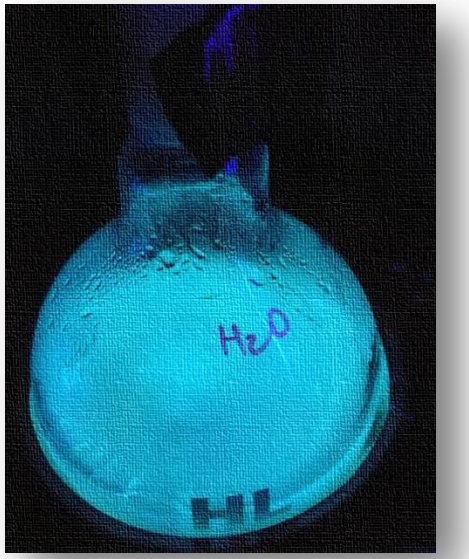
Departamento de Química
LAQAPAB laboratório
Adsorventes para análise química, proteção de ambiente e biomedicina

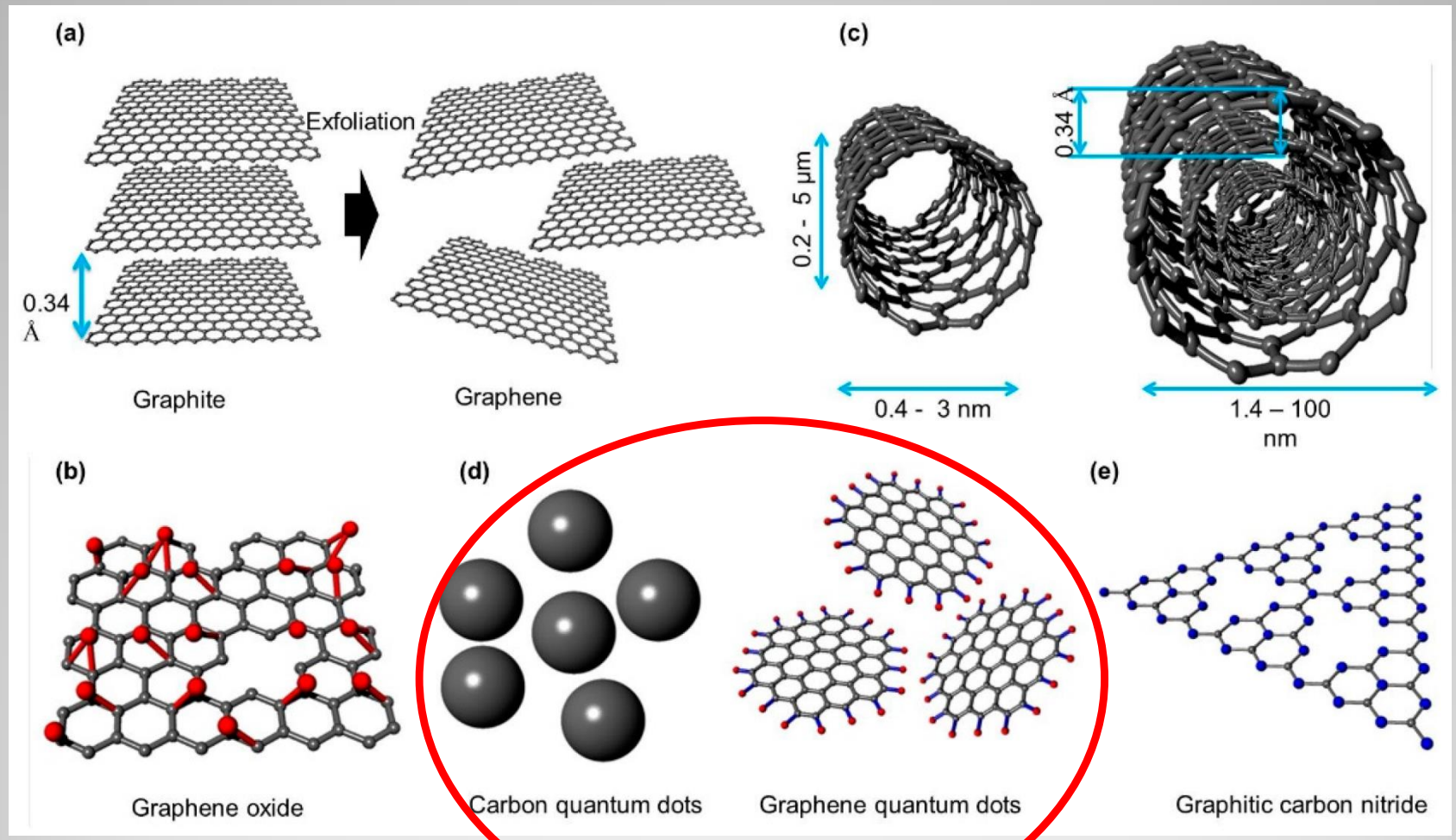
Carbon nanoparticles: Synthesis, Characterization and Application Prospects



Post-Doc: Albina Mikhraliieva (DSc, Brazil)
Supervisor: prof. Volodymyr Zaitsev

Ukraine,2021

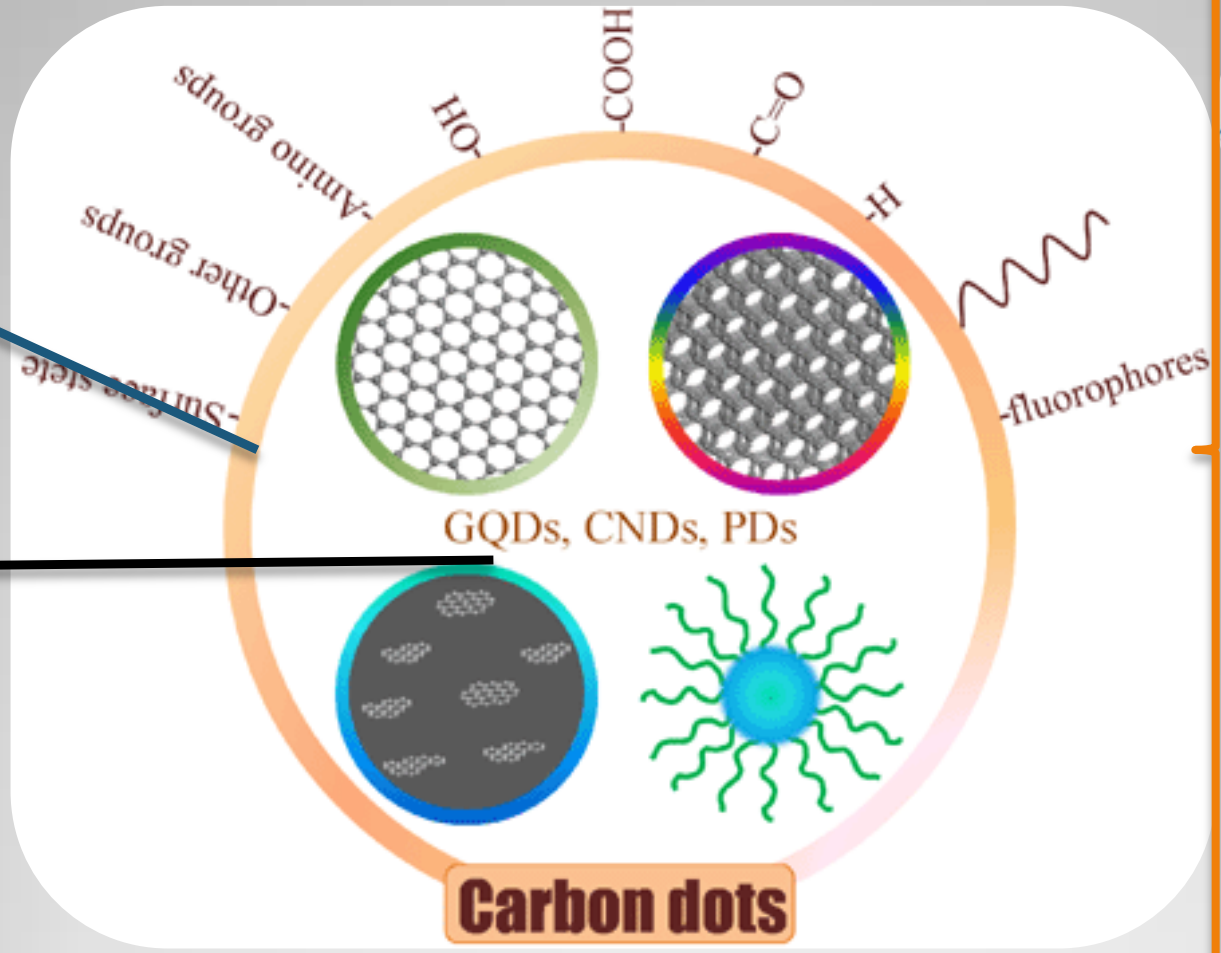
What are Carbon Dots?



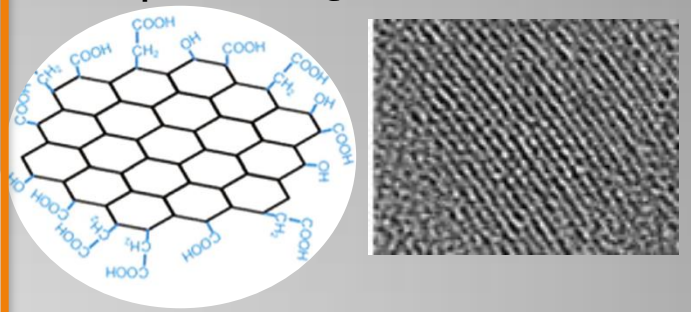
What are Carbon Dots?

