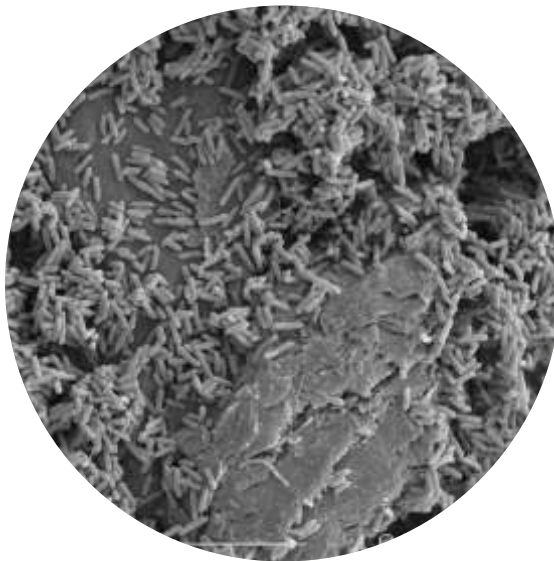


New energy conversions using microorganisms and electrodes

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Sub-department of Environmental Technology

Sep 24, 2015

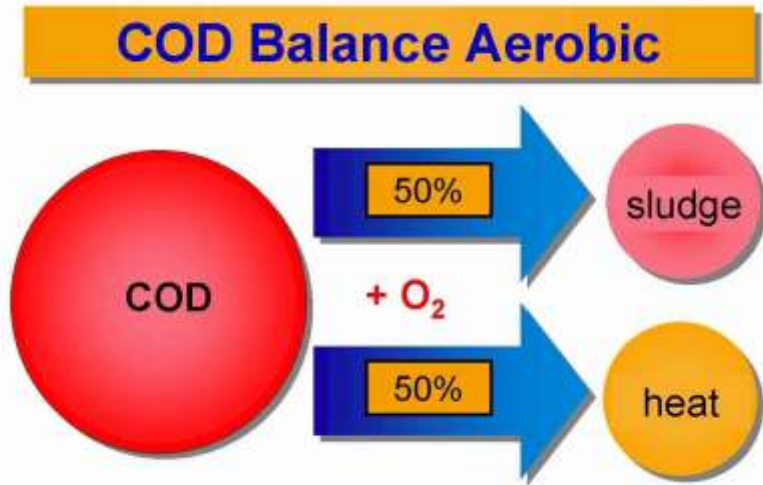


Wastewater contains energy!



From aerobic to anaerobic wastewater treatment

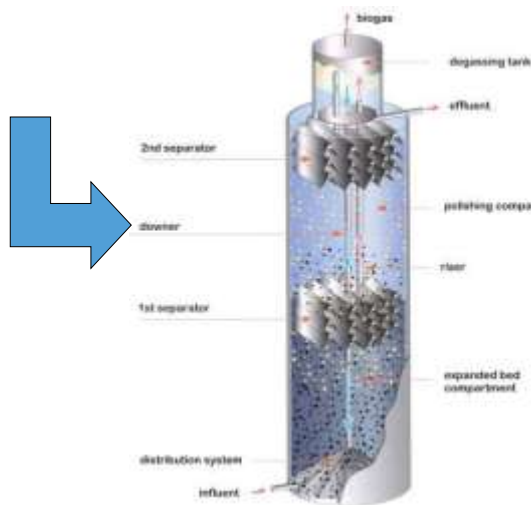
Before 1970/80's



COD = chemical oxygen demand = measure for organic components in wastewater

A next generation wastewater treatment is required

Biogas Production



Biogas Treatment (a.o. H₂S removal)



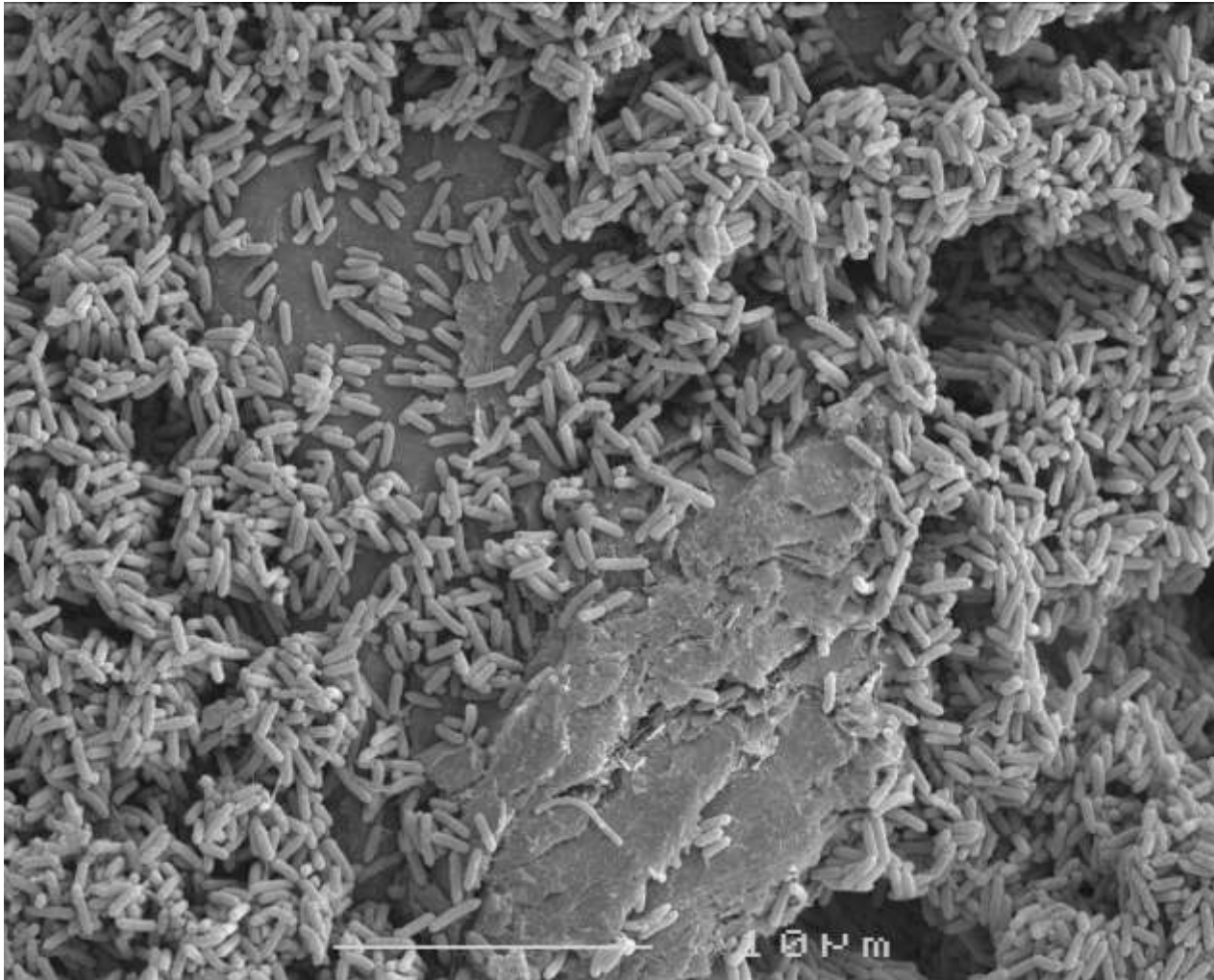
Electricity Production (gasmotor)



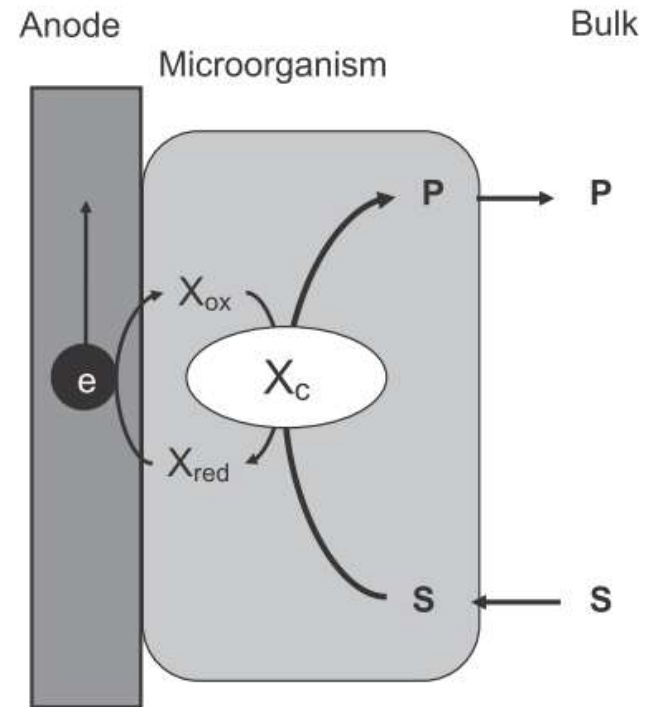
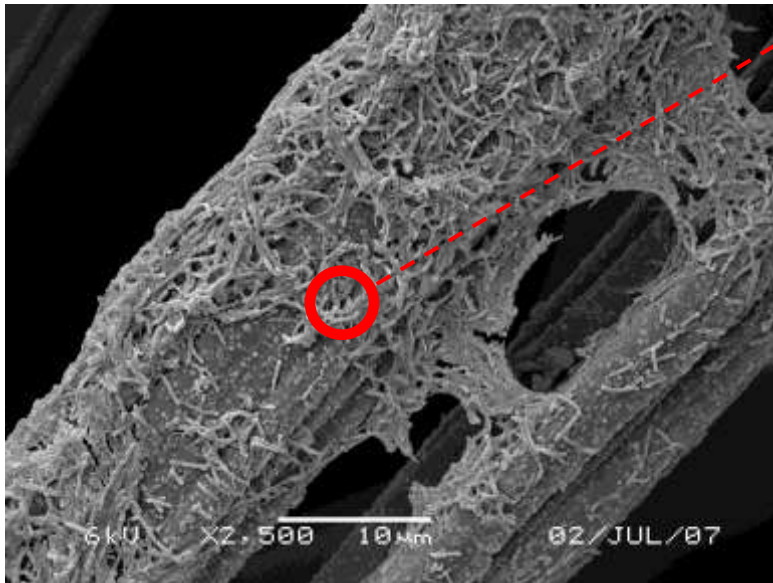
Electricity

Efficiency:	+/- 30%
# of Units:	At least 3

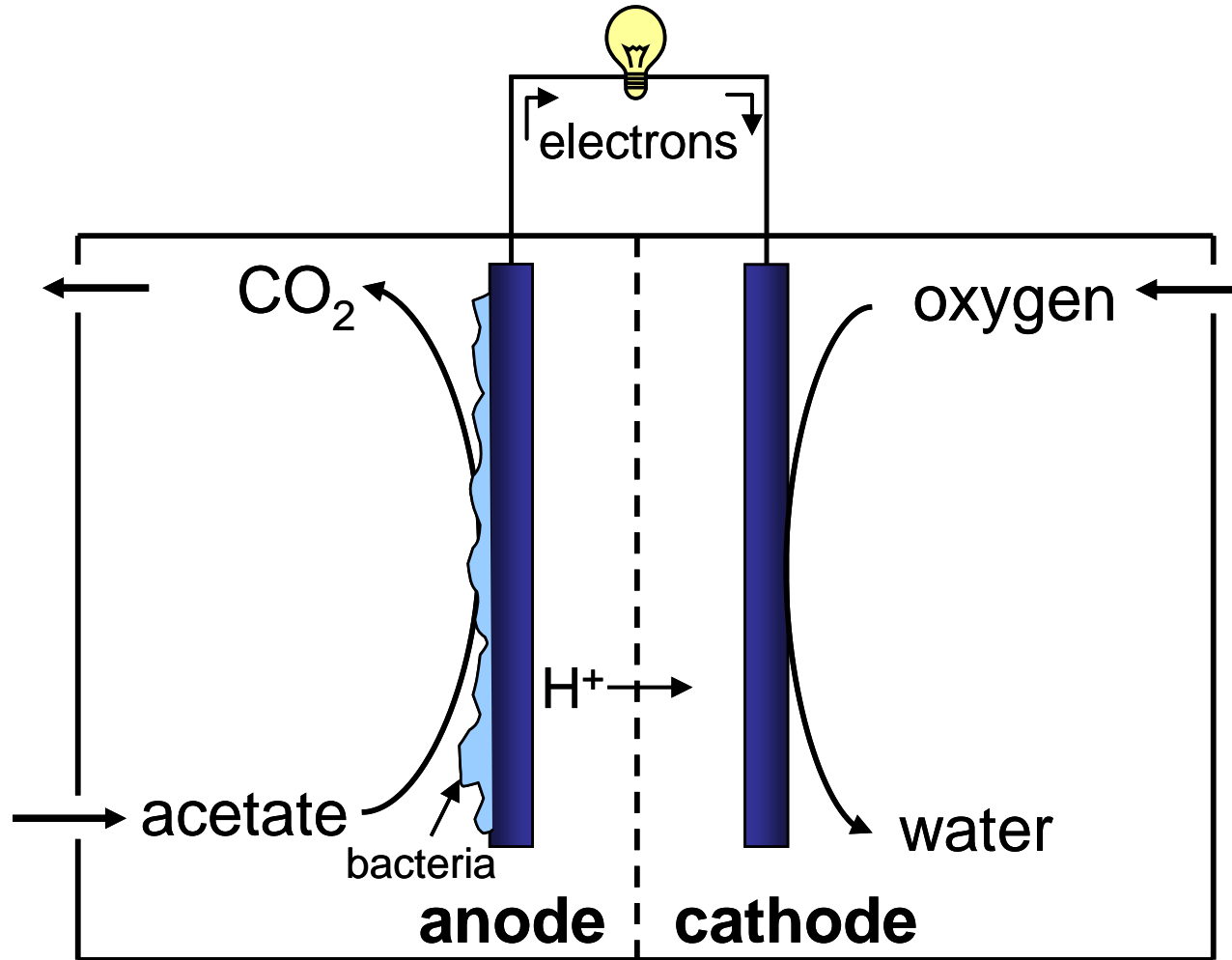
Electrochemically active microorganisms



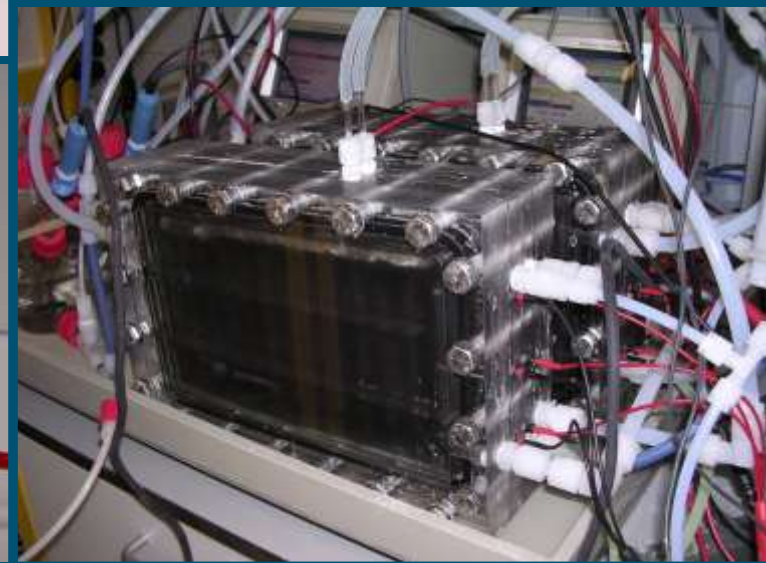
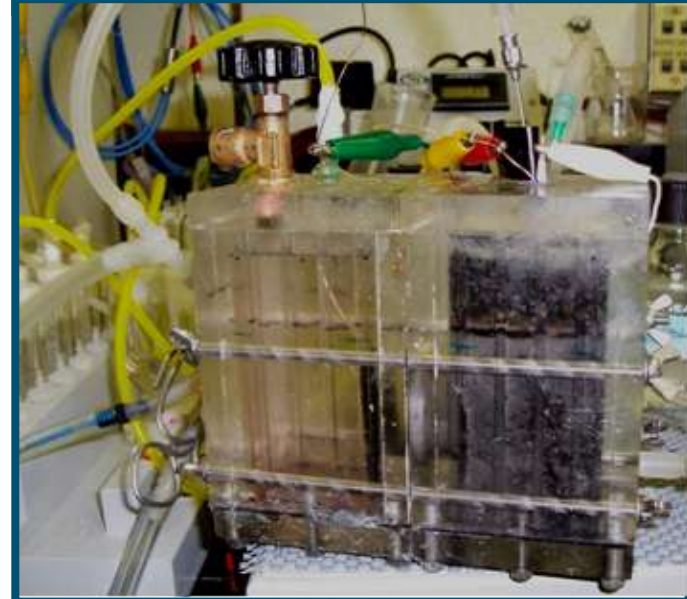
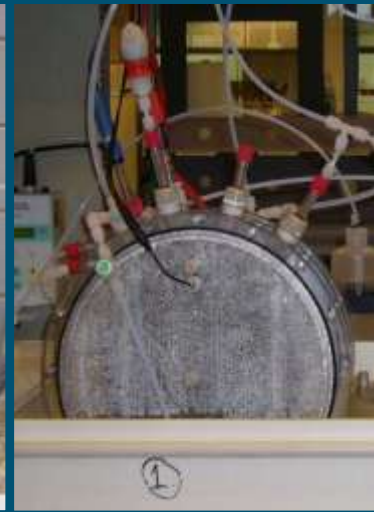
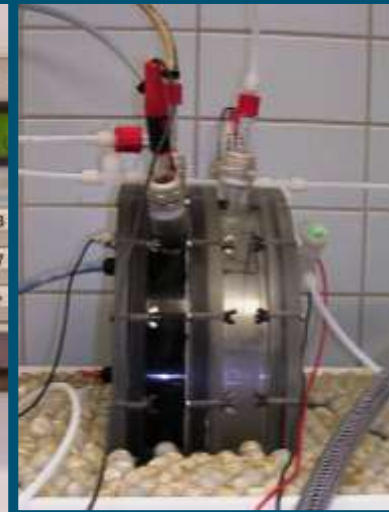
Microorganisms catalyze the oxidation of wastewater (acetate) at the bio-anode



