Quantum Dot Positioning Proposal

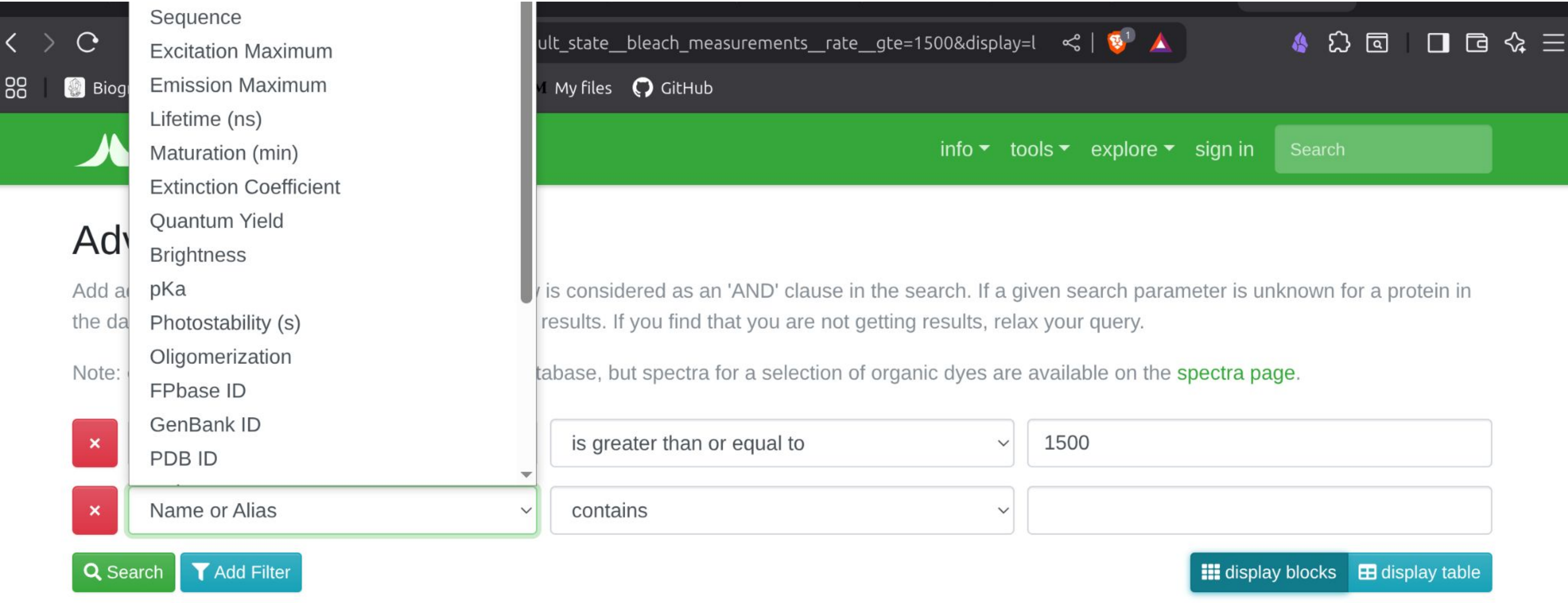
Frank Dininno

July 29, 2025

A note: biomolecules degrade fast

- Fluorophores and fluorescent proteins have a short running lifetime (0.1-1s).
- Other biomolecules have a limited lifetime - minute to hours at ambient temperature.

fpbase.org



Most photostable fluorescent proteins (FPs) by half-life

FPbase

info tools explore sign in Search

Advanced Protein Search

Add additional rows to refine your search. Each row is considered as an 'AND' clause in the search. If a given search parameter is unknown for a protein in the database, that protein will be excluded from the results. If you find that you are not getting results, relax your query.

Note: organic dyes are not yet searchable in the database, but spectra for a selection of organic dyes are available on the spectra page.

