



## *Annual Symposium*

***15 – 16<sup>th</sup> January 2024***

***Burlington House, Piccadilly, W1J OBA***

***London, United Kingdom***

# **Symposium Booklet**

*Keep up with us on X @RSC\_CNN*



*Conference hashtag*

***#RSCCNN2024***

Thank you to our sponsors



RSC  
Pharmaceuticals

***GoodFellow***  
innovation, delivered

**HIDEN**  
ISOHEMA



Thank you to our prize sponsors

**Aggregate**  
Open Access



RSC  
Pharmaceutics



*Aggregate for best oral presentation prize and runner up prize*

*Nanoscale Horizons for best poster presentation prize*

*Nanoscale for first runner up poster prize*

*Nanoscale Advances for second runner up poster prize*

*Pharmaceutics for best nanomedicine poster prize*

# Aggregate

Open Access



A New Open-Access Multidisciplinary Journal Dedicated to Publishing Cutting-Edge Research of Aggregate Science



## Broad Scope

### Subjects

Subjects	Aggregate
Chemistry	Dimer/Oligomer/Polymer
Materials Science	Mixture/Hybrid/Composite
Physics/Biology	Cluster/Assembly/Particle
Engineering/etc.	Protein/Cell/Pathogens/etc.



## Editorial Team



### Editor-in-Chief

Ben Zhong Tang

### Deputy Editor

Anjun Qin

### Editorial Board

2/5 Clarivate's

Highly cited scientists

### Associate Editor

Yuning Hong *Australia*

Gen-ichi Konishi *Japan*

Paul McGonigal *UK*

Eric Rivard *Canada*

Kazuo Tanaka *Japan*

Wei Tao *USA*

Jianping Xie *Singapore*

Ali Yetisen *UK*

Shuang-Quan Zang *China*

Yu Shrike Zhang *USA*



## Growing Impact

Vol. 1 No. 1 Published **2020-12**



DOAJ

Included in DOAJ

**2021-05**



Web of Science Group

Included in ESCI

**2021-09**



Clarivate™

Journal Citation Report

**2022-06**

### Q1 of 3 categories

**Q1**

Chemistry, Multidisciplinary

Chemistry, Physical

Materials Science, Multidisciplinary

First Journal Impact Factor(JIF) **2023-06**



Impact  
Factor

= **18.8**

Scopus™

Included in Scopus

**2023-08**



## Know More

Fast & fair peer review



Open access, no APC before Dec. 5, 2023



Multi-channel promotions



Website



Twitter



Google Scholar



aggregate@aietech.org.cn

Editorial Office

## Chemical Nanoscience and Nanotechnology Interest Group Annual Symposium

**Monday 15th January 2024**

12:00	<b>Registration</b>
12:55	<b>Welcome and Introductions</b>
13:00	<b>Plenary Lecture</b> George Malliaras "Thin film technology for bioelectronic medicine"
13:45	<b>Invited Lecture</b> Associate Professor George Sotiriou "Engineering nanostructured materials for biomedicine by aerosol processes"
14:20	<b>Talk</b> Dr Philip D. Howes "Microfluidic systems for high-throughput and data-rich nanomaterials chemistry"
14:40	<b>Talk</b> Dr Maria J. Marin "Two-photon fluorescent (nano)probes for a versatile intracellular detection and quantification of nitric oxide"
15:00	<b>Sponsor Presentation</b> Goodfellow
15:10	<b>Afternoon Tea</b>
15:40	<b>Sponsor Presentation</b> PerkinElmer
15:50	<b>Invited Lecture</b> Professor Neil Robertson "Asymmetric Supercapacitors using Hybrid Bi and Ni-based Materials"
16:25	<b>Invited Lecture</b> Associate Professor Ljiljana Fruk "Organic nanocarriers in biomedicine: Design principles and translational challenges"
16:00	<b>Talk</b> Dr Jonathan Foster "Liquid exfoliation of molecular materials into nanosheets"
16:20	<b>Talk</b> Dr Robert Menzel "Hierarchical graphene-based aerogel catalysts and sorbents"
16:40	<b>Invited Lecture</b> Professor Petra Rudolf "From solution to surface: applying supramolecular chemistry principles for device manufacturing through molecular self-assembly"
17:15	<b>Poster Session</b>
18:15	<b>Close of Session</b>
19:00	<b>Conference Dinner</b>

**Tuesday 16th January 2024**

8:45	<b>Coffee and Refreshments</b>
9:00	<b>Plenary Lecture</b> Professor Valeria Nicolosi “Processing of liquid-phase exfoliated 2D nanomaterials devices”
9:45	<b>Invited Lecture</b> Professor Yvonne Perrie “Formulation and manufacture of nanoparticles – what are the key considerations?”
10:20	<b>Talk</b> Dr Marziyeh Jannesari “Innovative Strategies for Combating Bacterial Contamination: Synergistic Effects of Oxygen Nanobubbles and Reduced Graphene Oxide”
10:40	<b>Talk</b> Dr Andrew Surman “Rapid low-cost characterisation of graphene-based materials to address the challenges of inhomogeneity and irreproducibility”
11:00	<b>Morning Tea</b>
11:30	<b>Invited Lecture</b> Professor George Christou “Bottom-up molecular routes to ultra-small (1 - 3 nm) nanoparticles of important metal oxides: ‘molecular nanoparticles’”
12:05	<b>Talk</b> Dr Anna Fantinati “Functionalized gold nanoparticles as an anchor to detect Coronavirus infection”
12:25	<b>Talk</b> Aine Coogan “Towards recyclable 2D material-based nanofiltration membranes for water purification”
12:45	<b>Lunch and Posters</b>
13:45	<b>Talk</b> Lauren Evans “Versatile vigilantes: Exploiting the intrinsic properties of hybrid nanoparticles for drug delivery”
14:05	<b>Talk</b> Muhamad Hartono “Non-invasive detection of chemotherapy-induced senescence in lung cancer via enzyme-targeting nanoprobe”
14:25	<b>Prizes and Closing Remarks</b>

Poster Number	Presenter	Poster title
1	Abdullah Akhdhar	Design and fabrication of silver nanoparticles doped $\beta$ -cyclodextrin-chitosan functionalized graphene nanocomposite modified electrode
2	Abubakar Dahiru	High-performance Supercapacitors Enabled by Highly-porous Date Stone-derived Activated Carbon and Organic Redox Gel Electrolyte
3	Áine Coogan	Lanthanide-doped Layered Double Hydroxide Nanostructures as Luminescent 'Turn-off' Environmental Chemosensors
4	Alexander Evtushenko	Protein-based nanotechnology for the treatment of pancreatic cancer
5	Alireza Fereydooni	Barley Husks as Anode Material for Li-ion Batteries
6	Ambreen Ashar	Fabrication of Calcium Zincate@Carbon Fabric based standalone Solar Photocatalytic reactor for remediation of textile effluent
7	Annalena Bock	Novel SERS Substrate using Polydopamine – Gold Nanoparticle Hybrid Films towards Qualitative Drug Analysis
8	Avinash Ingle	Nanocatalysts: The promising tools in biorefining industries
9	Beatriz Lozano Torres	Bioactive protein-based nanoparticles for biomedical applications
10	Benjamin Gfeller	Precursor-less Metal Nanoparticle Generation and Characterisation
11	Benjamin Jumbo	Enhancing Gemcitabine Efficacy in Pancreatic Ductal Adenocarcinoma through Novel Chemotherapeutic Strategies
12	Brandon Lowe	Synthesis and Functionalisation of (Ti/Zn)-Fe-Si Solid Acid Metal Oxide Nanocatalysts for Conversion of Low-Grade Waste Cooking Oil to Biodiesel
13	Brian Tam	All Chemical-Vapour-Deposited Nano-needle Structured WO <sub>3</sub> /BiVO <sub>4</sub> Heterojunction Photoanodes for Water Splitting
14	Daniel Zimmer	Synthesis and Impurity Analysis of Branched-Chain Ionizable Lipids for Lipid Nanoparticles
15	Daniel Zimmer	Capillary Electrophoresis Microfluidic Assessment of mRNA and pDNA Loaded Lipid Nanoparticles
16	Dongwon Choi	Application of a separator-integrated graphene/graphite anode to lithium metal batterie
17	Doory Dan	Molecular Models for Single Cobalt Ions on Cerium Dioxide Nanoparticles: Heterometallic Ce/Co-oxo Clusters
18	Ethan Fisher	Molecular mixed-metal-oxo clusters: well-defined models for mixed-metal oxide nanomaterials
19	Grace Ball	FRET Responsive Silica Nanoparticles for Localised Antibiotic Release Using Ultrasound
20	Konstantinos Kotoulas	Quantifying the impact and potential of carbon dots on plant photosynthesis
21	Lewis Dymock	Investigation into the impact of hydrogen bonding in loading of hydrophilic drugs into solid lipid nanoparticles
22	Manavalan Vijayakumar	Electrosynthesis of highly crystalline ZIF-67 using bio solvents: comparison of electrochemical performance as a supercapacitor electrode in various electrolyte medium
23	Mariia Becker	The Nanoscience Dalmatian: Metal decorated titanium dioxide nanoparticles via Spark Ablation



24	Marilia Barreto Dalla Benetta	Carbon Cloth Modified with Nickel and MoS <sub>x</sub> /MoS <sub>2</sub> for the Hydrogen Evolution Reaction
25	Marina Ratova	Visible light-active bismuth oxide photocatalytic coatings and their potential against biological contaminants
26	Marziyeh Jannesari	Electric Field-Based Air Nanobubbles (EF-ANBs) Irrigation on Efficient Crop Cultivation with Reduced Fertilizer Dependency
27	Masa Johar	Mesoporous g-C <sub>3</sub> N <sub>4</sub> , TiO <sub>2</sub> and g-C <sub>3</sub> N <sub>4</sub> /TiO <sub>2</sub> photonic films with a chiral nematic structure: slow photonic effect inducing improved H <sub>2</sub> generation
28	Meiyi Chen	Design and Synthesis of Cu(II/I) Complexes with 6,6'-Dimethyl-2,2'-Bipyridine Derivatives for Enhanced Hole Transport in Solid-State Dye-Sensitized Solar Cells
29	Miguel Jimenez-Munoz	Towards the Development of a Random Access DNA Memory (e-RADM)
30	Rachel Bocking	Development of an optimised coating technique for the functionalisation of micro and nanoelectrodes
31	Rachel Onchuru	Safety Optimisation of a hybrid nanoparticle based on thermo-responsive delivery system for pancreatic cancer treatment
32	Raeil Jeong	Investigation of water-soluble binder for nano-sized LiFePO <sub>4</sub> /C cathode in water solvent slurry system
33	Raeyoon Kim	Effect of different carbon precursor and deposition temperature on properties of SiO <sub>x</sub> @C electrode
34	Sarah Boyall	Palladium Nanoparticle Deposition on Spherical Carbon Supports for Heterogeneous Catalysis in Continuous Flow
35	Sean Leggatt-Bulaitis	Nanocarbon aerogels for catalytic flow processes
36	Shabnam Taghipour	Synthesis of Fe/TiNT photocatalyst for removal of pollutants from water
37	Sofia Patri	Magnetic nanogels for combined hyperthermia and chemotherapy of prostate cancer
38	Tianxin Liang	Development of novel antimony materials for next generation supercapacitors
39	Tony Byrne	Photoactive Coatings for Surface Disinfection and Decontamination
40	Vasiliki Tsikourkitoudi	Flame-made lithium titanate nanoparticles with superior cycle stability as promising anode materials for lithium-ion batteries
41	Vasiliki Tsikourkitoudi	NAD-boosting antioxidant nanoformulations for glaucoma treatment
42	Veronica Sofianos	Tuning the Catalytic Activity of Bifunctional Cobalt Boride Nanoflakes for Overall Water Splitting over a Wide pH Range
43	Xinyu Lu	Cationic sequence-controlled PEGylated multi-block polyesters for enhanced RNA delivery and thermostability
44	Yunji Lee	Fluoride-free porous TiO <sub>2</sub> fabricated by polymer resin assisted-anodization
45	Ziyu Zhao	Graphene aerogel and carbon black supported catalyst for proton exchange membrane fuel cells



# Plenary Oral Presentation Abstracts

## Thin Film Technology for Bioelectronic Medicine

GEORGE MALLIARAS

Department of Engineering, University of Cambridge, UK

### Abstract

Bioelectronic medicine provides a new means of addressing disease via the electrical stimulation of tissues: Deep brain stimulation, for example, has shown exceptional promise in the treatment of neurological and neuropsychiatric disorders, while stimulation of peripheral nerves is being explored to treat autoimmune disorders. The implanted electrodes used in these devices are assembled by hand, using top down techniques that herald from (mechanical) watchmaking! Using the (bottom up) microfabrication techniques of microelectronics promises to revolutionize implantable devices, enabling exceptionally precise stimulation and minimally invasive thin film form factors. I will overview the state-of-the-art in the use of thin film implants<sup>1-3</sup> and discuss the challenges that lie ahead on the road to deploying this technology to patients at scale.

### References

1. Lacour, S. P. et al., *Nat. Rev. Mater.* 2016, **1**, 1–14.
2. Rivnay, J. et al., G. G., *Sci. Adv.* 2017, **3**, e1601649.
3. Khodagholy, D. et al., *Nat. Neurosci.* 2015, **18**, 310–315.

## Processing of liquid-phase exfoliated 2D nanomaterials devices:

VALERIA NICOLOSI

Trinity College Dublin, School of Chemistry, CRANN, AMBER and IForm Centres, Dublin 2, Ireland

### Abstract

Liquid phase exfoliation has been proved to be a cheap, scalable method for the mass production of 2D sheets. This talk will first discuss the galaxy of existent layered materials, with emphasis on synthesis, liquid-phase exfoliation, and characterization, focussing on some key applications recently developed in our laboratories, ranging from energy storage to printed electronics.

We will for example discuss how two-dimensional nanomaterials can be formulated in aqueous and organic viscous inks for extrusion printing, inkjet printing, and aerosoljet 3D printing, and demonstrate direct printing on various substrates. The additive- and binary solvent-free inks do not show coffee ring effect, enabling high-resolution printing without substrate pre-treatment. The resulting printed micro-supercapacitors showcase excellent charge storage performance, including areal capacitance up to 100 mF/cm<sup>2</sup> and volumetric capacitance up to 800 F/cm<sup>3</sup> in protic gel electrolyte, coupled with long lifetime and good flexibility. The versatile direct-ink-printing technique highlights the promise of 2D nanomaterials functional inks for scalable fabrication of easy-to-integrate components of printable electronics. In this talk we will also demonstrate how such inks can be used to develop novel nanomaterials-based battery solutions.

Increasing the energy storage capability of batteries necessitates maximization of their areal capacity. This requires thick electrodes performing at near-theoretical specific capacity.

However, achievable electrode thicknesses are restricted by mechanical instabilities, with high-thickness performance limited by the attainable electrode conductivity. Here we show that forming a segregated network composite of carbon nanotubes with a range of lithium storage materials (for example, silicon, graphite and metal oxide particles) suppresses mechanical instabilities by toughening the composite, allowing the fabrication of high-performance electrodes with thicknesses of up to 800  $\mu\text{m}$ . Such composite electrodes display conductivities up to  $1 \times 10^4 \text{ S m}^{-1}$  and low charge-transfer resistances, allowing fast charge-delivery and enabling near-theoretical specific capacities, even for thick electrodes. The combination of high thickness and specific capacity leads to areal capacities of up to 45 and 30 mAh cm<sup>-2</sup> for anodes and cathodes, respectively. Combining optimized composite anodes and cathodes yields full cells with state-of-the-art areal capacities (29 mAh cm<sup>-2</sup>) and specific/volumetric energies (480 Wh kg<sup>-1</sup> and 1,600 Wh l<sup>-1</sup>).

# Invited Oral Presentation Abstracts

## Engineering nanostructured materials for biomedicine by aerosol processes

GEORGIOS A. SOTIRIOU

Department of Microbiology, Tumor and Cell Biology, Karolinska Institutet, 171 65 Stockholm, Sweden.

### Abstract

Even though there is concentrated effort from nanotechnology research laboratories worldwide against cancer, there is only limited nano-related research against infections. This might be counter-intuitive due to the more deaths globally attributed to infections than cancer. Furthermore, because of the continuous use and abuse of antibiotics to fight infections, antimicrobial resistance in some bacterial strains (the so-called “superbugs”) has emerged. That constitutes the most serious public health threat today termed as “slow-motion catastrophe”. Therefore, there is an urgent societal need to provide innovative antimicrobial solutions as also highlighted by the WHO. Nanoscale materials offer advantages and solutions to this public health threat because they may exert antimicrobial action by multiple mechanisms rendering the emergence of antimicrobial resistance rather unlikely.

In this talk, I will highlight a few examples utilizing responsive nanomaterials against infections. This is explored using a nanomanufacturing process with proven scalability and reproducibility, flame aerosol technology<sup>1-2</sup>, to assist rapid technology transfer to industry. We employ flame direct nanoparticle deposition on substrates and combine nanoparticle production and functional layer deposition in a single-step with close attention to product nanoparticle properties and assembly of devices<sup>3,4</sup>. For example, utilizing this technology, it is possible to develop nanomaterials as biosensors for physiological parameters (e.g. pH, H<sub>2</sub>O<sub>2</sub>)<sup>5-7</sup> relevant to bacterial infections or for food safety, as nano-enabled coatings on medical devices to eradicate bacterial biofilms<sup>8,9,10</sup>, or even as drug nanocarriers for biologics (e.g. peptides, proteins) for localized treatments<sup>11</sup>.

### References

- [1] G. A. Sotiriou, D. Franco, D. Poulikakos, A. Ferrari, *ACS Nano* **6**, 3888-3897 (2012).
- [2] G. A. Sotiriou, F. Starsich, A. Dasargyri, M. C. Wurnig, F. Krumeich, A. Boss, J.-C. Leroux, S. E. Pratsinis. *Adv. Funct. Mater.* **24**, 2818-2827 (2014).
- [3] G. A. Sotiriou, C. O. Blattmann & S. E. Pratsinis, *Adv. Funct. Mater.* **23**, 34-41 (2013).
- [4] D. F. Henning, P. Merkl, C. Yun, F. Iovino, L. Xie, E. Mouzourakis, C. Moularas, Y. Deligiannakis, B. Henriques-Normark, K. Leifer & G. A. Sotiriou. *Biosens. Bioelectron.* **132**, 286-293 (2019).
- [5] A. Pratsinis, G. A. Kelesidis, S. Zuercher, F. Krumeich, S. Bolisetty, R. Mezzenga, J.-C. Leroux & G. A. Sotiriou. *ACS Nano* **11**, 12210-12218 (2017).
- [6] P. Merkl, M.-S. Aschtgen, B. Henriques-Normark & G. A. Sotiriou. *Biosens. Bioelectron.* **171**, 112732 (2021).
- [7] H. Li, P. Merkl, J. Sommertune, T. Thersleff, & G. A. Sotiriou. *Adv. Sci.* **2201133** (2022).
- [8] P. Merkl, S. Zhou, A. Zaganianis, M. Shahata, A. Eleftheraki, T. Thersleff & G. A. Sotiriou. *ACS Appl. Nano Mater.* **4**, 5330-5339 (2021).
- [9] F. J. Geissel, V. Platania, A. Gogos, I. K. Herrmann, G. N. Belibasakis, M. Chatzinikolaidou & G. A. Sotiriou. *J. Colloid Interface Sci.* **608**, 3141-3150 (2022).
- [10] E. Bletsas, P. Merkl, T. Thersleff, S. Normark, B. Henriques-Normark & G. A. Sotiriou. *Chem. Eng. J.* **454**, 139971 (2023).
- [11] V. Tsikourkitoudi, J. Karlsson, P. Merkl, E. Loh, B. Henriques-Normark & G. A. Sotiriou. *Molecules* **25**, 1747 (2020).

## Asymmetric Supercapacitors using Hybrid Bi and Ni-based Materials

NEIL ROBERTSON<sup>A</sup>, CAROLINE KIRK<sup>A</sup>, HUAPENG SUN<sup>A</sup>, XUERUI YI<sup>A</sup>

<sup>A</sup>EaStCHEM School of Chemistry, University of Edinburgh, King's Buildings, David  
Brewster Road, Edinburgh EH9 3FJ, Scotland, UK

### Abstract

Demand for efficient, economic, and eco-friendly energy storage has grown dramatically in recent years for applications in electronic appliances, electric vehicles, and a smart and sustainable energy grid. Electrical double layer capacitors (EDLCs) and lithium-ion batteries can respectively provide high power-density and high energy-density electrical energy storage. Low-cost, solution-processed electrode materials have attracted significant research interest for their green and economical applications in such energy harvesting and storage devices. Bismuth chalcogenides, halides and chalcogenides have captured research interests for their manifold functionalities in photocatalysis, photovoltaics, and radiation detection, however applications in electrical energy storage remain mainly focused on Bi<sub>2</sub>O<sub>3</sub> and Bi<sub>2</sub>S<sub>3</sub>. Here, we demonstrate ambient-pressure and moderate-temperature synthetic routes to nanocrystals and films of bismuth chalcogenides and halides, including Bi<sub>13</sub>S<sub>18</sub>I<sub>2</sub><sup>1,2</sup>, BiSI<sup>2</sup>, BiSI-reduced-graphene-oxide<sup>3</sup> and [Organic-cation][BiI<sub>4</sub>]<sup>4</sup>. We demonstrate their potential as anode materials in electrical energy storage, including EDLC-type supercapacitors and pseudocapacitors, showing high capacitance/capacity and excellent cycle stability. We have also developed Ni(OH)<sub>2</sub>-based cathodes with exceptional charge-storage capacity<sup>5,6</sup>, and combine these with the Bi-based anodes to give full devices with excellent energy and power density.

### References

1. K. Adams, A. Franco-González, J. Mallows, T. Li, J. H. J. Thijssen, N. Robertson, *J. Mater. Chem. A*, 2019, **7**, 1638
2. H. Sun, G. Yang, J. Chen, C. Kirk, N. Roberson, *J. Mater. Chem. C*, 2020, **8**, 13253
3. H. Sun, X. Xiao, V. Celorrio, Z. Guo, Y. Hu, C. Kirk, N. Robertson, *J. Mater. Chem. A*, 2021, **10**, 15452
4. K. Roy, T. Li, S. Ogale, N. Robertson, *J. Mater. Chem. A*, 2021, **9**, 2689
5. X. Yi, H. Sun, N. Robertson, C. Kirk, *Sust. Energy & Fuels*, 2021, **5**, 5236
6. X. Yi, V. Celorrio, H. Zhang, N. Robertson, C. Kirk, *J. Mater. Chem. A*, 2023, **11**, 22275

## Organic Nanocarriers in Biomedicine: Design Principles and Translational Challenges

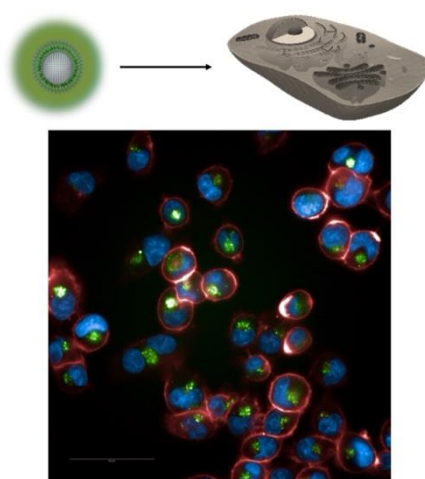
LJILJANA FRUK

*University of Cambridge, Department of Chemical Engineering and Biotechnology*

### Abstract

Around 100 nano-based formulations have received FDA approval since 1995, with many more in various stages of clinical trials.<sup>1</sup> Yet, there are still challenges that need to be tackled related to the design and validation, as well as to the regulation of the novel structures. The key in addressing these challenges is a multidisciplinary approach that allows rational design and preclinical validation that maximises the success of the formulation in clinical trials.

