Press Release

Keio University

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Breakthrough in Breaking Down Non-Biodegradable Plastic Straws

Multiple strains of bacteria, Suitable for P-Life, a Plastic Additive Providing Biodegradability, discovered in the soil of Nishikamakura Elementary School

A team of researchers has successfully identified a suitable biodegrading bacterium for polypropylene (PP) by adding the biodegradation-promoting additive P-Life[1]. Keio researchers involved in this project were Ayaka Futagi, a fourth-year student with the Department of Biosciences and Informatics at the Faculty of Science and Technology, Ying Huang, a researcher with the Keio Leading-edge Laboratory of Science and Technology, and Professor Kenji Miyamoto in the Keio University Faculty of Science and Technology. Other collaborators included Isao Toyama, president of P-Life Japan Inc., Yoshihito Abe, a representative of SI Jushisangyou, and Shuji Uchiyama of ITO EN, LTD.

This research could prove to be a vital step in microbial biodegradation efforts around polyolefins[2], a type of plastic that is especially difficult to degrade. The strains of bacteria that were unearthed in this study show great promise in breaking down polyolefin microplastics.

These findings were presented at the academic conference for the Molecular Biology Society of Japan held on November 28, 2024.

1. Main Points

- Several strains of bacteria that can be used in biodegradation of P-Life containing polypropylene found in the soil at the Nishikamakura Elementary School in Kamakura, Japan.
- When collected bacteria were applied to polypropylene plastic straws (hereafter "PP straws") containing P-Life, researchers were able to confirm that biodegradation had occurred.
- The bacteria were also found to be effective on polyethylene containing P-Life.

2. Research Background

The release and accumulation of plastics in the environment has become major issues in recent years. Among them, persistent plastics such as polyolefin-based plastics—and polypropylene in particular—are resistant to decomposition and biodegradation in natural ecosystems.

This is why Isao Toyama, president of P-Life Japan Inc., designed an additive that could be used with polyolefins to make them biodegradable. P-Life gradually transforms polypropylene into small molecules with functional groups that allow them to then be metabolized and broken down by naturally occurring microorganisms over time.

To ascertain P-Life's effectiveness, the biodegradability test with the plastic straws containing P-Life was conducted under JIS(Japan Industrial Standard) K6955, "Plastics-Determination of the Ultimate Aerobic Biodegradability of Plastic Materials in Soil by Measuring the Oxygen Demand in a Respirometer or the Amount of Carbon Dioxide Evolved."

However, due to slow biodegradation rates in the soil, the scientists were unable to obtain bacteria that are effective in the decomposition process through regular methods.

This study was the first to successfully devise methods for searching for and isolating specimens for this process.

3. Research Design and Findings

From October to December 2022, the research team conducted the “Back to Earth Straw Project” at Nishikamakura Elementary School in Kamakura as part of the Japan Science and Technology Agency’s COI-NEXT program which emphasizes symbiotic and creative ways of upcycling and showing respect for the environment.

For the initiative, the school replaced their plastic straws with those incorporating P-Life for their school lunches and treated them as compost to demonstrate their biodegradability.

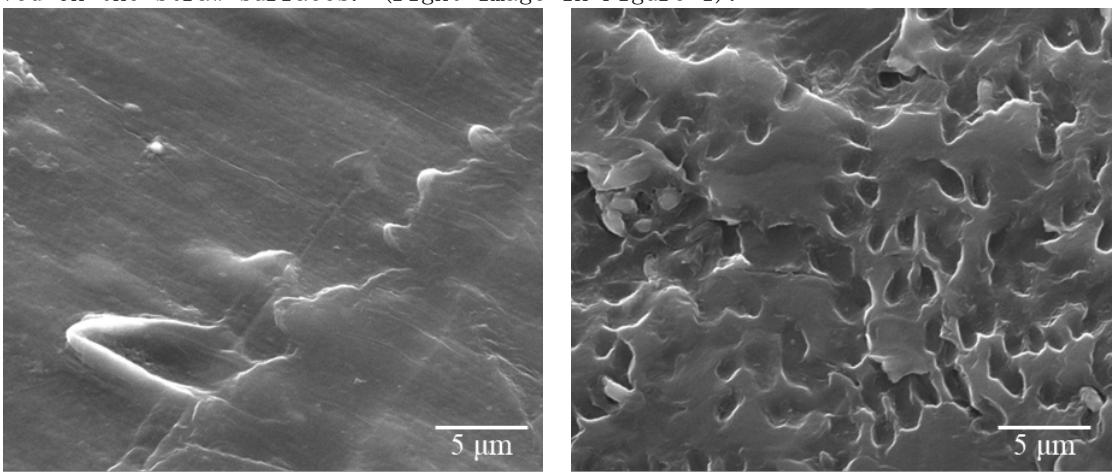
For this study, scientists examined the microorganisms in the soil at this location, assuming the presence of bacteria based on how effective decomposition had been during the initial experiment.