× | Photostability (s) | is greater than or equal to | 1500

Search | Add Filter | display blocks | display table

Search Results

Create collection from results

Electra1	StayGold
402 / 454	496 / 505

Only two have a fluorescent lifetime above 1500 seconds.

Jin Zhang has done renowned work in this area:

Article | Open access | Published: 04 April 2025

Bright and photostable yellow fluorescent proteins for extended imaging

Jihwan Lee, Shujuan Lai, Shuyuan Yang, Shiqun Zhao, Francisco A. Blanco, Anne C. Lyons, Raquel Merino-Urteaga, John F. Ahrens, Nathan A. Nguyen, Haixin Liu, Zhuohe Liu, Gerard G. Lambert, Nathan C. Shaner, Liangyi Chen, Kimberley F. Tolias, Jin Zhang, Taekjip Ha & François St-Pierre

Nature Communications **16**, Article number: 3241 (2025) | Cite this article

8711 Accesses | **2** Citations | **38** Altmetric | Metrics

She even references the second most photostable FP listed in the database and creates its equivalent in the yellow wavelength region.

A breakthrough in photostability came with the development of StayGold, a highly photostable green FP discovered through metagenomic screening of marine organisms[11]. StayGold and its monomeric versions set a new benchmark, allowing extended imaging with minimal fluorescence loss[11,12,13,14]. However, this advancement remains limited mainly to the green spectral class, leaving a gap in other color channels. Notably, yellow FPs (YFPs) photobleach more rapidly than FPs in other spectral classes, despite their widespread use in biosensors[15,16,17] and multi-spectral imaging[18,19,20]. Enhancing YFP photostability is crucial for enabling prolonged imaging and expanding their applicability in advanced microscopy.

Another possible solution: QD-protein conjugation

nature > scientific reports > articles > article

Article | Open access | Published: 02 October 2013

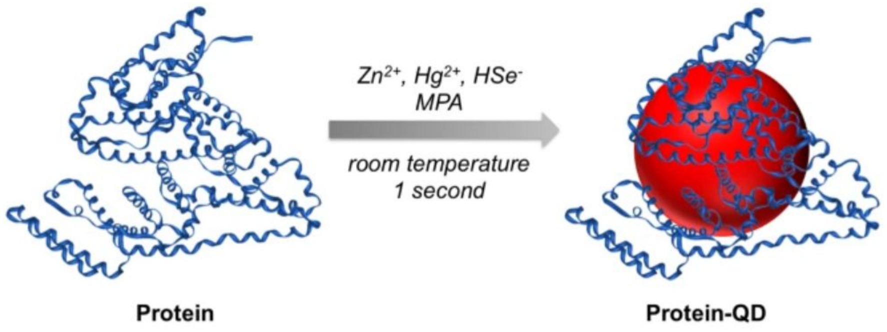
One-Step Instant Synthesis of Protein-Conjugated Quantum Dots at Room Temperature

Xuewen He, Li Gao & Nan Ma

Scientific Reports 3, Article number: 2825 (2013) | Cite this article

Figure 1

a



QD-DNA-Origami Conjugation is also an option

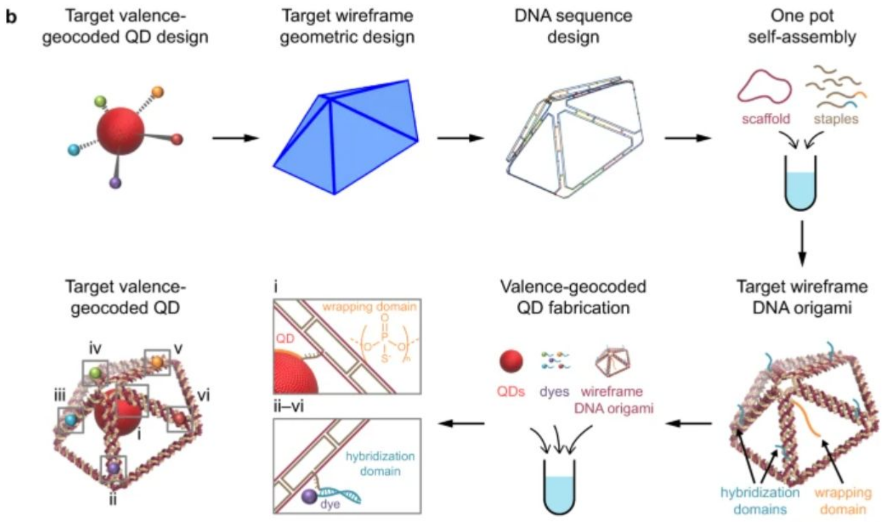
nature > nature communications > articles > article

