Supplementary Information

Totally Atom-Economical Synthesis of Nano/Micro-Structured Nickel Hydroxide Realized by an Ni–O_2 Fuel Cell

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1. Calculation for atom economy

(1) The conventional process

Atom economy is defined as a measure of the proportion of reactant atoms which are incorporated into the desired product of a chemical reaction. It can be calculated by the equation below.[1]

Atom economy = (mass or molecular weight of the desired product(s) ÷ mass or molecular weight of all reactants) × 100%

The calculation for atom economies of the reactions in Schematic 1a is as follows.

A1: $Ni + H_2SO_4 + 2HNO_3 = NiSO_4 + 2NO_2 + 2H_2O$

Atom economy = molecular weight of $NiSO_4$ ÷ (molecular weight of Ni + molecular weight of H_2SO_4 + 2 × molecular weight of HNO_3) × 100% = (58.7 + 32.1 + 16 × 4) ÷ (58.7 + (2 + 32.1 + 16 × 4) + 2 × (1 + 14 + 3 × 16)) × 100% = 154.8 ÷ 282.8 × 100% = 54.7%

A2: $NiSO_4 + 2NaOH = Ni(OH)_2 + Na_2SO_4$

Atom economy = molecular weight of $Ni(OH)_2$ ÷ (molecular weight of $NiSO_4$ + 2 × molecular weight of NaOH) × 100% = (58.7 + 17 × 2) ÷ (58.7 + 32.1 + 16 × 4 + 2 × (23 + 17)) × 100% = 92.7 ÷ 234.8 × 100% = 39.5%

Atom economy of the route = 54.7% × 39.5% = 21.6%

(2) The proposed process by a nickel–oxygen (Ni–O_2) fuel cell

$Ni + 1/2O_2 + H_2O = Ni(OH)_2$

Atom economy of the rout = molecular weight of $Ni(OH)_2$ ÷ (molecular weight of Ni + 1/2 ×molecular weight of O_2 + molecular weight of H_2O) × 100% = (58.7 + 17 × 2) ÷ (58.7 + 1/2×16×2 + 18) × 100% = 92.7 ÷ 92.7 × 100% = 100%

