UČNI NAČRT

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Ogljikovi materiali za shranjevanje in konverzijo energije
Course title:	Carbon materials for energy storage and conversion

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
45	15	15			75	6

Nosilec predmeta / Lecturer:	doc. dr. Boštjan Genorio / dr. Boštjan Genorio, Assistant Professor

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

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

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.

Prerequisites:

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:

Materiali na osnovi ogljika so nepogrešljivi v sodobnih tehnologijah. Poleg tega je nedavni razvoj ogljikovih nanomaterialov privedel do intenzivnih znanstvenih dejavnosti s ciljem, da se razvije nov razred materialov za nove aplikacije, vključujoč naprave za shranjevanje in pretvorbo energije (ESC). V zvezi s tem je namen tega predmeta kontekstualizirati nedavni napredek ogljikovih materialov z zagotavljanjem širšega pogleda na njihove lastnosti, na sintezne poti, njihove lastnosti in funkcionalizacije. Poleg opisa različnih vrst materialov iz ogljikovih alotropov, bo zajeta tudi njihova uporaba in vloga v ESC.

Content (Syllabus outline):

Carbon based materials are indispensable in modern technologies. Furthermore, recent development of carbon nanomaterials has resulted in intensive scientific activity with a goal to develop new class of materials for new applications including energy storage and conversion (ESC). In this respect this course aims to contextualize the recent advances in carbon materials by providing a broader view of their properties, how they are synthesized, how they are characterized, and how they are functionalized. Besides describing different types and uses of carbon allotrope materials, their application and role in ESC will be also be covered.

Temeljni literatura in viri / Readings:

1.) Wen Lu, Jong-Beom Baek, Liming Dai, *Carbon Nanomaterials for Advanced Energy Systems,* John Wiley & Sons, Inc., **2015**, Print ISBN:9781118580783 (80%)
2.) Brownson, Dale A. C., Banks, Craig E., *The Handbook of Graphene Electrochemistry*, Springer-Verlag London, **2014**, Hardcover ISBN: 978-1-4471-6427-2 (10%)
3.) Recent articles from the literature (10%).

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Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta študentje bodo znali: Določiti, kaj so ogljikovi materiali, in prepoznati različne alotropne modifikacije ter njihovo uporabo. Razumeli bodo sintezo, funkcionalizacijo, karakterizacijo in načine uporabe za različne ogljikove alotrope. Razumeli bodo uporabo alotropov ogljika v napravah ESC. Znali bodo ugotoviti in razložiti, zakaj imajo nanoogljiki drugačne lastnosti kot njihovi volumenski materiali. *Kompetence*: znanje, kako oblikovati in napisati manjši predlog raziskav v zvezi z uporabo ogljikovih alotropov v napravah ESC. Pridobljeno znanje je neposredno prenosljivo na druga znanstvena področja, kot so kemija, kemijsko inženirstvo in elektrotehnika.	*Objectives* students will be able to: Define what carbon materials are, identify different allotropes and their applications. Understand synthesis, functionalization, characterization and application routes for various carbon allotropes. Understand application of carbon allotropes in ESC devices. Identify and explain why nanocarbons have different properties from their bulk counterparts. *Competences*: ability to design and write a small research proposal related to application of carbon allotropes in ESC devices. Acquired knowledge is directly transferable to other fields of science such as chemistry, chemical engineering, and electrical engineering.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študenti spoznajo lastnosti ogljikovih alotropov, sintezo, funkcionalizacijo in aplikacije, povezane z materiali za shranjevanje in pretvorbo energije. Pridobljeno znanje znajo uporabiti za reševanje problemov za naprave za shranjevanje in pretvorbo energije nove generacije v akademskih krogih in evropski industriji. Znajo uporabiti znanje za reševanje trenutnih problemov alternativnih tehnologij prihodnosti.	Knowledge and understanding: Students learn about carbon allotropes properties, synthesis, functionalization and applications related to energy storage and conversion materials. They can apply the acquired knowledge to problem solving for the next generation energy storage and conversion devices in academia and European industry. They can apply their knowledge to solving current problems of important alternative technologies of the future.

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Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji s preučevanjem člankov in diskusijo, laboratorijsko delo.	Lectures, seminars with literature study and discussions, labwork.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Laboratorijske vaje	**30%**	Labwork
Analiza članka	**10%**	Article analysis
Raziskovalni predlog (pisni del)	**40%**	Research proposal (written part)
Raziskovalni predlog (predstavitev, diskusija)	**20%**	Research proposal (presentation, discussion)

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.;

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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.

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