# UNAT

## Ultra-small Nanohybrides for Advanced Theranostics

**Newsletter 4 – November 2023**

## Consortium

**Coordinator**

Université Claude Bernard Lyon 1
*France*

Corporation Science Park Taras Shevchenko University Of Kyiv
*Ukraine*

Consiglio Nazionale Delle Ricerche
*Italy*

Bioemission Technology Solutions IKE
*Greece*

Glincs
*France*

## The project

Nanoscale materials have gained a place in the spotlight as enablers of combination diagnostic-therapeutic technologies due to their tiny penetrating sizes and their unique functional properties.

**Nanohybrids** that contain both organic and inorganic components, including metallic ones, offer tremendous opportunity for the functionalisation of biological or bioactive molecules.

The EU-funded UNAT project will explore the capabilities of metal-carbon nanohybrids for multimodal in vivo imaging and therapy of tumours via electromagnetic radiation.

The diagnosis and therapy of cancer will be evaluated through an ambitious campaign of preclinical in vitro and in vivo experiments.

## Key figures

**5 years (2021-2025)**
**5 partners**
**4 countries**
**832 k€**

More information on **www.unat-project.eu**

## Annual visit of ISSMC-CNR laboratories for students of the Bedandi middle school

On March 30, 2023, the students of the Bedandi middle school in Faenza visited the laboratories of the ISSMC-CNR. Among the proposed activities, Dr. Federica Mancini explained to the children what carbon-dots are and what they are for, and how it is possible to obtain them from by-products of the food industry.

## Annual Conference of the Architects of Nano-hybrid – Nanohybrids XIX-2023

The annual conference Nanohybrids XIX-2023 took place from 21st May 2023 to 25th May 2023, Porquerolles–France https://ulrichdarbost.wixsite.com/nanohybrid

This conference is devoted to synthesis, characterizations and applications of nanohybrid compounds with a special focus on biological applications. It is addressed to academic researchers as well as to clinicians and industrial participants.
It was the excellent opportunity for a group of UNAT members to present their work to their colleagues from other multidisciplinary research teams.

### PROGRAMME :

**23th May: Imaging and spectroscopy**

12:00 – Intervention of **LYSENKO Vladimir**

*“ Förster resonance energy transfer between multicolor fluorescent carbon dots ”*

**24th May – Carbon based nanohybrids**

10 :00 – Intervention **ZADERKO Alexander**

*“ Soft fluorination of carbon nanostructures for multidisciplinary applications. ”*

10 :20 – Intervention of **TOPCHYLO Anna**

*“ Physico-chemical properties of fluorinated carbon dots for bio-imaging applications.”*

12:00 – Intervention of **PALIENKO Konstantyn**

*“ Green synthesis of Gd3+-doped ultrasmall carbon-based nanohybrids from coffee wastes ”*

12 :20 – Intervention of **KUZNIETSOVA Halyna**

*“ Chronic in vivo toxicity of Gd3+ doped ultrasmall carbon-based nanohybrids ”*

## 3 Recent publications co-authored with the Ukrainian partners in Scientific Reports, Discover Nano & Science Direct

Revue : Scientific Reports
Title: ***“ A comparative multi-level toxicity assessment of carbon-based Gd-free dots and Gd-doped nanohybrids from coffee waste: hematology, biochemistry, histopathology and neurobiology study ”***

Authors: Halyna Kuznietsova, Natalia Dziubenko, Konstantin Paliienko, Natalia Pozdnyakova, Natalia Krisanova, Artem Pastukhov, Tetiana Lysenko, Marina Dudarenko, Valeriy Skryshevsky, Vladimir Lysenko & Tatiana Borisova

DOI: 10.1038/s41598-023-36496-4 - Open access link on HAL

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Revue : Discover Nano
Title: ***“ In vitro and in vivo toxicity of carbon dots with different chemical compositions ”***
Authors: Halyna Kuznietsova, Alain Géloën, Nataliia Dziubenko, Alexander Zaderko, Sergei Alekseev, Vladimir Lysenko & Valeriy Skryshevsky

