

# NEKOVINSKI MATERIALI - RRP

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	Nekovinski materiali - RRP
<b>Course title:</b>	Non-metallic materials - RRP
<b>Članica nosilka/UL Member:</b>	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - razvojno raziskovalni program, prva stopnja, univerzitetni	Ni členitve (študijski program)	1. letnik	2. semester	obvezni

<b>Univerzitetna koda predmeta/University course code:</b>	0562745
<b>Koda učne enote na članici/UL Member course code:</b>	2008-U

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
45		30			50	5

<b>Nosilec predmeta/Lecturer:</b>	Alen Oseli, Lidija Slemenik Perše
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<b>Vrsta predmeta/Course type:</b>	Obvezni splošni predmet /Compulsory general course
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<b>Jeziki/Languages:</b>	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

<b>Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:</b>	<b>Prerequisites:</b>
Izpolnjevanje pogojev za vpis v	Meeting the enrollment conditions for

Univerzitetni študijski program I. stopnje Strojništvo - Razvojno raziskovalni program.	the Academic study programme of Mechanical Engineering - Research and Development program.
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### **Vsebina:**

<p>. Vsebina 1. Predavanja: ZGRADBA SNOVI in KEMIJSKE VEZI</p> <ul style="list-style-type: none"> <li>- Razdelitev snovi in njihove lastnosti, zakonitosti kemijskih sprememb, agregatna stanja, atomi, molekule, vrste in lastnosti kemijskih vezi, van der Waalove interakcije.</li> </ul> <p>2. Vsebina 2. Predavanja: LASTNOSTI in ZGRADBA TRDNIH SNOVI</p> <ul style="list-style-type: none"> <li>- Stehiometrija in IUPAC nomenklatura, periodni system, amorfna in kristalinična struktura, vpliv kristaliničnosti na mehanske lastnosti, kristali – zgradba, rast kristalov, napake v kristalni strukturi.</li> </ul> <p>3. Vsebina 3. Predavanja: KEMIJSKA KINETIKA in KATALIZA</p> <ul style="list-style-type: none"> <li>- Kemijsko ravnotežje, Le Chatelierjev princip, hitrost in mehanizem reakcije (vpliv reaktantov, temperature in tlaka, agregatnega stanja, katalizatorjev), homogena in heterogena kataliza.</li> </ul> <p>4. Vsebina 4. Predavanja: KEMIJSKE LASTNOSTI SNOVI in KEMIJSKI PROCESI v STROJNIŠTVU</p> <ul style="list-style-type: none"> <li>- Kisline in baze (pH), reaktivnost, topnost, gorljivost, procesi zgorevanja, degradacija snovi, zaščita nekovinskih materialov, procesi lepljenja.</li> </ul> <p>5. Vsebina 5. Predavanja: POVEZAVA MED STRUKTURO IN LASTNOSTMI SNOVI</p> <ul style="list-style-type: none"> <li>- Strukturne lastnosti suspenzij, emulzij, makromolekul, osnove reologije</li> <li>- vpliv zunanje obremenitve na strukturne lastnosti nekovinskih materialov, razumevanje odziva materialov na podlagi določenih reoloških lastnosti.</li> </ul> <p>6. Vsebina 6. Predavanja: ELEKTROKEMIJA</p> <ul style="list-style-type: none"> <li>- Osnove elektrokemije, redoks reakcije, redoks potenciali, termodinamika redoks reakcij, galvanski členi, elektroliza, uporaba elektrokemije</li> </ul>	<p><b>Content (Syllabus outline):</b></p> <p>. Content of Lecture 1: MATERIAL STRUCTURE and CHEMICAL BONDS</p> <ul style="list-style-type: none"> <li>- Materials and their properties, characteristics of chemical changes, state of matter, atoms, molecules, types and properties of chemical bonds, van der Waals interactions.</li> </ul> <p>2. Content of Lecture 2: PROPERTIES and STRUCTURE OF SOLIDS</p> <ul style="list-style-type: none"> <li>- Stoichiometry and IUPAC nomenclature, Periodic system, amorphous and crystalline structure, effect of crystallinity on mechanical properties, crystals - structure, growth, structural defects.