In this talk we will focus on biopolymeric organic nanocarriers for gene delivery<sup>2</sup> and treatment of solid tumours such as pancreatic cancer<sup>3</sup>, as well as the steps that need to be taken to ensure high translational value of the final design. The issue of manufacture and targeting will be addressed, as well as the development of appropriate models to establish preclinical go-no-go checkpoints.



### References (Style: Royal Society of Chemistry)

1. R. Kumar, J. O. Kim, *J. Pharm. Investig.* **2023**, *53*, 19-33.
2. C. Franck, A. Bistrovic-Popov, I. Ahmed, L. Fanslau, P. Tyagi, Lj. Fruk, *Nanoscale Horiz.* **2023**, *8*, 1588-1594
3. A. Bistrovic-Popov, F. Melle, E. Linnane, C. Gonzalez-Lopez, I. Ahmed, B. Parshad, C. O. Franck, H. Rahmoune, F. M. Richards, D. Munoz-Espin, D. I. Jodrell, D. Fairen-Jimenez, Lj. Fruk, *Nanoscale* **2022**, *14*, 6656-6669



## **From solution to surface: applying supramolecular chemistry principles for device manufacturing through molecular self-assembly**

PETRA RUDOLF

Materials Science Centre, University of Groningen, Netherlands

### **Abstract**

The application of supramolecular chemistry principles to the assembly of active layers for devices is challenging because molecule-substrate interactions are added to the molecule-molecule interactions present in solution. In this talk I shall illustrate what this implies for building an ordered array of fluorescent molecules at a specific distance from each other, while preserving their functionality by decoupling them from the surface. The approach was to make use of pedestals to which the fluorophore was attached by metal-ligand coordination. Zinc phthalocyanine or zinc diphenylporphyrin were chosen as pedestal, perylene as the functional unit, and a pyridyl group as linker. The successful assembly of the three building blocks on a graphene surface was verified with the help of scanning tunneling microscopy and X-ray photoelectron spectroscopy, while near-edge X-ray absorption fine structure spectroscopy was used to determine the precise orientation of the fluorescent unit with respect to the pedestal, and hence the surface. We demonstrate that supramolecular chemistry principles can indeed be applied to build ordered 3D arrays of functional molecules on surfaces and show that it is even possible to exploit the molecule-surface interaction to achieve an arrangement that is not favoured in solution.

## **Formulation and manufacture of lipid nanoparticles – what are the key considerations?**

YVONNE PERRIE

Strathclyde Institute of Pharmacy and Biomedical Science, 161 Cathedral St, University of Strathclyde, Glasgow, G4 0RE, UK

### **Abstract**

Lipid nanomedicines continue to gain considerable attention in their use for the delivery of drugs and vaccines and in particular, the use of lipid nanoparticles for the delivery of messenger ribonucleic acid (mRNA) vaccines is well demonstrated. In the design of lipid nanoparticles, critical considerations include the lipid selection, however other factors including buffer selection and manufacturing processes also play an impact. Understanding the nuanced effects of these factors is imperative for tailoring formulations to meet specific requirements in diverse targets and payloads.

Within our laboratory, we employ a range of microfluidic platforms to prepare lipid nanoparticles, and we have investigated material attributes (solvents and buffers) and microfluidic process parameters on nanoparticle critical quality attributes including particle size, polydispersity and payload loading. We have then investigated these formulations both in vitro and in vivo efficacy.

Our findings demonstrate the pivotal role of solvent, buffer, and lipid selection in the formulation process. During manufacturing, factors like mixing ratio and operation speed significantly impact nanoparticle attributes. While a variety of ionizable lipids demonstrate effectiveness in delivering nucleic acids, there remains a gap in in vitro and in vivo correlation. Manufacturing considerations reveal that higher aqueous mixing ratios, increased speeds, and the use of more polar alcohols result in reduced nanoparticle size while maintaining optimal payload incorporation. By comprehensively addressing these aspects, we aim to contribute to the intricate decisions and methodologies involved in lipid nanoparticle development.

## Bottom-up Molecular Routes to Ultra-small (1 - 3 nm) Nanoparticles of Important Metal Oxides: 'Molecular Nanoparticles'

GEORGE CHRISTOU, KYLIE B. MITCHELL, BRADLEY RUSSELL-WEBSTER, JAVI  
LOPEZ-NIETO, ALOK SINGH

Department of Chemistry, University of Florida, Gainesville, FL 32611, USA

### Abstract

Synthesis of truly monodisperse (single-size) nanoparticles and their structural characterization to atomic resolution are extremely important challenges in nanoscience. For many nanoscale materials important to next-generation electronic, magnetic, catalytic, and biomedical systems/devices, the 'top-down' approach is reaching its limits as the fabrication of monodisperse nanoparticles becomes more and more difficult with decreasing size. The bottom-up molecular approach to ultra-small nanoparticles (up to 3 nm – excluding ligands) promises a powerful alternative route if high nuclearity clusters that have the same structure as the bulk material can be synthesized. Such 'molecular nanoparticles' (MNP's) would bring the many powerful advantages of molecular chemistry to this area of nanoscience, particularly true monodispersity, solubility, and crystallinity. The latter also allows structural characterization to atomic resolution by single-crystal X-ray crystallography, including the monolayer shell of organic ligands that is extremely difficult to characterize for traditional nanoparticles.

Nanoparticles of  $\text{CeO}_2$ , various Fe oxides, Mn oxides,  $\text{Bi}_2\text{O}_3$  and others are widely used in many areas from industrial catalysis to medical applications. For  $\text{CeO}_2$ , we have developed routes to a family of MNP's using primarily carboxylate ligands,<sup>1,2</sup> such as the  $\text{Ce}_{40}$  of 1.6 nm dimensions shown in the Figure, and recently extended this to higher dimensions.<sup>3</sup> Breakthroughs have now also been achieved to MNPs of other important metal oxides. In addition, we have recently been targeting the use of MNP's as supports for 3d and/or 4f heterometals to model magnetic units or catalysts supported on traditional nanoparticles or other surfaces. This presentation will describe a number of the above systems.

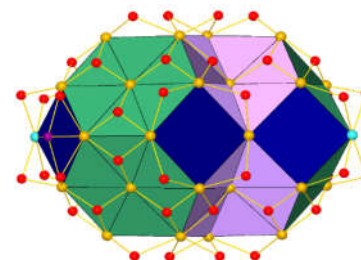


Figure. The core of the  $\text{Ce}_{40}$  MNP showing its facets. Organic ligands are omitted for clarity.

**Acknowledgements.** This work was supported by the USA National Science Foundation.

### References

1. K. J. Mitchell, K. A. Abboud, and G. Christou, *Nature Commun.* 2017, **8**, 1445.
2. K. J. Mitchell, J. Goodsell, B. Russell-Webster, U. Twahir, A. Angerhofer, K. A. Abboud, and G. Christou, *Inorg. Chem.*, 2021, **60**, 1641–1653.
3. B. Russell-Webster, J. Lopez-Nieto, K. A. Abboud, and G. Christou, *Angew. Chem. Int. Ed.*, 2021, **60**, 12591–12596.

# Oral Presentation Abstracts

## Microfluidic systems for high-throughput and data-rich nanomaterials chemistry

PHILIP D. HOWES <sup>A,B</sup>, NEAL MUNYEBVU <sup>B</sup>, ESME LANE <sup>B</sup>

<sup>A</sup> School of Engineering and Informatics, University of Sussex, UK

<sup>B</sup> School of Engineering, London South Bank University, UK

### Abstract

Colloidal nanoparticles are of growing importance in a broad range of practical applications, from medicine and biondiagnostics through to energy and environmental science. However, the fact that they are non-discreet reaction products, and their properties vary extremely sensitively as a function of size, shape and composition, makes materials discovery, characterization and optimization a daunting task in the face of an extensive reaction parameter space.

Here we present our experience in the development and application of microfluidic systems for the advanced synthesis, analysis and optimization of colloidal nanoparticles [1]. These systems allow rapid and efficient exploration of the mentioned extensive reaction parameter space. Intrinsic advantages include rapid heat and mass transfer in micro-isolated reaction volumes, leading to highly uniform and reproducible reaction conditions. Incorporation of in-line analytics (e.g., photoluminescence and absorption spectroscopy) allows real-time characterization and data feedback for powerful real-time reaction optimization. How this approach interfaces with new opportunities in data science, including machine learning, and how we are pushing to move materials chemistry into a new 'big data' regime, will be discussed. Examples from our lab of the application of such systems in nanomaterials investigations will be presented, with a particular focus on the synthesis and characterization of cesium lead halide perovskite nanocrystals, where multiparametric reaction mapping was used to elucidate how nanocrystal optical and morphological properties vary with ligand type, concentrations, and blend ratios.

There are many opportunities and challenges in the use of automated microfluidic systems in the future of colloidal nanocrystal synthesis, and there is vast potential for such systems to be developed and applied by a variety of research groups for broad impact.

**Acknowledgements:** We acknowledge the Royal Society of Chemistry for support with a Research Enablement Grant (E21-2246074803).

### References (Style: Royal Society of Chemistry)

1. N. Munyebvu, E. Lane, E. Grisan, P. D. Howes, *Materials Advances*, 2022, **3**, 6950.

## Two-photon fluorescent (nano)probes for a versatile intracellular detection and quantification of nitric oxide

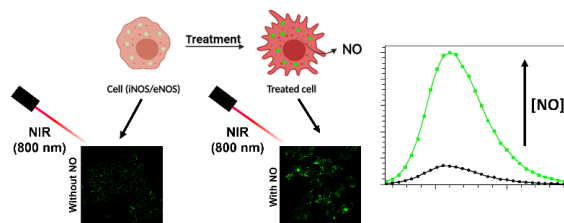
CARLA ARNAU DEL VALLE <sup>A</sup>, PAUL THOMAS <sup>B</sup>, FRANCISCO GALINDO <sup>C</sup>, M. PAZ MUÑOZ <sup>D</sup> AND MARÍA J. MARÍN <sup>A</sup>

<sup>A</sup> School of Chemistry, University of East Anglia, Norwich Research Park, Norwich, UK; <sup>B</sup> Henry Wellcome Laboratory for Cell Imaging, Faculty of Science, University of East Anglia, Norwich Research Park, Norwich, NR4 7T, UK; <sup>C</sup> Departamento de Química Inorgánica y Orgánica, Universitat Jaume I, Castellón, Spain; <sup>D</sup> Department of Chemistry, Lancaster University, Bailrigg, Lancaster, UK.

### Abstract

Nitric oxide (NO) is involved in numerous biological processes, playing an important role in the regulation of diverse physiological and pathophysiological mechanisms of the cardiovascular, nervous and immune systems; and alterations in the intracellular NO concentrations have been linked to a large number of diseased states.<sup>1, 2</sup> Considering the significant role that NO plays in important biological functions, the development and improvement of methods to detect and quantify intracellular NO are essential to further our understanding of the biological roles of NO.

This contribution will present near infrared (NIR) excitable (nano)probes<sup>3-5</sup> for the intracellular detection and quantification of NO that take advantage of the high photostability, high biological tissue penetration and minimal photodamage associated with this long-wavelength excitation (**Figure 1**). The (nano)probes are broadly applicable and are able to detect and potentially quantify NO levels in an extensive range of cellular environments including endogenous NO in RAW264.7γ NO- macrophages and THP-1 human leukemic cells, and endogenous and exogenous NO in endothelial cells. The (nano)probes accumulated in the acidic organelles of the tested cell lines showing negligible toxicity. Importantly, the nanomaterials showed potential to quantify intracellular NO concentrations in MDA-MB-231 breast cancer cells. Based on their excellent sensitivity and stability, and outstanding versatility, the developed (nano)probes can be applied for the spatiotemporal monitoring of in vitro and in vivo NO levels.



**Figure 1.** Schematic representation of the application of two-photon excitable fluorescent (nano)probes for a versatile intracellular detection of nitric oxide.

### References

1. R. M. Palmer, A. G. Ferrige and S. Moncada, *Nature*, 1987, **327**, 524-526.
2. A. R. Butler and D. L. H. Williams, *Chemical Society Reviews*, 1993, **22**, 233-241.
3. C. Arnau del Valle, L. Williams, P. Thomas, M. P. Muñoz, F. Galindo and M. J. Marín, *Manuscript in preparation*.
4. C. Arnau del Valle, L. Williams, P. Thomas, R. Johnson, S. Raveenthiraraj, D. Warren, A. Sobolewski, M. P. Muñoz, F. Galindo and M. J. Marín, *J. Photochem. Photobiol., B*, 2022, **234**, 112512.
5. C. Arnau del Valle, P. Thomas, F. Galindo, M. P. Muñoz and M. J. Marín, *J. Mater. Chem. B*, 2023, **11**, 3387-3396.

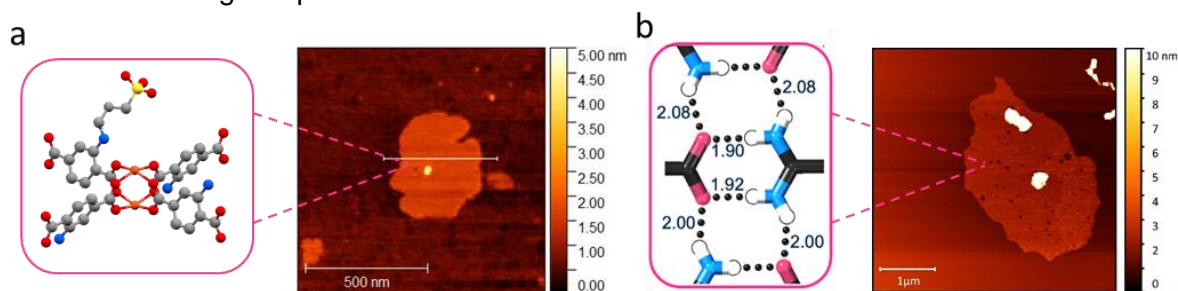
## Liquid Exfoliation of Molecular Materials into Nanosheets

JONATHAN A. FOSTER,<sup>1\*</sup>

<sup>A</sup> Department of Chemistry, University of Sheffield, Sheffield, UK

Liquid exfoliation is a simple and scalable approach for converting layered materials into free-standing single- and few-layer nanosheets with high aspect ratios. Early studies focused on inorganic two-dimensional materials such as graphene but more recent examples have shown this approach can be adapted to exfoliate supramolecular structures. The high surface area, aspect ratios, and nanoscopic dimensions of these supramolecular nanosheets combined with their diverse and tunable chemistry make them ideal for a wide range of applications. However, despite intensive research into these materials, the formation of monolayer nanosheets with high aspect ratios in good yields remains a challenge.<sup>1</sup>

In our work, we have developed a library of metal-organic framework nanosheets (MONs) based on the metal-paddlewheel secondary building unit (Figure 1a). By synthesising isorecticular series of layered frameworks incorporating dicarboxylate linkers with different functional groups we have sought to understand the design principles behind nanosheet formation.<sup>2-4</sup> We have also post-synthetically functionalised the frameworks with different functional groups to enhance exfoliation and add new properties.<sup>[4-5]</sup> We also recently utilised liquid exfoliation to access monolayer hydrogen-bonded organic nanosheets (HONs) with micron-sized lateral dimensions (Figure 1b).<sup>6</sup> These HONs show remarkable stability and maintain their extended crystallinity and monolayer structures even after being boiled in water. We are working with academic and industrial collaborators to develop MONs and HONs for a wide range of sensing, catalytic, electronic and separation applications. In particular we have shown that MONs can be used as additives to significantly enhance the performance of organic photovoltaic devices.<sup>6-9</sup>



**Figure 1:** AFM topographical image and graphical representation of a) post-synthetically functionalised MONs used for tandem in catalysis in [5] b) HONs obtained in [6]

**References** [1] J. Nicks, K. Sasitharan, R. R. R. Prasad, D. J. Ashworth, and J. A. Foster, *Adv. Funct. Mater.*, 2021, **31**, 2103723, [2] D. J. Ashworth, A. Cooper, M. Trueman, R. W. M. Al-Saedi, L. D. Smith, A. J. H. M. Meijer and J. A. Foster, *Chem.- A Eur. J.*, 2018, **24**, 17986–17996. [3] D. J. Ashworth, T. M. Roseveare, A. Schneemann, M. Flint, I. D. Bernáldes, P. Vervoorts, R. A. Fischer, L. Brammer and J. A. Foster, *Inorg. Chem.*, 2019, **58**, 10837–10845. [4] D. J. Ashworth and J. A. Foster, *Nanoscale*, 2020, **12**, 7986–7994. [5] J. Nicks, J. Zhang and J. A. Foster, *Chem. Commun.*, 2019, **55**, 8788–8791. [6] J. Nicks, S. A. Boer, N. G. White and J. A. Foster, *Chem. Sci.*, 2021, **12**, 3322–332 [7] K. Sasitharan, D. G. Bossanyi, N. Vaenas, A. J. Parnell, J. Clark, A. Iraqi, D. G. Lidzey and J. A. Foster, *J. Mater. Chem. A*, 2020, **8**, 6067–6075. [8] K. Sasitharan, R. C. Kilbride, E. L.K. Spooner, J. Clark, A. Iraqi, D. G. Lidzey, and J. A. Foster, *Adv. Sci.* 2022, **9**, 2200366 [9] D. J. Ashworth, J. Driver, K. Sasitharan, R. R.R. Prasad, J. Nicks, B. J. Smith, S. V. Patwardhan, J. A. Foster, *J. Chem. Eng.*, 2023, ASAP: 10.1016/j.cej.2023.146871



## Hierarchical Graphene-Based Aerogel Catalysts and Sorbents

ROBERT MENZEL<sup>A</sup>

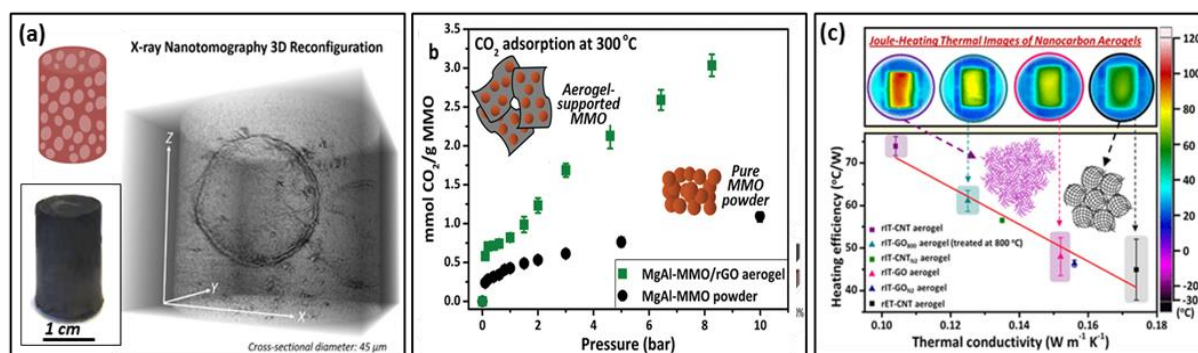
<sup>A</sup> School of Chemistry, University of Leeds, LS2 1TJ, Leeds, UK.

### Abstract

Directed self-assembly of graphene derivatives into structured aerogels and foams is explored as route to create unique, porous catalyst systems with highly-tailored materials characteristics, including hierarchical porosity, mechanical durability, and electro-thermal responsiveness. Here, template-based assembly approaches are explored to produce sponge-like nanocarbon aerogels with a wide range of well-controlled hierarchical microstructures. Different gas-phase and wet-chemical methodologies are developed to enable uniform and structure-preserving aerogel functionalisation with catalyst nanoparticles (anionic clays, mixed metal oxides, precious metals).<sup>1,2</sup> Advanced X-ray micro-CT and FIB-SEM-EDX techniques are employed to characterise the aerogels' three-dimensional microstructure and surface chemistry.

Embedding nanoparticles within the aerogels is shown to provide remarkable improvements in functional performance (activity, selectivity, kinetics, recyclability) across a range of chemical applications, including high-pressure CO<sub>2</sub> capture,<sup>1</sup> fine-chemical catalysis,<sup>2</sup> and fuel desulfurisation.<sup>3</sup> Beyond this boost in functional nanoparticle performance, graphene-derived aerogels also provide valuable additional functionality. For example, the electrical conductivity of the 3D-interconnected graphene network can be utilised for energy-efficient flash Joule-heating.<sup>4</sup> Ultrafast and ultrahot resistive aerogel heating (>2000°C) is exploited for highly controlled nano-catalyst synthesis and rapid thermal catalyst recycling.

Nanoparticle-decorated aerogels are also explored as flow-through catalysts within chemical flow processes, an area of increasing interest due to substantial benefits in process control and sustainability. Specifically, the performance of aerogel catalysts in chemical flow reactions and potential for controlling the chemical reaction profile through graphene aerogel microstructure are explored.



**Figure 1:** (a) X-ray nanotomography of an emulsion-templated nanocarbon aerogel catalyst; (b) High-pressure CO<sub>2</sub> capture performance of MMO/rGO aerogel sorbents (MMO= mixed-metal-oxide NPs). c) Thermo-electric structure-property relationship study of different nanocarbon aerogels.

### References

1. D Xia, D Iruretagoyena, R Menzel et al., *Adv. Funct. Mater.*, 2020, **30**:40, 2002788.
2. J Mannering, E Flahaut, R Brydson, R Menzel et al., *Adv. Mater.*, 2021, **33**:27.
3. D Xia, P Huang, R Menzel et al., *J. Mater. Chem. A*, 2019, **7**:41, 24027.
4. D Xia, M S Ismail, M Pourkashanian, R Menzel et al., *Chem. Mater.*, **33**:1, 392.

## Innovative Strategies for Combating Bacterial Contamination: Synergistic Effects of Oxygen Nanobubbles and Reduced Graphene Oxide

MARZIYEH JANNESARI<sup>A</sup>, NIAL J ENGLISH<sup>A</sup>

<sup>A</sup> School of Chemical and Bioprocess Engineering, University College Dublin, Belfield, D04 V1W8  
Dublin, Ireland

### Abstract

Bacterial contaminations pose a significant global threat, jeopardizing the health of millions and impacting various industries, including water treatment and food processing, each year<sup>1</sup>. Simultaneously, the escalating drug resistance observed in bacterial strains, attributed to the widespread misuse of antibiotics in both livestock and human health, has become a growing concern globally. The associated healthcare costs further compound the gravity of this issue, as highlighted in a recent report from the World Health Organization (WHO)<sup>2</sup>. As a result, there is an increasing requirement to introduce novel antibacterial materials that go beyond traditional antibiotics. Recent progress in nanoscience and nanotechnology has addressed this demand by developing nanomaterials with exceptional antibacterial properties. Among others, nanobubbles (NBs) with peculiar properties have been introduced not only to combat bacterial growth but also to compensate for the hypoxia in infectious tissues. NBs as nanoscale cavities filled with desired gases (such as oxygen) which transport therapeutic agents along with the gases, can release these agents and gases in the targeted sites. In this study, the effect of oxygen nanobubbles (O<sub>2</sub> NBs) in the absence and presence of reduced graphene oxide (rGO) has been investigated. The findings showed that O<sub>2</sub> NBs, imposing a very dynamic microenvironment inside the bacterial cells by growth and collapse revolutions, effectively inhibited bacterial growth of *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*). This effect was boosted in the presence of rGO. Indeed, reduced graphene oxide can yield synergistic effects by capturing certain respiratory electrons, causing significant disruption in the bacterial respiratory pathway. Simultaneously, these captured electrons can be transferred to O<sub>2</sub> NBs terminating in the generation of nanoscale reactive oxygen species (ROS), inducing disintegration on bacterial models leading to bacterial death.