DOI: 10.1186/s11671-023-03891-9 - Open access link on HAL

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Revue : Science Direct
Title: ***“ Green Synthesis of biocompatible Gd3+-doped Ultrasmall Carbon-based Nanohybrids from Coffee Wastes ”***
Authors: Konstantin Paliienko, Anna Topchylo, Sergei Alekseev, Alain Géloën, Yurii Milovanov, Tetiana Lysenko, Valeriy Skryshevsky, Tatiana Borisova, Vladimir Lysenko

DOI: 10.1016/j.crcon.2023.09.001 - Open access link on Zenodo

## C’Nano | The Nanoscience Meeting 2023 in Poitiers

In March 2023, UNAT members actively contributed to the C'Nano-2023 conference with the presentation of 1 oral and 1 poster.

Oral presentation :
Title : ***“ Green synthesis of Gd3+ -doped ultrasmall carbon-based nanohybrids from coffee wastes ”***
Authors : K. Paliienko, A. Topchylo, S. Alekssev, A. Géloën, Y. Milovanov, T. Lysenko, V. Skryshevsky, T. Borisova and V. Lysenko
→ *Access on page 5*

Poster :
Title : ***“ Förster resonance energy transfer between multicolor fluorescent carbon dots ”***
Authors : Ivan Lysenko, Anna Topchylo, Alexander Zaderko, Alain Géloën, Tetyana Nychyporuk, Valeriy Skryshevsky and Vladimir Lysenko
→ *Access on page 6*

## UNAT Implemented secondments

Research and Innovation Staff Exchange (RISE) projects fund short-term exchanges ("secondments") for staff to develop careers combining scientific excellence with exposure to other countries and sectors. RISE enables more interaction between academia and non-academic organisations within Europe and worldwide.
The following secondments were implemented between April 2023 and November 2023:

LYSENKO Tetiana from SCIENCE PARK to UCBL (01/03/2023 - 07/04/2023)
BORISOVA Tatiana from SCIENCE PARK to UCBL (10/01/2023 - 09/04/2023)
PALIIENKO Kostiantyn from SCIENCE PARK to UCBL (16/01/2023 - 15/04/2023)
DZIUBENKO Nataliia from SCIENCE PARK to UCBL (24/04/2023 - 07/06/2023)
KUZNIETSOVA Halyna from SCIENCE PARK to UCBL (24/04/2023 - 07/06/2023)
MANCINI Federica from CNR to GLINCS (16/05/2023 - 13/07/2023)
GANDOLFI Sara from CNR to GLINCS (15/05/2023 - 19/07/2023)
ZADERKO Alexander from SCIENCE PARK to UCBL (06/03/2023 - 28/07/2023)
ADAMIANO Alessio from CNR to BIOEMTECH (08/07/2023 - 07/08/2023)

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C'Nano
THE NANOSCIENCE MEETING
Poitiers
March, 15, 16 and 17
2023

**Thematic Session :** *Nanochemistry, Nanoparticles, Nanocatalysis*
**Keywords** (max. 4-5)**:** carbon-based nanohybrids, green synthesis, coffee wastes, doping with $Gd^{3+}$
**Disciplinary fields involved :** Chemistry, Physics, Biology
**Sustainable Development Goals* eventually involved in your research:** Goal 3: Good health and well-being

# Green synthesis of $Gd^{3+}$-doped ultrasmall carbon-based nanohybrids from coffee wastes

**K. Paliienko[1,2], A. Topchylo[3], S. Alekssev[4], A. Géloën[5], Y. Milovanov[2,3], T. Lysenko[1,2], V. Skryshevsky[2,3], T. Borisova[1] and V. Lysenko[6]**

