4TH YOUNG SCIENTISTS' DAY

07th October 2022

Faculty of Agrobiotehnical Sciences Osijek

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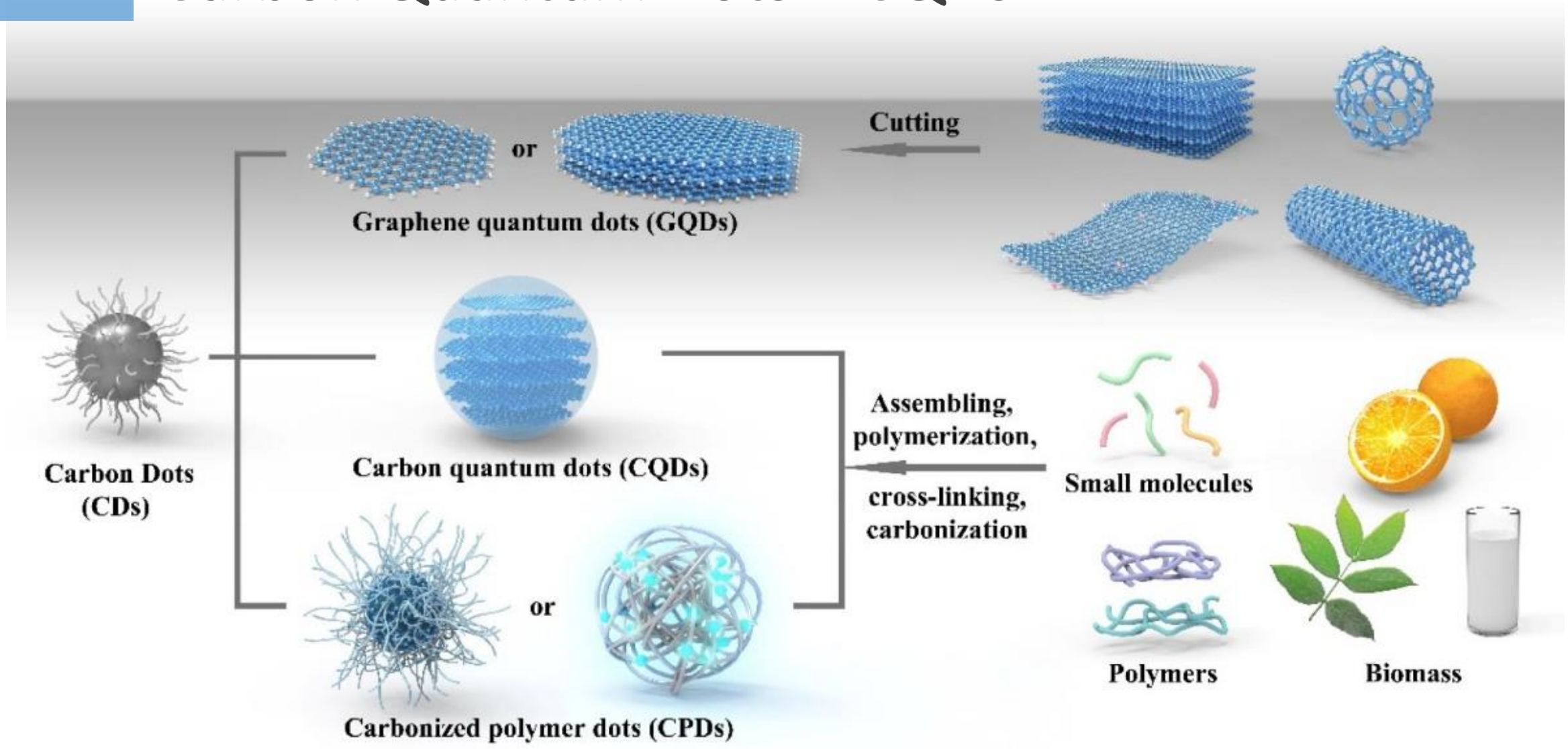
4th Young Scientists' Day

Preparation and Characterization of N-Doped/Hybrid Carbon Quantum Dots and Their Application in Metal Ion Detection

PhD Student: Silvija Šafranko, mag. chem.
Mentor: Stela Jokić, full professor
Co-Mentor: Ivica Strelec, full professor

Carbon Quantum Dots – CQDs

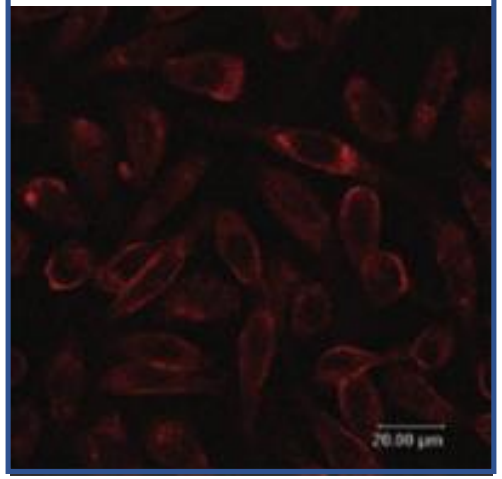


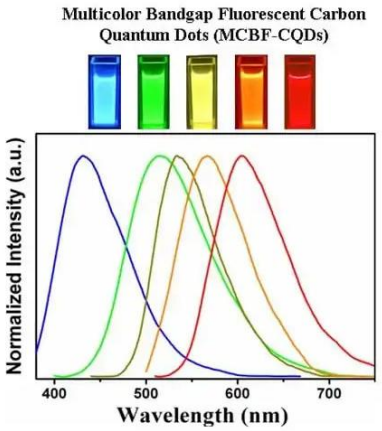
Carbon Dots: A Mystic Star in the World of Nanoscience

