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# Living plastics: A new solution for plastic degradation through synthetic biology

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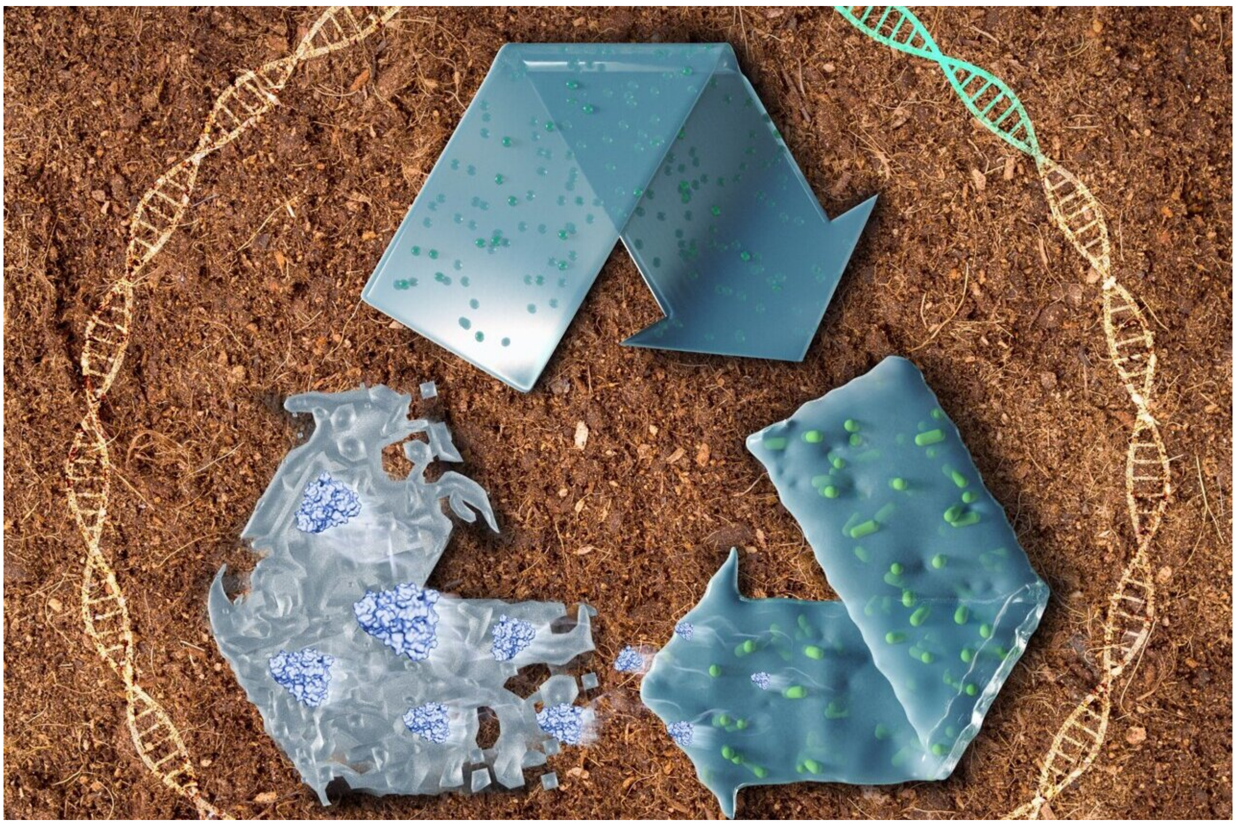


Plastics are widely used but difficult to degrade, posing an ecological challenge. A team from SIAT developed degradable "living plastics" using synthetic biology and polymer engineering. They engineered Bacillus subtilis spores to produce Burkholderia cepacia lipase (BC-lipase), an enzyme that breaks down plastic. These spores were mixed with poly(caprolactone) (PCL) to create the plastics, maintaining the material's physical properties. When the plastic surface is eroded, the spores release the enzyme, leading to nearly complete breakdown of the plastic. Credit: Dai Zhuojun

A study published in *Nature Chemical Biology* leverages the natural resilience of spores, which can endure extreme environmental conditions, by programming them to secrete plastic-degrading enzymes under specific circumstances. These spores are embedded into plastic matrices through standard plastic processing methods, such as high temperature, high pressure, or the use of organic solvents.

In normal conditions, the spores remain dormant, ensuring the plastic's stable performance. However, when exposed to specific triggers like surface erosion or composting, the spores activate and initiate the degradation process, leading to the plastic's complete breakdown.

The invention of plastics has improved our daily lives, but the massive production and improper disposal of plastic waste have made plastic pollution a major environmental issue. In 2016, Yoshida and team discovered a bacterium, Ideonella sakaiensis, in poly (ethylene terephthalate) (PET)-contaminated soil near a recycling facility in Japan. This bacterium can grow using PET as its main carbon source by producing two key enzymes: PETase and MHETase.

