Magistrski študijski program Kemija: izbirni predmet Trajnostna organska kemija v okviru mednarodne mreže predmetov s področja trajnostne kemije

Na razpisu »KA220-HED – Cooperation partnerships in higher education« v letu 2021 smo bili uspešni in pridobili projekt z naslovom *Digichem: Creating a Digital Study Environment for Sustainable Chemistry*. Vodilni partner je Justus Liebig Univerza v Giessnu, sodelujoči sta še Univerza v Padovi in Univerza v Zagrebu. Pripravljamo in uvajamo štiri nove predmete področja trajnostne kemije. Vsak se bo izvajal delno na eni od sodelujočih univerz (en teden »v živo«) in delno na daljavo (v digitalni obliki pred in po srečanju na lokaciji ene od štirih univerz), vsi v angleškem jeziku. Pri pripravi in izvedbi vseh štirih predmetov sodelujejo vse štiri univerze, vsaka pa je vodilna in ima največjo vlogo pri enem predmetu, katerega del v živo se izvaja na lokaciji te univerze. V spodnji razpredelnici so navedeni predmeti, lokacija in predviden čas izvedbe dela predmeta na eni od univerz.

Predmet	***Lokacija***	***Predviden čas izvedbe dela predmeta v živo***
Introduction to sustainable chemistry	Padova	februar 2023
Sustainable organic chemistry	**Ljubljana**	**junij 2023**
Sustainable materials chemistry: Energy materials	Giessen	september 2023
Sustainable water treatment	Zagreb	letni semester 2024

Predmeti so ovrednoteni s po 5 ECTS. Učni načrt za predmet »Sustainable organic chemistry«, pri katerem smo mi vodilni partner in se bo del v živo izvajal na naši fakulteti, je priložen in bo dostopen tudi v predmetniku MŠP Kemija na spletni strani. Pri nas smo akreditirali ta predmet v okviru magistrskega študija Kemije, ostale tri pa bomo študentom, ki se bodo odločili za celoten modul štirih predmetov iz trajnostne kemije, priznali na osnovi podpisanega učnega sporazuma ob vpisu v 1. letnik. Ti štirje predmeti bodo našim študentom šteli kot trije strokovni izbirni predmeti (Sustainable organic chemistry, Sustainable materials chemistry: Energy materials, Sustainable water treatment) in en splošni izbirni predmet (Introduction to Sustainable Chemistry). Takih študentov, ki bodo opravljali cel modul trajnostne kemije, bo 5 z vsake univerze, skupno 20 študentov. Projekt zagotavlja sredstva za mobilnost študentov. Če bo interesentov več kot 5, jih bomo izbrali glede na motivacijsko pismo, povprečno oceno predhodnega študija, življenjepisa in znanja angleščine. Študenti, ki bodo opravili celoten modul, bodo dobili s strani štirih univerz podpisano potrdilo o opravljenem izobraževanju s področja trajnostne kemije. Seveda pa lahko naši študenti izberejo le Trajnostno organsko kemijo kot strokovni izbirni predmet.

Več o samem izobraževanju s področja trajnostne kemije najdete v priloženem dokumentu v angleščini in pri meni kadarkoli po dogovoru. Če želite sodelovati pri vseh štirih predmetih, pošljete prošnjo z motivacijskim pismom na moj e-naslov (urska.lavrencic.stangar@fkkt.uni-lj.si) **do 10. 10. 2022**.

