Short Term Mobility 2017 – Massimo Trotta

Final report

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Foreign institution: Molecular Foundry – Lawrence Berkeley National Laboratory in Berkeley, California. Biological Nanostructures Facility.

Project title: ***ONIRYC*** – C*o*nverting *N*ear *I*nfrared *R*adiation by Photos*y*nthetic Ba*c*teria

Abstract:

The conversion of solar light into more viable form of energy is a topic of great interest in the quest of low environmental impact energy sources. Photosynthetic organisms represent a paramount example of photoconverters as they play the role of harvesting sunlight and converting in other forms of energy, which eventually power planet Earth.

During the period spent at the Molecular Foundry, the basis for the use of anoxygenic non-sulphur photosynthetic bacteria as current generator were set for and the preliminary results of this very challenging attempts are here described.

Background:

Non-sulphur photosynthetic bacteria are photosynthetic organisms who perform this metabolic process in anoxygenic fashion. There are estimates of the appearance of these microorganisms on planet Earth that date back to 3.2-3.6 Gya ago. Few interesting features make them very suitable for the present project that tackles the possibility to irradiate a living and metabolic active culture of these bacteria and extract electron flow:

1. The photosynthetic ability, *i.e.* the ability of converting the solar radiation in electron flow;
2. The ability to efficiently use the Near Infra-Red (NIR) wavelength range of the solar radiation for performing photosynthesis;
3. The ability to switch between oxygenic/non photosynthetic metabolism and anoxygenic/photosynthetic metabolism based on the availability of light and on the oxygen partial pressure.

In particular, the microorganism *Rhodobacter* (*R.*) *sphaeroides* is a model organism for photosynthesis and is the bacterium of choice for the present set of experiments.

Experiments performed at Molecular Foundry

1. The growth of the bacterial strain

Several strains of *R. sphaeroides* have been isolated in the environment, but we focussed on the wild type (or strain 2.4.1) for which the entire genome has been sequenced and annotated. The conditions chosen for the bacterial growth are low partial pressure of oxygen and high light flux. One issue to consider is the source of carbon. As the purpose of the present experiments in to retrieve currents from a steady-state culture of bacteria, a condition in which carbon is efficiently delivered to the growing bacteria must be found. The direct use of CO_2 is somehow questionable for practical reasons and, furthermore, for the rather slow kinetic by which a bacterial assimilated it. The typical alternative is a source of carbon chosen from the dicarboxylic acids, typically succinic or malic acids. Unfortunately, these species are electroactive and can impair the retrieval of electrons from the bacterial cells.

Time was spent in optimising this point, trying to minimise the sodium succinate concentration in the growth media still able to sustain bacterial growth.

Examples of the grown culture are given below:

Fig. 1. Bacterial growth in a carbon rich medium. The brown-red colour on the top of the plastic vial is due to the in-liquid growth of a biomass *R. sphaeroides* 2.4.1.

Fig. 2. Bacterial growth in a carbon poor medium (Medium M9). The faint reddish colour is due to the growth of a rather poor biomass *R. sphaeroides* 2.4.1.

2. Current generation

A three-electrode apparatus was employed for measuring electric current obtained from the culture of *R. sphaeroides* 2.4.1 under illumination.

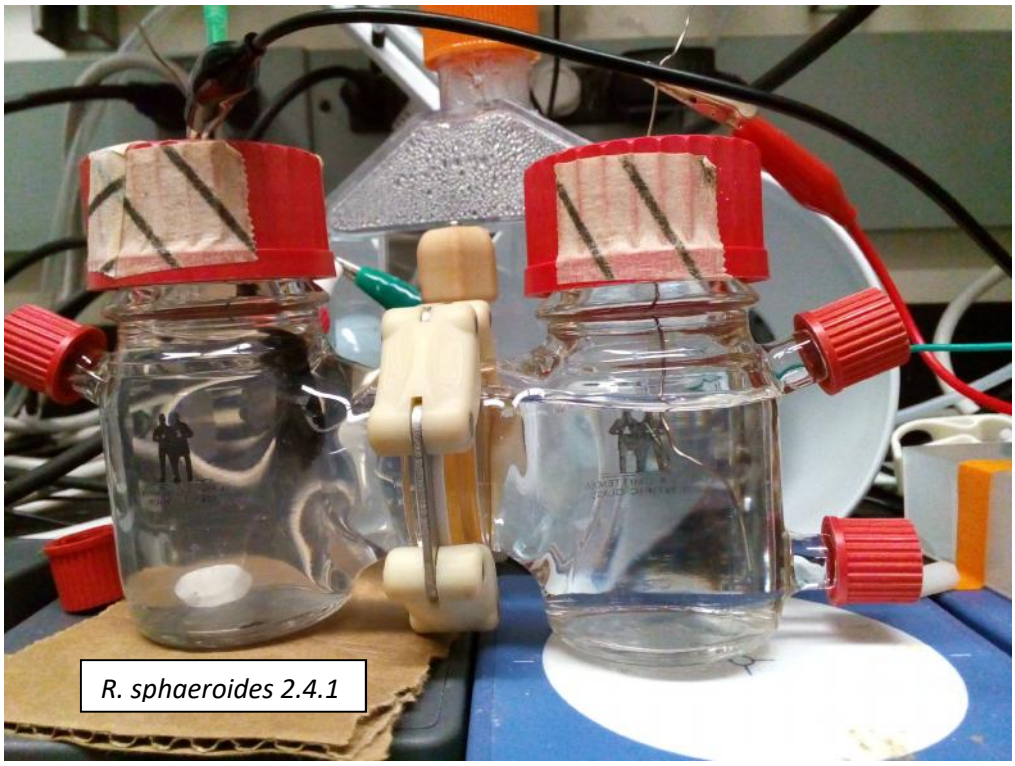

Figure 3. Assembly of the potentiometric apparatus for the recording of the photoinduced electric currents from *R. sphaeroides* culture (on the left).

