Analysis of cathodic bacterial communities reveals high diversity and potential new electroactive oxygen reducing microbes affiliated to Deinococci

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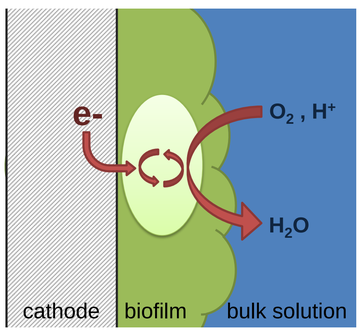
Context: oxygen reducing biocathodes



The formation of oxygen reducing biocathodes constitute a crucial step in the development of microbial fuel cells (MFCs) with aerated cathodes. Indeed, the slow kinetics of electrochemical oxygen reduction are currently limiting MFCs efficiency (Erable, Feron et al. 2012). Our knowledge on the diversity of bacteria able to catalyse electrochemical reactions has advanced fast, however the majority of the studies focused on anodic biofilms. On cathodes, the few analyses of the bacterial diversity have mostly relied on DGGE (Clauwaert, Van der Ha et al. 2007), clone library (Rabaey, Read et al. 2008) or PhyloChip (Wrighton, Virdis et al. 2010). In this study we used pyrosequencing to study the bacterial communities on oxygen reducing biocathodes.

Methods

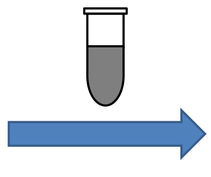
Electrochemical cells:

two compartment separated by an anion echange membrane at 40° C

WE:
Electrode material: carbon cloth
Medium: synthetic feeding medium
Inoculum: aerated sludge
Polarization: -0.2 V or +0,4 V / SCE

CE: platinum grid electrode
REF: saturated calomel electrode

Cathodic biofilm



454 pyrosequencing:

Bioinformatics:

qiime

- Data cleaning (trimming, chimera removal…)
- Classification as Operational Taxonomic Units (OTUs)
- Secondary analyses (taxonomic assignation, diversity indexes calculation, phylogeny…)

Results

Electrochemistry:

Chronoamperometry and cyclic voltammetry

E_{pol} / V	Electrode	$J_{-0.2\ V}$ / A m^{-2}	J_{lim} / A m^{-2}	$J_{-0.4\ V,\ air}$ / A m^{-2}
-0.2	1	-0.20	-0.15	-0.45
-0.2	2	-0.19	-0.65	-2.0
-0.2	3	-0.24	-1.1	-3.7
-0.2	4	-0.22	-0.77	-2.7
+0.4 / -0.2	5	-0.09	-0.64	-2.1
+0.4 / -0.2	6	-0.17	-0.63	-

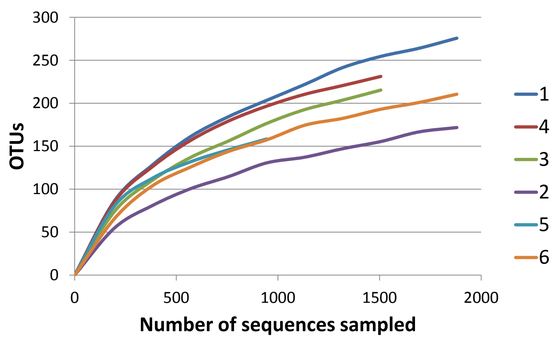
$J_{-0.2\ V}$: current density measured at -0.2 V in chronoamperometry after current stabilization
J_{lim}: current density limited by the diffusion displayed on the plateau in cyclic voltammetry
$J_{-0.4V,\ air}$: current density displayed in cyclic voltammetry under air bubbling at the arbitrarily chosen potential of -0.4 V