**Keywords:** Oxygen Nanobubbles (O<sub>2</sub> NBs); Antibacterial properties; Graphene oxide (GO); Reactive Oxygen Species (ROS); Synergistic Effect

(1) Wei, T.; Yu, Q.; Chen, H. Responsive and synergistic antibacterial coatings: fighting against bacteria in a smart and effective way. *Adv. Healthc. Mater.* **2019**, 8 (3), 1801381.

(2) Zheng, H.; Ji, Z.; Roy, K. R.; Gao, M.; Pan, Y.; Cai, X.; Wang, L.; Li, W.; Chang, C. H.; Kaweeteerawat, C. Engineered graphene oxide nanocomposite capable of preventing the evolution of antimicrobial resistance. *ACS nano* **2019**, 13 (10), 11488-11499.

## Fingerprinting of Graphenes: Rapid low-cost characterisation of graphene-based materials to address the challenges of inhomogeneity and irreproducibility.

BLANCA IVONNE VERGARA ARENAS, EDWARD CROSS, ESMÉ SHEPHERD, IVAN ALFARO, HAILEY (NGOC MINH HUONG) LE, ANDREW SURMAN

Department of Chemistry, King's College, London

### Abstract

The 'wonder material' potential of atomically-thin graphene materials (graphene, graphene oxide, etc) is real, but despite considerable international investment it remains unrealised. Irreproducibility is a notorious barrier to developing applications: every batch can be different, and anecdote suggests that it frequently is. A recent landmark study<sup>1</sup> demonstrated massive variation in 60 commercial "graphene" samples: few were predominantly graphene (see recent "War on Fake Graphene"<sup>2,3</sup> headlines). Addressing this irreproducibility problem should remove the barrier to exploiting these promising materials, but requires that materials users and producers alike have access to fast, cheap, characterisation.

Here I will present results from an ongoing project in our lab to develop a 'supramolecular fingerprinting' approach to rapidly and cheaply characterising graphene oxide (GO). We show that this kind of approach can complement the slow expensive 'gold standard' characterisation (weeks, \$thousands) with a 'quick and dirty' QC-level characterisation (minutes, \$few), removing another barrier to realising the potential of GO and of the graphene-based materials.<sup>4</sup>

### References

1. A. P. Kauling, A. T. Seefeldt, D. P. Pisoni, R. C. Pradeep, R. Bentini, R. V. B. Oliveira, K. S. Novoselov and A. H. C. Neto, *Advanced Materials*, 2018, **30**, 1803784.
2. P. Bøggild, *Nature*, 2018, **562**, 502.
3. D. Lowe, Graphene, <https://blogs.sciencemag.org/pipeline/archives/2018/10/11/graphene-you-dont-get-what-you-pay-for>, (accessed 2019).
4. Surman, Patent Application Pending, 2022.

## Abstract template for RSC Chemical Nanoscience & Nanotechnology Group Annual Symposium: Nanotechnology for Energy, Environment and Biomedicine

### Functionalized gold nanoparticles as an anchor to detect Coronavirus infection.

ANNA FANTINATI <sup>A</sup>, DAVIDE ILLUMINATI <sup>B</sup>, CLAUDIO TRAPELLA <sup>C</sup>, ROBERTA RIZZO <sup>C</sup>,  
REMO GUERRINI <sup>C</sup>

<sup>A</sup> Department of Environmental and Prevention Sciences, University of Ferrara, 44121 Ferrara, Italy;

<sup>B</sup> Department of Life Sciences, University of Modena and Reggio Emilia, Via G. Campi 213/d, 41125 Modena, Italy;

<sup>C</sup> Department of Chemical, Pharmaceutical and Agricultural Sciences, University of Ferrara, Via Fossato di Mortara 17, 44121 Ferrara, Italy.

#### Abstract

The outbreak of a novel and highly pathogenic coronavirus (SARS-CoV-2) has presented a serious global public health emergency of coronavirus disease (Covid-19). During the first lockdown our team joined forces with several research areas trying to contribute to the emergency situation dictated by the pandemic. We focused our interest on diagnostics. The aim of our project was to create a smart, rapid and sensible method to detect if people are affected by SARS-CoV-2 infection and that is affordable for everyone. The virus detection system initially involves the functionalization of gold nanoparticles (GNPs) with a specific peptide portion of ACE-2, the human protein that is essential for the infection to occur. These gold nanoparticles must pass through an electronic device developed by engineers of Elements, Cesena (Italy), which has a nanometer-sized pore through which flows an electric current. A sample of patient's spit is mixed together with a suspension of functionalized GNPs: if the patient is Covid-19 positive, a slowing down or an interruption of the current passage will be detected. This occurs because the functionalized GNPs act as an anchor and bind strictly and specifically the Receptor-Binding Domain (RBD) of the virus. Gold particles of known size and commercially available were functionalized by exploiting the high affinity of gold with sulfur to form the thioauric bond [1]. Various portions of the ACE-2 protein were synthesized. All peptides were modified by adding a cysteine to the N-terminal domain so that thioauric bond could take place. The best sequence is composed of 19 amino acids [2]. Gold nanoparticles were functionalized with both the peptide and Sulfobetaine-Thiol, for agglomeration issues (Figure 1). The future perspectives will be therefore to improve the diagnostic system and also to make tests using the Coronavirus in the high security chamber BSL-3 of the University of Ferrara.

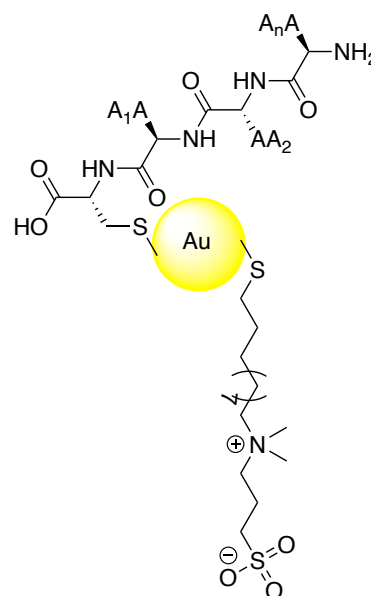


Figure 1. Simplified structure of functionalized gold nanoparticle.

**References (Style: Royal Society of Chemistry)**

1. Wang et al., *Langmuir*, 2019, **35** (5), 1652-1661.
2. Patent N. **102021000015827**.

## Towards recyclable 2D material-based nanofiltration membranes for water purification

ÁINE COOGAN<sup>A</sup>, NATALIA GARCÍA DOMÉNECH<sup>AB</sup>, DONAGH MC GINLEY<sup>A</sup>, TIGRAN SIMONIAN<sup>ACDE</sup>, ARAN RAFFERTY<sup>F</sup>, QUENTIN FEDIX<sup>G</sup>, AMY DONLON<sup>A</sup>, VALERIA NICOLOSI<sup>ACEF</sup>, YURII K. GUN'KO<sup>ABC</sup>

<sup>A</sup> School of Chemistry, Trinity College Dublin, Ireland; <sup>B</sup> BiOrbic, Bioeconomy Research Centre, University College Dublin, Ireland; <sup>C</sup> AMBER Research Centre, Trinity College Dublin, Ireland; <sup>D</sup> Centre for Doctoral Training in the Advanced Characterisation of Materials, AMBER Research Centre, Trinity College Dublin, Ireland; <sup>E</sup> Advanced Microscopy Laboratory, Trinity College Dublin, Ireland; <sup>F</sup> CRANN Research Centre, Trinity College Dublin, Ireland; <sup>G</sup> Département Chimie Science des Matériaux, Institut Universitaire de Technologie Clermont-Auvergne, France.

Increasing scarcity in access to clean, safe water is being fuelled by escalating industrialisation, rapid urbanisation and biodiversity loss, and the relentless forces of climate change. Therefore, the need for development of innovative and sustainable methods of water purification is of the utmost urgency. Nanofiltration is proving to be an increasingly attractive potential solution to this global issue.<sup>1,2</sup>

Previous reports of nanofiltration membranes using boron nitride (BN) and partially oxidised BN (BNOx) have demonstrated outstanding performance, achieving retentions of up to 100% for various water-soluble dyes which can be harmful to humans and aquatic life.<sup>3,4</sup> However, the main drawback of these membranes is their vulnerability to membrane fouling, meaning they must be disposed of after a single use. Consequently, innovative approaches to mitigate membrane fouling are crucial to ensure the long-term sustainability of current and future nanofiltration technologies. Herein, we report the development of novel high-performance nanofiltration membranes based on a recyclable CuAl-CO<sub>3</sub> LDH/BNOx nanocomposite. These membranes have demonstrated up to 100% retention of several water-soluble dyes (Evans blue, methyl orange, methylene blue and rhodamine B). Additionally, they exhibit excellent water flux, over 2 orders of magnitude higher than commercially available nanofiltration membranes. The incorporation of CuAl-CO<sub>3</sub> LDH photocatalyst within the nanocomposite membranes enables up to 91% visible-light-induced photodegradation of these dyes within 120 minutes using a household LED lamp.

This introduction of photocatalytic functionality into existing nanofiltration membranes offers a low-cost, innovative route to the mitigation of membrane fouling. Significantly, this work demonstrates the first instance of Evans blue degradation by a visible-light active LDH photocatalyst. Overall, we believe this work represents a significant advancement in the field of advanced nanofiltration technology, offering superior performance and enhanced sustainability.<sup>5</sup>

### References

- 1 M. A. Montgomery and M. Elimelech, *Environ. Sci. Technol.*, 2007, **41**, 17–24.
- 2 H. Guo, X. Li, W. Yang, Z. Yao, Y. Mei, L. E. Peng, Z. Yang, S. Shao and C. Y. Tang, *Front. Chem. Sci. Eng.* 2021 165, 2021, **16**, 681–698.
- 3 N. G. Doménech, F. Purcell-Milton, A. S. Arjona, M.-L. C. García, M. Ward, M. B. Cabré, A. Rafferty, K. McKelvey, P. Dunne and Y. K. Gun'ko, *Nanomaterials*, 2022, **12**, 473.
- 4 N. García Doménech, Á. Coogan, F. Purcell-Milton, M. L. Casasín García, A. Sanz Arjona, M. Brunet Cabré, A. Rafferty, K. McKelvey, P. W. Dunne and Y. K. Gun'ko, *Nanoscale Adv.*, 2022, **4**, 4895–4904.
- 5 Á. Coogan, N. G. Doménech, D. Mc Ginley, T. Simonian, A. Rafferty, Q. Fedix, A. Donlon, V. Nicolosi and Y. K. Gun'ko, *J. Mater. Chem. A*, 2023, **11**, 12266–12281.

# Poster Presentation Abstracts



## Design and fabrication of silver nanoparticles doped $\beta$ -cyclodextrin-chitosan functionalized graphene nanocomposite modified electrode

ABDULLAH AKHDHAR

Chemistry Department, College of Science, University of Jeddah, Jeddah, Saudi Arabia

### Abstract

Water is the most important natural resource for maintaining both life and the environment. However, water pollution poses a significant risk to the continued sustainable development of human society as well as to the continued existence of humans <sup>1</sup>. This work reported the preparation of a nanocomposite film by doping silver nanoparticles onto  $\beta$ -cyclodextrin-chitosan functionalized reduced graphene oxide (RGO), denoted as Ag/  $\beta$ -CD/CS/G nanocomposite. The fabricated composite was applied for trace-level monitoring of copper ions in different industrial and environmental water samples. The morphology and microstructure of the fabricated sensor were extensively investigated using XRD, TGA, HR-TEM, FTIR, SEM, XPS, and EDX physicochemical techniques. For the electrochemical monitoring of Cu(II), the Ag/ $\beta$ -CD/CS/G nanocomposite electrode showed remarkable performance in terms of high sensitivity and a low limit of detection. The impact of different electrochemical parameters including medium pH, scanning rate, and interfering ions was investigated.

### References

1. F. C. Onuoha, Environmental degradation, livelihood and conflicts: A focus on the implications of the diminishing water resources of Lake Chad for north-eastern Nigeria. *African Journal on Conflict Resolution*, 2008, **8** (2), 35-61.

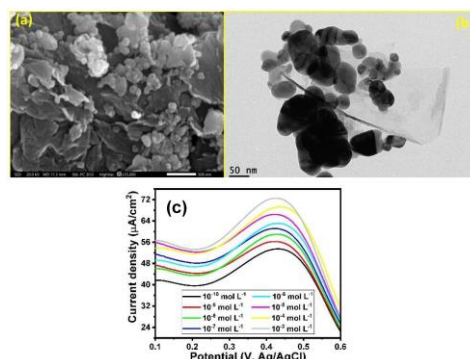


Figure 1. Ag/ $\beta$ -CD/CS/G nanocomposite modified ITO electrode for monitoring Cu(II)

## High-performance Supercapacitors Enabled by Highly-porous Date Stone-derived Activated Carbon and Organic Redox Gel Electrolyte

ABUBAKAR DAHIRU SHUAIBU<sup>A,B</sup>, ATIF SAEED ALZAHRANI<sup>A,B\*</sup>, MD. ABDUL AZIZ<sup>A\*</sup>

<sup>A</sup> Interdisciplinary Research Center for Hydrogen and Energy Storage (IRC-HES), King Fahd University of Petroleum & Minerals, KFUPM Box 5040, Dhahran 31261, Saudi Arabia

<sup>B</sup> Materials Science and Engineering Department, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia

### Abstract

Construction of eco-benign, cost effective, and high-performance supercapacitors with improved electrolytes and hierarchical porous electrodes is necessary for effective energy storage. In this study, a gel type organic redox electrolyte made of polyvinyl alcohol (PVA)-H<sub>2</sub>SO<sub>4</sub> and an organic redox molecule, anthraquinone (PVA-H<sub>2</sub>SO<sub>4</sub>-AQ) was prepared by simple solution casting method and was used to construct a symmetric supercapacitor (SSC) using activated carbon with a high BET surface area (1612 m<sup>2</sup>/g) made from date stones (DSAC). The DSAC was synthesized by simple carbonization method followed by activation with potassium hydroxide. The SSC exhibit a high specific capacitance of 126.5 F/g at 0.5 A/g, as well as a high energy density of 17.5 Wh/kg at a power density of 250 W/kg with high capacitance retention (87%) after 1000 GCD cycles. The present research suggests that adding anthraquinone to a PVA-H<sub>2</sub>SO<sub>4</sub> gel electrolyte improves the performance of the fabricated device significantly as compared to using pristine PVA-H<sub>2</sub>SO<sub>4</sub> or 1M H<sub>2</sub>SO<sub>4</sub> electrolytes. The research also presents a promising approach for the development of sustainable and eco-benign materials for energy storage applications. The use of date stone waste as a precursor material for activated carbon electrodes presents an opportunity for cost-effective and sustainable energy storage. Overall, the findings of this research have important implications for the future design and fabrication of high-performance and cost-effective supercapacitors.

## Lanthanide-doped Layered Double Hydroxide Nanostructures as Luminescent 'Turn-off' Environmental Chemosensors

ÁINE COOGAN<sup>A</sup>, YURII K. GUN'KO<sup>ABC</sup>

<sup>A</sup> School of Chemistry, Trinity College Dublin, Ireland; <sup>B</sup> AMBER Research Centre, Trinity College Dublin, Ireland; <sup>C</sup> BiOrbic, SFI Bioeconomy Research Centre, University College Dublin, Ireland

### Abstract

Heavy metal pollution is a persistent and critical global health concern, with developing nations being disproportionately affected. Among the various heavy metal contaminants, the dichromate anion ( $\text{Cr}_2\text{O}_7^{2-}$ ) - a source of hexavalent chromium ( $\text{Cr(VI)}$ ) - raises significant alarms. Prolonged exposure to  $\text{Cr(VI)}$  poses severe health risks, including major skin irritation, respiratory distress and disease, and most concerningly, carcinogenesis. Thus, it is clear that accurate, reliable and affordable detection and monitoring of dichromate levels in water is necessary for safeguarding human health.<sup>1</sup>

In this regard, luminescent sensing is an exciting prospect for environmental monitoring of anionic pollutants. While lanthanide-containing systems have been previously utilized in such applications, lanthanide-doped layered double hydroxide nanostructures may offer significant advantages over previous systems.<sup>2</sup> Their two-dimensional architecture, high adsorption capacity for anions, as well as their mild, green, scalable and cost-effective synthetic routes are highly appealing characteristics.<sup>3</sup> Furthermore, their tunability allows for seamless integration of dopants, including trivalent lanthanides cations such as europium and terbium, utilising low dopant concentrations while preserving their unique photophysical properties.<sup>4</sup>

This work presents the co-precipitation synthesis, photophysical and structural characterisation of europium- and terbium-doped magnesium-aluminium and zinc-aluminium layered double hydroxide nanostructures. The resultant materials were tested for rapid luminescent 'turn-off' sensing of dichromate in water, with limits of detection calculated in the low ppm to high ppb range. The low and rapid detection limits and unique photophysical properties, coupled with the mild synthetic routes and economic benefits of using lanthanide-doped 2D systems over pure lanthanide-based layered materials, make these doped LDHs a potential viable candidate for environmental chemosensing, specifically for oxyanion contamination.

### References

- 1 – P. Sharma, S.P. Singh, S.K. Parakh, Y.W. Tong, *Bioengineered*, 2022, **13**, 4923–4938.
- 2 – K. Binnemans, P.T. Jones, *Journal of Sustainable Metallurgy*, 2015, **1**, 29–38
- 3 – Á. Coogan, N. Garcia Domenech, D. Mc Ginley et al., *Journal of Materials Chemistry A*, 2023, **11**, 12266-12281
- 4 – Y. Fu, F. Ning, S. Xu, et al., *Journal of Materials Chemistry A*, 2016, **4**, 3907–3913.

## Protein-Based Nanotechnology for the Treatment of Pancreatic Cancer

A. S. EVTUSHENKO <sup>A</sup>, B. LOZANO TORRES <sup>A</sup>, C. YADAV <sup>A</sup>, L. FRUK <sup>A</sup>

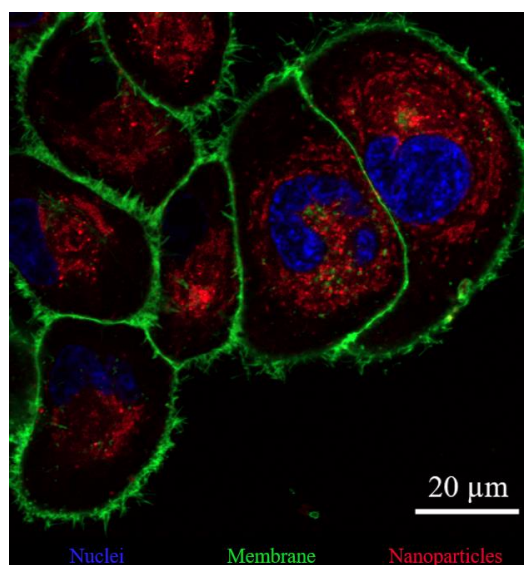
<sup>A</sup> University of Cambridge

### Abstract

Pancreatic ductal adenocarcinoma (PDAC) is the most common cancer of the pancreas. The 5-year survival of PDAC remains extremely low at 8% despite decades of biomedical research<sup>1</sup>. The majority of PDAC patients present with advanced, non-resectable disease due to a lack of specific symptoms or biomarkers and are treated by multi-agent chemotherapy. Unfortunately, the effectiveness of this approach is limited, with the “state-of-the-art” regimen FOLFIRINOX prolonging survival by just six months<sup>2</sup>. Clearly, there exists an urgent need for new PDAC treatment options.

One promising solution is offered by SN-38, the active metabolite of the anti-neoplastic drug irinotecan. It is very powerful but challenging to formulate due to its severe side effects, poor solubility and rapid deactivation *in vivo*. In order to overcome these issues, a novel ultrasonication-based method to encapsulate SN-38 in human serum albumin nanoparticles (NPs) has been developed. The method is reproducible, rapid, cheap and free from toxic cross-linking agents. The resulting formulation is stable and water-soluble while retaining the high cytotoxicity of SN-38. Additionally, the NPs can be readily functionalised with diverse species, allowing for fluorescent labelling or molecular targeting.

Having been extensively validated in 2D and 3D *in vitro* cell culture, this formulation is currently moving towards initial *in vivo* trials. It is hoped that this research, in combination with advances in early detection, will finally result in a meaningful improvement of PDAC prognosis.



**Figure 1** Uptake of fluorescently labelled HSA NPs in PANC-1 PDAC cells seen by confocal microscopy.

### References

1. W. Park, A. Chawla & E. M. O'Reilly, *JAMA*, 2021, **326**, 851.
2. A. Teague, K.-H. Lim & A. Wang-Gillam, *Ther Adv Med Oncol*, 2015, **7**, 68–84.

1. T. G. Cassarino, M. Barrett, *App. Energy*, 2022, 306, 118051.
2. L. Sun, Y. Liu, R. Shao, J. Wu, R. Jiang, Z. Jin, *Energy Storage Mater*, 2022, **46**, 485-502.
3. Y. Sun, N. Liu, Y. Cui, *Nature Energy*, 2016, **1**, 1-12.



## Fabrication of Calcium Zincate@Carbon Fabric based standalone Solar Photocatalytic reactor for remediation of textile effluent

AMBREEN ASHAR <sup>A,B</sup>, AHMED I. OSMAN <sup>C</sup>, AHMED EL-SHAFEI <sup>A</sup>, REZA A. GHILADI <sup>D</sup>,  
MUNIR ASHRAF <sup>E</sup>, ZEESHAN AHMAD BHUTTA <sup>F</sup>, MOHAMED R. ELETMANY <sup>A,G</sup>, DAVID  
W. ROONEY <sup>C</sup>

<sup>A</sup> TECS Department, Wilson College of Textiles, NC State University, Raleigh 27606, United States

<sup>B</sup> Department of Chemistry, University of Agriculture, Faisalabad 38040, Pakistan

<sup>C</sup> School of Chemistry and Chemical Engineering, Queen's University Belfast, Belfast, BT9 5AG, Northern Ireland, UK.

<sup>D</sup> Department of Chemistry, North Carolina State University, Raleigh, North Carolina 27695, United States

<sup>E</sup> Functional Textiles Research Group, National Textile University, Faisalabad, 37610, Pakistan

<sup>F</sup> Laboratory of Veterinary Immunology and Biochemistry, College of Veterinary Medicine, Chungbuk National University, Cheongju 28644, Republic of Korea

<sup>G</sup> Chemistry Department, Faculty of Science, South Valley University, Qena 83523, Egypt

### Abstract

Dyes are hazardous refractory pollutants, requiring effective elimination from textile effluents<sup>1, 2</sup>. This study consists of a novel remediation technique using calcium zincate nanocomposite (CZ<sub>2</sub>O) graphited onto carbon fabric via a low-temperature hydrothermal method to fabricate a solar photocatalytic reactor<sup>3</sup>. The rod shape, high crystallinity nano dimensions, and elemental composition of CZ<sub>2</sub>O were confirmed through SEM, TEM, STEM, AFM, XRD, EDX, FTIR, ICPMS, and Raman spectroscopy. Nanocomposite CZ<sub>2</sub>O demonstrated a significant surface area (300 m<sup>2</sup>/g), enhanced roughness, and positive surface charge (+17.4 mV), making it a potential candidate for adsorbing anionic dye molecules. The diffused reflectance spectroscopy and photoluminescence analysis indicated the ability of nanocomposite to efficiently harvest sunlight, owing to the low band gap energy (2.7 eV). The solar photocatalytic activity of the designed reactor based on CZ<sub>2</sub>O@CF has been determined by the degradation of the anionic dye Ramazol Reactive black 5 (RB5). The optimization of reaction parameters (Initial dye concentration, pH, oxidant concentration, and solar irradiation time) was executed by the Response surface method as statistical software. Under optimized conditions, CZ<sub>2</sub>O@CF achieved up to 90% degradation of Reactive black 5 dye within 3 hours under artificial sunlight (D65 cool daylight). CZ<sub>2</sub>O@CF showcased superior photocatalytic activity (90.25%) compared to its ancestors, intrinsic nano ZnO (85.55%) and multiphasic nano CaCO<sub>3</sub>/Ca(OH)<sub>2</sub> (88.78%). The assessment of photocatalytic activity of surface grafted CZ<sub>2</sub>O@CF for degradation of RB5 was executed by evaluation through UV/visible and FTIR spectroscopy, HPLC, and LC-MS. It has been confirmed that toxic dye molecule was degraded into innocuous products after oxidation, rendering the textile effluent reusable. Additionally, CZ<sub>2</sub>O@CF exhibited excellent reusability, maintaining 95% efficiency after 15 cycles of dye removal.

