As reported in the June 25 issue of *Nature* (DOI: 10.1038/nature08115; p. 1110), the research team used high-speed photography to measure nanoscale forces that cause droplet formation. The researchers observed falling 100-µm-diameter glass beads, or streaming sand, and found that forces as much as 100,000 times smaller than those that produce surface tension in ordinary liquids could cause droplet formation in granular streams and cause these dry streams to behave like an ultra-low surface-tension liquid.

Royer, a graduate student in physics at the University of Chicago, who developed the apparatus, and his colleagues also directly measured grain-to-grain interactions with an atomic force microscope.

"At first we thought grain-grain interactions would be far too weak to influence the granular stream," said Royer. "The atomic force microscopy surprised us by demonstrating that small changes in these interactions could have a large impact on the break-up of the stream, conclusively showing that these interactions were actually controlling the droplet formation."

"Our experiments ask two questions for which currently there is no established answer," said Jaeger. "Both questions are about how a liquid breaks apart. How does the break-up proceed in the ultra-low surface-tension limit and what happens in the ultra-low temperature limit when particles cease to move relative to each other?

"It is quite remarkable that a granular stream consisting of macroscopic particles provides a model system to explore it."

## Lanthanide-Doped Nanocrystals Serve as Single-Molecule Imaging Probes

S. Wu, G. Han, D.J. Milliron, S. Aloni, V. Altoe, B.E. Cohen, and P.J. Schuck of Lawrence Berkeley National Laboratory (Berkeley Lab.), and D.V. Talapin of the University of Chicago have developed lanthanide-doped upconverting nanoparticles (UCNPs) that act as individual investigators of activity within a cell. These light-emitting probes represent a significant step in scrutinizing the behaviors of proteins and other components in complex systems such as a living cell.

Labeling a given cellular component and tracking it through a typical biological environment is fraught with issues: the probe can randomly turn on and off, competes with light emitting from the cell, and often requires such intense laser excitation that it eventually destroys the probe.

"The nanoparticles we've designed can be used to study biomolecules one at a time," said Bruce Cohen, a staff scientist in the Biological Nanostructures Facility at Berkeley Lab.'s nanoscience research center, the Molecular Foundry. "These single-molecule probes will allow us to track proteins in a cell or around its surface, and to look for changes in activity when we add drugs or other bioactive compounds."

As reported in the July 7 issue of *Proceedings of the National Academy of Sciences* (DOI: 10.1073/pnas.0904792106; p. 10917), the researchers developed nanocrystals containing rare earth elements—specifically, hexagonal phase $NaYF_4$ with multiple $Yb^{3+}$ and $Er^{3+}$ dopants—that absorb low-energy infrared light and transform it into visible light (known as "upconversion") when illuminated by light from a 980-nm continuous wave, near-infrared laser (see Figure 1). Biological tissues are more transparent to near-infrared light, making these nanocrystals well suited for imaging living systems with minimal damage or light scatter.

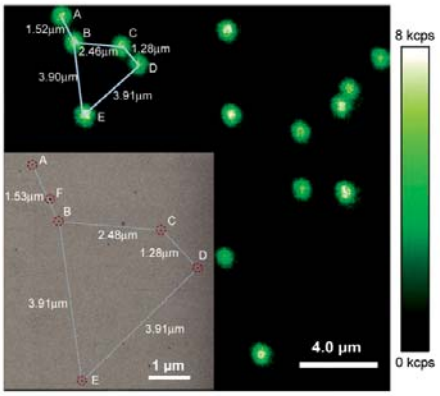


Figure 1. Confocal upconverted luminescent image of individual upconverting nanoparticles ($NaYF_4$: $Yb^{3+}$/ $Er^{3+}$) on a silicon nitride membrane. Laser power density is ~$3 \times 10^6$ W/cm$^2$, and dwell time per pixel is 10 ms. (Inset) The transmission mode-scanning electron microscope image taken at the upper left corner region of the optical image shows that the individual diffraction-limited luminescent spots are emitted from individual UCNPs. The five individual nanocrystals are labeled as A–E; an impurity is labeled as F. Reproduced by permission from *Proceedings of the National Academy of Sciences* **106** (27) (2009) DOI: 10.1073/pnas.0904792106, p. 10917. ©2009 by the National Academy of Sciences.

To study how these probes might behave in a real biological system, the research team wrapped them with low molecular weight amphiphilic polymers and incubated the nanocrystals with embryonic mouse fibroblasts, cells crucial to the development of connective tissue, allowing the nanocrystals to be taken up into the interior of the cell. Live-cell imaging using the same near-infrared laser showed similarly strong luminescence from the nanocrystals within the mouse cell, without any measurable blinking or photobleaching. The researchers reported that blinking is suppressed in the nanocrystals because each nanocrystal contains many $Yb^{3+}$ and $Er^{3+}$ ions resulting in steady-state emission under the low-power continuous illumination. The low power illumination also essentially eliminates multiphonon fluorescence background signal that occurs with high-power laser sources.

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