Article | Open access | Published: 23 August 2022

Nanoscale 3D spatial addressing and valence control of quantum dots using wireframe DNA origami

Chi Chen, Xingfei Wei, Molly F. Parsons, Jiajia Guo, James L. Banal, Yinong Zhao, Madelyn N. Scott, Gabriela S. Schlau-Cohen, Rigoberto Hernandez & Mark Bathe

Nature Communications 13, Article number: 4935 (2022) | Cite this article



QD-DNA-Origami Cages

ACS Nano > Vol 14/Issue 2 > Article

Cite Share Jump to Expand

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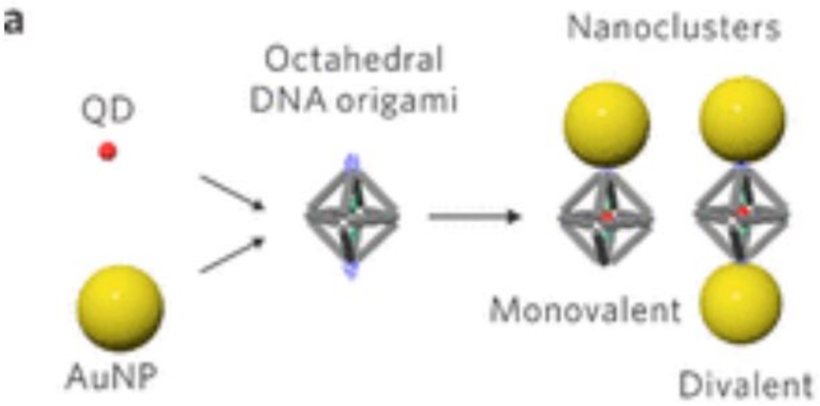
ARTICLE | December 26, 2019

Polarized Single-Particle Quantum Dot Emitters through Programmable Cluster Assembly

Click to copy article link

Honghu Zhang, Mingxing Li, Kaiwei Wang, Ye Tian, Jia-Shiang Chen, Katherine T. Fountaine, Donald DiMarzio, Mingzhao Liu, Mircea Cotlet, and Oleg Gang*



In both cases, how do you isolate the proteins?

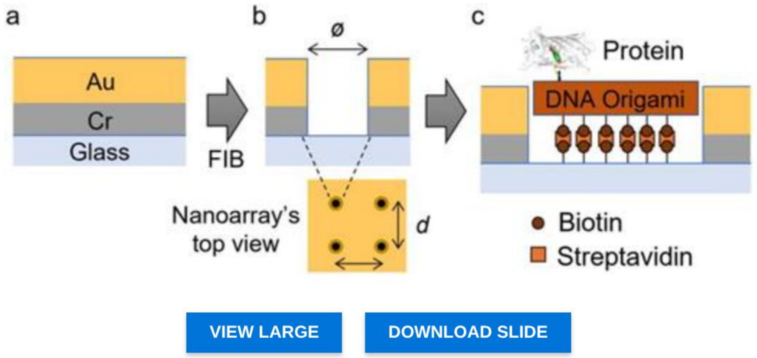
There are two viable options:

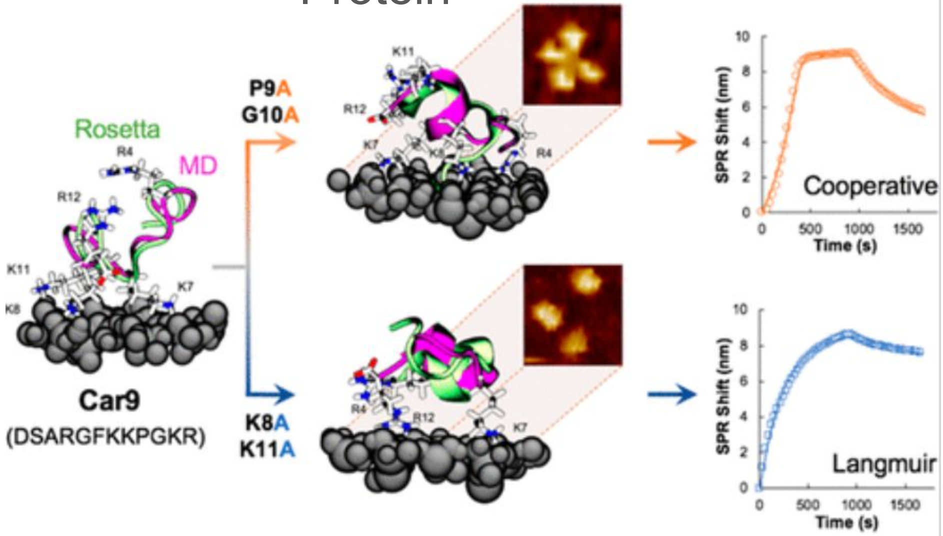
DNA origami positioning OR Special Protein Domains

DNA

Protein

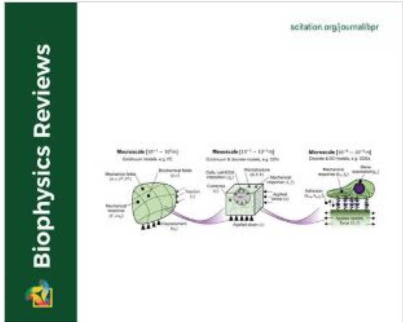
FIG. 1.





DNA Origami Positioning

Volume 3, Issue 3
September 2022



RESEARCH ARTICLE | AUGUST 18 2022

Single molecule DNA origami nanoarrays with controlled protein orientation

FREE

K. Cervantes-Salguero; M. Freeley; R. E. A. Gwyther; D. D. Jones; J. L. Chávez; M. Palma

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+ Author & Article Information

Biophysics Rev. 3, 031401 (2022)
https://doi.org/10.1063/5.0099294

Article history

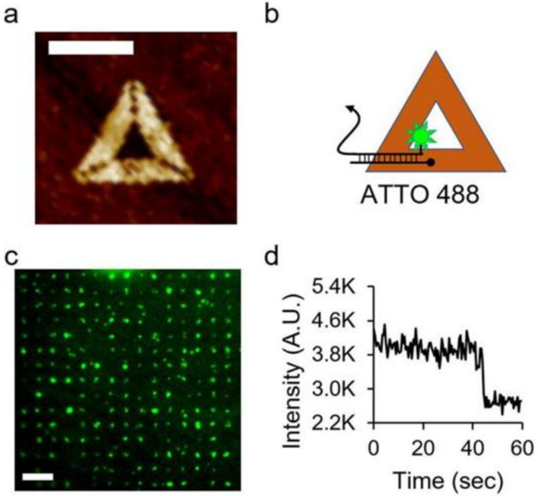
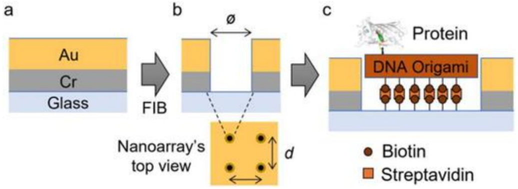


FIG. 1.



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You could attempt a similar scheme by using a custom protein rather than DNA origami.

