Extraordinarily Efficient Electrocatalytic Hydrogen Evolution Achieved by Amorphous MoO_xS_y Catalysts Electrodeposited on Crystalline TiO_2 Nanotube Arrays

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Abstract

Hydrogen evolution reaction (HER) is one of the most important half reactions in electrolyzers and photoelectrochemical cells. In order for these electrochemical devices to be widely employed, developing highly efficient, durable and low-cost HER electrocatalysts is critically needed. Molybdenum disulfide (MoS_2) has recently emerged as a promising alternative catalyst to precious platinum to catalyze HER [1]. Despite remarkable progress made recently, the intrinsic poor electrical conductivity and unfavorably exposed active sites have hampered further improvement of the HER activity of MoS_2. Herein, we report that amorphous MoO_xS_y electrodeposited on a high surface area crystalline TiO_2 nanotube (TNT) array support can exhibit extraordinarily high electrocatalytic activity toward HER (see Figure 1), with unprecedentedly large current density of 115.8 mA cm^{-2} at an overpotential as low as 150 mV and an extremely low overpotential of 29.1 mV to reach a current density of 20 mA cm^{-2} [2]. Furthermore, after iR correction, a cathodic current density as high as 171.8 mA cm^{-2} can be achieved at an overpotential of 150 mV, the largest one reported so far to the best of our knowledge. Besides, the TNT supported MoO_xS_y catalyst (TNT@MoO_xS_y) also shows excellent durability in acidic solutions without obvious performance degradation after 3000 cyclic voltammetric scans (see Figure 2). The remarkable HER performance of the TNT@MoO_xS_y can be attributed, on the one hand, to the high specific surface area and excellent electron transport property of the TNT/Ti array support; and on the other hand, possibly to the enhanced electrical conductivity of the catalyst itself because of the incorporation of oxygen.

References

[1] Vrubel, H.; Merki, D.; Hu, X.L. *Energy Environ. Sci.* 5 **(2012)** 6136-6144.
[2] L.F. Liu, under preparation

Figures

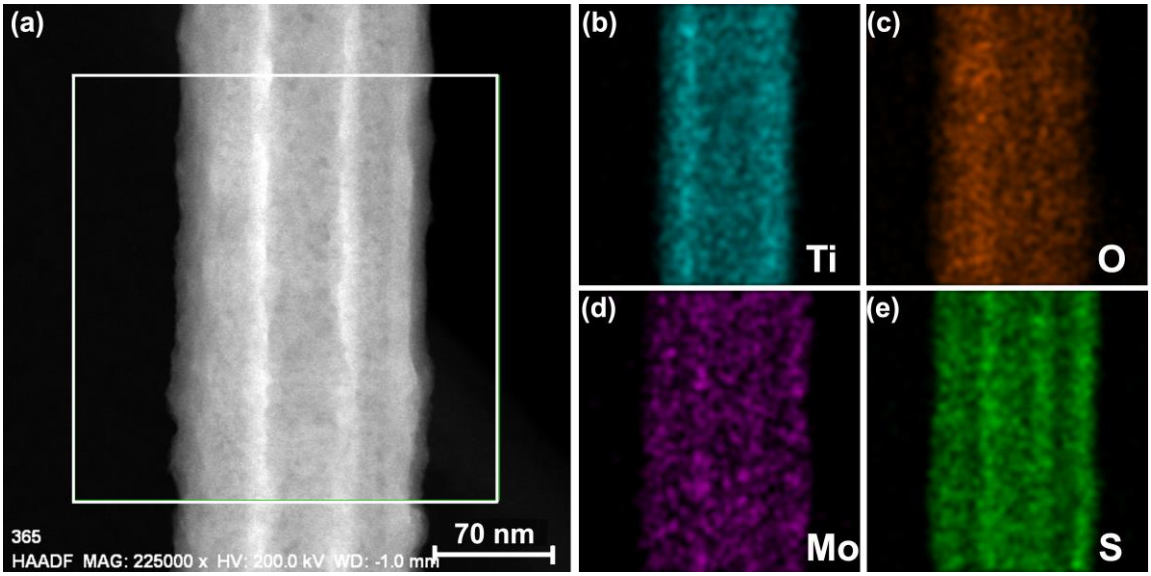

Figure 1. (a) HAADF image of a single TiO_2@MoO_xS_y nanotube. Elemental maps of (b) Ti, (c) O, (d) Mo and (e) S.

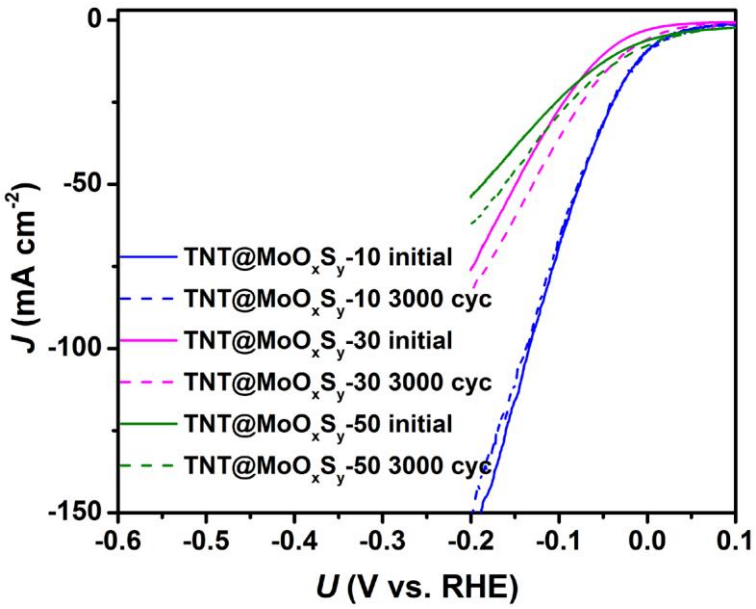

Figure 2. The stability test of the TiO_2@MoO_xS_y electrodes.