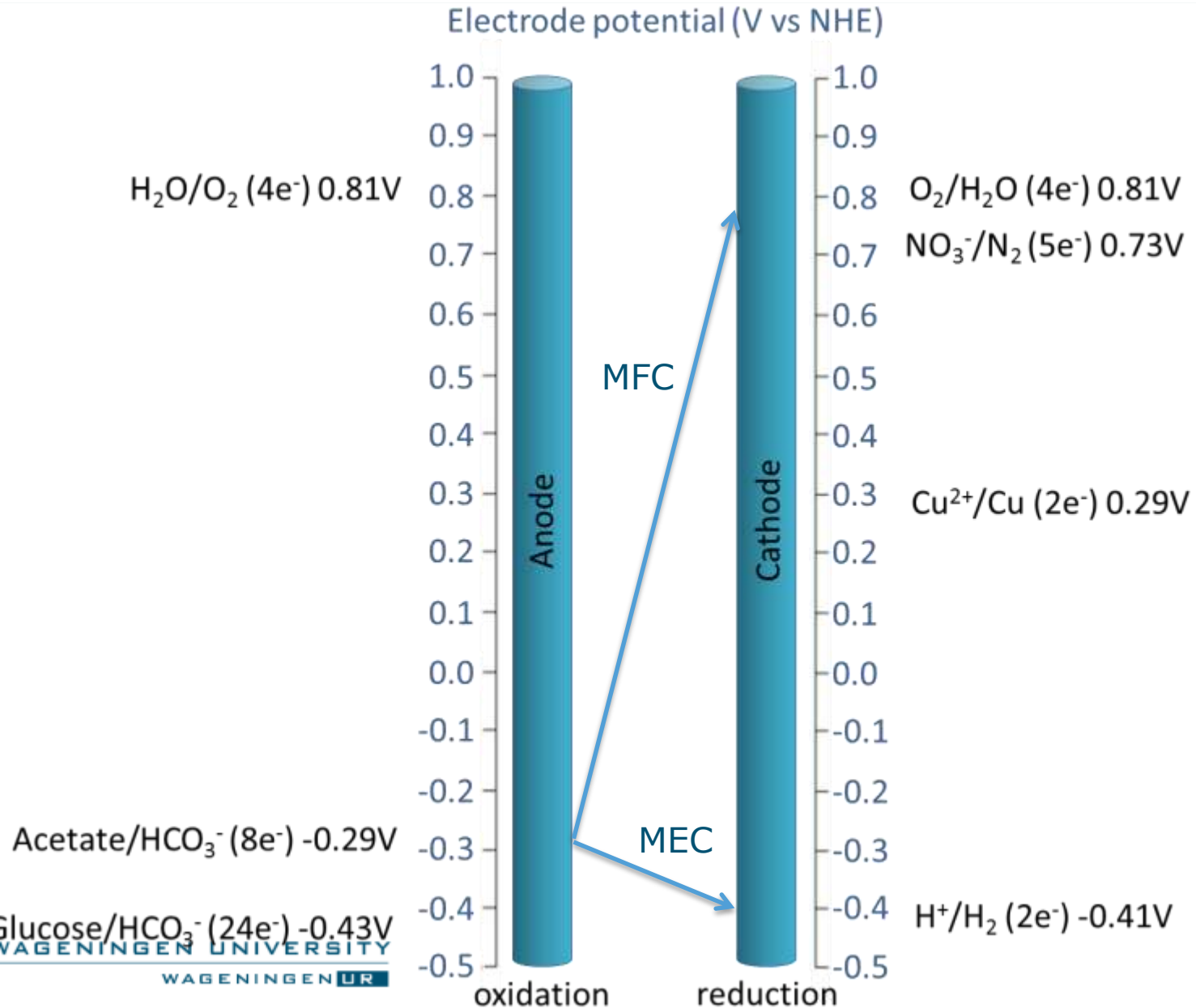
Microbial Fuel Cells convert wastewater directly into electricity



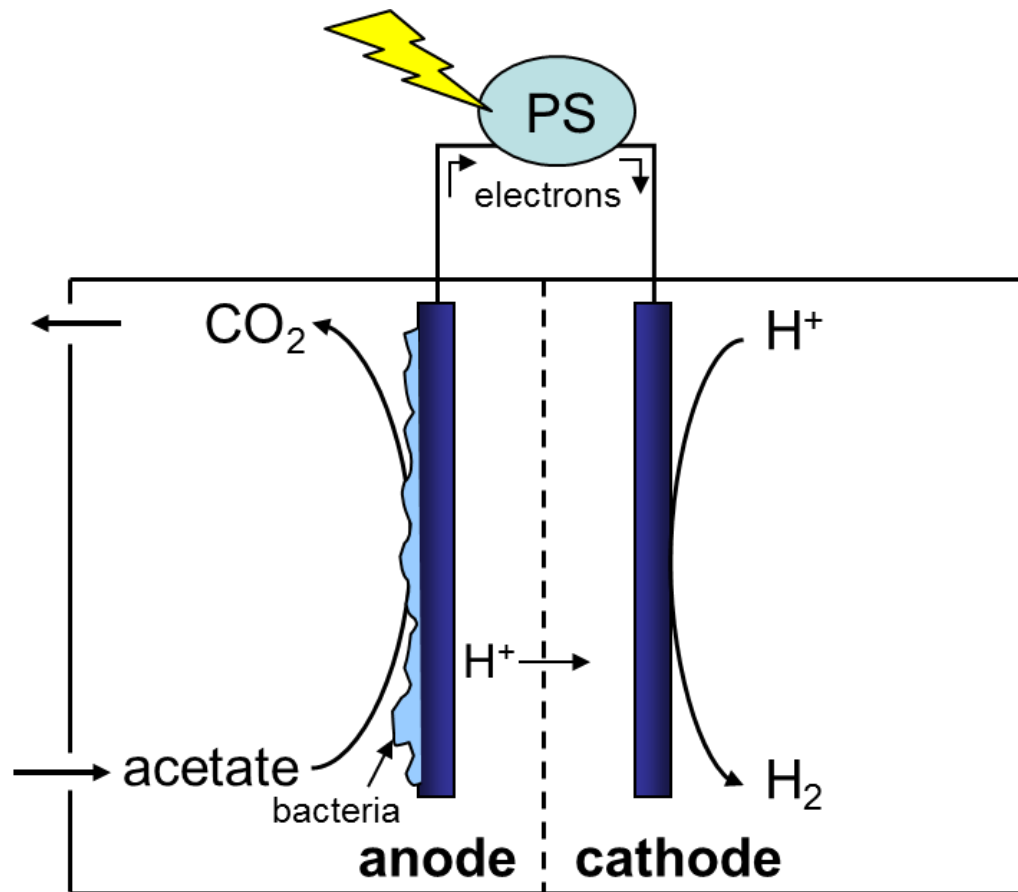
Cell configurations for bioelectrochemical systems



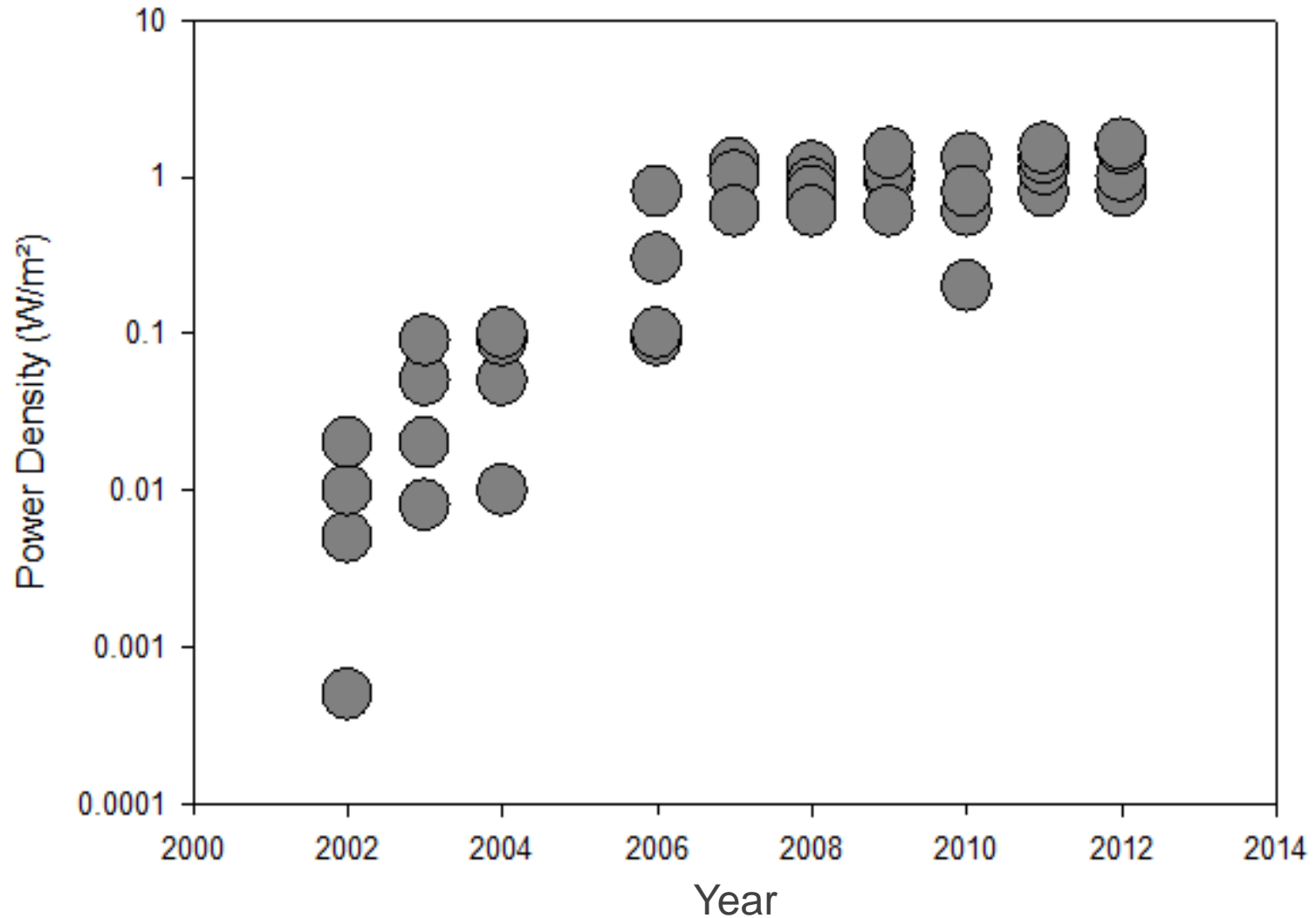
Versatility in reactions and applications



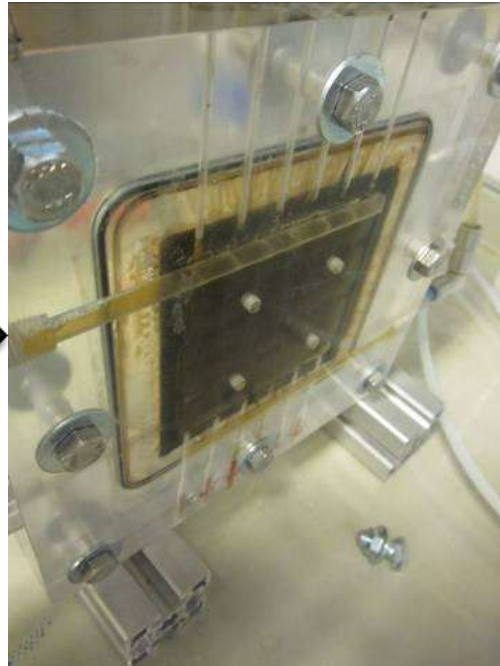
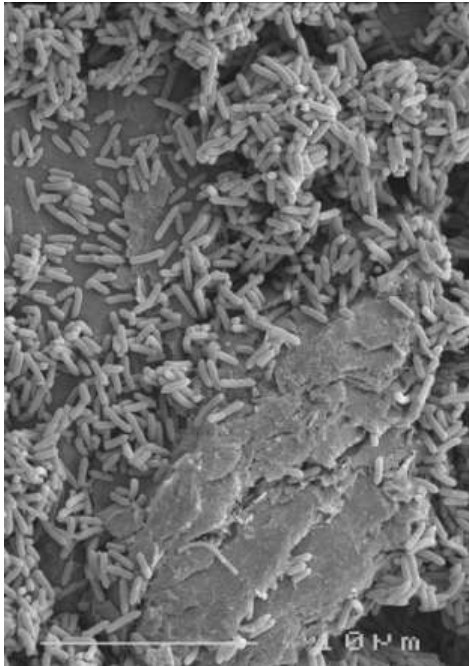
Microbial Electrolysis Cells for hydrogen production from wastewater



We need a breakthrough...