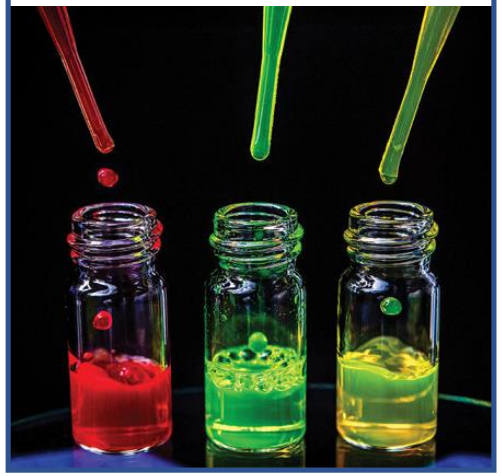
04

- Why are carbon quantum dots important and special?

BIOCOMPATIBILITY	TUNABLE PL*	FACILE SYNTHESIS	VERSATILE APPLICATION
Low toxicity important for biological and biomedical applications	CQDs exhibit strong and tunable fluorescence emission properties	Relative simple synthesis and functionalization; low-cost and green techniques	Strong photoluminescent properties and water solubility - applicability







*PL-Photoluminescence

THE IMPORTANCE OF CITRUS WASTE UTILIZATION – BY-PRODUCT OF FOOD INDUSTRY

CITRUS IS ONE OF THE MAJOR FRUIT CROPS GLOBALLY

Citrus peels, seeds, and membrane residue generated in the citrus processing industry account for approximately 50–60% of the total weight of fruit. Citrus peel waste requires high-cost disposal management and causes potential environmental pollution.

AN URGENT NEED FOR INNOVATIVE SOLUTIONS!

INNOVATIVE EXTRACTION METHODS

PREPARATION OF INNOVATIVE MATERIALS

CITRUS

JUICE

PEEL

MEMBRANE AND PULP

SEEDS

Citrus peels consist of the variety of bioactive compounds that can be used in pharmaceutical, cosmetic and food industry.

Biomass-derived CQDs

06

CAN WE USE BIOMASS FOR THE CQDs PREPARATION?

Low-cost resources and waste valorization

Different synthetic techniques can be applied

POTENTIAL PROBLEMS?

Lower toxicity and ease of modifications

Outstanding optical and chemical properties

Our Preliminary Results in CQDs Research

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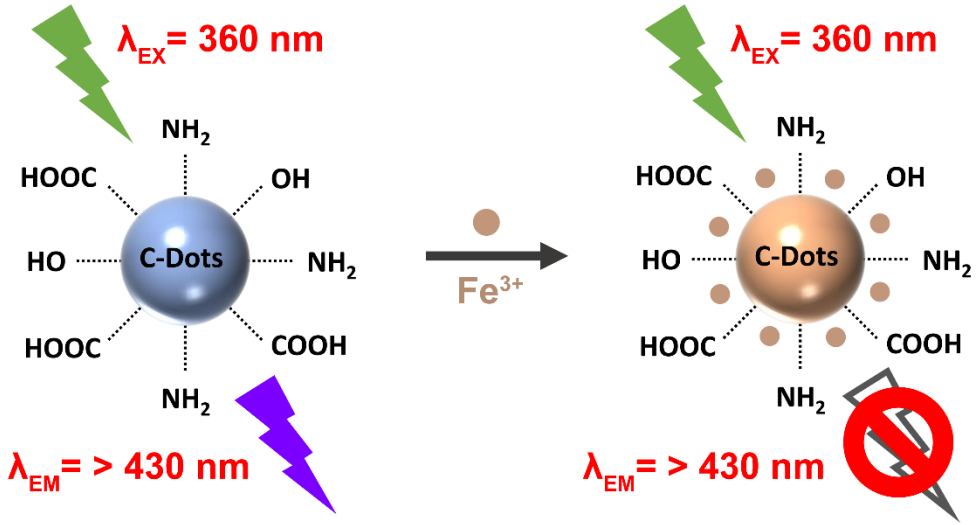
Citrus clementina waste