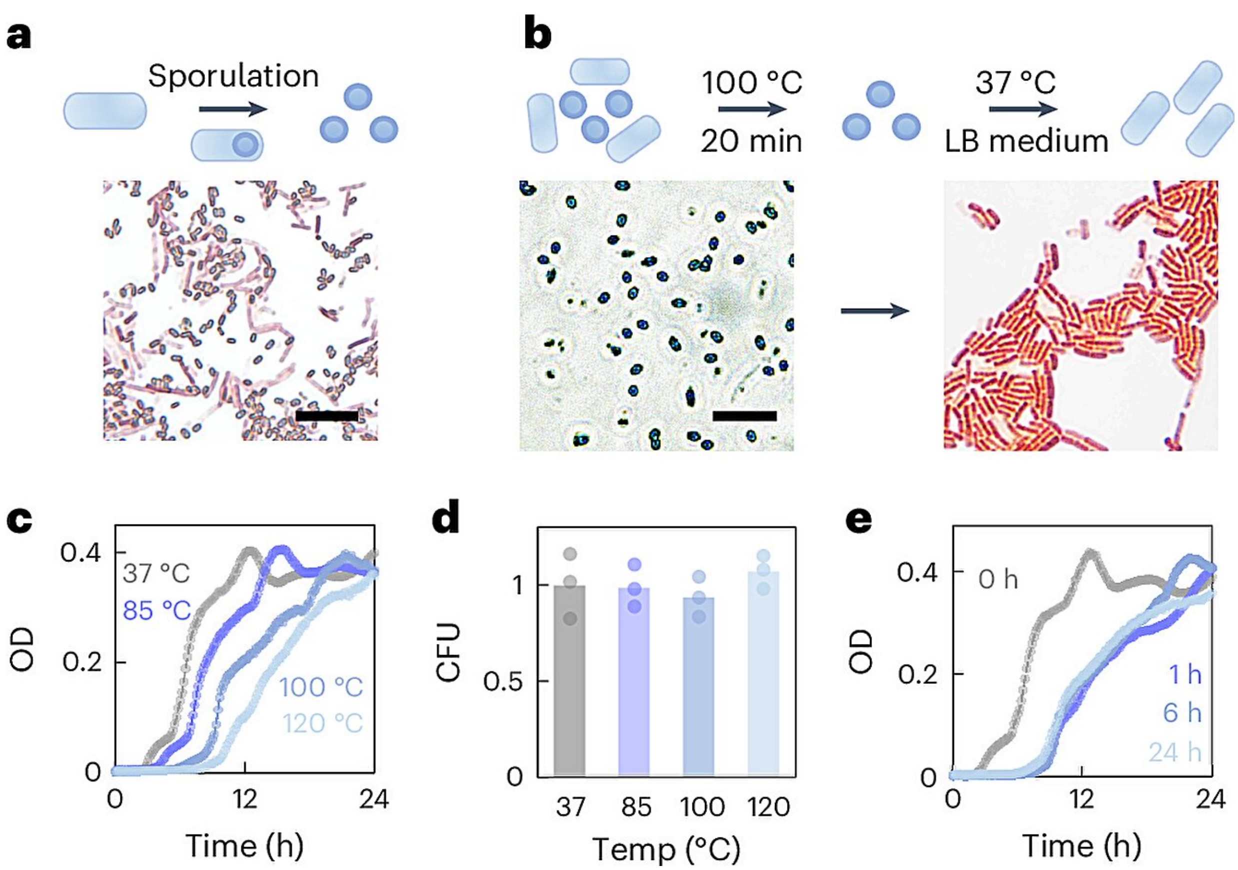
Since then, numerous synthetic biology research has been focusing on discovering, designing and evolving the relevant plastic-degrading enzymes. There has been little exploration of innovative methods for creating degradable plastics.

## Dormant spores and living plastics

Microorganisms have developed intrinsic mechanisms to defend harsh conditions over billions of years. One classical example is the formation of spores that are resilient to dryness, high temperatures and high pressure (similar conditions in plastics processing).

Using synthetic biology, the research team engineered Bacillus subtilis with a genetic circuit to control the secretion of a plastic-degrading enzyme (lipase BC from Burkholderia cepacia). Under stress from heavy metal ions, Bacillus subtilis forms spores.

The team mixed these engineered spores with poly (caprolactone) (PCL) plastic granules and produced spore-containing plastics through high-temperature extrusion or solvent dissolution. Tests showed that these "living plastics" had similar physical properties to regular PCL plastics. During daily use, the spores remain dormant, ensuring the plastic's stable performance.




The spores were resilient to environmental perturbations. Credit: *Nature Chemical Biology* (2024). DOI: 10.1038/s41589-024-01713-2, https://www.nature.com/articles/s41589-024-01713-2

## Spore release and degradation initiation

The first key step in plastic degradation is to release the spores embedded in the living plastic for cell reviving. Researchers have first demonstrated two methods of spore release. One method uses an enzyme (lipase CA) to erode the plastic surface.

These released spores then germinated and expressed the lipase BC, which bound to the ends of PCL polymer chains and near-completely degraded the PCL molecules (final molecular weight

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