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PROCEEDINGS

Natural Sciences

Banja Luka
2022.

NANOSENSOR FOR DETECTION OF GLUTATHIONE

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Introduction: Mesoporous silica nanoparticles (MSN) are promising materials for bioanalyte detection and targeted drug delivery applications due to their characteristic properties, large specific surface area and porosity, and the possibility of surface functionalization. The development of optimized and personalized diagnostic tools targeting glutathione (GSH), based on these nanomaterials for detection in the tumor environment, will provide real-time data on patients' cancer tissue.

Aim: Synthesis of glutathione-specific MSN to develop a fast and efficient sensor for real-time monitoring of tumor treatment progress.

Material and Methods: The materials were synthesized from tetraethyl orthosilicate as a precursor, using cetrimonium bromide as a template in a basic environment at a temperature of 80 °C. The surface of the nanoparticles was functionalized with amino groups, and an inclusion complex with cyclodextrin (CD) was formed using a thiol bond. In this way, CD, as a large molecule, blocked the pores and prevented the color from coming out. The mesopores of the material were filled with the dye tris(bipyridine)ruthenium(II), ([Ru (Bpy)3]2+). Characterization was performed by infrared spectroscopy (IR), Brunauer-Emmett-Teller adsorption method (BET), and scanning electron microscope (SEM). The release of the dye was monitored by UV/VIS spectroscopy without and with the presence of glutathione at different concentrations.

Results: Surface functionalization, pore filling with dye molecules, and capping with cyclodextrin enabled the functionality of the nanomaterial as a sensor for glutathione in the concentration range from 5 to 20 mM. Namely, in the presence of GSH, the thiol bond between the CD, which retains the color in the pores, and the surface of the MSN is breached, allowing the detection of the released color as a signal of an increased GSH concentration. The characterization of the material proved the structure of MSN, and the bands at 1082 cm-1 and 1633 cm-1 in the IR spectrum proved the Si-O-Si vibrations and successful functionalization of amino groups on the surface of the material, respectively. The BET analysis of the starting material displayed a type IV isotherm and a high surface area (701 m2/g), while SEM analysis confirmed the particle size distribution from 80 to 200 nm.

Conclusion: The synthesized nanomaterial showed the ability to detect an increased concentration of glutathione under physiological conditions, which will allow faster and easier diagnosis through further development of a sensor for its detection.