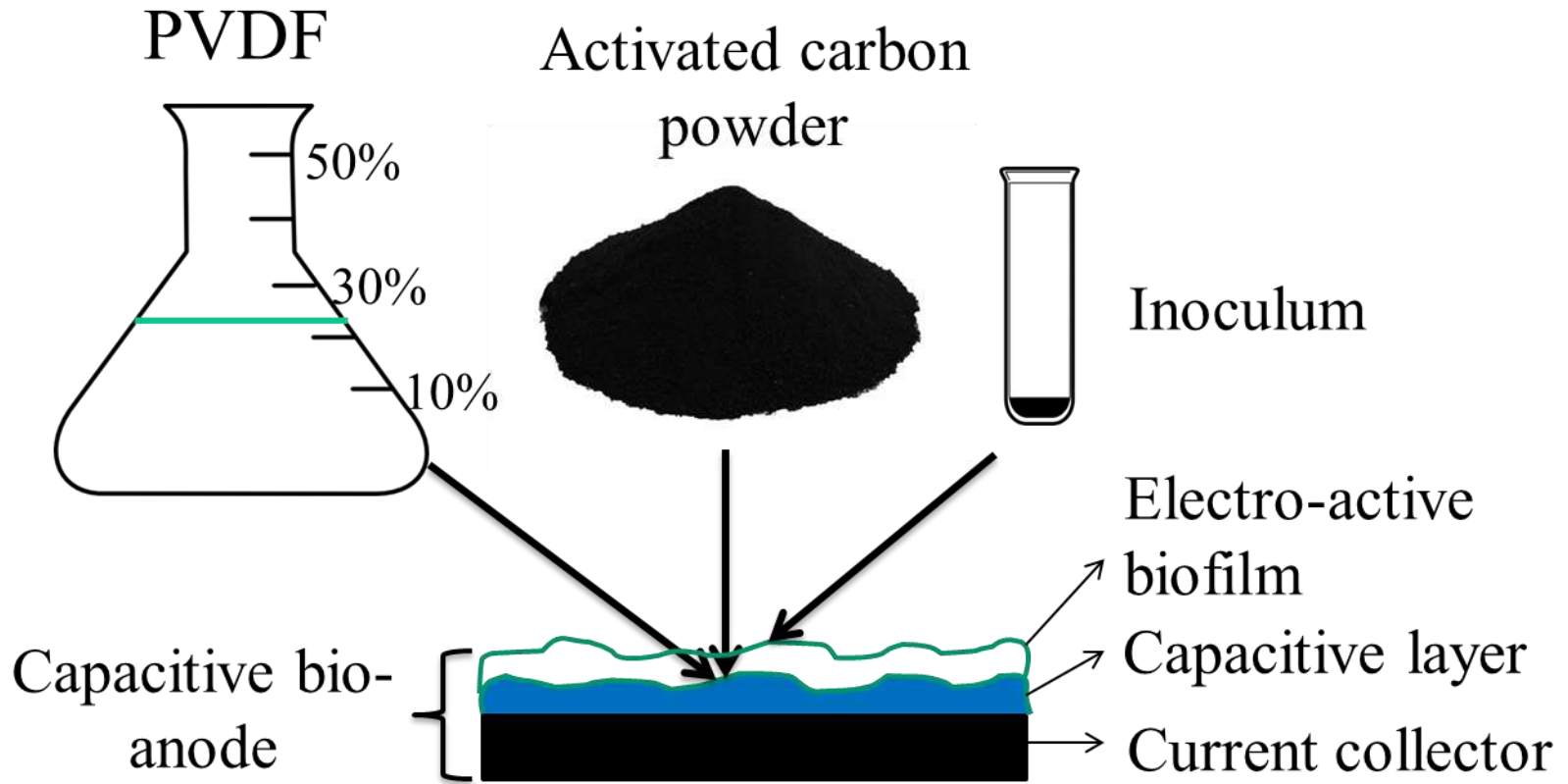
... and we need experience with scaling-up



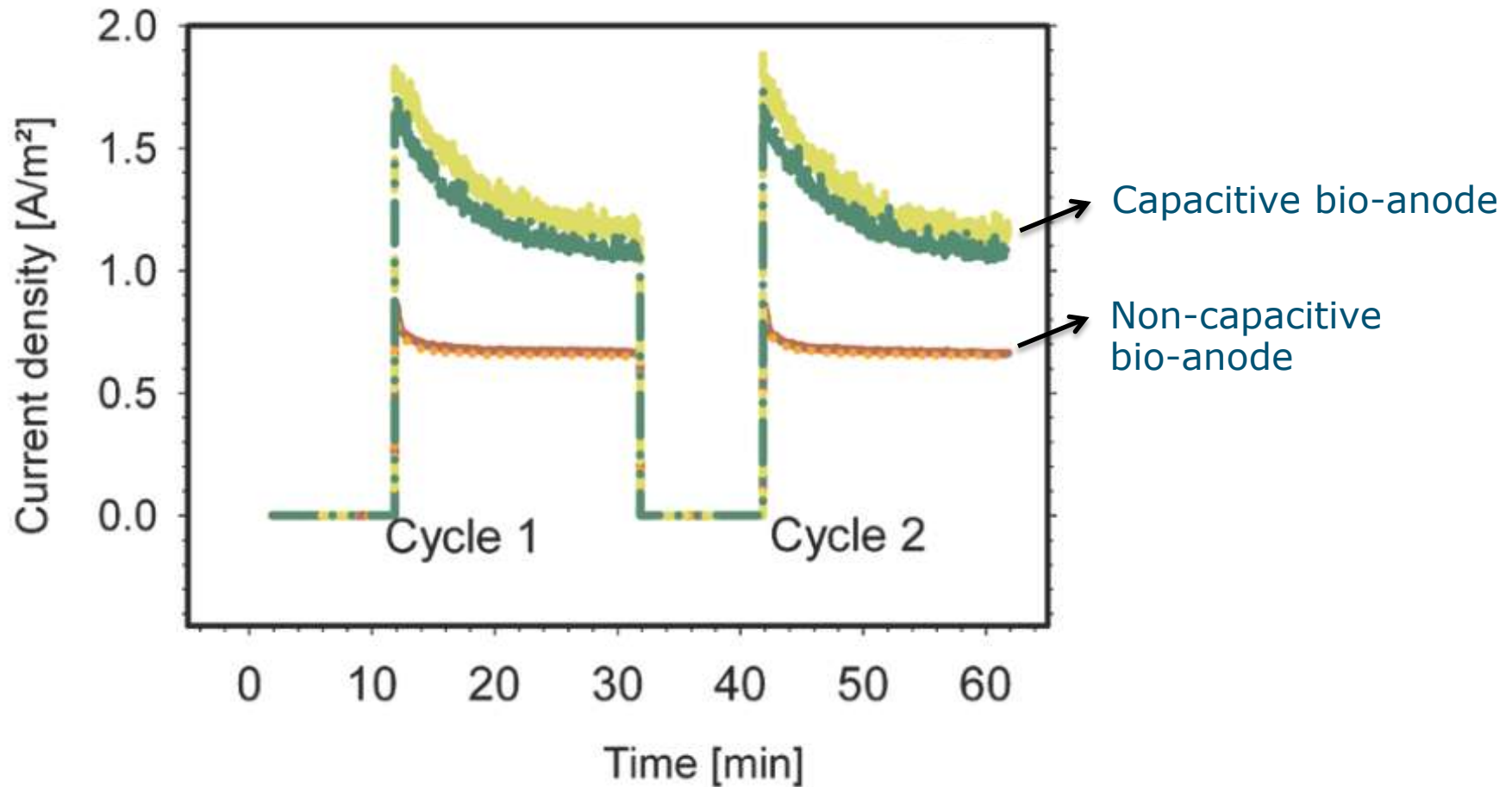
- Decreasing internal resistance
- Decreasing material cost
- Increasing revenues (niche applications)



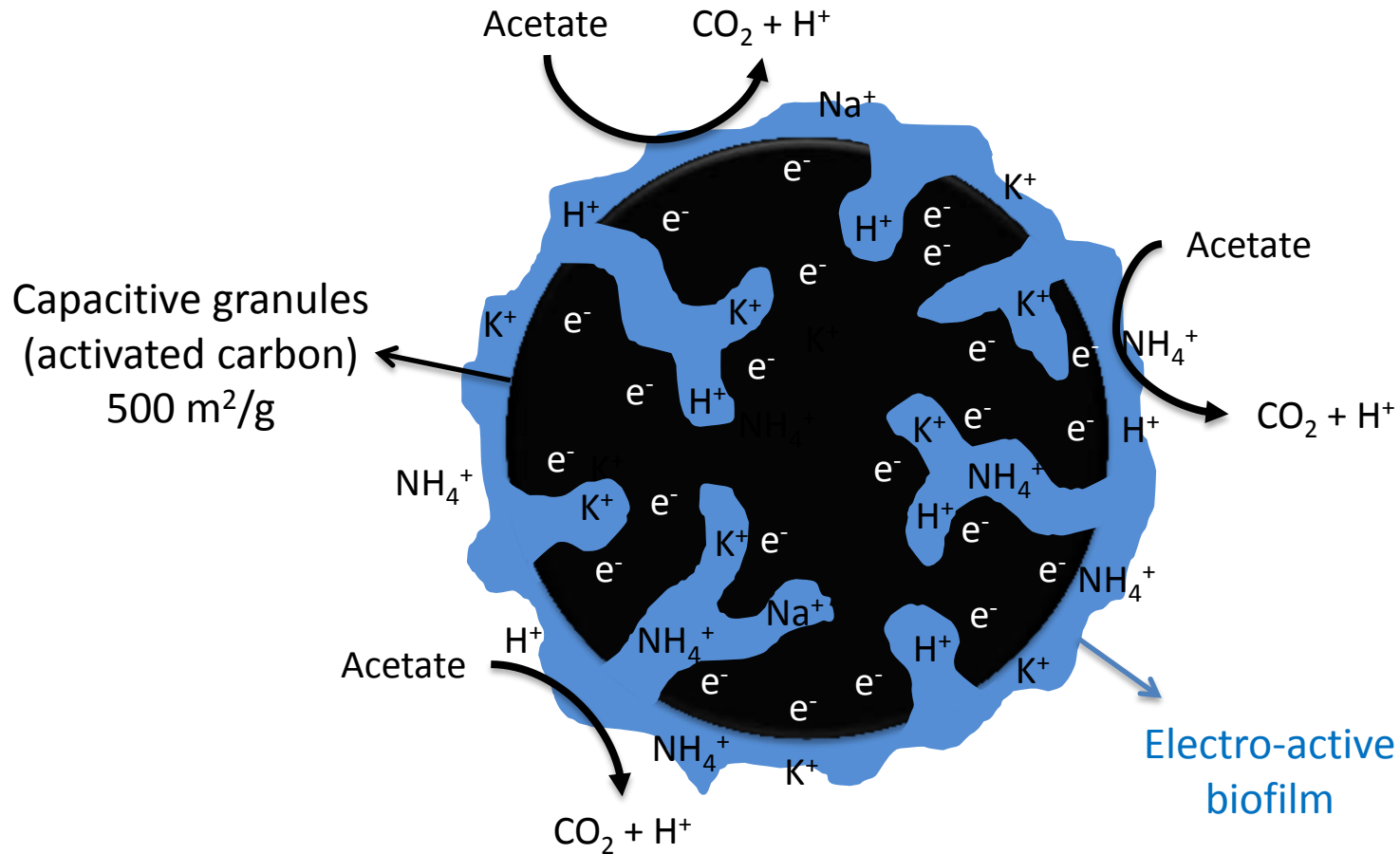
Capacitive electrodes for bio-anodes



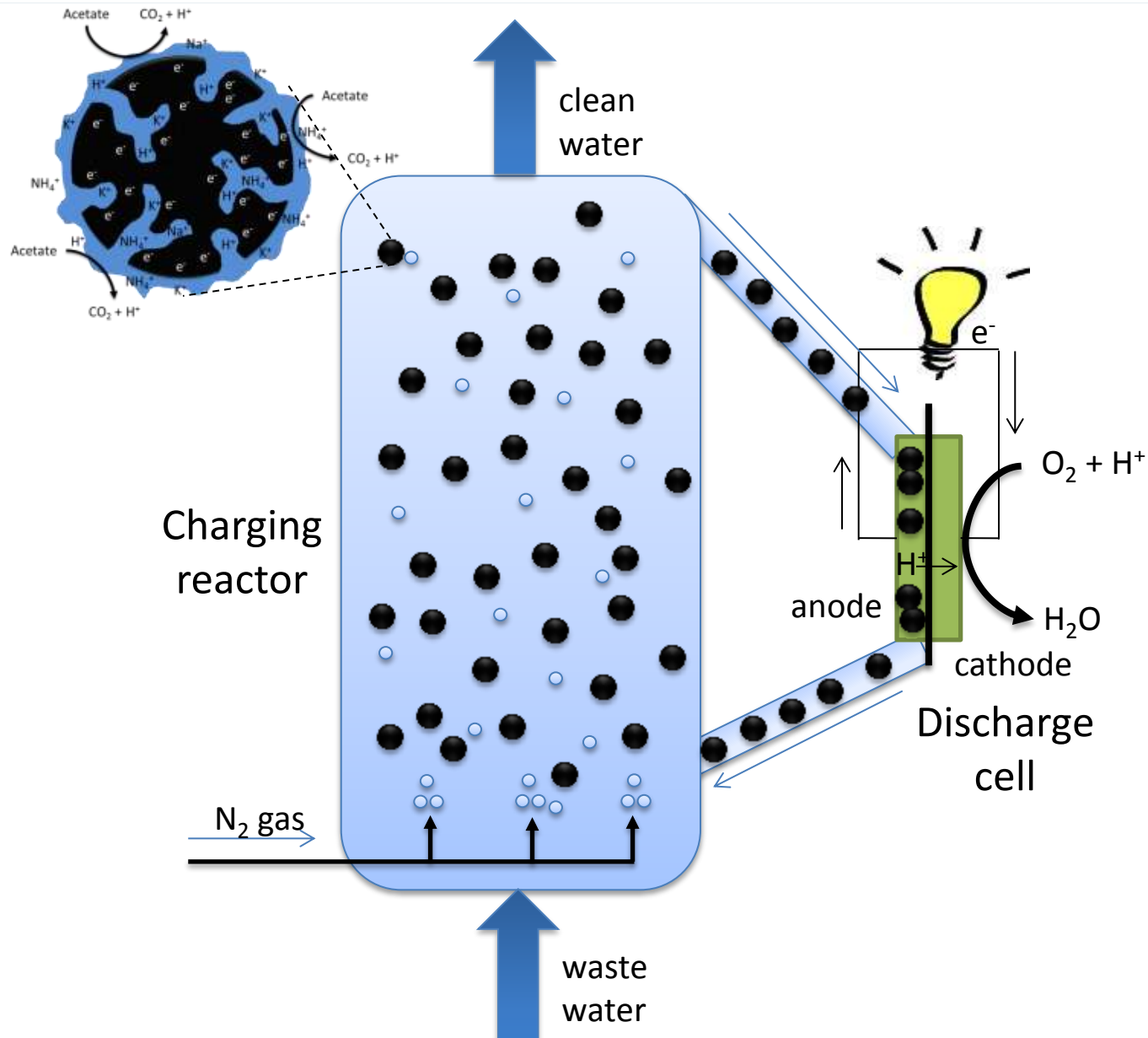
Improved performance with a capacitive layer



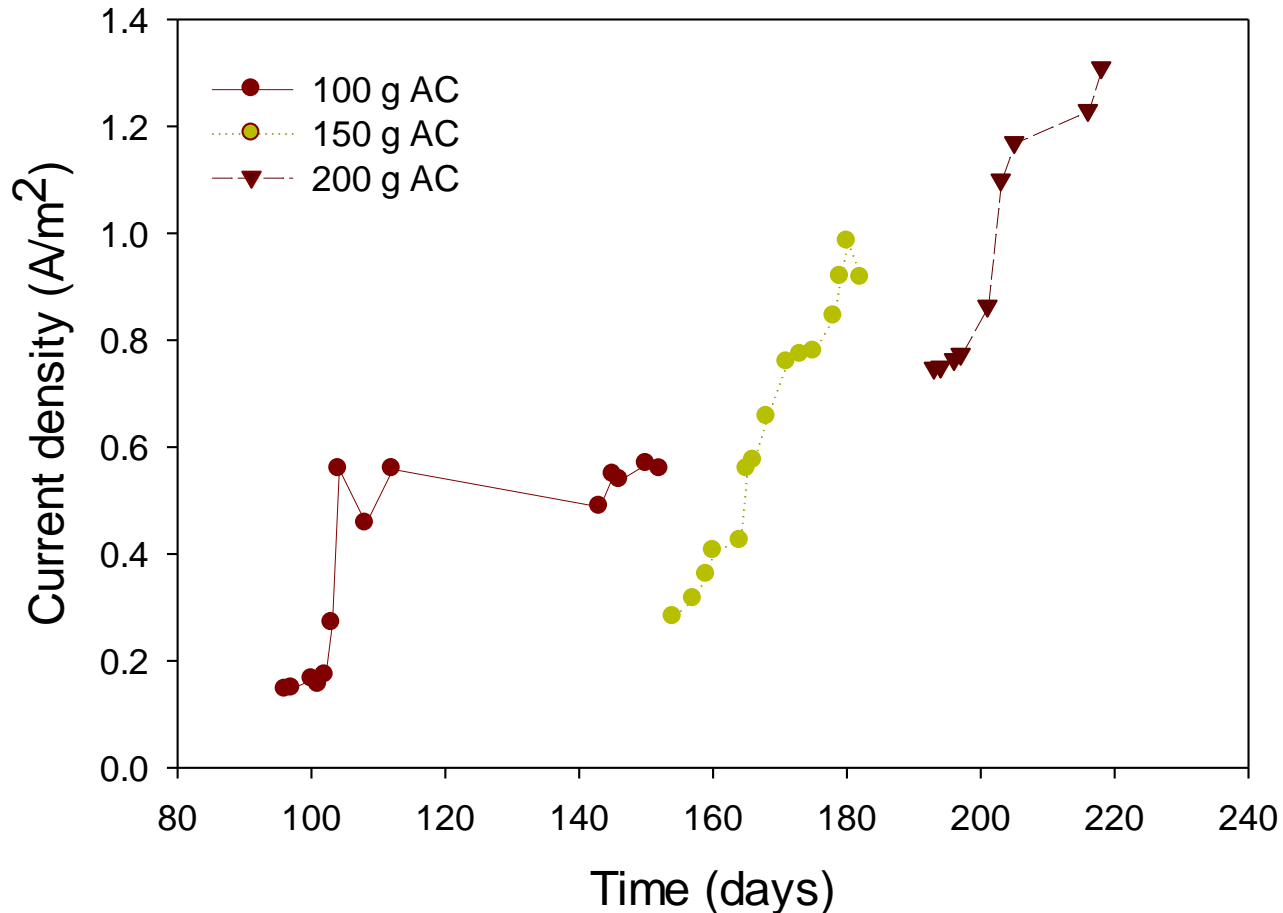
Activated carbon granules as a basis for a fluidized bed Microbial Fuel Cell



