Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

SUPPLEMENATRY INFORMATION

Energy and economic advantages of simultaneous hydrogen and biogas production in microbial electrolysis cells as a function of the applied voltage and biomass content

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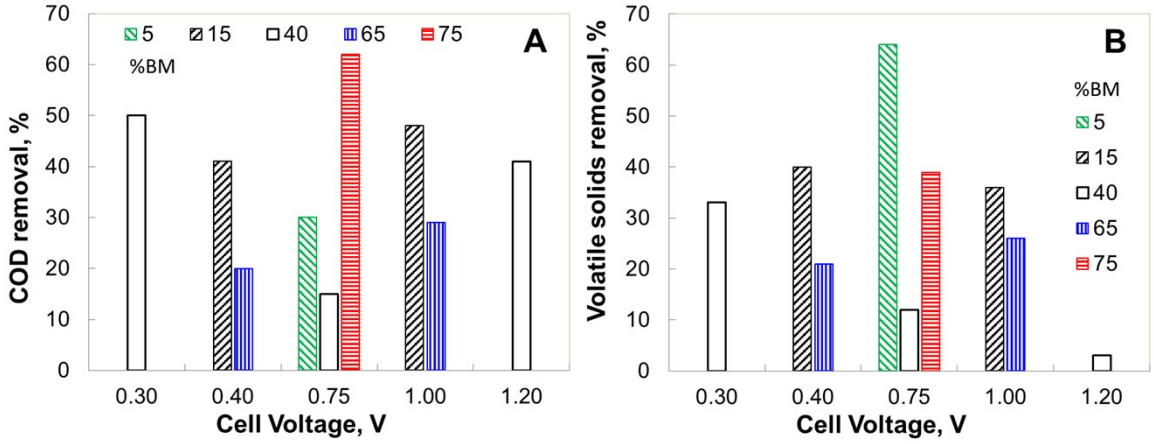
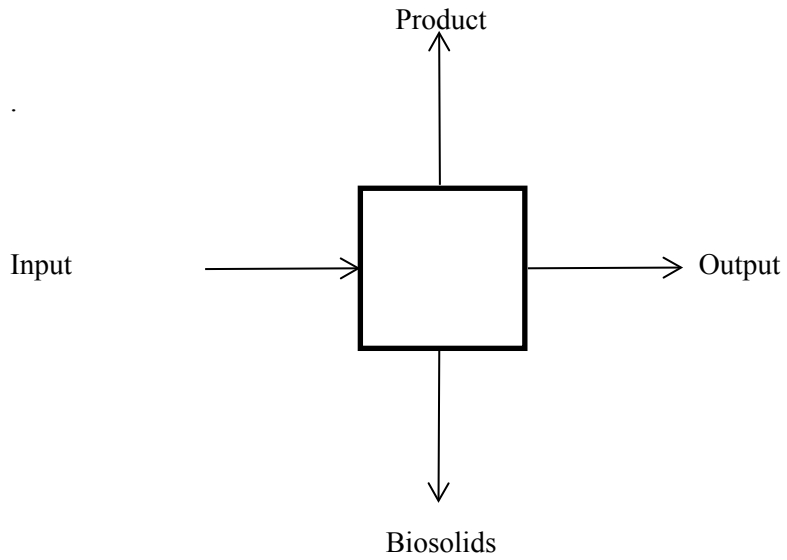


Figure S1 Organics removal in the anodic chamber of MECs as a function of the cell voltage and percentage of biomass (%BM).

Table S1. COD mass balance for the anodic chamber of MECs installed with carbon felt in fermenter effluents at various combinations of voltage and biomass content.



