Colloidal Semiconductor Nanocrystals: From Artificial Atoms to Artificial Molecules

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Colloidal semiconductor Quantum Dots (CQDs), often considered as artificial atoms, have reached an exquisite level of control, alongside gaining fundamental understanding of their size, composition and surface-controlled properties. Their tuned characteristics and scalable bottom-up synthesis accompanied by the applicability of solution based manipulation, have led to their wide implementation in displays, lasers, light emitting diodes, single photon sources, photodetectors and more.[1]

For the next step towards enhancing their functionalities, inspired by molecular chemistry, we introduce the controlled linking and fusion of two core/shell quantum dots creating an artificial molecule manifesting two coupled emitting centers.[2] The size effect and mechanism of the fusion reaction reveals an interesting behavior of atomic migration allowing to create a crystalline connection between the two emitting centers.[3] The nature of the fusion interface between the two emission centers is found to strongly affect the optoelectronic characteristics.[4] Accordingly, the coupled colloidal quantum dot molecules (CQDMs) present novel behaviors differing than their quantum dot building blocks. Notably, such CQDMs open the path to a novel electric field induced instantaneous color switching effect, allowing color tuning without intensity loss, that is not possible in single quantum dots. All in all, such quantum dot molecules, manifesting two coupled emission centers, may be tailored to emit distinct colors, opening the path for sensitive field sensing and color switchable devices such as a novel pixel design for displays or an electric field color tunable single photon source.

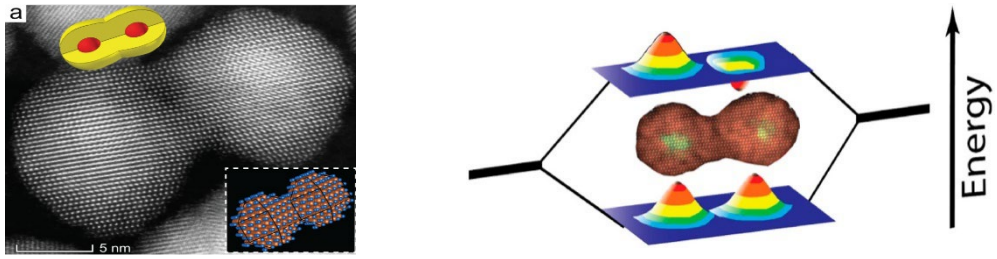

Fig. 1: Coupled homodimer molecule formed by fusing two core/shell colloidal quantum dots. Left: A high resolution electron microscopy image. Right: illustration of the hybridization of the electron wavefunction.

[1] Y.E. Panfil, M. Oded, amd U. Banin, *Angew. Chem. Int. Ed.* **57**, 4274-4295 (2018).

[2] J. Cui, Y.E. Panfil, S. Koley, D. Shamalia, N. Waiskopf, S. Remennik, I. Popov, M. Oded, and U. Banin, *Nature Comm* **10**, 5401 (2019).

[3] J. Cui, S. Koley, Y.E. Panfil, A. Levi, Y. Ossia, N. Waiskopf, S. Remennik, M. Oded and U. Banin, *J. Am Chem Soc.* **143**, 19816 (2021).

[4] S. Koley, J. Cui, Y. E. Panfil, Y. Ossia, A. Levi, E. Scharf, L. Verbitsky and U. Banin, *Matter* **5**, 3997 (2022).