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Interfacing photosynthetic microorganisms with electrodes for optoelectronics and photoelectrochemistry

Gianluca M. Farinola[1], Danilo Vona[1], Rossella Labarile[1], Gabriella Buscemi[1], Roberta Ragni[1], Francesco Milano[2], Matteo Grattieri[1], Massimo Trotta[3]

1Dipartimento di Chimica, Università degli Studi di Bari Aldo Moro, Via Orabona 4, 70125, Bari, Italy
2CNR-ISPA, Institute of Sciences of Food Production, Lecce Unit, Via Prov.le Monteroni, 73100, Lecce,Italy
3CNR-IPCF Institute for Physical-Chemical Processes (IPCF), CNR, Via Orabona 4, 70125, Bari, Italy

Photosynthetic microorganisms have optimized their molecular apparatuses and structures for light absorption and photoconversion over billions of years of evolution. We are interested in exploiting molecules and structures isolated from these microorganisms, or their entire living cells, as the active components for photoconversion in optoelectronic devices and photoelectrochemical cells, particularly focusing on interfaces with electrodes.

Our study started with the Reaction Center (RC), a transmembrane photosynthetic protein which generates charged separated states after absorption of photons, extracted from the purple non-sulphur bacterium *Rhodobacter sphaeroides*. The RC was initially modified by covalent functionalization with a molecular antenna to increase its light absorption capability [1]. The same RC was then integrated in devices [2], such as photoelectrochemical cells, photosensors and photoactive transistors [3], using molecular or polymeric semiconductor thin films deposited onto metal electrodes as interfaces [4]. Among them polydopamine (PDA) gave very interesting results for the stabilization of *Rhodobacter sphaeroides* RCs. PDA is a biocompatible polymer produced *via* self-oxidative polymerization of the dopamine monomer in mild aqueous conditions, which displays intrinsic conductivity and adhesive properties. RC can be immobilized both in PDA thin films on the electrode surfaces or in PDA nanoparticles, without altering the enzymatic photoactivity, and it can produce photocurrents in photoelectrochemical cells [5]. PDA can also be modified with diamines, leading to more transparent nanostructures incorporating RC molecules, which outperform RC/PDA structures in light transmission and photoconversions [6].

Finally, we have investigated different approaches for interfacing intact photosynthetic microorganisms with electrodes, enabling photoconversion with living cells. Two anoxygenic purple bacteria with high metabolic versatility have been studied, *Rhodobacter sphaeroides* and *Rhodobacter capsulatus*, using PDA as the interface material either as a coating on the cells' surface, or as a film entrapping the cells on the electrode surface. Photoelectrochemical cells were developed with both configurations, enabling the production of photocurrents.

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