prof. dr. Urška Lavrenčič Štangar

prodekanja za dodiplomski in magistrski študij

Univerza v Ljubljani
Fakulteta za kemijo in kemijsko tehnologijo

Erasmus+

Co-funded by the Erasmus+ Programme of the European Union

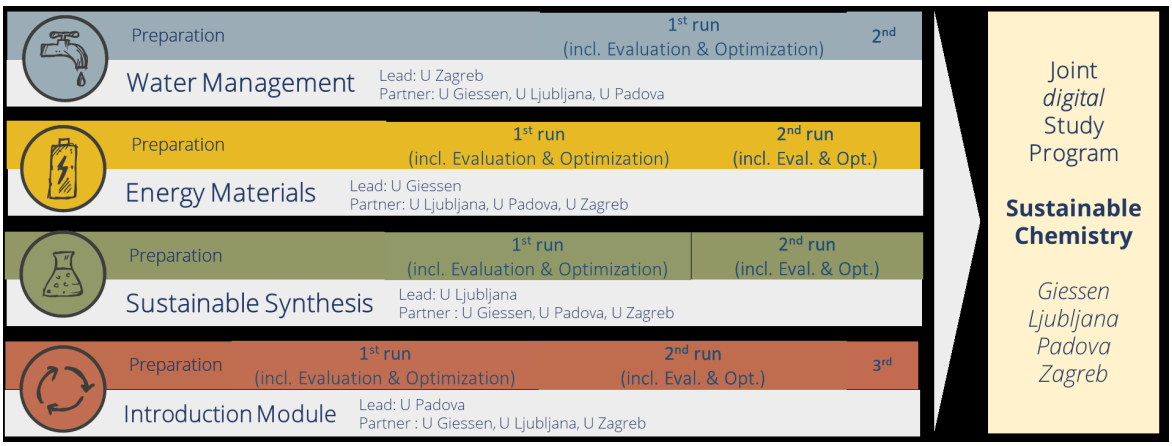
Be part of an international network for the study of sustainable chemistry!

Project "DigiChem - Creating a digital study environment for sustainable chemistry" with international partners to start in October 2022

Circular economy, use of renewable raw materials, sustainable energy and water management: chemistry plays an important role with regard to a sustainable economy and society. As new chemical processes must be developed and existing processes must be adapted to changing conditions. This topic involves transnational problems and therefore international viewpoints should be included in the study program. For this reason within the framework of an "Erasmus+ Cooperation Partnership" the project "DigiChem" started this year with partners from **Gießen, Ljubljana, Padua and Zagreb**. "DigiChem" includes four new modules (elective courses), each taking place at one of the partner universities, which participants will follow digitally. These modules will include online lectures, seminars as well as digital lab courses. In addition the program **will allow a group of students from each partner to follow the lectures in person and participate in the lab courses on site**. Thus enabling intercultural exchange for students and teachers in the digital space as well as in the context of mutual visits.

The composition of the scientific consortium was chosen to make best use of the technical expertise of all partners and incorporate a well-rounded range of topics in the field of sustainability. These include "Green Chemistry", materials science, energy materials, technical chemistry, recycling management and sustainability in organic chemistry. The modules and teaching units to be developed are intended to ensure high-quality inclusive teaching with the innovative subject-specific focus on "Sustainable Chemistry." The program will allow you to participate in up to four modules (= four elective courses):

Introduction, Sustainable Synthesis, Energy Materials and Water Management



Be part of this exciting and new joint study program towards Sustainable Chemistry! If you are enrolled at one of the four universities in October 2022 in a chemical Master program, you can apply by sending your current transcript of records and a motivation letter to urska.lavrencic.stangar@fkkt.uni-lj.si until 10.10.2022 to become one of the 20 students (5 from UL) allowed to participate in presence and travel to the partner universities (costs covered by the project).

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Trajnostna organska kemija
Course title:	Sustainable Organic Chemistry
Članica nosilka/UL Member:	UL FKKT

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Kemija, druga stopnja, magistrski	Ni členitve (študijski program)	1. letnik, 2. letnik	1. semester 2. semester

Univerzitetna koda predmeta/University course code: 0642774

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30	30	15			75	5

Nosilec predmeta/Lecturer: Jernej Iskra

Vrsta predmeta/Course type: izbirni/elective

Jeziki/Languages:

Predavanja/Lectures:	Angleščina
Vaje/Tutorial:	Angleščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
V predmet se lahko vključijo študenti magistrskega študijskega programa Kemija, ki so vključeni v projekt "Ustvarjanje digitalnega študijskega okolja za trajnostno kemijo" (DigiChem). Lahko se vključijo tudi drugi študenti na magistrskem študijskem programu Kemija in tuji študenti na mednarodni izmenjavi na UL. Pogoji za pristop k izpitu: prisotnost in udeležba na predavanjih (min. 75 %) ter seminarjih in v laboratoriju (100 %), pisna seminarska in laboratorijska poročila.	The course is available for students of the Master Study Program Chemistry who are part of the project “Creating a Digital Study Environment for Sustainable Chemistry” (DigiChem). It is available also to other students on the study programme Chemistry 2nd cycle and foreign international exchange students as well. Conditions for taking the exam: attendance and participation on lectures (75% min) and seminars and lab (100%), written seminars and laboratory reports.

