

The Synthesis of Transition Metal Sulfide Catalysts for H₂S-Powered Solid Oxide Fuel Cells

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Currently over 40×10^6 tons of hydrogen sulfide are generated world-wide as by-product from the petroleum, natural gas and coal gasification industries. Its concentration ranges from a few ppm to above 80% in refining and natural gas industries. The adverse effects of H₂S on industrial processes, human health and the environment make it necessary to remove it from all effluent streams [1]. Many processes have been developed to remove and/or recover H₂S, including adsorption, absorption, hydrogen production and conversion to elemental sulfur via the two-step Claus process [2]. There are few direct commercial uses for H₂S; hence most of it is converted to sulfur [1]. The overall reaction is highly exothermic and although some of the heat can be recovered as steam it would be far more desirable to either directly recover hydrogen or to electrochemically oxidize H₂S in situ at the anode of a solid oxide fuel cell (SOFC).

It is well known that H₂S decomposes at high temperatures into hydrogen and sulfur via the general equilibrium reaction



Therefore, it would be highly desirable if hydrogen originating from this reaction could be electrochemically oxidized in a SOFC to generate electrical energy, leaving sulfur and water as exclusive anode reaction products. Thus utilization of H₂S in solid oxide fuel cells provides a potentially economical and powerful alternative for concurrent chemical conversion and power generation [2].

One of the major technical challenges in the development of H₂S/O₂ SOFC is to identify anode materials that are conductive, chemically and electrochemically stable, and catalytically active in H₂S-rich environments. In the last 20 years many groups have investigated several materials as potential candidates as anodes for SOFC operated on H₂S. Unfortunately, none of these materials fully satisfies criteria required for a successful and effective anode [1].

It is well known that catalytic activity of metals is strongly dependent on shape, size and size distribution of the metal particles [3]. Smaller particles are more desirable for electrodes in fuel cells because the smaller the particles, the greater the particle surface area to reduce hydrogen.

This paper is reported that vanadium molybdenum sulfur particles were synthesized using H₂S as reducing agent by chemical reduction of ammonium monovanadate and ammonium heptamolybdate tetrahydrate. The aim of this study was to investigate effects of temperature, pH and rate of H₂S on the structure of vanadium molybdenum sulfur particles. In all experiments, deionized water was used as solvent. The morphology of vanadium molybdenum sulfur particles was investigated by JEOL JSM-5410LX scanning electron microscope (SEM). A further part of this study will be present results of anode performance at low operating temperatures.

References:

- [1] Vorontsov, V., Luo, J.L., Sanger, A.R. and Chuang, K.T., Journal of Power Sources, **183** (2008) 76-83.
[2] Vorontsov, An, W., V., Luo, J.L., Sanger, A.R. and Chuang, K.T., Journal of Power Sources, **179** (2008) 9-16.
[3] Wang, H., Sun, X., Ye, Y. and Qiu, S., Journal of Power Sources, **161**(2006) 839-842.

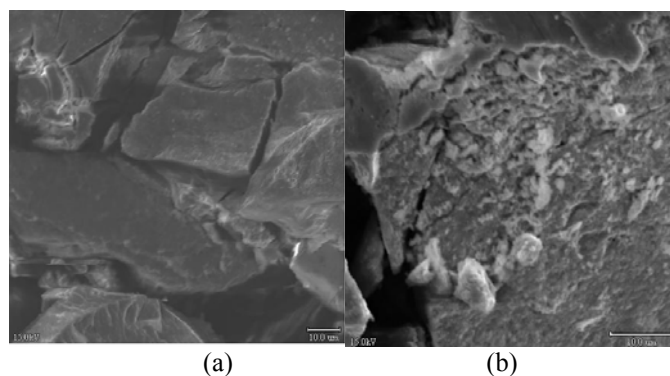
Figures:

Figure 1. Molybdenum vanadium sulfur particles synthesized at room temperature and (a) pH=6.0; (b) pH<1

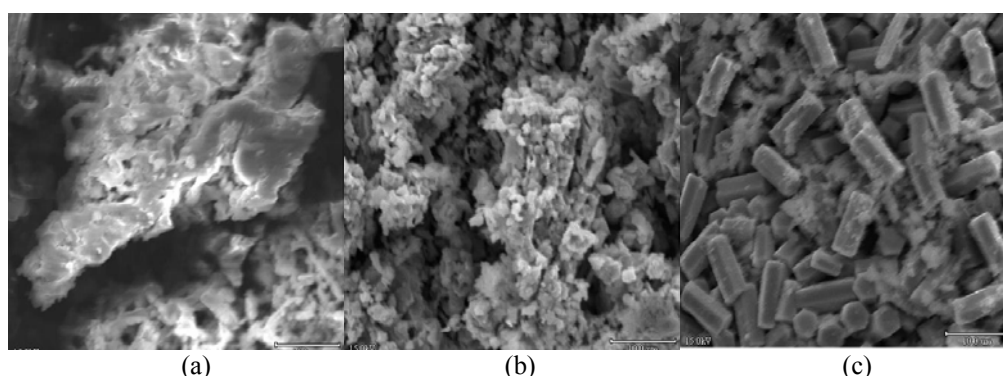


Figure 2. Molybdenum vanadium sulfur particles synthesized at pH<1 and (a) 0°C; (b) 40°C; (c) 80°C