

V. Symposium of Young Researchers on Pharmaceutical Technology, Biotechnology and Regulatory Science Conference (Szeged, Hunagry)

Multifunctional Biomass-derived and Ndoped Carbon Quantum Dots – The Versatile Nanoparticles for Ion Sensing with Potential Biological and Pharmacological Activity

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Carbon Quantum Dots – CQDs



Carbon Dots: A Mystic Star in the World of Nanoscience

Why are carbon quantum dots important and special?



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!



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

Biomass-derived CQDs

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CAN WE USE BIOMASS FOR THE CQDs PREPARATION?



Our Preliminary Results in CQDs Research



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		
					1 st experiment	20.59 ± 0.02	
Pure CQD	>100	>100	>100	>100	2 nd experiment	1.50 ± 0.02	
					3 rd experiment	>100	
CQD@Arg	>100	>100	>100		1 st experiment	7.85 ± 0.02	
				>100	2 nd experiment	Proliferative	
				2100	2 experiment	effect	
					3 rd experiment	>100	
CQD@Gly	>100	6.91 ± 0.81	>100		1 st experiment	0.46 ± 0.01	
				>100	>100 2 nd experiment	Proliferative	
				>100	2 experiment	effect	
					3 rd experiment	>100	

Antitumor activity and cell viability

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

Our Preliminary Results in CQDs Research (4)



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Cellular imaging

• Why are hybrid CQD are prepared?



Biological and pharmacological activity of CQDs



BIOLOGICAL ACTIVITY OF CQDs



PHARMACOLOGICAL ACTIVITY OF CQDs



CQD	Control sample	Inhibition of protein denaturation / % (BSA)					
concentration / µg/mL	Reference drug	CQD _{CA+Leu}	CQD _{KK+Arg}	CQD _{CA+KK+Leu}	Aqueous extract CP*		
750	60.80 ± 2.41	35.90 ± 3.63	64.83±1.12	46.31±1.85	64.69 ± 0.98		
500	54.89 ± 3.19	18.18 ± 0.01	61.90±0.03	43.55 ± 2.05	60.80 ± 2.41		
250	33.24 ± 3.50	23.64 ± 5.14	58.95 ± 1.49	37.09 ± 2.54	57.14 ± 0.03		
50	25.59 ± 4.82	23.11 ± 3.71	54.25 ± 1.85	11.86 ± 4.99	51.32 ± 1.87		

(A)

80

40

20

CQD	Control sample	Inhibition of protein denaturation/ % (Ovalbumin)					
concentration / µg/mL	Reference drug	CQD _{CA+Leu}	CQD _{KK+Arg}	CQD _{CA+KK+Leu}	Aqueous extract CP*		
750	76.39 ± 0.53	57.31 ± 2.62	80.55 ± 0.35	65.25 ± 1.37	81.69 ± 0.40		
500	72.29 ± 0.74	40.21 ± 2.06	78.05 ± 0.57	59.94 ± 2.27	79.85 ± 0.11		
250	68.35 ± 0.84	23.92 ± 4.17	76.32 ± 0.90	55.15 ± 0.85	77.45 ± 0.27		
50	58.86 ± 1.42	4.77 ± 3.92	70.31 ± 0.35	51.88 ± 1.97	73.16±0.67		

СР

• Why are hybrid CQD are prepared?



The process toward obtaining high quantum yield is optimized



The highest QY was obtained at 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 predicted QY of QY = 17,16 % are: 199,2 °C during 10,5 hours.

Investigation the effects of time and temperature on the QY efficiency

The characterization of the CQD nanoparticles were carried out.



OPTICAL CHARACTERIZATION

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EDS analysis

CHEMICAL AND STRUCTURAL CHARACTERIZATION







PXRD, AFM and HR-TEM analysis





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

PL intensity (a.u.)

Fe³⁺ determined by CQD Fe³⁺ - standard RSD Experimental results (µg/L) Recovery (%) Sample method (µg/L) method (µg/L) (%) 2 StDev 1 Average Nettle 9569 ± 0,04 78.96 6.58 77.67 69.65 74.31 8.86 sample Oregano 82.35 ± 0,01 75.48 82.80 79.14 5.18 96.10 6.54 sample

1.0-

0,8

^{0,6} 1/(1-⁰)

0,2

0,0

700

Nettle and oregano analysis





Review An Overview of the Recent Developments in Carbon Ouantum **Dots**—**Promising** U: Neke mogućnosti iskorištenja nusproizvoda ISBN: 978-953-7005-75-7 prehrambene industrije - Knjiga 3. (Bio)Molecule Ser Urednici: Drago Šubarić ©2021 Sveučilište Josipa Jurja Silvija Šafranko ¹, Dominik G Borislav Miličević Strossmayera u Osijeku, Tihomir Moslavac¹, Igor Jerkovi Prehrambeno-tehnološki fakultet Osijek, Veleučilište u Požegi 2 Poglavlje 3 **Carbon Quantum** ating Targeted 3 ZELENE SINTEZE UGLJIKOVIH KVANTNIH TOČAKA IZ al Application for * **BIOMASE – PRIMJENA U BIOMEDICINI I FARMACEUTSKOJ** ANALIZI D, Ivica Strelec ¹D, Silvija Šafranko, Dajana Gašo-Sokač, Stela Jokić* 🔘, Sandra Kraljević Pavelić ⁸0, and Stela Jokić 1,* Sveučilište Josipa Jurja Strossmayera u Osijeku, Prehrambeno-tehnološki fakultet Osijek,

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Scientific Publications and Book Chapter

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Uni







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Thank You for the attention!