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Supporting Information

Ultrathin Dendritic IrTe Nanotubes for Efficient Oxygen Evolution Reaction with a Wide pH Range

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Experimental Section

Chemical: sodium tellurite (IV) (Na_2TeO_3, 99.5%), hydrazine monohydrate ($H_2NNH_2•H_2O$, 98%), Iridium (III) chloride hydrate ($IrCl_3•xH_2O$, x=3.5, 99.8 %), Ruthenium (IV) oxide powder (RuO_2, 99 %) were purchased from Alfa Aesar Ltd. poly-(N-vinyl-2-ppyrrolidone) (PVP, MW=40000), Nafion perfluorinated resin solution (5 wt. % in mixture of lower aliphatic alcohols and water, contains 45% water), ethylene glycol (EG) (anhydrous, 99.8 %), 2-propanol (anhydrous, 99.5 %) were obtained from Sigma-Aldrich. Carbon black (VXC72) was purchased from CABOT. All aqueous solutions were prepared with ultrapure water (>18 MΩ) from a Milli-Q Plus system (Millipore).

Synthesis of Te nanowires (NWs): Typically, 0.8 g PVP was dissolved in 25 mL of double-distilled water under vigorous magnetic stirring to form a homogeneous solution at room temperature. Then, 0.1335 g of Na_2TeO_3 was added into the previous solution and dissolved, followed by the addition of hydrazine hydrate (1.25 mL) and 2.45 mL of an ammonia solution. After thoroughly mixing, the solution was transferred into a Teflon-lined stainless steel autoclave and maintained at 180 °C for 4 h in a forced air oven (Fisher Scientific Isotemp). Finally, the product was centrifuged with acetone, and dissolved in 30 mL EG.

Synthesis of IrTe Nanotubes (NTs): Typically, 3 mL freshly prepared Te NWs were dissolved in 9 mL EG under stirring, followed by adding 3 mL $IrCl_3$ solution (0.05 M, dissolved in EG and aged for 6 hrs at room temperature) and stirred for 30 mins. The mixed solution was transferred to reflux and heated at 190 °C under stirring for 1 h.

The as-prepared IrTe NTs were washed with ethanol for three times and followed by washing with water for three times by centrifuging.

Apparatus: Transmission electron microscopy (TEM) images were obtained by Philips CM200 UT (Field Emission Instruments, USA). High-resolution TEM (HRTEM) images were obtained with a JEOL JEM 2100F TEM at an accelerating voltage of 200 kV. High angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) and elemental mapping images were acquired by energy dispersive X-ray spectroscopy (EDS) using a JEOL-2100F electron microscope equipped with a STEM unit. X-ray Diffraction (XRD) characterization was carried out by Rigaku Miniflex 600. The tube was operated at 40 kV accelerating voltage and 15 mA current. X-ray photoelectron spectroscopy (XPS) measurements were performed with a Physical Electronics Quantera Scanning X-ray Microprobe. The electrochemical measurements were carried out by an electrochemical workstation (CHI 630E) coupled with a three-electrode system. A saturated calomel electrode (SCE) filled with saturated KCl aqueous solution and Pt wire were used as reference electrode and counter electrode, respectively.

Electrocatalytic experiments: Prior to the surface coating, the rotating disk electrode (RDE) was polished carefully with 0.3 and 0.05 μm alumina powder, respectively, and rinsed with deionized water, followed by sonicated in ethanol and doubly distilled water successively. Then, the electrode was allowed to dry under nitrogen. In order to get homogeneous catalysts ink, we loaded IrTe NTs onto carbon black with 20 % loading weight. The 1 mg_{Ir}/mL IrTe NTs/C and commercial IrO_2 ink were prepared by dispersing their powders into the mix solution that containing 2-propanol (2 mL), water (8 mL) and Nafion (5%) (0.05 mL), respectively, followed by ultrasonic for 15 mins. The loading of Ir and commercial IrO_2 NPs on RDE are 25.5 μg/cm^2.

