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COUPLING BIOELECTROCHEMICAL OXIDATION TO C1 OF THE MELISSA LOOP

Dr. Amanda Luther 18-05-2018

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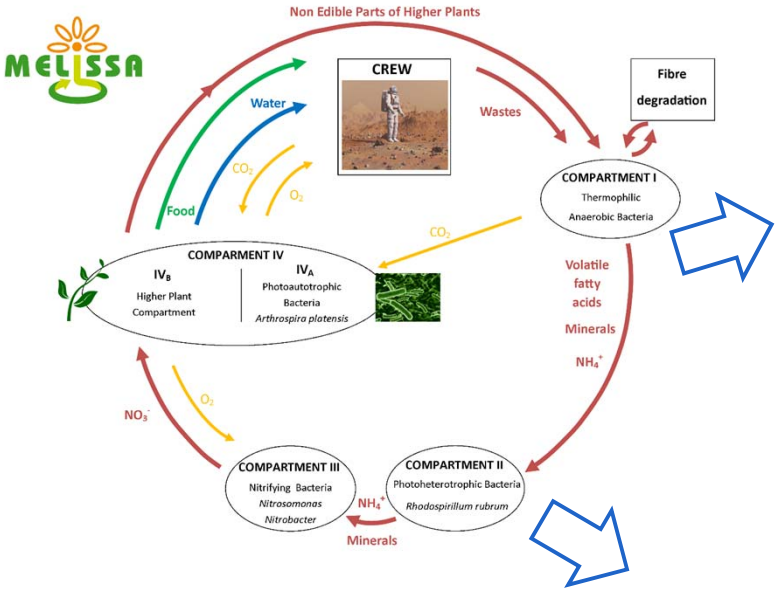
esa MELISSA

MELISSA

Challenge: organics mineralization to CO_2



C1 fermentation (optimized)

- 15% organic carbon mineralized to CO_2
- ~35% carbon (soluble) routed to C2
- ~45% of nitrogen (organics + ammonium) routed to C2

C2 compartment (aim)

- mineralize organic carbon to CO_2
- retain minerals in effluent, and nitrogen as ammonia

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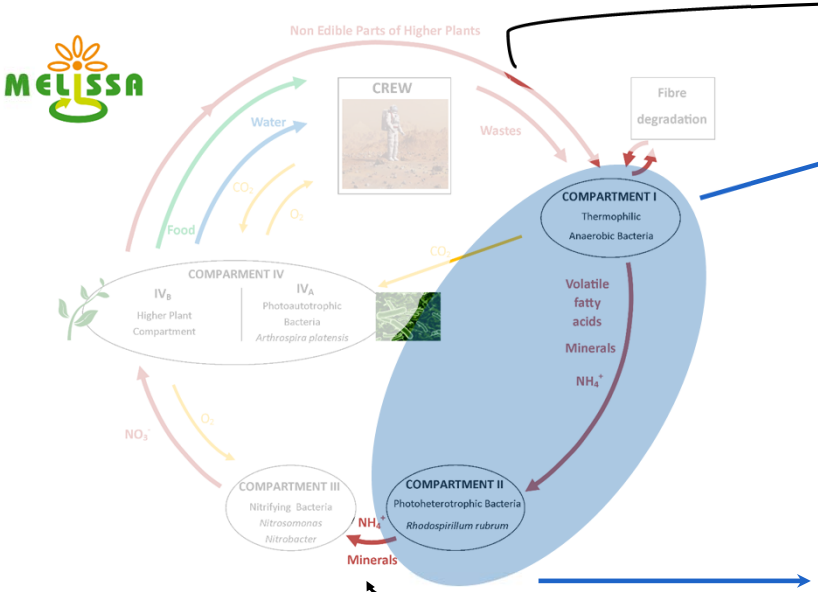
MELISSA

Bioanodic oxidation of fermentation products



Wastes

(Beetroot, lettuce, straw, paper, feces, water)

Fermentation

Mixed organic acids, CO_2, minerals, NH_4^+

Bioelectrochemical oxidation

CO_2, minerals, NH_4^+, H_2

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C1 FERMENTATION

Standard MELiSSA C1

- **5 L reactor**
- **55 °C**
- **pH 5.3**
- **External membrane filtration**
- **HRT = 10 Days**
- **SRT = 80 Days**

