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DESIGN REQUIREMENTS OF DIRECT BOROHYDRIDE–HYDROGEN PEROXIDE FUEL CELL SYSTEM FOR SPACE MISSIONS

Abstract

Proton exchange membrane fuel cells (PEMFCs) have been widely investigated for mobile applications such as vehicles, unmanned aerial vehicles, unmanned underwater vehicles, and space systems, but hydrogen storage problems limit their mission capability. As a result, research groups in India, USA, China, UK, and Portugal with advanced aerospace technology have investigated direct borohydride–hydrogen peroxide fuel cells (DBPFCs) to use them as new power sources for space missions. Because DBPFCs have many advantages such as high theoretical voltage, high maximum power density, fast response characteristics, easy cooling, easy refueling, simple system, and fuel storability, DBPFCs are suitable for space missions. Many research groups have developed the electrocatalysts, bipolar plates, fuel cell stack, and system, but the DBPFC performance remains far from perfect. Because the energy density of the power sources is related with mission capability, the energy density is important for space missions. However, the energy density of the DBPFC system has rarely been investigated. In this study, the design requirements of the DPBFC system for space missions were determined based on the energy density. Electrodes with electrocatalysts supported on multiwalled carbon nanotubes were developed and investigated by transmission electron microscopy, scanning electron microscopy, energy dispersive spectroscopy, and X-ray diffraction. The DBPFC performance was also evaluated to obtain a relationship between current density and voltage. The experimental relationship was used to calculate the total mass of the DBPFC system at various voltage efficiencies and fuel concentrations. Maximum power and total energy of the DBPFC system for space missions were assumed to be 100 W and 5 kWh, respectively. The total mass was the lowest at the optimum voltage efficiency, regardless of fuel concentrations. Finally, the effect of the fuel concentrations on the energy density was evaluated at the optimum voltage efficiency, and the design requirements of the DBPFC system were determined based on the results. When NaBH4 and H2O2 concentrations are 20 wt% and 65 wt%, the energy density of the DBPFC system is 402 Wh/kg. This value is higher than those of the PEMFC system, lithium-ion battery, and sodium-ion battery. If the performance of the DBPFC system is increased as suggested in this study, the DBPFC system can be widely used as a new power source for space missions. This study will give a new performance target for DBPFC research.