Surface state

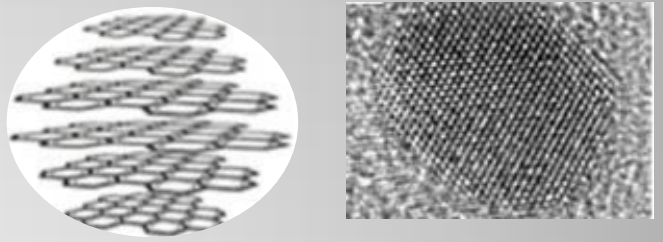
Carbon core



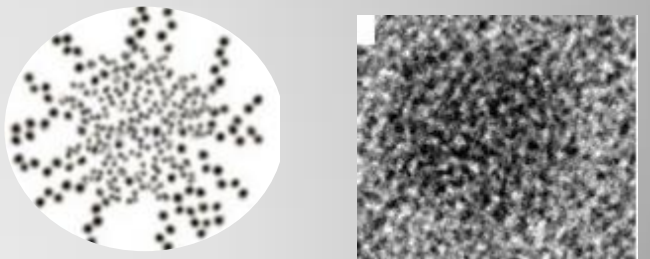
Graphene Quantum Dots



Carbon Quantum Dots



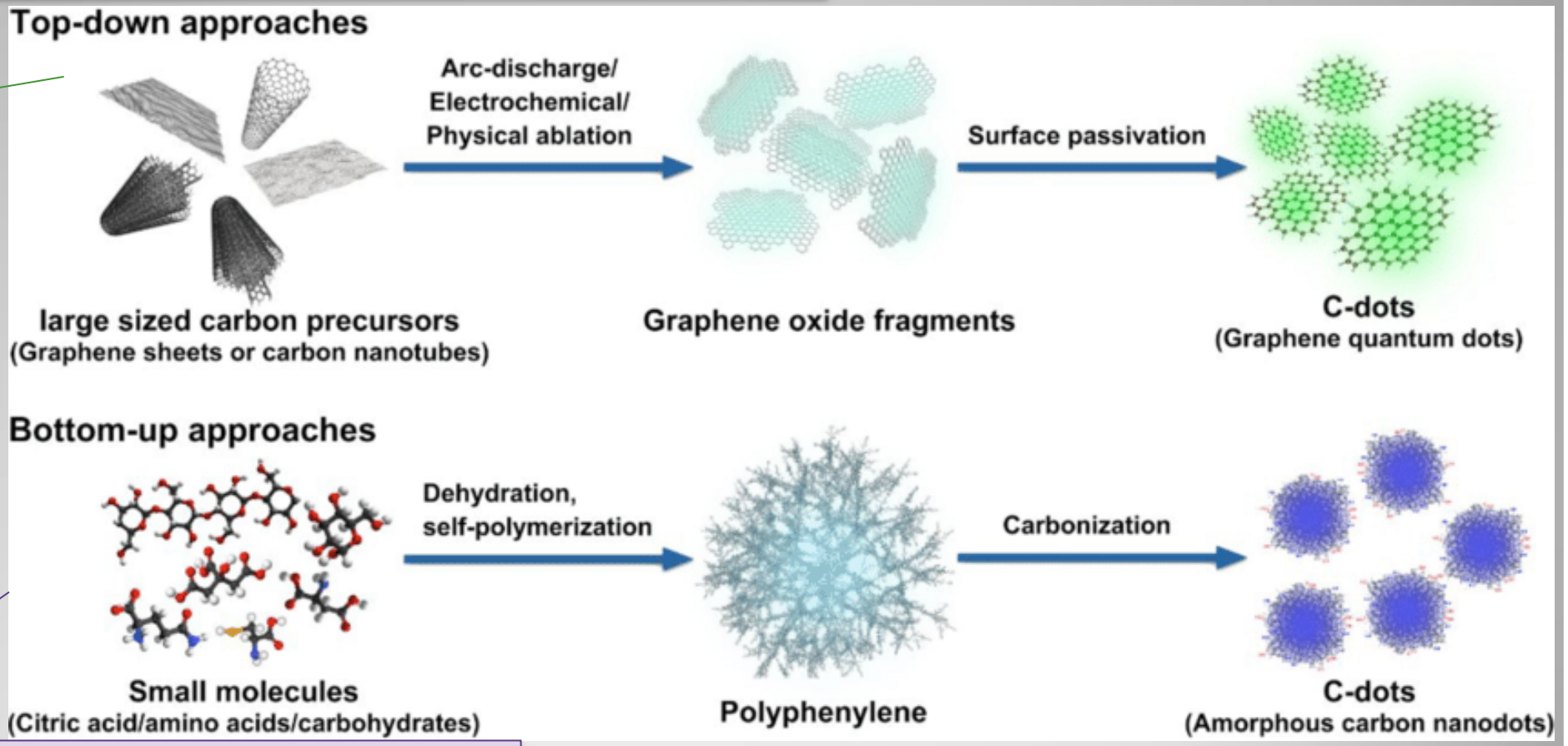
Carbon Nanodots



Average size <10 nm

Synthesis

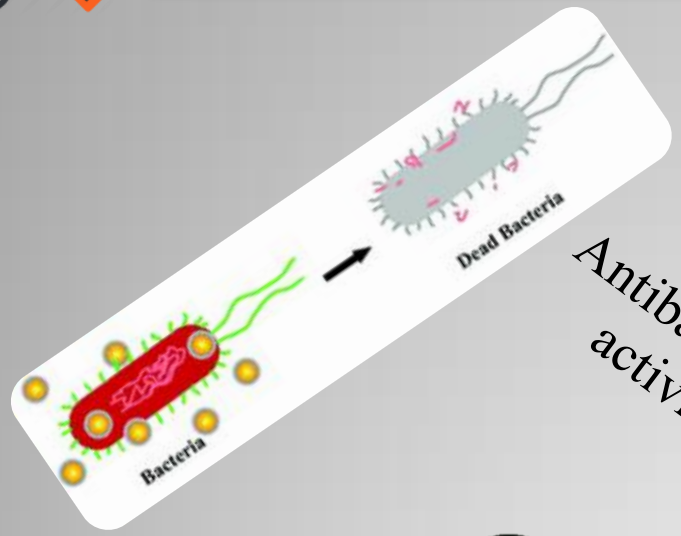
Breaking down larger carbon structures



- Pyrolysis
- Ultrasonic and microwave synthesis
- Support approach
- Hydrothermal/solvothermal
- Passivation agents
- Biomass