MEC	Biogas	CH_4	CO_2	Biogas	CH_4	CO_2	CH_4	CO_2
	mL	%	%	g	g	g	g-COD	g-COD
0.43V-65%	29	86.8	13.2	0.035	0.0302	0.0046	0.1208	0
1.06V-65%	30	75.2	24.8	0.036	0.0271	0.0089	0.1083	0
0.75V-75%	33	69.2	30.8	0.040	0.0274	0.0122	0.1096	0
	Initial SCOD	Final SCOD	Initial SCOD	Final SCOD				
	g/L	g/L	g	g				
0.43V-65%	11.64	3.12	1.57	0.42				
1.06V-65%	11.64	3.18	1.57	0.43				
0.75V-75%	10.67	6.7	1.44	0.90				
	VS-initial	VS-initial	VS-initial	VS -final	VS- final	VS-final		
	g / L	g	g-COD	g / L	g	g-COD		
0.43V-65%	11.006	1.49	2.53	8.672	1.171	1.990		
1.06V-65%	11.006	1.49	2.53	8.188	1.105	1.879		
0.75V-75%	12.75	1.72	2.93	7.739	1.045	1.776		
Gas density	1.2	g/L						
Reactor volume	0.135	L						
g COD/mol CH_4	64	g						
g COD/mol CO_2	0	g						
Molecular weight CH_4	16	g/mol						
g COD/g VS	1.7	econdary sludge						
L CH4/g COD	0.35	Standard yield						

			0.43V-65%	1.06V-65%	0.75V-75%	
Input, g-COD	COD-anolyte		1.57	1.57	1.44	
	COD-VS		2.53	2.53	2.93	
	Total input		4.10	4.10	4.37	
Output, g-COD	COD-anolyte		0.42	0.43	0.90	
	COD-VS		1.99	1.88	1.78	
	COD-CH_4		0.12	0.11	0.11	
	Total output		2.53	2.42	2.79	
Indeterminated	Input-Output		1.57	1.68	1.58	
Percentage balance	Input base		100%	100%	100%	
	Anolyte		10%	10%	21%	
	VS		49%	46%	41%	
	CH_4 gas		3%	3%	3%	
	Indeterminate		38%	41%	36%	

Table S2. Comparison of economic data from MEC systems for hydrogen and methane production.

MEC design	Volume	Influent	Applied voltage	Performance	Assumptions	Economic information	References
Cylindrical dual chamber	0.4 L	Acetate, 25 mM 1100-1700 mg COD L^{-1} 0.3 - 6.3 kg COD m^{-3} d^{-1}	1.2 V	0.066-0.137 m^3 H_2 m^{-2} membrane d^{-1} 0.276-0.420 m^3 H_2 kWh^{-1} 8.3-11 A m^{-2} Cathodic efficiency 94%	Not reported	Production cost 1.7-2.6 USD kg^{-1} H_2 Revenue 0.03-0.12 USD kg^{-1} COD (calculated) [a]	An et al. 2013
Up flow anaerobic reactor with a separated cathodic chamber in an inside cylinder.	1.2 L	Synthetic fermentation effluent. Input COD, not reported.	0.8 V	0.247 mL CH_4 mL^{-1} d^{-1} 0.122 m^3 CH_4 kg^{-1} COD Energy efficiency 400 % Electricity consumption 0.19 x 10^{-3} kWh (total) COD removal 49 %	Electricity cost 0.06892 € kWh^{-1}	Revenue 0.067 € m^{-3} reactor d^{-1} 0.02 USD kg^{-1} COD (calculated) [b]	Cai et al. 2016
Two chamber MEC	0.38 L	Actual digester effluents 65 % biomass 21768 mg COD L^{-1} 11.1 g VS L^{-1}	0.43 V	14.4 mL CH_4 L^{-1} d^{-1} Hydrogen production rate [c] 5.2 mL H_2 Lc^{-1} d^{-1} Energy efficiency (H_2) 336 % Electricity consumption 0.71 kWh m^{-3} H_2	Sale price 5.1 USD kg^{-1} H_2, Sale price 0.193 USD m^3 biogas (65 % CH_4) Electricity cost 0.0649 USD kWh^{-1}	Revenue 0.01 USD kg^{-1} COD	This work

[a.] From Figure 5 in the reference. Case 1: 265 L H_2 kg^{-1} COD. Case 2: 63.75 L H_2 kg^{-1} COD. Assuming a hydrogen density of 0.089 kg m^{-3}. Assuming a hydrogen price of 5.1 USD kg^{-1} H_2.
[b.] From the value 0.122 m^3 CH_4 kg^{-1} COD. Assuming 0.193 USD m^{-3} CH_4
[c] Value from the Gompertz model for 0.43V-65% MEC. Cathode compartment 0.190 L

References

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