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Citation for final published version:

Hou, Bo 2019. Colloidal quantum dots: the artificial building blocks for new-generation photo-electronics and photochemistry. *Israel Journal of Chemistry* 59 (8) , pp. 637-638.
10.1002/ijch.201900069 file

Publishers page: <http://dx.doi.org/10.1002/ijch.201900069>
<<http://dx.doi.org/10.1002/ijch.201900069>>

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Colloidal Quantum Dots: The Artificial Building Blocks for New-Generation Photo-Electronics and Photochemistry

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Our ability to design nanostructured semiconductors, organic-inorganic hybrid assemblies, and molecular assemblies have opened up new ways to design excitonic light-matter interactions.¹ Nanoscale absorbers can quickly separate the photo-generated carriers into two different media, which allows for less demand on materials quality, and therefore facilitates costs reduction. This concept has already been widely utilized and studied in the molecular photo-electrochemistry, such as dye-sensitized solar cells (DSSCs),^{2,3} where a molecular dye acts as an absorber in a cell formed by complementary nanostructured electron and hole transport materials. On the other hand, semiconductor materials clearly constitute the basis of the photovoltaic devices governing the energy market (>99%). When these materials are translated to the nanoscale, new and fascinating properties appear as consequence of quantum confinement.⁴ A surge in the developments in nanoscience in recent years has opened the door to new possibilities in the field of semiconductors, in particular, the fabrication of high-quality semiconductor nanocrystals. Solution-processed nanoscale semiconductors, known as colloidal quantum dots (QDs), is one of the significant growth areas in interdisciplinary field of physics, chemistry, materials science, and electrical engineering for the exploration of fundamental physical properties and new functionalities, and for the creation of unique applications with a view of potential fabrication routes through the design of materials and systems.⁵ Mark Reed coined the term quantum dot,⁶ and the interest in QDs was triggered by the discovery of quantum-size effects in the optical spectra of semiconductor nanocrystals, by teams of Alexei Ekimov⁷ and Louis E. Brus⁸ from a glass matrix and colloidal solutions, respectively. The major challenge of mastering the synthesis of QDs with uniform size distribution and adjustable physical chemistry properties was accomplished in 1993 when the hot-injection technique was introduced by Murray, Norris, Bawendi⁹ and this technique was further developed by teams of Peng¹⁰ and Alivisatos¹¹.

QDs have been brought to the forefront of new high-definition TVs over the past 2-3 years leading to a high color purity, and more versatile alternative to organic LEDs.¹² As an immediate relative technology, the development of QD-based photovoltaic, photocatalysis and photochemistry can benefit directly from the QD LEDs as highly promising technologies.¹³ QDs have unique physical properties such as large spectral tunability, high ambient stability, high sensitivity, and quantum efficiency with narrow spectral bandwidth. Compared to Si and organic materials, QDs not only have high light absorption efficiency and spectral tunability due to strong quantum confinement effect but also has higher ambient stability associated with their inorganic natures.¹⁴ However, there are remaining challenges that need to be addressed before the further development QD photo-

electronics and photochemistry such as compositions (containing Cd, Pb), high efficiency, and longer lifetime.¹⁵

This special issue is dedicated to an overview and prospect of the development in QD photo-electronics and photochemistry. Enormous opportunities will arise by addressing several key challenges in this special issue. Reviewed topics include, for example, QD LEDs, QD photocatalysis, QD PVs, Spectroelectrochemistry of QDs, Perovskite QDs, QD Electrochromic Applications, Computational Simulations in QDs and QD Display. I would like to thank all the authors of this special issue for their efforts and valuable contributions. I want to thank Prof. Ehud Keinan for the invitation, and it's a great honor for me to serve as guest editors of this special issue. I also thank Prof. Charles E. Diesendruck and Dr. Brian Johnson (Wiley-VCH) for their kind help during the preparation of this special issue.

I hope this special issue can provide an overview of QD photo-electronics and photochemistry for our readers.



Bo Hou, 10 June 2019 at Cambridge, England.

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