Application

modification
photoluminescence
stability
biocompatibility



Antibacterial activity

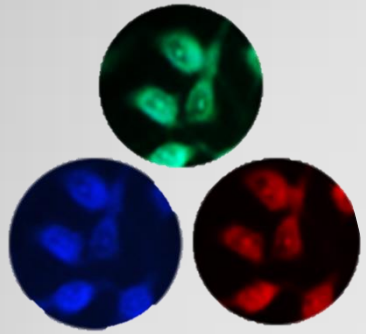
CDs

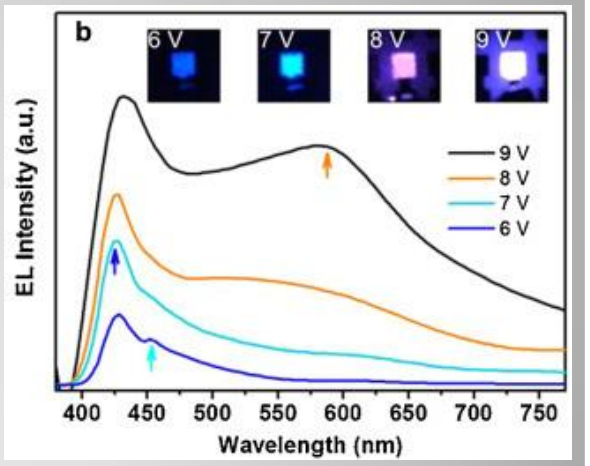
Catalysis

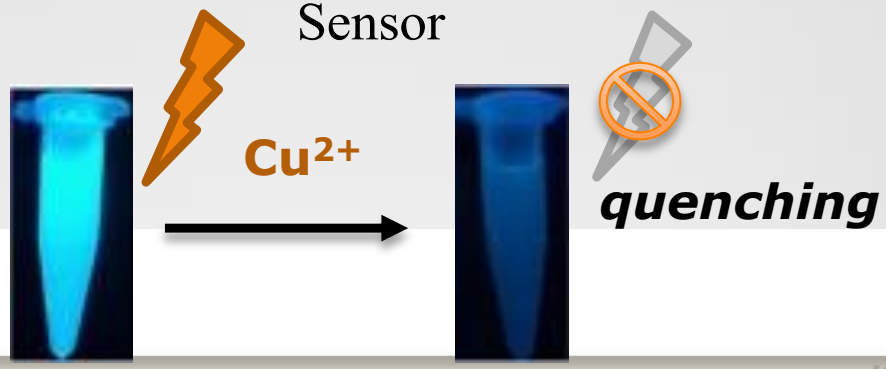
Bioimaging

Optoelectronic

Sensor





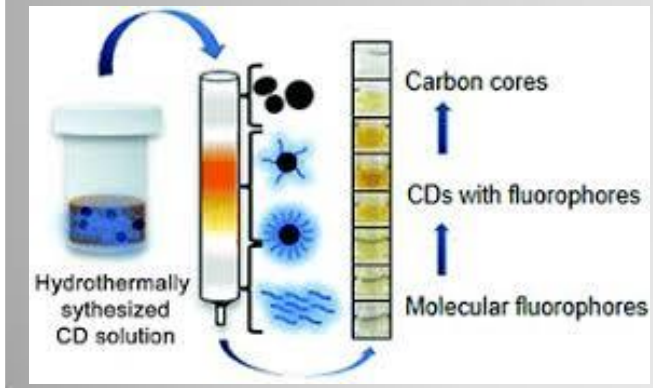


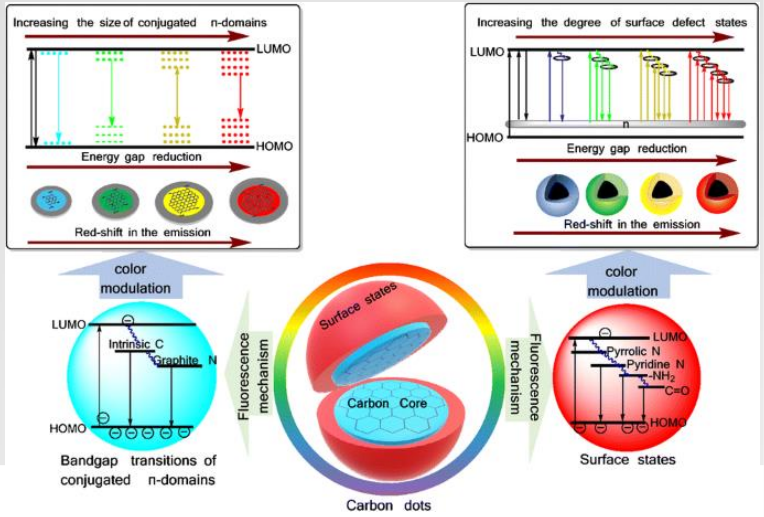
quenching

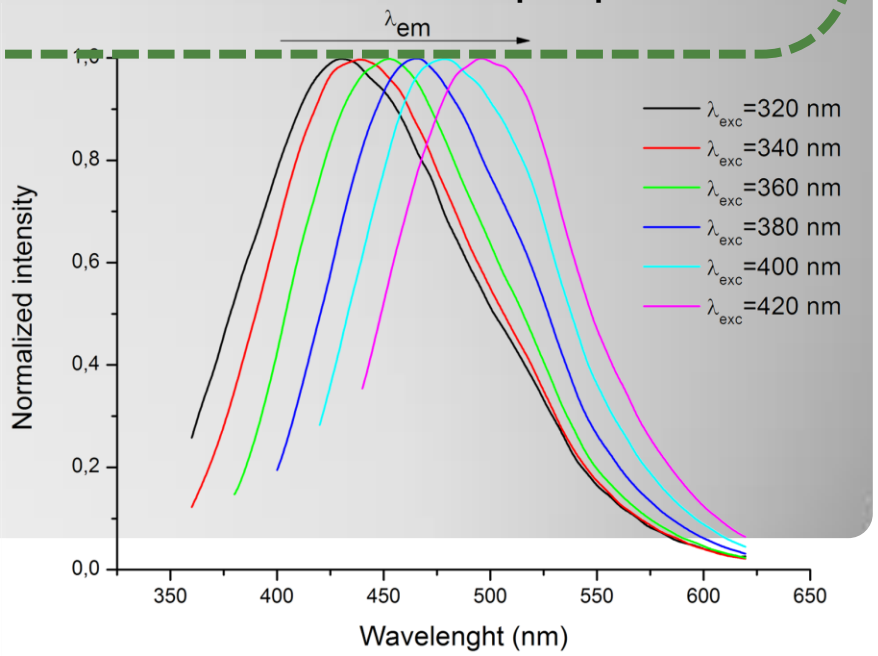
Problems

Control of the morphology and size distribution of CDs are the principal challenges.

- Structure, composition and photo-physics of CDs are not fully understood.
- Carbon source and synthesis conditions are crucial criteria of fabrication
- Unclear mechanism of CDs synthesis
- Aggregation of the pyrolytic products, most of the bottom-up synthesis results in the mixture of CDs with different particle sizes and surface properties and thus require chromatographic separation
- Tedious purification of C-dots
- **Excitation-dependent** behavior → the broad size distribution of the prepared particles.



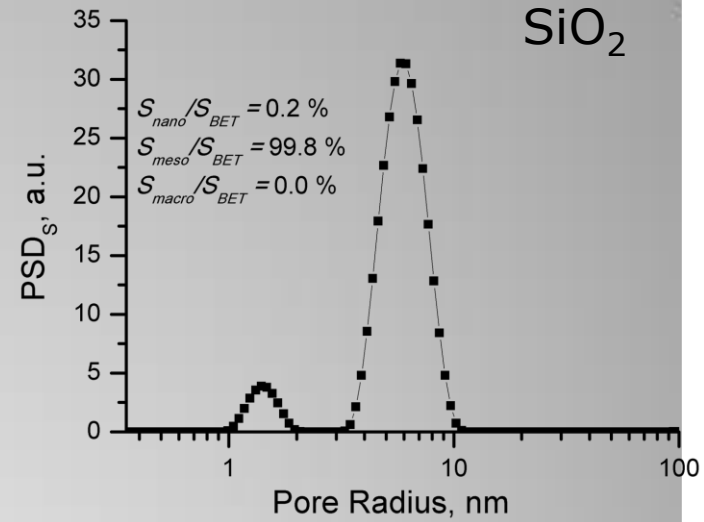


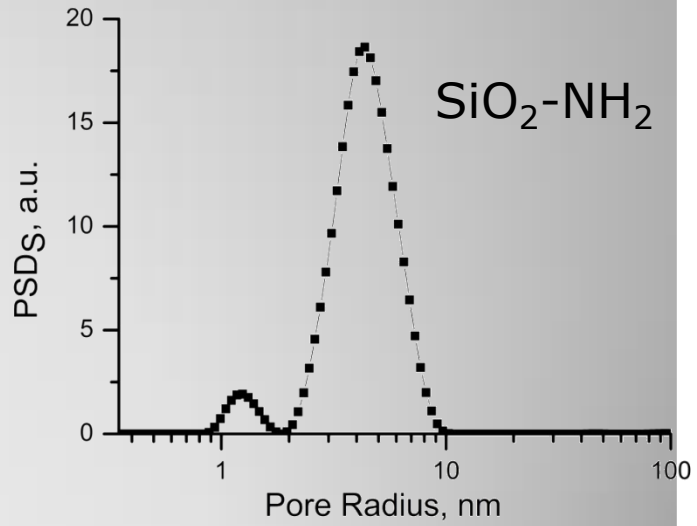


Solution

Combination of a traditional preparation method of CDs with pyrolysis of citric acid in a size-limiting reactor was used to overcome these difficulties and obtain a homogeneous

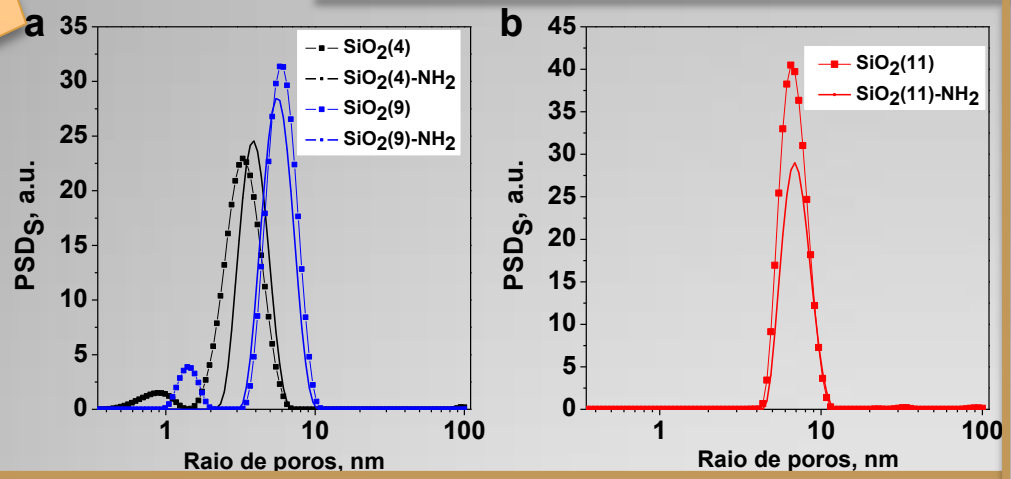
- Nanoreactor is the porous material with high thermal resistance
- Nanoporous silica gel is a suitable material due to monomodal pore size distribution varying in the range from 2 to 15 nm and has high thermal and chemical stability



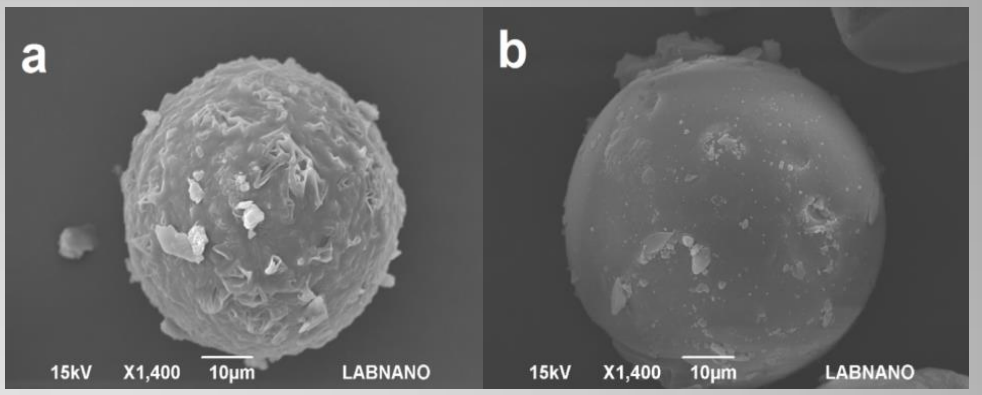


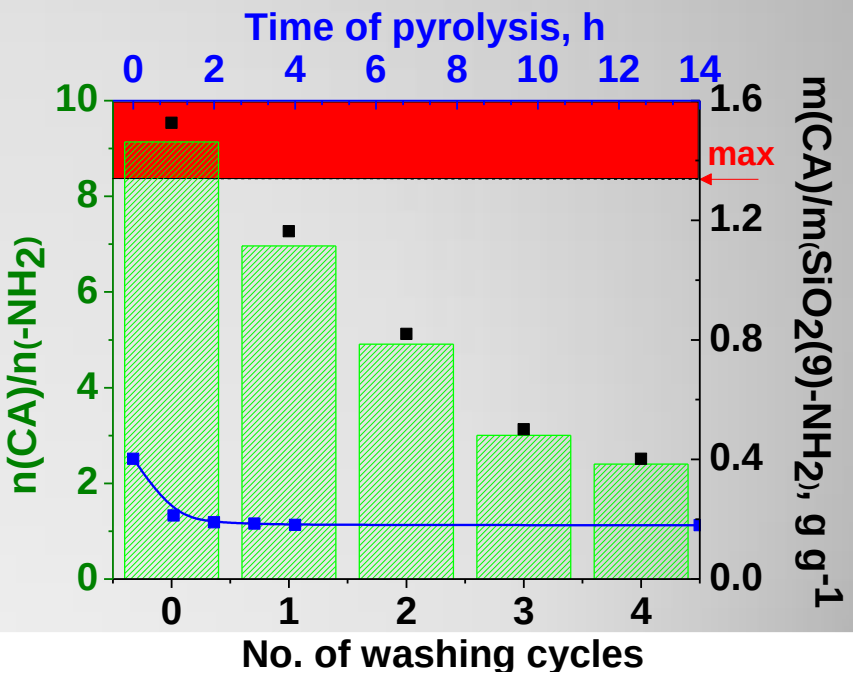
SiO2
SiO2-NH2

Solid support

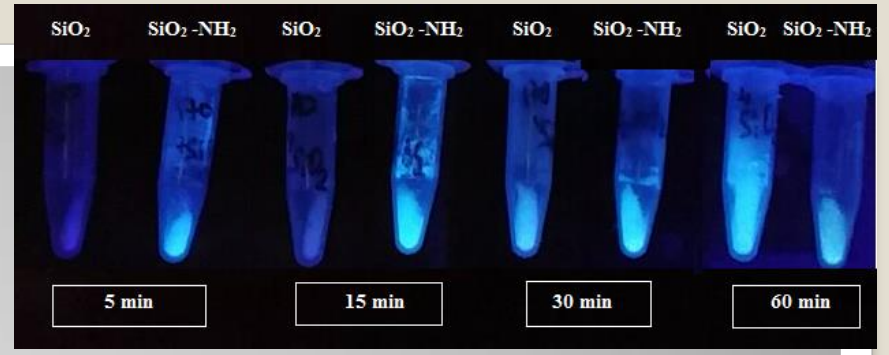


Silicas	S_{BET} ($m^2\ g^{-1}$)	S_{meso}/S_{BET} (%)	Volume pore ($cm^3\ g^{-1}$)	Concentration of immobilized groups* (mmol g^{-1})	Maximum loading of CA on SiO_2-NH_2, (g g^{-1})
$SiO_2(4)$	360.3	94.9	0.72	0	1.12
$SiO_2(4)$-NH_2	278.0	100	0.47	0.8±0.2	0.73
$SiO_2(6)$	—[b]	—	0.80	0	1.24
$SiO_2(6)$-NH_2	278.6	100	0.59	0.8±0.1	0.91
$SiO_2(9)$	387.4	99.8	1.01	0	1.57
$SiO_2(9)$-NH_2	325.8	99.9	0.86	0.9±0.1	1.35
$SiO_2(11)$	400.2	99.6	1.25	0	1.94
$SiO_2(11)$-NH_2	290.0	99.4	0.95	0.7±0.2	1.47





