cost ACTION TD1102 - 2nd Plenary Workshop
PHOTOTECH: BIOSENSORS AND BIOCHIPS

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

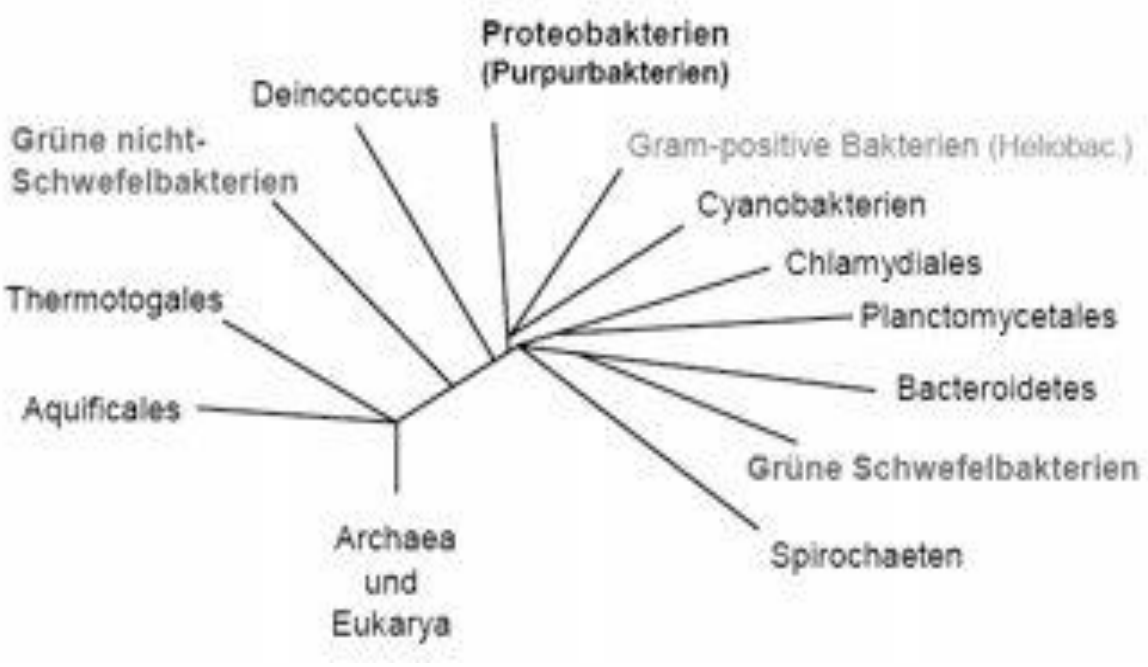
A new designed microbial fuel cell: An electricity production study by *Rhodobacter sphaeroides*

Dr. Bilge Hilal CADIRCI

Bioengineering Department
Gaziosmanpasa University
Tokat, Turkey

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- cyanobacteria,
- proteobacteria (purple bacte
- green nonsulfur bacteria,
- green sulfur bacteria
- the Gram-positive heliobacte



Phylogenetic affiliation of phototrophic bacteria

- The purple bacteria and green nonsulfur bacteria synthesize a nonoxygen-evolving type II photosystem;
- the green sulfur bacteria

  and
- heliobacteria have a homodimeric type I photosystem;
- Cyanobacteria contain a type I photosystem and an oxygen-evolving type II photosystem, both of which are heterodimeric.

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

Physiological properties of phototrophic Bacteria

	Cyanobacteria	Purplebacteria	Green Sulfur bacteria	Green non-Sulfur bacteria	Heliobacter
PS-type	PS I and II	PS II	PS I	PS II	PS I
Pigments	Chl a (b)	BChl a, b	BChl a, c, (d, e)	BChl a, c	BCHl g
Autotrophy	+	(+)	+	+/-	-(?)
Physiology	Photoauto-Lithoauto-	Photoauto-Lithoauto-Organohetero-	Photoauto-Lithoauto-	Photoauto-Lithoauto-Organohetero-	Photoauto-Organohetero-
CO_2 fixation	Calvin-cycle	Calvin-cycle	Reductive TCA	3OH-Propionate	None ?
Electron donor	H_2O	H_2S/ organic	H_2S	H_2/ organic	Organic

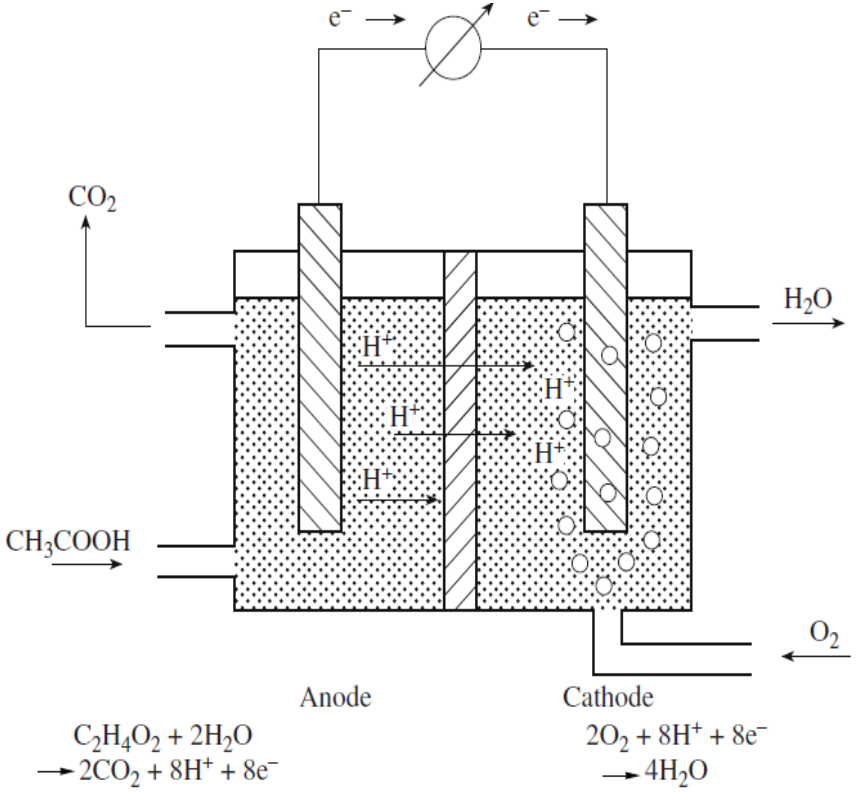
Adapted from Fuchs and Schlegel
'Allgemeine Mikrobiologie'

