Cobalt nickel phosphide nanowires on the nickel foam as an highly efficient and ultrastable bifunctional catalyst for overall water splitting

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Abstract

Electrochemical water splitting into hydrogen and oxygen is a promising method for renewable energy storage.[1] The development of ultrastable, efficient and low-cost bifunctional electrocatalysts that are active for both the hydrogen evolution and oxygen evolution reactions remains a huge challenge.[2],[3] Herein, cobalt nickel phosphide nanowires integrated nickel foam is presented as an efficient, robust and cost-effective bifunctional electrocatalyst for full water splitting into hydrogen and oxygen. The cobalt nickel phosphide nanowires-nickel foam (Ni foam@Co-Ni-P NWs) composite electrode was fabricated by hydrothermal synthesis of cobalt precursor nanowires on the Ni foam, followed by a facile one-step phosphorization treatment in red phosphorous vapor at 500 °C. The Ni foam@Co-Ni-P NWs material was thoroughly characterized by transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and energy dispersive X-ray spectrometer (EDX) mapping as well as various electrochemical techniques. The as-fabricated Ni foam@Co-Ni-P NWs electrode exhibited remarkable electrocatalytic performance towards hydrogen evolution reaction (HER) in both acidic and basic solutions. It also showed superior catalytic performance towards oxygen evolution reaction (OER) in the basic solution. A full alkaline electrolyzer was set up with two identical Ni foam@Co-Ni-P NWs electrodes for overall water splitting. The energy efficiency of the electrolyzer was as high as 91% at 10 mA cm^{-2}, and remained 75% and 67% at a high current density of 100 mA cm^{-2} and 200 mA cm^{-2}. More importantly, the electrolyzer displayed extremely stable performance, which could run at 100 mA cm^{-2} for over 2 months under a stable potential of 1.96 V. Due to its low cost, high efficiency and extremely high stability, the cobalt nickel phosphide nanowires-nickel foam composite electrode is a promising candidate for practical overall water splitting.

References

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[3] Qian Liu, Jingqi Tian, Wei Cui, Ping Jiang, Ningyan Cheng, Abdullah M. Asiri and Xuping Sun, Angew. Chem. Int. Ed. **53** (2014) 6710 –6714.

Figure

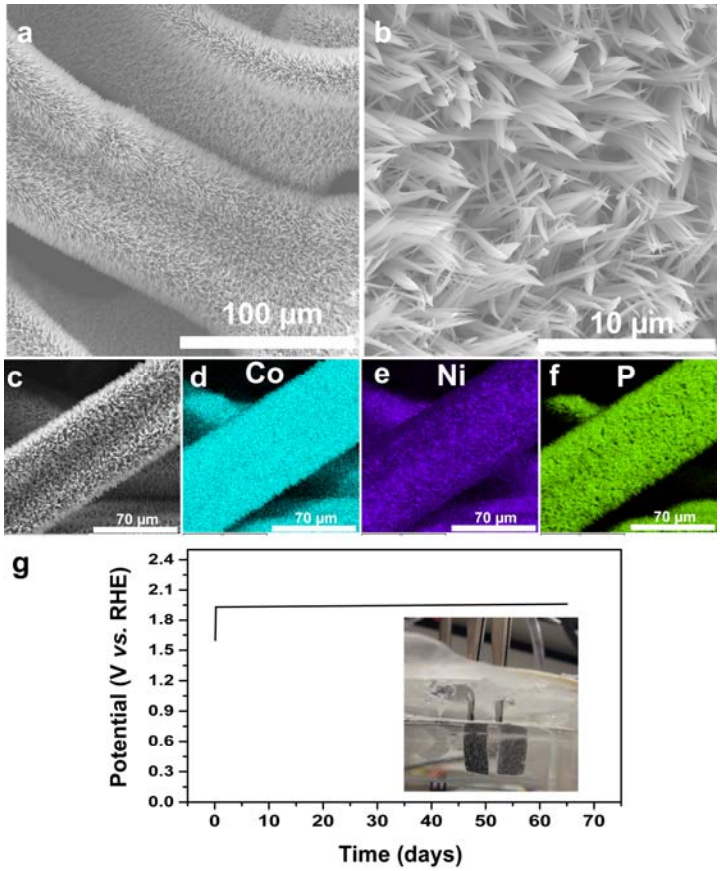

Figure 1. SEM images (a-b) and EDX mapping (c-f) of cobalt nickel phosphide nanowires on the nickel foam and (g) chronopotentiostatic curve of the Ni foam@Co-Ni-P NWs electrodes recorded at 100 mA cm^{-2} to show their ultrastable durability. Inset of (g) is a photo of the electrolyzer composed of two identical Ni foam@Co-Ni-P NWs electrodes.