Keywords: mesoporous silica nanoparticles, glutathione, sensor

Nanosenzor za detekciju glutationa

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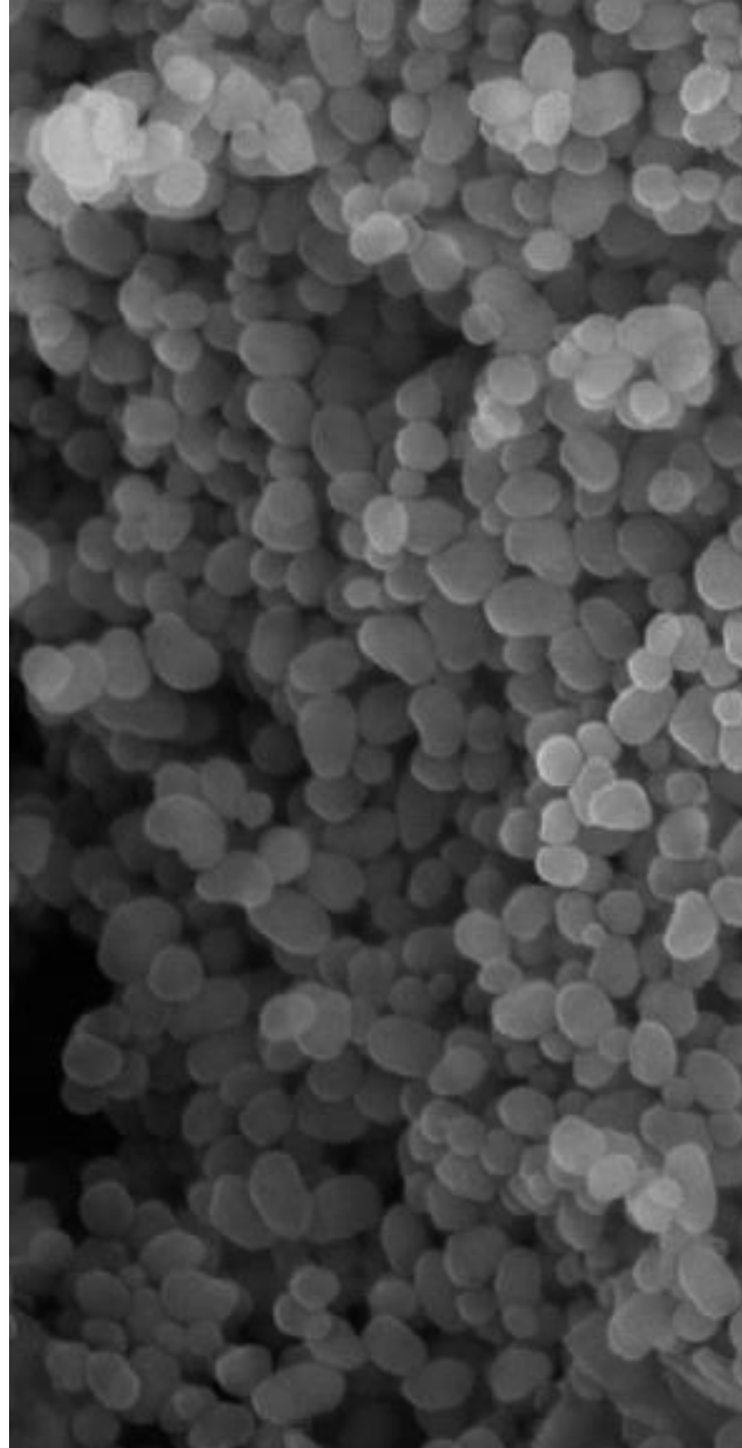
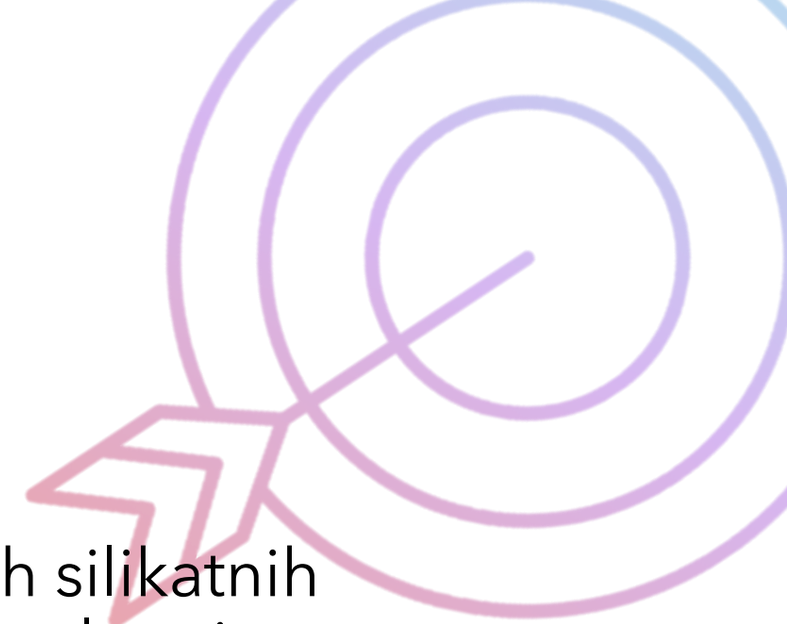


CILJ istraživanja

Sintetisanje mezoporoznih silikatnih nanočestica specifičnih za glutation u cilju razvoja brzog i efikasnog senzora za praćenje napretka terapije lečenja tumora u realnom vremenu.



ZAŠTO je važno?

Glutation se u tumorskom okruženju nalazi u povećanoj koncentraciji u odnosu na zdravo tkivo. Prema tome, predstavlja važan ciljani analit za mogućnost **rane detekcije** kancera, a time i uspostavljanja rane dijagnoze.

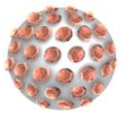
Nanosenzor za detekciju glutationa

1

NANOSENZOR

Mesoporozne silikatne nanočestice (MSN)