Realization



SiO_2
SiO_2-NH_2

4, 6, 9, 11 nm

d

CA

Impregnation

170 °C

N_2

Lavagem

Elimination of silica support

CDs

FL

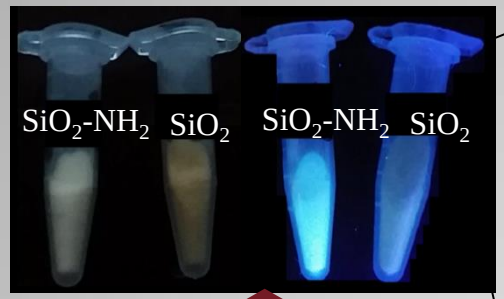
445 nm

= silica pore

= CA, citric acid

= Silica@CDs (composite)

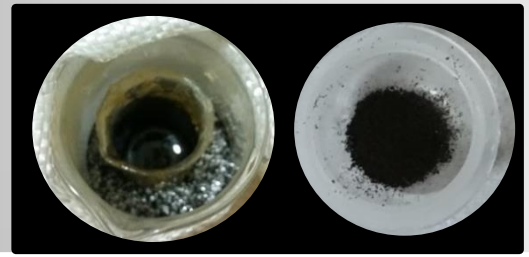
Composite



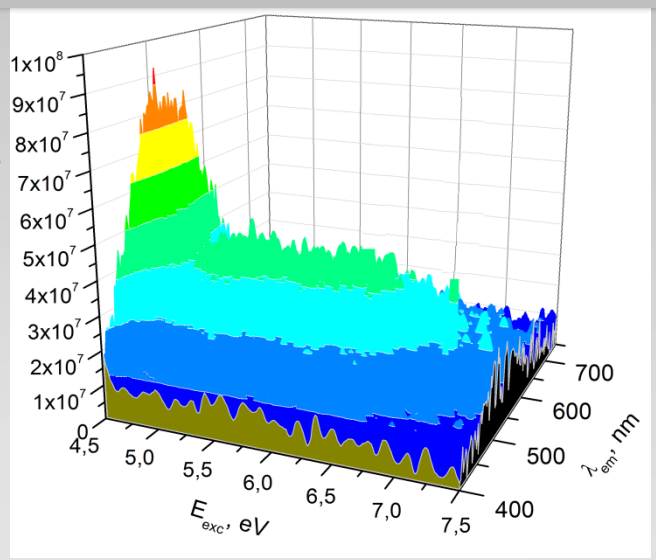
With silica gel

170^{0C}, 180 min

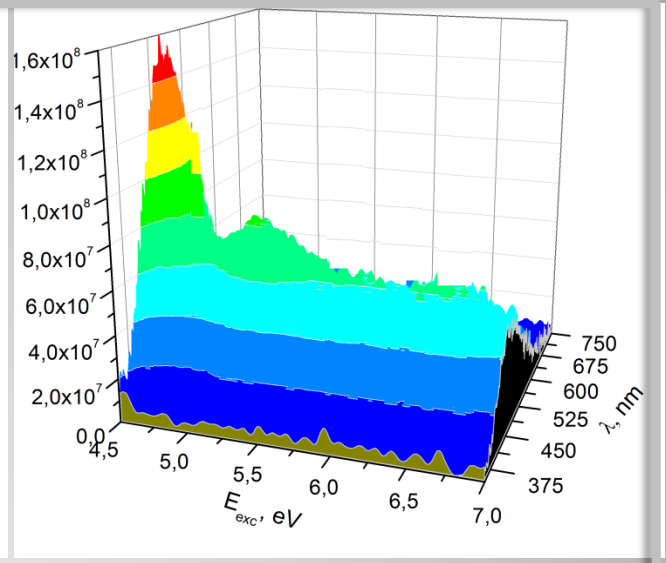
Without silica gel

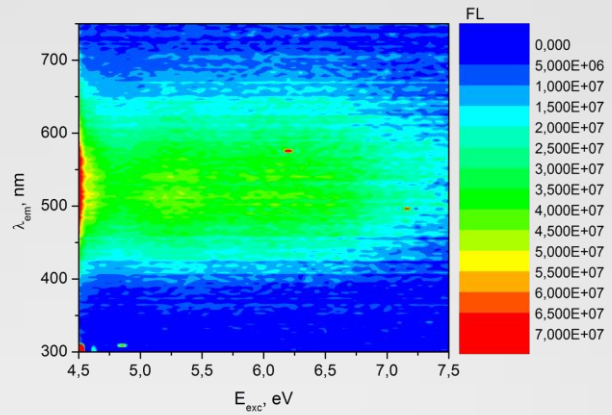


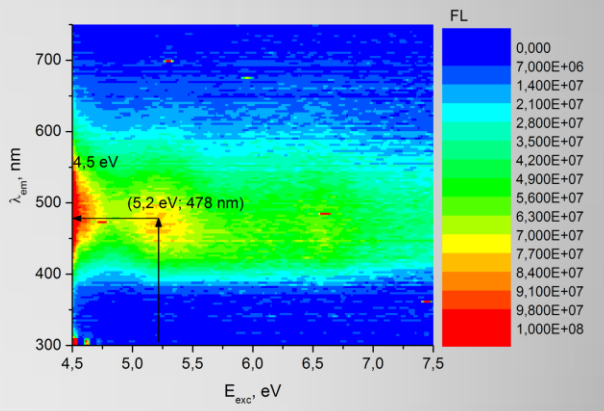
SiO_2@CDs – 180 min



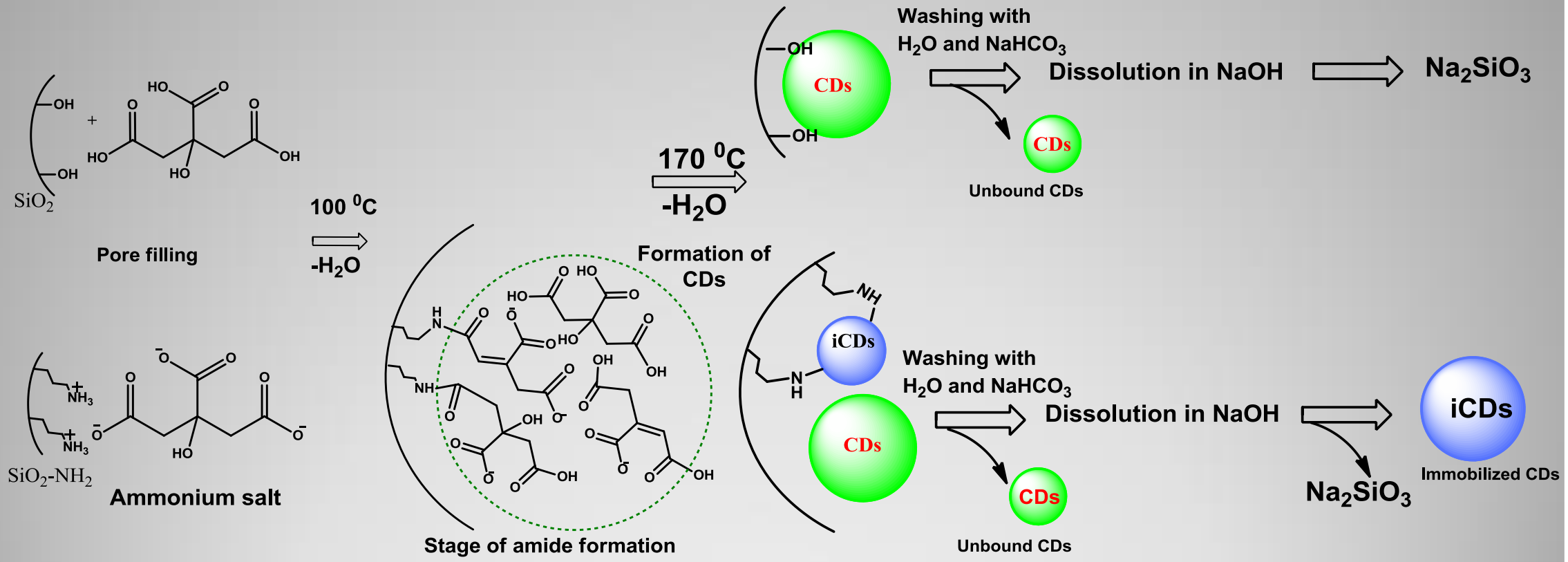
