An electroactive bacteria, the iron biodegradation and the microampere supplying battery

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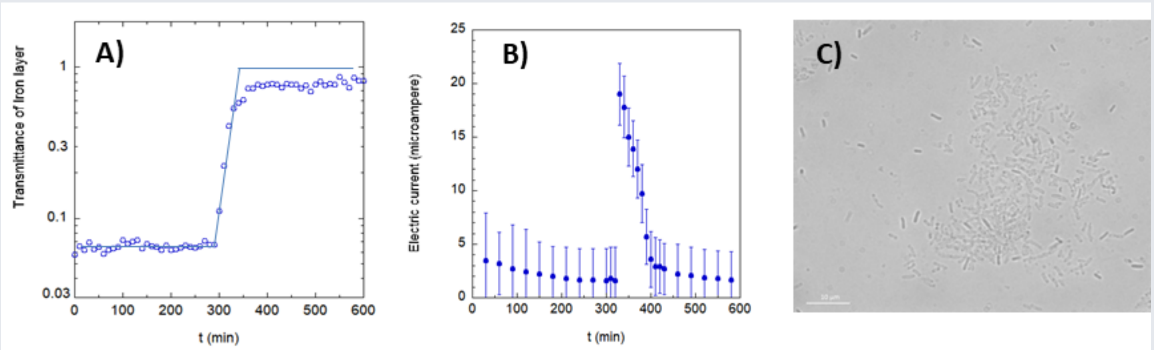
Shewanella oneidensis MR-1 is considered as a model of electroactive bacteria and is well-studied for its respiration versatility. For example, *S oneidensis* is able to reduce metal ions (like ferric ions) by electron transfer processes or to adhere to electrodes surfaces and to form a biofilm that generates low levels of current. In spite of numerous applications (waste water treatment, biosynthesis of metal nanoparticules, green fuel cell), the exact mechanisms used by the bacteria to transfer electrons to metals remain unclear. In fall 2015, an interdisciplinary group of Paris-Saclay University, gathering two biophysicists from LPS and ISMO labs and a microbiologist from I2BC lab, starts a research project named "e-connect bacteria" to study these electroactive properties.

After buying small equipments, funding interns, and searching for the optimal growth conditions to form a biofilm, we now try to link the affinity of *S oneidensis* to metals and the current generation. We have chosen to work on one of the most abundant metal in the soil, the iron and on metallic layer, thin enough to be semitransparent and to allow us optical microscopy observations. The layer is then placed at the bottom of our samples where we pour the growth medium and bacteria as well. We first observe a rapid increase of the optical transmittance of the sample only few hours after letting the metal in contact with the bacteria medium. The transmittance, plotted in Figure A) in a log scale, increases abruptly up to unity suggesting rapid and total iron degradation within one hour.



This unexpected result suggests that bacteria convert the solid Iron layer into soluble iron components like in classical corrosion of metals. The rusting of iron involves multisteps of electrochemical process starting by an oxidation of iron thanks to an electron transfer from iron to oxygen. As electrons issued from the iron oxidation may delocalize within the metal, we have tried here to derive them in a different circuit. The metal layer has been connected to another solid and "inert" platinum electrode by an external electric wire, the platinum electrode being immersed into the same liquid. By connecting in series an ammeter, we have then measured the electric current potentially generated by the iron oxidation and flowing in the circuit. Figure B) shows the current measurement as a function of time. Five to six hours following the liquid inoculation with bacteria, the current rises abruptly up to 20 microamperes before decreasing slowly within the next hour. Both changes in transmittance and electric current are concumitant and clearly related to the microbial biocorrosion.

These two results open new perspectives for basic microbiology applications as well as for biotechnical applications like green bioreactors. Besides the applications, a lot of fundamental work remains to be done to understand the electroactive properties of bacteria, ranging from local measurements and observations (as shown, in Figure C, a preliminary image obtained by phase contrast microscopy) to macroscopic settings with iron foils in combination with a microbiology approach. Genetics tools are under development (construction of mutants Impaired In the phenomenon) in order to better understand and maybe improved the electric current production.

Résultats obtenus dans le cadre du projet E-CONNECT BACTERIA financé par le thème émergence du LabEx PALM et porté par Eric Raspaud (LPS), Christian Marlière (ISMO), Christophe Regeard (IGM) et Renaud Cornut (NIMBE, CEA).