



Nanomaterials for gas sensing and delivery

Cite this: *Nanoscale Adv.*, 2024, 6, 2739Run Zhang, ^a Songjun Zeng ^b and Rona Chandrawati ^c

DOI: 10.1039/d4na90050b

rsc.li/nanoscale-advances

Gas molecules play an essential role in various environmental and health applications, spanning from atmospheric

^aAustralian Institute for Bioengineering and Nanotechnology, The University of Queensland, St. Lucia, Queensland 4072, Australia. E-mail: r.zhang@uq.edu.au

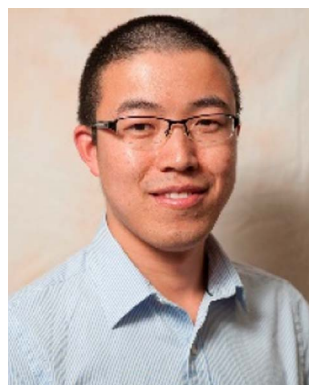
^bSchool of Physics and Electronics, Key Laboratory of Low-dimensional Quantum Structures and Quantum Control of the Ministry of Education, Hunan Normal University, Changsha, Hunan 410081, China. E-mail: songjunz@hunnu.edu.cn

^cSchool of Chemical Engineering, Australian Centre for Nanomedicine (ACN), The University of New South Wales, Sydney, NSW 2052, Australia. E-mail: rona.chandrawati@unsw.edu.au

composition and climate regulation to biomedical diagnosis and therapies, as well as industrial processes. For instance, oxygen (O₂), nitrogen (N₂), carbon dioxide (CO₂), methane (CH₄), and ozone (O₃) are key atmospheric components, while elevated levels of CO₂, CH₄, O₃ and other greenhouse gases, such as nitrous oxide (N₂O) resulting from increasing human activities, pose significant environmental and human health risks. Other gases, such as nitric oxide (NO), hydrogen sulfide (H₂S), carbon monoxide (CO), and sulfur dioxide (SO₂) are known for their high toxicity. However, recent studies

have established their role as gaso-transmitters in the body with important physiological functions. Therefore, effective management and responsible use of gases is essential for sustainable development and safeguarding human health and the environment.

Gas sensors are instrumental in enhancing gas management practices by providing reliable, real-time data for decision-making, risk assessment, and implementing proactive measures to protect human health and the environment. Specifically for biomedical studies, several gas molecules have been key



Run Zhang

Run Zhang is a senior research fellow at the Australian Institute for Bioengineering and Nanotechnology, The University of Queensland (AIBN UQ). He received his PhD in analytical chemistry from the Dalian University of Technology in 2012. He worked at Macquarie University (MQ) as a postdoc (2012) and then as an independent MQ research fellow (2013–15). He joined AIBN UQ in 2016 and received ARC DECRA

(2017–19) and NHMRC Emerging Leadership (2020) awards. He now leads the Sensing and Imaging Research Group at UQ, focusing on the development of responsive molecules/nanomaterials for biosensing and imaging, early disease detection and treatment, and food/agricultural/environmental analysis.



Songjun Zeng

Songjun Zeng is a professor at the School of Physics and Electronics and Institute of Interdisciplinary Studies, Hunan Normal University (HNNU China). He received his PhD in material physics and chemistry from Xiangtan University (2010), and conducted post-doctoral research at the Hong Kong Polytechnic University (2011–2012). His research interests focus on the development of multifunction optical nanoprobe for bioimaging and sensing applications.



biomarkers for various diseases, such as cardiovascular disease, cancers, and neurodegenerative disorders (*e.g.*, Alzheimer's and Parkinson's disease). Detection of these gaseous biomarkers using sensors tailored for biomedical investigations is contributing significantly to early diagnosis of these diseases and monitoring the treatment efficiency. Moreover, considering the important roles of gaseous biomolecules in disease development, recent research involves the delivery of exogenously therapeutic gases (*e.g.*, gasotransmitters, hydrogen) to the targeted diseased tissues for therapy.

Despite notable progress in gas sensing and delivery technologies, several challenges persist in their development and implementation. Selectivity, sensitivity, response time and stability are common considerations in developing advanced sensors for gas detection. In gas therapies, precise delivery of the gas to the targeted diseased tissue and the subsequent controlled release by external and internal stimulations are

crucial to achieve high treatment outcomes with minimal side effects.

The last few decades have witnessed rapid progress in the development of advanced nanotechnology for various applications in medicine, environmental and life sciences, energy, and catalysis. In particular, to address the challenges in the management of gases (including noxious gas and therapeutic gas), a series of nanoscale materials with fascinating structural, physical, and chemical characteristics have been developed for gas sensing and delivery in recent years. Specifically, nanosensors with a reliable, fast, sensitive, and specific response to target gaseous molecules or vapours, are proved to be one of the most direct and effective tools for gas detection and identification. In biomedical and medicinal investigations, theranostic nanoparticles have shown great potential in shuttling drug-like gases (*e.g.* gasotransmitters, H₂, O₂, *etc.*) to remote diseased sites for therapeutic purposes.

Nanoscale Advances is an international gold open access journal, publishing

high-quality papers across the breadth of nanoscience and nanotechnology. In this themed collection of *Nanoscale Advances*, we aim to provide a forum for recent trends in the rapidly evolving field of nanomaterials for gas sensing and delivery. The selection includes both review and original research articles, covering the preparation and characterization of nanomaterials (*e.g.*, graphene, quantum dots, monocrystalline, metal-organic framework, and two-dimensional nanomaterials, such as Mxene), their applications in the management of gases (*e.g.*, nitrogen dioxide), and the development of nanomaterials-based devices for gas sensing.

As Guest Editors of this themed issue, we would like to express our sincere gratitude to the authors for their high quality contributions, all anonymous reviewers who dedicated their valuable time to evaluate the submissions, and members of the *Nanoscale Advances* editorial team (especially Dr Hannah Kerr) for their guidance and support throughout the preparation of this issue.



Rona Chandrawati

Rona Chandrawati is a Scientia associate professor and NHMRC Emerging Leadership fellow at the University of New South Wales (UNSW Sydney), and a co-director of the Australian Centre for Nanomedicine. She obtained her PhD from the Department of Chemical and Biomolecular Engineering at the University of Melbourne in 2012. She was then a Marie Curie Fellow at Imperial College London before returning to Australia in 2015 to establish her research group. Her research interests include organic and inorganic nanomaterials for sensing and drug delivery.

