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CHARACTERIZATION OF A FIVE-FACE PARALLELEPIPED MICROBIAL FUEL CELL EQUIPPED WITH SANDWICH ELECTRODES

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Abstract

A microbial fuel cell (MFC) is a promising technology for generating electricity directly from biodegradable compounds using bacteria under anaerobic conditions.The actual voltage output of an MFC is less than the predicted thermodynamic ideal voltage due to irreversible losses; this limits MFC performance. The aim of this work was to design and characterize a novel, multiface parallelepiped MFC in the perspective of decreasing the internal resistance (R_{int}) and increasing volumetric power (P_v) output.
The multiface MFC consisted of a parallelepiped built in plexiglass with a liquid volume of 270 mL. Five faces of this cell were fitted with 'sandwich' cathode-membrane-anode assemblages (CMA) and possessed a high ratio electrode surface area-to-volume ξ. The MFC was loaded with 14 mL of a model extract and 256 mL of a mixed liquor from a sulphate-reducing, mesophilic, complete mixed, continuous bioreactor as described elsewhere. The values of internal resistances were 400 and 84 Ω for the MFC connected in series and parallel, respectively.
Maximum volumetric powers P_V in MFC connected in series and parallel were 655 and 1800 mW/m^3, respectively, and anode density powers P_{An} of the MFC connected in series and parallel were 18.4 and 50 mW/m^2, respectively. During the connection in series, the voltage was 0.66 V; this voltage was almost double of that obtained when the MFC was connected in parallel (0.34 V). All the other response variables in MFC connected in parallel were higher than MFC connected in series.
Parallel connection decreased the R_{int} by presumably increasing the cross sectional area for ion flow. The values of the resistances for each face of MFC were 354, 425, 321, 373, and 421 Ω. Calculations using the Ohm´s law for parallel resistance connection agrees with the the total experimental value of 84 ± 5 Ω. In effect, $1/R_{int\ total} = \Sigma\ (1/R_{int,j}),\ j = 1, ..., 5\ (1)$.
When substituting the $R_{int,j}$ of each face, Eq. 1 gives $R_{int\ total}$ = 76 ± 4 Ω, this calculated value is close to the experimental one obtained with the polarization curve method (84 ± 3 Ω).
Energy loss in the series connection is known to be caused by lateral ion cross-conduction between electrodes; this phenomenon is common when fuel cell arrays sharing the same electrolyte are connected in series to increase voltage output. Parallel connection of multiple electrodes of MFC significantly increased $P_{V\text{-}max}$ compared to that of the MFC connected in series. Also, multiple MFC can be connected in series, forming a stacked system in order to increase the voltage. However, when this is done the stack usually undergoes voltage reversal, resulting in a dramatic decrease of stack voltage.
Our results confirm the positive effect of ξ on P_v, show the advantages of the 'sandwich' assemblage of CMA over separated electrodes, and demonstrate the convenience of parallel connection of faces in multi-face MFC-P in order to further abate the internal resistance of the cell.