ADVANCED SCIENCE RESEARCH CENTER
THE GRADUATE CENTER
CITY UNIVERSITY OF NEW YORK

FACT SHEET

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Frequently Asked Questions

Ulijn, Rein V., et. al. June 9, 2017. Polymeric peptide pigments with sequence-encoded properties. *Science*.

What did the study seek to achieve?
Scientists have long known that melanin — a family of biopolymers that give color to skin, hair, and eyes — has a variety of useful properties, including the ability to provide protection from cancer-causing UV rays and radicals, to store energy, and absorb light. Researchers from across City University of New York (CUNY), centered at the Advanced Science Research Center (ASRC) at the Graduate Center, CUNY, sought a way to create melanin-like materials in order to harness these beneficial properties and translate them for use in a variety of products, including cosmetics, biomedicines, and, potentially, energy and image development.

What are the outcomes of the study?
Investigators developed a technique to produce materials that mimic some of the properties of melanin, according to a paper published in the June 9, 2017, issue of *Science*.

A key aspect of their discovery is that the properties (such as degree of pigment formation) and functions (such as UV absorbance and charge storage capacity) of melanin-like polymers could be dictated by the precursors that were used. Researchers achieved this level of control by systematically altering the molecular makeup of the tripeptides — designed, minimalistic versions of proteins — that were used as precursors. While proteins found in biological systems are typically composed of strings of hundreds of amino acids with specific chemical functionality, tripeptides are made of just three amino acids. Each of the six tripeptide sequences that were tested contained the same amino acids, but in a different order. The researchers demonstrated that the order of the amino acids acts as a molecular code that controls the degree of aggregation, resulting in variable architectures at the molecular level. The resulting, differently-ordered peptide structures were subsequently subjected to an oxidation process, and it was found that the peptides then morph into melanin-like materials that expressed specific traits, encoded by the tripeptide starting materials.

The resulting morphologies include spherical particles, fibers, and extended two-dimensional sheet-like structures that could be useful for a variety of applications. For example, the polymeric sheets could be useful in developing surface coatings. These sheets also demonstrated the capacity to store and release ions, which could be useful in creating new battery technology.

What is peptide nanotechnology?
Rein Ulijn is a pioneer in the area of *peptide nanotechnology*. His research is based on a simple observation: that living systems derive their astonishing array of functionality from just 20 chemically simple components — the DNA encoded amino acids that are shared across all life forms. Ulijn's group investigates how to combine these versatile amino acids into short peptide building blocks, with the objective to use them as structural and functional components of nanostructures. They have demonstrated that a tremendous array of functionality may be found even in peptides that are composed of as few as two or three amino acids.

What is the impact of the study?
The impact of the work is threefold:

- It addresses a longstanding challenge of controlling and directing the oxidation and polymerization processes that allow for laboratory-based production of melanin-like materials.
- The paper demonstrates that tremendously versatile structures may be obtained by using peptides as building materials for nanotechnology and materials science. This is important because short peptides, compared to conventional polymers, have low barriers to application, are scalable, biodegradable, and may be produced from renewable sources.
- The research opens up opportunities to learn about the structural properties of natural melanins, which have been difficult to study systematically due to their structural complexity and disorder.

What are commercialization possibilities for the findings of this study?
The short peptides used in developing these materials have low barriers to application due to their simple structure and, as such, are easily scaled. The ASRC team is pursuing commercialization of this new technology, with near-term possibilities in cosmetics and biomedicine. Cosmetics applications may include use in products that provide skin tone matched coloration, linked with protection of the skin against UV radiation and free radicals that cause cancer and promote aging.

Where was the research performed?
The formation of polymeric pigments based on catalytic oxidation following tripeptide assembly was discovered in Rein V. Ulijn's ASRC-based lab in June 2016.

The ASRC is the Graduate Center's University-wide venture that elevates CUNY's legacy of scientific research and education through initiatives in five distinctive but increasingly interconnected disciplines: Nanoscience, Photonics, Structural Biology, Neuroscience and Environmental Sciences. The ASRC is designed to promote a unique, interdisciplinary research culture with researchers from each of the initiatives working side by side in the ASRC's core facilities, sharing equipment that is among the most advanced available.

What research facilities were used by the research team to conduct experiments related to the study?
The research facilities used for the paper include the ASRC's imaging, surface science, and mass spectroscopy suites. The availability of high-end characterization facilities on-site was essential to characterizing the materials and learning about their structure-property relationships.

Who participated in the study?

ASRC — New York, NY

- Principal Investigator: Rein V. Ulijn, Director of the ASRC Nanoscience Initiative
- First author: Ayala Lampel, Postdoctoral Fellow
- Rinat R. Abzalimov, Research Assistant Professor and Mass Spectrometry Facility Manager
- Scott A. McPhee, Nanoscience Research Programs Specialist
- Tai-De Li, Research Assistant Professor and Surface Science Facility Manager

Hunter College — New York, NY

- Principal Investigator: Rein V. Ulijn, Albert Einstein Professor of Chemistry
- Steven G. Greenbaum, Professor of Physics
- Barney Yoo, Mass Spectrometry Facility Director
- Sunita Humagain, Ph.D. Student

Carnegie Mellon University — Pittsburg, PA

- Christopher J. Bettinger, Associate Professor of Materials Science and Biomedical Engineering
- Hang-Ah Park, Postdoctoral Research Associate

University of Strathclyde — Glasgow, UK

- Tell Tuttle, Senior Lecturer of Pure and Applied Chemistry
- Gary G. Scott, Ph.D. Student

Harvard University — Cambridge, MA

- Doeke R. Hekstra, Assistant Professor of Molecular and Cellular Biology

University of Groningen — Groningen, Netherlands

- Pim W.J.M. Frederix, Postdoctoral Fellow

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- Chunhua Hu, Research Professor of Chemistry

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