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INDUSTRY

Heat, salt, pressure, acidity - how 'extremophile' bacteria are yielding exotic enzymes

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Some of the extreme conditions endured by microbes are total darkness, acute salinity, and high pressures. Image: Shutterstock/Paul Cowell

Bacteria that survive in the world's harshest conditions produce enzymes that could be perfect for use in industrial processes, thanks to their ability to withstand high temperatures, high pressure and high salt environments.

Scientists are screening the deep ocean, sea floor and hydrothermal vents for species of bacteria – and primitive single-celled life forms known as archaea – that could produce previously unknown enzymes, and working out how to grow them in a lab environment.

Thanks to their capacity for breaking down large molecules into smaller ones, enzymes can be effective catalysts – substances that help chemical reactions happen more efficiently.

Researchers in the chemicals, medicine and food industries have been studying the power of enzymes for decades but a new frontier in enzyme research is opening up, thousands of metres below sea level.

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Professor Peter Golyshin of Bangor University in the UK says the ocean is teeming with microorganisms that have yet to be explored. These bacteria, archaea, fungi and single-cell algae all produce enzymes, but their huge potential remains untapped.

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*Prof. Peter Golyshin,
University of Bangor, UK*



'A lot of work has been done looking at bacteria in the gut of animals or in the soil, but marine life is hugely under-sampled and there are many more species in the sea,' he said. 'We know more about space than the vast and diverse ecosystem below the seas.'

Research by microbiologists suggests that more than 99 % of microbes are not yet known to scientists, with many of these species existing under extraordinarily challenging conditions that cannot be reproduced in the lab. It's life, but not as we know it.

For a start, most deep-sea microbial life exists in total darkness. The deeper you go, the greater the pressure due to the weight of the water above. Temperatures too can be extreme, with some archaea and bacteria surviving in icy waters while others thrive in the intense heat of thermal vents. There are others still which have adapted to waters with very high salt concentrations or with pH levels as low as sulfuric acid.

What makes these deep-sea 'extremophiles' so attractive? 'From a basic biology point of view, understanding microbes that live in harsh conditions gives us insights into how life evolved on this planet,' said Prof. Golyshin.

'Secondly, chemical synthesis is often conducted in harsh conditions with high temperatures, high pressures and high solvent concentrations. The anticipation is that enzyme catalysts produced by microbes that live in hostile environments could be used in these industrial processes.'

New techniques

These microbes have proven difficult to grow in the lab using tried and trusted microbiology techniques. This may be because standard culture media – a kind of nutrient-rich jelly on which bacteria can be grown in a lab – does not contain all the other microscopic organisms that live in the natural deep-sea environment.

It seems that extreme marine bacteria rely partly on the by-products of metabolism produced by other microbial species that thrive in their shared habitat.

Another problem with traditional methods of studying bacteria or archaea is that scientists typically sequence their DNA and compare it with a database of known species. As only a limited number of extremophile marine species have been found, referring to existing databases is not always useful when dealing with a novel microorganism.

Prof. Golyshin worked on an EU-funded project called MAMBA, which found alternative ways to work with marine archaea and bacteria.

'Instead of trying to grow the microbes in the usual way we can just harvest their DNA, express their genes in surrogate hosts such as yeast or E.coli, and apply substrates to see if they actively convert it or not,' he explained.

MAMBA has already uncovered new enzymes and one of the project's industrial partners, evocatal, is working towards commercialising some of these. Another partner, PharmaMar, is focussed on marine-derived anti-tumour drugs.

Extreme sampling

To gather extreme marine microbes, researchers participate in month-long cruises and use high-tech machinery to collect water samples from hydrothermal vents close to Milos island, Greece.

Professor Mohamed Jebbar of the University of Brest, France, says getting high-quality samples requires marine biology expertise, high-tech equipment and a little luck.

'The average depth of the deep sea floor is 3 800 metres so we need very large and sophisticated technology to explore these remote areas,' he said.

Cutting-edge kit is required back in the lab too. Prof. Jebbar is part of the MaCuMBA consortium and has been working on applying innovative techniques to analyse samples and improve the ability to isolate new archaea and bacteria.

The researchers developed a system which uses a robot to make testing the samples more efficient. 'Our approach uses a culture medium which mimics the marine ecosystem and, with the help of the robot, we can add several substrates,' said Prof Jebbar.

'These automated and high-throughput technologies are increasingly used in other areas like gene sequencing, for example. But in isolation and culturing of uncultured microorganisms it is still in its infancy.'

Enzymes and you

Many of the detergents used in laundries rely on enzymes to accelerate the chemical reactions required to remove grease and grime from clothing. Enzymes can also play an important role in brewing beer and are often employed in food production.

But that is not all. Some enzymes break down tough material such as cellulose from plants and agricultural or urban residues to make biofuels.

Scientists working on enzymes extracted from extremophile bacteria hope to identify new examples that can act as biocatalysts and even help to break up cancerous tumours.

More info

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