SiO_2-NH_2@CDs – 180 min





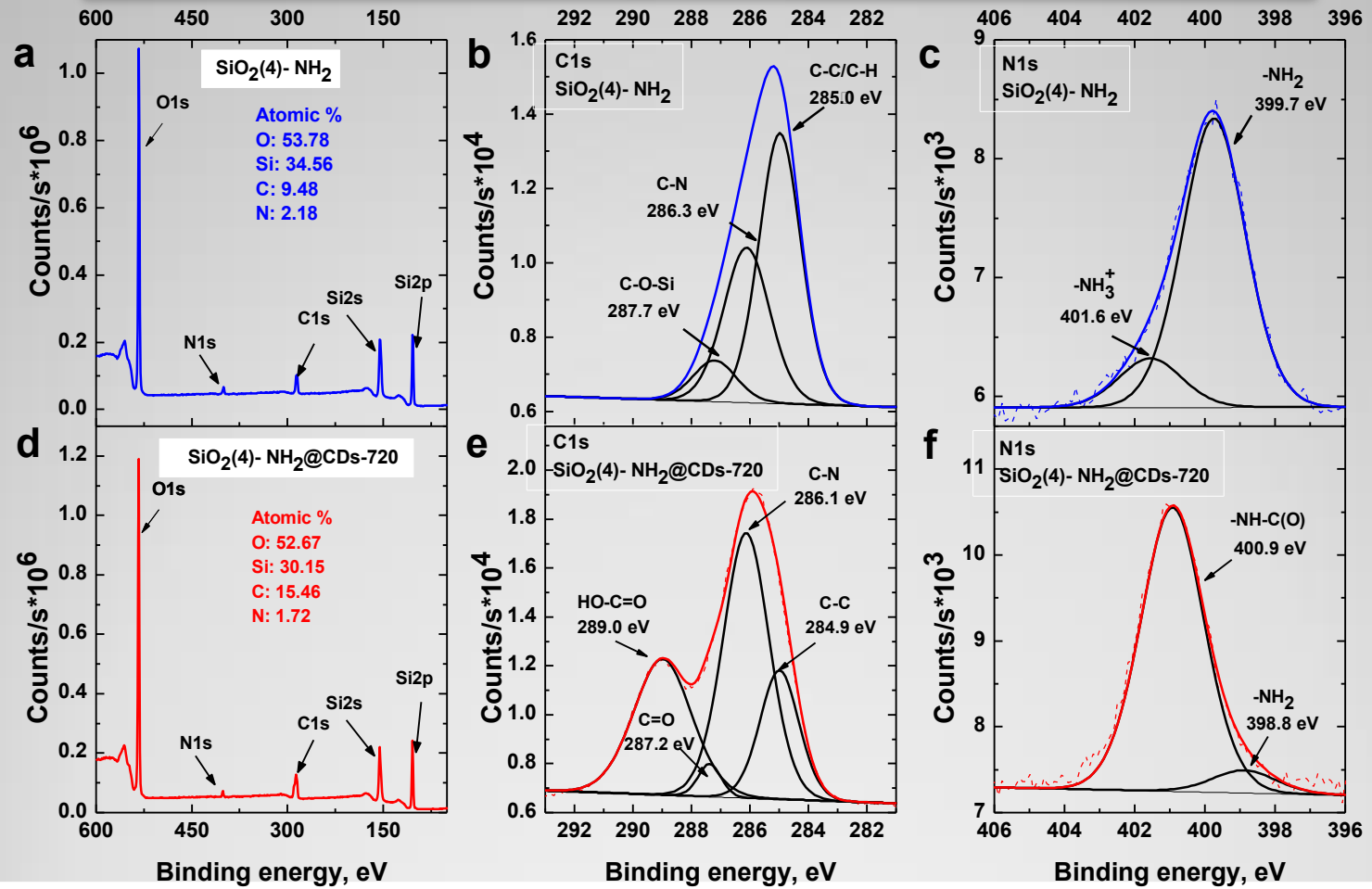


Bottom-up aproach



Composite characterization. XPS

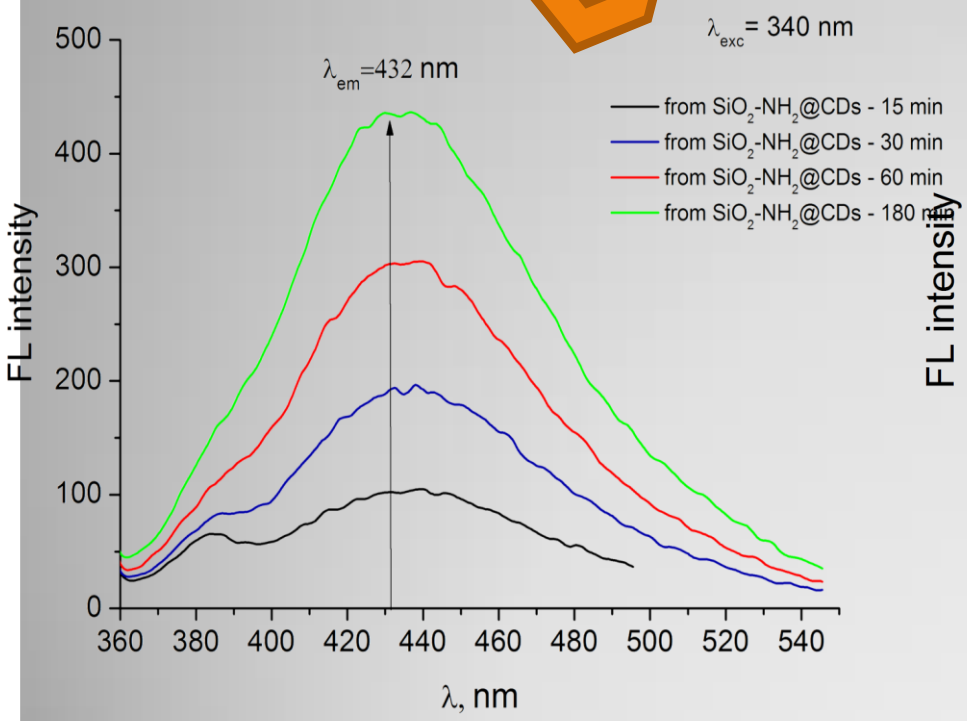
Survey spectra C1s spectra N1s spectra

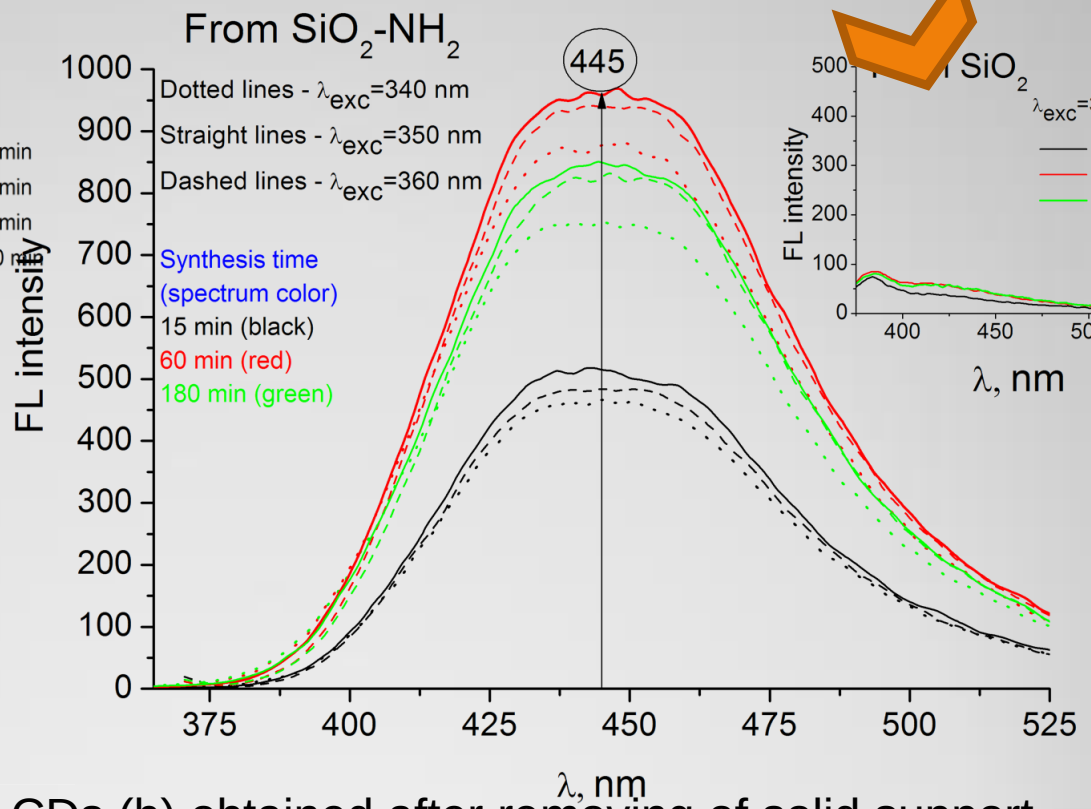


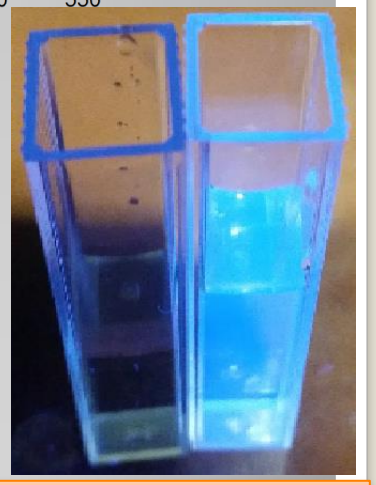
Washing – SiO_2-NH_2@CDs

Silica-based@ CDs

Agua → **$NaHCO_3$** → **NaOH**



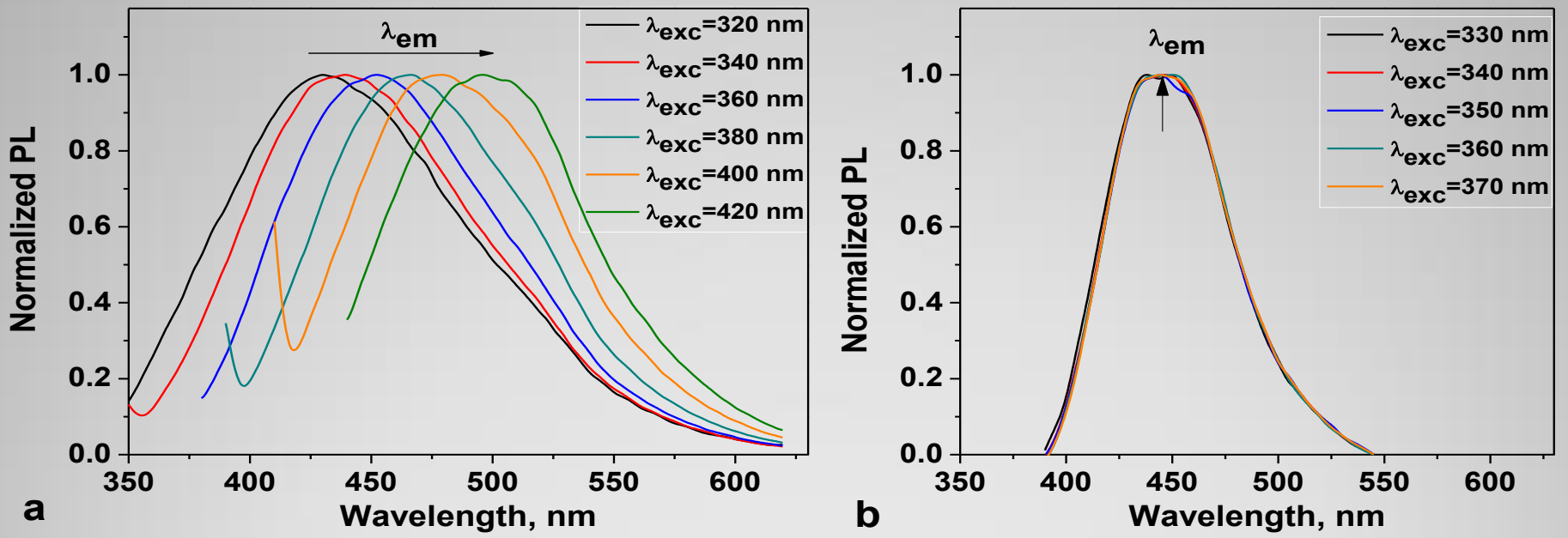




PL spectra of water extracted CDs(a) and CDs (b) obtained after removing of solid support in SiO_2(11)-NH_2@CDs and SiO_2(11)@CDs (inset). The excitation wavelength of 340 nm