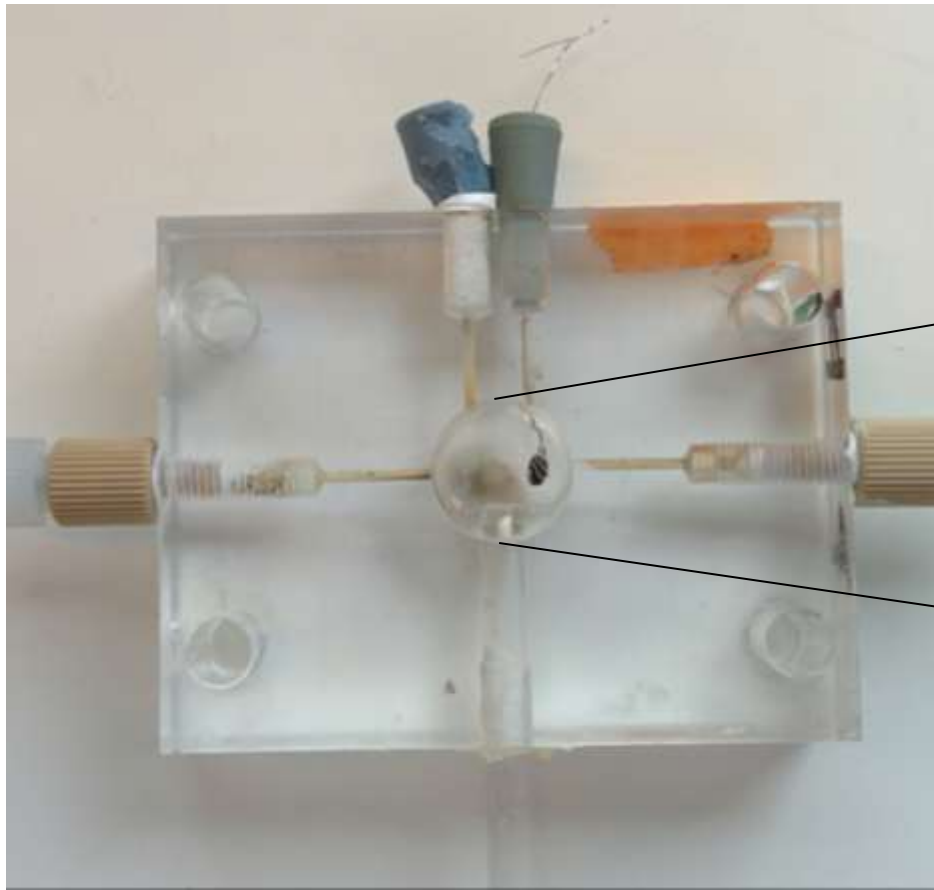
Capacitive Fluidized Bio-anode



Increase in current density with increasing granule loading: proof of principle



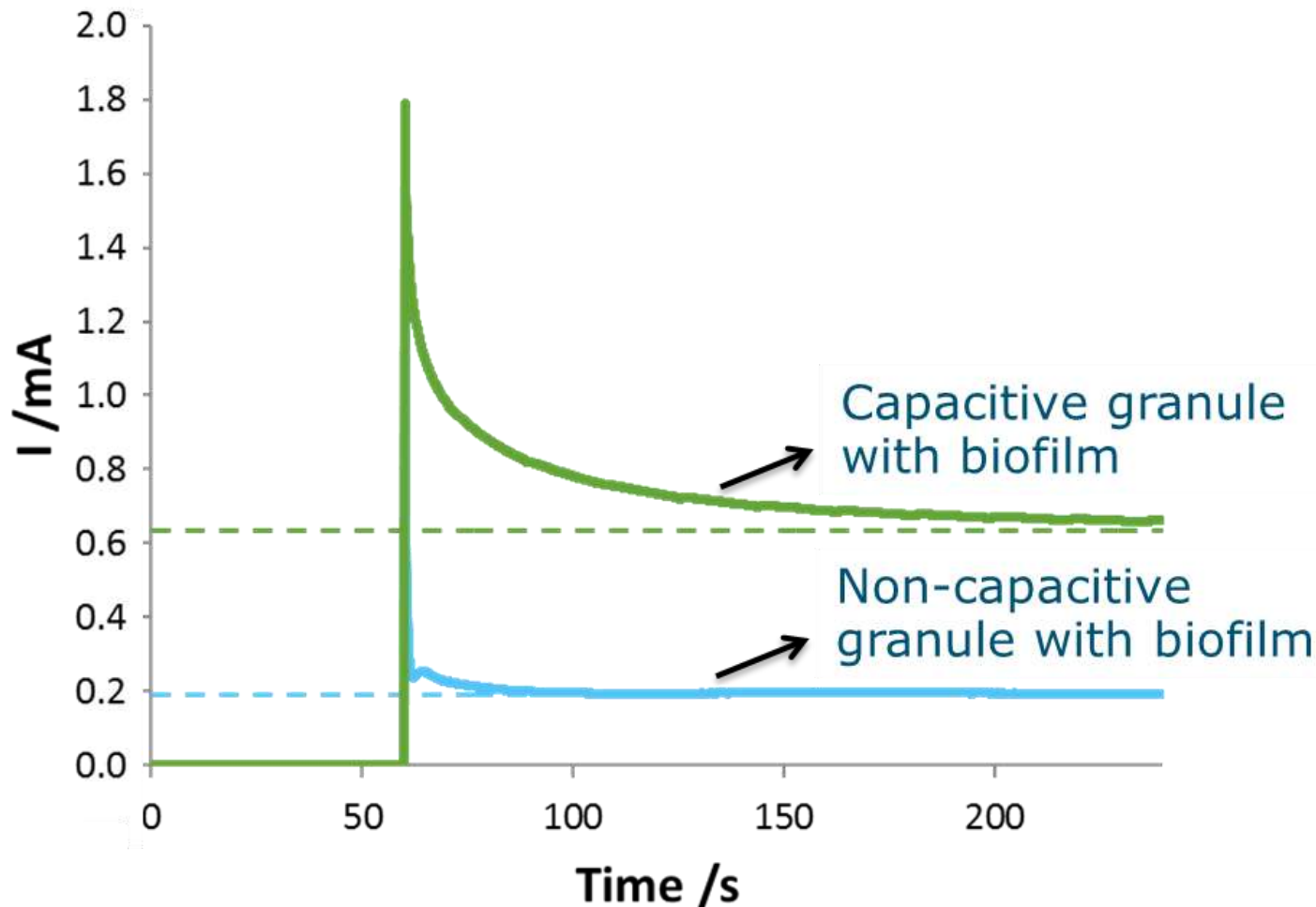
Measure single granule behaviour under controlled conditions



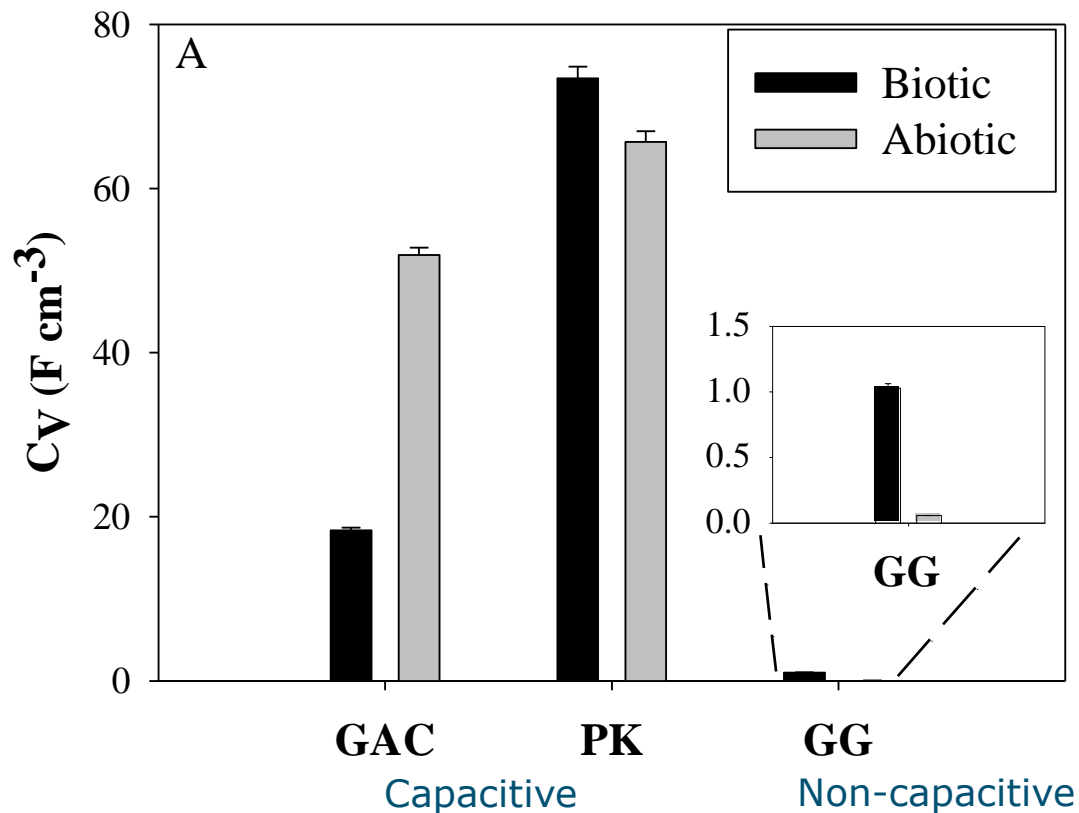
1.5
cm



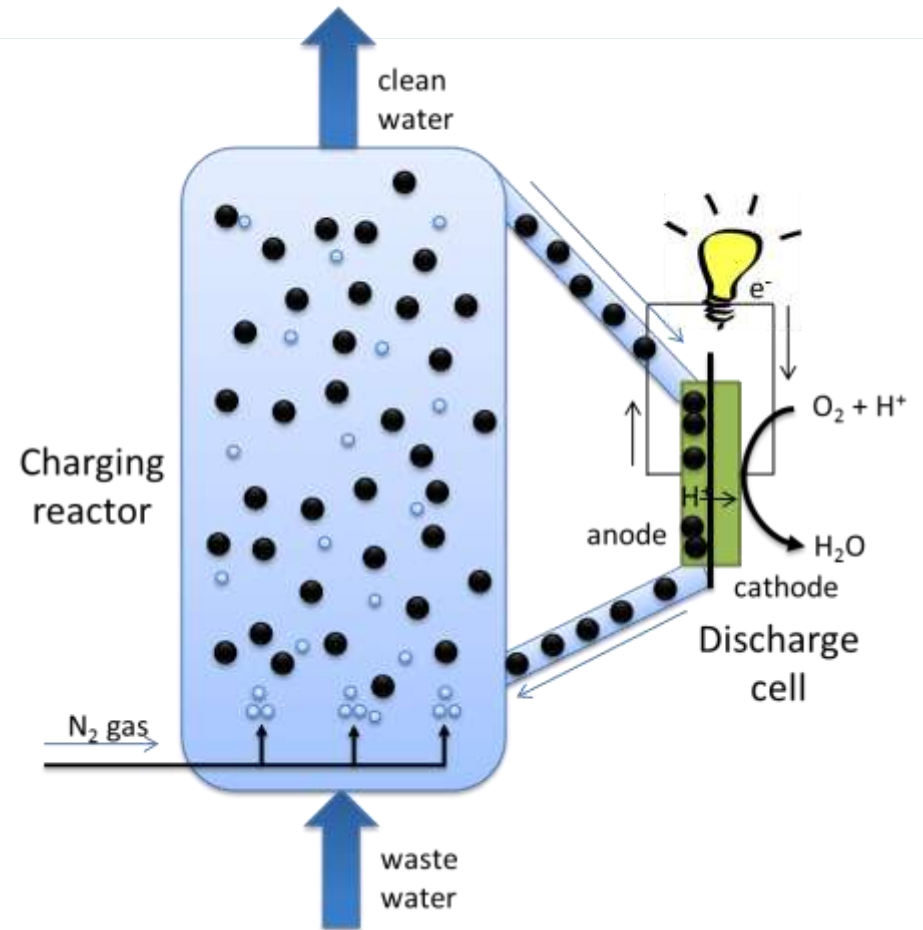
One single granule can produce 0.6 mA:
>1,000x more than achieved in reactor



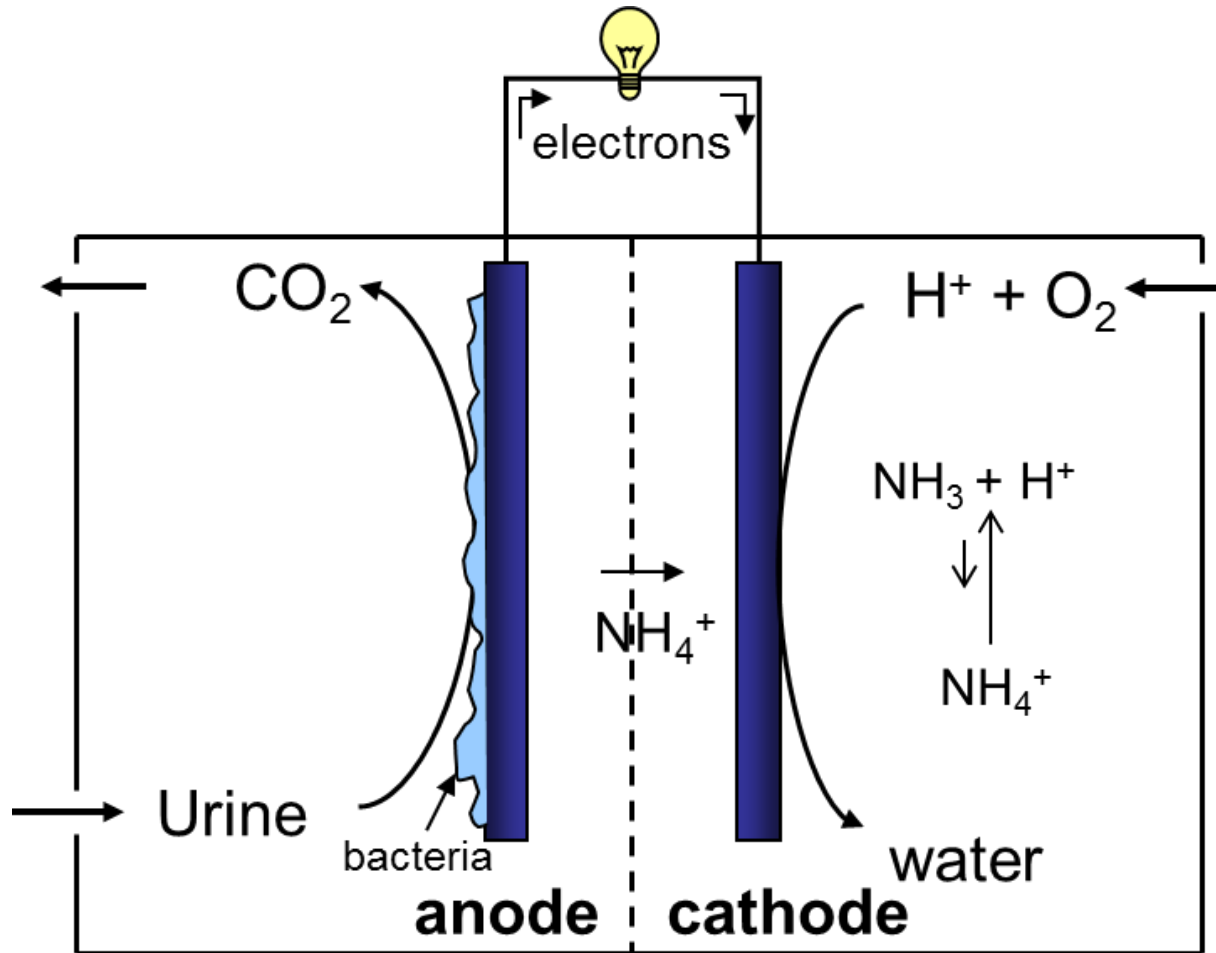
Understand fundamentals: Capacitance of electrode influenced by biofilm



