UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Okolju prijazna funkcionalizacija organskih materialov
Course title:	Environmentally Friendly Functionalization of Organic Materials

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Ekotehnologije, 3. stopnja	/	1	1
Ecotechnologies, 3rd cycle	/	1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: EKO3-763

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	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 transfered to individual work.*

Nosilec predmeta / Lecturer: Doc. dr. Alenka Vesel
Prof. dr. Miran Mozetič

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina, angleščina Slovenian, English
	Vaje / Tutorial:	slovenščina, angleščina Slovenian, English

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

Znanje, ki je ekvivalentno univerzitetni izobrazbi s področja naravoslovja ali tehnologije.

Prerequisits:

Knowledge, which is equivalent to a university degree from natural sciences or technology.

Vsebina:

- Površinska energija in hidrofilnost
- Tehnologije za modifikacijo površin
- Plazemska funkcionalizacija organskih materialov
- Praktični primeri modifikacije površinskih lastnosti organskih materialov za različne aplikacije
- Metode za preiskavo površin organskih materialov
- Določanje vrste in koncentracije funkcionalnih skupin na organskih materialih z metodo rentgenske fotoelektronske spektroskopije (XPS)

Content (Syllabus outline):

- Surface energy and hydrophilicity
- Technologies for surface modification
- Plasma functionalization of organic materials
- Practical examples of surface modification of organic materials in various applications
- Methods for surface characterization of organic materials
- Determination of the type and concentration of functional groups by X-ray photoelectron spectroscopy (XPS)
- Specific features of XPS method for characterization of organic materials
- Interpretation of results

• Specifičnosti metode XPS pri preiskavi organskih materialov • Interpretacija rezultatov • Primeri XPS analiz funkcionaliziranih organskih materialov • Praktične vaje	• Examples of XPS analyses of functionalized materials • Laboratory work

Temeljni literatura in viri / Readings:

- A. Fridman, Plasma Chemistry, Cambridge University Press, Cambridge, 2012
- D. Briggs, Surface analysis of polymers by XPS and static SIMS, Cambridge University Press, New York, 2005
- T. Jacobs, R. Morent, N. De Geyter, P. Dubruel, C. Leys, Plasma Surface Modification of Biomedical Polymers: Influence on Cell-Material Interaction, Plasma Chem. Plasma Process. 32 (2012) 1039–1073
- R. Morent, N. De Geyter, T. Desmet, P. Dubruel, C. Leys, Plasma Surface Modification of Biodegradable Polymers: A Review, Plasma Process. Polym., 8 (2011) 171–190.
- T. Desmet, R. Morent, N. De Geyter, C. Leys, E. Schacht, P. Dubruel, Nonthermal Plasma Technology as a Versatile Strategy for Polymeric Biomaterials Surface Modification: A Review, Macromolecules, 10 (2009) 2351–2378.
- R. Morent, N. De Geyter, J. Verschuren, K. De Clerck, P. Kiekens, C. Leys, Non-thermal plasma treatment of textiles, Surf. Coat. Technol. 202 (2008) 3427–3449
- N. Recek, A. Vesel, Surface modification of polymer polyethylene terephthalate with plasmas created in different gases, Mater. Tehnol., 48 (2014) 893-897.
- A. Vesel. XPS study of surface modification of different polymer materials by oxygen plasma treatment, Inform. Midem, 38 (2008) 257-265.
- A. Vesel, N. Recek, M. Modic, Plazemska modifikacija polimernih materialov za biomedicinske aplikacije. Vakuumist, 33/3 (2013) 4-8.
- A. Vesel, M. Mozetič, New developments in surface functionalization of polymers using controlled plasma treatments, J. Phys. D: Appl. Phys. 50 (2017) 293001.
- A. Vesel, M. Mozetic, Low-pressure plasma-assisted polymer surface modification, in Printing on Polymers, Ed. J. Izdebska, S. Thomas, Elsevier, Amsterdam (2016) pp. 101-122.
- J. Kovac, Surface characterization of polymers by XPS and SIMS techniques, Materials and technology 45 (2011) 3, 191–197.
- T. Vukusic in ostali, Modification of Physico-Chemical Properties of Acryl-Coated Polypropylene Foils for Food Packaging by Reactive Particles from Oxygen Plasma, Materials, 11 (2018) 372.
- A. Vesel, Modification of polystyrene with a highly reactive cold oxygen plasma, Surf. Coat. Technol. 205 (2010) 490–497.
- M. Resnik in ostali, Comparison of SF6 and CF4 Plasma Treatment for Surface Hydrophobization of PET Polymer, Materials, 11 (2018) 311.
- A. Vesel, Effect of H2S Plasma Treatment on the Surface Modification of a Polyethylene Terephthalate Surface, *Materials*, 9 (2016) 95.

Cilji in kompetence:	**Objectives and competences:**
Študentje spoznajo osnove o površinskih lastnostih organskih materialov, ki so odvisne predvsem od vrste in koncentracije funkcionalnih skupin na površini teh materialov. Spoznajo metode za modificiranje površine organskih materialov in postopke plazemske funkcionalizacije teh materialov z različnimi funkcionalnimi skupinami,	Students gain knowledge on surface properties of organic materials, which depend predominantly on the type and concentration of functional groups on the surface of these materials. They get knowledge on modification of the surface of organic materials and methods for plasma functionalization with different functional groups such as nitrogen (amino,

