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# Introduction to metal nanoclusters

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Metal nanoclusters play a crucial role in understanding the evolution of bulk structures from molecules, offering insights into their unique physicochemical properties. Due to their unique structural geometry and elegant properties, metal nanoclusters show potential across diverse fields, from molecular chemistry and nanotechnology to materials science and biology. This themed collection from *Nanoscale* presents recent advancements in atomically

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**Di Sun**

*Prof. Di Sun received his B.S. (2005) from Liaocheng University, and M.S. (2008) and his Ph.D. (2011) from Xiamen University under the guidance of Prof. Su-Yuan Xie, Rong-Bin Huang and Lan-Sun Zheng, respectively. In 2011, he was appointed as a Lecturer at Shandong University, and in 2014 and 2017 he was promoted to Associate Professor and Professor, respectively. His research interests include coordination chemistry and high-nuclear metal cluster chemistry. Prof. Sun has published over 200 research publications, which have been cited over 10 000 times, H index = 68.*

**Yuichi Negishi**

*Prof. Yuichi Negishi is a Professor of the Institute of Multidisciplinary Research for Advanced Materials at Tohoku University. He received his Ph.D. degree in Chemistry (2001) from Keio University. Prior to joining Tohoku University in 2024, he was employed as a Professor at Tokyo University of Science since 2008 and before that worked as an Assistant Professor at Keio University and the Institute for Molecular Science. His research interests include the structural and functional exploration of atomically precise metal NCs, metal NC-assembled materials, and covalent organic frameworks.*

precise metal clusters and their assemblies, covering their structures, properties, and applications.

This collection features pioneering research in cutting-edge areas, covering new structures, photoluminescence, catalysis, mass spectrometry of cluster–DNA conjugates, nanocluster transformation reactions, and theoretical studies. Key topics in photoluminescence include infrared emission, ultrafast relaxation dynamics, and thermally activated delayed fluorescence, while catalytic studies focus on $CO_2$ reduction, CO oxidation, and hydrogen evolution reactions.

**Anindita Das**

*Dr Anindita Das obtained her Ph.D. with Prof. Rongchao Jin at Carnegie Mellon University, where her research focused on the synthesis and catalytic applications of atomically precise coinage metal nanoclusters. Following her Ph.D., she carried out postdoctoral research with Prof. Chad Mirkin at Northwestern University, where her work centered on the development of spherical nucleic acids based on atomically precise metal clusters. In 2020, Anindita started her independent lab at Southern Methodist University where her lab's research focuses on metal nanoclusters and their interactions with MOFs and COFs for applications in catalysis and biology.*

This collection includes articles that discuss the origin of infrared emission in gold and copper nanoclusters. For example, Jin and co-workers' study on a highly luminescent $Au_{39}(PET)_{29}$ (PET = 2-phenylethanethiolate) nanocluster with 19% PLQY in the NIR range (915 nm) in solution and 32% in film (**https://doi.org/10.1039/D4NR00677A**). This work on enhanced NIR-luminescence along with the mechanistic insights, is crucial for the fundamental understanding of PL and for future imaging and optoelectronic applications.

Demonstrating progress on mass spectrometry analysis of cluster–DNA conjugates, Copp and co-workers investigated 21 different Ag cluster–DNA species using ESI-MS, where the fragmentation is strongly dependent on the Ag-DNA template sequence. This work provides insights into the mechanisms by which Ag-DNAs degrade and transform, with relevance for their applications in sensing and biomedical applications (**https://doi.org/10.1039/D4NR03533J**).

This collection also covers the antibacterial application of $Au_{22}$ nanoclusters modified with arginine for bacteria-infected wound healing, in work by Sipaut and co-workers. This work provides an approach for designing nanocluster-based photodynamic antibacterials for utilization in antibacterial therapies (**https://doi.org/10.1039/D4NR03278K**).

Catalytic innovations include Tang's work on alkynyl-protected $Ag_{19}Cu_2$ nanoclusters for $CO_2$ reduction (**https://doi.org/10.1039/D4NR02702G**), and Cheng's theoretical analysis of Au clusters of 2 to 300 atoms for CO oxidation (**https://doi.org/10.1039/D4NR02705A**).

This collection concludes with review articles covering a diverse range of topics, including the application of luminescent nanoclusters in bioimaging, the role of metal clusters in catalyzing hydrogen production, recent advancements in the synthesis and properties of silver nanoclusters, and circularly polarized luminescence in clusters. Some examples include a review by Hyeon and co-workers on the recent developments in the synthesis and properties of silver nanoclusters (**https://doi.org/10.1039/D4NR01788A**) and an article by Ramankutty discussing circular dichroism and circularly polarized luminescence in ligand-protected metal clusters (**https://doi.org/10.1039/D4NR01232A**).

This themed collection presents a glance at atomically precise metal cluster research across various disciplines, highlighting both specialized and interdisciplinary advancements. It combines insights into synthesis techniques, unique structural properties, and applications of atom-precise metal nanoclusters, and the innovative concepts that can materialize the future of this field.