</li> </ul> <p>3. Content of Lecture 3: CHEMICAL KINETICS and CATALYSIS</p> <ul style="list-style-type: none"> <li>- Chemical equilibrium, Le Chatelier's principle, rate and mechanism of reaction (effect of reactants, temperature, pressure, state of matter, catalysts), homogeneous, heterogeneous catalysis.</li> </ul> <p>4. Content of Lecture 4: CHEMICAL PROPERTIES and CHEMICAL PROCESSES in MECHANICAL ENGINEERING</p> <ul style="list-style-type: none"> <li>- Acids and bases (pH), reactivity, solubility, flammability, combustion, degradation, protection of non-metallic materials, bonding processes.</li> </ul> <p>5. Content of Lecture 5: STRUCTURE - PROPERTY RELATIONSHIP</p> <ul style="list-style-type: none"> <li>- Structural properties of suspensions, emulsions, macromolecules, basic rheology - effect of external loading on structural properties of non-metallic materials, understanding the response of materials based on rheological properties.</li> </ul> <p>6. Content of Lecture 6: ELECTROCHEMISTRY</p> <ul style="list-style-type: none"> <li>- Fundamentals of electrochemistry, redox reactions, redox potentials, thermodynamics of redox reactions,</li> </ul>
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<p>v industriji.</p> <p>7. Vsebina 7. Predavanja: KERAMIKA in STEKLO</p> <ul style="list-style-type: none"> <li>- Razdelitev in pregled osnovnih skupin nekovinskih materialov, osnovne značilnosti keramike in stekla, zgradba keramike; mikrostruktura keramičnih materialov, postopki izdelave keramike, stekla.</li> </ul> <p>8. Vsebina 8. Predavanja: POLIMERNI MATERIALI</p> <ul style="list-style-type: none"> <li>- Definicije pojmov, značilnosti polimernih materialov, razdelitev polimerov v osnovne skupine, posebni polimerni materiali.</li> </ul> <p>9. Vsebina 9. Predavanja: OSNOVE ORGANSKE KEMIJE in SINTETIČNI POLIMERI</p> <ul style="list-style-type: none"> <li>- Zgradba organskih spojin, ogljikovodiki, osnovne reakcije alkanov, alkenov, alkinov; osnovne skupine sintetičnih polimerov, lastnosti in primeri uporabe termoplastov, duroplastov, elastoplastov.</li> </ul> <p>10. Vsebina 10. Predavanja: TERMIČNE ZNAČILNOSTI NEKOVINSKIH MATERIALOV</p> <ul style="list-style-type: none"> <li>- Fazni prehodi, karakteristične temperature prehodov, toplotni razteznostni koeficient, proces fizikalnega staranja, vpliv hitrosti segrevanja oz. ohlajanja na fazne prehode, koncept prostega volumna, metode za določitev termičnih lastnosti nekovinskih materialov.</li> </ul> <p>11. Vsebina 11. Predavanja: NEKOVINSKI KOMPOZITI</p> <ul style="list-style-type: none"> <li>- Osnovne komponente in vrste kompozitnih struktur, vrste in lastnosti ojačitvenih komponent (vlakna, delci, nanodelci), vrste polimernih matric, postopki izdelave, računanje mehanskih lastnosti.</li> </ul> <p>12. Vsebina 8. Predavanja: VISKOELASTIČNE LASTNOSTI NEKOVINSKIH MATERIALOV</p> <ul style="list-style-type: none"> <li>- Osnove viskoelastičnosti, teorija linearne viskoelastičnosti, mehanski modeli za popis viskoelastičnih odzivov, osnovne materialne funkcije, statične in dinamične materialne funkcije,</li> </ul>	<p>galvanic cells, electrolysis, application of electrochemistry in industry.</p> <p>7. Content of Lecture 7: CERAMICS and GLASS</p> <ul style="list-style-type: none"> <li>- Basic groups of non-metallic materials, basic characteristics of ceramics and glass, structure and microstructure of ceramic materials, manufacturing processes of ceramics and glass.</li> </ul> <p>8. Content of Lecture 8: POLYMERS</p> <ul style="list-style-type: none"> <li>- Basic definitions, characteristics of polymeric materials, basic groups of polymers, specific polymeric materials.