Funkcionalizacija, punjenje pora i zatvaranje pora



Karakterizacija materijala

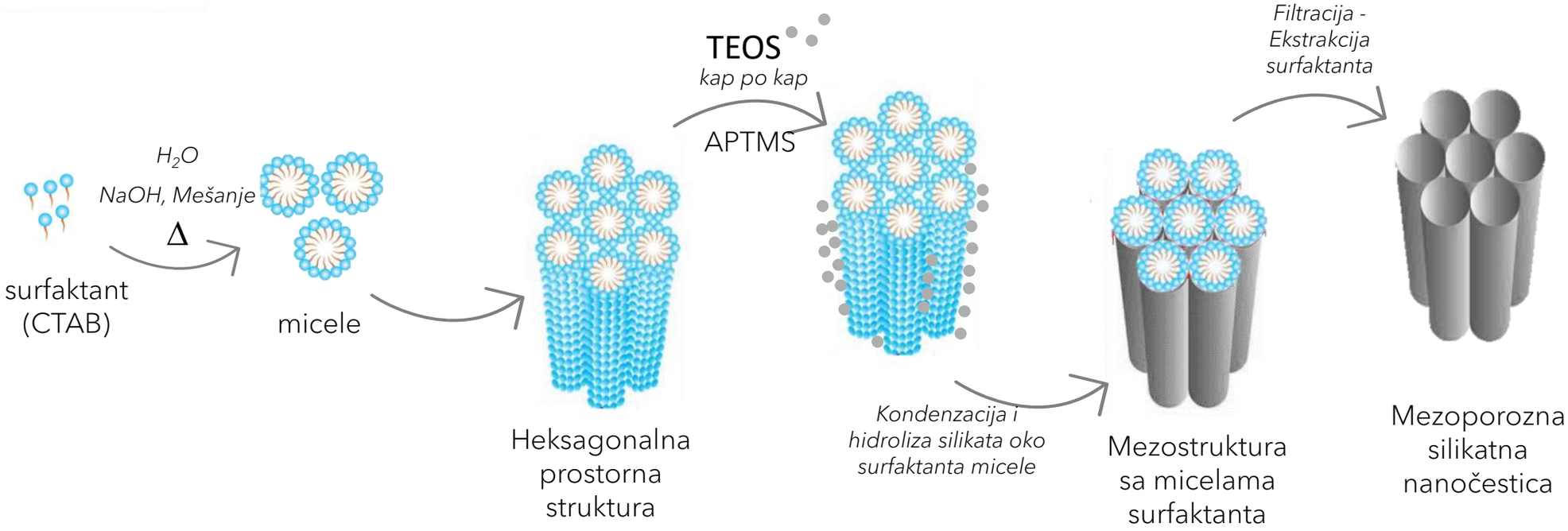
2

Detekcija glutationa

Spektroskopsko praćenje kinetike otpuštanja – pH responsivne nanočestice

Mesoporozne silikatne nanočestice (MSN)

velika specifična površina funkcionalizovanje površine poroznost



Mesoporozne silikatne nanočestice (MSN)

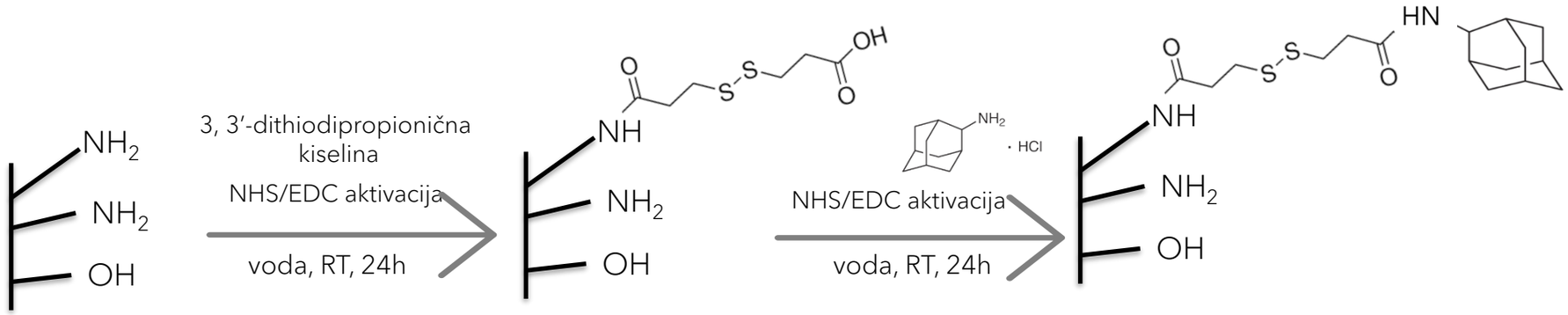
velika specifična površina funkcionalizovanje površine poroznost

Funkcionalizacija površine materijala

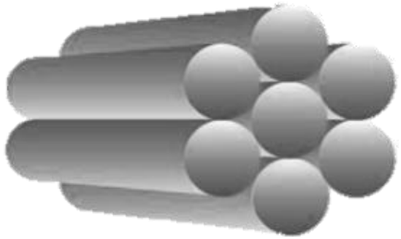
Punjenje mezopora materijala bojom, tris(bipiridin)rutenium(II), $[Ru(Bpy)_3]^{2+}$

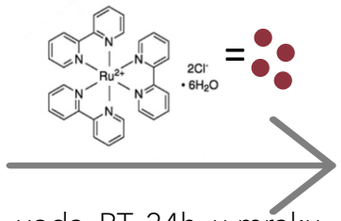
Zatvaranje pora ciklodekstrinom, molekulom koji sprečava izlazak boje