Cleavable proteins binding directly to inorganic substrates

Journal of the American Chemical Society > Vol 142/Issue 5 > Article

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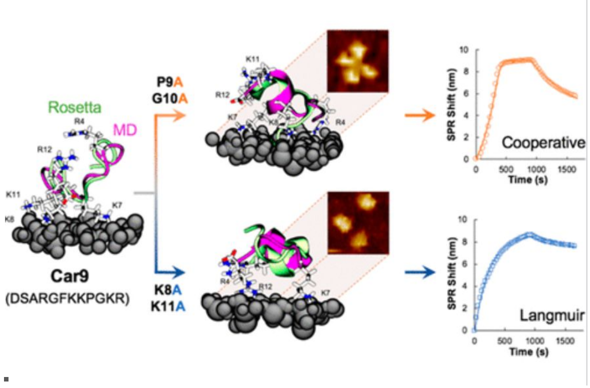
ARTICLE | January 14, 2020

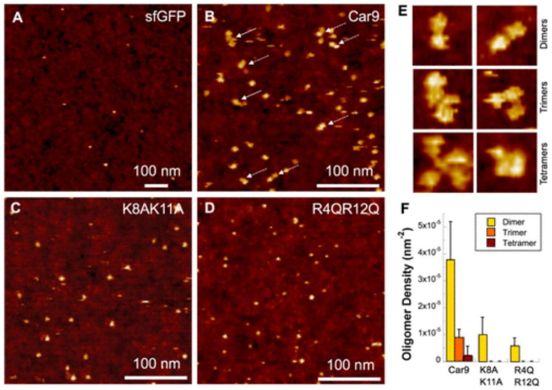
Sequence–Structure–Binding Relationships Reveal Adhesion Behavior of the Car9 Solid-Binding Peptide: An Integrated Experimental and Simulation Study

Brittney Hellner, Sarah Alamdari, Harley Pyles, Shuai Zhang, Arushi Prakash, Kayla G. Sprenger, James J. De Yoreo, David Baker, Jim Pfaendtner*, and François Baneyx*

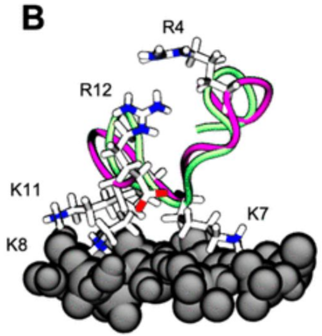
Make a small patch of silica that only one protein has room to attach to.

You may attempt a similar scheme by using DNA origami rather than a protein.





Comparison between the two methods

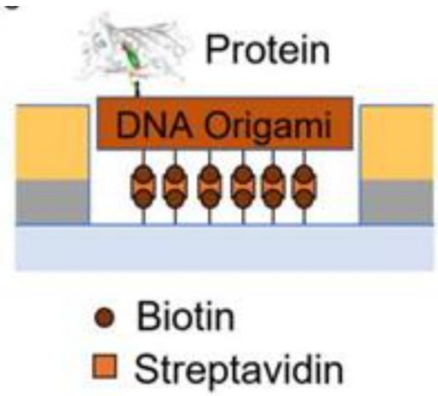


Direct inorganic binding:

- The biomolecule can be completely cleaved without residues left on the inorganic substrate.
- This implies replenishability of the biomolecule at the sensing site.

Biotin binding:

- The bond survives in harsh chemical conditions.
- But, biotin groups leave residues when cleaved.



Comparison between Proteins and DNA origami

1. Proteins have have a smaller footprint than DNA origami (10x smaller).
2. Proteins are more functional than DNA origami (e.g. enzymes, and more).
3. DNA origami is more programmable and modular than designing a protein is.
4. DNA origami is a better scaffold than proteins are and can even serve to scaffold proteins.
5. DNA origami is cheaper to synthesize.

However, these two molecules are still prone to biodegradation.

Overcoming the biodegradation problem: “QD fossilization”

The following paper shows how a protein or DNA strand can be encapsulated in an inorganic material at room temperature.