</li> </ul> <p>9. Content of Lecture 9: BASICS of ORGANIC CHEMISTRY AND SYNTHETIC POLYMERS</p> <ul style="list-style-type: none"> <li>- Structure of organic compounds, hydrocarbons, basic reactions of alkanes, alkenes, alkynes; basic groups of synthetic polymers, properties and use of thermoplastics, duroplasts, elastoplastics.</li> </ul> <p>10. Content of Lecture 10: THERMAL CHARACTERISTICS OF NON-METALLIC MATERIALS</p> <ul style="list-style-type: none"> <li>- Phase transitions, characteristic transition temperatures, thermal expansion coefficient, physical aging, effect of heating or cooling rate on phase transitions, free volume concept, methods for determination of thermal properties of non-metallic materials.</li> </ul> <p>11. Content of Lecture 11: NON-METALLIC COMPOSITES</p> <ul style="list-style-type: none"> <li>- Basic components and types of composite structures, types and properties of reinforcement components (fibers, particles, nanoparticles), types of polymer matrices, fabrication processes, calculation of mechanical properties.</li> </ul> <p>12. Content of Lecture 12: VISCOELASTIC PROPERTIES of NON-METALLIC MATERIALS</p> <ul style="list-style-type: none"> <li>- Fundamentals of viscoelasticity, theory of linear viscoelasticity, mechanical models for the description of viscoelastic responses, basic material functions, static and dynamic material functions, Poisson number.</li> </ul> <p>13. Content of Lecture 13: TIME-</p>
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<p>Poissonovo število.</p> <p>13. Vsebina 13. Predavanja: ČASOVNO-ODVISNE ZNAČILNOSTI POLIMERNIH MATERIALOV</p> <ul style="list-style-type: none"> <li>- Časovno odvisno mehansko vedenje polimerov, materialne (prenosne) funkcije (statične in dinamične), fizikalno ozadje procesov lezenja in relaksacije, mehanski spekter materiala (relaksacijski, retardacijski), fizikalni pomen mehanskega spektra.</li> </ul> <p>14. Vsebina 14. Predavanja: VPLIV TEMPERATURE, TLAKA in VLAGE NA ČASOVNO-ODVISNO MEHANSKO VEDENJE POLIMERNIH MATERIALOV</p> <ul style="list-style-type: none"> <li>- Vpliv vlage, temperature in tlaka na mehanske lastnosti, eksperimentalne metode in principi karakterizacije časovno odvisnega vedenja polimerov: Boltzmanov superpozicijski princip, izohrone, sumarna krivulja, premaknitveni faktorji, WLF enačba, Doolittle enačba.</li> </ul> <p>15. Vsebina 15. Predavanja: RECIKLIRANJE POLIMERNIH MATERIALOV</p> <ul style="list-style-type: none"> <li>- Vrste recikliranja, vpliv strukture na izbiro postopka recikliranja, vpliv recikliranja na termične, strukturne in mehanske lastnosti.</li> </ul>	<p>DEPENDENT CHARACTERISTICS of POLYMER MATERIALS</p> <ul style="list-style-type: none"> <li>- Time dependent mechanical behavior of polymers, material (transfer) functions (static and dynamic), physical background of creep and relaxation processes, material mechanical spectrum (relaxation, retardation), physical significance of mechanical spectrum.</li> </ul> <p>14. Content of Lecture 14: The EFFECT of TEMPERATURE, PRESSURE and MOISTURE on the TIME-DEPENDENT MECHANICAL BEHAVIOUR of POLYMER MATERIALS</p> <ul style="list-style-type: none"> <li>- The effect of moisture, temperature and pressure on mechanical properties, experimental methods and principles of characterization of the time-dependent behavior of polymers: Boltzmann superposition principle, isochrones, master curves, shift factors, WLF equation, Doolittle equation.</li> </ul> <p>15. Content of Lecture 15: RECYCLING of POLYMER MATERIALS</p> <ul style="list-style-type: none"> <li>- Types of recycling processes, the impact of structure on the selection of the recycling process, the impact of recycling on thermal, structural and mechanical properties.</li> </ul>
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### Temeljna literatura in viri/Readings:

<ol style="list-style-type: none"> <li>1. F. Lazarini in J. Brenčič: Splošna in Anorganska kemija, Založba FKKT, Ljubljana 1989, [COBISS.SI-ID <a href="#">8362496</a>]</li> <li>2. Atkins, Peter William, De Paula, Julio, Atkins' physical chemistry, Oxford [etc.] : Oxford University Press, cop. 2006, ISBN - 0-19-870072-5, [COBISS.SI-ID <a href="#">27638277</a>]</li> <li>3. Ferry J.D.: Viscoelastic properties of polymers. John Wiley &amp; Sons, 1980, ISBN - 0-471-04894-1, [COBISS.SI-ID <a href="#">139823</a>].</li> <li>4. Ward I.M., and John Sweeney. Mechanical properties of solid polymers. John Wiley &amp; Sons, 2012, ISBN - 0-471-91995-0, [COBISS.SI-ID <a href="#">141289</a>].</li> <li>5. McCrum N.G., Buckley C.P., Bucknall C.B., Principles of Polymer Engineering, Oxford University Press, New York, 1997, ISBN - 978-0-19-856526-0, [COBISS.SI-ID <a href="#">16337179</a>].</li> </ol>
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### Cilji in kompetence:

<p>Cilji:</p> <ol style="list-style-type: none"> <li>1. Cilj 1: spoznati pomen kemije v</li> </ol>	<p>Aims:</p> <ol style="list-style-type: none"> <li>1. Aim 1: to understand the importance</li> </ol>
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### Objectives and competences:

<p>inženirstvu s poudarkom na realnih primerih v strojništvu</p> <p>2. Cilj 2: spoznati povezavo poznavanja zgradbe snovi in njen vpliv na kemijske in fizikalne lastnosti materiala</p> <p>3. Cilj 3: spoznati lastnosti nekovinskih materialov pri različnih okoljskih pogojih</p> <p>4. Cilj 4: spoznati lastnosti nekovinskih materialov pri različnih pogojih obremenjevanja</p> <p>5. Cilj 5: spoznati pomen trajnostnega razvoja</p> <p>Kompetence:</p> <p>1. Kompetenca 1: sinteza osnov kemije v strojniške aplikacije (S6-RRP + P1-RRP)</p> <p>2. Kompetenca 2: sposobnost analize zgradbe snovi ter njenega vpliva na kemijske in fizikalne lastnosti materiala (S1-RRP, S8-RRP + P2-RRP)</p> <p>3. Kompetenca 3: sposobnost napovedovanja vedenja nekovinskih materialov pri različnih okoljskih pogojih (S7-RRP + P3-RRP)</p> <p>4. Kompetenca 4: sposobnost napovedovanja vedenja nekovinskih materialov pri različnih pogojih obremenjevanja (S2-RRP + P6-RRP)</p> <p>5. Kompetenca 5: sposobnost izbire ustreznega postopka predelave po končani življenjski dobi izdelka (S9-RRP + P5-RRP)</p>	<p>of chemistry in engineering with a focus on real-life examples in mechanical engineering</p> <p>2. Aim 2: to understand the connection between the structure and the chemical and physical properties of the material</p> <p>3. Aim 3: to learn about the properties of non-metallic materials under different environmental conditions</p> <p>4. Aim 4: to learn about the properties of non-metallic materials under various loading conditions</p> <p>5. Aim 5: to understand the importance of sustainable development</p> <p>Competences:</p> <p>1. Competence 1: the ability to use the basic knowledge of chemistry in mechanical engineering (S6-RRP + P1-RRP)</p> <p>2. Competence 2: the ability to analyze the structure of the material and its effect on the chemical and physical properties (S1-RRP, S8-RRP + P2-RRP)</p> <p>3. Competence 3: the ability to predict the behavior of non-metallic materials under different environmental conditions (S7-RRP + P3-RRP)</p> <p>4. Competence 4: the ability to predict the behavior of non-metallic materials under different loading conditions (S2-RRP + P6-RRP)</p> <p>5. Competence 5: the ability to select the appropriate recycling process after the end of the product's lifetime (S9-RRP + P5-RRP)</p>
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### **Predvideni študijski rezultati:**

#### **Znanja:**

Z1: Poglobljeno strokovno teoretično in praktično znanje kemije v inženirstvu s poudarkom na dejanskih realnih primerih snovi in nekovinskih materialov v strojništvu. Osnovno znanje kemije s povezavo poznavanja zgradbe snovi in njen vpliv na kemijske ter fizikalne lastnosti materiala.