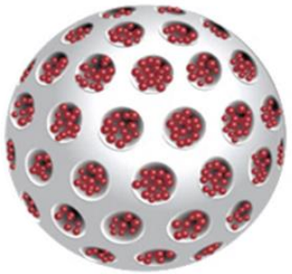
Funkcionalizacija površine materijala



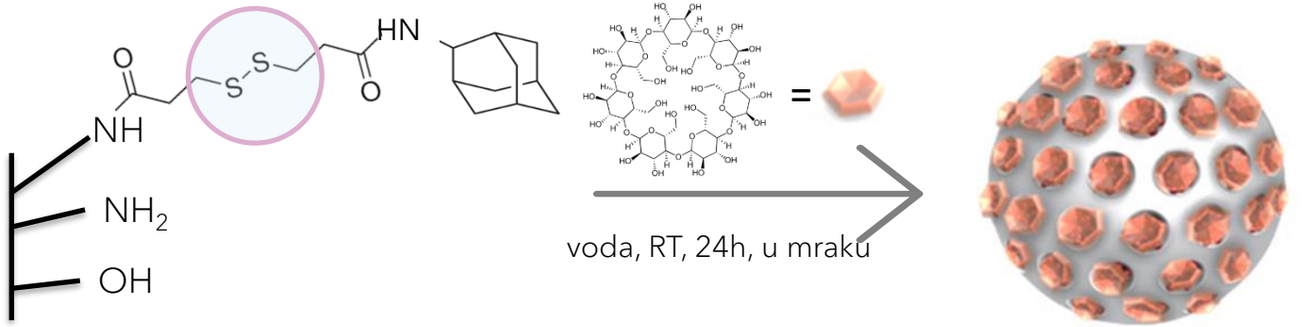
Punjenje mezopora materijala bojom, tris(bipiridin)rutenium(II), $[Ru(Bpy)_3]^{2+}$





