Power Generation Characteristics of SOFCs for Simulated Biogas

M. Uchimura, K. Sasaki, H. Kusaba, Y. Teraoka
Kyushu University, Interdisciplinary Graduate School of Engineering Sciences, Kasuga-Koen 6-1, Kasuga-shi, Fukuoka 816-8580, JAPAN
(Email:sasaki@mm.kyushu-u.ac.jp)

1. Introduction

Solid oxide fuel cells (SOFCs) are the most flexible fuel cells with respect to their multifuel capability, so that not only hydrogen and carbon monoxide but also various kinds of hydrocarbon-related species could be used as SOFC fuels via internal reforming and/or via simple external reforming [1-3]. Among various possible SOFC fuels, biogas, consisting mainly of methane and carbon dioxide but also with a small amount of impurity, is an important energy resource to reduce CO_2 emission. Biogas can be obtained from biomass, so that their use may enable to realize a zero-emission energy system based only on natural resources [3] as illustrated in Fig.1. The aim of this study is therefore to examine the applicability of simulated biogas by analyzing and comparing the electrochemical performance of SOFCs in the case that such fuels are directly supplied to the fuel electrodes.

2. Experimental

Planar-type cells were used in this study. Sintered electrolyte plates of 8mol% Y_2O_3-ZrO_2 (YSZ) (supplied by Tosoh Corp.) and 10mol% Sc_2O_3-1mol% CeO_2-ZrO_2 (ScSZ) (supplied by Shinko Electric Industries) with a thickness of 200 μm and a diameter of 20 mm were used, on which anode layers (80 wt% NiO-YSZ) were deposited via screen-printing and were sintered at 1400°C for 5 hours. The cathode layers ($La_{0.6}Sr_{0.4}MnO_3$) were then deposited, followed by sintering at 1150°C for 5 hours. The area of both electrodes was 5×5 mm^2.

3. Results and discussion

Fig.3 shows the current-voltage (I-V) characteristics of an SOFC for simulated biogas with different S/C ratios at 1000°C. Fig.4 shows the I-V characteristics of an SOFC for simulated biogas with different CH_4/CO_2 ratios at 1000°C. First of all, in case that simulated biogas was directly supplied, SOFC power generation was possible within the experimental range of S/C and CH_4/CO_2 studied. A low S/C and a high CH_4/CO_2 led to an increase in cell voltage. Thermochemical equilibrium calculations revealed that theoretical electromotive force increased with decreasing S/C ratio, but with increasing CH_4/CO_2. These relationships are consistent with the experimental results in Fig.3 and Fig.4, especially for higher S/C and for lower CH_4/CO_2. However the difference in I-V characteristics became smaller with increasing current density. This result may be explained by the fact that more amount of steam is generated around fuel electrodes with increasing current density. In order to examine the temperature dependence of power generation characteristics down to lower operational temperatures, electrolytes based on ScSZ were applied. S/C dependency and CH_4/CO_2 dependency of I-V characteristics were similar to those at 1000°C with YSZ as electrolyte materials.

References

1. K. Sasaki and Y. Teraoka, *J. Electrochem. Soc.*, **150**[7] A878-A884 (2003).
2. K. Sasaki and Y. Teraoka, *J. Electrochem. Soc.*, **150**[7] A885-A888 (2003).
3. K. Sasaki, K. Watanabe, Y. Teraoka, *J. Electrochem. Soc.*, **151**[7] A965-A970 (2004).

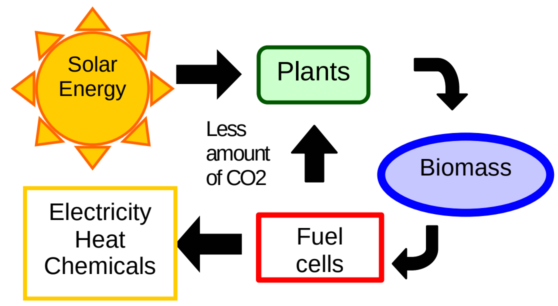

Fig.1: Carbon-neutral zero-emission renewable energy system with SOFCs.

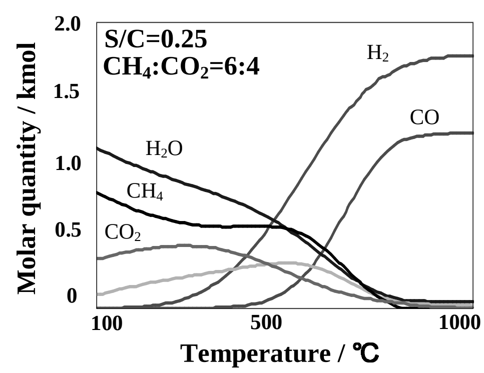

Fig.2: Equilibrium products from biogas with the steam-to-carbon ratio of 0.25.

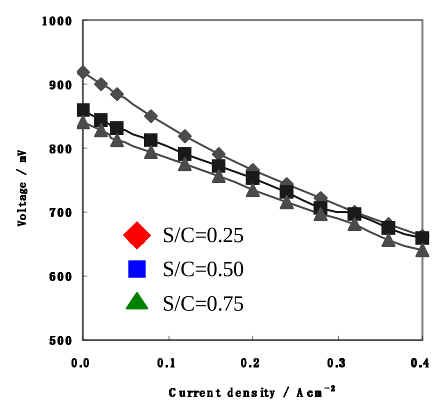

Fig.3: I-V characteristics of YSZ-supported cells for simulated biogas at 1000℃.

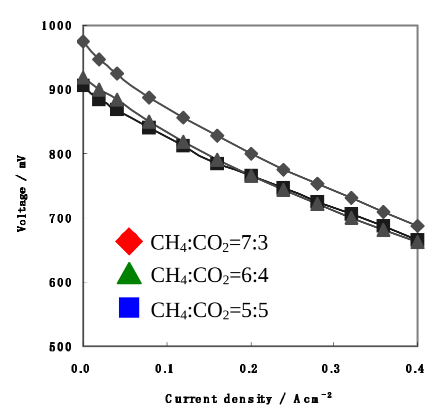

Fig.4: I-V characteristics of YSZ-supported cells for simulated biogas at 1000℃.