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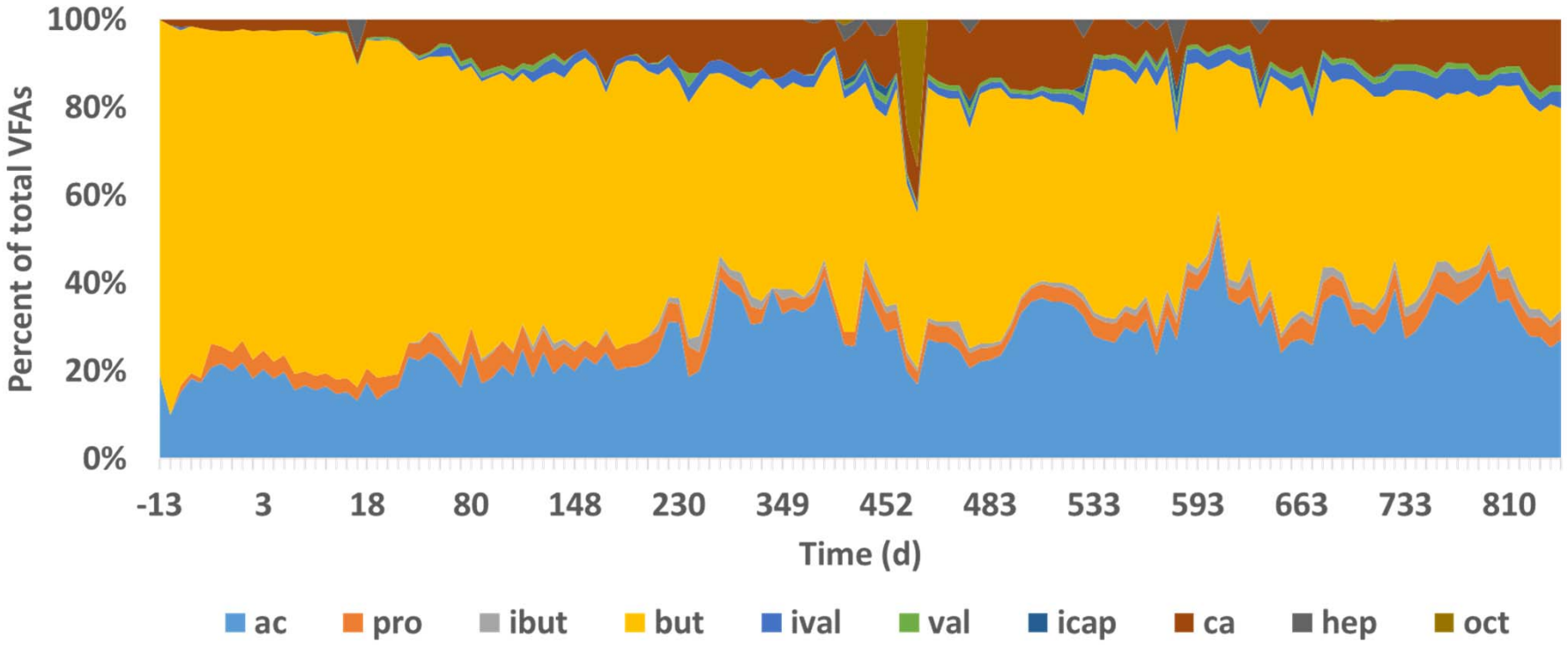
INFLUENT CONTAINS REDUCED C AND N

Total COD (g/L)	9.6	± 1.6	
Total organic acids (g COD/L)	8.0	± 0.9	(83% of total COD)
Acetic acid (g COD/L)	2.4	± 0.1	(25% of total COD)
Butyric acid (g COD/L)	3.9	± 0.1	(41% of total COD)
Caproic acid (g COD/L)	0.8	± 0.0	(8% of total COD)
Ethanol (g COD/L)	1.4	± 1.1	(15% of total COD)
Other	0.2		(2% of total COD)
Total Nitrogen (mg N/L)	270	± 47	
Total ammonia nitrogen (mg N/L)	153	± 23	(57% of total nitrogen)
Total organic nitrogen (mg N/L)	124	± 57	(46% of total nitrogen)