Biomass waste
+ Amino acid

180 °C, 12 h

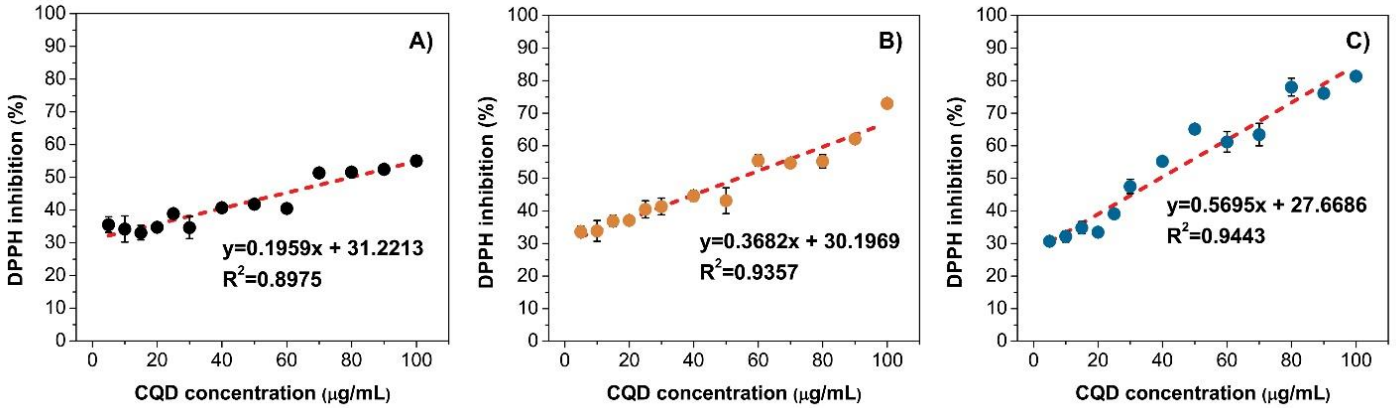


THREE SAMPLE WERE PREPARED:

BLANK (Pure CQDs)	CQDs@Gly	CQDs@Arg
QY=1.17% ζ-potential = -31.3±2.4 mV	QY=1.53% -21.0±3.2 mV	QY=2.17% -12.7±2.1 mV

The prepared CQDs exhibited good biocompatibility, stability in aqueous and high ionic strength media, similar optical properties, while differences were observed regarding the structural and chemical diversity, biological and antioxidant activity.

Our Preliminary Results in CQDs Research (3)



Antiradical activity

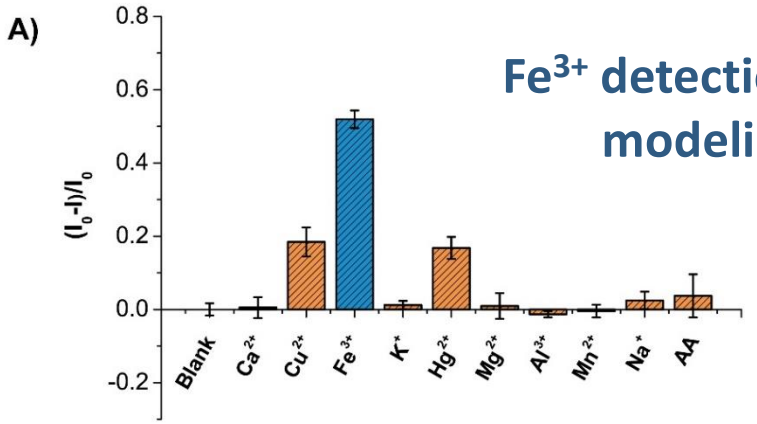
Pure CQD<CQDs@Gly<CQDs@Arg

Sample	Cell line IC_{50} (μg/mL)[1]					
	HepG2	CFPAC-1	MCF-7	HCT-116	HFF-1	
Pure CQD	>100	>100	>100	>100	1st experiment	20.59 ± 0.02
					2nd experiment	1.50 ± 0.02
					3rd experiment	>100
CQD@Arg	>100	>100	>100	>100	1st experiment	7.85 ± 0.02
					2nd experiment	*Proliferative effect*
					3rd experiment	>100
CQD@Gly	>100	6.91 ± 0.81	>100	>100	1st experiment	0.46 ± 0.01
					2nd experiment	*Proliferative effect*
					3rd experiment	>100

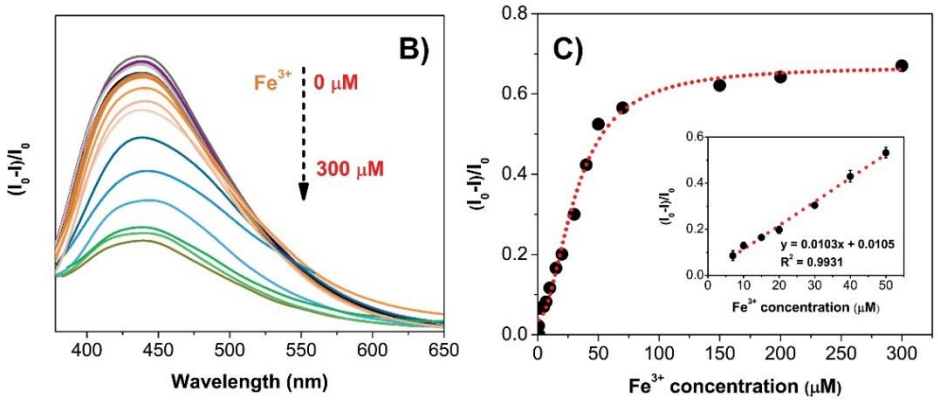
Antitumor activity and cell viability

Specific antitumor activity – CFPAC-1 cells (CQDs@Gly)

Our Preliminary Results in CQDs Research (4)