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Solar energy reaches the Earth at the rate of the 178,000 TW of which 0.2% to 0.3% is harnessed by microorganisms

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Microbial fuel cells, a type of bio-electrochemical system, directly capture electrons



- the oxidation of a carbon source occurs at the anode while the reduction of 02 to H20 occurs at the cathode

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

Species studied by the researchers in anode chamber.

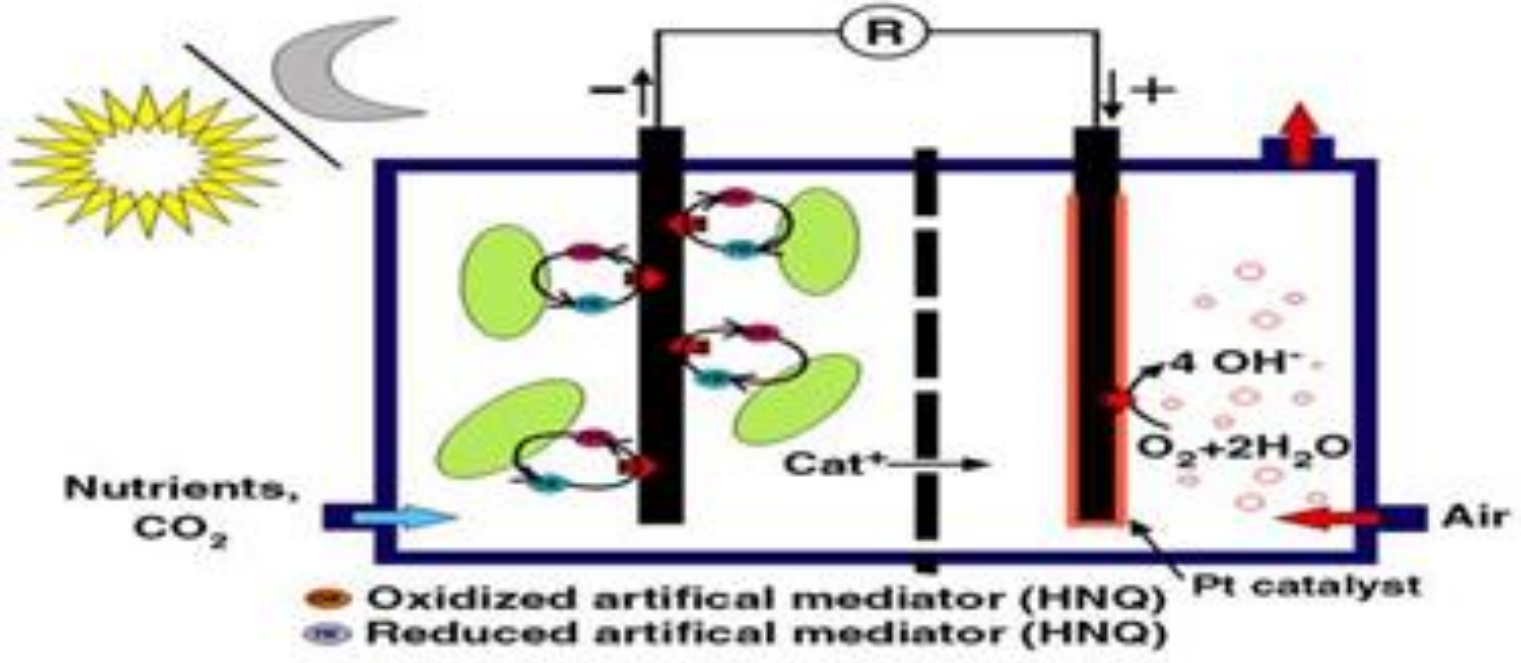
S. no.	Species	References
1.	*E. coli*	Potter [14], Zhang et al. [15], Habermann and Pommer [22], Zou et al. [59], Park and Zeikus [60], Qiao et al. [61], Xi and Sun [62]
2.	*Shewanella oneidensis* DSP10	Ringeisen et al. [16], Biffinger et al. [18,19]
3.	*Shewanella oneidensis* MR-1	Manohar et al. [17], Biffinger et al. [18]
4.	*Shewanella putrefaciens*	Kim et al. [1], Park and Zeikus [21]
5.	*Pseudomonas aeruginosa*	Habermann and Pommer [22], Rabaey et al. [23–24]
6.	*Geobacter sulfurreducens*	Bond et al. [26], Reguera et al. [27,31], Trinh et al. [33]
7.	*Geobacteraceae*	Holmes et al. [29], Bond et al. [30]
8.	*Geobacter metallireducens*	Min et al. [32]
9.	*Dessulfobulbus propionicus*	Lovley et al. [53]
10.	*Geothrix fermentans*	Lovley et al. [54]
11.	*Paracoccus denitrificans* and *Paracoccus pantotrophus*	Rabaey et al. [55]
12.	*Rhodopseudomonas palustris* DX-1	Xing et al. [56]
13.	*Klebsiella pneumoniae*	Lewandowski et al. [57,58]

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- The photosynthetic microbial fuel cell (PMFC) is a bioelectrochemical system capable of converting sunlight into electricity based on the exploitation of biocatalytic reactions within active microbial cells