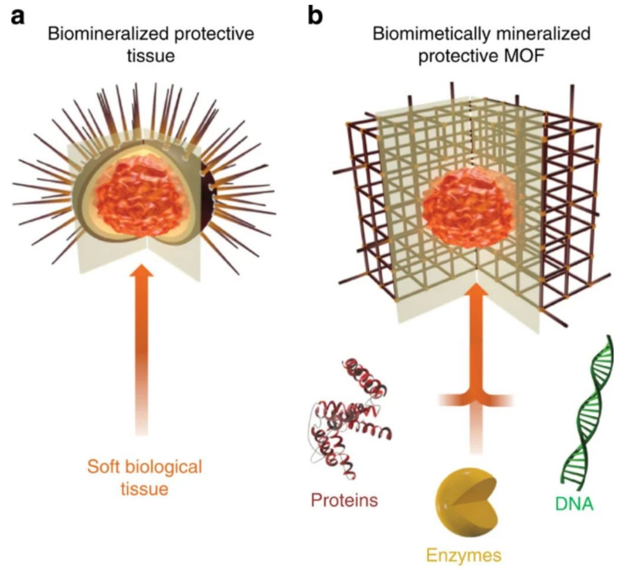
Article | Open access | Published: 04 June 2015

Biomimetic mineralization of metal-organic frameworks as protective coatings for biomacromolecules

Kang Liang, Raffaele Ricco, Cara M. Doherty, Mark J. Styles, Stephen Bell, Nigel Kirby, Stephen Mudie, David Haylock, Anita J. Hill, Christian J. Doonan & Paolo Falcaro

Nature Communications **6**, Article number: 7240 (2015) | Cite this article

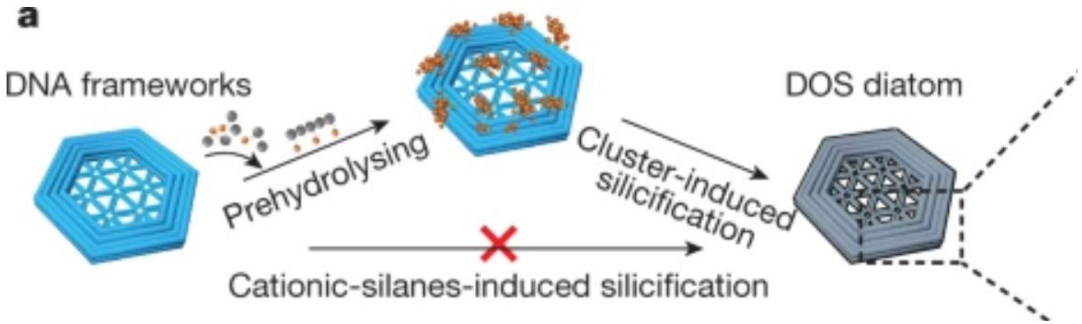
Figure 1: Schematic illustration of biomimetically mineralized MOF.



DNA-origami mineralization

This study focuses specifically on achieving mineralization on DNA origami surfaces.

Fig. 1: Schematic illustration and molecular dynamics sim



NANO · MICRO small

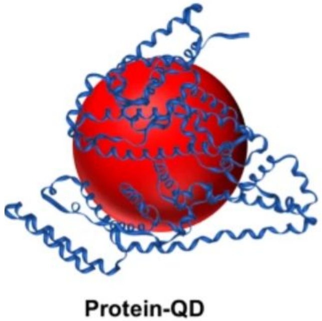
Communication | Full Access

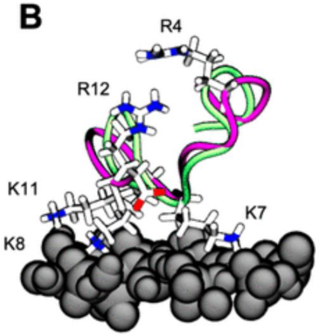
Encapsulation, Visualization and Expression of Genes with Biomimetically Mineralized Zeolitic Imidazolate Framework-8 (ZIF-8)