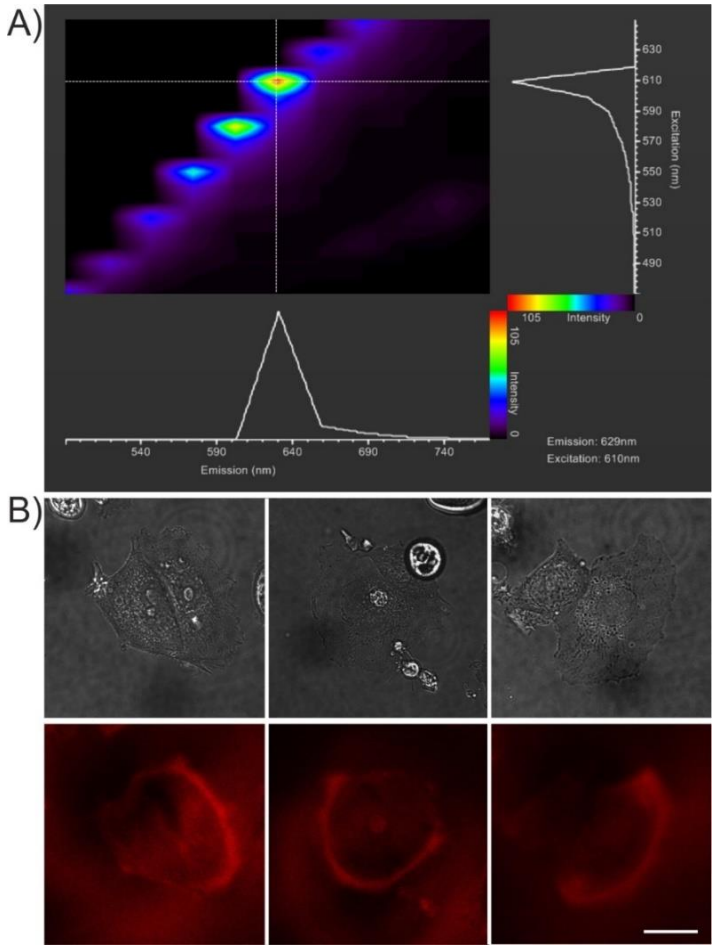


Fe^{3+} detection and modeling



Exponential function ($y=0.6992-0.6331/(1+(x/31.5993)^{1.94})$)

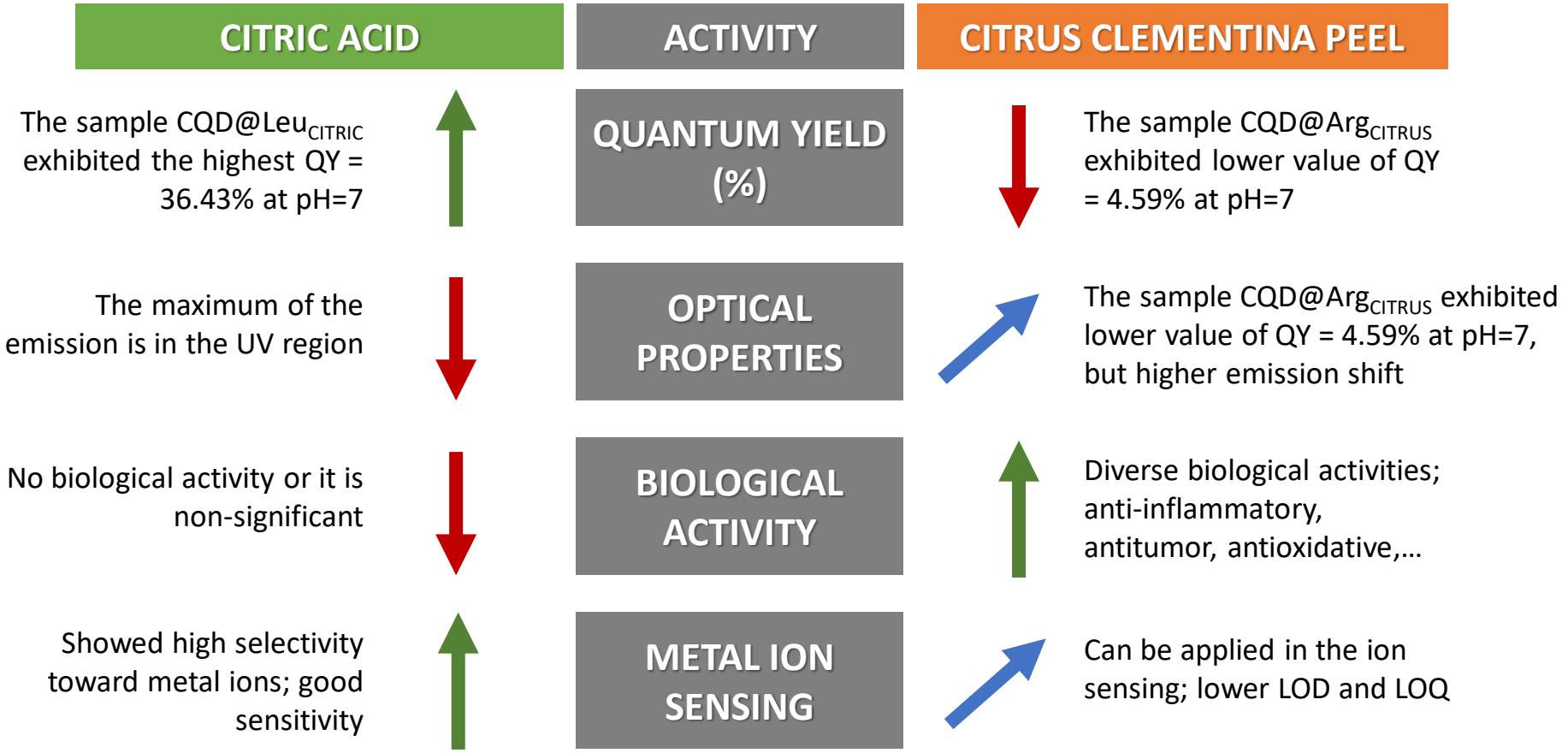
R^2=0.9891



Cellular imaging

N-Doped/Hybrid Carbon Quantum Dots (1)

- The preparation of CQD@hybrid, is it necessary?