### **Intended learning outcomes:**

#### **Knowledge:**

Z1: In-depth theoretical and practical knowledge of chemistry in engineering with a focus on actual real-life examples of non-metallic materials in mechanical engineering. Basic knowledge of chemistry with relation between the knowledge of structure and its effect on chemical and physical properties of

<p>Poglobljeno strokovno teoretično in praktično znanje na področju vedenja nekovinskih materialov pri različnih okoljskih vplivih in obremenitvah.</p> <p>Spretnosti:</p> <ol style="list-style-type: none"> <li>1. S1 Izvajanje kompleksnih karakterizacijskih tehnik in metod za določevanje različnih lastnosti nekovinskih materialov.</li> <li>2. S1.2 Obvladovanje zahtevnih, kompleksnih lastnosti nekovinskih materialov ob samostojni uporabi pridobljenega znanja v realnih delovnih situacijah.</li> <li>3. S1.3 Diagnosticiranje in reševanje problemov uporabe nekovinskih materialov v industrijskih procesih na področju strojništva.</li> <li>4. S1.4 Osnova za izvirne rešitve napak nekovinskih produktov oz. tehnoloških procesov predelave nekovinskih materialov ter kritično refleksijo.</li> </ol>	<p>material.</p> <p>In-depth theoretical and practical knowledge of the behavior of non-metallic materials at various environmental impacts and loads.</p> <p>Skills:</p> <ol style="list-style-type: none"> <li>1. S1 Implementation of complex characterization techniques and methods for determination of various properties of non-metallic materials.</li> <li>2. S1.2 Mastering demanding and complex properties of non-metallic on the basis of creative use of acquired knowledge in specialised professional fields.</li> <li>3. S1.3 Solving problems of using non-metallic materials in industrial processes.</li> <li>4. S1.4 Ability of unique solutions in technological processes and critical reflections.</li> </ol>
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### **Metode poučevanja in učenja:**

<ol style="list-style-type: none"> <li>1. Metoda 1: Klasične oblike poučevanja: P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki. P5 Uporaba študijskega gradiva v obliki skripta, e-verzija predstavitve predavanj P9 Skupinsko delo (razprave za - proti, strukturirana diskusija, viharjenje možganov)</li> <li>2. Metoda 2: Moderne in prožne oblike poučevanja: P10 Uporaba anket v realnem času P14 Virtualni eksperimenti P15 Uporaba video vsebin kot priprava na predavanja</li> </ol>
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### **Learning and teaching methods:**

<ol style="list-style-type: none"> <li>1. Method 1: Conventional teaching methods: P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases. P2 Presenting the content according to the explained system. P5 Application of study material (textbook, e-book of the lectures). P9 Team work (discussions pro and contra, structured discussion, brainstorming)</li> <li>1. Method 2: Contemporary and flexible teaching methods: P10 Application of questionnaires in real time. P14 Virtual experiments. P15 Application of videos for preparations to the lectures and exercises.</li> </ol>
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**Načini ocenjevanja:****Delež/  
Weight****Assessment:**

- Teoretične vsebine (predavanja).	60,00 %	- Theoretical part (lectures).
- Samostojno delo na vajah.	20,00 %	- Individual work during laboratory practice.
- Delo na laboratorijskih vajah (vključno s poročili).	20,00 %	- Laboratory work (report included).

