Engineered adhesion makes programmed self-assembly of bacteria possible

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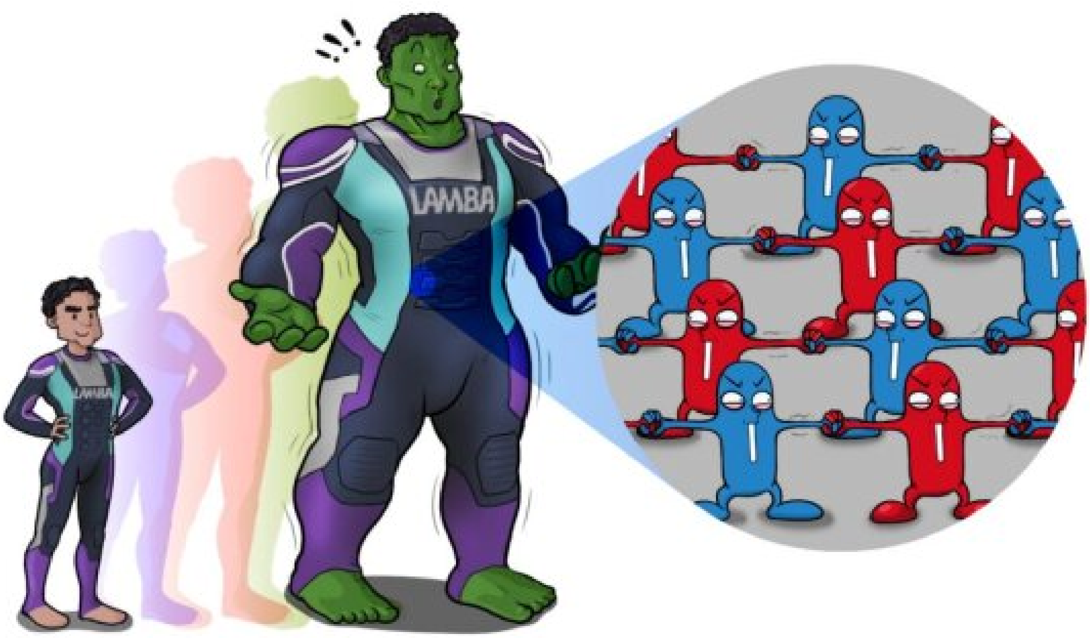

LAMBA possesses excellent stretchability, which is an ideal material for wearable devices or clothing manufacturing. Credit: SIAT

Researchers from the Shenzhen Institute of Advanced Technology (SIAT) of the Chinese Academy of Sciences have reported the programmed self-assembly of bacterial populations by engineered adhesion.

The study was published in *Nature Chemical Biology* on Dec. 21.

Engineered living materials (ELMs) can act as functional materials recapitulating the desirable properties of natural living systems. One of the most appealing properties of ELMs is self-healing, since the encapsulated cells of the biofilm can self-regenerate and heal the material over time.

This self-healing process is caused, in theory, by cell growth, which takes hours. However, in applications involving soft and conformable devices, the healing process needs to happen in minutes, which is obviously much faster than cell cycles.

Previous studies have reported the engineering of fast self-healing material by incorporating non-covalent interactions such as hydrogen bonds. Inspired by this strategy, the scientists from SIAT sought to functionalize each bacterium with non-covalent binding groups to generate macroscopic living functional materials by adhering bacteria together.

Previously, David S. Glass et al. developed a synthetic bacterial cell-cell adhesion toolbox based on outer membrane-anchored nanobody (Nb)-antigen (Ag) pairs.

Using this toolbox, the team engineered cells to display nanobodies or antigens on their surfaces and cultured these cells separately in liquid cultures. Mixing the two populations in large quantities generated processable macroscopic materials known as "living assembled material by bacterial adhesion" (LAMBA).

LAMBA demonstrates better mechanical properties and processability than individual cells (Nb-cells or Ag-cells) and can be subjected to versatile engineering methods to fabricate macroscale or microscale objects.

By functionalizing LAMBA extracellularly and intracellularly, the material is able to degrade organophosphate pesticides through a hybrid enzyme-inorganic sequential catalysis or synthesize trehalose by harnessing extracellular-intracellular bioconversions.

LAMBA also can self-heal. Besides the self-healing process led by cell growth, adhesion between Nb-Ag pairs leads to the recovery of the material's property within several minutes. For example, sliced LAMBA, after recovery, can maintain its conductivity under multiple cycles of stretching.

The team assembled stretchable LAMBA sensors to detect bioelectrical or biomechanical signals. Results showed that the stretchable LAMBA strain sensor could report a finger joint bending in a stable and reliable manner, while a traditional stretchable sensor made of gold film lost function easily due to the large deformation of the finger joint.

The LAMBA strain sensor functioned properly to monitor finger-joint bending with repeated usage (25-150 finger-bending cycles) every day for a month.

This work established a novel methodology for assembling living material by bacterial adhesion. Inspiration from polymer physics armed the bacteria with non-covalent binding groups that can self-heal in minutes.

The genetically editable cells allow flexible programming of living functional material such that the materials can be used in biomanufacturing and bioremediation.

More information: Baizhu Chen et al, Programmable living assembly

of materials by bacterial adhesion, *Nature Chemical Biology* (2021).
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