### References

1. R. Al-Tohamy, J. Sun, M. F. Fareed, E.-R. Kenawy and S. S. Ali, *Scientific Reports*, 2020, **10**, 12370.
2. W. Ben Mbarek, J. Daza, L. Escoda, N. Fiol, E. Pineda, M. Khitouni and J.-J. Suñol, *Metals*, 2023, **13**, 474.
3. S. Msahli and F. Debbabi, *Advances in Applied Research on Textile and Materials-IX: Proceedings of the 9th International Conference of Applied Research on Textile and Materials (CIRATM)*, Springer Nature, 2022.

## Novel SERS Substrate using Polydopamine – Gold Nanoparticle Hybrid Films towards Qualitative Drug Analysis

ANNALENA M. BOCK<sup>A</sup>, AHMED A. QURESHI<sup>A</sup>, ASHLEIGH RUANE<sup>B</sup>, WILLIAM  
ETHERIDGE<sup>A</sup>, MATTHEW ELLIS<sup>A</sup>, HEATHER GREER<sup>C</sup>, LJILJANA FRUK<sup>A</sup>

<sup>A</sup> BioNano Engineering Lab, Department of Chemical Engineering and Biotechnology, University of  
Cambridge, Philippa Fawcett Drive, Cambridge CB3 0AS, UK. If389@cam.ac.uk

<sup>B</sup> Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge, CB3 0HE, UK.

<sup>C</sup> Yusuf Hamied Department of Chemistry, University of Cambridge, Lensfield Road, Cambridge CB2  
1EW, UK.

### Abstract

Counterfeit drugs are a significant, established issue and “a substantial threat to the EU and affect most, if not all, Member States”<sup>1</sup> according to Europol. A relatively new facet to this is the emergence of counterfeit Semaglutide, more commonly known as the diabetes medication Ozempic. Detecting and combatting the proliferation of these fraudulent pharmaceuticals demands innovative approaches. Therefore, it is essential to have a rapid and straightforward method for identifying the various compounds present in an alleged pharmaceutical product.<sup>2</sup> In response to this challenge, we present the development of a novel surface-enhanced Raman scattering (SERS) substrate for the fast and reliable detection of counterfeit drugs.

Our approach utilises a polydopamine-gold nanoparticle (AuNP@PDA) hybrid film as a SERS substrate. The film is formed via a facile one-pot synthesis procedure, whereby the gold precursor is reduced by polydopamine *in situ*. The resulting hybrid film is immobilised on glass slides, forming a robust matrix for drug analysis.<sup>3-5</sup>

Drugs suspected of being counterfeit can be simply drop-dried onto the film, allowing for their chemical composition to be examined by SERS. The presence of clustered gold nanoparticles on the substrate leads to significant signal enhancement in the SERS spectra, ensuring a very high sensitivity.<sup>6,7</sup>

This novel SERS substrate offers a promising solution for the rapid identification of counterfeit drugs, providing a valuable tool for pharmaceutical quality control and public safety. The simplicity of the synthesis process coupled with the substrate's enhanced detection capabilities, positions the polydopamine-gold nanoparticle hybrid film as a robust platform in the ongoing battle against the widespread issue of counterfeit pharmaceuticals.



## References

1. Europol and European Union Intellectual Property Office. Intellectual Property Crime Threat Assessment 2022 [Internet]. European Union Intellectual Property Office; 2022, 20-22.
2. S. Neuberger, C. Neusüß, *J Pharm Biomed Anal.* 2015, **112**, 70-78.
3. R. Subair, B. Prakash Tripathi, P. Formanek, F. Simon, P. Uhlmann, M. Stamm, *Chemical Engineering Journal*, 2016, **295**, 358-369.
4. H. Chen, L. Zhao, D. Chen, W. Hu, *Journal of Colloid and Interface Science*, 2015, **460**, 258-263.
5. E. Songfeng, L. Shi, Z. Guo, *Applied Surface Science*, 2014, **292**, 750-755.
6. E. De Barros Santos, E. Lima, C. Santos de Oliveira F. Sigoli, I. Mazali, *Anal. Methods*, 2014, **6**, 3564-3568.
7. A. Yilmaz, M. Yilmaz, *Nanomaterials*, 2020, **10**, 688.

## Nanocatalysts: The promising tools in biorefining industries

AVINASH P. INGLE, MANGESH MOHARIL, SRESHTHA SAXENA, SANJAY SAKHARE  
Biotechnology Centre, Department of Agricultural Botany, Dr. Panjabrao Deshmukh Agricultural  
University, Akola, Maharashtra, India

### Abstract

The major contributors of energy and chemicals in modern-day are fossil-based resources. However, continuous depletion in their resources and their negative environmental impacts has pressurized the scientific community and governments to find the renewable and sustainable alternative sources<sup>1</sup>. In this context, development and implementation of biomass-based biorefineries such lignocellulosic materials based biorefineries can be the promising alternative to fossil-based refineries<sup>2</sup>. Conventionally, various catalysts and biocatalysts viz. homogeneous and heterogeneous catalysis are being used in the degradation of a variety of lignocellulosic biomass into biofuels and other high-value products including specialty chemicals. These conventional catalysts have certain limitations which mainly include requirements of specialized equipment's, generation of toxic inhibitors, less yield, etc. Therefore, development of novel and most effective catalyst is essentially required.

In this context, nano-based catalysts are found to be the most promising biomaterials in the degradation of biomass which are usually produced by synergistically integrating advanced biotechnology and nanotechnology. Considering the possible application of nano-based catalysts in biorefinery it is believed that these can have a lot of potential to improve enzyme stability, function, efficiency and engineering performance in biorefining processing.

**Acknowledgements:** API is highly thankful to Science and Engineering Research Board (SERB), Department of Science and Technology, Ministry of Science and Technology. Government of India for providing financial assistance in the form of Ramanujan Fellowship.

### References

1. B. Kumar and P. Verma, Biomass-based biorefineries: An important archetype towards a circular economy, *Fuel*, 2021, 288, 119622.
2. A. Arias, G. Feijoo and F. T. Moreira, Biorefineries as a driver for sustainability: Key aspects, actual development and future prospects. *Journal of Cleaner Production* 2023, **418**, 137925.

## Bioactive Protein-based Nanoparticles for Biomedical Applications

BEATRIZ LOZANO-TORRES<sup>A</sup>, ALEXANDER S. EVTUSHENKO<sup>A</sup>, MICHELLE S. ARNET<sup>A</sup>,  
LUCIE M. LEFEVRE<sup>A</sup>, CHITRA YADAV<sup>A</sup>, LJILJANA FRUK<sup>A</sup>

<sup>A</sup> BioNano Engineering Lab, Department of Chemical Engineering and Biotechnology, University of Cambridge, Philippa Fawcett Drive, Cambridge CB3 0AS, UK. [lf389@cam.ac.uk](mailto:lf389@cam.ac.uk)

### Abstract

Nanosized drug delivery vehicles continue to attract widespread attention in the biomedical field. Historically, biologically inert nanocarriers such as polymeric nanoparticles (NPs) or liposomes have been preferred for *in vivo* applications.<sup>1</sup> By contrast, our innovative approach uses NPs composed entirely of biologically active proteins, which can synergistically perform their natural functions and simultaneously release pharmaceutical ingredients. Administering these proteins as NPs preserves their activity while mitigating the fragility, cell uptake and clearance issues faced by free proteins.<sup>2</sup>

Myoglobin (Mb), lysozyme (Lys) and cytochrome c (CytC) possess specific biological functions, namely oxygen transport, immune cell activation and apoptosis triggering respectively. In this context, delivery of oxygen via Mb has shown great potential against tissue hypoxia.<sup>3</sup> Pancreatic ductal adenocarcinoma (PDAC), the most common cancer of the pancreas, is oxygen-deprived as a result of its dense stroma, promoting metastasis and therapy resistance.<sup>4</sup> While some inorganic nanocarriers have been developed to address PDAC hypoxia, oxygen carrier protein-based NPs remain unexplored. Additionally, Lys has been demonstrated to enhance the immune response within the tumour microenvironment, which could increase tumour sensitivity to chemo- and immunotherapy.<sup>5</sup>

Protein therapy has also emerged as a promising strategy for addressing cellular senescence. Senescent cells are non-proliferating apoptosis-resistant cells overexpressing anti-apoptotic BCL-2 proteins, which impair the release of intrinsic CytC from mitochondria.<sup>6</sup> The loading of senomorphics, *i.e.* drugs which suppress the detrimental effects of the secretome of these cells, into intrinsically cytotoxic CytC NPs presents a new potential approach for targeting deleterious cellular senescence.

By harnessing the intrinsic activity of the nanocarriers themselves and their capability to encapsulate small molecules that aid in weakening the tumour microenvironment or disrupting senescence-associated inflammation, we anticipate enhanced therapeutic outcomes compared to passive nanocarriers.

**Acknowledgements:** B. L.-T. acknowledges her awarded MSCA PF funded by UKRI.

### References

1. B. Crivelli, S. Perteghella, E. Bari, M. Sorrenti, G. Tripodo, T. Chlapanidas and M. L. Torre, *Soft Matter*, 2018, **14**, 546-557.
2. S. Le Saux, A. Aubert-Pouëssel, L. Ouchait, K. Elhady Mohamed, P. Martineau, L. Guglielmi, J.-M. Devoisselle, P. Legrand, J.I. Chopineau and M. Morille, *Adv. Ther.*, 2021, **4**, 2100009.
3. J. Cases-Díaz, B. Lozano-Torres, and M. Giménez-Marqués, *Chem. Mater.*, 2022, **34**, 7817–7827.
4. J. Tao, G. Yang, W. Zhou, J. Qiu, G. Chen, W. Luo, F. Zhao, L. You, L. Zheng, T. Zhang and Y. Zhao, *J. Hematol. Oncol.*, 2021, **14**, 14.
5. S. Mohanty, S. Panda, U. Devadharshini and S. Paul, *Biochim. Biophys. Acta, Rev. Cancer.*, 2023, **1878**, 188862
6. J. Yang, X. Liu, K. Bhalla, C. N. Kim, A. M. Ibrado, J. Cai, T. I. Peng, D. P. Jones, X. Wang, *Science*, 1997, **275**, 1129-1132.

## Precursor-less Metal Nanoparticle Generation and Characterisation

BENJAMIN GFELLER<sup>A</sup>, MARIIA BECKER<sup>A</sup>, MARKUS KALBERER<sup>A</sup>

<sup>A</sup> Department of Environmental Science, University of Basel, Basel, 4056, Switzerland

### Abstract

Various techniques of generating nanoparticles have been developed in recent years. An effective way, using a precursor-less method, is the generation of metal nanoparticles via the physical process of spark ablation. This gas phase particle production method allows high purity and high number concentrations of well above  $10^6$  particles per  $\text{cm}^3$  gas volume. Applications of this method include the functionalization of nanoparticles e.g., via the coagulation of different types of particles, for example, through a decoration of seed particles in the aerosol phase.

This study focuses on the generation of metal nanoparticles, such as Au and Cu, using a spark discharge generator. The resulting aerosol particles are characterised with a scanning mobility particle sizer (SMPS) for number size distribution as well as electron microscopy for particle morphology (Scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM) combined with electron dispersive x-ray spectroscopy (EDX)).

TEM imaging showed that particles present in the aerosol are as small as 0.5 nm with a mode ranging between 3.5 nm and 9 nm. SMPS is an online technique characterising particle size in a continuous air flow but is limited to  $>2.5$  nm particles, making the two measurement techniques complementary.

For the four metals investigated, significant differences in particle size and morphology were observed (Fig. 1) with a range of fractal like agglomerates (Pt, Ni, Cu) and spherically shaped particles (Au). These differences can be rationalised by material specific properties such as the surface energy.<sup>1</sup>

The measurements conducted illustrate advantages of the gas phase spark ablation nanoparticle generation method. The small particle diameters and as well as high number concentrations and vast range of morphologies of the synthesised nanoparticles give access to a wide range of applications in the field of heterogeneous catalysis.

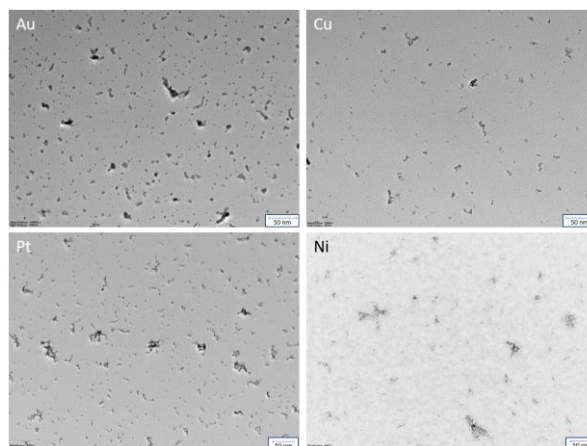


Figure 1 – TEM overviews of spark generated metal nanoparticles.

**Acknowledgements:** This work was supported by the Swiss National Science Foundation (200021\_192192/1). Access to SEM, TEM, STEM and EDX instruments was given by the Swiss Nanoscience Institute of the University of Basel.

### References

1. B. O. Meuller, M. E. Messing, D. L. J. Engberg, A. M. Jansson, L. I. M. Johansson, S. M. Norlén, N. Tureson and K. Deppert, *Aerosol Sci. Technol.*, 2012, **46**, 1256-1270.

## Enhancing Gemcitabine Efficacy in Pancreatic Ductal Adenocarcinoma through Novel Chemotherapeutic Strategies

BENJAMIN JUMBO<sup>A</sup>, ADEOLU OLUWASANMI<sup>A</sup>, CLARE HOSKINS<sup>A</sup>

<sup>A</sup> Department of Pure and Applied Chemistry, University of Strathclyde, Glasgow, UK

### Abstract

Pancreatic ductal adenocarcinoma (PDAC) remains a major contributor to cancer-related mortality, ranking as the fourth leading cause of cancer-related deaths in 2020<sup>1</sup>. Gemcitabine is the gold standard for the treatment of advanced-stage PDAC; however, its clinical efficacy is hampered by chemoresistance, primarily attributable to rapid enzymatic deamination leading to the formation of the inactive metabolite, 2',2'difluorodeoxyuridine, which is subsequently eliminated via urine<sup>2</sup>. Higher doses of gemcitabine (1000 mg/m<sup>2</sup>) are administered to overcome this, which results in several severe side effects.

In this study, we present a novel approach to enhance the efficacy of gemcitabine in PDAC treatment by chemically modifying the drug through amide conjugation with spermine. This new compound, termed GemSper, offers the potential to overcome chemoresistance barriers.

To enable targeted delivery, GemSper will be immobilised onto hybrid gold-iron oxide nanoparticles, exploiting the electrostatic interactions between the negatively charged gold surface of the nanohybrids and the cationic spermine. The synthesis of these nanohybrids involves a multi-step process: the precipitation of iron salts at 90°C, capping of magnetic iron oxide nanoparticles with poly(ethyleneimine) (PEI), and subsequent reduction of gold(III) chloride. The synthesised nanoparticles (zeta potential = +31.8 mV; size = 100 - 150 nm; Polydispersity Index, Pdl = 0.36) were characterised using photon correlation spectroscopy, zeta potential measurements, inductively coupled plasma-optical emission spectroscopy (ICP-OES), and transmission electron microscopy.

The unique surface plasmon resonance characteristic of gold nanoparticles will be exploited for thermally triggered drug release via laser ablation. Laser ablation-triggered drug release from the nanoparticles will not only enhance precise drug delivery but also generate localized hyperthermia within the tumour microenvironment, boosting therapeutic efficacy.

The potential of this therapeutic cocktail will be evaluated through in vitro assays, including MTT and trypan blue assays, to determine their efficacy in terms of cytotoxicity and cell viability.

**Acknowledgements:** This work is being funded by grants from the Tertiary Education Trust Fund, Nigeria.

### References

- 1 M. Malekigorji, M. Alfahad, P. Kong Thoo Lin, S. Jones, A. Curtis and C. Hoskins, *Nanoscale*, 2017, **9**, 12735–12745.
- 2 E. Moysan, G. Bastiat and J.-P. Benoit, *Mol. Pharm.*, 2013, **10**, 430–444.

## Synthesis and Functionalisation of (Ti/Zn)-Fe-Si Solid Acid Metal Oxide Nanocatalysts for Conversion of Low-Grade Waste Cooking Oil to Biodiesel

BRANDON LOWE<sup>A</sup>, ALI HASSANPOUR<sup>A</sup>

<sup>A</sup> University of Leeds

### Abstract

There is an urgent need to transition away from fossil fuel-based modes of transportation, however the continuing widespread prevalence of internal combustion engines means a demand for diesel products is likely to persist for the near future. Although the use of biodiesel has been argued to be a cleaner burning and lower carbon impact fuel source<sup>1</sup>, common feedstocks such as animal and vegetable fats present an undesirable competition of food versus fuel<sup>2</sup>. The potential to upgrade low quality waste products such as waste cooking oil (WCO) could remedy such competition providing a resilient catalyst is developed that can handle the high levels of free fatty acid (FFA) and moisture content present in low-grade feedstocks<sup>3</sup>. Acidic catalysts are typically more suitable for high FFA oils but suffer reduced reactivity as compared to base catalysed routes<sup>4</sup>. Heterogeneous catalysts allow for simpler material recovery and catalyst recycling yet also generally demonstrate reduced reactivity as compared to homogenous catalysis<sup>5</sup>. This has led to great interest in developing solid acid nanocatalysts for biodiesel production and many examples of sulfated metal oxide nanomaterials have been explored in the literature to date<sup>6</sup>. This current work explores novel mixed metal oxide nanocatalysts that have been produced based on a core-shell design principle. Highly spherical silica nanospheres have been coated with successive layers of hematite and zinc/titanium oxide before functionalisation with varying concentrations of chlorosulfonic acid to provide Brønsted-Lowry acidic sites. A range of characterisation methods have been utilised to determine morphological, structural, and chemical nature of the six resulting nanocatalysts, including: BET, DLS/Zetapotential, FTIR, SEM-EDX, TGA, and XRD. The results of these characterisation studies confirm successful production of highly crystalline nanoscale catalysts loaded with varying concentrations of surface sulfonic acid sites. Work is now underway to optimise biodiesel production from low-grade waste cooking oil via these produced nanocatalysts.

**Acknowledgements:** B.L. acknowledges financial support from an EPSRC Doctoral Training Partnership (EP/T517860/1)

### References

1. J. Sheehan, V. Camobreco, J. Duffield, M. Graboski and H. Shapouri, An overview of biodiesel and Petroleum Diesel Life Cycles, 1998.
2. D. W. McLaughlin, Conservation Biology, 2011, 25, 1117–1120.
3. Y.-M. Park, D.-W. Lee, D.-K. Kim, J.-S. Lee and K.-Y. Lee, Catalysis Today, 2008, 131, 238–243.
4. D. Samios, F. Pedrotti, A. Nicolau, Q. B. Reiznautt, D. D. Martini and F. M. Dalcin, Fuel Processing Technology, 2009, 90, 599–605.
5. B. Lowe, A. M. Ahmad, J. Gardy and A. Hassanpour, Nanotechnology for Biorefinery, 2023, 27–87.
6. B. Lowe, J. Gardy and A. Hassanpour, Catalysts, 2022, 12, 223.



## All Chemical-Vapour-Deposited Nano-needle Structured WO<sub>3</sub>/BiVO<sub>4</sub> Heterojunction Photoanodes for Water Splitting

BRIAN TAM<sup>A B</sup>, JENNY NELSON<sup>A</sup>, ANDREAS KAFIZAS<sup>B C</sup>,

<sup>A</sup> Department of Physics, Imperial College London, South Kensington, London SW7 2AZ;

<sup>B</sup> Department of Chemistry, Molecular Sciences Research Hub, Imperial College London;

<sup>C</sup> London Centre for Nanotechnology, Imperial College London, South Kensington, London

### Abstract

Bismuth vanadate (BiVO<sub>4</sub>) is a well-studied, earth-abundant, visible light absorbing metal oxide material used as a photoanode in water splitting. The bandgap of BiVO<sub>4</sub> is 2.4 eV and allows for a maximum solar-to-hydrogen conversion efficiency of up to 9.2%. While the efficiency of oxidation is limited by its short electron diffusion length and relatively large recombination rate, the efficiency can be improved by forming a heterojunction with a material such as WO<sub>3</sub> with complementary conduction and valence bands for water oxidation. Additionally, nanostructural control is needed to achieve efficient charge carrier separation across the heterojunction interface, reducing recombination and improving the efficiency of the water oxidation reaction.<sup>1</sup>

These semiconductors are typically deposited by electrodeposition and photo-deposition, which offer useful control, but homogenous deposition may be difficult to be achieved for larger-area depositions.<sup>2</sup> Herein we demonstrate a facile atmospheric-pressure chemical vapour deposition method for producing nanostructured photoanodes consisting of BiVO<sub>4</sub> coated onto WO<sub>3</sub> nanoneedles such as those shown in Figure 1. WO<sub>3</sub> nanoneedles have previously been shown to have fast water oxidation kinetics.<sup>3</sup>

In this work, nanostructured WO<sub>3</sub>/ BiVO<sub>4</sub> heterojunction photoanodes show up to 60% incident photon to current conversion efficiency when illuminated with light between 300-500 nm in wavelength under 1.23 V vs RHE of applied potential. Flat BiVO<sub>4</sub> photoanodes both with and without the heterojunction with WO<sub>3</sub>, in contrast, show a much poorer performance. One benefit of the chemical vapour deposition method used herein is that layers may be deposited sequentially over large substrate areas, and is a technique commonly used by industry for semiconductor fabrication. This versatile approach yields a potentially transformative method for fabricating large-area thin film photoelectrodes.

**Acknowledgements:** J.N. would like to acknowledge financial support from the ERC through an Advanced Grant (Grant No. 742708) and the EPSRC (Grant No. EP/T028513/1) and thanks the Royal Society for the award of a Research Professorship. A.K. thanks the EPSRC for a Programme Grant (Grant No. EP/W017075/1) and B.T. thanks the Imperial College London for support via the President's PhD Scholarship.

### References:

1. S. Selim, L. Francas, M. Garcia-Tecedor, S. Corby, C. Blackman, S. Gimenez, J. R. Durrant, A. Kafizas, *Chem. Sci.* 2019, **10**, 2643.
2. B. Moss, O. Babacan, A. Kafizas, A. Hankin, *Adv. Energy Mater.* 2021, **11**, 2008386.
3. S. Corby, L. Francas, S. Selim, M. Sachs, C. Blackman, A. Kafizas, J. R. Durrant, *J. Am. Chem. Soc.* 2018, **140**, 16168.

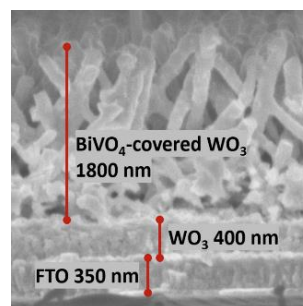


Figure 1 – SEM image of BiVO<sub>4</sub>-coated WO<sub>3</sub> nanoneedles.



