Acrylic acid and electrical power cogeneration in SOFC reactor

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Supporting Information

Details for experimental process

1. Preparation of membrane and catalyst

$Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ powers were prepared by solid-state reaction method. Stoichiometric amounts of Bi_2O_3 (99.9%), V_2O_5 (99.9%) and CuO (99.9%) were mixed and ground in an agate mortar. The resulting mixture was then successively heated at 500, 600 and 700 ^oC for 12 h, with a 20 $^oC\ h^{-1}$ heating/cooling rate. Pure phase $Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ powders were obtained. $Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ powders was pressed into disks of 18mm in diameter, and sintered at 780^oC for 2 h with a heating and cooling rate of 3 $^oC\ min^{-1}$.

The MoVTeNbO catalyst was prepared by the hydrothermal method, which has been reported in detail in literature [1]. Firstly, 5.35 g $(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$ and 1.16 g H_6TeO_6 were dissolved in 20 ml water at 80 ^oC. A second solution was prepared by dissolving 2.37 g $VOSO_4{\cdot}nH_2O$ in 10 ml water. The third solution was simultaneously prepared by dissolving 2.33 g $Nb_2(C_2O_4)_5{\cdot}nH_2O$ in 10 ml water at 80 ^oC. Then the second solution was added to the solution containing molybdenum and tellurium and the resulted solution was stirred for 5 min. After that, the third solution was put into the mixture and stirred for 10 min at 80 ^oC before being introduced into the autoclave. After 5 min N_2 bubbling, the autoclave was heated at 175 ^oC for 48 h. The obtained slurry was filtrated and dried at 80^oC for 12 h and then calcined under N_2 at 600 ^oC for 2 h.

2. Measurment of conductivity of MOVTeNb catalyst

Total conductivity of the catalyst was measured using a bar-shaped sample (20 mm *4 mm *0.4 mm) in 10% C_3H_8 diluted by N_2 with a four-probe method on a Keithly 2000 multimeter and potentialstat 263A (Princeton Applied Research).

3. Fabrication and test of fuel cellls

In this experiment, a pellet cell unit with the form (air/Ag-$Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$/$Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$/MoVTeNbO /$C_3H_8$) was used. A $Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ membrane (thickness=0.4 mm) was used as electrolyte. Slurry of $Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ and Ag (57 wt.%) was brushed to the $Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ membrane as cathode, followed by heating at 575 ^oC in air for 4 h with a heating and cooling rate of 5 $^oC\ min^{-1}$[2]. The superficial area was 1.0 cm^2 and the loaded Ag- $Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ catalyst was 36 mg cm^{-2}. The anode was prepared by MoVTeNbO paste with a load of 50 mg cm^{-2} with the superficial area of 1.0 cm^2. MoVTeNbO catalyst was grinded with glycol, then was pasted to the anodic side of membrane followed by heating at 300 ^oC for 2 h in air and then 550 ^oC in N_2 for 1 h to eliminate the glycol. Gold wires were pressed against the two sides of pellet by means of an adjustable spring to conduct electrons. The mixture of C_3H_8: H_2O (gas): He =1: 12:15 was fed to the anode side (MoVTeNbO side), while 50 ml min^{-1} air to cathode side. Current-voltage data was obtained on two multimeters (keithley 2000 multimeter and keithley 177 microvoltage DMM) with an adjustable resistance. The reaction temperature was maintained at the range of 400-450 ^oC. The liquid products were collected with cold water and analyzed by GC equipped with FID and the gas products were analyzed on TCD.

References

1 W. Ueda, D. Vitry, T. Katou, *Catal. Today*, 2005, **99**, 43.
2 C. R. Xia, M. L. Liu, *Adv. Mater.*, 2002, **14**, 521.

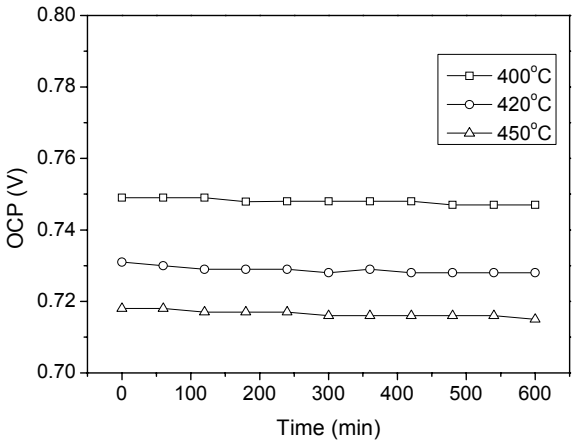

Fig.S1 Open circuit potential of the cell at 400, 420, 450 ^{o}C.

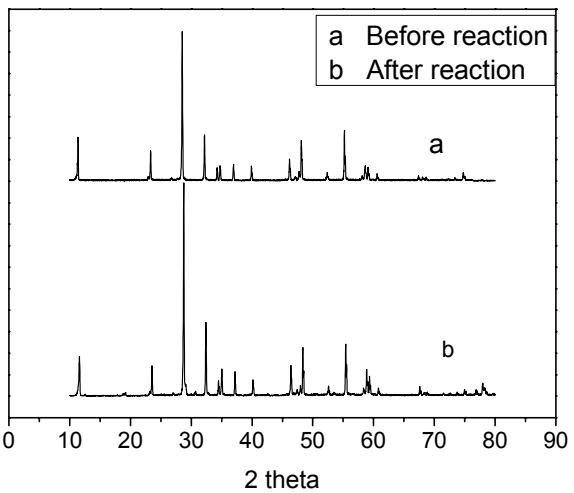

Fig.S2 XRD pattern for $Bi_4Cu_{0.2}V_{1.8}O_{11-\delta}$ before and after exposing to mixture of C_3H_8 :H_2O:He