VFA PRODUCTION IN C1



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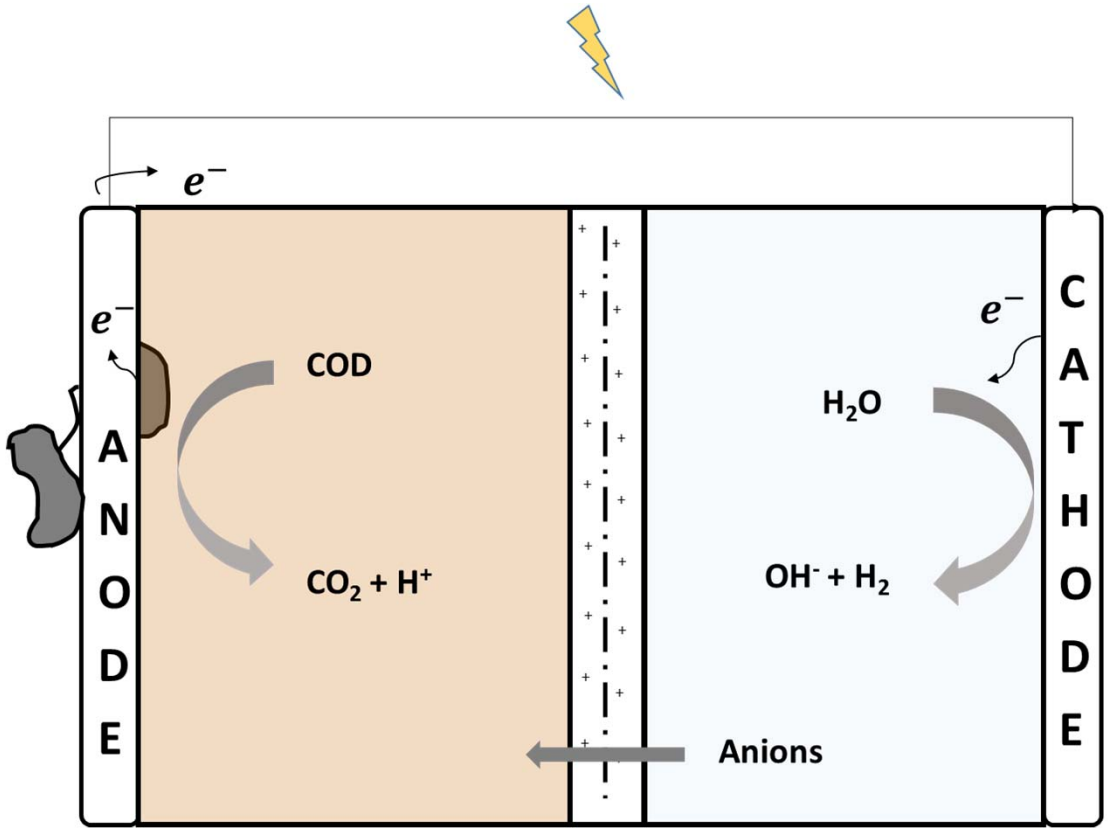
BIOANODIC OXIDATION

- **Organics expressed as chemical oxygen demand (COD)**
- **Bio-anodic oxidation of organics produces a current**
- **Charge balanced by anion transfer from cathode to anode**



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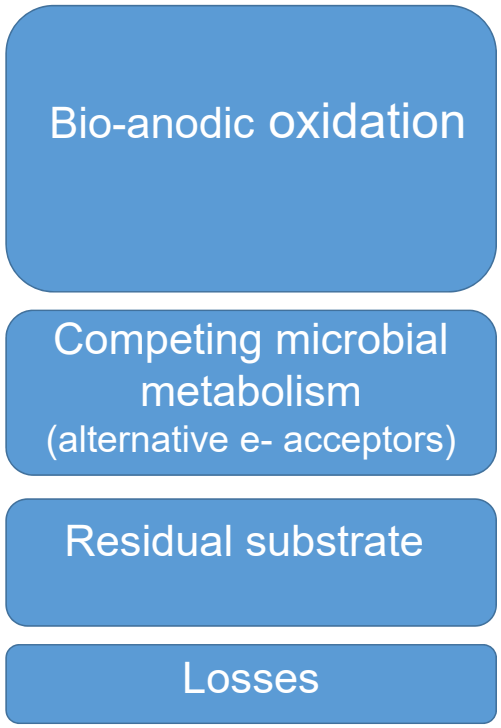
POSSIBLE CARBON AND ELECTRON SINKS