## **Synthesis and Impurity Analysis of Branched-Chain Ionizable Lipids for Lipid Nanoparticles**

DANIEL ZIMMER<sup>A</sup>, MATTHEW STONE<sup>B</sup>, ROBERT PROOS<sup>B</sup>, SANTOSH KUPIL KUMAR GORTI<sup>B</sup>, CHRISTINA M. BAILEY-HYTHOLT, PH.D.<sup>A</sup>

<sup>A</sup>DEPARTMENT OF CHEMICAL ENGINEERING, WORCESTER POLYTECHNIC INSTITUTE, WORCESTER, MA, USA; <sup>B</sup>SCIEX MASS SPECTROMETRY, FRAMINGHAM, MA, USA

### **Abstract**

With the rapid growth in lipid nanoparticle technologies catalyzed by the onset of COVID-19 and the groundbreaking lipid nanoparticle vaccines developed by Moderna and BioNTech/Pfizer, new ionizable lipids have been explored. C12-200, a branched-chain ionizable lipid known for its efficacy in transfecting challenging tissues and cell types, has gained significant attention. The branched chain structure of C12-200 makes reaction intermediates very hydrophobic and thus a challenging lipid to purify and analyze. This study focuses on synthesizing C12-200 under varying conditions, including protic solvents, aprotic solvents, and solvent-free approaches, while also conducting reaction time course experiments. Additionally, the synthesized lipids from various reaction conditions were used to formulate mRNA lipid nanoparticles and assessed for size, zeta potential, polydispersity, and encapsulation efficiency. From our results, we hypothesize the lipid synthesis conditions impact the formation of the nanoparticles and their resulting attributes.

Lipid components from the reactions were separated by reversed-phase chromatography. Relative amounts of covalently attached aliphatic chains were quantified by mass spectrometry to assess reaction progress and yield. Low energy electron impact fragmentation on the SCIEX ZenoTOF 7600 mass spectrometer was used to help distinguish isomeric intermediate structures to provide insights on preferred reaction pathways, as well as give insights to manufacturing impurities. Through the development of more precise analytical methods that characterize chemical structures and synthesis conditions leading to enhanced yields of pharmaceutical ingredients, our research contributes to advancing both academic and industrial comprehension of nanoparticle synthesis and analysis processes.

## Capillary Electrophoresis Microfluidic Assessment of mRNA and pDNA Lipid Nanoparticles

DANIEL ZIMMER<sup>A</sup>, ADRIANA COLL DE PEÑA<sup>B</sup>, BELLE SETHACHUTKUL<sup>A</sup>, NICOLE CHEN<sup>B</sup>, EVERETT GUTTERMAN-JOHNS<sup>B</sup>, ANUBHAV TRIPATHI, PH.D.<sup>B</sup> CHRISTINA M. BAILEY-HYTHOLT, PH.D.<sup>A</sup>

<sup>A</sup> Department of Chemical Engineering, Worcester Polytechnic Institute, Worcester, MA, USA;

<sup>B</sup> Center for Biomedical Engineering, School of Engineering, Brown University, Providence, RI, USA

### Abstract

Lipid nanoparticles (LNPs) have rapidly come to prominence through their success in the Moderna and Pfizer/BioNTech COVID-19 vaccines. Due to this clinical application, there has been extensive exploration to use LNP systems for the delivery of RNA, DNA, and other therapeutics. However, there is currently a need for high-throughput and low volume characterization of the nucleic acid to LNP ratio. To address this need, we have developed an electrophoresis-mediated microfluidics approach, that is independent of input concentration, to estimate the sample composition by comparing its lipid and nucleic acid content relative to a standard. Here, we analyzed the composition of LNPs with different clinical lipid compositions (Onpattro<sup>®</sup>, Comirnaty<sup>®</sup>, and Spikevax<sup>®</sup>) and nucleic acid (plasmid DNA (pDNA) and messenger RNA (mRNA)) formulations. The electrophoresis method developed in this work enables the high throughput screening of LNPs using a 96- or 384-well plate with approximate times of 2-4 minutes per sample using a total volume of 11  $\mu$ L. The lipid analysis requires concentrations approximately between  $10^9$  and  $10^{10}$  particles/mL, as determined through LNP concentration measurements using a Malvern Nanosight, and has an average prediction error under ~20%. The nucleic acid analysis requires extremely low concentrations of 1.17 ng/ $\mu$ L for pDNA and 0.17 ng/ $\mu$ L for mRNA and has an average prediction error under ~10%, depending on the standard used. In addition, our method quantifies the relative concentration of nucleic acid and lipid in the LNP. By developing a robust and rapid quality control assay for LNP loading, this study addresses a critical need within the gene and molecular therapy community and offers a rapid way to evaluate the quality and purity of LNP products.

**Acknowledgements:** We would like to thank the Kilguss Institute at Providence Women and Infants hospital for providing access to their equipment.

## Application of a separator-integrated graphene/graphite anode to lithium metal batteries

DONGWON CHOI<sup>A</sup>, YONG-TAE KIM<sup>\*B</sup>, JINSUB CHOI<sup>\*AC</sup>

<sup>A</sup>Department of Chemistry and Chemical Engineering, Inha University, 22212, Incheon, Republic of Korea

<sup>B</sup>Department of Chemical and Biomolecular Engineering, Chonnam National University, 59626, Yeosu, Republic of Korea

<sup>C</sup>Core Facility Center for Sustainable Energy Materials, Inha University, 22212, Incheon, Republic of Korea

\*Corresponding author: yongtaekim@jnu.ac.kr, jinsub@inha.ac.kr

### Abstract

Flexible lithium-ion batteries have been at the forefront of active research over the past few decades, driven by the increasing demand for roll-up displays, wearable electronic devices, and smart electronic devices. Since most of such equipment have space constraints, they require batteries with high energy density. As a result, lithium metal has been identified as a promising next-generation battery anode material. Lithium metal has the lowest electrochemical reaction potential (-3.04 V vs SHE) and a high theoretical capacity of 3860 mAh/g, surpassing existing graphite anodes. However, challenges such as internal short circuits caused by dendrite structures that form during charging/discharging cycles, and mechanical instability due to the volume expansion of lithium metal during deposition remain.

In this study, we synthesized reduced graphene oxide via electrochemical exfoliation to address the performance degradation and mechanical stability issues caused by dendrite formation on the lithium metal anode. Furthermore, we synthesized a flexible separator-integrated electrode composed of graphene and graphite through a simple filtration process. The structure of the synthesized electrode was examined using a scanning electron microscope (SEM), and qualitative analysis was conducted through Raman spectroscopy and X-ray diffraction analysis (XRD). The synthesized electrode was used as an anode in a lithium metal battery to evaluate battery performance through CE tests and symmetric cell tests.

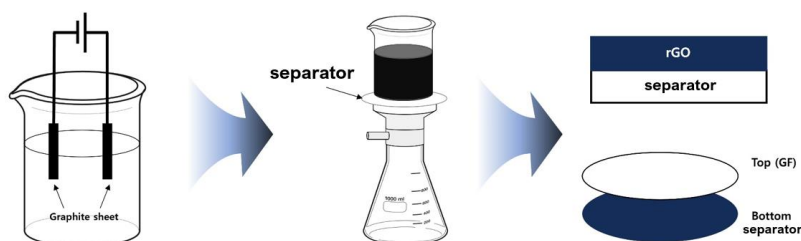


Figure 1 – Schematic image for the synthesis of integrated electrode

## Molecular Models for Single Cobalt Ions Supported on Cerium Dioxide Nanoparticles: Heterometallic Ce/Co-oxo Clusters

DOORY DAN<sup>A</sup>, KHALIL A. ABBOUD<sup>A</sup>, LUKASZ WOJTAS<sup>B</sup>, GEORGE CHRISTOU<sup>A</sup>

<sup>A</sup> Department of Chemistry, University of Florida, Gainesville, FL 32611;

<sup>B</sup> Department of Chemistry, University of South Florida, Tampa, FL 33612

### Abstract

Cerium dioxide (CeO<sub>2</sub>, ceria) nanoparticles (CNPs) have gained substantial interest in a wide range of fields including industrial catalysis and, more recently, biomedical applications. In addition, ceria-containing materials have often been used as redox support materials, solid oxide fuel cells, UV filters, and three-way catalysts (TWCs) for the control of auto-exhaust pollutants. This outstanding versatility is partially due to the significant natural abundance of cerium and its facile Ce<sup>3+</sup>/Ce<sup>4+</sup> redox capability.

Despite the widespread use of nanoceria, the current synthetic procedures suffer from poor size control (i.e., polydispersity) and require extreme reaction conditions. In addition, the detailed structural analysis of nanoparticles to atomic resolution remains a massive challenge. Therefore, we have developed molecular ‘bottom-up’ routes to molecular cerium-oxo-carboxylate clusters that are ultra-small (1–3 nm) CNPs. These bring all the advantages of molecular chemistry to the area, including monodispersity (single-size), solubility, and crystallinity, the latter enabling structural characterization to atomic resolution by single-crystal X-ray crystallography. Given their strong resemblance to the bulk material, we classify these clusters as “molecular nanoparticles” (MNPs).<sup>1-3</sup>

More recently, we have extended this approach towards using CeO<sub>2</sub> MNPs as supports for 3d transition metals such as Mn<sup>III</sup> on their surface.<sup>4</sup> Co ions supported on traditional CNPs exhibit enhanced catalytic activity such as dehydrogenation of ethane and low temperature methanation at low partial pressure of CO<sub>2</sub>.<sup>5,6</sup> However, there are no reports to date of molecular Ce/Co-oxo clusters that can be described as models of ceria-supported Co<sup>III</sup> ions. We have therefore taken on the synthetic challenge of attaining such compounds, and this presentation will describe the synthesis and structures of a family of novel Ce/Co-oxo clusters that represent molecular models of Co<sup>III</sup> ions on CNP surfaces.

**Acknowledgements:** National Science Foundation

### References

1. K. J. Mitchell, K. A. Abboud, G. Christou, *Nat. Commun.*, 2017, **8**, 1445.
2. K. J. Mitchell, J. L. Goodsell, B. Russell-Webster, U. Twahir, A. Angerhofer, K. A. Abboud, G. Christou, *Inorg. Chem.*, 2021, **60**, 1641-1653.
3. B. Russell-Webster, J. Lopez-Nieto, K. A. Abboud, G. Christou, *Angew. Chem. Int. Ed.*, 2021, **60**, 12591-12596.
4. S. Das Gupta, A. Thuijs, E. Fisher, K. A. Abboud, G. Christou, *Inorg. Chem.*, 2022, **61**, 6392-6402.
5. Y. Hosono, H. Saito, T. Higo, K. Watanabe, K. Ito, H. Tsuneki, K. Hashimoto, Y. Sekine, *J. Phys. Chem. C.*, 2021, **125**, 11411-11418.
6. J. Struijs, V. Muravev, M. Verheijen, E. Hensen, N. Kosinov, *Angew. Chem. Int. Ed.*, 2022, **62**, e202214864 (1-9).

## Molecular Mixed-Metal-oxo Clusters: Well-defined Models for Mixed-Metal Oxide Nanomaterials

ETHAN G. FISHER, KHALIL A. ABBOUD, GEORGE CHRISTOU

Department of Chemistry, University of Florida, Gainesville, FL 32611

### Abstract

Metal oxides such as  $\text{CeO}_2$  and  $\text{Bi}_2\text{O}_3$  are employed in various applications spanning environmental remediation, sustainable energy development, and medicine. While effective, there remains ongoing debate regarding various material properties and mechanisms-of-action due to the inherent limitations of traditional nanoparticle syntheses (such as the range of sizes and shapes in any given batch) and characterization techniques (such as limited resolution). In contrast, the complementary 'bottom-up' approach can yield molecular metal-oxo clusters, which are identical in size and shape and adopt the same structure as the bulk solid; they therefore represent ultra-small (1–3 nm), atomically-precise pieces of the latter. As such, the so-called "molecular nanoparticles" enable a robust investigation into critical material properties and the establishment of structure-property relationships with atomic precision.<sup>1-3</sup> Once characterized, comparisons and contrasts with the traditional nanomaterials can also be explored.

Recently, interest in mixed-metal oxide nanomaterials has exploded owing to their enhanced properties, often arising from the synergistic interactions between each component in the bulk or at interfaces between different phases. For example,  $\text{Ti/CeO}_2$  shows promise as a photoanode for water splitting under visible light, and  $\text{Cu/Bi}_2\text{O}_3$  is being investigated as a photo/electrocatalytic material for the reduction of  $\text{CO}_2$ .<sup>4,5</sup> While these mixed-metal oxides often display several enhancements over those of the individual binary metal oxides, their mixed-metal nature also increases their complexity, further limiting our ability to characterize them to atomic resolution. Herein, we describe the successful extension of our 'molecular nanoparticle' approach to various unprecedented molecular  $\text{Ce/Ti}$ -oxo and  $\text{Bi/Cu}$ -oxo clusters, and their characterization as well-defined models for the analogous mixed-metal oxide nanomaterials. These examples will further emphasize the advantages, benefits, and potential universality of the molecular approach to ultra-small nanomaterials.

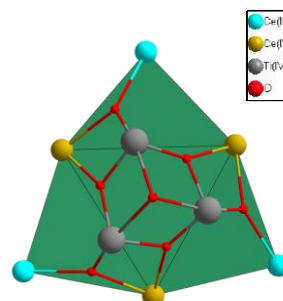


Figure – The metal-oxo core of  $\{\text{Ce}_6\text{Ti}_6\}$  represents an atomically-precise model for the interface between a  $\text{CeO}_2$  (111) surface (green plane) and surface-bound  $\text{Ti}$ -oxo species, thought critical to the enhanced photocatalytic activity of the analogous solid-state materials.

**Acknowledgement:** National Science Foundation

### References

1. K. Mitchell, K. Abboud, G. Christou, *Nat. Commun.*, 2017, **8**, 1445.
2. K. Mitchell, J. Goodsell, B. Russell-Webster, U. Twahir, A. Angerhofer, K. Abboud, G. Christou, *Inorg. Chem.*, 2021, **60**, 1641-1653.
3. B. Russell-Webster, J. Lopez-Nieto, K. Abboud, G. Christou, *Angew. Chem. Int. Ed.*, 2021, **60**, 12591-12596.
4. S. Kundu, J. Ciston, S. Senanayake, D. Arena, E. Fujita, D. Stacchiola, L. Barrio, R. Navarro, J. Fierro, J. Rodriguez, *J. Phys. Chem. C*, 2012, **116**, 14062-14070.
5. C. Dai, Y. Qiu, Y. He, Q. Zhang, R. Liu, J. Du, C. Tao, *New J Chem.*, 2019, **43**, 3493-3499.

## FRET Responsive Silica Nanoparticles for Localised Antibiotic Release Using Ultrasound

GRACE BALL<sup>A</sup>, CHARLIE TOBIAS<sup>B</sup>, SARAH KUEHNE<sup>C</sup>, DAMIEN WALMSLEY<sup>D</sup>, KNUT RURACK<sup>B</sup>, ZOE PIKRAMENOU<sup>A</sup>

<sup>A</sup> School of Chemistry <sup>D</sup> School of Dentistry, University of Birmingham. B15 2TT, UK, <sup>B</sup> Chemical and Optical Sensing Division, Bundesanstalt für Materialforschung und -prüfung (BAM), 12489, Berlin, Germany <sup>C</sup> Department of Biomedical Sciences, Nottingham Trent University, NG1 4FQ, UK

### Abstract

Localised antibiotic release offers the advantage of minimising antimicrobial resistance.<sup>1</sup> Silica nanoparticles demonstrate excellent capabilities as drug delivery agents where their amorphous structure enables encapsulation of small molecules, they are also biocompatible, and can be functionalised.<sup>2-5</sup> Low frequency ultrasound is clinically relevant where it is used in dental applications<sup>6</sup> and has been shown to facilitate drug release from materials.<sup>7</sup> In this work we present a novel FRET pair between an antibiotic, Ciprofloxacin, and a luminescent metal complex, [Ru(phen)<sub>3</sub>]<sup>2+</sup>Cl<sub>2</sub>, encapsulated in 100 nm silica nanoparticles with excellent FRET efficiency (up to 70 %).

Four different architectures of silica nanoparticles were synthesised demonstrating how the silica framework can affect molecular interactions between encapsulated cargo leading to differences in energy transfer. The nanoparticles show selective drug release *in vitro* upon application of ultrasound. Characterisation of ultrasound has been shown by detection of ROS production using KI, confirming the presence of cavitation bubbles in solution. This system demonstrates advantageous properties where triggered release can be achieved through application of low frequency ultrasound and detection of release can be achieved by monitoring FRET.

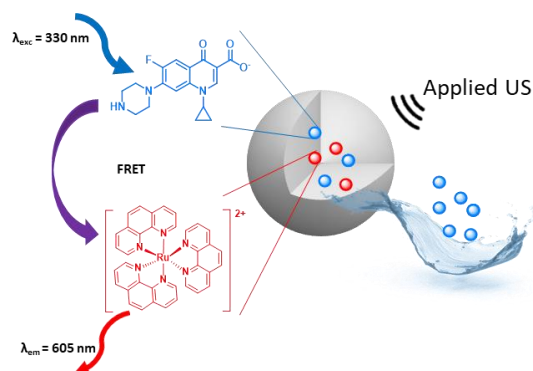


Figure 1: Ultrasound triggered release of ciprofloxacin from silica nanoparticles.

### References

1. Antimicrobial Resistance Collaborators, *The Lancet*, 2022, **399**, 629-655
2. A. R. Muguruza, A. di Maio, N. K. Hodges, J. M. A. Blair, and Z. Pikramenou, *Nanoscale Adv.*, 2023, **5**, 2453-2461
3. D. J. Lewis, V. Dore, N. J. Rogers, T. K. Mole, G. B. Nash, P. Angeli, and Z. Pikramenou, *Langmuir*, 2013, **29**, 14701-14708
4. S. Claire, A. D. Walmsley, S. Ginton, H. Floyd, R. Sammons, and Z. Pikramenou, *J. Dent*, 2015, **43**, 1242-1248
5. A. R. Muguruza, M. L. Odyneic, M. Manhota, Z. Habib, K. Rurack, J. M.A. Blair, S. A. Kuehne, A. D. Walmsley, Z. Pikramenou, *Microporous Mesoporous Mater.*, 2024, **363**, 112841
6. N. Vyas, Q. X. Wang, A. D. Walmsley, *Ultrason. Sonochem.*, 2021, **70**, 105338
7. G. A. Hussein, W. G. Pitt, *Adv. Drug Deliv. Rev.*, 2008, **60**, 1137-1152



## Quantifying the impact and potential of carbon dots on plant photosynthesis

KONSTANTINOS TELEMACHUS KOTOULAS<sup>A</sup>, MING XIE<sup>A</sup>, ANDREW BURROWS<sup>B</sup>, ...

<sup>A</sup> Department of Chemical Engineering, University of Bath, Bath, BA2 7AY, United Kingdom;

<sup>B</sup> Department of Chemistry, University of Bath, Bath, BA2 7AY, United Kingdom

### Abstract

Research on quantum dots has been at the forefront of many fields in the past decade, with extensive progressions in electronics and bioimaging. Even though the Nobel prize in chemistry for 2023 was awarded for their discovery and synthesis, there is still a long way to go to unlock their full potential. In recent years carbon quantum dots (CQDs) have risen in popularity due to their cheap, scalable synthesis, high chemical stability, and low cytotoxicity.<sup>1</sup> Amidst surging energy costs and a rapidly changing climate, it is critical for the agricultural sector to improve electron transport efficiency and nutrient uptake to reduce energy and fertiliser consumption. Food and agricultural waste can be used as CQD precursors,<sup>2-3</sup> whilst their fluorescence intensity can be enhanced with heteroatom doping.<sup>4</sup> Quantum dots can utilize wavelengths from the solar spectrum that are not usually accessible to plants and can therefore transfer electrons to the light harvesting complex via three mechanisms: 1. Fluorescence, 2. Direct electron transport and 3. Donor-acceptor interaction via near relation.<sup>5-6</sup> Due to their heteroatom doping, even after the quantum dots become photo inert, they can be utilized to improve nutrient uptake as a substitute for fertilisers,<sup>7</sup> and can even be recycled (treated leaves) as precursors for the next CQD synthesis. In the future, optimization of the bottom-up synthesis approaches for CQDs can improve their quantum yields, which would make them a greener alternative to metal-based greenhouse films.<sup>8</sup>

**Acknowledgements:** The authors would like to express their appreciation to the Leverhulme Trust for funding this research and to Nottingham Trent University for the forthcoming collaboration.

### References:

1. Y. Gong and J. Zhao, J. Agric. Food Chem. 2018, **66**, 9159–9161
2. H. Ding, Y. Ji, J.S. Wei, Q.Y. Gao, Z.Y. Zhou and H.M. Xiong, J. Mater. Chem. B, 2017, **5**, 5272–5277
3. L. Li, R. Zhang, C. Lu, J. Sun, L. Wang, B. Qu, T. Li and S. Li, J. Mater. Chem. B, 2017, **5**, 7328–7334
4. S.Y. Lim, W. Shen, Z. Gao, Chem. Soc. Rev., 2015, **44**, 362–381
5. H. Wang, M. Zhang, Y. Song, H. Li, H. Huang, M. Shao, Y. Liu and Z. Kang, Carbon 136, 2018, **136**, 94–102
6. Y. A.P. Chowmasundaram, T.L. Tan, R. Nulit, M. Jusoh and S.A. Rashid, RSC Adv., 2023, **13**, 25093–25117
7. F. Zhao, X. Xin, Y. Cao, D. Su, P. Ji, Z. Zhu and Z. He, Nanomaterials, 2021, **11**, 2717
8. D. Herbert, J. Boonekamp, C.H. Parrish, K. Ramasamy, N.K. Makarov, C. Castaneda, L. Schuddebeurs, H. McDaniel and M.R. Bergren, Front. Chem., 2022, **10**, 988227



## Investigation into the impact of hydrogen bonding in loading of hydrophilic drugs into solid lipid nanoparticles

LEWIS DYMOCK<sup>A</sup>, PAUL EVANS<sup>B</sup>, CLARE HOSKINS<sup>A</sup>

<sup>A</sup> Pure and Applied Chemistry, University of Strathclyde, 99 George Street, Glasgow, G1 1RD

<sup>B</sup> NextPharma Edinburgh, Oakbank Park Way, Livingston, EH53 0TH

### Abstract

Solid lipid nanoparticles used for drug delivery show a large entrapment of hydrophilic drugs within the lipid matrix which is counterintuitive to their physicochemical properties. In order to investigate the cause of this phenomena, analysis of entrapment efficiency of hydrophilic drugs in SLNs composed of glyceryl monostearate, glyceryl distearate, and glyceryl tristearate was carried in order to show an effect of hydrogen bonding. The entrapment was hypothesised to be higher for monoglycerides, decreasing for diglycerides and again for triglycerides. Due to the chemical nature of these lipids, the free hydroxyl groups in the lipids with less stearate residues offer a greater hydrogen bond donor capability thus providing anchor points from the lipid to the hydrophilic drug. Initial trials showed this decreasing trend when entrapping vancomycin in these lipids containing stearic acid residues, entrapment efficiency values were 62.70%, 57.74%, and 50.14% for glyceryl monostearate, glyceryl distearate, and glyceryl tristearate respectively. These formulations were lyophilised and analysed by infrared spectroscopy in an effort to show an increase in the vibrational strength of peaks due to the presence of hydrogen bonding.

Further analysis of these formulations will be carried out using drugs containing decreasing hydrogen bonding capability and also analysis of the lyophilised particles with differential scanning calorimetry in order to show the presence of hydrogen bonds.

## Electrosynthesis of highly crystalline ZIF-67 using bio solvents: comparison of electrochemical performance as a supercapacitor electrode in various electrolyte medium

Manavalan Vijayakumar <sup>A,B</sup>, Vesna Najdanovic-Visak <sup>A</sup>, Stephen D. Worrall <sup>B</sup>

<sup>A</sup> Chemical Engineering and Applied Chemistry, Energy & Bioproducts Research Institute, Aston University, Birmingham, B4 7ET, UK.