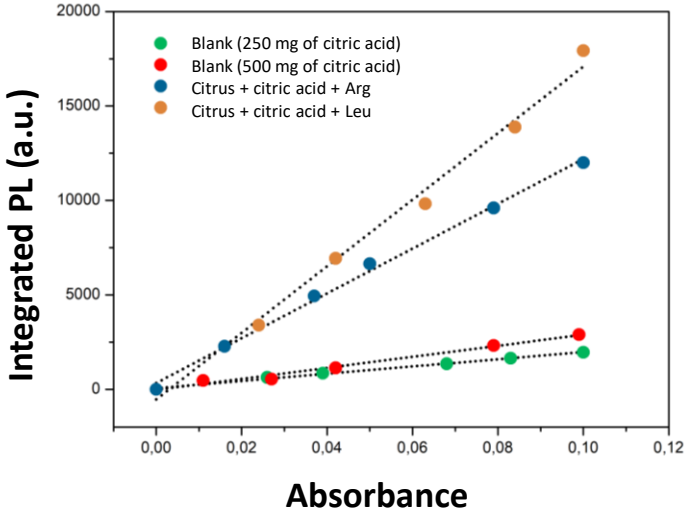


N-Doped/Hybrid Carbon Quantum Dots (2)

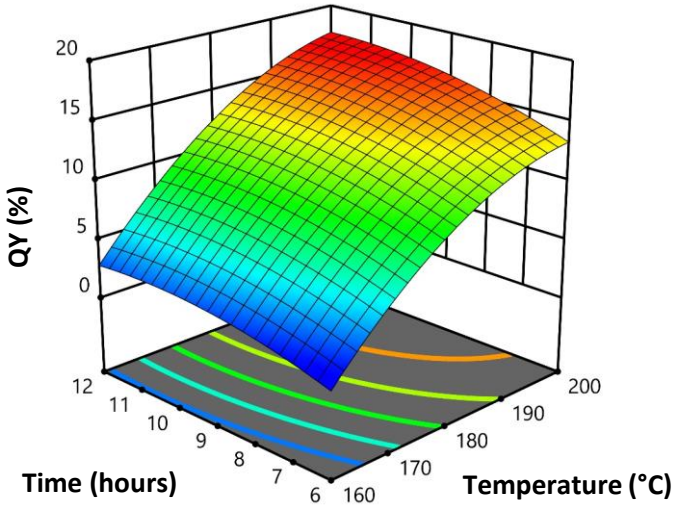
011

- The process toward obtaining higher quantum yield is optimized

No.	Extract (1:30) [mL]	Citric acid [mg] in 5 mL	Leucine [mg]	Arginine [mg]	QY [%]
1.	15	250	-	-	1,25
2.	15	500	-	-	2,05
After QY calculation of the Blank System					
3.	15	500	175	-	10,04
4.	15	500	-	175	7,36



RSM method



Investigation of the effects of time and temperature on the QY efficiency

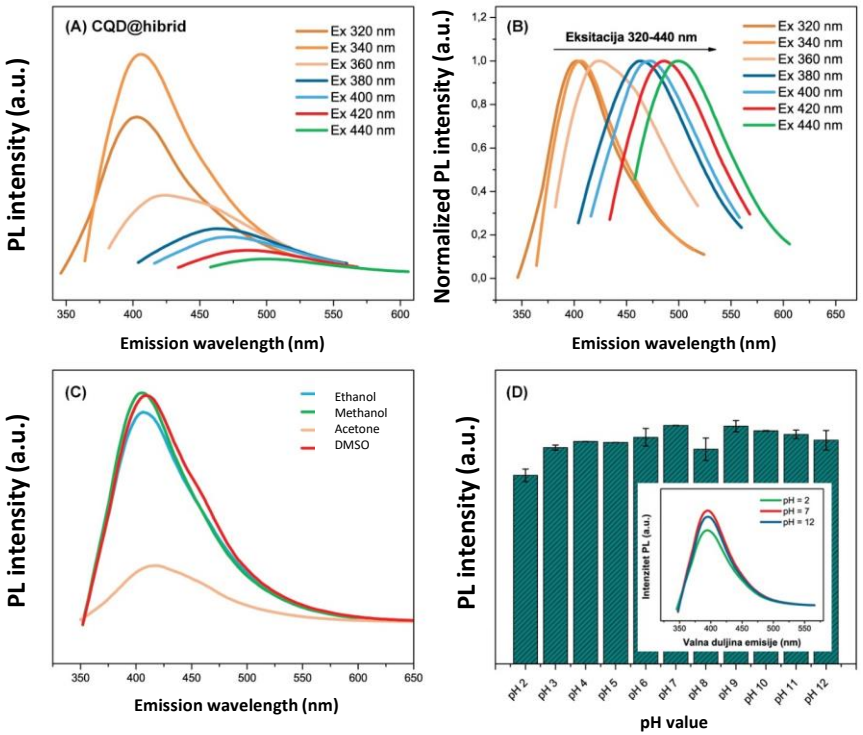
The highest QY was obtained at the following conditions: temperature of 200°C during 12 hours of treatment, and the highest QY was calculated to be QY = 17.04 %. The optimal conditions toward obtaining predicted QY of QY = 17.16 % are: 199.2 °C during 10.5 hours.