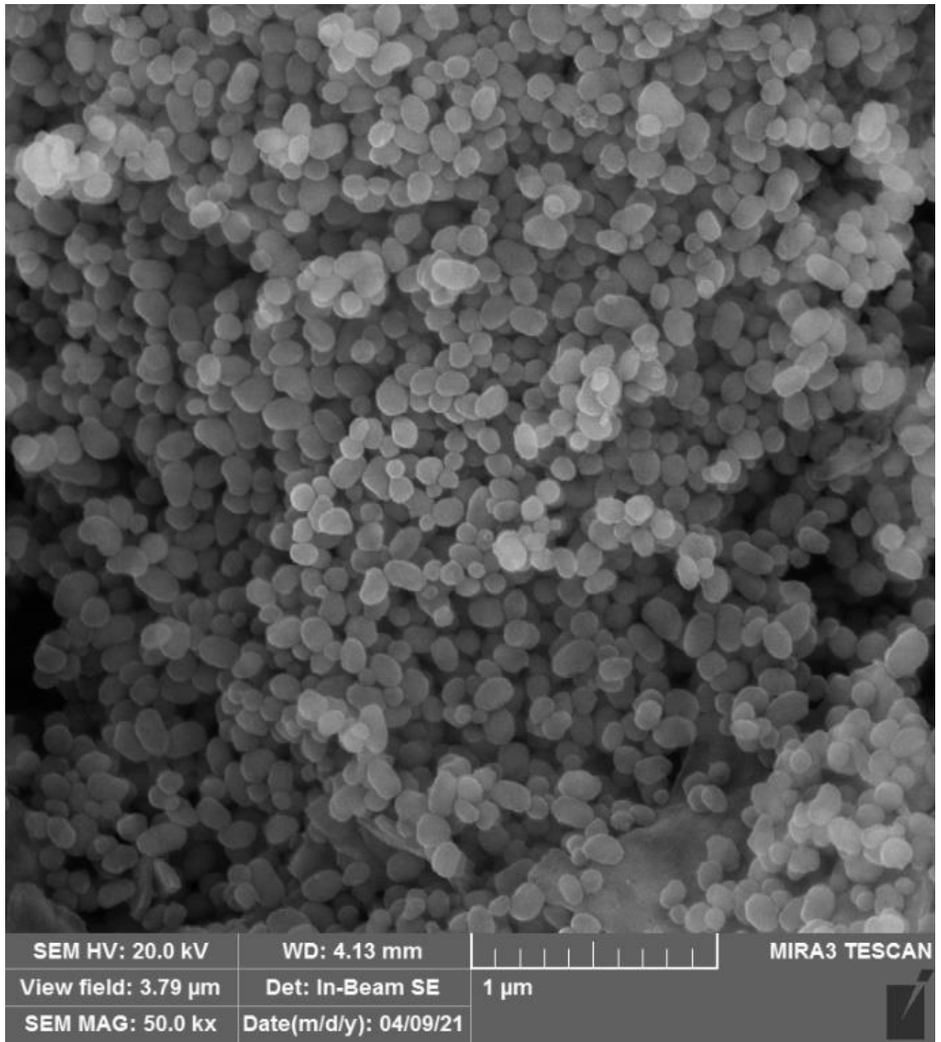


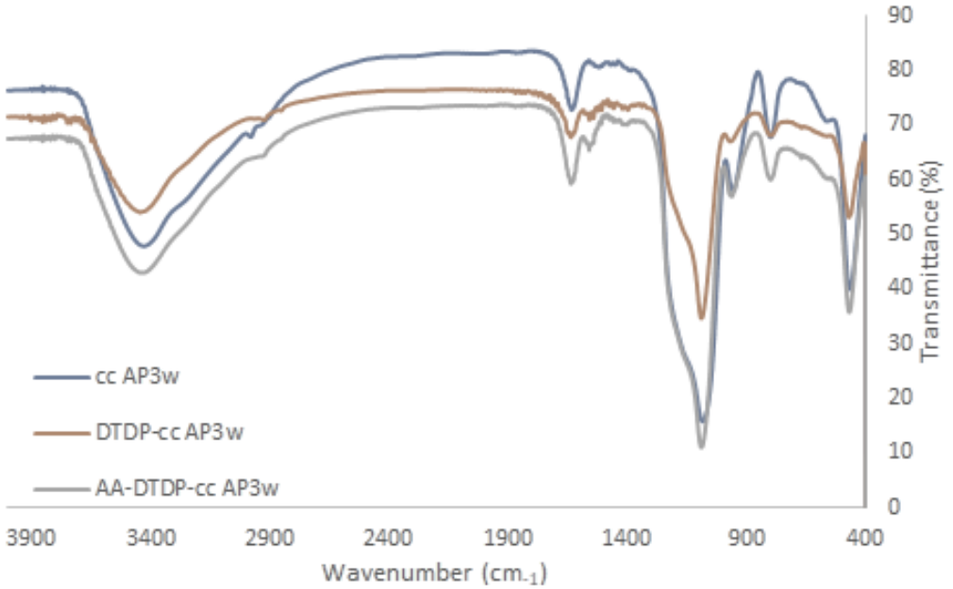
Zatvaranje pora ciklodekstrinom, molekulom koji sprečava izlazak boje



Karakterizacija materijala FTIR BET TGA SEM DLS/ELS

Raspodela veličine čestica od 80 do 200 nm.