SiO_2 SiO_2-NH_2

Photoluminescence

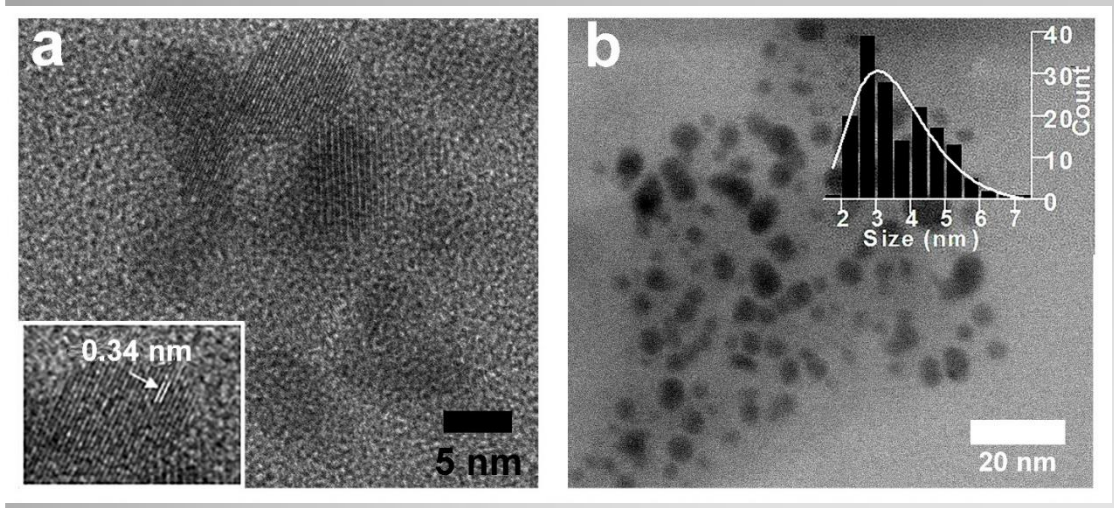


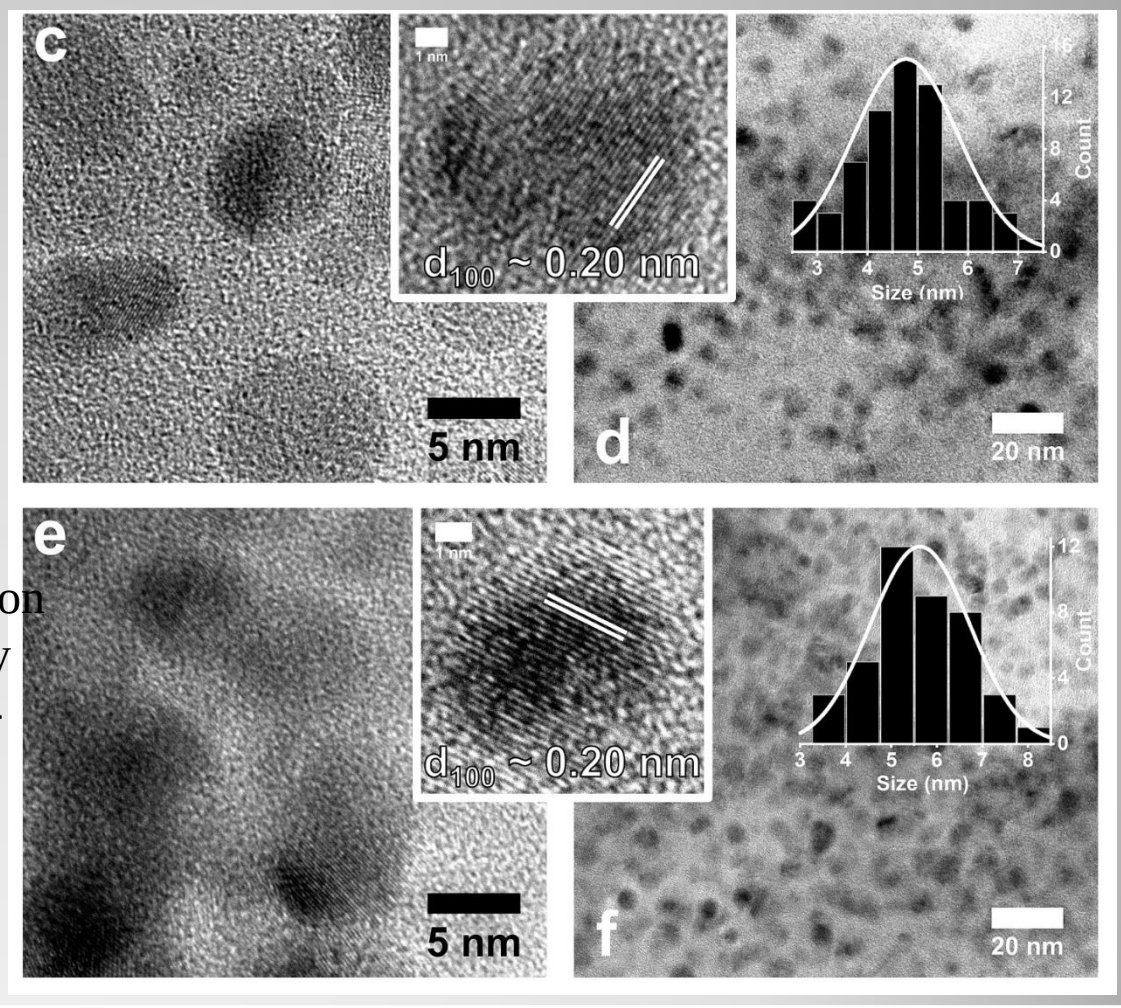
Excitation-dependent

Excitation-independent

Normalized PL spectra of non-fixed CDs from SiO_2(11)@CDs-480 (a) and CDs after removing SiO_2(4)–NH_2@CDs-240 (b)

Particle size. TEM

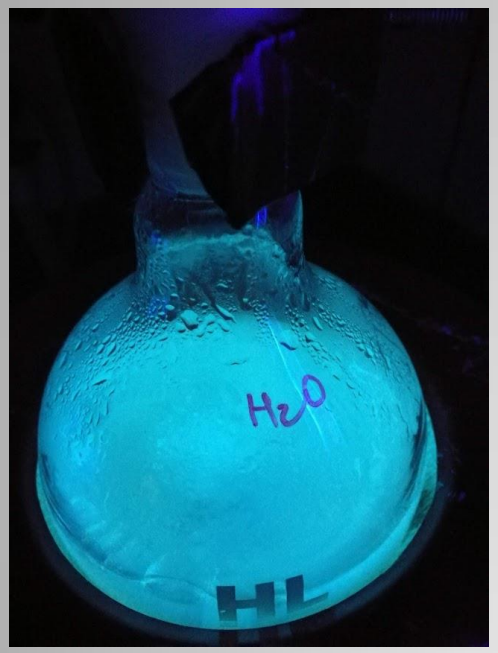


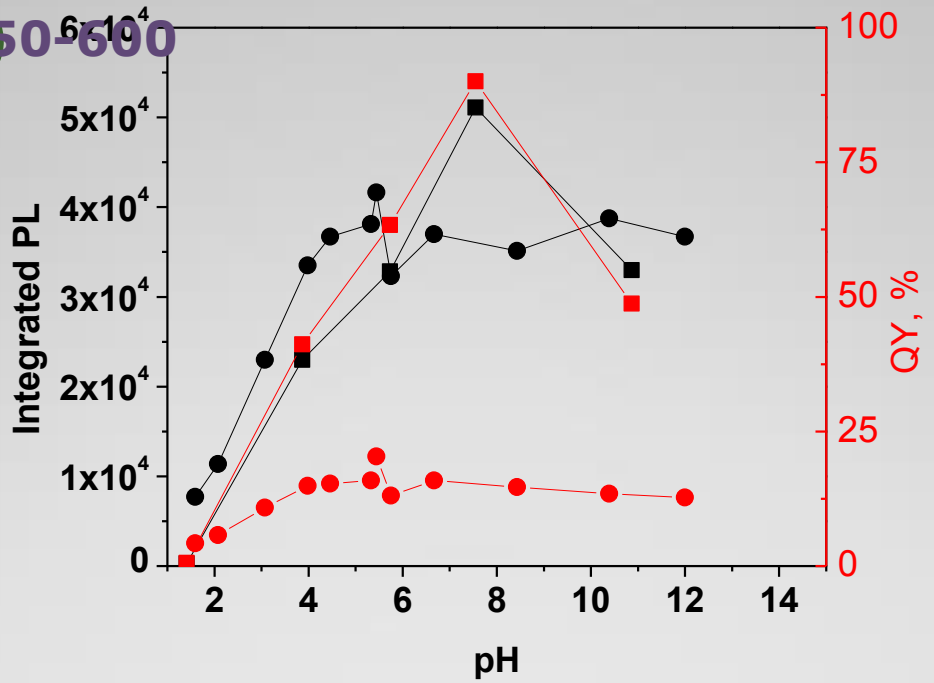


TEM and HRTEM (in insets) images with the size distribution profiles of water extracted CDs (a, b) and CDs obtained by dissolution of SiO_2(4)-NH@CDs-240 (c, d) and SiO_2(11)-NH@CDs-600 (e, f).