N-Doped/Hybrid Carbon Quantum Dots (3)

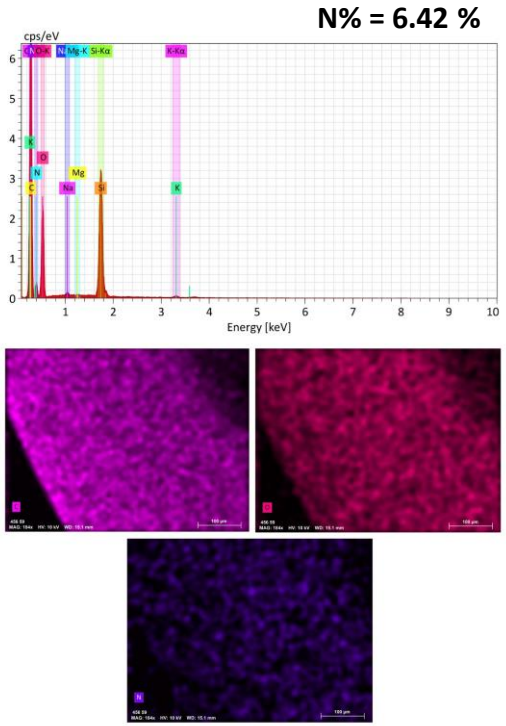
012

- The characterization of the CQD nanoparticles were carried out

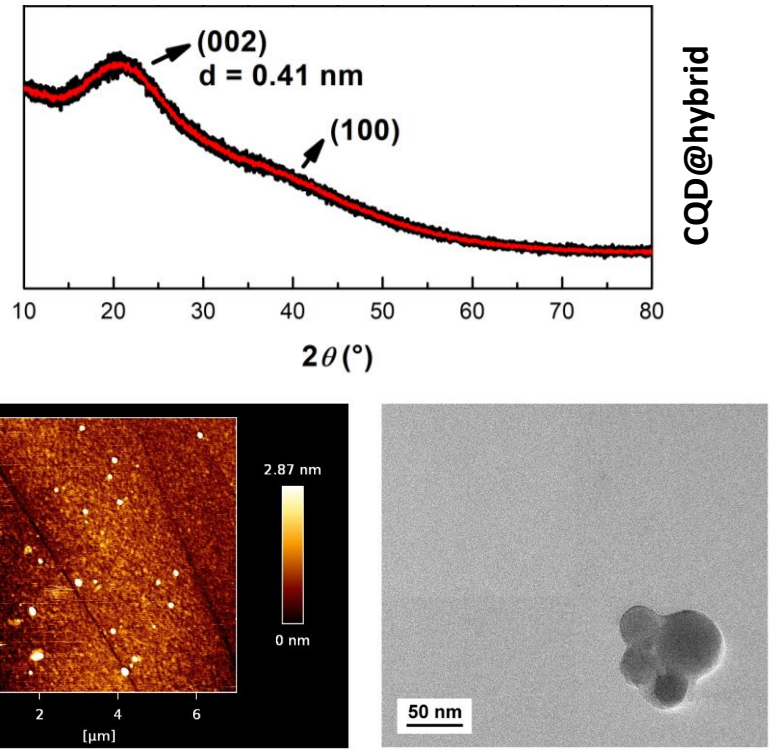
OPTICAL CHARACTERIZATION



CHEMICAL AND STRUCTURAL CHARACTERIZATION



EDS analysis

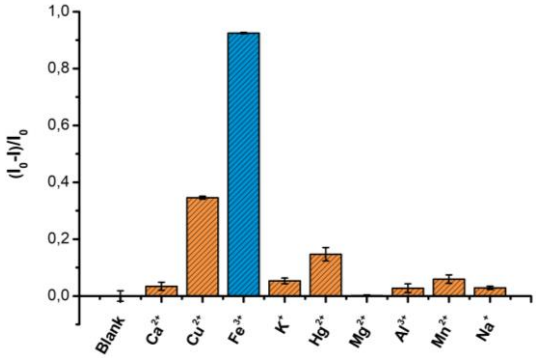


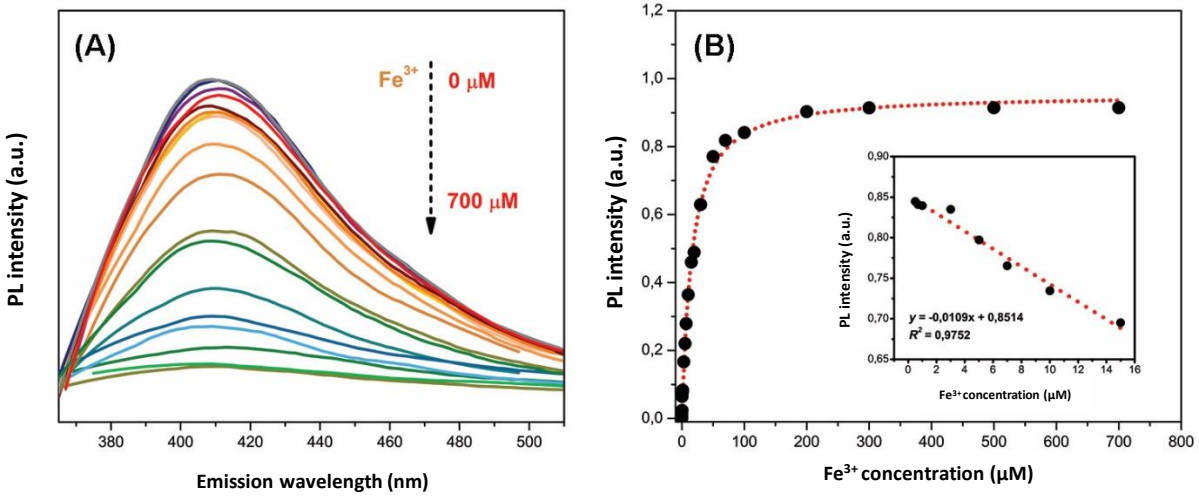
PXRD, AFM and HR-TEM analysis

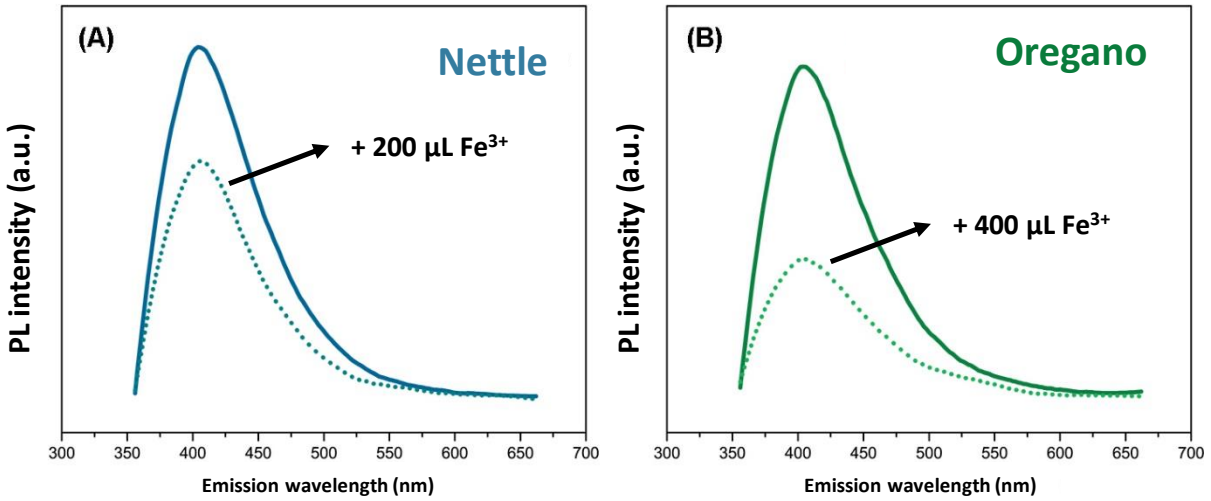
N-Doped/Hybrid Carbon Quantum Dots

013

- The application of CQD@hybrid in sensing







Sample	Fe^{3+} - standard method (μg/L)	Experimental results (μg/L)		Fe^{3+} determined by CQD method (μg/L)		Recovery (%)	RSD (%)
