Complementary biomolecular coassemblies direct energy transport for cardiac photostimulators

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What was achieved?:
A biomolecular photostimulation platform was developed using self-assembled, π-conjugated peptide nanostructures that convert light into electrical signals at the cell interface. By designing complementary peptide sequences that drive donor–acceptor coassembly, the researchers created ordered nanostructures capable of efficient energy and charge transport. These materials generate photocurrents under physiological conditions and can be integrated into soft biomaterial interfaces. When interfaced with cardiomyocytes, the system enables light-driven modulation of cellular behavior, including changes in contraction dynamics and gene expression, without the need for genetic modification.

Why is it important?:
Controlling electrical signaling in cardiac tissue is critical for both fundamental studies and therapeutic development, but existing approaches often rely on rigid electrodes or genetic modification. This work introduces a fully biomolecular alternative that combines soft materials, molecular programmability, and optical control. The ability to induce electrophysiological responses using light-responsive peptide assemblies opens new opportunities for non-invasive cardiac stimulation, bioelectronic interfaces, and tissue engineering. More broadly, it demonstrates how sequence-defined biomolecules can be engineered to perform complex electronic functions in biological environments.

How did BioPACIFIC MIP enable this?
BioPACIFIC MIP enabled this work through access to small-angle X-ray scattering (SAXS) instrumentation, which was critical for characterizing the nanoscale structure and ordering of the peptide assemblies that underpin their optoelectronic function.

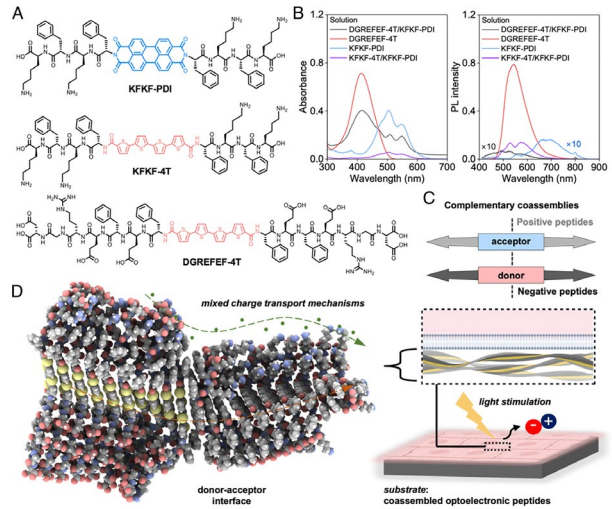


Figure 1. *Photocurrent-generating coassembly of π-conjugated peptides as a cellular photostimulation platform. (A) Chemical structures of designed peptides of KFKF-PDI, KFKF-4T, and DGREFEF-4T. (B) Absorption and photoluminescence (PL) spectra of coassembly system (λexc = 400 nm). (C) Schematic for donor–acceptor coassembly with charge-complementary peptide sequence. (D) Optimized geometry of the coassembly between DGREFEF-4T (ten molecules on the left) and KFKF-PDI (ten molecules on the right) and mixed charge transport with light stimulation; schematic of the cellular photostimulation platform based on photocurrent-generating peptide assemblies.*

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