Vsebina:	Content (Syllabus outline):
Osnovni koncepti zelene in trajnostne kemije ter njen razvoj. Pregled alternativnih virov aktivacije kemijske reakcije (mikrovalovi, ultrazvok, svetloba...), njihovo delovanje in uporaba v organski kemiji. Principi uporabe fotokemije in fotokatalize v sintezi organskih molekul. Uporaba mehanokemije za selektivne pretvorbe organskih molekul. Principi delovanja elektrokemije in njena uporaba v organski sintezi. Osnove pretočnih sistemov in njihov dizajn za aplikacijo v sintezi. Homogeni in heterogeni katalizatorji za razvoj zelenih/trajnostnih kemijskih procesov.	Basic concepts of green and sustainable chemistry and the evolution of the field. Overview of alternative modes of activation of chemical reactions (microwaves, ultrasound, light...), their mode of action and use in organic chemistry. Principles of photochemistry and photocatalysis for the synthesis of organic molecules. Application of mechanochemistry for selective transformation of organic molecules. Principles of electrochemistry and their application in organic synthesis. Design of flow systems for their application in synthesis. Homogeneous and heterogeneous catalysts for the development of green/sustainable chemical processes.

Vrednotenje uporabe organskih topil in pregled razvoja alternativnih topil (nova topila iz biomase, ionske tekočine, evtektična topila, voda...). Biomasa kot vir industrijskih kemikalij in analiza trajnostnega vidika uporabe biomase v industriji. Biorafinerije in njihov koncept za valorizacijo biomase v uporabne kemikalije in materiale. Osnovne platforme kemikalij iz biomase. Primeri zelene kemije v farmacevtski industriji. Metrika zelene kemije za valorizacijo kemijskih reakcij in procesov. Kvantitativno in kvalitativno ovrednotenje okoljskega potenciala kemijskih procesov. Aplikacija znanja o zeleni kemiji za trajnostni dizajn procesov.	Valorization of the use of organic solvents and an overview of the development of alternative solvents (new solvents from biomass resources, ionic liquids, deep eutectic salts, water...). Biomass as a source of industrial chemicals and an analysis of the sustainable use of biomass for industry. Biorefinery concept for valorization of biomass to useful chemicals and materials. Basic platform of chemicals from biomass. Examples of green chemistry in the pharmaceutical industry. Green chemistry metrics for valorization of chemical reactions and processes. Quantitative and qualitative evaluation of the environmental potential of chemical processes. Application of green chemistry principles to the design of sustainable chemical processes.

Temeljna literatura in viri/Readings:

- Gradivo za predmet, ki ga pripravi učitelj in je na voljo v spletni učilnici/Course materials prepared by the course teacher, available through the course website.
- *Green Chemistry: An Introductory Text*, 3rd Edition M. Lancaster, RSC Publishing, 2016.
- *Green Chemistry: Fundamentals and Applications*, S. C. Ameta, R. Ameta (Eds.), CRC Press, 2014.
- *Introduction to Chemicals from Biomass*, J. Clark, F. Deswarte (Eds.), Wiley, 2008.
- *Green Chemistry Metrics: A Guide to Determining and Evaluating Process Greenness*, A. P. Dicks, A. Hent, Springer, 2015.

Cilji in kompetence:	**Objectives and competences:**
Seznaniti študente s trajnostnimi vidiki organske kemije in razviti razumevanje povezanih izzivov in priložnosti. Študent bo pridobil specifično teoretično znanje in praktične spretnosti, povezane s trajnostnimi načini izvajanja kemijskih reakcij, s poudarkom na alterantivnih topilih, alternativnih načinih aktivacije in izvedbe (mikrovalovi, ultrazvok, fotokemija, elektrokemija, mehanokemija). Študent bo spoznal orodja za kvantitativno in kvalitativno vrednotenje trajnostnega potenciala kemijskih procesov.	To introduce students to sustainable organic chemistry, and to develop understanding of related challenges and opportunities. To adopt specific theoretical knowledge and practical skills related to the sustainable chemical transformations with an emphasis on alternative solvents, alternative modes of activation and use (microwaves, ultrasound, photochemistry, electrochemistry, mechanochemistry). To adopt tools for quantitative and qualitative evaluation of sustainable potential of chemical processes.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje - Povezati vire in razpoložljive tehnologije za dizajn trajnostnih kemijskih procesov. - Razumevanje alternativnih načinov izvedbe kemijskih pretvorb. - Povezati kvantitativna in kvalitativna merila za ovrednotenje trajnostnega potenciala kemijskega procesa. - Opredeliti glavne vire iz biomase in njihovo valorizacijo za uporabne kemikalije in materiale. *Uporaba* - Ugotavljanje in ocenjevanje okoljskih parametrov kemijskega procesa. - Dizajn trajnostnega kemijskega procesa.	*Knowledge and Comprehension* - Correlate sources and available technologies for designing sustainable chemical processes. - Comprehension of alternative modes of performing chemical transformations. - Correlate quantitative and qualitative measures to evaluate the sustainable potential of chemical processes. - Define major sources of biomass and their valorization for useful chemicals and materials. *Application* - Identify and evaluate the environmental parameters of a chemical process. - Design a sustainable chemical process.

