

FUNDING PROGRAM FOR NEXT GENERATION WORLD-LEADING RESEARCHERS

Project Title: Green-biochemistry: applying survival strategies of deep-sea microorganisms adapted to extreme biosphere

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1. Background of research

The largest reservoir of the Earth's carbon is located in the deep-ocean, with 37,000 billion tons of carbon stored, whereas approximately 65,500 billion tons are found in the globe. Carbon flows between each reservoir via the carbon cycle, which has slow and fast components. In the slow cycle, carbon moves through a series of chemical reactions and tectonic activity, whereas in the fast carbon cycle, it moves via life forms on the Earth. The annual carbon flux in the fast cycle is 1000-fold greater on average than that in the slow cycles. Recently, some microorganisms capable of mineralizing recalcitrant complex organic materials are being recognized as having a key role in enhancing the turnover rate of carbon. In particular, deep-sea microorganisms have a high potential to metabolize any materials for their survival in dark and oligotrophic biospheres without primary production from photosynthesis. Most abundant biomasses on Earth are cellulose and lignin. Components of lignin, called "phenolics" are toxic for most organisms. Thereby, biological processing of lignin is extremely difficult and remains challenging. However, the molecular structure of lignin is basically similar to that of petroleum components. Lignin can be converted into the most of current petro-chemicals.

2. Research objectives

We will conduct extensive screening for new and powerful lignin-converting microorganisms and related genes encoding enzymes from unexplored deep-sea soil samples, aiming to discover a means of bioconverting lignin into plastics by applying a series of enzymatic reactions.

3. Research characteristics (incl. originality and creativity)

Deep-sea microorganisms have a promising sources of undescribed, yet useful biological functions. In the Earth's long history, deep-sea microorganisms evolved to adapt to extreme biospheres, where nutrients are deprived. We will unveil novel biological functions from unexplored soil samples collected by a manned research submersible, "SHINKAI 6500", and a deep-sea drilling vessel, "CHIKYU". In this project, we applied an original recombinant gene expression system based on phenolics (lignin-related toxic compounds) -resistant microorganisms for gene mining. Through the combination of newly discovered enzymatic reactions, we will attempt to find a means of bioconverting lignin into plastics.

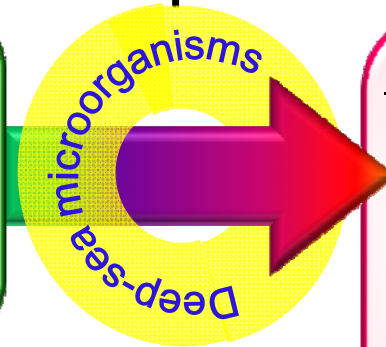
4. Anticipated effects and future applications of research

We aim to develop an eco-friendly process called green-biochemistry through efficient biological functions, producing plastics from abundant renewable materials in non-food plants for an oil-free sustainable future.

Green-biochemistry: applying survival strategies of deep-sea microorganisms adapted to extreme biosphere

LIGNIN

- Renewable materials in non-food plants
- One of the most abundant biomasses on earth (30% of woods, 10% of rice straws, found also in some seaweeds)
- Convertible into 95% of current petro-chemicals



Into PLASTICS for daily life

Screening deep-sea microorganisms possessing powerful enzymes for new applications



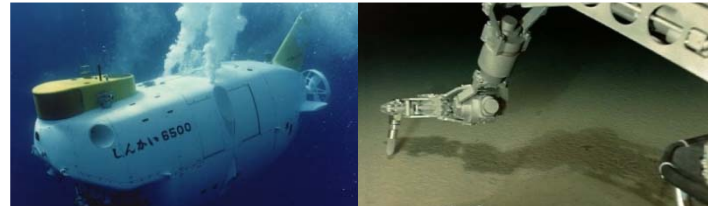
For an oil-free sustainable future

Promising potential of Deep-sea microorganisms

- Many useful functions have been discovered from deep-sea microorganisms.
- Deep-sea microorganisms can metabolize recalcitrant materials for their survival in dark and oligotrophic biospheres without primary production from photosynthesis.
- Unveiling novel biological-functions from unexplored soil samples collected by "SHINKAI6500" and "CHIKYU".



Deep-sea floor

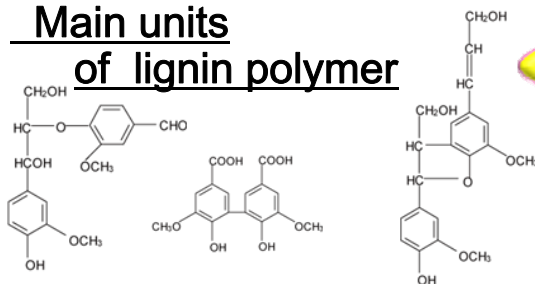


Manned research submersible "SHINKAI 6500"



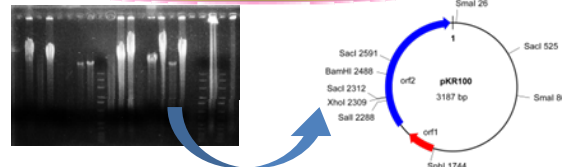
Deep-sea drilling vessel "CHIKYU"

Main units of lignin polymer



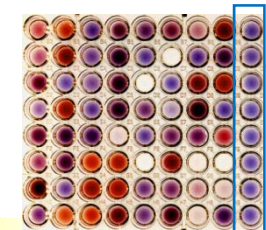
These compounds, called phenolics, are toxic for most organisms. To find processes using bioconversions remains extremely challenging.

Original system for gene mining !



A new recombinant gene expression system based on a phenolics-resistant bacteria

Many deep-sea organisms can convert lignin related compounds



Control (No micro-organisms)

Discovery of new metabolites from undescribed reactions