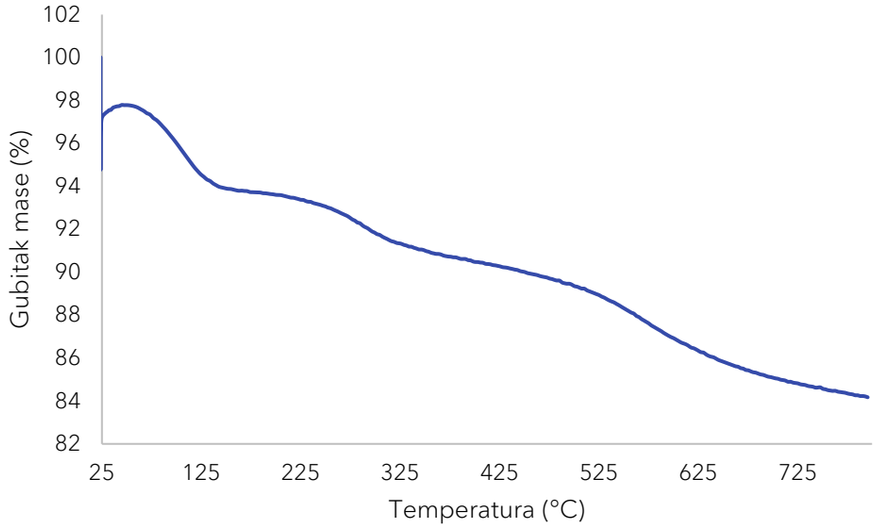


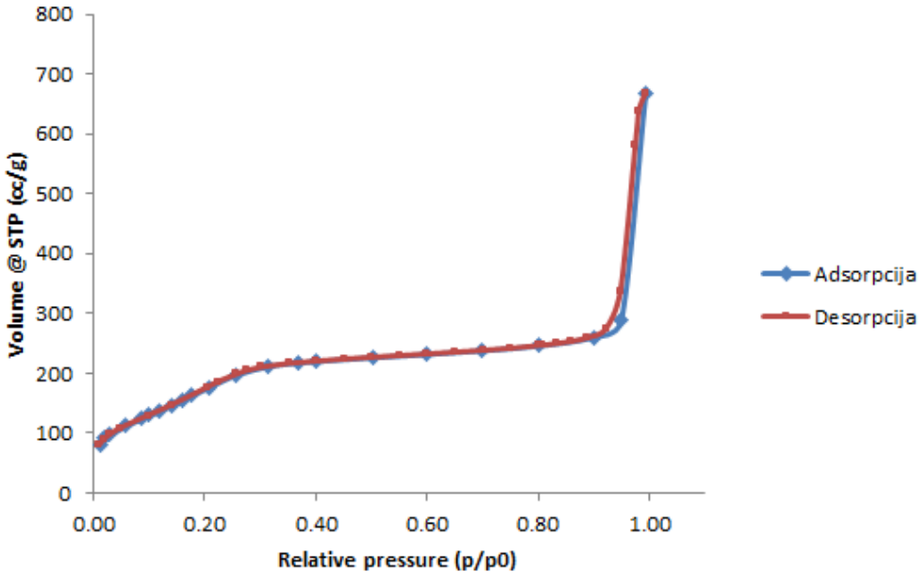


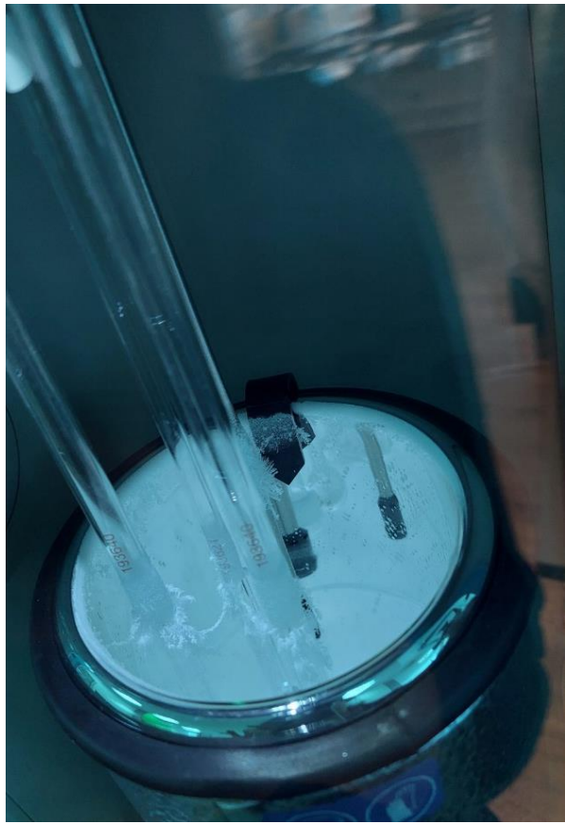
Talasne dužine (cm^{-1})	Funkcionalne grupe
1082	Si-O-Si
1633	Amino grupe

Karakterizacija materijala

FTIR BET TGA SEM DLS/ELS







Materijal	ccAP3
Zeta potencijal (mV)	+3.1
Prečnik čestice (nm)	405
Specifična površina (m^2/g)	701

Nanosenzor za detekciju glutationa

1

NANOSENZOR

Mesoporozne silikatne nanočestice (MSN)

Funkcionalizacija, punjenje pora I zatvaranje pora

Karakterizacija materijala

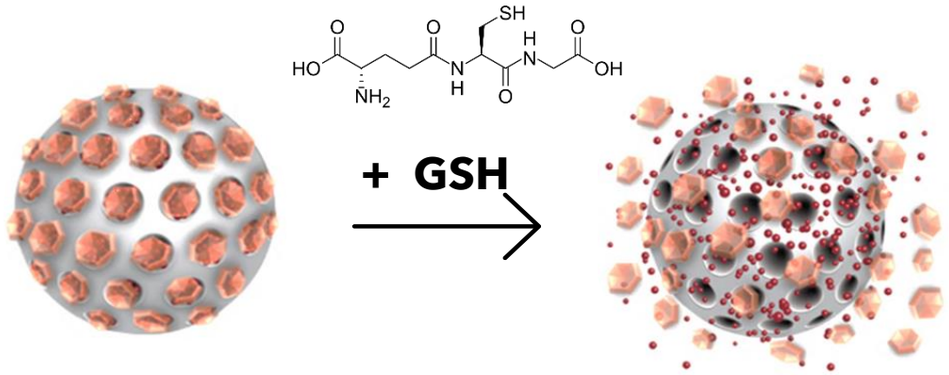
2

Detekcija glutationa

Spektroskopsko praćenje kinetike otpuštanja boje – pH responsivne nanočestice

Postavka eksperimenta

Disperzija sintetisanog materijala u PBS-u 7,4 u koji je u određenim vremenskim intervalima dodavan glutation (GSH).