<sup>B</sup> Aston Institute of Materials Research, College of Engineering and Applied Science, Aston University, Birmingham, B4 7ET, UK.

### Abstract

Metal organic framework (MOF) are novel materials which finds a considerable attention in recent years towards energy storage and photocatalysis applications<sup>1</sup>. The anodic electrochemical synthesis offers advantages over other conventional methods to synthesis high quality MOFs. Also, electrodeposition method offers greater beneficial in terms of better MOF coating, shorter reaction time and less energy consumption<sup>2</sup>. In the present article, the study was carried out to find the effect of crystallinity and morphology of Cobalt ZIF-67 synthesized through anodic deposition method in fossil fuel (N,N-dimethylformamide (DMF) and bio-derived ( $\gamma$ -valerolactone (GVL)) solvent<sup>3</sup>. Also, the effect of temperature (55, 85, and 105 °C), and reaction time (1, 3, and 5 h) were evaluated to obtain a high-quality MOF which is characterized through SEM images and shown in fig. 1 (a). It is observed that the bio-derived solvent produces high quality MOF than fossil fuel solvent<sup>3</sup>. Also, the electrode coating was uniform on the surface of the electrode and greater crystalline morphology than the DMF solvent. Furthermore, the investigation is carried out to test the electrochemical performance of the Co-ZIF electrode in a coin cell assembly for supercapacitor application. It is observed that the GVL derived MOF shows better performance than DMF derived MOF material: the area inside the curve is increased with the increase in scan rate also at higher potential there is a capacitive effect which is desirable for pseudo-capacitance. (fig. 1(b)).

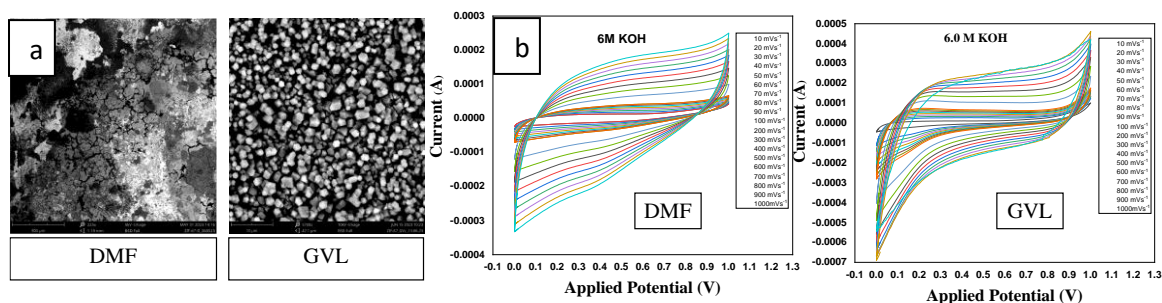


Figure 1 - (a) SEM image of ZIF- 67 (Co and mM) coating obtained using DMF and GVL; (b) Cyclic voltammograms of symmetrical coin cells for ZIF-67 electrodes from DMF and GVL in 6M KOH (scan rate from 10 mV/s to 1000 mV/s).

### References

1. A. A. Bhoite, K. V. Patil, R. S. Redekar, J. H. Jang, V. A. Sawant and N. L. Tarwal, *Journal of Energy Storage*, 2023, **72**.
2. S. D. Worrall, H. Mann, A. Rogers, M. A. Bissett, M. P. Attfield and R. A. W. Dryfe, *Electrochimica Acta*, 2016, **197**, 228-240.
3. M. Bhindi, L. Massengo, J. Hammerton, M. J. Derry and S. D. Worrall, *Applied Sciences*, 2023, **13**.

## The Nanoscience Dalmatian: Metal Decorated Titanium Dioxide Nanoparticles via Spark Ablation

MARIIA BECKER<sup>A</sup>, BENJAMIN GFELLER<sup>A</sup>, MARKUS KALBERER<sup>A</sup>

<sup>A</sup> University of Basel, Department of Environmental Sciences,  
Klingelbergstrasse 27, 4056 Basel, Switzerland; [mariia.karpacheva@unibas.ch](mailto:mariia.karpacheva@unibas.ch)

### Abstract

It is difficult to overestimate the importance of titania (TiO<sub>2</sub>) for material science applications. This unique material is studied due to its photoactivity and semiconductive properties. Moreover, the low cost of TiO<sub>2</sub> contributes to its attractiveness. For further enhancement of electronic and optical properties of TiO<sub>2</sub>, a lot of research was conducted on semiconductor modification with transition metals.<sup>1</sup>

Our research is focusing on the optimization of TiO<sub>2</sub> coating with metals *via* Spark Ablation. Despite a wide range of 'wet' synthesis procedures, typically they are time consuming and often require environmentally unfriendly metal precursors. This is not the case for the generation of metal nanoparticles *via* Spark Ablation which is a precursor-less method.<sup>2</sup>

Our main goal was to generate a system that has a real-life application. Therefore, Au, Pt, Cu and Ni were chosen as metals that are commonly used for heterogeneous catalysis. Despite being close neighbours in the Periodic table, each metal revealed a unique TiO<sub>2</sub> decoration behaviour.

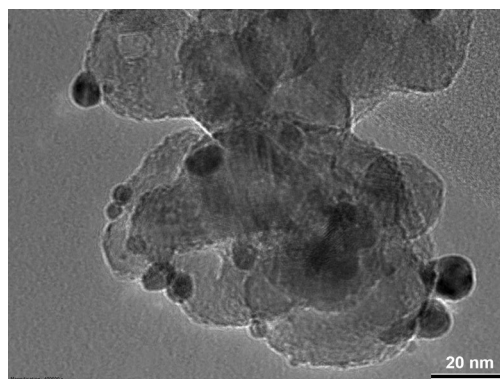


Figure 1 – TEM image of Au nanoparticles coated TiO<sub>2</sub>.

Au forms single nanoparticles with distinct spherical shape that can be clearly detected on TiO<sub>2</sub> surface (Figure 1). In case of Pt and Ni, nanoparticles have a strong tendency to coagulate to fractal-like agglomerates that attach to TiO<sub>2</sub>. Cu demonstrates a unique behaviour and coats the TiO<sub>2</sub> surface with a veil-like layer of nanoparticles.

For the characterization of TiO<sub>2</sub> coating with nanoparticles several complementary techniques were used: Scanning Mobility Particle Sizer (SMPS), electron microscopy (SEM, TEM) and energy dispersive X-ray spectroscopy (EDX) as well as Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES).

Titania is a key material for numerous applications like heterogeneous catalysis, water splitting and many more. A simple and efficient TiO<sub>2</sub> decoration procedure allows accessing a broad variety of applications with improved performances.

**Acknowledgements:** We thank NanolmagingLab at the University of Basel for the possibility to record TEM, SEM and EDX images.

### References

1. L. Liu, X. Chen, *Chem. Rev.*, 2014, **114**, 9890-9918.
2. S. Schwyn, E. Garwin, A. Schmidt-Ott, *J. Aerosol Sci.*, 1988, **19**, 639-642.

## Carbon Cloth Modified with Nickel and MoS<sub>x</sub>/MoS<sub>2</sub> for the Hydrogen Evolution Reaction

MARILIA DALLA BENETTA\*, CARMEL BRESLIN AND EITHNE DEMPSEY

*Department of Chemistry, Maynooth University, Maynooth, Co. Kildare, Ireland*

### Abstract

The development and design of cleaner and more sustainable sources of energy have become necessities due to climate change and an increase in energy demand. The Hydrogen Evolution Reaction (HER) presents itself as a promising green renewable source, potentially serving as the solution to the energy crisis. Hydrogen can be produced through the electrolysis of water with renewable sources, such as solar, wave or wind, and this approach is attracting considerable interest. In electrolysis, water is split into hydrogen and oxygen through two half-cell reactions, with the hydrogen evolution reaction (HER) occurring at the cathode and the oxygen evolution reaction (OER) at the anode. Platinum (Pt) or carbon-supported Pt nanoparticles have proven to be the best-performing electrocatalytic materials for the HER, both in acidic and alkaline environments. However, these Pt-based electrocatalytic materials are expensive and lack cost-effectiveness and sustainability.<sup>1</sup>

In this study, carbon cloth (CC) was modified with different nickel nanostructures using hydrothermal methods and electrodeposition, aiming to increase the surface area. Subsequently, an optimized electrodeposition process of MoS<sub>x</sub> around the CC threads was employed. A series of electrochemical and characterization analyses were performed on the CC. Nickel foam was also used as a substrate for reference.<sup>2</sup>

These materials were evaluated as electrocatalysts for the HER in acidic conditions and compared with platinum electrodes, which are recognized as the best electrocatalysts for the HER. Impressive HER performance was observed, indicating that these materials are potential alternatives to platinum as catalysts for water splitting under acidic electrolytes.

In this presentation, I will describe the carbon cloth activation and modification processes, discuss the performance of the materials as electrocatalysts, emphasizing their suitability as alternatives in the context of water splitting, and discuss the electrochemical properties and stability of the materials.

**Acknowledgements:** National University of Ireland Maynooth and the Sustainable Energy Authority of Ireland, under grant number SEAI/22/RDD/841

- 1 Y. Gong, J. Yao, P. Wang, Z. Li, H. Zhou and C. Xu, *Chin J Chem Eng*, 2022, 43.
- 2 D. Muthu, T. Sadhasivam and T. H. Oh, *Mater Lett*, 2023, 350.

## **Visible light-active bismuth oxide photocatalytic coatings and their potential against biological contaminants**

Marina Ratova

Department of Engineering, Manchester Metropolitan University, Manchester

### **Abstract**

Rapid development of semiconductor photocatalysis over the past few decades resulted in realisation of growing potential of this technique for environmental remediation processes. Indeed, various types of photocatalytic materials are being successfully implemented in construction industry, healthcare settings, water treatment and energy production facilities recently. However, there is also a growing need in development and exploitation of novel photocatalytic materials, as the most widely used one, titanium dioxide, is often not applicable for high throughput processes due to low quantum efficiency and lack of visible light activity.

Bismuth oxide and complex oxides have attracted a considerable amount of researchers' attention over the past few years. With band gap values ranging from 2.3 to 2.8 eV these materials are typically visible-light active and therefore represent promising candidates for development of efficient solar-responsive photocatalysts. Various types of bismuth complex oxide-based photocatalysts have been reported of being efficient for water purification, green hydrogen production, VOC abatement and microbial inactivation processes.

The present study is focused around bismuth oxide photocatalytic coatings, deposited by magnetron sputtering – physical vapour deposition technique of industrial significance. The bismuth oxide coatings have been deposited, optimised and thoroughly analysed against a variety of environmentally-relevant applications, including bacteria/viruses/algae inactivation [1], water treatment [2], etc. The combination of high antimicrobial activity under visible light irradiation with non-specific antimicrobial action makes bismuth oxide photocatalyst a promising candidate for application in real-world water treatment systems.

### **References**

- [1] Derqui et al, The Lancet Microbe, 2023, 4 (3), E397-E408
- [2] Cassidy et al, PLoS Pathog. 2020, 16(10): e1008880.d

## **Electric Field-Based Air Nanobubbles (EF-ANBs) Irrigation on Efficient Crop Cultivation with Reduced Fertilizer Dependency**

MARZIYEH JANNESARI<sup>A</sup>, NIAL J ENGLISH<sup>A</sup>, ANNA CASLIN<sup>A</sup>

<sup>A</sup> School of Chemical and Bioprocess Engineering, University College Dublin, Belfield, D04 V1W8  
Dublin, Ireland

### **Abstract**

The implementation of electric field-based air nanobubbles (EF-ANBs) irrigation presents a promising approach to enhance agricultural crop efficiency, concurrently promoting environmentally sustainable practices through reducing fertilizer usage. This study investigated the impact of EF-ANBs on the germination and overall growth of agricultural crops in soil. Results indicated a substantial enhancement in both germination rates and plant growth upon the application of EF-ANBs. Notably, the introduction of air nanobubbles led to a significant increase in the germination rate of lettuce and basil, escalating from approximately 20% to 96% and 16% to 53%, respectively over a two-day period. Moreover, the presence of EF-ANBs facilitates superior hypocotyl elongation, exhibiting a 2.8- and a 1.6-fold increase in the elongation of lettuce and basil, respectively over a six-day observation period. The enriched oxygen levels within the air nanobubbles expedite aerobic respiration, amplifying electron leakage from the electron transport chain (ETC) and resulting in heightened reactive oxygen species (ROS) production, playing a pivotal role in stimulating growth signaling. Furthermore, the application of EF-ANBs in irrigation surpasses the impact of traditional fertilizers, demonstrating a robust catalytic effect on the shoot, stem, and root length, as well as the leaf count of lettuce plants. Considering these parameters, a single fertilizer treatment (at various concentrations) during EF-ANBs administration, demonstrates superior plant growth compared to regular water combined with fertilizer. The findings underscore the synergistic interaction between aerobic respiration and the generation of reactive oxygen species (ROS) in promoting plant growth, particularly in the context of reduced fertilizer levels facilitated by the presence of EF-ANBs. This promising correlation holds significant potential in establishing a more sustainable framework for the upcoming environmentally conscious agriculture. This research sheds light on potential avenues for optimizing plant growth strategies through targeted interventions, offering valuable insights into agricultural practices and crop management.

**Keywords:** Air Nanobubbles (ANBs); Germination; Sustainable Agriculture; Fertilizer; Plant growth.



## Mesoporous g-C<sub>3</sub>N<sub>4</sub>, TiO<sub>2</sub> and g-C<sub>3</sub>N<sub>4</sub>/TiO<sub>2</sub> photonic films with a chiral nematic structure: slow photonic effect inducing improved H<sub>2</sub> generation

MASA JOHAR<sup>1</sup>, CONG WANG<sup>1</sup>, AND MOHAMED-NAWFAL GHAZZAL<sup>1\*</sup>

<sup>1</sup> Institut de Chimie Physique, UMR 8000 CNRS, Université Paris Saclay, 91405 Orsay, France

\*corresponding author: mohamed-nawfal.ghazzal@universite-paris-saclay.fr

### Abstract

Energy crises have flashed in the last few decades. Different materials and technologies were developed to convert solar light into usable energy, such as photovoltaic solar cells, H<sub>2</sub> generation, and CO<sub>2</sub> reduction. However, these technologies suffer from poor energy-conversion efficiency due to low optical-absorption coefficients and quantum-conversion yield of the currently developed materials. Photocatalysis is one of the promising sustainable processes to convert solar energy into chemical fuel under a mild reaction. Different semiconductors were used as photocatalysts, such as nitrides and metal oxides. However, most semiconductors share common problems, which are high recombination of charge carriers and low absorption factor directly affecting their photocatalytic efficiencies.

Photonic structures, engineered to manipulate the propagation of light and utilizing phenomena such as the slow photon effect, are employed to enhance light harvesting capabilities<sup>1,2</sup>. This work proposes the fabrication of three different bioinspired photonic crystal systems: SiO<sub>2</sub>/ g-C<sub>3</sub>N<sub>4</sub>, SiO<sub>2</sub>/ TiO<sub>2</sub>, and SiO<sub>2</sub>/g-C<sub>3</sub>N<sub>4</sub>/TiO<sub>2</sub> films with a chiral-nematic structure. The fabrication method combines soft chemistry (sol-gel chemistry) with bio-template nanomaterials, specifically cellulose nanocrystals (CNCs)<sup>3,4</sup>. The resulting films exhibit iridescent colors and Bragg peak reflection, which can be controlled by adjusting the sol formulation. Characterization techniques such as UV-vis spectroscopy, scanning electron microscopy (SEM), scanning transmission electron microscopy (STEM), and X-ray photoelectron spectroscopy (XPS) were used to analyze the films. The photocatalytic activity was evaluated for H<sub>2</sub> generation under Mercury lamp illumination. The results demonstrate that the structure can be controlled by adjusting the sol formulation, thereby influencing the optical properties and the position of the Bragg peak reflection. It was observed that adjusting the Bragg position directly affects the photocatalytic performance of the photocatalyst, exploiting the slow photon effect.

### Acknowledgements

Masa Johar acknowledges all collaborators: François Brisset for SEM analysis, Diana Dragoie for XPS analysis, and Marie-Claire Schanne-Klein for the access to the polarized microscope, as well as Campus France and An-Najah National University for their joint scholarship.

### References

1. J. I. Chen, et al., Adv. Mater., 2006, 18(14), 1915-1919
2. G. D. Gesesse, et al., Chem. Mater., 2019, 31, 4851-4863
3. C. Wang, et al., J. Mater. Chem. A, 2020, 8, 10779-10786
4. W. Lin, et al., ChemSusChem, 2018, 11(1), 114-119

<https://events.rsc.org/rsc/frontend/reg/tAbsTopicList.csp?pageID=1007078&eventID=2836&userType=submitter>.



## Design and Synthesis of Cu(II/I) Complexes with 6,6'-Dimethyl-2,2'-Bipyridine Derivatives for Enhanced Hole Transport in Solid-State Dye-Sensitized Solar Cells.

MEIYI CHEN<sup>A</sup>, NEIL ROBERTSON<sup>A</sup>, YUE HU<sup>A</sup>

<sup>A</sup> The University of Edinburgh, David Brewster Road, Edinburgh EH9 3FJ, U.K.

### Abstract

#### 1. Identification of Problem and Significance to Dye-Sensitized Solar Cells (DSSCs):

Building upon our group's recent work<sup>1</sup>, the Rapid Zombie (RZ) Cell method offers a more efficient, stable, and affordable route for dye-sensitized solar cells. This establishes DSSCs as the potentially optimal photovoltaic solution for indoor and artificial light utilization for powering the internet-of-things. However, polyiodides as hole-transport material (HTM) present a challenge in RZ cells, causing high charge-recombination rates. To counter this, incorporating a more appropriate HTM is required to boost overall solar cell performance.

#### 2. Rationale:

Copper, abundant and non-toxic, serves as an ideal redox-species for the HTM in DSSCs. Cu ( I / II ) complexes with appropriate redox potentials and a unique distorted tetragonal geometry minimize energy loss through recombination, while enabling the application of thicker TiO<sub>2</sub> films hence more dye, enhancing the efficiency of DSSCs. However, the effectiveness of this type of HTM is affected by unwanted crystallization.

#### 3. Experimental Approach:

In this study, we design new copper complexes, utilizing the efficient 6,6'-dimethyl-2,2'-bipyridine scaffold for Cu(I) stabilization. Functionalizing the 4,4' position with various side chains aimed to hinder crystallization. Heteroleptic complexes were favoured for their precise adjustment of opto-electronic and structural properties compared to homoleptic complexes, leading to the preference for selecting Heteroleptic Cu(I/II) complexes in the preparation process.

#### 4. Conclusion:

In this study, building on these promising developments, we are poised to selectively favour heteroleptic copper(I/II) complexes as charge transport materials, with forthcoming application as HTM in dye-sensitized solar cells. The utilization of the Rapid Zombie Cell method for DSSC fabrication is expected to yield promising experimental outcomes.

### References

1. M. Sutton, B. Lei, H. Michaels, M. Freitag and N. Robertson, *ACS Applied Materials & Interfaces*, 2022, **14**, 43456–43462.

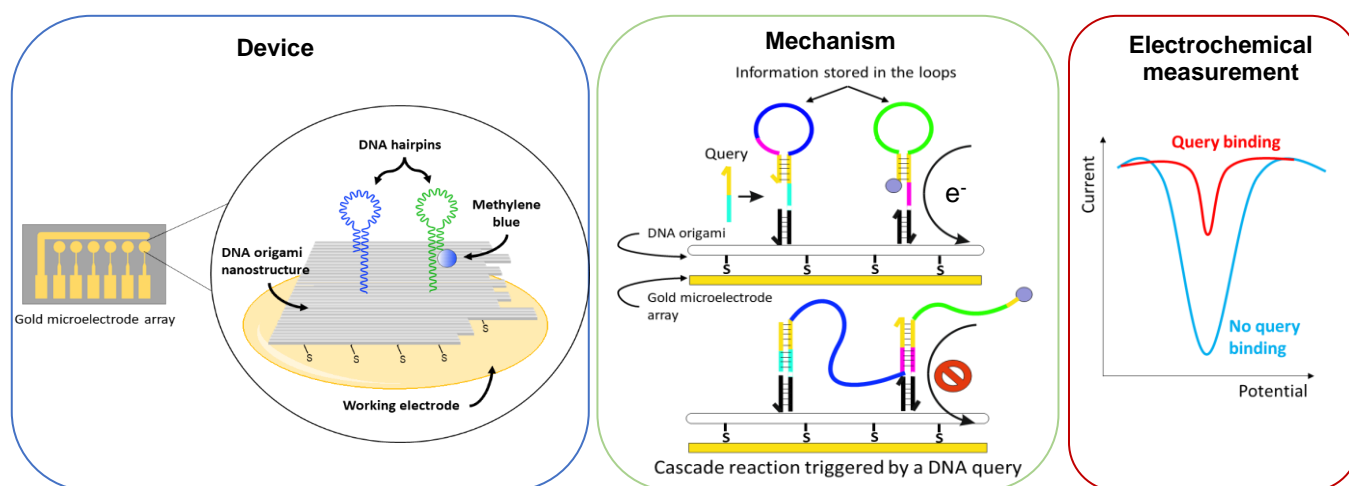
## Towards the Development of a Random Access DNA Memory (e-RADM)

MIGUEL JIMENEZ-MUNOZ<sup>1,2</sup>, CHRISTOPHER WOOD<sup>2</sup>, CHRISTOPH WÄLTI<sup>1,2</sup>

<sup>1</sup> Bragg Centre for Materials Research, University of Leeds. LS2 9JT. UK.; <sup>2</sup> School of electrical and electronic engineering. University of Leeds. LS2 9JT. UK

### Abstract

Over the last decades, we have produced an unprecedented and exponentially growing amount of information, now approaching the limit that current technology can physically store.<sup>1</sup> As a result, new approaches to data storage are required. DNA has emerged as a promising alternative for next generation data storage technology owing to its Shannon capacity of 2 bits of information per nucleotide.<sup>2</sup> This would, in theory, allow all data produced by 2025 to be stored in a single gram of DNA.<sup>3</sup> Current strategies aiming to use DNA as a data storage material rely on sequencing technologies for data recovery. However, the requirement to sequence all DNA strands in the memory device to retrieve a specific subset of information results in high levels of latency and poses a risk to the integrity of the information. To address this limitation, random access strategies are required.<sup>4</sup> Here, we present the first stages of an electrochemical Random Access DNA memory (e-RADM), which utilizes DNA origami nanostructures and localized strand displacement reactions (SDRs) for data manipulation. Short DNA hairpins containing toeholds complementary to parts of the sequence of adjacent hairpins are attached to a DNA origami such that cascades of SDRs can occur. When a data retrieval query is submitted in the form of a short oligonucleotide, only those hairpins with toeholds complementary to the oligo will open, triggering a cascade reaction. The unzipping of redox-labelled hairpins can be monitored by electrochemical means, as opened hairpins increase the average distance of the redox probe to the surface, preventing electrons to transfer to the electrode. We will show preliminary results demonstrating the feasibility of this.