**Ocenjevalna lestvica:****Grading system:**

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**Reference nosilca/Lecturer's references:****Lidija Slemenik Perše:**

1. HAJZERI, Metka, **SLEMENIK PERŠE, Lidija**, KOŽELJ, Matjaž, OREL, Boris, SURCA, Angelja Kjara. Structural investigation of ormolytes for EC devices : IR spectroscopic characterization and relation between viscoelastic properties, conductivity and optical modulation. Solar energy materials and solar cells, ISSN 0927-0248. [Print ed.], Aug. 2015, vol. 139, str. 51-64. [COBISS.SI-ID [5675802](#)]
2. BEK, Marko, AULOVA, Alexandra, PUŠNIK ČREŠNAR, Klementina, MATKOVIČ, Sebastjan, KALIN, Mitjan, **SLEMENIK PERŠE, Lidija**. Long-term creep compliance of wood polymer composites: using untreated wood fibers as a filler in recycled and neat polypropylene matrix. Polymers. June 2022, vol. 14, iss. 13 (2539), 19 str., ilustr. ISSN 2073-4360.  
<https://repozitorij.uni-lj.si/IzpisGradiva.php?id=137942>,  
<https://dk.um.si/IzpisGradiva.php?id=82068>, DOI: 10.3390/polym14132539. [COBISS.SI-ID [113069315](#)]
3. SHANKAR VADIVEL, Hari, BEK, Marko, ŠEBENIK, Urška, **SLEMENIK PERŠE, Lidija**, KÁDÁR, Roland, EMAMI, Nazanin, KALIN, Mitjan. Do the particle size, molecular weight, and processing of UHMWPE affect its thermomechanical and tribological performance?. Journal of Materials Research and Technology. May-Jun. 2021, vol. 12, str. 1728-1737, ilustr. ISSN 2238-7854.  
<https://www.sciencedirect.com/science/article/pii/S2238785421003148>,  
<https://repozitorij.uni-lj.si/IzpisGradiva.php?id=126861>, DOI: 10.1016/j.jmrt.2021.0087. [COBISS.SI-ID [59130883](#)]
4. OPARA KRAŠOVEC, Urša, VIDMAR, Tjaša, KLANJŠEK GUNDE, Marta, CERC KOROŠEC, Romana, **SLEMENIK PERŠE, Lidija**. In-depth rheological characterization of tungsten sol-gel inks for inkjet printing. Coatings. 2022, vol. 12, iss. 2, 15 str., ilustr. ISSN 2079-6412. <https://www.mdpi.com/2079-6412/12/2/112>, <https://dirros.openscience.si/IzpisGradiva.php?id=14744&lang=slv>, <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=137098>, <https://dirros.openscience.si/IzpisGradiva.php?id=14744>, DOI: 10.3390/coatings12020112. [COBISS.SI-ID [96639491](#)]
5. AULOVA, Alexandra, BEK, Marko, **SLEMENIK PERŠE, Lidija**. Effect of calendering temperatures on mechanical properties of polypropylene foils. V:

Book of abstract : MTDM 2018. The 11th International Conference on the Mechanics of Time Dependent Materials, September 4th-7th, 2018. [COBISS.SI-ID [16267035](#)]

**Alen Oseli:**

1. **OSELI, Alen**, TOMKOVIĆ, Tanja, HATZIKIRIAKOS, Savvas G., VESEL, Alenka, ARZENŠEK, Matija, ROJAC, Tadej, MIHELČIČ, Mohor, SLEMENIK PERŠE, Lidija. Carbon nanotube network formation and configuration/morphology on reinforcing and conductive performance of polymer-based nanocomposites. *Composites science and technology*. 26 May 2023, vol. 237, [article no.] 110010, str. 1-9, ilustr. ISSN 1879-1050.  
<https://www.sciencedirect.com/science/article/pii/S0266353823001033>,  
<https://repozitorij.uni-lj.si/IzpisGradiva.php?id=145001>, DOI:  
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2. **OSELI, Alen**, VESEL, Alenka, ŽAGAR, Ema, SLEMENIK PERŠE, Lidija. Mechanisms of single-walled carbon nanotube network formation and its configuration in polymer-based nanocomposites. *Macromolecules*. Apr. 2021, vol. 54, iss. 7, str. 3334-3346, ilustr. ISSN 0024-9297.  
<https://pubs.acs.org/doi/10.1021/acs.macromol.0c02763>, <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=126692>, DOI: [10.1021/acs.macromol.0c02763](https://doi.org/10.1021/acs.macromol.0c02763). [COBISS.SI-ID [58206467](#)]
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