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3. *Institute of High Technologies, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
4. *Chemistry Faculty, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
5. *UMR Ecologie Microbienne Lyon (LEM), CNRS 5557, INRAE 1418, Claude Bernard University of Lyon, Villeurbanne, France*
6. *Light Matter Institute, UMR CNRS 5306, Claude Bernard University of Lyon, Villeurbanne, France*

Carbon-based nanomaterials are a huge subgroup of nanosized materials of the IVth group. Carbon dots (CDs) have sparked a special interest among the all other carbon-based nanomaterials because of their unique properties, multidisciplinary applications, as well as extremely cheap and simple production methods [1]. According to the great principles of green synthesis, bio-wastes treated with microwave energy sources appear to be the best feedstock to produce CDs [2]. Waste-derived CDs are very perspective for a variety of applications: sensorics, catalysis, drug delivery, bioimaging, diagnostics and therapy [1].
The main goal of our work is to synthesize ultra-small nontoxic carbon-based nanomaterials which will be able to ensure perfect contrast in magnetic resonance imaging (MRI). Microwave-assisted green synthesis of $Gd^{3+}$-free CDs (GFCDs) and $Gd^{3+}$-doped carbon-based nanohybrids (GDNHs) from coffee wastes will be reported in details. A special attention will paid to an impact of $Gd^{3+}$-ions on size distribution, surface chemistry, optical properties and biological toxicity of the GDNHs in comparison with the $Gd^{3+}$-free CDs obtained from the same coffee waste sources.

References:
[1] H. Salimi Shahraki et al., FlatChem 2022, 31, 100310, DOI: 10.1016/J.FLATC.2021.100310.
[2] O. V. Kharissova et al., R. Soc. Open Sci. 2019, 6 (11), DOI: 10.1098/RSOS.191378.

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C'Nano
THE NANOSCIENCE MEETING
2023
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**Thematic Session :** *Nanochemistry, Nanoparticles, Nanocatalysis*
**Keywords** (max. 4-5)**:** carbon nanodots, photoinduced electronic transitions, fluorescence, resonant energy transfer, cell fluorescence imaging
**Disciplinary fields involved :** Physics, Chemistry, Biology
**Sustainable Development Goals* eventually involved in your research:** Goal 3: Good health and well-being

# Förster resonance energy transfer between multicolor fluorescent carbon dots

**Ivan Lysenko[1], Anna Topchylo[2], Alexander Zaderko[2,3], Alain Géloën[4], Tetyana Nychyporuk[5], Valeriy Skryshevsky[2,3] and Vladimir Lysenko[6]**

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6. *Light Matter Institute, UMR CNRS 5306, Claude Bernard University of Lyon, Villeurbanne, France*

Scientific interest in carbon nanodots (CNDs) began to grow exponentially since 2004, when pronounced fluorescent properties of carbon-based nanomaterials have been reported [1]. Since then, a variety of CNDs characterized by a high quantum yield of fluorescence, high biocompatibility and low toxicity for living organisms were chemically synthesized [2]. CNDs are ideally suited for multidisciplinary applications in various fields of science and technology, such as, for example: photonics, imaging of biological objects, medicine, sensors and others [3].
In our work, optical properties of CNDs chemically synthesized by solvothermal methods were studied. Optical absorption, photoluminescence excitation (PLE) and emission (PL) spectra as well as the characteristic photoluminescence lifetimes (7-11 ns) were measured. The studied concentration dependences of PL/PLE maps of the CNDs allowed to illustrate the phenomenon of resonant energy transfer of electronic excitation according to Forster mechanism (FRET). Temperature and pH dependences of the PL/PLE-maps of CNDs colloids allowed to confirm the FRET effect. The possibility of CNDs application for multicolor cell fluorescence imaging were also shown.

References:
[1] Xu X., Ray R., Gu Y., et al., J. Am. Chem. Soc., **126**, (2004), p. 12736.
[2] Speranza G., Nanomaterials, **11**, 967 (2021).
[3] Liu J., Li R., Yang B., ACS Cent. Sci., **6**, (2020) p. 2179

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