### References

1. P. Stanley, L. Strittmatter, A. Vickers, K. Lee, *Biotechnol Adv*, 2020, DOI: 10.1016/j.biotechadv.2020.107639
2. Y. Dong, F. Sun, Z. Ping, Q. Ouyang, L. Qian, *Natl Sci Rev*, 2020, **7**, 1092–1107
3. Y. Hao, Q. Li, C. Fan, F. Wang, *Small Struct*, 2020, DOI: 10.1002/ssr.202000046
4. D. Carmean, L. Ceze, G. Seelig, K. Stewart, K. Strauss, M. Willsey, *Proc IEEE*, 2019, **107**, 63-72

## Development of an optimised coating technique for the functionalisation of micro and nanoelectrodes

RACHEL BOCKING<sup>A</sup>, THOMAS DIXON<sup>A</sup>, PROF HELEN PICTON<sup>B</sup>, DR PAOLO ACTIS<sup>C</sup>,  
DR ROBERT MENZEL<sup>A</sup>

<sup>A</sup> School of Chemistry, University of Leeds, U.K; <sup>B</sup> School of Medicine, University of Leeds, U.K, <sup>C</sup>  
School of Electrical & Electronic Engineering, University of Leeds, U.K

### Abstract

Micro and nanoscale electrodes present an exciting opportunity for the improvement of sensitivity, limit of detection and spatial resolution of electrochemical metabolite sensing measurements. While carbon nanoelectrodes and microelectrodes have been utilised for minimally invasive sensing in tissue<sup>1</sup>, their use in single cell studies remains underexplored due to poor signal-to-noise and selectivity issues. Through modification of these electrodes using high surface area catalytic materials, such as metal nanoparticle-nanocarbon composites, it is possible to achieve even higher sensitivity and tune the selectivity of these sensors. However, traditional coating techniques based on drop-casting are insufficiently precise on micro and nanoscale surfaces and there is evidence that extremely well-dispersed nanocarbons are required to produce non-charging deposits which do not produce excess capacitive currents.<sup>2</sup> Our work presents an adaptable and efficient method that uses a 'Design of Experiments' approach to optimise the functionalisation of microelectrodes using electrophoretic deposition, which to the best of our knowledge has not been used before in this context. Three variables were explored: voltage, deposition time and composite concentration, in a 3D design space. The results of this showed that a minimum threshold voltage was required and so, a further 2D design space was used at a fixed voltage to further optimise the deposition. This method was applicable across different solvent systems, showing the versatility of this approach for others' research. The resulting optimised electrode showed reduced capacitive contribution when used for electrochemical sensing, and an improved limit of detection compared to electrodes modified using un-optimised deposition parameters.

**Acknowledgements:** We would like to acknowledge the work by Ms. Brenna Parke (Imperial College London) for her contributions towards the work involving carbon fibre microelectrodes.

### References (Style: Royal Society of Chemistry)

1. P. Actis, S. Tokar, J. Clausmeyer, B. Babakinejad, S. Mikhaleva, R. Cornut, Y. Takahashi, A. L. Cordoba, P. Novak, A. I. Shevchuck, J. A. Dougan, S. G. Kazarian, P. V. Gorelkin, A. S. Erofeev, I. V. Yaminsky, P. R. Unwin, W. Schuhmann, D. Klenerman, D. A. Rusakov, E. V. Sviderskaya and Y. E. Korchev, *ACS Nano*, 2014, **8**, 875–884.
2. C. B. Jacobs, T. L. Vickrey and B. J. Venton, *The Analyst*, 2011, **136**, 3557.

**Abstract submission:** Abstracts must be submitted as a word or pdf file using the link below.

<https://events.rsc.org/rsc/frontend/reg/tAbsTopicList.csp?pageID=1007078&eventID=2836&userType=submitter>.

## Annual Symposium: Nanotechnology for Energy, Environment and Biomedicine

RACHEL ONCHURU<sup>A</sup>, PROFESSOR CLARE HOSKINS<sup>A</sup>

<sup>A</sup> Department of Pure and Applied Chemistry, University of Strathclyde, Glasgow, Scotland.

### Abstract

Pancreatic cancer is a very aggressive form of cancer, accounting for 7% of all cancer deaths. It is the eighth most common cancer in women and tenth most common cancer in men. The incidence rates of pancreatic cancer have gone up by around 1% each year since 2000. The lack of symptoms results in a delayed diagnosis and therefore, a delay in the treatment of cancer. Current therapies for pancreatic cancer include fluorouracil, gemcitabine and paclitaxel. Nanotechnology offers the benefit of enhancing drug delivery to the targeted tissue because of increased drug permeability. This also reduces side effects and sustains drug release over a long period of time. Thermo-responsive hybrid nanoparticles exhibit the potential for use as drug delivery systems for controlled drug release and have shown promise *in vivo* in pancreatic models, however further work is needed to get them ready for clinical trial. The focus for this project is to safely optimise a hybrid nanoparticle for pancreatic cancer treatment. Therefore, a range of assays will be performed to assess cytotoxicity of the nanoparticles. Hybrid particles have been surface engineered to protect the drug molecules from metabolism until they are heated and drug release occurs, and their surface protection via different polymers determined. The particles have been fully characterised and their *in vitro* effects on cell response monitored in cytotoxicity assays: MTT and Trypan Blue assay. The particles have been incubated with BxPC-3 cells and preliminary data suggests that addition of a poly (ethylene glycol) long chain linker, further protects the cells from any associated stress or toxicity from the hybrid surface. Tests are currently ongoing to determine the effect on another pancreatic cancer cell line: PANC-1. This is a revolutionary area for nanotechnology therapies to be applied in the treatment of cancers particularly pancreatic cancer. Thermo-responsive drug delivery also offers a new approach to nanotechnology and will ensure controlled drug release. More work is needed to fully evaluate these systems and is ongoing in the lab.

### Acknowledgements:

This work was done at the University of Strathclyde and supported by Keele University (TEM analysis and ICP), Warwick (SQUID analysis) and UWS (ICP analysis).

## Investigation of water-soluble binder for nano-sized $\text{LiFePO}_4/\text{C}$ cathode in water solvent slurry system

RAEIL JEONG<sup>A</sup>, YONG-TAE KIM<sup>\*B</sup>, JINSUB CHOI<sup>\*AC</sup>

<sup>A</sup>Department of Chemistry and Chemical Engineering, Inha University, 22212, Incheon, Republic of Korea

<sup>B</sup>Department of Chemical and Biomolecular Engineering, Chonnam National University, 59626, Yeosu, Republic of Korea

<sup>C</sup>Core Facility Center for Sustainable Energy Materials, Inha University, 22212, Incheon, Republic of Korea

\*Corresponding author: yongtaekim@jnu.ac.kr, jinsub@inha.ac.kr

### Abstract

With the rising demand for energy, energy storage and conversion have become global issues. Among the many types of energy storage devices, lithium-ion batteries (LIBs) have a significant share in the energy market, particularly in applications such as electric vehicles (EVs). One of the components of lithium-ion batteries, the cathodes are produced by mixing with polyvinylidene difluoride (PVDF) binder and 1-methyl-2-pyrrolidone (NMP) organic solvent. However, this combination is relatively expensive, toxic, and environmentally harmful. To address these issues, the development of a water-based cathode slurry is in demand.

In this study, we researched the aqueous processing of cathodes using LFP and investigated suitable new water-soluble binders. LFP was synthesized into nano-sized particles using ethylene glycol as a solvent through solvothermal synthesis. The physical properties, surface conditions, and crystal structures of the synthesized materials were confirmed using X-ray diffraction analysis (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). Electrochemical properties were then measured using coin half-cells to compare water and organic systems.

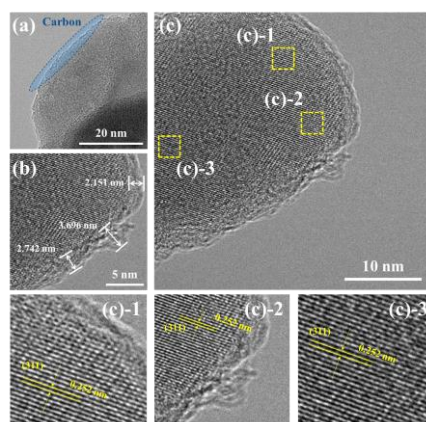


Figure 1 - TEM images of  $\text{LiFePO}_4/\text{C}$ : (a), (b) a carbon layer around the LFP surface. (c 1-3) Magnified images corresponding to the yellow box of (c).



## Effect of different carbon precursor and deposition temperature on properties of SiO<sub>x</sub>@C electrode

RAEYOON KIM<sup>A</sup>, YONG-TAE KIM<sup>\*B</sup>, JINSUB CHOI<sup>\*AC</sup>

<sup>A</sup>Department of Chemistry and Chemical Engineering, Inha University, 22212, Incheon, Republic of Korea

<sup>B</sup>Department of Chemical and Biomolecular Engineering, Chonnam National University, 59626, Yeosu, Republic of Korea

<sup>C</sup>Core Facility Center for Sustainable Energy Materials, Inha University, 22212, Incheon, Republic of Korea

\*Corresponding author: yongtaekim@jnu.ac.kr, jinsub@inha.ac.kr

### Abstract

With the escalating demand for large-scale batteries, particularly for use in electric vehicles (EVs) and energy storage systems (ESS), silicon has emerged as a promising next-generation anode material due to its high theoretical capacity of 4,200 mAh g<sup>-1</sup>. However, despite its potential, silicon has not yet been able to effectively replace carbonaceous anodes due to its low electrical conductivity and significant volume expansion during the charge and discharge process. Current research is tackling this issue by coating the surface of silicon with a carbon layer. However, there is a lack of comprehensive research evaluating the properties of this carbon layer based on the type of precursor and coating temperature.

In this study, we used chemical vapor deposition (CVD) to deposit a carbon layer onto the surface of SiO<sub>x</sub>, using either methane or acetylene as carbon precursors. We optimized the carbon coating process at various deposition temperatures based on property evaluations. The morphology and thickness of the carbon layer were assessed using transmission electron microscopy (TEM). In addition, we analyzed the composition and crystallinity using X-ray diffraction (XRD) and Raman spectroscopy. Finally, we evaluated the electrochemical performance of the Si-based anode materials by fabricating lithium-ion battery electrode half-cells.

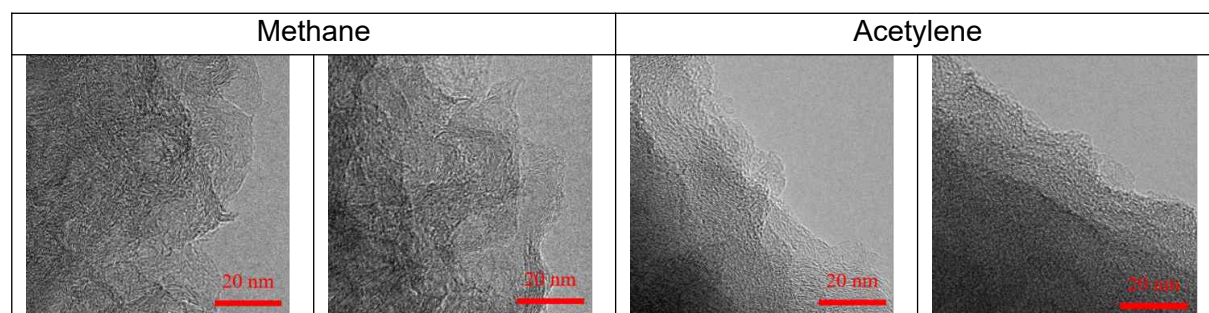


Figure 1 – TEM images of SiO<sub>x</sub>@C coated by different carbon precursor



## Palladium Nanoparticle Deposition on Spherical Carbon Supports for Heterogeneous Catalysis in Continuous Flow

SARAH L. BOYALL,<sup>A</sup> KEVIN LESLIE,<sup>B</sup> GRAEME CLEMENS,<sup>B</sup> FRANS L. MULLER,<sup>A</sup>  
RICHARD A. BOURNE,<sup>A</sup> AND THOMAS W. CHAMBERLAIN<sup>A</sup>

<sup>A</sup> Institute of Process Research and Development, University of Leeds, Leeds, LS2 9JT

<sup>B</sup> Chemical Development, Pharmaceutical Technology & Development, Operations,  
AstraZeneca, Macclesfield, SK10 2NA, United Kingdom

Heterogeneous catalysis is widely exploited by the chemical industry, both in batch reactors and in continuous flow, the latter via the use of packed bed reactors. Unfortunately, the transfer of commercially available heterogeneous catalysts to high pressure flow systems is often difficult, with challenges such as catalyst deactivation through metal leaching, and the crushing of pelleted supports. Thus, finding suitable catalysts for heterogeneous flow processes is a major bottle neck in the commercial implementation of these systems. Polymer-based spherical activated carbon beads (diameter = ~500  $\mu\text{m}$ ) offer a promising solution: these small, spherical and monodisperse beads have high mechanical strengths and large surface areas ( $1583 \pm 8 \text{ m}^2 \text{ g}^{-1}$ ), offering desirable properties for this task, such as reproducible packing and low pressure drops across packed catalyst beds. Two series of Pd/C spherical bead catalysts were synthesised, where highly active palladium nanoparticles (PdNPs) supported on spherical carbon beads with a narrow size distribution ( $d_{\text{NP}} = 5.0 \pm 1.4 \text{ nm}$ ) were formed via solution phase deposition. The catalysts were compared to a commercial catalyst from Johnson Matthey (1 wt.% Pd/C pellets), in small scale screenings (20 mg) via a recirculating batch platform, for their activity in a model nitro reduction reaction. The applicability of these NP catalysts for use in continuous flow was subsequently demonstrated on a larger scale (0.5-1 g), with a high activity and stability achieved over a two-day operating period. This work demonstrates the production of an active, stable heterogeneous catalyst suitable application in a pilot scale continuous flow packed bed reactor, for the production of APIs.

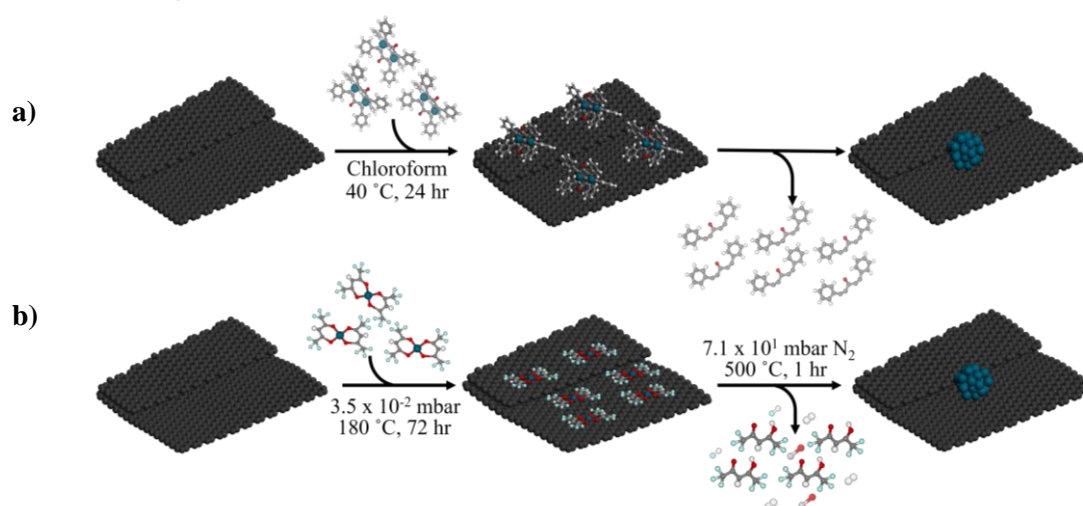


Figure 1 - a) Solution phase, dissociative adsorption of  $\text{Pd}_2(\text{dba})_3$  from  $\text{CHCl}_3$ , and b) gas phase deposition of  $\text{Pd}(\text{hexaFacac})_2$ , followed by thermal decomposition.

## Nanocarbon Aerogels for Catalytic Flow Processes

SEAN LEGGATT-BULAITIS<sup>A</sup>, JAMIE MANNERING<sup>A</sup>, ROBERT MENZEL<sup>A</sup>.

<sup>A</sup> School of Chemistry, University of Leeds

### Abstract

Continuous flow systems have been used for the past twenty years in the drive to automate chemical processes.<sup>1</sup> Researchers have endeavoured to convert batch catalytic systems to flow processes, leading to an improvement in scale, efficiency, safety, and cost. Currently, industrial chemical processes tend to use homogeneous catalysts for their optimised yields, conversions, and selectivity.<sup>2</sup> Yet there are many challenges such as sustainability, cost, and modifiability, that homogeneous processes face. Heterogeneous catalysts present a more versatile, robust, and comparatively cheaper approach to catalysing chemical processes in flow.

Conventional commercial heterogeneous catalysts tend to be powders, which prove difficult to retrieve, are prone to leaching and problematic to implement into packed bed reactor systems. Herein, this work shows effective use of macro-structured graphene aerogels as catalyst supports in fine chemical catalysis and small molecule electrocatalysis. Benefits of using 3D materials that fit directly into packed bed reactors include improving reaction kinetics through a series of factors: diffusion, confinement, and mass transport. In conjunction with this, we show that ice-templated hydrothermal synthesis of graphene aerogels enables fine-tuning of pore size, pore alignment and nanoparticle dispersity. Resultant metal nanoparticle-decorated graphene aerogels have appealing properties (i.e. large surface areas, high porosities, mechanical strength, impressive electrical and thermal conductivity) for use in fine-chemical flow reactors (such as Ru decorated graphene aerogels for transfer hydrogenation processes). These fine-chemical reactions give indications of how metal nanoparticle decorated graphene aerogels will fare in electrocatalytic flow systems (e.g. electrochemical CO<sub>2</sub> reduction). Through the implementation of heterogeneous catalysis in flow, robust and uncomplicated practices can be designed for a variety of valuable (electro)chemical reactions, leading to sustainable and efficient development of future catalytic systems.

### References

1. T. Noël, Y. Cao and G. Laudadio, *Acc. Chem. Res.*, 2019, **52**, 2858–2869.
2. V. Papa, Y. Cao, A. Spannenberg, K. Junge and M. Beller, *Nat. Catal.*, 2020, **3**, 135-142.

## Synthesis of Fe/TiNT photocatalyst for removal of pollutants from water

SHABNAM TAGHIPOUR<sup>A,B</sup>, NATEE WONGSRISUJARIT<sup>A</sup>, KING LUN YEUNG<sup>A</sup>, BEHZAD ATAIE-ASHTIANI<sup>B</sup>

<sup>A</sup> Department of Chemical and Biological Engineering, The Hong Kong University of Science and Technology, Kowloon, Hong Kong; <sup>B</sup> Department of Civil Engineering, Sharif University of Technology, Tehran, Iran.

### Abstract

Photocatalysis is one of the favorable technologies for environmental decontamination. This technology utilizes sunlight energy to activate the photocatalyst for chemical reactions. Titanium dioxide is one of the most-widely used catalyst in many area such as photocatalysis<sup>1</sup>. Beside nontoxicity, cheapness, and high chemical stability its large band gap (>3 eV) has considerably limited its application in solar-based photocatalytic application<sup>2</sup>.

This study presents the preparation of Fe(III) doped titanate nanotubes (Fe/TiNT) for photocatalytic degradation of 2,4-dichlorophenol (2,4-DCP). The obtained nanomaterial demonstrated high photocatalytic activity under visible light irradiation and effectively reduced the large band gap of TiNT by formation of heterojunction with TiNT. Moreover, nanoconfinement of Fe in the TiNT interlayer hindered the leakage of harmful dopants into water during treatment. Therefore, this study put forward a cost-effective, and environmentally friendly catalyst for possible application in large scales.

**Acknowledgements:** The authors are grateful for the financial support from the Hong Kong Research Grant Council (16211421), the Project of Hetao Shenzhen-Hong Kong Science and Technology Innovation Cooperation Zone (HZQB-KCZYB-2020083), and the staff from the MCPF, AEMF, and CBE in HKUST.

### References

1. A. Khadir, A.M. Ramezanali, S. Taghipour, K. Jafari, 2021. Physical, Chemical, and Biological Techniques. *Applied Water Science: Remediation Technologies*, 2021, **2**, 1-47.
2. Q. Guo, C. Zhou, Z. Ma, X. Yang, *Adv Mater*, 2019, **31(50)**, 1901997.

## Magnetic nanogels for combined hyperthermia and chemotherapy of prostate cancer

SOFIA PATRI<sup>A</sup>, LIUDMYLA STOROZHUK<sup>B</sup>, THANH NGUYEN<sup>B</sup>, NAZILA KAMALY<sup>C</sup>

<sup>A</sup> Department of Materials, Imperial College London; <sup>B</sup> Department of Physics and Astronomy, University College London; <sup>C</sup> Department of Chemistry, Imperial College London

### Abstract

Iron Oxide Nanoparticles (IONPs) are FDA approved for biomedical applications, such as magnetic hyperthermia<sup>1</sup>: IONP can generate heat as a consequence of their relaxation mechanism after being placed in an Alternating Magnetic Field (AMF)<sup>2</sup>. The heat generation is measured in Specific Absorption Rate (SAR) and agglomerations of IONPs, known as NanoFlowers (NFs), have shown to have the highest SAR out of all the variations of this material<sup>3</sup>. The surface of IONPs and IONFs can be modified with an organic coating to increase their biocompatibility<sup>2</sup>. By selecting the appropriate soft material, the organic shell can also encapsulate a cargo and release overtime: this new magnetic nanogel can combine hyperthermia with drug delivery, making it an effective treatment against cancer cells<sup>2</sup>. Nanogels, which are hydrogels in the nanoscale, are highly biocompatible and stable in the biological environment thanks to their crosslinked network; more importantly, they can be engineered to respond to an external stimulus<sup>4</sup>. By including a thermo-responsive unit in the nanogel, an increase in temperature will induce a coil to globule transition of the chains causing the shrinkage of the nanogel and the expulsion of water along with the encapsulated cargo<sup>5</sup>. In this multifunctional therapy, we aim to trigger drug release by using the heat generated by the IONFs in an AMF. To improve the stability of the nanocarrier in the physiological environment, we demonstrate the necessity to anchor the nanogel to the IONFs through a surface ligand. The development of a functional and stable magnetic nanogels provides a more effective, localised and precise therapy that combines the benefit of the monotherapies while minimising their individual drawbacks whilst establishing synergistic actions.

**Acknowledgements:** The authors would like to thank EPSRC U.K. for financial support through the CDT Advanced Materials Characterisation.

### References

1. P. Majewski and B. Thierry, *Crit. Rev. Solid State Mater. Sci.*, 2007, **32**, 203–215.
2. E. Guisasola, A. Baeza, L. Asín, J. M. dela Fuente and M. Vallet-Regí, *Small Methods*, 2018, **2**, 1800007–1800018.
3. L. Storozhuk, M. O. Besenhard, S. Mourdikoudis, A. P. LaGrow, M. R. Lees, L. D. Tung, A. Gavrilidis and N. T. K. Thanh, *ACS Appl. Mater. Interfaces*, 2021, **12**, 45870–45880.
4. N. T. Thanh, in *Magnetic Nanoparticles: From Fabrication to Clinical Applications*, CRC press, Taylor & Francis group, 1st edn, 2012, ch. 1, pp. 7–8.
5. B. Sung, M.-H. Kim and L. Abelman, *Bioeng. Transl. Med.*, 2021, **6**, e10190

## Development of novel antimony materials for next generation supercapacitors

TIANXIN LIANG<sup>A</sup>, DR. CAROLINE KIRK<sup>\*A</sup>, PROF. NEIL ROBERTSON<sup>\*A</sup>

<sup>A</sup> School of Chemistry, University of Edinburgh, David Brewster Road, Edinburgh, UK

### Abstract

This poster introduces the synthesis, characterization, and potential applications of antimony sulfide iodide (SbSI) in the realm of supercapacitors, addressing the increasing global demand for advanced energy storage solutions. We report the synthesis, characterisation and electrochemical performance of SbSI, prepared using an innovative precipitation method which is energy efficient, environmentally friendly, and operational convenient compared to conventional hydrothermal and ultrasonic methods. The precipitation method operates under ambient conditions, offering ecological advantages by minimizing solvent usage and avoiding the generation of hazardous by-products.