Supporting Figures

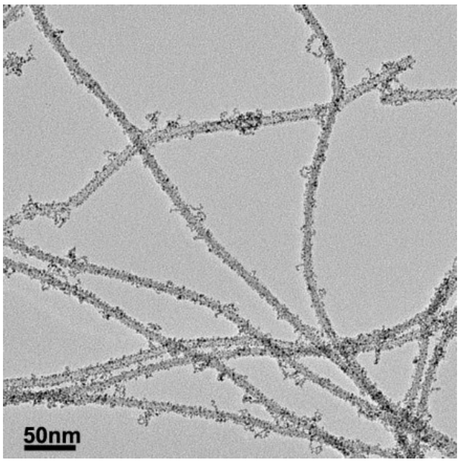

Figure S1. TEM image of IrTe NTs with the molar ratio of Ir/Te reached 4/3, while the reaction equation is: $4Ir^{3+} + 3Te \longrightarrow 3Te^{4+} + 4Ir$.

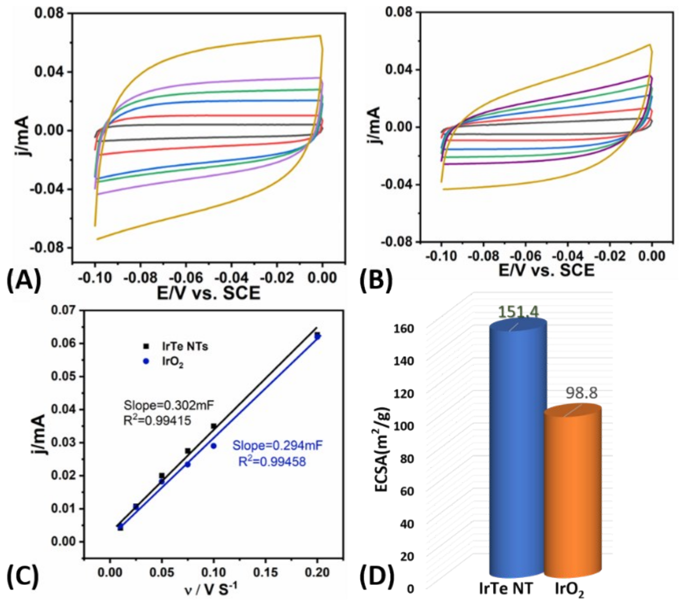

Figure S2. Charging currents measured at different scan rates (0.01, 0.025, 0.05, 0.075, 0.1 and 0.2 V/s) in N_2-sauturated 0.1 M $HClO_4$ aqueous solution for (A) IrTe NTs and (B) IrO_2. (C) The cathodic charging currents measured at -0.02 V *vs.* SCE plotted as a function of scan rate. (D) The as-calculated ECSA of IrTe NTs and IrO_2.

ECSA calculation:

Briefly, the double layer capacitance (C_{DL}) is obtained from the charge current i_c as function of the scan rate (ν), equal to the slope based on equation (1) shown as following:[1]

$i_c = v * C_{DL}$ (1)

ECSA is calculated through the follow equation (2):

$ECSA = C_{DL}/(C_s * m_{Ir})$ (2)

Whereas the specific capacitance (C_s) is 0.035 mF cm^{-2} in 0.1M $HClO_4$ aqueous solution, the mass loading (m_{Ir}) of IrTe NTs and IrO_2 are 5 µg and 4.25 µg on the electrode, respectively.”

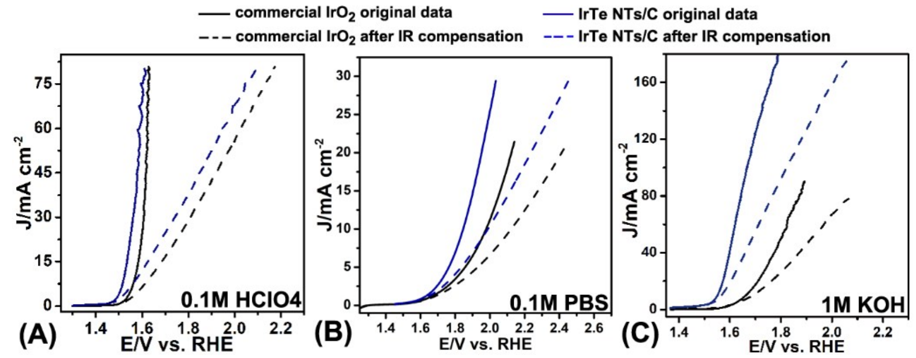

Figure S3. Polarization curves before and after iR compensation in 0.1 M $HClO_4$ (A), 0.1 M PBS (B) and 1 M KOH (C), respectively.

