Biodiesel fuel conversion to renewable electricity with a new SOFC concept

Tran Quang-Tuyen
Kyushu University
Department of Hydrogen Energy Systems, Faculty of Engineering
Motooka 744, Nishi-ku, Fukuoka 819-0395, Japan

Fuel cells are electrochemical devices that convert chemical energy directly into electrical energy with higher efficiency and lower environmental emission levels than conventional conversion systems. Therefore, the fuel cell is regarded as a promising candidate for a next generation distributed power source. Although most fuel cells, solid oxide fuel cells (SOFCs) operated at high temperature range between 600 and 900 ^{o}C accept the direct use of hydrocarbon fuels. Taking the depletion of fossil fuel reserves and increasing of carbon dioxide into account, SOFC, however, operated with biofuels should be more promoted. The aim of this study is, therefore, to investigate the viability of anode–supported type cells (Ni-based anodes) operating with several practical biodiesel fuels (BDFs), produced from refined vegetable oils by the alkali catalyzed trans-esterification reaction. The results demonstrated that in principle direct-feeding of practical BDFs into SOFC is viable. So far, we recorded 0.32 W cm^{-2} at 0.4 A cm^{-2} for wet palm-biodiesel, which is comparable to dry-H_2 operation, and this was the world's first result succeeded long-term operation of direct internal reforming SOFC (DIRSOFC) with wet palm-biodiesel for 1 month (see Fig. 1a). However, carbon deposition on the anode surface accompanied by C_2H_4 formation, which is well-known as a precursor of carbon formation, was still significant leading to large voltage degradation of around 15%/1000 h (see Fig. 1b). Our results showed that catalytic activity of conventional Ni-Zirconia anode was insufficient for BDFs steam reforming, and the degree of unsaturation of BDFs (the number of C=C double bond) is a predominant factor to determine the performance of DIRSOFC. In this study, a novel µ-reformer was prepared by a low-cost wet process, which can be integrated with SOFC single cell for operating with practical BDF. The µ-reformer is composed of inorganic fiber network. In this study, Ni, Ni-Mg, Ru, Ni-Mg/ $BaTiO_3$ and Ru/ $BaTiO_3$ were tested as catalysts. Among these catalysts, combination of Ni-Mg/$BaTiO_3$ and Ru/$BaTiO_3$ catalysts resulted in stable performance of µ-reformer for palm-BDF steam reforming. Concentrations of light hydrocarbons (CH_4 and C_2H_4) in the reformate were nearly zero and no degradation of catalytic activities occurred during 50 h operation (see Fig. 2).

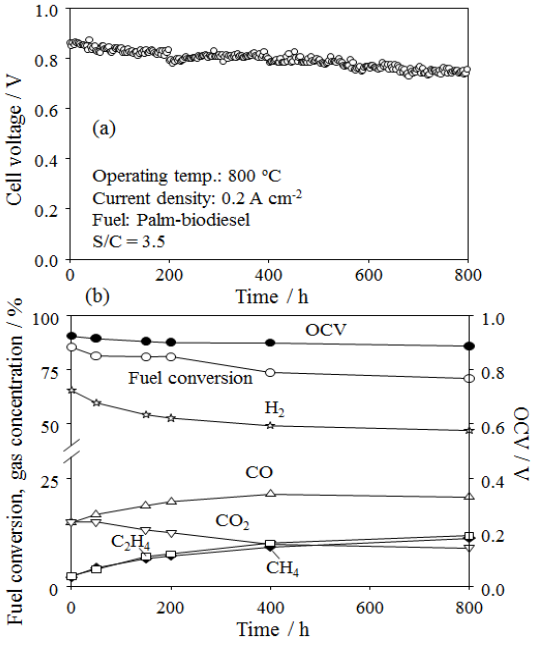

Fig. 1 Time dependence of (a) cell voltage under current density of 0.2 A cm^{-2}, and (b) OCV, fuel conversion and anode off-gas composition under open-circuit condition during the durability test of DIRSOFC running on wet palm-BDF (S/C = 3.5) at 800 ^{o}C.

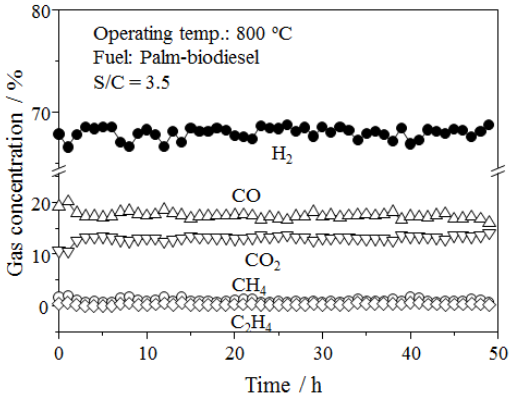

Fig. 2 Reformate gas composition after starting steam reforming of palm-biodiesel in combination of Ni-Mg/$BaTiO_3$ and Ru/$BaTiO_3$ based catalysts.