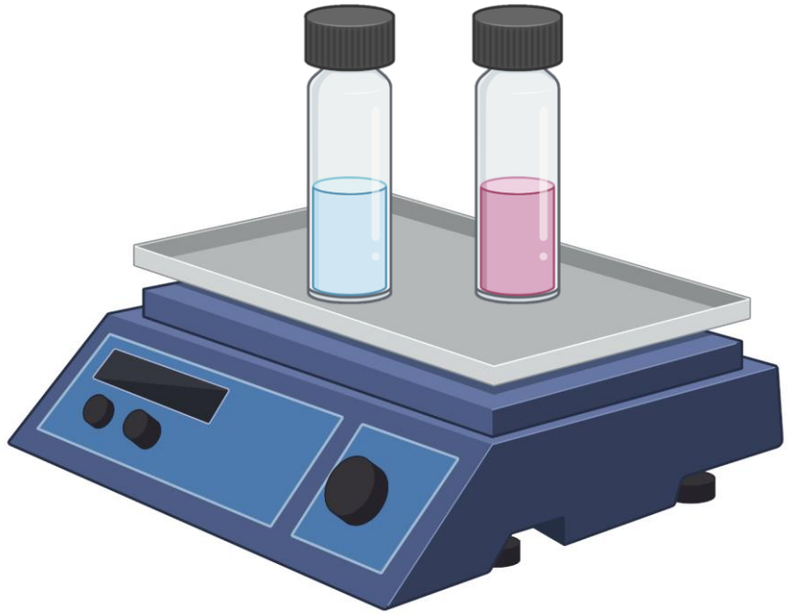
U prisustvu GSH dolazi do **raskidanja tiolne veze** između CD koji zadržava boju u porama i površine MSN-a, što omogućava detekciju otpuštene boje kao signala za povišenu koncentraciju GSH.

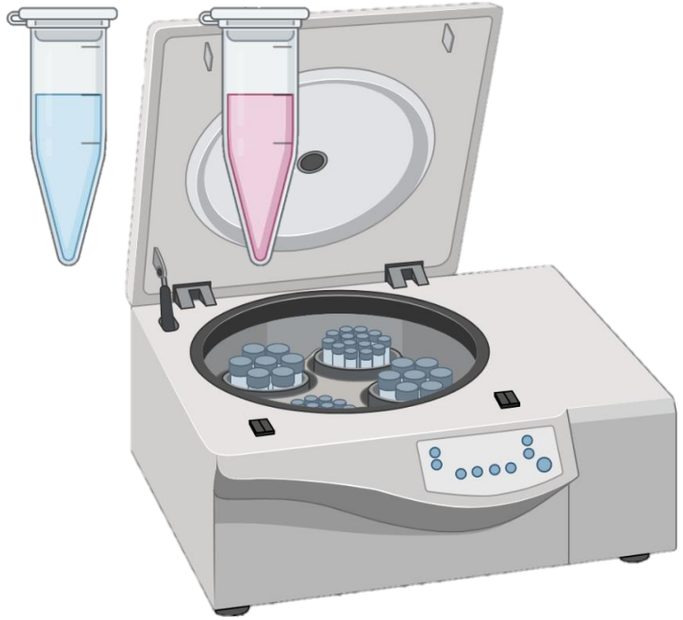
Detekcija otpušene boje praćena je spektofotometrijskom metodom.

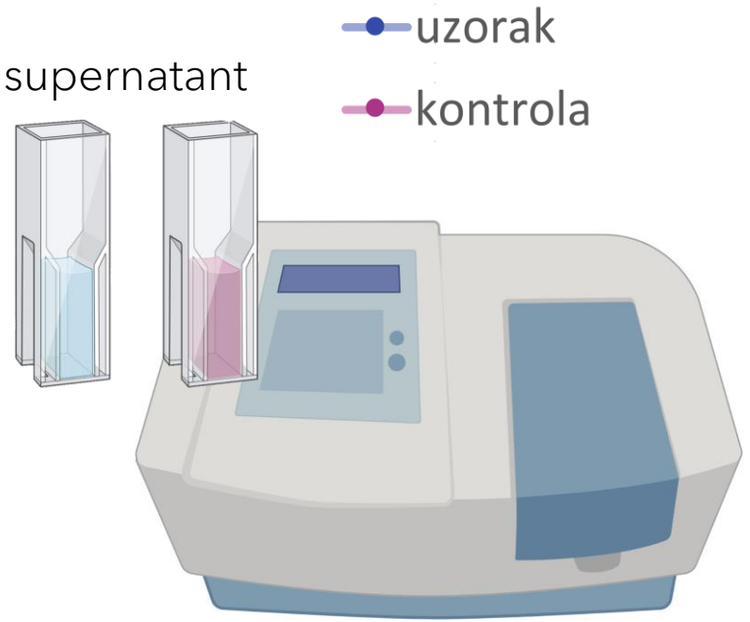
Postavka eksperimenta

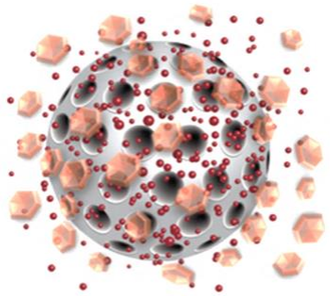
Disperzija materijala u PBS 7,4 - **uzorak** u koji je u određenim vremenskim intervalima dodavan glutation (GSH)