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

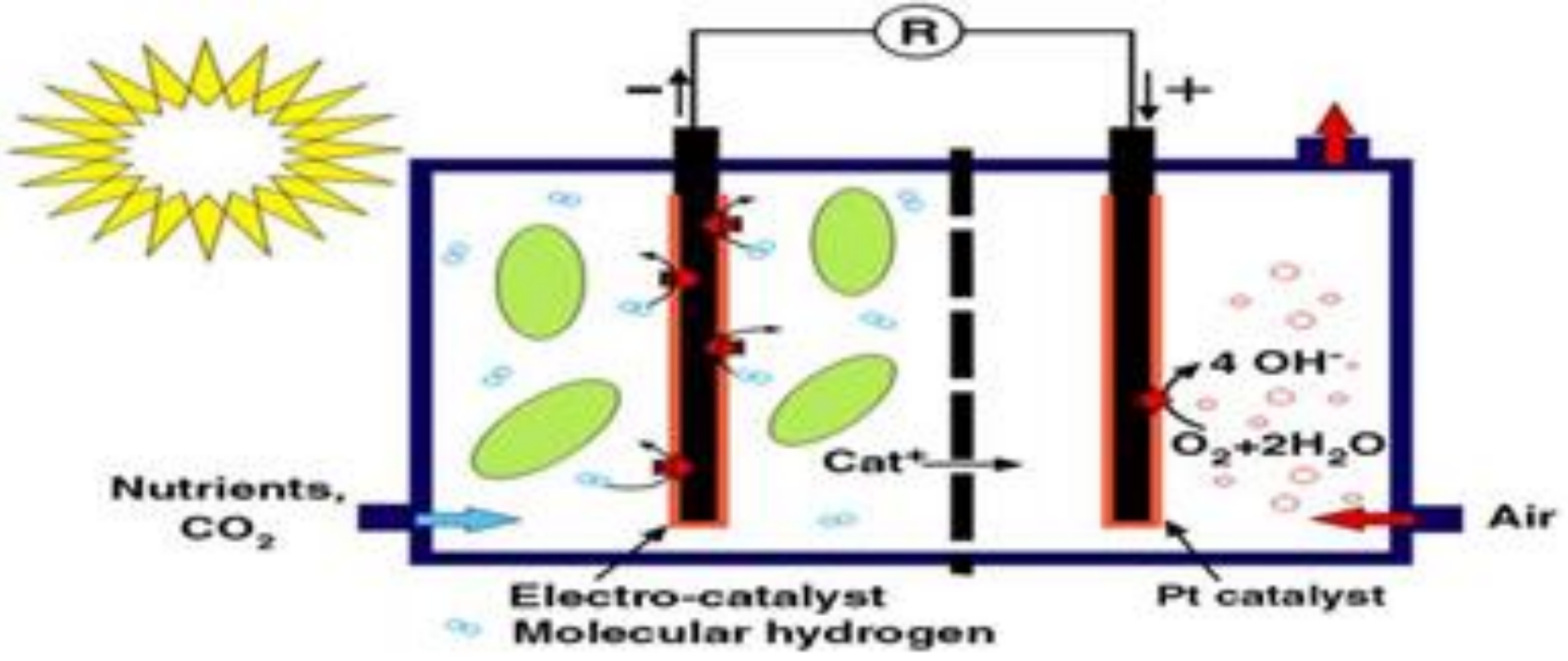
Photosynthetic bacteria at the anode with artificial mediators



2-hydroxy-1,4-naphtoquinone

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

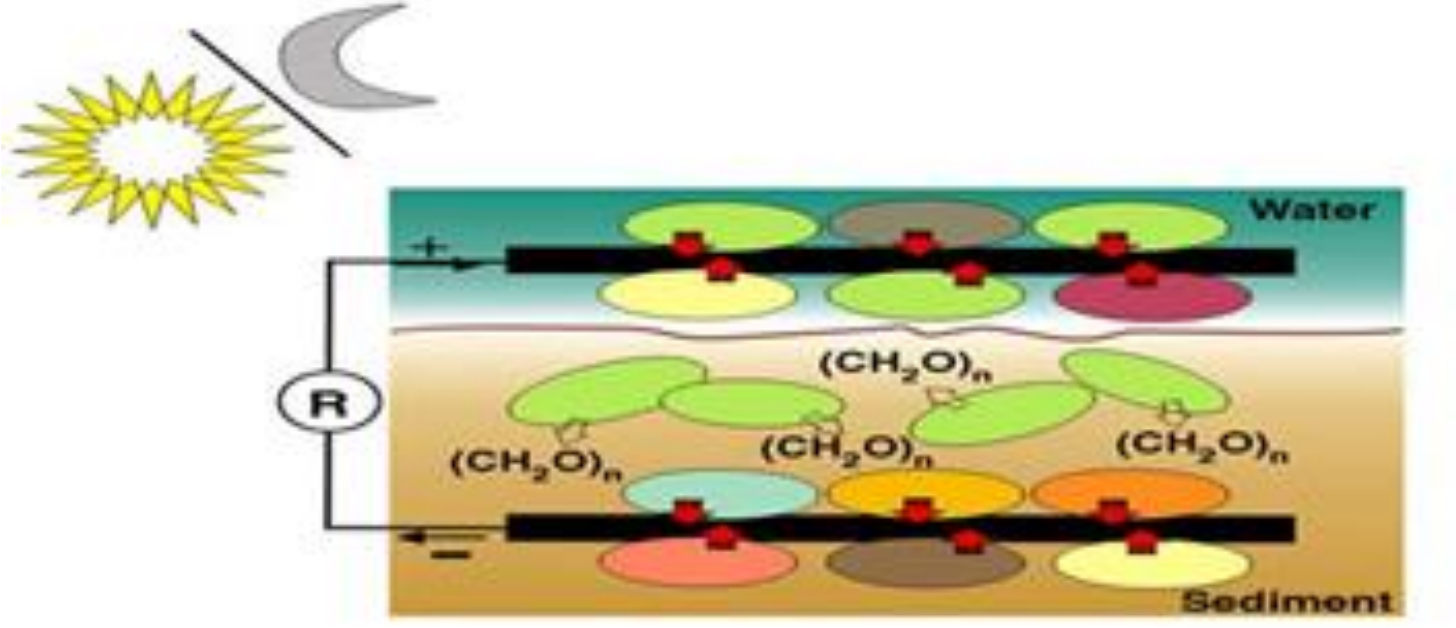
- Hydrogen-generating photosynthetic bacteria with an electrocatalytic anode



HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

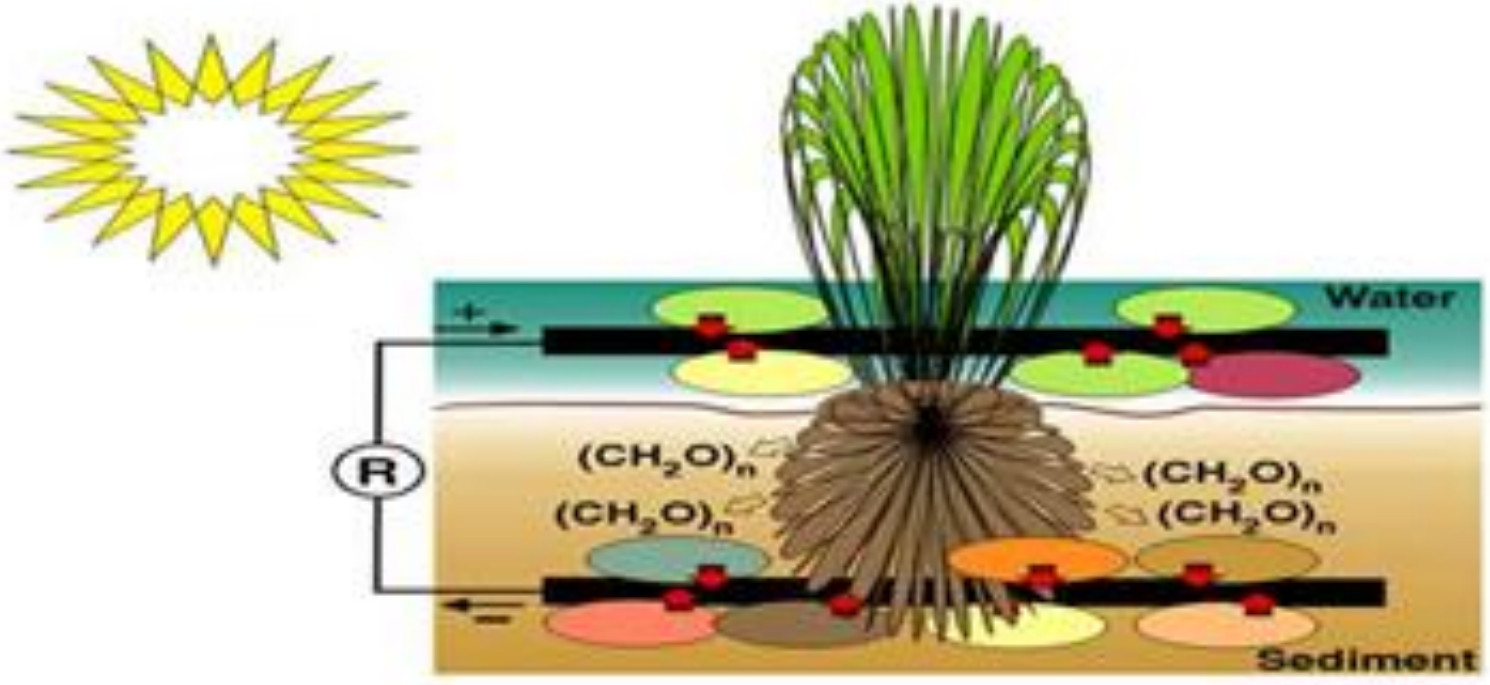
Photosynthesis coupled with mixed heterotrophic bacteria at the anode

- Synergism between phototrophic microorganisms and mixed heterotrophic bacteria in sediments



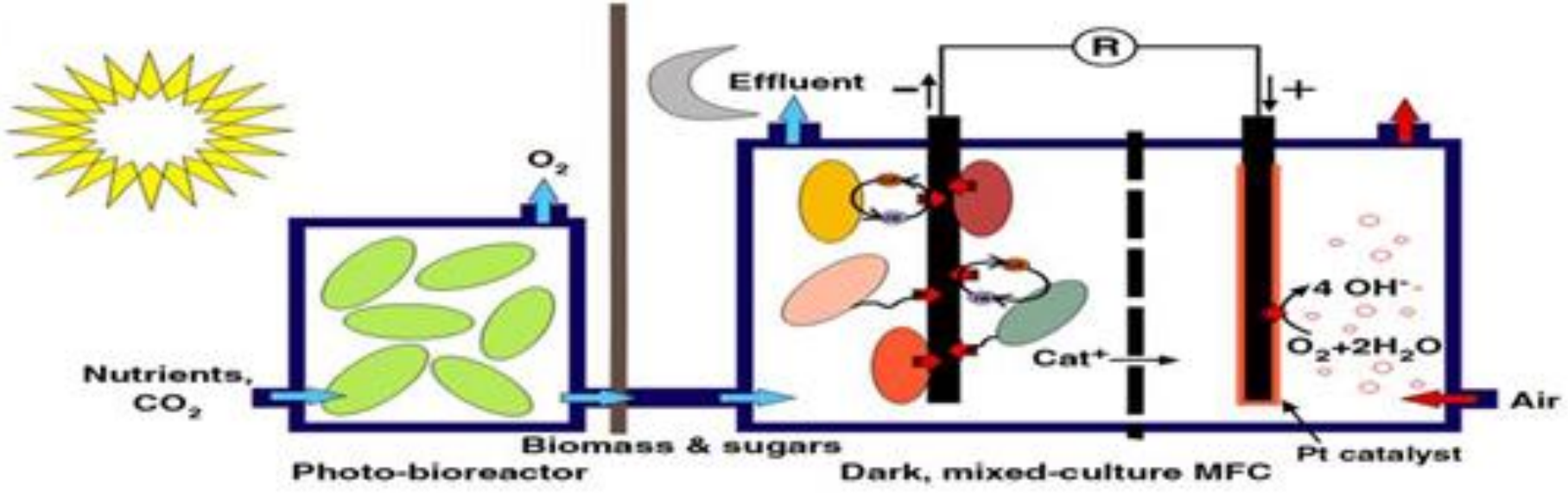
HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Synergism between plants and mixed heterotrophic bacteria in sediments



