Discovery of long-distance microbial electron transport in the seafloor of the North Sea

Meysman Filip

Vrije Universiteit Brussel, Goudenregenlaan 20, 2950 Kapellen, Belgium
E-mail: filip.meysman@nioz.nl

A living battery in the seafloor
Long filamentous bacteria that are capable of conducting electricity over long distances, and in this way, they create a natural living battery in the ocean floor. It may seem hard to believe, but it is a recent discovery by the Microbial Electricity research team of Prof. Filip Meysman at the Vrije Universiteit Brussel (VUB, Belgium) and the Royal Netherlands Institute of Sea Research (NIOZ, The Netherlands). These "living batteries" perform a whole new form of microbial respiration and were first discovered at various locations in the North Sea, where they have a strong impact on the functioning of the seafloor ecosystem. The electron-conducting capabilities of the bacteria may lead to novel bio-electrical applications.

A surprise in the seafloor
In 2010, Danish microbiologists at Aarhus University made a fabulous discovery. In laboratory experiments they discovered a new type of bacteria, which can generate electricity and are capable of conducting electrons over long distances. Now, a new study, published in the ISME Journal (a high ranking research journal for microbiology), demonstrates that these bacteria are not a laboratory "curiosum", but are widespread in the marine environment, where they turn the seafloor into a living battery system. 'In field studies in the North Sea, we discovered several locations where these electrogenic bacteria are present, and the sediment geochemistry unequivocally shows that electrical currents occur the seafloor' explains team leader Prof. dr. ir. Filip Meysman 'By subsequently analyzing the DNA and comparing it with genetic archives, we know that the same micro-organisms occur in many different habitats, such as mangrove swamps, underneath fish farms and even in hydrothermal vents in the deep ocean.'

An entirely biological battery
The electrochemical battery was invented Alessandro Volta in the year 1800, and is typically regarded as a masterpiece of human engineering talent. The new study however shows that long filamentous bacteria in the seafloor have mastered the trick a few million years ago. By creating a natural battery, these bacteria have a substantial advantage in the competition for energy-rich metabolic resources. 'These bacteria are 100x thinner than a human hair, and form long winding spaghetti-like strings, consisting of 1000's of cells that pass electrons on to each other' explains dr. Sairah Malkin, lead author of the study. 'By generating electricity, these bacteria can harvest their metabolic energy from the seafloor in an ingenuous way. One side of the filament is buried deep into the seafloor, and is "mining" electrons from energy-rich sulphur compounds. These electrons are subsequently passed on from cell to cell upwards along the filament. Cells located at the sediment-water interface are channeling the electrons to oxygen, which is a favorable electron acceptor. As a result of this, an electrical current runs through the seafloor, from deeper sediments horizons towards the surface. It is known for long that microbes can be used to generate electricity, such as in microbial fuel cells, but this process still requires that we supply the electrodes and connecting wires. Here the process is completely microbial, it's a true natural biological battery."

A new form of life
All living cells require energy, and until now, it has been assumed that the energy supply occurs in the same manner, from bacteria to elephants. The general principle is that every cells looks after its own energy supply. The newly discovered bacteria are now challenging this principle as different cells cooperate to ensure the energy supply of the whole organism. "This mechanism, whereby bacteria are generating electricity and are transporting electrons over centimeter-scale distances, amazes microbiologists.' adds Meysman. 'It completely changes the way we think of how cells can cooperate. It's like having two brothers that cooperate in breathing: one brothers exclusively inhales, while the other brother always exhales. It just shows how inventive biological evolution can be."

Bacterial smartphones
The use of organic materials in electronic engineering is an active field of research, for example, in the development of flexible photo-voltaic panels. However, the creation of efficient electrical conduction in organic materials remains notoriously challenging. "Now we have a microbe from the seafloor that has somehow has evolved the enzymatic machinery to master this trick. If we can find out how our

electrogenic bacteria are achieving this, this clearly offers great opportunities for research into novel bio-electrical materials and applications" explains Meysman "Maybe within some years, our smartphones are equipped with minuscule conducting wires of bacterial origin."

More information about the research team can be found on the project website:
www.microbial-electricity.eu