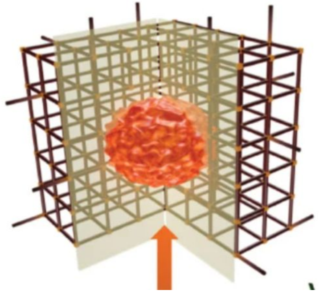
Arpita Poddar, José J. Conesa, Kang Liang, Sudip Dhakal, Philipp Reineck, Gary Bryant, Eva Pereiro, Raffaele Ricco, Heinz Amenitsch, Christian Doonan, Xavier Mulet, Cara M. Doherty ... See all authors

First published: 01 July 2019 | https://doi.org/10.1002/smll.201902268 | Citations: 105

What if we delivered the QD using a protein and then fossilized the protein, permanently trapping the QD in place?







Incorporation of a QD

Delivering it to the active site

Trapping it in an inorganic layer of sediment (the protein acts as a nucleation site)

All this happens at room temperature (including the QD synthesis)!

Who could be a point of contact for this idea?

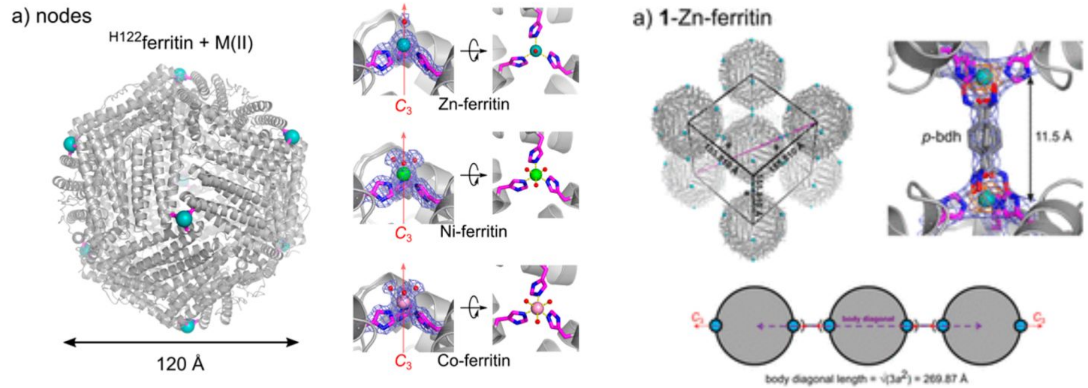
Akif Tezcan has worked with MOFs and extensive custom protein design. He is likely able to create a nanocarrier for our quantum dots and likely more capable than any other of designing a protein capable of nucleating bio-sedimentation due to his knowledge of metal-organic frameworks.

JACS
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
Article
pubs.acs.org/JACS

Synthetic Modularity of Protein–Metal–Organic Frameworks

Jake B. Bailey, Ling Zhang, Jerika A. Chiong, Sunhyung Ahn, and F. Akif Tezcan*

Department of Chemistry and Biochemistry, University of California at San Diego, 9500 Gilman Drive, La Jolla, California 92093, United States