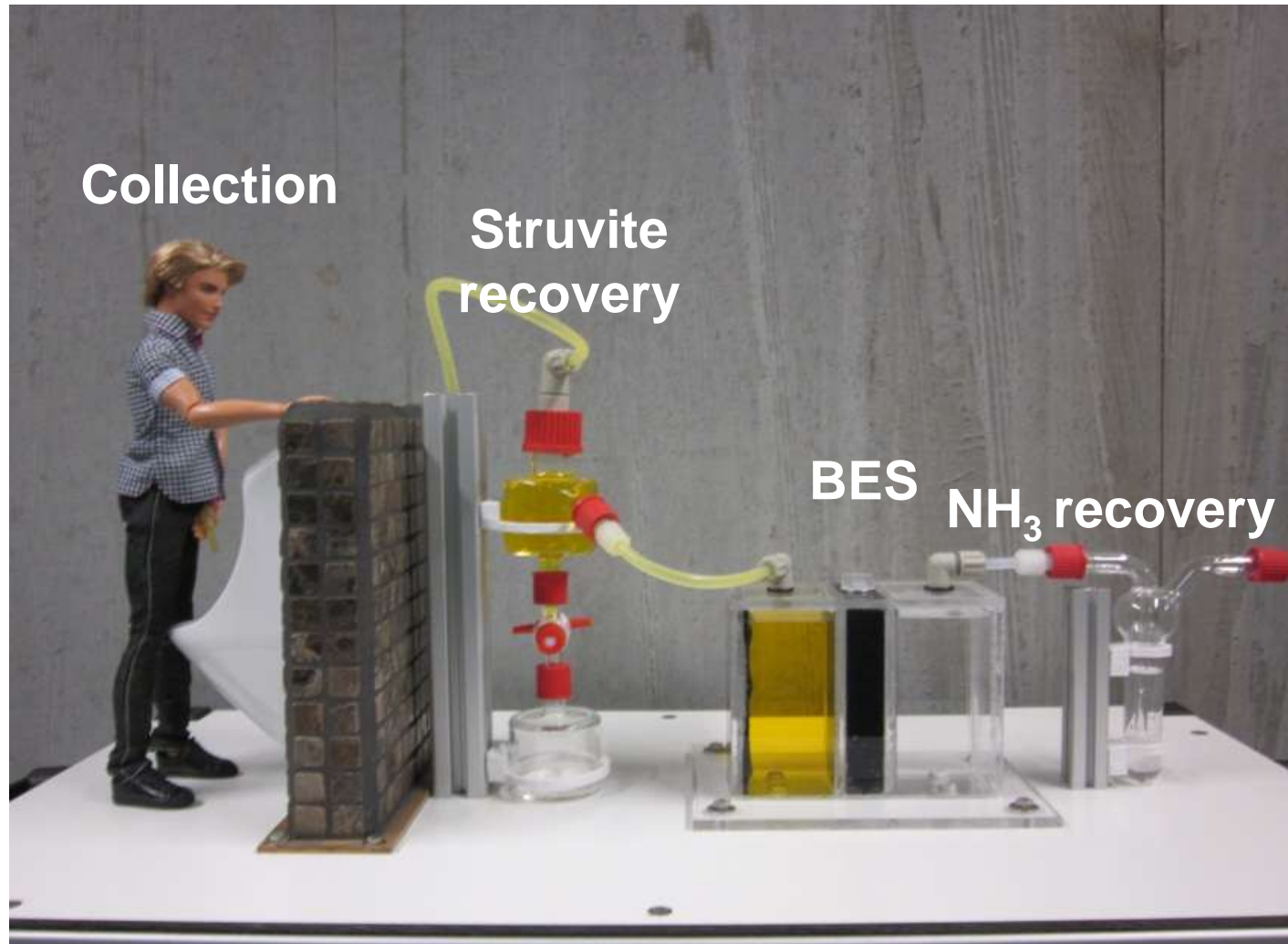
Develop a reactor that can achieve higher conversion rates (current)



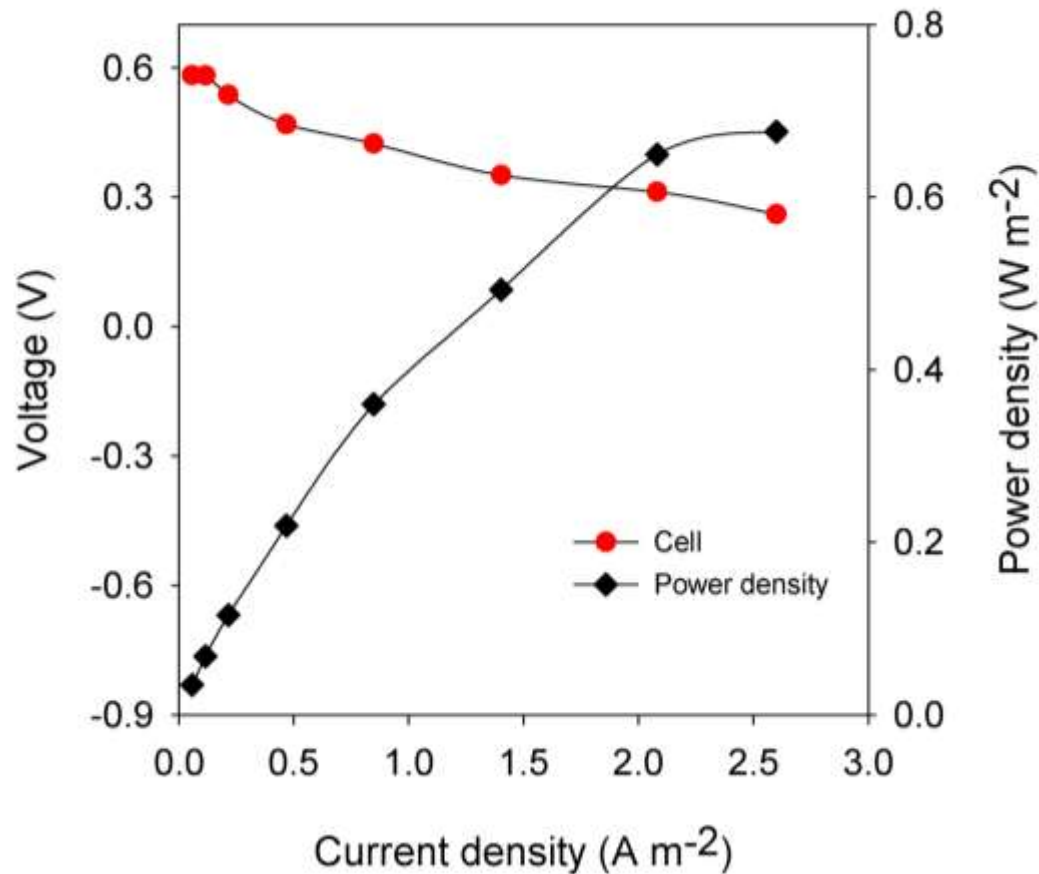
Nitrogen and energy recovery from urine: high soluble COD and NH_4^+ concentrations



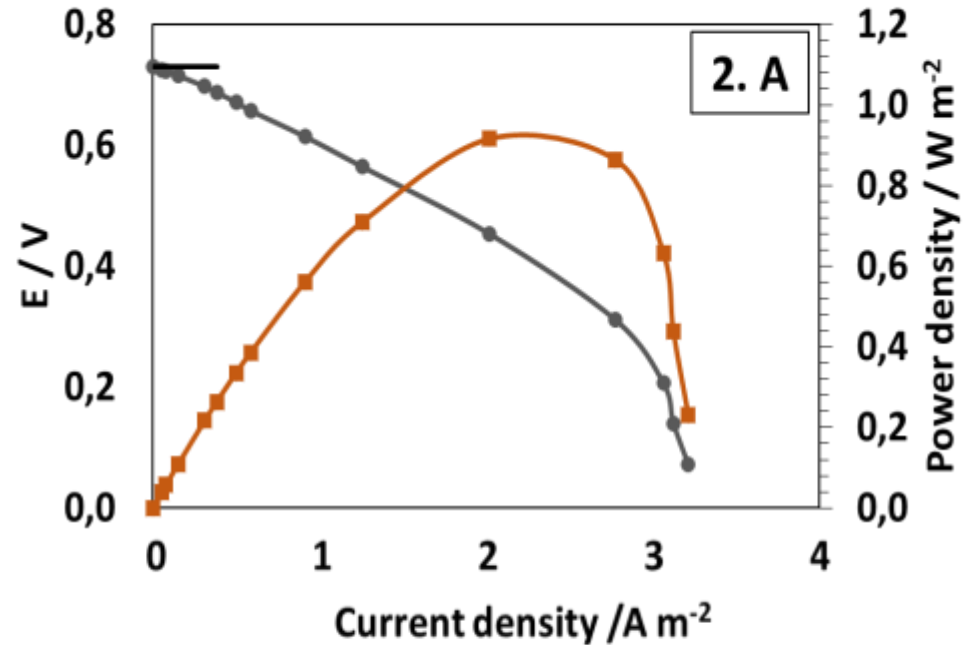
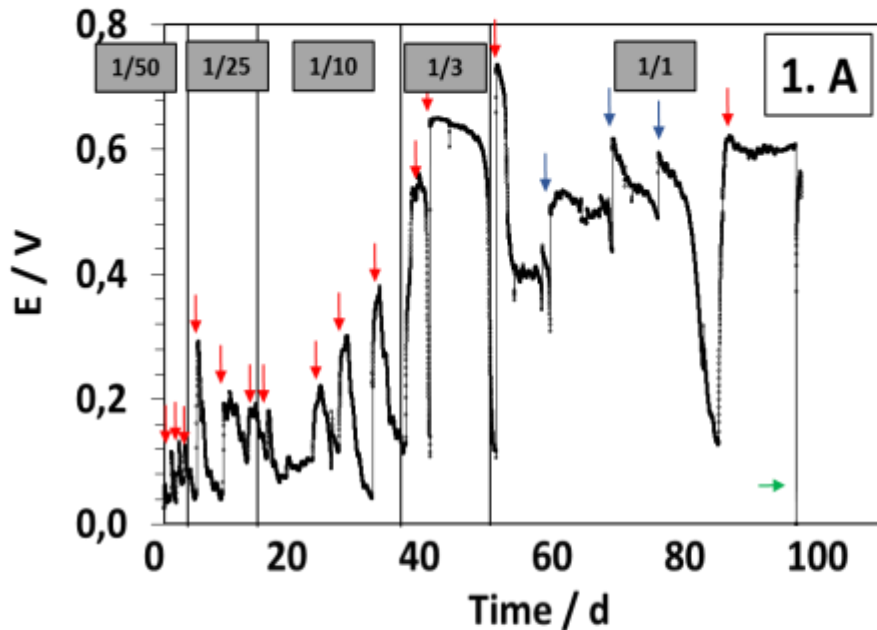
Value from Urine principle



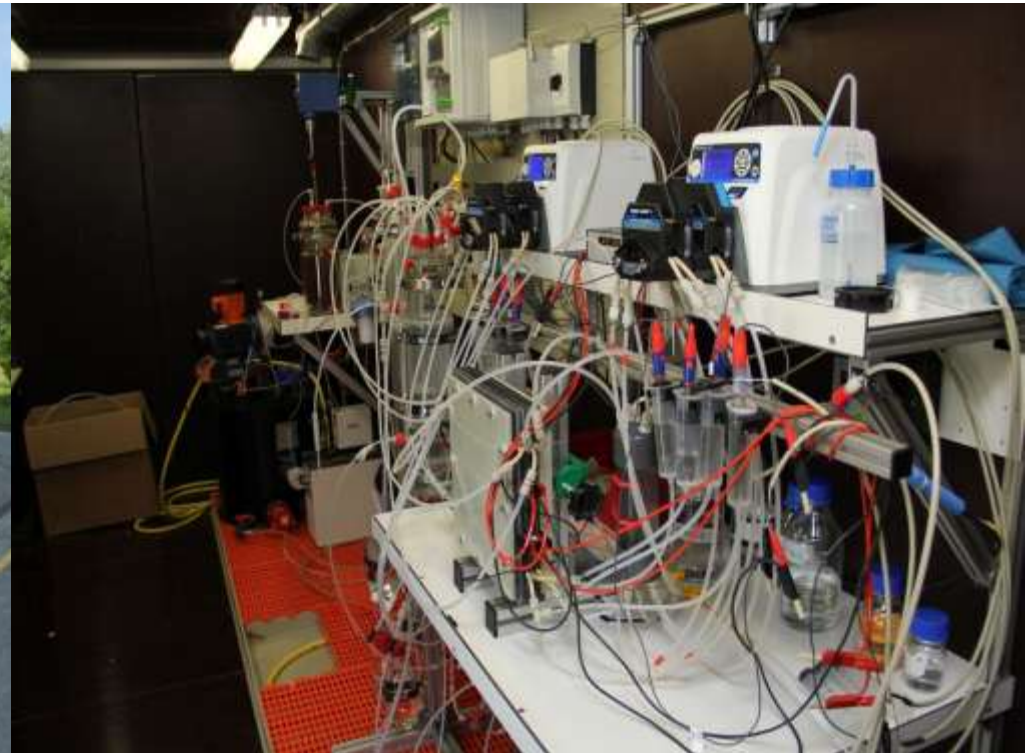
Microorganisms catalyze N and energy recovery from urine



