

## Supplementary Information

### Microbial Electrosynthesis: Is it sustainable for bioproduction of acetic acid?

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### Life Cycle Inventory

This section presents the life cycle inventory for all the components analysed in the MES plant, for both contribution and scenario analysis.

**Table S1:** Life cycle Inventory data per kg AA of the different MES reactors used in the analysis for bioproduction of 1000t/year AA:

	Scenario 1 and 2	Scenario 3 and 4
Cathode	3D-GFCF	3D-GFCF
Mode of operation	Continuous	Fed-batch
Dilution rate (h <sup>-1</sup> ) / operation cycle (d)	0.042 (h <sup>-1</sup> )	30 (d)
Space time yield (g L <sup>-1</sup> d <sup>-1</sup> )	148	148
Cathode (g/kg AA)	0.00013	0.00756
Anode (g/kg AA)	0.00017	0.01001
Nafion (m <sup>2</sup> /kg AA)	0.00042	0.02512
Current collector (g/kg AA)	0.00008	0.00476
Catholyte/anolyte (m <sup>3</sup> /kg AA)	0.00068	0.00676
Energy (kWh/kg AA)	2.80	2.80
CO <sub>2</sub> capture (kWh/kg AA)	0.39	0.39
AA wt% from MES	12.88	12.88
Extraction (MJ/kg AA)	117.00	117.00

For the catholyte and anolyte, 90% recycle rate has been assumed.

**Table S2:** Data sources of the different inputs used in the LCA analysis:

Process Input	Data Source
Grid Electricity	Electricity, medium voltage {GB}
Renewable electricity	Electricity production photovoltaic {GB}, 570kWp open ground installation, multi-Si
CF Cathode	Minke et al. 2017
3D-GFCF Cathode	Aryal et al. 2016, Dey et al. 2015
Graphite Stick	Graphite, battery grade {GLO}
Anolyte, Catholyte	Jourdin et al. 2014
Current Collector	Copper {RER}   production, primary
Nafion	Evangelisti et al. 2017
Carbon dioxide, fossil	Ecoinvent data on emissions to air
Oxygen	Ecoinvent data on emissions to air
Acetic acid	Acetic acid production, in 98% solution state {RER}
Heat	Heat, from steam, in chemical industry {RER}

## Life cycle impact assessment results

This section presents the life cycle impact assessment data in terms of individual contributions to GHG emissions and NREU from different sub-processes for the case studies investigated under contribution and scenario analysis.

**Table S3:** GHG emissions (kg CO<sub>2</sub> eq.) of individual subprocesses from production of 1000t/year AA using MES with CF and 3D-GFCF cathode.

	GHG Emissions (kg CO <sub>2</sub> eq.)	
	MES-CF	MES-3D-GFCF
Cathode	1.99E+05	6.81E+06
Anode	4.74E+03	7.06E+02
Membrane	8.49E+07	1.27E+07
CC	2.14E+03	3.19E+02
Catholyte	3.20E+06	4.78E+05
Anolyte	3.20E+06	4.76E+05
MES Operation	1.14E+06	1.05E+06
CO <sub>2</sub> capture	1.48E+05	1.48E+05
CO <sub>2</sub> utilization	-1.47E+06	-1.47E+06
TOTAL	9.14E+07	2.02E+07

**Table S4:** NREU (MJ) of individual subprocesses for production of 1000t/year AA using MES with CF and 3D-GFCF cathode.

	NREU (MJ)	
	MES-CF	MES-3D-GFCF
Cathode	5.31E+06	1.75E+08
Anode	1.12E+05	1.68E+04
Membrane	3.38E+08	5.03E+07
CC	2.98E+04	4.45E+03
Catholyte	3.34E+07	4.98E+06
Anolyte	3.32E+07	4.96E+06
MES Operation	2.99E+07	2.75E+07
CO <sub>2</sub> capture	3.88E+06	3.88E+06
TOTAL	4.43E+08	2.67E+08

**Table S5:** GHG emissions (kg CO<sub>2</sub> eq.) from producing 1000t/year of AA using MES as described in Scenario 1, 2, 3 and 4.

		GHG Emissions (kg CO <sub>2</sub> eq.)			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Reactor	Cathode	2.83E+03	2.83E+03	1.70E+05	1.70E+05
	Anode	2.94E-01	2.94E-01	1.76E+01	1.76E+01
	Membrane	5.27E+03	5.24E+03	3.16E+05	3.16E+05
	CC	1.34E-01	1.34E-01	7.96E+00	7.96E+00
Operation	Catholyte	3.69E+01	3.68E+01	1.19E+04	1.19E+04
	Anolyte	3.68E+01	3.69E+01	1.19E+04	1.19E+04
	MES Operation	1.01E+06	2.17E+05	1.01E+06	2.17E+05
	CO <sub>2</sub> capture	1.42E+05	3.05E+04	1.42E+05	3.05E+04
	CO <sub>2</sub> utilization	-1.47E+06	-1.47E+06	-1.47E+06	-1.47E+06
Extraction		1.21E+07	2.52E+06	1.21E+07	2.52E+06
TOTAL		1.18E+07	1.30E+06	1.23E+07	1.81E+06

**Table S6:** NREU (MJ) for producing 1000t/year of AA using MES as described in Scenario 1, 2, 3 and 4.

		NREU (MJ)			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Reactor	Cathode	7.29E+04	7.29E+04	4.38E+06	4.38E+06
	Anode	6.97E+00	6.97E+00	4.18E+02	4.18E+02
	Membrane	2.09E+04	2.08E+04	1.26E+06	1.26E+06
	CC	1.87E+00	1.87E+00	1.11E+02	1.11E+02
Operation	Catholyte	3.85E+02	3.83E+02	1.24E+05	1.24E+05
	Anolyte	3.83E+02	3.85E+02	1.24E+05	1.24E+05
	MES Operation	2.61E+07	2.97E+06	2.61E+07	2.97E+06
	CO <sub>2</sub> capture	3.67E+06	4.18E+05	3.67E+06	4.18E+05
Extraction		1.92E+08	3.45E+07	1.92E+08	3.45E+07
TOTAL		2.22E+08	3.80E+07	2.28E+08	4.37E+07

## References:

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