Quantum yield

SiO_2(11)-EDA@CDs-150-600





Samples	QY, %
SiO_2(11)-EDA@CDs-150-600	90
SiO_2(11)-EDA@CDs-180-600	18
SiO_2(6)-NH2@CDs - 60	6.28
SiO_2(6)-NH2@CDs - 180	3.61

SiO_2(11)-EDA@CDs-180-600

Realization

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Excitation-Independent Blue-Emitting Carbon Dots from Mesoporous Aminosilica Nanoreactor for Bioanalytical Application

Albina Mikhraliieva, Vladimir Zaitsev*, Yutao Xing, Horácio Coelho-Júnior, and Rubem Luis Sommer

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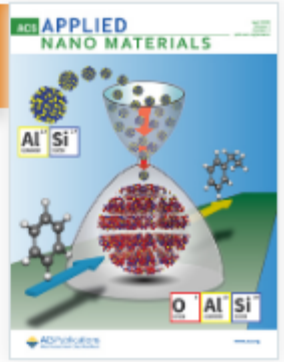

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Benefit of porous silica nanoreactor in preparation of fluorescence carbon dots from citric acid

Albina Mikhraliieva[1], Vladimir Zaitsev[1], Ricardo Q Aucélio[1], Henrique B da Motta[1] and Michael Nazarkovsky[1]

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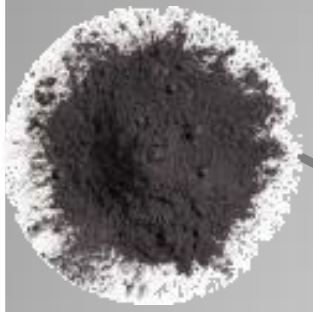
Preparation of SiO_2-GOQDs

Top-down



Graphite

1. H_2SO_4/H_3PO_4 (180 ml:20 ml)
2. $KMnO_4$ (9 g)
3. 50 ℃, 12 h
4. H_2O_2 (30%, 20 ml)
5. Washing with H_2O, HCl, EtOH
6. Vacuum-dry

GO

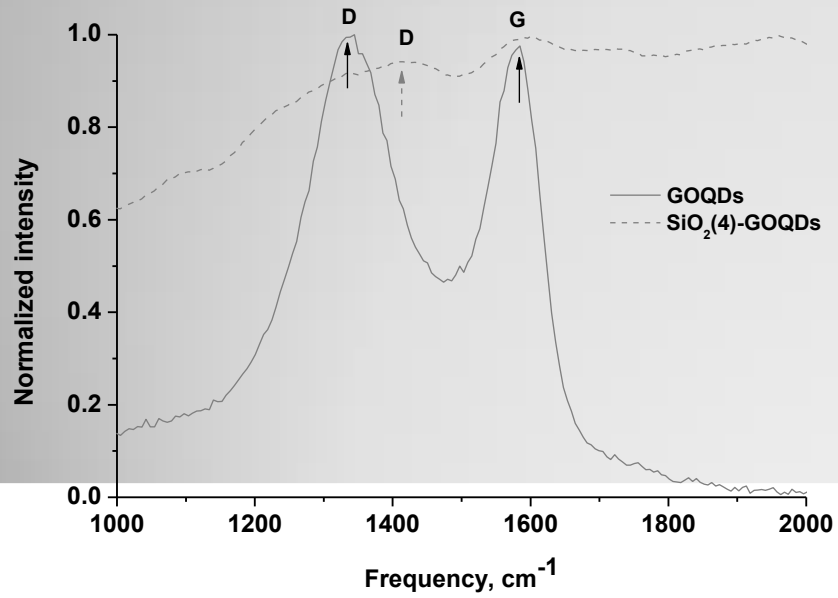
Ultrason. 2h

GOQDs

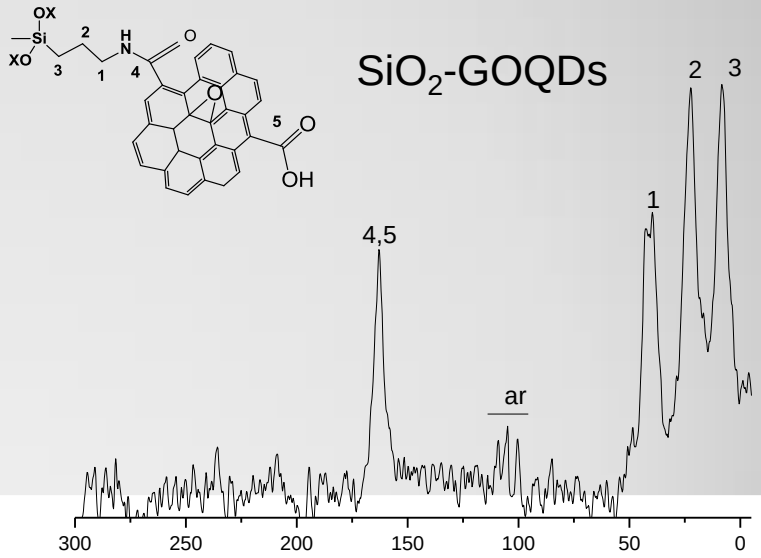
$SiO_2(4)$-NH_2
DCC
DMF

SiO_2-GOQDs

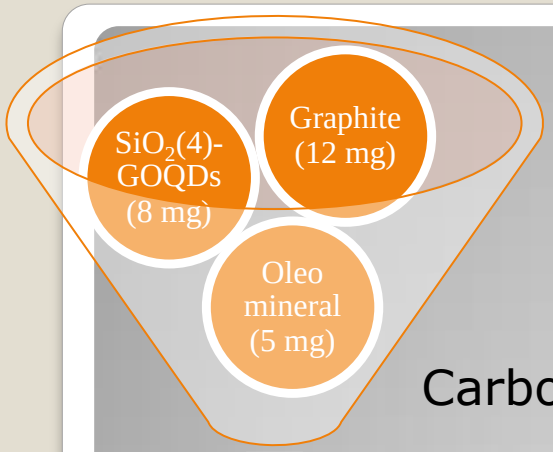
Raman spectra

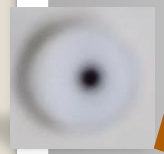


^{13}C CP/MAS RMN, solid state

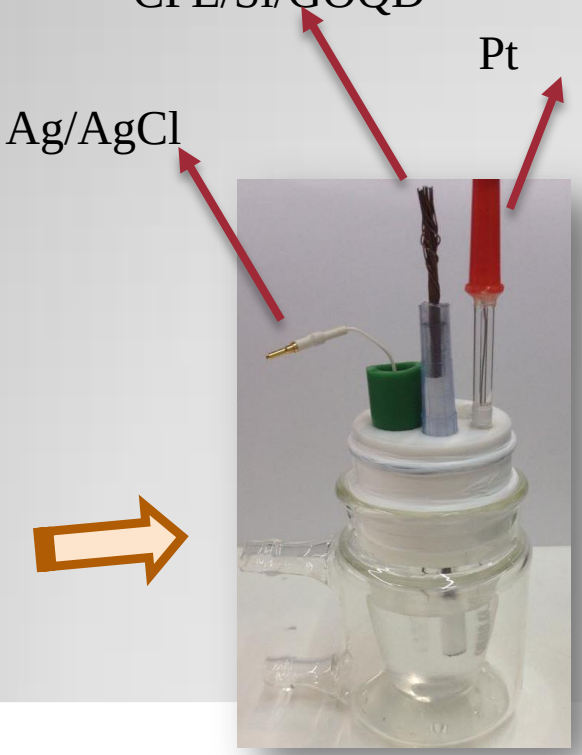


Voltammetry - SiO_2-GOQDs



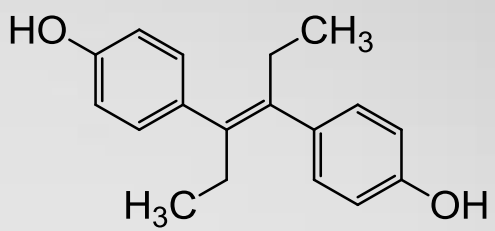


Carbon paste electrode (CPE)

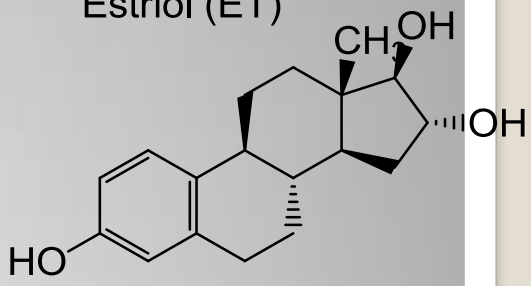


Analytes

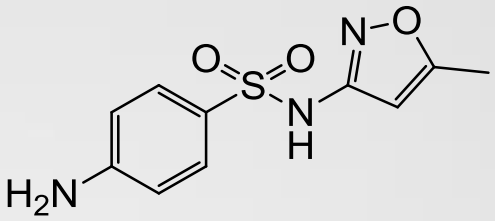
Dietilestilbestrol (DES)



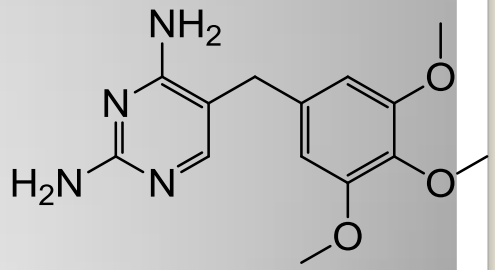
Estriol (ET)



Sulfametoxazol (SMZ)



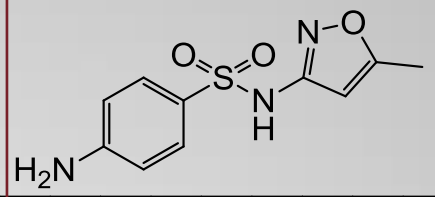
Trimetoprim (TMP)