Coulombic efficiency expresses the fraction of oxidized COD converted to current

Electron balance on COD to identify sinks

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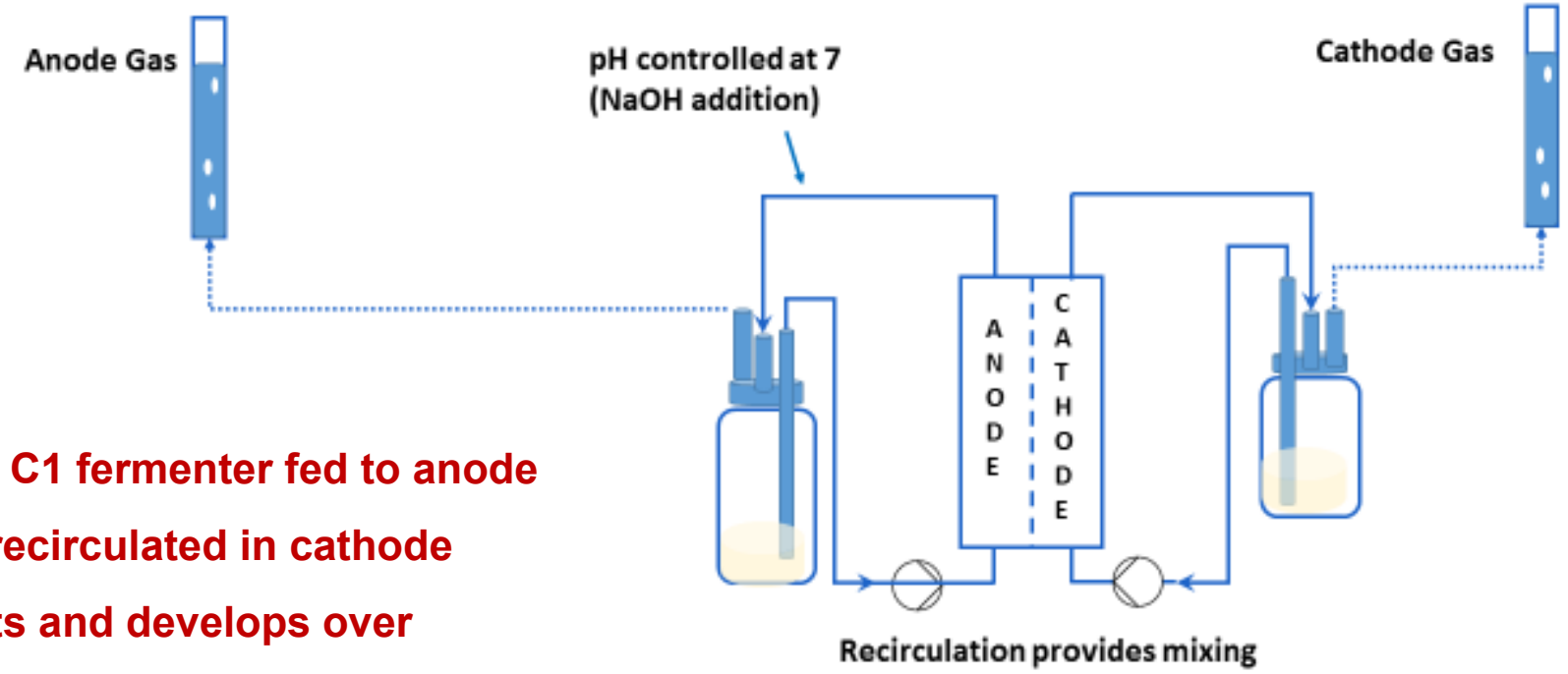
BATCH TESTS ON C1 EFFLUENT