Supplementary Figures

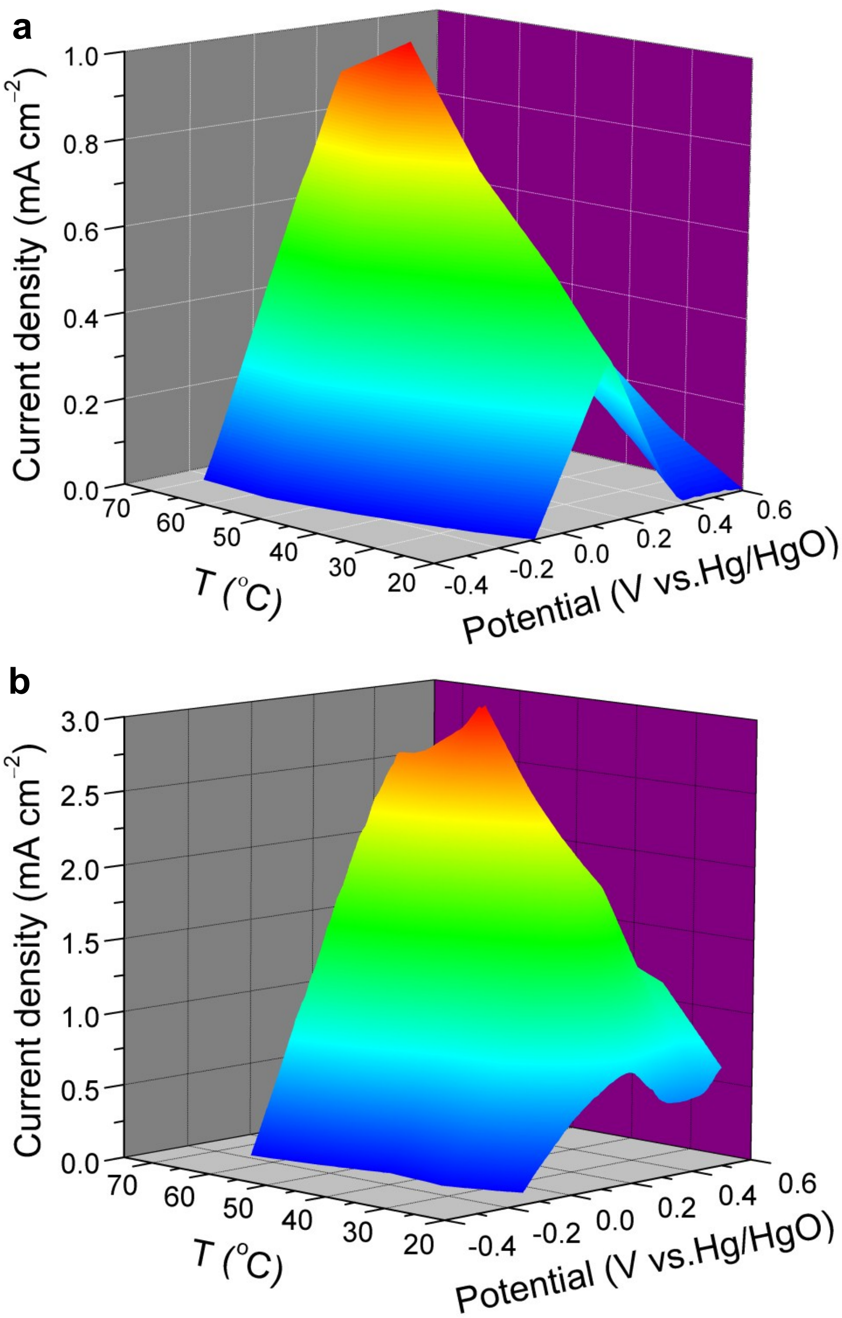

Fig. S1 Anodic polarization curves of (a) an Ni plate anode and (b) an Ni foam anode against temperature. An Ni anode, an Ni wire, and an Hg/HgO electrode were, respectively, used as the working electrode, the counter electrode, and the reference electrode. The electrolyte was a mixture of 0.50 mol L^{-1} Na_2SO_4 and 1.0 mol L^{-1} $NH_3{\cdot}H_2O$. Its pH was adjusted by NaOH in the range of 11.30–11.50. The potential scanning rate was 2 mV s^{-1} in the range of −0.3 to 0.6 V.

