Power Generating Property of Direct Dimethyle Ether SOFC Using $LaGaO_3$ Based Perovskite Electrolyte

Akio Tatemi, Shizhong Wang, Tatsumi Ishihara, Hiroyasu Nishiguchi, and Yusaku Takita
Department of Applied Chemistry, Faculty of Engineering, Oita University,
Dannoharu 700, Oita 870-1192, Japan

The most significant advantage of SOFC is the flexibility in the fuels compared with other types of fuel cells. Internal reforming reaction, mainly steam reforming reaction of CH_4, is now generally considered for improving the cell efficiency. Various chemicals have been tested as the fuel for SOFCs, such as H_2, CH_4, methanol, and other light hydrocarbons [1-2]. In particular, direct usage of dry hydrocarbon for a fuel of SOFC is attractive from the simplification of the system, since humidifying equipment is not required. In this point of view, direct hydrocarbon SOFC is now studying intensively. However, suitability of the hydrocarbon species or the fuel of SOFC is still not thoroughly studied. On the other hand, decrease in the operating temperature of SOFC is another important subjects. However, at low temperature, overpotential of anode becomes larger when hydrocarbon is directly used. In this study, power-generating property of the cell using dimethyl ether (DME) for fuel was investigated in order to achieve the high power density.

$La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2-X}Co_XO_3$ electrolyte was prepared by the conventional solid state reaction method. The sintered disks were always polished to a thickness of 0.3 mm before use. Commercial 15 mol % Sm^{3+} doped CeO_2 (Daiichi Kigenso Co. Ltd) was used to prepare Ni-SDC cermet. The green powder of Ni-SDC cermet was synthesized by vaporizing the mixture containing stoichiometric amount of $Ni(NO_3)_2.6H_2O$ aqueous solution and SDC powder, and then calcining at 1273 K for 2 h after drying at 343 K. The composition of Ni-SDC anode was fixed to 75 wt % Ni and 25 wt % SDC in this study. The effective electrode areas for both anode and cathode were 0.5 cm^2. The dry mixture of N_2 (25 ml/min) and DME (25 ml/min) was fed as a fuel. The anode was reduced using 100 ml/min H_2 before the introduction of DME. Pure oxygen with a flow rate of 100 ml/min was used as an oxidant. Power generation characteristics were measured with four-probes method.

Figure 1 shows the comparison of the power generation characteristics of DME and H_2 fueled cells. By using DME fuel, open circuit potential (OCV) of the cell is lower than that of H_2 cell, and the difference becomes significant with decreasing operating temperature. On the other hand, high power density is achieved for both DME and H_2 fueled cells. The maximum power density of the cell reaches a value as high as 0.53 W/cm^2 at 1073 K with DME fuel, which is almost the same as that of H_2 one (0.55 W/cm^2). However, the difference between the maximum power density between DME and H_2 fueled cells becomes significant with decreasing operating temperature. This may be caused by the low reactivity of DME compared with that of H_2.

In our previous study, it was found that the doping small amount of Co for Ga site is effective for increasing the power density of the cell. In this study, effects of small amount of Co addition for LSGM on the power density of the DME fueled cell were investigated. Figure 2 shows the maximum power density and open circuit potential of H_2-O_2 and DME-O_2 cell at 1073 K as a function of Co content. It is seen that the maximum power density of both H_2-O_2 and DME-O_2 cells increased with increasing the amount of Co and the extremely large power density was achieved at 9 mol% Co. On the other hand, the open circuit potential decreased with increasing amount of Co. At 9 mol% Co, the open circuit potential became lower than 1.0V. Therefore, excess amount of Co is not desirable from the energy conversion efficiency point of view. In any case, even though DME was directly used for fuel, the maximum power density of the cell as high as 1.5W/cm^2 was attained at 1073 K when 9 mol% Co doped $LaGaO_3$ was used for the electrolyte. Therefore, it can be said that the DME is suitable as the fuel for SOFC operating at intermediate temperature. Detail analysis of the internal resistance suggested that the improvement in power density by addition of Co was assigned to an decreased electrical resistance. In any way, doping small amount of Co is effective for increasing the power density of the DME fueled cell. This study reveals that the power density of the cell using DME as a fuel is almost the same as that of H_2 cell at 1073 K

References

1) M. Sahibzada, B. C. H. Steele, K. Hellgardt, D. Barth, A. Effendi, D. Mantzavinos, I. S. Metcalfe, Chemical Engineering News, 55 (16) (2000), 3077
2) E.P. Murray, T.Tsai, and S.A. Barnett, Nature, 400, 649 (1999).

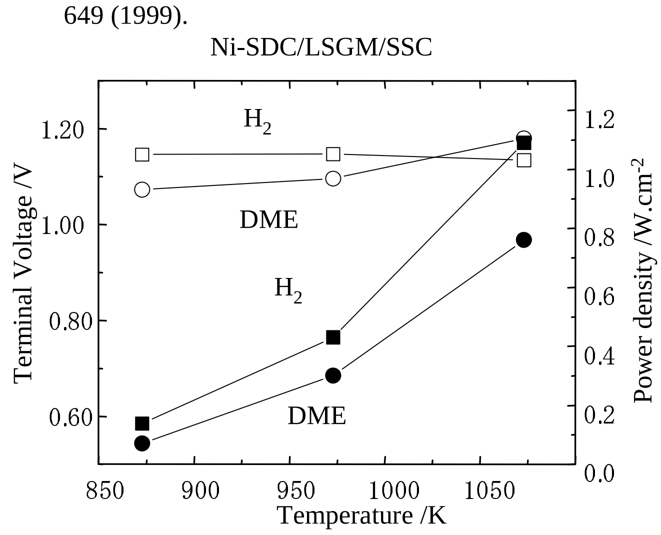

Fig. 1Comparison of the power generation characteristics of DME and H_2 fueled cells.

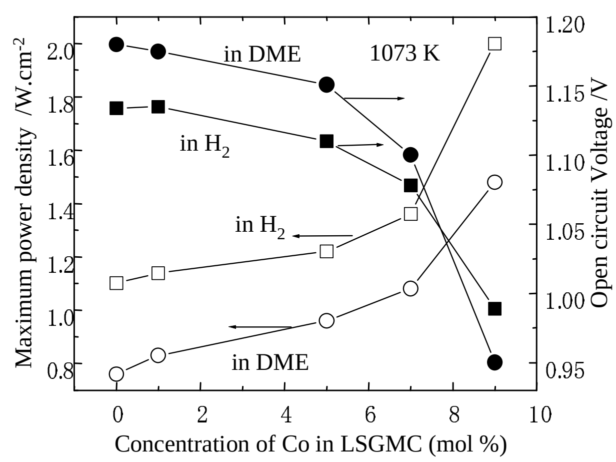

Fig.2 Power generating characteristics of DME and H_2 fueled cell at 1073K as a function of Co content.