To increase the probability of finding the correct bacteria, the scientists heated P-life polypropylene straws to begin the thermal decomposition process ahead of time.

The thermally degraded materials were then divided into two groups: low-molecular compounds soluble in acetone (believed to be easier for microorganisms to consume) and insoluble high-molecular compounds (considered harder to consume).

The two groups of compounds were then added to soil samples from Nishikamakura Elementary School in order to identify microorganisms that would break down these substances. After measuring the results, the research team was able to isolate two strains of bacteria for the low molecular weight compounds and three strains for the high molecular weight compounds.

When the research team applied these identified bacteria to P-Life containing polypropylene straws without any thermal treatment, the clear decomposition marks were observed on the straw surfaces. (right image in Figure 1).



Firgure 1. Scanning Electron Microscope Images of P-Life-Containing PP Straw Surface
Untreated Straw (Left) and Microorganism-Treated Straw (Right)

Furthermore, the research team collected soil samples from various locations, added P-Life-containing PP straws, and compared the bacterial community one month later with that in samples without adding straws.

In nearly all samples, the proportion of degrading bacteria significantly increased when PP straws with P-Life were present (Figure 2). This strongly suggests that these bacteria play a major role in straw decomposition.

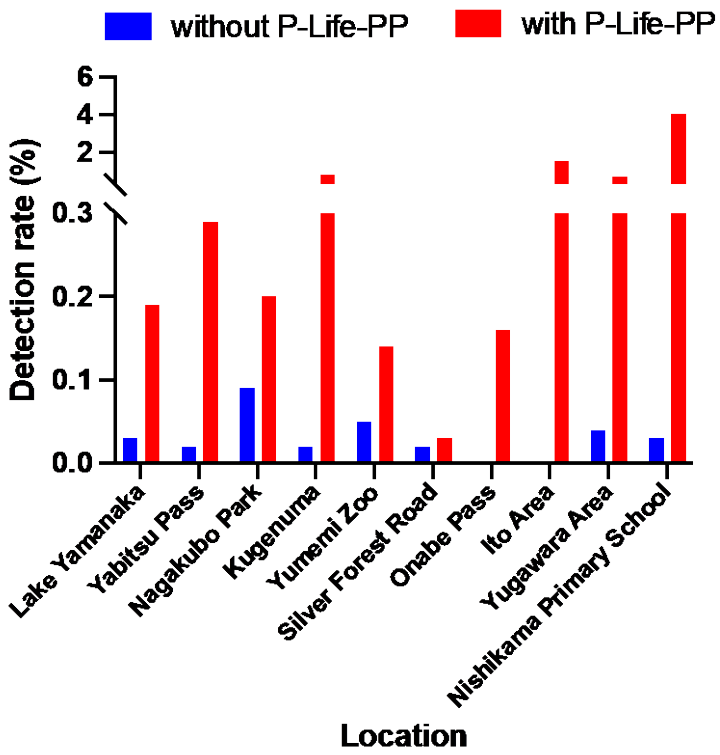


Figure 2: Comprehensive analysis of bacteria used in biodegradation

4. Future Outlook

This research unearthed strains of bacteria capable of breaking down polypropylene with P-Life as well as the bacteria's effectiveness in the biodegradation process. Combining the discovered bacterial strains with P-Life products will lead to huge improvements in efficiency for biodegradability. These bacteria are expected to make an important contribution toward solving the problem of persistent plastics.

Presentations at Academic Conferences

The 47th Annual Meeting of the Molecular Biology Society of Japan, November 28, Marine Messe Fukuoka.
Title: Biodegradation of P-Life-containing polypropylene and its mechanism
Speakers: Ayaka Futagi, Ying Huang, Isao Toyama, Yoshito Abe, Shuji Uchiyama, Kenji Miyamoto

Research Funding

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Glossary

1. P-Life: an innovative additive designed to enable the microbial degradation of plastics previously considered non-biodegradable. P-Life transforms these plastics into low-molecular-weight compounds with functional groups, which microorganisms can more easily degrade. Additionally, P-Life is made from plant-based oils, ensuring its safety, and does not affect the physical properties or processability of PP.

2. Polyolefins: a generic term for polymer compounds synthesized from a small set of simple olefins. The most common types of polyolefins are polyethylene and polypropylene. In general,

these types of plastics are not considered biodegradable.

*Please direct any requests or inquiries to the contacts listed below in advance of any press coverage.

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