

Biology, materials science get a boost from robust imaging tool

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Andrew H. Marcus is a professor of chemistry at the University of Oregon.
Credit: University of Oregon

Shape and alignment are everything. How nanometer-sized pieces fit together into a whole structure determines how well a living cell or an artificially fabricated device performs. A new method to help understand and predict such structure has arrived with the successful use a new imaging tool.

Coupling laser-driven, two-dimensional fluorescence imaging and high-performance computer modeling, a six-member team -- led by University of Oregon chemist Andrew H. Marcus and Harvard University chemist Alan Aspuru-Guzik -- solved the conformation of self-assembled porphyrin molecules in a biological membrane.

Porphyrins are [organic compounds](#) that are ubiquitous in living things. They carry mobile electrical charges that can hop from molecule-to-molecule and allow for nanoscale communications and energy transfer. They are also building blocks in nanodevices.

The new technique -- phase-modulation 2D [fluorescence spectroscopy](#) -- is detailed in a paper scheduled to appear online this week ahead of regular publication in the [Proceedings of the National Academy of Sciences](#). The breakthrough skirts the often-needed step of obtaining crystals of molecules that are being studied, said Marcus, a member of the Oregon Center for Optics, Materials Science Institute and Institute of Molecular Biology. Most functional [biological molecules](#) don't easily form crystals.

"Our technique is a workable way to determine how macromolecular objects assemble and form the structures they will in biological environments," Marcus said. "It's robust and will provide a means to study biological protein-nucleic acid interactions."

Work already is underway to modify the experimental instrumentation in the UO's stable and temperature-controlled High Stability Optics Lab to apply the research on [DNA replication](#) machinery -- one category of the best-known macromolecular complexes, which consist of [nucleic acids](#) and proteins that must be properly aligned to function correctly. "It's a strategy that will allow us to do two things: Look at these complexes one molecule at a time, and perform experiments at short ultraviolet wavelengths to look at DNA problems," he said.

In addition, the approach should be useful to materials scientists striving to understand and harness the necessary conformation of polymers used in the production of nanoscale devices. "In biology, large molecules assemble to form very complex structures that all work together like a machine," Marcus said. "The way these nanoscale structures form and

become functional is an actively pursued question."

The technique builds on earlier versions of two-dimensional (2D) optical spectroscopy that emerged in efforts to get around limitations involved in applying X-ray crystallography and nuclear magnetic resonance to such research. The previous 2D approaches depended on the detection of transmitted signals but lacked the desired sensitivity.

The new approach can be combined with single-molecule fluorescence microscopy to allow for research at the tiniest of scales to date, Marcus said. "With fluorescence, you can see and measure what happens one molecule at time. We expect this approach will allow us to look at individual molecular assemblies."

Provided by University of Oregon

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