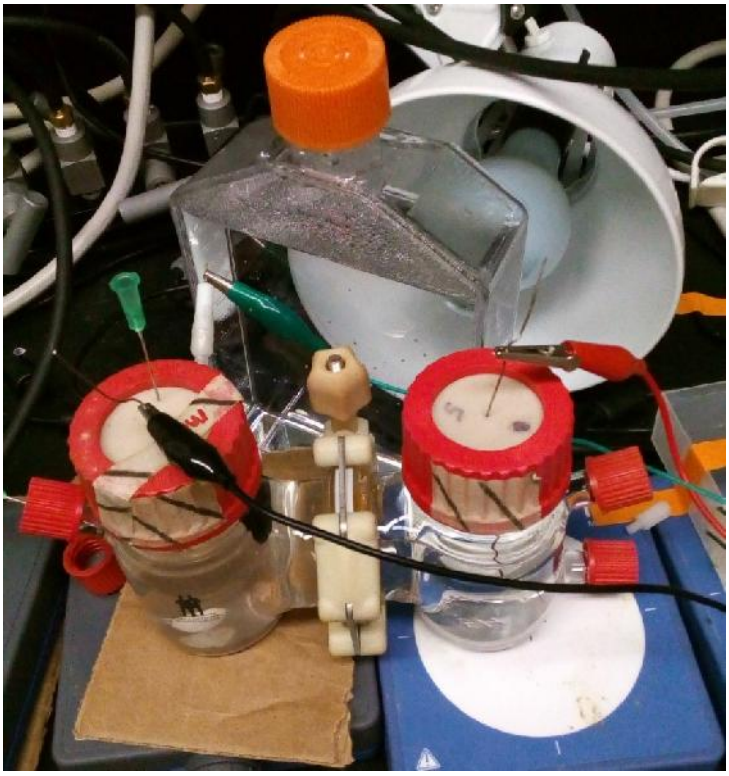

Figure 4. Top view of the potentiometric apparatus for the recording of the photoinduced electric currents. The irradiating source (a 100W incandescence lamp bulb) is screened by a water bottle 2.5 cm thick to maintain constant temperature.

The syringe needles are used for a gentle N_2 stream for Oxygen purging.

Electrodes:

Working Electrode – carbon felt contacted via Titanium wire

Reference Electrode – Ag/AgCl (3M in KCl)

Counter Electrode – Platinum wire.
Potentiostat (CH Instruments 1000B).
Medium: M9 supplemented with mineral elements and 0.04 g/L of Sodium succinate.

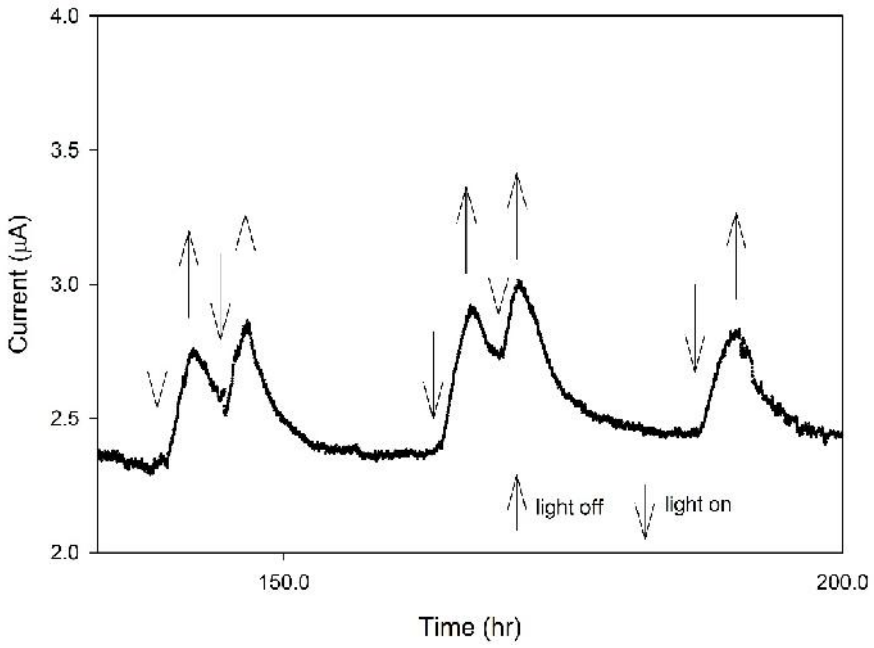

Figure 5. Data relative to current response of R. sphaeroides. Arrows indicate turning light on and off.

Discussion

The results have shown that the wild type of the photosynthetic bacterium Rhodobacter sphaeroides is indeed amenable for current generation under illumination.