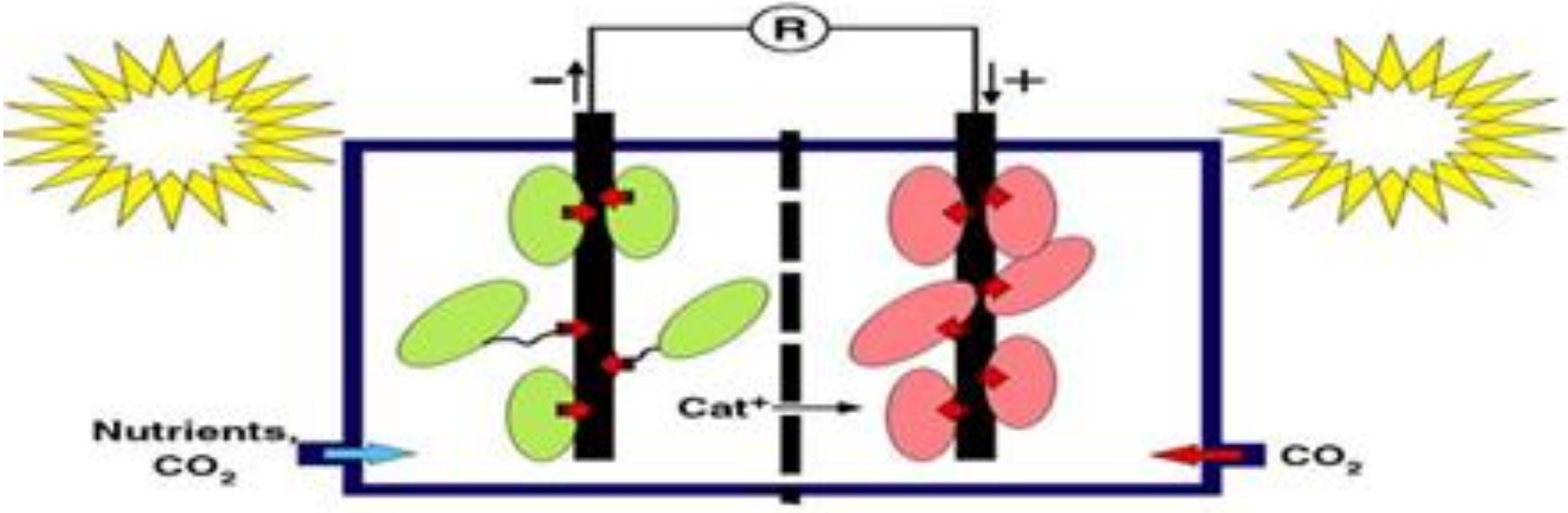
HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Ex situ photosynthesis coupled with mixed heterotrophic bacteria at a dark anode



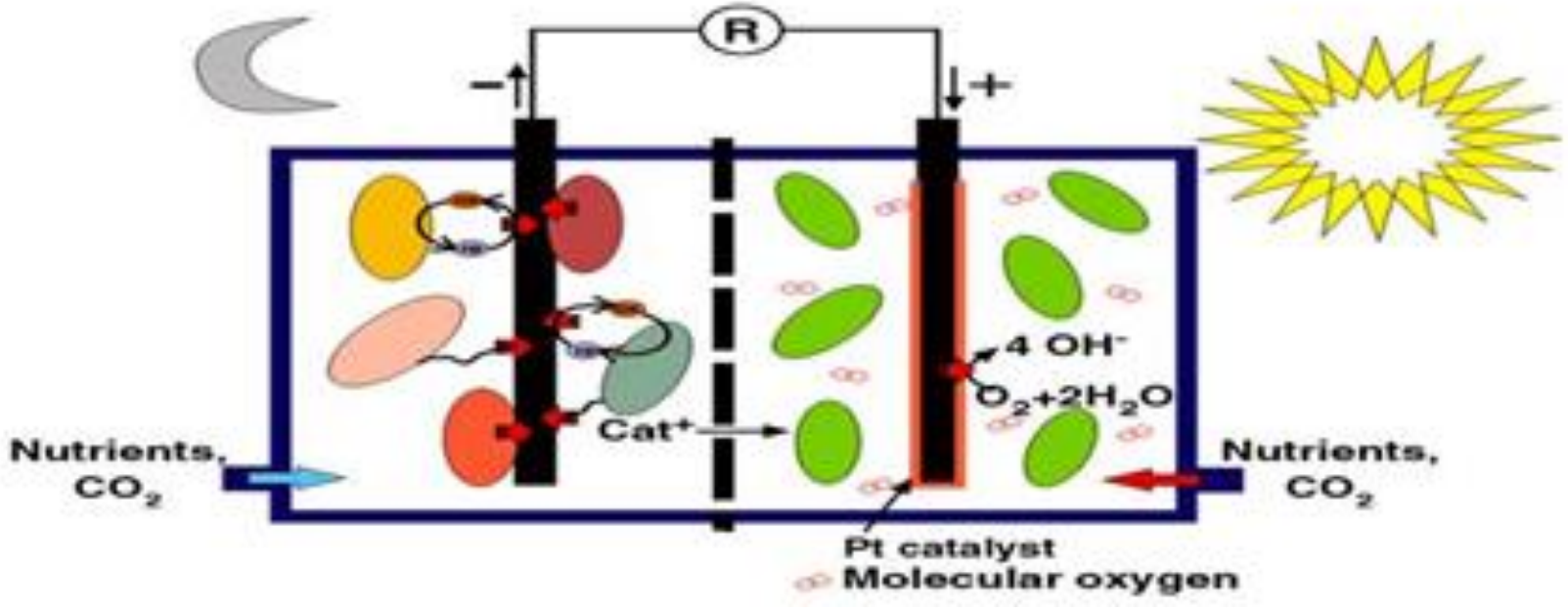
HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Direct electron transfer between photosynthetic bacteria and electrodes



HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Photosynthesis at the cathode to provide oxygen



HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

Electrogenic yield of diverse cyanobacteria genera and mixed pond consortium.