- Trajnostna izraba biomase za uporabne kemikalije in materiale. *Refleksija* - Razpravljanje o značilnostih različnih metod trajnostne izvedbe kemijske transformacije. - Analiza vpliva posameznih reakcijskih komponent in izolacijskih postopkov na trajnostne parametre kemijskega procesa. *Prenosljive spretnosti* - Razvoj kritične presoje in ocene postopkov ali procesov z vidika trajnostnih standardov. - Uporaba naprednih laboratorijskih postopkov za sintezo novih produktov in ustvarjanje trajnostnih procesov. - Uporabljati različne sintezne tehnike in postopke pri ustvarjalnem reševanju sinteznih izzivov in predlagati trajnostne rešitve. - Presoja vpliva industrijskega izkoriščanja biomase in razvoj trajnostnih procesov uporabe biomase. - Samostojno organizirati in načrtovati časovni razpored, uporabljati splošno metodologijo za načrtovanje in vodenje projektov v poslovnem okolju. - Izdelati kritično analizo, oceno in interpretacijo osebnih rezultatov ter jih primerjati z obstoječimi podatki v znanstveni in strokovni literaturi. - Jasno in skladno predstaviti rezultate samostojnega in skupinskega dela v pisni in ustni obliki nestrokovnjakom in strokovnjakom. - Komunicirati z znanstveno in strokovno skupnostjo ter družbo na splošno v lokalnem in mednarodnem okolju.	- Sustainable utilisation of biomass for useful chemicals and materials. *Analysis* - Discuss the characteristics of different types of sustainable chemical transformation. - Analyse the influence of reaction components and isolation procedures on the sustainable parameters of a chemical process. *Skill-Transference Ability* - Develop critical judgement and evaluate processes in terms of sustainable standards. - Apply advanced laboratory techniques to synthesise new products and develop sustainable processes. - Apply various synthesis techniques and processes in creative problem solving of synthetic challenges to propose sustainable technological solutions. - Evaluate industrial uses of biomass and develop processes for their sustainable use. - Independently organise and plan schedules, applying a general methodology for project planning and management in a business environment. - Prepare a critical analysis, evaluation and interpretation of own results and compare them with existing data in scientific and professional literature. - Present the results of independent and team work clearly and coherently in written and oral form to lay and expert audiences. - Communicate with the scientific and professional community and society in local and international settings.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji in delavnice, vaje, delno e-učenje, samostojne naloge, multimedija in internet, laboratorij. Izvajanje na daljavo: 40 ur (predavanja in seminar). Izvajanje na UL: 35 ur (vaje, seminar in predavanja). Za študente, ki se ne bodo mogli udeležiti predmeta v živo, bodo vse aktivnosti dostopne on-line.	Lectures, seminars and workshops, exercises, partial e-learning, independent assignments, multimedia and the internet, laboratory. On-line: 40 hours (lectures, seminar). In person: 35 hours (practical work, seminar, lectures). On-line material will be available to students that will not be able to attend the course in person.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Ustni izpit.	70,00 %	Oral examination.
Seminar, uspešno opravljene laboratorijske vaje.	30,00 %	Seminar, successful completion of laboratory exercises.

Reference nosilca/Lecturer's references:

- M. Horvat, **J. Iskra**: Oxidative cleavage of C–C double bond in cinnamic acids with hydrogen peroxide catalysed by vanadium(V) oxide. ***Green Chemistry***. **2022**, *24,* 2073-2081.
- R. Narobe, S. Dussel, **J. Iskra**, B. Konig: *Photocatalytic oxidative iodination of electron-rich arenes*. ***Adv. Synth. Catal.*** **2019**, *361*, 3998.
- Š. Možina, **J. Iskra**. *Aerobic oxidation of secondary alcohols with nitric acid and iron(III) chloride as catalysts in fluorinated alcohol*. ***J. Org. Chem.*** **2019**, *84*, 14579.