UC San Diego
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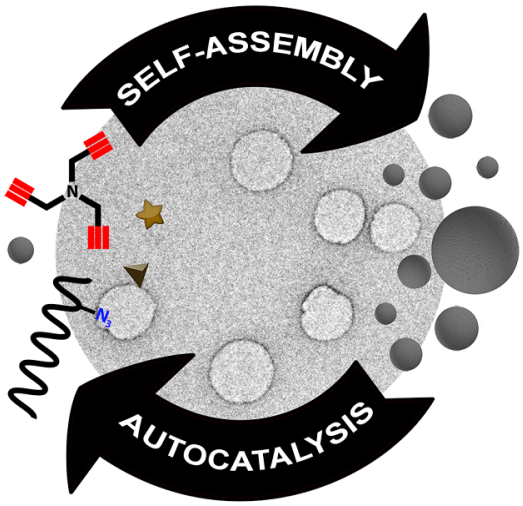
UC San Diego Researchers May Be Shedding Light on Life's Chemical Origins

Living things reproduce and after billions of years of evolution, modern living organisms are molecularly complex. But scientific interest in developing simple self-reproducing living systems is gaining attention. This is because such molecular assemblies could answer key questions about the origins of life. With this in mind, biochemical researchers at the University of California San Diego—Neal K. Devaraj, associate professor in the Department of Chemistry and Biochemistry, and Roberto J. Brea, postdoctoral scholar in the department—set out to design an autocatalytic peptide system for the development of functional self-synthesizing biomaterials, which may clarify life's chemical origins.



Continuous generation of autocatalytic self-assembling peptides, which exhibit rapid self-organization into nanospheres. Image by Roberto J. Brea

"We feel this is a step toward the ambitious goal of creating self-reproducing materials," said Devaraj. "Self-reproducing molecules can shed light on the underlying principles that led to the first living systems on Earth."

Based on their research findings, Devaraj and Brea co-wrote a paper titled "Continual reproduction of self-assembling oligotriazole peptide nanomaterials," published in Nature Communications. The paper outlines the methods they used to study certain peptide-based autocatalysts. Peptides are polymers—large molecules—made up of amino acids, which are the building blocks of proteins, which are important in the reproductive process. Autocatalysts are chemical reactions in which molecules are able to stimulate their own formation—a process that occurs in nature and is believed to be critical to the development of life. While several molecular autocatalysts have been previously studied, actually linking autocatalytic behavior to molecular self-assembly has remained a challenge. Devaraj and Brea, however, present a

straightforward method that uses certain peptide-based autocatalysts that are capable of self-assembly. Their approach presents a powerful tool for developing self-reproducing bionanomaterials based on peptide architecture.

“The ease with which the size and properties of autocatalytic peptide nanospheres can be controlled should allow the use of such supramolecular functional structures in fields such as biosensing, medicine and electronics,” noted Brea of the practical applications of their research, beyond the lab.

Working in the lab, the researchers synthesized a series of autocatalytic peptides by mixing water-soluble precursors in the presence of copper. Then, they confirmed that the resulting peptides self-assembled into spherical structures by using a transmission electron microscope. Fluorescence microscopy—the use of an optical microscope to study properties of organic or inorganic substances with fluorescence or phosphorescence, rather than by reflection and absorption—indicated that self-reproducing nanospheres can entrap relevant molecules. Finally, their use of high performance liquid chromatography—a technique used to separate a sample into its individual parts—demonstrated continual self-propagation of peptide nanospheres.

At UC San Diego, graduate and undergraduate students in the Division of Physical Sciences have the opportunity to learn about autocatalytic chemical reactions and their importance in the origin of life. Additionally, in current work, several students are synthesizing some new peptides that can self-associate into spherical bioinspired nanostructures.

“Further studies will help to describe a detailed mechanism for the autocatalytic process, which could lead to the efficient manufacturing of relevant self-propagating peptide materials,” said Brea.

Devaraj’s and Brea’s research is based on work supported by the National Science Foundation under CHE-1254611. Brea thanks the Human Frontier Science Program (HFSP) for his Cross-Disciplinary Fellowship.

The UC San Diego Department of Chemistry and Biochemistry ranks #21, according to U.S. News & World Report. Part of the Division of Physical Sciences at UC San Diego, the department’s history dates back to 1958 with the hiring of Nobel Prize-winning chemist Harold Urey.

MEDIA CONTACT

Cynthia Dillon, 858-822-6673, cdillon@ucsd.edu

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