Culture	Yield, % [1]
Pond consortium	0.304±0.009
Calothrix	0.265±0.006
Pseudoanabaena	0.165±0.008
Synechococcus	0.155±0.006
Ananbaena	0.149±0.015
Phormidium	0.149±0.015
Nostoc	0.136±0.013
Lyngbya	0.130±0.016
Spirulina	0.099±0.09
Synechocystis	0.075±.008
Leptolyngbya	0.051±0.015

[1] The yield is shown as a mean of three 24 h illumination cycles with' a standard deviation.

References

Pisciotta JM, Zou Y, Baskakov IV (2010) Light-Dependent Electrogenic Activity of Cyanobacteria. PLoS ONE 5(5): e10821. doi:10.1371/journal.pone.0010821

Rosenbaum M., He Z., Angenent, LT. 2010, Light energy to bioelectricity: photosynthetic microbial fuel cells. Current Opinion in Biotechnology, 21:259–264

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Material and Methods:

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

Thanks Dr. Lasszlo for R. sphaeroides

permanganate as cathodic electron acceptor

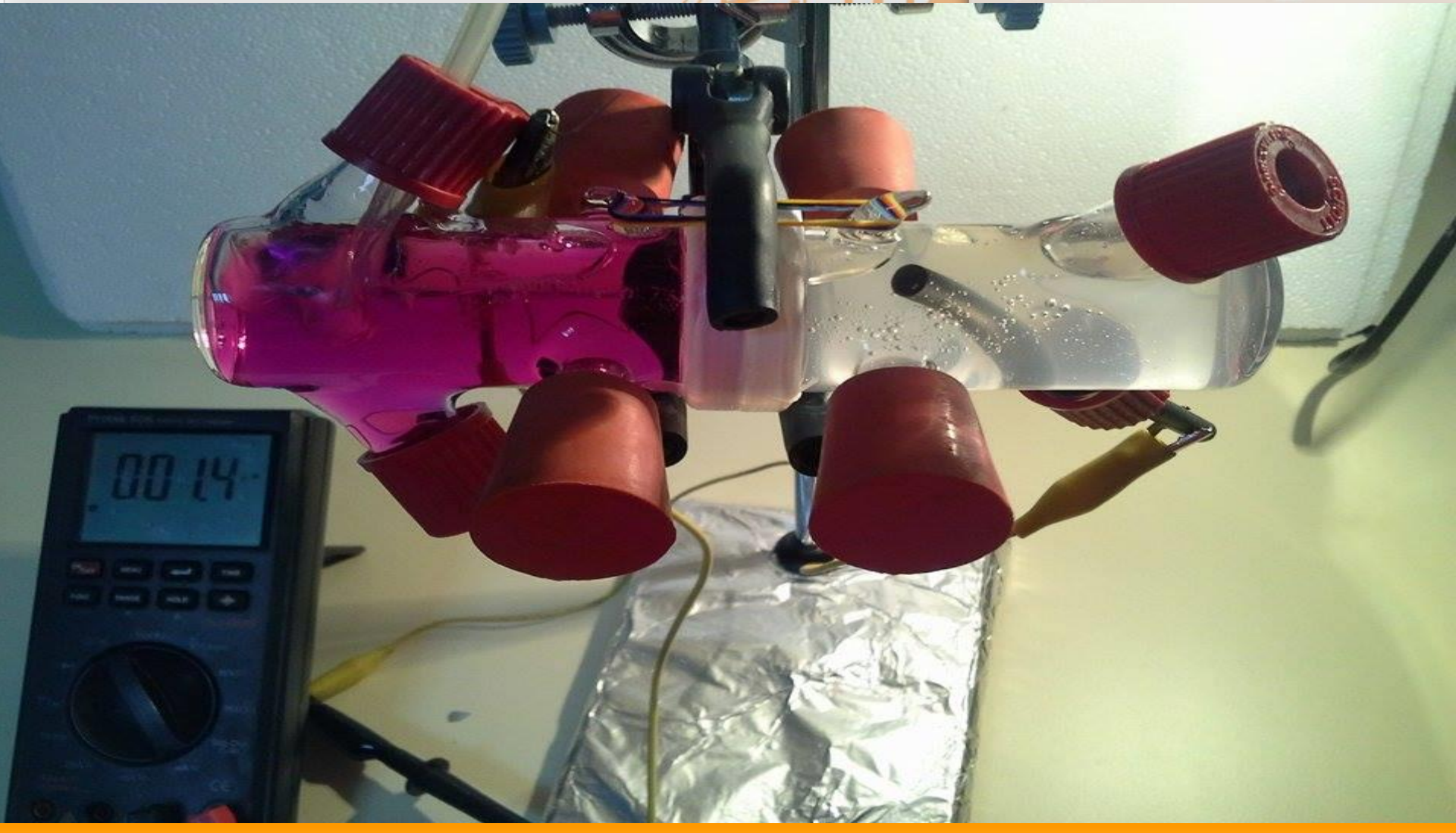
- 50 ml volume of cells
- Carbon electrode for anode
- Platine electrode for catode