- **Effluent from C1 fermenter fed to anode**
- **Sodium salt recirculated in cathode**
- **Biofilm adapts and develops over consecutive batches**

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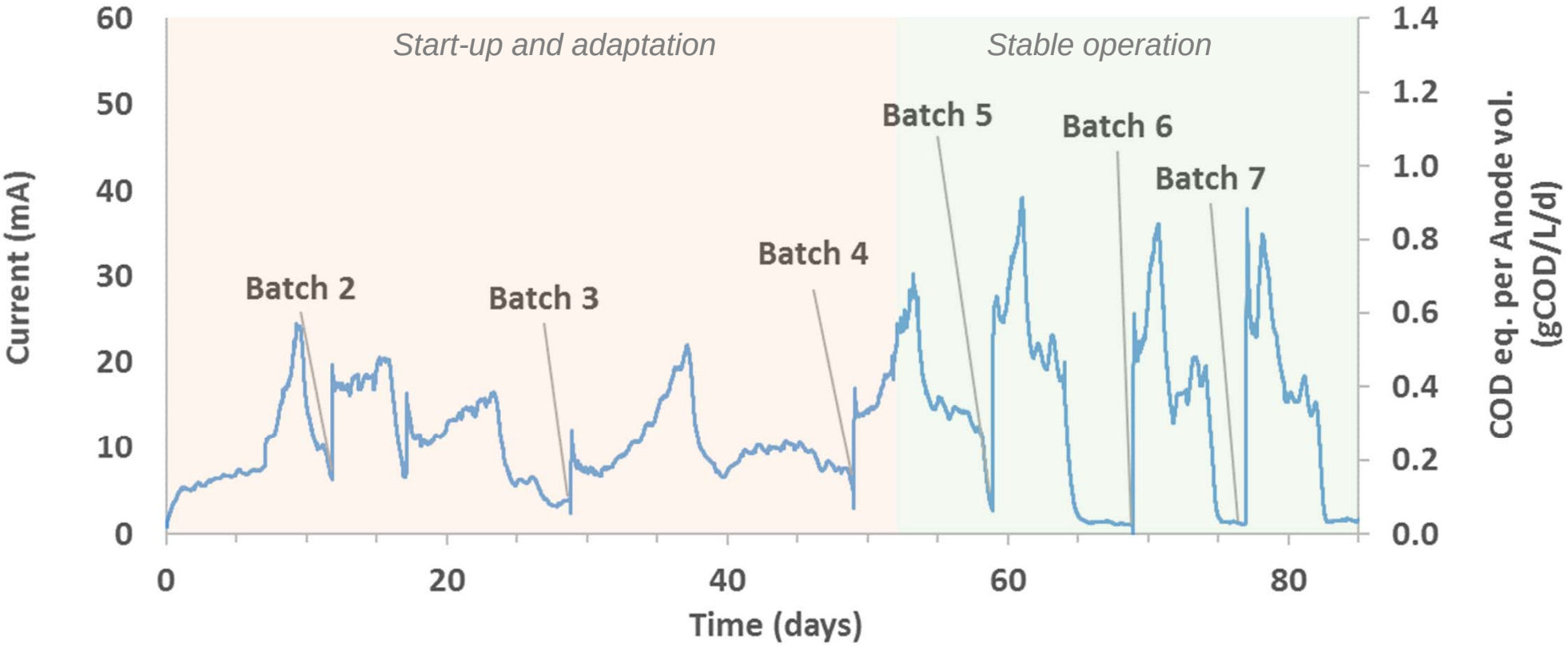
STABLE BATCH OPERATION



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PERFORMANCE OVERVIEW

Batch #	RE_{COD} (%)	tVFA RE (%)	CE_{COD} (%)	pH anode (t_f)	pH cathode (t_f)
4	77	85	79	7.8	12.9
6	85	100	64	8.8	12.5
7	89	93	57	8.5	12.6