		1	2	Average	StDev		
16	1338.00	1443.47	1484.29	1463.88	28.86	109.41	1.97
17	2036.00	2042.05	2106.26	2074.16	45.40	101.87	2.19
18	4960.00	5027.48	4616.77	4822.12	290.42	97.22	6.02

Well Water System

Sample	Fe^{3+} - standard method (μg/L)	Experimental results (μg/L)		Fe^{3+} determined by CQD method (μg/L)		Recovery (%)	RSD (%)
		1	2	Average	StDev		
Nettle sample	9569 ± 0,04	69.65	78.96	74.31	6.58	77.67	8.86
Oregano sample	82.35 ± 0,01	75.48	82.80	79.14	5.18	96.10	6.54

Nettle and oregano analysis

Further investigation will include…

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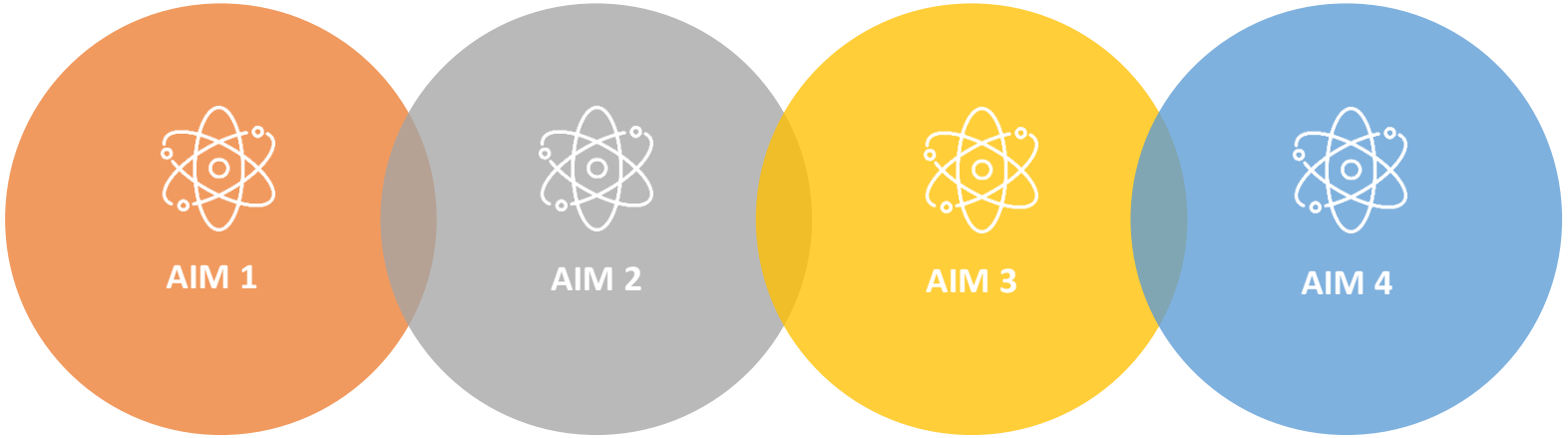