Youa, S., Zhaoa, Q., Zhanga, J., Jianga, J., Zhaob, S., A microbial fuel cell using permanganate as the cathodic electron acceptorJournal of Power Sources 162 (2006) 1409–1415

cost ACTION TD1102 - 2nd Plenary Workshop

PHOTOTECH: BIOSENSORS AND BIOCHIPS

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE



cost ACTION TD1102 - 2nd Plenary Workshop

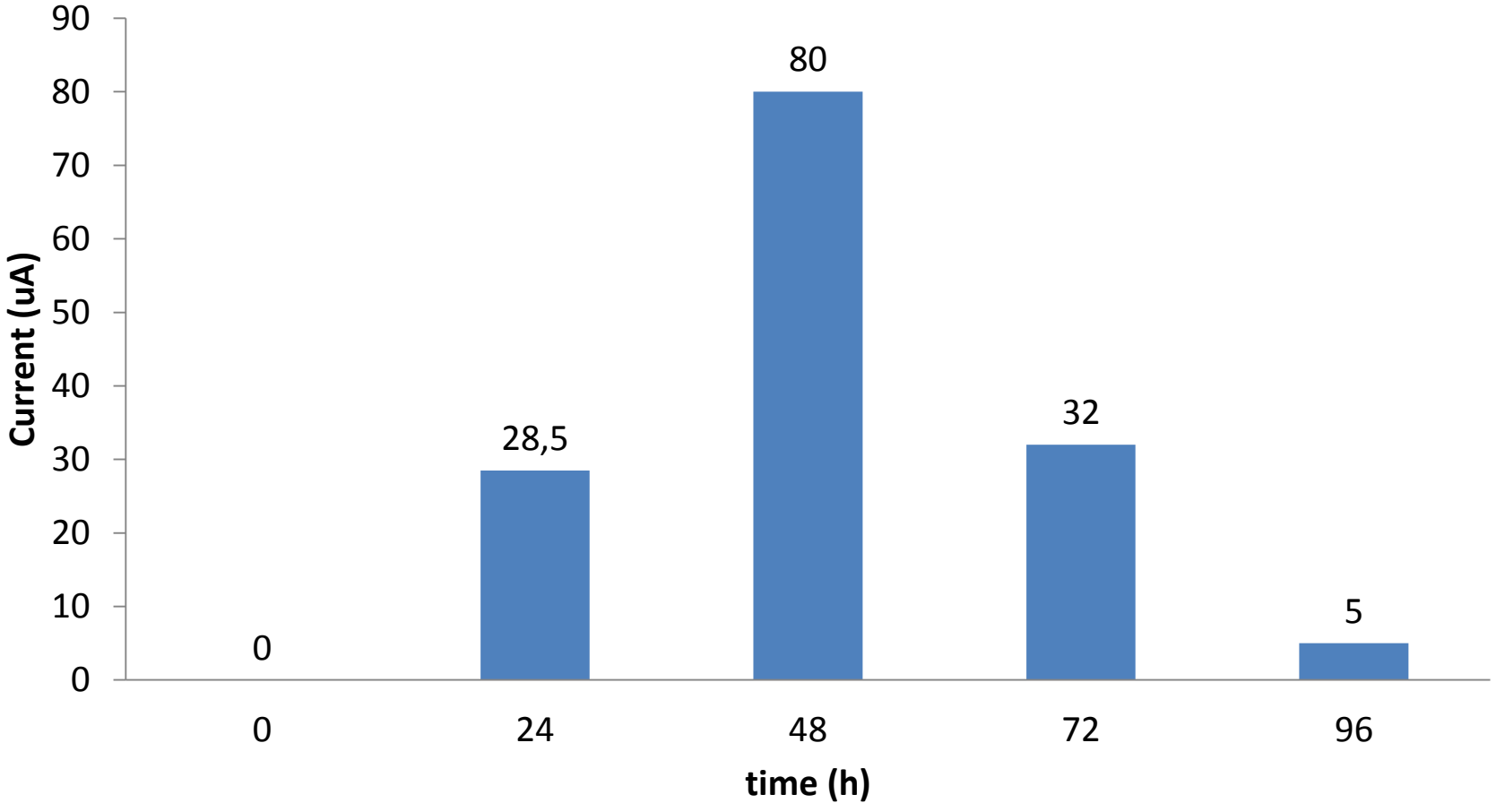
PHOTOTECH: BIOSENSORS AND BIOCHIPS

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

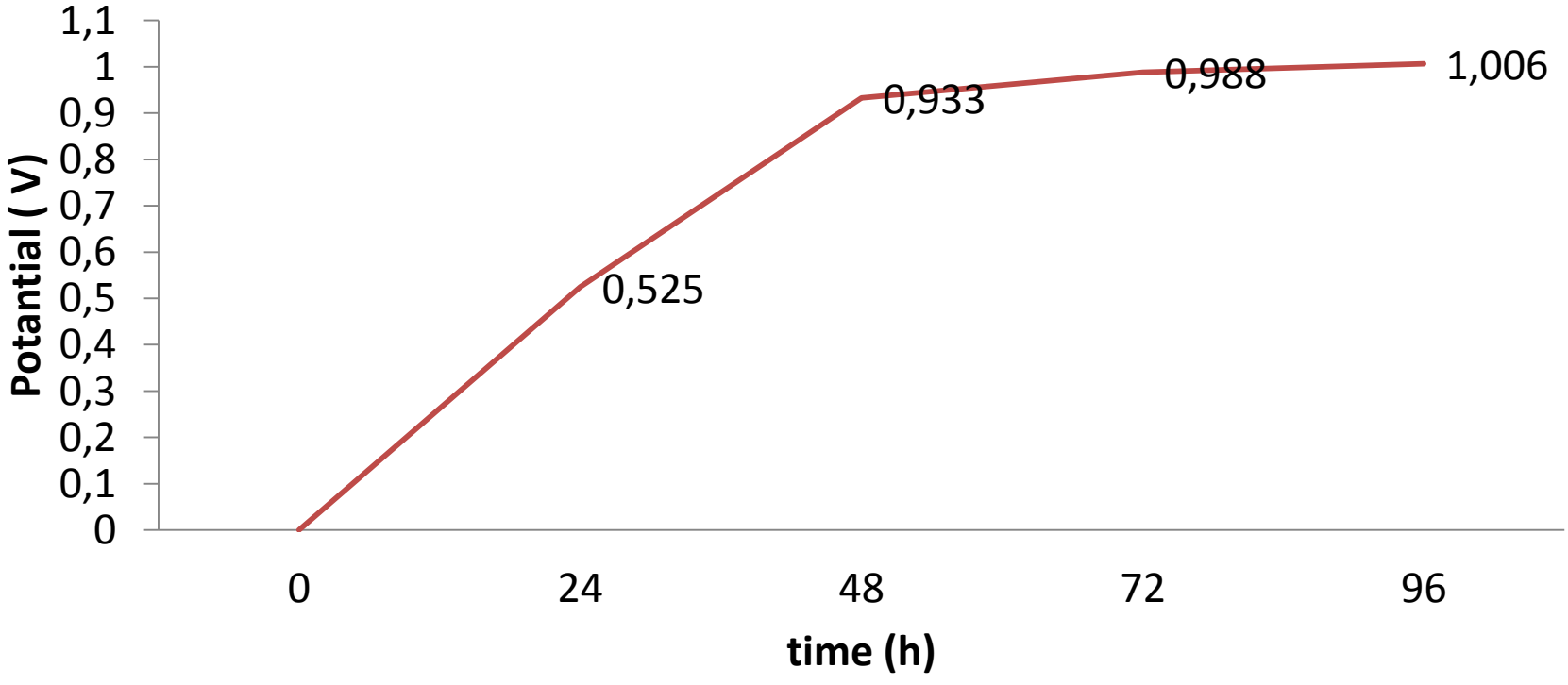
HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- Results

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE



HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