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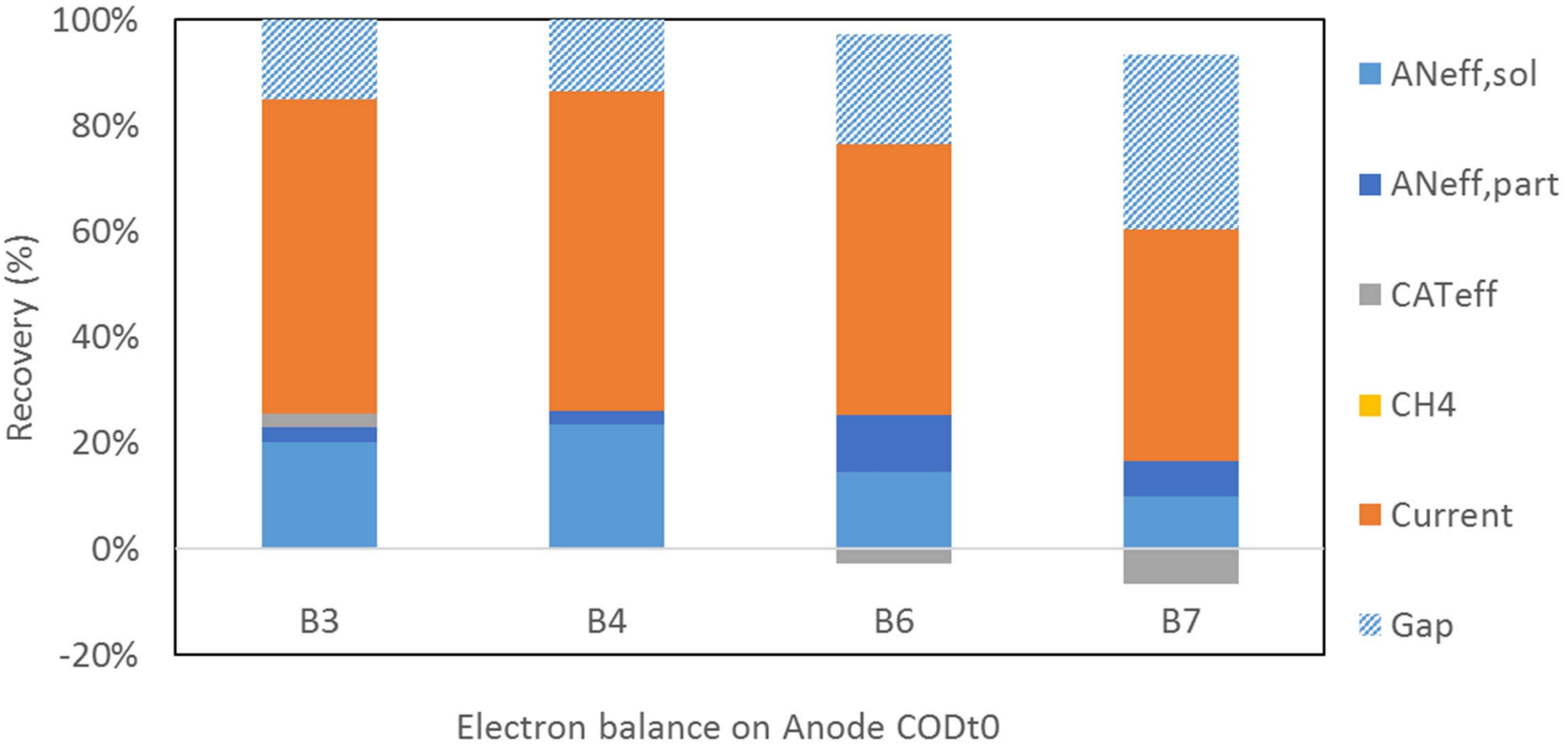
COD (ELECTRON) BALANCE



CONTINUOUS TESTS

Test 1 **2 g COD L^{-1} d^{-1}**	**Test 2** **2 g COD L^{-1} d^{-1}**	**Test 3** **1 g COD L^{-1} d^{-1}**
• Continuous feed following batch test • Same bioanode	• modifications to set-up • Same bioanode	• Reduced organic loading • Refresh anode