Electrochemical assessments of SbSI electrodes through cyclic voltammetry (CV) and galvanostatic charge/discharge (GCD) tests uncover distinctive features. The CV curve exhibits oxidation and reduction peaks at 0.5 V and 0.18 V, respectively, reflecting a substantial specific capacity of 2206 C g<sup>-1</sup>, and capacitance of 359 F g<sup>-1</sup> albeit slightly lower than reported literature values, potentially influenced by electrolyte differences and material dislodgment during testing.

Future work will focus on improving electrode preparation methods (e.g. in-situ growth) and electrochemical testing. The research will also extend to testing and performance optimisation of capacitors in non-aqueous environments, as well as investigating long-term stability and scalability.

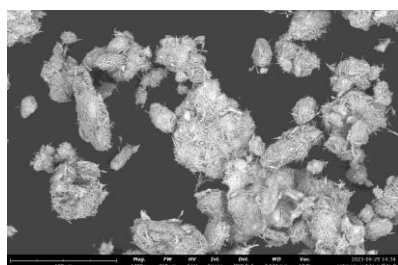


Figure 1 - SEM image of SbSI synthesised using a precipitation method

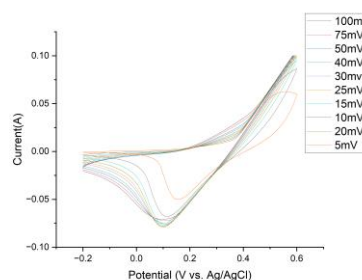


Figure 2 - CV curves at different scan rates

### References

1. S. Manoharan, D. Kesavan, P. Pazhamalai, K. Krishnamoorthy and S. Kim, *Materials Chemistry Frontiers*, 2021, **5**, 2303–2312.
2. R. Justinabraham, S. Subramanian, A. Durairaj, S. Thangavel, R. Wesley, V. Vijaikanth and S. Vasanthkumar, *Journal of Alloys and Compounds*, 2023, **935**, 168115–168115.

## **Photoactive Coatings for Surface Disinfection and Decontamination**

J. Anthony Byrne

School of Engineering, Ulster University, Belfast

### **Abstract**

During the COVID pandemic there was increased awareness about surface disinfection and the potential for the transmission of infectious diseases by contaminated surfaces (fomite spread). Although the evidence to support transmission of COVID via surface contamination was limited at the time, there was an explosion of research activity related to the decontamination of surfaces and the marketing of surface disinfection products. A recent study has shown that the presence of SARS-CoV-2 RNA on primary cases' and contacts' hands and on frequently-touched household surfaces associates with transmission, identifying these as potential vectors for spread in households [1]. There is also real concern in relation to the transmission of other infectious agents via surface contamination, including antimicrobial resistant pathogens, particularly in healthcare settings.

One potential solution to reduce the transmission of disease is to use photoactive surface coatings which can inactivate infectious agents and maintain activity, providing a 'residual' disinfection function. This contribution will discuss work that has been done over a period of years at Ulster in relation to surface disinfection and decontamination using UV or light activated coatings.

There are many challenges to be addressed including the development of visible light active coatings which can be excited under ambient lighting conditions in healthcare environments or other enclosed spaces. Such coatings must be robust and maintain activity even after rigorous physical and chemical cleaning. Also, the development of photo-active coatings which can be applied to polymer surfaces is another challenging area.

Validating the effectiveness of such interventions can prove to be very challenging not only in the laboratory, but even more so in healthcare settings where the situation is very complex pertaining to infection transmission. Furthermore, some researchers argue that the indiscriminate use antimicrobial surfaces is not without risk and potentially counterproductive in that partial or ineffective disinfection could lead to an increased risk of antimicrobial resistance [2].

Research into effective photoactive coatings for surface disinfection and decontamination remains to be an exciting and challenging interdisciplinary field.

### **References**

[1] Derqui et al, The Lancet Microbe, 2023, 4 (3), E397-E408

[2] Cassidy et al, PLoS Pathog. 2020, 16(10): e1008880.d



## **Flame-made lithium titanate nanoparticles with superior cycle stability as promising anode materials for lithium-ion batteries**

VASILIKI TSIKOURKITOUDI

Department of Microbiology, Tumor and Cell Biology, Karolinska Institutet, Stockholm, Sweden;

### **Abstract**

Lithium titanate ( $\text{Li}_4\text{Ti}_5\text{O}_{12}$ , LTO) is currently considered as one of the most promising anode materials to replace graphite in lithium-ion cells for large scale applications, since it has a negligible volume change upon lithiation/delithiation process and a lithium (de-) insertion potential of around 1.55 V vs.  $\text{Li}^+/\text{Li}$ , that assists in dendrite formation risk, lithium plating, and electrolyte decomposition<sup>1</sup>. However, the size of LTO nanoparticles affect their electrochemical performance.

In this regard, here, we synthesize LTO nanoparticles of different sizes by flame spray pyrolysis (FSP), that is a one-step synthesis process famous for its scalability and reproducibility. During FSP, a liquid precursor solution is converted to nanoparticles after combustion of the spray in the flame zone. The nanoparticles are formed after nucleation, growth, and agglomeration/aggregation. The ability of FSP to easily tune nanoparticle properties (such as their specific surface area/size) is highlighted. Various LTO nanoparticles with primary particle sizes ranging from 8 to 21 nm are produced and thoroughly characterized by various analytical tools. Their electrochemical properties are evaluated in half cells by cyclic voltammetry and galvanostatic charge/discharge studies.

LTO nanoparticles of 18 nm show the best electrochemical performance with almost 100% capacity retention after 400 charge/discharge cycles. The smallest particles tested (8 nm) have a capacity loss of more than 60%. Less efficient use of the intercalation sites is observed for particles with size < 16 nm, due to higher ratio of surface to bulk atoms and to stress caused by the higher curvature at the crystallite surface. Maximum utilization of the active material per charging/discharging cycle is achieved since the specific capacity of LTO nanoparticles with optimal properties is close to the theoretical value for LTO (175 mAh/g). Moreover, flame-made LTO shows remarkable electrochemical performance in comparison to commercial one and to the one prepared by conventional sol-gel method.

### **References**

1. Xiangcheng Sun, Pavle V. Radovanovic, Bo Cui, *New J. Chem*, 2015, **39**, 38-63.

## NAD-boosting antioxidant nanoformulations for glaucoma treatment

VASILIKI TSIKOURKITOUDI<sup>A</sup>, MELISSA JÖE<sup>B</sup>, PETE A. WILLIAMS<sup>B</sup>,  
GEORGIOS A. SOTIRIOU<sup>A</sup>

<sup>A</sup> Department of Microbiology, Tumor and Cell Biology, Karolinska Institutet, Stockholm, Sweden;

<sup>B</sup> Department of Clinical Neuroscience, Division of Eye and Vision, St. Erik Eye Hospital, Karolinska Institutet, Stockholm, Sweden

### Abstract

Glaucoma is a common age-related progressive optic neuropathy that leads to irreversible blindness. Current therapies have been proven insufficient since the risk of blindness remains high. Therefore, there is an urgent medical need for alternative treatments. Recently, an ideal target for neuroprotective glaucoma therapies was identified, namely the metabolic intermediate nicotinamide adenine dinucleotide (NAD), that is associated to glaucoma pathogenesis<sup>1</sup>. Moreover, it was demonstrated that natural antioxidants can boost NAD production. However, the effectiveness of such antioxidants is limited due to poor bioavailability.

To address these challenges, here, we propose a novel nanoparticle-mediated drug delivery system consisting of biocompatible SiO<sub>2</sub> nanoparticles and green tea polyphenols that boost NAD production. We synthesize SiO<sub>2</sub> nanoparticles by flame spray pyrolysis that is a highly reproducible and intrinsically scalable technique in which a liquid precursor is ignited and combusted. Nanoparticles are formed in the flame by nucleation, surface growth, coagulation, and coalescence and collected on a glass fibre filter.

As-synthesized SiO<sub>2</sub> nanoparticles (specific surface area 216m<sup>2</sup>/g, primary particle size 10nm) are first functionalized by 3-aminopropyl-triethoxysilane and then gallic acid (GA) and epigallocatechin gallate (EGCG) are covalently grafted on their surface. High loading values are achieved (90mg GA/g<sub>particle</sub> and 150mg EGCG/g<sub>particle</sub>) because of the high surface-to-volume ratio<sup>2</sup> of nanoparticles that renders them suitable for long term drug administration with enhanced bioavailability. NAD-boosting capability of the nanoparticle formulations is evaluated *in vitro* by luminometry assay on cortical neurons in suspension after 2h incubation. GA and EGCG-loaded SiO<sub>2</sub> nanoparticles induce a higher fold change of NAD compared to SiO<sub>2</sub> nanoparticles at equivalent particle concentrations.

Our results imply that high drug loading delivery systems based on flame-made nanocarriers can improve eye drug delivery for glaucoma prevention. Since the proposed drug delivery system consists of biocompatible and natural compounds, clinical translation can be facilitated.

**Acknowledgements:** This work was supported by European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (ERC Grant agreement n°758705) and the Strategic Research Area Neuroscience (StratNeuro). Funding from Ögonfonden (Eye Foundation) and Loo and Hans Osterman Foundation is also kindly acknowledged.

### References

1. James R. Tribble *et al.*, *Redox Biol.*, 2021, **43**, 101988.
2. Vasiliki Tsikourkitoudi *et al.*, *Molecules*, 2020, **25**, 1747.

## Tuning the Catalytic Activity of Bifunctional Cobalt Boride Nanoflakes for Overall Water Splitting over a Wide pH Range

FATMA ABDEL GHAFAR<sup>A,B</sup>, DIOR ETHEERTON<sup>C</sup>, SHAOMIN LIU<sup>D</sup>, CRAIG E. BUCKLEY<sup>C</sup>,  
NIALL J. ENGLISH<sup>E</sup>, DEBBIE S. SILVESTER<sup>A</sup>, M. VERONICA SOFIANOS<sup>C,E</sup>,

<sup>A</sup>School of Molecular and Life Sciences, Curtin University, Perth 6845, Western Australia, Australia,

<sup>B</sup>Department of Evaluation and Analysis, Egyptian Petroleum Research Institute, Cairo, Egypt

<sup>C</sup>Physics and Astronomy, Curtin University, Perth, Bentley 6102, Australia

<sup>D</sup>College of Chemical Engineering, Beijing University of Chemical Technology, Beijing 100029, People's Republic of China

<sup>E</sup>School of Chemical and Bioprocess Engineering, University College Dublin, Belfield, Dublin 4, Ireland

### Abstract

The world is in the process of transitioning towards a more sustainable energy future, with green hydrogen considered an attractive energy vector that can replace fossil fuel consumption, meeting global energy demands. To date, the most advanced method to produce green hydrogen is through water electrolysis using the residual supply of renewable energy.<sup>1</sup> The current state-of-the-art catalysts used in electrolyzers are platinum-based metals and ruthenium/iridium oxides.<sup>2</sup> The scarceness of these elements, combined with their high price, make these catalysts not economically viable for largescale production of hydrogen through water electrolysis. This study presents cobalt boride nanoflakes as materials to be used in both the anode and the cathode of an electrolyzer for electrochemical water splitting over a wide pH range. The cobalt boride nanoflakes were synthesized by the chemical reduction of  $\text{CoCl}_2$  using  $\text{NaBH}_4$  at three different concentrations to obtain CoB and  $\text{Co}_2\text{B}$  nanoflakes. CoB nanoflakes exhibited both a higher specific surface area and greatest disparity in charge between B and Co, in comparison to  $\text{Co}_2\text{B}$ . It was demonstrated that by tuning the properties of the cobalt boride nanoflakes, higher catalytic activities for both the hydrogen and oxygen evolution reaction can be achieved, showing good overall stability.

**Acknowledgements:** MVS acknowledges the financial support from the Research and Development Committee Small Grant Program 2018 from Curtin University, the UCD Ad Astra fellowship programme, and the Royal Chemical Society for the Research Enablement Grant #72049. CEB acknowledges the financial support of the Australian Research Council (ARC) for LIEF equipment grants LE0775551, LE120100026 and LE140100075, which enabled the XRD, XPS and SAXS measurements to be undertaken. DSS thanks the ARC for a Future Fellowship (FT170100315). FAG acknowledges the Egyptian Ministry of Higher Education and Scientific Research, Cultural Affairs and Missions sector, Egypt for a PhD scholarship. The authors acknowledge the technical assistance of Matthew Rowles and the facilities of the X-ray Diffraction Facility of the John de Laeter Centre at Curtin University.

### References

1. G. N. Glavee, K. J. Klabunde, C. M. Sorensen and G. C. Hadjipanayis, *Langmuir*, 1993, **9**, 162-169.
2. J. Wang, X. Yue, Y. Yang, S. Sirisomboonchai, P. Wang, X. Ma, A. Abudula and G. Guan, *Journal of Alloys and Compounds*, 2020, **819**, 153346.

## Cationic sequence-controlled PEGylated multi-block polyesters for enhanced RNA delivery and thermostability

XINYU LU, RONGJUN CHEN\*

Department of Chemical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, United Kingdom

### Abstract

mRNA-based vaccines have recently gained considerable attention as they outperform conventional vaccines in terms of large-scale production and cost-effectiveness without the compromise on vaccine efficacy. Self-amplifying RNA (saRNA) vaccines on the other hand, can achieve adequate protein expression with lower doses compared to mRNA vaccines, owing to the self-replicative activity of saRNA. However, efficient intracellular delivery of saRNA remains challenging since saRNA molecules are highly negatively charged and have much larger molecular weight than other RNA molecules including mRNA<sup>1</sup>. In addition, it is also very challenging to maintain RNA stability, as the currently approved mRNA vaccines have to be stored in an ultra-cold chain at a temperature of -20 or -70 °C<sup>2</sup>. To address these constraints, we developed a series of novel biodegradable cationic PEGylated multi-block polyesters (PEG-mbPE) with different block arrangements and molecular weights. All PEG-mbPE were synthesized from lactone monomers via our recently developed quantitative one-pot iterative living ring-opening polymerization (QOIL-ROP) method by using mPEG as an initiator. The saRNA/PEG-mbPE polymeric nanoparticles (PNPs) with controllable hydrodynamic size were obtained at various N/P ratios via a simple nanoprecipitation method. It was demonstrated that the cell transfection efficiency was highly dependent on both block arrangement and molecular weight of the copolymers. The saRNA/PEG-mbPE PNPs showed remarkably enhanced protein expression and negligible cytotoxicity compared to the benchmark system based on cationic polyethylenimine (PEI). The saRNA/PEG-mbPE PNPs were also capable of co-delivery of hydrophobic drug ruxolitinib, leading to further enhanced transfection efficiency. Furthermore, the optimal saRNA/PEG-mbPE PNPs retained excellent colloidal and RNA stability for at least 16 weeks in a lyophilized form at refrigerator temperatures. This work presents our sequence-controlled cationic PEG-mbPE as a promising saRNA delivery platform due to the simple and scalable production of polymers and nanoparticles, excellent biocompatibility, and improved long-term colloidal and RNA stability.

**Acknowledgements:** This research was funded by the Department of Health and Social Care using U.K. Aid funding and managed by the Engineering and Physical Sciences Research Council (EPSRC; grant number: EP/R013764/1). The authors thank Prof. Robin Shattock's group for offering fLuc-saRNA.

### References

1. A. K. Blakney, Y. Zhu, P. F. McKay, C. R. Bouton, J. Yeow, J. Tang, K. Hu, K. Samnuan, C. L. Grigsby, R. J. Shattock and M. M. Stevens, *ACS Nano*, 2020, **14**, 5711–5727.
2. M. N. Uddin and M. A. Roni, *Vaccines*, 2021, **9**, 1033.

## Fluoride-free porous TiO<sub>2</sub> fabricated by polymer resin assisted-anodization

YUNJI LEE<sup>A</sup>, YONG-TAE KIM<sup>\*B</sup>, JINSUB CHOI<sup>\*AC</sup>

<sup>A</sup>Department of Chemistry and Chemical Engineering, Inha University, 22212, Incheon, Republic of Korea

<sup>B</sup>Department of Chemical and Biomolecular Engineering, Chonnam National University, 59626, Yeosu, Republic of Korea

<sup>C</sup>Core Facility Center for Sustainable Energy Materials, Inha University, 22212, Incheon, Republic of Korea

\*Corresponding author: yongtaekim@jnu.ac.kr, jinsub@inha.ac.kr

### Abstract

Titanium (Ti) is currently under investigation to fabricate the oxide films with unique nanostructures through anodization. Its robust corrosion resistance, semiconductor properties, and lightweight nature make it a preferred choice in various sectors such as medicine, photocatalysis, and aviation. Traditionally, anodization is performed in an electrolyte containing fluoride ions. However, this method results in weak adhesion between the oxide film and Ti substrate due to the fluoride-rich layers. Recently, additional treatment after anodization was researched to enhance the adhesion properties. However, there is a fundamental limitation on anodization using electrolytes with fluorine ions.

In this study, we successfully fabricated an oxide film with excellent adhesive strength using a polymer resin-assisted anodization that does not induce a fluoride-rich layer. By adjusting the reaction voltage, we could control the thickness and pore size of the oxide film. We compared the surface roughness and hardness of the oxide films with and without fluoride-rich layers. Additionally, we investigated the morphology and crystallinity using scanning electron microscopy (SEM) and X-ray diffraction (XRD). By introducing a novel anodization mechanism, we have broadened the application scope of anodized titanium oxide, which was previously limited due to the fluoride-rich layer.

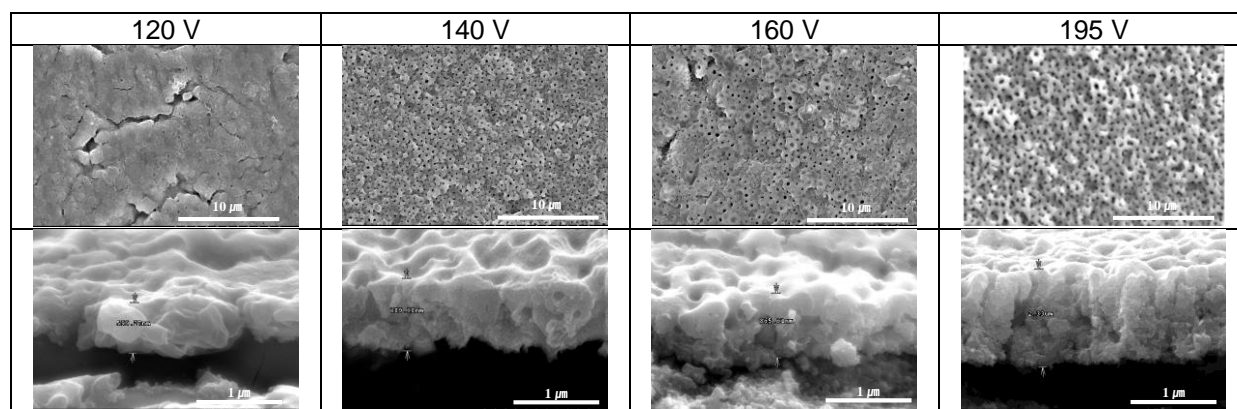


Figure 1 – SEM images of TiO<sub>2</sub> controlled by reaction voltage



## Graphene aerogel and carbon black supported catalyst for proton exchange membrane fuel cells

ZIYU ZHAO<sup>A</sup>, LING AI<sup>A</sup>, ZEYU ZHOU<sup>A</sup>, XIAOCHEN YANG<sup>A</sup>, HENG ZHAI<sup>A</sup>, STUART HOLMES<sup>A</sup>

<sup>A</sup> Department of Chemical Engineering and Analytical Science, The University of Manchester, Manchester M13 9PL, UK

### Abstract

Carbon supported Pt nanocatalysts, which are commonly used in hydrogen fuel cells, suffer from Pt degradation and carbon corrosion<sup>1</sup>. Graphene aerogels (GA) are a prospective material with porous 3D-structure, large surface area, high conductivity, and good electrochemical stability<sup>2, 3</sup>. The nitrogen doped GA (NGA) could improve ORR activity and electronic conductivity by changing the electronic structure and provide a stable anchor point for Pt nanoparticles to enhance the durability of catalysts<sup>4, 5</sup>.

However, most GAs are made from graphene oxide (GO) produced by Hummers method which may cause safety issue due to the highly toxic chemicals<sup>2, 5</sup>. Also, there are few articles on the application of GA in fuel cells. It may be limited by the collapse of pore structure caused by compression in a fuel cell.

In this work, GO produced by electrochemical exfoliation (EGO) was used to prepare NGA via hydrothermal treatment with ammonia solution. Moreover, NGA was mixed with carbon black (CB) as a hybrid support material that can avoid collapse of the macropore and generate a graphene-carbon network to provide large surface area. A rich macro-mesoporous structure of NGA was observed in Figure 1 (a). Pt catalyst with 20% NGA has a maximum power density of 838 mW cm<sup>-2</sup> which is a 31% improvement over that of Pt/CB (Figure 1 (b)).

In conclusion, this study presents an efficient way to synthesize NGA. The introduction of NGA into CB as catalyst supports can improve the electrochemical active surface area and performance of fuel cells due to GA's high conductivity and porosity. This will help to reduce the cost of fuel cells and facilitate their commercialization in various fields of application.

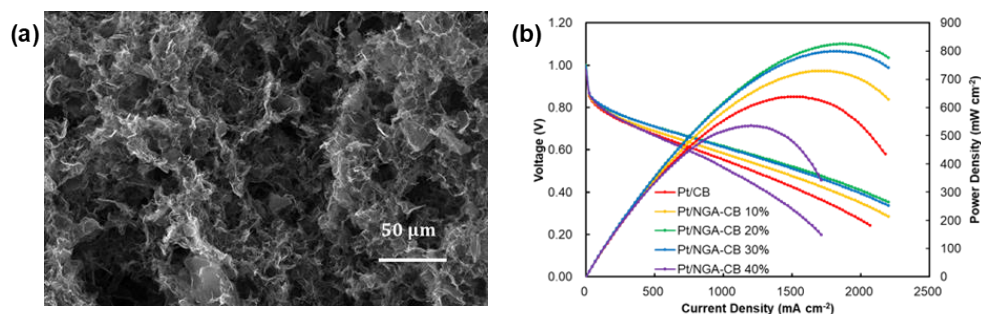


Figure 1 (a) SEM images of dried NGA. (b) Performance of Pt/NGA-CB and Pt/CB catalysts in a hydrogen fuel cell at 60 °C with 100% RH.

### References

1. J. Liu, X. Wu, L. Yang, F. Wang and J. Yin, *Electrochim. Acta*, 2019, **297**, 539-544.
2. F. E. Sarac Oztuna, S. B. Barim, S. E. Bozbag, H. Yu, M. Aindow, U. Unal and C. Erkey, *Electrochim. Acta*, 2017, **250**, 174-184.
3. Z.-S. Wu, S. Yang, Y. Sun, K. Parvez, X. Feng and K. Müllen, *J. Am. Chem. Soc.*, 2012, **134**, 9082-9085.
4. O. L. Li, S. Chiba, Y. Wada, G. Panomsuwan and T. Ishizaki, *J. Mater. Chem. A*, 2017, **5**, 2073-2082.
5. B. Xie, Y. Zhang and R. Zhang, *J. Mater. Chem. A*, 2017, **5**, 17544-17548.



# Thank you!

from the Chemical Nanoscience and Nanotechnology  
Committee

**Aaron Lau**, United Kingdom

**Clare Hoskins**, United Kingdom

**Dionisia Jesus**, United Kingdom

**Euan Kay**, United Kingdom

**John (Tony) Byrne**, United Kingdom

**Junwang Wang**, United Kingdom

**Lauren Evans**, United Kingdom

**Paul McNaughter**, United Kingdom

**Susete Fernandes**, Portugal

**Veronica Sofianos**, Ireland

**Yimin Chao**, United Kingdom





ROYAL SOCIETY  
OF **CHEMISTRY**

CHEMICAL NANOSCIENCE  
AND NANOTECHNOLOGY  
GROUP