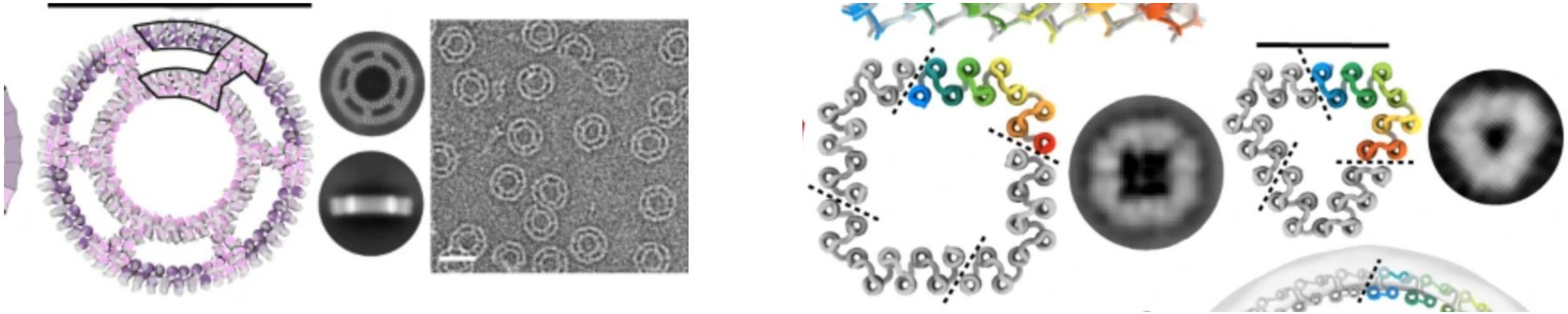


Neville Bethal has collaborated strongly with David Baker, a Nobel Prize winner in the field of custom protein design. He could likely help create the nanocarrier for our quantum dots. He does not have a background in MOFs.

Article | Open access | Published: 13 March 2024

Blueprinting extendable nanomaterials with standardized protein blocks

Timothy F. Huddy, Yang Hsia, Ryan D. Kibler, Jinwei Xu, Neville Bethel, Deepesh Nagarajan, Rachel Redler, Philip J. Y. Leung, Connor Weidle, Alexis Courbet, Erin C. Yang, Asim K. Bera, Nicolas Coudray, S. John Calise, Fatima A. Davila-Hernandez, Hannah L. Han, Kenneth D. Carr, Zhe Li, Ryan McHugh, Gabriella Reggiano, Alex Kang, Banumathi Sankaran, Miles S. Dickinson, Brian Coventry, … David Baker



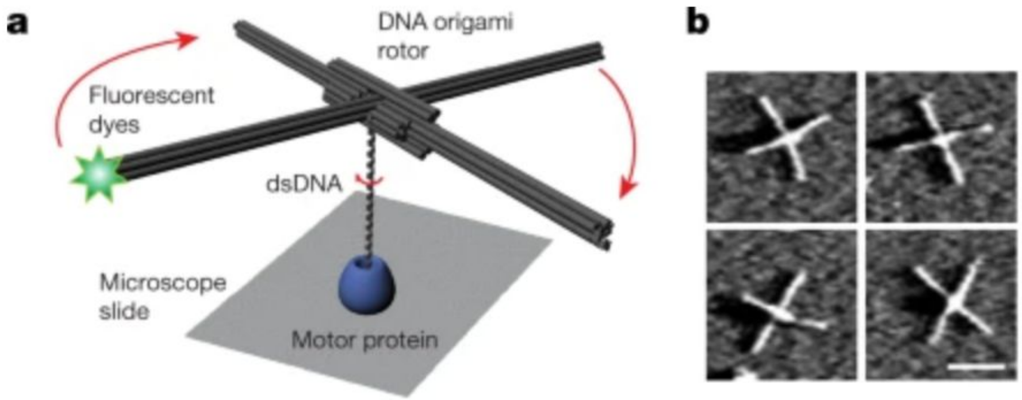
DNA Origami Specialist

Pallak Kosuri has created elaborate DNA origami devices. He is also a part of the *Salk Institute*. Likely, he will be able to use DNA-origami to create a QD nanocarrier and nucleation point for sedimentation due to the modularity of DNA origami; for this reason, he is a firm contact.

Letter | Published: 17 July 2019

Rotation tracking of genome-processing enzymes using DNA origami rotors

Pallav Kosuri, Benjamin D. Altheimer, Mingjie Dai, Peng Yin & Xiaowei Zhuang



Jin Zhang

Contact for making single molecule biosensor chips.

Akif Tezcan

Contact for using proteins as a taxi for quantum dots.

Pallack Kosuri

Contact for using DNA origami as a scaffold for quantum dots.

Neville Bethel

A potential second contact after Akif Tezcan.