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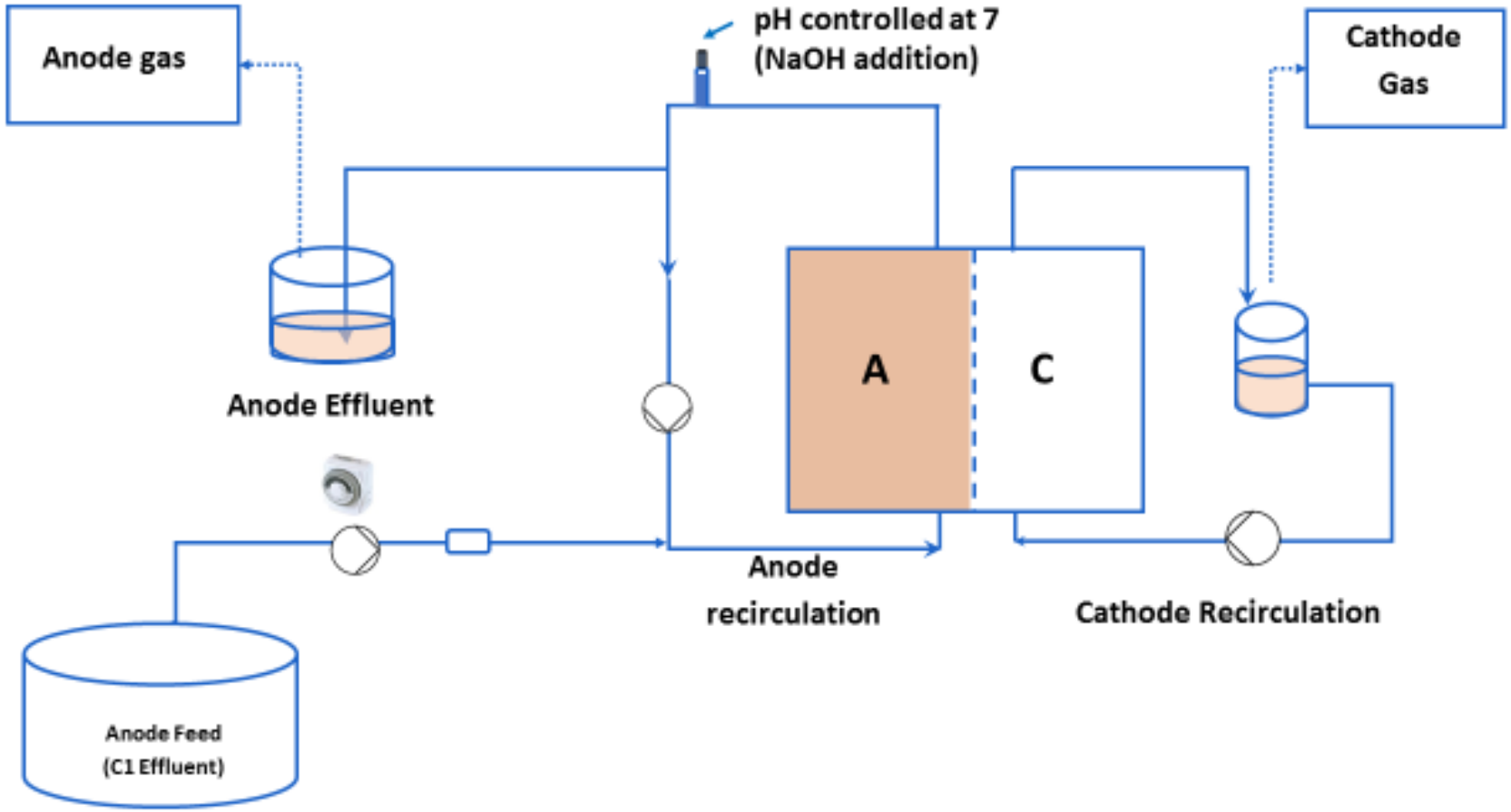
CONTINUOUS TESTS



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PERFORMANCE OVERVIEW

Test #	Stable operation period (d)	COD loading (g L_{AN}^{-1} d^{-1})	COD RE (%)	VFA RE (%)	CE_{COD} (%)	Anode pH	Cathode pH
1	21	2	88	96	73	7.8 ± 0.2	13.0 ± 0.1
2	63	2.4	76	82	23	7.6 ± 0.5	10.4 ± 0.6
3	33	0.7	92	98	56	7.0 ± 0.1	12.2 ± 0.4