01

HETEROATOM DOPING AND SURFACE FUNCTIONALIZATION

Investigation of chemical composition and surface complexity on the optical properties od prepared CQDs, as well as applicability

02

PREPARATION OF NANOCOMPOSITES

Preparation of different nanocomposites and further investigation on the pharmacological and biological activity

03

DEVELOPMENT OF ELECTROCHEMICAL SENSORS

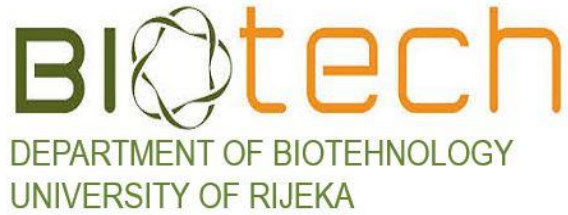
Electrode coating with different CQDs nanocomposite and detection of different ions and (bio)molecules; pesticides, application in food control, drug detection,…

04

TESTING PHOTOCATALYTICAL ACTIVITES

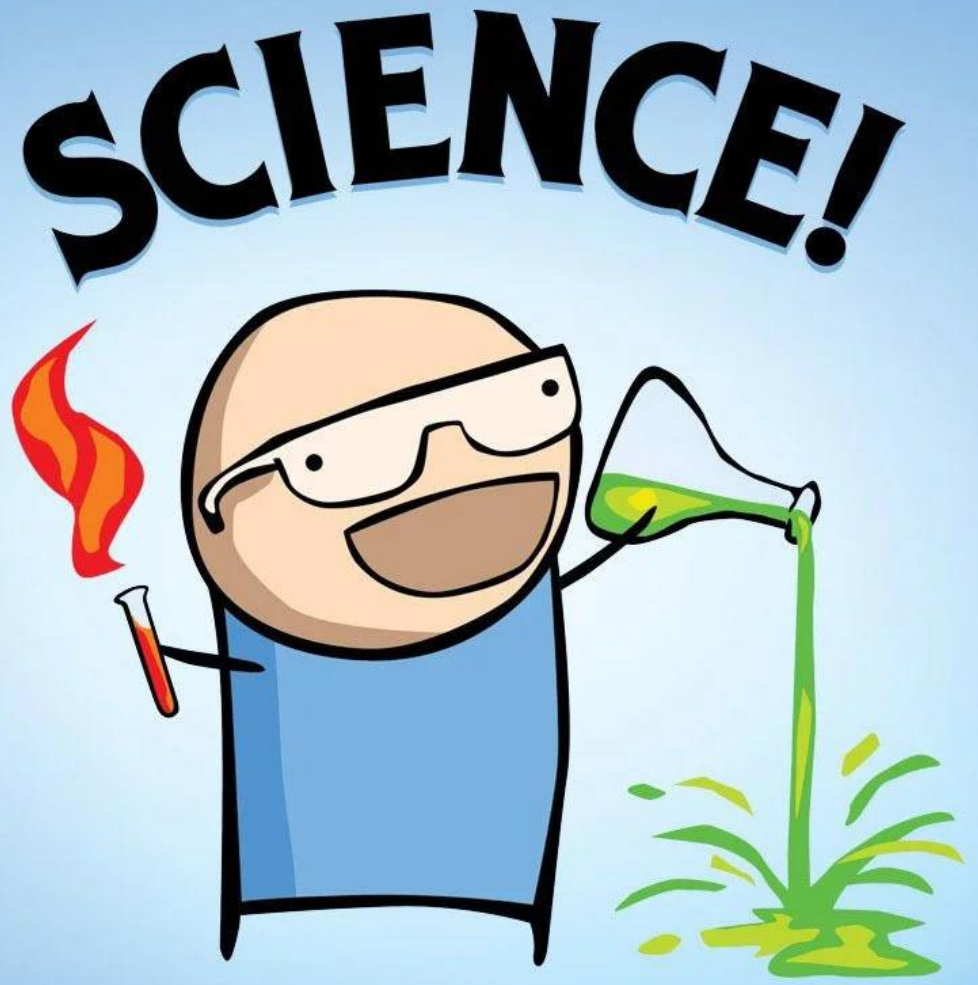
Due to their outstanding electronic properties, unique fluorescence behavior and photoelectron transfer properties.

Our Distinguished Collaborations



UP MEDICAL SCHOOL
Institute of Pharmaceutical Technology and Biopharmacy

This work has been supported by Croatian Science Foundation under the project "**Application of innovative techniques of the extraction of bioactive compounds from by-products of plant origin**" (UIP-2017-05-9909; 2018 - 2023)
Principal Investigator: Stela Jokić, full professor



Thank You for Your Attention!