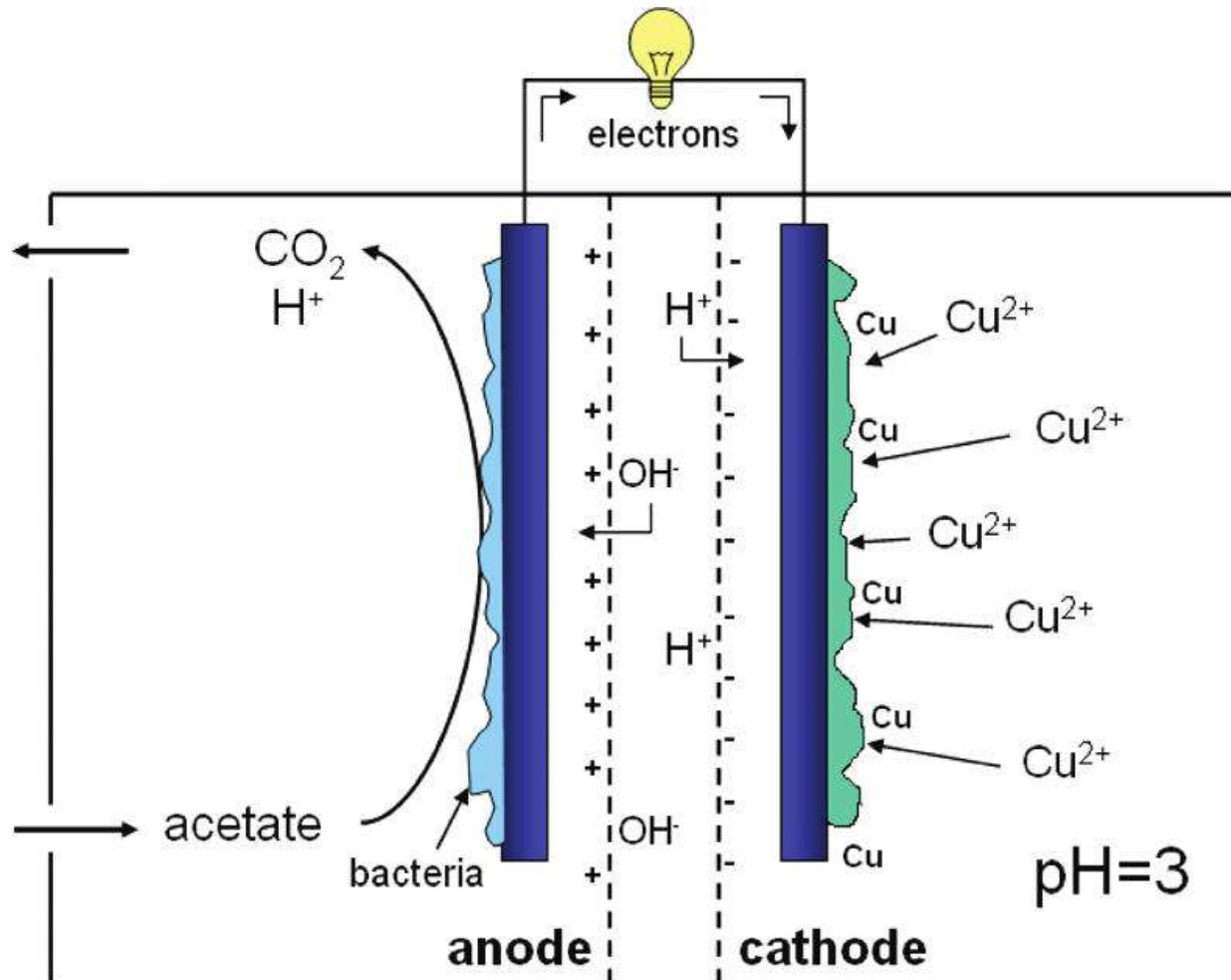
Acclimation of bio-anodes to urine



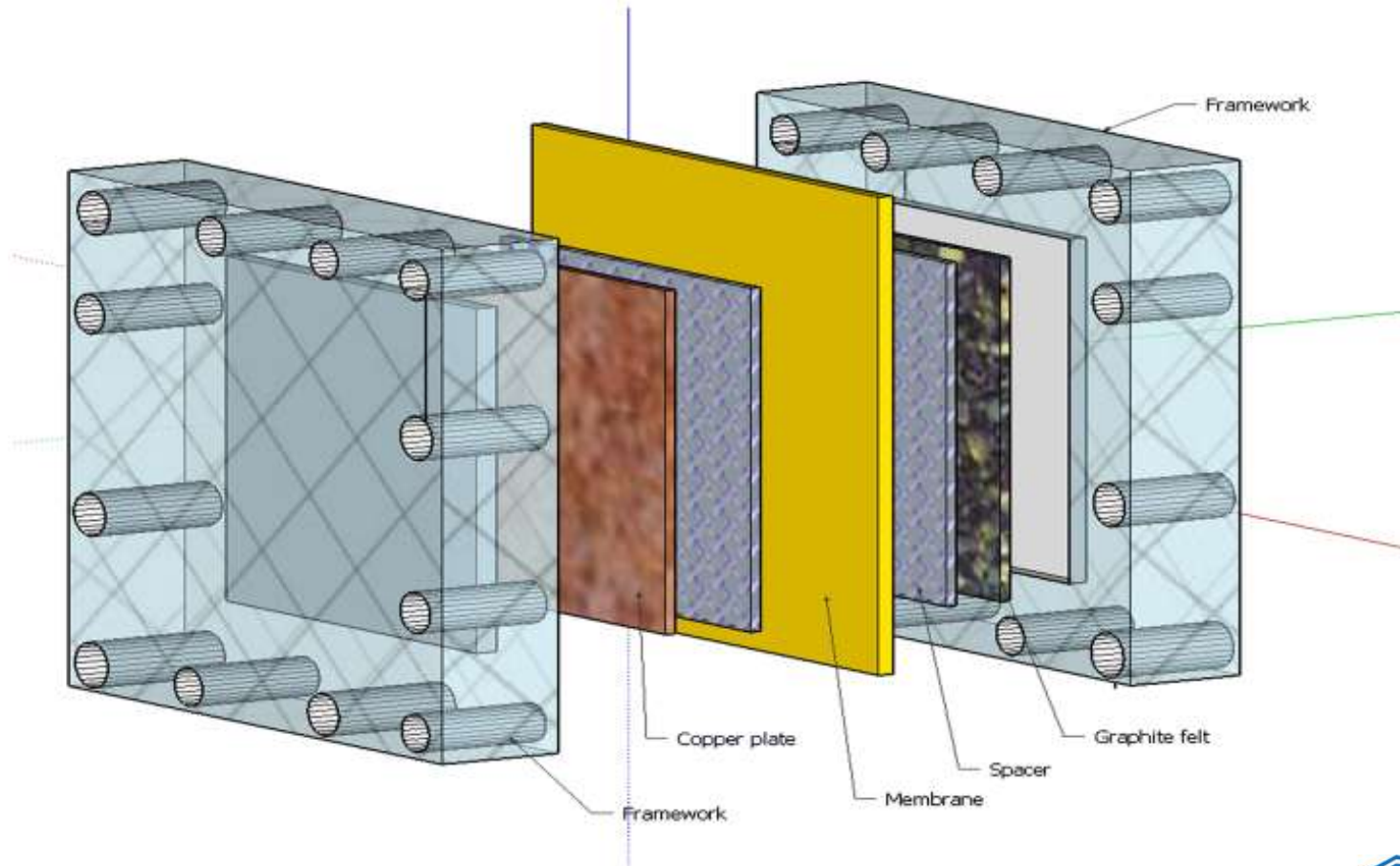
Piloting urine treatment (30 persons) at Wetherskip Fryslan & Wetsus



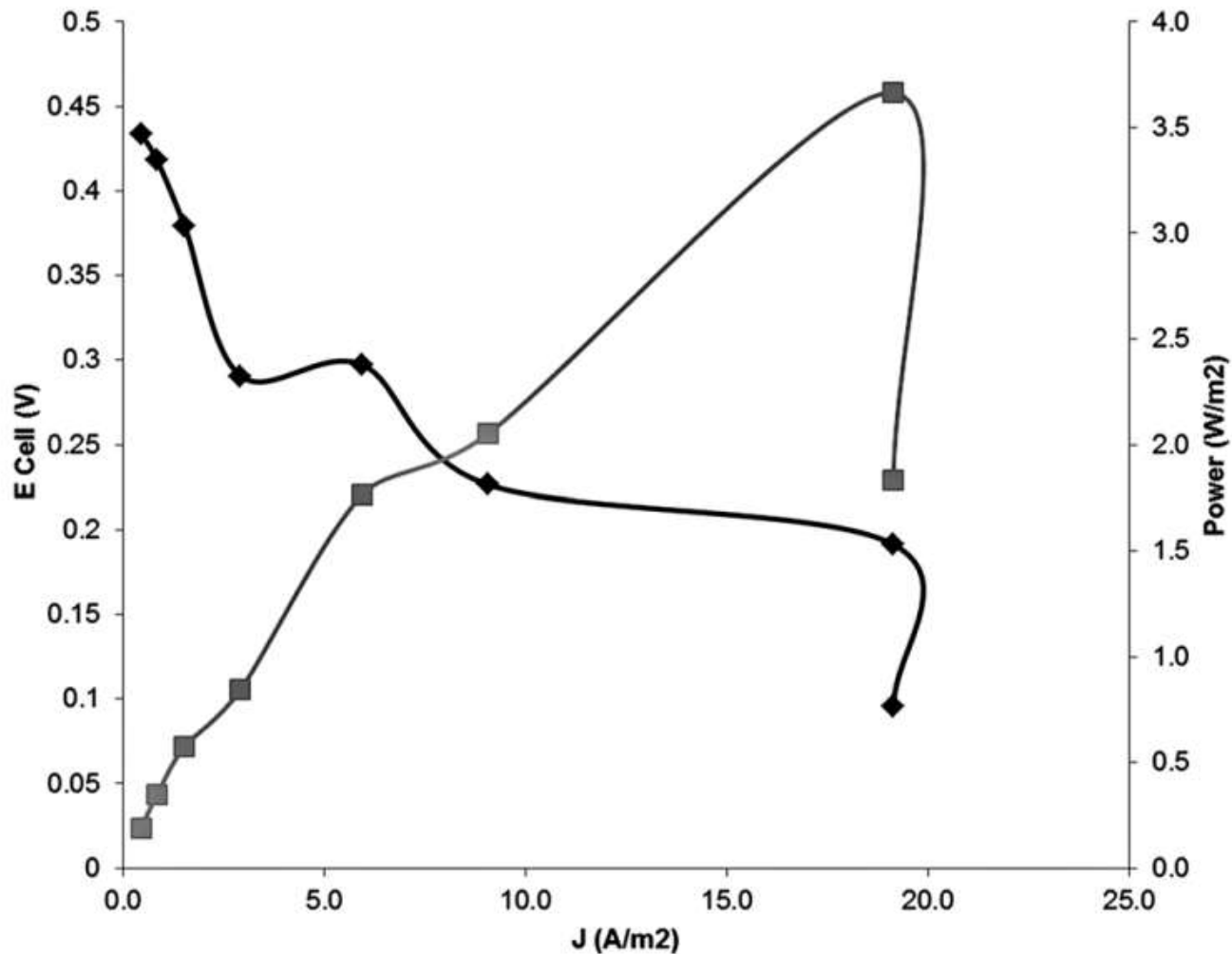
Proof of principle: copper and electricity recovery



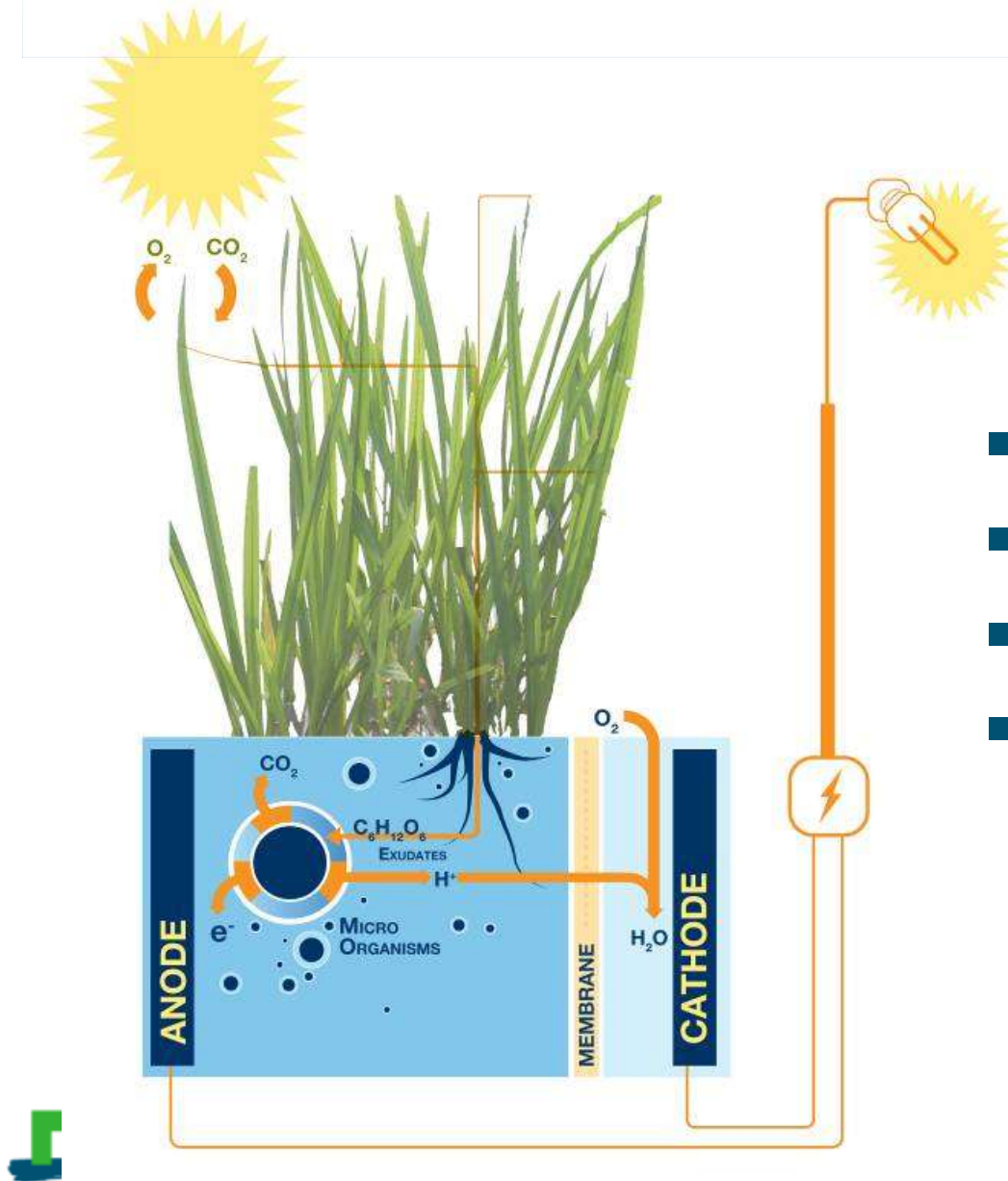
Cell configuration with low internal resistance