Disperzija materijala u PBS 7,4 - **kontrola**









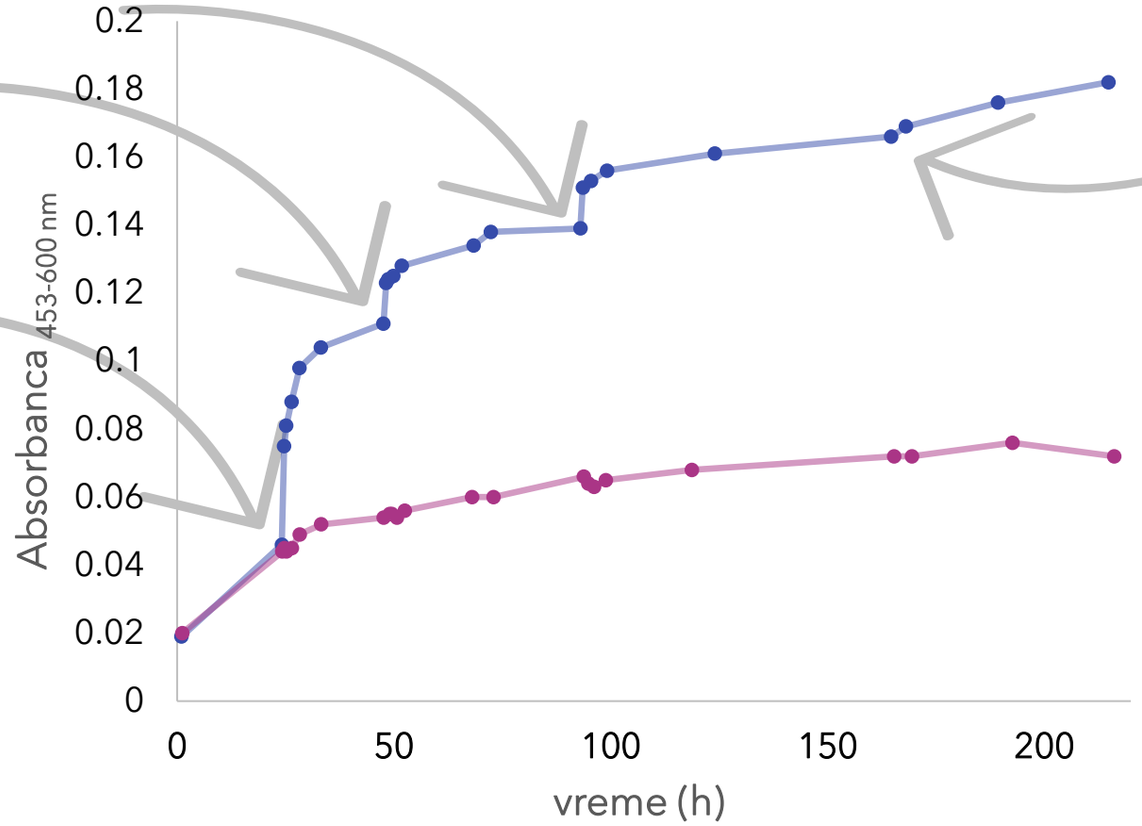
Kinetika otpuštanja

2

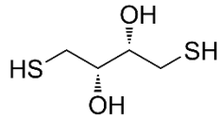
+ 10mM GSH

+ 5mM GSH

+ 5mM GSH



+ 20mM DTT (Ditiotretol)



zaključak

Sintetisani nanomaterijal je pokazao mogućnost detekcije povišene koncentracije glutationa u fiziološkim uslovima, što će kroz dalji razvoj senzora za njegovu detekciju omogućiti bržu i jednostavniju dijagnostiku.

Naš TIM

dr Nikola Knežević
Naučni Savetnik

Minja Mladenović
Istraživač saradnik

Mirjana Mundžić
Istraživač pripravnik

Aleksandra Pavlović
Istraživač pripravnik

Networking **A**ctivites for **N**an**o**technology – **Fa**cilitated **C**ancer **T**heranostic**s** Widespread

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Prediction of Cancer Treatment Effectiveness with Stimuli-responsive Nanomaterials

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HVALA NA PAŽNJI.

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