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Optimization of BES by unravelling the storing mechanisms of electro-active bacteria

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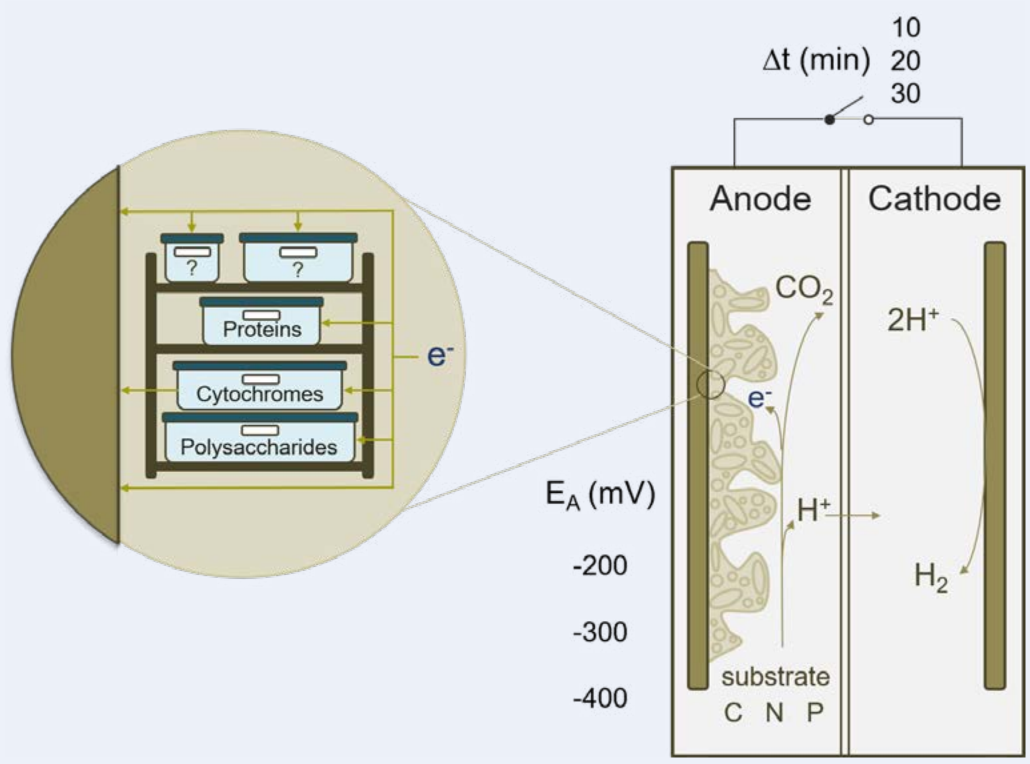
Motivation

Bio-electrochemical systems (BESs) have been referred as a new technology for chemicals productions, bioremediation and power generation [1]. The role of electro-active microorganisms in these systems is crucial [2-3]. However, their performance in terms of current output is not competitive for practical application. Recently, higher currents have been reported for electro-active bacteria (EAB) controlled under intermittent polarization. Using this regime, biofilm morphology also differed from the structure typically observed under continuous polarization. However, the underlying mechanisms are still to be unraveled. In this project we propose the study of charge storage capabilities of electro-active bacteria by integrating several techniques to understand biofilm growth kinetics and biochemical composition. These results will provide valuable information to control and optimize biofilms performances in BES.



Technological challenge

The main challenge will be the integration of different quantification and characterization methods to assess the biofilm development on the anode. Due to the limited number of in-situ techniques available to track biofilm growth kinetics and chemical composition, the integration of several optical and electrochemical approaches is essential to a better understanding of biofilm behavior and a more detailed biofilm analysis (Figure 1). By studying the effect of operational conditions on the biofilm development, a final inherent challenge will be the creation of knowledge to control biofilm growth kinetics towards better performances in BES.

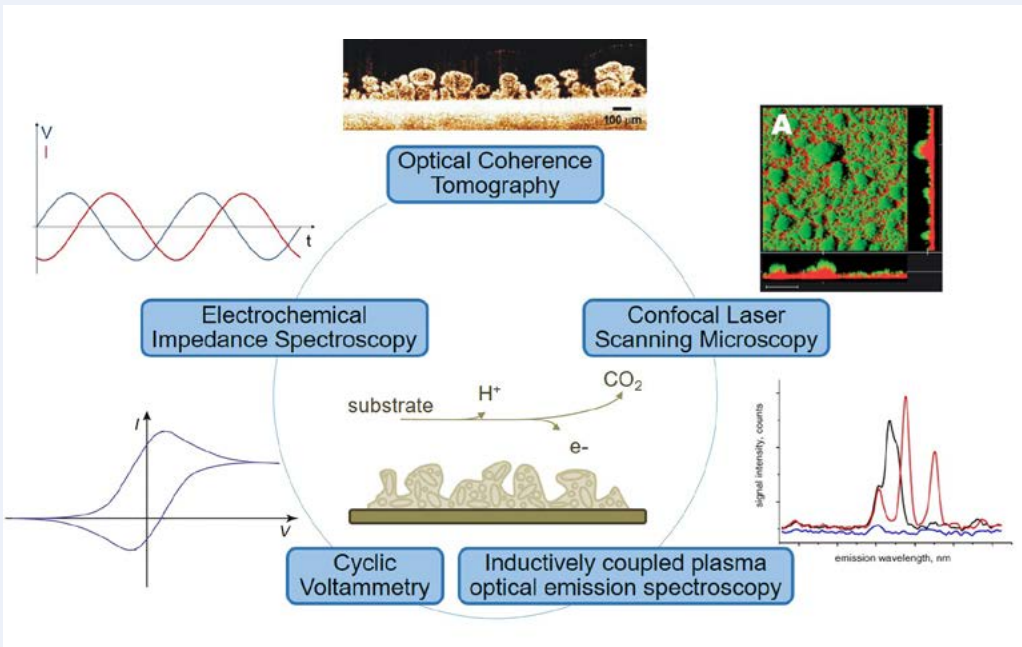


Fig 1. Examples of techniques to evaluate biofilm growth in BES: optical techniques (Optical Coherence Tomography and Confocal Laser Scanning Microscopy), electro-chemical analysis (Electrochemical Impedance Spectroscopy, Cyclic Voltammetry) and chemical methods (Inductively Coupled Plasma Optical Emission Spectroscopy)

Research goals

With the outcomes of this research we will be able to explain and establish the causality between biofilm development and intermittent polarization, unravelling the fate of electrons and formulating a more accurate electron balance in BES. The following topics will be considered:

1. Comparison of the effect of continuous and intermittent potential in electro-active biofilms growth dynamics;
2. Evaluation of electron storage mechanisms as function of intermittent/continuous polarization;
3. Starving and stress conditions effect in biofilm structure and composition;
4. Integration of visualization methods for more detailed in-situ analysis of biofilm development.

[1] Borole, Energy & Environmental Science, 4(12), 2015, 4813-4834
[2] Erable, Biofouling, 26(1), 2010, 57-71
[3] Deeke, Journal of Power Sources, 243,2013, 611-616

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