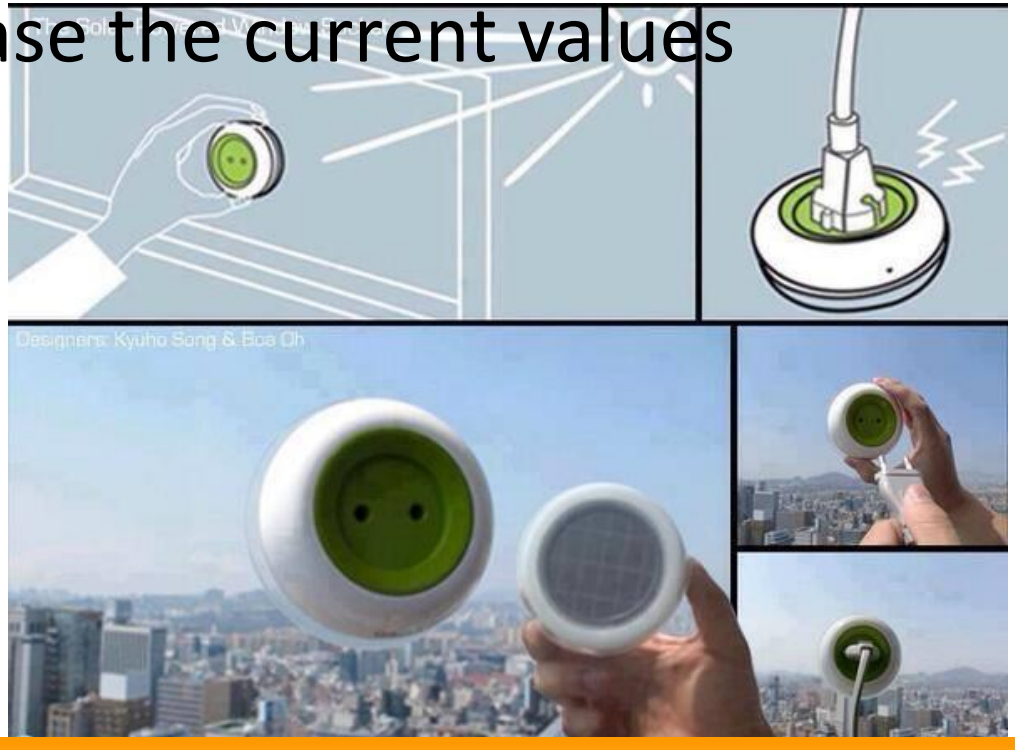


HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

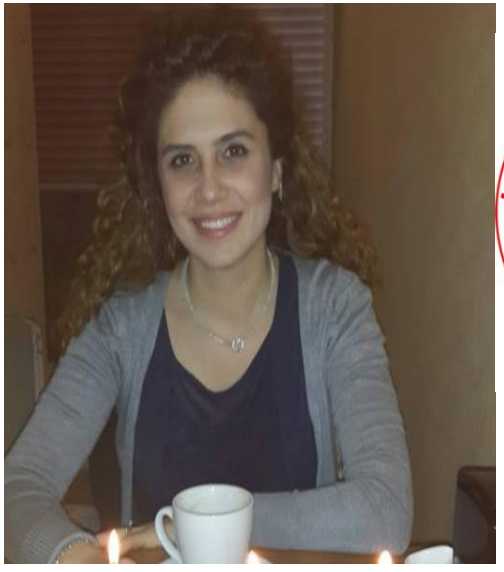
- High anode potential (1 volt) but low electrogenic capacity. (80 µA)
- 36.4 mA/m2 current density (2,1 cm2 cathodic surface)
- 0,07464 mW =34 mW/m2 Power density
- Pisciotta et al., (2010) have max 6 mW/m2 power density with Cyanobacteria (Lyngbia)

HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE

- The optimization studies are continued to increase the current values



HACETTEPE UNIVERSITY
Department of Food Engineering
Faculty of Engineering Beytepe Campus
06800 Ankara / TURKIYE



- Thank you for your attention!!!