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# Novel sulfur and carbon highly tolerant current collecting materials for SOFC

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## Introduction

Solid oxide fuel cells (SOFC) have attracted increasingly attentions since they exhibit excellent efficiency and fuel diversity. However, when using an unpretreated feed such as sour gas ($H_2S$+$CH_4$), the conventional catalyst Ni will suffer serious $H_2S$ poisoning and carbon deposition, both of which are extremely detrimental to SOFC operation[1,2]. Therefore, developing sulfur and carbon tolerant anode catalyst has recently become one of the main focuses in SOFC study. Although anode current collector is also a key component for SOFC, little effort has been devoted to discover new candidate materials for anode current collecting, which also resist both sulfur and coke. Herein, we studied a novel current collecting material based on transition metal carbide, which should show high electrical conductivity and excellent stability in 0.5%$H_2S$ + $CH_4$.

## Experimental

Various transition metal carbides including $V_8C_7$ and WC powders were heated up to 850 $^oC$ in a quartz tube in 10% $H_2$ + $N_2$. The powders were then treated in either humidified 0.5%$H_2S$ + $CH_4$ or $H_2$ for 36 h before being characterized with X-ray diffraction. 50 wt% WC and 50 wt% $La_{0.2}Sr_{0.8}TiO_3$ (LST-WC) powders were mixed thoroughly using ball milling and the mixed powders were then pressed into disc with a thickness of ~2 mm[3]. The discs were finally sintered in 10% $H_2$ + $N_2$ at 1200 $^oC$ for 5 h.

The electrical conductivities of the sample discs were measured in either humidified $H_2$ or 0.5%$H_2S$ + $CH_4$ via Van der Pauw 4-point method. Thick yittria-stabilized zirconia (YSZ) disc was used as the electrolyte with $La_{0.7}Sr_{0.3}MnO_3$ /YSZ as the cathode and LST/YSZ as the anode. LST-WC paste was screen printed onto the anode site as the current collector. The fuel cell was finally tested in both $H_2$ and sour gases.

## Results and discussions

According to the XRD pattern, $V_8C_7$ decomposed to vanadium oxides whereas WC partially transformed to W in humidified $H_2$ at 850 $^oC$ through the following reaction:

$$2WC + H_2O = W + H_2 + CO \quad (1)$$

However, after the treatment in humidified sour gas, no metallic tungsten or tungsten sulfide was identified. This can be explained by the following reaction:

$$2W + CH_4 = WC + 2H_2 \quad (2)$$

LST-WC composite current collecting material exhibited excellent electronic conductivity (~ 5000 S $cm^{-1}$) in both $H_2$ and 0.5% $H_2S$ + $CH_4$ at various temperatures (Fig. 2).

The addition of LST increased the sinterability of the composite and the surface adhesion between the anode and the current collector. The electrolyte-supported button cell using LST-WC paste as the anode current collecting layer showed essentially identical performance with the ones using Au paste. In longevity test under pontentiostatic mode, no performance degradation of fuel cell was observed during 150 h test in either pure $H_2$ or 0.5%$H_2S$ + $CH_4$ gases.

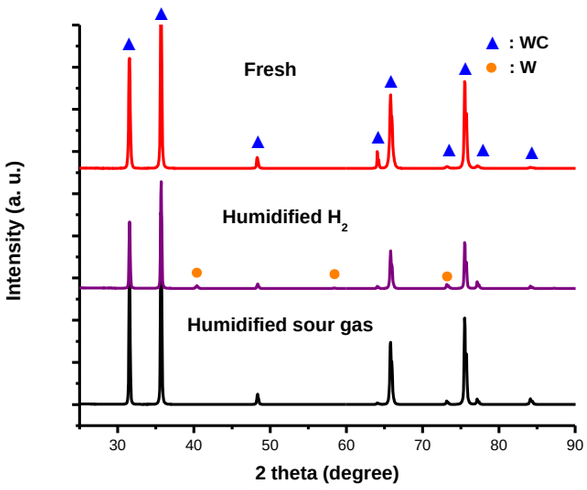


Figure 1. XRD patterns of WC after 36 h treatment in different atmosphere at 850 $^oC$.

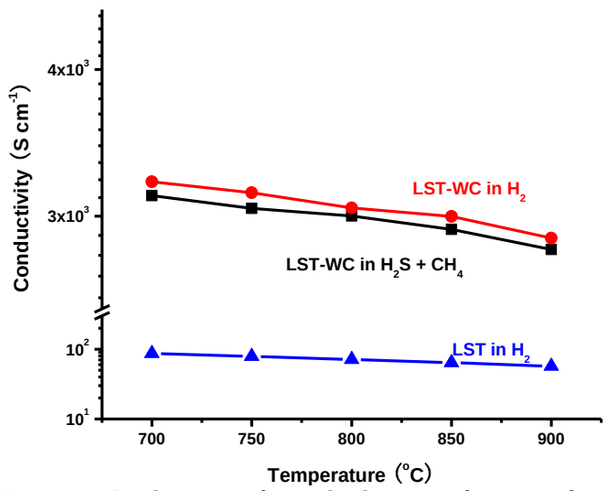


Figure 2. Conductivity of sample disc as a function of temperature in sour gas and $H_2$.

## References

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[2] Z. Cheng *et al.*, *Energy Environ. Sci.* **4**, 4380 (2011).
[3] A. Vincent, J.L. Luo, K. T. Chuang, A. R. Sanger, *J. Power Sources* **195**, 769–774 (2010) .