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Microfluidic Fuel Cell Harnessing Osmosis-driven Passive Pump

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Extended Abstract

The fuel cell has been regarded as an effective power source of the future with benefits of high efficiency and free of pollution. Various types of fuel cell systems have been proposed to replace electric power sources such as batteries and electricity generators using internal combustion engines. Thanks to the emerging technology of MEMS (micro-electric mechanical system), it has been successful to create miniaturized fuel cell (; microfluidic fuel cell; MFFC). Being started in 2002, MFFC has been developed steadily and many prospective results have been reported (kjeang et al., 2008). In MFFC, electrochemical reaction occurs on each electrode (cathode and anode) patterned in a microchannel where co-flows of liquid fuel and liquid oxidant are constantly supplied. In microchannel, the flow is usually laminar, and diffusion is the major mixing mechanism of laminar flow and a function of flow rate. Thus the mixing of fuel and oxidant flowing parallel in the microchannel can be separated with controlling flow rate in the microchannel without need of installing membrane between the co-flows, which is one of dominant benefits of MFFC. In addition, MFFCs do not require cooling systems (since operating at room temperature), water management, and humidification. A pump is an essential component in MFFC system to generate constant co-laminar flow in microchannel of MFFC, and such additional power consumption for the pumps such as syringe pump or pneumatic pump greatly reduce in total electrical efficiency. In addition, adding on such peripheral pumping systems increase the total MFFC system size and weight, discouraging portability of MFFCs. Here, we propose an osmosis-driven pump embedded MFFC. The operating mechanism of the osmosis-driven pump is molecular movement through the semipermeable membrane driven by osmotic pressure occurred by concentration differences of two solutions (Park et al., 2007). Since its flow rate is a linear function of the mole concentration, it is convenient to control and maintain the flow rate for long terms (days to weeks). The osmosis-driven pump is external power-free, and passive, and it is small (less than 1x1x1 cm) and light, suitable for adding on the MFFC system. Methanol was used as fuel and sulfuric acid as electrolyte. Poly(dimethylsiloxane) (PDMS) was used to fabricate the microfluidic channel (4 x 10 x 0.05 mm) of MFFC. We measured the open circuit voltage (0.5V) and the maximum current (0.4 mA). We confirmed the validity of our MFFC system using a commercial computational simulation (COMSOL multi physics). We believe our MFFC system harnessing passive pumping mechanism will be a solution to increases the net efficiency (since it does not require external power/energy). In addition, the small-sized and light-weight osmosis-driven pump enables MFFC applications such as power source for portable electrical devices or stack-up battery.

References

Kjeang E. (2008). Microfluidic fuel cells: A review. Journal of power sources, 186, 353-369.
Park J.Y., Lee S.H. (2007), Gradient generation by an osmotic pump and the behavior of human mesenchymal stem cells under the fetal bovine serum concentration gradient. Lab on a chip, 7, 1673-1680