objectives and competences:**
Ob zaključenem kurzu študenti: • Razumejo principe različnih analiznih tehnik s področja ved o materialih • Znajo uporabiti različne analizne tehnike za analitiko materialov s področja shranjevanja in konverzije energije • Razumejo omejitve pri uporabi različnih analiznih tehnik • Znajo samostojno delati z izbrano sofisticirano analizno opremo.	At the end of this course students should be able to: • Understand the principles of the various analytical techniques applied in Material science. • Apply individual analytical techniques for novel materials related to energy storage and conversion applications. • Understand the limitations of individual analytical techniques. • Be able to perform specific measurements on specific analytical apparatus.

Predvideni študijski rezultati:	**Intended learning outcomes:**
<u>Znanje in razumevanje</u> Študentje spoznajo različne analizne tehnike, ki omogočajo poglobljeno analizo različnih materialov.	<u>Knowledge and Comprehension</u> Students learn about various analytical techniques that enable thorough characterization of materials.

Uporaba	Application
Pridobljeno znanje se lahko uporabi za reševanje problemov, povezanih z razvojem naslednje generacije materialov za shranjevanje in konverzijo energije na akademskem in industrijskem nivoju. Refleksija Pridobljeno znanje je orodje, ki študentu omogoča reševanje problemov, povezanih z alternativnimi tehnologijami prihodnosti. Prenosljive spretnosti Pridobljeno znanje je direktno prenosljivo tudi na druga področja znanosti.	Acquired knowledge will be used in problem solving for the next generation energy storage and conversion devices in academia and European industry. Analysis The acquired knowledge is a tool that gives a student the leverage to solving current problems of important alternative technologies of the future. Skill-transference Ability Acquired knowledge is directly transferable to other fields of science.

Metode poučevanja in učenja: **Learning and teaching methods:**

Predavanja, seminarji, laboratorijsko delo	Lectures, seminars and labwork.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Laboratorijsko delo	**30%**	Labwork
Pisni izpit	**70%**	Written exam

Reference nosilca / Lecturer's references:

(1) Genorio, B.; Strmcnik, D.; Subbaraman, R.; Tripkovic, D.; Karapetrov, G.; Stamenkovic, V. R.; Pejovnik, S.; Marković, N. M. Selective Catalysts for the Hydrogen Oxidation and Oxygen Reduction Reactions by Patterning of Platinum with Calix [4] Arene Molecules. *Nat. Mater.* **2010**, *9* (12), 998–1003.

(2) Genorio, B.; Lu, W.; Dimiev, A. M.; Zhu, Y.; Raji, A.-R. O.; Novosel, B.; Alemany, L. B.; Tour, J. M. In Situ Intercalation Replacement and Selective Functionalization of Graphene Nanoribbon Stacks. *ACS Nano* **2012**, *6* (5), 4231–4240. https://doi.org/10.1021/nn300757t.

(3) Vizintin, A.; Lozinšek, M.; Chellappan, R. K.; Foix, D.; Krajnc, A.; Mali, G.; Drazic, G.; Genorio, B.; Dedryvère, R.; Dominko, R. Fluorinated Reduced Graphene Oxide as an Interlayer in Li–S Batteries. *Chem. Mater.* **2015**, *27* (20), 7070–7081. https://doi.org/10.1021/acs.chemmater.5b02906.

(4) Strmcnik, D.; Lopes, P. P.; Genorio, B.; Stamenkovic, V. R.; Markovic, N. M. Design Principles for Hydrogen Evolution Reaction Catalyst Materials. *Nano Energy* **2016**, *29*, 29–36. https://doi.org/10.1016/j.nanoen.2016.04.017.

(5) Staszak-Jirkovský, J.; Malliakas, C. D. D.; Lopes, P. P. P.; Danilovic, N.; Kota, S. S. S.; Chang, K.-C.; Genorio, B.; Strmcnik, D.; Stamenkovic, V. R. R.; Kanatzidis, M. G.; et al. Design of Active and Stable Co-Mo-Sx Chalcogels as PH-Universal Catalysts for the Hydrogen Evolution Reaction. *Nat. Mater.* **2016**, *15* (November), 197–203. https://doi.org/10.1038/nmat4481.

(6) Bobnar, J.; Lozinšek, M.; Kapun, G.; Njel, C.; Dedryvère, R.; Genorio, B.; Dominko, R. Fluorinated Reduced Graphene Oxide as a Protective Layer on the Metallic Lithium for Application in the High Energy Batteries. *Sci. Rep.* **2018**, *8* (1), 5819. https://doi.org/10.1038/s41598-018-23991-2.

(7) SKALAR, Tina, ZUPAN, Klementina, MARINŠEK, Marjan. Microstructure tailoring of combustion-derived Ni-GDC and Ni-SDC composites as anode materials for intermediate temperature solid oxide fuel cells. *Journal of the Australian Ceramic Society*, ISSN 2510-1579, Mar. 2019, vol. 55, iss. 1, str. 123-133, ilustr. https://link.springer.com/article/10.1007/s41779-018-0218-z.

(8) MARQUES, Susana, MESTRE, Ana S., MACHUQUEIRO, Miguel, ŽGAJNAR GOTVAJN, Andreja, MARINŠEK, Marjan, CARVALHO, Ana Paula. Apple tree branches derived activated carbons for the removal of ß-blocker atenolol. *Chemical engineering journal*, ISSN 1385-8947. [Print ed.], Aug. 2018, vol. 345, str. 669-678, ilustr. https://www.sciencedirect.com/science/article/pii/S1385894718300925.

(9) ŠTUKOVNIK, Petra, BOKAN-BOSILJKOV, Violeta, MARINŠEK, Marjan. Microstructural changes in cement mortar due to an alkali carbonate reaction = Spremembe mikrostrukture cementne malte zaradi alkalno karbonatne reakcije. *Materiali in tehnologije*, ISSN 1580-2949. [Tiskana izd.], 2019, letn. 53, št. 3, str. 425-432, ilustr. http://mit.imt.si/Revija/izvodi/mit193/stukovnik.pdf

(10) PORI, Maja, ARČON, Iztok, LAŠIČ JURKOVIĆ, Damjan, MARINŠEK, Marjan, DRAŽIĆ, Goran, LIKOZAR, Blaž, CRNJAK OREL, Zorica. Synthesis of a Cu/ZnO nanocomposite by electroless plating for the catalytic conversion of CO2 to methanol. *Catalysis letters*, ISSN 1011-372X, May 2019, vol. 149, iss. 5, str. 1427-1439, ilustr. https://link.springer.com/article/10.1007/s10562-019-02717-7