Unprecedentedly efficient overall water splitting in acid with anisotropic metal nanosheets

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Water electrolysis is among the most wanted techniques to produce hydrogen, however, it accounts for only 4% of global hydrogen production.[1] One of the reasons is the high cost and low performance of catalysts promoting the anodic oxygen evolution reaction (OER). OER is an uphill energy transformation process involving four-proton and -electron transfers per oxygen molecule, which typically requires catalysts to work under high overpotentials and counteracts the long-term operation of catalysts. Currently, only Ir oxides show moderate stability for OER in acid,[2] but still require high overpotentials (generally over 300 mV). In contrast, Ru is the most active OER catalyst and is nearly 5~16 times cheaper than Ir these five years, however, Ru cannot be practically used because of serious degradation problem.[3]

We report a highly efficient catalyst in acid, that is solid-solution Ru-Ir nanosized-coral (**RuIr-NC**) consisting of 3 nm-thick sheets with only 6 at.% of Ir (Figure (a, b)). **RuIr-NC** achieves high mass activity and specific activity for OER, which are 1-2 orders of magnitude higher than the reported highly active catalysts. An overall water-splitting cell using **RuIr-NC** as both electrodes can reach 10 mA/cm^2 at 1.485 V for 120 h without noticeable degradation (Figure (c)), which outperforms the known cells. Operando spectroscopy and atomic-resolution electron microscopy indicated that the high performance results from the ability of the preferentially exposed {0001} facets to resist the formation of dissolvable metal oxides and to transform ephemeral Ru into a long-lived catalyst.

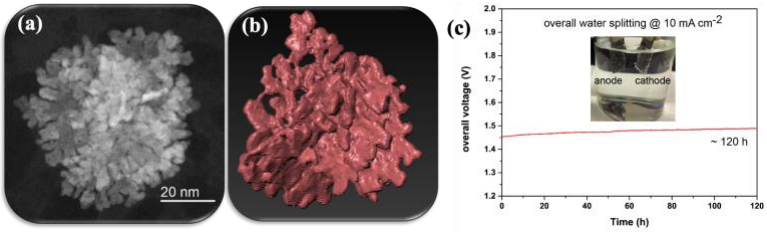

Figure (a) High-angle annular dark-field-Scanning transmission electron microscopy image of RuIr-NC (b) an image from 3D tomographic reconstructions showing coral-like morphology. (c) Chronopotentiometric curves of **RuIr-NC** ‖ **RuIr-NC** full cell at 10 mA cm^{-2}_{geo}. The inset shows the two-electrode configuration with bubbles on both electrodes.

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