High-rate microbial fuel cell with copper



Plant Microbial Fuel Cell



- New source
- 24 h/d
- Self repairing
- No fine dust emissions

Proof-of-principle: plants produce electricity

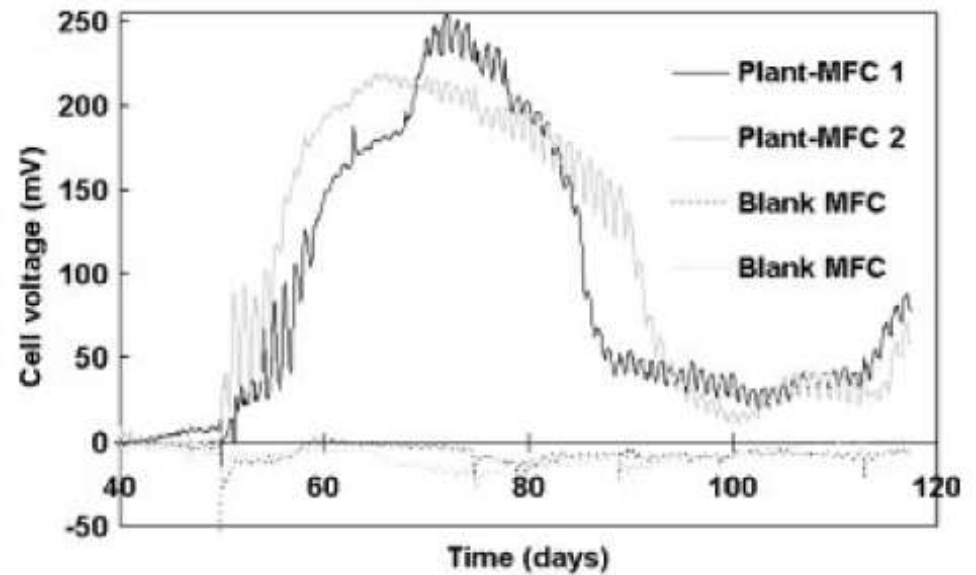
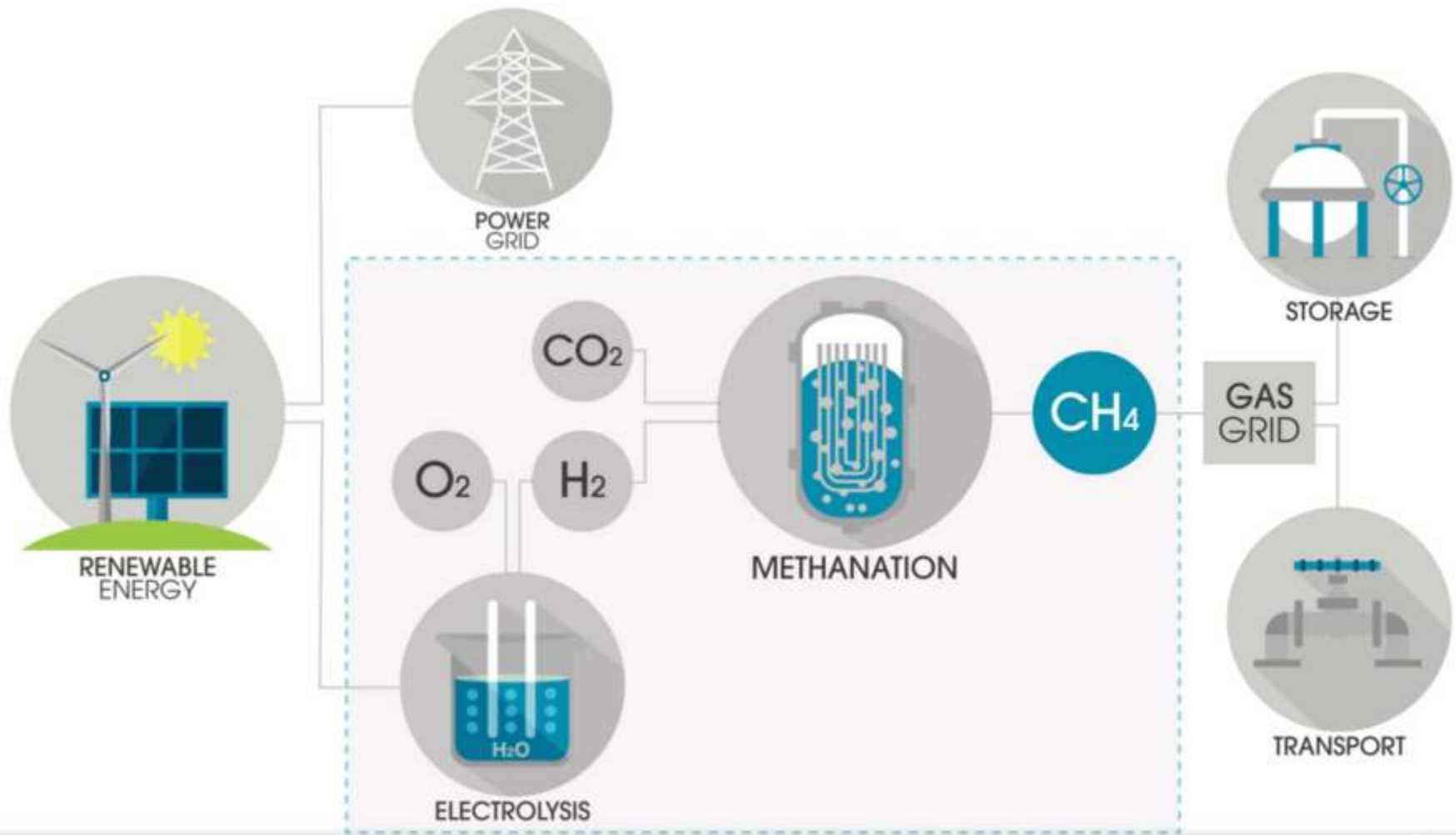


Figure 2. Plant-MFC proof of principle. Cell voltage (mV) of two plant-MFCs and two blank MFCs.

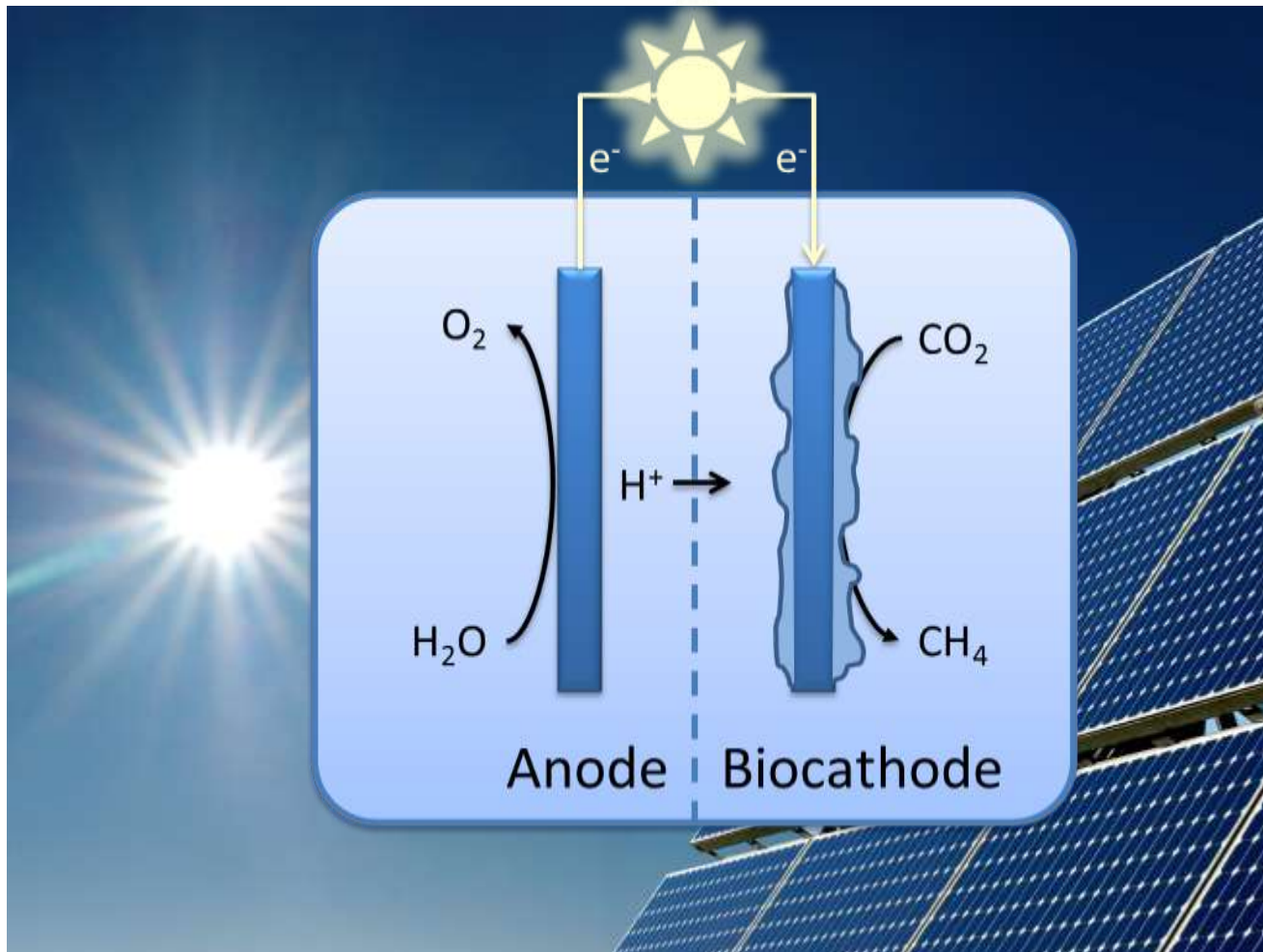


living plants generate electricity

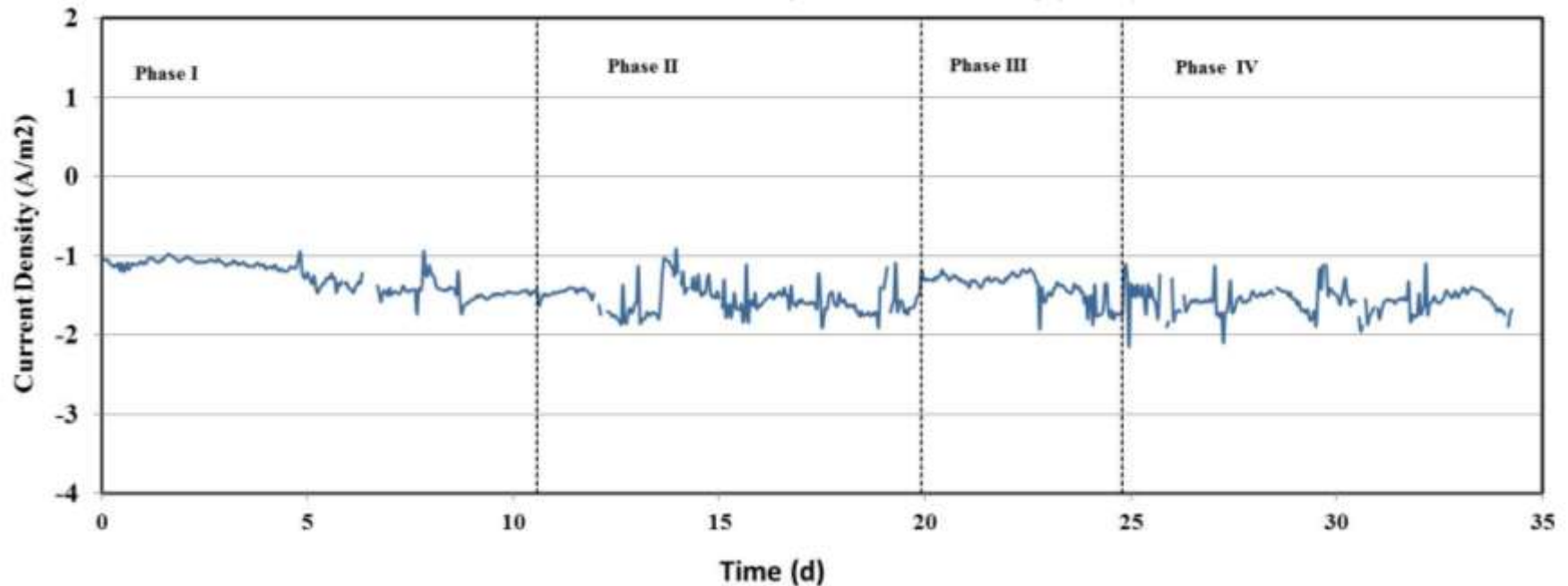
Power to (bio-)gas



Biocathodes offer an energy efficient alternative for power to gas



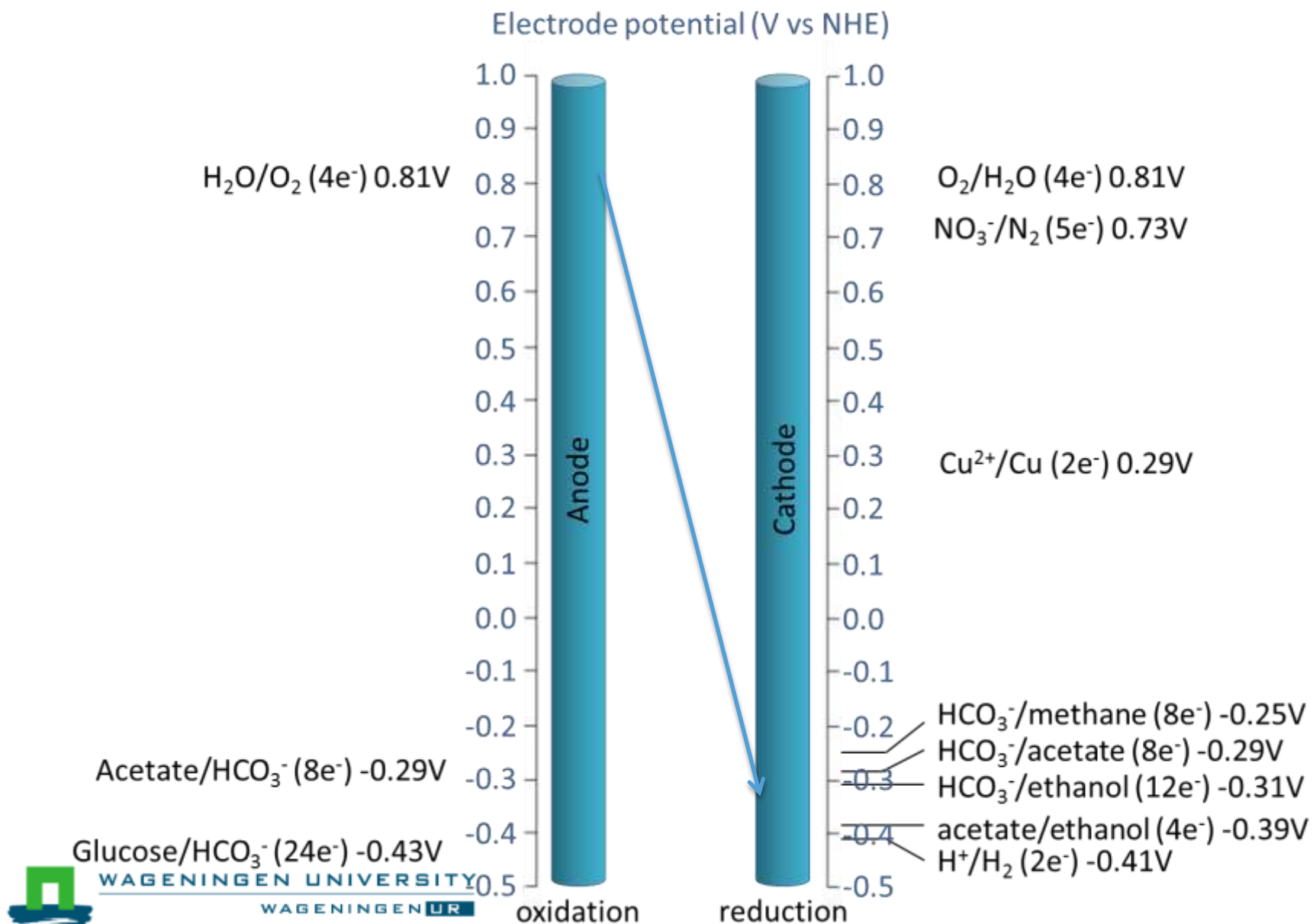
Continuous and stable methane production