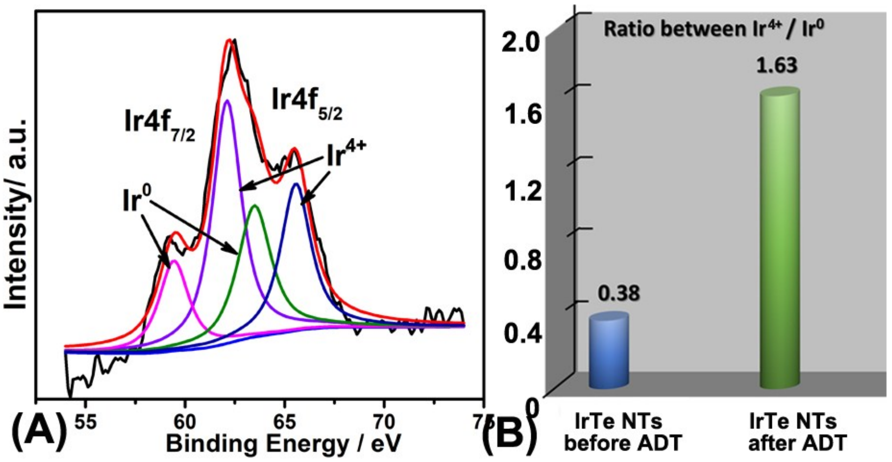

Figure S4. (A) XPS of Ir 4f of IrTe NTs after ADT. (B) Ratio between Ir^{4+} and Ir^0 of IrTe NTs before and after ADT, respectively.

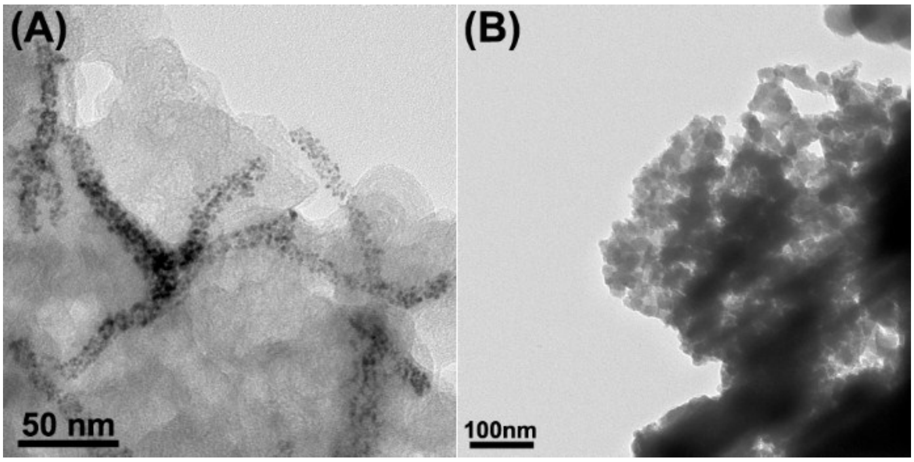

Figure S5. TEM images of IrTe NTs/C (A) and commercial IrO_2 NPs (B) after ADT.

Table S1. Comparison OER activity of IrTe Nanotubes with other electrocatalysts in 0.1M $HClO_4$ acidic solutions at the current density of 10 mA/cm^2.

electrocatalyst	mass loading (ug/cm^2)	Overpotential (mV)	Ref.
IrCoNi porous hollow nanocrystals	10	303	2
Co-IrCu octahedral nanocage	20	290	3
IrNi oxide	20	310	4
IrNiCu double-layered nanoframe	20	300	5
IrTe nanotube	25.5	290	This work

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