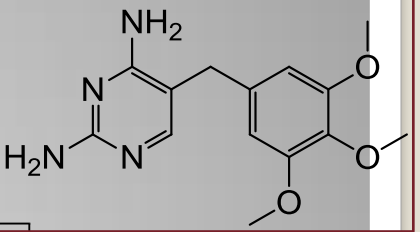
Detection of antibiotics

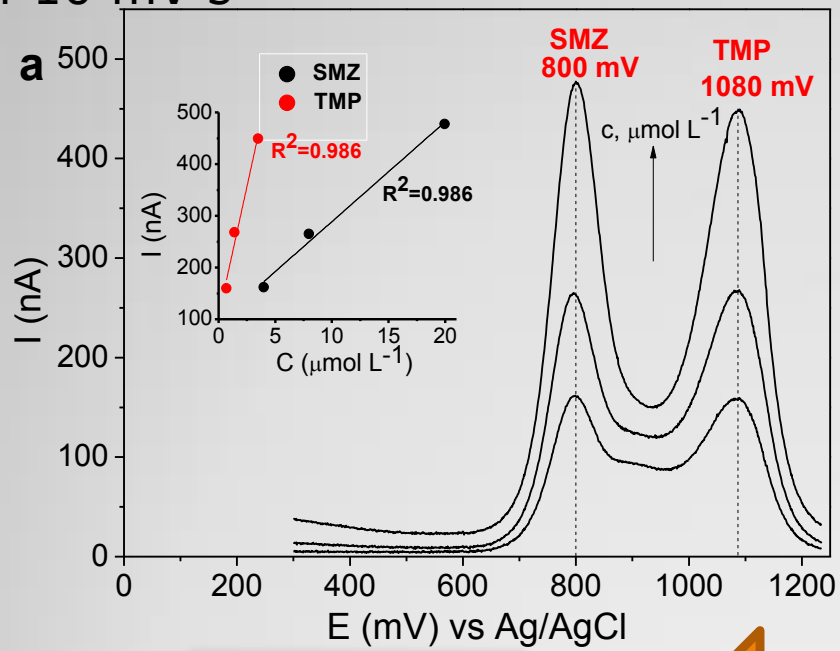
Differential pulse voltammograms (DPV)
pulse amplitude of 50 mV,
a pulse time of 50 ms,
a step potential of 1 mV,
a scan rate of 10 mV s^{-1}

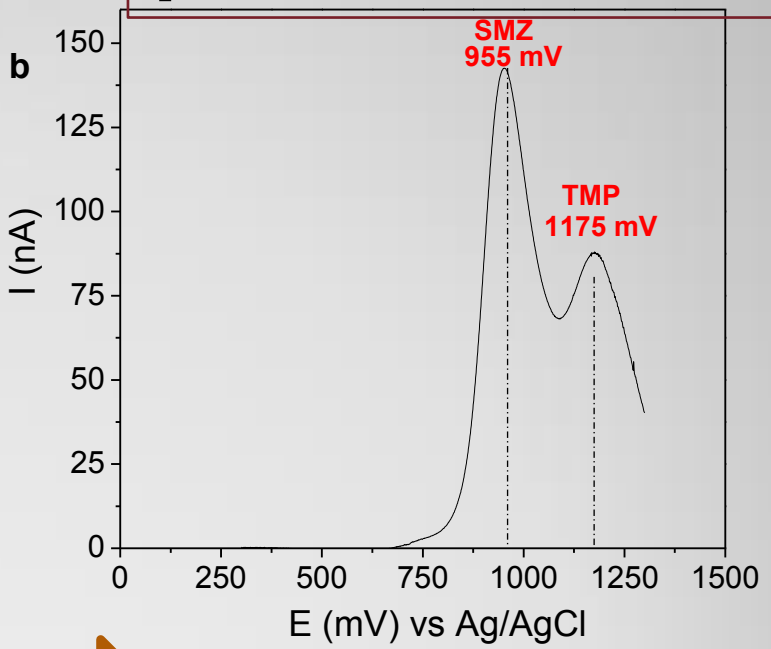
Sulfametoxazol (SMZ)



Trimetoprim (TMP)







SiO_2-GOQDs

Graphite

4.0, 8.0 e 20 μmol L^{-1} de SMZ

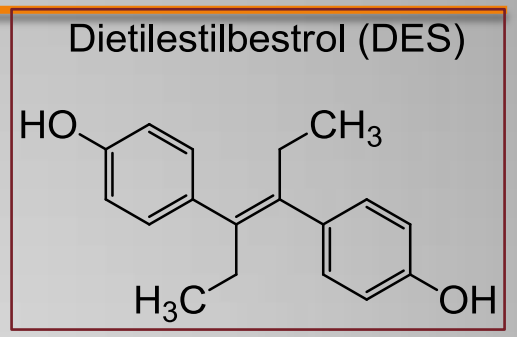
4.0 μmol L^{-1} de SMZ

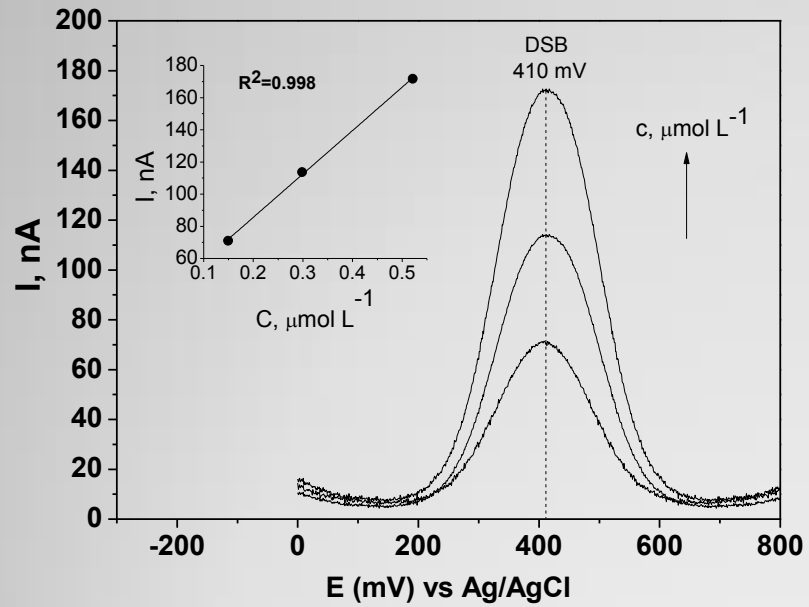
Analytos: c(SMZ):c(TMP)=5:1

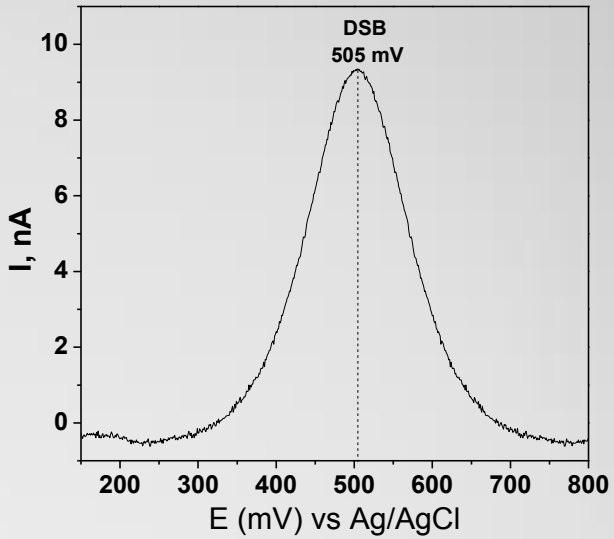
Detection of hormones

Differential pulse voltammograms (DPV)
pulse amplitude of 50 mV,
a pulse time of 50 ms,
a step potential of 1 mV,
a scan rate of 10 mV s−1

Analito:







SiO_2-GOQDs

CPE
eléctrodo

Graphite

0.15, 0.30 and 0.52 µmol L^{-1}

0.15 µmol L^{-1}

Publication

Issue 52, 2020, Issue in Progress

Previous Article | Next Article

From the journal:
RSC Advances

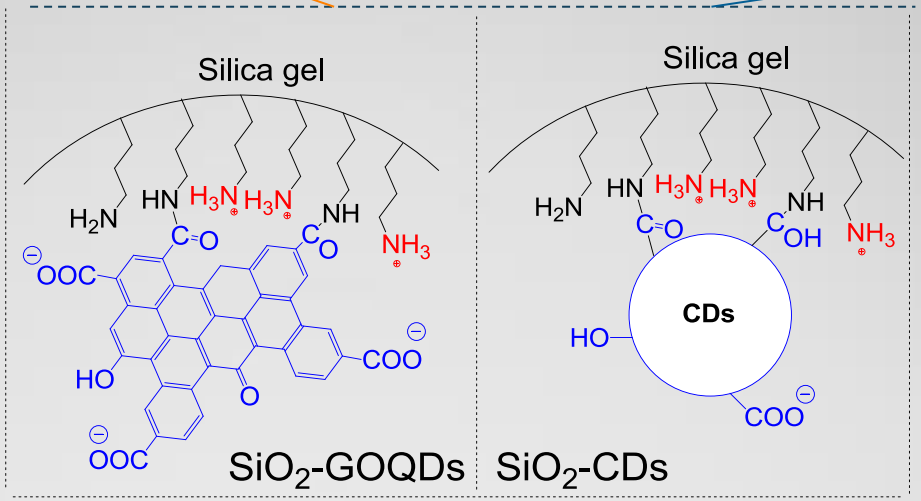
Graphene oxide quantum dots immobilized on mesoporous silica: preparation, characterization and electroanalytical application†

Check for updates

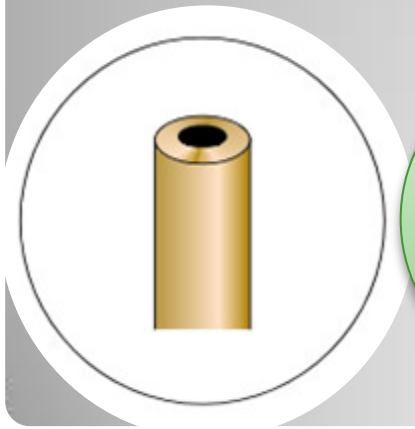
Albina Mikhraliieva, [a] Vladimir Zaitsev, [*ab] Oleg Tkachenko, [cd] Michael Nazarkovsky, [a] Yutao Xing [e] and Edilson V. Benvenutti [c]

Materiais and application

Adsorbents for solid-phase extraction



Antibacterial and antiviral activity



Modified carbon paste electrode

Acknowledgment

Thank you!

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LAQAPAB laboratório
Adsorventes para análise química, proteção de ambiente e biomedicina