IC-12

Electrochemistry and influence of flowrate to a reverse electro-dialysis stack in microbial reverse electrodialysis cell

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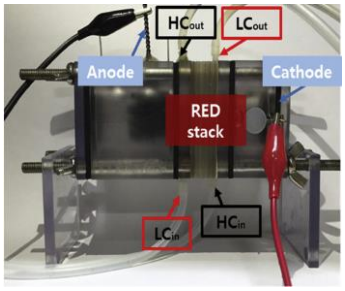
Abstract

An MRC is a bioelectrochemical system combining a microbial fuel cell (MFC) with a RED stack to generate electricity from salinity gradient and organic wastewater with simultaneous treatment. Operating an MRC at an optimum flowrate to RED is important because it is closely related with energy production rate and economic feasibility. However, influence of RED flowrates on MRC electrochemistry and power production have not been investigated. For this purpose, four different flowrates of high concentration and low concentration solutions were tested. Maximum power density was highest in 10 mL/min (3.71 W/m^2) and optimum current density was highest in 7.5 mL/min (5.36 A/m^2). By mere increasing the flowrate to MRC, maximum power and optimum current densities increased by 17.7% and 16.2%. EIS showed that impedances of anode, cathode and full-cell were decreased by 51%, 31% and 19%, respectively. Anode CV showed that peak current density was increased by 25.7%. COD removal and CE were not affected by RED flowrate. Power generation at 7.5 mL/min and 10 mL/min were not so different, but current production was better at 7.5 mL/min. Therefore, considering energy production, the RED flowrate of 7.5 mL/min is a reasonable choice for MRC operation.

Material and Methods



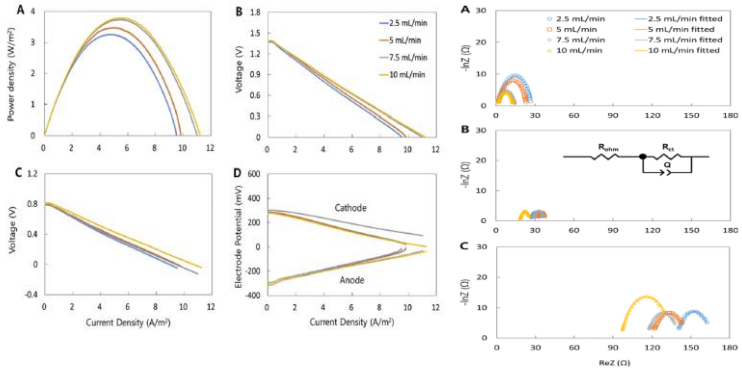
- Two-chamber MRC
- Anode chamber (45 mL), Cathode chamber (18 mL)
- Anode: Carbon brush
- Cathode: Catalyst mixture of (AC+CB)-coated SSM , projected area of 7cm^2
- Inoculum: 1000-Ω external resistance, over 6 months,
- Anolyte: 100 mM CBS + 1.0 g/L sodium acetate
  Catholyte: 100 mM CBS
- RED stack: 5 cell pairs / 1 cell pair: AEM, CEM, High concentration (HC), Low concentration (LC)
- Flow-rate: 2.5, 5.0, 7.5, 10.0 mL/m
- HC solution: 35 g/L NaCl solution/
- LC solution: 0.7 g/L NaCl solution

- LSV Polarization test
- Electrochemical Impedance Spectroscopy
- COD measurement
- COD removal rate, COD removal ratio, coulombic efficiency (CE), energy efficiency (EE), energy recovery (ER)
- Solution conductivity
- Solution pH

Conclusions

- We tested influence of the RED flow-rates (2.5, 5.0, 7.5 and 10.0 mL/min) on performance, electrochemistry and find optimal flow-rate for maximum power production in MRCs
- Flow-rate up to 7.5 mL/min decreased RED stack resistance, internal resistance and optimum resistance of the MRC
- Considering electricity production, energy efficiency and energy recovery, RED flow-rate 7.5 mL/min is the best choice among the tested flowrates in the MRC

Results and Discussions



Flow-rate (mL/min)	2.5	5.0	7.5	10.0
Pmax (W/m2)	3.16 ± 0.11	3.39 ± 0.09	3.70 ± 0.04	3.71 ± 0.08
Imax (A/m2)	9.35 ± 0.18	9.72 ± 0.11	10.51 ± 0.51	10.93 ± 0.33
Iopt (A/m2)	4.61 ± 0.15	4.96 ± 0.09	5.36 ± 0.13	5.24 ± 0.18
Ropt (Ω)	205 ± 2	197 ± 2	184 ± 7	193 ± 10
Rint (Ω)	219 ± 8	208 ± 3	188 ± 2	192 ± 7
Ran (Ω)	33 ± 5	39 ± 1	32 ± 1	30 ± 2
Rcat (Ω)	45 ± 2	41 ± 3	32 ± 0	36 ± 5
Batch time (hr)	23.7	22.9	24.6	23.3
COD removal rate (mg/L/hr)	10.0	9.4	12.0	11.0
COD removal ratio (%)	35.4	33.9	46.1	40.1
CE (%)	65.9	69.6	57.7	63.5
EE (%)	17.6	10.3	8.5	6.9
ER (%)	3.7	2.0	1.5	1.1

pH and conductivity of Influents and Effluents

Flow-rate (mL/min)		2.5	5.0	7.5	10.0
Influent	HC	51.4	51.4	51.4	51.4
	LC	1.42	1.42	1.42	1.42
	Anolyte	9.15	9.15	9.15	9.15
	Catholyte	8.57	8.57	8.57	8.57
Effluent	HC	51.4			
	LC	2.64	2.56	2.27	2.14
	Anolyte	12.33	12.29	12.61	12.47
	Catholyte	11.66	11.32	11.83	11.92

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