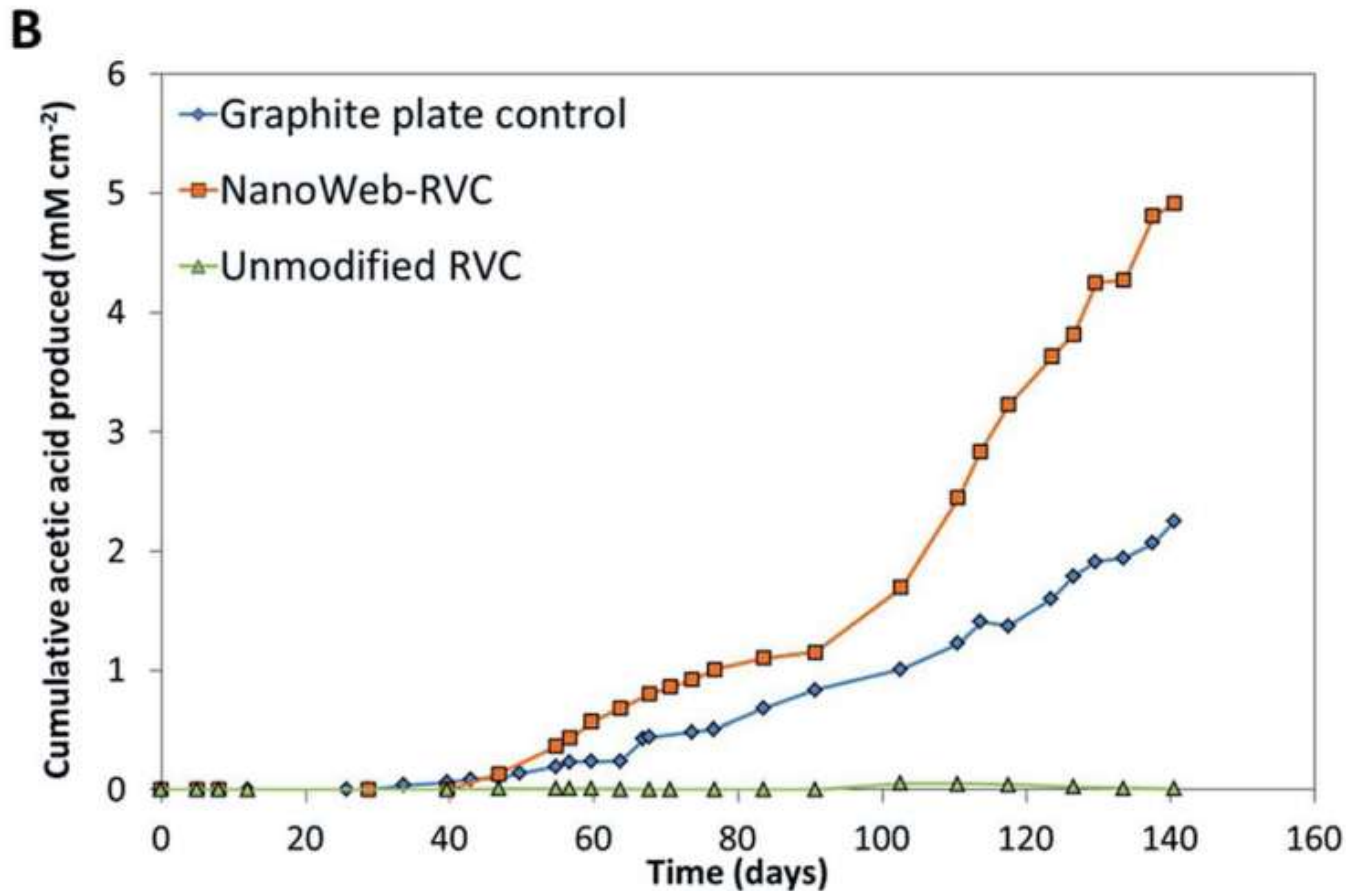
	Methane production rate (m³/m³ per day)	$\eta_{\text{Coulombic}}$ (%) methane
Phase I	0.2119	59.49
Phase II	0.2875	56.23
Phase III	0.2454	58.31
Phase IV	0.2604	55.35



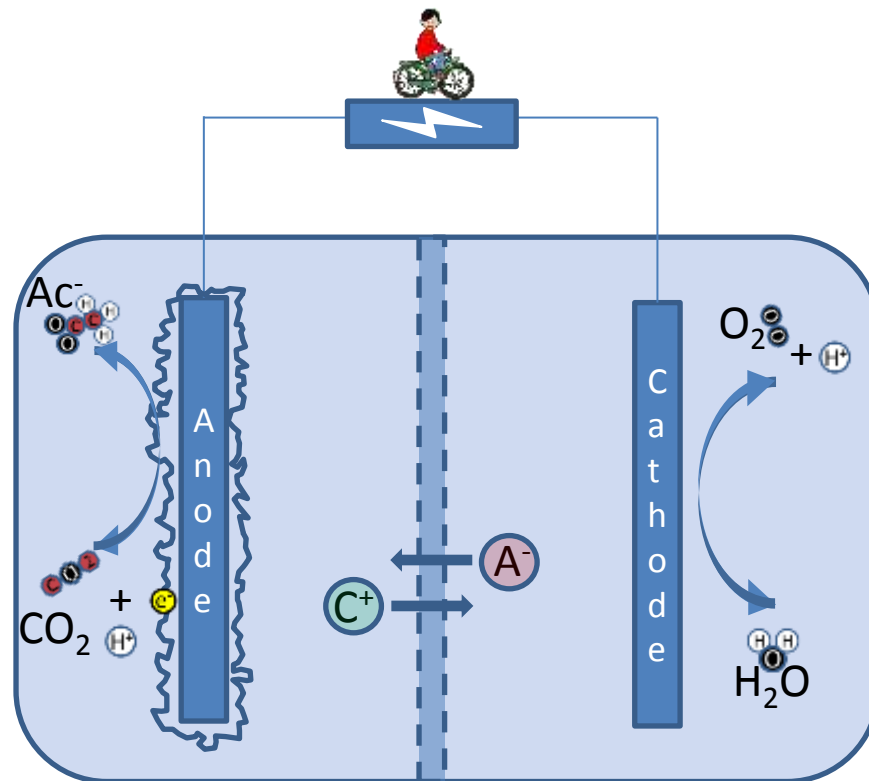
Electricity storage as chemical energy



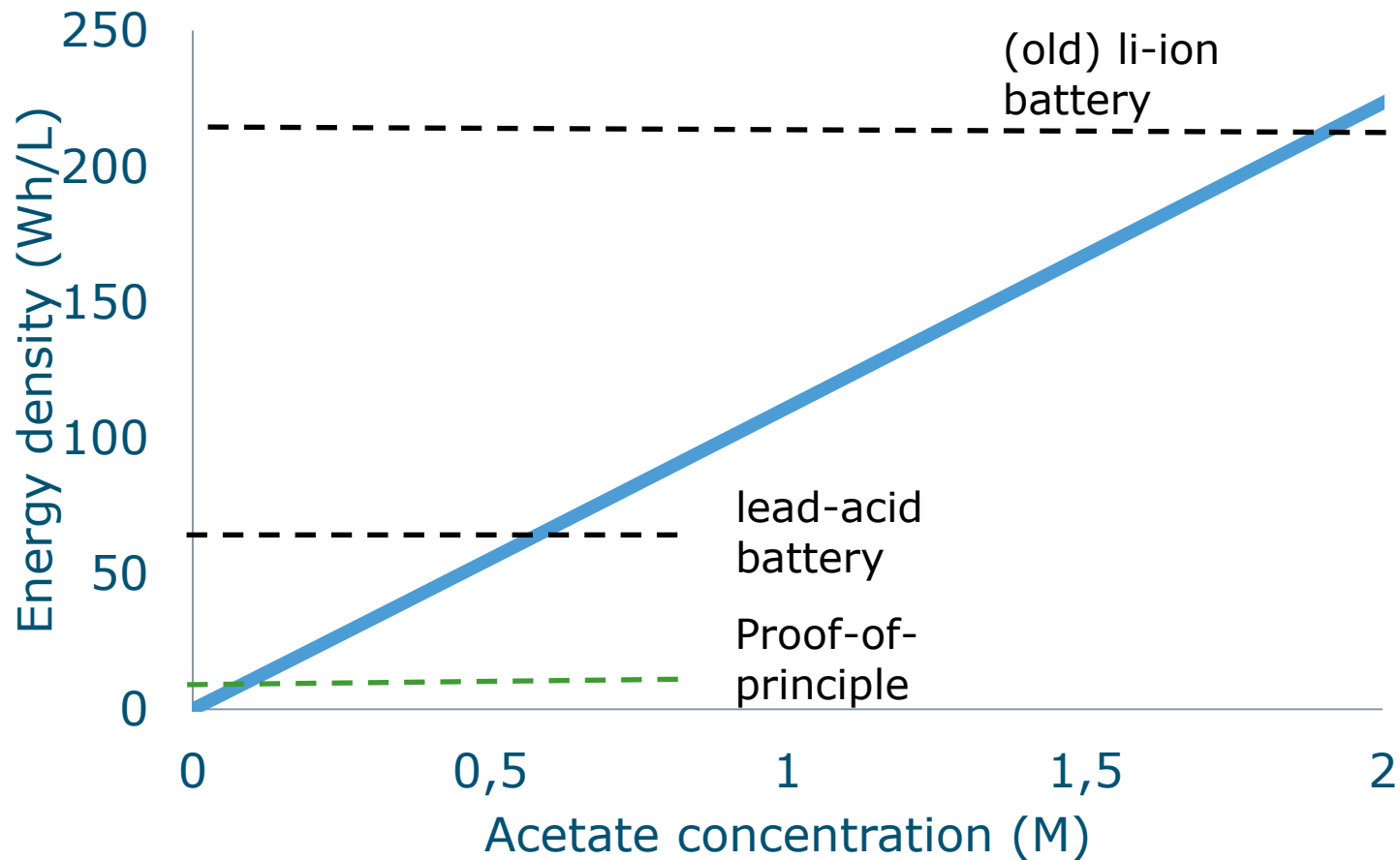
Acetate production at biocathodes as alternative to methane



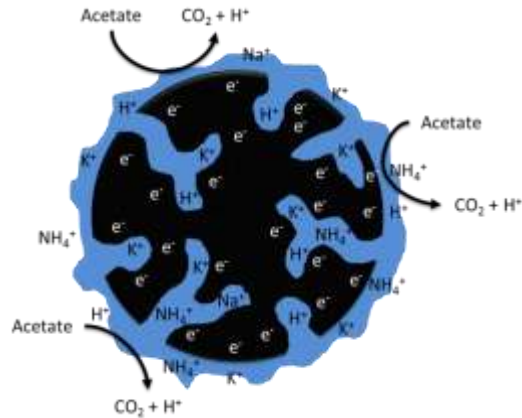
Biobattery for storage of electricity in the form of acetate: proof of principle



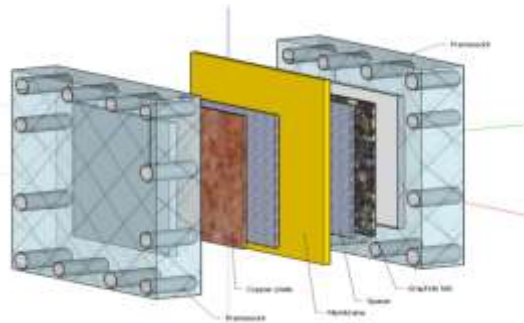
Biobattery perspective depends on maximum acetate concentration



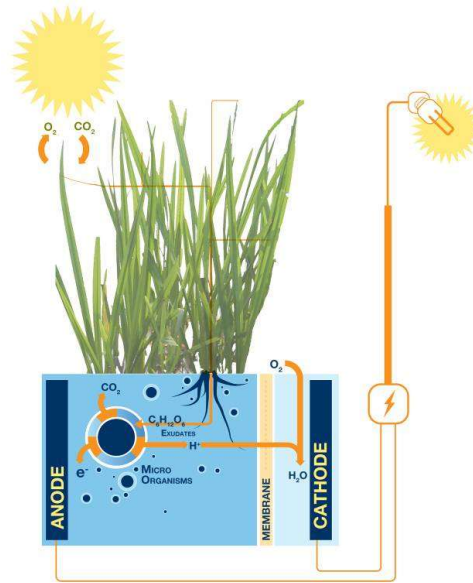
Microorganisms and electrodes offer new exciting possibilities for energy conversions



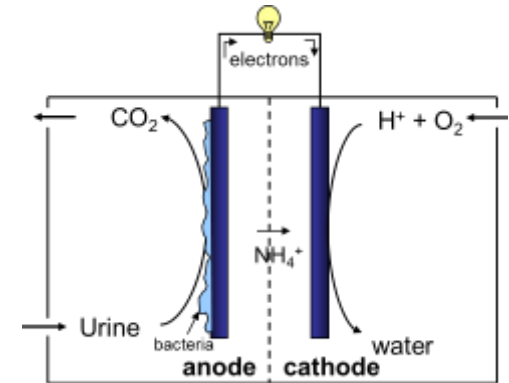
Capacitive granules



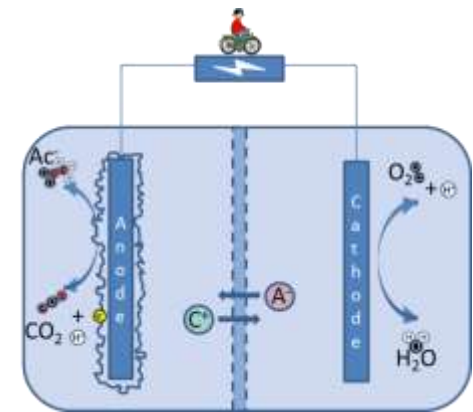
Copper recovery



Plant MFC



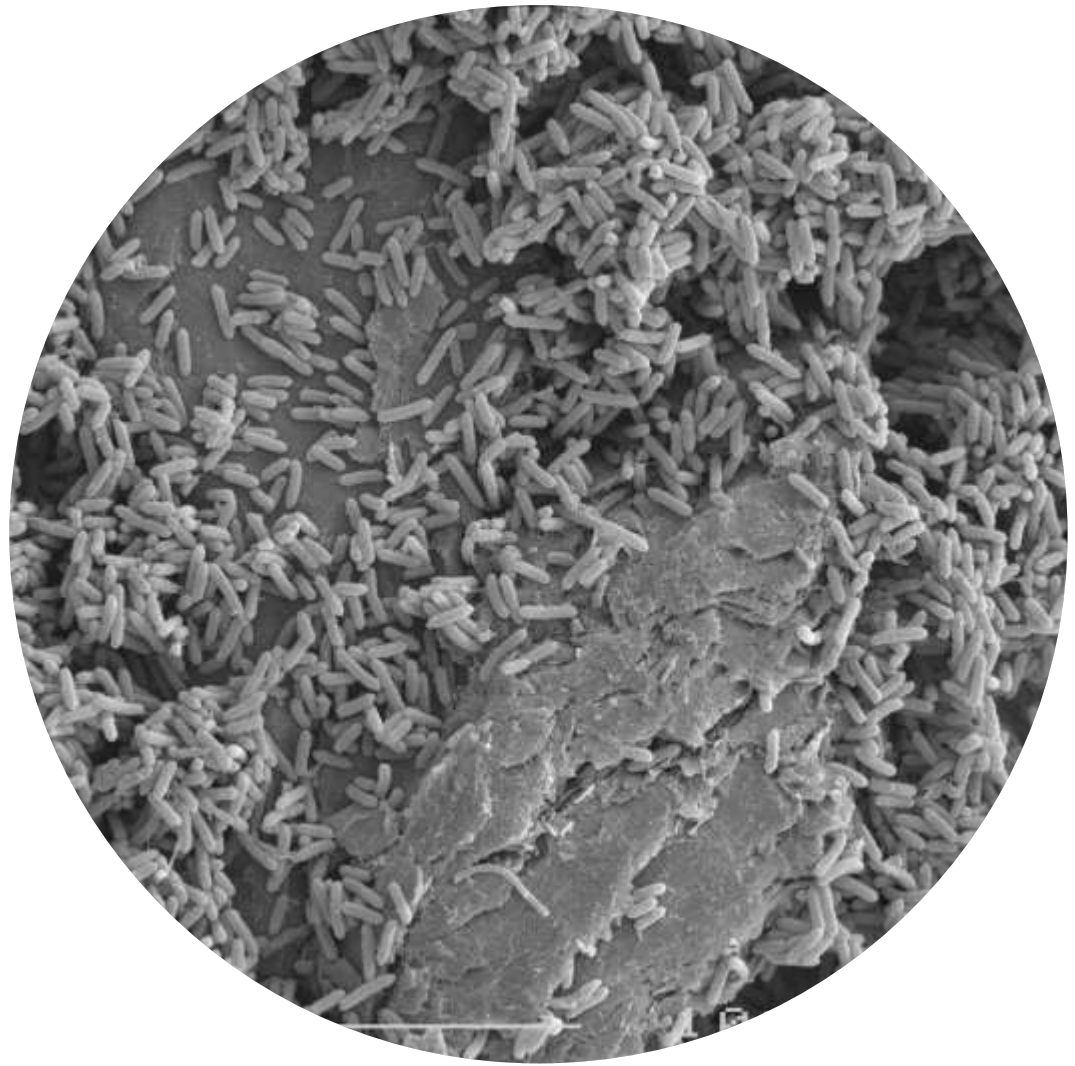
Urine treatment



Biobattery

Thank you for
your attention

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