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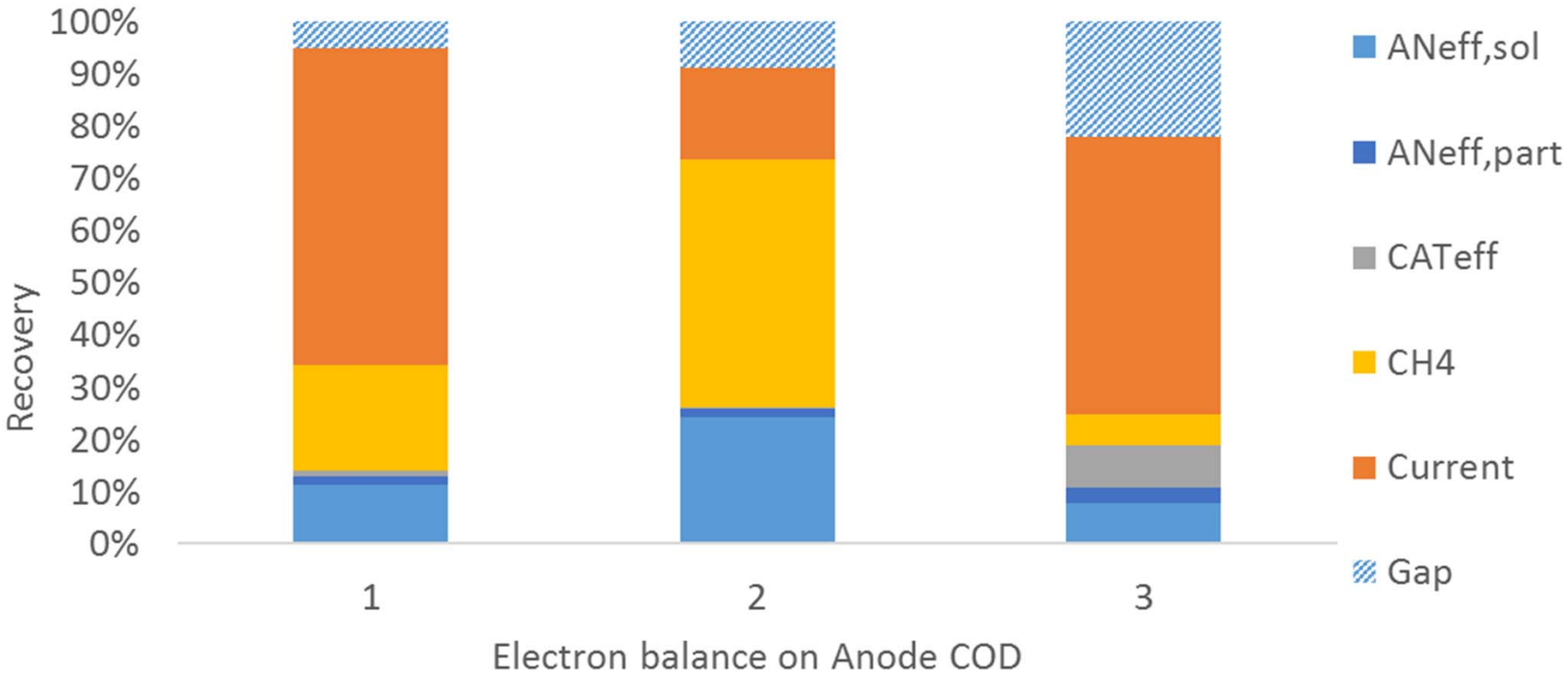
COD (ELECTRON) BALANCE



PROOF OF CONCEPT ESTABLISHED

- Real C1 effluent is amenable to bio-anodic oxidation
- High removal efficiencies could be achieved
- Bio-anodic activity favored under batch conditions, but not sustained under continuous operation
- Limited COD removal: ~15% COD remains in effluent

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NEXT STEPS

- Optimize continuous operation
- Carbon and nitrogen balance through system
- In-depth characterization of long-term performance

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