kot so dušikove (amino, amidna), kisikove (hidroksilna, karbonilna, karboksilna) in halogene. Seznanijo se tudi z metodami za karakterizacijo funkcionalnih skupin na površini organskih materialov in metodami za merjenje hidrofilnosti/hidrofobnosti teh materialov. Na koncu se študentje seznanijo še s praktičnimi primeri uporabe plazme za površinsko modifikacijo organskih materialov na primeru aplikacij iz različnih panog (industrija, biologija, medicina…).	amide), oxygen (hydroxyl, carbonyl, carboxyl) and halogen. Students also get knowledge on methods for characterization of functional groups on the surface of organic materials and measuring hydrophilicity/ hydrophobicity of these materials. Finally, the students gain knowledge on applications of plasma surface modification of organic materials in the case of various practical applications (industry, biology, medicine ...).
Predvideni študijski rezultati:	**Intended learning outcomes:**
Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili: • Poznavanje metod za funkcionalizacijo organskih materialov. • Razumevanje interakcije plazme s površinami organskih materialov. • Razumevanje površinskih lastnosti organskih materialov, predvsem površinske energije, hidrofilnosti in hidrofobnosti kot posledico vrste in koncentracije funkcionalnih skupin na njihovi površini. • Presoja ustreznih plazemskih parametrov, ki vodijo do želenih efektov na površini. • Ugotavljanje površinske energije materialov in ocena hidrofilnosti oziroma hidrofobnosti materiala. • Poznavanje osnov metode XPS za preiskavo površin materialov in poznavanje specifik analize organskih materialov s to metodo. • Načrtovanje znanstveno-raziskovalnega dela, ki praviloma vodi do znanstvenega članka. <u>Splošne kompetence:</u> • obvladanje izbranih raziskovalnih metod, postopkov in procesov, • razvoj kritične in samokritične presoje, • sposobnost uporabe znanja v praksi, • kooperativnost, delo v skupini, • industrijska relevantnost. <u>Predmetno-specifične kompetence:</u> • Predmet pripravlja študente za delo na področju modifikacije površinskih lastnosti organskih materialov, kar lahko v praksi uporabijo za funkcionalizacijo različnih materialov v industriji, kemiji, biologiji in medicini.	Students successfully completing this course will acquire: • Learning the methods for surface functionalization of organic materials. • Understanding the plasma-surface interactions. • Understanding the surface properties of organic materials, hydrophilicity and hydrophobicity as a consequence of the type and concentration of functional groups on the surface. • Discussing about the appropriate plasma parameters leading to desired surface effects. • Understanding the methods for surface functionalization of organic materials. • Understanding specific features of the XPS method for surface characterization of organic materials. • Conceiving and designing a scientific and research work that usually leads to preparation of a scientific paper. <u>General Competences:</u> • The student will master selected research methods, procedures and processes. • The student will develop critical thinking and self-assessment. • The student will develop communication skills to present research results in an international environment. • The student will be able to cooperate in a team. <u>Course Specific Competences:</u> • This course prepares students to work on the field of surface modification of organic materials, which is suitable for application in industry as well as chemistry, biology and medicine.

Metode poučevanja in učenja:	**Learning and teaching methods:**
• predavanja • seminarji • laboratorijsko delo	• lectures • seminar work • laboratory work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminar. Ustni izpit, v katerem kandidat dokaže poznavanje in razumevanje temeljnih vsebin predmeta in predstavi njihovo vključevanje v svoj raziskovalni projekt pred komisijo, ki jo sestavljata nosilec predmeta ter mentor podiplomca.	50 % 50 %	Seminar. Oral exam, in which the candidate demonstrates his/her knowledge and understanding of the essential course content, and presents how this new knowledge can be included in his/her research project – in front of the course leader and postgraduate's project supervisor.

Reference nosilca / Lecturer's references:

- VESEL, Alenka, MOZETIČ, Miran. New developments in surface functionalization of polymers using controlled plasma treatments. *Journal of physics. D, Applied physics*, ISSN 0022-3727, 2017, vol. 50, no. 29, str. 293001-1-293001-21, doi: 10.1088/1361-6463/aa748a.
- MOZETIČ, Miran, VESEL, Alenka, CVELBAR, Uroš, PRIMC, Gregor, DRAŽIĆ, Goran, STANA-KLEINSCHEK, Karin, DRMOTA, Ana, et al. Recent advances in vacuum sciences and applications. *Journal of physics. D, Applied physics*, ISSN 0022-3727, 2014, vol. 47, no. 15, str. 153001-1-153001-23, doi: 10.1088/0022-3727/47/15/153001.
- VESEL, Alenka, ZAPLOTNIK, Rok, PRIMC, Gregor, XIANGYU, Liu, XU, Kaitian, CHEN, Kevin C., WEI, Chiju, MOZETIČ, Miran. Functionalization of polyurethane/urea copolymers with amide groups by polymer treatment with ammonia plasma. *Plasma chemistry and plasma processing*, ISSN 0272-4324. [Print ed.], 2016, vol. 36, no. 3, str. 835-848, doi: 10.1007/s11090-016-9696-3.
- VESEL, Alenka, KOVAČ, Janez, ZAPLOTNIK, Rok, MODIC, Martina, MOZETIČ, Miran. Modification of polytetrafluoroethylene surfaces using H_2S plasma treatment. *Applied Surface Science*, ISSN 0169-4332. [Print ed.], 2015, vol. 357, part B, str. 1325-1332, doi: 10.1016/j.apsusc.2015.09.243.
- VESEL, Alenka, KOLAR, Metod, RECEK, Nina, KUTASI, Kinga, STANA-KLEINSCHEK, Karin, MOZETIČ, Miran. Etching of blood proteins in the early and late flowing afterglow of oxygen plasma. *Plasma processes and polymers*, ISSN 1612-8850, 2014, vol. 11, no. 1, str. 12-23, doi: 10.1002/ppap.201300067.