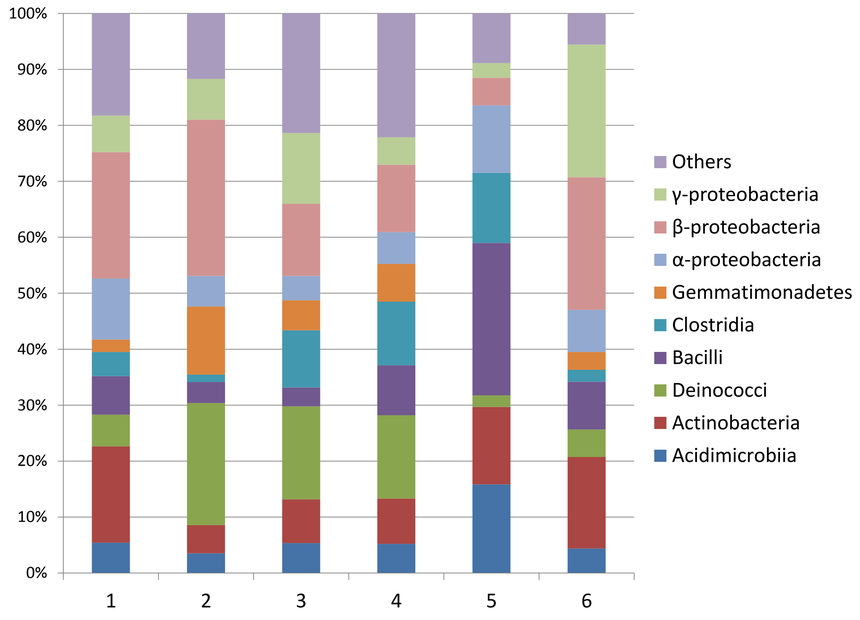
=> Formation of oxygen reducing biocathodes with high current densities

Microbial diversity:

diversity indexes, rarefaction curves and distributions of bacterial classes

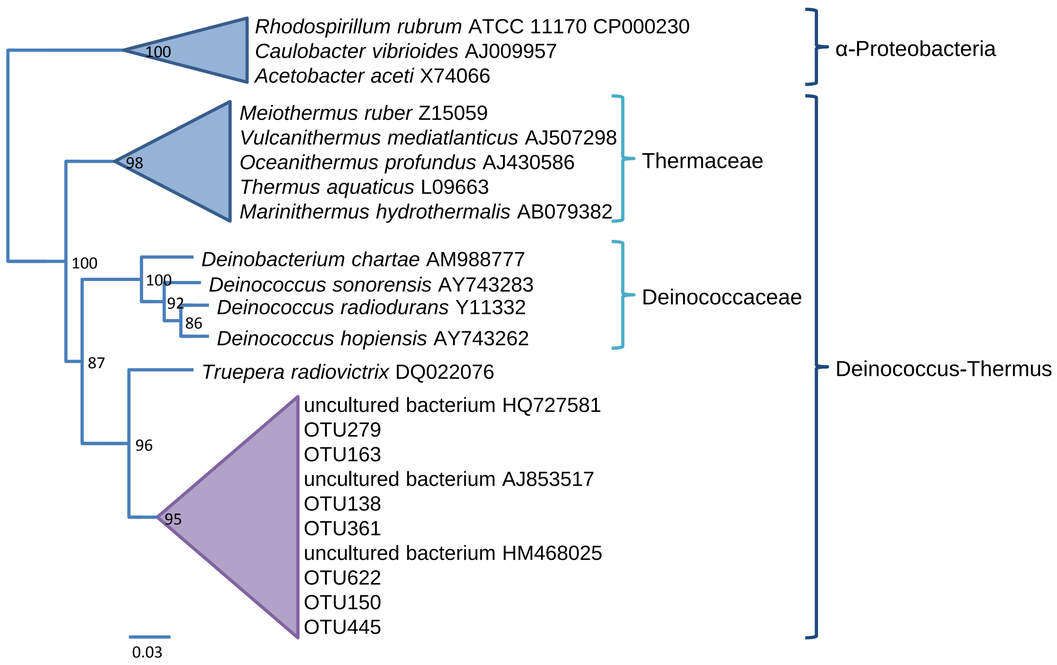
	Number of OTUs	chao1	shannon	simpson
1	329	413	6,54	0,97
2	181	297	4,99	0,92
3	220	276	5,95	0,96
4	239	309	6,44	0,97
5	162	190	6,13	0,97
6	227	261	5,39	0,92





=> High diversity of identified microorganisms on the cathode

Phylogeny of sequences identified as Deinococci:



=> New lineage sister to Truepera

Conclusions

- Efficient oxygen reducing biocathodes are formed from aerated slugdes.
- Pyrosequencing reveals high diversity for oxygen reducing biofilms
- A selection is operated when a relatively low potential (-0.2 V) is applied to the cathode compared to higher one (+0.4 V) and this selection allows higher current densities.
- A new lineage belonging to Deinococci is highlighted that might be an important actor of oxygen reducing ecosystems.

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