# UČNI NAČRT

| UČNI NAČRT PREDMETA / COURSE SYLLABUS | |
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| **Predmet:** | Sodobne tehnike sinteze nanomaterialov |
| **Course title:** | Modern techniques for the synthesis of nanomaterials |

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

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

| Predavanja<br>Lectures | Seminar<br>Seminar | Vaje<br>Tutorial | Klinične vaje<br>work | Druge oblike študija | Samost. delo<br>Individ. work | ECTS |
|---|---|---|---|---|---|---|
| 30 | / | 15 | / | / | 45 | 3 |

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| **Nosilec predmeta / Lecturer:** | prof. dr. Robert Dominko/ dr. Robert Dominko, Full Professor |

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| **Jeziki / Languages:** | **Predavanja / Lectures:** | **angleški/ English** |
| | **Vaje / Tutorial:** | **angleški/ English** |

**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:**

- Sinteza nanomaterialov: ravnotežje trdne snovi / raztopine v precipitacijskih tehnikah; sol gel tehnika; hibridni materiali; hidrotermalna in templatna sinteza; lastnosti materialov na nanoskali
- Uporaba nanomaterialov pri shranjevanju in pretvorbi energije
- Karakterizacijske tehnike za nanomateriale
- Praktična uporaba nanomaterialov v različnih elektrokemičnih celicah
- Prednosti in slabosti uporabe nanomaterialov
- Kritična ocena praktične uporabe nanomaterialov

**Content (Syllabus outline):**

- Nanomaterials synthesis: solid/solution equilibria applied to the precipitation; sol gel technique; hybrid Materials; hydrothermal and templating synthesis; materials at the nanoscale
- Application of nanomaterials in energy storage and conversion
- Characterization techniques for nanomaterials
- Practical implementation of nanomaterials into different electrochemical cells
- Advantages and drawbacks of using nanomaterials
- Critical assessment of nanomaterials in practical application

**Temeljni literatura in viri / Readings:**

1.) Cao Guozhong, Ying Wang, Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, World scientific publishing Co., **2011**, Print ISBN: 9814322504 (60%)
2.) Mahmood Aliofkhazraei, Handbook of Functional Nanomaterials: Application and Development, Nova Science Publishers, **2014**, Hardcover ISBN: 1629485667 (20%)
3.) Najnovejša literature (20%)

**Cilji in kompetence:**

Študenti se seznanijo z različnimi sinteznimi tehnikami za pripravo nanomaterialov za shranjevanje in pretvorbo energije. Med predavanji in seminarji so navedeni različni primeri uporabe nanomaterialov pri shranjevanju in pretvorbi energije. Dodaten poudarek je na karakterizacijskih tehnikah ter prednostih in slabostih nanomaterialov pri shranjevanju in pretvorbi energije.

**Objectives and competences:**

Students are introduced to various synthesis techniques for the preparation of nanomaterials for energy storage and conversion. Different cases of application of nanomaterials in energy storage and conversion are given during the lectures and seminars. Additional emphasize is on the characterization techniques and advantages and disadvantages of nanomaterials in energy storage and conversion.

**Predvideni študijski rezultati:**

Znanje in razumevanje:

Študenti spoznajo različne sintezne pristope za pripravo nanomaterialov, njihove lastnosti, karakterizacijo in uporabo v zvezi z materiali za shranjevanje in pretvorbo energije.

Uporaba:

Pridobljeno znanje bo uporabljeno v akademskih krogih in evropski industriji pri načrtovanju in sintezi nove generacije aktivnih materialov za naprave za shranjevanje in pretvorbo energije.

Refleksija:

Pridobljeno znanje je orodje, ki študentu daje vzvod za reševanje trenutnih problemov pomembnih alternativnih tehnologij prihodnosti.

**Intended learning outcomes:**

Knowledge and Comprehension

Students learn about different synthesis approaches for nanomaterials preparation, their properties, characterization and applications related to energy storage and conversion materials.

Application

Acquired knowledge will be used in the design and synthesis of novel active materials 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

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| Prenosljive spretnosti:<br><br>Pridobljeno znanje je neposredno prenosljivo na druga znanstvena področja, kot so kemija, kemijsko inženirstvo in elektrotehnika. | future.<br><br>Skill-transference Ability<br><br>Acquired knowledge is directly transferable to other fields of science such as chemistry, chemical engineering, and electrical engineering. |

| **Metode poučevanja in učenja:** | **Learning and teaching methods:** |
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| Predavanja, laboratorijske vaje in preučevanje literature | Lectures, labwork and literature study |

| **Načini ocenjevanja:** | Delež (v %) / Weight (in %) | **Assessment:** |
|---|---|---|
| Izpit (pisni) | **60%** | Exam (Written) |
| Vaje | **40%** | Labwork |

**Reference nosilca / Lecturer's references:**

(1) Dominko, R; Bele, M; Gaberscek, M; Remskar, M; Hanzel, D; Goupil, JM; Pejovnik, S; Jamnik, J, J., Porous olivine composites synthesized by sol-gel technique, Power Sources, 153, 274-280 (2006)

(2) Dominko, R; Bele, M; Gaberscek, M; Remskar, M; Hanzel, D; Pejovnik, S; Jamnik, J, Impact of the carbon coating thickness on the electrochemical performance of $LiFePO_4$/C composites,J. Eletrochem. Soc., 152, A607-A610 (2005).

(3) G. Križan, J. Križan, R. Dominko, M. Gaberscek, Pulse combustion reactor as a fast and scalable synthetic method for preparation of Li-ion cathode materials, J. Power Sources, 363, 218-226 (2017)

(4) F.A, Strauss, G. Rousse, D. Batuk, M. Tang, E. Salager, G. Drazic, R. Dominko, J.-M.

Tarascon, Electrochemical behavior of $Bi_4B_2O_9$ towards lithium-reversible conversion reactions without nanosizing. PCCP. Physical chemistry chemical physics, 20, 2330-2338 (2018).

(5) Dominko, R; Bele, M; Gaberscek, M; Meden, A; Remskar, M; Jamnik, J, Structure and electrochemical performance of $Li_2MnSiO_4$ and $Li_2FeSiO_4$ as potential Li-battery cathode materials, Electrochem Commun. 8, 217-220 (2007)

(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. 8*, 5819 (2018).