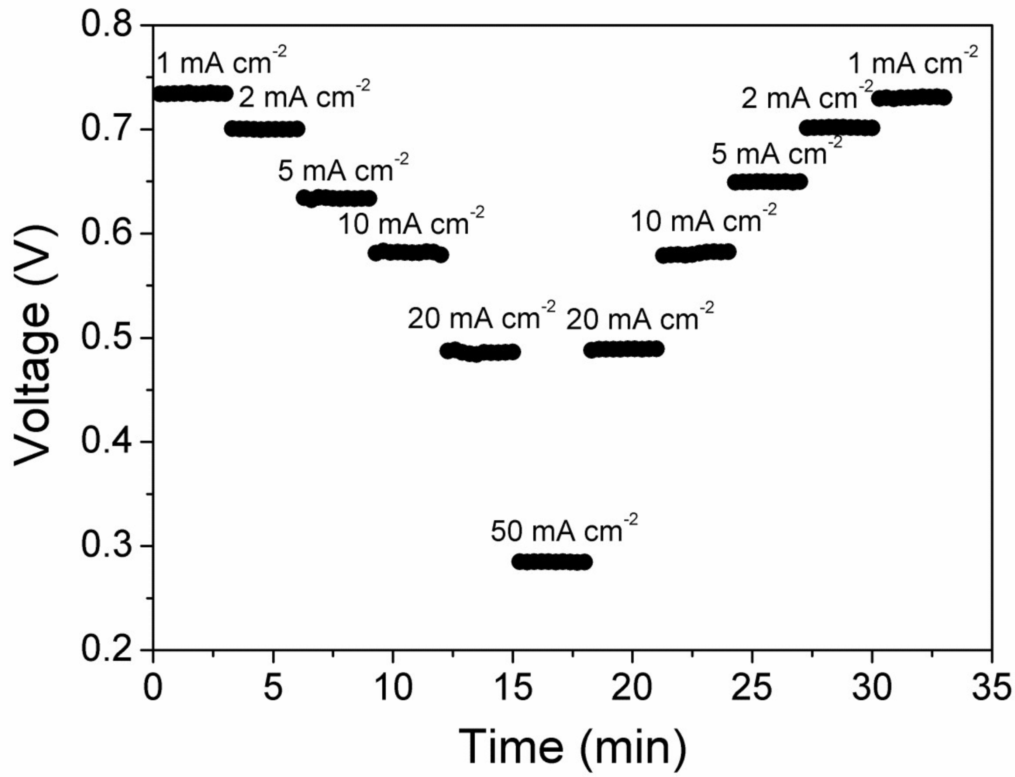

Fig. S2 Stability testing of the Ni–O_2 fuel cell with an Ni foam anode. The fuel cell operated galvanostatically in an aqueous electrolyte of 0.50 mol L^{-1} Na_2SO_4, 2.0 mol L^{-1} $NH_3{\cdot}H_2O$, and 0.60 mol L^{-1} NaCl at 55 °C.

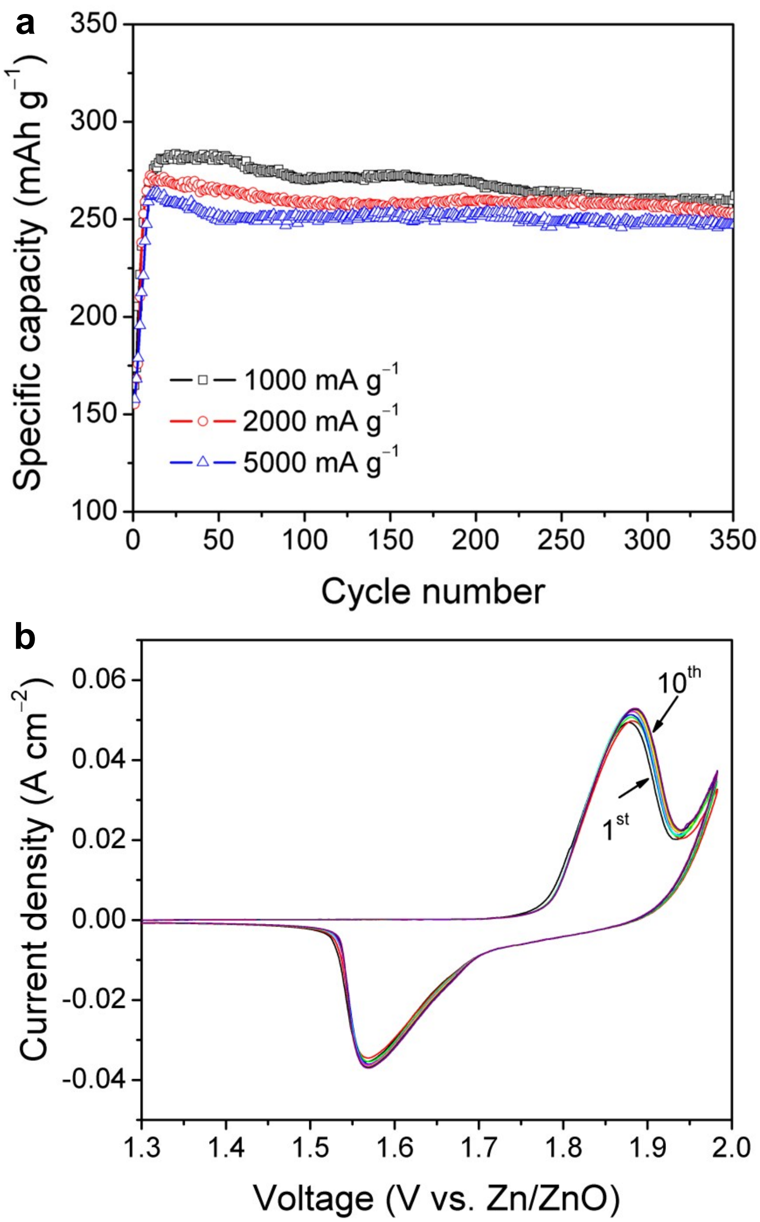

Fig. S3 (a) Cycle curves at three different discharge current densities and (b) first 10 cycles of the cyclic voltammograms of the synthesized nano/micro structured β-$Ni(OH)_2$ samples at potential scanning rate of 1 mV S^{-1}. The experiments were carried out with a three-electrode configuration (β-$Ni(OH)_2$ working electrode, Zn/ZnO reference electrode, and Ni wire counter electrode) in a 6.0 mol L^{-1} KOH aqueous solution.

References:

[1] **B.** Trost**,** ***Science*** **1991,** ***254*****, 1471-1477.**