Scientists develop molecular code for melanin-like materials

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Polymeric pigments were produced by guided oxidation of peptide assemblies. Credit: Matej Vakula, NYC

Scientists have long known that melanin—the pigments that give color to skin, hair and eyes—has numerous useful qualities, including providing protection from cancer-causing UV radiation and free radicals, but also electronic conductance, adhesiveness and the capacity to store energy.

To take advantage of these qualities, scientists across the City University of New York (CUNY) have developed a new approach for producing materials that not only mimic the properties of melanin, but also provide unprecedented control over expressing specific properties of the biopolymer, according to a paper published today in the journal *Science*. The discovery could enable the development of cosmetic and biomedical products.

Unlike other biopolymers, such as DNA and proteins, where a direct link exists between the polymers' ordered structures and their properties, melanin is inherently disordered, so directly relating structure to function is not possible. As a result, researchers have been unable to fully exploit melanin's properties because the laboratory-based synthesis of melanin has been thwarted by the difficulty of engineering its disorderly molecular structure.

"We took advantage of simple versions of proteins—tripeptides, consisting of just three amino acids—to produce a range of molecular architectures with precisely controlled levels of order and disorder," said lead researcher Rein V. Ulijn, director of the Nanoscience Initiative at the Advanced Science

Research Center (ASRC) at the Graduate Center, CUNY. "We were amazed to see that, upon oxidation of these peptide structures, polymeric pigments with a range of colors—from light beige to deep brown- were formed."

Subsequent, in-depth characterization of the approach demonstrated that further properties, such as UV absorbance and nanoscale morphology of the melanin-like materials, could also be systematically controlled by the amino acid sequence of the tripeptide.

"We found that the key to achieving polymers with controlled disorder is to start from systems that have variable order built in," said Ayala Lampel, a postdoctoral ASRC researcher and the paper's first author. "First, we figured out how the amino acid sequence of a set of tripeptides gives rise to differently ordered architectures. Next, we leveraged these ordered structures as templates for catalytic oxidation to form peptide pigments with a range of properties."

The findings published in *Science* build on previous research conducted by Ulijn, who is also the Albert Einstein Professor of Chemistry at Hunter College and a member of the biochemistry and chemistry doctoral faculty at the Graduate Center. His lab will now turn its attention to further clarifying the chemical structures that form and expanding the resulting functionalities and properties of the various melanin-like materials they produce. The researchers are also pursuing commercialization of this new technology, which includes near-term possibilities in cosmetics and biomedicine.

Christopher J. Bettinger, a Carnegie Mellon University researcher who specializes in melanin applications in energy storage, collaborated with the ASRC team on the current work. Among the materials discovered, he found that two-dimensional, sheet-like polymers show significant charge-storage capacity. "Expanding the compositional parameters of these peptides could substantially increase the utility of the resulting pigments, and this research can also help us better understand the structural property and functions of natural melanins," Bettinger said.

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More information: A. Lampel el al., "Polymeric peptide pigments with sequence-encoded properties," *Science* (2017). **science.sciencemag.org/cgi/doi … 1126/science.aal5005**

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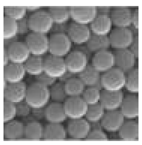

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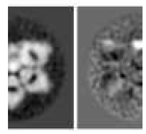

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